Table 13.2(g) Exterior Masonry Chimney

					Number of Appliances:	Two or More		
					Appliance Type:	NAT + NAT		
					Appliance Vent Connection:	Type B Double-Wall Connector		
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
	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
	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
	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
	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
	Local 99% winter design temperature: 4°F or lower Not recommended for any vent configurations							

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu/hr = 0.293 kW, °C = (°F - 32)/1.8.
Note: See Figure F.2.4 for a map showing local 99 percent winter design temperatures in the United States.

Table 13.2(h) Exterior Masonry Chimney

					Number of Appliances:		Two or More	
					Appliance Type:		FAN + NAT	
					Appliance Vent Connection:		Type B Double-Wall Connector	
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

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu/hr = 0.293 kW.

13.2.21 Connections to Chimney Liners. Where double-wall connectors are required, tee and wye fittings used to connect to the common vent chimney liner shall be listed double-wall fittings. Connections between chimney liners and listed double-wall fittings shall be made with listed adapter fittings designed for such purpose.

13.2.22 Chimneys and Vent Locations. Table 13.2(a) through Table 13.2(e) shall be used only for chimneys and vents not exposed to the outdoors below the roof line. A Type B vent or listed chimney lining system passing through an unused masonry chimney flue shall not be considered to be exposed to the outdoors. A Type B vent passing through an unventilated enclosure or chase insulated to a value of not less than R8 shall not be considered to be exposed to the outdoors. Where vents extend outdoors above the roof more than 5 ft (1.5 m) higher than required by Table 12.7.3, and where vents terminate in accordance with 12.7.3(1)(b), the outdoor portion of the vent shall be enclosed as required by this paragraph for vents not considered to be exposed to the outdoors, or such venting system shall be engineered. Table 13.2(f), Table 13.2(g), Table 13.2(h), and Table 13.2(i) shall be used for clay tile lined exterior masonry chimneys, provided all the following conditions are met:

(1) The vent connector is Type B double wall.
(2) At least one appliance is draft hood equipped.
(3) The combined appliance input rating is less than the maximum capacity given by Table 13.2(f) (for NAT+NAT) or Table 13.2(h) (for FAN+NAT).
(4) The input rating of each space-heating appliance is greater than the minimum input rating given by Table 13.2(g) (for NAT+NAT) or Table 13.2(i) (for FAN+NAT).
(5) The vent connector sizing is in accordance with Table 13.2(c).

13.2.23 Draft Hood Conversion Accessories. Draft hood conversion accessories for use with masonry chimney venting listed Category I fan-assisted appliances shall be listed and installed in accordance with the listed accessory manufacturer's installation instructions.

13.2.24 Vent Connector Sizing. Vent connectors shall not be increased more than two sizes greater than the listed appliance categorized vent diameter, flue collar diameter, or draft hood outlet diameter. Vent connectors for draft hood–equipped appliances shall not be smaller than the draft hood outlet diameter. Where a vent connector size(s) determined from the tables for a fan-assisted appliance(s) is smaller than the flue collar diameter, the use of the smaller size(s) shall be permitted, provided that the installation complies with all of the following conditions:

(1) Vent connectors for fan-assisted appliance flue collars 12 in. (300 mm) in diameter or smaller are not reduced by more than one table size [e.g., 12 in. to 10 in. (300 mm to 250 mm) is a one-size reduction], and those larger than 12 in. (300 mm) in diameter are not reduced more than two table sizes [e.g., 24 in. to 20 in. (610 mm to 510 mm) is a two-size reduction].
(2) The fan-assisted appliance(s) is common vented with a draft hood–equipped appliance(s).
(3) The vent connector has a smooth interior wall.

13.2.25 Multiple Vent and Connector Sizes. All combinations of pipe sizes, single-wall metal pipe, and double-wall metal pipe shall be allowed within any connector run(s) or within the common vent, provided ALL of the appropriate tables permit ALL of the desired sizes and types of pipe, as if they were used for the entire length of the subject connector or vent. Where single-wall and Type B double-wall metal pipes are used for vent connectors within the same venting system, the common vent shall be sized using Table 13.2(b) or Table 13.2(d) as appropriate.

