NFPA 54
National Fuel Gas Code

1999 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 54

ANSI Z223.1-1999

National Fuel Gas Code

1999 Edition

This 1999 edition incorporates changes to the 1996 edition. It was adopted by the National Fire Protection Association (NFPA) on July 22, 1999, and was approved by the American National Standards Institute, Inc. (ANSI) on August 5, 1999. The ANSI designation is Z223.1–1999. The NFPA designation is NFPA 54–1999.

Changes other than editorial, including dimensional abbreviations, from the 1996 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:*

American National Standard Installation of Gas Appliances and Gas Piping, ANSI Z21.30 (NFPA 54)
Installation of Gas Piping and Gas Equipment on Industrial Premises and Certain Other Premises, ANSI Z83.1 (NFPA 54A)
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, and fifth editions were issued in 1984, 1988, and 1992, respectively. The scope of the code was expanded in 1988 to include piping systems up to and including 125 psi (862 kPa).

The 1999 edition includes a revised Table 6.2.3(a), formerly Table V, now applicable only to unlisted gas-fired furnaces, boilers, and air conditioners; new requirements for installation of gas appliances in closets opening into residential garages; a revised definition of Unusually Tight Construction to reflect current construction practices; and a change to make the code applicable to the installation of appliances in manufactured housing after the initial sale.

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

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of this 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 the procedures of the American National Standards Institute 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, cosponsored by the American Gas Association (Administrative Secretariat) and the National Fire Protection Association. In the NFPA context the Committee is an NFPA Technical Committee.

Committee Scope: This Committee shall have primary responsibility for a document 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 psi. 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.

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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 Appendix A.

Information on referenced publications can be found in Chapter 11 and Appendix M.

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

Chapter 1 General

1.1 Scope.

1.1.1 Applicability.

(a) 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 follows:

(1) 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.
(2) 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 2.5.2.

(3) Piping systems requirements shall include design, materials, components, fabrication, assembly, installation, testing, inspection, operation, and maintenance.
(4) Requirements for gas utilization equipment and related accessories shall include installation, combustion, and ventilation air and venting.

(b) This code shall not apply to the following (reference standards for some of which appear in Appendix M):

(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*

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 Alternate Materials, Equipment, and Procedures. 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 1.7)*. The authority having jurisdiction shall require that sufficient evidence be submitted to substantiate any claims made regarding the safety of such alternates.

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 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.

1.5 Interruption of Service.

1.5.1 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.

1.5.2* Before Turning Gas Off. Before the gas is turned off to the premises, or section of piping to be serviced, for the purpose of installation, repair, replacement, or maintenance of gas piping or gas utilization equipment, all equipment shutoff valves shall be turned off.

A leakage test shall be performed to determine that all equipment is turned off in the piping section affected.

Exception: In cases of emergency, these paragraphs shall not apply.

1.5.3 Turn Gas Off. All gas piping installations, equipment installations, and modifications to existing systems shall be performed with the gas turned off and the piping purged in accordance with Section 4.3.

Exception: Hot taps shall be permitted if they are installed by trained and experienced crews utilizing equipment specifically designed for such a purpose.

1.5.4 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.

1.6 Prevention of Accidental Ignition.

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

(a) Provisions for electrical continuity shall be made before alterations are made in a metallic piping system.

(b) Smoking, open flames, lanterns, welding, or other sources of ignition shall not be permitted.

(c) A metallic electrical bond shall be installed around the location of cuts in metallic gas pipes made by other than cutting torches. If 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 4.3 before welding or cutting with a torch is attempted.

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

1.6.2 Handling of Flammable Liquids.

(a) *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.

(b) *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.

1.7 Definitions. The terms used in this code are defined within the parameters of the scope of the code.

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

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

Agency, Qualified. *See* Qualified Agency.

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

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

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.

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

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.

Anodeless Riser. A transition assembly where plastic piping is permitted to be installed and terminated above ground outside of a building. The plastic piping is piped from below grade to an aboveground location inside a protective steel casing and terminates in either a factory-assembled transition fitting or a field-assembled service head adapter-type transition fitting.

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

Appliance, Automatically Controlled. Appliance equipped with an automatic burner ignition and safety shutoff device and other automatic devices that (1) accomplish complete turn-on and shutoff of the gas to the main burner or burners and (2) graduate the gas supply to the burner or burners, but do not effect complete shutoff of the gas.

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.

Appliance, Fan-Assisted Combustion. An appliance equipped with an integral mechanical means to either draw or force products of combustion through the combustion chamber or heat exchanger.

Appliance, Low-Heat. An appliance such as a food service range, pressing machine boiler operating at any pressure, bake oven, candy furnace, stereotype furnace, drying and curing appliance, and other process appliances in which materials are heated or melted at temperatures (excluding flue-gas temperatures) not exceeding 600°F (315°C).

Approved.* Acceptable to the authority having jurisdiction.

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.

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

Automatic Damper Regulator. A mechanically or electrically actuated device designed to maintain a constant draft on combustion equipment.

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. Present units are customarily equipped with spring- or weight-loaded valves released for closure by a fusible link or by movement of bimetallic elements; they are also equipped with metallic screens for stopping the progress of a flame front.

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.

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.

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.

Backfire Preventer. *See* Safety Blowout.

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

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

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.

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.

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

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

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

Breeching. *See* Vent Connector.

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

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).

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

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

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.

Burner, Injection (Atmospheric). A burner in which the air at atmospheric pressure is injected into the burner by a jet of gas.

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.

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.

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.

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

Carbon Steel. By common custom, steel that is considered to be carbon steel when no minimum content is specified or required for aluminum, boron, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other element added to obtain a desired alloying effect; when the specified minimum for copper does not exceed 0.40 percent; or when the maximum content specified for any of the following elements does not exceed the percentages noted: manganese, 1.65; silicon, 0.60; copper, 0.60.

Central Premix System. A system that distributes flammable gas–air mixtures to two or more remote stations and is employed to provide one or more of the following: (1) wide in-plant distribution of a centrally controlled gas–air mixture; (2) a wider range of mixture pressures (frequently in the 1 to 5 psi range) (7 to 34 kPa) than is available from other gas–air mixing equipment; (3) close control of gas–air ratios over a wide turndown range (often 20 to 1 or more); or (4) ability to change total connected burner port area without installing new mixing devices or inserts. Central premix systems either may proportion the flows of pressurized air and pressurized gas for subsequent mixing in a downstream tee or comparable fitting, or they may draw room air at essentially atmospheric pressure through a proportioning mixing valve and then through a blower or compressor downstream.

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

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

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.

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

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

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. Usually the smallest unit physically and in function output.

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. Not designed for use in individual family living environment. May be small, medium, or large in relative size.

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.

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.

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

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

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.

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

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.

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

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

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.

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

Conversion Burner, Gas, Firing Door Type. A conversion burner specifically for boiler or furnace firing door installation.

Conversion Burner, Gas, Inshot Type. A conversion burner normally for boiler or furnace ash pit installation and fired in a horizontal position.

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.

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

Cubic Foot (ft^3) of Gas. The amount of gas that would occupy 1 ft^3 (0.3 m) when at a temperature of 60°F (16°C), saturated with water vapor and under a pressure equivalent to that of 30.0 in. (7.5 kPa) mercury column.

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.

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.

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.

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.

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. A radiant heater has no external jacket. A radiant appliance is designed for installation in a vented fireplace.

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

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.

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

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

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.

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.

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.

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

Draft. The flow of gases or air through chimney, flue, or equipment, caused by pressure differences.

Draft, Mechanical or Induced. The draft developed by fan or air or steam jet or other mechanical means.

Draft, Natural. The draft developed by the difference in temperature of hot gases and outside atmosphere.

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.

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

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

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

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.

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

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

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

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.

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

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

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

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.

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

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

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.

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).

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.

Floor Furnace, Fan-Type. A floor furnace equipped with a fan that provides the primary means for circulation of air.

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.

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

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

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

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

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.

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.

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.

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.

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.

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

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

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.

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.

Furnace, Downflow. A furnace designed with airflow discharge vertically downward at or near the bottom of the furnace.

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

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

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.

Furnace, Gravity. A furnace depending primarily on circulation of air by gravity.

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.

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.

Furnace, Horizontal. A furnace designed for low headroom installation with airflow across the heating element essentially in a horizontal path.

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.

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.

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

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.

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

Gas Main or Distribution Main. A pipe installed in a community to convey gas to individual services or other mains.

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.

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

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.

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

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.

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

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.

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.

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

Gravity. *See* Specific Gravity.

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.

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.

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.

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

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

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.

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.

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.

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

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.

Incinerator, Domestic. A domestic, fuel-gas burning appliance, used to reduce refuse material to ashes, that is manufactured, sold, and installed as a complete unit.

Indirect Oven. An oven in which the flue gases do not flow through the oven compartment.

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.

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).

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

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.

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.

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

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

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.

Leak Check. An operation performed on a complete gas piping system and connected equipment prior to placing it into operation following initial installation and pressure testing or interruption of gas supply to verify that the system does not leak.

Leak Detector. An instrument for determining concentration of gas in air.

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.

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.

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.

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.

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

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 horizontial projections when erected on site. These dimensions include all expandable rooms, cabinets, and other projections containing interior space, but do not include bay windows.

Maximum Working Pressure. The maximum pressure at which a piping system may be operated in accordance with the provisions of this code. It is the pressure used in determining the setting of pressure-relieving or pressure-limiting devices installed to protect the system from accidental overpressuring.

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

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

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. 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.

NA. Vent configuration is not permitted due to potential for condensate formation or pressurization of the venting system, or not applicable due to physical or geometric restraints.

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

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

Noncombustible Material. For the purpose of this code, noncombustible material shall mean material that is not capa-

ble 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.

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.

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.

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.

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.

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.

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

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

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

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.

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

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

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.

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

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.

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

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

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

Pressure Control. Manual or automatic maintenance of pressure, in all or part of a system, at a predetermined level, or within a selected range.

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

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.

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

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

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

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.

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.

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

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

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

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; the adjustment means shall be concealed.

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. Each of these settings may be either adjustable or nonadjustable. The regulator may modulate outlet pressures automatically between its maximum and minimum predetermined outlet pressure settings.

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.

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

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.

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

Regulator, Series. A pressure regulator in series with one or more other pressure regulators. The regulator nearest to the gas supply source is set to continuously limit the pressure on the inlet to the regulator downstream to some predetermined value (between the pressure of the gas supply source and the pressure of the system being controlled) that can be tolerated in the downstream system.

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

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.

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.

Room Heater, Unvented. An unvented, self-contained, freestanding, nonrecessed [except as noted under (b) of the following classifications], 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. Unvented room heaters do not normally have input ratings in excess of 40,000 Btu/hr (11,720 W).

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. Unvented circulators have an external jacket surrounding the burner and may be equipped with radiants with the jacket open in front of the radiants.

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.

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. Vented circulators may be equipped with transparent panels and radiating surfaces to increase radiant heat transfer as long as separation of flue gases from circulating air is maintained. Vented circulators may also be equipped with an optional circulating air fan but should perform satisfactorily with or without the fan in operation.

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.

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.

Room Heater, Wall Heater, Unvented Closed Front. An unvented circulator having a closed front, for insertion in or attachment to a wall or partition. These heaters are marked "UNVENTED HEATER" and do not have normal input ratings in excess of 25,000 Btu/hr (7325 W).

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. Total volume of the appliance is determined from exterior dimensions and is to include fan compartments and burner vestibules, when used. When 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).

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. A check valve, signaling means, or both may also be incorporated.

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.

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.

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.

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

Shall. Indicates a mandatory requirement.

Shutoff. *See* Valve.

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.

Space, Confined. For the purposes of this code, a space whose volume is less than 50 ft^3 per 1000 Btu/hr (4.8 m^3/kW) of the aggregate input rating of all appliances installed in that space.

Space, Unconfined. For purposes of this code, a space whose volume is not less than 50 ft^3 per 1000 Btu/hr (4.8 m^3/kW) of the aggregate input rating of all appliances installed in that space. Rooms communicating directly with the space in which the appliances are installed, through openings not furnished with doors, are considered a part of the unconfined space.

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.

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

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

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).

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

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.

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.

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

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

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

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

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

Unit Broiler. A broiler constructed as a separate appliance.

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. It is equipped with provisions for attaching an outlet air duct and, when the appliance is for indoor installation remote from the space to be heated, is also equipped with provisions for attaching an inlet air duct.

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.

Unusually Tight Construction. Construction where (1) walls and ceilings exposed to the outside atmosphere have a continuous water vapor retarder with a rating of 1 perm (6×10^{-11} kg/pa-sec-m^2) or less with openings gasketed or sealed; and (2) weatherstripping has been added on openable windows and doors; and (3) caulking or sealants are applied to areas such as joints around window and door frames, between sole plates and floors, between wall–ceiling joints, between wall panels, at penetrations for plumbing, electrical, and gas lines, and at other openings; and (4) the building has an average air infiltration rate of less than 0.35 air changes per hour.

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

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

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. The operator may be actuated by application of gas pressure on a flexible diaphragm, by electrical means, by mechanical means, or by other means.

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. It may be constructed integrally with the gas shutoff device or be a separate assembly.

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

Valve, Individual Main Burner. A valve that controls the gas supply to an individual main burner.

Valve, Main Burner Control. A valve that controls the gas supply to the main burner manifold.

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.

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.

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.

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.

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.

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.

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.

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.

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

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

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.

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

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.

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.

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.

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.

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.

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.

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.

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. Such appliances should not be provided with duct extensions beyond the vertical and horizontal limits of the casing proper, except that boots not to exceed 10 in. (250 mm) beyond the horizontal limits of the casing for extension through walls of nominal thickness are permitted. When such boots are provided, they shall be supplied by the manufacturer as an integral part of the appliance. This definition excludes floor furnaces, unit heaters, direct vent wall furnaces, and central furnaces.

Vented Wall Furnace, Fan-Type. A wall furnace that is equipped with a fan.

Vented Wall Furnace, Gravity-Type. A wall furnace that depends on circulation of air by gravity.

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

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.

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.

Venting System, Mechanical Draft, Forced. A portion of a venting system using a fan or other mechanical means to cause the removal of flue or vent gases under positive static vent pressure.

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.

Venting System, Mechanical Draft, Power. *See* Venting System, Mechanical Draft, Forced.

Venting System, Natural Draft. *See* Draft.

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. The appliance shall be complete with grilles or equivalent, designed for incorporation in or permanent attachment to the structure of a building, mobile home, or recreational vehicle, and shall furnish heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing. Such appliances shall not be provided with duct extensions beyond the vertical and horizontal limits of the appliance casing, except that boots not to exceed 10 in. (250 mm) beyond the horizontal limits of the casing for extension through walls or nominal thickness may be permitted. This definition excludes floor furnaces, unit heaters, vented wall furnaces, and central furnaces as defined in appropriate American National Standards.

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

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

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 may be either gravity or forced.

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.

Water Heater, Coil Circulation. A water heater whose heat transfer surface is composed primarily of water tubes less than $1^1/_2$ in. (38 mm) in internal diameter and that requires circulation.

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.

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.

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).

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.

Chapter 2 Gas Piping System Design, Materials, and Components

2.1 Piping Plan.

2.1.1 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.

2.1.2 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 2.4.3)*. If inadequate, the existing system shall be enlarged as required, or separate gas piping of adequate capacity shall be provided.

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

2.3 Interconnections Between Gas Piping Systems.

2.3.1 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.

2.3.2 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.

2.4 Sizing of Gas Piping Systems.

2.4.1* 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.

2.4.2* Maximum Gas Demand. 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 for estimating the volume of gas to be supplied.

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

Exception: Smaller sized piping shall be permitted where a diversity of load is established.

2.4.3* Gas piping shall be sized in accordance with one of the following:

(1) The tables in Chapter 9
(2) Other approved engineering methods acceptable to the authority having jurisdiction

2.4.4 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.

2.5 Piping System Operating Pressure Limitations.

2.5.1 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.

2.5.2 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.

2.6 Acceptable Piping Materials and Joining Methods.

2.6.1 General.

(a) *Material Application.* Materials and components conforming to standards or specifications listed herein or acceptable to the authority having jurisdiction shall be permitted to be used for appropriate applications, as prescribed and limited by this code.

(b) *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.

(c) *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.

2.6.2 Metallic Pipe.

(a) Cast-iron pipe shall not be used.

(b) 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, *Standard for 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*

(c) *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).

Threaded copper, brass, or aluminum alloy pipe in iron pipe sizes shall be permitted to be used with gases not corrosive to such material.

(d) 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.

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

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

(a) 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.*

(b) *Copper and brass tubing shall not be used if the gas contains more than an average of 0.3 g 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.*

(c) 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.

(d) Corrugated stainless steel tubing shall be tested and listed in compliance with the construction, installation, and performance requirements of ANSI/AGA LC-1, *Standard for Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing.*

2.6.4 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."

Anodeless risers shall comply with the following:

(a) 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.

(b) 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 the *Code of Federal Regulations,* Title 49, Part 192.281(e). The manufacturer shall provide the user qualified installation instructions as prescribed by the *Code of Federal Regulations,* Title 49, Part 192.283(b).

(c) 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.*

2.6.5 Workmanship and Defects. Gas pipe or 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 or tubing or fittings shall not be repaired. When defective pipe, tubing, or fittings are located in a system, the defective material shall be replaced. *[See 4.1.1(c).]*

2.6.6 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.

2.6.7 Metallic Pipe Threads.

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

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

(c) *Number of Threads.* Field threading of metallic pipe shall be in accordance with Table 2.6.7.

(d) *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.

2.6.8 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

Table 2.6.7 Specifications for Threading Metallic Pipe

Iron Pipe Size (in.)	Approximate Length of Threaded Portion (in.)	Approximate No. of Threads to Be Cut
1/2	3/4	10
3/4	3/4	10
1	7/8	10
1 1/4	1	11
1 1/2	1	11
2	1	11
2 1/2	1 1/2	12
3	1 1/2	12
4	1 5/8	13

For SI units, 1 in. = 25.4 mm.

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.

(a) **Pipe Joints.* Pipe joints shall be threaded, flanged, or welded, and nonferrous pipe shall be permitted to also be brazed with materials having a melting point in excess of 1000°F (538°C). Brazing alloys shall not contain more than 0.05 percent phosphorus.

(b) *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.

(c) *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.

(d) *Metallic Fittings (Including Valves, Strainers, Filters).*

(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.*

a. Flanges shall be permitted to be used.

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) *Brass, Bronze, or Copper Fittings.* Fittings, if exposed to soil, shall have a minimum 80 percent copper content.

(7) *Aluminum Alloy Fittings.* Threads shall not form the joint seal.

(8) *Zinc–Aluminum Alloy Fittings.* Fittings shall not be used in systems containing flammable gas–air mixtures.

(9) *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 permitted to be used provided they are (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.

2.6.9 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:

(a) 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.

(b) 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."

(c) 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.

(d) Plastic piping joints and fittings for use in liquefied petroleum gas piping systems shall be in accordance with *Liquefied Petroleum Gas Code,* NFPA 58.

2.6.10 Flanges. All flanges shall comply with ANSI/ASME B16.1, *Standard for Cast Iron Pipe Flanges and Flanged Fittings;* ANSI/ASME B16.20, *Standard for Ring-Joint Gaskets and Grooves for Steel Pipe Flanges;* 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.

(a) *Flange Facings.* Standard facings shall be permitted for use under this code. Where 150-psi (1090 kPa) steel flanges are bolted to Class 125 cast-iron flanges, the raised face on the steel flange shall be removed.

(b) *Lapped Flanges.* Lapped flanges shall be permitted to be used only above ground or in exposed locations accessible for inspection.

2.6.11 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.

(1) Acceptable materials include the following:

a. Metal or metal-jacketed asbestos (plain or corrugated)
b. Asbestos
c. Aluminum "O" rings and spiral-wound metal gaskets

(2) When a flanged joint is opened, the gasket shall be replaced.

(3) Full-face gaskets shall be used with all bronze and cast-iron flanges.

2.7* Gas Meters.

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

2.7.2 Location.

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

(b) 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.

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

(d) 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.

2.7.3 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.

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

2.7.5 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.

2.8* Gas Pressure Regulators.

2.8.1 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.

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

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

2.8.4 Venting.

(a) *Line Gas Pressure Regulators.*

(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 2.9.7 for information on properly locating the vent.) Materials for vent piping shall be in accordance with Section 2.6.

Exception: A regulator and vent limiting means combination listed as complying with ANSI Z21.80, Standard for 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.

(b) *Gas Appliance Pressure Regulators.* For venting of gas appliance pressure regulators, see 5.1.18.

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

2.8.6 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.

2.9 Overpressure Protection Devices.

2.9.1 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 2.9.5.)*

(a) 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.

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.

(b) 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.

2.9.2 Devices. Any of the following pressure-relieving or pressure-limiting devices shall be permitted to be used.

(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

The preceding devices shall be installed as an integral part of the service or line pressure regulator or as separate units. If separate pressure relieving or pressure limiting devices are installed, they shall comply with 2.9.3 through 2.9.8.

2.9.3 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.

2.9.4 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.

2.9.5 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.

2.9.6 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.

2.9.7 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 atmosphere. 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.

2.9.8 Size of Fittings, Pipe, and Openings. The openings, pipe, and fittings 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.

2.10 Back Pressure Protection.

2.10.1 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.

2.10.2 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

2.11 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.

2.12 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.

2.13 Expansion and Flexibility.

2.13.1 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.

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. If 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.

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

2.13.2 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 3 Gas Piping Installation

3.1 Piping Underground.

3.1.1 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.

3.1.2 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.

(a) *Cover Requirements.* Underground piping systems shall be installed with at least 18 in. (460 mm) of cover. The cover shall be permitted to be reduced to 12 in. (300 mm) if external damage to the pipe is not likely to result. If a minimum of 12 in. (300 mm) of cover cannot be maintained, the pipe shall be installed in conduit or bridged (shielded).

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

(c) *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.

3.1.3* 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.

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

3.1.5 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.

3.1.6 Piping Under Ground 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. If 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.

3.1.7 Plastic Pipe.

(a) *Connection of Plastic Piping.* Plastic pipe shall be installed outside, under ground only.

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

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

(b) Connections made outside and under ground 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.

(c) 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 above ground at a building wall or riser.

3.2 Aboveground Piping Outside. Piping installed aboveground shall be securely supported and located where it will be protected from physical damage *(also see 3.1.4).* 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.

3.3 Piping in Buildings.

3.3.1 Building Structure.

(1) The installation of gas piping shall not cause structural stresses within building components to exceed allowable design limits.
(2) Before any beams or joists are cut or notched, permission shall be obtained from the authority having jurisdiction.

3.3.2 Other than Dry Gas. Drips, sloping, protection from freezing, and branch pipe connections, as provided for in 3.1.4, 3.3.3, 3.7.1, and Section 3.9, shall be provided when other than dry gas is distributed and climatic conditions make such provisions necessary.

3.3.3 Gas Piping to Be Sloped. Piping for other than dry gas conditions shall be sloped not less than $^1/_4$ in. in 15 ft (7 mm in 4.6 m) to prevent traps.

3.3.4 Ceiling Locations. Gas piping shall be permitted to be installed in accessible spaces between a fixed ceiling and a dropped ceiling, whether or not such spaces are used as a plenum. Valves shall not be located in such spaces.

Exception: Equipment shutoff valves required by this code shall be permitted to be installed in accessible spaces containing vented gas utilization equipment.

3.3.5 Prohibited Locations. Gas piping inside any building shall not be installed in or through a circulating air duct, clothes chute, chimney or gas vent, ventilating duct, dumbwaiter, or elevator shaft. This provision shall not apply to ducts used to provide combustion and ventilation air in accordance with Section 5.3 or to above-ceiling spaces as covered in 3.3.4.

3.3.6 Hangers, Supports, and Anchors.

(a) 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.*

(b) Spacings of supports in gas piping installations shall not be greater than shown in Table 3.3.6.

(c) 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.

3.3.7 Removal of Pipe. If 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 4.3.)*

3.4 Concealed Piping in Buildings.

3.4.1 General. Gas piping shall be permitted to be installed in concealed locations in accordance with this section.

3.4.2 Connections. When gas piping that is to be concealed is being installed, unions, tubing fittings, right and left couplings, bushings, swing joints, and compression couplings made by combinations of fittings shall not be used. Pipe fittings such as elbows, tees, and couplings shall be permitted to be used.

Table 3.3.6 Support of Piping

Steel Pipe, Nominal Size of Pipe (in.)	Spacing of Supports (ft)	Nominal Size of Tubing (in. O.D.)	Spacing of Supports (ft)
$^1/_2$	6	$^1/_2$	4
$^3/_4$ or 1	8	$^5/_8$ or $^3/_4$	6
$1^1/_4$ or larger (horizontal)	10	$^7/_8$ or 1	8
$1^1/_4$ or larger (vertical)	every floor level		

For SI units, 1 ft = 0.305 m.

Exception No. 1: Joining tubing by brazing [see 2.6.8(b)] shall be permitted.

Exception No. 2: 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 shall be permitted to be used.

Exception No. 3: Where necessary to insert fittings in gas pipe that has been installed in a concealed location, the pipe shall be permitted to be reconnected by welding, flanges, or the use of a ground joint union with the nut center-punched to prevent loosening by vibration.

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

3.4.4 Tubing in Partitions. This provision shall not apply to tubing that pierces walls, floors, or partitions.

Tubing shall be permitted to be installed vertically and horizontally inside hollow walls or partitions without protection along its entire concealed length where both of the following requirements are met:

(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.

3.4.5 Piping in Floors. 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.

Exception: In other than industrial occupancies and where approved by the authority having jurisdiction, gas piping shall be permitted to be embedded in concrete floor slabs constructed with portland cement. Piping shall be surrounded with a minimum of $1^1/_2$ 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 2.6.6. Piping shall not be embedded in concrete slabs containing quickset additives or cinder aggregate.

3.5 Piping in Vertical Chases. Where gas piping exceeding 5 psi (34 kPa) is located within vertical chases in accordance

with 2.5.1(2), the requirements of 3.5.1 through 3.5.3 shall apply.

3.5.1 Pressure Reduction. If pressure reduction is required in branch connections for compliance with 2.5.1, 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 2.8.4 and Section 2.9. The regulator shall be accessible for service and repair.

(1) Regulators equipped with a vent-limiting means shall be permitted to be vented into the chase.
(2) 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.

Exception: If the fuel gas is heavier than air, the vent shall be vented only directly to the outdoors.

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

3.5.3* Ventilation. A chase shall be ventilated to the outdoors and only at the top. The opening(s) shall have a minimum free area (in square inches) 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.

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

3.6.1 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.

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

(1) The pipe shall not be damaged, and the internal diameter of the pipe shall not be effectively reduced.
(2) Joints shall not be located in pipe bends.
(3) The radius of the inner curve of such bends shall 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.

3.6.3* 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.

3.6.4 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.

3.7 Drips and Sediment Traps.

3.7.1 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.

3.7.2 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.

3.7.3 Sediment Traps. *(See 5.5.7.)*

3.8 Outlets.

3.8.1 Location and Installation.

(1) The outlet fittings or piping shall be securely fastened in place.
(2) Outlets shall not be located behind doors.
(3) Outlets shall be located far enough from floors, walls, patios, slabs, and ceilings to permit the use of wrenches without straining, bending, or damaging the piping.
(4) The unthreaded portion of gas piping outlets shall extend not less than 1 in. (25 mm) through finished ceilings or indoor or outdoor walls.
(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) The provisions of 3.8.1(4) and (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.

3.8.2 Cap All Outlets.

(a) Each outlet, including a valve or cock outlet, 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.

Outlets shall not be closed with tin caps, wooden plugs, corks, or by other improvised methods.

Exception No. 1: Laboratory equipment installed in accordance with 5.5.2(a) 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.

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

3.9 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.

3.10 Manual Gas Shutoff Valves. *(Also see 5.5.4.)*

3.10.1 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.

3.10.2 Valves Controlling Multiple Systems.

(a) *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.

(b) *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.

3.10.3 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.

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

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

3.13 Systems Containing Flammable Gas–Air Mixtures.

3.13.1 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 $2^1/_2$ in. nominal pipe size or the equivalent

3.13.2 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)

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

3.13.4* Special Requirements for Mixing Blowers. A mixing blower system shall be limited to applications with minimum practical lengths of mixture piping, limited to a maximum mixture pressure of 10-in. water column (25 Pa) 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.

3.13.5 Installation of Gas-Mixing Machines.

(a) *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.

(b) 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 electrical equipment and wiring shall be installed in accordance with NFPA 70, *National Electrical Code,* for hazardous locations (Articles 500 and 501, Class I, Division 2).

(c) Air intakes for gas-mixing machines using compressors or blowers shall be taken from outdoors whenever practical.

(d) *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.

(e) 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.

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

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

(b) 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.

(c) 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 $2^1/_2$ 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.

(d) Explosion heads (rupture disc) shall be permitted to be provided in large-capacity premix systems to relieve excessive pressure in pipelines. They 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.

3.14 Electrical Bonding and Grounding.

(a) Each aboveground portion of a gas piping system upstream from the equipment shutoff valve shall be electrically continuous and bonded to any grounding electrode, as defined by NFPA 70, *National Electrical Code.*

(b) Gas piping shall not be used as a grounding conductor or electrode.

3.15 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.

3.16 Electrical Connections.

(a) 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 3.14.)*

(b) 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 4 Inspection, Testing, and Purging

4.1 Pressure Testing and Inspection.

4.1.1* General.

(a) 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.

(b) 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.

(c) In the event repairs or additions are made following the pressure test, the affected piping shall be tested.

Exception: Minor repairs or additions, provided 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.

(d) 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.

(e) 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.

4.1.2 Test Medium. The test medium shall be air or an inert gas. OXYGEN SHALL NEVER BE USED.

4.1.3 Test Preparation.

(a) Pipe joints, including welds, shall be left exposed for examination during the test.

