NFPA 54
National Fuel Gas Code

2002 Edition

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An International Codes and Standards Organization

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NFPA 54–2002

ANSI Z223.1–2002

National Fuel Gas Code

2002 Edition

This 2002 edition incorporates changes to the 1999 edition. It was adopted by the National Fire Protection Association (NFPA) on July 19, 2002 and was approved by the American National Standards Institute, Inc. (ANSI) on August 1, 2002. The ANSI designation is Z223.1–2002. The NFPA designation is NFPA 54–2002.

Changes other than editorial, including dimensional abbreviations, from the 1999 edition are denoted by a vertical line in the margin.

Origin and Development

This code offers general criteria for the installation and operation of gas piping and gas equipment on consumers' premises. It is the cumulative result of years of experience of many individuals and many organizations acquainted with the installation of gas piping and equipment designed for utilization of gaseous fuels. It is intended to promote public safety by providing requirements for the safe and satisfactory utilization of gas.

Changes in this code can become necessary from time to time. When any revision is deemed advisable, recommendations should be forwarded to the Secretary, Accredited Standards Committee Z223, 400 N. Capitol St. NW, Washington, DC 20001, and the Secretary, Standards Council, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

In October 1967, representatives of the American Gas Association, the American Society of Mechanical Engineers, and the National Fire Protection Association met as a Conference Group on Piping and Installation Standards to consider the development of a single *National Fuel Gas Code*. This conference was the result of the expressed need within the gas industry, among public safety authorities, insurance groups, architects, designers, and builders, for one code that would cover all facets of fuel gas piping and appliance installation downstream from meter set assemblies or other components comprising the gas service entrance to the consumer premises.

At a January 1968 meeting, the conference group developed the objectives and scope of a proposed National Standards Committee. The group envisioned the combining of the following standards into a single *National Fuel Gas Code:*

(1) *American National Standard Installation of Gas Appliances and Gas Piping*, ANSI Z21.30 (NFPA 54)
(2) *Installation of Gas Piping and Gas Equipment on Industrial Premises and Certain Other Premises*, ANSI Z83.1 (NFPA 54A)
(3) *Fuel Gas Piping*, ASME B31.2

The proposed scope at that time limited coverage of piping systems to 60 psi (414 kPa). The National Standards Committee agreed to relinquish Z21.30 (NFPA 54), Z83.1 (NFPA 54A), and applicable portions of ASME B31.2 covering piping systems up to and including 60 psi (414 kPa) to a new National Fuel Gas Code Committee, cosponsored by the three associations.

On August 13, 1971, the American National Standards Institute approved the scope of activities and the formation of the National Standards Committee on National Fuel Gas Code, Z223.

To establish a *National Fuel Gas Code* to satisfy the immediate needs of the gas industry, at its December 6, 1972, organizational meeting the Z223 Committee combined NFPA 54-1969, Z21.30-1969, and Z83.1-1972 with only those editorial revisions necessary to reflect the scope of the new code. Further revisions of the code would be necessary to incorporate pertinent coverage for fuel gas piping from ASME B31.2-1968.

The first edition of the code was issued in 1974. The American Gas Association and the National Fire Protection Association have continued cosponsorship of the code following the first edition.

The second edition of the code, incorporating pertinent portions of B31.2, was issued in 1980. The third, fourth, fifth, sixth, and seventh editions were issued in 1984, 1988, 1992, 1996, and 1999, respectively. The scope of the code was expanded in 1988 to include piping systems up to and including 125 psi (862 kPa).

The 2002 edition revises the requirements to determine if the indoor air volume is sufficient for combustion and ventilation air needs of appliances installed within the space. A new method is added that allows the use of actual or calculated building air exchange rate in determining if there is adequate indoor air volume based on the combustion air needs for fan-assisted combustion appliances and other appliance types.

Codifying the longest length method and adding a new branch length method result in the revision of the requirements for gas pipe sizing. The pipe sizing tables have been recalculated and pipe sizing equations have been revised.

Prior editions of this document have been translated into languages other than English, including Spanish.

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Rep. National Propane Gas Association

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*NFPA 54 Committee only. †Z223 Committee only.

Committee Scope: This Committee shall have primary responsibility for documents on safety code for gas piping systems on consumers' premises and the installation of gas utilization equipment and accessories for use with fuel gases such as natural gas, manufactured gas, liquefied petroleum gas in the vapor phase, liquefied petroleum gas-air mixtures, or mixtures of these gases, including: (a) The design, fabrication, installation, testing, operation, and maintenance of gas piping systems from the point of delivery to the connections with each gas utilization device. Piping systems covered by this code are limited to a maximum

operating pressure of 125 psig. For purposes of this code, the point of delivery is defined as the outlet of the meter set assembly, or the outlet of the service regulator or service shutoff valve where no meter is provided. (b) The installation of gas utilization equipment, related accessories, and their ventilation and venting systems.

This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

The National Fuel Gas Code Committee is a committee functioning jointly under American National Standards Institute Accredited Standard Committee Z223 procedures and the National Fire Protection Association and, accordingly, the *National Fuel Gas Code* bears two designations, ANSI Z223.1 and NFPA 54. In the ANSI context, the code is prepared by the Accredited Standards Committee on National Fuel Gas Code, Z223, sponsored by the American Gas Association (Administrative Secretariat). In the NFPA context the committee is an NFPA Technical Committee submitted to ANSI under the NFPA audited designation.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet between the paragraphs that remain.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, Annex L lists the complete title and edition of the source documents for both mandatory and nonmandatory extracts. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the appropriate technical committee.

Information on referenced publications can be found in Chapter 2 and Annex L.

All pressures used in this code are gauge pressure unless otherwise indicated.

Chapter 1 Administration

1.1 Scope.

1.1.1 Applicability.

1.1.1.1 This code is a safety code that shall apply to the installation of fuel gas piping systems, fuel gas utilization equipment, and related accessories as shown in 1.1.1.1(A) through 1.1.1.1(D).

(A) Coverage of piping systems shall extend from the point of delivery to the connections with each gas utilization device. For other than undiluted liquefied petroleum gas systems, the point of delivery shall be considered the outlet of the service meter assembly or the outlet of the service regulator or service shutoff valve where no meter is provided. For undiluted liquefied petroleum gas systems, the point of delivery shall be considered the outlet of the final pressure regulator, exclusive of line gas regulators, in the system.

(B) The maximum operating pressure shall be 125 psi (862 kPa).

Exception No. 1: Piping systems for gas–air mixtures within the flammable range are limited to a maximum pressure of 10 psi (69 kPa).

Exception No. 2: LP-Gas piping systems are limited to 20 psi (140 kPa), except as provided in 5.5.2.

(C) Piping systems requirements shall include design, materials, components, fabrication, assembly, installation, testing, inspection, operation, and maintenance.

(D) Requirements for gas utilization equipment and related accessories shall include installation, combustion, and ventilation air and venting.

1.1.1.2 This code shall not apply to the following items (reference standards for some of which appear in Annex L):

(1) Portable LP-Gas equipment of all types that are not connected to a fixed fuel piping system
(2) Installation of farm equipment such as brooders, dehydrators, dryers, and irrigation equipment
(3) Raw material (feedstock) applications except for piping to special atmosphere generators
(4) Oxygen–fuel gas cutting and welding systems
(5) Industrial gas applications using such gases as acetylene and acetylenic compounds, hydrogen, ammonia, carbon monoxide, oxygen, and nitrogen
(6) Petroleum refineries, pipeline compressor or pumping stations, loading terminals, compounding plants, refinery tank farms, and natural gas processing plants
(7) Large integrated chemical plants or portions of such plants where flammable or combustible liquids or gases are produced by chemical reactions or used in chemical reactions
(8) LP-Gas installations at utility gas plants
(9) Liquefied natural gas (LNG) installations
(10) Fuel gas piping in power and atomic energy plants
(11) Proprietary items of equipment, apparatus, or instruments such as gas generating sets, compressors, and calorimeters
(12) LP-Gas equipment for vaporization, gas mixing, and gas manufacturing
(13) LP-Gas piping for buildings under construction or renovations that is not to become part of the permanent building piping system — that is, temporary fixed piping for building heat
(14) Installation of LP-Gas systems for railroad switch heating
(15) Installation of LP-Gas and compressed natural gas systems on vehicles
(16) Gas piping, meters, gas pressure regulators, and other appurtenances used by the serving gas supplier in distribution of gas, other than undiluted LP-Gas
(17) Building design and construction, except as specified herein
(18) Fuel gas systems on recreational vehicles manufactured in accordance with NFPA 1192, *Standard on Recreational Vehicles*
(19) Fuel gas systems using hydrogen as a fuel

1.1.2 Other Standards. In applying this code, reference shall also be made to the manufacturers' instructions and the serving gas supplier regulations.

1.2 Purpose. (Reserved)

1.3 Retroactivity. Unless otherwise stated, the provisions of this code shall not be applied retroactively to existing systems that were in compliance with the provisions of the code in effect at the time of installation.

1.4 Equivalency. The provisions of this code are not intended to prevent the use of any material, method of construction, or installation procedure not specifically prescribed by this code, provided any such alternate is acceptable to the authority having jurisdiction *(see Section 3.3)*. The authority having jurisdiction shall require that sufficient evidence be submitted to substantiate any claims made regarding the safety of such alternates.

1.5* Enforcement. This code shall be administered and enforced by the authority having jurisdiction designated by the governing authority. *(See A.1.5 for sample wording for enabling legislation.)*

Chapter 2 Referenced Publications (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this code. Where terms are not included, common usage of the terms shall apply.

3.2 (Reserved)

3.3 General Definitions.

3.3.1 Accessible. Having access to but which first requires the removal of a panel, door, or similar covering of the item described.

3.3.2 Accessible, Readily. Having direct access without the need of removing or moving any panel, door, or similar covering of the item described.

3.3.3 Agency, Qualified. *See* Qualified Agency.

3.3.4 Air, Circulating. Air for cooling, heating, or ventilation distributed to habitable spaces.

3.3.5 Air Conditioner, Gas-Fired. A gas-burning, automatically operated appliance for supplying cooled and/or dehumidified air or chilled liquid.

3.3.6 Air Conditioning. The treatment of air so as to control simultaneously its temperature, humidity, cleanness, and distribution to meet the requirements of a conditioned space.

3.3.7 Air Shutter. An adjustable device for varying the size of the primary air inlet(s).

3.3.8 Anodeless Riser. An assembly of steel cased plastic pipe used to make the transition between plastic piping installed underground and metallic piping installed aboveground.

3.3.9 Appliance. Any device that utilizes gas as a fuel or raw material to produce light, heat, power, refrigeration, or air conditioning.

3.3.10 Appliance, Automatically Controlled. Appliance equipped with an automatic burner ignition and safety shutoff device and other automatic devices.

3.3.11 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.

3.3.12 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.

3.3.13 Appliance, Nonresidential, Low-Heat. A commercial, industrial, or institutional appliance needing a chimney capable of withstanding a continuous flue gas temperature not exceeding 1000°F (538°C). [**211:**1-5]

3.3.14 Appliance, Nonresidential, Medium-Heat. A commercial, industrial, or institutional appliance needing a chimney capable of withstanding a continuous flue gas temperature not exceeding 1800°F (982°C). [**211:**1-5]

3.3.15* Approved. Acceptable to the authority having jurisdiction.

3.3.16 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.

3.3.17* Authority Having Jurisdiction (AHJ). The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

3.3.18 Automatic Firecheck. A device for stopping the progress of a flame front in burner mixture lines (flashback) and for automatically shutting off the fuel–air mixture.

3.3.19 Automatic Gas Shutoff Device. A device constructed so that the attainment of a water temperature in a hot water supply system in excess of some predetermined limit acts in such a way as to cause the gas to the system to be shut off.

3.3.20 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.

3.3.21 Back Pressure. Pressure against which a fluid is flowing, resulting from friction in lines, restrictions in pipes or valves, pressure in vessel to which fluid is flowing, hydrostatic head, or other impediment that causes resistance to fluid flow.

3.3.22 Backfire Preventer. *See* Safety Blowout.

3.3.23 Baffle. An object placed in an appliance to change the direction of or retard the flow of air, air–gas mixtures, or flue gases.

3.3.24 Barometric Draft Regulator. A balanced damper device attached to a chimney, vent connector, breeching, or flue gas manifold to control chimney draft.

3.3.25 Boiler, Hot Water Heating. 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 psi (1100 kPa) and at water temperatures not exceeding 250°F (121°C) at or near the boiler outlet.

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

3.3.27 Boiler, Low-Pressure. A self-contained gas-burning appliance for supplying steam or hot water.

3.3.28 Boiler, Steam Heating. A boiler in which steam is generated and that operates at a steam pressure not exceeding 15 psi (100 kPa).

3.3.29 Branch Line. Gas piping that conveys gas from a supply line to the appliance.

3.3.30 Breeching. *See* Vent Connector.

3.3.31 Broiler. A general term including broilers, salamanders, barbecues, and other devices cooking primarily by radiated heat, excepting toasters.

3.3.32 Btu. Abbreviation for British thermal unit, which is the quantity of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit (equivalent to 1055 joules).

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

3.3.34 Burner, Forced-Draft. *See* Burner, Power.

3.3.35 Burner, Injection (Bunsen) Type. A burner employing the energy of a jet of gas to inject air for combustion into the burner and mix it with the gas.

3.3.36 Burner, Power. A burner in which either gas or air, or both, are supplied at a pressure exceeding, for gas, the line pressure, and for air, atmospheric pressure; this added pressure being applied at the burner. A burner for which air for combustion is supplied by a fan ahead of the appliance is commonly designated as a forced-draft burner.

3.3.37 Burner, Power, Fan-Assisted. A burner that uses either induced or forced draft.

3.3.38 Central Premix System. A system that distributes flammable gas–air mixtures to two or more remote stations.

3.3.39 Chimney. One or more passageways, vertical or nearly so, for conveying flue or vent gases to the outside atmosphere. *(See also Gas Vent, and Venting System.)*

3.3.40 Chimney, Factory-Built. A chimney composed of listed factory-built components assembled in accordance with the terms of listing to form the completed chimney.

3.3.41 Chimney, Masonry. A field-constructed chimney of solid masonry units, bricks, stones, listed masonry chimney units, or reinforced portland cement concrete, lined with suitable chimney flue liners.

3.3.42 Chimney, Metal. A field-constructed chimney of metal.

3.3.43 Clothes Dryer. A device used to dry wet laundry by means of heat derived from the combustion of fuel gases.

3.3.44 Clothes Dryer, Type 1. Factory-built package, multiply produced. Primarily used in family living environment. May or may not be coin-operated for public use.

3.3.45 Clothes Dryer, Type 2. Factory-built package, multiply produced. Used in business with direct intercourse of the function with the public. May or may not be operated by public or hired attendant. May or may not be coin-operated.

3.3.46 Combustible Material. As pertaining to materials adjacent to or in contact with heat-producing appliances, vent connectors, gas vents, chimneys, steam and hot water pipes, and warm air ducts, shall mean materials made of or surfaced with wood, compressed paper, plant fibers, or other materials that are capable of being ignited and burned. Such material shall be considered combustible even though flame-proofed, fire-retardant treated, or plastered.

3.3.47 Combustion. As used herein, the rapid oxidation of fuel gases accompanied by the production of heat or heat and light. Complete combustion of a fuel is possible only in the presence of an adequate supply of oxygen.

3.3.48 Combustion Chamber. The portion of an appliance within which combustion occurs.

3.3.49 Combustion Products. Constituents resulting from the combustion of a fuel with the oxygen of the air, including the inert but excluding excess air.

3.3.50 Common Vent. That portion of a vent or chimney system that conveys products of combustion from more than one appliance.

3.3.51 Common Vent Manifold. A horizontal extension of the common vent within the room in which the appliances are installed.

3.3.52 Concealed Gas Piping. Gas piping that, when in place in a finished building, would require removal of permanent construction to gain access to the piping.

3.3.53 Condensate (Condensation). The liquid that separates from a gas (including flue gas) due to a reduction in temperature or an increase in pressure.

3.3.54 Consumption. The maximum amount of gas per unit of time, usually expressed in cubic feet per hour, or Btu per hour, required for the operation of the appliance or appliances supplied.

3.3.55 Control Piping. All piping, valves, and fittings used to interconnect air, gas, or hydraulically operated control apparatus or instrument transmitters and receivers.

3.3.56 Controls. Devices designed to regulate the gas, air, water, or electrical supply to a gas appliance. These may be manual or automatic.

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

3.3.58 Conversion Burner, Gas. A unit consisting of a burner and its controls utilizing gaseous fuel for installation in an appliance originally utilizing another fuel.

3.3.59 Counter Appliances, Gas. *See* Food Service Equipment, Gas Counter Appliance.

3.3.60 Cubic Foot (ft^3) of Gas. The amount of gas that would occupy 1 ft^3 (0.03 m^3) when at a temperature of 60°F (16°C), saturated with water vapor and under a pressure equivalent to that of 30 in. w.c. (7.5 kPa).

3.3.61 Decorative Appliance for Installation in a Vented Fireplace. A self-contained, freestanding, fuel-gas burning appliance designed for installation only in a vented fireplace and whose primary function lies in the aesthetic effect of the flame.

3.3.62 Deep Fat Fryer. *See* Food Service Equipment, Gas Deep Fat Fryer.

3.3.63 Design Certification. The process by which a product is evaluated and tested by an independent laboratory to affirm that the product design complies with specific requirements.

3.3.64 Design Pressure. The maximum operating pressure permitted by this code, as determined by the design procedures applicable to the materials involved.

3.3.65 Dilution Air. Air that enters a draft hood or draft regulator and mixes with the flue gases.

3.3.66 Direct Gas-Fired Industrial Air Heater. A heater in which all of the products of combustion generated by the gas-burning device are released into the airstream being heated;

whose purpose is to offset the building heat loss by heating incoming outside air, inside air, or a combination of both.

3.3.67 Direct Gas-Fired Makeup Air Heater. A heater in which all the products of combustion generated by the fuel-gas burning device are released into the outside airstream being heated.

3.3.68 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 to the outside atmosphere.

3.3.69 Diversity Factor. Ratio of the maximum probable demand to the maximum possible demand.

3.3.70 Draft. A pressure difference that causes gases or air to flow through a chimney, vent, flue, or fuel burning equipment.

3.3.71 Draft, Mechanical. Draft produced by a fan or an air or steam jet. When a fan is located so as to push the flue gases through the chimney or vent, the draft is forced. When the fan is located so as to pull the flue gases through the chimney or vent, the draft is induced. [**211:**1-5]

3.3.72 Draft, Natural. Draft produced by the difference in the weight of a column of flue gases within a chimney or vent and a corresponding column of air of equal dimension outside the chimney or vent. [**211:**1-5]

3.3.73 Draft Hood. A nonadjustable device built into an appliance, or made a part of the vent connector from an appliance, that is designed to (1) provide for the ready escape of the flue gases from the appliance in the event of no draft, backdraft, or stoppage beyond the draft hood, (2) prevent a backdraft from entering the appliance, and (3) neutralize the effect of stack action of the chimney or gas vent upon the operation of the appliance.

3.3.74 Draft Regulator. A device that functions to maintain a desired draft in the appliance by automatically reducing the draft to the desired value.

3.3.75 Drip. The container placed at a low point in a system of piping to collect condensate and from which it may be removed.

3.3.76 Dry Gas. A gas having a moisture and hydrocarbon dew point below any normal temperature to which the gas piping is exposed.

3.3.77 Duct Furnace. A furnace normally installed in distribution ducts of air conditioning systems to supply warm air for heating. This definition applies only to an appliance that depends for air circulation on a blower not furnished as part of the furnace.

3.3.78 Effective Ground-Fault Current Path. An intentionally constructed, permanent, low impedance electrically conductive path designed and intended to carry underground fault conditions from the point of a ground fault on a wiring system to the electrical supply source.

3.3.79 Equipment. *See* Appliance.

3.3.80 Excess Air. Air that passes through the combustion chamber and the appliance flues in excess of that which is theoretically required for complete combustion.

3.3.81 Explosion Heads (Soft Heads or Rupture Discs). A protective device for relieving excessive pressure in a premix system by bursting of a rupturable disc.

3.3.82 Exterior Masonry Chimneys. Masonry chimneys exposed to the outdoors on one or more sides below the roof line.

3.3.83 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.

3.3.84 FAN Max. The maximum input rating of a Category I, fan-assisted appliance attached to a vent or connector.

3.3.85 FAN Min. The minimum input rating of a Category I, fan-assisted appliance attached to a vent or connector.

3.3.86 FAN+FAN. The maximum combined appliance input rating of two or more Category I, fan-assisted appliances attached to the common vent.

3.3.87 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.

3.3.88 Fireplace. A fire chamber and hearth constructed of noncombustible material for use with solid fuels and provided with a chimney.

3.3.89 Flame Arrester. A nonvalve device for use in a gas–air mixture line containing a means for temporarily stopping the progress of a flame front (flashback).

3.3.90 Floor Furnace. A completely self-contained unit furnace suspended from the floor of the space being heated, taking air for combustion from outside this space.

3.3.91 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.

3.3.92 Flue, Chimney. The passage(s) in a chimney for conveying the flue or vent gases to the outside atmosphere.

3.3.93 Flue Collar. That portion of an appliance designed for the attachment of a draft hood, vent connector, or venting system.

3.3.94 Flue Gases. Products of combustion plus excess air in appliance flues or heat exchangers.

3.3.95 Food Service Equipment, Gas Counter Appliance. An appliance such as a gas coffee brewer and coffee urn and any appurtenant water heating equipment, food and dish warmer, hot plate, and griddle.

3.3.96 Food Service Equipment, Gas Deep Fat Fryer. An appliance, including a cooking vessel in which oils or fats are placed to such a depth that the cooking food is essentially supported by displacement of the cooking fluid or a perforated container immersed in the cooking fluid rather than by the bottom of the vessel, designed primarily for use in hotels, restaurants, clubs, and similar institutions.

3.3.97 Food Service Equipment, Gas-Fired Kettle. An appliance with a cooking chamber that is heated either by a steam jacket in which steam is generated by gas heat or by direct gas heat applied to the cooking chamber.

3.3.98 Food Service Equipment, Gas Oven, Baking and Roasting. An oven primarily intended for volume food preparation that may be composed of one or more sections or units of the

following types: (1) cabinet oven, an oven having one or more cavities heated by a single burner or group of burners; (2) reel-type oven, an oven employing trays that are moved by mechanical means; or (3) sectional oven, an oven composed of one or more independently heated cavities.

3.3.99 Food Service Equipment, Gas Range. A self-contained gas range providing for cooking, roasting, baking, or broiling, or any combination of these functions, and not designed specifically for domestic use.

3.3.100 Food Service Equipment, Gas Steam Cooker. A gas appliance that cooks, defrosts, or reconstitutes food by direct contact with steam.

3.3.101 Food Service Equipment, Gas Steam Generator. A separate appliance primarily intended to supply steam for use with food service equipment.

3.3.102 Furnace, Central. A self-contained, gas-burning 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.

3.3.103 Furnace, Enclosed. A specific heating, or heating and ventilating, furnace incorporating an integral total enclosure and using only outside air for combustion.

3.3.104 Furnace, Forced-Air. A furnace equipped with a fan or blower that provides the primary means for circulation of air.

3.3.105 Furnace Plenum. A compartment or chamber that is supplied with the furnace or constructed of ductwork that is attached to the inlet or outlet of a furnace or air handling unit and has one or more circulating air ducts connected to it.

3.3.106 Garage, Repair. A building, structure, or portions thereof wherein major repair or painting or body and fender work is performed on motorized vehicles or automobiles, and includes associated floor space used for offices, parking, and showrooms.

3.3.107 Garage, Residential. A building or room in which self-propelled passenger vehicles are or can be stored and that will not normally be used for other than minor service or repair operations on such stored vehicles.

3.3.108 Gas Fireplace, Direct Vent. A system consisting of (1) an appliance for indoor installation that allows the view of flames and provides the simulation of a solid fuel fireplace, (2) combustion air connections between the appliance and the vent-air intake terminal, (3) flue-gas connections between the appliance and the vent-air intake terminal, (4) a vent-air intake terminal for installation outdoors, constructed such that all air for combustion is obtained from the outdoor atmosphere and all flue gases are discharged to the outdoor atmosphere.

3.3.109 Gas Fireplace, Vented. A vented appliance that allows the view of flames and provides the simulation of a solid fuel fireplace.

3.3.110 Gas-Mixing Machine. Any combination of automatic proportioning control devices, blowers, or compressors that supply mixtures of gas and air to multiple burner installations where control devices or other accessories are installed between the mixing device and burner.

3.3.111 Gas Utilization Equipment. Any device that utilizes gas as a fuel or raw material or both.

3.3.112 Gas Vent. A passageway composed of listed factory-built components assembled in accordance with the terms of listing for conveying vent gases from gas appliances or their vent connectors to the outside atmosphere.

3.3.113 Gas Vent, Special Type. Gas vents for venting listed Category II, III, and IV gas appliances.

3.3.114 Gas Vent, Type B. A vent for venting listed gas appliances with draft hoods and other Category I gas appliances listed for use with Type B gas vents.

3.3.115 Gas Vent, Type B-W. A vent for venting listed gas-fired vented wall furnaces.

3.3.116 Gas Vent, Type L. A vent for venting appliances listed for use with Type L vents and appliances listed for use with Type B gas vents.

3.3.117 Gases. Include natural gas, manufactured gas, liquefied petroleum (LP) gas in the vapor phase only, liquefied petroleum gas–air mixtures, and mixtures of these gases, plus gas–air mixtures within the flammable range, with the fuel gas or the flammable component of a mixture being a commercially distributed product.

3.3.118 Governor, Zero. A regulating device that is normally adjusted to deliver gas at atmospheric pressure within its flow rating.

3.3.119 Gravity. *See* Specific Gravity.

3.3.120 Heat Pump, Gas-Fired. A gas-burning, automatically operated appliance utilizing a refrigeration system for supplying either heated air or liquid or heated and/or cooled air or liquid.

3.3.121 Heating Value (Total). The number of British thermal units produced by the combustion, at constant pressure, of 1 ft^3 (0.03 m^3) of gas when the products of combustion are cooled to the initial temperature of the gas and air, when the water vapor formed during combustion is condensed, and when all the necessary corrections have been applied.

3.3.122 Hoop Stress. The stress in a pipe wall, acting circumferentially in a plane perpendicular to the longitudinal axis of the pipe and produced by the pressure of the fluid in the pipe.

3.3.123 Hot Plate. *See* Food Service Equipment, Gas Counter Appliance.

3.3.124 Hot Plate, Domestic. A fuel-gas burning appliance consisting of one or more open-top-type burners mounted on short legs or a base.

3.3.125 Hot Taps. Piping connections made to operating pipelines or mains or other facilities while they are in operation. The connection of the branch piping to the operating line and the tapping of the operating line are done while it is under gas pressure.

3.3.126 Household Cooking Gas Appliance. A gas appliance for domestic food preparation, providing at least one function of (1) top or surface cooking, (2) oven cooking, or (3) broiling.

3.3.127 Household Cooking Gas Appliance, Built-In Unit. A unit designed to be recessed into, placed upon, or attached to the construction of a building, but not for installation on the floor.

3.3.128 Household Cooking Gas Appliance, Broiler. A unit that cooks primarily by radiated heat.

3.3.129 Hybrid Pressure System. A piping system in which the pressure at the point of delivery is reduced by one or more line pressure regulators prior to the appliance connection.

3.3.130 Industrial Air Heaters, Direct Gas-Fired Non-Recirculating. A heater in which all the products of combustion generated by the gas-burning device are released into the air stream being heated to compensate for building heat loss by heating only incoming outside air.

3.3.131 Industrial Air Heaters, Direct Gas-Fired Recirculating. A heater in which all the products of combustion generated by the gas-burning device are released into the air stream being heated to compensate for building heat loss by heating incoming outdoor air, and, if applicable, inside air.

3.3.132 Infrared Heater. A heater that directs a substantial amount of its energy output in the form of infrared energy into the area to be heated. Such heaters may be of either the vented or unvented type.

3.3.133 Insulating Millboard. A factory fabricated board formed with noncombustible materials, normally fibers, and having a thermal conductivity in the range of 1 Btu/in./ft^2/°F/hr (0.14 W/m/°K).

3.3.134 Joint. A connection between two lengths of pipe or between a length of pipe and a fitting.

3.3.135 Kettle, Gas-Fired. *See* Food Service Equipment, Gas-Fired Kettle.

3.3.136 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.3.137 Laundry Stove, Domestic. A fuel-gas burning appliance consisting of one or more open-top-type burners mounted on high legs or having a cabinet base.

3.3.138 Leak Check. An operation performed on a complete gas piping system and connected equipment to verify that the system does not leak.

3.3.139 Limit Control. A device responsive to changes in pressure, temperature, or liquid level for turning on, shutting off, or throttling the gas supply to an appliance.

3.3.140* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction 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 that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.3.141 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.

3.3.142 Manifold, Gas. The conduit of an appliance that supplies gas to the individual burners.

3.3.143 Manufactured Home. A structure, transportable in one or more sections, that is 8 body-ft (24.4 cm) or more in width or 40 body-ft (1219 cm) or more in length in the traveling mode or, when erected on site, is 320 ft^2 (28 m^2) or more; which is built on a chassis and designed to be used as a dwelling, with or without a permanent foundation, when connected to the required utilities, including the plumbing, heating, air conditioning, and electrical systems contained therein. Calculations used to determine the number of square feet in a structure will be based on a structure's exterior dimensions, measured at the largest horizontal projections when erected on site. These dimensions include all expandable rooms, cabinets, and other projections containing interior space, but do not include bay windows. [**501:**1.2]

3.3.144 Maximum Working Pressure. The maximum pressure at which a piping system may be operated in accordance with the provisions of this code.

3.3.145 Mechanical Exhaust System. Equipment installed in and made a part of the vent, which will provide a positive induced draft.

3.3.146 Meter. An instrument installed to measure the volume of gas delivered through it.

3.3.147 Mixing Blower. A motor-driven blower to produce gas–air mixtures for combustion through one or more gas burners or nozzles on a single-zone industrial heating appliance or on each control zone of a multizone industrial appliance or on each control zone of a multizone installation.

3.3.148 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.

3.3.149 NAT Max. The maximum input rating of a Category I, draft hood-equipped appliance attached to a vent or connector.

3.3.150 NAT+NAT. The maximum combined appliance input rating of two or more Category I, draft hood-equipped appliances attached to the common vent.

3.3.151 Noncombustible Material. For the purpose of this code, noncombustible material shall mean material that is not capable of being ignited and burned, such as material consisting entirely of, or of a combination of, steel, iron, brick, tile, concrete, slate, asbestos, glass, and plaster.

3.3.152 Nondisplaceable Valve Member. A nondisplaceable valve member that cannot be moved from its seat by a force applied to the handle or by a force applied by a plane surface to any exterior portion of the valve.

3.3.153 Occupancy, Health Care. An occupancy used for purposes of medical or other treatment or care of four or more persons where such occupants are mostly incapable of self-preservation due to age, physical or mental disability, or because of security measures not under the occupants' control. [***101:*** 3.3.134.7]

3.3.154 Occupancy, Residential Board and Care. A building or portion thereof that is used for lodging and boarding of four or more residents, not related by blood or marriage to the owners or operators, for the purpose of providing personal care services. [***101:*** 3.3.134.13]

3.3.155 Offset, Vent. An arrangement of two or more fittings and pipe installed for the purpose of locating a vertical section of vent pipe in a different but parallel plane with respect to an adjacent section of vertical vent pipe.

3.3.156 Orifice. The opening in a cap, spud, or other device whereby the flow of gas is limited and through which the gas is discharged to the burner.

3.3.157 Outdoor Cooking Gas Appliance. As used in this code, a post-mounted, fuel-gas burning outdoor cooking appliance for installation directly on and attachment to a post provided as a part of the appliance by the manufacturer.

3.3.158 Oven, Gas Baking and Roasting. *See* Food Service Equipment, Gas Oven.

3.3.159 Parking Structure. A building, structure, or portion thereof used for the parking of motor vehicles.

3.3.160 Parking Structure, Basement or Underground. A parking structure or portion thereof located below grade.

3.3.161 Parking Structure, Enclosed. Having exterior enclosing walls that have less than 25 percent of the total wall area open to atmosphere at each level using at least two sides of the structure.

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

3.3.163 Pipe. Rigid conduit of iron, steel, copper, brass, aluminum, or plastic.

3.3.164 Pipe, Equivalent Length. The resistance of valves, controls, and fittings to gas flow expressed as equivalent length of straight pipe for convenience in calculating pipe sizes.

3.3.165 Piping. As used in this code, either pipe, tubing, or both. *See* Pipe, Tubing.

3.3.166 Piping System. All piping, valves, and fittings from the outlet of the point of delivery from the supplier to the outlets of the equipment shutoff valves.

3.3.167 Plenum. A compartment or chamber to which one or more ducts are connected and that forms part of the air distribution system.

3.3.168 Pool Heater. An appliance designed for heating nonpotable water stored at atmospheric pressure, such as water in swimming pools, therapeutic pools, and similar applications.

3.3.169 Pressure. Unless otherwise stated, is expressed in pounds per square inch above atmospheric pressure.

3.3.170 Pressure Drop. The loss in pressure due to friction or obstruction in pipes, valves, fittings, regulators, and burners.

3.3.171 Pressure Limiting Device. Equipment that under abnormal conditions will act to reduce, restrict, or shut off the supply of gas flowing into a system in order to prevent the gas pressure in that system from exceeding a predetermined value.

3.3.172 Pressure Test. An operation performed to verify the gastight integrity of gas piping following its installation or modification.

3.3.173 Primary Air. The air introduced into a burner that mixes with the gas before it reaches the port or ports.

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

3.3.175 Qualified Agency. Any individual, firm, corporation, or company that either in person or through a representative is engaged in and is responsible for (a) the installation, testing, or replacement of gas piping or (b) the connection, installation, testing, repair, or servicing of equipment; that is experienced in such work; that is familiar with all precautions required; and that has complied with all the requirements of the authority having jurisdiction.

3.3.176 Quick-Disconnect Device. A hand-operated device that provides a means for connecting and disconnecting an appliance or an appliance connector to a gas supply and that is equipped with an automatic means to shut off the gas supply when the device is disconnected.

3.3.177 Range. *See* Food Service Equipment, Gas Range.

3.3.178 Refrigerator (Using Gas Fuel). A fuel-gas-burning appliance that is designed to extract heat from a suitable chamber.

3.3.179 Regulator, Gas Appliance. A pressure regulator for controlling pressure to the manifold of gas equipment.

3.3.180 Regulator, Line Gas. A pressure regulator placed in a gas line between the service regulator and the gas appliance regulator.

3.3.181 Regulator, Monitoring. A pressure regulator set in series with another pressure regulator for the purpose of automatically taking over in an emergency the control of the pressure downstream of the regulator in case that pressure tends to exceed a set maximum.

3.3.182 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.

3.3.183 Regulator, Series. A pressure regulator in series with one or more other pressure regulators.

3.3.184 Regulator, Service. A pressure regulator installed by the serving gas supplier to reduce and limit the service line gas pressure to delivery pressure.

3.3.185 Regulator Vent. The opening in the atmospheric side of the regulator housing permitting the in and out movement of air to compensate for the movement of the regulator diaphragm.

3.3.186 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 inspiration of air into the draft hood in the event of a strong chimney updraft.

3.3.187 Room Heater, Unvented. An unvented, self-contained, freestanding, nonrecessed, fuel-gas-burning appliance for furnishing warm air by gravity or fan circulation to the space in which installed, directly from the heater without duct connection.

3.3.188 Room Large in Comparison with Size of Equipment. Rooms having a volume equal to at least 12 times the total volume of a furnace or air-conditioning appliance and at least 16 times the total volume of a boiler.

3.3.189 Safety Blowout (Backfire Preventer). A protective device located in the discharge piping of large mixing machines, incorporating a bursting disc for excessive pressure release, means for stopping a flame front, and an electric switch or other release mechanism for actuating a built-in or separate safety shutoff.

3.3.190 Safety Shutoff Device. A device that will shut off the gas supply to the controlled burner(s) in the event the source of ignition fails. This device can interrupt the flow of gas to main burner(s) only or to pilot(s) and main burner(s) under its supervision.

3.3.191 Service Head Adapter. A transition fitting for use with plastic piping (which is encased in non-pressure-carrying metal pipe) that connects the metal pipe casing and plastic pipe and tubing to the remainder of the piping system.

3.3.192 Service Meter Assembly. The piping and fittings installed by the serving gas supplier to connect the inlet side of the meter to the gas service and to connect the outlet side of the meter to the customer's house or yard piping.

3.3.193 Service Regulator. *See* Regulator, Pressure and Regulator, Service.

3.3.194 Shall. Indicates a mandatory requirement.

3.3.195 Shutoff. *See* Valve.

3.3.196 Sources of Ignition. Devices or equipment that, because of their intended modes of use or operation, are capable of providing sufficient thermal energy to ignite flammable gas–air mixtures.

3.3.197 Specific Gravity. As applied to gas, the ratio of the weight of a given volume to that of the same volume of air, both measured under the same conditions.

3.3.198 Steam Cooker. *See* Food Service Equipment, Gas Steam Cooker.

3.3.199 Steam Generator. *See* Food Service Equipment, Gas Steam Generator.

3.3.200 Stress. The resultant internal force that resists change in the size or shape of a body acted on by external forces. In this code, *stress* is often used as being synonymous with unit stress, which is the stress per unit area (psi).

3.3.201 Tensile Strength. The highest unit tensile stress (referred to the original cross section) a material can sustain before failure (psi).

3.3.202 Thermostat, 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.

3.3.203 Thermostat, 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.

3.3.204 Thread Joint Compounds. Nonhardening materials used on pipe threads to ensure a seal.

3.3.205 Tubing. Semirigid conduit of copper, steel, aluminum, or plastic.

3.3.206 Type B Gas Vent. *See* Gas Vent, Type B.

3.3.207 Type B-W Gas Vent. *See* Gas Vent, Type B-W.

3.3.208 Type L Vent. *See* Gas Vent, Type L.

3.3.209 Unit Broiler. A broiler constructed as a separate appliance.

3.3.210 Unit Heater, High-Static Pressure Type. A self-contained, automatically controlled, vented, fuel-gas-burning appliance having integral means for circulation of air against 0.2 in. (15 mm) H_2O or greater static pressure.

3.3.211 Unit Heater, Low-Static Pressure Type. A self-contained, automatically controlled, vented, fuel-gas burning appliance, intended for installation in the space to be heated without the use of ducts, having integral means for circulation of air, normally by a propeller fan(s), and may be equipped with louvers or face extensions made in accordance with the manufacturers' specifications.

3.3.212 Utility Gases. Natural gas, manufactured gas, liquefied petroleum gas–air mixtures, or mixtures of any of these gases.

3.3.213 Valve. A device used in piping to control the gas supply to any section of a system of piping or to an appliance.

3.3.214 Valve, Automatic. An automatic or semiautomatic device consisting essentially of a valve and operator that control the gas supply to the burner(s) during operation of an appliance.

3.3.215 Valve, Equipment Shutoff. A valve located in the piping system, used to shut off individual equipment.

3.3.216 Valve, Manual Reset. An automatic shutoff valve installed in the gas supply piping and set to shut off when unsafe conditions occur. The device remains closed until manually reopened.

3.3.217 Valve, Pressure Relief. A valve that automatically opens and closes a relief vent, depending on whether the pressure is above or below a predetermined value.

3.3.218 Valve, Relief. A safety valve designed to forestall the development of a dangerous condition by relieving either pressure, temperature, or vacuum in a hot water supply system.

3.3.219 Valve, Service Shutoff. A valve, installed by the serving gas supplier between the service meter or source of supply and the customer piping system, to shut off the entire piping system.

3.3.220 Valve, Temperature Relief. A valve that automatically opens and automatically closes a relief vent, depending on whether the temperature is above or below a predetermined value.

3.3.221 Valve, Vacuum Relief. 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.

3.3.222 Valve Member. That part of a gas valve rotating within or in respect to the valve body that, by its position with respect to the valve body, controls the flow of gas.

3.3.223 Vent. A passageway used to convey flue gases from gas utilization equipment or their vent connectors to the outside atmosphere.

3.3.224 Vent Connector. The pipe or duct that connects a fuel-gas-burning appliance to a vent or chimney.

3.3.225 Vent Damper Device, Automatic. A device that is intended for installation in the venting system, in the outlet of or downstream of the appliance draft hood, of an individual automatically operated fuel-gas-burning appliance and that is designed to automatically open the venting system when the appliance is in operation and to automatically close off the venting system when the appliance is in a standby or shutdown condition.

3.3.226 Vent Damper Device, Automatic, Electrically Operated. An automatic vent damper device that employs electrical energy to control the device.

3.3.227 Vent Damper Device, Automatic, Mechanically Actuated. An automatic vent damper device dependent for operation on the direct application or transmission of mechanical energy without employing any type of energy conversion.

3.3.228 Vent Damper Device, Automatic, Thermally Actuated. An automatic vent damper device dependent for operation exclusively on the direct conversion of the thermal energy of the vent gases into mechanical energy.

3.3.229 Vent Gases. Products of combustion from fuel-gas-burning appliances plus excess air, plus dilution air in the venting system above the draft hood or draft regulator.

3.3.230* Vented Appliance, 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.

3.3.231 Vented Appliance, Category II. An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent.

3.3.232 Vented Appliance, 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.

3.3.233 Vented Appliance, Category IV. An appliance that operates with a positive vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent.

3.3.234 Vented Wall Furnace. A self-contained, vented, fuel-gas-burning appliance complete with grilles or equivalent, designed for incorporation in or permanent attachment to the structure of a building and furnishing heated air, circulated by gravity or by a fan, directly into the space to be heated through openings in the casing.

3.3.235 Venting. Removal of combustion products as well as process fumes to the outer air.

3.3.236* Venting System. A continuous open passageway from the flue collar or draft hood of a gas-burning appliance to the outside atmosphere for the purpose of removing flue or vent gases.

3.3.237 Venting System, Mechanical Draft. A venting system designed to remove flue or vent gases by mechanical means, which may consist of an induced draft portion under nonpositive static pressure or a forced draft portion under positive static pressure.

3.3.238 Venting System, Mechanical Draft, Forced. A venting system in which a fan or other mechanical device issued to cause the flow of flue or vent gases under positive static vent pressure.

3.3.239 Venting System, Natural Draft. A venting system that relies on natural draft to convey the products of combustion.

3.3.240 Wall Furnace, Direct Vent. A system consisting of an appliance, combustion air, and flue gas connections between the appliance and the outdoor atmosphere, and a vent cap supplied by the manufacturer and constructed so that all air for combustion is obtained from the outdoor atmosphere and all flue gases are discharged to the outdoor atmosphere.

3.3.241 Wall Head Adapter. A transition fitting for terminating plastic pipe inside of buildings at the building wall.

3.3.242 Water Heater. An appliance for supplying hot water for domestic or commercial purposes.

Chapter 4 General

4.1 Qualified Agency. Installation, testing, and replacement of gas piping, gas utilization equipment, or accessories, and repair and servicing of equipment, shall be performed only by a qualified agency.

4.2 Interruption of Service.

4.2.1 Notification of Interrupted Service. When the gas supply is to be turned off, it shall be the duty of the qualified agency to notify all affected users. Where two or more users are served from the same supply system, precautions shall be exercised to ensure that service only to the proper user is turned off.

Exception: In cases of emergency, affected users shall be notified as soon as possible of the actions taken by the qualified agency.

4.2.2 Work Interruptions. When interruptions in work occur while repairs or alterations are being made to an existing piping system, the system shall be left in a safe condition.

4.3 Prevention of Accidental Ignition.

4.3.1 Potential Ignition Sources. Where work is being performed on piping that contains or has contained gas, the following shall apply:

(1) Provisions for electrical continuity shall be made before alterations are made in a metallic piping system.
(2) Smoking, open flames, lanterns, welding, or other sources of ignition shall not be permitted.
(3) A metallic electrical bond shall be installed around the location of cuts in metallic gas pipes made by other than cutting torches. Where cutting torches, welding, or other sources of ignition are unavoidable, it shall be determined that all sources of gas or gas–air mixtures have been secured and that all flammable gas or liquids have been cleared from the area. Piping shall be purged as required in Section 7.3 before welding or cutting with a torch is attempted.

(4) Artificial illumination shall be restricted to listed safety-type flashlights and safety lamps. Electric switches shall not be operated, on or off.

4.3.2 Handling of Flammable Liquids.

4.3.2.1 Drip Liquids. Liquid that is removed from a drip in existing gas piping shall be handled to avoid spillage or ignition. The gas supplier shall be notified when drip liquids are removed.

4.3.2.2 Other Flammable Liquids. Flammable liquids used by the installer shall be handled with precautions and shall not be left within the premises from the end of one working day to the beginning of the next.

Chapter 5 Gas Piping System Design, Materials, and Components

5.1 Piping Plan.

5.1.1 Installation of Piping System. Where required by the authority having jurisdiction, a piping sketch or plan shall be prepared before proceeding with the installation. This plan shall show the proposed location of piping, the size of different branches, the various load demands, and the location of the point of delivery.

5.1.2 Addition to Existing System. When additional gas utilization equipment is being connected to a gas piping system, the existing piping shall be checked to determine whether it has adequate capacity *(see 5.4.3)*. If inadequate, the existing system shall be enlarged as required, or separate gas piping of adequate capacity shall be provided.

5.2 Provision for Location of Point of Delivery. The location of the point of delivery shall be acceptable to the serving gas supplier.

5.3 Interconnections Between Gas Piping Systems.

5.3.1 Interconnections Supplying Separate Users. Where two or more meters, or two or more service regulators where meters are not provided, are located on the same premises and supply separate users, the gas piping systems shall not be interconnected on the outlet side of the meters or service regulators.

5.3.2 Interconnections for Standby Fuels. Where a supplementary gas for standby use is connected downstream from a meter or a service regulator where a meter is not provided, a device to prevent backflow shall be installed. A three-way valve installed to admit the standby supply and at the same time shut off the regular supply shall be permitted to be used for this purpose.

5.4 Sizing of Gas Piping Systems.

5.4.1* General Considerations. Gas piping systems shall be of such size and so installed as to provide a supply of gas sufficient to meet the maximum demand without undue loss of pressure between the point of delivery and the gas utilization equipment.

5.4.2* Maximum Gas Demand.

5.4.2.1 The volume of gas to be provided (in cubic feet per hour) shall be determined directly from the manufacturers' input ratings of the gas utilization equipment served. Where the input rating is not indicated, the gas supplier, equipment manufacturer, or a qualified agency shall be contacted, or the rating from Table 5.4.2.1 shall be used for estimating the volume of gas to be supplied.

Table 5.4.2.1 Approximate Gas Input for Typical Appliances

Appliance	Input Btu/hr (Approx.)
Space Heating Units	
Warm air furnace	
Single family	100,000
Multifamily, per unit	60,000
Hydronic boiler	
Single family	100,000
Multifamily, per unit	60,000
Space and Water Heating Units	
Hydronic boiler	
Single family	120,000
Multifamily, per unit	75,000
Water Heating Appliances	
Water heater, automatic storage 30 gal to 40 gal tank	35,000
Water heater, automatic storage 50 gal tank	50,000
Water heater, automatic instantaneous	
Capacity at 2 gal/min	142,800
Capacity at 4 gal/min	285,000
Capacity at 6 gal/min	428,400
Water heater, domestic, circulating or side-arm	35,000
Cooking Appliances	
Range, free standing, domestic	65,000
Built-in oven or broiler unit, domestic	25,000
Built-in top unit, domestic	40,000
Other Appliances	
Refrigerator	3,000
Clothes dryer, Type 1 (domestic)	35,000
Gas fireplace direct vent	40,000
Gas log	80,000
Barbecue	40,000
Gas light	2,500

For SI units, 1 Btu/hr = 0.293 W.

5.4.2.2 The total connected hourly load shall be used as the basis for piping sizing, assuming all equipment is operating at full capacity simultaneously.

Exception: Sizing shall be permitted to be based upon established load diversity factors.

5.4.3* Sizing Methods. Gas piping shall be sized in accordance with one of the following:

(1) Pipe sizing tables or sizing equations in Chapter 9
(2) Other approved engineering methods acceptable to the authority having jurisdiction
(3) Sizing tables included in a listed piping system manufacturer's installation instructions

5.4.4 Allowable Pressure Drop. The design pressure loss in any piping system under maximum probable flow conditions,

from the point of delivery to the inlet connection of the gas utilization equipment, shall be such that the supply pressure at the equipment is greater than the minimum pressure required for proper equipment operation.

5.5 Piping System Operating Pressure Limitations.

5.5.1 Maximum Design Operating Pressure. The maximum design operating pressure for piping systems located inside buildings shall not exceed 5 psi (34 kPa) unless one or more of the following conditions are met:

(1)*The piping system is welded.
(2) The piping is located in a ventilated chase or otherwise enclosed for protection against accidental gas accumulation.
(3) The piping is located inside buildings or separate areas of buildings used exclusively for one of the following:
  (a) Industrial processing or heating
  (b) Research
  (c) Warehousing
  (d) Boiler or mechanical equipment rooms
(4) The piping is a temporary installation for buildings under construction.

5.5.2 Liquefied Petroleum Gas Systems. The operating pressure for undiluted LP-Gas systems shall not exceed 20 psi (140 kPa). Buildings having 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 back into a liquid.

Exception: Buildings or separate areas of buildings constructed in accordance with Chapter 7 of NFPA 58, Liquefied Petroleum Gas Code, and used exclusively to house industrial processes, research and experimental laboratories, or equipment or processing having similar hazards.

5.6 Acceptable Piping Materials and Joining Methods.

5.6.1 General.

5.6.1.1 Acceptable Materials. Materials used for piping systems shall comply with the requirements of this chapter or shall be acceptable to the authority having jurisdiction.

5.6.1.2 Used Materials. Pipe, fittings, valves, or other materials shall not be used again unless they are free of foreign materials and have been ascertained to be adequate for the service intended.

5.6.1.3 Other Materials. Material not covered by the standards specifications listed herein shall be investigated and tested to determine that it is safe and suitable for the proposed service and, in addition, shall be recommended for that service by the manufacturer and shall be acceptable to the authority having jurisdiction.

5.6.2 Metallic Pipe.

5.6.2.1 Cast Iron. Cast-iron pipe shall not be used.

5.6.2.2 Steel and Wrought Iron. Steel and wrought-iron pipe shall be at least of standard weight (Schedule 40) and shall comply with one of the following standards:

(1) ANSI/ASME B36.10, *Welded and Seamless Wrought-Steel Pipe*
(2) ASTM A 53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless*
(3) ASTM A 106, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*

5.6.2.3* Copper and Brass. Copper and brass pipe shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 scf of gas (0.7 mg/100 L).

5.6.2.4 Threaded Copper, Brass, and Aluminum. Threaded copper, brass, or aluminum alloy pipe shall not be used with gases corrosive to such material.

5.6.2.5 Aluminum Alloy. Aluminum alloy pipe shall comply with ASTM B 241, *Specification for Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube* (except that the use of alloy 5456 is prohibited) and shall be marked at each end of each length indicating compliance. Aluminum alloy pipe shall be coated to protect against external corrosion where it is in contact with masonry, plaster, or insulation or is subject to repeated wettings by such liquids as water, detergents, or sewage.

5.6.2.6 Aluminum Installation. Aluminum alloy pipe shall not be used in exterior locations or underground.

5.6.3 Metallic Tubing. Seamless copper, aluminum alloy, or steel tubing shall not be used with gases corrosive to such material.

5.6.3.1 Steel. Steel tubing shall comply with ASTM A 539, *Standard Specification for Electric Resistance-Welded Coiled Steel Tubing for Gas and Fuel Oil Lines,* or ASTM A 254, *Standard Specification for Copper Brazed Steel Tubing.*

5.6.3.2* Copper and Brass. Copper and brass tubing shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 scf of gas (0.7 mg/100 L). Copper tubing shall comply with standard Type K or L of ASTM B 88, *Specification for Seamless Copper Water Tube,* or ASTM B 280, *Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.*

5.6.3.3 Aluminum. Aluminum alloy tubing shall comply with ASTM B 210, *Specification for Aluminum-Alloy Drawn Seamless Tubes,* or ASTM B 241, *Specification for Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube.* Aluminum alloy tubing shall be coated to protect against external corrosion where it is in contact with masonry, plaster, or insulation or is subject to repeated wettings by such liquids as water, detergent, or sewage. Aluminum alloy tubing shall not be used in exterior locations or underground.

5.6.3.4 Corrugated Stainless Steel. Corrugated stainless steel tubing shall be tested and listed in compliance with the construction, installation, and performance requirements of ANSI LC 1/CSA 6.26, *Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing.*

5.6.4 Plastic Pipe, Tubing, and Fittings. Plastic pipe, tubing, and fittings shall be used outside underground only and shall conform with ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.* Pipe to be used shall be marked "gas" and "ASTM D 2513."

5.6.4.1 Anodeless Risers. 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 by the manufacturer and shall be design-certified to meet the

requirements of Category I of ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings,* and 49 CFR 192.281(e). The manufacturer shall provide the user qualified installation instructions as prescribed by 49 CFR 192.283(b).

(3) The use of plastic pipe, tubing, and fittings in undiluted liquefied petroleum gas piping systems shall be in accordance with NFPA 58, *Liquefied Petroleum Gas Code*.

5.6.5 Workmanship and Defects. Gas pipe, tubing, and fittings shall be clear and free from cutting burrs and defects in structure or threading and shall be thoroughly brushed, and chip and scale blown. Defects in pipe, tubing, and fittings shall not be repaired. Defective pipe, tubing, and fittings shall be replaced. *[See 7.1.1.3.]*

5.6.6 Protective Coating. Where in contact with material or atmosphere exerting a corrosive action, metallic piping and fittings coated with a corrosion-resistant material shall be used. External or internal coatings or linings used on piping or components shall not be considered as adding strength.

5.6.7 Metallic Pipe Threads.

5.6.7.1 Specifications for Pipe Threads. Metallic pipe and fitting threads shall be taper pipe threads and shall comply with ANSI/ASME B1.20.1, *Pipe Threads, General Purpose, Inch.*

5.6.7.2 Damaged Threads. Pipe with threads that are stripped, chipped, corroded, or otherwise damaged shall not be used. Where a weld opens during the operation of cutting or threading, that portion of the pipe shall not be used.

5.6.7.3 Number of Threads. Field threading of metallic pipe shall be in accordance with Table 5.6.7.3.

Table 5.6.7.3 Specifications for Threading Metallic Pipe

Iron Pipe Size (in.)	Approximate Length of Threaded Portion (in.)	Approximate No. of Threads to Be Cut
½	¾	10
¾	¾	10
1	⅞	10
1¼	1	11
1½	1	11
2	1	11
2½	1½	12
3	1½	12
4	1⅝	13

For SI units, 1 in. = 25.4 mm.

5.6.7.4 Thread Compounds. Thread (joint) compounds (pipe dope) shall be resistant to the action of liquefied petroleum gas or to any other chemical constituents of the gases to be conducted through the piping.

5.6.8 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 due to the internal pressure and any additional forces due to temperature expansion or contraction, vibration, fatigue, or the weight of the pipe and its contents.

5.6.8.1* Pipe Joints. Pipe joints shall be threaded, flanged, brazed, or welded. Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1000°F (538°C). Brazing alloys shall not contain more than 0.05 percent phosphorus.

5.6.8.2 Tubing Joints. Tubing joints shall either be made with approved gas tubing fittings or be brazed with a material having a melting point in excess of 1000°F (538°C). Brazing alloys shall not contain more than 0.05 percent phosphorus.

5.6.8.3 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.

5.6.8.4 Metallic Fittings (Including Valves, Strainers, Filters). Metallic fittings shall comply with the following:

(1) Threaded fittings in sizes larger than 4 in. (100 mm) shall not be used unless acceptable to the authority having jurisdiction.
(2) Fittings used with steel or wrought-iron pipe shall be steel, brass, bronze, malleable iron, or cast iron.
(3) Fittings used with copper or brass pipe shall be copper, brass, or bronze.
(4) Fittings used with aluminum alloy pipe shall be of aluminum alloy.
(5) *Cast-Iron Fittings.* Cast-iron fittings shall comply with the following:
   (a) Flanges shall be permitted.
   (b) Bushings shall not be used.
   (c) Fittings shall not be used in systems containing flammable gas–air mixtures.
   (d) Fittings in sizes 4 in. (100 mm) and larger shall not be used indoors unless approved by the authority having jurisdiction.
   (e) Fittings in sizes 6 in. (150 mm) and larger shall not be used unless approved by the authority having jurisdiction.
(6) *Aluminum Alloy Fittings.* Threads shall not form the joint seal.
(7) *Zinc–Aluminum Alloy Fittings.* Fittings shall not be used in systems containing flammable gas–air mixtures.
(8) *Special Fittings.* Fittings such as couplings, proprietary-type joints, saddle tees, gland-type compression fittings, and flared, flareless, or compression-type tubing fittings shall be (1) used within the fitting manufacturers' pressure-temperature recommendations; (2) used within the service conditions anticipated with respect to vibration, fatigue, thermal expansion, or contraction; (3) installed or braced to prevent separation of the joint by gas pressure or external physical damage; and (4) acceptable to the authority having jurisdiction.

5.6.9 Plastic Piping, Joints, and Fittings. Plastic pipe, tubing, and fittings shall be joined in accordance with the manufacturers' instructions. The following shall be observed when making such joints:

(1) The joint shall be designed and installed so that the longitudinal pullout resistance of the joint will be at least equal to the tensile strength of the plastic piping material.

(2) Heat-fusion joints shall be made in accordance with qualified procedures that have been established and proven by test to produce gastight joints at least as strong as the pipe or tubing being joined. Joints shall be made with the joining method recommended by the pipe manufacturer. Heat fusion fittings shall be marked "ASTM D 2513."
(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 at least to the outside end of the pipe or tubing and shall extend at least to 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, *Liquefied Petroleum Gas Code*.

5.6.10 Flanges. All flanges shall comply with ANSI/ASME B16.1, *Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800;* ANSI/ASME B16.20, *Metal Gaskets for Pipe Flanges, Ring Joint Spiral Wound and Jacketed;* or MSS SP-6, *Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings*. The pressure-temperature ratings shall equal or exceed that required by the application.

5.6.10.1 Flange Facings. Standard facings shall be permitted for use under this code. Where 150 psi (1034 kPa) steel flanges are bolted to Class 125 cast-iron flanges, the raised face on the steel flange shall be removed.

5.6.10.2 Lapped Flanges. Lapped flanges shall be used only aboveground or in exposed locations accessible for inspection.

5.6.11 Flange Gaskets. The material for gaskets shall be capable of withstanding the design temperature and pressure of the piping system and the chemical constituents of the gas being conducted without change to its chemical and physical properties. The effects of fire exposure to the joint shall be considered in choosing the material.

5.6.11.1 Acceptable materials shall include the following:

(1) Metal or metal-jacketed asbestos (plain or corrugated)
(2) Asbestos
(3) Aluminum "O" rings and spiral-wound metal gaskets

5.6.11.2 When a flanged joint is opened, the gasket shall be replaced.

5.6.11.3 Full-face gaskets shall be used with all bronze and cast-iron flanges.

5.7* Gas Meters.

5.7.1 Capacity. Gas meters shall be selected for the maximum expected pressure and permissible pressure drop.

5.7.2 Location.

5.7.2.1 Gas meters shall be located in ventilated spaces readily accessible for examination, reading, replacement, or necessary maintenance.

5.7.2.2 Gas meters shall not be placed where they will be subjected to damage, such as adjacent to a driveway, under a fire escape, in public passages, halls, or coal bins, or where they will be subject to excessive corrosion or vibration.

5.7.2.3 Gas meters shall be located at least 3 ft (0.9 m) from sources of ignition.

5.7.2.4 Gas meters shall not be located where they will be subjected to extreme temperatures or sudden extreme changes in temperature. Meters shall not be located in areas where they are subjected to temperatures beyond those recommended by the manufacturer.

5.7.3 Supports. Gas meters shall be supported or connected to rigid piping so as not to exert a strain on the meters. Where flexible connectors are used to connect a gas meter to downstream piping at mobile homes in mobile home parks, the meter shall be supported by a post or bracket placed in a firm footing or by other means providing equivalent support.

5.7.4 Meter Protection. Meters shall be protected against overpressure, back pressure, and vacuum, where such conditions are anticipated.

5.7.5 Identification. Gas piping at multiple meter installations shall be marked by a metal tag or other permanent means attached by the installing agency, designating the building or the part of the building being supplied.

5.8* Gas Pressure Regulators.

5.8.1 Where Required. A line gas pressure regulator or gas equipment pressure regulator, as applicable, shall be installed where the gas supply pressure is higher than that at which the branch supply line or gas utilization equipment is designed to operate or varies beyond design pressure limits.

5.8.2 Line gas pressure regulators shall be listed in accordance with ANSI Z21.80, *Line Pressure Regulators*.

5.8.3 Location. The gas pressure regulator shall be accessible for servicing.

5.8.4 Regulator Protection. Pressure regulators shall be protected against physical damage.

5.8.5 Venting.

5.8.5.1 Line Gas Pressure Regulators. Line gas pressure regulators shall comply with the following:

(1) An independent vent to the outside of the building, sized in accordance with the regulator manufacturer's instructions, shall be provided where the location of a regulator is such that a ruptured diaphragm will cause a hazard. Where there is more than one regulator at a location, each regulator shall have a separate vent to the outside, or if approved by the authority having jurisdiction, the vent lines shall be permitted to be manifolded in accordance with accepted engineering practices to minimize back pressure in the event of diaphragm failure. (See 5.9.7 for information on properly locating the vent.) Materials for vent piping shall be in accordance with Section 5.6.

Exception: A regulator and vent limiting means combination listed as complying with ANSI Z21.80, Line Pressure Regulators, shall be permitted to be used without a vent to the outdoors.

(2) The vent shall be designed to prevent the entry of water, insects, or other foreign materials that could cause blockage.
(3) At locations where regulators might be submerged during floods, a special antiflood-type breather vent fitting shall

be installed, or the vent line shall be extended above the height of the expected flood waters.
(4) A regulator shall not be vented to the gas equipment flue or exhaust system.

5.8.5.2 Gas Appliance Pressure Regulators. For venting of gas appliance pressure regulators, see 8.1.19.

5.8.6 Bypass Piping. Valved and regulated bypasses shall be permitted to be placed around gas line pressure regulators where continuity of service is imperative.

5.8.7 Identification. Line pressure regulators at multiple regulator installations shall be marked by a metal tag or other permanent means designating the building or the part of the building being supplied.

5.9 Overpressure Protection Devices.

5.9.1 General. Overpressure protection devices shall be provided to prevent the pressure in the piping system from exceeding that value that would cause unsafe operation of any connected and properly adjusted gas utilization equipment. *(See 5.9.5.)*

5.9.1.1 The requirements of this section shall be met and a piping system deemed to have overpressure protection where all of the following are included in the piping system:

(1) Two devices (a service or line pressure regulator plus one other device) are installed.
(2) Each device limits the pressure to a value that does not exceed the maximum working pressure of the downstream system.
(3) The failure of both devices occurs simultaneously in order to overpressure the downstream system.

5.9.1.2 The pressure regulating, limiting, and relieving devices shall be properly maintained, and inspection procedures shall be devised or suitable instrumentation installed to detect failures or malfunctions of such devices, and replacements or repairs shall be promptly made.

5.9.1.3 A pressure relieving or limiting device shall not be required where (1) the gas does not contain materials that could seriously interfere with the operation of the service or line pressure regulator; (2) the operating pressure of the gas source is 60 psi (414 kPa) or less; and (3) the service or line pressure regulator has all of the following design features or characteristics:

(1) Pipe connections to the service or line regulator do not exceed 2-in. nominal diameter.
(2) It is self-contained with no external static or control piping.
(3) It has a single port valve with an orifice diameter no greater than that recommended by the manufacturer for the maximum gas pressure at the regulator inlet.
(4) The valve seat is made of resilient material designed to withstand abrasion of the gas, impurities in the gas, and cutting by the valve and to resist permanent deformation where it is pressed against the valve port.
(5) It is capable, under normal operating conditions, of regulating the downstream pressure within the necessary limits of accuracy and of limiting the discharge pressure under no-flow conditions to not more than 150 percent of the discharge pressure maintained under flow conditions.

5.9.2 Devices.

5.9.2.1 Pressure relieving or pressure limiting devices shall be one of the following:

(1) Spring-loaded relief device
(2) Pilot-loaded back pressure regulator used as a relief valve so designed that failure of the pilot system or external control piping will cause the regulator relief valve to open
(3) A monitoring regulator installed in series with the service or line pressure regulator
(4) A series regulator installed upstream from the service or line regulator and set to continuously limit the pressure on the inlet of the service or line regulator to the maximum working pressure of the downstream piping system
(5) An automatic shutoff device installed in series with the service or line pressure regulator and set to shut off when the pressure on the downstream piping system reaches the maximum working pressure or some other predetermined pressure less than the maximum working pressure This device shall be designed so that it will remain closed until manually reset.
(6) A liquid seal relief device that can be set to open accurately and consistently at the desired pressure

5.9.2.2 The devices in 5.9.2.1 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 devices are installed, they shall comply with 5.9.3 through 5.9.8.

5.9.3 Construction and Installation. All pressure relieving or pressure limiting devices shall meet the following requirements:

(1) Be constructed of materials so that the operation of the device will not be impaired by corrosion of external parts by the atmosphere or of internal parts by the gas.
(2) Be designed and installed so they can be operated to determine whether the valve is free. The devices shall also be designed and installed so they can be tested to determine the pressure at which they will operate and be examined for leakage when in the closed position.

5.9.4 External Control Piping. External control piping shall be protected from falling objects, excavations, or other causes of damage and shall be designed and installed so that damage to any control piping shall not render both the regulator and the overpressure protective device inoperative.

5.9.5 Setting. Each pressure limiting or pressure relieving device shall be set so that the pressure shall not exceed a safe level beyond the maximum allowable working pressure for the piping and appliances connected.

5.9.6 Unauthorized Operation. Precautions shall be taken to prevent unauthorized operation of any shutoff valve that will make a pressure relieving valve or pressure limiting device inoperative. The following are acceptable methods for complying with this provision:

(1) Lock the valve in the open position. Instruct authorized personnel in the importance of leaving the shutoff valve open and of being present while the shutoff valve is closed so that it can be locked in the open position before leaving the premises.
(2) Install duplicate relief valves, each having adequate capacity to protect the system, and arrange the isolating valves or three-way valve so that only one safety device can be rendered inoperative at a time.

5.9.7 Vents. The discharge stacks, vents, or outlet parts of all pressure relieving and pressure limiting devices shall be located so that gas is safely discharged into the outside atmo-

sphere. Discharge stacks or vents shall be designed to prevent the entry of water, insects, or other foreign material that could cause blockage. The discharge stack or vent line shall be at least the same size as the outlet of the pressure relieving device.

5.9.8 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.

5.10 Back Pressure Protection.

5.10.1 Where to Install. Protective devices shall be installed as close to the utilization equipment as practical where the design of utilization equipment connected is such that air, oxygen, or standby gases could be forced into the gas supply system. Gas and air combustion mixers incorporating double diaphragm "zero" or "atmosphere" governors or regulators shall require no further protection unless connected directly to compressed air or oxygen at pressures of 5 psi (34 kPa) or more.

5.10.2 Protective Devices. Protective devices shall include but not be limited to the following:

(1) Check valves
(2) Three-way valves (of the type that completely closes one side before starting to open the other side)
(3) Reverse flow indicators controlling positive shutoff valves
(4) Normally closed air-actuated positive shutoff pressure regulators

5.11 Low-Pressure Protection. A protective device shall be installed between the meter and the gas utilization equipment if the operation of the equipment is such (i.e., gas compressors) that it could produce a vacuum or a dangerous reduction in gas pressure at the meter; such devices include, but are not limited to, mechanical, diaphragm-operated, or electrically operated low-pressure shutoff valves.