13.2.26 Multiple Vent and Connector Sizes Permitted. Where a Chapter 13 table permits more than one diameter of pipe to be used for a connector or vent, all the permitted sizes shall be permitted to be used.

13.2.27 Interpolation. Interpolation shall be permitted in calculating capacities for vent dimensions that fall between table entries.

13.2.28 Extrapolation. Extrapolation beyond the table entries shall not be permitted.

Table 13.2(i) Exterior Masonry Chimney

					Number of Appliances:		Two or More	
					Appliance Type:		FAN + NAT	
					Appliance Vent Connection:		Type B Double-Wall Connector	
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
	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
	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	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
	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
	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
	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
	Local 99% winter design temperature: −11°F or lower Not recommended for any vent configurations							

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2, 1 ft = 0.305 m, 1000 Btu/hr = 0.293 kW.

Note: See Figure F.2.4 for a map showing local 99 percent winter design temperatures in the United States.

Table 13.2.2 Vent Connector Maximum Length

Connector Diameter (in.)	Maximum Connector Horizontal Length (ft)
3	4½
4	6
5	7½
6	9
7	10½
8	12
9	13½
10	15
12	18
14	21
16	24
18	27
20	30
22	33
24	36

For SI units, 1 in. = 25.4 mm, 1 ft = 0.305 m.

13.2.29 Sizing Vents Not Covered by Tables. For vent heights lower than 6 ft (1.8 m) and higher than shown in the tables, engineering methods shall be used to calculate vent capacities.

13.2.30 Height Entries. Where the actual height of a vent falls between entries in the height column of the applicable table in Table 13.2(a) through Table 13.2(i), either of the following shall be used:

(1) Interpolation
(2) The lower appliance input rating shown in the table entries, for FAN Max and NAT Max column values; and the higher appliance input rating for the FAN Min column values

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.1.1(A) The final pressure regulator in an undiluted liquefied petroleum gas (LP-Gas) system can include any one of the following:

(1) The second stage regulator or integral two-stage regulator
(2) A 2 psi (14 kPa) service regulator or integral 2 psi (14 kPa) service regulator
(3) A single-stage regulator, where single-stage systems are permitted by NFPA 58.

A.3.2.1 Approved. The American Gas Association, American National Standards Institute, and the National Fire Protection Association do not approve, inspect, or certify any installations, procedures, appliances, equipment, or materials; nor do they approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, appliances, 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 *(see 3.2.4)* of an organization that is concerned with product evaluations and is thus in a position to determine compliance with AGA, ANSI, CSA, NFPA, or appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

As used in the definition of Authority Having Jurisdiction, equipment includes appliances and materials.

A.3.2.3 Code. The decision to designate a standard as a "code" is based on such factors as the size and scope of the document, its intended use and form of adoption, and whether it contains substantial enforcement and administrative provisions.

A.3.2.5 Listed. The means for identifying listed appliances and equipment may vary for each organization concerned with product evaluation; some organizations do not recognize appliances and 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.

As used in the definition of Listed, equipment includes appliances and materials.

A.3.3.4.10.1 Category I Vented Appliance. For additional information on appliance categorization as shown in 3.3.4.10.1 through 3.3.4.10.4, see the appropriate Z21 and Z83 American National Standards.

A.3.3.53 Gas Vent. This definition does not apply to plastic plumbing piping that is specified as a venting material in the manufacturer's instructions for gas-fired appliances that are listed for venting with such piping.

A.3.3.64.1 Combustible (Material). Materials are considered to be combustible even if they have been fire-retardant treated.

A.3.3.84.4 Monitor Regulator. A monitor regulator is part of a two-regulator set in which one regulator is doing the work (i.e., the working regulator) and the second regulator (i.e., the monitor) is installed to back up the working regulator should it fail. The monitor regulator remains in a nearly full-open position until it senses a rise in the downstream pressure. Each regulator senses the same downstream pressure, which allows either regulator to limit that downstream pressure.

A.3.3.95.7 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.

N **A.4.3.2.1** Gas suppliers intend to provide gas that is free of liquids. Where liquids or condensates are removed from a drip, the gas supplier can be notified if it is determined that the liquid accumulation impedes the appliance operation or if the liquid accumulation appears to be at an unusual rate. This could mean that the gas supplier's liquid removal equipment has failed or is in need of service.