Exception: If the pipe end joints have been previously tested in accordance with this code, they shall be permitted to be covered or concealed.

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

(c) 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.

(d) 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).

(e) 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).

(f) 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.

4.1.4 Test Pressure.

(a) 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.

(b) The test pressure to be used shall be no less than $1^1/_2$ 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.

(c) Test duration shall be not less than $^1/_2$ 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 permitted to be reduced to 10 minutes. For piping systems having a volume of more than 24,000 ft^3 (680 m^3), the duration of the test shall not be required to exceed 24 hours.

4.1.5 Detection of Leaks and Defects.

(a) 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.

(b) 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.**

Where leakage or other defects are located, the affected portion of the piping system shall be repaired or replaced and retested. *[See 4.1.1(c).]*

4.2 System and Equipment Leakage Test.

4.2.1 Test Gases. Fuel gas shall be permitted to be used for leak checks in piping systems that have been tested in accordance with Section 4.1.

4.2.2 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 manual valves at outlets on equipment are closed and all unused valves at outlets are closed and plugged or capped.

4.2.3* 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. If leakage is indicated, the gas supply shall be shut off until the necessary repairs have been made.

4.2.4 Placing Equipment in Operation. Gas utilization equipment shall not be placed in operation until after the piping system has been tested in accordance with 4.2.3 and purged in accordance with 4.3.2.

4.3* Purging.

4.3.1 Removal from Service. When gas piping is to be opened for servicing, addition, or modification, 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.

If this section exceeds the lengths shown in Table 4.3.1, the remaining gas shall be displaced with an inert gas.

Table 4.3.1 Length of Gas Line Requiring Purging for Servicing or Modification

Nominal Pipe Size (in.)	Minimum Length of Piping Requiring Purging (ft)
$2^1/_2$	50
3	30
4	15
6	10
8 or larger	Any length

For SI units, 1 ft = 0.305 m.

4.3.2 Placing in Operation. When piping full of air is placed in operation, the air in the piping shall be displaced with fuel gas, provided the piping does not exceed the length shown in Table 4.3.2. 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.** The vent shall then be closed.

If the piping exceeds the lengths shown in Table 4.3.2, the air in the piping shall be displaced with an inert gas, and the inert gas shall then be displaced with fuel gas.

Table 4.3.2 Length of Piping Requiring Purging Before Being Placed in Operation

Nominal Pipe Size (in.)	Minimum 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.

4.3.3 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.

4.3.4 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 5 Equipment Installation

5.1 General.

5.1.1* 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.

5.1.2 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:

(a) Air for combustion and ventilation is provided where required, in accordance with the provisions of Section 5.3. If existing facilities are not adequate, they shall be upgraded to Section 5.3 specifications.

(b) The installation components and equipment meet the clearances to combustible material provisions of 5.2.2.

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.

(c) The venting system is constructed and sized in accordance with the provisions of Chapter 7. If the existing venting system is not adequate, it shall be upgraded to comply with Chapter 7.

5.1.3 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.

5.1.4 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.

5.1.5 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.*

5.1.6* Protection of Gas Equipment from Fumes or Gases Other Than Products of Combustion. 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.

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.

Exception: This requirement shall not apply to direct vent equipment that is constructed and installed so all air for combustion is obtained from the outside atmosphere and all flue gases are discharged to the outside atmosphere.

5.1.7 Building Structural Members.

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

(b) 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.

(c) 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.

(d) 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.

5.1.8 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 5.1.9, 5.1.10, or 5.1.11 shall be considered to comply with the intent of this provision.

5.1.9 Installation in Residential Garages.

(a) Gas utilization equipment in residential garages shall be installed so that all burners and burner ignition devices are located not less than 18 in. (450 mm) above the floor.

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

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

5.1.10 Installation in Commercial Garages.

(a) *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.*

(b) *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 (2.5 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 (2.5 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, Automotive and Marine Service Station Code.

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

5.1.12 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.

5.1.13 Venting of Flue Gases. Gas utilization equipment shall be vented in accordance with the provisions of Chapter 7.

5.1.14 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.

5.1.15 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 2.4.)* If 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.

5.1.16 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.

5.1.17 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.

5.1.18 Venting of Gas Appliance Pressure Regulators.

(a) 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.

(b) Vent limiting means shall be employed on listed gas appliance pressure regulators only.

(c) 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.

(d) Under no circumstances shall a regulator be vented to the gas utilization equipment flue or exhaust system.

(e) 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.

(f) 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.

5.1.19 Bleed Lines for Diaphragm-Type Valves.

(a) Diaphragm-type valves shall be equipped to convey bleed gas to the outside atmosphere or into the combustion chamber adjacent to a continuous pilot.

(b) 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.

(c) Bleed lines shall not terminate in the gas utilization equipment flue or exhaust system.

(d) 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.

(e) 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.

5.1.20 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.

5.1.21 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.

5.1.22 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 5.2.1.)*

5.2 Accessibility and Clearance.

5.2.1 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.

5.2.2 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 6 and 7. *(Reference can also be made to NFPA 211, Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances.)*

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

5.3* Air for Combustion and Ventilation.

5.3.1 General.

(a) The provisions of Section 5.3 shall apply to gas utilization equipment installed in buildings that require air for combustion, ventilation, and dilution of flue gases.

Exception No. 1: Direct vent equipment that is constructed and installed so that all air for combustion is obtained directly from the outdoors and all flue gases are discharged to the outdoors.

Exception No. 2: Enclosed furnaces that incorporate an integral total enclosure and use only outdoor air for combustion and dilution of flue gases.

(b) Equipment shall be located so as not to interfere with proper circulation of combustion, ventilation, and dilution air. Where normal infiltration does not provide the necessary air, outdoor air shall be introduced.

(c) In addition to air needed for combustion, process air shall be provided as required for cooling of equipment or material, controlling dew point, heating, drying, oxidation, dilution, safety exhaust, odor control, and air for compressors.

(d) In addition to air needed for combustion, air shall be supplied for ventilation, including all air required for comfort and proper working conditions for personnel.

(e) 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.

(f) Air for combustion, ventilation, and dilution of flue gases for gas utilization equipment vented by natural draft shall be obtained by application of one of the methods covered in 5.3.3 and 5.3.4.

(g) 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.

5.3.2* Equipment Located in Unconfined Spaces. Equipment located in buildings of unusually tight construction *(see Section 1.7)* shall be provided with air for combustion, ventilation, and dilution of flue gases using the methods described in 5.3.3(b) or 5.3.4.

5.3.3 Equipment Located in Confined Spaces.

(a) **All Air from Inside the Building.* The confined space shall be provided with two permanent openings communicating directly with other spaces of sufficient volume so that the combined volume of all such spaces meets the criteria for an unconfined space. The total input of all gas utilization equipment installed in the combined spaces shall be used to determine the required minimum volume. Each opening shall have a minimum free area of not less than 1 $in.^2$/1000 Btu/hr (220 mm^2/kW) of the total input rating of all gas utilization equipment in the confined 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.5.3.3(a)]*. The minimum dimension of air openings shall be not less than 3 in. (8 cm).

(b) *All Air from Outdoors.* The confined space shall communicate with the outdoors in accordance with method 1 or 2, which follow. The minimum dimension of air openings shall not be less than 3 in. (80 mm). Where ducts are used, they shall be of the same cross-sectional area as the free area of the openings to which they connect.

(1) 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.

   a. *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 $in.^2$ per 4000 Btu/hr (550 mm^2/kW) of total input rating of all equipment in the enclosure. *[See Figures A.5.3.3(b)1a1 and A.5.3.3(b)1a2.]*

   b. *Where communicating with the outdoors through horizontal ducts, each opening shall have a minimum free area of not less than 1 $in.^2$ per 2000 Btu/hr (1100 mm^2/kW) of total input rating of all equipment in the enclosure. *[See Figure A.5.3.3(b)1b.]*

(2) *One permanent opening, commencing within 12 in. (300 mm) of the top of the enclosure, shall be permitted where the equipment has clearances of at least 1 in. (25 mm) from the sides and back and 6 in. (160 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.5.3.3(b)2]* and shall have a minimum free area of

   a. 1 $in.^2$/3000 Btu/hr (700 mm^2 per kW) of the total input rating of all equipment located in the enclosure, and

   b. Not less than the sum of the areas of all vent connectors in the confined space.

(c) *Combination of air from the indoors and from the outdoors.* Where the building in which the fuel-burning appliances are located is not of unusually tight construction and the communicating interior spaces containing the fuel-burning appliances comply with all requirements of 5.3.3(a) except for the volumetric requirement of 5.3.3(a), required combustion and dilution air shall be obtained by opening the room to the outdoors utilizing a combination of indoor and outdoor air prorated in accordance with 5.3.3(c)6. Openings connecting the interior spaces shall comply with 5.3.3(a). The ratio of interior spaces shall comply with 5.3.3(c)5. The number, location, and ratios of openings connecting the space with the outdoor air shall comply with the following (see also sample calculation in Appendix L):

(1) *Number and Location of Openings.* At least two openings shall be provided, one within 1 ft (305 mm) of the ceiling of the room and one within 1 ft (305 mm) of the floor.

(2) *Ratio of Direct Openings.* Where direct openings to the outdoors are provided in accordance with 5.3.3(b), method 1a, the ratio of direct openings shall be the sum of the net free areas of both direct openings to the outdoors, divided by the sum of the required areas for both such openings as determined in accordance with 5.3.3(b), method 1a.

(3) *Ratio of Horizontal Openings.* Where openings connected to the outdoors through horizontal ducts are provided in accordance with 5.3.3(b), method 1b, the ratio of horizontal openings shall be the sum of the net free areas of both such openings, divided by the sum of the required areas for both such openings as determined in accordance with Section 5.3.3(b), method 1b.

(4) *Ratio of Vertical Openings.* Where openings connected to the outdoors through vertical ducts are provided in accordance with Section 5.3.3(b), method 1a, the ratio of vertical openings shall be the sum of the net free areas of both such openings, divided by the sum of the required areas for both such openings as determined in accordance with 5.3.3(b), method 1a.

(5) *Ratio of Interior Spaces.* The ratio of interior spaces shall be the available volume of all communicating spaces, divided by the required volume as determined in accordance with 5.3.3(a).

(6) *Prorating of Indoor and Outdoor Air.* In spaces that utilize a combination of indoor and outdoor air, the sum of the ratios of all direct openings, horizontal openings, vertical openings, and interior spaces shall equal or exceed 1.

5.3.4 Specially Engineered Installations. The requirements of 5.3.3 shall be permitted to be waived where special engineering, approved by the authority having jurisdiction, provides an adequate supply of air for combustion, ventilation, and dilution of flue gases.

5.3.5 Louvers and Grilles. In calculating free area in 5.3.3, the required size of openings for combustion, ventilation, and dilution air shall be based on the net free area of each opening. If 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. If the design and free area are not known, it shall be assumed that wood louvers will have 20–25 percent free area and metal louvers and grilles will have 60–75 percent free area. Louvers and grilles shall be fixed in the open position.

Exception: Louvers 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.

5.3.6 Combustion Air Ducts. Combustion air ducts shall comply with the following:

(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.

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

(3) Ducts shall serve a single space.

(4) Ducts shall not serve both upper and lower combustion air openings where both such openings are used. The separation between ducts serving upper and lower combustion air openings shall be maintained to the source of combustion air.

(5) Ducts shall not be screened where terminating in an attic space.

(6) Horizontal upper combustion air ducts shall not slope downward toward the source of combustion air.

5.4 Equipment on Roofs.

5.4.1 General.

(a) Gas utilization equipment on roofs shall be designed or enclosed so as to withstand climatic conditions in the area in which they are installed. If 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.

(b) 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.

(c) All access locks, screws, and bolts shall be of corrosion-resistant material.

5.4.2 Installation of Equipment on Roofs.

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

(b) 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 or guards at least 42 in. (1.1 m) in height shall be provided on the exposed side.

Exception: Parapets or other building structures at least 42 in. (1.1 m) in height shall be permitted to be utilized in lieu of rails or guards.

(c) 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.

(d) 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.

5.4.3 Access to Equipment on Roofs.

(a) Gas utilization equipment located on roofs or other elevated locations shall be accessible.

(b) 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.

(c) 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 at least 42 in. (1.1 m) in height shall be provided on the exposed side; parapets or other building structures at least 42 in. (1.1 m) in height shall be permitted to be utilized in lieu of guards or rails.

(d) Proper 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.

5.4.4 Additional Provisions. *(Also see 5.1.22, 5.2.1, and 7.3.4.)*

5.5 Equipment Connections to Building Piping.

5.5.1 Connecting Gas Equipment. Gas utilization equipment shall be connected to the building piping in compliance with 5.5.4 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) Listed connectors used in accordance with the terms of their listing that are completely in the same room as the equipment.
(4) Listed gas hose connectors in accordance with 5.5.2.
(5) 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, *Standard for Connectors for Movable Gas Appliances.*
(6) In 5.5.1(2), (3), and (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.

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

(a) *Indoor.* Indoor gas hose connectors shall be permitted to be used with laboratory, shop, or ironing equipment that requires 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.

(b) *Outdoor.* Outdoor gas hose connectors shall be permitted to be used 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.

5.5.3 Connection of Portable and Mobile Industrial Gas Equipment.

(a) Portable industrial gas utilization equipment or equipment requiring mobility or subject to vibration shall be permitted to be connected to the building gas piping system by the use of flexible hose suitable and safe for the conditions under which it can be used.

(b) Industrial gas utilization equipment requiring mobility shall be permitted to be connected to the rigid piping by the use of swivel joints or couplings that are suitable for the service required. Where swivel joints or couplings are used, only the minimum number required shall be installed.

(c) Industrial gas utilization equipment subject to vibration shall be permitted to be connected to the building piping system by the use of all metal flexible connectors suitable for the service required.

(d) 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.

5.5.4 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.

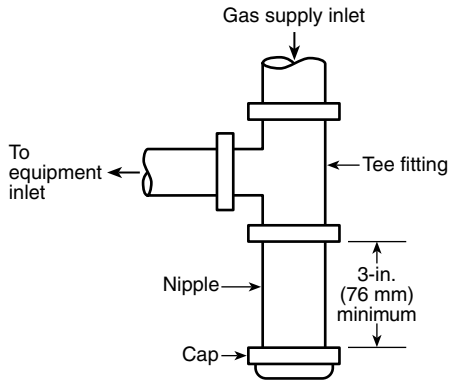
Shutoff valves serving decorative gas appliances shall be permitted to be installed in fireplaces if listed for such use.

5.5.5 Quick-Disconnect Devices. Gas utilization equipment connectors shall be permitted to be connected to the building piping by means of a listed quick-disconnect device and, where installed indoors, an approved manual shutoff valve with a nondisplaceable valve member shall be installed upstream of the quick-disconnect device.

5.5.6* 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.

5.5.7 Sediment Trap. If 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 5.5.7 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 5.5.7 Method of installing a tee fitting sediment trap.



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

5.6 Electrical.

5.6.1 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.*

5.6.2 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.

5.6.3 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.

5.6.4 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.

5.7 Room Temperature Thermostats.

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

5.7.2 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 6 Installation of Specific Equipment

6.1 General.

(a) 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 11 and Appendix M.

(b) *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 is an unconfined space. *(See 5.3.2 and Section 1.7, Definitions.)*

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

6.2.1 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 2.4.)*

6.2.2 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.

6.2.3 Clearances for Indoor Installation.

(a) 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 6.2.3(a) and Section 1.7 for definition.)*

(b) 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 6.2.3(b), regardless of whether the enclosure is of combustible or noncombustible material.

(c) 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.

(d) 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 6.2.3(b) *[see 6.2.3(b)]*.

(e) Where the 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.

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

6.2.4 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.

6.2.5 Plenums and Air Ducts. A plenum supplied as a part of the air-conditioning equipment shall be installed in accordance with the manufacturer's instructions. Where a 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.

6.2.6* Refrigeration Coils. *(See 6.3.7 and 6.3.8.)*

6.2.7 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.

Table 6.2.3(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.)					
	Above and Sides of 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 6.2.3 for additional requirements for air-conditioning equipment and 6.3.1 for additional requirements for central heating boilers and furnaces

6.3 Central Heating Boilers and Furnaces.

6.3.1 Clearance.

(a) 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 1.7 for definition.)*

(b) 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 6.2.3(b) and illustrated in Figures 6.3.1(b)1 through 6.3.1(b)3, regardless of whether the enclosure is of combustible or noncombustible material.

(c) 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 6.2.3(a).

(d) 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 6.2.3(b) *[see 6.3.1(b)]*.

(e) Front clearance shall be sufficient for servicing the burner and the furnace or boiler.

(f) Where the 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.

(g) The clearance to this equipment shall not interfere with combustion air, draft hood clearance and relief, and accessibility for servicing. *(See 5.2.1, Section 5.3, and 7.12.8.)*

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

(i) 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 plenum be not less than 6 in. (150 mm). No clearance is necessary beyond this distance.

(j) Central heating furnaces other than those listed in 6.3.1(h) or (i) shall have clearances from the supply ducts of not less than 18 in. (0.46 m) from the 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).

Table 6.2.3(b) Reduction of Clearances with Specified Forms of Protection

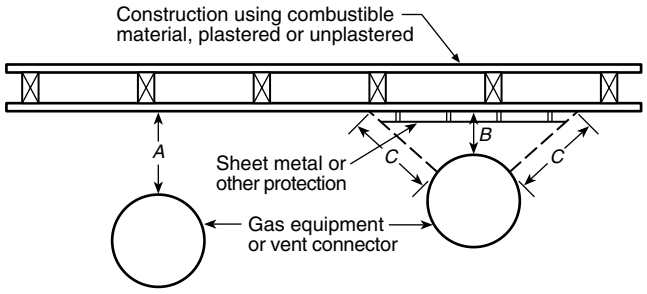
Type of protection applied to and covering all surfaces of combustible material within the distance specified as the required clearance with no protection *(see Figures 6.3.1(b)1 through 6.3.1(b)3)*	Where the required clearance with no protection from appliance, vent connector, or single wall metal pipe is:									
	36 in.		18 in.		12 in.		9 in.		6 in.	
	Allowable Clearances with Specified Protection (Inches)									
	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
(a) $3^1/_2$-in. thick masonry wall without ventilated air space	—	24	—	12	—	9	—	6	—	5
(b) $^1/_2$-in. insulation board over 1-in. glass fiber or mineral wool batts	24	18	12	9	9	6	6	5	4	3
(c) 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
(d) $3^1/_2$-in. thick masonry wall with ventilated air space	—	12	—	6	—	6	—	6	—	6
(e) 0.024 sheet metal with ventilated air space	18	12	9	6	6	4	5	3	3	2
(f) $^1/_2$-in. thick insulation board with ventilated air space	18	12	9	6	6	4	5	3	3	3
(g) 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
(h) 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 Figures 6.3.1(b)2 and 6.3.1(b)3.)*
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. If a wall protector is mounted on a single flat wall away from corners, adequate air circulation shall be permitted to be provided by leaving only the bottom and top edges or only the side and top edges open with at least a 1-in. (25-mm) air gap.
7. Mineral wool batts (blanket or board) shall have a minimum density of 8 lb/ft^3 (128 kg/m) 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 6.2.3(b).
10. All clearances and thicknesses are minimum; larger clearances and thicknesses are acceptable.
11. Listed single-wall connectors shall be permitted to be installed in accordance with the terms of their listing and the manufacturer's instructions.

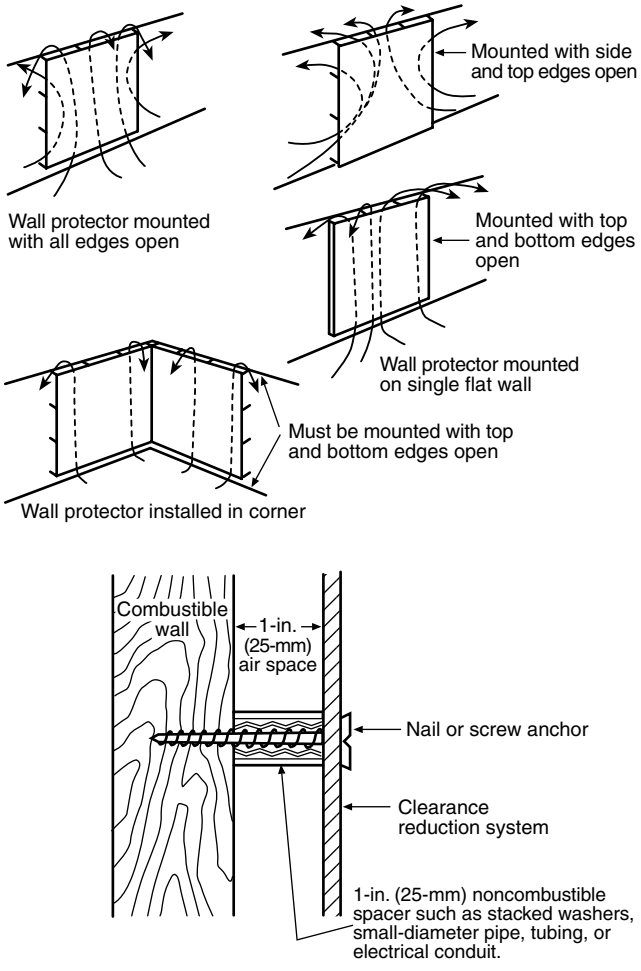
Figure 6.3.1(b)1 Extent of protection necessary to reduce clearances from gas equipment or vent connectors.



A equals the clearance with no protection specified in Tables 6.2.3(a) and 7.4.1 and in the sections applying to various types of equipment.

B equals the reduced clearance permitted in accordance with Table 6.2.3(b) The protection applied to the construction using combustible material shall extend far enough in each direction to make *C* equal to *A*.

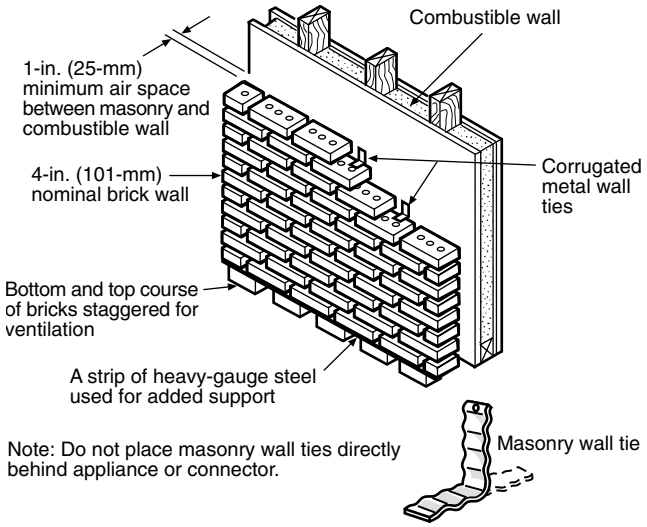
Figure 6.3.1(b)2 Wall protector clearance reduction system.



Masonry walls can be attached to combustible walls using wall ties.

Spacers should not be used directly behind appliance or connector.

Figure 6.3.1(b)3 Masonry clearance reduction system.



6.3.2 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.

6.3.3 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.

6.3.4 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.

6.3.5* 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.

(1) Relief valves shall be piped to discharge near the floor.
(2) The entire discharged piping shall be at least the same size as the relief valve discharge piping.
(3) Discharge piping shall not contain threaded end connection at its termination point.

6.3.6 Plenums and Air Ducts.

(a) 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.*

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

(c) *Where a 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.

(d) 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.

6.3.7 Refrigeration Coils.

(a) 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.

(b) 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.

(c) 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.

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

6.3.8 Cooling Units Used with Heating Boilers.

(a) 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.

(b) 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.

6.4 Clothes Dryers.

6.4.1 Clearance.

(a) Listed Type 1 clothes dryers shall be installed with a minimum clearance of 6 in. (15 cm) from adjacent combustible material, except that clothes dryers listed for installation at lesser clearances shall be permitted to be installed in accordance with their listing. Type 1 clothes dryers installed in closets shall be specifically listed for such installation.

(b) Listed Type 2 clothes dryers shall be installed with clearances of not less than 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.

(c) 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.

6.4.2 Exhausting to the Outdoors.

(a) Type 1 and Type 2 clothes dryers shall be exhausted to the outside air.

6.4.3 Provisions for Make-Up Air.

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

(b) Provision for makeup air shall be provided for Type 2 clothes dryers, with a minimum free area *(see 5.3.5)* of 1 in.^{2} (6.5 m^2) for each 1000 Btu/hr (2200 mm^2/kW) total input rating of the dryer(s) installed.

6.4.4 Exhaust Ducts for Type 1 Clothes Dryers.

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

(b) 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.

6.4.5 Exhaust Ducts for Type 2 Clothes Dryers.

(a) Exhaust ducts for Type 2 clothes dryers shall comply with 6.4.4.

(b) 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.

(c) Type 2 clothes dryers shall be equipped or installed with lint-controlling means.

(d) Exhaust ducts for Type 2 clothes dryers shall have a clearance of at least 6 in. (150 mm) to combustible material.

Exception: Exhaust ducts for Type 2 clothes dryers shall be permitted to be installed with reduced clearances to combustible material, provided the combustible material is protected as described in Table 6.2.3(b).

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

(f) 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.

6.4.6 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 6.4.5.

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

6.6 Decorative Appliances for Installation in Vented Fireplaces.

6.6.1* Prohibited Installations. Decorative appliances for installation in vented fireplaces shall not be installed in bathrooms or bedrooms unless the appliance is listed and the bed-

room or bathroom is an unconfined space. *(See 5.3.2 and Section 1.7.)*

6.6.2 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.

(1) A listed decorative appliance for installation in a vented fireplace shall be installed in accordance with its listing and the manufacturer's instructions.
(2) 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 6.6.2

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

6.7 Gas Fireplaces, Vented.

6.7.1* Prohibited Installations. Vented gas fireplaces shall not be installed in bathrooms or bedrooms unless the appliance is listed and the bedroom or bathroom is an unconfined space. *(See 5.3.2 and Section 1.7.)*

Exception: Direct-vent gas fireplaces.

6.7.2 Installation.

(a) Listed vented gas fireplaces shall be installed in accordance with their listing and the manufacturers' instructions. They shall be permitted to be installed in or attached to combustible material where so listed.

(b) 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 7.

Exception: Appliances that make use of 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 permitted to be installed with a clearance of 18 in. (460 mm) at the sides and 12 in. (300 mm) at the rear.

(c) Panels, grilles, and access doors that are required to be removed for normal servicing operations shall not be attached to the building.

(d) Direct-vent gas fireplaces shall be installed with the vent-air intake terminal in the outdoors and in accordance with the manufacturers' instructions.

6.7.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 5.3.

6.8 Direct Makeup Air Heaters.

6.8.1 Installation. Direct makeup air heaters shall not be used to supply any area containing sleeping quarters.

6.8.2 Clearance from Combustible Material. The following clearances shall not interfere with combustion air, accessibility for operation, and servicing:

(1) Listed direct makeup air heaters shall be installed in accordance with their listings and the manufacturers' instructions.
(2) Unlisted direct makeup air heaters shall be installed with clearances to combustible material of not less than 18 in. (460 mm). Combustible floors under unlisted floor-mounted heaters shall be protected in an approved manner.

6.8.3 Outside Air. All air handled by a direct makeup air heater, including combustion air, shall be brought in from outdoors. Indoor air shall be permitted to be added to the outdoor airstream after the outdoor airstream has passed the combustion zone.

6.8.4 Outside Louvers. If outside louvers of either the manual or automatic type are used, they shall be proved in the open position before the main burners operate.

6.8.5 Controls.

(a) Listed direct makeup air heaters shall be equipped with airflow sensing devices, safety shutoff devices, operating temperature controls, and thermally actuated temperature limit controls in accordance with the terms of their listings.

Table 6.6.2 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.

(b) Unlisted direct makeup air heaters shall be equipped with all of the following:

(1) Airflow sensing devices so designed and installed as to shut off the gas to the main burners upon failure of either combustion air or main air supply. Controls actuated by failure of the power supply to the blower motor shall not be permitted to meet this requirement.
(2) Combustion safeguards, including manual reset safety shutoff devices.
(3) Operating temperature controls and thermally actuated manual reset temperature limit controls, the latter of which shall not permit the discharge air temperature to exceed 150°F (66°C).

6.8.6 Input Ratings. Unlisted direct makeup air heaters shall have input ratings such that the ratio of gas input by volume to the total volume of gas–air mixture discharged will not exceed 0.2 percent.

6.8.7 Atmospheric Vents and Gas Reliefs or Bleeds. Direct makeup air heaters with valve train components equipped with atmospheric vents or gas reliefs or bleeds shall have their atmospheric vent lines or 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 by 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.

6.8.8 Relief Opening. The design of the installation shall include provision to permit makeup air heaters to operate at rated capacity by taking into account the structure's designed infiltration rate, providing properly designed relief openings or an interlocked power exhaust system, or a combination of these methods.

(1) The structure's designed infiltration rate and the size of relief openings shall be determined by approved engineering methods.
(2) Relief openings shall be permitted to be louvers or counterbalanced gravity dampers. Motorized dampers or closable louvers shall be permitted to be used, provided they are verified to be in their full open position prior to main burner operation.

6.8.9 Purging. The blower of an unlisted direct makeup heater and the exhaust system shall be operated to effect at least four air changes of the combustion chamber before the gas to the main burners is ignited.

6.9 Direct Gas-Fired Industrial Air Heaters.

6.9.1 Application. Direct gas-fired industrial air heaters shall be listed in accordance with ANSI Z83.18, *Standard for Direct Gas-Fired Industrial Air Heaters.*

Exception: Unlisted equipment shall be permitted to be installed where the installation is approved by the authority having jurisdiction and a site-specific equipment evaluation is performed by an independent testing agency based on the applicable requirements of ANSI Z83.18, Standard for Direct Gas-Fired Industrial Air Heaters.