5.12 Shutoff Valves. Shutoff valves shall be approved and shall be selected giving consideration to pressure drop, service involved, emergency use, and reliability of operation. Shutoff valves of size 1 in. National Pipe Thread and smaller shall be listed.

5.13 Expansion and Flexibility.

5.13.1 Design. Piping systems shall be designed to have sufficient flexibility to prevent thermal expansion or contraction from causing excessive stresses in the piping material, excessive bending or loads at joints, or undesirable forces or moments at points of connections to equipment and at anchorage or guide points. Formal calculations or model tests shall be required only where reasonable doubt exists as to the adequate flexibility of the system.

5.13.1.1 Flexibility shall be provided by the use of bends, loops, offsets, or couplings of the slip type. Provision shall be made to absorb thermal changes by the use of expansion joints of the bellows type or by the use of "ball" or "swivel" joints. Expansion joints of the slip type shall not be used inside buildings or for thermal expansion. Where expansion joints are used, anchors or ties of sufficient strength and rigidity shall be installed to provide for end forces due to fluid pressure and other causes.

5.13.1.2 Pipe alignment guides shall be used with expansion joints according to the recommended practice of the joint manufacturer.

5.13.2 Special Local Conditions. Where local conditions include earthquake, tornado, unstable ground, or flood hazards, special consideration shall be given to increased strength and flexibility of piping supports and connections.

Chapter 6 Gas Piping Installation

6.1 Piping Underground.

6.1.1 Clearances. Underground gas piping shall be installed with sufficient clearance from any other underground structure to avoid contact therewith, to allow maintenance, and to protect against damage from proximity to other structures. In addition, underground plastic piping shall be installed with sufficient clearance or shall be insulated from any source of heat so as to prevent the heat from impairing the serviceability of the pipe.

6.1.2 Protection Against Damage. Means shall be provided to prevent excessive stressing of the piping where there is heavy vehicular traffic or soil conditions are unstable and settling of piping or foundation walls could occur. Piping shall be buried or covered in a manner so as to protect the piping from physical damage. Piping shall be protected from physical damage where it passes through flower beds, shrub beds, and other such cultivated areas where such damage is reasonably expected.

6.1.2.1 Cover Requirements. Underground piping systems shall be installed with a minimum of 18 in. (460 mm) of cover. Where external damage to the pipe is not likely to result, the minimum cover shall be 12 in. (300 mm). Where a minimum of 12 in. (300 mm) of cover cannot be provided, the pipe shall be installed in conduit or bridged (shielded).

6.1.2.2 Trenches. The trench shall be graded so that the pipe has a firm, substantially continuous bearing on the bottom of the trench.

6.1.2.3 Backfilling. Where flooding of the trench is done to consolidate the backfill, care shall be exercised to see that the pipe is not floated from its firm bearing on the trench bottom.

6.1.3* Protection Against Corrosion. Gas piping in contact with earth or other material that could corrode the piping shall be protected against corrosion in an approved manner. When dissimilar metals are joined underground, an insulating coupling or fitting shall be used. Piping shall not be laid in contact with cinders. Uncoated threaded or socket welded joints shall not be used in piping in contact with soil or where internal or external crevice corrosion is known to occur.

6.1.4* Protection Against Freezing. Where the formation of hydrates or ice is known to occur, piping shall be protected against freezing.

6.1.5 Piping Through Foundation Wall. Underground piping, where installed through the outer foundation or basement wall of a building, shall be encased in a protective pipe. The space between the gas piping and the building shall be sealed to prevent entry of gas or water.

6.1.6 Piping Underground Beneath Buildings. Where the installation of gas piping underground beneath buildings is unavoidable, the piping shall be encased in an approved conduit designed to withstand the superimposed loads. The conduit shall extend into a normally usable and accessible portion of the building and, at the point where the conduit terminates in

the building, the space between the conduit and the gas piping shall be sealed to prevent the possible entrance of any gas leakage. Where the end sealing is of a type that will retain the full pressure of the pipe, the conduit shall be designed for the same pressure as the pipe. The conduit shall extend at least 4 in. (100 mm) outside the building, be vented above grade to the outside, and be installed so as to prevent the entrance of water and insects.

6.1.7 Plastic Pipe.

6.1.7.1 Connection of Plastic Piping. Plastic pipe shall be installed outside, underground only.

Exception No. 1: Plastic pipe shall be permitted to terminate aboveground where an anodeless riser is used.

Exception No. 2: Plastic pipe shall be permitted to terminate with a wall head adapter aboveground in buildings, including basements, where the plastic pipe is inserted in a piping material permitted for use in buildings.

6.1.7.2 Connections Between Metallic and Plastic Piping. Connections made outside and underground between metallic and plastic piping shall be made only with ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings,* Category I transition fittings.

6.1.7.3 Tracer Wire. An electrically continuous corrosion-resistant tracer wire (minimum AWG 14) or tape shall be buried with the plastic pipe to facilitate locating. One end shall be brought aboveground at a building wall or riser.

6.2 Installation of Piping.

6.2.1 Piping installed aboveground shall be securely supported and located where it will be protected from physical damage *(also see 6.1.4).* Where passing through an outside wall, the piping shall also be protected against corrosion by coating or wrapping with an inert material approved for such applications. Where piping is encased in a protective pipe sleeve, the annular space between the gas piping and the sleeve shall be sealed at the wall to prevent the entry of water, insects, or rodents.

6.2.2 Building Structure.

6.2.2.1 The installation of gas piping shall not cause structural stresses within building components to exceed allowable design limits.

6.2.2.2 Approval shall be obtained before any beams or joists are cut or notched.

6.2.3 Other than Dry Gas. Drips, sloping, protection from freezing, and branch pipe connections, as provided for in 6.1.4, 6.6.1, and Section 6.8, shall be provided when other than dry gas is distributed and climatic conditions make such provisions necessary.

6.2.4 Gas Piping to Be Sloped. Piping for other than dry gas conditions shall be sloped not less than ¼ in. in 15 ft (7 mm in 4.6 m) to prevent traps.

6.2.5* Prohibited Locations. Gas piping inside any building shall not be installed in or through a clothes chute, chimney or gas vent, dumbwaiter, elevator shaft, or air duct, other than combustion air ducts.

6.2.6 Hangers, Supports, and Anchors.

6.2.6.1 Piping shall be supported with pipe hooks, metal pipe straps, bands, brackets, or hangers 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 equipment and shall not be supported by other piping. Pipe hangers and supports shall conform to the requirements of ANSI/MSS SP-58, *Pipe Hangers and Supports — Materials, Design and Manufacture.*

6.2.6.2 Spacings of supports in gas piping installations shall not be greater than shown in Table 6.2.6.2. Spacing of supports of CSST shall be in accordance with the CSST manufacturer's instructions.

Table 6.2.6.2 Support of Piping

Steel Pipe, Nominal Size of Pipe (in.)	Spacing of Supports (ft)	Nominal Size of Tubing Smooth-Wall (in. O.D.)	Spacing of Supports (ft)
½	6	½	4
¾ or 1	8	⅝ or ¾	6
1¼ or larger (horizontal)	10	⅞ or 1 (horizontal)	8
1¼ or larger (vertical)	every floor level	1 or larger (vertical)	every floor level

For SI units, 1 ft = 0.305 m.

6.2.6.3 Supports, hangers, and anchors shall be installed so as not to interfere with the free expansion and contraction of the piping between anchors. All parts of the supporting equipment shall be designed and installed so they will not be disengaged by movement of the supported piping.

6.2.7 Removal of Pipe. Where piping containing gas is to be removed, the line shall be first disconnected from all sources of gas and then thoroughly purged with air, water, or inert gas before any cutting or welding is done. *(See Section 7.3.)*

6.3 Concealed Piping in Buildings.

6.3.1 General. Gas piping in concealed locations shall be installed in accordance with this section.

6.3.2 Connections. Where gas piping is to be concealed, unions, tubing fittings, right and left couplings, bushings, swing joints, and compression couplings made by combinations of fittings shall not be used. Connections shall be of the following type:

(1) Pipe fittings such as elbows, tees, and couplings
(2) Joining tubing by brazing *[see 5.6.8.2]*
(3) Fittings listed for use in concealed spaces that have been demonstrated to sustain, without leakage, any forces due to temperature expansion or contraction, vibration, or fatigue based on their geographic location, application, or operation.
(4) Where necessary to insert fittings in gas pipe that has been installed in a concealed location, the pipe shall be reconnected by welding, flanges, or the use of a ground joint union with the nut center-punched to prevent loosening by vibration.

6.3.3 Piping in Partitions. Concealed gas piping shall not be located in solid partitions.

6.3.4 Tubing in Partitions. This provision shall not apply to tubing that pierces walls, floors, or partitions. Tubing installed vertically and horizontally inside hollow walls or partitions without protection along its entire concealed length shall meet the following requirements:

(1) A steel striker barrier not less than 0.0508 in. (1.3 mm) thick, or equivalent, is installed between the tubing and the finished wall and extends at least 4 in. (100 mm) beyond concealed penetrations of plates, fire stops, wall studs, and so on.
(2) The tubing is installed in single runs and is not rigidly secured.

6.3.5 Piping in Floors.

6.3.5.1 Industrial Occupancies. In industrial occupancies, gas piping in solid floors such as concrete shall be laid in channels in the floor and covered to permit access to the piping with a minimum of damage to the building. Where piping in floor channels could be exposed to excessive moisture or corrosive substances, the piping shall be protected in an approved manner.

6.3.5.2 Other Occupancies. In other than industrial occupancies and where approved by the authority having jurisdiction, gas piping embedded in concrete floor slabs constructed with portland cement shall be surrounded with a minimum of 1½ in. (38 mm) of concrete and shall not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. All piping, fittings, and risers shall be protected against corrosion in accordance with 5.6.6. Piping shall not be embedded in concrete slabs containing quickset additives or cinder aggregate.

6.4 Piping in Vertical Chases. Where gas piping exceeding 5 psi (34 kPa) is located within vertical chases in accordance with 5.5.1(2) , the requirements of 6.4.1 through 6.4.3 shall apply.

6.4.1 Pressure Reduction. Where pressure reduction is required in branch connections for compliance with 5.5.1, such reduction shall take place either inside the chase or immediately adjacent to the outside wall of the chase. Regulator venting and downstream overpressure protection shall comply with 5.8.5 and Section 5.9. The regulator shall be accessible for service and repair and vented in accordance with one of the following:

(1) Where the fuel gas is lighter than air, regulators equipped with a vent-limiting means shall be permitted to be vented into the chase. Regulators not equipped with a vent-limiting means shall be permitted to be vented either directly to the outdoors or to a point within the top 1 ft (0.3 m) of the chase.
(2) Where the fuel gas is heavier than air, the regulator vent shall be vented only directly to the outdoors.

6.4.2 Chase Construction. Chase construction shall comply with local building codes with respect to fire resistance and protection of horizontal and vertical openings.

6.4.3* Ventilation. A chase shall be ventilated to the outdoors and only at the top. The opening(s) shall have a minimum free area (in square inches) equal to the product of one-half of the maximum pressure in the piping (in psi) times the largest nominal diameter of that piping (in inches), or the cross-sectional area of the chase, whichever is smaller. Where more than one fuel gas piping system is present, the free area for each system shall be calculated and the largest area used.

6.5 Gas Pipe Turns. Changes in direction of gas pipe shall be made by the use of fittings, factory bends, or field bends.

6.5.1 Metallic Pipe. Metallic pipe bends shall comply with the following:

(1) Bends shall be made only with bending equipment and procedures intended for that purpose.
(2) All bends shall be smooth and free from buckling, cracks, or other evidence of mechanical damage.
(3) The longitudinal weld of the pipe shall be near the neutral axis of the bend.
(4) Pipe shall not be bent through an arc of more than 90 degrees.
(5) The inside radius of a bend shall be not less than 6 times the outside diameter of the pipe.

6.5.2 Plastic Pipe. Plastic pipe bends shall comply with the following:

(1) The pipe shall not be damaged, and the internal diameter of the pipe shall not be effectively reduced.
(2) Joints shall not be located in pipe bends.
(3) The radius of the inner curve of such bends shall not be less than 25 times the inside diameter of the pipe.
(4) Where the piping manufacturer specifies the use of special bending equipment or procedures, such equipment or procedures shall be used.

6.5.3* Mitered Bends. Mitered bends shall be permitted subject to the following limitations:

(1) Miters shall not be used in systems having a design pressure greater than 50 psi (340 kPa). Deflections caused by misalignments up to 3 degrees shall not be considered as miters.
(2) The total deflection angle at each miter shall not exceed 90 degrees.

6.5.4 Elbows. Factory-made welding elbows or transverse segments cut therefrom shall have an arc length measured along the crotch of at least 1 in. (25 mm) for pipe sizes 2 in. and larger.

6.6 Drips and Sediment Traps.

6.6.1 Provide Drips Where Necessary. For other than dry gas conditions, a drip shall be provided at any point in the line of pipe where condensate could collect. Where required by the authority having jurisdiction or the serving gas supplier, a drip shall also be provided at the outlet of the meter. This drip shall be so installed as to constitute a trap wherein an accumulation of condensate will shut off the flow of gas before it will run back into the meter.

6.6.2 Location of Drips. All drips shall be installed only in such locations that they will be readily accessible to permit cleaning or emptying. A drip shall not be located where the condensate is likely to freeze.

6.6.3 Sediment Traps. *(See 8.5.7.)*

6.7 Outlets.

6.7.1 Location and Installation.

6.7.1.1 The outlet fittings or piping shall be securely fastened in place.

6.7.1.2 Outlets shall not be located behind doors.

6.7.1.3 Outlets shall be located far enough from floors, walls, patios, slabs, and ceilings to permit the use of wrenches without straining, bending, or damaging the piping.

6.7.1.4 The unthreaded portion of gas piping outlets shall extend not less than 1 in. (25 mm) through finished ceilings or indoor or outdoor walls.

6.7.1.5 The unthreaded portion of gas piping outlets shall extend not less than 2 in. (50 mm) above the surface of floors or outdoor patios or slabs.

6.7.1.6 The provisions of 6.7.1.4 and 6.7.1.5 shall not apply to listed quick-disconnect devices of the flush-mounted type or listed gas convenience outlets. Such devices shall be installed in accordance with the manufacturers' installation instructions.

6.7.2 Cap All Outlets.

6.7.2.1 Each outlet, including a valve, shall be closed gastight with a threaded plug or cap immediately after installation and shall be left closed until the gas utilization equipment is connected thereto. When equipment is disconnected from an outlet and the outlet is not to be used again immediately, it shall be closed gastight.

Exception No. 1: Laboratory equipment installed in accordance with 8.5.2(1) shall be permitted.

Exception No. 2: The use of a listed quick-disconnect device with integral shutoff or listed gas convenience outlet shall be permitted.

6.7.2.2 Equipment shutoff valves installed in fireplaces shall be removed and the piping capped gastight where the fireplace is used for solid fuel burning.

6.8 Branch Pipe Connection. When a branch outlet is placed on a main supply line before it is known what size pipe will be connected to it, the outlet shall be of the same size as the line that supplies it.

6.9 Manual Gas Shutoff Valves. *(Also see 8.5.4.)*

6.9.1 Valves at Regulators. An accessible gas shutoff valve shall be provided upstream of each gas pressure regulator. Where two gas pressure regulators are installed in series in a single gas line, a manual valve shall not be required at the second regulator.

6.9.2 Valves Controlling Multiple Systems.

6.9.2.1 Accessibility of Gas Valves. Main gas shutoff valves controlling several gas piping systems shall be readily accessible for operation and installed so as to be protected from physical damage. They shall be marked with a metal tag or other permanent means attached by the installing agency so that the gas piping systems supplied through them can be readily identified.

6.9.2.2 Shutoff Valves for Multiple House Lines. In multiple tenant buildings supplied through a master meter, or through one service regulator where a meter is not provided, or where meters or service regulators are not readily accessible from the equipment location, an individual shutoff valve for each apartment or tenant line shall be provided at a convenient point of general accessibility. In a common system serving a number of individual buildings, shutoff valves shall be installed at each building.

6.9.3 Emergency Shutoff Valves. An exterior shutoff valve to permit turning off the gas supply to each building in an emergency shall be provided. The emergency shutoff valves shall be plainly marked as such and their locations posted as required by the authority having jurisdiction.

6.10 Prohibited Devices. No device shall be placed inside the gas piping or fittings that will reduce the cross-sectional area or otherwise obstruct the free flow of gas, except where proper allowance in the piping system design has been made for such a device and where approved by the authority having jurisdiction.

6.11 Systems Containing Gas–Air Mixtures Outside the Flammable Range. Where gas–air mixing machines are employed to produce mixtures above or below the flammable range, they shall be provided with stops to prevent adjustment of the mixture to within or approaching the flammable range.

6.12 Systems Containing Flammable Gas–Air Mixtures.

6.12.1 Required Components. A central premix system with a flammable mixture in the blower or compressor shall consist of the following components:

(1) Gas-mixing machine in the form of an automatic gas–air proportioning device combined with a downstream blower or compressor
(2) Flammable mixture piping, minimum Schedule 40 NPS
(3) Automatic firecheck(s)
(4) Safety blowout(s) or backfire preventers for systems utilizing flammable mixture lines above 2½ in. nominal pipe size or the equivalent

6.12.2 Optional Components. The following components shall also be permitted to be utilized in any type central premix system:

(1) Flowmeter(s)
(2) Flame arrester(s)

6.12.3 Additional Requirements. Gas-mixing machines shall have nonsparking blowers and shall be so constructed that a flashback will not rupture machine casings.

6.12.4* Special Requirements for Mixing Blowers. A mixing blower system shall be limited to applications with minimum practical lengths of mixture piping, limited to a maximum mixture pressure of 10 in. w.c. (2.5 kPa) and limited to gases containing no more than 10 percent hydrogen. The blower shall be equipped with a gas-control valve at its air entrance so arranged that gas is admitted to the airstream, entering the blower in proper proportions for correct combustion by the type of burners employed, the said gas-control valve being of either the zero governor or mechanical ratio valve type that controls the gas and air adjustment simultaneously. No valves or other obstructions shall be installed between the blower discharge and the burner or burners.

6.12.5 Installation of Gas-Mixing Machines.

6.12.5.1* Location. The machine shall be located in a large, well-ventilated area or in a small detached building or cutoff room provided with room construction and explosion vents in accordance with sound engineering principles. Such rooms or belowgrade installations shall have adequate positive ventilation.

6.12.5.2 Electrical Requirements. Where gas-mixing machines are installed in well-ventilated areas, the type of electrical equipment shall be in accordance with NFPA 70, *National Electrical Code®*, for general service conditions unless other hazards in the area prevail. Where gas-mixing machines are installed in small detached buildings or cutoff rooms, the elec-

trical equipment and wiring shall be installed in accordance with NFPA 70 for hazardous locations (Articles 500 and 501, Class I, Division 2).

6.12.5.3 Air Intakes. Air intakes for gas-mixing machines using compressors or blowers shall be taken from outdoors whenever practical.

6.12.5.4* Controls. Controls for gas-mixing machines shall include interlocks and a safety shutoff valve of the manual reset type in the gas supply connection to each machine arranged to automatically shut off the gas supply in the event of high or low gas pressure. Except for open burner installations only, the controls shall be interlocked so that the blower or compressor will stop operating following a gas supply failure. Where a system employs pressurized air, means shall be provided to shut off the gas supply in the event of air failure.

6.12.5.5 Installation in Parallel. Centrifugal gas-mixing machines in parallel shall be reviewed by the user and equipment manufacturer before installation, and means or plans for minimizing these effects of downstream pulsation and equipment overload shall be prepared and utilized as needed.

6.12.6 Use of Automatic Firechecks, Safety Blowouts, or Backfire Preventers. Automatic firechecks and safety blowouts or backfire preventers shall be provided in piping systems distributing flammable air–gas mixtures from gas-mixing machines to protect the piping and the machines in the event of flashback, in accordance with the following:

(1)*Approved automatic firechecks shall be installed upstream as close as practicable to the burner inlets following the firecheck manufacturers' instructions.

(2) A separate manually operated gas valve shall be provided at each automatic firecheck for shutting off the flow of gas–air mixture through the firecheck after a flashback has occurred. The valve shall be located upstream as close as practical to the inlet of the automatic firecheck. Caution, these valves shall not be reopened after a flashback has occurred until the firecheck has cooled sufficiently to prevent reignition of the flammable mixture and has been reset properly.

(3) A safety blowout or backfiring preventer shall be provided in the mixture line near the outlet of each gas-mixing machine where the size of the piping is larger than 2½ in. NPS, or equivalent, to protect the mixing equipment in the event of an explosion passing through an automatic firecheck. The manufacturers' instructions shall be followed when installing these devices, particularly after a disc has burst. The discharge from the safety blowout or backfire preventer shall be located or shielded so that particles from the ruptured disc cannot be directed toward personnel. Wherever there are interconnected installations of gas-mixing machines with safety blowouts or backfire preventers, provision shall be made to keep the mixture from other machines from reaching any ruptured disc opening. Check valves shall not be used for this purpose.

(4) Large-capacity premix systems provided with explosion heads (rupture disc) to relieve excessive pressure in pipelines shall be located at and vented to a safe outdoor location. Provisions shall be provided for automatically shutting off the supply of the gas–air mixture in the event of rupture.

6.13 Electrical Bonding and Grounding.

6.13.1 Each aboveground portion of a gas piping system that is likely to become energized shall be electrically continuous and bonded to an effective ground-fault current path. Gas piping shall be considered to be bonded when it is connected to gas utilization equipment that is connected to the equipment grounding conductor of the circuit supplying that equipment.

6.13.2 Gas piping shall not be used as a grounding conductor or electrode.

6.14 Electrical Circuits. Electrical circuits shall not utilize gas piping or components as conductors.

Exception: Low-voltage (50 V or less) control circuits, ignition circuits, and electronic flame detection device circuits shall be permitted to make use of piping or components as a part of an electric circuit.

6.15 Electrical Connections.

6.15.1 All electrical connections between wiring and electrically operated control devices in a piping system shall conform to the requirements of NFPA 70, *National Electrical Code. (See Section 6.13.)*

6.15.2 Any essential safety control depending on electric current as the operating medium shall be of a type that will shut off (fail safe) the flow of gas in the event of current failure.

Chapter 7 Inspection, Testing, and Purging

7.1 Pressure Testing and Inspection.

7.1.1* General.

7.1.1.1 Prior to acceptance and initial operation, all piping installations shall be inspected and pressure tested to determine that the materials, design, fabrication, and installation practices comply with the requirements of this code.

7.1.1.2 Inspection shall consist of visual examination, during or after manufacture, fabrication, assembly, or pressure tests as appropriate. Supplementary types of nondestructive inspection techniques, such as magnetic-particle, radiographic, and ultrasonic, shall not be required unless specifically listed herein or in the engineering design.

7.1.1.3 Where repairs or additions are made following the pressure test, the affected piping shall be tested. Minor repairs and additions are not required to be pressure tested provided that the work is inspected and connections are tested with a noncorrosive leak-detecting fluid or other leak-detecting methods approved by the authority having jurisdiction.

7.1.1.4 Where new branches are installed from the point of delivery to new appliance(s), only the newly installed branch(es) shall be required to be pressure tested. Connections between the new piping and the existing piping shall be tested with a noncorrosive leak-detecting fluid or approved leak-detecting methods.

7.1.1.5 A piping system shall be tested as a complete unit or in sections. Under no circumstances shall a valve in a line be used as a bulkhead between gas in one section of the piping system and test medium in an adjacent section, unless two valves are installed in series with a valved "tell tale" located between these valves. A valve shall not be subjected to the test pressure unless it can be determined that the valve, including the valve closing mechanism, is designed to safely withstand the pressure.

7.1.1.6 Regulator and valve assemblies fabricated independently of the piping system in which they are to be installed

shall be permitted to be tested with inert gas or air at the time of fabrication.

7.1.2 Test Medium. The test medium shall be air, nitrogen, carbon dioxide, or an inert gas.
OXYGEN SHALL NEVER BE USED.

7.1.3 Test Preparation.

7.1.3.1 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.

7.1.3.2 Expansion joints shall be provided with temporary restraints, if required, for the additional thrust load under test.

7.1.3.3 Appliances and equipment that are not to be included in the test shall be either disconnected from the piping or isolated by blanks, blind flanges, or caps. Flanged joints at which blinds are inserted to blank off other equipment during the test shall not be required to be tested.

7.1.3.4 Where the piping system is connected to appliances, equipment, or equipment components designed for operating pressures of less than the test pressure, such appliances, equipment, or equipment components shall be isolated from the piping system by disconnecting them and capping the outlet(s).

7.1.3.5 Where the piping system is connected to appliances, equipment, or equipment components designed for operating pressures equal to or greater than the test pressure, such appliances and equipment shall be isolated from the piping system by closing the individual equipment shutoff valve(s).

7.1.3.6 All testing of piping systems shall be done with due regard for the safety of employees and the public during the test. Bulkheads, anchorage, and bracing suitably designed to resist test pressures shall be installed if necessary. Prior to testing, the interior of the pipe shall be cleared of all foreign material.

7.1.4 Test Pressure.

7.1.4.1 Test pressure shall be measured with a manometer or with a pressure measuring device designed and calibrated to read, record, or indicate a pressure loss due to leakage during the pressure test period. The source of pressure shall be isolated before the pressure tests are made. Mechanical gauges used to measure test pressures shall have a range such that the highest end of the scale is not greater than 5 times the test pressure.

7.1.4.2 The test pressure to be used shall be no less than 1½ times the proposed maximum working pressure, but not less than 3 psi (20 kPa), irrespective of design pressure. Where the test pressure exceeds 125 psi (862 kPa), the test pressure shall not exceed a value that produces a hoop stress in the piping greater than 50 percent of the specified minimum yield strength of the pipe.

7.1.4.3 Test duration shall be not less than ½ hour for each 500 ft^3 (14 m^3) of pipe volume or fraction thereof. When testing a system having a volume less than 10 ft^3 (0.28 m^3) or a system in a single-family dwelling, the test duration shall be a minimum of 10 minutes. The duration of the test shall not be required to exceed 24 hours.

7.1.5 Detection of Leaks and Defects.

7.1.5.1 The piping system shall withstand the test pressure specified without showing any evidence of leakage or other defects. Any reduction of test pressures as indicated by pressure gauges shall be deemed to indicate the presence of a leak unless such reduction can be readily attributed to some other cause.

7.1.5.2 The leakage shall be located by means of an approved gas detector, a noncorrosive leak detection fluid, or other approved leak detection methods. **Matches, candles, open flames, or other methods that provide a source of ignition shall not be used.**

7.1.5.3 Where leakage or other defects are located, the affected portion of the piping system shall be repaired or replaced and retested. *(See 7.1.1.3.)*

7.2 System and Equipment Leakage Test.

7.2.1 Test Gases. Leak checks using fuel gas shall be permitted in piping systems that have been pressure tested in accordance with Section 7.1.

7.2.2 Before Turning Gas On. Before gas is introduced into a system of new gas piping, the entire system shall be inspected to determine that there are no open fittings or ends and that all valves at unused outlets are closed and plugged or capped.

7.2.3* Test for Leakage. Immediately after the gas is turned on into a new system or into a system that has been initially restored after an interruption of service, the piping system shall be tested for leakage. Where leakage is indicated, the gas supply shall be shut off until the necessary repairs have been made.

7.2.4 Placing Equipment in Operation. Gas utilization equipment shall not be placed in operation until after the piping system has been tested in accordance with 7.2.3 and purged in accordance with 7.3.2.

7.3* Purging.

7.3.1 Removal from Service. When gas piping is to be opened for an addition, a modification, or for service, the section to be worked on shall be turned off from the gas supply at the nearest convenient point and the line pressure vented to the outdoors or to ventilated areas of sufficient size to prevent accumulation of flammable mixtures. The remaining gas in this section of pipe shall be displaced with an inert gas as required by Table 7.3.1.

Table 7.3.1 Length of Piping Requiring Purging with Inert Gas for Servicing or Modification

Nominal Pipe Size (in.)	Length of Piping Requiring Purging (ft)
2½	> 50
3	> 30
4	> 15
6	> 10
8 or larger	Any length

For SI units, 1 ft = 0.305 m.

7.3.2 Placing in Operation. When piping full of air is placed in operation, the air in the piping shall be displaced with fuel gas, except where such piping is required by Table 7.3.2 to be purged with an inert gas prior to introduction of fuel gas. The air can be safely displaced with fuel gas provided that a moderately rapid and continuous flow of fuel gas is introduced at

one end of the line and air is vented out at the other end. The fuel gas flow shall be continued without interruption until the vented gas is free of air. The point of discharge shall not be left unattended during purging. After purging, the vent shall then be closed. Where required by Table 7.3.2, the air in the piping shall first be displaced with an inert gas, and the inert gas shall then be displaced with fuel gas.

Table 7.3.2 Length of Piping Requiring Purging with Inert Gas Before Being Placed in Operation

Nominal Pipe Size (in.)	Length of Piping Requiring Purging (ft)
3	> 30
4	> 15
6	> 10
8 or larger	Any length

For SI units, 1 ft = 0.305 m.

7.3.3 Discharge of Purged Gases. The open end of piping systems being purged shall not discharge into confined spaces or areas where there are sources of ignition unless precautions are taken to perform this operation in a safe manner by ventilation of the space, control of purging rate, and elimination of all hazardous conditions.

7.3.4 Placing Equipment in Operation. After the piping has been placed in operation, all equipment shall be purged and then placed in operation, as necessary.

Chapter 8 Equipment Installation

8.1 General.

8.1.1* Appliances, Accessories, and Equipment to Be Approved. Gas appliances, accessories, and gas utilization equipment shall be approved. Approved shall mean "acceptable to the authority having jurisdiction." Acceptance of unlisted gas utilization equipment and accessories shall be on the basis of a sound engineering evaluation. In such cases, the equipment shall be safe and suitable for the proposed service and shall be recommended for the service by the manufacturer.

8.1.2 Added or Converted Equipment. When additional or replacement equipment is installed or an appliance is converted to gas from another fuel, the location in which the equipment is to be operated shall be checked to verify the following:

(1) Air for combustion and ventilation is provided where required, in accordance with the provisions of Section 8.3. Where existing facilities are not adequate, they shall be upgraded to meet Section 8.3 specifications.
(2) The installation components and equipment meet the clearances to combustible material provisions of 8.2.2. It shall be determined that the installation and operation of the additional or replacement equipment does not render the remaining equipment unsafe for continued operation.
(3) The venting system is constructed and sized in accordance with the provisions of Chapter 10. Where the existing venting system is not adequate, it shall be upgraded to comply with Chapter 10.

8.1.3 Type of Gas(es). It shall be determined whether the gas utilization equipment has been designed for use with the gas to which it will be connected. No attempt shall be made to convert the equipment from the gas specified on the rating plate for use with a different gas without consulting the installation instruction, the serving gas supplier, or the equipment manufacturer for complete instructions.

8.1.4 Safety Shutoff Devices for Unlisted LP-Gas Equipment Used Indoors. Unlisted gas utilization equipment for use with undiluted liquefied petroleum gases and installed indoors shall be equipped with safety shutoff devices of the complete shutoff type.

8.1.5 Use of Air or Oxygen Under Pressure. Where air or oxygen under pressure is used in connection with the gas supply, effective means such as a back-pressure regulator and relief valve shall be provided to prevent air or oxygen from passing back into the gas piping. Where oxygen is used, installation shall be in accordance with NFPA 51, *Standard for the Design and Installation of Oxygen–Fuel Gas Systems for Welding, Cutting, and Allied Processes.*

8.1.6* Protection of Gas Equipment from Fumes or Gases Other than Products of Combustion.

8.1.6.1 Where corrosive or flammable process fumes or gases are present, means for their safe disposal shall be provided. Such fumes or gases include carbon monoxide, hydrogen sulfide, ammonia, chlorine, and halogenated hydrocarbons.

8.1.6.2 Non-direct-vent type gas appliances installed in beauty shops, barber shops, or other facilities where chemicals that generate corrosive or flammable products such as aerosol sprays are routinely used shall be located in an equipment room separate or partitioned off from other areas with provisions for combustion and dilution air from outdoors. Direct vent equipment shall be in accordance with the appliance manufacturer's installation instructions.

8.1.7 Process Air. In addition to air needed for combustion in commercial or industrial processes, process air shall be provided as required for cooling of equipment or material, controlling dew point, heating, drying, oxidation, dilution, safety exhaust, odor control, air for compressors, and for comfort and proper working conditions for personnel.

8.1.8 Building Structural Members.

8.1.8.1 Structural members of a building shall not pass through gas utilization equipment having an operating temperature in excess of 500°F (260°C).

8.1.8.2 Structural members passing through gas utilization equipment having an operating temperature of 500°F (260°C) or less shall be of noncombustible material. Building columns, girders, beams, or trusses shall not be installed within equipment, unless insulation and ventilation are provided to avoid all deterioration in strength and linear expansion of the building structure in either a vertical or a horizontal direction.

8.1.8.3 Gas utilization equipment shall be furnished either with load distributing bases or with a sufficient number of supports to prevent damage to either the building structure or equipment.

8.1.8.4 At the locations selected for installation of gas utilization equipment, the dynamic and static load-carrying capacities of the building structure shall be checked to determine whether they are adequate to carry the additional loads. The equipment shall be supported and shall be connected to the piping so as not to exert undue stress on the connections.

8.1.9 Flammable Vapors. Gas appliances shall not be installed in areas where the open use, handling, or dispensing of flammable liquids occurs, unless the design, operation, or installation reduces the potential of ignition of the flammable vapors. Gas utilization equipment installed in compliance with 8.1.10 through 8.1.12 shall be considered to comply with the intent of this provision.

8.1.10 Installation in Residential Garages.

8.1.10.1 Gas utilization equipment in residential garages and in adjacent spaces that open to the garage and are not part of the living space of a dwelling unit shall be installed so that all burners and burner ignition devices are located not less than 18 in. (460 mm) above the floor unless listed as flammable vapor ignition resistant.

8.1.10.2 Such equipment shall be located or protected so it is not subject to physical damage by a moving vehicle.

8.1.10.3 When appliances are installed in a separate, enclosed space having access only from outside of the garage, such equipment shall be permitted to be installed at floor level, providing the required combustion air is taken from the exterior of the garage.

8.1.11 Installation in Commercial Garages.

8.1.11.1 Parking Structures. Gas utilization equipment installed in enclosed, basement, and underground parking structures shall be installed in accordance with NFPA 88A, *Standard for Parking Structures.*

8.1.11.2 Repair Garages. Gas utilization equipment installed in repair garages shall be installed in a detached building or room, separated from repair areas by walls or partitions, floors, or floor ceiling assemblies that are constructed so as to prohibit the transmission of vapors and having a fire resistance rating of not less than 1 hour, and that have no openings in the wall separating the repair area within 8 ft (2.4 m) of the floor. Wall penetrations shall be firestopped. Air for combustion purposes shall be obtained from outside the building. The heating room shall not be used for the storage of combustible materials.

Exception No. 1: Overhead heaters where installed not less than 8 ft (2.4 m) above the floor shall be permitted.

Exception No. 2: Heating equipment for vehicle repair areas where there is no dispensing or transferring of Class I or Class II flammable or combustible liquids or liquefied petroleum gas shall be installed in accordance with NFPA 30A, Code for Motor Fuel Dispensing Facilities and Repair Garages.

8.1.12 Installation in Aircraft Hangars. Heaters in aircraft hangars shall be installed in accordance with NFPA 409, *Standard on Aircraft Hangars.*

8.1.13 Gas Equipment Physical Protection. Where it is necessary to locate gas utilization equipment close to a passageway traveled by vehicles or equipment, guardrails or bumper plates shall be installed to protect the equipment from damage.

8.1.14 Venting of Flue Gases. Gas utilization equipment shall be vented in accordance with the provisions of Chapter 10.

8.1.15 Extra Device or Attachment. No device or attachment shall be installed on any gas utilization equipment that could in any way impair the combustion of gas.

8.1.16 Adequate Capacity of Piping. When additional gas utilization equipment is being connected to a gas piping system, the existing piping shall be checked to determine whether it has adequate capacity. *(See Section 5.4.)* Where inadequate, the existing system shall be enlarged as necessary, or separate gas piping of adequate capacity shall be run from the point of delivery to the equipment.

8.1.17 Avoiding Strain on Gas Piping. Gas utilization equipment shall be supported and so connected to the piping as not to exert undue strain on the connections.

8.1.18 Gas Appliance Pressure Regulators. Where the gas supply pressure is higher than that at which the gas utilization equipment is designed to operate or varies beyond the design pressure limits of the equipment, a gas appliance pressure regulator shall be installed.

8.1.19 Venting of Gas Appliance Pressure Regulators. Venting of gas appliance pressure regulators shall comply with the following requirements:

(1) Gas appliance pressure regulators requiring access to the atmosphere for successful operation shall be equipped with vent piping leading outdoors or, if the regulator vent is an integral part of the equipment, into the combustion chamber adjacent to a continuous pilot, unless constructed or equipped with a vent limiting means to limit the escape of gas from the vent opening in the event of diaphragm failure.
(2) Vent limiting means shall be employed on listed gas appliance pressure regulators only.
(3) In the case of vents leading outdoors, means shall be employed to prevent water from entering this piping and also to prevent blockage of vents by insects and foreign matter.
(4) Under no circumstances shall a regulator be vented to the gas utilization equipment flue or exhaust system.
(5) In the case of vents entering the combustion chamber, the vent shall be located so the escaping gas will be readily ignited by the pilot and the heat liberated thereby will not adversely affect the normal operation of the safety shutoff system. The terminus of the vent shall be securely held in a fixed position relative to the pilot. For manufactured gas, the need for a flame arrester in the vent piping shall be determined.
(6) A vent line(s) from a gas appliance pressure regulator and a bleed line(s) from a diaphragm-type valve shall not be connected to a common manifold terminating in a combustion chamber. Vent lines shall not terminate in positive-pressure-type combustion chambers.

8.1.20 Bleed Lines for Diaphragm-Type Valves. Bleed lines shall comply with the following requirements:

(1) Diaphragm-type valves shall be equipped to convey bleed gas to the outside atmosphere or into the combustion chamber adjacent to a continuous pilot.
(2) In the case of bleed lines leading outdoors, means shall be employed to prevent water from entering this piping and also to prevent blockage of vents by insects and foreign matter.

(3) Bleed lines shall not terminate in the gas utilization equipment flue or exhaust system.
(4) In the case of bleed lines entering the combustion chamber, the bleed line shall be located so the bleed gas will be readily ignited by the pilot and the heat liberated thereby will not adversely affect the normal operation of the safety shutoff system. The terminus of the bleed line shall be securely held in a fixed position relative to the pilot. For manufactured gas, the need for a flame arrester in the bleed line piping shall be determined.
(5) A bleed line(s) from a diaphragm-type valve and a vent line(s) from a gas appliance pressure regulator shall not be connected to a common manifold terminating in a combustion chamber. Bleed lines shall not terminate in positive-pressure-type combustion chambers.

8.1.21 Combination of Equipment. Any combination of gas utilization equipment, attachments, or devices used together in any manner shall comply with the standards that apply to the individual equipment.

8.1.22 Installation Instructions. The installing agency shall conform with the equipment manufacturers' recommendations in completing an installation. The installing agency shall leave the manufacturers' installation, operating, and maintenance instructions in a location on the premises where they will be readily available for reference and guidance of the authority having jurisdiction, service personnel, and the owner or operator.

8.1.23 Protection of Outdoor Equipment. Gas utilization equipment not listed for outdoor installation but installed outdoors shall be provided with protection to the degree that the environment requires. Equipment listed for outdoor installation shall be permitted to be installed without protection in accordance with the provisions of their listing. *(See 8.2.1.)*

8.2 Accessibility and Clearance.

8.2.1 Accessibility for Service. All gas utilization equipment shall be located with respect to building construction and other equipment so as to permit access to the gas utilization equipment. Sufficient clearance shall be maintained to permit cleaning of heating surfaces; the replacement of filters, blowers, motors, burners, controls, and vent connections; the lubrication of moving parts where necessary; the adjustment and cleaning of burners and pilots; and the proper functioning of explosion vents, if provided. For attic installation, the passageway and servicing area adjacent to the equipment shall be floored.

8.2.2 Clearance to Combustible Materials. Gas utilization equipment and their vent connectors shall be installed with clearances from combustible material so their operation will not create a hazard to persons or property. Minimum clearances between combustible walls and the back and sides of various conventional types of equipment and their vent connectors are specified in Chapters 9 and 10. *(Reference can also be made to NFPA 211, Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances.)*

8.2.3 Installation on Carpeting. Equipment shall not be installed on carpeting, unless the equipment is listed for such installation.

8.3* Air for Combustion and Ventilation.

8.3.1 General.

8.3.1.1 Air for combustion, ventilation, and dilution of flue gases for gas utilization equipment installed in buildings shall be obtained by application of one of the methods covered in 8.3.2 through 8.3.6. Where the requirements of 8.3.2 are not met, outdoor air shall be introduced in accordance with methods covered in 8.3.3 through 8.3.6.

Exception No. 1: This provision shall not apply to direct vent appliances.

Exception No. 2: Type I clothes dryers that are provided with makeup air in accordance with 9.4.3.

8.3.1.2 Gas appliances of other than natural draft design and other than Category I vented appliances shall be provided with combustion, ventilation, and dilution air in accordance with the appliance manufacturer's instructions.

8.3.1.3 Equipment shall be located so as not to interfere with proper circulation of combustion, ventilation, and dilution air.

8.3.1.4 Where used, a draft hood or a barometric draft regulator shall be installed in the same room or enclosure as the equipment served so as to prevent any difference in pressure between the hood or regulator and the combustion air supply.

8.3.1.5 Make-up air requirements for the operation of exhaust fans, kitchen ventilation systems, clothes dryers, and fireplaces shall be considered in determining the adequacy of a space to provide combustion air requirements.

8.3.2 Indoor Combustion Air. The required volume of indoor air shall be determined in accordance with the method in 8.3.2.1 or the method in 8.3.2.2 except that where the air infiltration rate is known to be less than 0.40 *ACH*, the method in 8.3.2.2 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 8.3.2.4 are considered a part of the required volume.

8.3.2.1* Standard Method. The minimum required volume shall be 50 ft^3 per 1000 Btu/hour (4.8 m^3/kW).

8.3.2.2* Known Air Infiltration Rate Method. Where the air infiltration rate of a structure is known, the minimum required volume shall be determined as follows:

(1) For appliances other than fan-assisted, calculate using the following equation:

$$\text{Required Volume}_{\,other} \geq \frac{21\ \text{ft}^3}{ACH}\left(\frac{I_{other}}{1000\ \text{Btu/hr}}\right)$$

(2) For fan-assisted appliances, calculate using the following equation:

$$\text{Required Volume}_{\,fan} \geq \frac{15\ \text{ft}^3}{ACH}\left(\frac{I_{fan}}{1000\ \text{Btu/hr}}\right)$$

where:

I_{other} = all appliances other than fan-assisted input in Btu per hour
I_{fan} = fan-assisted appliance input in Btu per hour
ACH = air change per hour (percent of volume of space exchanged per hour, expressed as a decimal)

(3) For purposes of this calculation, an infiltration rate greater than 0.60 *ACH* shall not be used in the equations in 8.3.2.2(1) and 8.3.2.2(2).

8.3.2.3 Indoor Opening Size and Location. Openings used to connect indoor spaces shall be sized and located in accordance with the following:

(1)*Combining spaces on the same story. Each opening shall have a minimum free area of 1 $in.^2$/1000 Btu/hr (2200 mm^2/kW) of the total input rating of all gas utilization equipment in the space, but not less than 100 $in.^2$ (0.06 m^2). One opening shall commence within 12 in. (300 mm) of the top, and one opening shall commence within 12 in. (300 mm) of the bottom, of the enclosure *[see Figure A.8.3.2.3(1)]*. The minimum dimension of air openings shall be not less than 3 in. (80 mm).

(2) Combining spaces in different stories. The volumes of spaces in different stories shall be considered as communicating spaces where such spaces are connected by one or more openings in doors or floors having a total minimum free area of 2 $in.^2$/1000 Btu/hr (8800 mm^2/kW) of total input rating of all gas utilization equipment.

8.3.3 Outdoor Combustion Air. Outdoor combustion air shall be provided through opening(s) to the outdoors in accordance with the methods in 8.3.3.1 or 8.3.3.2. The minimum dimension of air openings shall not be less than 3 in. (80 mm).

8.3.3.1 Two Permanent Openings Method. Two permanent openings, one commencing within 12 in. (300 mm) of the top and one commencing within 12 in. (300 mm) of the bottom of the enclosure, shall be provided. The openings shall communicate directly, or by ducts, with the outdoors or spaces that freely communicate with the outdoors, as follows:

(1)*Where directly communicating with the outdoors or where communicating to the outdoors through vertical ducts, each opening shall have a minimum free area of 1 $in.^2$/4000 Btu/hr (550 mm^2/kW) of total input rating of all equipment in the enclosure. *[See Figure A.8.3.3.1(1)(a) and Figure A.8.3.3.1(1)(b).]*

(2)*Where communicating with the outdoors through horizontal ducts, each opening shall have a minimum free area of not less than 1 $in.^2$/2000 Btu/hr (1100 mm^2/kW) of total input rating of all equipment in the enclosure. *[See Figure A.8.3.3.1(2).]*

8.3.3.2* One Permanent Opening Method. One permanent opening, commencing within 12 in. (300 mm) of the top of the enclosure, shall be provided. The equipment shall have clearances of at least 1 in. (25 mm) from the sides and back and 6 in. (150 mm) from the front of the appliance. The opening shall directly communicate with the outdoors or shall communicate through a vertical or horizontal duct to the outdoors or spaces that freely communicate with the outdoors *(see Figure A.8.3.3.2)* and shall have a minimum free area of the following:

(1) 1 $in.^2$/3000 Btu/hr (700 mm^2 per kW) of the total input rating of all equipment located in the enclosure, and
(2) Not less than the sum of the areas of all vent connectors in the space

8.3.4 Combination Indoor and Outdoor Combustion Air. The use of a combination of indoor and outdoor combustion air shall be in accordance with (1) through (3) *(see example calculation in Annex J)*:

(1) *Indoor Openings.* Where used, openings connecting the interior spaces shall comply with 8.3.2.3.
(2) *Outdoor Opening(s) Location.* Outdoor opening(s) shall be located in accordance with 8.3.3.
(3) *Outdoor Opening(s) Size.* The outdoor opening(s) size shall be calculated in accordance with the following:
   (a) The ratio of the interior spaces shall be the available volume of all communicating spaces divided by the required volume.
   (b) The outdoor size reduction factor shall be 1 minus the ratio of interior spaces.
   (c) The minimum size of outdoor opening(s) shall be the full size of outdoor opening(s) calculated in accordance with 8.3.3, multiplied by the reduction factor. The minimum dimension of air openings shall not be less than 3 in. (80 mm).

8.3.5 Engineered Installations. Engineered combustion air installations shall provide an adequate supply of combustion, ventilation, and dilution air and shall be approved by the authority having jurisdiction.

8.3.6 Mechanical Combustion Air Supply. Where all combustion air is provided by a mechanical air supply system, the combustion air shall be supplied from outdoors at the minimum rate of 0.35 ft^3/min per 1000 Btu/hr (0.034 m^3/min per kW) for all appliances located within the space.

8.3.6.1 Where exhaust fans are installed, additional air shall be provided to replace the exhausted air.

8.3.6.2 Each of the appliances served shall be interlocked to the mechanical air supply system to prevent main burner operation where the mechanical air supply system is not in operation.

8.3.6.3 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.

8.3.7 Louvers and Grilles.

8.3.7.1 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 or grille is known, it shall be used in calculating the size opening required to provide the free area specified. Where the design and free area 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. Nonmotorized louvers and grilles shall be fixed in the open position.

8.3.7.2 Motorized louvers shall be interlocked with the equipment so they are proven in the full open position prior to main burner ignition and during main burner operation. Means shall be provided to prevent the main burner from igniting should the louver fail to open during burner startup and to shut down the main burner if the louvers close during burner operation.

8.3.8 Combustion Air Ducts. Combustion air ducts shall comply with the following.

8.3.8.1 Ducts shall be of galvanized steel or an equivalent corrosion-resistant material.

Exception: Within dwellings units, unobstructed stud and joist spaces shall not be prohibited from conveying combustion air, provided that not more than one fireblock is removed.

8.3.8.2 Ducts shall terminate in an unobstructed space, allowing free movement of combustion air to the appliances.

8.3.8.3 Ducts shall serve a single space.

8.3.8.4 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.

8.3.8.5 Ducts shall not be screened where terminating in an attic space.

8.3.8.6 Horizontal upper combustion air ducts shall not slope downward toward the source of combustion air.

8.3.8.7 The remaining space surrounding a chimney liner, gas vent, special gas vent, or plastic piping installed within a masonry, metal, or factory built chimney shall not be used to supply combustion air.

Exception: Direct vent gas-fired appliances designed for installation in a solid fuel burning fireplace where installed in accordance with the listing and the manufacturer's instruction.

8.3.8.8 Combustion air intake openings located on the exterior of the building shall have the lowest side of the combustion air intake openings located at least 12 in. (300 mm) vertically from the adjoining grade level.

8.4 Equipment on Roofs.

8.4.1 General.

8.4.1.1 Gas utilization equipment on roofs shall be designed or enclosed so as to withstand climatic conditions in the area in which they are installed. Where enclosures are provided, each enclosure shall permit easy entry and movement, shall be of reasonable height, and shall have at least a 30 in. (760 mm) clearance between the entire service access panel(s) of the equipment and the wall of the enclosure.

8.4.1.2 Roofs on which equipment is to be installed shall be capable of supporting the additional load or shall be reinforced to support the additional load.

8.4.1.3 All access locks, screws, and bolts shall be of corrosion-resistant material.

8.4.2 Installation of Equipment on Roofs.

8.4.2.1 Gas utilization equipment shall be installed in accordance with its listing and the manufacturer's installation instructions.

8.4.2.2 Equipment shall be installed on a well-drained surface of the roof. At least 6 ft (1.8 m) of clearance shall be available between any part of the equipment and the edge of a roof or similar hazard, or rigidly fixed rails, guards, parapets, or other building structures at least 42 in. (1.1 m) in height shall be provided on the exposed side.

8.4.2.3 All equipment requiring an external source of electrical power for its operation shall be provided with (1) a readily accessible electrical disconnecting means within sight of the equipment that will completely deenergize the equipment, and (2) a 120-V ac grounding-type receptacle outlet on the roof adjacent to the equipment. The receptacle outlet shall be on the supply side of the disconnect switch.

8.4.2.4 Where water stands on the roof at the equipment or in the passageways to the equipment, or where the roof is of a design having a water seal, a suitable platform, walkway, or both shall be provided above the water line. Such platform(s) or walkway(s) shall be located adjacent to the equipment and control panels so that the equipment can be safely serviced where water stands on the roof.

8.4.3 Access to Equipment on Roofs.

8.4.3.1 Gas utilization equipment located on roofs or other elevated locations shall be accessible.

8.4.3.2 Buildings of more than 15 ft (4.6 m) in height shall have an inside means of access to the roof, unless other means acceptable to the authority having jurisdiction are used.

8.4.3.3 The inside means of access shall be a permanent or foldaway inside stairway or ladder, terminating in an enclosure, scuttle, or trapdoor. Such scuttles or trapdoors shall be at least 22 in. × 24 in. (560 mm × 610 mm) in size, shall open easily and safely under all conditions, especially snow, and shall be constructed so as to permit access from the roof side unless deliberately locked on the inside. At least 6 ft (1.8 m) of clearance shall be available between the access opening and the edge of the roof or similar hazard, or rigidly fixed rails or guards a minimum of 42 in. (1.1 m) in height shall be provided on the exposed side. Where parapets or other building structures are utilized in lieu of guards or rails, they shall be a minimum of 42 in. (1.1 m) in height.

8.4.3.4 Permanent lighting shall be provided at the roof access. The switch for such lighting shall be located inside the building near the access means leading to the roof.

8.4.4 Additional Provisions. *(Also see 8.1.23, 8.2.1, and 10.3.4.)*

8.5 Equipment Connections to Building Piping.

8.5.1 Connecting Gas Equipment. Gas utilization equipment shall be connected to the building piping in compliance with 8.5.4 through 8.5.6 by one of the following:

(1) Rigid metallic pipe and fittings.
(2) Semirigid metallic tubing and metallic fittings. Aluminum alloy tubing shall not be used in exterior locations.
(3) A listed connector in compliance with ANSI Z21.24, *Standard for Connectors for Gas Appliances.* The connector shall be used in accordance with the terms of its listing and shall be in the same room as the equipment. Only one connector shall be used per appliance.
(4) CSST where installed in accordance with the manufacturer's instructions.
(5) Listed nonmetallic gas hose connectors in accordance with 8.5.2.
(6) Gas-fired food service (commercial cooking) equipment listed for use with casters or otherwise subject to movement for cleaning, and other large and heavy gas utilization equipment that can be moved, shall be connected in accordance with the connector manufacturer's installation instructions using a listed appliance connector complying with ANSI Z21.69, *Connectors for Movable Gas Appliances.*
(7) In 8.5.1(2), 8.5.1(3), and 8.5.1(5), the connector or tubing shall be installed so as to be protected against physical and thermal damage. Aluminum alloy tubing and connectors shall be coated to protect against external corrosion where they are in contact with masonry, plaster, or insulation or are subject to repeated wettings by such liquids as water (except rain water), detergents, or sewage.

8.5.2 Use of Nonmetallic Gas Hose Connectors. Listed gas hose connectors shall be used in accordance with the terms of their listing and as follows:

(1) *Indoor.* Indoor gas hose connectors shall be used only to connect laboratory, shop, and ironing equipment requiring mobility during operation. An equipment shutoff valve shall be installed where the connector is attached to the building piping. The connector shall be of minimum length and shall not exceed 6 ft (1.8 m). The connector shall not be concealed and shall not extend from one room to another or pass through wall partitions, ceilings, or floors.

(2) *Outdoor.* Outdoor gas hose connectors are permitted to connect portable outdoor gas-fired equipment. An equipment shutoff valve, a listed quick-disconnect device, or a listed gas convenience outlet shall be installed where the connector is attached to the supply piping and in such a manner so as to prevent the accumulation of water or foreign matter. This connection shall only be made in the outdoor area where the equipment is to be used.

8.5.3 Connection of Portable and Mobile Industrial Gas Equipment.

8.5.3.1 Where portable industrial gas utilization equipment or equipment requiring mobility or subject to vibration is connected to the building gas piping system by the use of a flexible hose, the hose shall be suitable and safe for the conditions under which it can be used.

8.5.3.2 Where industrial gas utilization equipment requiring mobility is connected to the rigid piping by the use of swivel joints or couplings, the swivel joints or couplings shall be suitable for the service required and only the minimum number required shall be installed.

8.5.3.3 Where industrial gas utilization equipment subject to vibration is connected to the building piping system by the use of all metal flexible connectors, the connectors shall be suitable for the service required.

8.5.3.4 Where flexible connections are used, they shall be of the minimum practical length and shall not extend from one room to another or pass through any walls, partitions, ceilings, or floors. Flexible connections shall not be used in any concealed location. They shall be protected against physical or thermal damage and shall be provided with gas shutoff valves in readily accessible locations in rigid piping upstream from the flexible connections.

8.5.4 Equipment Shutoff Valves and Connections. Gas utilization equipment connected to a piping system shall have an accessible, approved manual shutoff valve with a nondisplaceable valve member, or a listed gas convenience outlet, installed within 6 ft (1.8 m) of the equipment it serves. Where a connector is used, the valve shall be installed upstream of the connector. A union or flanged connection shall be provided downstream from this valve to permit removal of controls. Shutoff valves serving decorative gas appliances shall be permitted to be installed in fireplaces if listed for such use.

8.5.5 Quick-Disconnect Devices. Quick-disconnect devices used to connect equipment to the building piping shall be listed. Where installed indoors, an approved manual shutoff valve with a nondisplaceable valve member shall be installed upstream of the quick-disconnect device.

8.5.6* Gas Convenience Outlets. Gas utilization equipment shall be permitted to be connected to the building piping by means of a listed gas convenience outlet, in conjunction with a listed appliance connector, used in accordance with the terms of their listings.

8.5.7 Sediment Trap. Where a sediment trap is not incorporated as a part of the gas utilization equipment, a sediment trap shall be installed as close to the inlet of the equipment as practicable at the time of equipment installation. The sediment trap shall be either a tee fitting with a capped nipple in the bottom outlet as illustrated in Figure 8.5.7 or other device recognized as an effective sediment trap. Illuminating appliances, ranges, clothes dryers, decorative appliances for installation in vented fireplaces, gas fireplaces, and outdoor grills shall not be required to be so equipped.

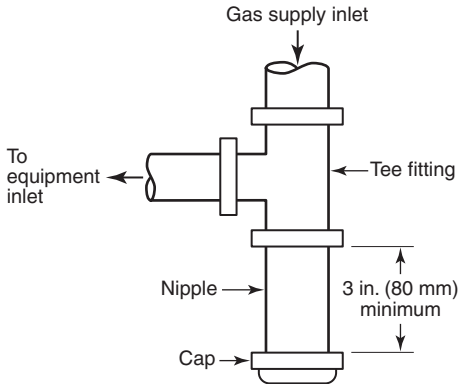


FIGURE 8.5.7 Method of Installing a Tee Fitting Sediment Trap.

8.5.8 Installation of Piping. Piping shall be installed in a manner not to interfere with inspection, maintenance, or servicing of the gas utilization equipment.

8.6 Electrical.

8.6.1 Electrical Connections. Electrical connections between gas utilization equipment and the building wiring, including the grounding of the equipment, shall conform to NFPA 70, *National Electrical Code.*

8.6.2 Electrical Ignition and Control Devices. Electrical ignition, burner control, and electrical vent damper devices shall not permit unsafe operation of the gas utilization equipment in the event of electrical power interruption or when the power is restored.

8.6.3 Electrical Circuit. The electrical circuit employed for operating the automatic main gas-control valve, automatic pilot, room temperature thermostat, limit control, or other electrical devices used with the gas utilization equipment shall be in accordance with the wiring diagrams supplied with the equipment.

8.6.4 Continuous Power. All gas utilization equipment using electrical controls shall have the controls connected into a permanently live electrical circuit — that is, one that is not controlled by a light switch. Central heating equipment shall be provided with a separate electrical circuit.

8.7 Room Temperature Thermostats.

8.7.1 Locations. Room temperature thermostats shall be installed in accordance with the manufacturers' instructions.

8.7.2 Drafts. Any hole in the plaster or panel through which the wires pass from the thermostat to the gas utilization equipment being controlled shall be sealed so as to prevent drafts from affecting the thermostat.

Chapter 9 Installation of Specific Equipment

9.1 General.

9.1.1 Application. This chapter is applicable primarily to nonindustrial-type gas utilization equipment and installations and, unless specifically indicated, does not apply to industrial-type equipment and installations. Listed gas utilization equipment shall be installed in accordance with their listing and the manufacturers' instructions, or as elsewhere specified in this chapter. Unlisted equipment shall be installed as specified in this part as applicable to the equipment. For additional information concerning particular gas equipment and accessories, including industrial types, reference can be made to the standards listed in Chapter 14 and Annex L.

9.1.2* Installation in a Bedroom or Bathroom. Gas utilization equipment shall not be installed so its combustion, ventilation, and dilution air are obtained only from a bedroom or bathroom unless the bedroom or bathroom has the required volume in accordance with 8.3.2.

9.1.3 Room Size in Comparison Calculation. Where the room size in comparison with the size of the equipment is to be calculated, the total volume of the appliance is determined from exterior dimensions and is to include fan compartments and burner vestibules, where used. Where the actual ceiling height of a room is greater than 8 ft (2.4 m), the volume of the room is figured on the basis of a ceiling height of 8 ft (2.4 m).

9.2 Air-Conditioning Equipment (Gas-Fired Air Conditioners and Heat Pumps).

9.2.1 Independent Gas Piping. Gas piping serving heating gas utilization equipment shall be permitted to also serve cooling equipment where heating and cooling equipment cannot be operated simultaneously. *(See Section 5.4.)*

9.2.2 Connection of Gas Engine-Powered Air Conditioners. To protect against the effects of normal vibration in service, gas engines shall not be rigidly connected to the gas supply piping.

9.2.3 Clearances for Indoor Installation. The installation of air-conditioning equipment shall comply with the following requirements:

(1) Listed air-conditioning equipment installed in rooms that are large in comparison with the size of the equipment shall be installed with clearances per the terms of their listing and the manufacturer's instructions. *(See Table 9.2.3(a) and Section 3.3 for definition.)*
(2) Air-conditioning equipment installed in rooms that are NOT large (such as alcoves and closets) in comparison with the size of the equipment shall be listed for such installations and installed in accordance with the manufacturer's instructions. Listed clearances shall not be reduced by the protection methods described in Table 9.2.3(b), regardless of whether the enclosure is of combustible or noncombustible material.
(3) Unlisted air-conditioning equipment shall be installed with clearances from combustible material of not less than 18 in. (460 mm) above the equipment and at the sides, front, and rear and 9 in. (230 mm) from the draft hood.
(4) Air-conditioning equipment (listed and unlisted) installed in rooms that are large in comparison with the size of the equipment shall be permitted to be installed with reduced clearances to combustible material provided the combustible material or equipment is protected as described in Table 9.2.3(b) *[see 9.2.3(2)]*.
(5) Where the furnace plenum is adjacent to plaster on metal lath or noncombustible material attached to combustible material, the clearance shall be measured to the surface

Table 9.2.3(a) Clearances to Combustible Material for Unlisted Furnaces, Boilers, and Air Conditioners Installed in Rooms That Are Large in Comparison with the Size of Equipment

	Minimum Clearance (in.)					
Equipment	Above and Sides of Furnace Plenum	Top of Boiler	Jacket Sides and Rear	Front	Draft Hood and Barometric Draft Regulator	Single-Wall Vent Connector
I Automatically fired, forced air or gravity system, equipped with temperature limit control that cannot be set higher than 250°F (121°C)	6		6	18	6	18
II Automatically fired heating boilers — steam boilers operating at not over 15 psi (103 kPa) and hot water boilers operating at 250°F (121°C) or less	6	6	6	18	18	18
III Central heating boilers and furnaces, other than in I or II	18	18	18	18	18	18
IV Air-conditioning equipment	18	18	18	18	18	18

Note: See 9.2.3 for additional requirements for air-conditioning equipment and 9.3.1 for additional requirements for central heating boilers and furnaces.

Table 9.2.3(b) Reduction of Clearances with Specified Forms of Protection

Type of protection applied to and covering all surfaces of combustible material within the distance specified as the required clearance with no protection *[See Figure 9.3.2.2(a) through Figure 9.3.2.2(c).]*	Where the required clearance with no protection from appliance, vent connector, or single-wall metal pipe is:									
	36 in.		18 in.		12 in.		9 in.		6 in.	
	Allowable Clearances with Specified Protection (in.)									
	Use Col. 1 for clearances above appliance or horizontal connector. Use Col. 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 in. thick masonry wall without ventilated air space	—	24	—	12	—	9	—	6	—	5
(2) ½ in. insulation board over 1 in. glass fiber or mineral wool batts	24	18	12	9	9	6	6	5	4	3
(3) 0.024 sheet metal over 1 in. glass fiber or mineral wool batts reinforced with wire on rear face with ventilated air space	18	12	9	6	6	4	5	3	3	3
(4) 3½ in. thick masonry wall with ventilated air space	—	12	—	6	—	6	—	6	—	6
(5) 0.024 sheet metal with ventilated air space	18	12	9	6	6	4	5	3	3	2
(6) ½ in. thick insulation board with ventilated air space	18	12	9	6	6	4	5	3	3	3
(7) 0.024 sheet metal with ventilated air space over 0.024 sheet metal with ventilated air space	18	12	9	6	6	4	5	3	3	3
(8) 1 in. glass fiber or mineral wool batts sandwiched between two sheets 0.024 sheet metal with ventilated air space	18	12	9	6	6	4	5	3	3	3

For SI units, 1 in. = 25.4 mm.

Notes:

1. Reduction of clearances from combustible materials shall not interfere with combustion air, draft hood clearance and relief, and accessibility of servicing.
2. All 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.
3. Spacers and ties shall be of noncombustible material. No spacer or tie shall be used directly opposite the appliance or connector.
4. Where all clearance reduction systems use a ventilated air space, adequate provision for air circulation shall be provided as described. *[See Figure 9.3.2.2(b) and Figure 9.3.2.2(c).]*
5. There shall be at least 1 in. (25 mm) between clearance reduction systems and combustible walls and ceilings for reduction systems using a ventilated air space.
6. Where a wall protector is mounted on a single flat wall away from corners, it shall have a minimum 1 in. (25 mm) air gap. To provide adequate air circulation, the bottom and top edges, or only the side and top edges, or all edges shall be left open.
7. Mineral wool batts (blanket or board) shall have a minimum density of 8 lb/ft^3 (128 kg/m^3) and a minimum melting point of 1500°F (816°C).
8. Insulation material used as part of a clearance reduction system shall have a thermal conductivity of 1.0 Btu in./ft^2/hr-°F (0.144 W/m-K) or less.
9. There shall be at least 1 in. (25 mm) between the appliance and the protector. In no case shall the clearance between the appliance and the combustible surface be reduced below that allowed in Table 9.2.3(b).
10. All clearances and thicknesses are minimum; larger clearances and thicknesses are acceptable.
11. Listed single-wall connectors shall be installed in accordance with the terms of their listing and the manufacturer's instructions.

of the plaster or other noncombustible finish where the clearance specified is 2 in. (50 mm) or less.

(6) Listed air-conditioning equipment shall have the clearance from supply ducts within 3 ft (0.9 m) of the furnace plenum be not less than that specified from the furnace plenum. No clearance is necessary beyond this distance.

9.2.4 Assembly and Installation. Air-conditioning equipment shall be installed in accordance with the manufacturer's instructions. Unless the equipment is listed for installation on a combustible surface such as a floor or roof, or unless the surface is protected in an approved manner, it shall be installed on a surface of noncombustible construction with noncombustible material and surface finish and with no combustible material against the underside thereof.

9.2.5 Furnace Plenums and Air Ducts. A furnace plenum supplied as a part of the air-conditioning equipment shall be installed in accordance with the manufacturer's instructions. Where a furnace plenum is not supplied with the equipment, any fabrication and installation instructions provided by the manufacturer shall be followed. The method of connecting supply and return ducts shall facilitate proper circulation of air. Where the air conditioner is installed within a room not large in comparison with the size of the equipment, the air circulated by the equipment shall be handled by ducts that are sealed to the casing of the equipment and that separate the circulating air from the combustion and ventilation air.

9.2.6* Refrigeration Coils. *(See 9.3.7 and 9.3.8.)*

9.2.7 Switches in Electrical Supply Line. Means for interrupting the electrical supply to the air-conditioning equipment and to its associated cooling tower (if supplied and installed in a location remote from the air conditioner) shall be provided within sight of and not over 50 ft (15 m) from the air conditioner and cooling tower.

9.3 Central Heating Boilers and Furnaces.

9.3.1 Location. Central heating furnace and low-pressure boiler installations in bedrooms or bathrooms shall comply with one of the following:

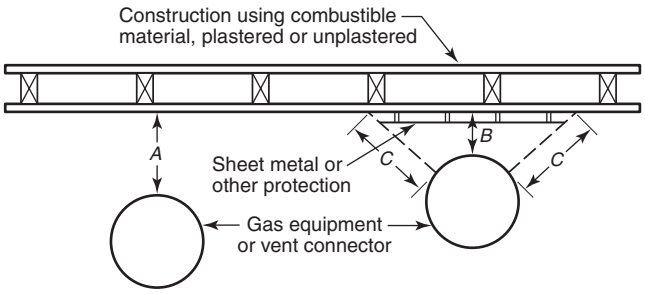
(1) Central heating furnaces and low-pressure boilers shall be installed in a closet located in the bedroom or bathroom, the closet shall have a weather-stripped solid door with a self-closing device, and all combustion air shall be obtained from the outdoors.