Handling and disposal of liquids might need to be done with the consideration of an industrial hygienist to avoid possible contact with trace amounts of benzene. Contact the gas supplier for a safety data sheet (SDS) or consider laboratory sampling before handling or disposing of liquids.

A.4.4 The provisions of Section 4.4 do not require noncombustible materials to be tested in order to be classified as noncombustible materials. Materials such as steel, concrete, and cement blocks are generally accepted to be noncombustible.

N **A.4.5(3)** The person performing the calculation or design can be one or more of the following:

(1) A registered/licensed professional engineer, with their stamp or registration/license number and state of registration/license
(2) A degreed engineer who is not registered/licensed
(3) Anyone who has experience in using the calculation method, along with a statement of their experience

A.5.3.1 The size of gas piping depends on the following factors:

(1) Allowable loss in pressure from point of delivery to appliance
(2) Maximum gas demand
(3) Length of piping and number of fittings
(4) Specific gravity of the gas
(5) Diversity factor
(6) Foreseeable future demand

A.5.3.2 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 appliances to be installed are not known, Table A.5.3.2.1 shows the approximate demand of typical appliances by types.

A.5.3.2.1 Some older appliances do not have a nameplate. In this case Table A.5.3.2.1 or an estimate of the appliance input should be used. The input can be based on the following:

(1) A rating provided by the manufacturer
(2) The rating of similar appliances
(3) Recommendations of the gas supplier
(4) Recommendations of a qualified agency
(5) A gas flow test
(6) Measurement of the orifice size of the appliance

The requirement of 5.3.1 that the piping system provide sufficient gas to each appliance inlet must be complied with.

Table A.5.3.2.1 Approximate Gas Input for Typical Appliances

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

A.5.3.3 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 6.

Table 6.2.1(a) through Table 6.2.1(x) 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 B.3.4.

For any gas piping system, for special appliances, or for conditions other than those covered by the capacity tables in Chapter 6, such as longer runs, greater gas demands, or greater pressure drops, the size of each gas piping system should be determined by the pipe sizing equations in Section 6.4 or by standard engineering methods acceptable to the authority having jurisdiction.

A suggested procedure for using the Chapter 6 tables to size a gas piping system is illustrated in Annex B.

A.5.4.4(1) For welding specifications and procedures that can be used, see the API STD 1104, *Welding of Pipelines and Related Facilities*; AWS B2.1/B2.1M, *Specification for Welding Procedure and*

Performance Qualification; or ASME *Boiler and Pressure Vessel Code*, Section IX.

• Δ **A.5.5.2.3** An average of 0.3 grains of hydrogen sulfide per 100 scf of gas (0.7 mg/100 L) is equivalent to a trace as determined by ASTM D2385, *Test Method for Hydrogen Sulfide and Mercaptan Sulfur in Natural Gas (Cadmium Sulfate — Iodometric Titration Method)*, or ASTM D2420, *Test Method for Hydrogen Sulfide in Liquefied Petroleum (LP) Gases (Lead Acetate Method)*.

A.5.5.3.4 Copper and copper alloy 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).

Δ **A.5.5.4.2** The reference to UL 651, *Schedule 40 and 80 Rigid PVC Conduit and Fittings*, is to require that PVC be a minimum of Schedule 40 and that it be resistant to the effects of ultraviolet light because it is likely to be exposed to the outdoors when used for regulator vents.

Δ **A.5.5.6.4** Joint sealing compounds are used in tapered pipe thread joints to provide lubrication to the joint as it is tightened so that less tightening torque is "used up" to overcome friction and also to provide a seal of the small leak paths that would otherwise remain in a metal-to-metal threaded joint.

Commonly used joint sealing compounds include pipe dope and polytetrafluoroethylene tape, also known as PTFE tape. Some pipe dopes also contain PTFE. Joint sealing compounds should be applied so that no sealing compound finds its way into the interior of a completed joint.

Pipe dope application should be made only to the male pipe thread of the joint and should coat all of the threads commencing one thread back from the end of the threaded pipe.