6.9.2 Prohibited Installations.

(a) Direct gas-fired industrial air heaters shall not use recirculation of 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.

(b) Direct gas-fired industrial air heaters shall not be installed in any area containing sleeping quarters.

6.9.3 Installation.

(a) Listed direct gas-fired industrial air heaters shall be permitted to be installed in accordance with their listing and the manufacturers' instructions.

(b) Unlisted direct gas-fired industrial air heaters shall be installed according to the manufacturers' instructions.

(c) Direct gas-fired industrial air heaters shall be installed only in industrial or commercial occupancies.

(d) Direct gas-fired industrial air heaters shall be permitted to provide fresh air ventilation.

6.9.4 Clearance from Combustible Materials.

(a) Listed direct gas-fired industrial air heaters shall be installed with a clearance from combustible material of not less than that shown on the marking plate and in the manufacturers' instructions.

(b) Clearances to combustible materials for unlisted direct gas-fired industrial air heaters shall be determined to be acceptable during evaluation testing. *[See 6.9.3(b).]*

6.9.5* Air Supply. Air to direct gas-fired industrial air heaters shall be taken from the building, ducted directly from outdoors, or a combination of both.

(a) Direct gas-fired industrial air heaters shall incorporate a means to supply outside ventilation air to the space at a rate of not less than 4 ft^3/min/1000 Btu/hr (0.38 m^3/min/kW) of rated input of the heater. If a separate means is used to supply ventilation air, an interlock shall be provided so as to lock out the main burner operation until the mechanical means is verified.

(b) If outside air dampers or closing louvers are used, they shall be verified to be in the open position prior to main burner operation.

6.9.6 Atmospheric Vents or Gas Reliefs or Bleeds. Direct gas-fired industrial air heaters with valve train components equipped with atmospheric vents, gas reliefs, or bleeds shall have their atmospheric vent lines and 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 by 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.

6.9.7 Relief Opening. The design of the installation shall include adequate provision to permit direct gas-fired industrial air heaters to operate at rated capacity by taking into account the structure's designed infiltration rate, providing properly designed relief openings, an interlocked power exhaust system, or a combination of these methods.

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

(b) Relief openings shall be permitted to be louvers or counterbalanced gravity dampers. Motorized dampers or closable louvers shall be permitted to be used, provided they are verified to be in their full open position prior to main burner operation.

6.10 Duct Furnaces.

6.10.1 Clearances.

(a) 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, except that furnaces listed for installation at lesser clearances shall be permitted to be installed in accordance with their listings. In no case shall the clearance be such as to interfere with combustion air and accessibility. *(See 5.2.1 and Section 5.3.)*

(b) Unlisted duct furnaces shall be installed with clearances to combustible material in accordance with the clearances specified for unlisted furnaces and boilers in Table 6.2.3(a). Combustible floors under unlisted duct furnaces shall be protected in an approved manner.

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

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

6.10.4 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.

6.10.5 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.

6.10.6 Duct Furnaces Used with Refrigeration Systems.

(a) 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.

(b) 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.

(c) 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.

(d) Duct furnaces shall be permitted to be installed downstream from evaporative coolers or air washers if the heating element is made of corrosion-resistant material. 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.

6.10.7 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 5.1.10 and 5.1.11.

6.11 Floor Furnaces.

6.11.1 Installation.

(a) Listed floor furnaces shall be permitted to be installed in accordance with their listing and the manufacturers' instructions.

(b) Unlisted floor furnaces shall not be installed in combustible floors.

(c) 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.

6.11.2 Temperature Limit Controls.

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

(b) 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.

6.11.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 5.3.

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

(a) *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.

(b) *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) to 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 permitted to be placed not closer than 6 in. (150 mm) to a wall. Wall register models shall not be placed closer than 6 in. (150 mm) to a corner.

(c) *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.

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

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

6.11.7 Clearance. The lowest portion of the floor furnace shall have at least a 6-in. (150-mm) clearance from the general ground level. 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.

Exception: Where the lower 6-in. (150-mm) portion of the floor furnace is sealed by the manufacturer to prevent entrance of water, the clearance shall be permitted to be reduced to not less than 2 in. (50 mm).

6.11.8 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. (600 mm × 460 mm) or by a trapdoor not less than 24 in. × 24 in. (600 mm × 600 mm) in any cross-section thereof, and a passageway not less than 24 in. × 18 in. (600 mm × 460 mm) in any cross-section thereof.

6.11.9 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.

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

6.11.11 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 5.3, 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.

6.11.12 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.

6.12 Food Service Equipment, Floor-Mounted.

6.12.1 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 permitted to 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.

6.12.2 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) at 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.

Exception No. 1: Unlisted floor-mounted food service equipment shall be permitted to be installed in rooms, but not in partially enclosed areas such as alcoves, with reduced clearances to combustible material, provided the combustible material or the equipment is protected as described in Table 6.2.3(b).

Exception No. 2: Unlisted floor-mounted food service equipment shall be permitted to be installed in rooms, but not in partially enclosed areas such as alcoves, with reduced clearance of 6 in. (150 mm) to combustible material provided the wall or combustible material is protected by sheet metal not less than 0.0152 in. (0.4 mm) thick, fastened with noncombustible spacers that are spaced at not less than 2-ft (0.6-m) vertical and horizontal intervals to provide a clearance of $1^1/_2$ in. (38 mm) from such wall or material. Such protection shall extend at least 12 in. (300 mm) beyond the back, side, top, or any other part of the equipment, and the space between the sheet metal and wall or combustible material shall be open on both sides and top and bottom to permit circulation of air.

6.12.3 Mounting on Combustible Floor.

(a) 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.

(b) Floor-mounted food service equipment that is not listed for mounting on a combustible floor shall be mounted in accordance with 6.12.4 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 $^3/_8$-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.

6.12.4 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.

6.12.5 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 6.12.2 for a distance of at least 2 ft (0.6 m) above the surface of the cooking top.

6.12.6 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.

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

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

6.13 Food Service Equipment Counter Appliances.

6.13.1 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.

6.13.2 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 permitted to be installed in accordance with their listing and the manufacturers' instructions.

6.13.3 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). Gas food service counter appliances shall be permitted to be installed with reduced clearances to combustible material provided as described in Table 6.2.3(b). Unlisted food and dish warmers shall be installed with a horizontal clearance from combustible material of not less than 6 in. (150 mm).

6.13.4 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 $^1/_4$ in. (6.4 mm) thick covered with sheet metal not less than 0.0122 in. (0.3 mm) thick, or with equivalent protection.

6.14 Hot Plates and Laundry Stoves.

(a) 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.

(b) 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.

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

6.15 Household Cooking Appliances.

6.15.1 Floor-Mounted Units.

(a) *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.

Exception No. 1: 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.

Exception No. 2: 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.

(2) 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.

(b) *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.

Exception: The clearance shall be permitted to be reduced to not less than 24 in. (610 mm) as follows:

(a) The underside of the combustible material or metal cabinet above the cooking top is protected with not less than $^1/_4$-in. (6.4-mm) insulating millboard covered with sheet metal not less than 0.0122 in. (0.3 mm) thick, or

(b) 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 $^1/_4$ in. (6.4 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.

(c) 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.

(c) *Level Installation.* Cooking appliances shall be installed so that the cooking top or oven racks are level.

6.15.2 Built-In Units.

(a) *Installation.* Listed built-in household cooking appliances shall be installed in accordance with their listing and the manufacturer's instructions. Listed built-in household cooking appliances shall be permitted to be installed in combustible material unless otherwise marked.

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.

(b) *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.

Exception: The clearance shall be permitted to be reduced to not less than 24 in. (610 mm) as follows:

(a) The underside of the combustible material or metal cabinet above the cooking top is protected with not less than $^1/_4$-in. (6.4-mm) insulating millboard covered with sheet metal not less than 0.0122 in. (0.3 mm) thick, or

(b) 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 $^1/_4$ in. (6.4 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.

(c) 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.

(c) *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.

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

6.16 Illuminating Appliances.

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

6.16.2 Clearances for Unlisted Appliances.

(a) *Enclosed Type.*

(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).

(b) *Open-Flame Type.*

(1) Unlisted open-flame illuminating appliances installed outdoors shall have clearances from combustible material not less than that specified in Table 6.16.2(b)1. The distance from ground level to the base of the burner shall be at least 7 ft (2 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 6.16.2(b)1.
(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 6.16.2(b)1 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.

6.16.3 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.

6.16.4 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 $2^1/_2$-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 $^3/_4$-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.

6.16.5 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 to the illuminating appliance. For multiple installations, one regulator of adequate capacity shall be permitted to be used to serve more than one illuminating appliance.

6.17 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.*

6.18 Incinerators, Domestic.

6.18.1 Clearance.

(a) Listed incinerators shall be installed in accordance with their listing and the manufacturers' instructions, pro-

vided that, in any case, the clearance shall be sufficient to afford ready accessibility for firing, cleanout, and necessary servicing.

(b) The clearances to combustible material above a charging door shall be not less than 48 in. (1220 mm).

Exception No. 1: The clearance shall be permitted to be reduced to 24 in. (610 mm), provided the combustible material is protected with sheet metal not less than 0.0122 in. (0.3 mm) thick, spaced out 1 in. (25 mm) on noncombustible spacers, or equivalent protection. Such protection shall extend 18 in. (460 mm) beyond all sides of the charging door opening.

Exception No. 2: Listed incinerators designed to retain the flame during loading need not comply with this paragraph.

(c) Unlisted incinerators shall be installed with clearances to combustible material of not less than 36 in. (920 mm) at the sides, top, and back and not less than 48 in. (1.2 m) at the front, but in no case shall the clearance above a charging door be less than 48 in. (1.2 m). Unlisted wall-mounted incinerators shall be installed on a noncombustible wall communicating directly with a chimney.

(d) Domestic-type incinerators shall be permitted to be installed with reduced clearances to combustible material in rooms, provided the combustible material is protected as described in Table 6.2.3(b).

Exception: In partially enclosed areas, such as alcoves, clearances shall not be so reduced.

(e) Where a domestic-type incinerator that is refractory lined or insulated with heat insulating material is encased in common brick not less than 4 in. (100 mm) in thickness, the clearances shall be permitted to be reduced to 6 in. (150 mm) at the sides and rear, and the clearance at the top shall be permitted to be reduced to 24 in. (610 mm), provided that the construction using combustible material above the charging door and within 48 in. (1220 mm) is protected with sheet metal not less than 0.0122 in. (0.3 mm) thick, spaced out 1 in. (25 mm), or equivalent protection.

6.18.2 Mounting.

(a) Listed incinerators specifically listed for installation on combustible floors shall be permitted to be so installed.

(b) Unlisted incinerators shall be mounted on the ground or on floors of noncombustible construction with noncombustible flooring or 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 extend not less than 12 in. (300 mm) beyond the incinerator base on all sides, except at the front or side where ashes are removed, where it shall extend not less than 18 in. (460 mm) beyond the incinerator.

Exception No. 1: Unlisted incinerators shall be permitted to be mounted on floors other than as specified in 6.18.2(b), provided the incinerator is so arranged that flame or hot gases do not come in contact with its base and, further, provided the floor under the incinerator is protected with hollow masonry not less than 4 in. (100 mm) thick, covered with sheet metal not less than 0.0195 in. (0.5 mm) thick. Such masonry course shall be laid with ends unsealed and joints matched in such a way as to provide a free circulation of air from side to side through the masonry. The floor for 18 in. (460 mm) beyond the front of the incinerator or side where ashes are removed, and 12 in. (300 mm) beyond all other sides of the incinerator, shall be protected with not less than $^1/_4$-in. (6.4-mm) insulating millboard covered with sheet metal not less than 0.0195 in. (0.5 mm) thick, or with equivalent protection.

Exception No. 2: Unlisted incinerators that are set on legs that provide not less than 4 in. (100 mm) open space under the base of the incinerator shall be permitted to be mounted on floors other than as specified in 6.18.2(b), provided the incinerator is such that flame or hot gases do not come in contact with its base and, further, provided the floor under the incinerator is protected with not less than $^1/_4$-in. (6.4-mm) insulating millboard covered with sheet metal not less than 0.0195 in. (0.5 mm) thick. The above specified floor protection shall extend not less than 18 in. (460 mm) beyond the front of the incinerator or side where ashes are removed and 12 in. (300 mm) beyond all other sides of the incinerator.

6.18.3 Draft Hood Prohibited. A draft hood shall not be installed in the vent connector of an incinerator.

6.18.4 Venting. Incinerators shall be vented in accordance with Sections 7.4, 7.5, 7.7, and 7.10.

6.19 Infrared Heaters.

6.19.1 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.

6.19.2 Clearance.

(a) Listed heaters shall be installed with clearances from combustible material in accordance with their listing and the manufacturers' instructions.

(b) Unlisted heaters shall be installed in accordance with clearances from combustible material acceptable to the authority having jurisdiction.

(c) 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.

6.19.3 Combustion and Ventilation Air.

(a) 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.

(b) Exhaust openings for removing flue products shall be above the level of the heaters.

6.19.4 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 5.1.10 and 5.1.11.

6.20 Open-Top Broiler Units.

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

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

6.20.3 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 $^1/_4$ in. (6.4 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 cook-

ing top and the combustible material or metal cabinet, and the hood shall be at least as wide as the open-top broiler unit and centered over the unit. Listed domestic open-top broiler units incorporating an integral exhaust system and listed for use without a ventilating hood need not be provided with a ventilating hood if installed in accordance with 6.15.1(b)1.

6.20.4 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.*

6.21 Outdoor Cooking Appliances.

6.21.1 Listed Units. Listed outdoor cooking appliances shall be installed in accordance with their listing and the manufacturers' instructions.

6.21.2 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.

6.22 Pool Heaters.

6.22.1 Location. A pool heater shall be located or protected so as to minimize accidental contact of hot surfaces by persons.

6.22.2 Clearance.

(a) 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.

(b) A listed pool heater shall be installed in accordance with its listing and the manufacturer's instructions.

(c) 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.

6.22.3 Temperature- or Pressure-Limiting Devices.

(a) An unlisted pool heater shall be provided with overtemperature protection or overtemperature and overpressure protection by means of an approved device(s).

(b) 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.

6.22.4 Bypass Valves. If 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.

6.22.5 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 7.2.5, 7.2.6, 7.3.4, and Section 7.8.)*

6.23 Refrigerators.

6.23.1 Clearance. Refrigerators shall be provided with clearances for ventilation at the top and back in accordance with the manufacturers' instructions. If 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.

6.23.2 Venting or Ventilating Kits Approved for Use with a Refrigerator. If 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.

6.24 Room Heaters.

6.24.1* 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 6.1(b).

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 6.1(b).

6.24.2 Installations in Institutions. Room heaters shall not be installed in institutions such as homes for the aged, sanitariums, convalescent homes, or orphanages.

6.24.3 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:

(a) *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).

(b) *Radiating Type.* Room heaters other than those of the circulating type described in 6.24.3(a) 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.

6.24.4 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.

6.25 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.*

6.26 Gas-Fired Toilets.

6.26.1 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.

6.26.2 Mounting. Listed gas-fired toilets specifically listed for installation on combustible floors shall be permitted to be so installed.

6.26.3 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.

6.27 Unit Heaters.

6.27.1 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.

6.27.2 Clearance.

(a) *Suspended-Type Unit Heaters.*

(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.

Exception: 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.

(b) *Floor-Mounted-Type Unit Heaters.*

(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.

Exception: 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 shall be permitted to be installed on combustible floors if 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.

6.27.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 5.3.

6.27.4 Ductwork. A unit heater shall not be attached to a warm air duct system unless listed and marked for such installation.

6.27.5 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 5.1.10 and 5.1.11.

6.28 Wall Furnaces.

6.28.1 Installation.

(a) Listed wall furnaces shall be installed in accordance with their listing and the manufacturers' instructions. They shall be permitted to be installed in or attached to combustible material.

(b) Unlisted wall furnaces shall not be installed in or attached to combustible material.

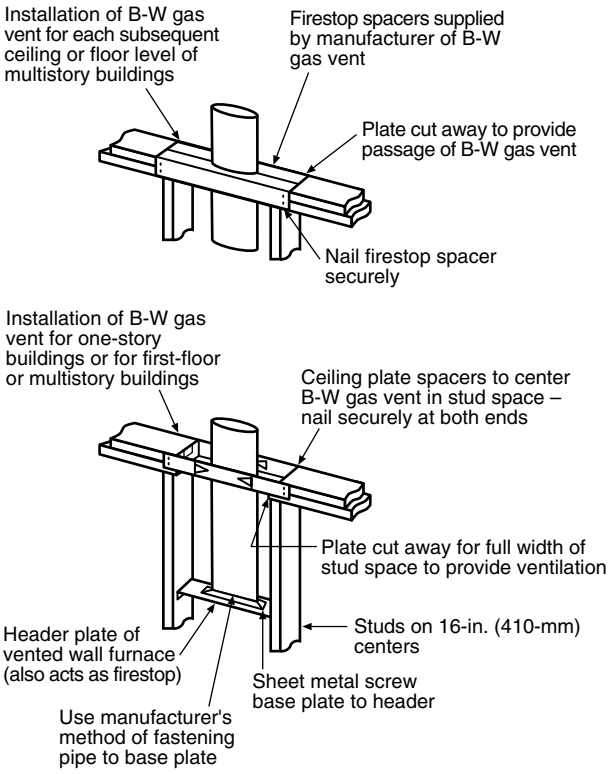
(c) Vented wall furnaces connected to a Type B-W gas vent system listed only for a single story shall be installed only in single-story buildings or the top story of multistory buildings. Vented wall furnaces connected to a Type B-W gas vent system listed for installation in multistory buildings shall 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 6.28.1(c) for Type B-W gas vent installation.]*

(d) 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.

(e) 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, consult Chapter 7 in this code.

Figure 6.28.1(c) Installation of Type B-W gas vents for vented wall furnaces.



6.28.2 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.

6.28.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 5.3.

6.29 Water Heaters.

6.29.1 Prohibited Installations.

(a) Water heaters shall not be installed in bathrooms, bedrooms, or any occupied rooms normally kept closed.

Exception No. 1: Direct-vent water heaters.

Exception No. 2: Water heaters shall be permitted to be installed in a closet located in a bathroom or bedroom where the closet has a weather-stripped solid door with a self-closing device and where all combustion air is obtained from the outdoors

(b) Single-faucet automatic instantaneous water heaters, as permitted under 7.2.2 in addition to (a), shall not be installed in kitchen sections of light housekeeping rooms or rooms used by transients.

(c) See 5.1.8 for flammable vapors.

6.29.2 Location. Water heaters of other than the direct-vent type shall be located as close as practical to the chimney or gas vent.

6.29.3 Clearance.

(a) 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.

(b) 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.

6.29.4 Pressure-Limiting Devices. A water heater installation shall be provided with overpressure protection by means of an approved device constructed, listed, and 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.

6.29.5 Temperature-Limiting Devices. Water heater installation or a hot water storage vessel installation shall be provided with overtemperature protection by means of an approved device constructed, listed, and installed in accordance with the terms of its listing and the manufacturers' instructions.

6.29.6 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.

6.29.7 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.

6.29.8 Circulating Tank Types.

(a) *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 6.29.8(a).]*

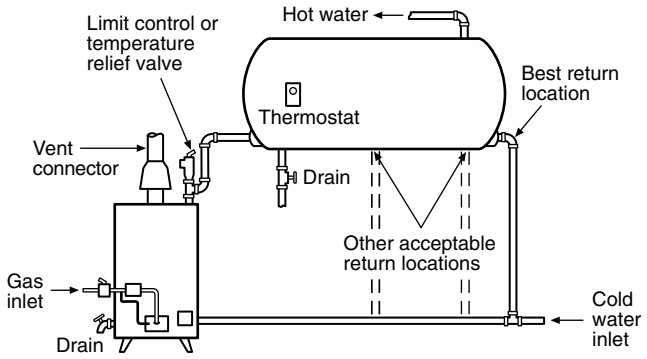
(b) *Size of Water Circulating Piping.* The size of the water circulating piping shall conform with the size of the water connections of the heater.

(c) *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.

6.29.9* 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.

6.30 Compressed Natural Gas (CNG) Vehicular Fuel Systems. The installation of compressed natural gas (CNG) fueling (dispensing) systems shall conform with NFPA 52, *Standard for Compressed Natural Gas (CNG) Vehicular Fuel Systems.*

Figure 6.29.8(a) Typical gravity circulating tank-type installation.



6.31 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 5.3.

Chapter 7 Venting of Equipment

7.1 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 1.7 for the definition of these vented appliance categories.

7.2 Specification for Venting.

7.2.1 Connection to Venting Systems. Except as permitted in 7.2.2 through 7.2.6, all gas utilization equipment shall be connected to venting systems.

7.2.2 Equipment Not Required to Be Vented.

(a) Listed ranges

(b) Built-in domestic cooking units listed and marked for optional venting

(c) Listed hot plates and listed laundry stoves

(d) Listed Type 1 clothes dryers *(see 6.4.4 for exhausting requirements)*

(e) 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.

(f) Listed refrigerators

(g) Counter appliances

(h) Room heaters listed for unvented use *(See 6.24.1 and 6.24.2.)*

(i) Direct gas-fired makeup air heaters

(j) Other equipment listed for unvented use and not provided with flue collars

(k) Specialized equipment of limited input such as laboratory burners or gas lights

Where any or all of the equipment in 7.2.2(e) through (k) 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 the 20 Btu/hr/ft^3 (207 W/m^3) figure. Where the room or space in which the equipment is installed is directly connected to another room or space by a doorway, archway, or other opening of comparable size that cannot be closed, the volume of such adjacent room or space shall be permitted to be included in the calculations.

7.2.3* Ventilating Hoods. Ventilating hoods and exhaust systems shall be permitted to be used to vent gas utilization equipment installed in commercial applications *(see 7.3.5)* and to vent industrial equipment, particularly where the process itself requires fume disposal. *(See 5.1.6 and 5.1.8.)*

7.2.4 Well-Ventilated Spaces. Where located in a large and well-ventilated space, industrial gas utilization equipment shall be permitted to be operated by discharging the flue gases directly into the space.

7.2.5 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 7.8(c).

7.2.6 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 7.8(a) and (b).

7.3 Design and Construction.

7.3.1 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.

7.3.2 Equipment Draft Requirements. A venting system shall satisfy the draft requirements of the equipment in accordance with the manufacturer's instructions.

7.3.3 Design and Construction. Gas utilization equipment required to be vented shall be connected to a venting system designed and constructed in accordance with the provisions of Sections 7.4 through 7.15.

7.3.4 Mechanical Draft Systems.

(a) 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.

(b) 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.

(c) Vent connectors serving equipment vented by natural draft shall not be connected into any portion of mechanical draft systems operating under positive pressure.

(d) 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.

(e) 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 7.8(a) and (b).

(f) Mechanical draft systems shall be installed in accordance with the terms of their listing and the manufacturers' instructions.

7.3.5* Ventilating Hoods and Exhaust Systems.

(a) Ventilating hoods and exhaust systems shall be permitted to be used to vent gas utilization equipment installed in commercial applications.

(b) 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.

7.3.6 Circulating Air Ducts and Plenums. No portion of a venting system shall extend into or pass through any circulating air duct or plenum.

7.4 Type of Venting System to Be Used.

7.4.1 The type of venting system to be used shall be in accordance with Table 7.4.1.

7.4.2 Plastic Piping. Approved plastic piping shall be permitted to be used for venting equipment listed for use with such venting materials.

7.4.3 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.

7.5 Masonry, Metal, and Factory-Built Chimneys.

7.5.1 Listing or Construction.

(a) 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.

(b) Metal chimneys shall be built and installed in accordance with NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances,* or local building codes.

(c) *Masonry chimneys shall be built and installed in accordance with NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances,* or local building codes 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 serving listed gas appliances with draft hoods, Category I appliances, and other gas appliances listed for use with Type B vents shall be permitted to be lined with a chimney lining system specifically listed for use only with such appliances. The liner shall be installed in accordance with the liner manufacturer's instructions 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."

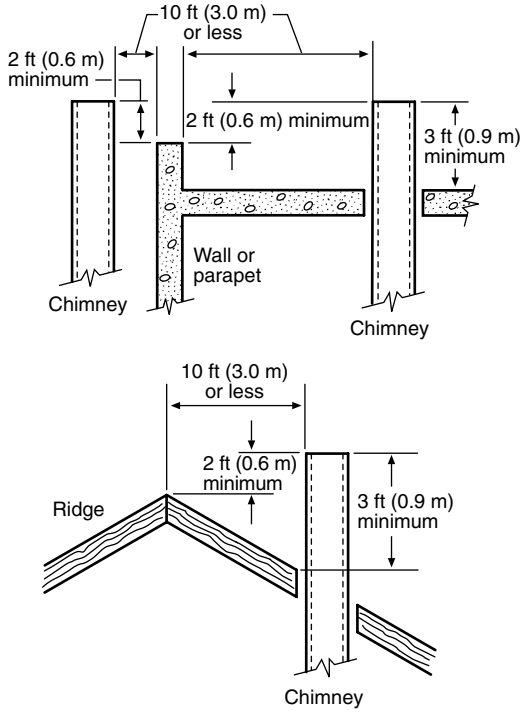
Table 7.4.1 Type of Venting System to Be Used

Gas Utilization Equipment	Type of Venting System
Listed Category I equipment	Type B gas vent (7.6)
Listed equipment equipped with draft hood	Chimney (7.5)
Equipment listed for use with Type B gas vent	Single-wall metal pipe (7.7) Listed chimney lining system for gas venting (7.5.1c). Special gas vent listed for this equipment (7.4.3)
Listed vented wall furnaces	Type B-W gas vent (7.6, 6.28)
Category II equipment Category III equipment Category IV equipment	As specified or furnished by manufacturers of listed equipment (7.4.2, 7.4.3)
Incinerators, outdoors	Single-wall metal pipe [7.7, 7.7.3(c)]
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 (7.5)
Listed combination gas- and oil-burning equipment	Type L vent (7.6) or chimney (7.5)
Decorative appliance in vented fireplace	Chimney [6.6.2(2)]
Gas-fired toilets	Single-wall metal pipe (7.7, 6.26.3)
Direct-vent equipment	See 7.2.5
Equipment with integral vent	See 7.2.6
Equipment in commercial and industrial installations	Chimney, ventilating hood, and exhaust system (7.3.5)

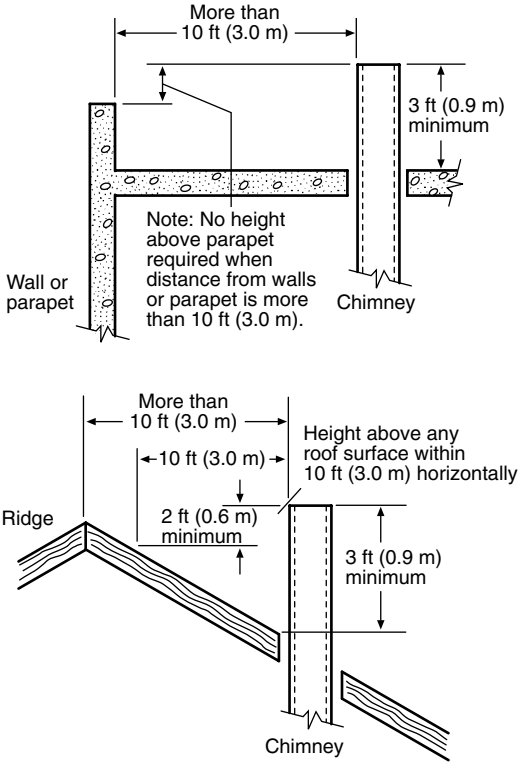
7.5.2 Termination.

(a) 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 (3.0 m). *[See Figure 7.5.2(a).]*

Figure 7.5.2(a) Typical termination locations for chimneys and single-wall metal pipes serving residential-type and low-heat equipment.



(a) Termination 10 ft (3.0 m) or Less from Ridge, Wall, or Parapet



(b) Termination More Than 10 ft (3.0 m) from Ridge, Wall, or Parapet

(b) A chimney for medium-heat equipment shall extend at least 10 ft (3.0 m) higher than any portion of any building within 25 ft (7.6 m).

(c) A chimney shall extend at least 5 ft (1.5 m) above the highest connected equipment draft hood outlet or flue collar.

(d) 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.

7.5.3 Size of Chimneys. 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 Chapter 10 or other approved engineering methods.

Exception No. 1: As an alternate method of 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.

Exception No. 2: As an alternate method 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.

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.

7.5.4 Inspection of Chimneys.

(a) 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.

(b) Chimneys shall be lined in accordance with NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances,* or local building codes.

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.

(c) Cleanouts shall be examined to determine they will remain tightly closed when not in use.

(d) 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,* or local building codes, and shall be suitable for the equipment to be attached.

7.5.5 Chimney Serving Equipment Burning Other Fuels.

(a) Gas utilization equipment shall not be connected to a chimney flue serving a separate appliance designed to burn solid fuel.

(b) Gas utilization equipment and equipment burning liquid fuel shall be permitted to be connected to one chimney flue through separate openings or shall be permitted to be connected through a single opening if joined by a suitable fitting located as close as practical to the chimney. If two or more openings are provided into one chimney flue, they shall be at

different levels. If the gas utilization equipment is automatically controlled, it shall be equipped with a safety shutoff device.

(c) *A listed combination gas- and solid fuel–burning appliance equipped with a manual reset device to shut off gas to the main burner in the event of sustained backdraft or flue gas spillage shall be permitted to be connected to a single chimney flue. The chimney flue shall be sized to properly vent the appliance.

(d) A listed combination gas- and oil-burning appliance shall be permitted to be connected to a single chimney flue. The chimney flue shall be sized to properly vent the appliance.