(2) Central heating furnaces and low-pressure boilers shall be of the direct vent type.

9.3.2 Clearance.

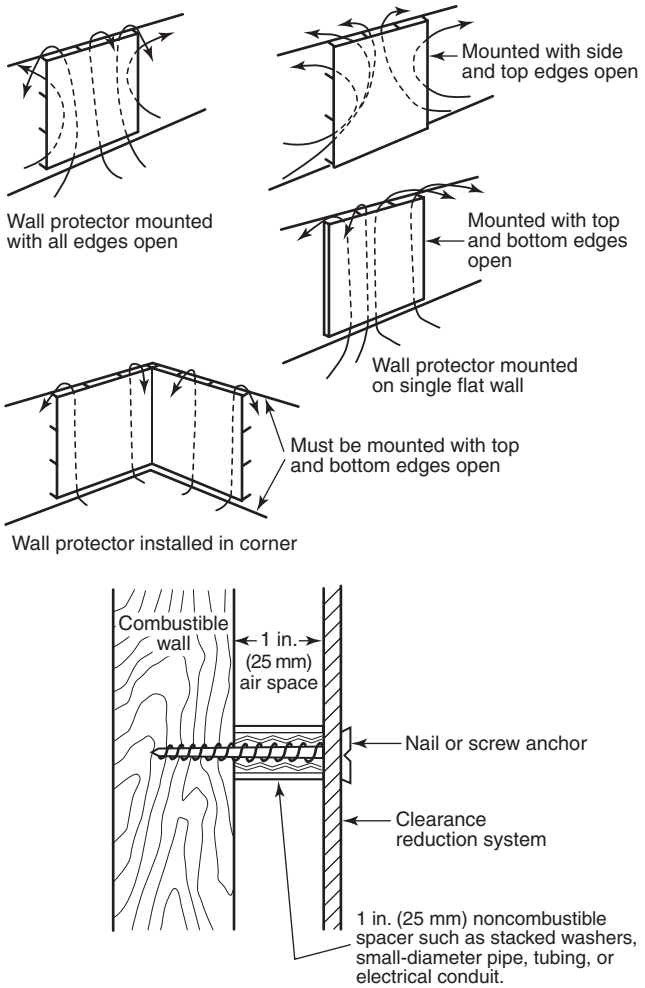
9.3.2.1 Listed central heating furnaces and low-pressure boilers installed in rooms that are large in comparison with the size of the equipment shall be installed with clearances per the terms of their listing and the manufacturer's instructions. *(See Section 3.3 for definition.)*

9.3.2.2 Central heating furnaces and low-pressure boilers installed in rooms that are NOT large (such as alcoves and closets) in comparison with the size of the equipment shall be listed for such installations. Listed clearances shall not be reduced by the protection methods described in Table 9.2.3(b) and illustrated in Figure 9.3.2.2(a) through Figure 9.3.2.2(c), regardless of whether the enclosure is of combustible or noncombustible material.



Notes:
A equals the clearance with no protection specified in Tables 9.2.3(a) and 10.4.1 and in the sections applying to various types of equipment.
B equals the reduced clearance permitted in accordance with Table 9.2.3(b). The protection applied to the construction using combustible material shall extend far enough in each direction to make *C* equal to *A*.

FIGURE 9.3.2.2(a) Extent of Protection Necessary to Reduce Clearances from Gas Equipment or Vent Connectors.



Masonry walls can be attached to combustible walls using wall ties.
Spacers should not be used directly behind appliance or connector.

FIGURE 9.3.2.2(b) Wall Protector Clearance Reduction System.

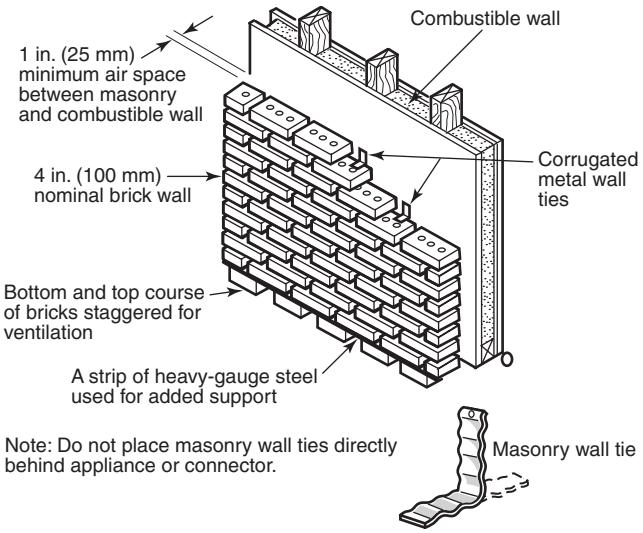


FIGURE 9.3.2.2(c) Masonry Clearance Reduction System.

9.3.2.3 Unlisted central heating furnaces and low-pressure boilers installed in rooms that are large in comparison with the size of the equipment shall be installed with clearances not less than those specified in Table 9.2.3(a).

9.3.2.4 Central heating furnaces and low-pressure boilers (listed and unlisted) installed in rooms that are large in comparison with the size of the equipment shall be permitted to be installed with reduced clearances to combustible material provided the combustible material or equipment is protected as described in Table 9.2.3(b) *(see 9.3.2)*.

9.3.2.5 Front clearance shall be sufficient for servicing the burner and the furnace or boiler.

9.3.2.6 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 in. (50 mm) or less.

9.3.2.7 The clearance to this equipment shall not interfere with combustion air, draft hood clearance and relief, and accessibility for servicing. *(See 8.2.1, Section 8.3, and 10.12.7.)*

9.3.2.8 Listed central heating furnaces shall have the clearance from supply ducts within 3 ft (0.9 m) of the furnace plenum be not less than that specified from the furnace plenum. No clearance is necessary beyond this distance.

9.3.2.9 Unlisted central heating furnaces with temperature limit controls that cannot be set higher than 250°F (121°C) shall have the clearance from supply ducts within 6 ft (1.8 m) of the furnace plenum be not less than 6 in. (150 mm). No clearance is necessary beyond this distance.

9.3.2.10 Central heating furnaces other than those listed in 9.3.2.8 or 9.3.2.9 shall have clearances from the supply ducts of not less than 18 in. (460 mm) from the furnace plenum for the first 3 ft (0.9 m), then 6 in. (150 mm) for the next 3 ft (0.9 m) and 1 in. (25 mm) beyond 6 ft (1.8 m).

9.3.3 Assembly and Installation. A central heating boiler or furnace shall be installed in accordance with the manufacturer's instructions and shall be installed on a floor of noncombustible construction with noncombustible flooring and surface finish and with no combustible material against the underside thereof, or on fire-resistive slabs or arches having no combustible material against the underside thereof.

Exception No. 1: Appliances listed for installation on a combustible floor.

Exception No. 2: Installation on a floor protected in an approved manner.

9.3.4 Temperature- or Pressure-Limiting Devices. Steam and hot water boilers, respectively, shall be provided with approved automatic limiting devices for shutting down the burner(s) to prevent boiler steam pressure or boiler water temperature from exceeding the maximum allowable working pressure or temperature. Safety limit controls shall not be used as operating controls.

9.3.5 Low Water Cutoff. Hot water boilers installed above the radiation level and all steam boilers shall be provided with an automatic means to shut off the fuel supply to the burner(s) if the boiler water level drops to the lowest safe water line.

9.3.6* Steam Safety and Pressure Relief Valves. Steam and hot water boilers shall be equipped, respectively, with listed or approved steam safety or pressure relief valves of appropriate discharge capacity and conforming with ASME requirements. A shutoff valve shall not be placed between the relief valve and the boiler or on discharge pipes between such valves and the atmosphere.

9.3.6.1 Relief valves shall be piped to discharge near the floor.

9.3.6.2 The entire discharged piping shall be at least the same size as the relief valve discharge piping.

9.3.6.3 Discharge piping shall not contain threaded end connection at its termination point.

9.3.7 Furnace Plenums and Air Ducts.

9.3.7.1 Furnace plenums and air ducts shall be installed in accordance with NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* or NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.*

9.3.7.2 A furnace plenum supplied as a part of a furnace shall be installed in accordance with the manufacturer's instructions.

9.3.7.3* Where a furnace plenum is not supplied with the furnace, any fabrication and installation instructions provided by the manufacturer shall be followed. The method of connecting supply and return ducts shall facilitate proper circulation of air.

9.3.7.4 Where a furnace is installed so supply ducts carry air circulated by the furnace to areas outside the space containing the furnace, the return air shall also be handled by a duct(s) sealed to the furnace casing and terminating outside the space containing the furnace.

9.3.8 Refrigeration Coils. The installation of refrigeration coils shall comply with the following requirements:

(1) A refrigeration coil shall not be installed in conjunction with a forced air furnace where circulation of cooled air is provided by the furnace blower, unless the blower has sufficient capacity to overcome the external static resistance imposed by the duct system and cooling coil and the air

throughput necessary for heating or cooling, whichever is greater.

(2) Furnaces shall not be located upstream from cooling units, unless the cooling unit is designed or equipped so as not to develop excessive temperature or pressure.

(3) Refrigeration coils shall be installed in parallel with or on the downstream side of central furnaces to avoid condensation in the heating element, unless the furnace has been specifically listed for downstream installation. With a parallel flow arrangement, the dampers or other means used to control flow of air shall be sufficiently tight to prevent any circulation of cooled air through the furnace.

(4) Means shall be provided for disposal of condensate and to prevent dripping of condensate on the heating element.

9.3.9 Cooling Units Used with Heating Boilers.

9.3.9.1 Boilers, where used in conjunction with refrigeration systems, shall be installed so that the chilled medium is piped in parallel with the heating boiler with appropriate valves to prevent the chilled medium from entering the heating boiler.

9.3.9.2 Where hot water heating boilers are connected to heating coils located in air-handling units where they can be exposed to refrigerated air circulation, such boiler piping systems shall be equipped with flow control valves or other automatic means to prevent gravity circulation of the boiler water during the cooling cycle.

9.4 Clothes Dryers.

9.4.1 Clearance. The installation of clothes dryers shall comply with the following requirements:

(1) Listed Type 1 clothes dryers shall be installed with a minimum clearance of 6 in. (150 mm) from adjacent combustible material. Clothes dryers listed for installation at reduced clearances shall be installed in accordance with their listing. Type 1 clothes dryers installed in closets shall be specifically listed for such installation.

(2) Listed Type 2 clothes dryers shall be installed with clearances of not less than that shown on the marking plate and in the manufacturers' instructions. Type 2 clothes dryers designed and marked "For use only in noncombustible locations" shall not be installed elsewhere.

(3) Unlisted clothes dryers shall be installed with clearances to combustible material of not less than 18 in. (460 mm). Combustible floors under unlisted clothes dryers shall be protected in an approved manner.

9.4.2 Exhausting to the Outdoors. Type 1 and Type 2 clothes dryers shall be exhausted to the outside air.

9.4.3 Provisions for Make-Up Air.

9.4.3.1 Make-up air shall be provided for Type 1 clothes dryers in accordance with the manufacturers' installation instructions.

9.4.3.2 Provision for make-up air shall be provided for Type 2 clothes dryers, with a minimum free area *(see 8.3.5)* of 1 $in.^2$/1000 Btu/hr (2200 mm^2/kW) total input rating of the dryer(s) installed.

9.4.4 Exhaust Ducts for Type 1 Clothes Dryers.

9.4.4.1 A clothes dryer exhaust duct shall not be connected into any vent connector, gas vent, chimney, crawl space, attic, or other similar concealed space.

9.4.4.2 Ducts for exhausting clothes dryers shall not be assembled with screws or other fastening means that extend into the duct and that would catch lint and reduce the efficiency of the exhaust system.

9.4.4.3 Exhaust ducts shall be constructed of rigid metallic material. Transition ducts used to connect the dryer to the exhaust duct shall be listed for that application or installed in accordance with the clothes dryer manufacturer's installation instructions.

9.4.5 Exhaust Ducts for Type 2 Clothes Dryers.

9.4.5.1 Exhaust ducts for Type 2 clothes dryers shall comply with 9.4.4.

9.4.5.2 Exhaust ducts for Type 2 clothes dryers shall be constructed of sheet metal or other noncombustible material. Such ducts shall be equivalent in strength and corrosion resistance to ducts made of galvanized sheet steel not less than 0.0195 in. (0.5 mm) thick.

9.4.5.3 Type 2 clothes dryers shall be equipped or installed with lint-controlling means.

9.4.5.4 Exhaust ducts for Type 2 clothes dryers shall be installed with a minimum clearance of 6 in. (150 mm) from adjacent combustible material. Where exhaust ducts for Type 2 clothes dryers are installed with reduced clearances, the adjacent combustible material shall be protected in accordance with Table 9.2.3(b).

9.4.5.5 Where ducts pass through walls, floors, or partitions, the space around the duct shall be sealed with noncombustible material.

9.4.5.6 Multiple installations of Type 2 clothes dryers shall be made in a manner to prevent adverse operation due to back pressures that might be created in the exhaust systems.

9.4.6 Multiple Family or Public Use. All clothes dryers installed for multiple-family or public use shall be equipped with approved safety shutoff devices and shall be installed as specified for a Type 2 clothes dryer under 9.4.5.

9.5 Conversion Burners. Installation of conversion burners shall conform to ANSI Z21.8, *Installation of Domestic Gas Conversion Burners.*

9.6 Decorative Appliances for Installation in Vented Fireplaces.

9.6.1* Prohibited Installations. Decorative appliances for installation in vented fireplaces shall not be installed in bathrooms or bedrooms unless the appliance is listed and the bedroom or bathroom has the required volume in accordance with 8.3.2.

9.6.2 Installation. A decorative appliance for installation in a vented fireplace shall be installed only in a vented fireplace having a working chimney flue and constructed of noncombustible materials. These appliances shall not be thermostatically controlled.

9.6.2.1 A listed decorative appliance for installation in a vented fireplace shall be installed in accordance with its listing and the manufacturer's instructions.

9.6.2.2 A decorative appliance for installation in a vented fireplace, where installed in a manufactured home, shall be listed for installation in manufactured homes.

9.6.2.3 An unlisted decorative appliance for installation in a vented fireplace shall be installed in a fireplace having a permanent free opening, based on appliance input rating and chimney height equal to or greater than that specified in Table 9.6.2.3.

9.6.3 Fireplace Screens. A fireplace screen shall be installed with a decorative appliance for installation in a vented fireplace.

9.7 Gas Fireplaces, Vented.

9.7.1* Prohibited Installations. Vented gas fireplaces shall not be installed in bathrooms or bedrooms unless the appliance is listed and the bedroom or bathroom has the required volume in accordance with 8.3.2.

Exception: Direct-vent gas fireplaces.

9.7.2 Installation. The installation of vented gas fireplaces shall comply with the following requirements:

(1) Listed vented gas fireplaces shall be installed in accordance with their listing and the manufacturers' instructions and where installed in or attached to combustible material shall be specifically listed for such installation.
(2) Unlisted vented gas fireplaces shall not be installed in or attached to combustible material. They shall have a clearance at the sides and rear of not less than 18 in. (460 mm). Combustible floors under unlisted vented gas fireplaces shall be protected in an approved manner. Unlisted appliances of other than the direct vent type shall be equipped with a draft hood and shall be properly vented in accordance with Chapter 10. Appliances that use metal, asbestos, or ceramic material to direct radiation to the front of the appliance shall have a clearance of 36 in. (910 mm) in front and, if constructed with a double back of metal or ceramic, shall be installed with a minimum clearance of 18 in. (460 mm) at the sides and 12 in. (300 mm) at the rear.
(3) Panels, grilles, and access doors that are required to be removed for normal servicing operations shall not be attached to the building.
(4) Direct-vent gas fireplaces shall be installed with the vent-air intake terminal in the outdoors and in accordance with the manufacturers' instructions.

9.7.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 8.3.

9.8 Non-Recirculating Direct Gas-Fired Industrial Air Heaters.

9.8.1 Application. Direct gas-fired industrial air heaters of the non-recirculating type shall be listed in accordance with ANSI Z83.4/CSA 3.7, *Non-Recirculating Direct Gas-Fired Industrial Air Heaters.*

9.8.2 Prohibited Installations.

9.8.2.1 Non-recirculating direct gas-fired industrial air heaters shall not serve any area containing sleeping quarters.

9.8.2.2 Non-recirculating direct gas-fired industrial air heaters shall not recirculate room air.

9.8.3 Installation.

9.8.3.1 Non-recirculating direct gas-fired industrial air heaters shall be installed in accordance with the manufacturer's instructions.

9.8.3.2 Non-recirculating direct gas-fired industrial air heaters shall be installed only in industrial or commercial occupancies.

9.8.3.3 Non-recirculating direct gas-fired industrial air heaters shall be permitted to provide fresh air ventilation.

9.8.3.4 Non-recirculating direct gas-fired industrial air heaters shall be provided with access for removal of burners; replacement of motors, controls, filters and other working parts; and for adjustment and lubrication of parts requiring maintenance.

9.8.4 Clearance from Combustible Materials. Non-recirculating direct gas-fired industrial air heaters shall be installed with a clearance from combustible materials of not less than that shown on the rating plate and the manufacturer's instructions.

9.8.5 Air Supply. All air to the non-recirculating direct gas-fired industrial air heater shall be ducted directly from outdoors. Where outside air dampers or closing louvers are used, they shall be verified to be in the open position prior to main burner operation.

Table 9.6.2.3 Free Opening Area of Chimney Damper for Venting Flue Gases from Unlisted Decorative Appliances for Installation in Vented Fireplaces

Chimney Height (ft)	Minimum Permanent Free Opening ($in.^2$)*						
	8	13	20	29	39	51	64
	Appliance Input Rating (Btu/hr)						
6	7,800	14,000	23,200	34,000	46,400	62,400	80,000
8	8,400	15,200	25,200	37,000	50,400	68,000	86,000
10	9,000	16,800	27,600	40,400	55,800	74,400	96,400
15	9,800	18,200	30,200	44,600	62,400	84,000	108,800
20	10,600	20,200	32,600	50,400	68,400	94,000	122,200
30	11,200	21,600	36,600	55,200	76,800	105,800	138,600

For SI units, 1 ft = 0.305 m; 1 $in.^2$ = 645 mm^2; 1000 Btu/hr = 0.293 kW.

*The first six minimum permanent free openings (8 $in.^2$ to 51 $in.^2$) correspond approximately to the cross-sectional areas of chimneys having diameters of 3 in. through 8 in., respectively. The 64 $in.^2$ opening corresponds to the cross-sectional area of standard 8 in. × 8 in. chimney tile.

9.8.6 Atmospheric Vents or Gas Reliefs or Bleeds. Non-recirculating direct gas-fired industrial air heaters with valve train components equipped with atmospheric vents, gas reliefs, or bleeds shall have their vent lines, gas reliefs, or bleeds lead to a safe point outdoors. Means shall be employed on these lines to prevent water from entering and to prevent blockage from insects and foreign matter. An atmospheric vent line shall not be required to be provided on a valve train component equipped with a listed vent limiter.

9.8.7 Relief Openings. The design of the installation shall include adequate provisions to permit the non-recirculating direct gas-fired industrial air heater to operate at its rated airflow without over-pressurizing the space served by the heater by taking into account the structure's designed infiltration rate, properly designed relief openings, or an interlocked powered exhaust system, or a combination of these methods.

9.8.7.1 The structure's designed infiltration rate and the size of relief opening(s) shall be determined by approved engineering methods.

9.8.7.2 Louver or counterbalanced gravity damper relief openings shall be permitted. Where motorized dampers or closeable louvers are used they shall be proved to be in their open position prior to main burner operation.

9.8.8 Purging. Inlet ducting, when used, shall be purged with at least four air changes prior to an ignition attempt.

9.9 Recirculating Direct Gas-Fired Industrial Air Heaters.

9.9.1 Application. Direct gas-fired industrial air heaters of the recirculating type shall be listed in accordance with ANSI Z83.18, *Recirculating Direct Gas-Fired Industrial Air Heaters.*

9.9.2 Prohibited Installations.

9.9.2.1 Recirculating direct gas-fired industrial air heaters shall not serve any area containing sleeping quarters.

9.9.2.2* Recirculating direct gas-fired industrial air heaters shall not recirculate room air in buildings that contain flammable solids, liquids, or gases, explosive materials, or substances that can become toxic when exposed to flame or heat.

9.9.3 Installation. Installation of direct gas-fired industrial air heaters shall comply with the following requirements:

(1) Recirculating direct gas-fired industrial air heaters shall be installed in accordance with the manufacturer's instructions.
(2) Recirculating direct gas-fired industrial air heaters shall be installed only in industrial or commercial occupancies.
(3) Recirculating direct gas-fired industrial air heaters shall be permitted to provide fresh air ventilation only for the amount that exceeds the minimum ventilation air specified on the heater's rating plate to maintain the combustion level created by the heater in the space being served by the heater below 25 ppm for carbon monoxide, 3 ppm for nitrogen dioxide, and 5000 ppm for carbon dioxide. Where gas-powered fork trucks or other fossil fueled equipment are utilized in the conditioned space, additional ventilation requirements for the facility must be addressed separately.
(4) Recirculating direct gas-fired industrial air heaters shall be provided with access for removal of burners; replacement of motors, controls, filters, and other working parts; and for adjustment and lubrication of parts requiring maintenance.

9.9.4 Clearance from Combustible Materials. Recirculating direct gas-fired industrial air heaters shall be installed with a clearance from combustible materials of not less than that shown on the rating plate and the manufacturer's instructions.

9.9.5 Air Supply. Ventilation air to the recirculating direct gas-fired industrial air heater shall be ducted directly from outdoors. Air to the recirculating direct gas-fired industrial air heater in excess of the minimum ventilation air specified on the heater's rating plate shall be taken from the building, ducted directly from outdoors, or a combination of both. Where outside air dampers or closing louvers are used, they shall be verified to be in the open position prior to main burner operation.

9.9.6 Atmospheric Vents, Gas Reliefs, or Bleeds. Recirculating direct gas-fired industrial air heaters with valve train components equipped with atmospheric vents, gas reliefs, or bleeds shall have their vent lines, gas reliefs, or bleeds lead to a safe point outdoors. Means shall be employed on these lines to prevent water from entering and to prevent blockage from insects and foreign matter. An atmospheric vent line shall not be required to be provided on a valve train component equipped with a listed vent limiter.

9.9.7 Relief Openings. The design of the installation shall include adequate provisions to permit the recirculating direct gas-fired industrial air heater to operate at its rated airflow without over-pressurizing the space served by the heater by taking into account the structure's designed infiltration rate, properly designed relief openings, an interlocked powered exhaust system, or a combination of these methods.

9.9.7.1 The structure's designed infiltration rate and the size of relief opening(s) shall be determined by approved engineering methods.

9.9.7.2 Louver or counterbalanced gravity damper relief openings shall be permitted. Where motorized dampers or closeable louvers are used, they shall be proved to be in their open position prior to main burner operation.

9.9.8 Purging. Inlet ducting, when used, shall be purged with at least four air changes prior to an ignition attempt.

9.10 Duct Furnaces.

9.10.1 Clearances. The installation of duct furnaces shall comply with the following clearance requirements:

(1) Listed duct furnaces shall be installed with clearances of at least 6 in. (150 mm) between adjacent walls, ceilings, and floors of combustible material and the furnace draft hood. Furnaces listed for installation at lesser clearances shall be installed in accordance with their listings. In no case shall the clearance be such as to interfere with combustion air and accessibility. *(See 8.2.1 and Section 8.3.)*
(2) Unlisted duct furnaces shall be installed with clearances to combustible material in accordance with the clearances specified for unlisted furnaces and boilers in Table 9.2.3(a). Combustible floors under unlisted duct furnaces shall be protected in an approved manner.

9.10.2 Erection of Equipment. Duct furnaces shall be erected and firmly supported in accordance with the manufacturers' instructions.

9.10.3 Access Panels. The ducts connected to duct furnaces shall have removable access panels on both the upstream and downstream sides of the furnace.

9.10.4 Location of Draft Hood and Controls. The controls, combustion air inlet, and draft hoods for duct furnaces shall be located outside the ducts. The draft hood shall be located in the same enclosure from which combustion air is taken.

9.10.5 Circulating Air. Where a duct furnace is installed so that supply ducts carry air circulated by the furnace to areas outside the space containing the furnace, the return air shall also be handled by a duct(s) sealed to the furnace casing and terminating outside the space containing the furnace. The duct furnace shall be installed on the positive-pressure side of the circulating air blower.

9.10.6 Duct Furnaces Used with Refrigeration Systems.

9.10.6.1 A duct furnace shall not be installed in conjunction with a refrigeration coil where circulation of cooled air is provided by the blower.

Exception: Where the blower has sufficient capacity to overcome the external static resistance imposed by the duct system, furnace, and the cooling coil and the air throughput necessary for heating or cooling, whichever is greater.

9.10.6.2 Duct furnaces used in conjunction with cooling equipment shall be installed in parallel with or on the upstream side of cooling coils to avoid condensation within heating elements. With a parallel flow arrangement, the dampers or other means used to control the flow of air shall be sufficiently tight to prevent any circulation of cooled air through the unit.

Exception: Where the duct furnace has been specifically listed for downstream installation.

9.10.6.3 Where duct furnaces are to be located upstream from cooling units, the cooling unit shall be so designed or equipped as to not develop excessive temperatures or pressures.

9.10.6.4 Where a duct furnace is installed downstream of an evaporative cooler or air washer, the heat exchanger shall be constructed of corrosion-resistant materials. Stainless steel, ceramic-coated steel, and an aluminum-coated steel in which the bond between the steel and the aluminum is an iron–aluminum alloy are considered to be corrosion resistant. Air washers operating with chilled water that deliver air below the dew point of the ambient air at the equipment are considered as refrigeration systems.

9.10.7 Installation in Commercial Garages and Aircraft Hangars. Duct furnaces installed in garages for more than three motor vehicles or in aircraft hangars shall be of a listed type and shall be installed in accordance with 8.1.11 and 8.1.12.

9.11 Floor Furnaces.

9.11.1 Installation. The installation of floor furnaces shall comply with the following requirements:

(1) Listed floor furnaces shall be installed in accordance with their listing and the manufacturers' instructions.
(2) Unlisted floor furnaces shall not be installed in combustible floors.
(3) Thermostats controlling floor furnaces shall not be located in a room or space that can be separated from the room or space in which the register of the floor furnace is located.

9.11.2 Temperature Limit Controls.

9.11.2.1 Listed automatically operated floor furnaces shall be equipped with temperature limit controls in accordance with the terms of their listing.

9.11.2.2 Unlisted automatically operated floor furnaces shall be equipped with a temperature limit control arranged to shut off the flow of gas to the burner in the event the temperature at the warm air outlet register exceeds 350°F (177°C) above room temperature.

9.11.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 8.3.

9.11.4 Placement. The following provisions apply to furnaces that serve one story:

(1) *Floors.* Floor furnaces shall not be installed in the floor of any doorway, stairway landing, aisle, or passageway of any enclosure, public or private, or in an exitway from any such room or space.
(2) *Walls and Corners.* The register of a floor furnace with a horizontal warm air outlet shall not be placed closer than 6 in. (150 mm) from the nearest wall. A distance of at least 18 in. (460 mm) from two adjoining sides of the floor furnace register to walls shall be provided to eliminate the necessity of occupants walking over the warm air discharge. The remaining sides shall be a minimum of 6 in. (150 mm) from a wall. Wall register models shall not be placed closer than 6 in. (150 mm) to a corner.
(3) *Draperies.* The furnace shall be placed so that a door, drapery, or similar object cannot be nearer than 12 in. (300 mm) to any portion of the register of the furnace.

9.11.5 Bracing. The space provided for the furnace shall be framed with doubled joists and with headers not lighter than the joists.

9.11.6 Support. Means shall be provided to support the furnace when the floor register is removed.

9.11.7 Clearance. The lowest portion of the floor furnace shall have at least a 6 in. (150 mm) clearance from the general ground level. A reduced clearance to a minimum of 2 in. (50 mm) is permitted provided the lower 6 in. (150 mm) portion of the floor furnace is sealed by the manufacturer to prevent entrance of water. Where these clearances are not present, the ground below and to the sides shall be excavated to form a "basin-like" pit under the furnace so that the required clearance is provided beneath the lowest portion of the furnace. A 12 in. (300 mm) clearance shall be provided on all sides except the control side, which shall have an 18 in. (460 mm) clearance.

9.11.8 Access. The space in which any floor furnace is installed shall be accessible by an opening in the foundation not less than 24 in. × 18 in. (610 mm × 460 mm) or by a trapdoor not less than 24 in. × 24 in. (610 mm × 610 mm) in any cross-section thereof, and a passageway not less than 24 in. × 18 in. (610 mm × 460 mm) in any cross-section thereof.

9.11.9 Seepage Pan. Where the excavation exceeds 12 in. (300 mm) in depth or water seepage is likely to collect, a watertight copper pan, concrete pit, or other suitable material shall be used, unless adequate drainage is provided or the equipment is sealed by the manufacturer to meet this condition. A copper pan shall be made of not less than 16 oz/ft^2 (4.9 kg/m^2) sheet copper. The pan shall be anchored in place so as to prevent floating, and the walls shall extend at least 4 in. (100 mm) above the ground level with at least 6 in. (150 mm) clearance on all sides, except the control side, which shall have at least 18 in. (460 mm) clearance.

9.11.10 Wind Protection. Floor furnaces shall be protected, where necessary, against severe wind conditions.

9.11.11 Upper Floor Installations. Listed floor furnaces shall be permitted to be installed in an upper floor, provided the furnace assembly projects below into a utility room, closet, garage, or similar nonhabitable space. In such installations, the floor furnace shall be enclosed completely (entirely separated from the nonhabitable space) with means for air intake to meet the provisions of Section 8.3, with access for servicing, the minimum furnace clearances of 6 in. (150 mm) to all sides and bottom, and with the enclosure constructed of portland cement plaster or metal lath or other noncombustible material.

9.11.12 First Floor Installation. Listed floor furnaces installed in the first or ground floors of buildings shall not be required to be enclosed unless the basements of these buildings have been converted to apartments or sleeping quarters, in which case the floor furnace shall be enclosed as specified for upper floor installations and shall project into a nonhabitable space.

9.12 Food Service Equipment, Floor-Mounted.

9.12.1 Clearance for Listed Equipment. Listed floor-mounted food service equipment, such as ranges for hotels and restaurants, deep fat fryers, unit broilers, gas-fired kettles, steam cookers, steam generators, and baking and roasting ovens, shall be installed at least 6 in. (150 mm) from combustible material except that at least a 2 in. (50 mm) clearance shall be maintained between a draft hood and combustible material. Floor-mounted food service equipment listed for installation at lesser clearances shall be installed in accordance with its listing and the manufacturer's instructions. Equipment designed and marked "For use only in noncombustible locations" shall not be installed elsewhere.

9.12.2 Clearance for Unlisted Equipment. Unlisted floor-mounted food service equipment shall be installed to provide a clearance to combustible material of not less than 18 in. (460 mm) from the sides and rear of the equipment and from the vent connector and not less than 48 in. (1.2 m) above cooking tops and at the front of the equipment. Clearances for unlisted equipment installed in partially enclosed areas such as alcoves shall not be reduced. Reduced clearances for unlisted equipment installed in rooms that are not partially enclosed shall be in accordance with Table 9.2.3(b).

9.12.3 Mounting on Combustible Floor.

9.12.3.1 Listed floor-mounted food service equipment that is listed specifically for installation on floors constructed of combustible material shall be permitted to be mounted on combustible floors in accordance with its listing and the manufacturer's instructions.

9.12.3.2 Floor-mounted food service equipment that is not listed for mounting on a combustible floor shall be mounted in accordance with 9.12.4 or be mounted in accordance with one of the following:

(1) Where the equipment is set on legs that provide not less than 18 in. (460 mm) open space under the base of the equipment or where it has no burners and no portion of any oven or broiler within 18 in. (460 mm) of the floor, it shall be permitted to be mounted on a combustible floor without special floor protection, provided there is at least one sheet metal baffle between the burner and the floor.
(2) Where the equipment is set on legs that provide not less than 8 in. (200 mm) open space under the base of the equipment, it shall be permitted to be mounted on combustible floors, provided the floor under the equipment is protected with not less than ⅜ in. (9.5 mm) insulating millboard covered with sheet metal not less than 0.0195 in. (0.5 mm) thick. The preceding specified floor protection shall extend not less than 6 in. (150 mm) beyond the equipment on all sides.
(3) Where the equipment is set on legs that provide not less than 4 in. (100 mm) under the base of the equipment, it shall be permitted to be mounted on combustible floors, provided the floor under the equipment is protected with hollow masonry not less than 4 in. (100 mm) in thickness covered with sheet metal not less than 0.0195 in. (0.5 mm) thick. Such masonry courses shall be laid with ends unsealed and joints matched in such a way as to provide for free circulation of air through the masonry.
(4) Where the equipment does not have legs at least 4 in. (100 mm) high, it shall be permitted to be mounted on combustible floors, provided the floor under the equipment is protected by two courses of 4 in. (100 mm) hollow clay tile, or equivalent, with courses laid at right angles and with ends unsealed and joints matched in such a way as to provide for free circulation of air through such masonry courses, and covered with steel plate not less than 3/16 in. (4.8 mm) in thickness.

9.12.4 Mounting on Noncombustible Floor. Listed floor-mounted food service equipment that is designed and marked "For use only in noncombustible locations" shall be mounted on floors of noncombustible construction with noncombustible flooring and surface finish and with no combustible material against the underside thereof, or on noncombustible slabs or arches having no combustible material against the underside thereof. Such construction shall in all cases extend not less than 12 in. (300 mm) beyond the equipment on all sides.

9.12.5 Combustible Material Adjacent to Cooking Top. Any portion of combustible material adjacent to a cooking top section of a food service range, even though listed for close-to-wall installation, that is not shielded from the wall by a high shelf, warming closet, and so on, shall be protected as specified in 9.12.2 for a distance of at least 2 ft (0.6 m) above the surface of the cooking top.

9.12.6 For Use with Casters. Floor-mounted equipment with casters shall be listed for such construction and shall be installed in accordance with their listing and the accompanying instructions for limiting the movement of the equipment to prevent strain on the connection.

9.12.7 Level Installation. Floor-mounted food service equipment shall be installed level on a firm foundation.

9.12.8* Ventilation. Means shall be provided to properly ventilate the space in which food service equipment is installed to permit proper combustion of the gas.

9.13 Food Service Equipment Counter Appliances.

9.13.1 Vertical Clearance. A vertical distance of not less than 48 in. (1.2 m) shall be provided between the top of all food service hot plates and griddles and combustible material.

9.13.2 Clearance for Listed Appliances. Listed food service counter appliances such as hot plates and griddles, food and dish warmers, and coffee brewers and urns, where installed on combustible surfaces, shall be set on their own bases or legs and shall be installed with a minimum horizontal clearance of 6 in. (150 mm) from combustible material, except that at least a 2 in. (50 mm) clearance shall be maintained between a draft

hood and combustible material. Food service counter appliances listed for installation at lesser clearances shall be installed in accordance with their listing and the manufacturers' instructions.

9.13.3 Clearance for Unlisted Appliances. Unlisted food service hot plates and griddles shall be installed with a horizontal clearance from combustible material of not less than 18 in. (460 mm). Unlisted gas food service counter appliances, including coffee brewers and urns, waffle bakers, and hot water immersion sterilizers, shall be installed with a horizontal clearance from combustible material of not less than 12 in. (300 mm). Reduced clearances for gas food service counter appliances shall be in accordance with Table 9.2.3(b). Unlisted food and dish warmers shall be installed with a horizontal clearance from combustible material of not less than 6 in. (150 mm).

9.13.4 Mounting of Unlisted Appliances. Unlisted food service counter appliances shall not be set on combustible material unless they have legs that provide not less than 4 in. (100 mm) of open space below the burners and the combustible surface is protected with insulating millboard at least ¼ in. (6 mm) thick covered with sheet metal not less than 0.0122 in. (0.3 mm) thick, or with equivalent protection.

9.14 Hot Plates and Laundry Stoves.

9.14.1 Listed domestic hot plates and laundry stoves installed on combustible surfaces shall be set on their own legs or bases. They shall be installed with minimum horizontal clearances of 6 in. (150 mm) from combustible material.

9.14.2 Unlisted domestic hot plates and laundry stoves shall be installed with horizontal clearances to combustible material of not less than 12 in. (300 mm). Combustible surfaces under unlisted domestic hot plates and laundry stoves shall be protected in an approved manner.

9.14.3 The vertical distance between tops of all domestic hot plates and laundry stoves and combustible material shall be at least 30 in. (760 mm).

9.15 Household Cooking Appliances.

9.15.1 Floor-Mounted Units.

9.15.1.1 Clearance from Combustible Material. The clearances specified as follows shall not interfere with combustion air, accessibility for operation, and servicing:

(1) Listed floor-mounted household cooking appliances, where installed on combustible floors, shall be set on their own bases or legs and shall be installed in accordance with their listing and the manufacturers' instructions.
(2) Listed household cooking appliances with listed gas room heater sections shall be installed so that the warm air discharge side shall have a minimum clearance of 18 in. (460 mm) from adjacent combustible material. A minimum clearance of 36 in. (910 mm) shall be provided between the top of the heater section and the bottom of cabinets.
(3) Listed household cooking appliances that include a solid or liquid fuel-burning section shall be spaced from combustible material and otherwise installed in accordance with the standards applying to the supplementary fuel section of the appliance.
(4) Unlisted floor-mounted household cooking appliances shall be installed with at least a 6 in. (150 mm) clearance at the back and sides to combustible material. Combustible floors under unlisted appliances shall be protected in an approved manner.

9.15.1.2 Vertical Clearance Above Cooking Top. Household cooking appliances shall have a vertical clearance above the cooking top of not less than 30 in. (760 mm) to combustible material or metal cabinets. A minimum clearance of 24 in. (610 mm) is permitted when one of the following is installed:

(1) The underside of the combustible material or metal cabinet above the cooking top is protected with not less than ¼ in. (6 mm) insulating millboard covered with sheet metal not less than 0.0122 in. (0.3 mm) thick.
(2) A metal ventilating hood of sheet metal not less than 0.0122 in. (0.3 mm) thick is installed above the cooking top with a clearance of not less than ¼ in. (6 mm) between the hood and the underside of the combustible material or metal cabinet, and the hood is at least as wide as the appliance and is centered over the appliance.
(3) A listed cooking appliance or microwave oven is installed over a listed cooking appliance and will conform to the terms of the upper appliance's listing and the manufacturer's instructions.

9.15.1.3 Level Installation. Cooking appliances shall be installed so that the cooking top or oven racks are level.

9.15.2 Built-In Units.

9.15.2.1 Installation. Listed built-in household cooking appliances shall be installed in accordance with their listing and the manufacturer's instructions. The installation shall not interfere with combustion air, accessibility for operation, and servicing. Unlisted built-in household cooking appliances shall not be installed in, or adjacent to, combustible material.

9.15.2.2 Vertical Clearance. Built-in top (or surface) cooking appliances shall have a vertical clearance above the cooking top of not less than 30 in. (760 mm) to combustible material or metal cabinets. A minimum clearance of 24 in. (610 mm) is permitted when one of the following is installed:

(1) The underside of the combustible material or metal cabinet above the cooking top is protected with not less than ¼ in. (6 mm) insulating millboard covered with sheet metal not less than 0.0122 in. (0.3 mm) thick.
(2) A metal ventilating hood of sheet metal not less than 0.0122 in. (0.3 mm) thick is installed above the cooking top with a clearance of not less than ¼ in. (6 mm) between the hood and the underside of the combustible material or metal cabinet, and the hood is at least as wide as the appliance and is centered over the appliance.
(3) A listed cooking appliance or microwave oven is installed over a listed cooking appliance and will conform to the terms of the upper appliance's listing and the manufacturer's instructions.

9.15.2.3 Horizontal Clearance. The minimum horizontal distance from the center of the burner head(s) of a listed top (or surface) cooking appliance to vertical combustible walls extending above the top panel shall be not less than that distance specified by the permanent marking on the appliance.

9.15.2.4 Level Installation. Built-in household cooking appliances shall be installed so that the cooking top, broiler pan, or oven racks are level.

9.16 Illuminating Appliances.

9.16.1 Clearances for Listed Appliances. Listed illuminating appliances shall be installed in accordance with their listing and the manufacturers' instructions.

9.16.2 Clearances for Unlisted Appliances.

9.16.2.1 Enclosed Type. Clearance shall comply with the following:

(1) Unlisted enclosed illuminating appliances installed outdoors shall be installed with clearances in any direction from combustible material of not less than 12 in. (300 mm).
(2) Unlisted enclosed illuminating appliances installed indoors shall be installed with clearances in any direction from combustible material of not less than 18 in. (460 mm).

9.16.2.2 Open-Flame Type. Clearance shall comply with the following:

(1) Unlisted open-flame illuminating appliances installed outdoors shall have clearances from combustible material not less than that specified in Table 9.16.2.2. The distance from ground level to the base of the burner shall be a minimum of 7 ft (2.1 m) where installed within 2 ft (0.6 m) of walkways. Lesser clearances shall be permitted to be used where acceptable to the authority having jurisdiction.
(2) Unlisted open-flame illuminating appliances installed outdoors shall be equipped with a limiting orifice or other limiting devices that will maintain a flame height consistent with the clearance from combustible material, as given in Table 9.16.2.2.
(3) Appliances designed for flame heights in excess of 30 in. (760 mm) shall be permitted to be installed if acceptable to the authority having jurisdiction. Such appliances shall be equipped with a safety shutoff device or automatic ignition.
(4) Unlisted open-flame illuminating appliances installed indoors shall have clearances from combustible material acceptable to the authority having jurisdiction.

Table 9.16.2.2 Clearances for Unlisted Outdoor Open-Flame Illuminating Appliances

Flame Height Above Burner Head (in.)	Minimum Clearance from Combustible Material (ft)*	
	Horizontal	Vertical
12	2	6
18	3	8
24	3	10
30	4	12

For SI units, 1 in. = 25.4 mm; 1 ft = 0.305 m.
*Measured from the nearest portion of the burner head.

9.16.3 Mounting on Buildings. Illuminating appliances designed for wall or ceiling mounting shall be securely attached to substantial structures in such a manner that they are not dependent on the gas piping for support.

9.16.4 Mounting on Posts. Illuminating appliances designed for post mounting shall be securely and rigidly attached to a post. Posts shall be rigidly mounted. The strength and rigidity of posts greater than 3 ft (0.9 m) in height shall be at least equivalent to that of a 2½ in. (64 mm) diameter post constructed of 0.064 in. (1.6 mm) thick steel or a 1 in. Schedule 40 steel pipe. Posts 3 ft (0.9 m) or less in height shall not be smaller than a ¾ in. Schedule 40 steel pipe. Drain openings shall be provided near the base of posts where there is a possibility of water collecting inside them.

9.16.5 Gas Appliance Pressure Regulators. Where a gas appliance pressure regulator is not supplied with an illuminating appliance and the service line is not equipped with a service pressure regulator, an appliance pressure regulator shall be installed in the line serving one or more illuminating appliances.

9.17 Incinerators, Commercial-Industrial. Commercial-industrial-type incinerators shall be constructed and installed in accordance with NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment.*

9.18 Infrared Heaters.

9.18.1 Support. Suspended-type infrared heaters shall be fixed in position independent of gas and electric supply lines. Hangers and brackets shall be of noncombustible material. Heaters subject to vibration shall be provided with vibration-isolating hangers.

9.18.2 Clearance. The installation of infrared heaters shall meet the following clearance requirements:

(1) Listed heaters shall be installed with clearances from combustible material in accordance with their listing and the manufacturers' instructions.
(2) Unlisted heaters shall be installed in accordance with clearances from combustible material acceptable to the authority having jurisdiction.
(3) In locations used for the storage of combustible materials, signs shall be posted to specify the maximum permissible stacking height to maintain required clearances from the heater to the combustibles.

9.18.3 Combustion and Ventilation Air.

9.18.3.1 Where unvented infrared heaters are used, natural or mechanical means shall be provided to supply and exhaust at least 4 ft^3/min/1000 Btu/hr (0.38 m^3/min/kW) input of installed heaters.

9.18.3.2 Exhaust openings for removing flue products shall be above the level of the heaters.

9.18.4 Installation in Commercial Garages and Aircraft Hangars. Overhead heaters installed in garages for more than three motor vehicles or in aircraft hangars shall be of a listed type and shall be installed in accordance with 8.1.11 and 8.1.12.

9.19 Open-Top Broiler Units.

9.19.1 Listed Units. Listed open-top broiler units shall be installed in accordance with their listing and the manufacturers' instructions.

9.19.2 Unlisted Units. Unlisted open-top broiler units shall be installed in accordance with the manufacturers' instructions but shall not be installed in combustible material.

9.19.3 Protection Above Domestic Units. Domestic open-top broiler units shall be provided with a metal ventilating hood not less than 0.0122 in. (0.3 mm) thick with a clearance of not less than ¼ in. (6 mm) between the hood and the underside of combustible material or metal cabinets. A clearance of at least 24 in. (610 mm) shall be maintained between the cooking top and the combustible material or metal cabinet, and the hood shall be at least as wide as the open-top broiler unit and cen-

tered over the unit. Listed domestic open-top broiler units incorporating an integral exhaust system and listed for use without a ventilating hood need not be provided with a ventilating hood if installed in accordance with 9.15.1.2(1).

9.19.4 Commercial Units. Commercial open-top broiler units shall be provided with ventilation in accordance with NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.*

9.20 Outdoor Cooking Appliances.

9.20.1 Listed Units. Listed outdoor cooking appliances shall be installed in accordance with their listing and the manufacturers' instructions.

9.20.2 Unlisted Units. Unlisted outdoor cooking appliances shall be installed outdoors with clearances to combustible material of not less than 36 in. (910 mm) at the sides and back and not less than 48 in. (1220 mm) at the front. In no case shall the appliance be located under overhead combustible construction.

9.21 Pool Heaters.

9.21.1 Location. A pool heater shall be located or protected so as to minimize accidental contact of hot surfaces by persons.

9.21.2 Clearance. The installation of pool heaters shall meet the following requirements:

(1) In no case shall the clearances be such as to interfere with combustion air, draft hood or vent terminal clearance and relief, and accessibility for servicing.
(2) A listed pool heater shall be installed in accordance with its listing and the manufacturer's instructions.
(3) An unlisted pool heater shall be installed with a minimum clearance of 12 in. (300 mm) on all sides and the rear. A combustible floor under an unlisted pool heater shall be protected in an approved manner.

9.21.3 Temperature- or Pressure-Limiting Devices.

9.21.3.1 An unlisted pool heater shall be provided with overtemperature protection or overtemperature and overpressure protection by means of an approved device(s).

9.21.3.2 Where a pool heater is provided with overtemperature protection only and is installed with any device in the discharge line of the heater that can restrict the flow of water from the heater to the pool (such as a check valve, shutoff valve, therapeutic pool valving, or flow nozzles), a pressure relief valve shall be installed either in the heater or between the heater and the restrictive device.

9.21.4 Bypass Valves. Where an integral bypass system is not provided as a part of the pool heater, a bypass line and valve shall be installed between the inlet and outlet piping for use in adjusting the flow of water through the heater.

9.21.5 Venting. A pool heater listed for outdoor installation shall be installed with the venting means supplied by the manufacturer and in accordance with the manufacturer's instructions. *(See 10.2.5, 10.2.6, 10.3.4, and Section 10.8.)*

9.22 Refrigerators.

9.22.1 Clearance. Refrigerators shall be provided with clearances for ventilation at the top and back in accordance with the manufacturers' instructions. Where such instructions are not available, at least 2 in. (50 mm) shall be provided between the back of the refrigerator and the wall and at least 12 in. (300 mm) above the top.

9.22.2 Venting or Ventilating Kits Approved for Use with a Refrigerator. Where an accessory kit is used for conveying air for burner combustion or unit cooling to the refrigerator from areas outside the room in which it is located, or for conveying combustion products diluted with air-containing waste heat from the refrigerator to areas outside the room in which it is located, the kit shall be installed in accordance with the refrigerator manufacturer's instructions.

9.23 Room Heaters.

9.23.1* Prohibited Installations. Unvented room heaters shall not be installed in bathrooms or bedrooms.

Exception No. 1: Where approved by the authority having jurisdiction, one listed wall-mounted unvented room heater equipped with an oxygen depletion safety shutoff system shall be permitted to be installed in a bathroom provided that the input rating shall not exceed 6000 Btu/hr (1760 W/hr) and combustion and ventilation air is provided as specified in 9.1.2.

Exception No. 2: Where approved by the authority having jurisdiction, one listed wall-mounted unvented room heater equipped with an oxygen depletion safety shutoff system shall be permitted to be installed in a bedroom provided that the input rating shall not exceed 10,000 Btu/hr (2930 W/hr) and combustion and ventilation air is provided as specified in 9.1.2.

9.23.2 Installations in Institutions. Room heaters shall not be installed in the following occupancies:

(1) Residential board and care
(2) Health care

9.23.3 Clearance. A room heater shall be placed so as not to cause a hazard to walls, floors, curtains, furniture, doors when open, and so on, and to the free movements of persons within the room. Heaters designed and marked "For use in noncombustible fireplace only" shall not be installed elsewhere. Listed room heaters shall be installed in accordance with their listings and the manufacturers' instructions. In no case shall the clearances be such as to interfere with combustion air and accessibility. Unlisted room heaters shall be installed with clearances from combustible material not less than the following:

(1) *Circulating Type.* Room heaters having an outer jacket surrounding the combustion chamber, arranged with openings at top and bottom so that air circulates between the inner and outer jacket, and without openings in the outer jacket to permit direct radiation, shall have clearance at sides and rear of not less than 12 in. (300 mm).
(2) *Radiating Type.* Room heaters other than those of the circulating type described in 9.23.3(1) shall have clearance at sides and rear of not less than 18 in. (460 mm), except that heaters that make use of metal, asbestos, or ceramic material to direct radiation to the front of the heater shall have a clearance of 36 in. (910 mm) in front and, if constructed with a double back of metal or ceramic, shall be permitted to be installed with a clearance of 18 in. (460 mm) at sides and 12 in. (300 mm) at rear. Combustible floors under unlisted room heaters shall be protected in an approved manner.

9.23.4 Wall-Type Room Heaters. Wall-type room heaters shall not be installed in or attached to walls of combustible material unless listed for such installation.

9.24 Stationary Gas Engines. The installation of gas engines shall conform with NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.*

9.25 Gas-Fired Toilets.

9.25.1 Clearance. A listed gas-fired toilet shall be installed in accordance with its listing and the manufacturer's instructions, provided that the clearance shall in any case be sufficient to afford ready accessibility for use, cleanout, and necessary servicing.

9.25.2 Mounting. Listed gas-fired toilets installed on combustible floors shall be listed for such installation.

9.25.3 Installation. Vents or vent connectors that are capable of being contacted during casual use of the room in which the toilet is installed shall be protected or shielded to prevent such contact.

9.26 Unit Heaters.

9.26.1 Support. Suspended-type unit heaters shall be safely and adequately supported with due consideration given to their weight and vibration characteristics. Hangers and brackets shall be of noncombustible material.

9.26.2 Clearance.

9.26.2.1 Suspended-Type Unit Heaters. Suspended-type unit heaters shall meet the following requirements:

(1) A listed unit heater shall be installed with clearances from combustible material of not less than 18 in. (460 mm) at the sides, 12 in. (300 mm) at the bottom, and 6 in. (150 mm) above the top where the unit heater has an internal draft hood, or 1 in. (25 mm) above the top of the sloping side of a vertical draft hood. A unit heater listed for reduced clearances shall be installed in accordance with its listing and the manufacturer's instructions.
(2) Unlisted unit heaters shall be installed with clearances to combustible material of not less than 18 in. (460 mm).
(3) Clearances for servicing shall be in accordance with the manufacturers' recommendations contained in the installation instructions.

9.26.2.2 Floor-Mounted-Type Unit Heaters. Floor-mounted-type unit heaters shall meet the following requirements:

(1) A listed unit heater shall be installed with clearances from combustible material at the back and one side only of not less than 6 in. (150 mm). Where the flue gases are vented horizontally, the 6 in. (150 mm) clearance shall be measured from the draft hood or vent instead of the rear wall of the unit heater. A unit heater listed for reduced clearances shall be installed in accordance with its listing and the manufacturer's instructions.
(2) Floor-mounted-type unit heaters installed on combustible floors shall be listed for such installation.
(3) Combustible floors under unlisted floor-mounted unit heaters shall be protected in an approved manner.
(4) Clearances for servicing shall be in accordance with the manufacturers' recommendations contained in the installation instructions.

9.26.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 8.3.

9.26.4 Ductwork. A unit heater shall not be attached to a warm air duct system unless listed and marked for such installation.

9.26.5 Installation in Commercial Garages and Aircraft Hangars. Unit heaters installed in garages for more than three motor vehicles or in aircraft hangars shall be of a listed type and shall be installed in accordance with 8.1.11 and 8.1.12.

9.27 Wall Furnaces.

9.27.1 Installation.

9.27.1.1 Listed wall furnaces shall be installed in accordance with their listing and the manufacturers' instructions. Wall furnaces installed in or attached to combustible material shall be listed for such installation.

9.27.1.2 Unlisted wall furnaces shall not be installed in or attached to combustible material.

9.27.1.3 Vented wall furnaces connected to a Type B-W gas vent system listed only for a single story shall be installed only in single-story buildings or the top story of multistory buildings. Vented wall furnaces connected to a Type B-W gas vent system listed for installation in multistory buildings shall be permitted to be installed in single-story or multistory buildings. Type B-W gas vents shall be attached directly to a solid header plate that serves as a firestop at that point and that shall be permitted to be an integral part of the vented wall furnace. The stud space in which the vented wall furnace is installed shall be ventilated at the first ceiling level by installation of the ceiling plate spacers furnished with the gas vent. Firestop spacers shall be installed at each subsequent ceiling or floor level penetrated by the vent. *(See Figure 9.27.1.3 for Type B-W gas vent installation.)*

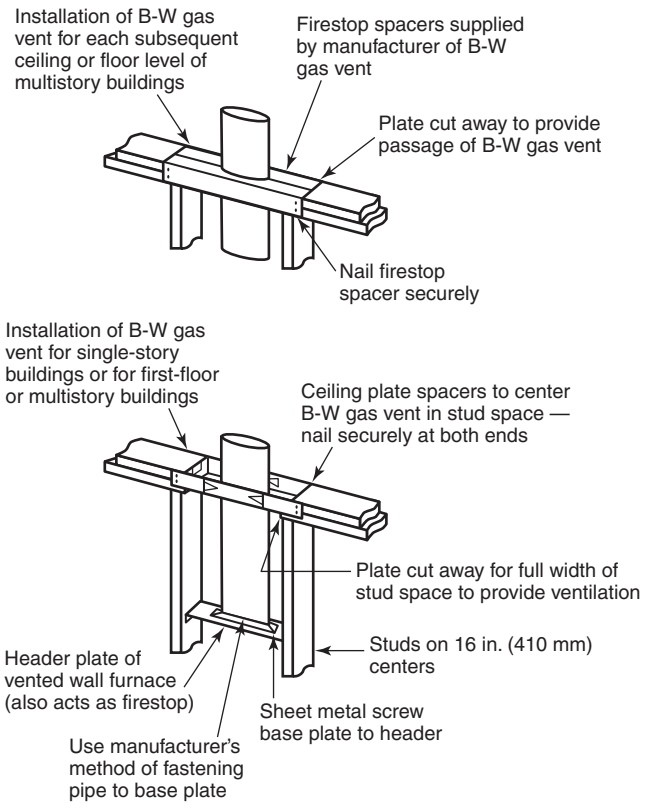


FIGURE 9.27.1.3 Installation of Type B-W Gas Vents for Vented Wall Furnaces.

9.27.1.4 Direct-vent wall furnaces shall be installed with the vent-air intake terminal in the outside atmosphere. The thickness of the walls on which the furnace is mounted shall be within the range of wall thickness marked on the furnace and covered in the manufacturers' installation instructions.

9.27.1.5 Panels, grilles, and access doors that are required to be removed for normal servicing operations shall not be attached to the building. *(For additional information on the venting of wall furnaces, see Chapter 10.)*

9.27.2 Location. Wall furnaces shall be located so as not to cause a hazard to walls, floors, curtains, furniture, or doors. Wall furnaces installed between bathrooms and adjoining rooms shall not circulate air from bathrooms to other parts of the building.

9.27.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 8.3.

9.28 Water Heaters.

9.28.1 Location.

9.28.1.1 Water heater installations in bedrooms and bathrooms shall comply with one of the following:

(1) Water heater shall be installed in a closet equipped with a weather-stripped door with a self-closing device, and all combustion air shall be obtained from the outdoors in accordance with 8.3.3.
(2) Water heater shall be of the direct-vent type.

9.28.1.2 Water heaters of other than the direct-vent type shall be located as close as practical to the chimney or gas vent.

9.28.2 Clearance.

9.28.2.1 The clearances shall not be such as to interfere with combustion air, draft hood clearance and relief, and accessibility for servicing. Listed water heaters shall be installed in accordance with their listing and the manufacturers' instructions.

9.28.2.2 Unlisted water heaters shall be installed with a clearance of 12 in. (300 mm) on all sides and rear. Combustible floors under unlisted water heaters shall be protected in an approved manner.

9.28.3 Pressure-Limiting Devices. A water heater installation shall be provided with overpressure protection by means of an approved, listed device installed in accordance with the terms of its listing and the manufacturer's instructions. The pressure setting of the device shall exceed the water service pressure and shall not exceed the maximum pressure rating of the water heater.

9.28.4 Temperature-Limiting Devices. A water heater installation or a hot water storage vessel installation shall be provided with overtemperature protection by means of an approved, listed device installed in accordance with the terms of its listing and the manufacturers' instructions.

9.28.5 Temperature, Pressure, and Vacuum Relief Devices. The installation of temperature, pressure, and vacuum relief devices or combinations thereof, and automatic gas shutoff devices, shall be in accordance with the terms of their listing and the manufacturers' instructions. A shutoff valve shall not be placed between the relief valve and the water heater or on discharge pipes between such valves and the atmosphere. The hourly Btu discharge capacity or the rated steam relief capacity of the device shall not be less than the input rating of the water heater.

9.28.6 Automatic Instantaneous Type: Cold Water Supply. The water supply to an automatic instantaneous water heater that is equipped with a water flow–actuated control shall be such as to provide sufficient pressure to properly operate the control when water is drawn from the highest faucet served by the heater.

9.28.7 Circulating Tank Types.

9.28.7.1 Connection to Tank. The method of connecting the circulating water heater to the tank shall provide proper circulation of water through the heater and permit a safe and useful temperature of water to be drawn from the tank. *(See Figure 9.28.7.1.)*

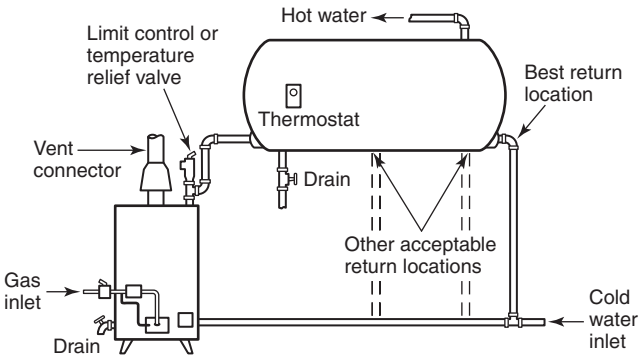


FIGURE 9.28.7.1 Typical Gravity Circulating Tank-Type Installation.

9.28.7.2 Size of Water Circulating Piping. The size of the water circulating piping shall conform with the size of the water connections of the heater.

9.28.7.3 Sediment Drain. A suitable water valve or cock, through which sediment can be drawn off or the tank emptied, shall be installed at the bottom of the tank.

9.28.8* Antisiphon Devices. Means acceptable to the authority having jurisdiction shall be provided to prevent siphoning in any water heater or any tank to which a circulating water heater that incorporates a cold water inlet tube is attached.

9.29 Compressed Natural Gas (CNG) Vehicular Fuel Systems. The installation of compressed natural gas (CNG) fueling (dispensing) systems shall conform with NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems Code.*

9.30 Appliances for Installation in Manufactured Housing. Appliances installed in manufactured housing after the initial sale shall be listed for installation in manufactured housing, or approved, and shall be installed in accordance with the requirements of this code and the manufacturers' installation instructions. Appliances installed in the living space of manufactured housing shall be in accordance with the requirements of Section 8.3.

9.31 Fuel Cell Power Plants. Fuel cell power plants with a power output of less than 50 kW shall be listed and installed in accordance with the manufacturer's instructions. Fuel cell power plants with a power output of greater than 50 kW shall be installed in accordance with NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Plants.*

Chapter 10 Venting of Equipment

10.1 General. This chapter recognizes that the choice of venting materials and the methods of installation of venting systems are dependent on the operating characteristics of the gas utilization equipment. The operating characteristics of vented gas utilization equipment can be categorized with respect to (1) positive or negative pressure within the venting system and (2) whether or not the equipment generates flue or vent gases that can condense in the venting system. See Section 3.3 for the definition of these vented appliance categories.

10.2 Specification for Venting.

10.2.1 Connection to Venting Systems. Except as permitted in 10.2.2 through 10.2.6, all gas utilization equipment shall be connected to venting systems.

10.2.2 Equipment Not Required to Be Vented. The following equipment shall not be required to be vented:

(1) Listed ranges
(2) Built-in domestic cooking units listed and marked for optional venting
(3) Listed hot plates and listed laundry stoves
(4) Listed Type 1 clothes dryers exhausted in accordance with Section 9.4
(5) A single listed booster-type (automatic instantaneous) water heater, when designed and used solely for the sanitizing rinse requirements of a dishwashing machine, provided that the equipment is installed, with the draft hood in place and unaltered, if a draft hood is required, in a commercial kitchen having a mechanical exhaust system; where installed in this manner, the draft hood outlet shall not be less than 36 in. (910 mm) vertically and 6 in. (150 mm) horizontally from any surface other than the equipment.
(6) Listed refrigerators
(7) Counter appliances
(8) Room heaters listed for unvented use *(see 9.23.1 and 9.23.2)*
(9) Direct gas-fired make-up air heaters
(10) Other equipment listed for unvented use and not provided with flue collars
(11) Specialized equipment of limited input such as laboratory burners or gas lights. Where any or all of the equipment in 10.2.2(5) through (11) is installed so the aggregate input rating exceeds 20 Btu/hr/ft^3 (207 W/m^3) of room or space in which it is installed, one or more shall be provided with venting systems or other approved means for removing the vent gases to the outside atmosphere so the aggregate input rating of the remaining unvented equipment does not exceed 20 Btu/hr/ft^3 (207 W/m^3). Where the calculation includes the volume of an adjacent room or space, the room or space in which the equipment is installed shall be directly connected to the adjacent room or space by a doorway, archway, or other opening of comparable size that cannot be closed.

10.2.3* Ventilating Hoods. Ventilating hoods and exhaust systems shall be permitted to be used to vent gas utilization equipment installed in commercial applications *(see 10.3.5)* and to vent industrial equipment, particularly where the process itself requires fume disposal. *(See 8.1.6 and 8.1.9.)*

10.2.4 Well-Ventilated Spaces. The operation of industrial gas utilization equipment such that its flue gases are discharged directly into a large and well-ventilated space shall be permitted.

10.2.5 Direct-Vent Equipment. Listed direct-vent gas utilization equipment shall be considered properly vented where installed in accordance with the terms of its listing, the manufacturers' instructions, and 10.8.3.

10.2.6 Equipment with Integral Vents. Gas utilization equipment incorporating integral venting means shall be considered properly vented where installed in accordance with its listing, the manufacturers' instructions, and 10.8.1 and 10.8.2.

10.3 Design and Construction.

10.3.1 Minimum Safe Performance. A venting system shall be designed and constructed so as to develop a positive flow adequate to remove flue or vent gases to the outside atmosphere.

10.3.2 Equipment Draft Requirements. A venting system shall satisfy the draft requirements of the equipment in accordance with the manufacturer's instructions.

10.3.3 Design and Construction. Gas utilization equipment required to be vented shall be connected to a venting system designed and installed in accordance with the provisions of Sections 10.4 through 10.15.

10.3.4 Mechanical Draft Systems.

10.3.4.1 Mechanical draft systems shall be listed and shall be installed in accordance with the terms of their listing and both the appliance and the mechanical draft system manufacturers' instructions.

10.3.4.2 Gas utilization equipment requiring venting shall be permitted to be vented by means of mechanical draft systems of either forced or induced draft design.

Exception: Incinerators.

10.3.4.3 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.

10.3.4.4 Vent connectors serving equipment vented by natural draft shall not be connected into any portion of mechanical draft systems operating under positive pressure.

10.3.4.5 Where a mechanical draft system is employed, provision shall be made to prevent the flow of gas to the main burners when the draft system is not performing so as to satisfy the operating requirements of the equipment for safe performance.

10.3.4.6 The exit terminals of mechanical draft systems shall be not less than 7 ft (2.1 m) above grade where located adjacent to public walkways and shall be located as specified in 10.8.1 and 10.8.2.

10.3.5* Ventilating Hoods and Exhaust Systems.

10.3.5.1 Ventilating hoods and exhaust systems shall be permitted to be used to vent gas utilization equipment installed in commercial applications.

10.3.5.2 Where automatically operated gas utilization equipment is vented through a ventilating hood or exhaust system equipped with a damper or with a power means of exhaust, provisions shall be made to allow the flow of gas to the main burners only when the damper is open to a position to properly vent the equipment and when the power means of exhaust is in operation.

10.3.6 Circulating Air Ducts and Furnace Plenums. No portion of a venting system shall extend into or pass through any circulating air duct or furnace plenum.

10.4 Type of Venting System to Be Used.

10.4.1 The type of venting system to be used shall be in accordance with Table 10.4.1.

Table 10.4.1 Type of Venting System to Be Used

Gas Utilization Equipment	Type of Venting System
Listed Category I equipment Listed equipment equipped with draft hood Equipment listed for use with Type B gas vent	Type B gas vent (10.6) Chimney (10.5) Single-wall metal pipe (10.7) Listed chimney lining system for gas venting (10.5.1.3) Special gas vent listed for this equipment (10.4.3)
Listed vented wall furnaces	Type B-W gas vent (10.6, 9.27)
Category II equipment Category III equipment Category IV equipment	As specified or furnished by manufacturers of listed equipment (10.4.2, 10.4.3)
Incinerators, outdoors	Single-wall metal pipe [10.7, 10.7.3(3)]
Incinerators, indoors Equipment that can be converted to use of solid fuel Unlisted combination gas- and oil-burning equipment Combination gas- and solid-fuel-burning equipment Equipment listed for use with chimneys only Unlisted equipment	Chimney (10.5)
Listed combination gas- and oil-burning equipment	Type L vent (10.6) or chimney (10.5)
Decorative appliance in vented fireplace	Chimney (9.6.2.3)
Gas-fired toilets	Single-wall metal pipe (10.7, 9.25.3)
Direct-vent equipment	See 10.2.5
Equipment with integral vent	See 10.2.6

10.4.2 Plastic Piping. Plastic piping used for venting equipment listed for use with such venting materials shall be approved.

10.4.3 Special Gas Vent. Special gas vent shall be listed and installed in accordance with the terms of the special gas vent listing and the manufacturers' instructions.

10.5 Masonry, Metal, and Factory-Built Chimneys.

10.5.1 Listing or Construction.

10.5.1.1 Factory-built chimneys shall be installed in accordance with their listing and the manufacturers' instructions. Factory-built chimneys used to vent appliances that operate at positive vent pressure shall be listed for such application.

10.5.1.2 Metal chimneys shall be built and installed in accordance with NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances.*

10.5.1.3* Masonry chimneys shall be built and installed in accordance with NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances,* and lined with approved clay flue lining, a listed chimney lining system, or other approved material that will resist corrosion, erosion, softening, or cracking from vent gases at temperatures up to 1800°F (982°C).