PTFE tape application should be made by wrapping the tape tightly around the male thread in a clockwise direction when viewed from the end of the pipe to which the tape is being applied. Tape application should wrap all of the threads commencing one thread back from the end of the threaded pipe.

A.5.5.7.1 For welding and brazing specifications and procedures that can be used, see API STD 1104, *Welding Pipelines and Related Facilities*; AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*; AWS B2.2/B2.2M, *Specification for Brazing Procedure and Performance Qualification*; or ASME *Boiler and Pressure Vessel Code*, Section IX.

A.5.6 This section applies to premises-owned meters.

A.5.7 This section applies to premises-owned regulators.

A.5.10 Appliances that can produce a vacuum or dangerous reduction in pressure include, but are not limited to, gas compressors.

A.6.1 Table A.6.1 provides nominal metric pipe size equivalents.

A.6.1.1 The Longest Length Method is the traditional method used to determine the equivalent piping length L that is then used along with the pipe sizing tables to determine the appropriate pipe diameter size.

A.6.1.2 The Branch Length Method is an alternate sizing method that could permit slightly smaller pipe diameters in some segments of a piping system when compared with the Longest Length Method.

Table A.6.1 Nominal Pipe

Nominal Pipe Diameter	
in.	mm
1/8	6
3/16	7
1/4	8
3/8	10
1/2	15
5/8	18
3/4	20
1	25
1 1/4	32
1 1/2	40
2	50
2 1/2	65
3	80
3 1/2	90
4	100
4 1/2	115
5	125
6	150
8	200
10	250
12	300

For pipe sizes >12 in. diam., use 1 in. = 25 mm.

A.6.4.1 The Low-Pressure Formula is the standard flow formula located in Annex B but rearranged to solve for the pipe diameter.

A.6.4.2 The High-Pressure Formula is the standard flow formula located in Annex B but rearranged to solve for the pipe diameter.

N **A.7.1.2.1(B)** Conduit as used here is intended to represent metallic or nonmetallic surround, which provides mechanical protection for the underground piping.

A.7.1.3 For information on corrosion protection of underground pipe, see NACE SP0169, *Control of External Corrosion on Underground or Submerged Metallic Piping Systems*. Information on installation, maintenance, and corrosion protection might be available from the gas supplier.

A.7.1.4 The gas supplier can be consulted for recommendations.

N **A.7.2.2** Painting can be an acceptable method of corrosion protection.

A.7.2.5 The intent is that gas piping, shutoff valves required by this code, and regulators be allowed to be installed in accessible portions of plenums, accessible ducts used to supply combustion and ventilation air in accordance with Section 9.3, and accessible spaces between a fixed ceiling and dropped ceiling.

A.7.4.3 Only vertical chases are recognized by the coverage. It is believed that welded joints for a horizontal gas line would be preferable to a horizontal chase.

N **A.7.8.4** System shutoff valves can serve as the emergency shutoff valve required by 7.8.3.2.

A.7.11.4 The mixing blower is acknowledged as a special case because of its inability to tolerate control valves or comparable restrictions between mixing blower(s) 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.7.11.5.1 For information on venting of deflagrations, see NFPA 68.

A.7.11.5.4 Additional interlocks might be necessary for safe operation of appliances supplied by the gas-mixing machine.

A.7.11.6(1) Two basic methods are generally used. One calls for a separate firecheck at each burner, the other a firecheck at each group of burners. The second method is generally more practical if a system consists of many closely spaced burners.

An approved automatic firecheck should be installed as near as practical upstream from a flame arrester used for local protection where test burners or lighting torches are employed.

A.7.12.2 The required bonding connection may be made from the piping to the electrical service equipment enclosure, to the grounded conductor at the electrical service, to the grounding electrode conductor (where of sufficient size), or directly to the grounding electrode. The bond may also be made to a lightning protection system grounding electrode (but not to down conductors) if the resulting length of the bonding conductor is shorter. Lightning protection grounding systems are bonded to the electrical service grounding electrodes, in accordance with NFPA 780, using a method to minimize impedance between the systems.

Listed clamps are manufactured to facilitate attachment of the bonding conductor to either a segment of rigid pipe or to a CSST-copper alloy fitting. Clamps should be installed to remain accessible when building construction is complete.

State and local laws can limit who can attach the bonding connection to the building grounding system.