7.5.6 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.

7.5.7 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.

7.5.8 Space Surrounding Lining or Vent. The remaining space surrounding a chimney liner, gas vent, special gas vent, or plastic piping installed within a masonry chimney flue 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.

7.6 Gas Vents. *(See Section 1.7.)*

7.6.1 Application.

(a) Gas vents shall be installed in accordance with the terms of their listings and the manufacturers' instructions.

(b) 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.

(c) 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.

(d) 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 10 or in accordance with other approved engineering methods.

Vents serving Category I fan-assisted appliances shall be installed in accordance with the appliance manufacturer's instructions and Chapter 10 or other approved engineering methods.

(e) 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."

7.6.2 Gas Vent Termination.

(a) A gas vent shall terminate 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 7.6.2(a), 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 (3.1 m).

Exception No. 1: Industrial gas utilization equipment as provided in 7.2.4.

Exception No. 2: Direct-vent systems as provided in 7.2.5.

Exception No. 3: Equipment with integral vents as provided in 7.2.6.

Exception No. 4: Mechanical draft systems as provided in 7.3.4.

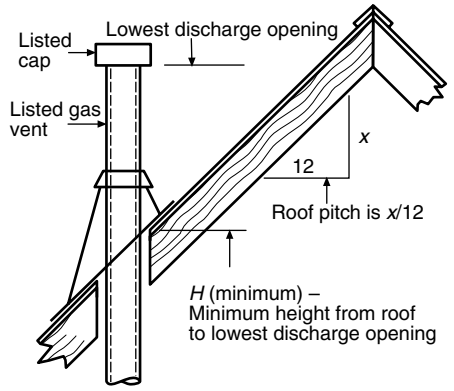
Exception No. 5: Ventilating hoods and exhaust systems as provided in 7.3.5.

(b) 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.

(c) 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.

(d) A gas vent extending through an exterior wall shall not terminate adjacent to the wall or below eaves or parapets, except as provided in 7.2.5 and 7.3.4.

Figure 7.6.2(a) 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.



Roof pitch	H (minimum) ft	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

7.6.3 Size of Gas Vents. Venting systems shall be sized and constructed in accordance with Chapter 10 or other approved engineering methods and the gas vent and gas equipment manufacturers' instructions.

(a) **Category I Appliances.* The sizing of natural draft venting systems serving one or more listed appliances equipped with a draft hood or appliances listed for use with Type B gas vent, installed in a single story of a building, shall be in accordance with Chapter 10 or in accordance with sound engineering practice.

Exception No. 1: As an alternate method 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. Vents serving fan-assisted combustion system appliances shall be sized in accordance with Chapter 10 or other approved engineering methods.

Exception No. 2: As an alternate method 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. 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 10 or other approved engineering methods.

(b) *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.

7.6.4 Gas Vents Serving Equipment on More Than One Floor. 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.

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 7.6.4.)*

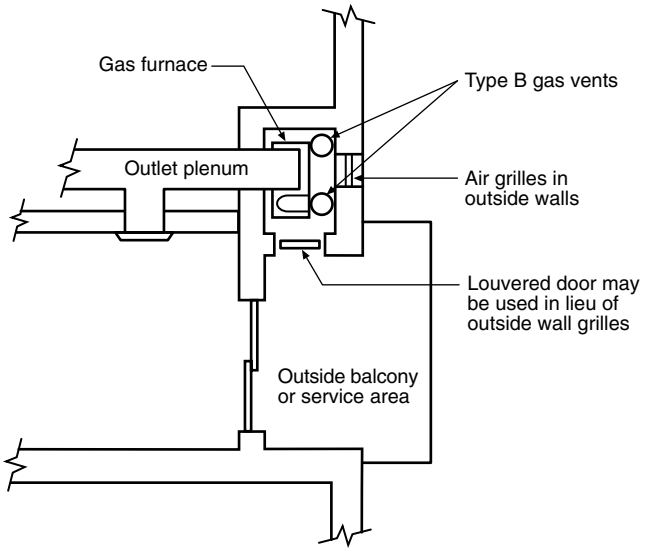
The size of the connectors and common segments of multistory venting systems for gas utilization equipment listed for use with Type B double-wall gas vent shall be in accordance with Table 10.6, provided:

(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.11.)*
(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.

7.6.5 Support of Gas Vents. Gas vents shall be supported and spaced in accordance with their listings and the manufacturers' instructions.

7.6.6 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."

Figure 7.6.4 Plan view of practical separation method for multistory gas venting.



The authority having jurisdiction shall determine whether its area constitutes such a locality.

7.7 Single-Wall Metal Pipe.

7.7.1 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.

7.7.2 Cold Climate. Uninsulated single-wall metal pipe shall not be used outdoors in cold climates for venting gas utilization equipment.

7.7.3 Termination.

(a) 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.

(b) 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 (3.1 m). *[See Figure 7.5.2(a).]*

(c) An approved cap or roof assembly shall be attached to the terminus of a single-wall metal pipe. *[Also see 7.7.4(c).]*

7.7.4 Installation with Equipment Permitted by 7.4.1.

(a) 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.

(b) 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 7.10.15(b).

(c) 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.

(d) Minimum clearances from single-wall metal pipe to combustible material shall be in accordance with Table 7.7.4(d). The clearance from single-wall metal pipe to combustible material shall be permitted to be reduced where the combustible material is protected as specified for vent connectors in Table 6.2.3(b).

(e) 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 7.10.15(b).

7.7.5 Size of Single-Wall Metal Pipe.

(a) *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:

(1) For a draft hood-equipped appliance, in accordance with Chapter 10

(2) For a venting system for a single appliance with a draft hood, the areas of the connector and the pipe each shall not be less than the area of the appliance flue collar or draft hood outlet, whichever is smaller. The vent area shall not be greater than seven times the draft hood outlet area.

(3) Other approved engineering methods

(b) Any shaped single-wall metal pipe shall be permitted to be used, provided its equivalent effective area is equal to the effective area of the round pipe for which it is substituted and provided the minimum internal dimension of the pipe is not less than 2 in. (50 mm).

(c) The vent cap or a roof assembly shall have a venting capacity not less than that of the pipe to which it is attached.

7.7.6 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.

7.7.7 Marking. Single-wall metal pipe shall comply with the marking provisions of 7.6.6.

7.8* Through the Wall Vent Termination.

(a) A mechanical draft venting system shall terminate at least 3 ft (0.9 m) above any forced air inlet located within 10 ft (3.1 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.

Table 7.7.4(d) 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
Residential incinerators	Not permitted	9 in.	18 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.

(b) 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, 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.

(c) 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.

(d) 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 of 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.

7.9 Condensation Drain.

(a) 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 7.8(d).

(b) 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 7.8(d).

7.10 Vent Connectors for Category I Gas Utilization Equipment.

7.10.1 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.

7.10.2 Materials.

(a) 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.

(b) 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 attic space or other unconditioned area, that portion of the vent connector shall be listed Type B or Type L or listed vent material or listed material having equivalent insulation qualities.

(c) 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.

(d) 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 7.10.2(d). Factory-built chimney sections shall be joined together in accordance with the chimney manufacturer's instructions.

(e) Vent connectors for medium-heat equipment and commercial and industrial incinerators shall be constructed of factory-built, medium-heat chimney sections or steel of a thickness not less than that specified in Table 7.10.2(e), 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 (ASTM C 64, *Specification for Refractories for Incinerators and Boilers, Type F)* or the equivalent.
(2) The lining shall be at least $2^1/_2$ 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 $4^1/_2$ in. (110 mm) thick laid on the $4^1/_2$-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 7.10.2(d) 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.

Table 7.10.2(e) 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.

7.10.3* Size of Vent Connector.

(a) 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 constructed in accordance with Chapter 10 and other approved engineering methods.

(b) 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. If 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.

(c) Where two or more gas appliances are connected to a common vent or chimney, each vent connector shall be sized in accordance with Chapter 10 or other approved engineering methods.

As an alternative method applicable only when 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.

(d) 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 10 or other approved engineering methods.

As an alternate method applicable only where there are two draft hood–equipped appliances, the effective area of the common vent connector or vent manifold and all junction fittings shall be not less than the area of the larger vent connector plus 50 percent of the areas of the smaller flue collar outlets.

(e) 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.

(f) The effective area of the vent connector, where connected to one or more appliances requiring draft for operation, shall be obtained by the application of approved engineering practices to perform as specified in 7.3.1 and 7.3.2.

7.10.4 Two or More Appliances Connected to a Single Vent.

(a) 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.

(b) 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.

7.10.5 Clearance. Minimum clearances from vent connectors to combustible material shall be in accordance with Table 7.7.4(d).

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 6.2.3(b).

7.10.6 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.

7.10.7 Joints. Joints between sections of connector piping and connections to flue collars or draft hood outlets shall be fastened by sheet metal screws or other approved means.

Exception: Vent connectors of listed vent material, which shall be assembled and connected to flue collars or draft hood outlets in accordance with the manufacturers' instructions.

7.10.8 Slope. A vent connector shall be installed without any dips or sags and shall slope upward at least $^1/_4$ in./ft (20 mm/m).

7.10.9 Length of Vent Connector.

(a) A vent connector shall be as short as practical and the gas utilization equipment located as close as practical to the chimney or vent.

(b) *Except as provided for in 7.10.3, 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 7.10.3, 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.

7.10.10 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.

7.10.11 Location. Where the vent connector used for gas utilization equipment having a draft hood or for Category I appliances is located in or passes through an attic, crawl space, or other area that can be cold, that portion of the vent connector shall be of listed double-wall Type B, Type L vent material or listed material having equivalent insulation qualities.

7.10.12 Chimney Connection. In entering a flue in a masonry or metal chimney, the vent connector shall be installed above the extreme bottom to avoid stoppage. A thimble or slip joint shall be permitted to be 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.

7.10.13 Inspection. The entire length of a vent connector shall be readily accessible for inspection, cleaning, and replacement.

7.10.14 Fireplaces. A vent connector shall not be connected to a chimney flue serving a fireplace unless the fireplace flue opening is permanently sealed.

7.10.15 Passage Through Ceilings, Floors, or Walls.

(a) A vent connector shall not pass through any ceiling, floor, fire wall, or fire partition. 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 Type B gas vents shall be permitted to pass through walls or partitions constructed of combustible material if the connectors are installed with not less than the listed clearance to combustible material.

(b) 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 gas utilization equipment equipped with draft hoods and equipment listed for use with Type B gas vents, 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 permitted to be 2 in. (50 mm) larger in diameter than the vent connector.
(2) For unlisted equipment having draft hoods, 6 in. (150 mm) larger in diameter than the vent connector
(3) For residential incinerators and all other residential and low-heat equipment, 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.

(c) Vent connectors for medium-heat equipment shall not pass through walls or partitions constructed of combustible material.

7.11 Vent Connectors for Category II, Category III, and Category IV Gas Utilization Equipment. *(See Section 7.4.)*

7.12 Draft Hoods and Draft Controls.

7.12.1 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.

7.12.2 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. 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.

Exception: If it is determined that a draft hood of special design is needed or preferable for a particular installation, the advice of the gas utilization equipment manufacturer and the approval of the authority having jurisdiction shall be secured.

7.12.3 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.

7.12.4* 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.

7.12.5 Incinerator Draft Regulator. A listed gas-fired incinerator shall be permitted to be equipped with a listed single acting barometric draft regulator where recommended by the incinerator manufacturer. This draft regulator shall be installed in accordance with the instructions accompanying the incinerator.

7.12.6 Install in Same Room. A draft hood or a barometric draft regulator 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.

7.12.7 Positioning. A draft hood or draft regulator shall be installed in the position for which it was 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 gas utilization equipment or adjacent construction. The equipment and its draft hood shall be located so that the relief opening is accessible for checking vent operation.

7.12.8 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 gas utilization 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. These clearances shall not be reduced.

7.13 Manually Operated Dampers. A manually operated damper shall not be placed in the vent connector from any gas utilization equipment. Fixed baffles shall not be classified as manually operated dampers.

Exception: A connector serving a listed gas-fired incinerator where recommended by the incinerator manufacturer and installed in accordance with the instructions accompanying the incinerator.

7.14 Automatically Operated Vent Dampers. An automatically operated vent damper shall be of a listed type.

7.15 Obstructions. A device that retards the flow of vent gases shall not be installed in a vent connector, chimney, or vent.

Exception No. 1: Draft regulators and safety controls (1) specifically listed for installation in venting systems and installed in accordance

with the terms of their listing and (2) designed and installed in accordance with approved engineering methods and approved by the authority having jurisdiction.

Exception No. 2: Listed heat reclaimers and automatically operated vent dampers installed in accordance with the terms of their listing.

Exception No. 3: 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 7.3.1 and 7.3.2 is obtained.

Tables in Chapter 10 shall not apply where the equipment covered in Section 7.15, Exception No. 1, 2, or 3 is installed in the vent. Other approved engineering methods shall be used to size these vents.

Chapter 8 Procedures to Be Followed to Place Equipment in Operation

8.1 Adjusting the Burner Input.

8.1.1* 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, by changing the adjustment of an adjustable orifice, or by readjusting the gas pressure regulator outlet pressure (where a regulator is provided). Overfiring shall be prohibited. *(See Table 8.1.1.)*

8.1.2 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 at the rate of 4 percent for each 1000 ft (300 m) above sea level before selecting appropriately sized equipment.

Exception No. 1: As permitted by the authority having jurisdiction.

Exception No. 2: Listed appliances shall be permitted to be derated in accordance with the terms of the listing.

8.2* 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.

8.3 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. If 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.

8.4 Automatic Ignition. Gas utilization equipment supplied with means for automatic ignition shall be checked for proper operation. If necessary, proper adjustments shall be made.

8.5 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.

8.6* 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. If the chimney or gas vent is drawing properly, the match flame will be drawn into the draft hood. If not, the combustion products will tend to extinguish this flame. If 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.

8.7 Operating Instructions. Operating instructions shall be furnished and shall be left in a prominent position near the equipment for the use of the consumer.

Table 8.1.1 Gas Input to Burner in Cubic Feet per Hour

Seconds for One Revolution	Size of Test Meter Dial			
	$^1/_2$ ft^3	1 ft^3	2 ft^3	5 ft^3
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

Table 8.1.1 Gas Input to Burner in Cubic Feet per Hour *(Continued)*

Seconds for One Revolution	Size of Test Meter Dial			
	$^1/_2$ ft^3	1 ft^3	2 ft^3	5 ft^3
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
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.

Chapter 9 Sizing Tables

9.1 Tables for Sizing Gas Piping Systems. Tables 9.1 through 9.34 can be used to size gas piping systems as required in Chapter 2. For SI units, 1 ft^3 = 0.028 m^3; 1 ft = 0.305 m; 1 in. water column = 0.249 kPa; 1 psi = 6.894 kPa; 1000 Btu/hr = 0.293 kW.

Table 9.1 Maximum Capacity of Pipe in Cubic Feet of Gas per Hour for Gas Pressures of 0.5 psi or Less and a Pressure Drop of 0.3 in. Water Column (Based on a 0.60 Specific Gravity Gas)

Nominal Iron Pipe Size (in.)	Internal Diameter (in.)	Length of Pipe (ft)													
		10	20	30	40	50	60	70	80	90	100	125	150	175	200
1/4	0.364	32	22	18	15	14	12	11	11	10	9	8	8	7	6
3/8	0.493	72	49	40	34	30	27	25	23	22	21	18	17	15	14
1/2	0.622	132	92	73	63	56	50	46	43	40	38	34	31	28	26
3/4	0.824	278	190	152	130	115	105	96	90	84	79	72	64	59	55
1	1.049	520	350	285	245	215	195	180	170	160	150	130	120	110	100
1 1/4	1.380	1,050	730	590	500	440	400	370	350	320	305	275	250	225	210
1 1/2	1.610	1,600	1,100	890	760	670	610	560	530	490	460	410	380	350	320
2	2.067	3,050	2,100	1,650	1,450	1,270	1,150	1,050	990	930	870	780	710	650	610
2 1/2	2.469	4,800	3,300	2,700	2,300	2,000	1,850	1,700	1,600	1,500	1,400	1,250	1,130	1,050	980
3	3.068	8,500	5,900	4,700	4,100	3,600	3,250	3,000	2,800	2,600	2,500	2,200	2,000	1,850	1,700
4	4.026	17,500	12,000	9,700	8,300	7,400	6,800	6,200	5,800	5,400	5,100	4,500	4,100	3,800	3,500

Table 9.2 Maximum Capacity of Pipe in Cubic Feet of Gas per Hour for Gas Pressures of 0.5 psi or Less and a Pressure Drop of 0.5 in. Water Column (Based on a 0.60 Specific Gravity Gas)

Nominal Iron Pipe Size (in.)	Internal Diameter (in.)	Length of Pipe (ft)													
		10	20	30	40	50	60	70	80	90	100	125	150	175	200
1/4	0.364	43	29	24	20	18	16	15	14	13	12	11	10	9	8
3/8	0.493	95	65	52	45	40	36	33	31	29	27	24	22	20	19
1/2	0.622	175	120	97	82	73	66	61	57	53	50	44	40	37	35
3/4	0.824	360	250	200	170	151	138	125	118	110	103	93	84	77	72
1	1.049	680	465	375	320	285	260	240	220	205	195	175	160	145	135
1 1/4	1.380	1400	950	770	660	580	530	490	460	430	400	360	325	300	280
1 1/2	1.610	2100	1460	1180	990	900	810	750	690	650	620	550	500	460	430
2	2.067	3950	2750	2200	1900	1680	1520	1400	1300	1220	1150	1020	950	850	800
2 1/2	2.469	6300	4350	3520	3000	2650	2400	2250	2050	1950	1850	1650	1500	1370	1280
3	3.068	11000	7700	6250	5300	4750	4300	3900	3700	3450	3250	2950	2650	2450	2280
4	4.026	23000	15800	12800	10900	9700	8800	8100	7500	7200	6700	6000	5500	5000	4600

Table 9.3 Pipe Sizing Table for 2 psi Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 2.0 psi with a 1.0 psi Pressure Drop and a Gas of 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe (in.)	Internal Diameter (in.)	Total Equivalent Length of Pipe (ft)													
		10	20	30	40	50	60	70	80	90	100	125	150	175	200
1/2	0.622	1506	1065	869	753	673	615	569	532	502	462	414	372	344	318
3/4	0.824	3041	2150	1756	1521	1360	1241	1150	1075	1014	934	836	751	695	642
1	1.049	5561	3932	3211	2781	2487	2270	2102	1966	1854	1708	1528	1373	1271	1174
1 1/4	1.380	11415	8072	6591	5708	5105	4660	4315	4036	3805	3508	3138	2817	2608	2413
1 1/2	1.610	17106	12096	9876	8553	7650	6983	6465	6048	5702	5257	4702	4222	3909	3613
2	2.067	32944	23295	19020	16472	14733	13449	12452	11647	10981	10125	9056	8130	7527	6959
2 1/2	2.469	52505	37127	30314	26253	23481	21435	19845	18563	17502	16138	14434	12960	11999	11093
3	3.068	92819	65633	53589	46410	41510	37893	35082	32817	30940	28530	25518	22911	21211	19608
4	4.026	189326	133873	109307	94663	84669	77292	71558	66937	63109	58194	52050	46732	43265	39997

Table 9.4 Pipe Sizing Table for 5 psi Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 5.0 psi with a 3.5 psi Pressure Drop and a Gas of 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe (in.)	Internal Diameter (in.)	Total Equivalent Length of Pipe (ft)													
		10	20	30	40	50	60	70	80	90	100	125	150	175	200
1/2	0.622	3185	2252	1839	1593	1425	1301	1204	1153	1062	979	876	786	728	673
3/4	0.824	6434	4550	3715	3217	2878	2627	2432	2330	2145	1978	1769	1589	1471	1360
1	1.049	11766	8320	6793	5883	5262	4804	4447	4260	3922	3617	3235	2905	2690	2487
1 1/4	1.380	24161	17084	13949	12080	10805	9864	9132	8542	8054	7427	6643	5964	5522	5104
1 1/2	1.610	36206	25602	20904	18103	16192	14781	13685	12801	12069	11128	9953	8937	8274	7649
2	2.067	69727	49305	40257	34864	31183	28466	26354	24652	23242	21433	19170	17211	15934	14729
2 1/2	2.469	111133	78583	64162	55566	49700	45370	42004	39291	37044	34159	30553	27431	25396	23478
3	3.068	196468	138924	113431	98234	87863	80208	74258	69462	65489	60387	54012	48494	44897	41504
4	4.026	400732	283361	231363	200366	179213	163598	151463	141680	133577	123173	110169	98911	91574	84656

Table 9.5 Pipe Sizing Table for Pressures Under 1 Pound Approximate Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour with Pressure Drop of 0.3 in. Water Column and 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe (in.)	Internal Diameter (in.)	Total Equivalent Length of Pipe (ft)										
		50	100	150	200	250	300	400	500	1000	1500	2000
1.00	1.049	215	148	119	102	90	82	70	62	43	34	29
1.25	1.380	442	304	244	209	185	168	143	127	87	70	60
1.50	1.610	662	455	366	313	277	251	215	191	131	105	90
2.00	2.067	1275	877	704	602	534	484	414	367	252	203	173
2.50	2.469	2033	1397	1122	960	851	771	660	585	402	323	276
3.00	3.068	3594	2470	1983	1698	1505	1363	1167	1034	711	571	488
3.50	3.548	5262	3616	2904	2485	2203	1996	1708	1514	1041	836	715
4.00	4.026	7330	5038	4046	3462	3069	2780	2380	2109	1450	1164	996
5.00	5.047	13261	9114	7319	6264	5552	5030	4305	3816	2623	2106	1802
6.00	6.065	21472	14758	11851	10143	8990	8145	6971	6178	4246	3410	2919
8.00	7.981	44118	30322	24350	20840	18470	16735	14323	12694	8725	7006	5997
10.00	10.020	80130	55073	44225	37851	33547	30396	26015	23056	15847	12725	10891
12.00	11.938	126855	87187	70014	59923	53109	48120	41185	36501	25087	20146	17242

Table 9.6 Pipe Sizing Table for Pressures Under 1 Pound Approximate Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour with Pressure Drop of 0.5 in. Water Column and 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe (in.)	Internal Diameter (in.)	Total Equivalent Length of Pipe (ft)										
		50	100	150	200	250	300	400	500	1000	1500	2000
1.00	1.049	284	195	157	134	119	108	92	82	56	45	39
1.25	1.380	583	400	322	275	244	221	189	168	115	93	79
1.50	1.610	873	600	482	412	366	331	283	251	173	139	119
2.00	2.067	1681	1156	928	794	704	638	546	484	333	267	229
2.50	2.469	2680	1842	1479	1266	1122	1017	870	771	530	426	364
3.00	3.068	4738	3256	2615	2238	1983	1797	1538	1363	937	752	644
3.50	3.548	6937	4767	3828	3277	2904	2631	2252	1996	1372	1102	943
4.00	4.026	9663	6641	5333	4565	4046	3666	3137	2780	1911	1535	1313
5.00	5.047	17482	12015	9649	8258	7319	6632	5676	5030	3457	2776	2376
6.00	6.065	28308	19456	15624	13372	11851	10738	9190	8145	5598	4496	3848
8.00	7.981	58161	39974	32100	27474	24350	22062	18883	16735	11502	9237	7905
10.00	10.020	105636	72603	58303	49900	44225	40071	34296	30396	20891	16776	14358
12.00	11.938	167236	114940	92301	78998	70014	63438	54295	48120	33073	26559	22731

Table 9.7 Pipe Sizing Table for 1 Pound Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 1.0 psi with a 10 Percent Pressure Drop and a Gas of 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe (in.)	Internal Diameter (in.)	Total Equivalent Length of Pipe (ft)										
		50	100	150	200	250	300	400	500	1000	1500	2000
1.00	1.049	717	493	396	338	300	272	233	206	142	114	97
1.25	1.380	1471	1011	812	695	616	558	478	423	291	234	200
1.50	1.610	2204	1515	1217	1041	923	836	716	634	436	350	300
2.00	2.067	4245	2918	2343	2005	1777	1610	1378	1222	840	674	577
2.50	2.469	6766	4651	3735	3196	2833	2567	2197	1947	1338	1075	920
3.00	3.068	11962	8221	6602	5650	5008	4538	3884	3442	2366	1900	1626
3.50	3.548	17514	12037	9666	8273	7332	6644	5686	5039	3464	2781	2381
4.00	4.026	24398	16769	13466	11525	10214	9255	7921	7020	4825	3875	3316
5.00	5.047	44140	30337	24362	20851	18479	16744	14330	12701	8729	7010	6000
6.00	6.065	71473	49123	39447	33762	29923	27112	23204	20566	14135	11351	9715
8.00	7.981	146849	100929	81049	69368	61479	55705	47676	42254	29041	23321	19960
10.00	10.020	266718	183314	147207	125990	111663	101175	86592	76745	52747	42357	36252
12.00	11.938	422,248	290209	233048	199459	176777	160172	137087	121498	83505	67057	57392

Table 9.8 Pipe Sizing Table for 2 Pounds Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 2.0 psi with a 10 Percent Pressure Drop and a Gas of 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe (in.)	Internal Diameter (in.)	Total Equivalent Length of Pipe (ft)										
		50	100	150	200	250	300	400	500	1000	1500	2000
1.00	1.049	1112	764	614	525	466	422	361	320	220	177	151
1.25	1.380	2283	1569	1260	1079	956	866	741	657	452	363	310
1.50	1.610	3421	2351	1888	1616	1432	1298	1111	984	677	543	465
2.00	2.067	6589	4528	3636	3112	2758	2499	2139	1896	1303	1046	896
2.50	2.469	10501	7217	5796	4961	4396	3983	3409	3022	2077	1668	1427
3.00	3.068	18564	12759	10246	8769	7772	7042	6027	5342	3671	2948	2523
3.50	3.548	27181	18681	15002	12840	11379	10311	8825	7821	5375	4317	3694
4.00	4.026	37865	26025	20899	17887	15853	14364	12293	10895	7488	6013	5147
5.00	5.047	68504	47082	37809	32359	28680	25986	22240	19711	13547	10879	9311
6.00	6.065	110924	76237	61221	52397	46439	42077	36012	31917	21936	17616	15077
8.00	7.981	227906	156638	125786	107657	95414	86452	73992	65578	45071	36194	30977
10.00	10.020	413937	284497	228461	195533	173297	157020	134389	119106	81861	65737	56263
12.00	11.938	655315	450394	361682	309553	274351	248582	212754	188560	129596	104070	89071

Table 9.9 Pipe Sizing Table for 5 Pounds Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 5.0 psi with a 10 Percent Pressure Drop and a Gas of 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe (in.)	Internal Diameter (in.)	Total Equivalent Length of Pipe (ft)										
		50	100	150	200	250	300	400	500	1000	1500	2000
1.00	1.049	1989	1367	1098	940	833	755	646	572	393	316	270
1.25	1.380	4084	2807	2254	1929	1710	1549	1326	1175	808	649	555
1.50	1.610	6120	4206	3378	2891	2562	2321	1987	1761	1210	972	832
2.00	2.067	11786	8101	6505	5567	4934	4471	3827	3391	2331	1872	1602
2.50	2.469	18785	12911	10368	8874	7865	7126	6099	5405	3715	2983	2553
3.00	3.068	33209	22824	18329	15687	13903	12597	10782	9556	6568	5274	4514
3.50	3.548	48623	33418	26836	22968	20356	18444	15786	13991	9616	7722	6609
4.00	4.026	67736	46555	37385	31997	28358	25694	21991	19490	13396	10757	9207
5.00	5.047	122544	84224	67635	57887	51304	46485	39785	35261	24235	19461	16656
6.00	6.065	198427	136378	109516	93732	83073	75270	64421	57095	39241	31512	26970
8.00	7.981	407692	280204	225014	192583	170683	154651	132361	117309	80626	64745	55414
10.00	10.020	740477	508926	408686	349782	310005	280887	240403	213065	146438	117595	100646
12.00	11.938	1172269	805694	647001	553749	490777	444680	380588	337309	231830	186168	159336

Table 9.10 Pipe Sizing Table for 10 Pounds Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 10.0 psi with a 10 Percent Pressure Drop and a Gas of 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe (in.)	Internal Diameter (in.)	Total Equivalent Length of Pipe (ft)										
		50	100	150	200	250	300	400	500	1000	1500	2000
1.00	1.049	3259	2240	1798	1539	1364	1236	1058	938	644	517	443
1.25	1.380	6690	4598	3692	3160	2801	2538	2172	1925	1323	1062	909
1.50	1.610	10024	6889	5532	4735	4197	3802	3254	2884	1982	1592	1362
2.00	2.067	19305	13268	10655	9119	8082	7323	6268	5555	3818	3066	2624
2.50	2.469	30769	21148	16982	14535	12882	11672	9990	8854	6085	4886	4182
3.00	3.068	54395	37385	30022	25695	22773	20634	17660	15652	10757	8638	7393
3.50	3.548	79642	54737	43956	37621	33343	30211	25857	22916	15750	12648	10825
4.00	4.026	110948	76254	61235	52409	46449	42086	36020	31924	21941	17620	15080
5.00	5.047	200720	137954	110782	94815	84033	76140	65166	57755	39695	31876	27282
6.00	6.065	325013	223379	179382	153527	136068	123288	105518	93519	64275	51615	44176
8.00	7.981	667777	458959	368561	315440	279569	253310	216800	192146	132061	106050	90765
10.00	10.020	1212861	833593	669404	572924	507772	460078	393767	348988	239858	192614	164853
12.00	11.938	1920112	1319682	1059751	907010	803866	728361	623383	552493	379725	304933	260983