Exception: Masonry chimney flues lined with a chimney lining system specifically listed for use with listed gas appliances with draft hoods, Category I appliances, and other gas appliances listed for use with Type B vents shall be permitted. The liner shall be installed in accordance with the liner manufacturer's instructions and the terms of the listing. 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."

10.5.2 Termination.

10.5.2.1 A chimney for residential-type or low-heat gas utilization equipment shall extend at least 3 ft (0.9 m) above the highest point where it passes through a roof of a building and at least 2 ft (0.6 m) higher than any portion of a building within a horizontal distance of 10 ft (3 m). *(See Figure 10.5.2.1.)*

10.5.2.2 A chimney for medium-heat equipment shall extend at least 10 ft (3 m) higher than any portion of any building within 25 ft (7.6 m).

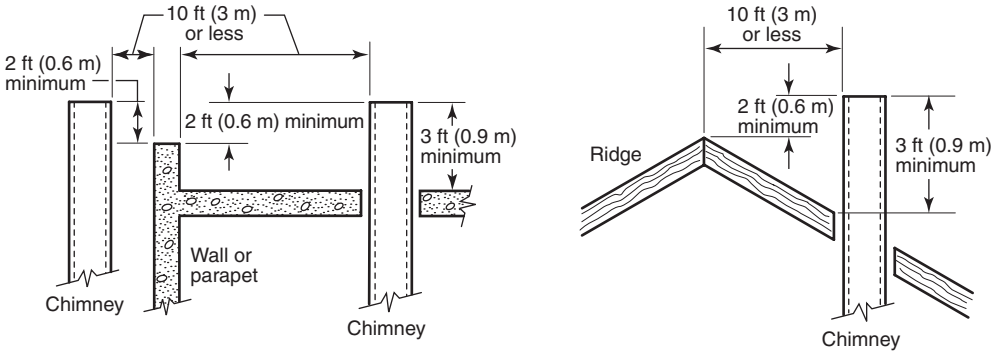
10.5.2.3 A chimney shall extend at least 5 ft (1.5 m) above the highest connected equipment draft hood outlet or flue collar.

10.5.2.4 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 manufacturers' installation instructions.

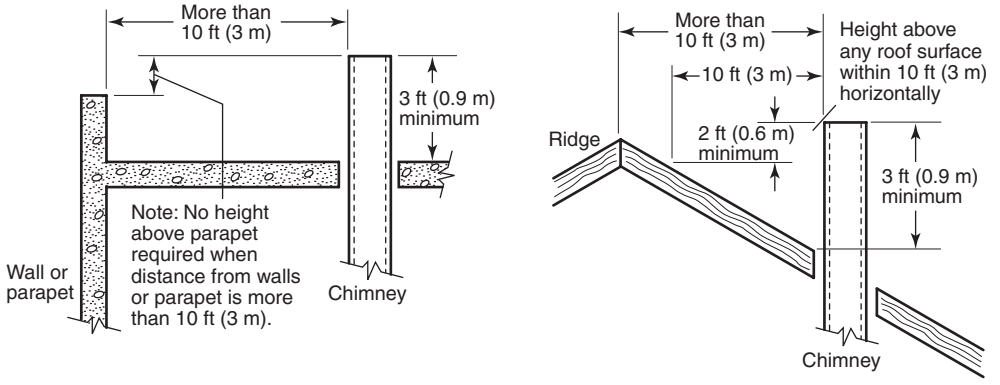
10.5.3 Size of Chimneys.

10.5.3.1 The effective area of a chimney venting system serving listed gas appliances with draft hoods, Category I appliances, and other appliances listed for use with Type B vents shall be in accordance with one of the following methods:

(1) Those listed in Chapter 13
(2) For sizing an individual chimney venting system for a single appliance with a draft hood, the effective areas of the vent connector and chimney flue shall be not less than the area of the appliance flue collar or draft hood outlet or greater than seven times the draft hood outlet area.
(3) For sizing a chimney venting system connected to two appliances with draft hoods, the effective area of the chimney flue shall be not less than the area of the larger draft hood outlet plus 50 percent of the area of the smaller draft hood outlet, or greater than seven times the smaller draft hood outlet area.



(a) Termination 10 ft (3 m) or less from ridge, wall, or parapet



(b) Termination more than 10 ft (3 m) from ridge, wall, or parapet

FIGURE 10.5.2.1 Typical Termination Locations for Chimneys and Single-Wall Metal Pipes Serving Residential-Type and Low-Heat Equipment.

(4) Chimney venting systems using mechanical draft shall be sized in accordance with approved engineering methods.
(5) Other approved engineering methods

10.5.3.2 Where an incinerator is vented by a chimney serving other gas utilization equipment, the gas input to the incinerator shall not be included in calculating chimney size, provided the chimney flue diameter is not less than 1 in. (25 mm) larger in equivalent diameter than the diameter of the incinerator flue outlet.

10.5.4 Inspection of Chimneys.

10.5.4.1 Before replacing an existing appliance or connecting a vent connector to a chimney, the chimney passageway shall be examined to ascertain that it is clear and free of obstructions and shall be cleaned if previously used for venting solid or liquid fuel-burning appliances or fireplaces.

10.5.4.2 Chimneys shall be lined in accordance with NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances.*

Exception: Existing chimneys shall be permitted to have their use continued when an appliance is replaced by an appliance of similar type, input rating, and efficiency.

10.5.4.3 Cleanouts shall be examined to determine that they will remain tightly closed when not in use.

10.5.4.4 When 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, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, and shall be suitable for the equipment to be attached.

10.5.5 Chimney Serving Equipment Burning Other Fuels.

10.5.5.1 Gas utilization equipment shall not be connected to a chimney flue serving a separate appliance designed to burn solid fuel.

10.5.5.2 Where one chimney serves gas utilization equipment and equipment burning liquid fuel, the equipment 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 gas utilization equipment is automatically controlled, it shall be equipped with a safety shutoff device.

10.5.5.3* A listed combination gas- and solid fuel-burning appliance connected to a single chimney flue shall be equipped with a manual reset device to shut off gas to the main burner in the event of sustained backdraft or flue gas spillage. The chimney flue shall be sized to properly vent the appliance.

10.5.5.4 A single chimney flue serving a listed combination gas- and oil-burning appliance shall be sized to properly vent the appliance.

10.5.6 Support of Chimneys. All portions of chimneys shall be supported for the design and weight of the materials employed. Listed factory-built chimneys shall be supported and spaced in accordance with their listings and the manufacturers' instructions.

10.5.7 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 at least 6 in. (150 mm) below the lower edge of the lowest chimney inlet opening.

10.5.8 Space Surrounding Lining or Vent.

10.5.8.1 The remaining space surrounding a chimney liner, gas vent, special gas vent, or plastic piping installed within a masonry, chimney shall not be used to vent another appliance.

Exception: The insertion of another liner or vent within the chimney as provided in this code and the liner or vent manufacturer's instructions.

10.5.8.2 The remaining space surrounding a chimney liner, gas vent, special gas vent, or plastic piping installed within a masonry, metal or factory-built chimney flue shall not be used to supply combustion air.

Exception: Direct vent gas-fired appliances designed for installation in a solid fuel-burning fireplace where installed in accordance with the listing and the manufacturer's instruction.

10.6 Gas Vents. See Section 3.3.

10.6.1 Application. The installation of gas vents shall meet the following requirements:

(1) Gas vents shall be installed in accordance with the terms of their listings and the manufacturers' instructions.
(2) A Type B-W gas vent shall have a listed capacity not less than that of the listed vented wall furnace to which it is connected.
(3) A gas vent passing through a roof shall extend through the entire roof flashing, roof jack, or roof thimble and be terminated with a listed termination cap.
(4) Type B or Type L vents shall extend in a generally vertical direction with offsets not exceeding 45 degrees, except that a vent system having not more than one 60-degree offset shall be permitted. Any angle greater than 45 degrees from the vertical is considered horizontal. The total horizontal distance of a vent plus the horizontal vent connector serving draft hood-equipped appliances shall not be greater than 75 percent of the vertical height of the vent.

Exception: Systems designed and sized as provided in Chapter 13 or in accordance with other approved engineering methods.

(5) Vents serving Category I fan-assisted appliances shall be installed in accordance with the appliance manufacturer's instructions and Chapter 13 or other approved engineering methods.
(6) Gas vents installed within masonry chimneys shall be installed in accordance with the terms of their listing and the manufacturers' installation instructions. Gas vents installed within masonry chimneys shall be identified with a permanent label installed at the point where the vent enters the chimney. The label shall contain the following language: "This gas vent is for appliances that burn gas. Do not connect to solid or liquid fuel-burning appliances or incinerators."

10.6.2 Gas Vent Termination. The termination of gas vents shall comply with the following requirements:

(1) A gas vent shall terminate in accordance with one of the following:
   (a) Above the roof surface with a listed cap or listed roof assembly. Gas vents 12 in. (300 mm) in size or smaller with listed caps shall be permitted to be terminated in accordance with Figure 10.6.2 and Table 10.6.2, provided they are at least 8 ft (2.4 m) from a vertical wall or similar obstruction. All other gas vents shall terminate not less than 2 ft (0.6 m) above the highest point where they pass through the roof and at least 2 ft (0.6 m) higher than any portion of a building within 10 ft (3 m).
   (b) Industrial gas utilization equipment as provided in 10.2.4.
   (c) Direct-vent systems as provided in 10.2.5.
   (d) Equipment with integral vents as provided in 10.2.6.
   (e) Mechanical draft systems as provided in 10.3.4.
   (f) Ventilating hoods and exhaust systems as provided in 10.3.5.
(2) A Type B or a Type L gas vent shall terminate at least 5 ft (1.5 m) in vertical height above the highest connected equipment draft hood or flue collar.
(3) A Type B-W gas vent shall terminate at least 12 ft (3.7 m) in vertical height above the bottom of the wall furnace.
(4) A gas vent extending through an exterior wall shall not terminate adjacent to the wall or below eaves or parapets, except as provided in 10.2.5 and 10.3.4.
(5) 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 manufacturers' installation instructions.

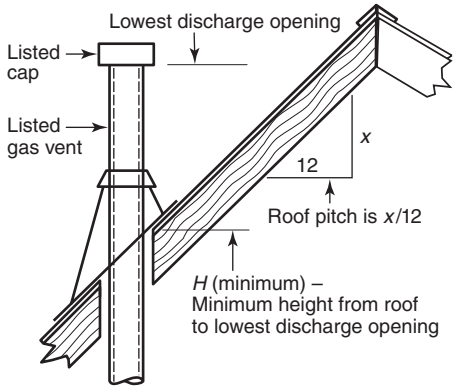


FIGURE 10.6.2 Gas Vent Termination Locations for Listed Caps 12 in. (300 mm) or Less in Size at Least 8 ft (2.4 m) from a Vertical Wall.

10.6.3 Size of Gas Vents. Venting systems shall be sized and constructed in accordance with Chapter 13 or other approved engineering methods and the gas vent and gas equipment manufacturers' instructions.

10.6.3.1* Category I Appliances. The sizing of natural draft venting systems serving one or more listed appliances equipped

Table 10.6.2 Roof Pitch Heights

Roof Pitch	*H* (minimum) ft	*H* (minimum) m
Flat to 6/12	1.0	0.30
6/12 to 7/12	1.25	0.38
Over 7/12 to 8/12	1.5	0.46
Over 8/12 to 9/12	2.0	0.61
Over 9/12 to 10/12	2.5	0.76
Over 10/12 to 11/12	3.25	0.99
Over 11/12 to 12/12	4.0	1.22
Over 12/12 to 14/12	5.0	1.52
Over 14/12 to 16/12	6.0	1.83
Over 16/12 to 18/12	7.0	2.13
Over 18/12 to 20/12	7.5	2.27
Over 20/12 to 21/12	8.0	2.44

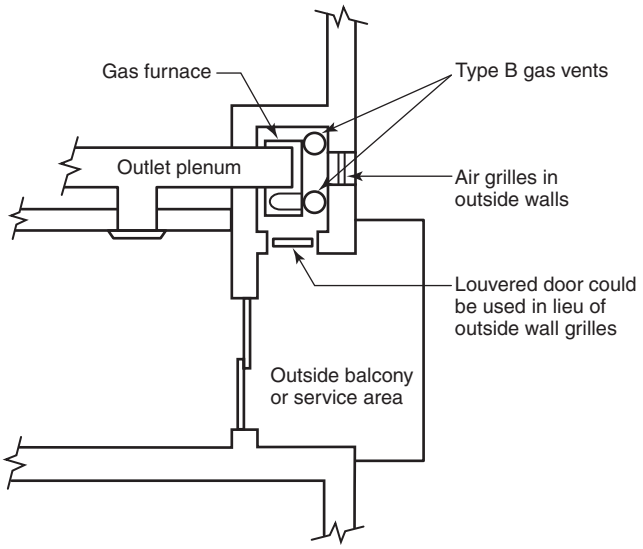


FIGURE 10.6.4.2 Plan View of Practical Separation Method for Multistory Gas Venting.

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 Chapter 13.
(2) Vents serving fan-assisted combustion system appliances, or combinations of fan-assisted combustion system and draft hood-equipped appliances shall be sized in accordance with Chapter 13 or other approved engineering methods.
(3) For sizing an individual gas vent for a single, draft hood-equipped appliance, the effective area of the vent connector and the gas vent shall be not less than the area of the appliance draft hood outlet or greater than seven times the draft hood outlet area.
(4) For sizing a gas vent connected to two appliances, with draft hoods, the effective area of the vent shall be not less than the area of the larger draft hood outlet plus 50 percent of the area of the smaller draft hood outlet or greater than seven times the smaller draft hood outlet area.
(5) Other approved engineering practices.

10.6.3.2 Category II, Category III, and Category IV Appliances. The sizing of gas vents for Category II, Category III, and Category IV gas utilization equipment shall be in accordance with the equipment manufacturers' instructions.

10.6.3.3 Sizing. Chimney venting systems using mechanical draft shall be sized in accordance with approved engineering methods.

10.6.4 Gas Vents Serving Equipment on More than One Floor.

10.6.4.1 A single or common gas vent shall be permitted in multistory installations to vent Category I gas utilization equipment located on more than one floor level, provided the venting system is designed and installed in accordance with approved engineering methods.

10.6.4.2 All gas utilization equipment connected to the common vent shall be located in rooms separated from habitable space. Each of these rooms shall have provisions for an adequate supply of combustion, ventilation, and dilution air that is not supplied from habitable space. *(See Figure 10.6.4.2.)*

10.6.4.3 The size of the connectors and common segments of multistory venting systems for gas utilization equipment listed for use with Type B double-wall gas vent shall be in accordance with Table 13.6, provided:

(1) The available total height *(H)* for each segment of a multistory venting system is the vertical distance between the level of the highest draft hood outlet or flue collar on that floor and the centerline of the next highest interconnection tee. *(See Figure G.1(k).)*
(2) The size of the connector for a segment is determined from its gas utilization equipment heat input and available connector rise and shall not be smaller than the draft hood outlet or flue collar size.
(3) The size of the common vertical vent segment, and of the interconnection tee at the base of that segment, shall be based on the total gas utilization equipment heat input entering that segment and its available total height.

10.6.5 Support of Gas Vents. Gas vents shall be supported and spaced in accordance with their listings and the manufacturers' instructions.

10.6.6 Marking. In those localities where solid and liquid fuels are used extensively, gas vents shall be permanently identified by a label attached to the wall or ceiling at a point where the vent connector enters the gas vent. The label shall read: "This gas vent is for appliances that burn gas. Do not connect to solid or liquid fuel-burning appliances or incinerators." The authority having jurisdiction shall determine whether its area constitutes such a locality.

10.7 Single-Wall Metal Pipe.

10.7.1 Construction. Single-wall metal pipe shall be constructed of galvanized sheet steel not less than 0.0304 in. (0.7 mm) thick or of other approved, noncombustible, corrosion-resistant material.

10.7.2 Cold Climate. Uninsulated single-wall metal pipe shall not be used outdoors in cold climates for venting gas utilization equipment.

10.7.3 Termination. The termination of single-wall metal pipe shall meet the following requirements:

(1) Single-wall metal pipe shall terminate at least 5 ft (1.5 m) in vertical height above the highest connected equipment draft hood outlet or flue collar.
(2) Single-wall metal pipe shall extend at least 2 ft (0.6 m) above the highest point where it passes through a roof of a building and at least 2 ft (0.6 m) higher than any portion of a building within a horizontal distance of 10 ft (3 m). *(See Figure 10.5.2.1.)*
(3) An approved cap or roof assembly shall be attached to the terminus of a single-wall metal pipe. *(Also see 10.7.4.3.)*

10.7.4 Installation with Equipment Permitted by 10.4.1.

10.7.4.1 Single-wall metal pipe shall be used only for runs directly from the space in which the gas utilization equipment is located through the roof or exterior wall to the outer air. A pipe passing through a roof shall extend without interruption through the roof flashing, roof jacket, or roof thimble.

10.7.4.2 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. *(For the installation of a single-wall metal pipe through an exterior combustible wall, see 10.10.14.2.)*

10.7.4.3 Single-wall metal pipe used for venting an incinerator shall be exposed and readily examinable for its full length and shall have suitable clearances maintained.

10.7.4.4 Minimum clearances from single-wall metal pipe to combustible material shall be in accordance with Table 10.7.4.4. Reduced clearances from single-wall metal pipe to combustible material shall be as specified for vent connectors in Table 9.2.3(b).

10.7.4.5 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 at least 18 in. (460 mm) above and 6 in. (150 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 10.10.14.2.

10.7.5 Size of Single-Wall Metal Pipe. Single-wall metal piping shall comply with the following requirements:

(1) *A venting system of a single-wall metal pipe shall be sized in accordance with one of the following methods and the gas equipment manufacturer's instructions:
   (a) For a draft hood-equipped appliance, in accordance with Chapter 13
   (b) For a venting system for a single appliance with a draft hood, the areas of the connector and the pipe each shall not be less than the area of the appliance flue collar or draft hood outlet, whichever is smaller. The vent area shall not be greater than seven times the draft hood outlet area.
   (c) Other approved engineering methods
(2) Where a single-wall metal pipe is used and has a shape other than round, it shall have an equivalent effective area equal to the effective area of the round pipe for which it is substituted and the minimum internal dimension of the pipe shall be 2 in. (50 mm).
(3) The vent cap or a roof assembly shall have a venting capacity not less than that of the pipe to which it is attached.

Table 10.7.4.4 Clearances for Connectors

Equipment	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 equipment with draft hoods and equipment listed for use with Type B gas vents	As listed	As listed	6 in.	As listed
Residential boilers and furnaces with listed gas conversion burner and with draft hood	6 in.	6 in.	9 in.	As listed
Residential appliances listed for use with Type L vents	Not permitted	As listed	9 in.	As listed
Listed gas-fired toilets	Not permitted	As listed	As listed	As listed
Unlisted residential appliances with draft hood	Not permitted	6 in.	9 in.	As listed
Residential and low-heat equipment other than those above	Not permitted	9 in.	18 in.	As listed
Medium-heat equipment	Not permitted	Not permitted	36 in.	As listed

For SI units, 1 in. = 25.4 mm.
Note: These clearances shall apply unless the listing of an appliance or connector specifies different clearances, in which case the listed clearances shall apply.

10.7.6 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.

10.7.7 Marking. Single-wall metal pipe shall comply with the marking provisions of 10.6.6.

10.8* Through the Wall Vent Termination.

10.8.1 A mechanical draft venting system shall terminate at least 3 ft (0.9 m) above any forced air inlet located within 10 ft (3 m).

Exception No. 1: This provision shall not apply to the combustion air intake of a direct-vent appliance.

Exception No. 2: This provision shall not apply to the separation of the integral outdoor air inlet and flue gas discharge of listed outdoor appliances.

10.8.2 A mechanical draft venting system of other than direct-vent type shall terminate at least 4 ft (1.2 m) below, 4 ft (1.2 m) horizontally from, or 1 ft (300 mm) above any door, operable window, or gravity air inlet into any building. The bottom of the vent terminal shall be located at least 12 in. (300 mm) above grade.

10.8.3 The vent terminal of a direct-vent appliance with an input of 10,000 Btu/hr (3 kW) or less shall be located at least 6 in. (150 mm) from any air opening into a building, and such an appliance with an input over 10,000 Btu/hr (3 kW) but not over 50,000 Btu/hr (14.7 kW) shall be installed with a 9 in. (230 mm) vent termination clearance, and an appliance with an input over 50,000 Btu/hr (14.7 kW) shall have at least a 12 in. (300 mm) vent termination clearance. The bottom of the vent terminal and the air intake shall be located at least 12 in. (300 mm) above grade.

10.8.4 Through-the-wall vents for Category II and Category IV appliances and noncategorized condensing appliances shall not terminate over public walkways or over an area where condensate or vapor could create a nuisance or hazard or could be detrimental to the operation of regulators, relief valves, or other equipment. Where local experience indicates that condensate is a problem with Category I and Category III appliances, this provision shall also apply.

10.9 Condensation Drain.

10.9.1 Provision shall be made to collect and dispose of condensate from venting systems serving Category II and Category IV gas utilization equipment and noncategorized condensing appliances in accordance with 10.8.4.

10.9.2 Where local experience indicates that condensation is a problem, provision shall be made to drain off and dispose of condensate from venting systems serving Category I and Category III gas utilization equipment in accordance with 10.8.4.

10.10 Vent Connectors for Category I Gas Utilization Equipment.

10.10.1 Where Required. A vent connector shall be used to connect gas utilization equipment 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 equipment.

10.10.2 Materials.

10.10.2.1 A vent connector shall be made of noncombustible, corrosion-resistant material capable of withstanding the vent gas temperature produced by the gas utilization equipment and of sufficient thickness to withstand physical damage.

10.10.2.2 Where the vent connector used for gas utilization equipment having a draft hood or a Category I appliance is located in or passes through an unconditioned area, that portion of the vent connector shall be listed Type B, Type L, or listed vent material having equivalent insulation qualities.

Exception: Single-wall metal pipe located within the exterior walls of the building and located in areas having a local 99 percent winter design temperature of 5°F or higher (see Figure G.2.4).

10.10.2.3 Where the vent connector used for gas utilization equipment having a draft hood or a Category I appliance is located in or passes through attics and crawl spaces, that portion of the vent connector shall be listed Type B, Type L, or listed vent material having equivalent insulation qualities.

10.10.2.4 Vent connectors for residential-type appliances shall comply with the following:

(1) Vent Connectors not Installed in Attics, Crawl Spaces, or Other Unconditioned Areas. Vent connectors for listed gas appliances having draft hoods and for appliances having draft hoods and equipped with listed conversion burners that are not installed in attics, crawl spaces, or other unconditioned areas shall be one of the following:
   (a) Type B or Type L vent material
   (b) Galvanized sheet steel not less than 0.018 in. (0.46 mm) thick
   (c) Aluminum (1100 or 3003 alloy or equivalent) sheet not less than 0.027 in. (0.69 mm) thick
   (d) Stainless steel sheet not less than 0.012 in. (0.31 mm) thick
   (e) Smooth interior wall metal pipe having resistance to heat and corrosion equal to or greater than that of (b), (c), or (d) above
   (f) A listed vent connector
(2) Vent connectors shall not be covered with insulation.

Exception: Listed insulated vent connectors shall be installed according to the terms of their listing.

10.10.2.5 A vent connector for low-heat equipment 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 10.10.2.5. Factory-built chimney sections shall be joined together in accordance with the chimney manufacturer's instructions.

10.10.2.6 Vent connectors for medium-heat equipment and commercial and industrial incinerators shall be constructed of

Table 10.10.2.5 Minimum Thickness for Galvanized Steel Vent Connectors for Low-Heat Appliances

Diameter of Connector (in.)	Minimum Thickness (in.)
Less than 6	0.019
6 to less than 10	0.023
10 to 12 inclusive	0.029
14 to 16 inclusive	0.034
Over 16	0.056

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2.

factory-built, medium-heat chimney sections or steel of a thickness not less than that specified in Table 10.10.2.6 and shall comply with the following:

(1) A steel vent connector for equipment with a vent gas temperature in excess of 1000°F (538°C) measured at the entrance to the connector shall be lined with medium-duty fire brick or the equivalent.
(2) The lining shall be at least 2½ in. (64 mm) thick for a vent connector having a diameter or greatest cross-sectional dimension of 18 in. (460 mm) or less.
(3) The lining shall be at least 4½ in. (110 mm) thick laid on the 4½ in. (110 mm) bed for a vent connector having a diameter or greatest cross-sectional dimension greater than 18 in. (460 mm).
(4) Factory-built chimney sections, if employed, shall be joined together in accordance with the chimney manufacturer's instructions.

Table 10.10.2.6 Minimum Thickness for Steel Vent Connectors for Medium-Heat Equipment and Commercial and Industrial Incinerators

Vent Connector Size		Minimum Thickness (in.)
Diameter (in.)	Area (in.^{2})	
Up to 14	Up to 154	0.053
Over 14 to 16	154 to 201	0.067
Over 16 to 18	201 to 254	0.093
Over 18	Larger than 254	0.123

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2.

10.10.3* Size of Vent Connector.

10.10.3.1 A vent connector for gas utilization equipment with a single draft hood or for a Category I fan-assisted combustion system appliance shall be sized and installed in accordance with Chapter 13 or other approved engineering methods.

10.10.3.2 For a single appliance having more than one draft hood outlet or flue collar, the manifold shall be constructed according to the instructions of the appliance manufacturer. Where there are no instructions, the manifold shall be designed and constructed in accordance with approved engineering practices. As an alternate method, the effective area of the manifold shall equal the combined area of the flue collars or draft hood outlets and the vent connectors shall have a minimum 1 ft (0.3 m) rise.

10.10.3.3 Where two or more gas appliances are connected to a common vent or chimney, each vent connector shall be sized in accordance with Chapter 13 or other approved engineering methods.

10.10.3.4 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.

10.10.3.5 Where two or more gas appliances are vented through a common vent connector or vent manifold, the common vent connector or vent manifold shall be located at the highest level consistent with available headroom and clearance to combustible material and shall be sized in accordance with Chapter 13 or other approved engineering methods.

10.10.3.6 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.

10.10.3.7 Where the size of a vent connector is increased to overcome installation limitations and obtain connector capacity equal to the equipment input, the size increase shall be made at the equipment draft hood outlet.

10.10.4 Two or More Appliances Connected to a Single Vent.

10.10.4.1 Where two or more vent connectors enter a common gas 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.

10.10.4.2 Vent connectors serving Category I appliances shall not be connected to any portion of a mechanical draft system operating under positive static pressure, such as those serving Category III or Category IV appliances.

10.10.5 Clearance. Minimum clearances from vent connectors to combustible material shall be in accordance with Table 10.7.4.4.

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 9.2.3(2).

10.10.6 Avoid Unnecessary Bends. A vent connector shall be installed so as to avoid turns or other construction features that create excessive resistance to flow of vent gases.

10.10.7 Joints. Joints between sections of connector piping and connections to flue collars or draft hood outlets shall be fastened in accordance with one of the following methods:

(1) By sheet metal screws.
(2) Vent connectors of listed vent material shall be assembled and connected to flue collars or draft hood outlets in accordance with the manufacturers' instructions.
(3) Other approved means.

10.10.8 Slope. A vent connector shall be installed without any dips or sags and shall slope upward toward the vent or chimney at least ¼ in./ft (20 mm/m).

Exception: Vent connectors attached to a mechanical draft system installed in accordance with the manufacturer's instructions.

10.10.9 Length of Vent Connector.

10.10.9.1 A vent connector shall be as short as practical and the gas utilization equipment located as close as practical to the chimney or vent.

10.10.9.2* Except as provided for in 10.10.3, the maximum horizontal length of a single-wall connector shall be 75 percent of the height of the chimney or vent. Except as provided for in 10.10.3, the maximum horizontal length of a Type B double-wall connector shall be 100 percent of the height of the chimney or vent. For a chimney or vent system serving multiple appliances, the maximum length of an individual connector, from the appliance outlet to the junction with the common vent or another connector, shall be 100 percent of the height of the chimney or vent.

10.10.10 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.

10.10.11 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 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.

10.10.12 Inspection. The entire length of a vent connector shall be readily accessible for inspection, cleaning, and replacement.

10.10.13 Fireplaces. A vent connector shall not be connected to a chimney flue serving a fireplace unless the fireplace flue opening is permanently sealed.

10.10.14 Passage Through Ceilings, Floors, or Walls.

10.10.14.1 A vent connector shall not pass through any ceiling, floor, or fire-resistance rated wall. A single-wall metal pipe connector shall not pass through any interior wall.

Exception: Vent connectors made of listed Type B or Type L vent material and serving listed equipment with draft hoods and other equipment listed for use with Type B gas vents that pass through walls or partitions constructed of combustible material shall be installed with not less than the listed clearance to combustible material.

10.10.14.2 A vent connector made of 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 a minimum of 4 in. (100 mm) larger in diameter than the vent connector. Where there is a run of not less than 6 ft (1.8 m) of vent connector in the opening between the draft hood outlet and the thimble, the thimble shall be a minimum of 2 in. (50 mm) larger in diameter than the vent connector.
(2) For unlisted appliances having draft hoods, the thimble shall be a minimum of 6 in. (150 mm) larger in diameter than the vent connector.
(3) For residential and low-heat appliances, the thimble shall be a minimum of 12 in. (300 mm) larger in diameter than the vent connector.

Exception: In lieu of thimble protection, all combustible material in the wall shall be removed from the vent connector a sufficient distance to provide the specified clearance from such vent connector to combustible material. Any material used to close up such opening shall be noncombustible.

10.10.14.3 Vent connectors for medium-heat equipment shall not pass through walls or partitions constructed of combustible material.

10.11 Vent Connectors for Category II, Category III, and Category IV Gas Utilization Equipment. See Section 10.4.

10.12 Draft Hoods and Draft Controls.

10.12.1 Equipment Requiring Draft Hoods. Vented gas utilization equipment shall be installed with draft hoods.

Exception: Dual oven-type combination ranges, incinerators, direct-vent equipment, fan-assisted combustion system appliances, equipment requiring chimney draft for operation, single-firebox boilers equipped with conversion burners with inputs greater than 400,000 Btu/hr (117 kW), equipment equipped with blast, power, or pressure burners that are not listed for use with draft hoods, and equipment designed for forced venting.

10.12.2 Installation. A draft hood supplied with or forming a part of listed vented gas utilization equipment shall be installed without alteration, exactly as furnished and specified by the equipment manufacturer.

10.12.2.1 If a draft hood is not supplied by the equipment manufacturer where one is required, a draft hood shall be installed, be of a listed or approved type, and, in the absence of other instructions, be of the same size as the equipment flue collar. Where a draft hood is required with a conversion burner, it shall be of a listed or approved type.

10.12.2.2 Where it is determined that a draft hood of special design is needed or preferable for a particular installation, the installation shall be in accordance with the recommendations of the equipment manufacturer and shall be with the approval of the authority having jurisdiction.

10.12.3 Draft Control Devices. Where a draft control device is part of the gas utilization equipment or is supplied by the equipment 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 equipment or as near to the equipment as practical.

10.12.4* Additional Devices. Gas utilization equipment (except incinerators) requiring controlled chimney draft shall be permitted to be equipped with a listed double-acting barometric draft regulator installed and adjusted in accordance with the manufacturers' instructions.

10.12.5 Location. Draft hoods and barometric draft regulators shall be installed in the same room or enclosure as the equipment in such a manner as to prevent any difference in pressure between the hood or regulator and the combustion air supply.

10.12.6 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 equipment or adjacent construction. The equipment and its draft hood shall be located so that the relief opening is accessible for checking vent operation.

10.12.7 Clearance. A draft hood shall be located so that its relief opening is not less than 6 in. (150 mm) from any surface except that of the equipment it serves and the venting system to which the draft hood is connected. Where a greater or lesser clearance is indicated on the equipment label, the clearance shall not be less than that specified on the label. Such clearances shall not be reduced.

10.13 Manually Operated Dampers. A manually operated damper shall not be placed in any equipment vent connector. Fixed baffles shall not be classified as manually operated dampers.

10.14 Automatically Operated Vent Dampers. An automatically operated vent damper shall be of a listed type.

10.15 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 terms of their listing.
(2) Approved draft regulators and safety controls designed and installed in accordance with approved engineering methods.
(3) Listed heat reclaimers and automatically operated vent dampers installed in accordance with the terms of their listing.
(4) Vent dampers serving listed appliances installed in accordance with 13.1.1 and 13.2.1 or other approved engineering methods.
(5) Approved economizers, heat reclaimers, and recuperators installed in venting systems of equipment not required to be equipped with draft hoods, provided the gas utilization equipment manufacturer's instructions cover the installation of such a device in the venting system and performance in accordance with 10.3.1 and 10.3.2 is obtained.

Chapter 11 Procedures to Be Followed to Place Equipment in Operation

11.1 Adjusting the Burner Input.

11.1.1* Adjusting Input. The input shall be adjusted to the proper rate in accordance with the equipment manufacturers' instructions by changing the size of a fixed orifice, changing the adjustment of an adjustable orifice, or readjusting the gas pressure regulator outlet pressure (where a regulator is provided). Overfiring shall be prohibited. *(See Table 11.1.1.)*

Table 11.1.1 Gas Input to Burner in Cubic Feet per Hour

Seconds for One Revolution	Size of Test Meter Dial			
	½ ft³	1 ft³	2 ft³	5 ft³
10	180	360	720	1800
11	164	327	655	1636
12	150	300	600	1500
13	138	277	555	1385
14	129	257	514	1286
15	120	240	480	1200
16	112	225	450	1125
17	106	212	424	1059
18	100	200	400	1000
19	95	189	379	947
20	90	180	360	900
21	86	171	343	857
22	82	164	327	818
23	78	157	313	783
24	75	150	300	750
25	72	144	288	720
26	69	138	277	692
27	67	133	267	667
28	64	129	257	643
29	62	124	248	621
30	60	120	240	600
31	58	116	232	581
32	56	113	225	563
33	55	109	218	545
34	53	106	212	529
35	51	103	206	514
36	50	100	200	500
37	49	97	195	486
38	47	95	189	474
39	46	92	185	462
40	45	90	180	450
41	44	88	176	440
42	43	86	172	430
43	42	84	167	420
44	41	82	164	410
45	40	80	160	400
46	39	78	157	391
47	38	77	153	383
48	37	75	150	375
49	37	73	147	367
50	36	72	144	360
51	35	71	141	353
52	35	69	138	346
53	34	68	136	340
54	33	67	133	333
55	33	65	131	327
56	32	64	129	321
57	32	63	126	316
58	31	62	124	310
59	30	61	122	305
60	30	60	120	300
62	29	58	116	290
64	29	56	112	281
66	29	54	109	273
68	28	53	106	265
70	26	51	103	257
72	25	50	100	250
74	24	48	97	243
76	24	47	95	237
78	23	46	92	231
80	22	45	90	225
82	22	44	88	220
84	21	43	86	214
86	21	42	84	209
88	20	41	82	205
90	20	40	80	200
94	19	38	76	192

Table 11.1.1 *Continued*

Seconds for One Revolution	Size of Test Meter Dial			
	½ ft³	1 ft³	2 ft³	5 ft³
98	18	37	74	184
100	18	36	72	180
104	17	35	69	173
108	17	33	67	167
112	16	32	64	161
116	15	31	62	155
120	15	30	60	150
130	14	28	55	138
140	13	26	51	129
150	12	24	48	120
160	11	22	45	112
170	11	21	42	106
180	10	20	40	100

Note: To convert to Btu per hour, multiply by the Btu heating value of the gas used.

11.1.2 High Altitude. Ratings of gas utilization equipment are based on sea level operation and shall not be changed for operation at elevations up to 2000 ft (600 m). For operation at elevations above 2000 ft (600 m), equipment ratings shall be reduced in accordance with one of the following methods:

(1) At the rate of 4 percent for each 1000 ft (300 m) above sea level before selecting appropriately sized equipment.
(2) As permitted by the authority having jurisdiction.
(3) Listed appliances derated in accordance with the terms of the listing shall be permitted.

11.2* Primary Air Adjustment. The primary air for injection (Bunsen)-type burners shall be adjusted for proper flame characteristics in accordance with the manufacturers' instructions. After setting the primary air, the adjustment means shall be secured in position.

11.3 Safety Shutoff Devices. Where a safety shutoff device is provided, it shall be checked for proper operation and adjustment in accordance with the manufacturer's instructions. Where the device does not function properly to turn off the gas supply in the event of pilot outage, it shall be properly serviced or replaced with new equipment.

11.4 Automatic Ignition. Gas utilization equipment supplied with means for automatic ignition shall be checked for proper operation. If necessary, proper adjustments shall be made.

11.5 Protective Devices. All protective devices furnished with the gas utilization equipment, such as a limit control, fan control to blower, temperature and pressure relief valve, low-water cutoff device, or manual operating features, shall be checked for proper operation.

11.6* Checking the Draft. Vent-connected gas utilization equipment shall be operated for several minutes and checked to see that the combustion products are going up the chimney or gas vent properly by passing a lighted match or taper around the edge of the relief opening of the draft hood. Where the chimney or gas vent is drawing properly, the match flame will be drawn into the draft hood. Where not, the combustion products will tend to extinguish this flame. Where the combustion products are escaping from the relief opening of the draft hood, the equipment shall not be operated until proper adjustments or repairs are made to provide adequate draft through the chimney or gas vent.

11.7 Operating Instructions. Operating instructions shall be furnished and shall be left in a prominent position near the equipment for the use of the consumer.

Chapter 12 Pipe Sizing

12.1 Pipe Sizing Methods. Where the pipe size is to be determined using any of the methods in 12.1.1 through 12.1.3, the diameter of each pipe segment shall be obtained from the pipe sizing tables in Section 12.2 or from the sizing equations in Section 12.3. *(See calculation examples in Annex C.)* For SI units, 1 ft³ = 0.028 m³, 1 ft = 0.305 m, 1 in. w.c. = 0.249 kPa, 1 psi = 6.894 kPa, 1000 Btu/hr = 0.293 kW.

12.1.1* Longest Length Method. The pipe size of each section of gas piping shall be determined using the longest length of piping from the point of delivery to the most remote outlet and the load of the section.

12.1.2* 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.

12.1.3 Hybrid Pressure. The pipe size for each section of higher pressure gas piping shall be determined using the longest length of piping from the point of delivery to the most remote line pressure regulator. The pipe size from the line pressure regulator to each outlet shall be determined using the length of piping from the regulator to the most remote outlet served by the regulator.

12.2 Tables for Sizing Gas Piping Systems. Table 12.1 through Table 12.33 shall be used to size gas piping in conjunction with one of the methods described in 12.1.1 through 12.1.3.

12.3 Sizing Equations. The inside diameter of smooth wall pipe or tubing shall be determined by the sizing equations in 12.3.1 and 12.3.2 using the equivalent pipe length determined by the methods in 12.1.1 through 12.1.3.

12.3.1* Low Pressure Gas Formula [Less than 1.5 psi (10.3 kPa)]:

$$D = \frac{Q^{0.381}}{19.17\left(\frac{\Delta H}{Cr \times L}\right)^{0.206}}$$

12.3.2* High Pressure Gas Formula [1.5 psi (10.3 kPa) and above]:

$$D = \frac{Q^{0.381}}{18.93\left[\frac{\left(P_1^2 - P_2\right)^2 \cdot Y}{Cr \times L}\right]^{0.206}}$$

Table 12.1 Schedule 40 Metallic Pipe

Gas	Natural
Inlet pressure	0.50 psi or less
Pressure Drop	0.30 in. w.c.
Specific Gravity	0.60

	Pipe Size (in.)										
Nominal	¼	⅜	½	¾	1	1¼	1½	2	2½	3	4
Actual ID	0.364	0.493	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**										
10	32	72	132	278	520	1,050	1,600	3,050	4,800	8,500	17,500
20	22	49	92	190	350	730	1,100	2,100	3,300	5,900	12,000
30	18	40	73	152	285	590	890	1,650	2,700	4,700	9,700
40	15	34	63	130	245	500	760	1,450	2,300	4,100	8,300
50	14	30	56	115	215	440	670	1,270	2,000	3,600	7,400
60	12	27	50	105	195	400	610	1,150	1,850	3,250	6,800
70	11	25	46	96	180	370	560	1,050	1,700	3,000	6,200
80	11	23	43	90	170	350	530	990	1,600	2,800	5,800
90	10	22	40	84	160	320	490	930	1,500	2,600	5,400
100	9	21	38	79	150	305	460	870	1,400	2,500	5,100
125	8	18	34	72	130	275	410	780	1,250	2,200	4,500
150	8	17	31	64	120	250	380	710	1,130	2,000	4,100
175	7	15	28	59	110	225	350	650	1,050	1,850	3,800
200	6	14	26	55	100	210	320	610	980	1,700	3,500

where:
D = inside diameter of pipe, in.
Q = input rate appliance(s), cubic feet per hour at 60°F and 30 in. 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, ft
ΔH = pressure drop, in. w.c. (27.7 in. H_2O = 1 psi)

See Table 12.3.2 for values of *Cr* and *Y*.

Table 12.3.2 *Cr* and *Y* for Natural Gas and Undiluted Propane at Standard Conditions

	Formula Factors	
Gas	***Cr***	***Y***
Natural Gas	0.6094	0.9992
Undiluted Propane	1.2462	0.9910

Table 12.2 Schedule 40 Metallic Pipe

Gas	Natural
Inlet pressure	0.50 psi or less
Pressure Drop	0.50 in. w.c.
Specific Gravity	0.60

	Pipe Size (in.)										
Nominal	¼	⅜	½	¾	1	1¼	1½	2	2½	3	4
Actual ID	0.364	0.493	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**										
10	43	95	175	360	680	1,400	2,100	3,950	6,300	11,000	23,000
20	29	65	120	250	465	950	1,460	2,750	4,350	7,700	15,800
30	24	52	97	200	375	770	1,180	2,200	3,520	6,250	12,800
40	20	45	82	170	320	660	990	1,900	3,000	5,300	10,900
50	18	40	73	151	285	580	900	1,680	2,650	4,750	9,700
60	16	36	66	138	260	530	810	1,520	2,400	4,300	8,800
70	15	33	61	125	240	490	750	1,400	2,250	3,900	8,100
80	14	31	57	118	220	460	690	1,300	2,050	3,700	7,500
90	13	29	53	110	205	430	650	1,220	1,950	3,450	7,200
100	12	27	50	103	195	400	620	1,150	1,850	3,250	6,700
125	11	24	44	93	175	360	550	1,020	1,650	2,950	6,000
150	10	22	40	84	160	325	500	950	1,500	2,650	5,500
175	9	20	37	77	145	300	460	850	1,370	2,450	5,000
200	8	19	35	72	135	280	430	800	1,280	2,280	4,600

Table 12.3 Schedule 40 Metallic Pipe

Gas	Natural
Inlet pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	0.60

	Pipe Size (in.)								
Nominal	½	¾	1	1¼	1½	2	2½	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**								
10	1,506	3,041	5,561	11,415	17,106	32,944	52,505	92,819	189,326
20	1,065	2,150	3,932	8,072	12,096	23,295	37,127	65,633	133,873
30	869	1,756	3,211	6,591	9,876	19,020	30,314	53,589	109,307
40	753	1,521	2,781	5,708	8,553	16,472	26,253	46,410	94,663
50	673	1,360	2,487	5,105	7,650	14,733	23,481	41,510	84,669
60	615	1,241	2,270	4,660	6,983	13,449	21,435	37,893	77,292
70	569	1,150	2,102	4,315	6,465	12,452	19,845	35,082	71,558
80	532	1,075	1,966	4,036	6,048	11,647	18,563	32,817	66,937
90	502	1,014	1,854	3,805	5,702	10,981	17,502	30,940	63,109
100	462	934	1,708	3,508	5,257	10,125	16,138	28,530	58,194
125	414	836	1,528	3,138	4,702	9,056	14,434	25,518	52,050
150	372	751	1,373	2,817	4,222	8,130	12,960	22,911	46,732
175	344	695	1,271	2,608	3,909	7,527	11,999	21,211	43,265
200	318	642	1,174	2,413	3,613	6,959	11,093	19,608	39,997

Table 12.4 Schedule 40 Metallic Pipe

Gas	Natural
Inlet pressure	5.0 psi
Pressure Drop	3.5 psi
Specific Gravity	0.60

	Pipe Size (in.)								
Nominal	¼	¾	1	1¼	1½	2	2½	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**								
10	3,185	6,434	11,766	24,161	36,206	69,727	111,133	196,468	400,732
20	2,252	4,550	8,320	17,084	25,602	49,305	78,583	138,924	283,361
30	1,839	3,715	6,793	13,949	20,904	40,257	64,162	113,431	231,363
40	1,593	3,217	5,883	12,080	18,103	34,864	55,566	98,234	200,366
50	1,425	2,878	5,262	10,805	16,192	31,183	49,700	87,863	179,213
60	1,301	2,627	4,804	9,864	14,781	28,466	45,370	80,208	163,598
70	1,204	2,432	4,447	9,132	13,685	26,354	42,004	74,258	151,463
80	1,153	2,330	4,260	8,542	12,801	24,652	39,291	69,462	141,680
90	1,062	2,145	3,922	8,054	12,069	23,242	37,044	65,489	133,577
100	979	1,978	3,617	7,427	11,128	21,433	34,159	60,387	123,173
125	876	1,769	3,235	6,643	9,953	19,170	30,553	54,012	110,169
150	786	1,589	2,905	5,964	8,937	17,211	27,431	48,494	98,911
175	728	1,471	2,690	5,522	8,274	15,934	25,396	44,897	91,574
200	673	1,360	2,487	5,104	7,649	14,729	23,478	41,504	84,656

Table 12.5 Schedule 40 Metallic Pipe

Gas	Natural
Inlet pressure	1.0 psi or less
Pressure Drop	0.30 in. w.c.
Specific Gravity	0.60

	Pipe Size (in.)												
Nominal	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12
Actual ID	1.049	1.380	1.610	2.067	2.469	3.068	3.548	4.026	5.047	6.065	7.981	10.020	11.938
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour												
50	215	442	662	1,275	2,033	3,594	5,262	7,330	13,261	21,472	44,118	80,130	126,855
100	148	304	455	877	1,397	2,470	3,616	5,038	9,114	14,758	30,322	55,073	87,187
150	119	244	366	704	1,122	1,983	2,904	4,046	7,319	11,851	24,350	44,225	70,014
200	102	209	313	602	960	1,698	2,485	3,462	6,264	10,143	20,840	37,851	59,923
250	90	185	277	534	851	1,505	2,203	3,069	5,552	8,990	18,470	33,547	53,109
300	82	168	251	484	771	1,363	1,996	2,780	5,030	8,145	16,735	30,396	48,120
400	70	143	215	414	660	1,167	1,708	2,380	4,305	6,971	14,323	26,015	41,185
500	62	127	191	367	585	1,034	1,514	2,109	3,816	6,178	12,694	23,056	36,501
1,000	43	87	131	252	402	711	1,041	1,450	2,623	4,246	8,725	15,847	25,087
1,500	34	70	105	203	323	571	836	1,164	2,106	3,410	7,006	12,725	20,146
2,000	29	60	90	173	276	488	715	996	1,802	2,919	5,997	10,891	17,242

Table 12.6 Schedule 40 Metallic Pipe

Gas	Natural
Inlet pressure	1.0 psi or less
Pressure Drop	0.50 in. w.c.
Specific Gravity	0.60

	Pipe Size (in.)												
Nominal	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12
Actual ID	1.049	1.380	1.610	2.067	2.469	3.068	3.548	4.026	5.047	6.065	7.981	10.020	11.938
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour												
50	284	583	873	1,681	2,680	4,738	6,937	9,663	17,482	28,308	58,161	105,636	167,236
100	195	400	600	1,156	1,842	3,256	4,767	6,641	12,015	19,456	39,974	72,603	114,940
150	157	322	482	928	1,479	2,615	3,828	5,333	9,649	15,624	32,100	58,303	92,301
200	134	275	412	794	1,266	2,238	3,277	4,565	8,258	13,372	27,474	49,900	78,998
250	119	244	366	704	1,122	1,983	2,904	4,046	7,319	11,851	24,350	44,225	70,014
300	108	221	331	638	1,017	1,797	2,631	3,666	6,632	10,738	22,062	40,071	63,438
400	92	189	283	546	870	1,538	2,252	3,137	5,676	9,190	18,883	34,296	54,295
500	82	168	251	484	771	1,363	1,996	2,780	5,030	8,145	16,735	30,396	48,120
1,000	56	115	173	333	530	937	1,372	1,911	3,457	5,598	11,502	20,891	33,073
1,500	45	93	139	267	426	752	1,102	1,535	2,776	4,496	9,237	16,776	26,559
2,000	39	79	119	229	364	644	943	1,313	2,376	3,848	7,905	14,358	22,731

Table 12.7 Semi-Rigid Copper Tubing

Gas	Natural
Inlet pressure	0.5 psi or less
Pressure Drop	0.3 in. w.c.
Specific Gravity	0.60

		Tube Size (in.)									
	K & L	¼	⅜	½	⅝	¾	1	1¼	1½	2	2½
Nominal	**ACR**	⅜	½	⅝	¾	⅞	1⅛	1⅜	1⅝	2⅛	2⅝
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside[1]		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		**Maximum Capacity in Cubic Feet of Gas per Hour**									
10		20	42	85	148	210	448	806	1,271	2,646	4,682
20		14	29	58	102	144	308	554	873	1,819	3,218
30		11	23	47	82	116	247	445	701	1,461	2,584
40		10	20	40	70	99	211	381	600	1,250	2,212
50		8.4	17	35	62	88	187	337	532	1,108	1,960
60		7.6	16	32	56	79	170	306	482	1,004	1,776
70		7.0	14	29	52	73	156	281	443	924	1,634
80		6.5	13	27	48	68	145	262	413	859	1,520
90		6.1	13	26	45	64	136	245	387	806	1,426
100		5.8	12	24	43	60	129	232	366	761	1,347
125		5.1	11	22	38	53	114	206	324	675	1,194
150		4.7	10	20	34	48	103	186	294	612	1,082
175		4.3	8.8	18	31	45	95	171	270	563	995
200		4.0	8.2	17	29	41	89	159	251	523	926
250		3.5	7.3	15	26	37	78	141	223	464	821
300		3.2	6.6	13	23	33	71	128	202	420	744

[1] Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

Table 12.8 Semi-Rigid Copper Tubing

Gas	Natural
Inlet pressure	0.5 psi or less
Pressure Drop	0.5 in. w.c.
Specific Gravity	0.60

		Tube Size (in.)									
	K & L	¼	⅜	½	⅝	¾	**1**	**1¼**	**1½**	**2**	**2½**
Nominal	**ACR**	⅜	½	⅝	¾	⅞	1⅛	1⅜	1⅝	2⅛	2⅝
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside[1]		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		**Maximum Capacity in Cubic Feet of Gas per Hour**									
10		27	55	111	195	276	590	1,062	1,675	3,489	6,173
20		18	38	77	134	190	406	730	1,151	2,398	4,242
30		15	30	61	107	152	326	586	925	1,926	3,407
40		13	26	53	92	131	279	502	791	1,648	2,916
50		11	23	47	82	116	247	445	701	1,461	2,584
60		10	21	42	74	105	224	403	635	1,323	2,341
70		9.3	19	39	68	96	206	371	585	1,218	2,154
80		8.6	18	36	63	90	192	345	544	1,133	2,004
90		8.1	17	34	59	84	180	324	510	1,063	1,880
100		7.6	16	32	56	79	170	306	482	1,004	1,776
125		6.8	14	28	50	70	151	271	427	890	1,574
150		6.1	13	26	45	64	136	245	387	806	1,426
175		5.6	12	24	41	59	125	226	356	742	1,312
200		5.2	11	22	39	55	117	210	331	690	1,221
250		4.7	10	20	34	48	103	186	294	612	1,082
300		4.2	8.7	18	31	44	94	169	266	554	980

[1] Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

Table 12.9 Semi-Rigid Copper Tubing

Gas	Natural
Inlet pressure	0.5 psi or less
Pressure Drop	1.0 in. w.c.
Specific Gravity	0.60

SPECIAL USE: **Use this Table to Size Tubing from House Line Regulator to the Appliance.**

		Tube Size (in.)									
	K & L	¼	⅜	½	⅝	¾	1	1¼	1½	2	2½
Nominal	**ACR**	⅜	½	⅝	¾	⅞	1⅛	1⅜	1⅝	2⅛	2⅝
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside[1]		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		**Maximum Capacity in Cubic Feet of Gas per Hour**									
10		39	80	162	283	402	859	1,546	2,437	5,076	8,981
20		27	55	111	195	276	590	1,062	1,675	3,489	6,173
30		21	44	89	156	222	474	853	1,345	2,802	4,957
40		18	38	77	134	190	406	730	1,151	2,398	4,242
50		16	33	68	119	168	359	647	1,020	2,125	3,760
60		15	30	61	107	152	326	586	925	1,926	3,407
70		13	28	57	99	140	300	539	851	1,772	3,134
80		13	26	53	92	131	279	502	791	1,648	2,916
90		12	24	49	86	122	262	471	742	1,546	2,736
100		11	23	47	82	116	247	445	701	1,461	2,584
125		9.8	20	41	72	103	219	394	622	1,295	2,290
150		8.9	18	37	65	93	198	357	563	1,173	2,075
175		8.2	17	34	60	85	183	329	518	1,079	1,909
200		7.6	16	32	56	79	170	306	482	1,004	1,776
250		6.8	14	28	50	70	151	271	427	890	1,574
300		6.1	13	26	45	64	136	245	387	806	1,426

[1] Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

Table 12.10 Semi-Rigid Copper Tubing

							Gas			Natural	
							Inlet pressure			2.0 psi or less	
							Pressure Drop			17.0 in. w.c.	
							Specific Gravity			0.60	
						Tube Size (in.)					
	K & L	¼	⅜	½	⅝	¾	1	1¼	1½	2	2½
Nominal	**ACR**	⅜	½	⅝	¾	⅞	1⅛	1⅜	1⅝	2⅛	2⅝
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside[1]		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		**Maximum Capacity in Cubic Feet of Gas per Hour**									
10		190	391	796	1,391	1,974	4,216	7,591	11,968	24,926	44,100
20		130	269	547	956	1,357	2,898	5,217	8,226	17,132	30,310
30		105	216	439	768	1,089	2,327	4,189	6,605	13,757	24,340
40		90	185	376	657	932	1,992	3,586	5,653	11,775	20,832
50		79	164	333	582	826	1,765	3,178	5,010	10,436	18,463
60		72	148	302	528	749	1,599	2,879	4,540	9,455	16,729
70		66	137	278	486	689	1,471	2,649	4,177	8,699	15,390
80		62	127	258	452	641	1,369	2,464	3,886	8,093	14,318
90		58	119	243	424	601	1,284	2,312	3,646	7,593	13,434
100		55	113	229	400	568	1,213	2,184	3,444	7,172	12,689
125		48	100	203	355	503	1,075	1,936	3,052	6,357	11,246
150		44	90	184	321	456	974	1,754	2,765	5,760	10,190
175		40	83	169	296	420	896	1,614	2,544	5,299	9,375
200		38	77	157	275	390	834	1,501	2,367	4,930	8,721
250		33	69	140	244	346	739	1,330	2,098	4,369	7,730
300		30	62	126	221	313	670	1,205	1,901	3,959	7,004

[1] Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

Table 12.11 Semi-Rigid Copper Tubing

							Gas			Natural	
							Inlet pressure			2.0 psi or less	
							Pressure Drop			1.0 psi	
							Specific Gravity			0.60	
						Tube Size (in.)					
	K & L	¼	⅜	½	⅝	¾	1	1¼	1½	2	2½
Nominal	**ACR**	⅜	½	⅝	¾	⅞	1⅛	1⅜	1⅝	2⅛	2⅝
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside[1]		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		**Maximum Capacity in Cubic Feet of Gas per Hour**									
10		245	506	1,030	1,800	2,554	5,455	9,820	15,483	32,247	57,051
20		169	348	708	1,237	1,755	3,749	6,749	10,641	22,163	39,211
30		135	279	568	993	1,409	3,011	5,420	8,545	17,798	31,488
40		116	239	486	850	1,206	2,577	4,639	7,314	15,232	26,949
50		103	212	431	754	1,069	2,284	4,111	6,482	13,500	23,885
60		93	192	391	683	969	2,069	3,725	5,873	12,232	21,641
70		86	177	359	628	891	1,904	3,427	5,403	11,253	19,910
80		80	164	334	584	829	1,771	3,188	5,027	10,469	18,522
90		75	154	314	548	778	1,662	2,991	4,716	9,823	17,379
100		71	146	296	518	735	1,570	2,826	4,455	9,279	16,416
125		63	129	263	459	651	1,391	2,504	3,948	8,223	14,549
150		57	117	238	416	590	1,260	2,269	3,577	7,451	13,183
175		52	108	219	383	543	1,160	2,087	3,291	6,855	12,128
200		49	100	204	356	505	1,079	1,942	3,062	6,377	11,283
250		43	89	181	315	448	956	1,721	2,714	5,652	10,000
300		39	80	164	286	406	866	1,559	2,459	5,121	9,060

[1] Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

Table 12.12 Semi-Rigid Copper Tubing

Gas	Natural
Inlet pressure	2.0 psi
Pressure Drop	1.5 psi
Specific Gravity	0.60

SPECIAL USE: **Pipe Sizing Between Point of Delivery and the House Line Regulator. Total Load Supplied by a Single House Line Regulator not Exceeding 150 Cubic Feet per Hour.[2]**

		Tube Size (in.)									
Nominal	K & L	¼	⅜	½	⅝	¾	1	1¼	1½	2	2½
	ACR	⅜	½	⅝	¾	⅞	1⅛	1⅜	1⅝	2⅛	2⅝
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside[1]		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		**Maximum Capacity in Cubic Feet of Gas per Hour**									
10		303	625	1,272	2,224	3,155	6,739	12,131	19,127	39,837	70,481
20		208	430	874	1,528	2,168	4,631	8,338	13,146	27,380	48,441
30		167	345	702	1,227	1,741	3,719	6,696	10,557	21,987	38,900
40		143	295	601	1,050	1,490	3,183	5,731	9,035	18,818	33,293
50		127	262	533	931	1,321	2,821	5,079	8,008	16,678	29,507
60		115	237	483	843	1,197	2,556	4,602	7,256	15,112	26,736
70		106	218	444	776	1,101	2,352	4,234	6,675	13,903	24,597
80		98	203	413	722	1,024	2,188	3,939	6,210	12,934	22,882
90		92	191	388	677	961	2,053	3,695	5,826	12,135	21,470
100		87	180	366	640	908	1,939	3,491	5,504	11,463	20,280
125		77	159	324	567	804	1,718	3,094	4,878	10,159	17,974
150		70	145	294	514	729	1,557	2,803	4,420	9,205	16,286
175		64	133	270	473	671	1,432	2,579	4,066	8,469	14,983
200		60	124	252	440	624	1,333	2,399	3,783	7,878	13,938
250		53	110	223	390	553	1,181	2,126	3,352	6,982	12,353
300		48	99	202	353	501	1,070	1,927	3,038	6,327	11,193

[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] When this table is used to size the tubing upstream of a line pressure regulator, the pipe or tubing downstream of the line pressure regulator shall be sized using a pressure drop no greater than 1 in. w.c.

Table 12.13 Semi-Rigid Copper Tubing

							Gas			Natural	
							Inlet pressure			5.0 psi or less	
							Pressure Drop			3.5 psi	
							Specific Gravity			0.60	
						Tube Size (in.)					
	K & L	¼	⅜	½	⅝	¾	1	1¼	1½	2	2½
Nominal	**ACR**	⅜	½	⅝	¾	⅞	1⅛	1⅜	1⅝	2⅛	2⅝
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside[1]		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		**Maximum Capacity in Cubic Feet of Gas per Hour**									
10		511	1,054	2,144	3,747	5,315	11,354	20,441	32,229	67,125	118,758
20		351	724	1,473	2,575	3,653	7,804	14,049	22,151	46,135	81,622
30		282	582	1,183	2,068	2,934	6,267	11,282	17,788	37,048	65,545
40		241	498	1,013	1,770	2,511	5,364	9,656	15,224	31,708	56,098
50		214	441	898	1,569	2,225	4,754	8,558	13,493	28,102	49,719
60		194	400	813	1,421	2,016	4,307	7,754	12,225	25,463	45,049
70		178	368	748	1,308	1,855	3,962	7,134	11,247	23,425	41,444
80		166	342	696	1,216	1,726	3,686	6,636	10,463	21,793	38,556
90		156	321	653	1,141	1,619	3,459	6,227	9,817	20,447	36,176
100		147	303	617	1,078	1,529	3,267	5,882	9,273	19,315	34,172
125		130	269	547	955	1,356	2,896	5,213	8,219	17,118	30,286
150		118	243	495	866	1,228	2,624	4,723	7,447	15,510	27,441
175		109	224	456	796	1,130	2,414	4,345	6,851	14,269	25,245
200		101	208	424	741	1,051	2,245	4,042	6,374	13,275	23,486
250		90	185	376	657	932	1,990	3,583	5,649	11,765	20,815
300		81	167	340	595	844	1,803	3,246	5,118	10,660	18,860

[1] Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

Table 12.14 Corrugated Stainless Steel Tubing (CSST)

							Gas			Natural	
							Inlet pressure			0.5 psi or less	
							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**	**46**	**62**
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**										
5	46	63	115	134	225	270	471	546	895	1,790	4,142
10	32	44	82	95	161	192	330	383	639	1,261	2,934
15	25	35	66	77	132	157	267	310	524	1,027	2,398
20	22	31	58	67	116	137	231	269	456	888	2,078
25	19	27	52	60	104	122	206	240	409	793	1,860
30	18	25	47	55	96	112	188	218	374	723	1,698
40	15	21	41	47	83	97	162	188	325	625	1,472
50	13	19	37	42	75	87	144	168	292	559	1,317
60	12	17	34	38	68	80	131	153	267	509	1,203
70	11	16	31	36	63	74	121	141	248	471	1,114
80	10	15	29	33	60	69	113	132	232	440	1,042
90	10	14	28	32	57	65	107	125	219	415	983
100	9	13	26	30	54	62	101	118	208	393	933
150	7	10	20	23	42	48	78	91	171	320	762
200	6	9	18	21	38	44	71	82	148	277	661
250	5	8	16	19	34	39	63	74	133	247	591
300	5	7	15	17	32	36	57	67	95	226	540

Note: Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends and/or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$, where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.
*EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

Table 12.15 Corrugated Stainless Steel Tubing (CSST)

							Gas			Natural	
							Inlet pressure			0.5 psi or less	
							Pressure Drop			3.0 in. w.c.	
							Specific Gravity			0.60	
						Tube Size (EHD)*					
Flow Designation:	**13**	**15**	**18**	**19**	**23**	**25**	**30**	**31**	**37**	**46**	**62**
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**										
5	120	160	277	327	529	649	1,182	1,365	2,141	4,428	10,103
10	83	112	197	231	380	462	828	958	1,528	3,199	7,156
15	67	90	161	189	313	379	673	778	1,254	2,541	5,848
20	57	78	140	164	273	329	580	672	1,090	2,197	5,069
25	51	69	125	147	245	295	518	599	978	1,963	4,536
30	46	63	115	134	225	270	471	546	895	1,790	4,142
40	39	54	100	116	196	234	407	471	778	1,548	3,590
50	35	48	89	104	176	210	363	421	698	1,383	3,213
60	32	44	82	95	161	192	330	383	639	1,261	2,934
70	29	41	76	88	150	178	306	355	593	1,166	2,717
80	27	38	71	82	141	167	285	331	555	1,090	2,543
90	26	36	67	77	133	157	268	311	524	1,027	2,398
100	24	34	63	73	126	149	254	295	498	974	2,276
150	19	27	52	60	104	122	206	240	409	793	1,860
200	17	23	45	52	91	106	178	207	355	686	1,612
250	15	21	40	46	82	95	159	184	319	613	1,442
300	13	19	37	42	75	87	144	168	234	559	1,317

Note: Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends and/or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$, where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.

*EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

Table 12.16 Corrugated Stainless Steel Tubing (CSST)

Gas	Natural
Inlet pressure	0.5 psi or less
Pressure Drop	6.0 in. w.c.
Specific Gravity	0.60

	Tube Size (EHD)*										
Flow Designation:	**13**	**15**	**18**	**19**	**23**	**25**	**30**	**31**	**37**	**46**	**62**
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**										
5	173	229	389	461	737	911	1,687	1,946	3,000	6,282	14,263
10	120	160	277	327	529	649	1,182	1,365	2,141	4,428	10,103
15	96	130	227	267	436	532	960	1,110	1,758	3,607	8,257
20	83	112	197	231	380	462	828	958	1,528	3,119	7,156
25	74	99	176	207	342	414	739	855	1,371	2,786	6,404
30	67	90	161	189	313	379	673	778	1,254	2,541	5,848
40	57	78	140	164	273	329	580	672	1,090	2,197	5,069
50	51	69	125	147	245	295	518	599	978	1,963	4,536
60	46	63	115	134	225	270	471	546	895	1,790	4,142
70	42	58	106	124	209	250	435	505	830	1,656	3,837
80	39	54	100	116	196	234	407	471	778	1,548	3,590
90	37	51	94	109	185	221	383	444	735	1,458	3,386
100	35	48	89	104	176	210	363	421	698	1,383	3,213
150	28	39	73	85	145	172	294	342	573	1,126	2,626
200	24	34	63	73	126	149	254	295	498	974	2,276
250	21	30	57	66	114	134	226	263	447	870	2,036
300	19	27	52	60	104	122	206	240	409	793	1,860

Note: Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends and/or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$, where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.
*EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

Table 12.17 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**	**46**	**62**
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**										
10	270	353	587	700	1,098	1,372	2,592	2,986	4,509	9,599	21,637
25	166	220	374	444	709	876	1,620	1,869	2,887	6,041	13,715
30	151	200	342	405	650	801	1,475	1,703	2,642	5,509	12,526
40	129	172	297	351	567	696	1,273	1,470	2,297	4,763	10,855
50	115	154	266	314	510	624	1,135	1,311	2,061	4,255	9,715
75	93	124	218	257	420	512	922	1,066	1,692	3,467	7,940
80	89	120	211	249	407	496	892	1,031	1,639	3,355	7,689
100	79	107	189	222	366	445	795	920	1,471	2,997	6,881
150	64	87	155	182	302	364	646	748	1,207	2,442	5,624
200	55	75	135	157	263	317	557	645	1,049	2,111	4,874
250	49	67	121	141	236	284	497	576	941	1,886	4,362
300	44	61	110	129	217	260	453	525	862	1,720	3,983
400	38	52	96	111	189	225	390	453	749	1,487	3,452
500	34	46	86	100	170	202	348	404	552	1,329	3,089

Notes:
1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds ¾ psi, do not use this table. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator may vary with flow rate.
2. CAUTION: Capacities shown in table may exceed maximum capacity for a selected regulator. Consult with regulator or tubing manufacturer for guidance.
3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger number of bends and/or fittings shall be increased by an equivalent length of tubing according to the following equation: $L = 1.3n$, where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.
*EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

Table 12.18 Corrugated Stainless Steel Tubing (CSST)

Gas	Natural
Inlet pressure	5.0 psi
Pressure Drop	3.5 psi
Specific Gravity	0.60

	Tube Size (EHD)*										
Flow Designation:	**13**	**15**	**18**	**19**	**23**	**25**	**30**	**31**	**37**	**46**	**62**
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**										
10	523	674	1,084	1,304	1,995	2,530	4,923	5,659	8,295	18,080	40,353
25	322	420	691	827	1,289	1,616	3,077	3,543	5,311	11,378	25,580
30	292	382	632	755	1,181	1,478	2,803	3,228	4,860	10,377	23,361
40	251	329	549	654	1,031	1,284	2,418	2,786	4,225	8,972	20,246
50	223	293	492	586	926	1,151	2,157	2,486	3,791	8,015	18,119
75	180	238	403	479	763	944	1,752	2,021	3,112	6,530	14,809
80	174	230	391	463	740	915	1,694	1,955	3,016	6,320	14,341
100	154	205	350	415	665	820	1,511	1,744	2,705	5,646	12,834
150	124	166	287	339	548	672	1,228	1,418	2,221	4,600	10,489
200	107	143	249	294	478	584	1,060	1,224	1,931	3,977	9,090
250	95	128	223	263	430	524	945	1,092	1,732	3,553	8,135
300	86	116	204	240	394	479	860	995	1,585	3,240	7,430
400	74	100	177	208	343	416	742	858	1,378	2,802	6,439
500	66	89	159	186	309	373	662	766	1,035	2,503	5,762

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 regulator manufacturer for pressure drops and capacity factors. Pressure drop across regulator may vary with the flow rate.
2. CAUTION: Capacities shown in table may exceed maximum capacity of selected regulator. Consult with tubing manufacturer for guidance.
3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends and/or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$, where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.
*EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

Table 12.19 Polyethylene Plastic Pipe

			Gas	Natural		
			Inlet pressure	1.0 psi or Less		
			Pressure Drop	0.3 in. w.c.		
			Specific Gravity	0.60		
			Pipe Size (in.)			
Nominal OD	½	¾	1	1¼	1½	2
Designation:	SDR 9.33	SDR 11.0	SDR 11.00	SDR 10.00	SDR 11.00	SDR 11.00
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**					
10	153	305	551	955	1,442	2,590
20	105	210	379	656	991	1,780
30	84	169	304	527	796	1,430
40	72	144	260	451	681	1,224
50	64	128	231	400	604	1,084
60	58	116	209	362	547	983
70	53	107	192	333	503	904
80	50	99	179	310	468	841
90	46	93	168	291	439	789
100	44	88	159	275	415	745
125	39	78	141	243	368	661
150	35	71	127	221	333	598
175	32	65	117	203	306	551
200	30	60	109	189	285	512

Table 12.20 Polyethylene Plastic Pipe

			Gas	Natural		
			Inlet pressure	1.0 psi or Less		
			Pressure Drop	0.5 in. w.c.		
			Specific Gravity	0.60		
			Pipe Size (in.)			
Nominal OD	½	¾	1	1¼	1½	2
Designation:	SDR 9.33	SDR 11.0	SDR 11.00	SDR 10.00	SDR 11.00	SDR 11.00
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**					
10	201	403	726	1,258	1,900	3,415
20	138	277	499	865	1,306	2,347
30	111	222	401	695	1,049	1,885
40	95	190	343	594	898	1,613
50	84	169	304	527	796	1,430
60	76	153	276	477	721	1,295
70	70	140	254	439	663	1,192
80	65	131	236	409	617	1,109
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

Table 12.21 Polyethylene Plastic Pipe

			Gas	Natural		
			Inlet pressure	2.0 psi		
			Pressure Drop	1.0 psi		
			Specific Gravity	0.60		
			Pipe Size (in.)			
Nominal OD	½	¾	1	1¼	1½	2
Designation:	SDR 9.33	SDR 11.0	SDR 11.00	SDR 10.00	SDR 11.00	SDR 11.00
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**					
10	1,858	3,721	6,714	11,631	17,565	31,560
20	1,277	2,557	4,614	7,994	12,072	21,691
30	1,026	2,054	3,706	6,420	9,695	17,419
40	878	1,758	3,172	5,494	8,297	14,908
50	778	1,558	2,811	4,869	7,354	13,213
60	705	1,412	2,547	4,412	6,663	11,972
70	649	1,299	2,343	4,059	6,130	11,014
80	603	1,208	2,180	3,776	5,703	10,246
90	566	1,134	2,045	3,543	5,351	9,614
100	535	1,071	1,932	3,347	5,054	9,081
125	474	949	1,712	2,966	4,479	8,048
150	429	860	1,551	2,688	4,059	7,292
175	395	791	1,427	2,473	3,734	6,709
200	368	736	1,328	2,300	3,474	6,241

Table 12.22 Schedule 40 Metallic Pipe

						Gas	Undiluted Propane		
						Inlet pressure	10.0 psi		
						Pressure Drop	1.0 psi		
						Specific Gravity	1.50		
SPECIAL USE:	**Pipe Sizing Between First Stage (High Pressure Regulator) and Second Stage (Low Pressure Regulator)**								
					Pipe Size (in.)				
Nominal Inside	½	¾	1	1¼	1½	2	3	3½	4
Actual	0.622	0.824	1.049	1.38	1.61	2.067	3.068	3.548	4.026
Length (ft)	**Maximum Capacity in Thousands of Btu per Hour**								
30	1,834	3,835	7,225	14,834	22,225	42,804	120,604	176,583	245,995
40	1,570	3,283	6,184	12,696	19,022	36,634	103,222	151,132	210,539
50	1,391	2,909	5,480	11,252	16,859	32,468	91,484	133,946	186,597
60	1,261	2,636	4,966	10,195	15,275	29,419	82,891	121,364	169,071
70	1,160	2,425	4,568	9,379	14,053	27,065	76,258	111,654	155,543
80	1,079	2,256	4,250	8,726	13,074	25,179	70,944	103,872	144,703
90	1,012	2,117	3,988	8,187	12,267	23,624	66,564	97,460	135,770
100	956	2,000	3,767	7,733	11,587	22,315	62,876	92,060	128,247
150	768	1,606	3,025	6,210	9,305	17,920	50,492	73,927	102,987
200	657	1,374	2,589	5,315	7,964	15,337	43,214	63,272	88,144
250	582	1,218	2,294	4,711	7,058	13,593	38,300	56,077	78,120
300	528	1,104	2,079	4,268	6,395	12,316	34,703	50,810	70,782
350	486	1,015	1,913	3,927	5,883	11,331	31,926	46,744	65,119
400	452	945	1,779	3,653	5,473	10,541	29,701	43,487	60,581
450	424	886	1,669	3,428	5,135	9,890	27,867	40,802	56,841
500	400	837	1,577	3,238	4,851	9,342	26,323	38,541	53,691
600	363	759	1,429	2,934	4,395	8,465	23,851	34,921	48,648
700	334	698	1,314	2,699	4,044	7,788	21,943	32,127	44,756
800	310	649	1,223	2,511	3,762	7,245	20,413	29,888	41,637
900	291	609	1,147	2,356	3,530	6,798	19,153	28,043	39,066
1,000	275	575	1,084	2,225	3,334	6,421	18,092	26,489	36,902
1,500	221	462	870	1,787	2,677	5,156	14,528	21,272	29,633
2,000	189	395	745	1,529	2,291	4,413	12,435	18,206	25,362

Table 12.23 Schedule 40 Metallic Pipe

					Gas		Undiluted Propane		
					Inlet pressure		2.0 psi		
					Pressure Drop		1.0 psi		
					Specific Gravity		1.50		
					Pipe Size (in.)				
Nominal	½	¾	1	1¼	1½	2	2½	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	**Maximum Capacity in Thousands of Btu per Hour**								
10	2,676	5,595	10,539	21,638	32,420	62,438	99,516	175,927	358,835
20	1,839	3,845	7,243	14,872	22,282	42,913	68,397	120,914	246,625
30	1,477	3,088	5,817	11,942	17,893	34,461	54,925	97,098	198,049
40	1,264	2,643	4,978	10,221	15,314	29,494	47,009	83,103	169,504
50	1,120	2,342	4,412	9,059	13,573	26,140	41,663	73,653	150,229
60	1,015	2,122	3,998	8,208	12,298	23,685	37,750	66,735	136,118
70	934	1,952	3,678	7,551	11,314	21,790	34,729	61,395	125,227
80	869	1,816	3,422	7,025	10,526	20,271	32,309	57,116	116,499
90	815	1,704	3,210	6,591	9,876	19,020	30,314	53,590	109,307
100	770	1,610	3,033	6,226	9,329	17,966	28,635	50,621	103,251
125	682	1,427	2,688	5,518	8,268	15,923	25,378	44,865	91,510
150	618	1,293	2,435	5,000	7,491	14,427	22,995	40,651	82,914
175	569	1,189	2,240	4,600	6,892	13,273	21,155	37,398	76,280
200	529	1,106	2,084	4,279	6,411	12,348	19,681	34,792	70,964

Table 12.24 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			
SPECIAL USE:	**Pipe Sizing Between Single or Second Stage (Low Pressure Regulator) and Appliance.**								
					Pipe Size (in.)				
Nominal Inside	½	¾	1	1¼	1½	2	3	3½	4
Actual:	0.622	0.824	1.049	1.38	1.61	2.067	3.068	3.548	4.026
Length (ft)	**Maximum Capacity in Thousands of Btu per Hour**								
10	291	608	1,145	2,352	3,523	6,786	19,119	27,993	38,997
20	200	418	787	1,616	2,422	4,664	13,141	19,240	26,802
30	160	336	632	1,298	1,945	3,745	10,552	15,450	21,523
40	137	287	541	1,111	1,664	3,205	9,031	13,223	18,421
50	122	255	480	984	1,475	2,841	8,004	11,720	16,326
60	110	231	434	892	1,337	2,574	7,253	10,619	14,793
80	94	197	372	763	1,144	2,203	6,207	9,088	12,661
100	84	175	330	677	1,014	1,952	5,501	8,055	11,221
125	74	155	292	600	899	1,730	4,876	7,139	9,945
150	67	140	265	543	814	1,568	4,418	6,468	9,011
200	58	120	227	465	697	1,342	3,781	5,536	7,712
250	51	107	201	412	618	1,189	3,351	4,906	6,835
300	46	97	182	373	560	1,078	3,036	4,446	6,193
350	42	89	167	344	515	991	2,793	4,090	5,698
400	40	83	156	320	479	922	2,599	3,805	5,301

Table 12.25 Semi-Rigid Copper Tubing

Gas	Undiluted Propane
Inlet pressure	10.0 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

SPECIAL USE: **Sizing Between First Stage (High Pressure Regulator) and Second Stage (Low Pressure Regulator)**

		Tube Size (in.)									
	K & L	¼	⅜	½	⅝	¾	1	1¼	1½	2	2½
Nominal	**ACR**	⅜	½	⅝	¾	⅞	1⅛	1⅜	1⅝	2⅛	2⅝
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside[1]		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		**Maximum Capacity in Thousands of Btu per Hour**									
10		513	1,058	2,152	3,760	5,335	11,396	20,516	32,347	67,371	119,193
20		352	727	1,479	2,585	3,667	7,832	14,101	22,232	46,303	81,921
30		283	584	1,188	2,075	2,944	6,290	11,323	17,853	37,183	65,785
40		242	500	1,016	1,776	2,520	5,383	9,691	15,280	31,824	56,304
50		215	443	901	1,574	2,234	4,771	8,589	13,542	28,205	49,901
60		194	401	816	1,426	2,024	4,323	7,782	12,270	25,556	45,214
70		179	369	751	1,312	1,862	3,977	7,160	11,288	23,511	41,596
80		166	343	699	1,221	1,732	3,700	6,661	10,502	21,873	38,697
90		156	322	655	1,145	1,625	3,471	6,250	9,853	20,522	36,308
100		147	304	619	1,082	1,535	3,279	5,903	9,307	19,385	34,297
125		131	270	549	959	1,361	2,906	5,232	8,249	17,181	30,396
150		118	244	497	869	1,233	2,633	4,741	7,474	15,567	27,541
175		109	225	457	799	1,134	2,423	4,361	6,876	14,321	25,338
200		101	209	426	744	1,055	2,254	4,057	6,397	13,323	23,572
225		95	196	399	698	990	2,115	3,807	6,002	12,501	22,117
250		90	185	377	659	935	1,997	3,596	5,669	11,808	20,891
275		85	176	358	626	888	1,897	3,415	5,385	11,215	19,841
300		81	168	342	597	847	1,810	3,258	5,137	10,699	18,929

[1] Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

Table 12.26 Semi-Rigid Copper Tubing

							Gas			Undiluted Propane	
							Inlet pressure			11.0 in. w.c.	
							Pressure Drop			0.5 in. w.c.	
							Specific Gravity			1.50	
SPECIAL USE:		**Sizing Between Single or Second Stage (Low Pressure Regulator) and Appliance**									
		Tube Size (in.)									
	K & L	¼	⅜	½	⅝	¾	1	1¼	1½	2	2½
Nominal	**ACR**	⅜	½	⅝	¾	⅞	1⅛	1⅜	1⅝	2⅛	2⅝
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside[1]		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		**Maximum Capacity in Thousands of Btu per Hour**									
10		45	93	188	329	467	997	1,795	2,830	5,895	10,429
20		31	64	129	226	321	685	1,234	1,945	4,051	7,168
30		25	51	104	182	258	550	991	1,562	3,253	5,756
40		21	44	89	155	220	471	848	1,337	2,784	4,926
50		19	39	79	138	195	417	752	1,185	2,468	4,366
60		17	35	71	125	177	378	681	1,074	2,236	3,956
70		16	32	66	115	163	348	626	988	2,057	3,639
80		15	30	61	107	152	324	583	919	1,914	3,386
90		14	28	57	100	142	304	547	862	1,796	3,177
100		13	27	54	95	134	287	517	814	1,696	3,001
125		11	24	48	84	119	254	458	722	1,503	2,660
150		10	21	44	76	108	230	415	654	1,362	2,410
175		10	20	40	70	99	212	382	602	1,253	2,217
200		8.9	18	37	65	92	197	355	560	1,166	2,062
225		8.3	17	35	61	87	185	333	525	1,094	1,935
250		7.9	16	33	58	82	175	315	496	1,033	1,828
275		7.5	15	31	55	78	166	299	471	981	1,736
300		7.1	15	30	52	74	158	285	449	936	1,656

[1] Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

Table 12.27 Semi-Rigid Copper Tubing

							Gas			Undiluted Propane	
							Inlet pressure			2.0 psi	
							Pressure Drop			1.0 psi	
							Specific Gravity			1.50	
						Tube Size (in.)					
	K & L	¼	⅜	½	⅝	¾	1	1¼	1½	2	2½
Nominal	**ACR**	⅜	½	⅝	¾	⅞	1⅛	1⅜	1⅝	2⅛	2⅝
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside[1]		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		**Maximum Capacity in Thousands of Btu per Hour**									
10		413	852	1,732	3,027	4,295	9,175	16,517	26,042	54,240	95,962
20		284	585	1,191	2,081	2,952	6,306	11,352	17,899	37,279	65,954
30		228	470	956	1,671	2,371	5,064	9,116	14,373	29,936	52,963
40		195	402	818	1,430	2,029	4,334	7,802	12,302	25,621	45,330
50		173	356	725	1,267	1,798	3,841	6,915	10,903	22,708	40,175
60		157	323	657	1,148	1,629	3,480	6,266	9,879	20,575	36,401
70		144	297	605	1,057	1,499	3,202	5,764	9,088	18,929	33,489
80		134	276	562	983	1,394	2,979	5,363	8,455	17,609	31,155
90		126	259	528	922	1,308	2,795	5,031	7,933	16,522	29,232
100		119	245	498	871	1,236	2,640	4,753	7,493	15,607	27,612
125		105	217	442	772	1,095	2,340	4,212	6,641	13,832	24,472
150		95	197	400	700	992	2,120	3,817	6,017	12,533	22,173
175		88	181	368	644	913	1,950	3,511	5,536	11,530	20,399
200		82	168	343	599	849	1,814	3,267	5,150	10,727	18,978
225		77	158	321	562	797	1,702	3,065	4,832	10,064	17,806
250		72	149	304	531	753	1,608	2,895	4,564	9,507	16,819
275		69	142	288	504	715	1,527	2,750	4,335	9,029	15,974
300		66	135	275	481	682	1,457	2,623	4,136	8,614	15,240

[1] Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

Table 12.28 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	
	Tube Size (EHD)*										
Flow Designation:	**13**	**15**	**18**	**19**	**23**	**25**	**30**	**31**	**37**	**46**	**62**
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**										
5	72	99	181	211	355	426	744	863	1,415	2,830	6,547
10	50	69	129	150	254	303	521	605	971	1,993	4,638
15	39	55	104	121	208	248	422	490	775	1,623	3,791
20	34	49	91	106	183	216	365	425	661	1,404	3,285
25	30	42	82	94	164	192	325	379	583	1,254	2,940
30	28	39	74	87	151	177	297	344	528	1,143	2,684
40	23	33	64	74	131	153	256	297	449	988	2,327
50	20	30	58	66	118	137	227	265	397	884	2,082
60	19	26	53	60	107	126	207	241	359	805	1,902
70	17	25	49	57	99	117	191	222	330	745	1,761
80	15	23	45	52	94	109	178	208	307	696	1,647
90	15	22	44	50	90	102	169	197	286	656	1,554
100	14	20	41	47	85	98	159	186	270	621	1,475
150	11	15	31	36	66	75	123	143	217	506	1,205
200	9	14	28	33	60	69	112	129	183	438	1,045
250	8	12	25	30	53	61	99	117	163	390	934
300	8	11	23	26	50	57	90	107	147	357	854

Note: Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends and/or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$, where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.
*EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

Table 12.29 Corrugated Stainless Steel Tubing (CSST)

Gas	Undiluted Propane
Inlet pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

	Tube Size (EHD)*										
Flow Designation:	**13**	**15**	**18**	**19**	**23**	**25**	**30**	**31**	**37**	**46**	**62**
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**										
10	426	558	927	1,106	1,735	2,168	4,097	4,720	7,128	15,174	34,203
25	262	347	591	701	1,120	1,384	2,560	2,954	4,564	9,549	21,680
30	238	316	540	640	1,027	1,266	2,331	2,692	4,176	8,708	19,801
40	203	271	469	554	896	1,100	2,012	2,323	3,631	7,529	17,159
50	181	243	420	496	806	986	1,794	2,072	3,258	6,726	15,357
75	147	196	344	406	663	809	1,457	1,685	2,675	5,480	12,551
80	140	189	333	393	643	768	1,410	1,629	2,591	5,303	12,154
100	124	169	298	350	578	703	1,256	1,454	2,325	4,738	10,877
150	101	137	245	287	477	575	1,021	1,182	1,908	3,860	8,890
200	86	118	213	248	415	501	880	1,019	1,658	3,337	7,705
250	77	105	191	222	373	448	785	910	1,487	2,981	6,895
300	69	96	173	203	343	411	716	829	1,363	2,719	6,296
400	60	82	151	175	298	355	616	716	1,163	2,351	5,457
500	53	72	135	158	268	319	550	638	1,027	2,101	4,883

Notes:
1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds ½ psi (based on 13 in. w.c. outlet pressure), do not use this table. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator may vary with flow rate.
2. CAUTION: Capacities shown in table may exceed maximum capacity for a selected regulator. Consult with regulator or tubing manufacturer for guidance.
3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger number of bends and/or fittings shall be increased by an equivalent length of tubing according to the following equation: $L = 1.3n$, where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.
*EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

Table 12.30 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**	**46**	**62**
Length (ft)	**Maximum Capacity in Cubic Feet of Gas per Hour**										
10	826	1,065	1,713	2,061	3,153	3,999	7,829	8,945	13,112	28,580	63,788
25	509	664	1,092	1,307	2,037	2,554	4,864	5,600	8,395	17,986	40,436
30	461	603	999	1,193	1,866	2,336	4,430	5,102	7,682	16,403	36,928
40	396	520	867	1,033	1,629	2,029	3,822	4,404	6,679	14,183	32,004
50	352	463	777	926	1,463	1,819	3,409	3,929	5,993	12,670	28,642
75	284	376	637	757	1,206	1,492	2,769	3,194	4,919	10,322	23,409
80	275	363	618	731	1,169	1,446	2,677	3,090	4,768	9,990	22,670
100	243	324	553	656	1,051	1,296	2,388	2,756	4,276	8,925	20,287
150	196	262	453	535	866	1,062	1,941	2,241	3,511	7,271	16,581
200	169	226	393	464	755	923	1,675	1,934	3,052	6,287	14,369
250	150	202	352	415	679	828	1,493	1,726	2,738	5,616	12,859
300	136	183	322	379	622	757	1,359	1,572	2,505	5,122	11,745
400	117	158	279	328	542	657	1,173	1,356	2,178	4,429	10,178
500	104	140	251	294	488	589	1,046	1,210	1,954	3,957	9,108

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 regulator manufacturer for pressure drops and capacity factors. Pressure drop across regulator may vary with the flow rate.
2. CAUTION: Capacities shown in table may exceed maximum capacity of selected regulator. Consult with tubing manufacturer for guidance.
3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends and/or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$, where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.
*EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

Table 12.31 Polyethylene Plastic Pipe

					Gas	Undiluted Propane
					Inlet pressure	11.0 in. w.c.
					Pressure Drop	0.5 in. w.c.
					Specific Gravity	1.50
			Pipe Size (in.)			
Nominal OD	½	¾	1	1¼	1½	2
Designation:	SDR 9.33	SDR 11.0	SDR 11.00	SDR 10.00	SDR 11.00	SDR 11.00
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	**Maximum Capacity in Thousands of Btu per Hour**					
10	340	680	1,227	2,126	3,211	5,769
20	233	467	844	1,461	2,207	3,965
30	187	375	677	1,173	1,772	3,184
40	160	321	580	1,004	1,517	2,725
50	142	285	514	890	1,344	2,415
60	129	258	466	807	1,218	2,188
70	119	237	428	742	1,121	2,013
80	110	221	398	690	1,042	1,873
90	103	207	374	648	978	1,757
100	98	196	353	612	924	1,660
125	87	173	313	542	819	1,471
150	78	157	284	491	742	1,333
175	72	145	261	452	683	1,226
200	67	135	243	420	635	1,141

Table 12.32 Polyethylene Plastic Pipe

					Gas	Undiluted Propane
					Inlet pressure	2.0 psi
					Pressure Drop	1.0 psi
					Specific Gravity	1.50
			Pipe Size (in.)			
Nominal OD	½	¾	1	1¼	1½	2
Designation:	SDR 9.33	SDR 11.0	SDR 11.00	SDR 10.00	SDR 11.00	SDR 11.00
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	**Maximum Capacity in Thousands of Btu per Hour**					
10	3,126	6,259	11,293	19,564	29,545	53,085
20	2,148	4,302	7,762	13,446	20,306	36,485
30	1,725	3,454	6,233	10,798	16,307	29,299
40	1,477	2,957	5,335	9,242	13,956	25,076
50	1,309	2,620	4,728	8,191	12,369	22,225
60	1,186	2,374	4,284	7,421	11,207	20,137
70	1,091	2,184	3,941	6,828	10,311	18,526
80	1,015	2,032	3,666	6,352	9,592	17,235
90	952	1,907	3,440	5,960	9,000	16,171
100	899	1,801	3,249	5,629	8,501	15,275
125	797	1,596	2,880	4,989	7,535	13,538
150	722	1,446	2,609	4,521	6,827	12,266
175	664	1,331	2,401	4,159	6,281	11,285
200	618	1,238	2,233	3,869	5,843	10,498

Table 12.33 Polyethylene Plastic Tubing

	Gas	Undiluted Propane
	Inlet pressure	11.0 in. w.c.
	Pressure Drop	0.5 in. w.c.
	Specific Gravity	1.50
Plastic Tubing Size (CTS) (in.)		
Nominal OD	½	¾
Designation:	SDR 7.00	SDR 11.00
Actual ID	0.445	0.927
Length (ft)	**Maximum Capacity in Thousands of Btu 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

Chapter 13 Sizing of Category I Venting Systems

13.1 Additional Requirements to Single Appliance Vent Table 13.1 Through Table 13.5

13.1.1 Obstructions and Vent Dampers. These venting tables shall not be used where obstructions (see Section 10.15) 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.

13.1.2 Vent Downsizing. Where the vent size determined from the tables is smaller than the appliance draft hood outlet or flue collar, the use of the smaller size shall be permitted provided that the installation complies with all of the following requirements:

(1) The total vent height *(H)* is at least 10 ft (3 m).
(2) Vents for appliance draft hood outlets or flue collars 12 in. (300 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 in. (300 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 × maximum table capacity).
(5) The draft hood outlet is greater than 4 in. (100 mm) in diameter. Do not connect a 3-in. (80-mm) diameter vent to a 4-in. (100-mm) diameter draft hood outlet. This provision shall not apply to fan-assisted appliances.

13.1.3 Elbows. Single-appliance venting configurations with zero (0) lateral lengths in Table 13.1, Table 13.2, and Table 13.5 shall not have elbows in the venting system. For each elbow up to and including 45 degrees, the maximum capacity listed in the venting tables shall be reduced by 5 percent. For each elbow greater than 45 degrees up to and including 90 degrees, the maximum capacity listed in the venting tables shall be reduced by 10 percent.

13.1.4 Zero Lateral. Zero (0) lateral *(L)* shall apply only to a straight vertical vent attached to a top outlet draft hood or flue collar.

13.1.5 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.

13.1.6 Two Stage/Modulating 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.

13.1.7* Corrugated Chimney Liners. Listed corrugated metallic chimney liner systems in masonry chimneys shall be sized by using Table 13.1 or Table 13.2 for Type B vents with the maximum capacity reduced by 20 percent (0.80 × maximum capacity) and the minimum capacity as shown in Table 13.1 or Table 13.2. Corrugated metallic liner systems installed with bends or offsets shall have their maximum capacity further reduced in accordance with 13.1.3. The 20 percent reduction for corrugated metallic chimney liner systems includes an allowance for one long radius 90-degree turn at the bottom of the liner.

13.1.8 Vertical Vent Upsizing/7× Rule. Where the vertical vent has a larger diameter than the vent connector, the vertical vent diameter shall be used to determine the minimum vent capacity, and the connector diameter shall be used to determine the maximum vent capacity. The flow area of the vertical vent shall not exceed seven times the flow area of the listed appliance categorized vent area, flue collar area, or draft

Table 13.1 Type B Double-Wall Gas Vent

Number of Appliances:	Single
Appliance Type:	Category I
Appliance Vent Connection:	Connected Directly to Vent

Height H (ft)	Lateral L (ft)	Vent Diameter — D (in.)																					
		3			4			5			6			7			8			9				
		Appliance Input Rating in Thousands of Btu per Hour																					
		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	
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	1006	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	1096	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	1263	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	1057	575	0	1384	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	1173	650	0	1548	855	
	2	9	81	56	13	166	112	14	283	185	18	432	280	27	613	394	33	826	535	42	1072	700	
	5	21	77	54	28	160	108	36	275	176	45	421	273	58	600	385	69	811	524	82	1055	688	
	10	27	70	50	37	150	102	48	262	171	59	405	261	77	580	371	91	788	507	107	1028	668	
	15	33	64	NA	44	141	96	57	249	163	70	389	249	90	560	357	105	765	490	124	1002	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	1297	708	0	1730	952	
	2	8	86	61	11	183	122	14	320	206	15	497	314	22	715	445	26	975	615	33	1276	813	
	5	20	82	NA	27	177	119	35	312	200	43	487	308	55	702	438	65	960	605	77	1259	798	
	10	26	76	NA	35	168	114	45	299	190	56	471	298	73	681	426	86	935	589	101	1230	773	
	15	59	70	NA	42	158	NA	54	287	180	66	455	288	85	662	413	100	911	572	117	1203	747	
	20	NA	NA	NA	50	149	NA	63	275	169	76	440	278	97	642	401	113	888	556	131	1176	722	
	30	NA	NA	NA	69	131	NA	84	250	NA	99	410	259	123	605	376	141	844	522	161	1125	670	
100	0	NA	NA	NA	0	218	NA	0	407	NA	0	665	400	0	997	560	0	1411	770	0	1908	1040	
	2	NA	NA	NA	10	194	NA	12	354	NA	13	566	375	18	831	510	21	1155	700	25	1536	935	
	5	NA	NA	NA	26	189	NA	33	347	NA	40	557	369	52	820	504	60	1141	692	71	1519	926	
	10	NA	NA	NA	33	182	NA	43	335	NA	53	542	361	68	801	493	80	1118	679	94	1492	910	
	15	NA	NA	NA	40	174	NA	50	321	NA	62	528	353	80	782	482	93	1095	666	109	1465	895	
	20	NA	NA	NA	47	166	NA	59	311	NA	71	513	344	90	763	471	105	1073	653	122	1438	880	
	30	NA	NA	NA	NA	NA	NA	78	290	NA	92	483	NA	115	726	449	131	1029	627	149	1387	849	
	50	NA	NA	NA	NA	NA	NA	NA	NA	NA	147	428	NA	180	651	405	197	944	575	217	1288	787	

Table 13.1 ***Continued***

Number of Appliances:	Single
Appliance Type:	Category I
Appliance Vent Connection:	Connected Directly to Vent

Height *H* (ft)	Lateral *L* (ft)	Vent Diameter — *D* (in.)																							
		10			12			14			16			18			20			22			24		
		Appliance Input Rating in Thousands of Btu per Hour																							
		FAN		NAT	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
6	0	0	1121	570	0	1645	850	0	2267	1170	0	2983	1530	0	3802	1960	0	4721	2430	0	5737	2950	0	6853	3520
	2	75	675	455	103	982	650	138	1346	890	178	1769	1170	225	2250	1480	296	2782	1850	360	3377	2220	426	4030	2670
	4	110	668	445	147	975	640	191	1338	880	242	1761	1160	300	2242	1475	390	2774	1835	469	3370	2215	555	4023	2660
	6	128	661	435	171	967	630	219	1330	870	276	1753	1150	341	2235	1470	437	2767	1820	523	3363	2210	618	4017	2650
8	0	0	1261	660	0	1858	970	0	2571	1320	0	3399	1740	0	4333	2220	0	5387	2750	0	6555	3360	0	7838	4010
	2	71	770	515	98	1124	745	130	1543	1020	168	2030	1340	212	2584	1700	278	3196	2110	336	3882	2560	401	4634	3050
	5	115	758	503	154	1110	733	199	1528	1010	251	2013	1330	311	2563	1685	398	3180	2090	476	3863	2545	562	4612	3040
	8	137	746	490	180	1097	720	231	1514	1000	289	2000	1320	354	2552	1670	450	3163	2070	537	3850	2530	630	4602	3030
10	0	0	1377	720	0	2036	1060	0	2825	1450	0	3742	1925	0	4782	2450	0	5955	3050	0	7254	3710	0	8682	4450
	2	68	852	560	93	1244	850	124	1713	1130	161	2256	1480	202	2868	1890	264	3556	2340	319	4322	2840	378	5153	3390
	5	112	839	547	149	1229	829	192	1696	1105	243	2238	1461	300	2849	1871	382	3536	2318	458	4301	2818	540	5132	3371
	10	142	817	525	187	1204	795	238	1669	1080	298	2209	1430	364	2818	1840	459	3504	2280	546	4268	2780	641	5099	3340
15	0	0	1596	840	0	2380	1240	0	3323	1720	0	4423	2270	0	5678	2900	0	7099	3620	0	8665	4410	0	10,393	5300
	2	63	1019	675	86	1495	985	114	2062	1350	147	2719	1770	186	3467	2260	239	4304	2800	290	5232	3410	346	6251	4080
	5	105	1003	660	140	1476	967	182	2041	1327	229	2696	1748	283	3442	2235	355	4278	2777	426	5204	3385	501	6222	4057
	10	135	977	635	177	1446	936	227	2009	1289	283	2659	1712	346	3402	2193	432	4234	2739	510	5159	3343	599	6175	4019
	15	155	953	610	202	1418	905	257	1976	1250	318	2623	1675	385	3363	2150	479	4192	2700	564	5115	3300	665	6129	3980
20	0	0	1756	930	0	2637	1350	0	3701	1900	0	4948	2520	0	6376	3250	0	7988	4060	0	9785	4980	0	11,753	6000
	2	59	1150	755	81	1694	1100	107	2343	1520	139	3097	2000	175	3955	2570	220	4916	3200	269	5983	3910	321	7154	4700
	5	101	1133	738	135	1674	1079	174	2320	1498	219	3071	1978	270	3926	2544	337	4885	3174	403	5950	3880	475	7119	4662
	10	130	1105	710	172	1641	1045	220	2282	1460	273	3029	1940	334	3880	2500	413	4835	3130	489	5896	3830	573	7063	4600
	15	150	1078	688	195	1609	1018	248	2245	1425	306	2988	1910	372	3835	2465	459	4786	3090	541	5844	3795	631	7007	4575
	20	167	1052	665	217	1578	990	273	2210	1390	335	2948	1880	404	3791	2430	495	4737	3050	585	5792	3760	689	6953	4550
30	0	0	1977	1060	0	3004	1550	0	4252	2170	0	5725	2920	0	7420	3770	0	9341	4750	0	11,483	5850	0	13,848	7060
	2	54	1351	865	74	2004	1310	98	2786	1800	127	3696	2380	159	4734	3050	199	5900	3810	241	7194	4650	285	8617	5600
	5	96	1332	851	127	1981	1289	164	2759	1775	206	3666	2350	252	4701	3020	312	5863	3783	373	7155	4622	439	8574	5552
	10	125	1301	829	164	1944	1254	209	2716	1733	259	3617	2300	316	4647	2970	386	5803	3739	456	7090	4574	535	8505	5471
	15	143	1272	807	187	1908	1220	237	2674	1692	292	3570	2250	354	4594	2920	431	5744	3695	507	7026	4527	590	8437	5391
	20	160	1243	784	207	1873	1185	260	2633	1650	319	3523	2200	384	4542	2870	467	5686	3650	548	6964	4480	639	8370	5310
	30	195	1189	745	246	1807	1130	305	2555	1585	369	3433	2130	440	4442	2785	540	5574	3565	635	6842	4375	739	8239	5225
50	0	0	2231	1195	0	3441	1825	0	4934	2550	0	6711	3440	0	8774	4460	0	11,129	5635	0	13,767	6940	0	16,694	8430
	2	41	1620	1010	66	2431	1513	86	3409	2125	113	4554	2840	141	5864	3670	171	7339	4630	209	8980	5695	251	10,788	6860
	5	90	1600	996	118	2406	1495	151	3380	2102	191	4520	2813	234	5826	3639	283	7295	4597	336	8933	5654	394	10,737	6818
	10	118	1567	972	154	2366	1466	196	3332	2064	243	4464	2767	295	5763	3585	355	7224	4542	419	8855	5585	491	10,652	6749
	15	136	1536	948	177	2327	1437	222	3285	2026	274	4409	2721	330	5701	3534	396	7155	4511	465	8779	5546	542	10,570	6710
	20	151	1505	924	195	2288	1408	244	3239	1987	300	4356	2675	361	5641	3481	433	7086	4479	506	8704	5506	586	10,488	6670
	30	183	1446	876	232	2214	1349	287	3150	1910	347	4253	2631	412	5523	3431	494	6953	4421	577	8557	5444	672	10,328	6603
100	0	0	2491	1310	0	3925	2050	0	5729	2950	0	7914	4050	0	10,485	5300	0	13,454	6700	0	16,817	8600	0	20,578	10,300
	2	30	1975	1170	44	3027	1820	72	4313	2550	95	5834	3500	120	7591	4600	138	9577	5800	169	11,803	7200	204	14,264	8800
	5	82	1955	1159	107	3002	1803	136	4282	2531	172	5797	3475	208	7548	4566	245	9528	5769	293	11,748	7162	341	14,204	8756
	10	108	1923	1142	142	2961	1775	180	4231	2500	223	5737	3434	268	7478	4509	318	9447	5717	374	11,658	7100	436	14,105	8683
	15	126	1892	1124	163	2920	1747	206	4182	2469	252	5678	3392	304	7409	4451	358	9367	5665	418	11,569	7037	487	14,007	8610
	20	141	1861	1107	181	2880	1719	226	4133	2438	277	5619	3351	330	7341	4394	387	9289	5613	452	11,482	6975	523	13,910	8537
	30	170	1802	1071	215	2803	1663	265	4037	2375	319	5505	3267	378	7209	4279	446	9136	5509	514	11,310	6850	592	13,720	8391
	50	241	1688	1000	292	2657	1550	350	3856	2250	415	5289	3100	486	6956	4050	572	8841	5300	659	10,979	6600	752	13,354	8100

For SI units, 1 in. = 25.4 mm, 1 ft = 0.305 m, 1000 Btu/hr = 0.293 kW, 1 in.^{2} = 645 mm^2.

Table 13.2 Type B Double-Wall Vent

Number of Appliances:	Single
Appliance Type:	Category I
Appliance Vent Connection:	Single Wall Metal Connector

		Vent Diameter — *D* (in.)																											
		3			**4**			**5**			**6**			**7**			**8**			**9**			**10**			**12**				
		Appliance Input Rating in Thousands of Btu per Hour																											
Height *H*	**Lateral *L***	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**		
(ft)	**(ft)**	**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	1118	569	537	1639	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	1002	536	360	1257	658	521	1852	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	1120	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	1104	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	1089	715		
10	0	37	87	53	57	174	99	82	293	165	120	444	254	158	628	344	202	844	449	253	1093	584	351	1373	718	507	2031	1057		
	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	1242	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	1224	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	1194	788		
15	0	36	93	57	56	190	111	80	325	186	116	499	283	153	713	388	195	966	523	244	1259	681	336	1591	838	488	2374	1237		
	2	38	69	47	57	136	93	80	225	149	115	337	224	148	473	314	187	631	413	232	812	543	319	1015	673	457	1491	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	1469	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	1433	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	1399	894		
20	0	35	96	60	54	200	118	78	346	201	114	537	306	149	772	428	190	1053	573	238	1379	750	326	1751	927	473	2631	1346		
	2	37	74	50	56	148	99	78	248	165	113	375	248	144	528	344	182	708	468	227	914	611	309	1146	754	443	1689	1098		
	5	50	68	47	73	140	94	100	239	158	141	363	239	178	514	334	224	692	457	279	896	596	381	1126	734	547	1665	1074		
	10	NA	NA	41	93	129	86	125	223	146	177	344	224	222	491	316	277	666	437	339	866	570	457	1092	702	646	1626	1037		
	15	NA	NA	NA	NA	NA	80	155	208	136	216	325	210	264	469	301	325	640	419	393	838	549	526	1060	677	730	1587	1005		
	20	NA	NA	NA	NA	NA	NA	186	192	126	254	306	196	309	448	285	374	616	400	448	810	526	592	1028	651	808	1550	973		
30	0	34	99	63	53	211	127	76	372	219	110	584	334	144	849	472	184	1168	647	229	1542	852	312	1971	1056	454	2996	1545		
	2	37	80	56	55	164	111	76	281	183	109	429	279	139	610	392	175	823	533	219	1069	698	296	1346	863	424	1999	1308		
	5	49	74	52	72	157	106	98	271	173	136	417	271	171	595	382	215	806	521	269	1049	684	366	1324	846	524	1971	1283		
	10	NA	NA	NA	91	144	98	122	255	168	171	397	257	213	570	367	265	777	501	327	1017	662	440	1287	821	620	1927	1243		
	15	NA	NA	NA	115	131	NA	151	239	157	208	377	242	255	547	349	312	750	481	379	985	638	507	1251	794	702	1884	1205		
	20	NA	NA	NA	NA	NA	NA	181	223	NA	246	357	228	298	524	333	360	723	461	433	955	615	570	1216	768	780	1841	1166		
	30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	389	477	305	461	670	426	541	895	574	704	1147	720	937	1759	1101		
50	0	33	99	66	51	213	133	73	394	230	105	629	361	138	928	515	176	1292	704	220	1724	948	295	2223	1189	428	3432	1818		
	2	36	84	61	53	181	121	73	318	205	104	495	312	133	712	443	168	971	613	209	1273	811	280	1615	1007	401	2426	1509		
	5	48	80	NA	70	174	117	94	308	198	131	482	305	164	696	435	204	953	602	257	1252	795	347	1591	991	496	2396	1490		
	10	NA	NA	NA	89	160	NA	118	292	186	162	461	292	203	671	420	253	923	583	313	1217	765	418	1551	963	589	2347	1455		
	15	NA	NA	NA	112	148	NA	145	275	174	199	441	280	244	646	405	299	894	562	363	1183	736	481	1512	934	668	2299	1421		
	20	NA	NA	NA	NA	NA	NA	176	257	NA	236	420	267	285	622	389	345	866	543	415	1150	708	544	1473	906	741	2251	1387		
	30	NA	NA	NA	NA	NA	NA	NA	NA	NA	315	376	NA	373	573	NA	442	809	502	521	1086	649	674	1399	848	892	2159	1318		
100	0	NA	NA	NA	49	214	NA	69	403	NA	100	659	395	131	991	555	166	1404	765	207	1900	1033	273	2479	1300	395	3912	2042		
	2	NA	NA	NA	51	192	NA	70	351	NA	98	563	373	125	828	508	158	1152	698	196	1532	933	259	1970	1168	371	3021	1817		
	5	NA	NA	NA	67	186	NA	90	342	NA	125	551	366	156	813	501	194	1134	688	240	1511	921	322	1945	1153	460	2990	1796		
	10	NA	NA	NA	85	175	NA	113	324	NA	153	532	354	191	789	486	238	1104	672	293	1477	902	389	1905	1133	547	2938	1763		
	15	NA	NA	NA	132	162	NA	138	310	NA	188	511	343	230	764	473	281	1075	656	342	1443	884	447	1865	1110	618	2888	1730		
	20	NA	NA	NA	NA	NA	NA	168	295	NA	224	487	NA	270	739	458	325	1046	639	391	1410	864	507	1825	1087	690	2838	1696		
	30	NA	NA	NA	NA	NA	NA	231	264	NA	301	448	NA	355	685	NA	418	988	NA	491	1343	824	631	1747	1041	834	2739	1627		
	50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	540	584	NA	617	866	NA	711	1205	NA	895	1591	NA	1138	2547	1489		

For SI units, 1 in. = 25.4 mm, l ft = 0.305 m, 1000 Btu/hr = 0.293 kW, 1 in.^{2} = 645 mm^2.

Table 13.3 Masonry Chimney

Number of Appliances:	Single
Appliance Type:	Category I
Appliance Vent Connection:	Type B Double Wall Connector

Type B Double-Wall Connector Diameter — *D* (in.)
To be used with chimney areas within the size limits at bottom

		3			4			5			6			7			8			9			10			12		
		Appliance Input Rating in Thousands of Btu per Hour																										
Height *H*	**Lateral *L***	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**	**FAN**		**NAT**
(ft)	**(ft)**	**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	2	NA	NA	28	NA	NA	52	NA	NA	86	NA	NA	130	NA	NA	180	NA	NA	247	NA	NA	320	NA	NA	401	NA	NA	581
	5	NA	NA	25	NA	NA	49	NA	NA	82	NA	NA	117	NA	NA	165	NA	NA	231	NA	NA	298	NA	NA	376	NA	NA	561
8	2	NA	NA	29	NA	NA	55	NA	NA	93	NA	NA	145	NA	NA	198	NA	NA	266	84	590	350	100	728	446	139	1024	651
	5	NA	NA	26	NA	NA	52	NA	NA	88	NA	NA	134	NA	NA	183	NA	NA	247	NA	NA	328	149	711	423	201	1007	640
	8	NA	NA	24	NA	NA	48	NA	NA	83	NA	NA	127	NA	NA	175	NA	NA	239	NA	NA	318	173	695	410	231	990	623
10	2	NA	NA	31	NA	NA	61	NA	NA	103	NA	NA	162	NA	NA	221	68	519	298	82	655	388	98	810	491	136	1144	724
	5	NA	NA	28	NA	NA	57	NA	NA	96	NA	NA	148	NA	NA	204	NA	NA	277	124	638	365	146	791	466	196	1124	712
	10	NA	NA	25	NA	NA	50	NA	NA	87	NA	NA	139	NA	NA	191	NA	NA	263	155	610	347	182	762	444	240	1093	668
15	2	NA	NA	35	NA	NA	67	NA	NA	114	NA	NA	179	53	475	250	64	613	336	77	779	441	92	968	562	127	1376	841
	5	NA	NA	35	NA	NA	62	NA	NA	107	NA	NA	164	NA	NA	231	99	594	313	118	759	416	139	946	533	186	1352	828
	10	NA	NA	28	NA	NA	55	NA	NA	97	NA	NA	153	NA	NA	216	126	565	296	148	727	394	173	912	567	229	1315	777
	15	NA	NA	NA	NA	NA	48	NA	NA	89	NA	NA	141	NA	NA	201	NA	NA	281	171	698	375	198	880	485	259	1280	742
20	2	NA	NA	38	NA	NA	74	NA	NA	124	NA	NA	201	51	522	274	61	678	375	73	867	491	87	1083	627	121	1548	953
	5	NA	NA	36	NA	NA	68	NA	NA	116	NA	NA	184	80	503	254	95	658	350	113	845	463	133	1059	597	179	1523	933
	10	NA	NA	NA	NA	NA	60	NA	NA	107	NA	NA	172	NA	NA	237	122	627	332	143	811	440	167	1022	566	221	1482	879
	15	NA	NA	NA	NA	NA	NA	NA	NA	97	NA	NA	159	NA	NA	220	NA	NA	314	165	780	418	191	987	541	251	1443	840
	20	NA	NA	NA	NA	NA	NA	NA	NA	83	NA	NA	148	NA	NA	206	NA	NA	296	186	750	397	214	955	513	277	1406	807
30	2	NA	NA	41	NA	NA	82	NA	NA	137	NA	NA	216	47	581	303	57	762	421	68	985	558	81	1240	717	111	1793	1112
	5	NA	NA	NA	NA	NA	76	NA	NA	128	NA	NA	198	75	561	281	90	741	393	106	962	526	125	1216	683	169	1766	1094
	10	NA	NA	NA	NA	NA	67	NA	NA	115	NA	NA	184	NA	NA	263	115	709	373	135	927	500	158	1176	648	210	1721	1025
	15	NA	NA	NA	NA	NA	NA	NA	NA	107	NA	NA	171	NA	NA	243	NA	NA	353	156	893	476	181	1139	621	239	1679	981
	20	NA	NA	NA	NA	NA	NA	NA	NA	91	NA	NA	159	NA	NA	227	NA	NA	332	176	860	450	203	1103	592	264	1638	940
	30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	188	NA	NA	288	NA	NA	416	249	1035	555	318	1560	877
50	2	NA	NA	NA	NA	NA	92	NA	NA	161	NA	NA	251	NA	NA	351	51	840	477	61	1106	633	72	1413	812	99	2080	1243
	5	NA	NA	NA	NA	NA	NA	NA	NA	151	NA	NA	230	NA	NA	323	83	819	445	98	1083	596	116	1387	774	155	2052	1225
	10	NA	NA	NA	NA	NA	NA	NA	NA	138	NA	NA	215	NA	NA	304	NA	NA	424	126	1047	567	147	1347	733	195	2006	1147
	15	NA	NA	NA	NA	NA	NA	NA	NA	127	NA	NA	199	NA	NA	282	NA	NA	400	146	1010	539	170	1307	702	222	1961	1099
	20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	185	NA	NA	264	NA	NA	376	165	977	511	190	1269	669	246	1916	1050
	30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	327	NA	NA	468	233	1196	623	295	1832	984
Minimum internal area of chimney ($in.^2$)			12			19			28			38			50			63			78			95			132	
Maximum internal area of chimney ($in.^2$)			49			88			137			198			269			352			445			550			792	

For SI units, 1 in. = 25.4 mm, l ft = 0.305 m, 1000 Btu/hr = 0.293 kW, 1 $in.^2$ = 645 mm^2.

Table 13.4 Masonry Chimney

Number of Appliances:	Single
Appliance Type:	Category I
Appliance Vent Connection:	Single Wall Metal Connector

Single-Wall Metal Connector Diameter — *D* (in.)
To be used with chimney areas within the size limits at bottom

Appliance Input Rating in Thousands of Btu per Hour

Height *tH* (ft)	Lateral *L* (ft)	3 FAN Min	3 FAN Max	3 NAT Max	4 FAN Min	4 FAN Max	4 NAT Max	5 FAN Min	5 FAN Max	5 NAT Max	6 FAN Min	6 FAN Max	6 NAT Max	7 FAN Min	7 FAN Max	7 NAT Max	8 FAN Min	8 FAN Max	8 NAT Max	9 FAN Min	9 FAN Max	9 NAT Max	10 FAN Min	10 FAN Max	10 NAT Max	12 FAN Min	12 FAN Max	12 NAT Max
6	2	NA	NA	28	NA	NA	52	NA	NA	86	NA	NA	130	NA	NA	180	NA	NA	247	NA	NA	319	NA	NA	400	NA	NA	580
	5	NA	NA	25	NA	NA	48	NA	NA	81	NA	NA	116	NA	NA	164	NA	NA	230	NA	NA	297	NA	NA	375	NA	NA	560
8	2	NA	NA	29	NA	NA	55	NA	NA	93	NA	NA	145	NA	NA	197	NA	NA	265	NA	NA	349	382	725	445	549	1021	650
	5	NA	NA	26	NA	NA	51	NA	NA	87	NA	NA	133	NA	NA	182	NA	NA	246	NA	NA	327	NA	NA	422	673	1003	638
	8	NA	NA	23	NA	NA	47	NA	NA	82	NA	NA	126	NA	NA	174	NA	NA	237	NA	NA	317	NA	NA	408	747	985	621
10	2	NA	NA	31	NA	NA	61	NA	NA	102	NA	NA	161	NA	NA	220	216	518	297	271	654	387	373	808	490	536	1142	722
	5	NA	NA	28	NA	NA	56	NA	NA	95	NA	NA	147	NA	NA	203	NA	NA	276	334	635	364	459	789	465	657	1121	710
	10	NA	NA	24	NA	NA	49	NA	NA	86	NA	NA	137	NA	NA	189	NA	NA	261	NA	NA	345	547	758	441	771	1088	665
15	2	NA	NA	35	NA	NA	67	NA	NA	113	NA	NA	178	166	473	249	211	611	335	264	776	440	362	965	560	520	1373	840
	5	NA	NA	32	NA	NA	61	NA	NA	106	NA	NA	163	NA	NA	230	261	591	312	325	755	414	444	942	531	637	1348	825
	10	NA	NA	27	NA	NA	54	NA	NA	96	NA	NA	151	NA	NA	214	NA	NA	294	392	722	392	531	907	504	749	1309	774
	15	NA	NA	NA	NA	NA	46	NA	NA	87	NA	NA	138	NA	NA	198	NA	NA	278	452	692	372	606	873	481	841	1272	738
20	2	NA	NA	38	NA	NA	73	NA	NA	123	NA	NA	200	163	520	273	206	675	374	258	864	490	252	1079	625	508	1544	950
	5	NA	NA	35	NA	NA	67	NA	NA	115	NA	NA	183	NA	NA	252	255	655	348	317	842	461	433	1055	594	623	1518	930
	10	NA	NA	NA	NA	NA	59	NA	NA	105	NA	NA	170	NA	NA	235	312	622	330	382	806	437	517	1016	562	733	1475	875
	15	NA	NA	NA	NA	NA	NA	NA	NA	95	NA	NA	156	NA	NA	217	NA	NA	311	442	773	414	591	979	539	823	1434	835
	20	NA	NA	NA	NA	NA	NA	NA	NA	80	NA	NA	144	NA	NA	202	NA	NA	292	NA	NA	392	663	944	510	911	1394	800
30	2	NA	NA	41	NA	NA	81	NA	NA	136	NA	NA	215	158	578	302	200	759	420	249	982	556	340	1237	715	489	1789	1110
	5	NA	NA	NA	NA	NA	75	NA	NA	127	NA	NA	196	NA	NA	279	245	737	391	306	958	524	417	1210	680	600	1760	1090
	10	NA	NA	NA	NA	NA	66	NA	NA	113	NA	NA	182	NA	NA	260	300	703	370	370	920	496	500	1168	644	708	1713	1020
	15	NA	NA	NA	NA	NA	NA	NA	NA	105	NA	NA	168	NA	NA	240	NA	NA	349	428	884	471	572	1128	615	798	1668	975
	20	NA	NA	NA	NA	NA	NA	NA	NA	88	NA	NA	155	NA	NA	223	NA	NA	327	NA	NA	445	643	1089	585	883	1624	932
	30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	182	NA	NA	281	NA	NA	408	NA	NA	544	1055	1539	865
50	2	NA	NA	NA	NA	NA	91	NA	NA	160	NA	NA	250	NA	NA	350	191	837	475	238	1103	631	323	1408	810	463	2076	1240
	5	NA	NA	NA	NA	NA	NA	NA	NA	149	NA	NA	228	NA	NA	321	NA	NA	442	293	1078	593	398	1381	770	571	2044	1220
	10	NA	NA	NA	NA	NA	NA	NA	NA	136	NA	NA	212	NA	NA	301	NA	NA	420	355	1038	562	447	1337	728	674	1994	1140
	15	NA	NA	NA	NA	NA	NA	NA	NA	124	NA	NA	195	NA	NA	278	NA	NA	395	NA	NA	533	546	1294	695	761	1945	1090
	20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	180	NA	NA	258	NA	NA	370	NA	NA	504	616	1251	660	844	1898	1040
	30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	318	NA	NA	458	NA	NA	610	1009	1805	970
Minimum internal area of chimney (in.^{2})			12			19			28			38			50			63			78			95			132	
Maximum internal area of chimney (in.^{2})			49			88			137			198			269			352			445			550			792	

For SI units, 1 in. = 25.4 mm, 1 ft = 0.305 m, 1000 Btu/hr = 0.293 kW, 1 in.^{2} = 645 mm^2.

Table 13.5 Single-Wall Metal Pipe or Type B Asbestos Cement Vent

				Number of Appliances:			Single		
				Appliance Type:			Draft Hood-Equipped		
				Appliance Vent Connection:			Connected Directly to Pipe or Vent		
		Single-Wall Metal Connector Diameter – *D* (in.) To be used with chimney areas within the size limits at bottom							
		3	**4**	**5**	**6**	**7**	**8**	**10**	**12**
		Appliance Input Rating in Thousands of Btu per Hour							
Height *H* (ft)	**Lateral *L* (ft)**	**Maximum Appliance Input Rating in Thousands of Btu per Hour**							
6	0	39	70	116	170	232	312	500	750
	2	31	55	94	141	194	260	415	620
	5	28	51	88	128	177	242	390	600
8	0	42	76	126	185	252	340	542	815
	2	32	61	102	154	210	284	451	680
	5	29	56	95	141	194	264	430	648
	10	24	49	86	131	180	250	406	625
10	0	45	84	138	202	279	372	606	912
	2	35	67	111	168	233	311	505	760
	5	32	61	104	153	215	289	480	724
	10	27	54	94	143	200	274	455	700
	15	NA	46	84	130	186	258	432	666
15	0	49	91	151	223	312	420	684	1040
	2	39	72	122	186	260	350	570	865
	5	35	67	110	170	240	325	540	825
	10	30	58	103	158	223	308	514	795
	15	NA	50	93	144	207	291	488	760
	20	NA	NA	82	132	195	273	466	726
20	0	53	101	163	252	342	470	770	1190
	2	42	80	136	210	286	392	641	990
	5	38	74	123	192	264	364	610	945
	10	32	65	115	178	246	345	571	910
	15	NA	55	104	163	228	326	550	870
	20	NA	NA	91	149	214	306	525	832
30	0	56	108	183	276	384	529	878	1370
	2	44	84	148	230	320	441	730	1140
	5	NA	78	137	210	296	410	694	1080
	10	NA	68	125	196	274	388	656	1050
	15	NA	NA	113	177	258	366	625	1000
	20	NA	NA	99	163	240	344	596	960
	30	NA	NA	NA	NA	192	295	540	890
50	0	NA	120	210	310	443	590	980	1550
	2	NA	95	171	260	370	492	820	1290
	5	NA	NA	159	234	342	474	780	1230
	10	NA	NA	146	221	318	456	730	1190
	15	NA	NA	NA	200	292	407	705	1130
	20	NA	NA	NA	185	276	384	670	1080
	30	NA	NA	NA	NA	222	330	605	1010

For SI units, 1 in. = 25.4 mm, 1 ft = 0.305 m, 1000 Btu/hr = 0.293 kW, 1 in.^{2} = 645 mm^2.

hood outlet area unless designed in accordance with approved engineering methods.

13.1.9 Exterior Chimneys and Vents. Table 13.1 through Table 13.5 shall be used for chimneys and vents not exposed to the outdoors below the roof line. A Type B vent or listed chimney lining system passing through an unused masonry chimney flue shall not be considered to be exposed to the outdoors. Table 13.3 in combination with Table 13.11 shall be used for clay-tile-lined exterior masonry chimneys, provided all of the following requirements are met:

(1) The vent connector is Type B double wall.
(2) The vent connector length is limited to 18 in./in. (18 mm/mm) of vent connector diameter.
(3) The appliance is draft hood–equipped.
(4) The input rating is less than the maximum capacity given in Table 13.3.
(5) For a water heater, the outdoor design temperature shall not be less than 5°F (–15°C).
(6) For a space-heating appliance, the input rating is greater than the minimum capacity given by Table 13.11.

Exception: Vents serving listed appliances installed in accordance with the appliance manufacturer's instructions and the terms of the listing.

13.1.10 Corrugated Vent Connector Size. Corrugated vent connectors shall not be smaller than the listed appliance categorized vent diameter, flue collar diameter, or draft hood outlet diameter.

13.1.11 Upsizing. Vent connectors shall not be upsized more than two sizes greater than the listed appliance categorized vent diameter, flue collar diameter, or draft hood outlet diameter.

13.1.12 Multiple Vertical Vent Sizes. In a single run of vent or vent connector, more than one diameter and type shall be permitted to be used, provided that all the sizes and types are permitted by the tables.

13.1.13 Interpolation. Interpolation shall be permitted in calculating capacities for vent dimensions that fall between table entries. *(See Example 3, Annex G.)*

13.1.14 Extrapolation. Extrapolation beyond the table entries shall not be permitted.

13.1.15 Sizing Vents not Covered by Tables. For vent heights lower than 6 ft and higher than shown in the tables, engineering methods shall be used to calculate vent capacities.

13.2 Additional Requirements to Multiple Appliance Vent Table 13.6 Through Table 13.13(a) and Table 13.13(b).

13.2.1 Obstructions and Vent Dampers. These venting tables shall not be used where obstructions (see Section 10.15) 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 when the second appliance is a fan-assisted appliance, or the NAT+NAT column when the second appliance is equipped with a draft hood.
(3) The minimum capacity shall be determined as if the appliance were a fan-assisted appliance, as follows:
   (a) The minimum capacity of the vent connector shall be determined using the FAN Min column.
   (b) The FAN+FAN column shall be used when the second appliance is a fan-assisted appliance, and the FAN+NAT column shall be used when the second appliance is equipped with a draft hood, to determine whether the vertical vent or chimney configuration is not permitted (NA). Where the vent configuration is NA, the vent configuration shall not be permitted and an alternative venting configuration shall be utilized.

13.2.2 Vent Connector Maximum Length. The maximum vent connector horizontal length shall be 18 in./in. (18 mm/mm) of connector diameter as shown in Table 13.2.2.

13.2.3 Vent Connector Exceeding Maximum Length. The vent connector shall be routed to the vent utilizing the shortest possible route. Connectors with longer horizontal lengths than those listed in Table 13.2.2 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 listed in Table 13.2.2. For example, the maximum length listed for a 4-in. (100-mm) connector is 6 ft (1.8 m). With a connector length greater than 6 ft (1.8 m) but not exceeding 12 ft (3.7 m), the maximum capacity must be reduced by 10 percent (0.90 × maximum vent connector capacity). With a connector length greater than 12 ft (3.7 m) but not exceeding 18 ft (5.5 m), the maximum capacity must be reduced by 20 percent (0.80 × 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 13.1 shall be used. For single-wall connectors, Table 13.2 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.

Table 13.2.2 Vent Connector Maximum Length

Connector Diameter Maximum (in.)	Connector Horizontal Length (ft)
3	4½
4	6
5	7½
6	9
7	10½
8	12
9	13½
10	15
12	18
14	21
16	24
18	27
20	30
22	33
24	36

For SI units, 1 in. = 25.4 mm; 1 ft = 0.305 m.

Table 13.6 Type B Double-Wall Vent

Number of Appliances:	Two or More
Appliance Type:	Category I
Appliance Vent Connection:	Type B Double Wall Connector

Vent Connector Capacity

Vent Height *H* (ft)	Connector Rise *R* (ft)	Type B Double-Wall Vent and Connector Diameter — *D* (in.)																					
		3			4			5			6			7			8			9			10		
		Appliance Input Rating Limits in Thousands of Btu per Hour																					
		FAN		NAT	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
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
50	1	19	71	36	30	133	64	43	216	101	57	349	145	78	477	197	97	627	257	120	797	330	144	984	403
	2	21	73	43	32	137	76	45	223	119	59	358	172	81	490	234	100	645	306	123	820	392	148	1014	478
	3	22	75	48	33	141	86	46	229	134	61	366	194	83	502	263	103	661	343	126	842	441	151	1043	538
100	1	18	82	37	28	158	66	40	262	104	53	442	150	73	611	204	91	810	266	112	1038	341	135	1285	417
	2	19	83	44	30	161	79	42	267	123	55	447	178	75	619	242	94	822	316	115	1054	405	139	1306	494
	3	20	84	50	31	163	89	44	272	138	57	452	200	78	627	272	97	834	355	118	1069	455	142	1327	555

Common Vent Capacity

Vent Height *H* (ft)	Type B Double-Wall Common Vent Diameter — *D* (in.)																					
	4			5			6			7			8			9			10		
	Combined Appliance Input Rating in Thousands of Btu per Hour																				
	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	1035	826	640
30	152	138	118	244	210	185	361	297	266	547	459	360	720	585	470	979	808	605	1209	975	740
50	167	153	134	279	244	214	421	353	310	641	547	423	854	706	550	1164	977	705	1451	1188	860
100	175	163	NA	311	277	NA	489	421	NA	751	658	479	1025	873	625	1408	1215	800	1784	1502	975

Table 13.6 *Continued*

		Number of Appliances:	Two or More
		Appliance Type:	Category I
		Appliance Vent Connection:	Type B Double Wall Connector

Vent Height *H* (ft)	Connector Rise *R* (ft)	Type B Double-Wall Vent and Connector Diameter — *D* (in.)																					
		12			14			16			18			20			22			24				
		Appliance Input Rating Limits in Thousands of Btu per Hour																					
		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	
6	2	174	764	496	223	1046	653	281	1371	853	346	1772	1080	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	4	180	897	616	230	1231	827	287	1617	1081	352	2069	1370	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
8	2	186	822	516	238	1126	696	298	1478	910	365	1920	1150	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	4	192	952	644	244	1307	884	305	1719	1150	372	2211	1460	471	2737	1800	560	3319	2180	662	3957	2590	
	6	198	1050	772	252	1445	1072	313	1902	1390	380	2434	1770	478	3018	2180	568	3665	2640	669	4373	3130	
10	2	196	870	536	249	1195	730	311	1570	955	379	2049	1205	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	4	201	997	664	256	1371	924	318	1804	1205	387	2332	1535	486	2887	1890	581	3502	2280	686	4175	2710	
	6	207	1095	792	263	1509	1118	325	1989	1455	395	2556	1865	494	3169	2290	589	3849	2760	694	4593	3270	
15	2	214	967	568	272	1334	790	336	1760	1030	408	2317	1305	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	4	221	1085	712	279	1499	1006	344	1978	1320	416	2579	1665	523	3197	2060	624	3881	2490	734	4631	2960	
	6	228	1181	856	286	1632	1222	351	2157	1610	424	2796	2025	533	3470	2510	634	4216	3030	743	5035	3600	
20	2	223	1051	596	291	1443	840	357	1911	1095	430	2533	1385	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	4	230	1162	748	298	1597	1064	365	2116	1395	438	2778	1765	554	3447	2180	661	4190	2630	772	5005	3130	
	6	237	1253	900	307	1726	1288	373	2287	1695	450	2984	2145	567	3708	2650	671	4511	3190	785	5392	3790	
30	2	216	1217	632	286	1664	910	367	2183	1190	461	2891	1540	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	4	223	1316	792	294	1802	1160	376	2366	1510	474	3110	1920	619	3840	2365	728	4861	2860	847	5606	3410	
	6	231	1400	952	303	1920	1410	384	2524	1830	485	3299	2340	632	4080	2875	741	4976	3480	860	5961	4150	
50	2	206	1479	689	273	2023	1007	350	2659	1315	435	3548	1665	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	4	213	1561	860	281	2139	1291	359	2814	1685	447	3730	2135	580	4601	2633	709	5569	3185	851	6633	3790	
	6	221	1631	1031	290	2242	1575	369	2951	2055	461	3893	2605	594	4808	3208	724	5826	3885	867	6943	4620	
100	2	192	1923	712	254	2644	1050	326	3490	1370	402	4707	1740	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	4	200	1984	888	263	2731	1346	336	3606	1760	414	4842	2220	523	5982	2750	639	7254	3330	769	8650	3950	
	6	208	2035	1064	272	2811	1642	346	3714	2150	426	4968	2700	539	6143	3350	654	7453	4070	786	8892	4810	

Common Vent Capacity

Vent Height *H* (ft)	Type B Double-Wall Common Vent Diameter — *D* (in.)																						
	12			14			16			18			20			22			24				
	Combined Appliance Input Rating in Thousands of Btu per Hour																						
	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	900	696	588	1284	990	815	1735	1336	1065	2253	1732	1345	2838	2180	1660	3488	2677	1970	4206	3226	2390		
8	994	773	652	1423	1103	912	1927	1491	1190	2507	1936	1510	3162	2439	1860	3890	2998	2200	4695	3616	2680		
10	1076	841	712	1542	1200	995	2093	1625	1300	2727	2113	1645	3444	2665	2030	4241	3278	2400	5123	3957	2920		
15	1247	986	825	1794	1410	1158	2440	1910	1510	3184	2484	1910	4026	3133	2360	4971	3862	2790	6016	4670	3400		
20	1405	1116	916	2006	1588	1290	2722	2147	1690	3561	2798	2140	4548	3552	2640	5573	4352	3120	6749	5261	3800		
30	1658	1327	1025	2373	1892	1525	3220	2558	1990	4197	3326	2520	5303	4193	3110	6539	5157	3680	7940	6247	4480		
50	2024	1640	1280	2911	2347	1863	3964	3183	2430	5184	4149	3075	6567	5240	3800	8116	6458	4500	9837	7813	5475		
100	2569	2131	1670	3732	3076	2450	5125	4202	3200	6749	5509	4050	8597	6986	5000	10,681	8648	5920	13,004	10,499	7200		

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu per hr = 0.293 kW.

Table 13.7 Type B Double-Wall Vent

Number of Appliances:	Two or More
Appliance Type:	Category I
Appliance Vent Connection:	Single Wall Metal Connector

Vent Connector Capacity

Vent Height *H* (ft)	Connector Rise *R* (ft)	Single-Wall Metal Vent Connector Diameter — *D* (in.)																					
		3			4			5			6			7			8			9			10		
		Appliance Input Rating Limits in Thousands of Btu per Hour																					
		FAN		NAT	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
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
50	1	46	69	34	75	128	60	109	207	96	162	336	137	217	460	188	284	604	245	364	768	314	507	951	384
	2	49	71	40	79	132	72	114	215	113	170	345	164	226	473	223	294	623	293	376	793	375	520	983	458
	3	52	72	45	83	136	82	119	221	123	178	353	186	235	486	252	304	640	331	387	816	423	535	1013	518
100	1	45	79	34	71	150	61	104	249	98	153	424	140	205	585	192	269	774	249	345	993	321	476	1236	393
	2	48	80	41	75	153	73	110	255	115	160	428	167	212	593	228	279	788	299	358	1011	383	490	1259	469
	3	51	81	46	79	157	85	114	260	129	168	433	190	222	603	256	289	801	339	368	1027	431	506	1280	527

Common Vent Capacity

Vent Height *H* (ft)	Type B Double-Wall Vent Diameter — *D* (in.)																							
	4			5			6			7			8			9			10					
	Combined Appliance Input Rating in Thousands of Btu per Hour																							
	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	1013	808	626			
30	145	132	113	236	202	180	350	286	257	533	446	349	703	570	459	958	790	593	1183	952	723			
50	159	145	128	268	233	208	406	337	296	622	529	410	833	686	535	1139	954	689	1418	1157	838			
100	166	153	NA	297	263	NA	469	398	NA	726	633	464	999	846	606	1378	1185	780	1741	1459	948			

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu per hr = 0.293 kW.