The size of the bonding conductor, a 6 AWG copper wire, is a minimum size, and larger wire can be used. The requirement also permits conductors of different materials (of equivalent size) and both single wire and multi-strand.

A.7.12.2.3 The maximum length of the bonding connection was established based on studies conducted by the Gas Technology Institute in Project Number 21323, *Validation of Installation Methods for CSST Gas Piping to Mitigate Indirect Lightning Related Damage.* The shortest practical length should always be used.

If the bonding jumper required would be longer than 75 ft (22 m), an additional grounding electrode can be installed to allow a bonding jumper that is 75 ft (22 m) or less.

A.7.12.4.1 This requirement does not preclude the bonding of metallic piping to a grounding system.

A.7.12.5 Section 4.14 of NFPA 780 requires that all grounding media, including underground metallic piping systems, be interconnected to provide a common ground potential. These underground piping systems are not permitted to be substituted for grounding electrodes but must be bonded to the lightning protection grounding system. Where galvanic corrosion is of concern, the bond may be made via a spark gap or gas discharge tube.

A.8.1.1 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.8.1.1.7 Fuel gas piping operating above 125 psi should be cleaned in accordance with NFPA 56.

A.8.1.4.3 During pressure tests conducted over long periods of time, such as overnight, the effects of temperature on pressure should be considered. Temperature drops can cause a drop in pressure great enough to be indicated by the test gauge. These temperature drops can cause test evaluators to think that a leak exists in the piping system when in fact the pressure drop was caused by a decrease in the ambient temperature. See Example 5 in B.7.5.

A.8.2.3 See Annex C for a suggested method.

A.8.3 The process of purging gas piping that contains fuel gas or charging gas piping that contains air must be performed in a manner that will minimize the potential for a flammable mixture to be developed within the piping.

Natural gas and propane suppliers add a distinctive odor to their gas. Persons conducting purging operations should not rely upon their sense of smell. When a gas piping system is brought into service and unodorized gas is detected, the company supplying the gas should be contacted to inform it of the situation and to determine what action should be taken. (More information on odorization of fuel gas is available in the *National Fuel Gas Code Handbook*, "Fuel Gas Odorization" supplement.)

A.8.3.1 Subsection 8.3.1 describes the characteristics of gas piping systems that are required to be purged only to the outdoors. The criteria were selected to distinguish between piping systems located in industrial, large commercial, and large multifamily buildings from those located in light commercial and smaller residential buildings. The gas piping systems installed in industrial, large commercial and large multifamily buildings are considered to be larger, more complex systems for the purposes of defining their purging requirements. Because of their larger pipe volumes or potential for higher flow rates, these systems require procedures to ensure that a large volume of fuel gas is not released to the indoors and that flammable mixtures do not occur within the piping itself. Installers of these complex systems deal with considerably more variables that can result in a higher potential for discharge of large gas volumes during purging operations.

Specific occupancy categories such as industrial, manufacturing, commercial and large multifamily were not included in the fuel gas code. United States building codes define these occupancies for the purpose of construction and safety requirements. There is no general relation between the occupancy types, as defined by the building codes, and the size of gas piping system to be installed in that occupancy. The gas piping size and operating pressure are based on the nature of the piping system and gas appliances to be installed and are not dependent upon a building's occupancy type or classification.

A.8.3.1.2 It is recommended that the oxygen levels in the piping be monitored during the purging process to determine when sufficient inert gas has been introduced. The manufacturer's instructions for monitoring instruments must be followed when performing purge operations.

A.8.3.1.4 Combustible gas indicators are available with different scales. For purging, it is necessary to use the percent gas in air scale and to follow the manufacturer's operating instructions. The percent lower explosible limit (% LEL) scale should not be used because it is not relevant to purging.

Users should verify that the indicator will detect fuel gas in the absence of oxygen. Many combustible gas indicators will not indicate fuel gas concentration accurately if no oxygen is present.

A.8.3.2 The criteria were selected to describe typical gas piping systems located in light commercial and the smaller residential family buildings. Gas piping systems installed in these buildings are considered to be smaller and less complex systems for the purposes of defining their purging requirements. Installers have familiarity with purging these systems and the potential for discharge of large gas volumes during purging operations is low. Also see A.8.3.1.