Table 9.11 Pipe Sizing Table for 20 Pounds Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 20.0 psi with a 10 Percent Pressure Drop and a Gas of 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe (in.)	Internal Diameter (in.)	Total Equivalent Length of Pipe (ft)										
		50	100	150	200	250	300	400	500	1000	1500	2000
1.00	1.049	5674	3900	3132	2680	2375	2152	1842	1633	1122	901	771
1.25	1.380	11649	8006	6429	5503	4877	4419	3782	3352	2304	1850	1583
1.50	1.610	17454	11996	9633	8245	7307	6621	5667	5022	3452	2772	2372
2.00	2.067	33615	23103	18553	15879	14073	12751	10913	9672	6648	5338	4569
2.50	2.469	53577	36823	29570	25308	22430	20323	17394	15416	10595	8509	7282
3.00	3.068	94714	65097	52275	44741	39653	35928	30750	27253	18731	15042	12874
3.50	3.548	138676	95311	76538	65507	58058	52604	45023	39903	27425	22023	18849
4.00	4.026	193187	132777	106624	91257	80879	73282	62720	55538	38205	30680	26258
5.00	5.047	349503	240211	192898	165096	146322	132578	113470	100566	69118	55505	47505
6.00	6.065	565926	388958	312347	267329	236928	214674	183733	162840	111919	89875	76921
8.00	7.981	1162762	799160	641754	549258	486797	441074	377502	334573	229950	184658	158043
10.00	10.020	2111887	1451488	1165596	997600	884154	801108	685645	607674	417651	335388	287049
12.00	11.938	3343383	2297888	1845285	1579326	1399727	1268254	1085462	962025	661194	530962	454435

Table 9.12 Pipe Sizing Table for 50 Pounds Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 50.0 psi with a 10 Percent Pressure Drop and a Gas of 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe (in.)	Internal Diameter (in.)	Total Equivalent Length of Pipe (ft)										
		50	100	150	200	250	300	400	500	1000	1500	2000
1.00	1.049	12993	8930	7171	6138	5440	4929	4218	3739	2570	2063	1766
1.25	1.380	26676	18335	14723	12601	11168	10119	8661	7676	5276	4236	3626
1.50	1.610	39970	27471	22060	18881	16733	15162	12976	11501	7904	6348	5433
2.00	2.067	76977	52906	42485	36362	32227	29200	24991	22149	15223	12225	10463
2.50	2.469	122690	84324	67715	57955	51365	46540	39832	35303	24263	19484	16676
3.00	3.068	216893	149070	119708	102455	90804	82275	70417	62409	42893	34445	29480
3.50	3.548	317564	218260	175271	150009	132950	120463	103100	91376	62802	50432	43164
4.00	4.026	442393	304054	244166	208975	185211	167814	143627	127294	87489	70256	60130
5.00	5.047	800352	550077	441732	378065	335072	303600	259842	230293	158279	127104	108784
6.00	6.065	1295955	890703	715266	612175	542559	491598	420744	372898	256291	205810	176147
8.00	7.981	2662693	1830054	1469598	1257785	1114752	1010046	864469	766163	526579	422862	361915
10.00	10.020	4836161	3323866	2669182	2284474	2024687	1834514	1570106	1391556	956409	768030	657334
12.00	11.938	7656252	5262099	4225651	3616611	3205335	2904266	2485676	2203009	1514115	1215888	1040643

Table 9.13 Maximum Capacity of Semi-Rigid Tubing in Cubic Feet of Gas per Hour for Gas Pressures of 0.5 psi or Less and a Pressure Drop of 0.3 in. Water Column (Based on a 0.60 Specific Gravity Gas)

Outside Diameter (in.)	Length of Tubing (ft)													
	10	20	30	40	50	60	70	80	90	100	125	150	175	200
3/8	20	14	11	10	9	8	7	7	6	6	5	5	4	4
1/2	42	29	23	20	18	16	15	14	13	12	11	10	9	8
5/8	86	59	47	40	36	33	30	28	26	25	22	20	18	17
3/4	150	103	83	71	63	57	52	49	46	43	38	35	32	30
7/8	212	146	117	100	89	81	74	69	65	61	54	49	45	42

Table 9.14 Maximum Capacity of Semi-Rigid Tubing in Cubic Feet of Gas per Hour for Gas Pressures of 0.5 psi or Less and a Pressure Drop of 0.5 in. Water Column (Based on a 0.60 Specific Gravity Gas)

Outside Diameter (in.)	Length of Tubing (ft)													
	10	20	30	40	50	60	70	80	90	100	125	150	175	200
3/8	27	18	15	13	11	10	9	9	8	8	7	6	6	5
1/2	56	38	31	26	23	21	19	18	17	16	14	13	12	11
5/8	113	78	62	53	47	43	39	37	34	33	29	26	24	22
3/4	197	136	109	93	83	75	69	64	60	57	50	46	42	39
7/8	280	193	155	132	117	106	98	91	85	81	71	65	60	55

Table 9.15 Maximum Capacity of Semi-Rigid Tubing in Cubic Feet of Gas per Hour for Gas Pressures of 0.5 psi or Less and a Pressure Drop of 1.0 in. Water Column (Based on a 0.6 Specific Gravity Gas)

Use this table to size tubing from house line regulator to the appliance.

Length (ft)	Diameter: Inside (Outside)						
	1/4 in. (0.315 in.)	3/8 in. (0.430 in.)	1/2 in. (0.545 in.)	5/8 in. (0.666 in.)	3/4 in. (0.785 in.)	1 in. (1.025 in.)	1 1/4 in. (1.265 in.)
10	42	95	177	300	461	928	1612
15	34	76	142	241	370	745	1294
20	29	65	122	206	317	638	1108
30	23	52	98	165	255	512	890
40	20	45	84	142	218	439	761
50	18	40	74	125	193	389	675
60	16	36	67	114	175	352	611
70	15	33	62	105	161	324	563
80	14	31	57	97	150	301	523
90	13	29	54	91	140	283	491
100	12	27	51	86	133	267	464
125	11	24	45	76	118	237	411
150	10	22	41	69	107	215	372
175	9	20	38	64	98	197	343
200	8	19	35	59	91	184	319
250	7	17	31	53	81	163	283
300	7	15	28	48	73	147	256

Table 9.16 Maximum Capacity of Semi-Rigid Tubing in Cubic Feet per Hour for a Gas Pressure of 2 psi or Less and Pressure Drop of 17 in. Water Column (Based on a 0.6 Specific Gravity Gas)

Length (ft)	Diameter: Inside (Outside)						
	1/4 in. (0.315 in.)	3/8 in. (0.430 in.)	1/2 in. (0.545 in.)	5/8 in. (0.666 in.)	3/4 in. (0.785 in.)	1 in. (1.025 in.)	1 1/4 in. (1.265 in.)
10	201	454	845	1435	2200	4428	7690
15	161	364	678	1152	1766	3556	6175
20	138	312	581	986	1512	3044	5285
30	111	250	466	792	1214	2444	4244
40	95	214	399	678	1039	2092	3632
50	84	190	354	601	921	1854	3219
60	76	172	320	544	834	1680	2917
70	70	158	295	501	768	1545	2684
80	65	147	274	466	714	1438	2496
90	61	139	257	437	670	1349	2342
100	58	131	243	413	633	1274	2213
125	51	116	215	366	561	1129	1961
150	46	105	195	332	508	1023	1777
175	43	96	180	305	468	941	1635
200	40	90	167	284	435	876	1521
250	35	80	148	251	386	776	1348
300	32	72	134	228	349	703	1121

Table 9.17 Maximum Capacity of Semi-Rigid Tubing in Cubic Feet of Gas per Hour for a Gas Pressure of 2.0 psi or Less and a Pressure Drop of 1.0 psi (Based on a 0.6 Specific Gravity Gas)

Nominal Tubing Diameter Inside (in.)	Internal Diameter (in.)	Length of Tubing (ft)																	
		5	10	15	20	30	40	50	60	70	80	90	100	125	150	175	200	250	300
1/4	0.315	459	306	242	204	163	139	122	110	100	93	87	82	72	65	59	54	49	43
3/8	0.430	1071	722	569	484	382	323	285	255	234	217	204	191	168	151	139	124	119	102
1/2	0.545	2040	1385	1088	918	731	620	548	493	450	416	391	365	323	289	268	246	217	195
5/8	0.666	3527	2363	1827	1581	1258	1062	935	850	773	722	671	629	552	497	459	425	374	336
3/4	0.785	5524	3697	2932	2507	1955	1700	1487	1326	1215	1130	1045	986	871	782	718	671	586	527
1	1.025	8923	6459	5269	4589	3739	3229	2847	2592	2380	2252	2125	1997	1785	1615	1530	1445	1275	1147
1 1/4	1.265	17847	12748	10198	8923	7309	6374	5694	5184	459	4419	4164	3994	3627	3229	3017	2804	2507	2295
1 1/2	1.505	26345	18696	15297	12748	11048	9348	8328	7649	6969	6544	6119	5779	5184	4759	4419	4164	3654	3399
2	1.985	49291	34843	28894	24645	20396	16997	15297	14447	12748	11898	11473	10623	9603	8838	8243	7649	6884	6289
2 1/2	2.465	76485	54390	44192	38243	30594	27195	23795	22096	20396	18696	17847	16997	15297	13597	13172	11898	10623	9773

Table 9.18 Maximum Capacity of Semi-Rigid Tubing in Cubic Feet of Gas per Hour for a Gas Pressure of 5.0 psi or Less and a Pressure Drop of 3.5 psi (Based on a 0.6 Specific Gravity Gas)

Nominal Tubing Diameter Inside (in.)	Internal Diameter (in.)	Length of Tubing (ft)																	
		5	10	15	20	30	40	50	60	70	80	90	100	125	150	175	200	250	300
1/4	0.315	791	527	417	351	281	239	209	190	173	161	149	141	124	111	101	94	85	75
3/8	0.430	1845	1245	981	835	659	556	490	439	403	373	351	329	290	261	240	214	205	176
1/2	0.545	3514	2387	1874	1581	1259	1069	944	849	776	717	674	630	556	498	461	425	373	337
5/8	0.666	6076	4070	3148	2723	2167	1830	1611	1464	1332	1245	1157	1083	952	857	791	732	644	578
3/4	0.785	9517	6369	5051	4319	3368	2928	2562	2284	2094	1947	1801	1698	1501	1347	1237	1142	1010	906
1	1.025	15374	11127	9078	7906	6442	5564	4905	4466	4100	3880	3660	3441	3075	2782	2635	2489	2196	1977
1 1/4	1.265	30747	21962	17570	15374	12592	10981	9810	8931	8199	7614	7174	6881	6076	5564	5198	4832	4319	3853
1 1/2	1.505	45388	32211	26355	21962	19034	16106	14349	13177	12006	11274	10542	9956	8931	8199	7614	7174	6296	5857
2	1.985	84920	60030	49781	42460	35139	29283	26356	24890	21962	20498	19766	18302	16545	15227	14202	13177	11860	10835
2 1/2	2.465	131773	93705	76135	65886	52709	46853	40996	38068	35139	32211	30747	29283	26355	23426	22694	20498	18302	16838

Table 9.19 Maximum Capacity of CSST in Cubic Feet per Hour for Gas Pressure of 0.5 psi or Less and Pressure Drop of 0.5 in. Water Column (Based on a 0.60 Specific Gravity Gas)

EHD* Flow Designation	Tubing Length (ft)																
	5	10	15	20	25	30	40	50	60	70	80	90	100	150	200	250	300
13	46	32	25	22	19	18	15	13	12	11	10	10	9	7	6	5	5
15	63	44	35	31	27	25	21	19	17	16	15	14	13	10	9	8	7
18	115	82	66	58	52	47	41	37	34	31	29	28	26	20	18	16	15
19	134	95	77	67	60	55	47	42	38	36	33	32	30	23	21	19	17
23	225	161	132	116	104	96	83	75	68	63	60	57	54	42	38	34	32
25	270	192	157	137	122	112	97	87	80	74	69	65	62	48	44	39	36
30	471	330	267	231	206	188	162	144	131	121	113	107	101	78	71	63	57
31	546	383	310	269	240	218	188	168	153	141	132	125	118	91	82	74	67

Note: Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$ where L is additional length (ft) of tubing and n is the number of additional fittings or bends.

*EHD — equivalent hydraulic diameter — 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 9.20 Maximum Capacity of CSST in Cubic Feet per Hour for Gas Pressure of 0.5 psi or Less and a Pressure Drop of 3 in. Water Column (Based on a 0.60 Specific Gravity Gas)

EHD* Flow Designation	Tubing Length (ft)																
	5	10	15	20	25	30	40	50	60	70	80	90	100	150	200	250	300
13	120	83	67	57	51	46	39	35	32	29	27	26	24	19	17	15	13
15	160	112	90	78	69	63	54	48	44	41	38	36	34	27	23	21	19
18	277	197	161	140	125	115	100	89	82	76	71	67	63	52	45	40	37
19	327	231	189	164	147	134	116	104	95	88	82	77	73	60	52	46	42
23	529	380	313	273	245	225	196	176	161	150	141	133	126	104	91	82	75
25	649	462	379	329	295	270	234	210	192	178	167	157	149	122	106	95	87
30	1182	828	673	580	518	471	407	363	330	306	285	268	254	206	178	159	144
31	1365	958	778	672	599	546	471	421	383	355	331	311	295	240	207	184	168

Note: Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$ where L is additional length (ft) of tubing and n is the number of additional fittings or bends.

*EHD — equivalent hydraulic diameter — 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 9.21 Maximum Capacity of CSST in Cubic Feet per Hour for a Gas Pressure of 0.5 psi or Less and a Pressure Drop of 6 in. Water Column (Based on a 0.60 Specific Gravity Gas)

EHD* Flow Designation	Tubing Length (ft)																
	5	10	15	20	25	30	40	50	60	70	80	90	100	150	200	250	300
13	173	120	96	83	74	67	57	51	46	42	39	37	35	28	24	21	19
15	229	160	130	112	99	90	78	69	63	58	54	51	48	39	34	30	27
18	389	277	227	197	176	161	140	125	115	106	100	94	89	73	63	57	52
19	461	327	267	231	207	189	164	147	134	124	116	109	104	85	73	66	60
23	737	529	436	380	342	313	273	245	225	209	196	185	176	145	126	114	104
25	911	649	532	462	414	379	329	295	270	250	234	221	210	172	149	134	122
30	1687	1182	960	828	739	673	580	518	471	435	407	383	363	294	254	226	206
31	1946	1365	1110	958	855	778	672	599	546	505	471	444	421	342	295	263	240

Note: Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$ where L is additional length (ft) of tubing and n is the number of additional fittings or bends.
*EHD — equivalent hydraulic diameter — 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 9.22 Maximum Capacity of CSST in Cubic Feet per Hour for Gas Pressure of 2 psi and a Pressure Drop of 1 psi (Based on 0.60 Specific Gravity Gas)

EHD* Flow Designation	Tubing Length (ft)													
	10	25	30	40	50	75	80	100	150	200	250	300	400	500
13	270	166	151	129	115	93	89	79	64	55	49	44	38	34
15	353	220	200	172	154	124	120	107	87	75	67	61	52	46
18	587	374	342	297	266	218	211	189	155	135	121	110	96	86
19	700	444	405	351	314	257	249	222	182	157	141	129	111	100
23	1098	709	650	567	510	420	407	366	302	263	236	217	189	170
25	1372	876	801	696	624	512	496	445	364	317	284	260	225	202
30	2592	1620	1475	1273	1135	922	892	795	646	557	497	453	390	348
31	2986	1869	1703	1470	1311	1066	1031	920	748	645	576	525	453	404

Notes:
1. Table does not include effect of pressure drop across line regulator. If regulator loss exceeds $^3/_4$ psi, DO NOT USE THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across regulator may vary with the 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 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 or bends.
*EHD — equivalent hydraulic diameter — 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 9.23 Maximum Capacity of CSST in Cubic Feet per Hour for a Gas Pressure of 5 psi and a Pressure Drop of 3.5 psi (Based on a 0.60 Specific Gravity Gas)

EHD* Flow Designation	Tubing Length (ft)													
	10	25	30	40	50	75	80	100	150	200	250	300	400	500
13	523	322	292	251	223	180	174	154	124	107	95	86	74	66
15	674	420	382	329	293	238	230	205	166	143	128	116	100	89
18	1084	691	632	549	492	403	391	350	287	249	223	204	177	159
19	1304	827	755	654	586	479	463	415	339	294	263	240	208	186
23	1995	1289	1181	1031	926	763	740	665	548	478	430	394	343	309
25	2530	1616	1478	1284	1151	944	915	820	672	584	524	479	416	373
30	4923	3077	2803	2418	2157	1752	1694	1511	1228	1060	945	860	742	662
31	5659	3543	3228	2786	2486	2021	1955	1744	1418	1224	1092	995	858	766

Notes:
1. Table does not include effect of pressure drop across line regulator. If 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 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 or bends.

*EHD — equivalent hydraulic diameter — 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 9.24 Multipliers to Be Used with Tables 9-1 Through 9-12 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

Table 9.25 Pipe Sizing Between First Stage (High-Pressure Regulator) and Second Stage (Low-Pressure Regulator) Maximum undiluted propane capacities listed are based on a 10-psi first stage setting and 1 psi pressure drop. Capacities in 1000 Btu/hr.

	Schedule 40 Pipe Size, 1 psi drop								
Pipe Length (ft)	1/2 in. 0.622	3/4 in. 0.824	1 in. 1.049	1 1/4 in. 1.38	1 1/2 in. 1.61	2 in. 2.067	3 in. 3.068	3 1/2 in. 3.548	4 in. 4.026
30	1843	3854	7259	14904	22331	43008	121180	177425	247168
40	1577	3298	6213	12756	19113	36809	103714	151853	211544
50	1398	2923	5507	11306	16939	32623	91920	134585	187487
60	1267	2649	4989	10244	15348	29559	83286	121943	169877
70	1165	2437	4590	9424	14120	27194	76622	112186	156285
80	1084	2267	4270	8767	13136	25299	71282	104368	145393
90	1017	2127	4007	8226	12325	23737	66882	97925	136417
100	961	2009	3785	7770	11642	22422	63176	92499	128859
150	772	1613	3039	6240	9349	18005	50733	74280	103478
200	660	1381	2601	5340	8002	15410	43421	63574	88564
250	585	1224	2305	4733	7092	13658	38483	56345	78493
300	530	1109	2089	4289	6426	12375	34868	51052	71120
350	488	1020	1922	3945	5911	11385	32078	46967	65430
400	454	949	1788	3670	5499	10591	29843	43694	60870
450	426	890	1677	3444	5160	9938	28000	40997	57112
500	402	841	1584	3253	4874	9387	26449	38725	53948
600	364	762	1436	2948	4416	8505	23965	35088	48880
700	335	701	1321	2712	4063	7825	22047	32280	44969
800	312	652	1229	2523	3780	7279	20511	30031	41835
900	293	612	1153	2367	3546	6830	19245	28177	39253
1000	276	578	1089	2236	3350	6452	18178	26616	37078
1500	222	464	875	1795	2690	5181	14598	21373	29775
2000	190	397	748	1537	2302	4434	12494	18293	25483

Table 9.26 Pipe Sizing Between Single or Second Stage (Low-Pressure Regulator) and Appliance

	Nominal Pipe Size, Schedule 40								
Pipe Length (ft)	1/2 in. 0.622	3/4 in. 0.824	1 in. 1.049	1 1/4 in. 1.38	1 1/2 in. 1.61	2 in. 2.067	3 in. 3.068	3 1/2 in. 3.548	4 in. 4.026
10	291	608	1146	2353	3525	6789	19130	28008	39018
20	200	418	788	1617	2423	4666	13148	19250	26817
30	161	336	632	1299	1946	3747	10558	15458	21535
40	137	287	541	1111	1665	3207	9036	13230	18431
50	122	255	480	985	1476	2842	8009	11726	16335
60	110	231	435	892	1337	2575	7256	10625	14801
80	94	198	372	764	1144	2204	6211	9093	12668
100	84	175	330	677	1014	1954	5504	8059	11227
125	74	155	292	600	899	1731	4878	7143	9950
150	67	141	265	544	815	1569	4420	6472	9016
200	58	120	227	465	697	1343	3783	5539	7716
250	51	107	201	412	618	1190	3353	4909	6839
300	46	97	182	374	560	1078	3038	4448	6196
350	43	89	167	344	515	992	2795	4092	5701
400	40	83	156	320	479	923	2600	3807	5303

Table 9.27 Copper Tube Sizing Between First Stage (High-Pressure Regulator) and Second Stage (Low-Pressure Regulator). Maximum undiluted propane capacities listed are based on a 10 psi first stage setting and 1 psi drop. Capacities in 1000 Btu/hr.

Tubing Length (ft)	Outside Diameter Copper Tubing, Type L				
	7/8 in. 0.785	3/8 in. 0.315	1/2 in. 0.430	5/8 in. 0.545	3/4 in. 0.666
30	309	700	1303	2205	3394
40	265	599	1115	1887	2904
50	235	531	988	1672	2574
60	213	481	896	1515	2332
70	196	443	824	1394	2146
80	182	412	767	1297	1996
90	171	386	719	1217	1873
100	161	365	679	1149	1769
150	130	293	546	923	1421
200	111	251	467	790	1216
250	90	222	414	700	1078
300	89	201	375	634	976
350	82	185	345	584	898
400	76	172	321	543	836
450	71	162	301	509	784
500	68	153	284	481	741
600	61	138	258	436	671
700	56	127	237	401	617
800	52	118	221	373	574
900	49	111	207	350	539
1000	46	105	195	331	509
1500	37	84	157	266	409
2000	32	72	134	227	350

Table 9.28 Copper Tube Sizing Between Single or Second Stage (Low-Pressure Regulator) and Appliance. Maximum undiluted propane capacities are based on an 11 in. water column setting and a 0.5 in. water column pressure drop. Capacities in 1000 Btu/hr.

Tubing Length (ft)	Outside Diameter Copper Tubing, Type L				
	3/8 in. 0.315	1/2 in. 0.430	5/8 in. 0.545	3/4 in. 0.666	7/8 in. 0.785
10	49	110	206	348	536
20	34	76	141	239	368
30	27	61	114	192	296
40	23	52	97	164	253
50	20	46	86	146	224
60	19	42	78	132	203
80	16	36	67	113	174
100	14	32	59	100	154
125	12	28	52	89	137
150	11	26	48	80	124
200	10	22	41	69	106
250	9	19	36	61	94
300	8	18	33	55	85
350	7	16	30	51	78
400	7	15	28	47	73

Table 9.29 Maximum Capacity of CSST in Thousands of Btu per Hour of Undiluted Liquefied Petroleum Gases at a Pressure of 11 in. Water Column and a Pressure Drop of 0.5 in. Water Column (Based on a 1.52 Specific Gravity Gas)

EHD* Flow Designation	Tubing Length (ft)																
	5	10	15	20	25	30	40	50	60	70	80	90	100	150	200	250	300
13	72	50	39	34	30	28	23	20	19	17	15	15	14	11	9	8	8
15	99	69	55	49	42	39	33	30	26	25	23	22	20	15	14	12	11
18	181	129	104	91	82	74	64	58	53	49	45	44	41	31	28	25	23
19	211	150	121	106	94	87	74	66	60	57	52	50	47	36	33	30	26
23	355	254	208	183	164	151	131	118	107	99	94	90	85	66	60	53	50
25	426	303	248	216	192	177	153	137	126	117	109	102	98	75	69	61	57
30	744	521	422	365	325	297	256	227	207	191	178	169	159	123	112	99	90
31	863	605	490	425	379	344	297	265	241	222	208	197	186	143	129	117	107

Note: Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$ where L is additional length (ft) of tubing and n is the number of additional fittings or bends.

*EHD — equivalent hydraulic diameter — 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 9.30 Maximum Capacity of CSST in Thousands of Btu per Hour of Undiluted Liquefied Petroleum Gases at a Pressure of 2 psi and a Pressure Drop of 1 psi (Based on 1.52 Specific Gravity Gas)

EHD* Flow Designation	Tubing Length (ft)													
	10	25	30	40	50	75	80	110	150	200	250	300	400	500
13	426	262	238	203	181	147	140	124	101	86	77	69	60	53
15	558	347	316	271	243	196	189	169	137	118	105	96	82	72
18	927	591	540	469	420	344	333	298	245	213	191	173	151	135
19	1106	701	640	554	496	406	393	350	287	248	222	203	175	158
23	1735	1120	1027	896	806	663	643	578	477	415	373	343	298	268
25	2168	1384	1266	1100	986	809	768	703	575	501	448	411	355	319
30	4097	2560	2331	2012	1794	1457	1410	1256	1021	880	785	716	616	550
31	4720	2954	2692	2323	2072	1685	1629	1454	1182	1019	910	829	716	638

Notes:

1. Table does not include effect of pressure drop across the line regulator. If regulator loss exceeds $^1/_2$ psi (based on 13 in. water column outlet pressure), DO NOT USE THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator can vary with flow rate.
2. CAUTION: Capacities shown in table can 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 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 or bends.

*EHD — equivalent hydraulic diameter — 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 9.31 Maximum Capacity of CSST in Thousands of Btu per Hour of Undiluted Liquefied Petroleum Gases at a Pressure of 5 psi and a Pressure Drop of 3.5 psi (Based on a 1.52 Specific Gravity Gas)

EHD* Flow Designation	Tubing Length (ft)													
	10	**25**	**30**	**40**	**50**	**75**	**80**	**100**	**150**	**200**	**250**	**300**	**400**	**500**
13	826	509	461	396	352	284	275	243	196	169	150	136	117	104
15	1065	664	603	520	463	376	363	324	262	226	202	183	158	140
18	1713	1092	999	867	777	637	618	553	453	393	352	322	279	251
19	2061	1307	1193	1033	926	757	731	656	535	464	415	379	328	294
23	3153	2037	1866	1629	1463	1206	1169	1051	866	755	679	622	542	488
25	3999	2554	2336	2029	1819	1492	1446	1296	1062	923	828	757	657	589
30	7829	4864	4430	3822	3409	2769	2677	2388	1941	1675	1493	1359	1173	1046
31	8945	5600	5102	4404	3929	3194	3090	2756	2241	1934	1726	1572	1356	1210

Notes:
1. Table does not include effect of pressure drop across line regulator. If regulator loss exceeds 1 psi water column, DO NOT USE THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drop across regulator can vary with the flow rate.
2. CAUTION: Capacities shown in table can 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 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 or bends.

*EHD — equivalent hydraulic diameter — 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 9.32 Polyethylene Plastic Pipe Sizing Between First-Stage and Second-Stage Regulator: Maximum undiluted propane capacities listed are based on 10 psi first-stage setting and 1 psi pressure drop. Capacities in 1000 Btu/hr.

Pipe Length (ft)	Plastic Pipe Nominal Outside Diameter (IPS) (dimensions in parenthesis are inside diameter)					
	1/2 in. SDR 9.33 (0.660)	3/4 in. SDR 11.0 (0.860)	1 in. SDR 11.00 (1.077)	1 1/4 in. SDR 10.00 (1.328)	1 1/2 in. SDR 11.00 (1.554)	2 in. SDR 11.00 (1.943)
30	2143	4292	7744	13416	20260	36402
40	1835	3673	6628	11482	17340	31155
50	1626	3256	5874	10176	15368	27612
60	1473	2950	5322	9220	13924	25019
70	1355	2714	4896	8483	12810	23017
80	1261	2525	4555	7891	11918	21413
90	1183	2369	4274	7404	11182	20091
100	1117	2238	4037	6994	10562	18978
125	990	1983	3578	6199	9361	16820
150	897	1797	3242	5616	8482	15240
175	826	1653	2983	5167	7803	14020
200	778	1539	2775	4807	7259	13043
225	721	1443	2603	4510	6811	12238
250	681	1363	2459	4260	6434	11560
275	646	1294	2336	4046	6111	10979
300	617	1235	2228	3860	5830	10474
350	567	1136	2050	3551	5363	9636
400	528	1057	1907	3304	4989	8965
450	495	992	1789	3100	4681	8411
500	468	937	1690	2928	4422	7945
600	424	849	1531	2653	4007	7199
700	390	781	1409	2441	3686	6623
800	363	726	1311	2271	3429	6161
900	340	682	1230	2131	3217	5781
1000	322	644	1162	2012	3039	5461
1500	258	517	933	1616	2441	4385
2000	221	443	798	1383	2089	3753

Table 9.33 Polyethylene Plastic Tube Sizing Between First-Stage Regulator and Second-Stage Regulator. Maximum undiluted propane capacities listed are based on 10-psi first-stage setting and 1-psi pressure drop. Capacities in 1000 Btu/hr.

	Plastic Tubing Size (CTS) (dimensions in parenthesis are inside diameter)	
Plastic Tubing Length (ft)	$^1/_2$ in. CTS SDR 7.00 (0.445)	1 in. CTS SDR 11.00 (0.927)
30	762	5225
40	653	4472
50	578	3964
60	524	3591
70	482	3304
80	448	3074
90	421	2884
100	397	2724
125	352	2414
150	319	2188
175	294	2013
200	273	1872
225	256	1757
250	242	1659
275	230	1576
300	219	1503
350	202	1383
400	188	1287
450	176	1207
500	166	1140
600	151	1033
700	139	951
800	129	884
900	121	830
1000	114	784
1500	92	629
2000	79	539

Table 9.34 Polyethylene Plastic Tube Sizing Between Single- or Second-Stage Regulator and Building. Maximum undiluted propane capacities listed are based on 11-in. water column setting and a 0.5 in. water column pressure drop. Capacities in 1000 Btu/hr.

	Plastic Tubing Size (CTS) (dimensions in parenthesis are inside diameter)	
Plastic Tubing Length (ft)	$^1/_2$ in. CTS SDR 7.00 (0.445)	1 in. CTS SDR 11.00 (0.927)
10	121	829
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 10 Sizing of Category I Venting Systems

10.1 Additional Requirements to Single Appliance Vent Tables 10.1 Through 10.5

10.1.1 These venting tables shall not be used where obstructions, as described in the exceptions to Section 7.15, 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.