Table 13.8 Masonry Chimney

Number of Appliances:	Two or More
Appliance Type:	Category I
Appliance Vent Connection:	Type B Double Wall Connector

Vent Connector Capacity

Vent Height *H* (ft)	Connector Rise *R* (ft)	Type B Double-Wall Vent Connector Diameter — *D* (in.)																					
		3			4			5			6			7			8			9			10		
		Appliance Input Rating Limits in Thousands of Btu per Hour																					
		FAN		NAT	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
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	1011	452
	3	26	63	35	40	123	65	57	204	104	75	353	157	104	493	222	129	661	301	156	851	396	187	1067	505
30	1	24	54	25	37	111	48	52	192	82	69	357	127	96	504	187	119	680	255	145	883	337	175	1115	432
	2	25	60	32	38	122	58	54	208	95	72	376	145	99	531	209	122	715	287	149	928	378	179	1171	484
	3	26	64	36	40	131	66	56	221	107	74	392	163	101	554	233	125	746	317	152	968	418	182	1220	535
50	1	23	51	25	36	116	51	51	209	89	67	405	143	92	582	213	115	798	294	140	1049	392	168	1334	506
	2	24	59	32	37	127	61	53	225	102	70	421	161	95	604	235	118	827	326	143	1085	433	172	1379	558
	3	26	64	36	39	135	69	55	237	115	72	435	180	98	624	260	121	854	357	147	1118	474	176	1421	611
100	1	23	46	24	35	108	50	49	208	92	65	428	155	88	640	237	109	907	334	134	1222	454	161	1589	596
	2	24	53	31	37	120	60	51	224	105	67	444	174	92	660	260	113	933	368	138	1253	497	165	1626	651
	3	25	59	35	38	130	68	53	237	118	69	458	193	94	679	285	116	956	399	141	1282	540	169	1661	705

Common Vent Capacity

Vent Height *H* (ft)	Minimum Internal Area of Masonry Chimney Flue (in.^{2})																							
	12			19			28			38			50			63			78			113		
	Combined Appliance Input Rating in Thousands of Btu per Hour																							
	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 +FAN	NAT +NAT
6	NA	74	25	NA	119	46	NA	178	71	NA	257	103	NA	351	143	NA	458	188	NA	582	246	1041	853	NA
8	NA	80	28	NA	130	53	NA	193	82	NA	279	119	NA	384	163	NA	501	218	724	636	278	1144	937	408
10	NA	84	31	NA	138	56	NA	207	90	NA	299	131	NA	409	177	606	538	236	776	686	302	1226	1010	454
15	NA	NA	36	NA	152	67	NA	233	106	NA	334	152	523	467	212	682	611	283	874	781	365	1374	1156	546
20	NA	NA	41	NA	NA	75	NA	250	122	NA	368	172	565	508	243	742	668	325	955	858	419	1513	1286	648
30	NA	NA	NA	NA	NA	NA	NA	270	137	NA	404	198	615	564	278	816	747	381	1062	969	496	1702	1473	749
50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	620	328	879	831	461	1165	1089	606	1905	1692	922
100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	348	NA	NA	499	NA	NA	669	2053	1921	1058

Table 13.9 Masonry Chimney

Number of Appliances:	Two or More
Appliance Type:	Category I
Appliance Vent Connection:	Single Wall Metal Connector

Vent Connector Capacity

Vent Height *H* (ft)	Connector Rise *R* (ft)	Single-Wall Metal Vent Connector Diameter — *D* (in.)																					
		3			4			5			6			7			8			9			10		
		Appliance Input Rating Limits in Thousands of Btu per Hour																					
		FAN		NAT	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
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	387
	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	1042	496
30	1	NA	NA	24	86	108	47	126	187	80	193	347	124	259	492	183	338	665	250	430	864	330	600	1089	421
	2	NA	NA	31	91	119	57	132	203	93	201	366	142	269	518	205	348	699	282	442	908	372	613	1145	473
	3	NA	NA	35	95	127	65	138	216	105	209	381	160	277	540	229	358	729	312	452	946	412	626	1193	524
50	1	NA	NA	24	85	113	50	124	204	87	188	392	139	252	567	208	328	778	287	417	1022	383	582	1302	492
	2	NA	NA	31	89	123	60	130	218	100	196	408	158	262	588	230	339	806	320	429	1058	425	596	1346	545
	3	NA	NA	35	94	131	68	136	231	112	205	422	176	271	607	255	349	831	351	440	1090	466	610	1386	597
100	1	NA	NA	23	84	104	49	122	200	89	182	410	151	243	617	232	315	875	328	402	1181	444	560	1537	580
	2	NA	NA	30	88	115	59	127	215	102	190	425	169	253	636	254	326	899	361	415	1210	488	575	1570	634
	3	NA	NA	34	93	124	67	133	228	115	199	438	188	262	654	279	337	921	392	427	1238	529	589	1604	687

Common Vent Capacity

Vent Height *H* (ft)	Minimum Internal Area of Masonry Chimney Flue (in.^{2})																							
	12			19			28			38			50			63			78			113		
	Combined Appliance Input Rating in Thousands of Btu per Hour																							
	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 +FAN	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	1136	928	405
10	NA	NA	31	NA	136	56	NA	205	89	NA	295	129	NA	405	175	NA	532	234	771	680	300	1216	1000	450
15	NA	NA	36	NA	NA	66	NA	230	105	NA	335	150	NA	400	210	677	602	280	866	772	360	1359	1139	540
20	NA	NA	NA	NA	NA	74	NA	247	120	NA	362	170	NA	503	240	765	661	321	947	849	415	1495	1264	640
30	NA	NA	NA	NA	NA	NA	NA	NA	135	NA	398	195	NA	558	275	808	739	377	1052	957	490	1682	1447	740
50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	612	325	NA	821	456	1152	1076	600	1879	1672	910
100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	494	NA	NA	663	2006	1885	1046

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu per hr = 0.293 kW.

Table 13.10 Single-Wall Metal Pipe or Type B Asbestos Cement Vent

Number of Appliances:	Two or More
Appliance Type:	Draft Hood-Equipped
Appliance Vent Connection:	Direct to Pipe or Vent

Vent Connector Capacity

Total Vent Height *H* (ft)	Connector Rise *R* (ft)	Vent Connector Diameter — *D* (in.)					
		3	4	5	6	7	8
		Maximum Appliance Input Rating in Thousands of Btu per Hour					
6–8	1	21	40	68	102	146	205
	2	28	53	86	124	178	235
	3	34	61	98	147	204	275
15	1	23	44	77	117	179	240
	2	30	56	92	134	194	265
	3	35	64	102	155	216	298
30 and up	1	25	49	84	129	190	270
	2	31	58	97	145	211	295
	3	36	68	107	164	232	321

Common Vent Capacity

Total Vent Height *H* (ft)	Common Vent Diameter — *D* (in.)						
	4	5	6	7	8	10	12
	Combined Appliance Input Rating in Thousands of Btu per Hour						
6	48	78	111	155	205	320	NA
8	55	89	128	175	234	365	505
10	59	95	136	190	250	395	560
15	71	115	168	228	305	480	690
20	80	129	186	260	340	550	790
30	NA	147	215	300	400	650	940
50	NA	NA	NA	360	490	810	1190

Note: See Figure G.1(f), Figure G.6 and Section 13.2.
For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu per hr = 0.293 kW.

Table 13.11 Exterior Masonry Chimney

Special Use:	**Minimum Allowable Input Rating of Space-Heating Appliance in Thousands of Btu per Hour**							
Number of Appliances:	Single							
Appliance Type:	NAT							
Appliance Vent Connection:	Type B Double Wall Connector							
Vent Height *H* (ft)	**Internal Area of Chimney (in.^{2})**							
	12	**19**	**28**	**38**	**50**	**63**	**78**	**113**
37°F or greater	Local 99% winter design temperature: 37°F or greater							
6	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
15	NA	0	0	0	0	0	0	0
20	NA	NA	123	190	249	184	0	0
30	NA	NA	NA	NA	NA	393	334	0
50	NA	NA	NA	NA	NA	NA	NA	579
27°F to 36°F	Local 99% winter design temperature: 27°F to 36°F							
6	0	0	68	116	156	180	212	266
8	0	0	82	127	167	187	214	263
10	0	51	97	141	183	201	225	265
15	NA	NA	NA	NA	233	253	274	305
20	NA	NA	NA	NA	NA	307	330	362
30	NA	NA	NA	NA	NA	419	445	485
50	NA	NA	NA	NA	NA	NA	NA	763
17°F to 26°F	Local 99% winter design temperature: 17°F to 26°F							
6	NA	NA	NA	NA	NA	215	259	349
8	NA	NA	NA	NA	197	226	264	352
10	NA	NA	NA	NA	214	245	278	358
15	NA	NA	NA	NA	NA	296	331	398
20	NA	NA	NA	NA	NA	352	387	457
30	NA	NA	NA	NA	NA	NA	507	581
50	NA	NA	NA	NA	NA	NA	NA	NA
5°F to 16°F	Local 99% winter design temperature: 5°F to 16°F							
6	NA	NA	NA	NA	NA	NA	NA	416
8	NA	NA	NA	NA	NA	NA	312	423
10	NA	NA	NA	NA	NA	289	331	430
15	NA	NA	NA	NA	NA	NA	393	485
20	NA	NA	NA	NA	NA	NA	450	547
30	NA	NA	NA	NA	NA	NA	NA	682
50	NA	NA	NA	NA	NA	NA	NA	972
–10°F to 4°F	Local 99% winter design temperature: –10°F to 4°F							
6	NA	NA	NA	NA	NA	NA	NA	484
8	NA	NA	NA	NA	NA	NA	NA	494
10	NA	NA	NA	NA	NA	NA	NA	513
15	NA	NA	NA	NA	NA	NA	NA	586
20	NA	NA	NA	NA	NA	NA	NA	650
30	NA	NA	NA	NA	NA	NA	NA	805
50	NA	NA	NA	NA	NA	NA	NA	1003
–11°F or lower	Local 99% winter design temperature: –11°F or lower Not recommended for any vent configurations							

Note: See Figure G.19 for a map showing local 99 percent winter design temperatures in the United States.
For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu per hr = 0.293 kW.

Table 13.12(a) Exterior Masonry Chimney

Special Use:	Combined Appliance Maximum Input Rating in Thousands of Btu per Hour							
Number of Appliances:	Two or More							
Appliance Type:	NAT + NAT							
Appliance Vent Connection:	Type B Double Wall Connector							
Vent Height *H* (ft)	Internal Area of Chimney (in.^{2})							
	12	19	28	38	50	63	78	113
6	25	46	71	103	143	188	246	NA
8	28	53	82	119	163	218	278	408
10	31	56	90	131	177	236	302	454
15	NA	67	106	152	212	283	365	546
20	NA	NA	NA	NA	NA	325	419	648
30	NA	NA	NA	NA	NA	NA	496	749
50	NA	NA	NA	NA	NA	NA	NA	922
100	NA	NA	NA	NA	NA	NA	NA	NA

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu per hr = 0.293 kW.

13.2.4 Vent Connector Manifolds. Where the vent connectors are combined prior to entering the vertical portion of the common vent to form a common vent manifold, the size of the common vent manifold and the common vent shall be determined by applying a 10 percent reduction (.90 × maximum common vent capacity) to the Common Vent Capacity part of the common vent tables. The length of the common vent manifold *(LM)* shall not exceed 18 in./in. (18 mm/mm) of common vent diameter *(D)*.

13.2.5 Vent Offsets. Where the common vertical vent is offset, the maximum capacity of the common vent shall be reduced in accordance with 13.2.6 and the horizontal length of the common vent offset shall not exceed 18 in./in. (18 mm/mm) of common vent diameter *(D)*.

13.2.6 Elbows in Vents. For each elbow up to and including 45 degrees 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 up to and including 90 degrees, the maximum common vent capacity listed in the venting tables shall be reduced by 10 percent.

13.2.7 Elbows in Connectors. The vent connector capacities listed in the common vent sizing tables include allowance for two 90 degree elbows. For each additional elbow up to and including 45 degrees, the maximum vent connector capacity listed in the venting tables shall be reduced by 5 percent. For each elbow greater than 45 degrees up to and including 90 degrees, the maximum vent connector capacity listed in the venting tables shall be reduced by 10 percent.

13.2.8 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.

13.2.9 Tee and Wye Sizing. 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.

13.2.10 High Altitude Installations Sea level input ratings shall be used when determining maximum capacity for high-altitude installation. Actual input (derated for altitude) shall be used for determining minimum capacity for high-altitude installation.

13.2.11 Connector Rise. The connector rise *(R)* for each appliance connector shall be measured from the draft hood outlet or flue collar to the centerline where the vent gas streams come together.

13.2.12 Vent Height. For multiple units of gas utilization equipment 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.

13.2.13 Multistory Vent Height. For multistory installations, available total height *(H)* for each segment of the system shall be the vertical distance between the highest draft hood outlet or flue collar entering that segment and the centerline of the next higher interconnection tee. *(See Figure G.13.)*

13.2.14 Multistory Lowest Vent and Vent Connector Sizing. The size of the lowest connector and of the vertical vent leading to the lowest interconnection of a multistory system shall be in accordance with Table 13.1 or Table 13.2 for available total height *(H)* up to the lowest interconnection. *(See Figure G.14.)*

13.2.15 Multistory B Vents Required. Where used in multistory systems, vertical common vents shall be Type B double-wall and shall be installed with a listed vent cap.

13.2.16 Multistory Vent Offsets and Capacity. Offsets in multistory common vent systems shall be limited to a single offset in each system, and systems with an offset shall comply with all of the following:

(1) The offset angle shall not exceed 45 degrees from vertical.
(2) The horizontal length of the offset shall not exceed 18 in./in. (18 mm/mm) of common vent diameter of the segment in which the offset is located.
(3) For the segment of the common vertical vent containing the offset, the common vent capacity listed in the common venting tables shall be reduced by 20 percent (0.80 × maximum common vent capacity).
(4) A multistory common vent shall not be reduced in size above the offset.

Table 13.12(b) Exterior Masonry Chimney

Special Use:	Minimum Allowable Input Rating of Space-Heating Appliance in Thousands of Btu per Hour							
Number of Appliances:	Two or More							
Appliance Type:	NAT + NAT							
Appliance Vent Connection:	Type B Double Wall Connector							
Vent Height *H* (ft)	**Internal Area of Chimney (in.^{2})**							
	12	**19**	**28**	**38**	**50**	**63**	**78**	**113**
37°F or greater	Local 99% winter design temperature: 37°F or greater							
6	0	0	0	0	0	0	0	NA
8	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
15	NA	0	0	0	0	0	0	0
20	NA	NA	NA	NA	NA	184	0	0
30	NA	NA	NA	NA	NA	393	334	0
50	NA	NA	NA	NA	NA	NA	NA	579
100	NA	NA	NA	NA	NA	NA	NA	NA
27°F to 36°F	Local 99% winter design temperature: 27°F to 36°F							
6	0	0	68	NA	NA	180	212	NA
8	0	0	82	NA	NA	187	214	263
10	0	51	NA	NA	NA	201	225	265
15	NA	NA	NA	NA	NA	253	274	305
20	NA	NA	NA	NA	NA	307	330	362
30	NA	NA	NA	NA	NA	NA	445	485
50	NA	NA	NA	NA	NA	NA	NA	763
100	NA	NA	NA	NA	NA	NA	NA	NA
17°F to 26°F	Local 99% winter design temperature: 17°F to 26°F							
6	NA	NA	NA	NA	NA	NA	NA	NA
8	NA	NA	NA	NA	NA	NA	264	352
10	NA	NA	NA	NA	NA	NA	278	358
15	NA	NA	NA	NA	NA	NA	331	398
20	NA	NA	NA	NA	NA	NA	387	457
30	NA	NA	NA	NA	NA	NA	NA	581
50	NA	NA	NA	NA	NA	NA	NA	862
100	NA	NA	NA	NA	NA	NA	NA	NA
5°F to 16°F	Local 99% winter design temperature: 5°F to 16°F							
6	NA	NA	NA	NA	NA	NA	NA	NA
8	NA	NA	NA	NA	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA	NA	430
15	NA	NA	NA	NA	NA	NA	NA	485
20	NA	NA	NA	NA	NA	NA	NA	547
30	NA	NA	NA	NA	NA	NA	NA	682
50	NA	NA	NA	NA	NA	NA	NA	NA
100	NA	NA	NA	NA	NA	NA	NA	NA
4°F or lower	Local 99% winter design temperature: 4°F or lower Not recommended for any vent configurations							

Note: See Figure G.19 for a map showing local 99 percent winter design temperatures in the United States.
For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu per hr = 0.293 kW.

13.2.17 Vertical Vent Size Limitation. Where two or more appliances are connected to a vertical vent or chimney, the flow area of the largest section of vertical vent or chimney shall not exceed seven times the smallest listed appliance categorized vent areas, flue collar area, or draft hood outlet area unless designed in accordance with approved engineering methods.

13.2.18 Two Stage/Modulating Appliances. For appliances with more than one input rate, the minimum vent connector capacity (FAN Min) determined from the tables shall be less than the lowest appliance input rating, and the maximum vent connector capacity (FAN Max or NAT Max) determined from the tables shall be greater than the highest appliance input rating.

Table 13.13(a) Exterior Masonry Chimney

Special Use:	Combined Appliance Maximum Input Rating in Thousands of Btu per Hour							
Number of Appliances:	Two or More							
Appliance Type:	FAN + NAT							
Appliance Vent Connection:	Type B Double Wall Connector							
Vent Height *H* (ft)	Internal Area of Chimney (in.^{2})							
	12	19	28	38	50	63	78	113
6	74	119	178	257	351	458	582	853
8	80	130	193	279	384	501	636	937
10	84	138	207	299	409	538	686	1010
15	NA	152	233	334	467	611	781	1156
20	NA	NA	250	368	508	668	858	1286
30	NA	NA	NA	404	564	747	969	1473
50	NA	NA	NA	NA	NA	831	1089	1692
100	NA	NA	NA	NA	NA	NA	NA	1921

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu per hr = 0.293 kW.

13.2.19* Corrugated Chimney Liners. Listed, corrugated metallic chimney liner systems in masonry chimneys shall be sized by using Table 13.6 or Table 13.7 for Type B vents, with the maximum capacity reduced by 20 percent (0.80 × maximum capacity) and the minimum capacity as shown in Table 13.6 or Table 13.7. Corrugated metallic liner systems installed with bends or offsets shall have their maximum capacity further reduced in accordance with 13.2.5 and 13.2.6. The 20 percent reduction for corrugated metallic chimney liner systems includes an allowance for one long radius 90-degree turn at the bottom of the liner.

13.2.20 Exterior Chimneys and Vents. Table 13.6 through Table 13.10 shall be used for chimneys and vents not exposed to the outdoors below the roof line. A Type B vent or listed chimney lining system passing through an unused masonry chimney flue shall not be considered to be exposed to the outdoors. Table 13.12(a), Table 13.12(b), Table 13.13(a), and Table 13.13(b) shall be used for clay-tile-lined exterior masonry chimneys, provided all the following conditions are met:

(1) Vent connector is Type B double-wall.
(2) At least one appliance is draft hood–equipped.
(3) The combined appliance input rating is less than the maximum capacity given by Table 13.12(a) (for NAT+NAT) or Table 13.13(a) (for FAN+NAT).
(4) The input rating of each space-heating appliance is greater than the minimum input rating given by Table 13.12(b) (for NAT+NAT) or Table 13.13(b) (for FAN+NAT).
(5) The vent connector sizing is in accordance with Table 13.8.

Where these conditions cannot be met, an alternative venting design shall be used, such as a listed chimney lining system.

Exception: Vents serving listed appliances installed in accordance with the appliance manufacturer's instructions and the terms of the listing.

13.2.21 Vent Connector Upsizing. Vent connectors shall not be increased more than two sizes greater than the listed appliance categorized vent diameter, flue collar diameter, or draft hood outlet diameter. Vent connectors for draft hood–equipped appliances shall not be smaller than the draft hood outlet diameter. Where a vent connector size(s) determined from the tables for a fan-assisted appliance(s) is smaller than the flue collar diameter, the use of the smaller size(s) shall be permitted provided that the installation complies with all of the following conditions:

(1) Vent connectors for fan-assisted appliance flue collars 12 in. (300 mm) in diameter or smaller are not reduced by more than one table size [e.g., 12 in. to 10 in. (300 mm to 250 mm) is a one-size reduction] and those larger than 12 in. (300 mm) in diameter are not reduced more than two table sizes [e.g., 24 in. to 20 in. (610 mm to 510 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.

13.2.22 Multiple Vent and Connector Sizes. All combination of pipe sizes, single-wall, and double-wall metal pipe shall be allowed within any connector run(s) or within the common vent, provided ALL of the appropriate tables permit ALL of the desired sizes and types of pipe, as if they were used for the entire length of the subject connector or vent. Where single-wall and Type B double-wall metal pipes are used for vent connectors within the same venting system, the common vent must be sized using Table 13.7 or Table 13.9 as appropriate.

13.2.23 Multiple Vent and Connector Sizes Permitted. Where a table permits more than one diameter of pipe to be used for a connector or vent, all the permitted sizes shall be permitted to be used.

13.2.24 Interpolation. Interpolation shall be permitted in calculating capacities for vent dimensions that fall between table entries. *(See Example 3, Annex G.)*

13.2.25 Extrapolation. Extrapolation beyond the table entries shall not be permitted.

13.2.26 Sizing Vents not Covered by Tables. For vent heights lower than 6 ft and higher than shown in the tables, engineering methods shall be used to calculate vent capacities.

Table 13.13(b) Exterior Masonry Chimney

Special Use:	Minimum Allowable Input Rating of Space-Heating Appliance in Thousands of Btu per Hour							
Number of Appliances:	Two or More							
Appliance Type:	NAT + NAT							
Appliance Vent Connection:	Type B Double Wall Connector							
Vent Height *H* (ft)	**Internal Area of Chimney (in.^{2})**							
	12	**19**	**28**	**38**	**50**	**63**	**78**	**113**
37°F or greater	Local 99% winter design temperature: 37°F or greater							
6	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
15	NA	0	0	0	0	0	0	0
20	NA	NA	123	190	249	184	0	0
30	NA	NA	NA	334	398	393	334	0
50	NA	NA	NA	NA	NA	714	707	579
100	NA	NA	NA	NA	NA	NA	NA	1600
27°F to 36°F	Local 99% winter design temperature: 27°F to 36°F							
6	0	0	68	116	156	180	212	266
8	0	0	82	127	167	187	214	263
10	0	51	97	141	183	210	225	265
15	NA	111	142	183	233	253	274	305
20	NA	NA	187	230	284	307	330	362
30	NA	NA	NA	330	319	419	445	485
50	NA	NA	NA	NA	NA	672	705	763
100	NA	NA	NA	NA	NA	NA	NA	1554
17°F to 26°F	Local 99% winter design temperature: 17°F to 26°F							
6	0	55	99	141	182	215	259	349
8	52	74	111	154	197	226	264	352
10	NA	90	125	169	214	245	278	358
15	NA	NA	167	212	263	296	331	398
20	NA	NA	212	258	316	352	387	457
30	NA	NA	NA	362	429	470	507	581
50	NA	NA	NA	NA	NA	723	766	862
100	NA	NA	NA	NA	NA	NA	NA	1669
5°F to 16°F	Local 99% winter design temperature: 5°F to 16°F							
6	NA	78	121	166	214	252	301	416
8	NA	94	135	182	230	269	312	423
10	NA	111	149	198	250	289	331	430
15	NA	NA	193	247	305	346	393	485
20	NA	NA	NA	293	360	408	450	547
30	NA	NA	NA	377	450	531	580	682
50	NA	NA	NA	NA	NA	797	853	972
100	NA	NA	NA	NA	NA	NA	NA	1833
−10°F to 4°F	Local 99% winter design temperature: −10°F to 4°F							
6	NA	NA	145	196	249	296	349	484
8	NA	NA	159	213	269	320	371	494
10	NA	NA	175	231	292	339	397	513
15	NA	NA	NA	283	351	404	457	586
20	NA	NA	NA	333	408	468	528	650
30	NA	NA	NA	NA	NA	603	667	805
50	NA	NA	NA	NA	NA	NA	955	1003
100	NA	NA	NA	NA	NA	NA	NA	NA
−11°F or lower	Local 99% winter design temperature: −11°F or lower Not recommended for any vent configurations							

Note: See Figure G.19 for a map showing local 99 percent winter design temperatures in the United States.
For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu per hr = 0.293 kW.

Chapter 14 Referenced Publications

14.1 General. The following documents or portions thereof are referenced within this code as mandatory requirements and shall be considered part of the requirements of this code. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this code. Annex L contains a list of other associated appliance and installation standards for informational purposes.

14.1.1 ASME Publications. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990, (800)843-2763, www.asme.org.
ANSI/ASME B1.20.1, *Pipe Threads, General Purpose, Inch,* 1983 (Reaffirmed 2001).
ANSI/ASME B16.1, *Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800,* 1998.
ANSI/ASME B16.20, *Metal Gaskets for Pipe Flanges, Ring Joint Spiral Wound and Jacketed,* 2000.
ANSI/ASME B36.10, *Welded and Seamless Wrought-Steel Pipe,* 2001.

14.1.2 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, (610)832-9585, www.astm.org.
ASTM A 53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless,* 2001.
ASTM A 106, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service,* 1999.
ASTM A 254, *Standard Specification for Copper Brazed Steel Tubing,* 2002.
ASTM A 539, *Standard Specification for Electric Resistance-Welded Coiled Steel Tubing for Gas and Fuel Oil Lines,* 1999.
ASTM B 88, *Specification for Seamless Copper Water Tube,* 1999.
ASTM B 210, *Specification for Aluminum-Alloy Drawn Seamless Tubes,* 2000.
ASTM B 241, *Specification for Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube,* 2000.
ASTM B 280, *Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service,* 1999.
ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings,* 2001.

14.1.3 CSA-America Publications. CSA-America, Inc., 8501 East Pleasant Valley Road, Cleveland, OH 44131, (216)524-4990, www.csa-america.org.
ANSI Z21.8, *Installation of Domestic Gas Conversion Burners,* 2000.
ANSI Z21.24/CSA 6.10, *Standard for Connectors for Gas Appliances,* 1997.
ANSI Z21.69/CSA 6.22, *Connectors for Movable Gas Appliances,* 2001.
ANSI Z21.80/CSA 3.7, *Line Pressure Regulators,* 2001.
ANSI Z83.4/CSA 3.7, *Non-Recirculating Direct Gas Fired Industrial Air Heaters,* 1999.
ANSI Z83.18, *Recirculating Direct Gas-Fired Industrial Air Heaters,* 1990 (2000).
ANSI LC 1/CSA 6.26, *Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing,* 2001.

14.1.4 MSS Publications. Manufacturers Standardization Society of the Valve and Fittings Industry, 124 Park Street, NE, Vienna, VA 22180-6671, (703)281-6613, www.mss-hq.com.
MSS SP-6, *Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings,* 2001.
ANSI/MSS SP-58, *Pipe Hangers and Supports — Materials, Design and Manufacture,* 1993.

14.1.5 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, (617)770-3000, www.nfpa.org.
NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages,* 2000 edition.
NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines,* 2002 edition.
NFPA 51, *Standard for the Design and Installation of Oxygen–Fuel Gas Systems for Welding, Cutting, and Allied Processes,* 2002 edition.
NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems Code,* 1998 edition.
NFPA 58, *Liquefied Petroleum Gas Code,* 2001 edition.
NFPA 70, *National Electrical Code®,* 2002 edition.
NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment,* 1999 edition.
NFPA 88A, *Standard for Parking Structures,* 2002 edition.
NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* 2002 edition.
NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems,* 2002 edition.
NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations,* 2001 edition.
NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances,* 2000 edition.
NFPA 409, *Standard on Aircraft Hangars,* 2001 edition.
NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Plants,* 2000 edition.
NFPA 1192, *Standard on Recreational Vehicles,* 2002 edition.

14.1.6 U.S. Government Publication. U.S. Government Printing Office, Washington, DC 20402, www.gpo.gov.
Title 49, *Code of Federal Regulations,* Part 192.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.5 The following sample ordinance is provided to assist a jurisdiction in the adoption of this code and is not part of this code.

ORDINANCE NO._____

An ordinance of the [jurisdiction] adopting the [year] edition of NFPA 54/ANSI Z223.1, *National Fuel Gas Code,* documents listed in 14 of that code; prescribing regulations governing conditions hazardous to life and property from fire or explosion; providing for the issuance of permits and collection of fees; repealing Ordinance No._____ of the [jurisdiction] and all other ordinances and parts of ordinances in conflict therewith; providing a penalty; providing a severability clause; and providing for publication; and providing an effective date.

BE IT ORDAINED BY THE [governing body] OF THE [jurisdiction]:

SECTION 1 That the *National Fuel Gas Code* and documents adopted by 14, three (3) copies of which are on file and are open to inspection by the public in the office of the [jurisdiction's keeper of records] of the [jurisdiction], are hereby adopted and incorporated into this ordinance as fully as if set out at length herein, and from the date on which this ordinance shall take effect, the provisions thereof shall be controlling within the limits of the [jurisdiction]. The same are hereby adopted as the code of the [jurisdiction] for the purpose of prescribing regulations

governing conditions hazardous to life and property from fire or explosion and providing for issuance of permits and collection of fees.

SECTION 2 Any person who shall violate any provision of this code or standard hereby adopted or fail to comply therewith; or who shall violate or fail to comply with any order made thereunder; or who shall build in violation of any detailed statement of specifications or plans submitted and approved thereunder; or failed to operate in accordance with any certificate or permit issued thereunder; and from which no appeal has been taken; or who shall fail to comply with such an order as affirmed or modified by or by a court of competent jurisdiction, within the time fixed herein, shall severally for each and every such violation and noncompliance, respectively, be guilty of a misdemeanor, punishable by a fine of not less than $ _____ nor more than $_____ or by imprisonment for not less than_____ days nor more than_____ days or by both such fine and imprisonment. The imposition of one penalty for any violation shall not excuse the violation or permit it to continue; and all such persons shall be required to correct or remedy such violations or defects within a reasonable time; and when not otherwise specified the application of the above penalty shall not be held to prevent the enforced removal of prohibited conditions. Each day that prohibited conditions are maintained shall constitute a separate offense.

SECTION 3 Additions, insertions, and changes that the [year] edition of NFPA 54/ANSI Z223.1, *National Fuel Gas Code*, is amended and changed in the following respects: List Amendments

SECTION 4 That ordinance No._____ of [jurisdiction] entitled [fill in the title of the ordinance or ordinances in effect at the present time] and all other ordinances or parts of ordinances in conflict herewith are hereby repealed.

SECTION 5 That if any section, subsection, sentence, clause, or phrase of this ordinance is, for any reason, held to be invalid or unconstitutional, such decision shall not affect the validity or constitutionality of the remaining portions of this ordinance. The [governing body] hereby declares that it would have passed this ordinance, and each section, subsection, clause, or phrase hereof, irrespective of the fact that any one or more sections, subsections, sentences, clauses, and phrases be declared unconstitutional.

SECTION 6 That the [jurisdiction's keeper of records] is hereby ordered and directed to cause this ordinance to be published. [NOTE: An additional provision may be required to direct the number of times the ordinance is to be published and to specify that it is to be in a newspaper in general circulation. Posting may also be required.]

SECTION 7 That this ordinance and the rules, regulations, provisions, requirements, orders, and matters established and adopted hereby shall take effect and be in full force and effect [time period] from and after the date of its final passage and adoption.

A.3.3.15 Approved. The American Gas Association and the National Fire Protection Association do not approve, inspect, or certify any installations, procedures, equipment, or materials; nor do they approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.3.17 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in this code in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.3.140 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.230 Vented Appliance, Category I. For additional information on appliance categorization as shown in 3.3.230 through 3.3.233, see the appropriate Z21 and Z83 American National Standards.

A.3.3.236 Venting System. A venting system is usually composed of a vent or a chimney and vent connector(s), if used, assembled to form the open passageway.

A.5.4.1 The size of gas piping depends on the following factors:

(1) Allowable loss in pressure *(see 5.4.4)* from point of delivery to equipment
(2) Maximum gas demand
(3) Length of piping and number of fittings
(4) Specific gravity of the gas
(5) Diversity factor
(6) Foreseeable future demand

A.5.4.2 To obtain the cubic feet per hour of gas required, divide the Btu per hour rating by the Btu per cubic foot heating value of the gas supplied. The heating value of the gas can be obtained from the local gas supplier.

Where the ratings of the equipment to be installed are not known, Table 5.4.2.1 shows the approximate demand of typical appliances by types.

A.5.4.3 *Gas Piping Size.* The gas-carrying capacities for different sizes and lengths of iron pipe, or equivalent rigid pipe, and semirigid tubing are shown in the capacity tables in Chapter 12.

Table 12.1 through Table 12.21 indicate approximate capacities for single runs of piping. If the specific gravity of the gas is other than 0.60, correction factors should be applied. Correction factors for use with these tables are given in Table C.2(d).

For any gas piping system, for special gas utilization equipment, or for conditions other than those covered by the capacity tables in Chapter 12, such as longer runs, greater gas demands, or greater pressure drops, the size of each gas piping system should be determined by the pipe sizing equation in 12.3 or by

standard engineering methods acceptable to the authority having jurisdiction.

A suggested procedure with an example of using tables to size a gas piping system is presented in Annex C.

A.5.5.1(1) For welding specifications and procedures that can be used, see the API 1104, *Standard for Welding Pipelines and Related Facilities;* AWS B2.1, *Standard for Welding Procedure and Performance Qualification*; or ASME *Boiler and Pressure Vessel Code,* Section IX.

A.5.6.2.3 An average of 0.3 grains of hydrogen sulfide per 100 scf (0.7 mg/100 L) is equivalent to a trace as determined by ANSI/ASTM D 2385, *Method of Test for Hydrogen Sulfide and Mercaptan Sulfur in Natural Gas (Cadmium Sulfate — Iodometric Titration Method),* or ANSI/ASTM D 2420, *Method of Test for Hydrogen Sulfide in Liquefied Petroleum (LP) Gases (Lead Acetate Method).*

A.5.6.3.2 See A.5.6.2.3.

Copper and brass tubing and fittings (except tin-lined copper tubing) should not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 scf of gas (0.7 mg/100 L).

A.5.6.8.1 For welding and brazing specifications and procedures that can be used, see API 1104, *Standard for Welding Pipelines and Related Facilities;* AWS B2.1, *Standard for Welding Procedure and Performance Qualification;* AWS B2.2, *Standard for Brazing Procedure and Performance Qualification;* or ASME *Boiler and Pressure Vessel Code,* Section IX.

A.5.7 This section applies to premises-owned meters *[see 1.1.1.2(16)]*.

A.5.8 This section applies to premises-owned regulators *[see 1.1.1.2(16)]*.

A.6.1.3 For information on corrosion protection of underground pipe, see NACE RP 0169, *Control of External Corrosion on Underground or Submerged Metallic Piping Systems.* Information on installation, maintenance, and corrosion protection may be available from the gas supplier.

A.6.1.4 The gas supplier can be consulted for recommendations.

A.6.2.5 It is the intent that gas piping, shutoff valves required by this code, and regulators be allowed to be installed in accessible portions of plenums, accessible ducts used to supply combustion and ventilation air in accordance with Section 5.3, and accessible spaces between a fixed ceiling and dropped ceiling.

A.6.4.3 Only vertical chases are recognized by the coverage. It is believed that welded joints for a horizontal gas line would be preferable to a horizontal chase.

A.6.5.3 Care should be taken in making mitered joints to provide proper root opening and alignment and full weld penetration.

A.6.12.4 The mixing blower is acknowledged as a special case because of its inability to tolerate control valves or comparable restrictions between mixing blower and burner(s). With these limitations, mixing blower installations are not required to utilize safety blowouts, backfire preventers, explosion heads, flame arresters, or automatic firechecks that introduce pressure losses.

A.6.12.5.1 For information on venting of deflagrations, see NFPA 68, *Guide for Venting of Deflagrations.*

A.6.12.5.4 Additional interlocks might be necessary for safe operation of equipment supplied by the gas-mixing machine.

A.6.12.6(1) Two basic methods are generally used. One calls for a separate firecheck at each burner, the other a firecheck at each group of burners. The second method is generally more practical if a system consists of many closely spaced burners.

An approved automatic firecheck should be installed as near as practical upstream from a flame arrester used for local protection where test burners or lighting torches are employed.

A.7.1.1 Because it is sometimes necessary to divide a piping system into test sections and install test heads, connecting piping, and other necessary appurtenances for testing, it is not required that the tie-in sections of pipe be pressure-tested. Tie-in connections, however, should be tested with a noncorrosive leak detection fluid after gas has been introduced and the pressure has been increased sufficiently to give some indications whether leaks exist.

The test procedure used should be capable of disclosing all leaks in the section being tested and should be selected after giving due consideration to the volumetric content of the section and to its location.

Under no circumstances should a valve in a line be used as a bulkhead between gas in one section of the piping system and test medium in an adjacent section, unless two valves are installed in series with a valved "telltale" located between these valves. A valve should 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.

A.7.2.3 See Annex D for a suggested method.

A.7.3 The processes of purging a gas pipeline of fuel gas and replacing the fuel gas with air or charging a gas pipeline that is full of air with fuel gas require that a significant amount of combustible mixture not be developed within the pipeline or released within a confined space.

A.8.1.1 The American Gas Association, American National Standards Institute, and the National Fire Protection Association do not approve, inspect, or certify any installations, procedures, equipment, or materials. In determining acceptability of installations or procedures, the authority having jurisdiction can base acceptance on compliance with AGA, ANSI, or NFPA, or other appropriate standards. In the absence of such standards, said authority can require evidence of proper installation, procedure, or use. The authority having jurisdiction can also refer to the listings or labeling practices *(see Section 3.3)* of an organization concerned with product evaluations and is in a position to determine compliance with appropriate standards for the current production of listed items. Additional information regarding the coordination of gas utilization equipment design, construction, and maintenance can be found in Annex B.

A.8.1.6 Halogenated hydrocarbons are particularly injurious and corrosive after contact with flames or hot surfaces.

A.8.3 *Special Conditions Created by Mechanical Exhausting or Fireplaces.* Operation of exhaust fans, ventilation systems, clothes dryers, or fireplaces can create conditions requiring special attention to avoid unsatisfactory operation of installed gas utilization equipment.

A.8.3.2.1 See Table A.8.3.2.1.

A.8.3.2.2 See Table A.8.3.2.2(a) and Table A.8.3.2.2(b).

Table A.8.3.2.1 Standard Method: Required Volume, All Appliances

Appliance Input (Btu/hr)	Required Volume (ft^3)
5,000	250
10,000	500
15,000	750
20,000	1,000
25,000	1,250
30,000	1,500
35,000	1,750
40,000	2,000
45,000	2,250
50,000	2,500
55,000	2,750
60,000	3,000
65,000	3,250
70,000	3,500
75,000	3,750
80,000	4,000
85,000	4,250
90,000	4,500
95,000	4,750
100,000	5,000
105,000	5,250
110,000	5,500
115,000	5,750
120,000	6,000
125,000	6,250
130,000	6,500
135,000	6,750
140,000	7,000
145,000	7,250
150,000	7,500
160,000	8,000
170,000	8,500
180,000	9,000
190,000	9,500
200,000	10,000
210,000	10,500
220,000	11,000
230,000	11,500
240,000	12,000
250,000	12,500
260,000	13,000
270,000	13,500
280,000	14,000
290,000	14,500
300,000	15,000

A.8.3.2.3(1) See Figure A.8.3.2.3(1).

A.8.3.3.1(1) See Figure A.8.3.3.1(1)(a) and Figure A.8.3.3.1(1)(b).

A.8.3.3.1(2) See Figure A.8.3.3.1(2).

A.8.3.3.2 See Figure A.8.3.3.2.

A.8.5.6 For information on gas convenience outlets, see AGA 7-90, *Requirements for Gas Convenience Outlets.*

Table A.8.3.2.2(a) Known Air Infiltration Rate Method, Minimum Space Volume for Appliances Other than Fan Assisted, for Specified Infiltration Rates (ACH)

Appliance Input (Btu/hr)	Space Volume 0.25 ACH (ft^3)	Space Volume 0.30 ACH (ft^3)	Space Volume 0.35 ACH (ft^3)
5,000	420	350	300
10,000	840	700	600
15,000	1,260	1,050	900
20,000	1,680	1,400	1,200
25,000	2,100	1,750	1,500
30,000	2,520	2,100	1,800
35,000	2,940	2,450	2,100
40,000	3,360	2,800	2,400
45,000	3,780	3,150	2,700
50,000	4,200	3,500	3,000
55,000	4,620	3,850	3,300
60,000	5,040	4,200	3,600
65,000	5,460	4,550	3,900
70,000	5,880	4,900	4,200
75,000	6,300	5,250	4,500
80,000	6,720	5,600	4,800
85,000	7,140	5,950	5,100
90,000	7,560	6,300	5,400
95,000	7,980	6,650	5,700
100,000	8,400	7,000	6,000
105,000	8,820	7,350	6,300
110,000	9,240	7,700	6,600
115,000	9,660	8,050	6,900
120,000	10,080	8,400	7,200
125,000	10,500	8,750	7,500
130,000	10,920	9,100	7,800
135,000	11,340	9,450	8,100
140,000	11,760	9,800	8,400
145,000	12,180	10,150	8,700
150,000	12,600	10,500	9,000
160,000	13,440	11,200	9,600
170,000	14,280	11,900	10,200
180,000	15,120	12,600	10,800
190,000	15,960	13,300	11,400
200,000	16,800	14,000	12,000
210,000	17,640	14,700	12,600
220,000	18,480	15,400	13,200
230,000	19,320	16,100	13,800
240,000	20,160	16,800	14,400
250,000	21,000	17,500	15,000
260,000	21,840	18,200	15,600
270,000	22,680	18,900	16,200
280,000	23,520	19,600	16,800
290,000	24,360	20,300	17,400
300,000	25,200	21,000	18,000

Note: ACH = air change per hour.

Table A.8.3.2.2(b) Known Air Infiltration Rate Method, Minimum Space Volume for Fan Assisted Appliance, for Specified Infiltration Rates (ACH)

Appliance Input (Btu/hr)	Required Volume 0.25 ACH (ft^3)	Required Volume 0.30 ACH (ft^3)	Required Volume 0.35 ACH (ft^3)
5,000	300	250	214
10,000	600	500	429
15,000	900	750	643
20,000	1,200	1,000	857
25,000	1,500	1,250	1,071
30,000	1,800	1,500	1,286
35,000	2,100	1,750	1,500
40,000	2,400	2,000	1,714
45,000	2,700	2,250	1,929
50,000	3,000	2,500	2,143
55,000	3,300	2,750	2,357
60,000	3,600	3,000	2,571
65,000	3,900	3,250	2,786
70,000	4,200	3,500	3,000
75,000	4,500	3,750	3,214
80,000	4,800	4,000	3,429
85,000	5,100	4,250	3,643
90,000	5,400	4,500	3,857
95,000	5,700	4,750	4,071
100,000	6,000	5,000	4,286
105,000	6,300	5,250	4,500
110,000	6,600	5,500	4,714
115,000	6,900	5,750	4,929
120,000	7,200	6,000	5,143
125,000	7,500	6,250	5,357
130,000	7,800	6,500	5,571
135,000	8,100	6,750	5,786
140,000	8,400	7,000	6,000
145,000	8,700	7,250	6,214
150,000	9,000	7,500	6,429
160,000	9,600	8,000	6,857
170,000	10,200	8,500	7,286
180,000	10,800	9,000	7,714
190,000	11,400	9,500	8,143
200,000	12,000	10,000	8,571
210,000	12,600	10,500	9,000
220,000	13,200	11,000	9,429
230,000	13,800	11,500	9,857
240,000	14,400	12,000	10,286
250,000	15,000	12,500	10,714
260,000	15,600	13,000	11,143
270,000	16,200	13,500	11,571
280,000	16,800	14,000	12,000
290,000	17,400	14,500	12,429
300,000	18,000	15,000	12,857

Note: ACH = air change per hour.

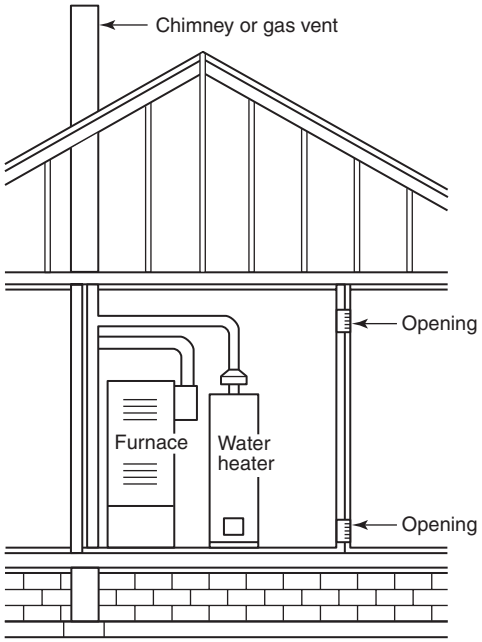


FIGURE A.8.3.2.3(1) All Combustion Air from Adjacent Indoor Spaces through Indoor Combustion Air Openings.

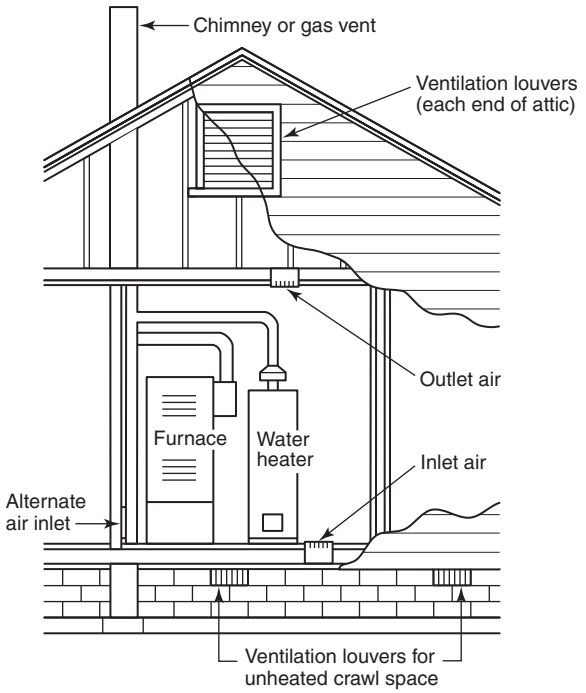


FIGURE A.8.3.3.1(1)(a) All Combustion Air from Outdoors — Inlet Air from Ventilated Crawl Space and Outlet Air to Ventilated Attic.

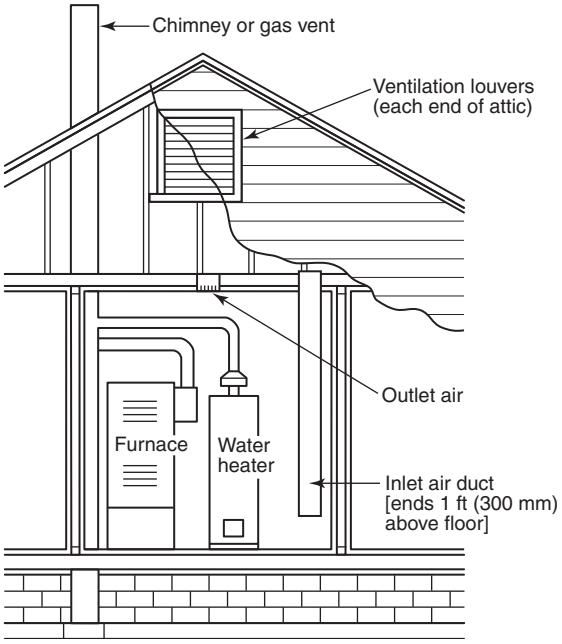


FIGURE A.8.3.3.1(1)(b) All Combustion Air from Outdoors through Ventilated Attic.

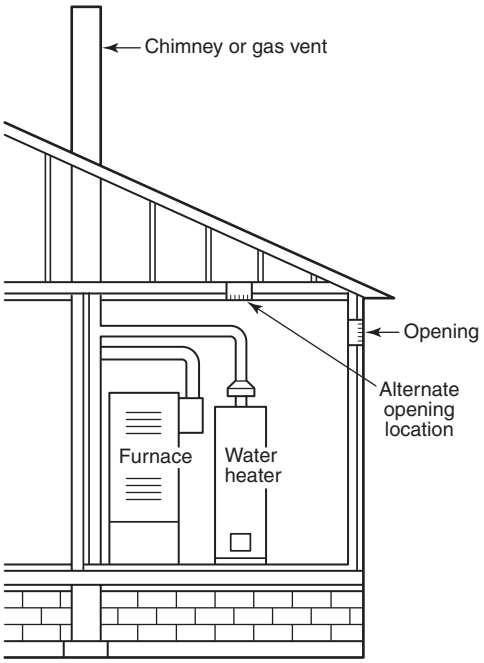


FIGURE A.8.3.3.2 All Combustion Air from Outdoors through Single Combustion Air Opening.

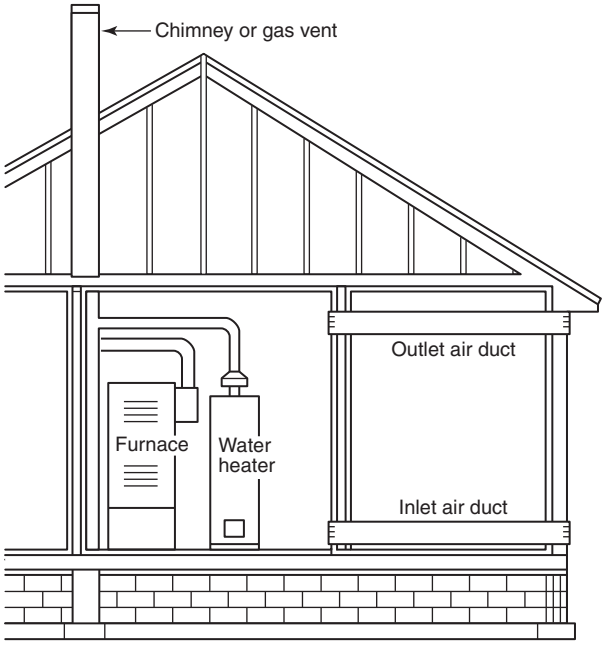


FIGURE A.8.3.3.1(2) All Combustion Air from Outdoors through Horizontal Ducts.

A.9.1.2 Also see Prohibited Installations, 9.6.1, 9.7.1, 9.8.2, 9.9.2, and 9.23.1.

A.9.2.6 Reference can be made to NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, or NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.*

A.9.3.6 For details of requirements on low-pressure heating boiler safety devices, refer to ASME *Boiler and Pressure Vessel Code,* Section IV, "Rules for Construction of Heating Boilers."

A.9.3.7.3 Reference can be made to NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems,* or to NFPA 90B, *Standard for the Installation of Warm Air Heating and Air Conditioning Systems.*

A.9.6.1 For information on decorative appliances for installation in vented fireplaces, see ANSI Z21.60/CGA 2.26, *Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces.*

A.9.7.1 For information on vented gas fireplaces, see ANSI Z21.50/CGA 2.22, *Vented Gas Fireplaces.*

A.9.9.2.2 Recirculation of room air can be hazardous in the presence of flammable solids, liquids, gases, explosive materials (e.g., grain dust, coal dust, gun powder), and substances (e.g., refrigerants, aerosols) that can become toxic when exposed to flame or heat.

A.9.12.8 Where exhaust fans are used for ventilation, precautions might be necessary to avoid interference with the operation of the equipment.

A.9.23.1 It is recommended that space heating appliances installed in all bedrooms or rooms generally kept closed be of the direct vent type. *(See Section 9.27.)*

A.9.28.8 A hole near the top of a cold water inlet tube that enters the top of the water heater or tank is commonly accepted for this purpose.

A.10.2.3 Information on the construction and installation of ventilating hoods can be obtained from NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.*

A.10.3.5 See A.10.2.3.

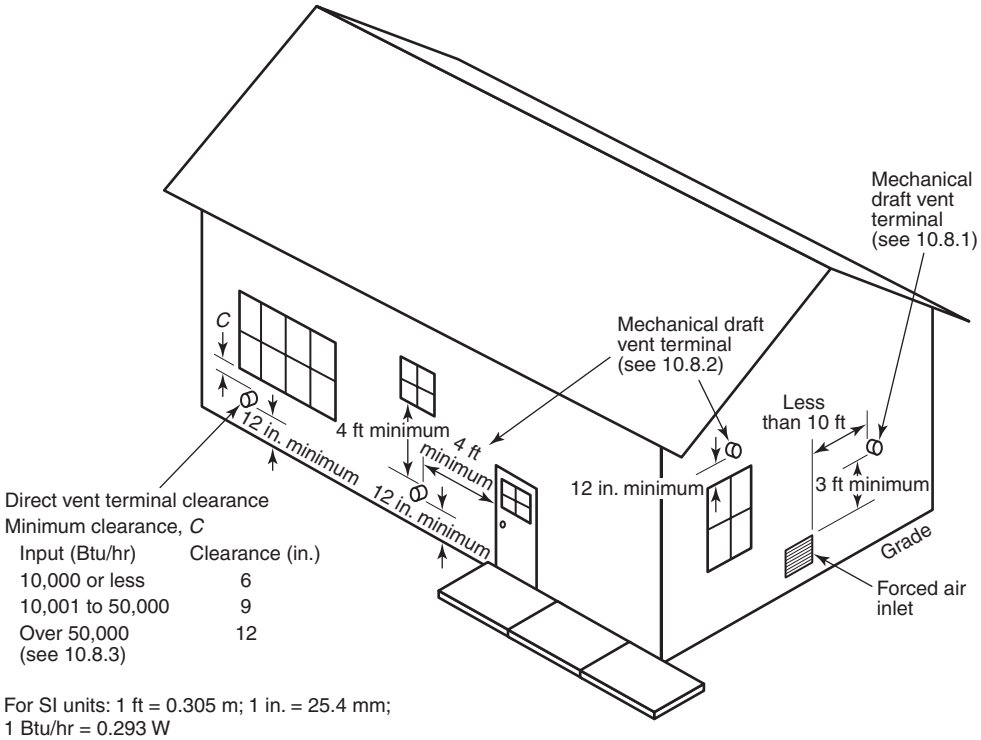


FIGURE A.10.8 Exit Terminals of Mechanical Draft and Direct-vent Venting Systems.

A.10.5.1.3 For information on the installation of gas vents in existing masonry chimneys, see Section 10.6.

A.10.5.5.3 Reference can also be made to the chapter on chimney, gas vent, and fireplace systems of the *ASHRAE Handbook — HVAC Systems and Equipment.*

A.10.6.3.1 Additional information on sizing venting systems can be found in the following:

(1) Tables in Chapter 13
(2) The gas equipment manufacturer's instructions
(3) The venting equipment manufacturer's sizing instructions
(4) Drawings, calculations, and specifications provided by the venting equipment manufacturer
(5) Drawings, calculations, and specifications provided by a competent person
(6) The chapter on chimney, gas vent, and fireplace systems of the *ASHRAE Handbook — HVAC Systems and Equipment.*

Category I appliances may be either draft hood-equipped or fan-assisted combustion system in design. Different vent design methods are required for draft hood-equipped and fan-assisted combustion system appliances.

A.10.7.5(1) Reference can also be made to the chapter on chimney, gas vent, and fireplace systems of the *ASHRAE Handbook — HVAC Systems and Equipment.*

A.10.8 See Figure A.10.8.

A.10.10.3 Reference can also be made to the chapter on chimney, gas vent, and fireplace systems of the *ASHRAE Handbook — HVAC Systems and Equipment.*

A.10.10.9.2 See A.10.6.3.1.

A.10.12.4 A device that will automatically shut off gas to the burner in the event of sustained backdraft is recommended if such backdraft might adversely affect burner operation or if flue gas spillage might introduce a hazard. Figure A.10.12.4 shows examples of correct and incorrect locations for barometric draft regulators.

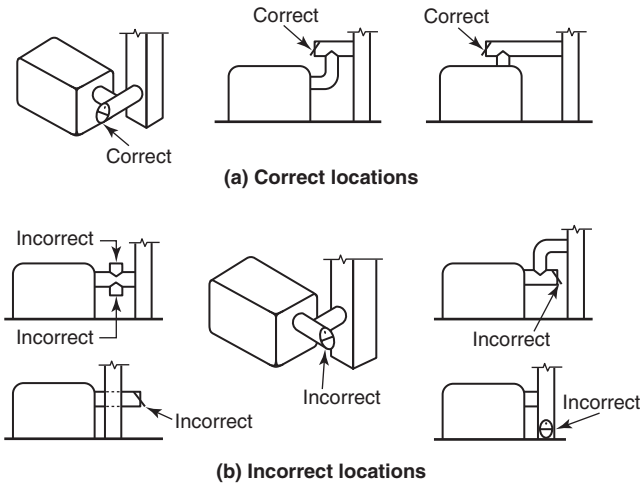


FIGURE A.10.12.4 Locations for Barometric Draft Regulators.

A.11.1.1 *Checking Burner Input.* Burner input can be checked as follows:

(1) *Checking Burner Input Using a Meter.* To check the Btu input rate, the test hand on the meter should be timed for at least one revolution and the input determined from this timing. Test dials are generally marked ½, 1, 2, or 5 ft^3/ revolution depending on the size of the meter. Instructions for converting the test hand readings to cubic feet per hour are given in Table 11.1.1.
(2) *Checking Burner Input Not Using a Meter.* The fixed orifice size for each burner can be determined in accordance with for utility gases and for undiluted liquefied petroleum gases.

A.11.2 Normally, the primary air adjustment should first be set to give a soft blue flame having luminous tips and then increased to a point where the yellow tips just disappear. If the burner cannot be so adjusted, the manufacturer or serving gas supplier should be contacted.

A.11.6 A procedure for checking draft can be found in Annex H, steps 7, 8, and 10 through 14.

A.12.1.1 *Longest Length Method.* The longest length method is the traditional method used to determine the equivalent piping length L that is then used along with the pipe sizing tables to determine the appropriate pipe diameter size.

A.12.1.2 *Branch Length Method.* This method is an alternate sizing method that could permit slightly smaller pipe diameters in some segments of a piping system when compared with the longest length method.

A.12.3.1 *Low Pressure Formula.* The presented formula is the standard flow formula located in Annex C but rearranged to solve for the pipe diameter.

A.12.3.2 *High Pressure Formula.* The presented formula is the standard flow formula located in Annex C but rearranged to solve for the pipe diameter.

A.13.1.7 A long radius turn is a turn where the centerline radius is equal to or greater than 1.5 times the vent diameter.

A.13.2.19 A long radius turn is a turn where the centerline radius is equal to or greater than 1.5 times the vent diameter.

Annex B Coordination of Gas Utilization Equipment Design, Construction, and Maintenance

This annex is not a part of the requirements of this code but is included for informational purposes only.

B.1 Coordination.

B.1.1 Because industrial gas applications are so varied in nature, many agencies are jointly involved with their safe and satisfactory use. Prior to installation, the specific assignments should be agreed upon by the parties concerned. A typical, but not mandatory, delineation of assignments is given in B.1.2 through B.1.5, and a detailed checklist is given in B.2.

B.1.2 The person or agency planning an installation of gas equipment does the following:

(1) Verifies the adequacy of the gas supply, volume, pressure, and meter location
(2) Determines suitability of gas for the process
(3) Notifies gas suppliers of significant changes in requirements

B.1.3 Upon request, the gas supplier furnishes the user complete information on the following:

(1) Combustion characteristics and physical or chemical properties such as specific gravity, heating value, pressure, and the approximate analysis of the gas
(2) Conditions under which an adequate supply of gas at suitable pressure can be brought to the site
(3) Continuity of the gas supply

B.1.4 The gas equipment manufacturer or builder provides the following:

(1) Design and construction of all gas equipment or assemblies shipped from its plant
(2) Design and construction of all gas equipment fabricated, erected, or assembled by the gas equipment manufacturer or builder in the field
(3) A statement of the maximum hourly Btu input, type of gas, and design pressure range
(4) Written installation and operating instructions for the user

B.1.5 The person or agency installing the gas equipment and the person or agency authorizing the installation of gas equipment (purchaser) jointly should do the following:

(1) Select, erect, or assemble gas equipment, components, or designs purchased or developed by that person or agency
(2) Ensure conformance to codes, ordinances, or regulations applicable to the installation
(3) Provide adequate means of disposal of products of combustion
(4) Initially operate the gas equipment in a safe manner

B.2 Gas Equipment Design and Construction Checklist.

B.2.1 The basic design and installation should consider the following:

(1) Suitability of equipment for process requirements
(2) Adequate structural strength and stability
(3) Reasonable life expectancy
(4) Conformance to existing safety standards
(5) Adequate combustion space and venting
(6) Means for observation and inspection of combustion

B.2.2 Materials of construction used, other than pipe, fittings, and valves, should provide reasonable life expectancy for the service intended and should be capable of satisfactorily withstanding the following:

(1) Operating temperatures
(2) Chemical action
(3) Thermal shock
(4) Load stresses

B.2.3 Combustion systems should be selected for the characteristics of the available gas so that they will operate properly at the elevation at point of use and produce the following:

(1) Proper heat distribution
(2) Adequate operating temperature range
(3) Suitable flame geometry
(4) Flame stability
(5) Operating flexibility
(6) Desired heating chamber atmosphere

B.2.4 Pipe, fittings, and valves should conform to applicable American National Standards as indicated in Section 5.6. Piping, bushings, and material in fittings should not be selected nor used until the following factors have been considered:

(1) Correct size to handle required volume (consideration of pressure drop in controls and manifolds is particularly important in low pressure systems)
(2) Material specifications suitable for pressures and temperatures encountered
(3) Adequate supports and protection against physical damage
(4) Tight assembly and thorough leak inspection
(5) Use of sufficient unions and flanges, where permitted, for convenient field replacement or repair
(6) Arrangement of piping to provide accessibility for equipment adjustments and freedom from thermal damage

B.2.5 Information concerning the characteristics of the gas and electricity available at the point of utilization should be specific and complete. Gas controls and electrical equipment should be selected to conform to these characteristics, which include the following:

(1) Gas characteristics: Heat content, pressure, specific gravity, and approximate analysis
(2) Electrical characteristics: Voltages, number of phases, and frequencies for both control and power circuits
(3) Location of electrical equipment and wiring to avoid thermal damage and excessive concentrations of dust, dirt, or foreign material
(4) Requirements of applicable electrical codes and standards, with particular reference to NFPA 70, Article 500, of the *National Electrical Code.*

B.2.6 Temperature controls, if used, should be carefully selected considering:

(1) Range and type of instruments and sensing elements
(2) Type of control action
(3) Suitability for service required
(4) Correlation of control instruments with operating equipment

B.2.7 In enclosed chambers, the accumulation of gas–air or solvent–air mixtures that can be accidentally ignited constitutes a potential hazard to life and property. For this reason, consideration should be given to the selection and installation of suitable protective equipment. The selection of a satisfactory protective system and components not otherwise covered by existing codes or standards should be based on the requirements of each individual installation after consultation with the various interested parties, including the user, designer, insurance company, and local authorities having jurisdiction. Factors and considerations involved in the selection of protective equipment include the following:

(1) Feasibility of its installation
(2) Its adaptability to process and control requirements
(3) Conformance to existing standards, ordinances, requirements, and other regulations that apply *(See Annex L for listing of standards and specifications.)*

B.3 Maintenance of Gas Equipment.

B.3.1 These recommendations are prepared for maintenance of gas equipment. Special types of equipment demand special attention.

B.3.2 Burners and pilots should be kept clean and in proper operating condition. Burner refractory parts should be examined at frequent regular intervals to ensure good condition.

B.3.3 Where automatic flame safeguards are used, a complete shutdown and restart should be made at frequent intervals to check the components for proper operation.

B.3.4 Other Safeguard Equipment.

B.3.4.1 Accessory safeguard equipment, such as manual reset valves with pressure or vacuum switches, high-temperature limit switches, draft controls, shutoff valves, airflow switches, door switches, and gas valves, should be operated at frequent regular intervals to ensure proper functioning. If inoperative, they should be repaired or replaced promptly.

B.3.4.2 Where firechecks are installed in gas–air mixture piping to prevent flashbacks from traveling farther upstream, the pressure loss across the firechecks should be measured at regular intervals. When excessive pressure loss is found, screens should be removed and cleaned. Water-type backfire checks should be inspected at frequent regular intervals and liquid level maintained.

B.3.4.3 All safety shutoff valves should be checked for leakage and proper operation at frequent regular intervals.

B.3.5 Auxiliary Devices.

B.3.5.1 A necessary part of the gas equipment maintenance is the proper maintenance of auxiliary devices. Maintenance instructions as supplied by the manufacturers of these devices should be followed.

B.3.5.2 Gas combustion equipment, including blowers, mechanical mixers, control valves, temperature control instruments, air valves, and air filters, should be kept clean and should be examined at frequent regular intervals.

B.3.5.3 Necessary repairs and replacements should be made promptly.

B.3.6 Regulator and zero governor vents and impulse or control piping and tubing should be kept clear. Regulator valves that operate improperly should be cleaned, repaired, or replaced promptly.

B.3.7 A necessary part of the gas equipment maintenance is the proper maintenance of the gas piping system. It is recommended that gas piping be inspected and tested for leakage at regular intervals in accordance with the provisions of 7.1.5. Air piping should be kept internally clean to prevent accumulation of dust, lint, and grease in air jets and valves. Where conditions warrant, filters should be installed at the intake to the fans.

B.3.8 Standby or substitute fuel equipment and systems for gas equipment should be kept in good operating condition and tested periodically.

B.3.9 An adequate supply of repair parts should be maintained.

Annex C Sizing and Capacities of Gas Piping

This annex is not a part of the requirements of this code but is included for informational purposes only.

C.1 General. To determine the size of piping used in a gas piping system, the following factors must be considered:

(1) Allowable loss in pressure from point of delivery to equipment
(2) Maximum gas demand
(3) Length of piping and number of fittings
(4) Specific gravity of the gas
(5) Diversity factor

For any gas piping system, or special gas utilization equipment, or for conditions other than those covered by the tables provided in this code, such as longer runs, greater gas demands, or greater pressure drops, the size of each gas piping system should be determined by standard engineering practices acceptable to the authority having jurisdiction.

C.2 Description of Tables.

C.2.1 General. The quantity of gas to be provided at each outlet should be determined, whenever possible, directly from the manufacturer's Btu input rating of the equipment that will be installed. In case the ratings of the equipment to be installed are not known, Table 5.4.2.1 shows the approximate consumption (in Btu per hour) of certain types of typical household appliances.

To obtain the cubic feet per hour of gas required, divide the total Btu input of all equipment by the average Btu heating value per cubic foot of the gas. The average Btu per cubic foot of the gas in the area of the installation can be obtained from the serving gas supplier.

C.2.2 Low Pressure Natural Gas Tables. Capacities for gas at low pressure [0.5 psig (3.5 kPa gauge) or less] in cubic feet per hour of 0.60 specific gravity gas for different sizes and lengths are shown in Table 12.1 and Table 12.2 for iron pipe or equivalent rigid pipe, in Table 12.7 through Table 12.9 for smooth wall semi-rigid tubing, in Table 12.14 through Table 12.16 for corrugated stainless steel tubing. Table 12.1 and Table 12.7 are based upon a pressure drop of 0.3 in. w.c. (75 Pa), whereas Table 12.2, Table 12.8, and Table 12.14 are based upon a pressure drop of 0.5 in. w.c. (125 Pa). Table 12.9, Table 12.15, and Table 12.16 are special low-pressure applications based upon pressure drops greater than 0.5 in. w.c. (125 Pa). In using these tables, an allowance (in equivalent length of pipe) should be considered for any piping run with four or more fittings *(see Table C.2.2)*.