10.1.2 If the vent size determined from the tables is smaller than the appliance draft hood outlet or flue collar, the smaller size shall be permitted to be used, provided the following requirements are met:

(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.

10.1.3 Single-appliance venting configurations with zero (0) lateral lengths in Tables 10.1, 10.2, and 10.5 shall have no elbows in the venting system. For vent configurations with lateral lengths, the venting tables include allowance for two 90 degree turns. For each additional 90 degree turn, or equivalent, the maximum capacity listed in the venting tables shall be reduced by 10 percent (0.90 × maximum table capacity). Two or more turns, the combined angles of which equal 90 degrees, shall be considered equivalent to one 90 degree turn.

10.1.4 Zero (0) lateral *(L)* shall apply only to a straight vertical vent attached to a top outlet draft hood or flue collar.

10.1.5 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.

10.1.6 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.

10.1.7 Listed corrugated metallic chimney liner systems in masonry chimneys shall be sized by using Table 10.1 or 10.2 for Type B vents with the maximum capacity reduced by 20 percent (0.80 × maximum capacity) and the minimum capacity as shown in Table 10.1 or 10.2. Corrugated metallic liner systems installed with bends or offsets shall have their maximum capacity further reduced in accordance with 10.1.3.

10.1.8 If the vertical vent has a larger diameter than the vent connector, the vertical vent diameter shall be used to determine the minimum vent capacity, and the connector diameter shall be used to determine the maximum vent capacity. The flow area of the vertical vent shall not exceed seven times the flow area of the listed appliance categorized vent area, flue collar area, or draft hood outlet area unless designated in accordance with approved engineering methods.

10.1.9 Tables 10.1 through 10.5 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 10.3 in combination with Table 10.11 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 $1^1/_2$ ft for each inch (180 mm/mm) of vent connector diameter.

(3) The appliance is draft hood–equipped.

(4) The input rating is less than the maximum capacity given by in Table 10.3.

(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 10.11.

Exception: The installation of vents serving listed appliances shall be permitted to be in accordance with the appliance manufacturer's instructions and the terms of the listing.

10.1.10 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.

10.1.11 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.

10.1.12 Interpolation shall be permitted in calculating capacities for vent dimensions that fall between table entries. *(See Example 3, Appendix G.)*

10.1.13 Extrapolation beyond the table entries shall not be permitted.

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.

10.1.14 For vent heights lower than 6 ft and higher than shown in the tables, engineering methods shall be used to calculate vent capacities.

Table 10.1 Capacity of Type B Double-Wall Gas Vents When Connected Directly to a Single Category I Appliance

		Vent Diameter — *D*																					
		3 in.			4 in.			5 in.			6 in.			7 in.			8 in.			9 in.		
		Appliance Input Rating in Thousands of Btu per Hour																					
Height *H* (ft)	Lateral *L* (ft)	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 10.1 Capacity of Type B Double-Wall Gas Vents When Connected Directly to a Single Category I Appliance (Continued)

		Vent Diameter — *D*																					
		10 in			12 in.			14 in.			16 in.			18 in.			20 in.			22 in.			24 in.		
		Appliance Input Rating in Thousands of Btu per Hour																					
Height *H* (ft)	Lateral *L* (ft)	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	10393	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	11753	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	11483	5850	0	13848	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	11129	5635	0	13767	6940	0	16694	8430
	2	41	1620	1010	66	2431	1513	86	3409	2125	113	4554	2840	141	5864	3670	171	7339	4630	209	8980	5695	251	10788	6860
	5	90	1600	996	118	2406	1495	151	3380	2102	191	4520	2813	234	5826	3639	283	7295	4597	336	8933	5654	394	10737	6818
	10	118	1567	972	154	2366	1466	196	3332	2064	243	4464	2767	295	5763	3585	355	7224	4542	419	8855	5585	491	10652	6749
	15	136	1536	948	177	2327	1437	222	3285	2026	274	4409	2721	330	5701	3534	396	7155	4511	465	8779	5546	542	10570	6710
	20	151	1505	924	195	2288	1408	244	3239	1987	300	4356	2675	361	5641	3481	433	7086	4479	506	8704	5506	586	10488	6670
	30	183	1446	876	232	2214	1349	287	3150	1910	347	4253	2631	412	5523	3431	494	6953	4421	577	8557	5444	672	10328	6603
100	0	0	2491	1310	0	3925	2050	0	5729	2950	0	7914	4050	0	10485	5300	0	13454	6700	0	16817	8600	0	20578	10300
	2	30	1975	1170	44	3027	1820	72	4313	2550	95	5834	3500	120	7591	4600	138	9577	5800	169	11803	7200	204	14264	8800
	5	82	1955	1159	107	3002	1803	136	4282	2531	172	5797	3475	208	7548	4566	245	9528	5769	293	11748	7162	341	14204	8756
	10	108	1923	1142	142	2961	1775	180	4231	2500	223	5737	3434	268	7478	4509	318	9447	5717	374	11658	7100	436	14105	8683
	15	126	1892	1124	163	2920	1747	206	4182	2469	252	5678	3392	304	7409	4451	358	9367	5665	418	11569	7037	487	14007	8610
	20	141	1861	1107	181	2880	1719	226	4133	2438	277	5619	3351	330	7341	4394	387	9289	5613	452	11482	6975	523	13910	8537
	30	170	1802	1071	215	2803	1663	265	4037	2375	319	5505	3267	378	7209	4279	446	9136	5509	514	11310	6850	592	13720	8391
	50	241	1688	1000	292	2657	1550	350	3856	2250	415	5289	3100	486	6956	4050	572	8841	5300	659	10979	6600	752	13354	8100

Table 10.2 Capacity of Type B Double-Wall Vents with Single-Wall Metal Connectors Serving a Single Category I Appliance

Height *H* (ft)	Lateral *L* (ft)	Vent Diameter — *D*																											
		3 in.			4 in.			5 in.			6 in.			7 in.			8 in.			9 in.			10 in.			12 in.		
		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	FAN		NAT
		Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max
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

Table 10.3 Capacity of Masonry Chimney Flue with Type B Double-Wall Vent Connectors Serving a Single Category I Appliance

Height *H* (ft)	Lateral *L* (ft)	Type B Double-Wall Connector Diameter — *D* To be used with chimney areas within the size limits at bottom																											
		3 in.			4 in.			5 in.			6 in.			7 in.			8 in.			9 in.			10 in.			12 in.		
		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	FAN		NAT
		Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max
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	

Table 10.4 Capacity of Masonry Chimney Flue with Single-Wall Vent Connectors Serving a Single Category I Appliance

Height *H* (ft)	Lateral *L* (ft)	Single-Wall Metal Connector Diameter — *D* To be used with chimney areas within the size limits at bottom																																	
		3 in.				4 in.				5 in.				6 in.				7 in.				8 in.				9 in.				10 in.				12 in.			
		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	FAN			NAT
		Min		Max	Max	Min		Max	Max	Min		Max	Max	Min		Max	Max	Min		Max	Max	Min		Max	Max	Min		Max	Max	Min		Max	Max	Min		Max	Max
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	

Table 10.5 Capacity of Single-Wall Metal Pipe or Type B Asbestos Cement Vents Serving a Single Draft Hood–Equipped Appliance

Height *H* (ft)	Lateral *L* (ft)	Vent Diameter — *D*							
		3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	10 in.	12 in.
		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

10.2 Additional Requirements to Multiple Appliance Vent Tables 10.6 Through 10.13(a) and (b).

10.2.1 These venting tables shall not be used where obstructions, as described in the exceptions to Section 7.15, 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.
   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.

10.2.2 The maximum vent connector horizontal length shall be 18 in./in. (180 mm/mm) of connector diameter as follows:

Connector Diameter Maximum (in.)	Connector Horizontal Length (ft)
3	$4^1/_2$
4	6
5	$7^1/_2$
6	9
7	$10^1/_2$
8	12
9	$13^1/_2$
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.

10.2.3 The vent connector shall be routed to the vent utilizing the shortest possible route. Connectors with longer horizontal lengths than those listed in 10.2.2 are permitted under the following conditions:

(a) 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 10.2.2. 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).

(b) 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 10.1 shall be used. For single-wall connectors, Table 10.2 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.

10.2.4 If the vent connectors are combined prior to entering the common vent, the maximum common vent capacity listed in the common venting tables shall be reduced by 10 percent (0.90 × maximum common vent capacity). The length of the common vent connector manifold *(LM)* shall not exceed 18 in./in. (180 mm/mm) of common vent connector manifold diameter *(D). (See Figure G.11.)*

10.2.5 If the common vertical vent is offset as shown in Figure G.12, the maximum common vent capacity listed in the common venting tables shall be reduced by 20 percent (0.80 × maximum common vent capacity), the equivalent of two 90 degree turns. The horizontal length of the common vent offset *(LM)* shall not exceed 18 in./in. (180 mm/mm) of common vent diameter *(D).*

10.2.6 Excluding elbows counted in 10.2.5, for each additional 90 degree turn in excess of two, the maximum capacity of that portion of the venting system shall be reduced by 10 percent (0.90 × maximum common vent capacity). Two or more turns, the combined angles of which equal 90 degrees, shall be considered equivalent to one 90 degree turn.

10.2.7 The cross-sectional area of the common vent shall be equal to or greater than the cross-sectional area of the largest connector.

10.2.8 Interconnection fittings shall be the same size as the common vent.

10.2.9 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.

10.2.10 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.

10.2.11 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.

10.2.12 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.)*

10.2.13 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 10.1 or 10.2 for available total height *(H)* up to the lowest interconnection. *(See Figure G.14.)*

10.2.14 Where used in multistory systems, vertical common vents shall be Type B double-wall and shall be installed with a listed vent cap. A multistory common vertical vent shall be permitted to have a single offset, provided all the following requirements are met:

(1) The offset angle does not exceed 45 degrees.
(2) The horizontal length of the offset does not exceed 18 in./in. (180 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 is reduced by 20 percent (0.80 × maximum common vent capacity).
(4) A multistory common vent shall not be reduced in size above the offset.

10.2.15 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.

10.2.16 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.

10.2.17 Listed, corrugated metallic chimney liner systems in masonry chimneys shall be sized by using Table 10.6 or 10.7 for Type B vents, with the maximum capacity reduced by 20 percent (0.80 × maximum capacity) and the minimum capacity as shown in Table 10.6 or 10.7. Corrugated metallic liner systems installed with bends or offsets shall have their maximum capacity further reduced in accordance with 10.2.5 and 10.2.6.

10.2.18 Tables 10.6 through 10.10 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. Tables 10.12(a) and (b) and 10.13(a) and (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 10.12(a) (for NAT+NAT) or Table 10.13(a) (for FAN+NAT).
(4) The input rating of each space-heating appliance is greater than the minimum input rating given by Table 10.12(b) (for NAT+NAT) or Table 10.13(b) (for FAN+NAT).
(5) The vent connector sizing is in accordance with Table 10.8.

If these conditions cannot be met, an alternative venting design shall be used, such as a listed chimney lining system.

Exception: The installation of vents serving listed appliances shall be permitted to be in accordance with the appliance manufacturer's instructions and the terms of the listing.

10.2.19 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. Vent connectors for draft hood–equipped appliances shall not be smaller than the draft hood outlet diameter. If a vent connector size(s) determined from the tables for a fan-assisted appliance(s) is smaller than the flue collar diameter, the smaller size(s) shall be permitted to be used provided the following conditions are met:

(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).

10.2.20 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. If single-wall and Type B double-wall metal pipes are used for vent connectors, the common vent must be sized using Table 10.7 or 10.9 as appropriate.

10.2.21 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.

10.2.22 Interpolation shall be permitted in calculating capacities for vent dimensions that fall between table entries. *(See Example 3, Appendix G.)*

10.2.23 Extrapolation beyond the table entries shall not be permitted.

10.2.24 For vent heights lower than 6 ft and higher than shown in the tables, engineering methods shall be used to calculate vent capacities.

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 10.6 Capacity of Type B Double-Wall Vents with Type B Double-Wall Connectors Serving Two or More Category I Appliances

Vent Connector Capacity

Vent Height *H* (ft)	Connector Rise *R* (ft)	Type B Double-Wall Vent and Connector Diameter — *D*																							
		3 in.			4 in.			5 in.			6 in.			7 in.			8 in.			9 in.			10 in.		
		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*																				
	4 in.			5 in.			6 in.			7 in.			8 in.			9 in.			10 in.		
	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 10.6 Vent Connector Capacity *(Continued)*

Vent Height H (ft)	Connector Rise R (ft)	Type B Double-Wall Vent and Connector Diameter — D																				
		12 in.			14 in.			16 in.			18 in.			20 in.			22 in.			24 in.		
		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																				
	12 in.			14 in.			16 in.			18 in.			20 in.			22 in.			24 in.		
	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	10681	8648	5920	13004	10499	7200

Table 10.7 Capacity of Type B Double-Wall Vent with Single-Wall Connectors Serving Two or More Category I Appliances

Vent Connector Capacity

Vent Height *H* (ft)	Connector Rise *R* (ft)	Single-Wall Metal Vent Connector Diameter — *D*																					
		3 in.			4 in.			5 in.			6 in.			7 in.			8 in.			9 in.			10 in.		
		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*																				
	4 in.			5 in.			6 in.			7 in.			8 in.			9 in.			10 in.		
	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

Table 10.8 Capacity of Masonry Chimney with Type B Double-Wall Connectors Serving Two or More Category I Appliances

Vent Connector Capacity

Vent Height *H* (ft)	Connector Rise *R* (ft)	Type B Double-Wall Vent Connector Diameter — *D*																							
		3 in.			4 in.			5 in.			6 in.			7 in.			8 in.			9 in.			10 in.		
		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 10.9 Capacity of Masonry Chimney with Single-Wall Connectors Serving Two or More Category I Appliances

Vent Connector Capacity

Vent Height *H* (ft)	Connector Rise *R* (ft)	Single-Wall Metal Vent Connector Diameter — *D*																					
		3 in.			4 in.			5 in.			6 in.			7 in.			8 in.			9 in.			10 in.		
		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	NAT	FAN	FAN	NAT	FAN	FAN	NAT	FAN	FAN	NAT	FAN	FAN	NAT	FAN	FAN	NAT	FAN	FAN	NAT	FAN	FAN	NAT
	+FAN	+NAT	+NAT	+FAN	+NAT	+NAT	+FAN	+NAT	+NAT	+FAN	+NAT	+NAT	+FAN	+NAT	+NAT	+FAN	+NAT	+NAT	+FAN	+NAT	+NAT	+FAN	+FAN	+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

Table 10.10 Capacity of Single-Wall Metal Pipe or Type B Asbestos Cement Venting Serving Two or More Draft Hood-Equipped Appliances

Vent Connector Capacity

Total Vent Height *H* (ft)	Connector Rise *R* (ft)	Vent Connector Diameter — *D*					
		3 in.	4 in.	5 in.	6 in.	7 in.	8 in.
		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						
	4 in.	5 in.	6 in.	7 in.	8 in.	10 in.	12 in.
	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.6 and Section 10.2.

Table 10.11 Exterior Masonry Chimney, Single NAT Installations with Type B Double-Wall Vent Connectors Minimum Allowable Input Rating of Space-Heating Appliance in Thousands of Btu per Hour

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.

Table 10.12(a) Exterior Masonry Chimney, NAT+NAT Installations with Type B Double-Wall Vent Connectors: Combined Appliance Maximum Input Rating in Thousands of Btu per Hour

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

Table 10.12(b) Exterior Masonry Chimney, NAT+NAT Installations with Type B Double-Wall Vent Connections: Minimum Allowable Input Rating of Space-Heating Appliance in Thousands of Btu per Hour

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

Table 10.12(b) Exterior Masonry Chimney, NAT+NAT Installations with Type B Double-Wall Vent Connections: Minimum Allowable Input Rating of Space-Heating Appliance in Thousands of Btu per Hour *(Continued)*

Vent Height *H* (ft)	Internal Area of Chimney (in.^{2})							
	12	19	28	38	50	63	78	113
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.

Table 10.13(a) Exterior Masonry Chimney, FAN+NAT Installations with Type B Double-Wall Vent Connectors: Combined Appliance Maximum Input Rating in Thousands of Btu per Hour

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

Table 10.13(b) Exterior Masonry Chimney, FAN+NAT Installations with Type B Double-Wall Vent Connectors: Minimum Allowable Input Rating of Space-Heating Appliance in Thousands of Btu per Hour

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

Table 10.13(b) Exterior Masonry Chimney, FAN+NAT Installations with Type B Double-Wall Vent Connectors: Minimum Allowable Input Rating of Space-Heating Appliance in Thousands of Btu per Hour ***(Continued)***

Vent Height *H* (ft)	Internal Area of Chimney (in.^{2})							
	12	**19**	**28**	**38**	**50**	**63**	**78**	**113**
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.

Chapter 11 Referenced Publications

11.1 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. Some of these mandatory documents might also be referenced in this code for specific informational purposes and, therefore, are also listed in Appendix M.

11.1.1 ASME Publications. American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017.

ANSI/ASME B1.20.1, *Pipe Threads, General Purpose, Inch,* 1983 (Reaffirmed 1992).

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,* 1993.

ANSI/ASME B36.10, *Welded and Seamless Wrought-Steel Pipe,* 1996.

11.1.2 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless,* 1999.

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,* 1997.

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,* 1996.

ASTM B 210, *Specification for Aluminum-Alloy Drawn Seamless Tubes,* 1995.

ASTM B 241, *Specification for Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube,* 1996.

ASTM B 280, *Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service,* 1997.

ASTM C 64, *Specification for Refractories for Incinerators and Boilers,* 1994.

ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings,* 1999.

11.1.3 CSA International Publications. CSA International, 8501 East Pleasant Valley Road, Cleveland, OH 44131.

ANSI Z21.8, *Installation of Domestic Gas Conversion Burners,* 1994.

ANSI Z21.18/CGA 6.3, *Gas Appliance Pressure Regulators,* 1995.

ANSI Z21.69, *Connectors for Movable Gas Appliances,* 1997.

ANSI Z21.80, *Line Pressure Regulators,* 1997.

ANSI Z83.18, *Direct Gas-Fired Industrial Air Heaters,* 1990 (1998).

ANSI LC 1/CSA 6.26, *Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing,* 1997.

11.1.4 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.

11.1.5 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 30A, *Automotive and Marine Service Station Code,* 1996 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines,* 1998 edition.

NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes,* 1997 edition.

NFPA 52, *Standard for Compressed Natural Gas (CNG) Vehicular Fuel Systems,* 1998 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 1998 edition.

NFPA 70, *National Electrical Code®,* 1999 edition.

NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment,* 1999 edition.

NFPA 88A, *Standard for Parking Structures,* 1998 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* 1999 edition.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems,* 1999 edition.

NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations,* 1998 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances,* 1996 edition.

NFPA 409, *Standard on Aircraft Hangars,* 1995 edition.

NFPA 1192, *Standard on Recreational Vehicles,* 1999 edition.

11.1.6 U.S. Government Publication. U.S. Government Printing Office, Washington, DC 20402.

Code of Federal Regulations, Title 49, Part 192.

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this code but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.5.2 See Appendix D for a method of leakage testing.

A.1.7 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.1.7 Authority Having Jurisdiction. The phrase "authority having jurisdiction" 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, 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 delegated 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.1.7 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.1.7 Vented Appliance Categories I–IV. For additional information on appliance categorization, see the appropriate Z21 and Z83 American National Standards.

A.1.7 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.2.4.1 The size of gas piping depends on the following factors:

(1) Allowable loss in pressure *(see 2.4.4)* 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.2.4.2 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 C.2 in Appendix C shows the approximate demand of typical appliances by types.

A.2.4.3 *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 9.

Tables 9.1 through 9.12 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 9.13.

For any gas piping system, for special gas utilization equipment, or for conditions other than those covered by the capacity tables in Chapter 9, such as longer runs, greater gas demands, or greater pressure drops, the size of each gas piping system should be determined 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 Appendix C.

A.2.5.1(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.2.6.2(c) 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.2.6.3(b) See A.2.6.2(c).

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.2.6.8(a) 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.2.7 This section applies to premises-owned meters *[see 1.1.1(b)16].*

A.2.8 This section applies to premises-owned regulators *[see 1.1.1(b)16].*

A.3.1.3 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.3.1.4 The gas supplier can be consulted for recommendations.

A.3.5.3 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.3.6.3 Care should be taken in making mitered joints to provide proper root opening and alignment and full weld penetration.

A.3.13.4 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.3.13.5(a) For information on venting of deflagrations, see NFPA 68, *Guide for Venting of Deflagrations.*

A.3.13.5(d) Additional interlocks might be necessary for safe operation of equipment supplied by the gas-mixing machine.

A.3.13.6(a) 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.4.1.1 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.4.2.3 See Appendix D for a suggested method.

A.4.3 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.5.1.1 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 1.7)* 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 Appendix B.

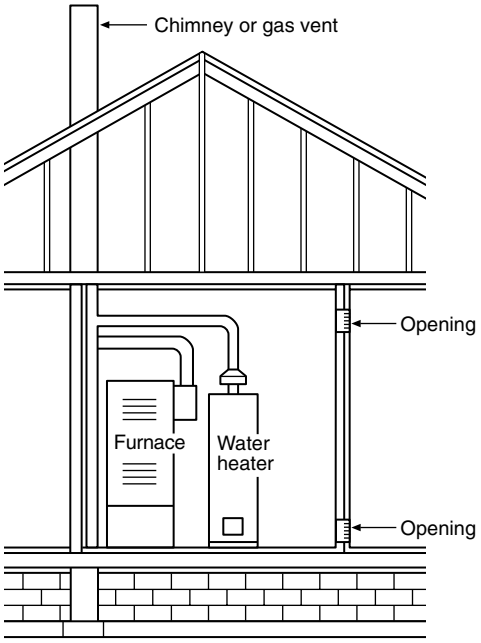
A.5.1.6 Halogenated hydrocarbons are particularly injurious and corrosive after contact with flames or hot surfaces.

A.5.3 *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.5.3.2 In unconfined spaces in buildings of other than unusually tight construction *(see Section 1.7)*, infiltration can be adequate to provide air for combustion, ventilation, and dilution of flue gases.

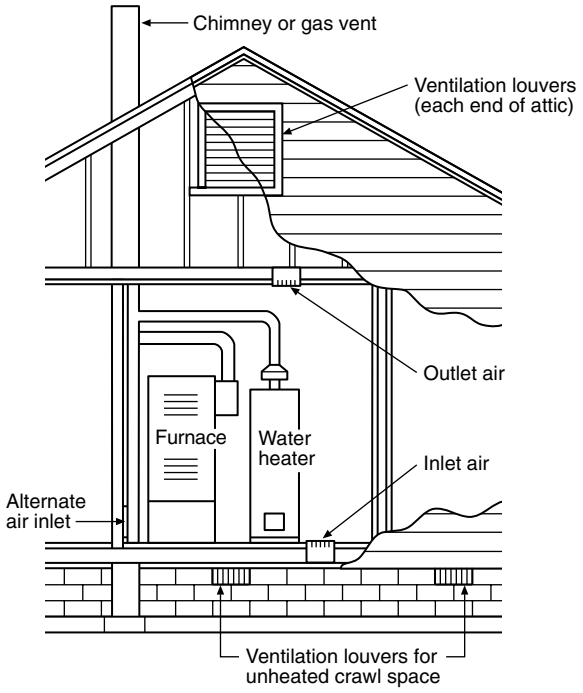
A.5.3.3(a) See Figure A.5.3.3(a).

Figure A.5.3.3(a) Equipment located in confined spaces; all air from inside the building. ***[See 5.3.3(a).]***



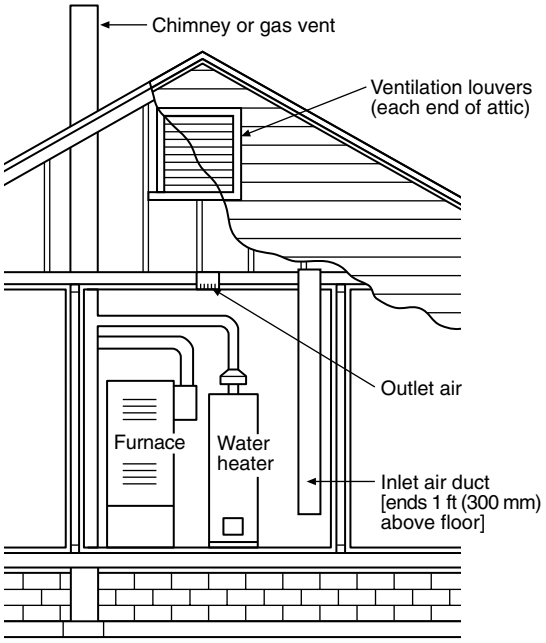
A.5.3.3(b)1a See Figure A.5.3.3(b)1a1.

Figure A.5.3.3(b)1a1 Equipment located in confined spaces; all air from outdoors — inlet air from ventilated crawl space and outlet air to ventilated attic. ***[See 5.3.3(b).]***



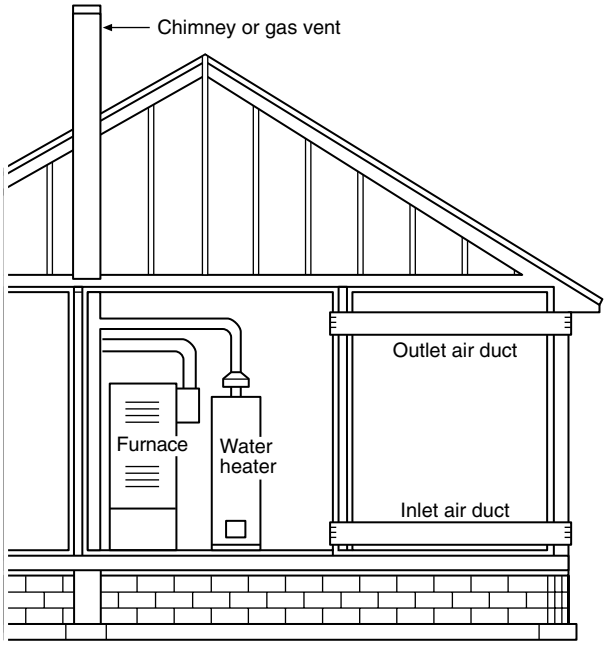
A.5.3.3(b)1a2 See Figure A.5.3.3(b)1a2.

Figure A.5.3.3(b)1a2 Equipment located in confined spaces; all air from outdoors through ventilated attic. ***[See 5.3.3(b).]***



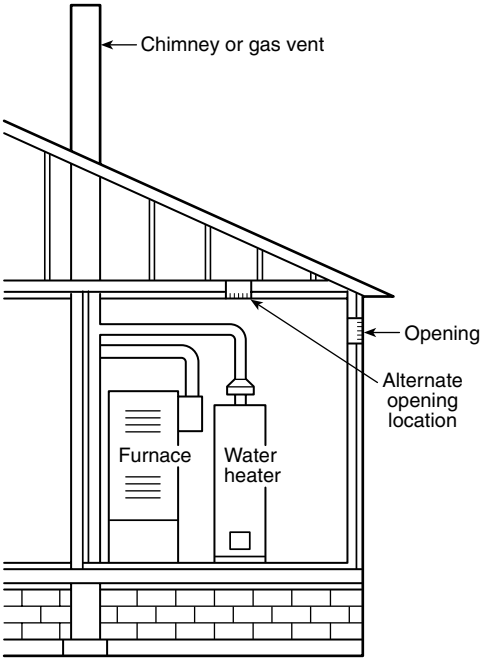
A.5.3.3(b)1b See Figure A.5.3.3(b)1b.

Figure A.5.3.3(b)1b Equipment located in confined spaces; all air from outdoors. ***[See 5.3.3(b).]***



A.5.3.3(b)2 See Figure A.5.3.3(b)2.

Figure A.5.3.3(b)2 Equipment located in confined spaces; single combustion air opening, all air from the outdoors. ***[See 5.3.3(b).]***



A.5.5.6 For information on gas convenience outlets, see *Requirements for Gas Convenience Outlets,* AGA 7-90.

A.6.1(b) Also see Prohibited Installations, 6.6.1, 6.7.1, 6.24.1, and 6.29.1.

A.6.2.6 Reference can be made to ANSI/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.6.3.5 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.6.3.6(c) 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.*

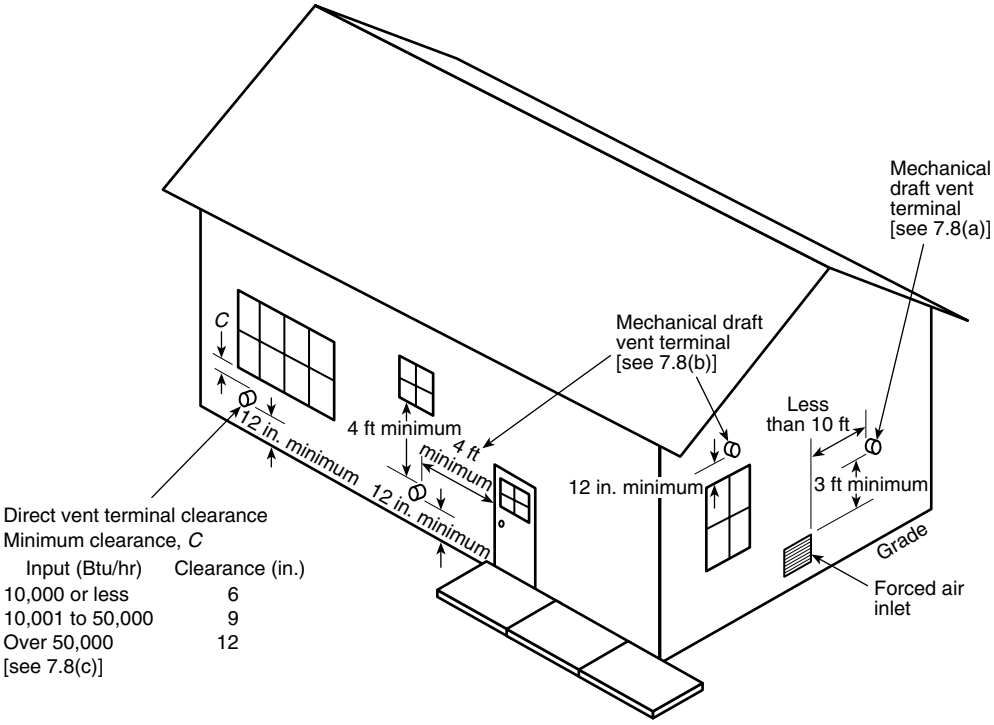
A.6.6.1 For information on decorative appliances for installation in vented fireplaces, see ANSI Z21.60, *Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces.*

A.6.7.1 For information on vented gas fireplaces, see ANSI Z21.50, *Vented Gas Fireplaces.*

A.6.9.5 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.6.12.8 Where exhaust fans are used for ventilation, precautions might be necessary to avoid interference with the operation of the equipment.