C.2.3 Undiluted Liquefied Petroleum Gas Tables. Capacities in thousands of Btu per hour of undiluted liquefied petroleum gases based on a pressure drop of 0.5 in. w.c. (125 Pa) for different sizes and lengths are shown in Table 12.24 for iron pipe or equivalent rigid pipe, in Table 12.26 for smooth wall semi-rigid tubing, in Table 12.28 for corrugated stainless steel tubing, and in Table 12.31 and Table 12.33 for polyethylene plastic pipe and tubing. Table 12.29 and Table 12.30 for corrugated stainless steel tubing and Table 12.32 polyethylene plastic pipe are based on operating pressures greater than 0.5 psi (3.5 kPa) and pressure drops greater than 0.5 in. w.c. (125 Pa). In using these tables, an allowance (in equivalent length of pipe) should be considered for any piping run with four or more fittings *(see Table C.2.2)*.

C.2.4 Natural Gas Specific Gravity. Gas piping systems that are to be supplied with gas of a specific gravity of 0.70 or less can be sized directly from the tables provided in this code, unless the authority having jurisdiction specifies that a gravity factor be applied. Where the specific gravity of the gas is greater than 0.70, the gravity factor should be applied.

Application of the gravity factor converts the figures given in the tables provided in this code to capacities for another gas of different specific gravity. Such application is accomplished by multiplying the capacities given in the tables by the multipliers shown in Table C.2.4. In case the exact specific gravity does not appear in the table, choose the next higher value specific gravity shown.

C.2.5 Higher Pressure Natural Gas Tables. Capacities for gas at pressures greater than 0.5 psig (3.5 kPa gauge) in cubic feet per hour of 0.60 specific gravity gas for different sizes and lengths are shown in Table 12.3 through Table 12.6 for iron pipe or equivalent rigid pipe, Table 12.10 through Table 12.13 for semi-rigid tubing, Table 12.17 and Table 12.18 for corrugated stainless steel tubing, and Table 12.19 through Table 12.21 for polyethylene plastic pipe.

C.3 Use of Capacity Tables.

C.3.1 The Longest Length Method. This sizing method is conservative in its approach by applying the maximum operating conditions in the system as the norm for the system and by setting the length of pipe used to size any given part of the piping system to the maximum value.

To determine the size of each section of gas piping in a system within the range of the capacity tables, proceed as follows. *(Also see sample calculations included in this annex.)*

(1) Divide the piping system into appropriate segments consistent with the presence of tees, branch lines, and main runs. For each segment, determine the gas load (assuming all appliances operate simultaneously) and its overall length. An allowance (in equivalent length of pipe) as determined from Table C.2.2, shall be considered for piping segments that include four or more fittings.
(2) Determine the gas demand of each appliance to be attached to the piping system. Where Table 12.1 through Table 12.23 are to be used to select the piping size, calculate the gas demand in terms of cubic feet per hour for each piping system outlet. Where Table 12.24 through Table 12.33 are to be used to select the piping size, calculate the gas demand in terms of thousands of Btu per hour for each piping system outlet.
(3) Where the piping system is for use with other than undiluted liquefied petroleum gases, determine the design system pressure, the allowable loss in pressure (pressure drop), and specific gravity of the gas to be used in the piping system.
(4) Determine the length of piping from the point of delivery to the most remote outlet in the building/piping system.
(5) In the appropriate capacity table, select the row showing the measured length or the next longer length if the table does not give the exact length. This is the only length used in determining the size of any section of gas piping. If the gravity factor is to be applied, the values in the selected row of the table are multiplied by the appropriate multiplier from Table C.2.4.
(6) Use this horizontal row to locate ALL gas demand figures for this particular system of piping.
(7) Starting at the most remote outlet, find the gas demand for that outlet in the horizontal row just selected. If the exact figure of demand is not shown, choose the next larger figure left in the row.
(8) Opposite this demand figure, in the first row at the top, the correct size of gas piping will be found.
(9) Proceed in a similar manner for each outlet and each section of gas piping. For each section of piping, determine the total gas demand supplied by that section.

When a large number of piping components (such as elbows, tees, and valves) are installed in a pipe run, additional pressure loss can be accounted for by the use of equivalent lengths. Pressure loss across any piping component can be equated to the pressure drop through a length of pipe. The equivalent length of a combination of only four elbows/tees can result in a jump to the next larger length row, resulting in a significant reduction in capacity. The equivalent lengths in feet shown in Table C.2.2 have been computed on a basis that the inside diameter corresponds to that of Schedule 40 (standard-weight) steel pipe, which is close enough for most purposes involving other schedules of pipe. Where a more specific solution for equivalent length is desired, this may be made by multiplying the actual inside diameter of the pipe in inches by $n/12$, or the actual inside diameter in feet by n. N can be read from the table heading. The equivalent length values can be used with reasonable accuracy for copper or brass fittings and bends although the resistance per foot of copper or brass pipe is less than that of steel. For copper or brass valves, however, the equivalent length of pipe should be taken as 45 percent longer than the values in the table, which are for steel pipe.

C.3.2 The Branch Length Method. This sizing method reduces the amount of conservatism built into the traditional Longest Length Method. The longest length as measured from the meter to the farthest remote appliance is only used to size the initial parts of the overall piping system. The Branch Length Method is applied in the following manner:

(1) Determine the gas load for each of the connected appliances.
(2) Starting from the meter, divide the piping system into a number of connected segments, and determine the length and amount of gas that each segment would carry

Table C.2.2 Equivalent Lengths of Pipe Fittings and Valves

		Screwed Fittings[1]				90° Welding Elbows and Smooth Bends[2]					
		45°/Ell	90°/Ell	180° Close Return Bends	Tee	R/d = 1	R/d = 1⅓	R/d = 2	R/d = 4	R/d = 6	R/d = 8
k factor =		0.42	0.90	2.00	1.80	0.48	0.36	0.27	0.21	0.27	0.36
L/d' ratio[4] n =		14	30	67	60	16	12	9	7	9	12
Nominal Pipe Size (in.)	Inside Diam. d (in.), Sched. 40[6]										
		L = Equivalent Length in Feet of Schedule 40 (Standard Weight) Straight Pipe[6]									
½	0.622	0.73	1.55	3.47	3.10	0.83	0.62	0.47	0.36	0.47	0.62
¾	0.824	0.96	2.06	4.60	4.12	1.10	0.82	0.62	0.48	0.62	0.82
1	1.049	1.22	2.62	5.82	5.24	1.40	1.05	0.79	0.61	0.79	1.05
1¼	1.380	1.61	3.45	7.66	6.90	1.84	1.38	1.03	0.81	1.03	1.38
1½	1.610	1.88	4.02	8.95	8.04	2.14	1.61	1.21	0.94	1.21	1.61
2	2.067	2.41	5.17	11.5	10.3	2.76	2.07	1.55	1.21	1.55	2.07
2½	2.469	2.88	6.16	13.7	12.3	3.29	2.47	1.85	1.44	1.85	2.47
3	3.068	3.58	7.67	17.1	15.3	4.09	3.07	2.30	1.79	2.30	3.07
4	4.026	4.70	10.1	22.4	20.2	5.37	4.03	3.02	2.35	3.02	4.03
5	5.047	5.88	12.6	28.0	25.2	6.72	5.05	3.78	2.94	3.78	5.05
6	6.065	7.07	15.2	33.8	30.4	8.09	6.07	4.55	3.54	4.55	6.07
8	7.981	9.31	20.0	44.6	40.0	10.6	7.98	5.98	4.65	5.98	7.98
10	10.02	11.7	25.0	55.7	50.0	13.3	10.0	7.51	5.85	7.51	10.0
12	11.94	13.9	29.8	66.3	59.6	15.9	11.9	8.95	6.96	8.95	11.9
14	13.13	15.3	32.8	73.0	65.6	17.5	13.1	9.85	7.65	9.85	13.1
16	15.00	17.5	37.5	83.5	75.0	20.0	15.0	11.2	8.75	11.2	15.0
18	16.88	19.7	42.1	93.8	84.2	22.5	16.9	12.7	9.85	12.7	16.9
20	18.81	22.0	47.0	105	94.0	25.1	18.8	14.1	11.0	14.1	18.8
24	22.63	26.4	56.6	126	113	30.2	22.6	17.0	13.2	17.0	22.6

assuming that all appliances were operated simultaneously. An allowance (in equivalent length of pipe) as determined from Table C.2.2 should be considered for piping segments that include four or more fittings.

(3) Determine the distance from the outlet of the gas meter to the appliance farthest removed from the meter.

(4) Using the longest distance (found in Step 3), size each piping segment from the meter to the most remote appliance outlet.

(5) For each of these piping segments, use the longest length and the calculated gas load for all of the connected appliances for the segment and begin the sizing process in Steps 6 through 8.

(6) Referring to the appropriate sizing table (based on operating conditions and piping material), find the longest length distance in the first column or the next larger distance if the exact distance is not listed. The use of alternative operating pressures and/or pressure drops will require the use of a different sizing table, but will not alter the sizing methodology. In many cases, the use of alternative operating pressures and/or pressure drops will require the approval of both the authority having jurisdiction and the local gas serving utility.

(7) Trace across this row until the gas load is found or the closest larger capacity if the exact capacity is not listed.

(8) Read up the table column and select the appropriate pipe size in the top row. Repeat Steps 6, 7, and 8 for each pipe segment in the longest run.

(9) Size each remaining section of branch piping not previously sized by measuring the distance from the gas meter location to the most remote outlet in that branch, using the gas load of attached appliances and follow the procedures of Steps 2 through 8.

Table C.2.2 ***Continued***

Miter Elbows[3] (No. of Miters)					Welding Tees		Valves (Screwed, Flanged, or Welded)			
1-45°	**1-60°**	**1-90°**	**2-90°**	**3-90°**	**Forged**	**Miter[3]**	**Gate**	**Globe**	**Angle**	**Swing Check**
0.45	**0.90**	**1.80**	**0.60**	**0.45**	**1.35**	**1.80**	**0.21**	**10**	**5.0**	**2.5**
15	**30**	**60**	**20**	**15**	**45**	**60**	**7**	**333**	**167**	**83**
			5 	5 						
***L* = Equivalent Length in Feet of Schedule 40 (Standard Weight) Straight Pipe[6]**										
0.78	1.55	3.10	1.04	0.78	2.33	3.10	0.36	17.3	8.65	4.32
1.03	2.06	4.12	1.37	1.03	3.09	4.12	0.48	22.9	11.4	5.72
1.31	2.62	5.24	1.75	1.31	3.93	5.24	0.61	29.1	14.6	7.27
1.72	3.45	6.90	2.30	1.72	5.17	6.90	0.81	38.3	19.1	9.58
2.01	4.02	8.04	2.68	2.01	6.04	8.04	0.94	44.7	22.4	11.2
2.58	5.17	10.3	3.45	2.58	7.75	10.3	1.21	57.4	28.7	14.4
3.08	6.16	12.3	4.11	3.08	9.25	12.3	1.44	68.5	34.3	17.1
3.84	7.67	15.3	5.11	3.84	11.5	15.3	1.79	85.2	42.6	21.3
5.04	10.1	20.2	6.71	5.04	15.1	20.2	2.35	112	56.0	28.0
6.30	12.6	25.2	8.40	6.30	18.9	25.2	2.94	140	70.0	35.0
7.58	15.2	30.4	10.1	7.58	22.8	30.4	3.54	168	84.1	42.1
9.97	20.0	40.0	13.3	9.97	29.9	40.0	4.65	222	111	55.5
12.5	25.0	50.0	16.7	12.5	37.6	50.0	5.85	278	139	69.5
14.9	29.8	59.6	19.9	14.9	44.8	59.6	6.96	332	166	83.0
16.4	32.8	65.6	21.9	16.4	49.2	65.6	7.65	364	182	91.0
18.8	37.5	75.0	25.0	18.8	56.2	75.0	8.75	417	208	104
21.1	42.1	84.2	28.1	21.1	63.2	84.2	9.85	469	234	117
23.5	47.0	94.0	31.4	23.5	70.6	94.0	11.0	522	261	131
28.3	56.6	113	37.8	28.3	85.0	113	13.2	629	314	157

For SI units, 1 ft = 0.305 m.

Note: Values for welded fittings are for conditions where bore is not obstructed by weld spatter or backing rings. If appreciably obstructed, use values for "Screwed Fittings."

[1]Flanged fittings have three-fourths the resistance of screwed elbows and tees.

[2]Tabular figures give the extra resistance due to curvature alone to which should be added the full length of travel.

[3]Small size socket-welding fittings are equivalent to miter elbows and miter tees.

[4]Equivalent resistance in number of diameters of straight pipe computed for a value of $f - 0.0075$ from the relation $n - k/4f$.

[5]For condition of minimum resistance where the centerline length of each miter is between d and $2\frac{1}{2}d$.

[6]For pipe having other inside diameters, the equivalent resistance may be computed from the above n values.

Source: From *Piping Handbook*, Table XIV, pp. 100–101. Used by permission of McGraw-Hill Book Company.

Table C.2.4 SPECIAL USE: Multipliers to Be Used with Tables 12.1 Through 12.21 When the Specific Gravity of the Gas Is Other than 0.60

Specific Gravity	Multiplier	Specific Gravity	Multiplier
0.35	1.31	1.00	0.78
0.40	1.23	1.10	0.74
0.45	1.16	1.20	0.71
0.50	1.10	1.30	0.68
0.55	1.04	1.40	0.66
0.60	1.00	1.50	0.63
0.65	0.96	1.60	0.61
0.70	0.93	1.70	0.59
0.75	0.90	1.80	0.58
0.80	0.87	1.90	0.56
0.85	0.84	2.00	0.55
0.90	0.82	2.10	0.54

C.3.3 Hybrid Pressure Method. The sizing of a 2 psi (13.8 kPa) gas piping system is performed using the traditional Longest Length Method but with modifications. The 2 psi (13.8 kPa) system consists of two independent pressure zones, and each zone is sized separately. The Hybrid Pressure Method is applied as follows.

The 2 psi (13.8 kPa) section (from the meter to the line regulator) is sized as follows:

(1) Calculate the gas load (by adding up the name plate ratings) from all connected appliances. (In certain circumstances the installed gas load may be increased up to 50 percent to accommodate future addition of appliances.) Ensure that the line regulator capacity is adequate for the calculated gas load and that the required pressure drop (across the regulator) for that capacity does not exceed ¾ psi (5.2 kPa) for a 2 psi (13.8 kPa) system. If the pressure drop across the regulator is too high (for the connected gas load), select a larger regulator.
(2) Measure the distance from the meter to the line regulator located inside the building.
(3) If there are multiple line regulators, then measure the distance from the meter to the regulator farthest removed from the meter.
(4) The maximum allowable pressure drop for the 2 psi (13.8 kPa) section is 1 psi (6.9 kPa).
(5) Referring to the appropriate sizing table (based on piping material) for 2 psi (13.8 kPa) systems with a 1 psi (6.9 kPa) pressure drop, find this distance in the first column, or the closest larger distance if the exact distance is not listed.
(6) Trace across this row until the gas load is found or the closest larger capacity if the exact capacity is not listed.
(7) Read up the table column to the top row and select the appropriate pipe size.
(8) If there are multiple regulators in this portion of the piping system, each line segment must be sized for its actual gas load, but using the longest length previously determined above.

The low pressure section (all piping downstream of the line regulator) is sized as follows:

(1) Determine the gas load for each of the connected appliances.
(2) Starting from the line regulator, divide the piping system into a number of connected segments and/or independent parallel piping segments and determine the amount of gas that each segment would carry assuming that all appliances were operated simultaneously. An allowance (in equivalent length of pipe) as determined from Table C.2.2 should be considered for piping segments that include four or more fittings.
(3) For each piping segment, use the actual length or longest length (if there are sub–branch lines) and the calculated gas load for that segment and begin the sizing process as follows:
   (a) Referring to the appropriate sizing table (based on operating pressure and piping material), find the longest length distance in the first column or the closest larger distance if the exact distance is not listed. The use of alternative operating pressures and/or pressure drops will require the use of a different sizing table, but will not alter the sizing methodology. In many cases, the use of alternative operating pressures and/or pressure drops may require the approval of the authority having jurisdiction.
   (b) Trace across this row until the appliance gas load is found or the closest larger capacity if the exact capacity is not listed.
   (c) Read up the table column to the top row and select the appropriate pipe size.
   (d) Repeat this process for each segment of the piping system.

C.4 Use of Sizing Equations. Capacities of smooth wall pipe or tubing can also be determined by using the following formulae:

(1) *High Pressure* [1.5 psi (10.3 kPa) and above]:

$$Q = 181.6\sqrt{\frac{D^5 \cdot \left(P_1^2 - P_2^2\right) \cdot Y}{Cr \cdot fba \cdot L}}$$

$$= 2237 D^{2.623}\left[\frac{\left(P_1^2 - P_2^2\right) \cdot Y}{Cr \cdot L}\right]^{0.541}$$

(2) *Low Pressure* [less than 1.5 psi (10.3 kPa)]:

$$Q = 187.3\sqrt{\frac{D^5 \cdot \Delta H}{Cr \cdot fba \cdot L}}$$

$$= 2313 D^{2.623}\left(\frac{\Delta H}{Cr \cdot L}\right)^{0.541}$$

where:

Q = rate, cubic feet per hour at 60°F and 30 in. mercury column
D = inside diameter of pipe, in.
P_1 = upstream pressure, psia
P_2 = downstream pressure, psia
Y = superexpansibility factor = 1/supercompressibility factor
fba = Base friction factor for air at 60°F (CF = 1)
L = Length of pipe, ft
H = Pressure drop, in. w.c. (27.7 in. H_2O = 1 psi) = $0.00354\ ST(Z/S)^{0.152}$
Cr = Factor for viscosity, density, and temperature
S = Specific gravity of gas at 60°F and 30 in. mercury column (0.60 for natural gas, 1.53 for propane)
T = Absolute temperature, °F or = t + 460
t = Temperature, °F
Z = Viscosity of gas, centipoise (0.012 for natural gas, 0.008 for propane), or = 1488

See Table 12.3.2 for values of *Cr* and *Y* for natural gas and propane.

C.5 Pipe and Tube Diameters. Where the internal diameter is determined by the formulas in Section 12.3, Table C.5(a) and Table C.5(b) can be used to select the nominal or standard pipe size based on the calculated internal diameter.

Table C.5(a) Schedule 40 Steel Pipe Standard Sizes

Nominal Size (in.)	Internal Diameter (in.)	Nominal Size (in.)	Internal Diameter (in.)
¼	0.364	1½	1.610
⅜	0.493	2	2.067
½	0.622	2½	2.469
¾	0.824	3	3.068
1	1.049	3½	3.548
1¼	1.380	4	4.026

Table C.5(b) Copper Tube Standard Sizes

Tube Type	Nominal or Standard Size (in.)	Internal Diameter (in.)	Tube Type	Nominal or Standard Size (in.)	Internal Diameter (in.)
K	¼	0.305	K	1	0.995
L	¼	0.315	L	1	1.025
ACR (D)	⅜	0.315	ACR (D,A)	1⅛	1.025
ACR (A)	⅜	0.311	K	1¼	1.245
K	⅜	0.402	L	1¼	1.265
L	⅜	0.430	ACR (D,A)	1⅜	1.265
ACR (D)	½	0.430	K	1½	1.481
ACR (A)	½	0.436	L	1½	1.505
K	½	0.527	ACR (D,A)	1⅝	1.505
L	½	0.545	K	2	1.959
ACR (D)	⅝	0.545	L	2	1.985
ACR (A)	⅝	0.555	ACR (D,A)	2⅛	1.985
K	⅝	0.652	K	2½	2.435
L	⅝	0.666	L	2½	2.465
ACR (D)	¾	0.666	ACR (D,A)	2⅝	2.465
ACR (A)	¾	0.680	K	3	2.907
K	¾	0.745	L	3	2.945
L	¾	0.785	ACR (D,A)	3⅛	2.945
ACR (D,A)	⅞	0.785			

C.6 Use of Sizing Charts. A third method of sizing gas piping is detailed below as an option that is useful when large quantities of piping are involved in a job (e.g., an apartment house) and material costs are of concern. If the user is not completely familiar with this method, the resulting pipe sizing should be checked by a knowledgeable gas engineer. The sizing charts are applied as follows:

(1) With the layout developed according to Section 2.1 of the code, indicate in each section the *design gas flow* under maximum operation conditions. For many layouts, the maximum design flow will be the sum of all connected loads. However, in some cases, certain combinations of utilization equipment will not occur simultaneously (e.g., gas heating and air conditioning). For these cases, the design flow is the greatest gas flow that can occur at any one time.

(2) Determine the *inlet gas pressure* for the system being designed. In most cases, the point of inlet will be the gas meter or service regulator, but in the case of a system addition, it could be the point of connection to the existing system.

(3) Determine the *minimum pressure* required at the inlet to the critical utilization equipment. Usually, the critical item will be the piece of equipment with the highest required pressure for satisfactory operation. If several items have the same required pressure, it will be the one with the greatest length of piping from the system inlet.

(4) The difference between the inlet pressure and critical item pressure is the *allowable system pressure drop*. Figure C.6(a) and Figure C.6(b) show the relationship between gas flow, pipe size, and pipe length for natural gas with 0.60 specific gravity.

(5) To use Figure C.6(a) (low pressure applications), calculate the piping length from the inlet to the critical utilization equipment. Increase this length by 50 percent to allow for fittings. Divide the allowable pressure drop by the equivalent length (in hundreds of feet) to determine the allowable pressure drop per hundred feet. Select the pipe size from Figure C.6(a) for the required volume of flow.

(6) To use Figure C.6(b)(high pressure applications), calculate the equivalent length as above. Calculate the *index number* for Figure C.6(b) by dividing the difference between the squares of the absolute values of inlet and outlet pressures by the equivalent length (in hundreds of feet). Select the pipe size from Figure C.6(b) for the gas volume required.

C.7 Examples of Piping System Design and Sizing.

C.7.1 Example 1 — Longest Length Method. Determine the required pipe size of each section and outlet of the piping system shown in Figure C.7.1, with a designated pressure drop of 0.50 in. w.c. (125 Pa) using the Longest Length Method. The gas to be used has 0.60 specific gravity and a heating value of 1000 Btu/ft^3 (37.5 MJ/m^3).

Solution

(1) Maximum gas demand for outlet A:

$$\frac{\text{Consumption}\left(\begin{matrix}\text{rating plate input, or}\\ \text{Table 5.4.2.1 if necessary}\end{matrix}\right)}{\text{Btu of gas}} =$$

$$\frac{35{,}000\ \text{Btu/hr rating}}{1{,}000\ \text{Btu/ft}} = 35\ \text{ft}^3/\text{hr} = 35\ \text{cfh}$$

Maximum gas demand for outlet B:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{75{,}000}{1{,}000} = 75\ \text{cfh}$$

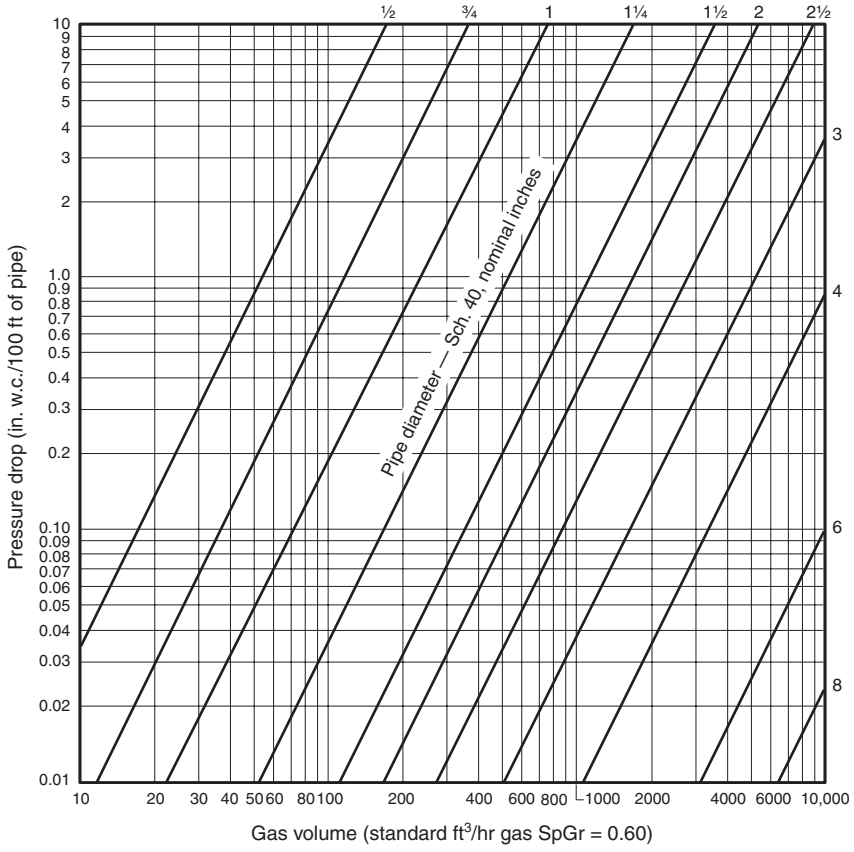


FIGURE C.6(a) Capacity of Natural Gas Piping, Low Pressure (0.60 in. w.c.).

Maximum gas demand for outlet C:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{35{,}000}{1{,}000} = 35 \text{ cfh}$$

Maximum gas demand for outlet D:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{100{,}000}{1{,}000} = 100 \text{ cfh}$$

(2) The length of pipe from the point of delivery to the most remote outlet (A) is 60 ft (18.3 m). This is the only distance used.
(3) Using the row marked 60 ft (18.3 m) in Table 12.2:
  (a) Outlet A, supplying 35 cfh (0.99 m^3/hr), requires ⅜ in. pipe.
  (b) Outlet B, supplying 75 cfh (2.12 m^3/hr), requires ¾ in. pipe.
  (c) Section 1, supplying outlets A and B, or 110 cfh (3.11 m^3/hr), requires ¾ in. pipe.
  (d) Section 2, supplying outlets C and D, or 135 cfh (3.82 m^3/hr), requires ¾ in. pipe.
  (e) Section 3, supplying outlets A, B, C, and D, or 245 cfh (6.94 m^3/hr), requires 1 in. pipe.
(4) If a different gravity factor is applied to this example, the values in the row marked 60 ft (18.3 m) of Table 12.2 would be multiplied by the appropriate multiplier from Table C.2.4 and the resulting cubic feet per hour values would be used to size the piping.

C.7.2 Example 2 — Hybrid or Dual Pressure Systems. Determine the required CSST size of each section of the piping system shown in Figure C.7.2, with a designated pressure drop of 1 psi (6.9 kPa) for the 2 psi (13.8 kPa) section and 3 in. w.c. (0.75 kPa) pressure drop for the 10 in. w.c. (2.49 kPa) section. The gas to be used has 0.60 specific gravity and a heating value of 1000 Btu/ft^3 (37.5 MJ/m^3).

Solution

(1) Size 2 psi (13.8 kPa) line using Table 12.17.
(2) Size 10 in. w.c. (2.5 kPa) lines using Table 12.15.
(3) Using the following steps, determine if sizing tables can be used:
  (a) Total gas load shown in Figure C.7.2 equals 110 chf (3.11 m^3/hr).
  (b) Determine pressure drop across regulator (see notes in Table 12.17).
  (c) If pressure drop across regulator exceeds ¾ psi (5.2 kPa), Table 12.17 cannot be used. Note that if pressure drop exceeds ¾ psi (5.2 kPa), then a larger regulator must be selected or an alternative sizing method must be used.
  (d) Pressure drop across the line regulator [for 110 cfh/(3.11 m^3/hr)] is 4 in. w.c. (0.99 kPa) based on manufacturer's performance data.
  (e) Assume the CSST manufacturer has tubing sizes or EHDs of 13, 18, 23, and 30.
(4) From Section A [2 psi (13.8 kPa) zone]:

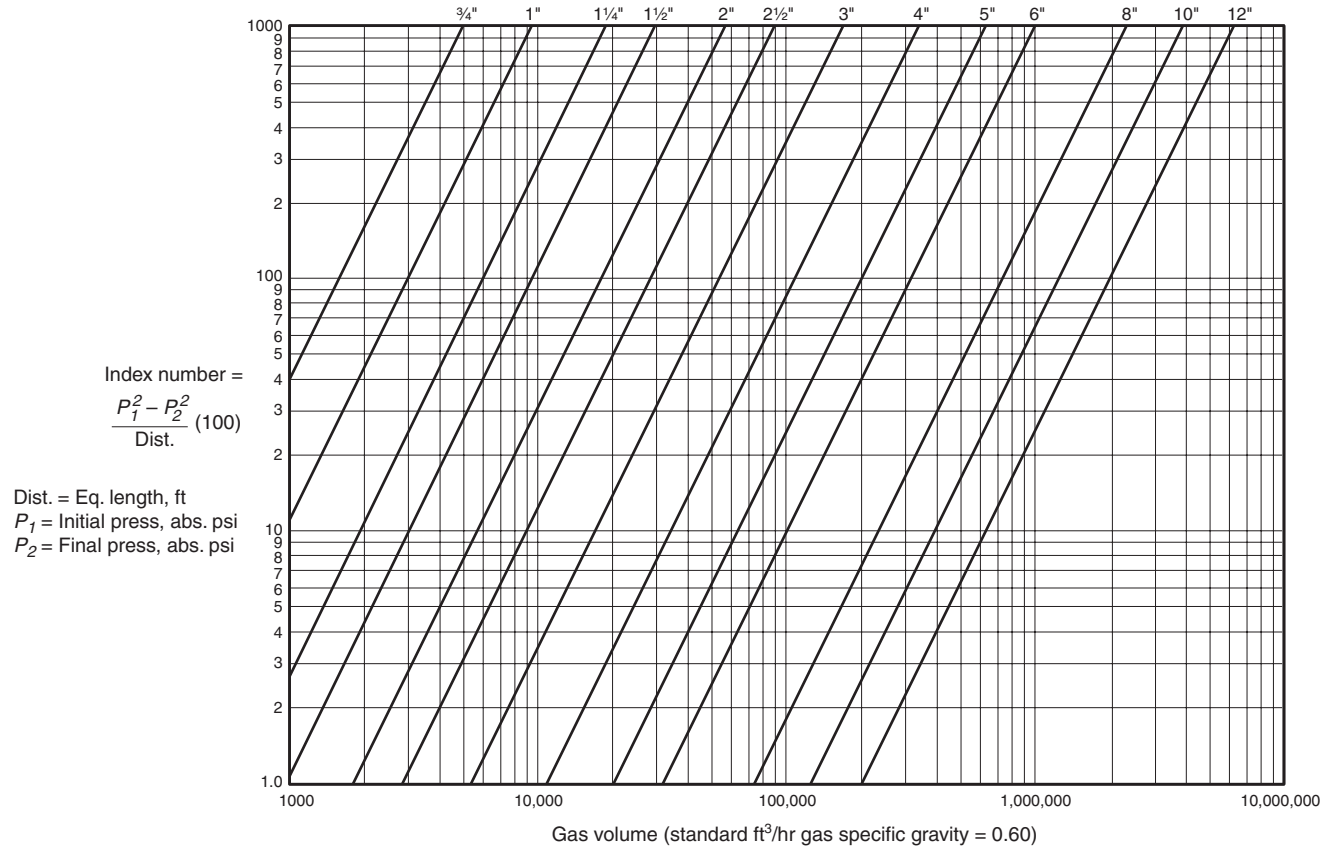
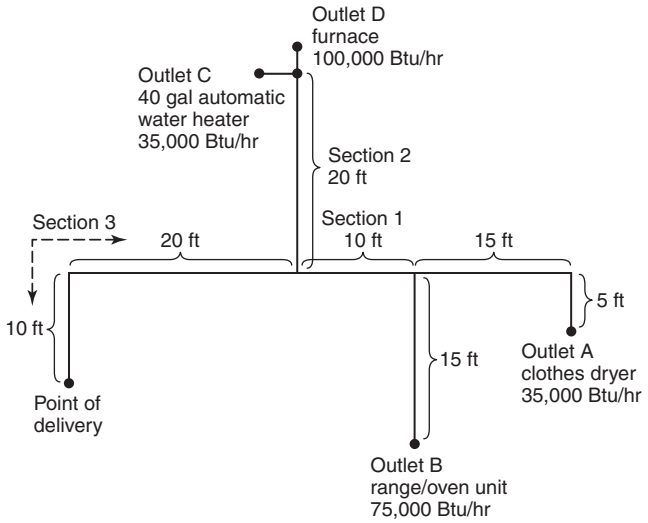


FIGURE C.6(b) Capacity of Natural Gas Piping, High Pressure (1.5 psi and above).



For SI units, 1 ft = 0.305 m, 1 gal = 3.785 L, 1000 Btu/hr = 0.293 kW.

FIGURE C.7.1 Piping Plan Showing a Steel Piping System.

(a) Determine distance from meter to regulator = 100 ft (30.48 m).
(b) Determine total load supplied by A = 110 cfh (3.11 m^3/hr) (furnace + water heater + dryer).
(c) Table 12.17 shows that EHD size 18 should be used. Note that it is not unusual to oversize the supply line by 25 to 50 percent of the as-installed load. EHD size 18 has a capacity of 189 cfh (5.35 m^3/hr).

(5) From Section B (low pressure zone):
(a) Distance from regulator to furnace is 15 ft (4.57 m).
(b) Load is 60 cfh (1.70 m^3/hr).
(c) Table 12.15 shows that EHD size 13 should be used.

(6) From Section C (low pressure zone):
(a) Distance from regulator to water heater is 10 ft (3 m).
(b) Load is 30 cfh (0.85 m^3/hr).
(c) Table 12.15 shows that EHD size 13 should be used.

(7) From Section D (low pressure zone):
(a) Distance from regulator to dryer is 25 ft (7.62 m).
(b) Load is 20 cfh (0.57 m^3/hr).
(c) Table 12.15 shows that EHD size 13 should be used.

C.7.3 Example 3 — Branch Length Method. Determine the required semi-rigid copper tubing size of each section of the piping system shown in Figure C.7.3, with a designated pressure drop of 1 in. w.c. (250 Pa) (using the Branch Length Method). The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/ft^3 (37.5 MJ/m^3).

Solution

(1) Section A:
(a) The length of tubing from the point of delivery to the most remote appliance is 50 ft (15 m), A + C.

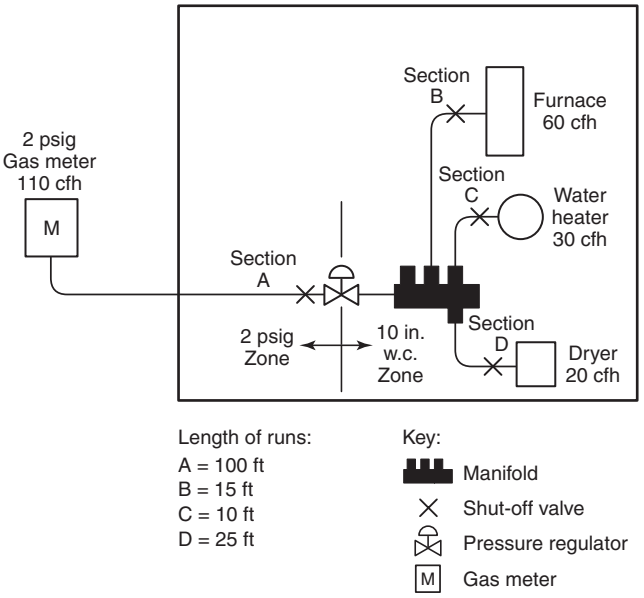


FIGURE C.7.2 Piping Plan Showing a CSST System.

(b) Use this longest length to size Sections A and C.
(c) Using the row marked 50 ft (15 m) in Table 12.9, Section A supplying 220 cfh (6.23 m^3/hr) for four appliances requires 1 in. tubing.

(2) Section B:
(a) The length of tubing from the point of delivery to the range/oven at the end of Section B is 30 ft (9.14 m), A + B.
(b) Use this branch length to size Section B only.
(c) Using the row marked 30 ft (9.14 m) in Table 12.9, Section B supplying 75 cfh (2.12 m^3/hr) for the range/oven requires ½ in. tubing.

(3) Section C:
(a) The length of tubing from the point of delivery to the dryer at the end of Section C is 50 ft (15 m), A + C.
(b) Use this branch length (which is also the longest length) to size Section C.
(c) Using the row marked 50 ft (15 m) in Table 12.9, Section C supplying 30 cfh (0.85 m^3/hr) for the dryer requires ⅜ in. tubing.

(4) Section D:
(a) The length of tubing from the point of delivery to the water heater at the end of Section D is 30 ft (9.14 m), A + D.
(b) Use this branch length to size Section D only.
(c) Using the row marked 30 ft (9.14 m) in Table 12.9, Section D supplying 35 cfh (34.69 m^3/hr) for the water heater requires ⅜ in. tubing.

(5) Section E:
(a) The length of tubing from the point of delivery to the furnace at the end of Section E is 30 ft (9.14 m), A + E.
(b) Use this branch length to size Section E only.
(c) Using the row marked 30 ft (9.14 m) in Table 12.9, Section E supplying 80 cfh (0.99 m^3/hr) for the furnace requires ½ in. tubing.

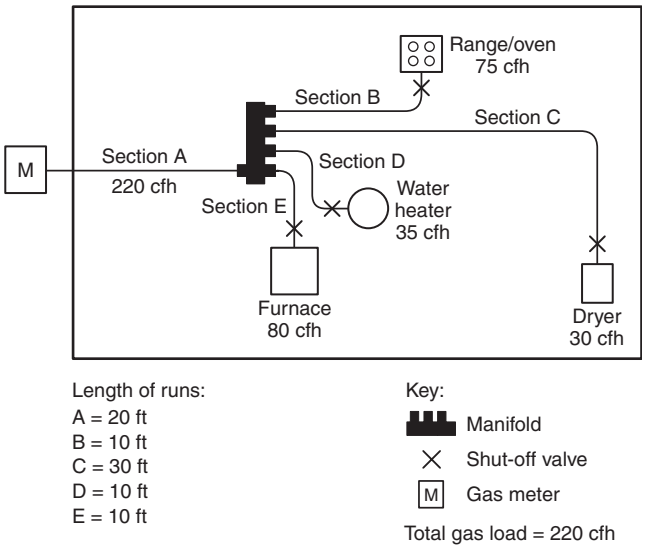


FIGURE C.7.3 Piping Plan Showing a Copper Tubing System.

C.7.4 Example 4 — Modification to Existing Piping System. Determine the required CSST size for Section G (retrofit application) of the piping system shown in Figure C.7.4, with a designated pressure drop of 0.50 in. w.c. (125 Pa) using the Branch Length Method. The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/ft^3 (37.5 MJ/m^3).

Solution

(1) The length of pipe and CSST from the point of delivery to the retrofit appliance (barbecue) at the end of Section G is 40 ft (12.19 m), A + B + G.
(2) Use this branch length to size Section G.
(3) Assume the CSST manufacturer has tubing sizes or EHDs of 13, 18, 23, and 30.

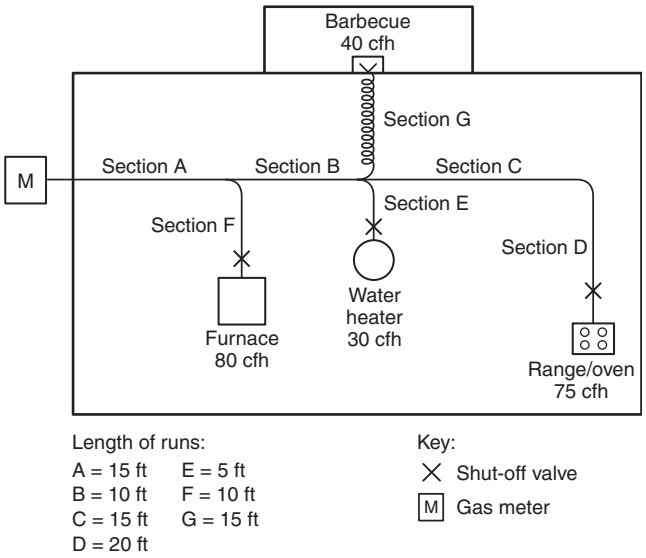


FIGURE C.7.4 Piping Plan Showing Modification to an Existing Piping System.

(4) Using the row marked 40 ft (12.19 m) in Table 12.14, Section G supplying 40 cfh (1.13 m^3/hr) for the barbecue requires EHD 18 CSST.
(5) The sizing of Sections A, B, F, and E must be checked to ensure adequate gas carrying capacity since an appliance has been added to the piping system. See C.7.1 for details.

Annex D Suggested Method of Checking for Leakage

This annex is not a part of the requirements of this code but is included for informational purposes only.

D.1 Use of Lights. Artificial illumination used in connection with a search for gas leakage should be restricted to battery-operated flashlights (preferably of the safety type) or approved safety lamps. In searching for leaks, electric switches should not be operated. If electric lights are already turned on, they should not be turned off.

D.2 Testing for Leakage Using the Gas Meter. Immediately prior to the test, it should be determined that the meter is in operating condition and has not been bypassed.

Checking for leakage can be done by carefully watching the test dial of the meter to determine whether gas is passing through the meter. To assist in observing any movement of the test hand, wet a small piece of paper and paste its edge directly over the centerline of the hand as soon as the gas is turned on. This observation should be made with the test hand on the upstroke. Table D.2 can be used for determining the length of observation time.

Table D.2 Test Observation Times for Various Meter Dials

Dial Styles (ft^3)	Test Time (min)
¼	5
½	5
1	7
2	10
5	20
10	30

For SI units, 1 ft^3 = 0.028 m^3.

In case careful observation of the test hand for a sufficient length of time reveals no movement, the piping should be purged and a small gas burner turned on and lighted and the hand of the test dial again observed. If the dial hand moves (as it should), it will show that the meter is operating properly. If the test hand does not move or register flow of gas through the meter to the small burner, the meter is defective and the gas should be shut off and the serving gas supplier notified.

D.3 Testing for Leakage not Using a Meter. This test can be done by one of the following methods:

(1) *For Any Gas System.* To an appropriate checkpoint, attach a manometer or pressure gauge between the inlet to the piping system and the first regulator in the piping system, momentarily turn on the gas supply, and observe the gauging device for pressure drop with the gas supply shut off. No discernible drop in pressure should occur during a period of 3 minutes.
(2) *For Gas Systems Using Undiluted Liquefied Petroleum Gas System Preparation for Propane.* A leak check performed on an LP-Gas system being placed back in service should include all regulators, including appliance regulators, and control valves in the system. Accordingly, each individual equipment shutoff valve should be supplying pressure to its appliance for the leak check. This check will prove the integrity of the 100 percent pilot shutoff of each gas valve so equipped, so the manual gas cock of each gas valve incorporating a 100 percent pilot shutoff should be in the on position. Pilots not incorporating a 100 percent pilot shutoff valve and all manual gas valves not incorporating safety shutoff systems are to be placed in the off position prior to leak checking, by using one of the following methods:
   (a) By inserting a pressure gauge between the container gas shutoff valve and the first regulator in the system, admitting full container pressure to the system and then closing the container shutoff valve. Enough gas should then be released from the system to lower the pressure gauge reading by 10 psi (69 kPa). The system should then be allowed to stand for 3 minutes without showing an increase or a decrease in the pressure gauge reading.
   (b) For systems serving appliances that receive gas at pressures of ½ psi (3.5 kPa) or less, by inserting a water manometer or pressure gauge into the system downstream of the final system regulator, pressurizing the system with either fuel gas or air to a test pressure of 9 in. w.c. ± ½ in. w.c. (2.2 kPa ± 0.1 kPa), and observing the device for a pressure change. If fuel gas is used as a pressure source, it is necessary to pressurize the system to full operating pressure, close the container service valve, and then release enough gas from the system through a range burner valve or other suitable means to drop the system pressure to 9 in. w.c. ± ½ in. w.c. (2.2 kPa ± 0.1 kPa). This ensures that all regulators in the system are unlocked and that a leak anywhere in the system is communicated to the gauging device. The gauging device should indicate no loss or gain of pressure for a period of 3 minutes.

D.4 When Leakage Is Indicated. If the meter test hand moves or a pressure drop on the gauge is noted, all equipment or outlets supplied through the system should be examined to see whether they are shut off and do not leak. If they are found tight, there is a leak in the piping system.

Annex E Suggested Emergency Procedure for Gas Leaks

This annex is not a part of the requirements of this code but is included for informational purposes only.

E.1 Where an investigation discloses a concentration of gas inside of a building, it is suggested the following immediate actions be taken:

(1) Clear the room, building, or area of all occupants. Do not re-enter the room, building, or area until the space has been determined to be safe.
(2) Use every practical means to eliminate sources of ignition. Take precautions to prevent smoking, striking matches, operating electrical switches or devices, opening furnace doors, and so on. If possible, cut off all electric circuits at a remote source to eliminate operation of automatic switches in the dangerous area. Safety flashlights designed for use in hazardous atmospheres are recommended for use in such emergencies.

(3) Notify all personnel in the area and the gas supplier from a telephone remote from the area of the leak.
(4) Ventilate the affected portion of the building by opening windows and doors.
(5) Shut off the supply of gas to the areas involved.
(6) Investigate other buildings in the immediate area to determine the presence of escaping gas therein.

Annex F Flow of Gas Through Fixed Orifices

This annex is not a part of the requirements of this code but is included for informational purposes only.

F.1 Use of Orifice Tables.

F.1.1 To Check Burner Input not Using a Meter. Gauge the size of the burner orifice and determine flow rate at sea level from Table F.1, Utility Gases (cubic feet per hour), or from

Table F.1 Utility Gases (cubic feet per hour at sea level)

Orifice or Drill Size	Pressure at Orifice (in. w.c.)								
	3	3.5	4	5	6	7	8	9	10
80	0.48	0.52	0.55	0.63	0.69	0.73	0.79	0.83	0.88
79	0.55	0.59	0.64	0.72	0.80	0.84	0.90	0.97	1.01
78	0.70	0.76	0.78	0.88	0.97	1.04	1.10	1.17	1.24
77	0.88	0.95	0.99	1.11	1.23	1.31	1.38	1.47	1.55
76	1.05	1.13	1.21	1.37	1.52	1.61	1.72	1.83	1.92
75	1.16	1.25	1.34	1.52	1.64	1.79	1.91	2.04	2.14
74	1.33	1.44	1.55	1.74	1.91	2.05	2.18	2.32	2.44
73	1.51	1.63	1.76	1.99	2.17	2.32	2.48	2.64	2.78
72	1.64	1.77	1.90	2.15	2.40	2.52	2.69	2.86	3.00
71	1.82	1.97	2.06	2.33	2.54	2.73	2.91	3.11	3.26
70	2.06	2.22	2.39	2.70	2.97	3.16	3.38	3.59	3.78
69	2.25	2.43	2.61	2.96	3.23	3.47	3.68	3.94	4.14
68	2.52	2.72	2.93	3.26	3.58	3.88	4.14	4.41	4.64
67	2.69	2.91	3.12	3.52	3.87	4.13	4.41	4.69	4.94
66	2.86	3.09	3.32	3.75	4.11	4.39	4.68	4.98	5.24
65	3.14	3.39	3.72	4.28	4.62	4.84	5.16	5.50	5.78
64	3.41	3.68	4.14	4.48	4.91	5.23	5.59	5.95	6.26
63	3.63	3.92	4.19	4.75	5.19	5.55	5.92	6.30	6.63
62	3.78	4.08	4.39	4.96	5.42	5.81	6.20	6.59	6.94
61	4.02	4.34	4.66	5.27	5.77	6.15	6.57	7.00	7.37
60	4.21	4.55	4.89	5.52	5.95	6.47	6.91	7.35	7.74
59	4.41	4.76	5.11	5.78	6.35	6.78	7.25	7.71	8.11
58	4.66	5.03	5.39	6.10	6.68	7.13	7.62	8.11	8.53
57	4.84	5.23	5.63	6.36	6.96	7.44	7.94	8.46	8.90
56	5.68	6.13	6.58	7.35	8.03	8.73	9.32	9.92	10.44
55	7.11	7.68	8.22	9.30	10.18	10.85	11.59	12.34	12.98
54	7.95	8.59	9.23	10.45	11.39	12.25	13.08	13.93	14.65
53	9.30	10.04	10.80	12.20	13.32	14.29	15.27	16.25	17.09
52	10.61	11.46	12.31	13.86	15.26	16.34	17.44	18.57	19.53
51	11.82	12.77	13.69	15.47	16.97	18.16	19.40	20.64	21.71
50	12.89	13.92	14.94	16.86	18.48	19.77	21.12	22.48	23.65
49	14.07	15.20	16.28	18.37	20.20	21.60	23.06	24.56	25.83
48	15.15	16.36	17.62	19.88	21.81	23.31	24.90	26.51	27.89
47	16.22	17.52	18.80	21.27	23.21	24.93	26.62	28.34	29.81
46	17.19	18.57	19.98	22.57	24.72	26.43	28.23	30.05	31.61
45	17.73	19.15	20.52	23.10	25.36	27.18	29.03	30.90	32.51
44	19.45	21.01	22.57	25.57	27.93	29.87	31.89	33.96	35.72
43	20.73	22.39	24.18	27.29	29.87	32.02	34.19	36.41	38.30
42	23.10	24.95	26.50	29.50	32.50	35.24	37.63	40.07	42.14
41	24.06	25.98	28.15	31.69	34.81	37.17	39.70	42.27	44.46

Table F.1 *Continued*

Orifice or Drill Size	Pressure at Orifice (in. w.c.)								
	3	3.5	4	5	6	7	8	9	10
40	25.03	27.03	29.23	33.09	36.20	38.79	41.42	44.10	46.38
39	26.11	28.20	30.20	34.05	37.38	39.97	42.68	45.44	47.80
38	27.08	29.25	31.38	35.46	38.89	41.58	44.40	47.27	49.73
37	28.36	30.63	32.99	37.07	40.83	43.62	46.59	49.60	52.17
36	29.76	32.14	34.59	39.11	42.76	45.77	48.88	52.04	54.74
35	32.36	34.95	36.86	41.68	45.66	48.78	52.10	55.46	58.34
34	32.45	35.05	37.50	42.44	46.52	49.75	53.12	56.55	59.49
33	33.41	36.08	38.79	43.83	48.03	51.46	54.96	58.62	61.55
32	35.46	38.30	40.94	46.52	50.82	54.26	57.95	61.70	64.89
31	37.82	40.85	43.83	49.64	54.36	58.01	61.96	65.97	69.39
30	43.40	46.87	50.39	57.05	62.09	66.72	71.22	75.86	79.80
29	48.45	52.33	56.19	63.61	69.62	74.45	79.52	84.66	89.04
28	51.78	55.92	59.50	67.00	73.50	79.50	84.92	90.39	95.09
27	54.47	58.83	63.17	71.55	78.32	83.59	89.27	95.04	99.97
26	56.73	61.27	65.86	74.57	81.65	87.24	93.17	99.19	104.57
25	58.87	63.58	68.22	77.14	84.67	90.36	96.50	102.74	108.07
24	60.81	65.67	70.58	79.83	87.56	93.47	99.83	106.28	111.79
23	62.10	67.07	72.20	81.65	89.39	94.55	100.98	107.49	113.07
22	64.89	70.08	75.21	85.10	93.25	99.60	106.39	113.24	119.12
21	66.51	71.83	77.14	87.35	95.63	102.29	109.24	116.29	122.33
20	68.22	73.68	79.08	89.49	97.99	104.75	111.87	119.10	125.28
19	72.20	77.98	83.69	94.76	103.89	110.67	118.55	125.82	132.36
18	75.53	81.57	87.56	97.50	108.52	116.03	123.92	131.93	138.78
17	78.54	84.82	91.10	103.14	112.81	120.33	128.52	136.82	143.91
16	82.19	88.77	95.40	107.98	118.18	126.78	135.39	144.15	151.63
15	85.20	92.02	98.84	111.74	122.48	131.07	139.98	149.03	156.77
14	87.10	94.40	100.78	114.21	124.44	133.22	142.28	151.47	159.33
13	89.92	97.11	104.32	118.18	128.93	138.60	148.02	157.58	165.76
12	93.90	101.41	108.52	123.56	135.37	143.97	153.75	163.69	172.13
11	95.94	103.62	111.31	126.02	137.52	147.20	157.20	167.36	176.03
10	98.30	106.16	114.21	129.25	141.82	151.50	161.81	172.26	181.13
9	100.99	109.07	117.11	132.58	145.05	154.71	165.23	175.91	185.03
8	103.89	112.20	120.65	136.44	149.33	160.08	170.96	182.00	191.44
7	105.93	114.40	123.01	139.23	152.56	163.31	174.38	185.68	195.30
6	109.15	117.88	126.78	142.88	156.83	167.51	178.88	190.46	200.36
5	111.08	119.97	128.93	145.79	160.08	170.82	182.48	194.22	204.30
4	114.75	123.93	133.22	150.41	164.36	176.18	188.16	200.25	210.71
3	119.25	128.79	137.52	156.26	170.78	182.64	195.08	207.66	218.44
2	128.48	138.76	148.61	168.64	184.79	197.66	211.05	224.74	235.58
1	136.35	147.26	158.25	179.33	194.63	209.48	223.65	238.16	250.54

For SI units, 1 Btu/hr = 0.293 W, 1 ft^3 = 0.028 m^3, 1 ft = 0.305 m, 1 in. w.c. = 249 Pa.

Notes:

1. Specific gravity = 0.60; orifice coefficient = 0.90.
2. For utility gases of another specific gravity, select multiplier from Table F.3. For altitudes above 2000 ft, first select the equivalent orifice size at sea level from Table F.4.

Table F.2 LP-Gases (Btu per hour at sea level)

Orifice or Drill Size	Propane	Butane
0.008	519	589
0.009	656	744
0.010	812	921
0.011	981	1,112
0.012	1,169	1,326
80	1,480	1,678
79	1,708	1,936
78	2,080	2,358
77	2,629	2,980
76	3,249	3,684
75	3,581	4,059
74	4,119	4,669
73	4,678	5,303
72	5,081	5,760
71	5,495	6,230
70	6,375	7,227
69	6,934	7,860
68	7,813	8,858
67	8,320	9,433
66	8,848	10,031
65	9,955	11,286
64	10,535	11,943
63	11,125	12,612
62	11,735	13,304
61	12,367	14,020
60	13,008	14,747
59	13,660	15,486
58	14,333	16,249
57	15,026	17,035
56	17,572	19,921
55	21,939	24,872
54	24,630	27,922
53	28,769	32,615
52	32,805	37,190
51	36,531	41,414
50	39,842	45,168
49	43,361	49,157
48	46,983	53,263
47	50,088	56,783
46	53,296	60,420
45	54,641	61,944
44	60,229	68,280
43	64,369	72,973
42	71,095	80,599
41	74,924	84,940
40	78,029	88,459
39	80,513	91,215
38	83,721	94,912
37	87,860	99,605
36	92,207	104,532
35	98,312	111,454
34	100,175	113,566
33	103,797	117,672
32	109,385	124,007
31	117,043	132,689
30	134,119	152,046
29	150,366	170,466
28	160,301	181,728
27	168,580	191,114
26	175,617	199,092
25	181,619	205,896
24	187,828	212,935
23	192,796	218,567
22	200,350	227,131
21	205,525	232,997
20	210,699	238,863
19	223,945	253,880
18	233,466	264,673

Notes:

	Propane	Butane
1. Btu per cubic foot	2,516	3,280
2. Specific gravity	1.52	2.01
3. Pressure at orifice, in. w.c.	11	11
4. Orifice coefficient	0.9	0.9

5. For altitudes above 2000 ft (610 m), first select the equivalent orifice size at sea level from Table F.4.

Table F.3 Multipliers for Utility Gases of Another Specific Gravity

Specific Gravity	Multiplier	Specific Gravity	Multiplier
0.45	1.155	0.95	0.795
0.50	1.095	1.00	0.775
0.55	1.045	1.05	0.756
0.60	1.000	1.10	0.739
0.65	0.961	1.15	0.722
0.70	0.926	1.20	0.707
0.75	0.894	1.25	0.693
0.80	0.866	1.30	0.679
0.85	0.840	1.35	0.667
0.90	0.817	1.40	0.655

Table F.4 Equivalent Orifice Sizes at High Altitudes (includes 4% input reduction for each 1000 ft)

Orifice Size at Sea Level	Orifice Size Required at Other Elevations								
	2000	3000	4000	5000	6000	7000	8000	9000	10,000
1	2	2	3	3	4	5	7	8	10
2	3	3	4	5	6	7	9	10	12
3	4	5	7	8	9	10	12	13	15
4	6	7	8	9	11	12	13	14	16
5	7	8	9	10	12	13	14	15	17
6	8	9	10	11	12	13	14	16	17
7	9	10	11	12	13	14	15	16	18
8	10	11	12	13	13	15	16	17	18
9	11	12	12	13	14	16	17	18	19
10	12	13	13	14	15	16	17	18	19
11	13	13	14	15	16	17	18	19	20
12	13	14	15	16	17	17	18	19	20
13	15	15	16	17	18	18	19	20	22
14	16	16	17	18	18	19	20	21	23
15	16	17	17	18	19	20	20	22	24
16	17	18	18	19	19	20	22	23	25
17	18	19	19	20	21	22	23	24	26
18	19	19	20	21	22	23	24	26	27
19	20	20	21	22	23	25	26	27	28
20	22	22	23	24	25	26	27	28	29
21	23	23	24	25	26	27	28	28	29
22	23	24	25	26	27	27	28	29	29
23	25	25	26	27	27	28	29	29	30
24	25	26	27	27	28	28	29	29	30
25	26	27	27	28	28	29	29	30	30
26	27	28	28	28	29	29	30	30	30
27	28	28	29	29	29	30	30	30	31
28	29	29	29	30	30	30	30	31	31
29	29	30	30	30	30	31	31	31	32
30	30	31	31	31	31	32	32	33	35
31	32	32	32	33	34	35	36	37	38
32	33	34	35	35	36	36	37	38	40
33	35	35	36	36	37	38	38	40	41
34	35	36	36	37	37	38	39	40	42
35	36	36	37	37	38	39	40	41	42
36	37	38	38	39	40	41	41	42	43
37	38	39	39	40	41	42	42	43	43
38	39	40	41	41	42	42	43	43	44
39	40	41	41	42	42	43	43	44	44
40	41	42	42	42	43	43	44	44	45
41	42	42	42	43	43	44	44	45	46
42	42	43	43	43	44	44	45	46	47
43	44	44	44	45	45	46	47	47	48
44	45	45	45	46	47	47	48	48	49
45	46	47	47	47	48	48	49	49	50
46	47	47	47	48	48	49	49	50	50
47	48	48	49	49	49	50	50	51	51
48	49	49	49	50	50	50	51	51	52
49	50	50	50	51	51	51	52	52	52
50	51	51	51	51	52	52	52	53	53

Table F.4 *Continued*

Orifice Size at Sea Level	Orifice Size Required at Other Elevations								
	2000	3000	4000	5000	6000	7000	8000	9000	10,000
51	51	52	52	52	52	53	53	53	54
52	52	53	53	53	53	53	54	54	54
53	54	54	54	54	54	54	55	55	55
54	54	55	55	55	55	55	56	56	56
55	55	55	55	56	56	56	56	56	57
56	56	56	57	57	57	58	59	59	60
57	58	59	59	60	60	61	62	63	63
58	59	60	60	61	62	62	63	63	64
59	60	61	61	62	62	63	64	64	65
60	61	61	62	63	63	64	64	65	65
61	62	62	63	63	64	65	65	66	66
62	63	63	64	64	65	65	66	66	67
63	64	64	65	65	65	66	66	67	68
64	65	65	65	66	66	66	67	67	68
65	65	66	66	66	67	67	68	68	69
66	67	67	68	68	68	69	69	69	70
67	68	68	68	69	69	69	70	70	70
68	68	69	69	69	70	70	70	71	71
69	70	70	70	70	71	71	71	72	72
70	70	71	71	71	71	72	72	73	73
71	72	72	72	73	73	73	74	74	74
72	73	73	73	73	74	74	74	74	75
73	73	74	74	74	74	75	75	75	76
74	74	75	75	75	75	76	76	76	76
75	75	76	76	76	76	77	77	77	77
76	76	76	77	77	77	77	77	77	77
77	77	77	77	78	78	78	78	78	78
78	78	78	78	79	79	79	79	80	80
79	79	80	80	80	80	.013	.012	.012	.01
80	80	.013	.013	.013	.012	.012	.012	.012	.011

For SI units, 1 ft = 0.305 m.

Table F.2, LP-Gases (Btu per hour). When the specific gravity of the utility gas is other than 0.60, select the multiplier from Table F.3 for the specific gravity of the utility gas served, and apply to the flow rate as determined from Table F.1. When the altitude is above 2000 ft (600 m), first select the equivalent orifice size at sea level using Table F.4, then determine the flow rate from Table F.1 or Table F.2 as directed. Having determined the flow rate (as adjusted for specific gravity and/or altitude where necessary), check the burner input at sea level with the manufacturer's rated input.

F.1.2 To Select Correct Orifice Size for Rated Burner Input. The selection of a fixed orifice size for any rated burner input is affected by many variables, including orifice coefficient, and it is recommended that the appliance manufacturer be consulted for that purpose. When the correct orifice size cannot be readily determined, the orifice flow rates, as stated in the tables in this annex, can be used to select a fixed orifice size with a flow rate to approximately equal the required rated burner input.

For gases of the specific gravity and pressure conditions stipulated at elevations under 2000 ft (600 m), Table F.1 (in cubic feet per hour) or Table F.2 (in Btu per hour) can be used directly.

Where the specific gravity of the gas is other than 0.60, select the multiplier from Table F.3 for the utility gas served and divide the rated burner input by the selected factor to determine equivalent input at a specific gravity of 0.60; then select orifice size as directed above.

Where the appliance is located at an altitude of 2000 ft (600 m) or above, first use the manufacturer's rated input at sea level to select the orifice size as directed, then use Table F.4 to select the equivalent orifice size for use at the higher altitude.

Annex G Sizing of Venting Systems Serving Appliances Equipped with Draft Hoods, Category I Appliances, and Appliances Listed for Use with Type B Vents

This annex is not a part of the requirements of this code but is included for informational purposes only.

G.1 Examples Using Single Appliance Venting Tables. See Figure G.1(a) through Figure G.1(n).

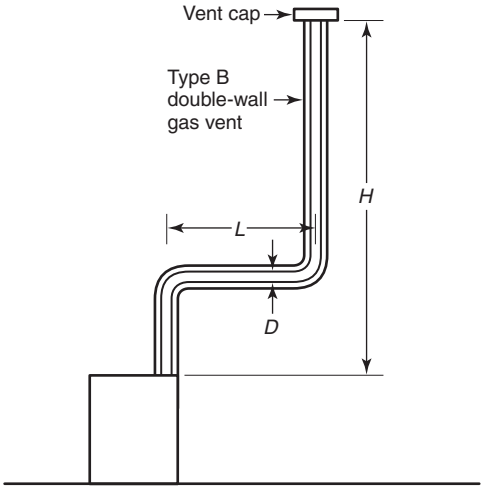


Table 13.1 is used when sizing Type B double-wall gas vent connected directly to the appliance.

Note: The appliance can be either Category I draft hood-equipped or fan-assisted type.

FIGURE G.1(a) Type B Double-Wall Vent System Serving a Single Appliance with a Type B Double-Wall Vent.

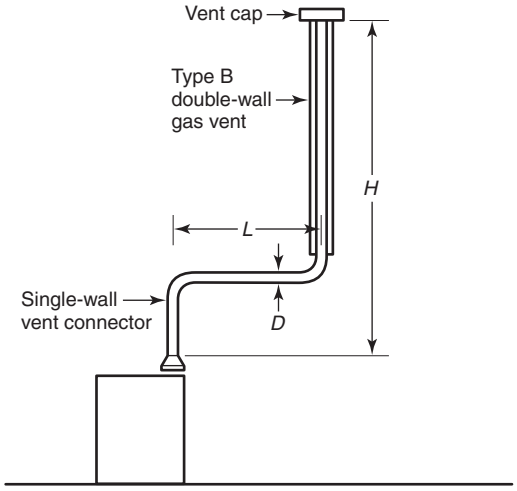


Table 13.2 is used when sizing a single-wall metal vent connector attached to a Type B double-wall gas vent.

Note: The appliance can be either Category I draft hood-equipped or fan-assisted type.

FIGURE G.1(b) Type B Double-Wall Vent System Serving a Single Appliance with a Single-Wall Metal Vent Connector.

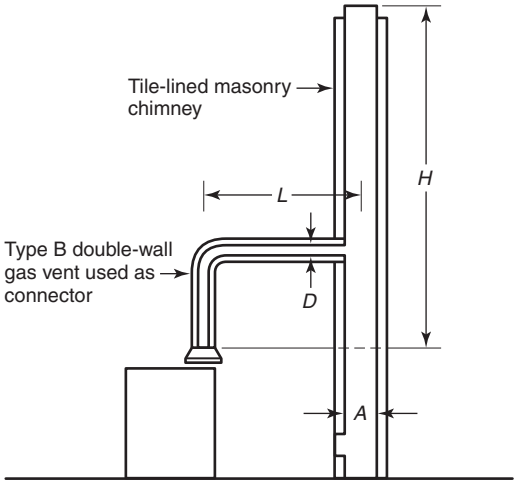


Table 13.3 is used when sizing a Type B double-wall gas vent connector attached to a tile-lined masonry chimney.

Notes:
1. *A* is the equivalent cross-sectional area of the tile liner.
2. The appliance can be either Category I draft hood-equipped or fan-assisted type.

FIGURE G.1(c) Vent System Serving a Single Appliance with a Masonry Chimney and a Type B Double-Wall Vent Connector.

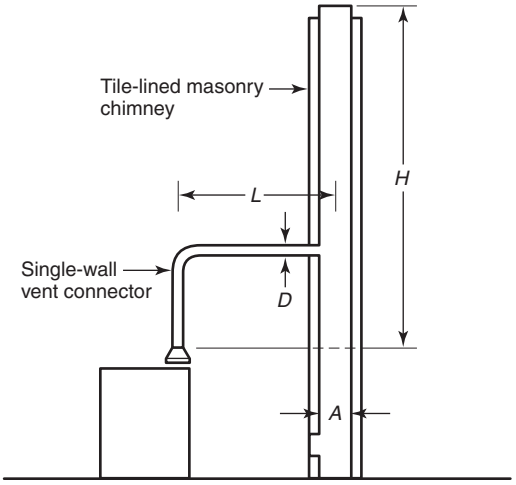
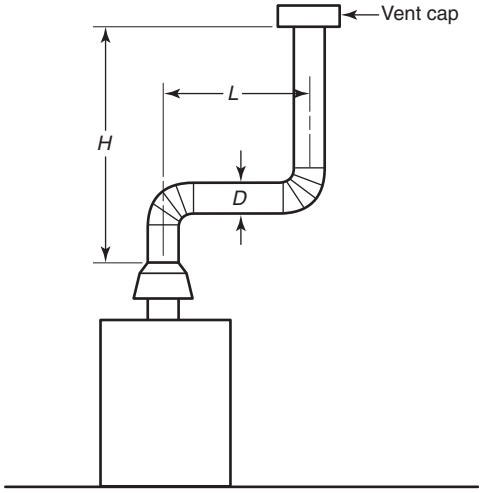


Table 13.4 is used when sizing a single-wall vent connector attached to a tile-lined masonry chimney.

Notes:
1. *A* is the equivalent cross-sectional area of the tile liner.
2. The appliance can be either Category I draft hood-equipped or fan-assisted type.

FIGURE G.1(d) Vent System Serving a Single Appliance Using a Masonry Chimney and a Single-Wall Metal Vent Connector.