Figure A.7.8 Exit terminals of mechanical draft and direct-vent venting systems.



For SI units: 1 ft = 0.305 m; 1 in. = 25.4 mm;
1 Btu/hr = 0.293 W

A.6.24.1 It is recommended that space heating appliances installed in all bedrooms or rooms generally kept closed be of the direct vent type. *(See Section 6.28.)*

A.6.29.9 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.7.2.3 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.7.3.5 See A.7.2.3.

A.7.5.1(c) For information on the installation of gas vents in existing masonry chimneys, see Section 7.6.

A.7.5.5(c) Reference can also be made to the chapter on chimney, gas vent, and fireplace systems of the *ASHRAE Handbook — HVAC Systems and Equipment.*

A.7.6.3(a) Additional information on sizing venting systems can be found in the following:

(1) Tables in Chapter 10
(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.7.7.5(a) Reference can also be made to the chapter on chimney, gas vent, and fireplace systems of the *ASHRAE Handbook — HVAC Systems and Equipment.*

A.7.8 See Figure A.7.8.

A.7.10.3 Reference can also be made to the chapter on chimney, gas vent, and fireplace systems of the *ASHRAE Handbook — HVAC Systems and Equipment.*

A.7.10.9(b) See A.7.6.3(a).

A.7.12.4 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.7.12.4 shows examples of correct and incorrect locations for barometric draft regulators.

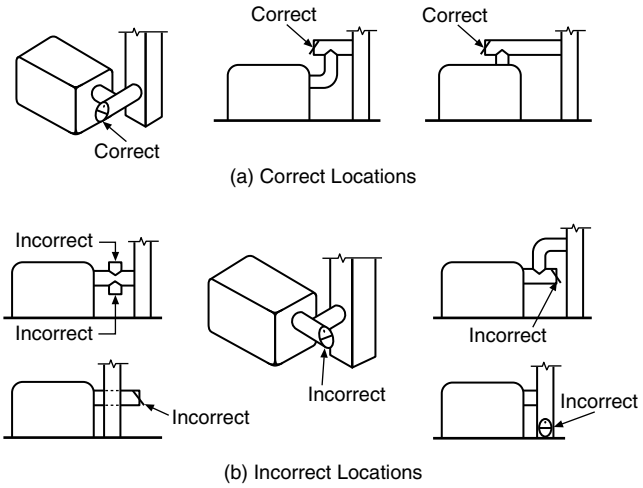
A.8.1.1 Checking Burner Input.

(a) *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 $^1/_2$, 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 8.1.1.

(b) *Checking Burner Input Not Using a Meter.* The fixed orifice size for each burner can be determined in accordance

with Table F.1 for utility gases and Table F.2 for undiluted liquefied petroleum gases.

Figure A.7.12.4 Locations for barometric draft regulators.



A.8.2 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.8.6 A procedure for checking draft can be found in Appendix H, steps 7, 8, and 10 through 14.

Appendix B Coordination of Gas Utilization Equipment Design, Construction, and Maintenance

This appendix 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 expectation
(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 2.6. 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 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 Appendix M 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 4.1.5. 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.

Appendix C Sizing and Capacities of Gas Piping

This appendix is not a part of the requirements of this code but is included for informational purposes only.

C.1 General. In determining the size of piping to be used in designing 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, for special gas utilization equipment, or for conditions other than those covered by Tables 9.1, 9.2, 9.13, and 9.14, or Tables 9.26, 9.27, or 9.28 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.

(a) 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 to be installed. In case the ratings of the equipment to be installed are not known, Table C.2 shows the approximate consumption of average appliances of certain types in Btu per hour.

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 feet of gas. The average Btu per cubic feet of gas in the area of the installation can be obtained from the serving gas supplier.

Table C.2 Approximate Gas Input for Typical Appliances

Appliance	Input Btu/hr (Approx.)
Range, free-standing, domestic	65,000
Built-in oven or broiler unit, domestic	25,000
Built-in top unit, domestic	40,000
Water heater, automatic storage	
30- to 40-gal tank	45,000
Water heater, automatic storage	
50 gal tank	55,000
Water heater, automatic instantaneous	
Capacity at 2 gal/minute	142,800
Capacity at 4 gal/minute	285,000
Capacity at 6 gal/minute	428,400
Water heater, domestic, circulating, or side-arm	35,000
Refrigerator	3,000
Clothes dryer, Type 1 (domestic)	35,000
Gas light	2,500
Incinerator, domestic	35,000

For SI units, 1 Btu per hour = 0.293 W.
Note: For specific appliances or appliances not shown, the input should be determined from the manufacturer's rating.

(b) Capacities for gas at low pressure [0.5 psi (35 kPa) or less] in cubic feet per hour of 0.60 specific gravity gas for different sizes and lengths are shown in Tables 9.1 and 9.2 for iron pipe or equivalent rigid pipe, in Tables 9.13 and 9.14 for smooth wall semirigid tubing, and in Tables 9.19, 9.20, and 9.21 for corrugated stainless steel tubing. Tables 9.1 and 9.3 are based on a pressure drop of 0.3 in. (75 Pa) water column, whereas Tables 9.2, 9.14, and 9.17 are based upon a pressure drop of 0.5 in. (125 Pa) water column. Tables 9.20 and 9.21 are special low-pressure applications based upon pressure drops greater than 0.5 in. water column (125 Pa). In using these tables, no additional allowance is necessary for an ordinary number of fittings.

(c) Capacities in thousands of Btu per hour of undiluted liquefied petroleum gases based on a pressure drop of 0.5 in. (125 Pa) water column for different sizes and lengths are shown in Table 9.25 for iron pipe or equivalent rigid pipe, in Table 9.26 for smooth wall semi-rigid tubing, and in Table 9.29 for corrugated stainless steel tubing. Tables 9.30 and 9.31 for corrugated stainless steel tubing are based on pressure drops greater than 0.5 in. water column (125 Pa). In using these tables, no additional allowance is necessary for an ordinary number of fittings.

(d) Gas piping systems that are to be supplied with gas of a specific gravity of 0.70 or less can be sized directly from Tables 9.1, 9.2, 9.13, and 9.14, 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 Tables 9.1, 9.2, 9.13, and 9.14 to capacities with another gas of different specific gravity. Such application is accomplished by multiplying the capacities given in Tables 9.1, 9.2, 9.13, and 9.14 by the multipliers shown in Table 9.24. In case the exact specific gravity does not appear in the table, choose the next higher value specific gravity shown.

(e) Capacities for gas at pressures greater than 0.5 psi (3.5 kPa) in cubic feet per hour of 0.60 specific gravity gas for different sizes and lengths are shown in Tables 9.5 to 9.12 for iron pipe or equivalent rigid pipe and Tables 9.29 and 9.30 for corrugated stainless steel tubing.

C.3 Use of Capacity Tables. 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 calculation in Section C.4.)*

(a) Determine the gas demand of each appliance to be attached to the piping system. Where Tables 9.1, 9.2, 9.13, and 9.14 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 Tables 9.25 through 9.27 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.

(b) 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 the specific gravity of the gas to be used in the piping system.

(c) Measure the length of piping from the point of delivery to the most remote outlet. Where a multipressure gas piping system is used, gas piping shall be sized for the maximum length of pipe measured from the gas pressure regulator to the most remote outlet of each similarly pressure section.

(d) In the appropriate capacity table, select the column 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 column of the table are multiplied by the appropriate multiplier from Table 9.24.

Capacities of smooth wall pipe or tubing can also be determined by using the following formulas:

High Pressure [1.5 psi (10.3 kPa) and above]:

$$Q = 181.6\sqrt{\frac{D^5 \cdot (P_1^2 - P_2^2) \cdot Y}{Cr \cdot fba \cdot L}}$$

$$= 2237 D^{2.623}\left[\frac{(P_1^2 - P_2^2) \cdot Y}{Cr \cdot L}\right]^{0.541}$$

Table C.3 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	$R/d = 1$	$R/d = 1^1/_3$	$R/d = 2$	$R/d = 4$	$R/d = 6$	$R/d = 8$
k factor =		0.42	0.90	2.00	1.80	0.48	0.36	0.27	0.21	0.27	0.36
$L/d^{\prime}$ 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]											
$^1/_2$	0.622	0.73	1.55	3.47	3.10	0.83	0.62	0.47	0.36	0.47	0.62
$^3/_4$	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
$1^1/_4$	1.380	1.61	3.45	7.66	6.90	1.84	1.38	1.03	0.81	1.03	1.38
$1^1/_2$	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
$2^1/_2$	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

Table C.3 ***(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
										
***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 foot = 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 $2^1/_2 d$.

[6]For pipe having other inside diameters, the equivalent resistance may be computed from the above n values.

Source: From *Piping Handbook*, by Sabin Crocker, 4th Ed., Copyright 1945 by McGraw-Hill, Inc., Table XIV, pp. 100–101. Used by permission of McGraw-Hill Book Company.

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, cu ft per hr 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

NOTE: For Y values for natural gas, refer to *Manual for Determination of Supercompressibility Factors for Natural Gas,* available from American Gas Association, 400 N. Capitol St., NW, Washington, DC 20001. For values for liquefied petroleum gases, refer to Engineering Data Book, available from Gas Processors Association, 1812 First Place, Tulsa, Oklahoma 74102.

Cr = factor for viscosity, density, and temperature

$$= 0.00354 ST\left(\frac{Z}{S}\right)^{0.152}$$

S = specific gravity of gas at 60°F and 30 in. mercury column
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 1488μ
m = viscosity, pounds per second ft
fba = base friction factor for air at 60°F (CF=1)
L = length of pipe, ft
ΔH = pressure drop, in. water column (27.7 in. H_2O =1 psi)
CF = factor $CF = \left(\frac{fb}{fba}\right)$
fb = base friction factor for any fluid at a given temperature, °F

NOTE: For further details on the formulas, refer to "Polyflo Flow Computer," available from Polyflo Company, 3412 High Bluff, Dallas, Texas 75234.

(e) Use this vertical column to locate ALL gas demand figures for this particular system of piping.

(f) Starting at the most remote outlet, find in the vertical column just selected the gas demand for that outlet. If the exact figure of demand is not shown, choose the next larger figure below in the column.

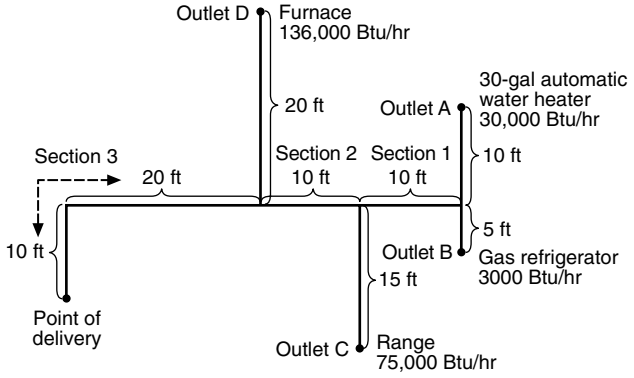
(g) Opposite this demand figure, in the first column at the left, will be found the correct size of gas piping.

(h) 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.

The equivalent lengths in feet shown in Table C.3 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 can be made by multiplying the actual inside diameter of the pipe in inches by $n/12$, or the actual inside diameter in ft 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. 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. Resistance per foot of copper or brass pipe is less than that of steel.

C.4 Example of Piping System Design. Determine the required pipe size of each section and outlet of the piping system shown in Figure C.4, with a designated pressure drop of 0.50 in. water column (125 Pa). The gas to be used has 0.65 specific gravity and a heating value of 1000 Btu/ft^3 (37.5 MJ/m^3).

Figure C.4 Piping plan.



For SI units: 1 ft = 0.305 m; 1 gal = 3.785 L; 1000 Btu/hr = 0.293 kW

C.4.1 Exhibit 1. *Solution*

(a) Maximum gas demand for outlet A:

$$\frac{\text{Consumption (rating plate input, or Table C.2 if necessary)}}{\text{Btu of gas}} = \frac{30{,}000 \text{ Btu/hr rating}}{1000 \text{ Btu/ft}^3} = 30 \text{ ft}^3\text{/hr}$$

Maximum gas demand for outlet B:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{3000}{1000} = 3 \text{ ft}^3\text{/hr}$$

Maximum gas demand for outlet C:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{75{,}000}{1000} = 75 \text{ ft}^3\text{/hr}$$

Maximum gas demand for outlet D:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{136{,}000}{1000} = 136 \text{ ft}^3\text{/hr}$$

(b) 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.

(c) Using the column marked 60 ft (18.3 m) in Table 9.2:

(1) Outlet A, supplying 30 ft^3/hr (0.8 m^3/hr), requires $^3/_8$-in. pipe.
(2) Outlet B, supplying 3 ft^3/hr (0.08 m^3/hr), requires $^1/_4$-in. pipe.
(3) Section 1, supplying outlets A and B, or 33 ft^3/hr (0.9 m^3/hr), requires $^3/_8$-in. pipe.
(4) Outlet C, supplying 75 ft^3/hr (2.1 m^3/hr), requires $^3/_4$-in. pipe.
(5) Section 2, supplying outlets A, B, and C, or 108 ft^3/hr (3.0 m^3/hr), requires $^3/_4$-in. pipe.
(6) Outlet D, supplying 136 ft^3/hr (3.8 m^3/hr), requires $^3/_4$-in. pipe.
(7) Section 3, supplying outlets A, B, C, and D, or 244 ft^3/hr (6.8 m^3/hr), requires 1-in. pipe.

(d) If the gravity factor *[see C.2(d)]* is applied to this example, the values in the column marked 60 ft (18.3 m) of Table 9.2 would be multiplied by the multiplier (0.962) from Table 9.13 and the resulting cubic feet per hour values would be used to size the piping.

Appendix D Suggested Method for Checking for Leakage

This appendix 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 (minutes)
$^1/_4$	5
$^1/_2$	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:

(a) *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, and 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.

(b) *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:

(1) 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.

(2) For systems serving appliances that receive gas at pressures of $^1/_2$ 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. ± $^1/_2$ in. (2.2 kPa ± 0.1 kPa) water column, 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. ± $^1/_2$ in. (2.2 kPa ± 0.1 kPa) water column. 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.

Appendix E Suggested Emergency Procedure for Gas Leaks

This appendix 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.

Appendix F Flow of Gas Through Fixed Orifices

This appendix 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.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.

Table F.1 Utility Gases (cubic feet per hour at sea level)

Orifice or Drill Size	Pressure at Orifice — Inches Water Column								
	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
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

(continues)

Table F.1 Utility Gases (cubic feet per hour at sea level) ***(Continued)***

Orifice or Drill Size	Pressure at Orifice — Inches Water Column								
	3	3.5	4	5	6	7	8	9	10
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. water column = 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)

	Propane	Butane
Btu per cubic foot =	2516	3280
Specific gravity =	1.52	2.01
Pressure at orifice, inches water column =	11	11
Orifice coefficient =	0.9	0.9
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	1112
0.012	1169	1326
80	1480	1678
79	1708	1936
78	2080	2358
77	2629	2980
76	3249	3684
75	3581	4059
74	4119	4669
73	4678	5303
72	5081	5760
71	5495	6230
70	6375	7227
69	6934	7860
68	7813	8858
67	8320	9433
66	8848	10031
65	9955	11286
64	10535	11943
63	11125	12612
62	11735	13304
61	12367	14020
60	13008	14747
59	13660	15486
58	14333	16249
57	15026	17035
56	17572	19921
55	21939	24872
54	24630	27922
53	28769	32615
52	32805	37190
51	36531	41414
50	39842	45168

Table F.2 LP-Gases (Btu per hour at sea level) ***(Continued)***

Orifice or Drill Size	Propane	Butane
49	43361	49157
48	46983	53263
47	50088	56783
46	53296	60420
45	54641	61944
44	60229	68280
43	64369	72973
42	71095	80599
41	74924	84940
40	78029	88459
39	80513	91215
38	83721	94912
37	87860	99605
36	92207	104532
35	98312	111454
34	100175	113566
33	103797	117672
32	109385	124007
31	117043	132689
30	134119	152046
29	150366	170466
28	160301	181728
27	168580	191114
26	175617	199092
25	181619	205896
24	187828	212935
23	192796	218567
22	200350	227131
21	205525	232997
20	210699	238863
19	223945	253880
18	233466	264673

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	10000
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

Table F.4 Equivalent Orifice Sizes at High Altitudes (Includes 4% input reduction for each 1000 ft) *(Continued)*

Orifice Size at Sea Level	Orifice Size Required at Other Elevations								
	2000	3000	4000	5000	6000	7000	8000	9000	10000
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
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

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 appendix, 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 cu ft per hr) 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.

Appendix G Sizing of Venting Systems Serving Appliances Equipped with Draft Hoods, Category I Appliances, and Appliances Listed for Use with Type B Vents

This appendix 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 Figures G.1 through G.14.

Figure G.1 Type B double-wall vent system serving a single appliance with a Type B double-wall vent.

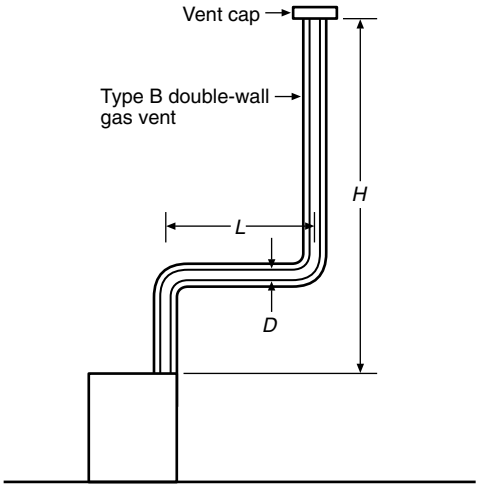


Table 10.1 is used when sizing Type B double-wall gas vent connected directly to the appliance.

Note: The appliance can be either Category I draft hood–equipped or fan-assisted type.

Figure G.2 Type B double-wall vent system serving a single appliance with a single-wall metal vent connector.

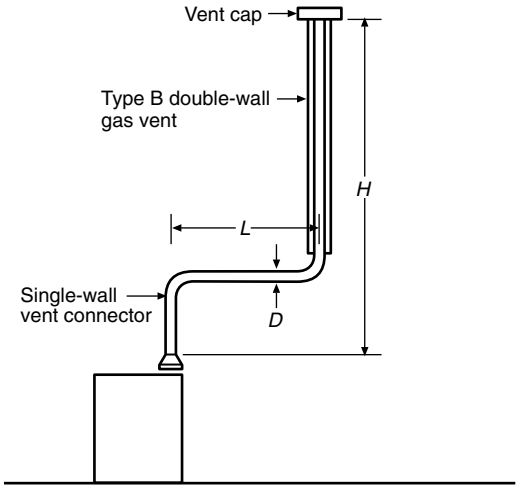


Table 10.2 is used when sizing a single-wall metal vent connector attached to a Type B double-wall gas vent.

Note: The appliance can be either Category I draft hood–equipped or fan-assisted type.

Figure G.3 Vent system serving a single appliance with a masonry chimney and a Type B double-wall vent connector.

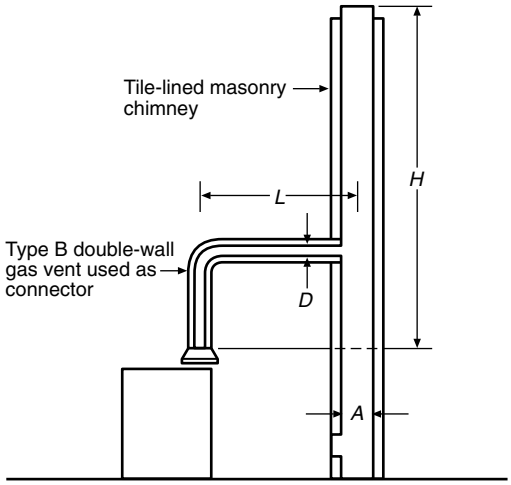


Table 10.3 is used when sizing a Type B double-wall gas vent connector attached to a tile-lined masonry chimney.

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.4 Vent system serving a single appliance using a masonry chimney and a single-wall metal vent connector.

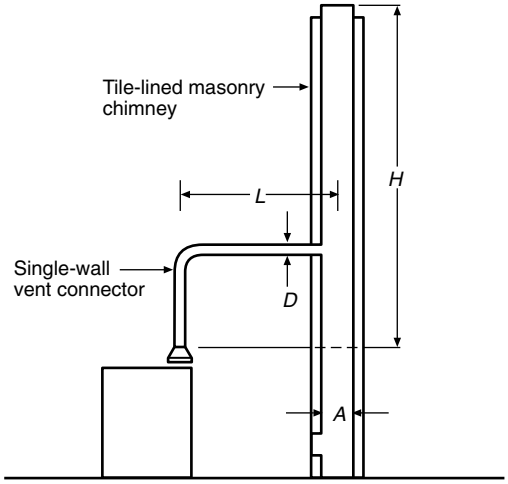
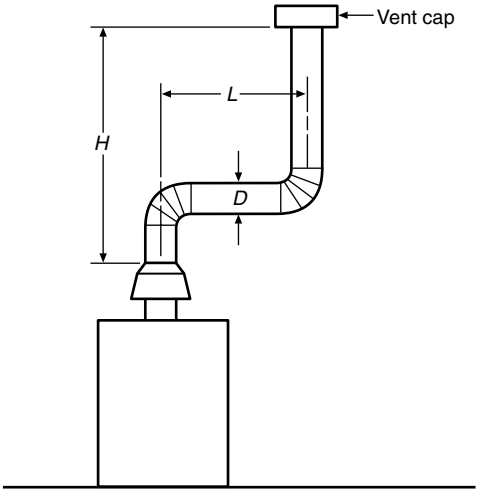


Table 10.4 is used when sizing a single-wall vent connector attached to a tile-lined masonry chimney.

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.5 Asbestos cement Type B or single-wall metal vent system serving a single draft hood-equipped appliance.



Asbestos cement Type B or single-wall metal vent serving a single draft hood–equipped appliance. *(See Table 10.5.)*

Figure G.6 Vent system serving two or more appliances with Type B double-wall vent and Type B double-wall vent connectors.

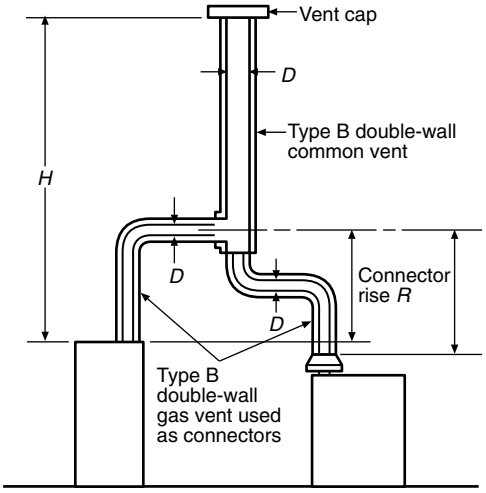


Table 10.6 is used when sizing Type B double-wall gas vent connectors attached to a Type B double-wall common vent.

Note: Each appliance can be either Category I draft hood–equipped or fan-assisted type.

Figure G.7 Vent system serving two or more appliances with Type B double-wall vent and single-wall metal vent connectors.

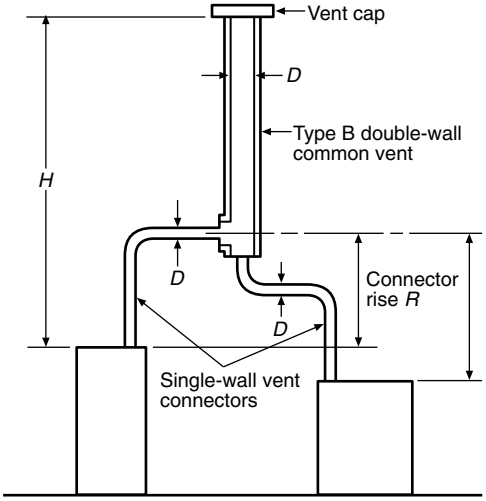


Table 10.7 is used when sizing single-wall vent connectors attached to a Type B double-wall common vent.

Note: Each appliance can be either Category I draft hood–equipped or fan-assisted type.

Figure G.8 Masonry chimney serving two or more appliances with Type B double-wall vent connectors.

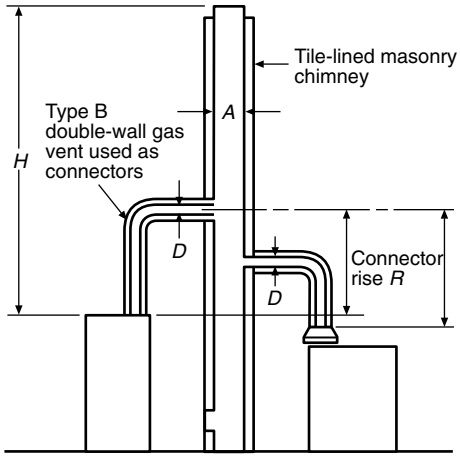


Table 10.8 is used when sizing Type B double-wall vent connectors attached to a tile-lined masonry chimney.

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.9 Masonry chimney serving two or more appliances with single-wall metal vent connectors.

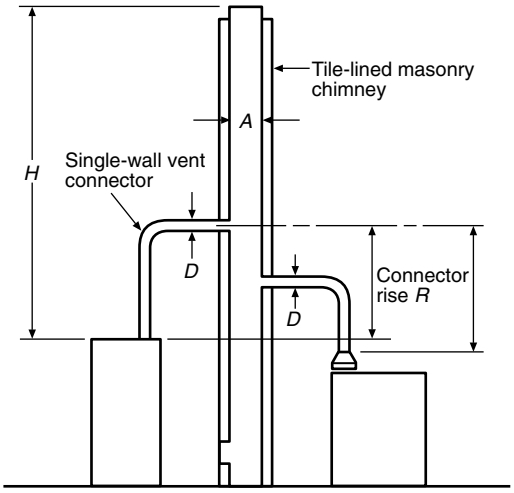
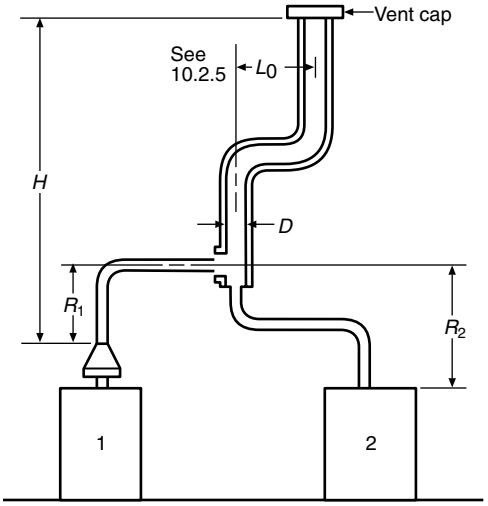


Table 10.9 is used when sizing single-wall metal vent connectors attached to a tile-lined masonry chimney.

Notes:

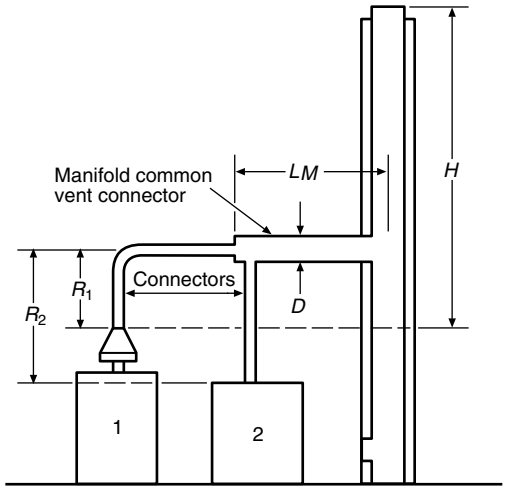
1. *A* is the equivalent cross-sectional area of the tile liner.
2. Each appliance can be either Category I draft hood–equipped or fan-assisted type.

Figure G.10 Asbestos cement Type B or single-wall metal vent system serving two or more draft hood-equipped appliances.



Asbestos cement Type B or single-wall metal pipe vent serving two or more draft hood–equipped appliances. *(See Table 10.10.)*

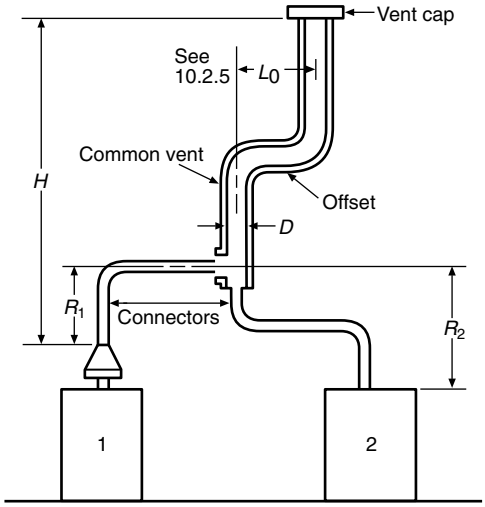
Figure G.11 Use of manifolded common vent connector.