Asbestos cement Type B or single-wall metal vent serving a single draft hood-equipped appliance. *(See Table 13.5.)*

FIGURE G.1(e) Asbestos Cement Type B or Single-Wall Metal Vent System Serving a Single Draft Hood-Equipped Appliance.

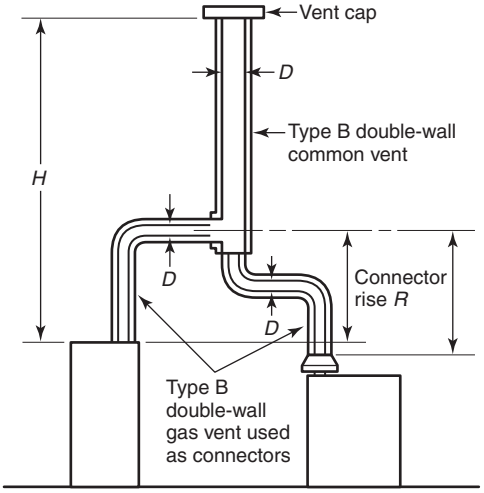


Table 13.6 is used when sizing Type B double-wall gas vent connectors attached to a Type B double-wall common vent.

Note: Each appliance can be either Category I draft hood-equipped or fan-assisted type.

FIGURE G.1(f) Vent System Serving Two or More Appliances with Type B Double-Wall Vent and Type B Double-Wall Vent Connectors.

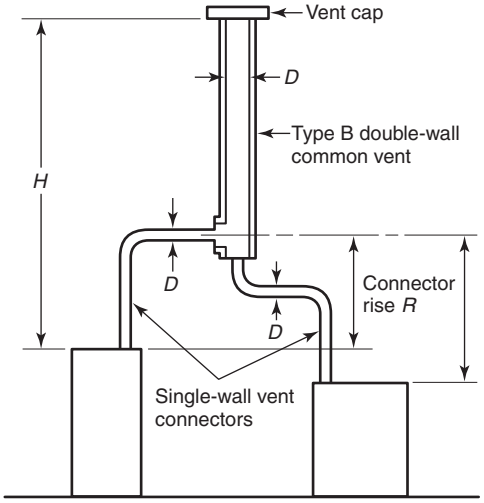


Table 13.7 is used when sizing single-wall vent connectors attached to a Type B double-wall common vent.

Note: Each appliance can be either Category I draft hood-equipped or fan-assisted type.

FIGURE G.1(g) Vent System Serving Two or More Appliances with Type B Double-Wall Vent and Single-Wall Metal Vent Connectors.

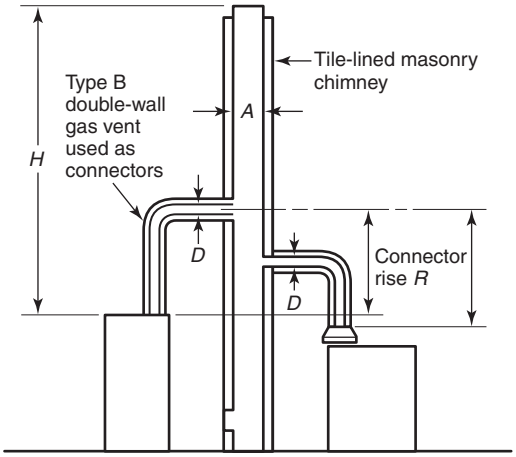


Table 13.8 is used when sizing Type B double-wall vent connectors attached to a tile-lined masonry chimney.

Notes:
1. *A* is the equivalent cross-sectional area of the tile liner.
2. Each appliance can be either Category I draft hood-equipped or fan-assisted type.

FIGURE G.1(h) Masonry Chimney Serving Two or More Appliances with Type B Double-Wall Vent Connectors.

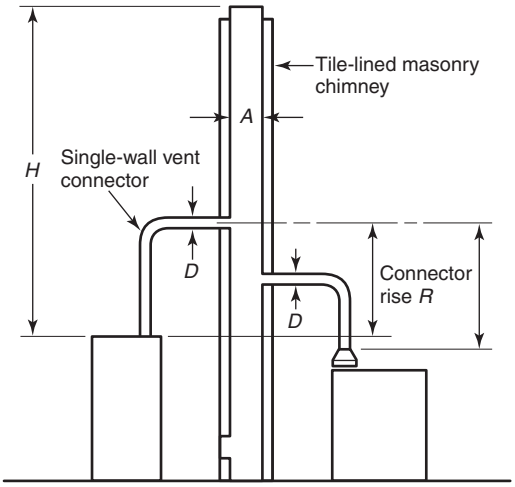
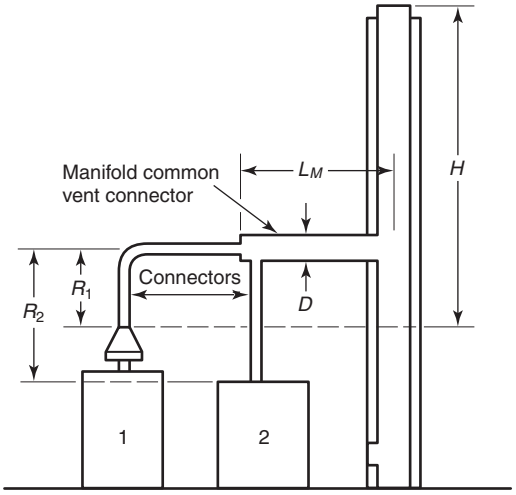


Table 13.9 is used when sizing single-wall metal vent connectors attached to a tile-lined masonry chimney.

Notes:
1. *A* is the equivalent cross-sectional area of the tile liner.
2. Each appliance can be either Category I draft hood-equipped or fan-assisted type.

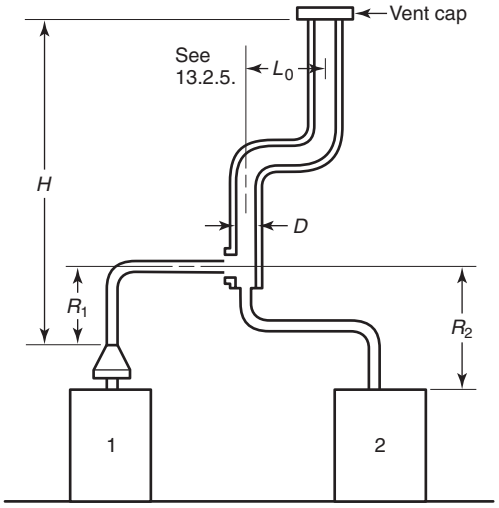
FIGURE G.1(i) Masonry Chimney Serving Two or More Appliances with Single-Wall Metal Vent Connectors.



Example: Manifolded common vent connector L_M can be no greater than 18 times the common vent connector manifold inside diameter; that is, a 4 in. (100 mm) inside diameter common vent connector manifold should not exceed 72 in. (1800 mm) in length. *(See 13.2.4.)*

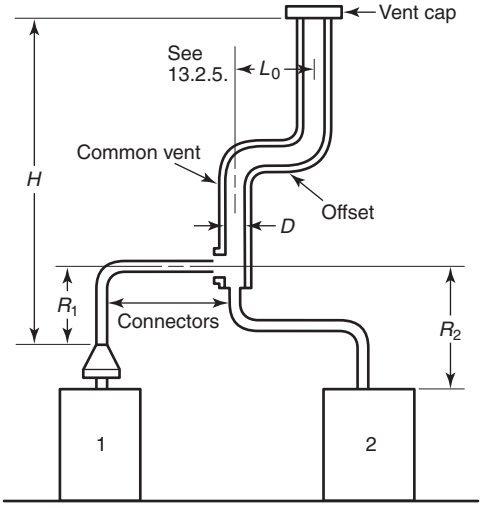
Note: This is an illustration of a typical manifolded vent connector. Different appliance, vent connector, or common vent types are possible. *(See Section 13.2.)*

FIGURE G.1(k) Use of Manifolded Common Vent Connector.



Asbestos cement Type B or single-wall metal pipe vent serving two or more draft hood-equipped appliances. *(See Table 13.10.)*

FIGURE G.1(j) Asbestos Cement Type B or Single-Wall Metal Vent System Serving Two or More Draft Hood-Equipped Appliances.



Example: Offset common vent

Note: This is an illustration of a typical offset vent. Different appliance, vent connector, or vent types are possible. *(See Sections 13.1. and 13.2.)*

FIGURE G.1(l) Use of Offset Common Vent.

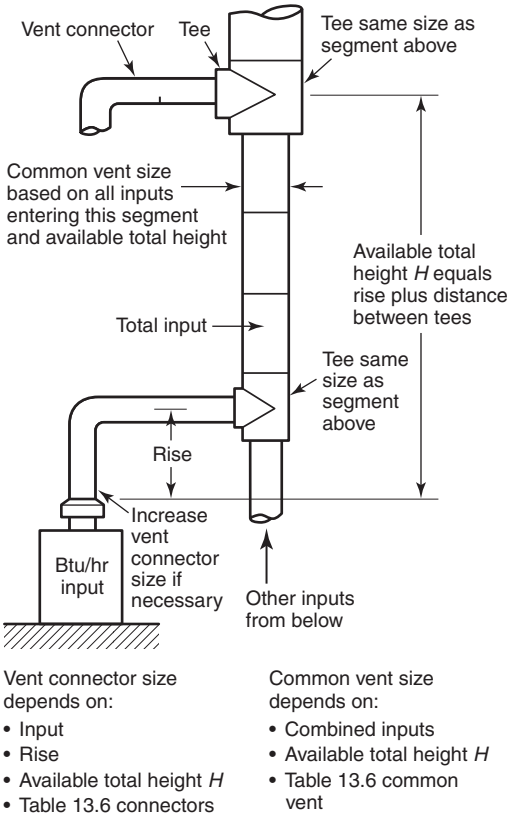


FIGURE G.1(m) Multistory Gas Vent Design Procedure for Each Segment of System.

G.1.1 Example 1: Single Draft Hood-Equipped Appliance. An installer has a 120,000-Btu/hr input appliance with a 5 in. diameter draft hood outlet that needs to be vented into a 10 ft high Type B vent system. What size vent should be used assuming (1) a 5 ft lateral single-wall metal vent connector is used with two 90 degree elbows or (2) a 5 ft lateral single-wall metal vent connector is used with three 90 degree elbows in the vent system? See Figure G.1.1.

Solution

Table 13.2 should be used to solve this problem, because single-wall metal vent connectors are being used with a Type B vent, as follows:

(1) Read down the first column in Table 13.2 until the row associated with a 10 ft height and 5 ft lateral is found. Read across this row until a vent capacity greater than 120,000 Btu/hr is located in the shaded columns labeled NAT Max for draft hood-equipped appliances. In this case, a 5 in. diameter vent has a capacity of 122,000 Btu/hr and can be used for this application.

(2) If three 90 degree elbows are used in the vent system, then the maximum vent capacity listed in the tables must be reduced by 10 percent *(see 13.1.3)*. This implies that the 5 in. diameter vent has an adjusted capacity of only 110,000 Btu/hr. In this case, the vent system must be increased to 6 in. in diameter. See the following calculations:

$$122{,}000 \times 0.90 = 110{,}000 \text{ for 5 in. vent}$$

From Table 13.2, select 6 in. vent.

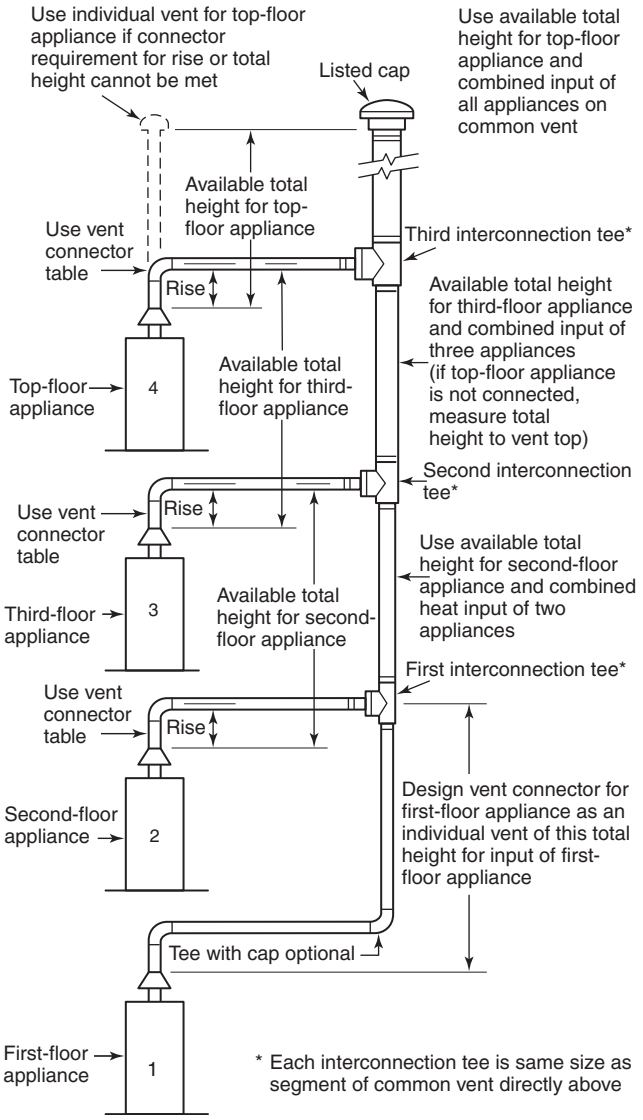


FIGURE G.1(n) Principles of Design of Multistory Vents Using Vent Connector and Common Vent Design Tables. ***(See 13.2.13 through 13.2.16.)***

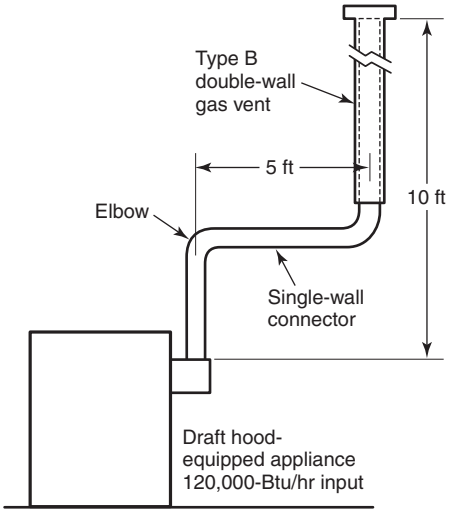
$$186{,}000 \times 0.90 = 167{,}000$$

This figure is greater than the required 120,000. Therefore, use a 6 in. vent and connector where three elbows are used.

G.1.2 Example 2: Single Fan-Assisted Appliance. An installer has an 80,000 Btu/hr input fan-assisted appliance that must be installed using 10 ft of lateral connector attached to a 30 ft high Type B vent. Two 90 degree elbows are needed for the installation. Can a single-wall metal vent connector be used for this application? See Figure G.1.2.

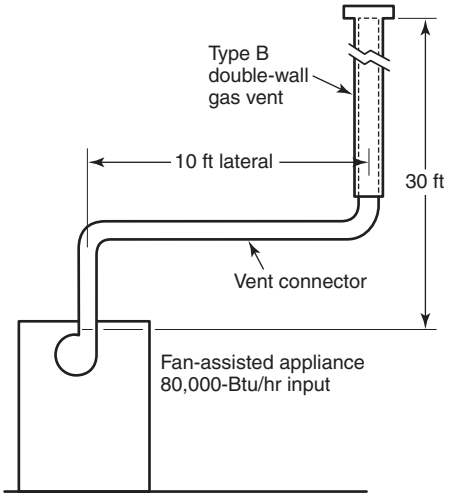
Solution

Table 13.2 refers to the use of single-wall metal vent connectors with Type B vent. In the first column find the row associated with a 30 ft height and a 10 ft lateral. Read across this row, looking at the FAN Min and FAN Max columns, to find that a 3 in. diameter single-wall metal vent connector is



For SI units, 1 ft = 0.305 m.

FIGURE G.1.1 Single Draft Hood-Equipped Appliance — Example 1.



For SI units, 1 ft = 0.305 m.

FIGURE G.1.2 Single Fan-Assisted Appliance — Example 2.

not recommended. Moving to the next larger size single wall connector (4 in.), we find that a 4 in. diameter single-wall metal connector has a recommended minimum vent capacity of 91,000 Btu/hr and a recommended maximum vent capacity of 144,000 Btu/hr. The 80,000 Btu/hr fan-assisted appliance is outside this range, so the conclusion is that a single-wall metal vent connector cannot be used to vent this appliance using 10 ft of lateral for the connector.

However, if the 80,000 Btu/hr input appliance could be moved to within 5 ft of the vertical vent, then a 4 in. single-wall metal connector could be used to vent the appliance. Table 13.2 shows the acceptable range of vent capacities for a 4 in. vent with 5 ft of lateral to be between 72,000 Btu/hr and 157,000 Btu/hr.

If the appliance cannot be moved closer to the vertical vent, then Type B vent could be used as the connector material. In this case, Table 13.1 shows that, for a 30 ft high vent with 10 ft of lateral, the acceptable range of vent capacities for a 4 in. diameter vent attached to a fan-assisted appliance is between 37,000 Btu/hr and 150,000 Btu/hr.

G.1.3 Example 3: Interpolating Between Table Values. An installer has an 80,000 Btu/hr input appliance with a 4 in. diameter draft hood outlet that needs to be vented into a 12 ft high Type B vent. The vent connector has a 5 ft lateral length and is also Type B. Can this appliance be vented using a 4 in. diameter vent?

Solution

Table 13.1 is used in the case of an all Type B vent system. However, since there is no entry in Table 13.1 for a height of 12 ft, interpolation must be used. Read down the 4 in. diameter NAT Max column to the row associated with 10 ft height and 5 ft lateral to find the capacity value of 77,000 Btu/hr. Read further down to the 15 ft height, 5 ft lateral row to find the capacity value of 87,000 Btu/hr. The difference between the 15 ft height capacity value and the 10 ft height capacity value is 10,000 Btu/hr. The capacity for a vent system with a 12 ft height is equal to the capacity for a 10 ft height plus ⅖ of the difference between the 10 ft and 15 ft height values, or 77,000 + ⅖ × 10,000 = 81,000 Btu/hr. Therefore, a 4 in. diameter vent can be used in the installation.

G.2 Examples Using Common Venting Tables.

G.2.1 Example 4: Common Venting Two Draft Hood–Equipped Appliances. A 35,000-Btu/hr water heater is to be common vented with a 150,000 Btu/hr furnace, using a common vent with a total height of 30 ft. The connector rise is 2 ft for the water heater with a horizontal length of 4 ft. The connector rise for the furnace is 3 ft with a horizontal length of 8 ft. Assume single-wall metal connectors will be used with Type B vent. What size connectors and combined vent should be used in this installation? See Figure G.2.1.

Solution

Table 13.7 should be used to size single-wall metal vent connectors attached to Type B vertical vents. In the vent connector capacity portion of Table 13.7, find the row associated with a 30 ft vent height. For a 2 ft rise on the vent connector for the water heater, read the shaded columns for draft hood-

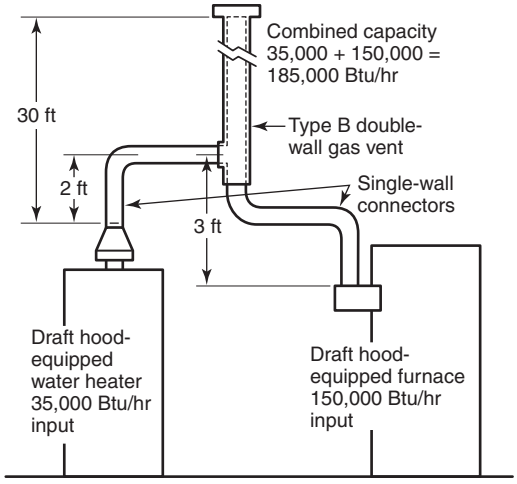
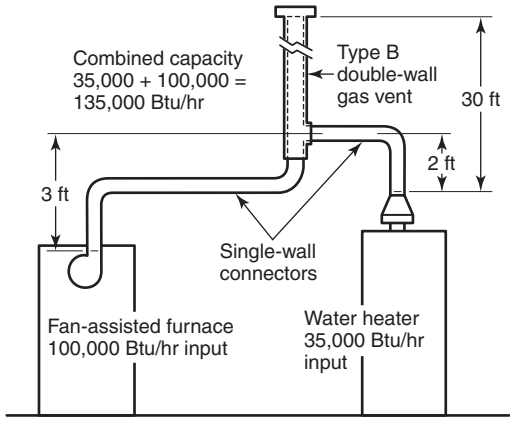


FIGURE G.2.1 Common Venting Two Draft Hood-Equipped Appliances — Example 4.

equipped appliances to find that a 3 in. diameter vent connector has a capacity of 37,000 Btu/hr. Therefore, a 3 in. single-wall metal vent connector can be used with the water heater. For a draft hood-equipped furnace with a 3 ft rise, read across the appropriate row to find that a 5 in. diameter vent connector has a maximum capacity of 120,000 Btu/hr (which is too small for the furnace) and a 6 in. diameter vent connector has a maximum vent capacity of 172,000 Btu/hr. Therefore, a 6 in. diameter vent connector should be used with the 150,000 Btu per hr furnace. Since both vent connector horizontal lengths are less than the maximum lengths listed in 13.2.2, the table values can be used without adjustments.

In the common vent capacity portion of Table 13.7, find the row associated with a 30 ft vent height and read over to the NAT + NAT portion of the 6 in. diameter column to find a maximum combined capacity of 257,000 Btu/hr. Since the two appliances total only 185,000 Btu/hr, a 6 in. common vent can be used.

G.2.2 Example 5(a): Common Venting a Draft Hood–Equipped Water Heater with a Fan-Assisted Furnace into a Type B Vent. In this case, a 35,000-Btu/hr input draft hood–equipped water heater with a 4 in. diameter draft hood outlet, 2 ft of connector rise, and 4 ft of horizontal length is to be common vented with a 100,000 Btu/hr fan-assisted furnace with a 4 in. diameter flue collar, 3 ft of connector rise, and 6 ft of horizontal length. The common vent consists of a 30 ft height of Type B vent. What are the recommended vent diameters for each connector and the common vent? The installer would like to use a single-wall metal vent connector. See Figure G.2.2.



For SI units, 1000 Btu/hr = 0.293 kW, 1 ft = 0.305 m.

FIGURE G.2.2 Common Venting a Draft Hood-Equipped Water Heater with a Fan-Assisted Furnace into a Type B Double-Wall Common Vent — Example 5(a).

Solution (See Table 13.7.)

Water Heater Vent Connector Diameter. Since the water heater vent connector horizontal length of 4 ft is less than the maximum value listed in Table 13.7, the venting table values can be used without adjustments. Using the Vent Connector Capacity portion of Table 13.7, read down the Total Vent Height *(H)* column to 30 ft and read across the 2 ft Connector Rise *(R)* row to the first Btu/hr rating in the NAT Max column that is equal to or greater than the water heater input rating. The table shows that a 3 in. vent connector has a maximum input rating of 37,000 Btu/hr. Although this rating is greater than the water heater input rating, a 3 in. vent connector is prohibited by 13.2.19. A 4 in. vent connector has a maximum input rating of 67,000 Btu/hr and is equal to the draft hood outlet diameter. A 4 in. vent connector is selected. Since the water heater is equipped with a draft hood, there are no minimum input rating restrictions.

Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 13.7, read down the Total Vent Height *(H)* column to 30 ft and across the 3 ft Connector Rise *(R)* row. Since the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu/hr rating greater than the furnace input rating. The 4 in. vent connector has a maximum input rating of 119,000 Btu/hr and a minimum input rating of 85,000 Btu/hr.

The 100,000-Btu/hr furnace in this example falls within this range, so a 4 in. connector is adequate. Since the furnace vent connector horizontal length of 6 ft is less than the maximum value listed in 13.2.2, the venting table values can be used without adjustment. If the furnace had an input rating of 80,000 Btu/hr, then a Type B vent connector *[see Table 13.6]* would be needed in order to meet the minimum capacity limit.

Common Vent Diameter. The total input to the common vent is 135,000 Btu/hr. Using the Common Vent Capacity portion of Table 13.7, read down the Total Vent Height *(H)* column to 30 ft and across this row to find the smallest vent diameter in the FAN + NAT column that has a Btu/hr rating equal to or greater than 135,000 Btu/hr. The 4 in. common vent has a capacity of 132,000 Btu/hr and the 5 in. common vent has a capacity of 202,000 Btu/hr. Therefore, the 5 in. common vent should be used in this example.

Summary. In this example, the installer can use a 4 in. diameter, single-wall metal vent connector for the water heater and a 4 in. diameter, single-wall metal vent connector for the furnace. The common vent should be a 5 in. diameter Type B vent.

G.2.3 Example 5(b): Common Venting into an Interior Masonry Chimney. In this case, the water heater and fan-assisted furnace of Example 5(a) are to be common-vented into a clay-tile-lined masonry chimney with a 30 ft height. The chimney is not exposed to the outdoors below the roof line. The internal dimensions of the clay tile liner are nominally 8 in. × 12 in. Assuming the same vent connector heights, laterals, and materials found in Example 5(a), what are the recommended vent connector diameters, and is this an acceptable installation?

Solution

Table 13.9 is used to size common venting installations involving single-wall connectors into masonry chimneys.

Water Heater Vent Connector Diameter. Using Table 13.9, Vent Connector Capacity, read down the Total Vent Height *(H)* column to 30 ft, and read across the 2 ft Connector Rise *(R)* row to the first Btu/hr rating in the NAT Max column that is equal to or greater than the water heater input rating. The table shows that a 3 in. vent connector has a maximum input of only 31,000 Btu/hr, while a 4 in. vent connector has a maximum input of 57,000 Btu/hr. A 4 in. vent connector must therefore be used.

Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 13.9, read down the Total Vent Height *(H)* column to 30 ft and across the 3 ft Connector Rise *(R)* row. Because the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu/hr rating greater than the furnace input rating. The 4 in. vent connector has a maximum input rating of 127,000 Btu/hr and a minimum input rating of 95,000 Btu/hr. The 100,000 Btu/hr fur-

nace in this example falls within this range, so a 4 in. connector is adequate.

Masonry Chimney. From Table G.2.3, the Equivalent Area for a Nominal Liner size of 8 in. × 12 in. is 63.6 in.^{2}. Using Table 13.9, Common Vent Capacity, read down the FAN + NAT column under the Minimum Internal Area of Chimney value of 63 to the row for 30 ft height to find a capacity value of 739,000 Btu/hr. The combined input rating of the furnace and water heater, 135,000 Btu/hr, is less than the table value, so this is an acceptable installation.

Section 13.2.15 requires the common vent area to be no greater than seven times the smallest listed appliance categorized vent area, flue collar area, or draft hood outlet area. Both appliances in this installation have 4 in. diameter outlets. From Table G.2.3, the equivalent area for an inside diameter of 4 in. is 12.2 in.^{2}. Seven times 12.2 equals 85.4, which is greater than 63.6, so this configuration is acceptable.

Table G.2.3 Masonry Chimney Liner Dimensions with Circular Equivalents

Nominal Liner Size (in.)	Inside Dimensions of Liner (in.)	Inside Diameter or Equivalent Diameter (in.)	Equivalent Area (in.^{2})
4 × 8	2½ × 6½	4.0	12.2
		5.0	19.6
		6.0	28.3
		7.0	38.3
8 × 8	6¾ × 6¾	7.4	42.7
		8.0	50.3
8 × 12	6½ × 10½	9.0	63.6
		10.0	78.5
12 × 12	9¾ × 9¾	10.4	83.3
		11.0	95.0
12 × 16	9½ × 13½	11.8	107.5
		12.0	113.0
		14.0	153.9
16 × 16	13¼ × 13¼	14.5	162.9
		15.0	176.7
16 × 20	13 × 17	16.2	206.1
		18.0	254.4
20 × 20	16½ × 16¾	18.2	260.2
		20.0	314.1
20 × 24	16½ × 20½	20.1	314.2
		22.0	380.1
24 × 24	20¼ × 20¼	22.1	380.1
		24.0	452.3
24 × 28	20¼ × 24¼	24.1	456.2
28 × 28	24¼ × 24¼	26.4	543.3
		27.0	572.5
30 × 30	25½ × 25½	27.9	607.0
		30.0	706.8
30 × 36	25½ × 31½	30.9	749.9
		33.0	855.3
36 × 36	31½ × 31½	34.4	929.4
		36.0	1017.9

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2.

Note: When liner sizes differ dimensionally from those shown in this table, equivalent diameters can be determined from published tables for square and rectangular ducts of equivalent carrying capacity or by other engineering methods.

G.2.4 Example 5(c): Common Venting into an Exterior Masonry Chimney. In this case, the water heater and fan-assisted furnace of Examples 5(a) and 5(b) are to be common-vented into an exterior masonry chimney. The chimney height, clay-tile-liner dimensions, and vent connector heights and laterals are the same as in Example 5(b). This system is being installed in Charlotte, North Carolina. Does this exterior masonry chimney need to be relined? If so, what corrugated metallic liner size is recommended? What vent connector diameters are recommended? See Table G.2.3 and Figure G.2.4.

Solution

According to 13.2.18, Type B vent connectors are required to be used with exterior masonry chimneys. Use Table 13.13(a) and Table 13.13(b) to size FAN+NAT common venting installations involving Type-B double wall connectors into exterior masonry chimneys.

The local 99 percent winter design temperature needed to use Table 13.13(a) and Table 13.13(b) can be found in *ASHRAE Handbook — Fundamentals*. For Charlotte, North Carolina, this design temperature is 19°F.

Chimney Liner Requirement. As in Example 5(b), use the 63 in.^{2} Internal Area columns for this size clay tile liner. Read down the 63 in.^{2} column of Table 13.13(a) to the 30 ft height row to find that the Combined Appliance Maximum Input is 747,000 Btu/hr. The combined input rating of the appliances in this installation, 135,000 Btu/hr, is less than the maximum value, so this criterion is satisfied. Table 13.13(b), at a 19°F Design Temperature, and at the same Vent Height and Internal Area used earlier, shows that the minimum allowable input rating of a space-heating appliance is 470,000 Btu/hr. The furnace input rating of 100,000 Btu/hr is less than this minimum value. So this criterion is not satisfied, and an alternative venting design needs to be used, such as a Type B vent shown in Example 5(a) or a listed chimney liner system shown in the remainder of the example.

According to 13.2.19, Table 13.6 or Table 13.7 are used for sizing corrugated metallic liners in masonry chimneys, with the maximum common vent capacities reduced by 20 percent. This example will be continued assuming Type B vent connectors.

Water Heater Vent Connector Diameter. Using Table 13.6, Vent Connector Capacity, read down the Total Vent Height *(H)* column to 30 ft, and read across the 2 ft Connector Rise *(R)* row to the first Btu/hour rating in the NAT Max column that is equal to or greater than the water heater input rating. The table shows that a 3 in. vent connector has a maximum capacity of 39,000 Btu/hr. Although this rating is greater than the water heater input rating, a 3 in. vent connector is prohibited by 13.2.19. A 4 in. vent connector has a maximum input rating of 70,000 Btu/hr and is equal to the draft hood outlet diameter. A 4 in. vent connector is selected.

Furnace Vent Connector Diameter. Using Table 13.6, Vent Connector Capacity, read down the Total Vent Height *(H)* column to 30 ft, and read across the 3 ft Connector Rise *(R)* row to the first Btu/hr rating in the FAN Max column that is equal to or greater than the furnace input rating. The 100,000 Btu/hr furnace in this example falls within this range, so a 4 in. connector is adequate.

Chimney Liner Diameter. The total input to the common vent is 135,000 Btu/hr. Using the Common Vent Capacity Portion of Table 13.6, read down the Total Vent Height *(H)* column to 30 ft and across this row to find the smallest vent diameter in the FAN+NAT column that has a Btu/hr rating greater than

99% Winter Design Temperatures for the Contiguous United States

This map is a necessarily generalized guide to temperatures in the contiguous United States. Temperatures shown for areas such as mountainous regions and large urban centers may not be accurate. The data used to develop this map are from the 1993 *ASHRAE Handbook—Fundamentals* (Chapter 24, Table 1: Climate Conditions for the United States).

For 99% winter design temperatures in Alaska, consult the *ASHRAE Handbook—Fundamentals*.

99% winter design temperatures for Hawaii are greater than 37°F.

FIGURE G.2.4 Range of Winter Design Temperatures Used in Analyzing Exterior Masonry Chimneys in the United States.

135,000 Btu/hr. The 4 in. common vent has a capacity of 138,000 Btu/hr. Reducing the maximum capacity by 20 percent *(see 13.2.19)* results in a maximum capacity for a 4 in. corrugated liner of 110,000 Btu/hr, less than the total input of 135,000 Btu/hr. So a larger liner is needed. The 5 in. common vent capacity listed in Table 13.6 is 210,000 Btu/hr, and after reducing by 20 percent is 168,000 Btu/hr. Therefore, a 5 in. corrugated metal liner should be used in this example.

Single Wall Connectors. Once it has been established that relining the chimney is necessary, Type B double wall vent connectors are not specifically required. This example could be redone using Table 13.7 for single-wall vent connectors. For this case, the vent connector and liner diameters would be the same as found for Type B double-wall connectors.

Annex H Recommended Procedure for Safety Inspection of an Existing Appliance Installation

This annex is not a part of the requirements of this code but is included for informational purposes only.

H.1 General. The following procedure is intended as a guide to aid in determining that an appliance is properly installed and is in a safe condition for continuing use.

This procedure is predicated on central furnace and boiler installations, and it should be recognized that generalized procedures cannot anticipate all situations. Accordingly, in some cases, deviation from this procedure is necessary to determine safe operation of the equipment.

(1) This procedure should be performed prior to any attempt to modify the appliance or the installation.
(2) If it is determined a condition that could result in unsafe operation exists, the appliance should be shut off and the owner advised of the unsafe condition.

The following steps should be followed in making the safety inspection:

(1) Conduct a test for gas leakage. *(See Section 7.2.)*
(2) Visually inspect the venting system for proper size and horizontal pitch, and determine that there is no blockage, restriction, leakage, corrosion, or other deficiencies that could cause an unsafe condition.
(3) Shut off all gas to the appliance, and shut off any other fuel gas burning appliance within the same room. Use the shutoff valve in the supply line to each appliance.
(4) Inspect burners and crossovers for blockage and corrosion.

(5) *Applicable only to furnaces:* Inspect the heat exchanger for cracks, openings, or excessive corrosion.
(6) *Applicable only to boilers:* Inspect for evidence of water or combustion product leaks.
(7) Insofar as is practical, close all building doors and windows and all doors between the space in which the appliance is located and other spaces of the building. Turn on clothes dryers. Turn on any exhaust fans, such as range hoods and bathroom exhausts, so they will operate at maximum speed. Do not operate a summer exhaust fan. Close fireplace dampers. If, after completing Steps 8 through 13, it is believed sufficient combustion air is not available, refer to Section 8.3 of this code for guidance.
(8) Place the appliance being inspected in operation. Follow the lighting instructions. Adjust the thermostat so the appliance will operate continuously.
(9) Determine that the pilot(s), where provided, is burning properly and that the main burner ignition is satisfactory by interrupting and re-establishing the electrical supply to the appliance in any convenient manner. If the appliance is equipped with a continuous pilot(s), test the pilot safety device(s) to determine whether it is operating properly by extinguishing the pilot(s) when the main burner(s) is off and determining, after 3 minutes, that the main burner gas does not flow upon a call for heat. If the appliance is not provided with a pilot(s), test for proper operation of the ignition system in accordance with the appliance manufacturer's lighting and operating instructions.
(10) Visually determine that the main burner gas is burning properly (i.e., no floating, lifting, or flashback). Adjust the primary air shutter(s) as required. If the appliance is equipped with high and low flame controlling or flame modulation, check for proper main burner operation at low flame.
(11) Test for spillage at the draft hood relief opening after 5 minutes of main burner operation. Use a flame of a match or candle or smoke.
(12) Turn on all other fuel-gas-burning appliances within the same room so they will operate at their full inputs. Follow lighting instructions for each appliance.
(13) Repeat Steps 10 and 11 on the appliance being inspected.
(14) Return doors, windows, exhaust fans, fireplace dampers, and any other fuel-gas-burning appliance to their previous conditions of use.
(15) *Applicable only to furnaces:* Check both the limit control and the fan control for proper operation. Limit control operation can be checked by blocking the circulating air inlet or temporarily disconnecting the electrical supply to the blower motor and determining that the limit control acts to shut off the main burner gas.
(16) *Applicable only to boilers:* Determine that the water pumps are in operating condition. Test low water cutoffs, automatic feed controls, pressure and temperature limit controls, and relief valves in accordance with the manufacturer's recommendations to determine that they are in operating condition.

Annex I Indoor Combustion Air Calculation Examples

This annex is not a part of the requirements of this code but is included for informational purposes.

I.1 New Installation. Determine if the indoor volume is sufficient to supply combustion air for the following new installation example.

Example Installation 1: A 100,000 Btu/hr fan assisted furnace and a 40,000 Btu/hr draft hood equipped water heater is being installed in a basement of a new single family home. The basement measures 25 ft × 40 ft with an 8 ft ceiling.

Solution

(1) Determine the total required volume: Since the air infiltration rate is unknown, the standard method to determine combustion air is used to calculate the required volume.
   (a) The combined input for the appliances located in the basement is calculated as follows:
   100,000 Btu/hr + 40,000 Btu/hr = 140,000 Btu/hr
   (b) The Standard Method requires that the required volume be determined based on 50 cubic feet per 1000 Btu/hour.
   (c) Using Table A.8.3.2(a), the required volume for a 140,000 Btu/hr water heater is 7,000 ft^3
(2) Determine available volume: The available volume is the total basement volume:
   Available Volume: 25 ft × 40 ft × 8 ft ceiling = 8,000 ft^3
   Conclusion: The installation can use indoor air because the available volume of 8,000 ft^3 exceeds the total required volume of 7,000 ft^3. No outdoor air openings are required.

I.2 New Installation, Known Air Infiltration Rate Method. Determine if the indoor volume is sufficient to supply combustion air for the following replacement installation example.

Example Installation 2: A 100,000 Btu/hr fan-assisted furnace and a 40,000 Btu/hr draft hood equipped water heater will be installed in a new single family house. It was determined (either by use of the ASHRAE calculation method or blower door test) that the house will have 0.65 air changes per hour. The furnace and water heater will be installed in a 20 ft × 35 ft basement with an 8 ft ceiling height.

Solution

(1) Determine the required volume: Because two types of appliances are located in the space, a fan-assisted furnace and a draft hood equipped water heater, the required volume must be determined for each appliance and then combined to determine the total required volume:
   (a) Fan-assisted furnace: For structures that the air infiltration rate is known, method 8.3.2.2 permits the use of the equation in 8.3.2.2(2) to determine the required volume for a fan-assisted appliance. Section 8.3.2.3 limits the use of the equation to air change rates equal to or less than 0.60 ACH. While the house was determined to have a 0.65 ACH, 0.60 is used to calculate the required volume. Using the equation in 8.3.2.2(2), the required volume for a 100,000 Btu/hr fan-assisted furnace is calculated as follows:

$$= \frac{15\ \text{ft}^3}{0.65}\left(\frac{100{,}000\ \text{Btu/hr}}{1{,}000\ \text{Btu/hr}}\right)$$

$$= 2{,}308\text{ft}^3$$

Section 8.3.2.2 specifies a lower required volume limitation for fan-assisted appliances at no smaller than 25 ft^3 per 1,000 Btu/hr. From Table A.8.3.2.2(2), the lower limit is

2,500 ft^3

Because the calculated required volume of 2,308 ft^3 falls below the lower required volume limit, the lower limit of 2,500 ft^3 must be used as the minimum required volume.

(b) Draft-hood equipped water heater:
For structures that the air infiltration rate is known, method 8.3.2.2 permits the use the equation in 8.3.2.2(1)to determine the required volume for a draft hood equipped appliance. Section 8.3.2.3 limits the use of the equation to air change rates equal to or less than 0.60 ACH. While the house was determined to have a 0.65 ACH, 0.60 is used to calculate the required volume. Using the equation in 8.3.2.2(1), the required volume for the 40,000 Btu/hr water heater is calculated as follows:

$$= \frac{21\ \text{ft}^3}{0.65}\left(\frac{40{,}000\ \text{Btu/hr}}{1{,}000\ \text{Btu/hr}}\right)$$

$$= 1{,}292\ \text{ft}^3$$

Section 8.3.2.2 specifies a lower required volume limitation for appliances other than fan-assisted at no smaller than 35 ft^3 per 1,000 Btu/hr. From Table A.8.3.2.2(1), the lower limit is

1,400 ft^3

Because the calculated required volume of 1,292 ft^3 falls below the lower required volume limit, the lower limit of 1,400 ft^3 must be used as the minimum required volume.

(c) Total required volume:
Section 8.3.2 states that the total required volume to use indoor air is the sum of the required volumes for all appliances located in the space.
Total Required = 2,500 ft^3+ 1,400 ft^3 = 3,900 ft^3

(2) Determine available volume: The available volume is determined as follows:

$$(20\ \text{ft} \times 35\ \text{ft}) \times 8\ \text{ft} = 5{,}600\ \text{ft}^3$$

Conclusion: The installation can use indoor air because the available volume of 5,600 ft^3 exceeds the total required volume of 3,900 ft^3. No outdoor air openings are required.

I.3 New Installation, Known Air Infiltration Rate Method. Determine if the indoor volume is sufficient to supply combustion air for the following replacement installation example.

Example Installation 3: A 100,000 Btu/hr fan-assisted furnace and a 40,000 Btu/hr draft hood equipped water heater will be installed in a new single family house. It was determined (either by use of the ASHRAE calculation method or blower door test) that the house will have 0.30 air changes per hour. The furnace and water heater will be installed in an 20 ft × 35 ft basement with a 8 ft ceiling height.

Solution

(1) Determine the required volume: Because two types of appliances are located in the space, a fan-assisted furnace and a draft hood equipped water heater, the required volume must be determined for each appliance and then combined to determine the total required volume:

(a) Fan-assisted furnace: For structures that the air infiltration rate is known, method 8.3.2.2 permits the use of the equation in 8.3.2.2(2) to determine the required volume for a fan-assisted appliance. Section 8.3.2.3 limits the use of the equation to air change rates equal to or less than 0.60 ACH. While the house was determined to have a 0.65 ACH, 0.60 is used to calculate the required volume. Using the equation in 8.3.2.2(2), the required volume for a 100,000 Btu/hr fan-assisted furnace is calculated as follows:

$$= \frac{15\ \text{ft}^3}{0.30}\left(\frac{100{,}000\ \text{Btu/hr}}{1{,}000\ \text{Btu/hr}}\right)$$

$$= 5{,}000\ \text{ft}^3$$

Section 8.3.2.2 specifies a lower required volume limitation for fan-assisted appliances at no smaller than 25 ft^3 per 1,000 Btu/hr. From Table A.8.3.2.2(2), the lower limit is

2,500 ft^3

Because the calculated required volume of 5,000 ft^3 is above the lower required volume limit, use this amount as the minimum required volume.

(b) Draft-hood equipped water heater: For structures that the air infiltration rate is known, method 8.3.2.2 permits the use of the equation in 8.3.2.2(1) to determine the required volume for a draft hood equipped appliance. Section 8.3.2.3 limits the use of the equation to air change rates equal to or less than 0.60 ACH. While the house was determined to have a 0.65 ACH, 0.30 ACH is used to calculate the required volume. Using the equation in 8.3.2.2(1), the required volume for the 40,000 Btu/hr water heater is calculated as follows:

$$= \frac{21\ \text{ft}^3}{0.30}\left(\frac{40{,}000\ \text{Btu/hr}}{1{,}000\ \text{Btu/hr}}\right)$$

$$= 2{,}800\ \text{ft}^3$$

Section 8.3.2.2 specifies a lower required volume limitation for appliances other than fan-assisted at no smaller than 35 ft^3 per 100,000 Btu/hr. From Table A.8.3.2.2(1), the lower limit is

1,400 ft^3

Because the calculated required volume of 2,800 ft^3 is above the lower required volume limit, use this amount as the minimum required volume.

(c) Total required volume: Section 8.3.2 states that the total required volume to use indoor air is the sum of the required volumes for all appliances located in the space.
Total Required = 5,000 ft^3+ 2,800 ft^3 = 7,800 ft^3

(2) Determine available volume:
The available volume is determined as follows:

$$(20 \text{ ft} \times 35 \text{ ft}) \times 8 \text{ ft} = 5{,}600 \text{ ft}^3$$

Conclusion:
The installation cannot use indoor air alone, because the available volume of 5,600 ft^3 is less than the total required volume of 7,800 ft^3. Outdoor air openings can be sized in accordance with all air from the outdoors *(see 8.3.3)* or by use of the combination of indoor/outdoor air method *(see 8.3.4)*.

Annex J Example of Combination of Indoor and Outdoor Combustion and Ventilation Opening Design

This annex is not a part of the requirements of this code but is included for informational purposes only.

J.1 Example of Combustion Indoor and Outdoor Combustion Air Opening Design. Determine the required combination of indoor and outdoor combustion air opening sizes for the following equipment installation example.

Example Installation: A fan-assisted furnace and a draft hood equipped water heater with the following inputs are located in a 15 ft × 30 ft basement with an 8 ft ceiling. No additional indoor spaces can be used to help meet the equipment combustion air needs.

Fan-Assisted Furnace Input: 100,000 Btu/hr

Draft Hood Equipped Water Heater Input: 40,000 Btu/hr

Solution

(1) Determine the total available room volume:
Equipment room volume: 15 ft × 30 ft with an 8 ft ceiling = 3600 ft^3

(2) Determine the total required volume: The standard method to determine combustion air will be used to calculate the required volume.
The combined input for the appliances located in the basement is calculated as follows:

$$100{,}000 \text{ Btu/hr} + 40{,}000 \text{ Btu/hr} = 140{,}000 \text{ Btu/hr}$$

The Standard Method requires that the required volume be determined based on 50 cubic feet per 1000 Btu/hour. Using Table A.8.3.2.1(a), the required volume for a 140,000 Btu/hr water heater is

$$7{,}000 \text{ ft}^3$$

Conclusion: Indoor volume is insufficient to supply combustion air since the total of 3600 ft^3 does not meet the required volume of 7000 ft^3. Therefore, additional combustion air must be provided from the outdoors.

(3) Determine ratio of the available volume to the required volume:

$$\frac{3600 \text{ ft}^3}{7000 \text{ ft}^3} = 0.51$$

(4) Determine the reduction factor to be used to reduce the full outdoor air opening size to the minimum required based on ratio of indoor spaces
1.00 – 0.51 (from Step 3) = 0.49

(5) Determine the single outdoor combustion air opening size as if all combustion air is to come from outdoors. In this example, the combustion air opening directly communicates with the outdoors.

$$\frac{140{,}000 \text{ Btu/hr}}{3{,}000 \text{ Btu/in.}^2} = 47 \text{ in.}^2$$

(6) Determine the minimum outdoor combustion air opening area:

Outdoor opening area = 0.49 (from Step 4) × 47 $in.^2$ = 23 $in.^2$
Section 8.3.4(3)(c) requires the minimum dimension of the air opening should not be less than 3 in.

Annex K Other Useful Definitions

This annex is not a part of the requirements of this code but is included for informational purposes only.

K.1 Useful Terms. The following terms are not used in the code. They are used in appliance standards and by manufacturers of products covered by the code.

K.1.1 Ambient Temperature. The temperature of the surrounding medium; usually used to refer to the temperature of the air in which a structure is situated or a device operates.

K.1.2 Automatic Damper Regulator. A mechanically or electrically actuated device designed to maintain a constant draft on combustion equipment.

K.1.3 Burner, 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.

K.1.4 Burner, Injection (Atmospheric). A burner in which the air at atmospheric pressure is injected into the burner by a jet of gas.

K.1.5 Burner, Power, Premixing. A power burner in which all or nearly all of the air for combustion is mixed with the gas as primary air.

K.1.6 Conversion Burner, Gas, Firing Door Type. A conversion burner specifically for boiler or furnace firing door installation.

K.1.7 Conversion Burner, Gas, Inshot Type. A conversion burner normally for boiler or furnace ash pit installation and fired in a horizontal position.

K.1.8 Conversion Burner, Gas, Upshot Type. A conversion burner normally for boiler or furnace ash pit installation and fired in a vertical position at approximately grate level.

K.1.9 Decorative Appliance for Installation in a Vented Fireplace, Coal Basket. An open-flame-type appliance consisting of a metal basket that is filled with simulated coals and gives the appearance of a coal fire when in operation.

K.1.10 Decorative Appliance for Installation in a Vented Fireplace, Fireplace Insert. Consists of an open-flame, radiant-type appliance mounted in a decorative metal panel to cover the fireplace or mantel opening and having provisions for venting into the fireplace chimney.

K.1.11 Decorative Appliance for Installation in a Vented Fireplace, Gas Log. An open-flame-type appliance consisting of a metal frame or base supporting simulated logs.

K.1.12 Decorative Appliance for Installation in a Vented Fireplace, Radiant Appliance. An open-front appliance designed primarily to convert the energy in fuel gas to radiant heat by means of refractory radiants or similar radiating materials.

K.1.13 Fireplace, Factory-Built. A fireplace composed of listed factory-built components assembled in accordance with the terms of listing to form the completed fireplace.

K.1.14 Fireplace, Masonry. A hearth and fire chamber of solid masonry units such as bricks, stones, listed masonry units, or reinforced concrete, provided with a suitable chimney.

K.1.15 Floor Furnace, Fan-Type. A floor furnace equipped with a fan that provides the primary means for circulation of air.

K.1.16 Floor Furnace, Gravity-Type. A floor furnace depending primarily on circulation of air by gravity. This classification also includes floor furnaces equipped with booster-type fans that do not materially restrict free circulation of air by gravity flow when such fans are not in operation.

K.1.17 Furnace, Direct Vent Central. A system consisting of (1) a central furnace for indoor installation, (2) combustion air connections between the central furnace and the outdoor atmosphere, (3) flue-gas connections between the central furnace and the vent cap, and (4) a vent cap for installation outdoors, supplied by the manufacturer and constructed so that all air for combustion is obtained from the outdoor atmosphere and all flue gases are discharged to the outdoor atmosphere.

K.1.18 Furnace, Downflow. A furnace designed with airflow discharge vertically downward at or near the bottom of the furnace.

K.1.19 Furnace, Forced Air, with Cooling Unit. A single-package unit, consisting of a gas-fired, forced-air furnace of the downflow, horizontal, or upflow type combined with an electrically or gas-operated summer air-conditioning system, contained in a common casing.

K.1.20 Furnace, Gravity. A furnace depending primarily on circulation of air by gravity.

K.1.21 Furnace, Gravity, with Booster Fan. A furnace equipped with a booster fan that does not materially restrict free circulation of air by gravity flow when the fan is not in operation.

K.1.22 Furnace, Gravity, with Integral Fan. A furnace equipped with a fan or blower as an integral part of its construction and operable on gravity systems only. The fan or blower is used only to overcome the internal furnace resistance to airflow.

K.1.23 Furnace, Horizontal. A furnace designed for low headroom installation with airflow across the heating element essentially in a horizontal path.

K.1.24 Furnace, Upflow. A furnace designed with airflow discharge vertically upward at or near the top of the furnace. This classification includes “highboy” furnaces with the blower mounted below the heating element and “lowboy” furnaces with the blower mounted beside the heating element.

K.1.25 Gas Main or Distribution Main. A pipe installed in a community to convey gas to individual services or other mains.

K.1.26 Household Cooking Gas Appliance, Floor-Supported Unit. A self-contained cooking appliance for installation directly on the floor. It has a top section and an oven section. It may have additional sections.

K.1.27 Indirect Oven. An oven in which the flue gases do not flow through the oven compartment.

K.1.28 Joint, Adhesive. A joint made in plastic piping by the use of an adhesive substance that forms a continuous bond between the mating surfaces without dissolving either one of them.

K.1.29 Joint, Solvent Cement. A joint made in thermoplastic piping by the use of a solvent or solvent cement that forms a continuous bond between the mating surfaces.

K.1.30 Leak Detector. An instrument for determining concentration of gas in air.

K.1.31 Loads, Connected. Sum of the rated Btu input to individual gas utilization equipment connected to a piping system. May also be expressed in cubic feet per hour.

K.1.32 Orifice Cap (Hood). A movable fitting having an orifice that permits adjustment of the flow of gas by the changing of its position with respect to a fixed needle or other device.

K.1.33 Orifice Spud. A removable plug or cap containing an orifice that permits adjustment of the flow of gas either by substitution of a spud with a different sized orifice or by the motion of a needle with respect to it.

K.1.34 Pressure Control. Manual or automatic maintenance of pressure, in all or part of a system, at a predetermined level, or within a selected range.

K.1.35 Regulator, Gas Appliance, Adjustable. (1) Spring type, limited adjustment: a regulator in which the regulating force acting upon the diaphragm is derived principally from a spring, the loading of which is adjustable over a range of not more than ±15 percent of the outlet pressure at the midpoint of the adjustment range; (2) spring type, standard adjustment: a regulator in which the regulating force acting on the diaphragm is derived principally from a spring, the loading of which is adjustable.

K.1.36 Regulator, Gas Appliance, Multistage. A regulator for use with a single gas whose adjustment means can be positioned manually or automatically to two or more predetermined outlet pressure settings.

K.1.37 Regulator, Gas Appliance, Nonadjustable. (1) Spring type, nonadjustable: a regulator in which the regulating force acting on the diaphragm is derived principally from a spring, the loading of which is not field adjustable; (2) weight type: a regulator in which the regulating force acting upon the diaphragm is derived from a weight or combination of weights.

K.1.38 Room Heater, Unvented Circulator. A room heater designed to convert the energy in fuel gas to convected and radiant heat by direct mixing of air to be heated with the combustion products and excess air inside the jacket.

K.1.39 Room Heater, Vented. A vented, self-contained, freestanding, nonrecessed, fuel-gas-burning appliance for furnishing warm air to the space in which installed, directly from the heater without duct connections.

K.1.40 Room Heater, Vented Circulator. A room heater designed to convert the energy in fuel gas to convected and radiant heat, by transfer of heat from flue gases to a heat exchanger surface, without mixing of flue gases with circulating heated air.

K.1.41 Room Heater, Vented Circulator, Fan Type. A vented circulator equipped with an integral circulating air fan, the operation of which is necessary for satisfactory appliance performance.

K.1.42 Room Heater, Vented Overhead Heater. A room heater designed for suspension from or attachment to or adjacent to the ceiling of the room being heated and transferring the energy of the fuel gas to the space being heated primarily by radiation downward from a hot surface, and in which there is no mixing of flue gases with the air of the space being heated.

K.1.43 Room Heater, Wall Heater, Unvented Closed Front. An unvented circulator having a closed front, for insertion in or attachment to a wall or partition.

K.1.44 Valve, Automatic Gas Shutoff. A valve used in conjunction with an automatic gas shutoff device to shut off the gas supply to a fuel-gas-burning water heating system.

K.1.45 Valve, Individual Main Burner. A valve that controls the gas supply to an individual main burner.

K.1.46 Valve, Main Burner Control. A valve that controls the gas supply to the main burner manifold.

K.1.47 Valve, 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 a pilot or pilots that are provided with independent shutoff.

K.1.48 Vented Wall Furnace, Fan-Type. A wall furnace that is equipped with a fan.

K.1.49 Vented Wall Furnace, Gravity-Type. A wall furnace that depends on circulation of air by gravity.

K.1.50 Venting System, Mechanical Draft, Induced. A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under nonpositive static vent pressure.

K.1.51 Venting System, Mechanical Draft, Power. *See* Venting System, Mechanical Draft, Forced.

K.1.52 Water Heater, Automatic Circulating Tank. A water heater that furnishes hot water to be stored in a separate vessel. Storage tank temperatures are controlled by means of a thermostat installed on the water heater. Circulation can be either gravity or forced.

K.1.53 Water Heater, Automatic Instantaneous. A water heater that has a rated input of at least 4000 Btu/hr/gal (5 kW/L) of self-stored water. Automatic control is obtained by water-actuated control, thermostatic control, or a combination of water-actuated control and thermostatic control. This classification includes faucet-type water heaters designed to deliver water through a single faucet integral with or directly adjacent to the appliance.

K.1.54 Water Heater, Coil Circulation. A water heater whose heat transfer surface is composed primarily of water tubes less than 1½ in. (38 mm) in internal diameter and that requires circulation.

K.1.55 Water Heater, Commercial Storage. A water heater that heats and stores water at a thermostatically controlled temperature for delivery on demand. Input rating: 75,000 Btu/hr (21,980 W) or more.

K.1.56 Water Heater, Countertop Domestic Storage. (1) Concealed type: a vented automatic storage heater that is designed for flush installation beneath a countertop 36 in. (910 mm) high, wherein the entire heater is concealed; (2) flush type: a vented automatic storage water heater that has flat sides, top, front, and back and is designed primarily for flush installation in conjunction with or adjacent to a counter 36 in. (910 mm) high, wherein the front and top of the heater casing are exposed; and (3) recessed type: a vented automatic storage water heater that has flat sides, top, front, and back and is designed for flush installation beneath a counter 36 in. (910 mm) high, wherein the front of the heater casing is exposed.

K.1.57 Water Heater, Domestic Storage. A water heater that heats and stores water at a thermostatically controlled temperature for delivery on demand. Input rating may not exceed 75,000 Btu/hr (21,980 W).

K.1.58 Water Heater, Nonautomatic Circulating Tank. A water heater that furnishes hot water to be stored in a separate vessel. Storage tank temperatures are controlled by means of a thermostat installed in the storage vessel.

Annex L Informational References

L.1 Referenced Publications. The following documents or portions thereof are referenced within this code for informational purposes only and are thus not part of the requirements of this document unless also listed in Chapter 14.

L.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, (617)770-3000, www.nfpa.org.

NFPA 30, *Flammable and Combustible Liquids Code,* 2000 edition.

NFPA 59, *Utility LP-Gas Plant Code,* 2001 edition.

NFPA 59A, *Standard for the Production, Storage and Handling of Liquefied Natural Gas (LNG),* 2001 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities,* 2002 edition.

NFPA 68, *Guide for Venting of Deflagrations,* 2002 edition.

NFPA 70, *National Electrical Code®*, 2002 edition.

NFPA 86, *Standard for Ovens and Furnaces,* 1999 edition.

NFPA 88B, *Standard for Repair Garages,* 1997 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* 2002 edition.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems,* 2002 edition.

NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations,* 2001 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, 2000 edition.

NFPA 501A, *Standard for Fire Safety Criteria for Manufactured Home Installations, Sites, and Communities,* 2000 edition.

L.1.2 Other Publications.

L.1.2.1 API Publication. American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005.

API 1104, *Standard for Welding Pipelines and Related Facilities,* 1999.

L.1.2.2 ASHRAE Publications. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329-2305, (404)636-8400, www.ashrae.org.

ASHRAE Handbook — Fundamentals, 1997.

ASHRAE Handbook — HVAC Systems and Equipment, 1999.

L.1.2.3 ASME Publication. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990, (800)843-2763, www.asme.org.

ASME *Boiler and Pressure Vessel Code,* Section IX and Section IV, 1998.

L.1.2.4 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, (610)833-9585, www.astm.org.

ANSI/ASTM D 2385, *Method of Test for Hydrogen Sulfide and Mercaptan Sulfur in Natural Gas (Cadmium Sulfate — Iodometric Titration Method),* 1981.

ANSI/ASTM D 2420, *Method of Test for Hydrogen Sulfide in Liquefied Petroleum (LP) Gases (Lead Acetate Method),* 1991 (Reaffirmed 1996).

L.1.2.5 AWS Publications. American Welding Society, 550 N. W. LeJeune Road, Miami, FL 33126, (800)443-9353, www.aws.org.

AWS B2.1, *Standard for Welding Procedure and Performance Qualification,* 1998.

AWS B2.2, *Standard for Brazing Procedure and Performance Qualification,* 1991.

L.1.2.6 CSA-America Publications. CSA-America, Inc., 8501 East Pleasant Valley Road, Cleveland, OH 44131, (216)524-4990, www.csa-america.org.

AGA/CGA NGV 1, *Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices,* 1999.

AGA/CGA NGV 3.1, *Fuel System Components for Natural Gas Powered Vehicles,* 1999.

ANSI/IAS LC 2A, *Agricultural Heaters,* 1998.

ANSI Z21.1, *Household Cooking Gas Appliances,* 2000.

ANSI Z21.5.1/CSA 7.1, *Gas Clothes Dryers — Volume I — Type 1 Clothes Dryers,* 1999.

ANSI Z21.5.2/CSA 7.2, *Gas Clothes Dryers — Volume II — Type 2 Clothes Dryers,* 2001.

ANSI Z21.10.1/CSA 4.1, *Gas Water Heaters — Volume I — Storage, Water Heaters with Input Ratings of 75,000 Btu per Hour or Less,* 2001.

ANSI Z21.10.3/CSA 4.3, *Gas Water Heaters — Volume III — Storage, Water with Input Ratings above 75,000 Btu per Hour, Circulating and Instantaneous,* 2001.

ANSI Z21.11.1, *Gas-Fired Room Heaters — Volume I — Vented Room Heaters,* 1991. (Included in Z21.86/CSA 2.32, 2000.)

ANSI Z21.11.2, *Gas-Fired Room Heaters — Volume II — Unvented Room Heaters,* 2000.

ANSI Z21.12, *Draft Hoods,* 1990 (Reaffirmed 2000).

ANSI Z21.13/CSA 4.9, *Gas-Fired Low-Pressure Steam and Hot Water Boilers,* 2000 (Reaffirmed 1998).

ANSI Z21.15/CGA 9.1, *Manually Operated Gas Valves for Appliances, Appliance Connector Valves, and Hose End Valves,* 1997.

ANSI Z21.17/CSA 2.7, *Domestic Gas Conversion Burners,* 1998.

ANSI Z21.18/CSA 6.3, *Gas Appliance Pressure Regulators,* 2000.

ANSI Z21.19/CSA 1.4, *Refrigerators Using Gas Fuel,* 2002 (Reaffirmed 1999).

ANSI Z21.20, *Automatic Gas Ignition Systems and Components,* 2000.

ANSI Z21.21/CGA 6.5, *Automatic Valves for Gas Appliances,* 2000.

ANSI Z21.22/CSA 4.4, *Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems,* 1999 (Reaffirmed 1998).

ANSI Z21.23, *Gas Appliance Thermostats,* 2000 (Reaffirmed 1998).

ANSI Z21.24/CSA 6.10, *Metal Connectors for Gas Appliances,* 2001.

ANSI Z21.35/CGA 6.8, *Pilot Gas Filters,* 1995.

ANSI Z21.40.1/CGA 2.91-M96, *Gas-Fired Absorption Summer Air Conditioning Appliances,* 1996.

ANSI Z21.40.2/CGA 2.92, *Gas-Fired Work Activated Air-Conditioning and Heat Pump Appliances (Internal Combustion),* 1996.

ANSI Z21.40.4/CGA 2.94, *Performance Testing and Rating of Gas Fired, Air-Conditioning and Heat Pump Appliances,* 1996.

ANSI Z21.41/CSA 6.9, *Quick-Disconnect Devices for Use With Gas Fuel,* 1998.

ANSI Z21.42, *Gas-Fired Illuminating Appliances,* 1993 (Reaffirmed 1998).

ANSI Z21.47/CSA 2.3, *Gas-Fired Central Furnaces,* 2001.

ANSI Z21.50/CSA 2.22, *Vented Gas Fireplaces,* 2000.

ANSI Z21.54/CSA 8.4, *Gas Hose Connectors for Portable Outdoor Gas-Fired Appliances,* 1996.

ANSI Z21.56/CSA 4.7, *Gas-Fired Pool Heaters,* 2001.

ANSI Z21.57, *Recreational Vehicle Cooking Gas Appliances,* 2001 (Reaffirmed 1998).

ANSI Z21.58/CGA 1.6, *Outdoor Cooking Gas Appliances,* 1995 (Reaffirmed 2001).

ANSI Z21.60/CGA 2.26, *Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces,* 1996.

ANSI Z21.61, *Gas-Fired Toilets,* 1983 (Reaffirmed 1996).

ANSI Z21.66/CGA 6.14, *Automatic Vent Damper Devices for Use with Gas-Fired Appliances,* 1996.

ANSI Z21.69/CSA 6.16, *Connectors for Movable Gas Appliances,* 1997 (Reaffirmed 2001).

ANSI Z21.71, *Automatic Intermittent Pilot Ignition Systems for Field Installations,* 1993 (Reaffirmed 1998).

ANSI Z21.77/CGA 6.23, *Manually-Operated Piezo-Electric Spark Gas Ignition Systems and Components,* 1995.

ANSI Z21.78/CGA 6.20, *Combination Gas Controls for Gas Appliances,* 2000.

ANSI Z21.83, *Fuel Cell Power Plants,* 1998.

ANSI Z21.84, *Manually Lighted, Natural Gas, Decorative Gas Appliances for Installation in Solid-Fuel Burning Appliances,* 1999.

ANSI Z21.86/CSA 2.32, *Vented Gas-Fired Space Heating Equipment,* 2000.

ANSI Z21.87/CSA 4.6, *Automatic Gas Shutoff Devices for Hot Water Supply Systems,* 1999.

ANSI Z21.88/CSA 2.33, *Vented Gas-Fireplace Heaters,* 2000.

ANSI Z21.91, *Ventless Firebox Enclosures for Gas-Fired Unvented Decorative Room Heaters,* 2001.

ANSI Z83.3, *Gas Utilization Equipment in Large Boilers,* 1971 (Reaffirmed 1995).

ANSI Z83.4/CSA 3.7, *Direct Gas-Fired Make-Up Air Heaters,* 1999 (Reaffirmed 1998).

ANSI Z83.6, *Gas-Fired Infrared Heaters,* 1990 (Reaffirmed 1998).

ANSI Z83.8/CGA 2.6, *Gas Fired Duct Furnaces and Unit Heaters,* 1996.

ANSI Z83.11/CGA 1.8, *Food Service Equipment,* 1996.

IAS U.S. 7, *Requirements for Gas Convenience Outlets and Optional Enclosures,* 1990.

IAS U.S. 9, *Requirements for Gas-Fired, Desiccant Type Dehumidifiers and Central Air Conditioners,* 1990.

IAS U.S. 42, *Requirement for Gas Fired Commercial Dishwashers,* 1992.

IAS NGV2, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Containers,* 1998.

L.1.2.7 MSS Publications. Manufacturers Standardization Society of the Valve and Fittings Industry, 5203 Leesburg Pike, Suite 502, Falls Church, VA 22041.

MSS SP-6, *Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings,* 1999.

ANSI/MSS SP-58, *Pipe Hangers and Supports — Materials, Design and Manufacture,* 1993.

L.1.2.8 NACE Publication. National Association of Corrosion Engineers, 1440 South Creek Drive, Houston, TX 77084.

NACE RP 0169, *Control of External Corrosion on Underground or Submerged Metallic Piping Systems,* 1996.

L.1.2.9 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 103, *Chimneys, Factory-Built, Residential Type and Building Heating Appliances,* 1995.

ANSI/UL 441, *Gas Vents,* 1996.

ANSI/UL 641, *Low-Temperature Venting Systems,* 1995.

UL 1738, *Venting Systems for Gas Burning Appliances, Categories II, III and IV,* 1993.

UL 1777, *Chimney Liners,* 1996.

L.1.2.10 U.S. Government Publication. U.S. Government Printing Office, Washington, DC 20402.

Manufactured Home Construction and Safety Standard, Title 24, *Code of Federal Regulations,* Part 3280.

L.2 Informational References. (Reserved)

L.3 References for Extracts. The following documents are listed here to provide reference information, including title and edition, for extracts given throughout this code as indicated by a reference in brackets [ ] following a section or paragraph. These documents are not a part of the requirements of this document unless also listed in Chapter 14 for other reasons.

NFPA *101®*, *Life Safety Code®*, 2000 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances,* 2000 edition.

NFPA 501, *Standard on Manufactured Housing,* 2000 edition.

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