Example: Manifolded common vent connector L_M shall 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 shall not exceed 72 in. (1800 mm) in length. *(See 10.2.4.)*

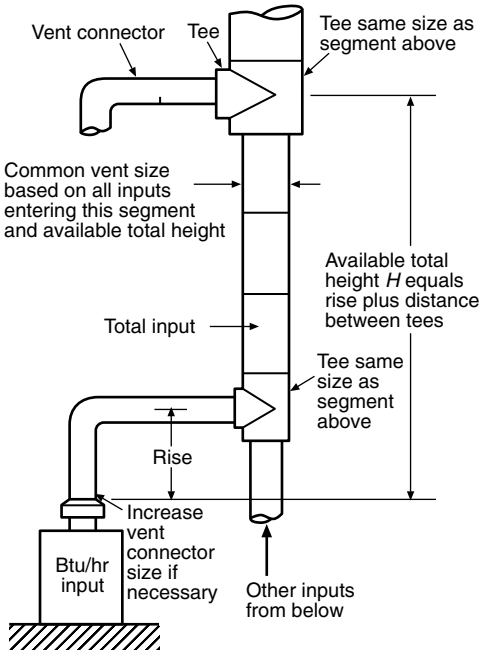
Note: This is an illustration of a typical manifolded vent connector. Different appliance, vent connector, or common vent types are possible. Consult Section 10.2.

Figure G.12 Use of offset common vent.



Example: Offset common vent
Note: This is an illustration of a typical offset vent. Different appliance, vent connector, or vent types are possible. *(Consult Sections 10.1. and 10.2.)*

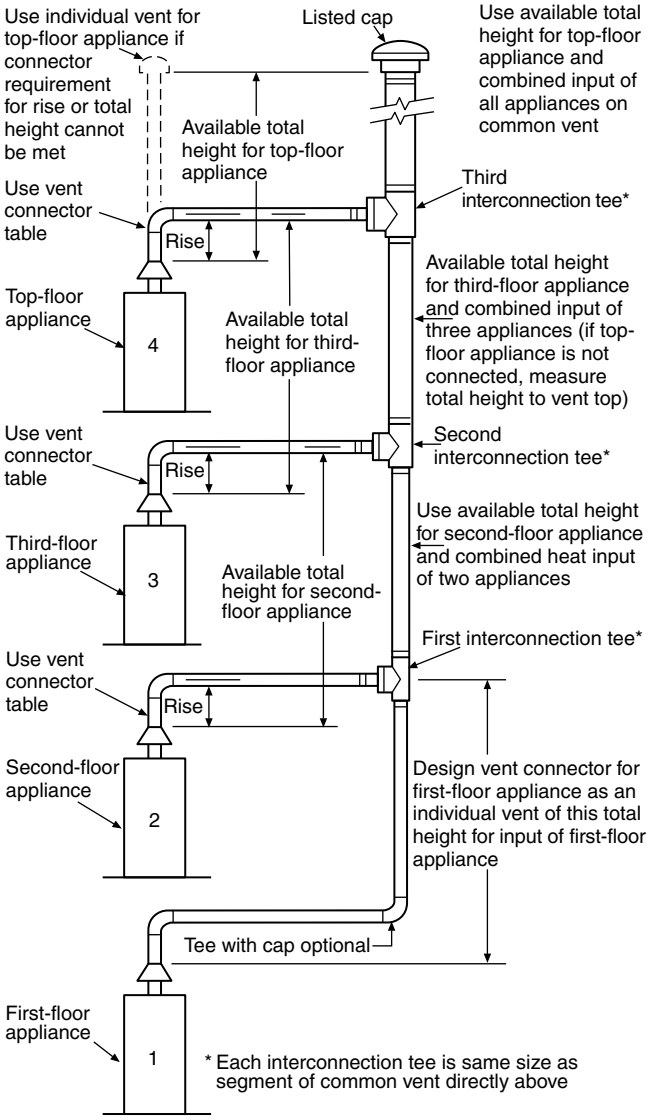
Figure G.13 Multistory gas vent design procedure for each segment of system.



Multistory gas vent design procedure for each segment of system

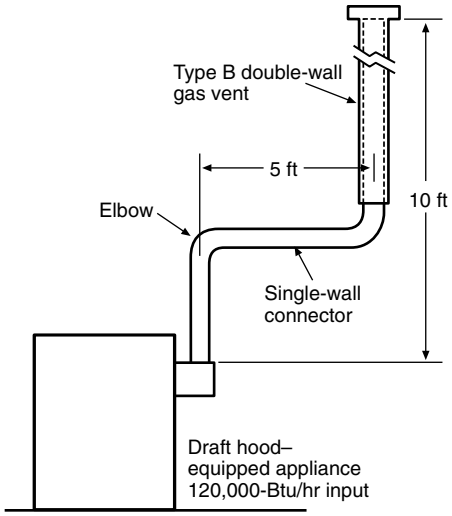
Vent connector size depends on:	Common vent size depends on:
• Input	• Combined inputs
• Rise	• Available total height *H*
• Available total height *H*	• Table 10.6 common vent
• Table 10.6 connectors	

Figure G.14 Principles of design of multistory vents using vent connector and common vent design tables. (See 10.2.10 through 10.2.15.)



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.15.

Figure G.15 Single draft hood-equipped appliance (Example 1).



Solution

Table 10.2 should be used to solve this problem, because single-wall metal vent connectors are being used with a Type B vent.

(a) Read down the first column in Table 10.2 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.

(b) 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 10.1.3)*. 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:

$$122{,}000 \times 0.90 = 110{,}000 \text{ for 5-in. vent}$$

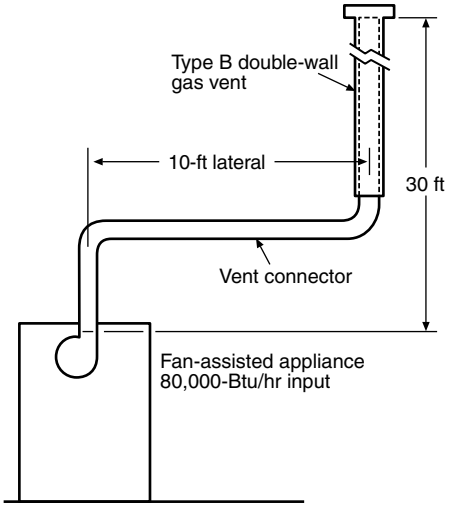
From Table 10.2, select 6-in. vent.

$$186{,}000 \times 0.90 = 167{,}000$$

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.16.

Figure G.16 Single fan-assisted appliance (Example 2).



Solution

Table 10.2 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 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 10.2 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 10.1 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

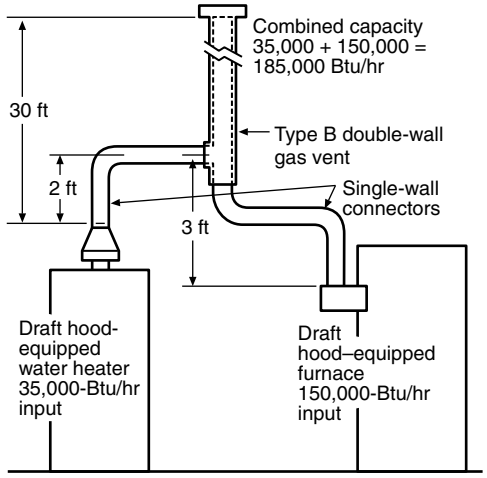
Table 10.1 is used in the case of an all Type B vent system. However, since there is no entry in Table 10.1 for a height of 12 ft, interpolation must be used. Read down the 4-in. diameter NAT Max column to the row associated with 10-ft height and 5-ft lateral to find the capacity value of 77,000 Btu/hr. 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 $^2/_5$ of the difference between the 10-ft and 15-ft height values, or $77{,}000 + {}^2/_5 \times 10{,}000 = 81{,}000$ 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.17.

Figure G.17 Common venting two draft hood–equipped appliances (Example 4).



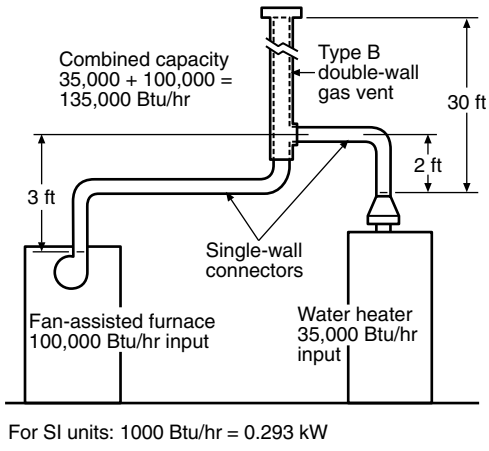
Solution

Table 10.7 should be used to size single-wall metal vent connectors attached to Type B vertical vents. In the vent connector capacity portion of Table 10.7, 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-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 10.2.2, the table values can be used without adjustments.

In the common vent capacity portion of Table 10.7, 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.18.

Figure G.18 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 (Table 10.7)

Water Heater Vent Connector Diameter. Since the water heater vent connector horizontal length of 4 ft is less than the maximum value listed in 10.7, the venting table values can be used without adjustments. Using the Vent Connector Capacity portion of Table 10.7, 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 10.2.19. 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 10.7, 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 10.2.2, 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 10.6]* 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 10.7, 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 10.9 is used to size common venting installations involving single-wall connectors into masonry chimneys.

Water Heater Vent Connector Diameter. Using Table 10.9, 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 10.9, 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 127,000 Btu/hr and a minimum input rating of 95,000 Btu/hr. The 100,000 Btu/hr furnace in this example falls within this range, so a 4-in. connector is adequate.

Masonry Chimney. From Table G.2.4, the Equivalent Area for a Nominal Liner size of 8 in. × 12 in. is 63.6 in.^{2}. Using Table 10.9, 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 10.2.15 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.2.4, 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.

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.2.4 and Figure G.19.

Table G.2.4 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	$2^1/_2 \times 6^1/_2$	4	12.2
		5	19.6
		6	28.3
		7	38.3
8 × 8	$6^3/_4 \times 6^3/_4$	7.4	42.7
		8	50.3
8 × 12	$6^1/_2 \times 10^1/_2$	9	63.6
		10	78.5
12 × 12	$9^3/_4 \times 9^3/_4$	10.4	83.3
		11	95
12 × 16	$9^1/_2 \times 13^1/_2$	11.8	107.5
		12	113.0
		14	153.9
16 × 16	$13^1/_4 \times 13^1/_4$	14.5	162.9
		15	176.7
16 × 20	13 × 17	16.2	206.1
		18	254.4
20 × 20	$16^1/_2 \times 16^3/_4$	18.2	260.2
		20	314.1
20 × 24	$16^1/_2 \times 20^1/_2$	20.1	314.2
		22	380.1
24 × 24	$20^1/_4 \times 20^1/_4$	22.1	380.1
		24	452.3
24 × 28	$20^1/_4 \times 24^1/_4$	24.1	456.2
28 × 28	$24^1/_4 \times 24^1/_4$	26.4	543.3
		27	572.5
30 × 30	$25^1/_2 \times 25^1/_2$	27.9	607
		30	706.8
30 × 36	$25^1/_2 \times 31^1/_2$	30.9	749.9
		33	855.3
36 × 36	$31^1/_2 \times 31^1/_2$	34.4	929.4
		36	1017.9

For SI units, 1 in. = 25.4 mm; 1 inch^2 = 645 mm^2.
Note: When liner sizes differ dimensionally from those shown in Table G.2.4, equivalent diameters can be determined from published tables for square and rectangular ducts of equivalent carrying capacity or by other engineering methods.

Figure G.19 Range of winter design temperatures were used in analyzing exterior masonry chimneys in the United States.

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 Fundamentals Handbook* (Chapter 24, Table 1: Climate Conditions for the United States).

For 99% winter design temperatures in Alaska, consult the *ASHRAE Fundamentals Handbook*.

99% winter design temperatures for Hawaii are greater than 37°F.

Solution

According to 10.2.18, Type B vent connectors are required to be used with exterior masonry chimneys. Use Tables 10.13(a) and (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 Tables 10.13(a) and (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 10.13(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 10.13(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 10.2.17, Tables 10.6 or 10.7 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 10.6, 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. So the 35,000 Btu/hr water heater in this example can use a 3-in. connector.

Furnace Vent Connector Diameter. Using Table 10.6, 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 10.6, 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 135,000 Btu/hr. The 4-in. common vent has a capacity of 138,000 Btu/hr. Reducing the maximum capacity by 20 percent *(10.2.17)* 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 10.6 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 10.7 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.

Appendix H Recommended Procedure for Safety Inspection of an Existing Appliance Installation

This appendix 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 5.5.4.)*

(2) Visually inspect the venting system for proper size and horizontal pitch, and determine there is no blockage or restriction, leakage, corrosion, and 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 5.3 of this code for guidance.

(8) Place the appliance being inspected in operation. **Follow the lighting instructions.** Adjust the thermostat so 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.

a. 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 from a cigarette, cigar, or pipe.

(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.

Appendix I Recommended Procedure for Installing Electrically Operated Automatic Vent Damper Devices in Existing Vents

This appendix is not a part of the requirements of this code but is included for informational purposes only.

I.1 General. This procedure is intended as a guide to aid in safely installing an electrically operated automatic vent damper device in the vent serving an existing appliance.

This procedure is based on the assumption that the history of the specific appliance has been one of safe and satisfactory operation.

This procedure is predicated on central furnace, boiler, and water heater 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.

The following steps should be followed in making the modifications:

(1) Perform a safety inspection of the existing appliance installation. See Appendix H for a recommended procedure for such a safety inspection.
(2) Shut off all gas and electricity to the appliance. **To shut off the gas, use the shutoff valve in the supply line to the appliance.**
(3) Install the damper device in strict accordance with the manufacturer's installation instructions. Make certain the device is not located in that portion of the venting system that serves any appliance other than the one for which the damper is installed.
(4) Make certain wiring connections are tight and wires are positioned and secured so they will not be able to contact high-temperature locations.
(5) Where an additional automatic valve has been incorporated or an existing gas control replaced, conduct a gas leakage test of the appliance piping and control system downstream of the shutoff valve in the supply line to the appliance.
(6) Visually inspect the modified venting system for proper horizontal pitch.
(7) Check that the damper operates properly and is properly sequenced with the appliance operating controls so that it opens when there is a call for heat and closes when the appliance is in a standby condition.

NOTE: If a boiler gas valve is sequenced by the aquastat, determine that the damper opens prior to the opening of the gas valve.

(8) Determine the amperage draw of the gas control circuit and damper device.
   a. Check the appliance transformer for adequate capacity.
   b. Check the heat anticipator in the comfort thermostat to determine that it is properly adjusted.
(9) Sequence the appliance through at least three normal operating cycles.
(10) 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.
(11) Place the appliance in operation. **Follow the lighting instructions.** Adjust the thermostat so the appliance will operate continuously.
(12) 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 from a cigarette, cigar, or pipe.
(13) Visually determine that the main burner gas is burning properly — that is, 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.

(14) 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 this 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.
(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:**
   a. Determine that the water pumps are in operating condition.
   b. Test low water cutoffs, automatic feed controls, pressure and temperature limit controls, and relief valves in accordance with the manufacturer's recommendations to determine they are in operating condition.
(17) Label the damper device with information on the following:
   a. Name of qualified agency responsible for damper installation
   b. Date of installation

Appendix J Recommended Procedure for Installing Mechanically Actuated Automatic Vent Damper Devices in Existing Vents

This appendix is not a part of the requirements of this code but is included for informational purposes only.

J.1 General. This procedure is intended as a guide to aid in safely installing a mechanically actuated automatic vent damper device in the vent serving an existing appliance.

This procedure is based on the assumption that the history of the specific appliance has been one of safe and satisfactory operation.

This procedure is predicated on central furnace, boiler, and water heater 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.

The following steps should be followed in making the modifications:

(1) Perform a safety inspection of the existing appliance installation. See Appendix H for a recommended procedure for such a safety inspection.
(2) Shut off all gas and electricity to the appliance. **To shut off the gas, use the shutoff valve in the supply line to the appliance.**
(3) Install the damper device in strict accordance with the manufacturer's installation instructions. Make certain the device is not located in that portion of the venting system that serves any appliance other than the one for which the damper is installed.

(4) Make certain wiring and mechanical connections are tight and wires are positioned and secured so they will not be able to contact high-temperature locations.
(5) Where an additional automatic valve has been incorporated or an existing gas control replaced, conduct a gas leakage test of the appliance piping and control system downstream of the shutoff valve in the supply line to the appliance.
(6) Visually inspect the modified venting system for proper horizontal pitch.
(7) Check that the damper operates properly and is properly sequenced with the appliance operating controls so that it opens when there is a call for heat and closes when the appliance is in a standby condition.

NOTE: If a boiler gas valve is sequenced by the aquastat, determine that the damper opens prior to the opening of the gas valve.

(8) Determine the amperage draw of the gas control circuit and damper device.
   a. Check the appliance transformer for adequate capacity.
   b. Check the heat anticipator in the comfort thermostat to determine it is properly adjusted.
(9) Sequence the appliance through at least three normal operating cycles.
(10) 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.
(11) Place appliance in operation. **Follow the lighting instructions.** Adjust the thermostat so the appliance will operate continuously.
(12) 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 from a cigarette, cigar, or pipe.
(13) 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.

(14) 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 this 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.
(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:**
   a. Determine that the water pumps are in operating condition.
   b. Test low-water cutoffs, automatic feed controls, pressure and temperature limit controls, and relief valves in accordance with the manufacturer's recommendations to determine they are in operating condition.
(17) Label the damper device with information on the following:
   a. Name of the qualified agency responsible for the damper installation
   b. Date of installation

Appendix K Recommended Procedure for Installing Thermally Actuated Automatic Vent Damper Devices in Existing Vents

This appendix is not a part of the requirements of this code but is included for informational purposes only.

K.1 General. This procedure is intended as a guide to aid in safely installing a thermally actuated automatic vent damper device in the vent serving an existing appliance.

This procedure is based on the assumption that the history of the specific appliance has been one of safe and satisfactory operation.

This procedure is predicated on central furnace, boiler, and water heater 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.

The following steps should be followed in making the modifications:

(1) Perform a safety inspection of the existing appliance installation. See Appendix H for a recommended procedure for such a safety inspection.
(2) Shut off all gas and electricity to the appliance. **To shut off the gas, use the shutoff valve in the supply line to the appliance.**
(3) Install the damper device in strict accordance with the manufacturer's installation instructions. Make certain the device is not located in that portion of the venting system that serves any appliance other than the one for which the damper is installed.
(4) Make certain that wiring connections are tight and wires are positioned and secured so they will not be able to contact high-temperature locations.
(5) Where an additional automatic valve has been incorporated or an existing gas control replaced, conduct a gas leakage test of the appliance piping and control system downstream of the shutoff valve in the supply line to the appliance.
(6) Visually inspect the modified venting system for proper horizontal pitch.
(7) Check the installation to determine there is no physical obstruction or deformation that could impair damper operation.
(8) Determine the amperage draw of the gas control circuit and damper device.
   a. Check the appliance transformer for adequate capacity.
   b. Check the heat anticipator in the comfort thermostat to determine that it is properly adjusted.

(9) Sequence the appliance through at least three normal operating cycles.

(10) 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.

(11) Place the appliance in operation. **Follow the lighting instructions.** Adjust the thermostat so the appliance will operate continuously.

(12) 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 from a cigarette, cigar, or pipe.

(13) 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.

(14) 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 this 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.

(15) Label the damper device with information on the following:

a. Name of the qualified agency responsible for the damper installation

b. Date of installation

Appendix L Example of Air Opening Design for Combustion and Ventilation.

This appendix is not a part of the requirements of this code but is included for informational purposes only.

L.1 Example of Combination Indoor and Outdoor Combustion Air Opening Design [5.3.3 (c)]. Determine the required combination of indoor and outdoor combustion air opening sizes for the following equipment installation example.

Example Installation. A furnace and a water heater with the following inputs are located in a 10 ft × 10 ft equipment room with an 8-ft ceiling. An adjacent room that measures 15 ft × 20 ft with an 8-ft ceiling can be used to help meet the equipment combustion air needs. The house construction is not unusually tight.

Furnace input: 100,000 Btu/hr

Water heater input: 40,000 Btu/hr

Solution

(1) Determine the total equipment input and the total available room volumes:

Total equipment input: 100,000 Btu/hr + 40,000 Btu/hr = 140,000 Btu/hr

Equipment room volume: 10 ft × 10 ft with 8-ft ceiling = 800 ft^3

Adjacent room volume: 10 ft × 15 ft with 8-ft ceiling = 2400 ft^3

Total indoor room volume: 800 ft^3 + 2400 ft^3 = 3200 ft^3

(2) Determine whether location is an unconfined space:

Total equipment input = 140,000 Btu/hr

Unconfined space determinations:

140,000 Btu × 50 ft^3/1000 Btu/hr = 7000 ft^3

Conclusion: Equipment is located in a confined space since the total of 3200 ft^3 does not meet the unconfined criteria of 7000 ft^3.

(3) Determine ratio of actual confined volume to required unconfined volume, actual confined/required unconfined ratio:

$$\frac{3200\ ft^3}{7000\ ft^3} = 0.46$$

(4) Determine indoor combustion air opening size for openings communicating with adjacent indoor spaces as though all combustion air is to come from the indoors, indoor opening (high and low) sizes:

$$\frac{140{,}000\ Btu/hr}{1000\ Btu/in.^2} = 140\ in.^2$$

(5) Determine the outdoor combustion air opening (upper and lower) size as if all combustion air is to come from the outdoors. In this example, the combustion air openings directly communicate with the outdoors.

$$\frac{140{,}000\ Btu/hr}{4000\ Btu/in.^2} = 35\ in.^2$$

(6) Determine outdoor combustion air opening area ratio:

Subsection 5.3.3(c)6 requires the sum of the indoor and outdoor ratios must be equal to or greater than 1.00, outdoor combustion opening ratio:

1.00 – 0.46 (from Step 3) = 0.54

(7) Determine reduced outdoor combustion air opening area:

Opening area = 0.54 (from Step 6) × 35 $in.^2$

Each opening area = 19 $in.^2$

(8) Final design summary:

One high and one low indoor opening each sized 140 $in.^2$

One high and one low outdoor opening each sized 19 $in.^2$

The minimum dimension of the air opening should not be less than 3 in. (76 mm).

Appendix M Referenced Publications

M.1 This list of documents is included because they pertain to equipment, accessories, materials, and installations that can be encountered in the application of this code and thus contain useful information. The documents are not considered part of the requirements of this code even though some are referenced in conjunction with the requirements in the code.

M.1.1 API Publication. American Petroleum Institute, 1220 L Street, N.W., Washington, DC 20005.

API 1104, *Standard for Welding Pipelines and Related Facilities,* 1999.

M.1.2 ASHRAE Publications. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329-2305.

ASHRAE Handbook — Fundamentals, 1997.

ASHRAE Handbook — HVAC Systems and Equipment, 1999.

M.1.3 ASME Publications. American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017.

ASME *Boiler and Pressure Vessel Code,* Section III ("Nuclear Power Plant Components"), Division 1-Subsections NB, NC, and ND, Article 3600, 1998.

ASME *Boiler and Pressure Vessel Code,* Section IX and Section IV, 1998.

ASME B1.20.1, *Pipe Threads, General Purpose, Inch,* 1983 (Reaffirmed: 1992).

ASME B16.1, *Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800,* 1998.

ASME B16.5, *Pipe Flanges and Flanged Fittings,* 1996.

ASME B31.1, *Power Piping,* 1998.

ASME B31.3, *Process Piping,* 1999.

ASME B31.4, *Liquid Transportation Systems for Liquid Hydrocarbons and Other Liquids,* 1998.

ASME B31.5, *Refrigeration Piping,* 1992.

ASME B31.8, *Gas Transmission and Distribution Piping Systems,* 1995.

ASME B36.10, *Welded and Seamless Wrought-Steel Pipe,* 1996.

M.1.4 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless,* 1999.

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,* 1997.

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,* 1996.

ASTM B 210, *Specification for Aluminum-Alloy Drawn Seamless Tubes,* 1995.

ASTM B 241, *Specification for Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube,* 1996.

ASTM B 280, *Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service,* 1997.

ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings,* 1999.

ASTM D 2517, *Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings,* 1994.

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).

M.1.5 AWS Publications. American Welding Society, 550 N. W. LeJeune Road, Miami, FL 33126.

AWS B2.1, *Standard for Welding Procedure and Performance Qualification,* 1998.

AWS B2.2, *Standard for Brazing Procedure and Performance Qualification,* 1991.

M.1.6 CSA International Publications. CSA International, 8501 East Pleasant Valley Road, Cleveland, OH 44131.

AGA NGV2, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Containers,* 1992.

AGA/CGA NGVI, *Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices,* 1994.

AGA/CGA NGV3.1, *Fuel System Components for Natural Gas Powered Vehicles,* 1995.

ANSI LC 1/CSA 6.26, *Gas Piping Systems Using Corrugated Stainless Steel Tubing,* 1997.

ANSI LC 2, *Agricultural Heaters,* 1996.

ANSI Z21.1, *Household Cooking Gas Appliances,* 1996.

ANSI Z21.5.1/CGA 7.1, *Gas Clothes Dryers — Volume I — Type 1 Clothes Dryers,* 1995.

ANSI Z21.5.2, 7.2, *Gas Clothes Dryers — Volume II — Type 2 Clothes Dryers,* 1998.

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,* 1998.

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,* 1998.

ANSI Z21.11.1, *Gas-Fired Room Heaters — Volume I — Vented Room Heaters,* 1991. (Included in Z21.86/CSA 2.32 after 1/1/98.)

ANSI Z21.11.2, *Gas-Fired Room Heaters — Volume II — Unvented Room Heaters,* 1996.

ANSI Z21.12, *Draft Hoods,* 1990 (Reaffirmed 1998).

ANSI Z21.13, *Gas-Fired Low-Pressure Steam and Hot Water Boilers,* 1991 (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/CGA 6.3, *Gas Appliance Pressure Regulators,* 1995.

ANSI Z21.19, *Refrigerators Using Gas Fuel,* 1990 (Reaffirmed 1999).

ANSI Z21.20, *Automatic Gas Ignition Systems and Components,* 1997.

ANSI Z21.21/CGA 6.5, *Automatic Valves for Gas Appliances,* 1997.

ANSI Z21.22, *Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems,* 1986 (Reaffirmed 1998).

ANSI Z21.23, *Gas Appliance Thermostats,* 1993 (Reaffirmed 1998).

ANSI Z21.24/CGA 6.10, *Metal Connectors for Gas Appliances,* 1997.

ANSI Z21.35/CGA 6.8, *Pilot Gas Filters,* 1995.

ANSI Z21.40.1/CGA 2.91-M99, *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/CGA 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,* 1999.

ANSI Z21.48, *Gas-Fired Gravity and Fan Type Floor Furnaces,* 1992 (Included in Z21.86/CSA 2.32 after 1/1/98).

ANSI Z21.49, *Gas-Fired Gravity and Fan Type Vented Wall Furnaces,* 1993 (Included in Z21.86/CSA 2.32 after 1/1/98).

ANSI Z21.50/CSA 2.22, *Vented Gas Fireplaces,* 1998.

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,* 1998.

ANSI Z21.57, *Recreational Vehicle Cooking Gas Appliances,* 1993 (Reaffirmed 1998).

ANSI Z21.58/CGA 1.6, *Outdoor Cooking Gas Appliances,* 1995.

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.

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, *Combination Gas Controls for Gas Appliances,* 1995.

ANSI Z21.86/CSA 2.32, *Vented Gas-Fired Space Heating Equipment,* 1998.

ANSI Z21.88/CSA 2.33, *Vented Gas-Fireplace Heaters,* 1998.

ANSI Z83.3, *Gas Utilization Equipment in Large Boilers,* 1971 (Reaffirmed 1995).

ANSI Z83.4, *Direct Gas-Fired Make-Up Air Heaters,* 1991 (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.

M.1.7 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.

M.1.8 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.

M.1.9 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 30, *Flammable and Combustible Liquids Code,* 1996 edition.

NFPA 59, *Standard for the Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants,* 1998 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG),* 1996 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Products Facilities,* 1999 edition.

NFPA 68, *Guide for Venting of Deflagrations,* 1998 edition.

NFPA 70, *National Electrical Code®*, 1999 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,* 1999 edition.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems,* 1999 edition.

NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations,* 1998 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances,* 1996 edition.

NFPA 501A, *Standard for Fire Safety Criteria for Manufactured Home Installations, Sites, and Communities,* 1999 edition.

NFPA 8501, *Standard for Single Burner Boiler Operation,* 1997 edition.

NFPA 8502, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boilers,* 1999 edition.

M.1.10 UL Publications. Underwriters Laboratories Inc., Publication Stock, 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.

M.1.11 U.S. Government Publication. U.S. Government Printing Office, Washington, DC 20402.

Manufactured Home Construction and Safety Standard, Title 24 *CFR,* Part 3280.

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Formal Interpretation

NFPA 54

National Fuel Gas Code

1999 Edition

Reference: 3.14 (a)
F.I. No.: 54-99-1

"Each aboveground portion of a gas piping system upstream of the equipment shutoff valve shall be electrically continuous and bonded to the grounding electrode system."

Question: Is it the intent of NFPA 54, 3.14(a) and NEC 250-104(b) (metal gas piping), to consider this bonding requirement to be satisfied where a grounded gas appliance is attached to the metal gas piping system?

Answer: Yes.

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