A.8.3.2.1 Where small piping systems contain air and are purged to either the indoors or outdoors with fuel gas, a rapid and uninterrupted flow of fuel gas must be introduced into one end of the piping system and vented out of the other end so as to prevent the development of a combustible fuel–air mixture. Purging these systems can be done either using a source of ignition to ignite the fuel gas or by using a listed combustible gas detector that can detect the presence of fuel gas.

A.9.1.1 The American Gas Association, American National Standards Institute, Inc., and the National Fire Protection Association do not approve, inspect, or certify any installations, procedures, appliances, equipment, or materials; nor do they approve or evaluate testing laboratories. In determining acceptability of installations, procedures, appliances, equipment, or materials, the authority having jurisdiction can base acceptance on compliance with AGA, ANSI, CSA, 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 of an organization concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.9.1.6 Halogenated hydrocarbons are particularly injurious and corrosive after contact with flames or hot surfaces.

N **A.9.1.20** The instructions are needed for reference and guidance for the authority having jurisdiction, service personnel, and the owner or operator.

A.9.1.22 Building envelope changes made under weatherization practices intended to reduce air infiltration and contractor activities, such as the replacement of whole windows and exterior doors and extensive exterior modifications, will reduce the amount of infiltration air and could impact the amount of combustion air that is available for existing appliance installations. Proper vent sizing and configuration is crucial to maintaining the required vent performance in structures that have reduced air infiltration.

A.9.3 Operation of exhaust fans, ventilation systems, clothes dryers, or fireplaces can create conditions requiring special attention to avoid unsatisfactory operation of installed appliances.

A.9.3.2.1 See Table A.9.3.2.1.

A.9.3.2.2 See Table A.9.3.2.2(a) and Table A.9.3.2.2(b).

A.9.3.2.3(1) See Figure A.9.3.2.3(1).

A.9.3.3.1(1) See Figure A.9.3.3.1(1)(a) and Figure A.9.3.3.1(1)(b).

A.9.3.3.1(2) See Figure A.9.3.3.1(2).

A.9.3.3.2 See Figure A.9.3.3.2.

A.9.6.1.5 The expansion and contraction of the heater and the vibration from the blower motor can lead to work hardening of the rigid pipe or semirigid metallic tubing, which can ultimately lead to fractures and leakage. Connectors for this type of heater should have adequate flexibility, temperature rating, and vibration resistance to accommodate the characteristics of the heater. Such flexible connectors for suspended heaters should meet the following criteria:

(1) Be determined to be appropriate for the application
(2) Be specified by the heater manufacturer
(3) Be installed in accordance with the manufacturer's installation instructions

A.9.6.3 Laboratory burners, commonly called Bunsen burners, are a type of burner used in laboratories. The original Bunsen burner was invented by Robert Bunsen in 1852. The use of the term in NFPA 54 is intended to include all types of portable laboratory burners used in laboratories and educational facilities.

A.10.1.1 This chapter is applicable primarily to nonindustrial-type appliances and installations and, unless specifically indicated, does not apply to industrial appliances and installations.

For additional information concerning particular gas appliances and accessories, including industrial types, reference can be made to the standards listed in Chapter 2 and Annex K.

A.10.1.2 Also see prohibited installations in 10.6.2, 10.7.2, 10.8.2, 10.9.2, and 10.21.2.

A.10.2.7 Reference can be made to NFPA 90A or to NFPA 90B.

Table A.9.3.2.1 Standard Method: Required Volume, All Appliances

Appliance Input (Btu/hr)	Required Volume (ft^3)
5,000	250
10,000	500
15,000	750
20,000	1,000
25,000	1,250
30,000	1,500
35,000	1,750
40,000	2,000
45,000	2,250
50,000	2,500
55,000	2,750
60,000	3,000
65,000	3,250
70,000	3,500
75,000	3,750
80,000	4,000
85,000	4,250
90,000	4,500
95,000	4,750
100,000	5,000
105,000	5,250
110,000	5,500
115,000	5,750
120,000	6,000
125,000	6,250
130,000	6,500
135,000	6,750
140,000	7,000
145,000	7,250
150,000	7,500
160,000	8,000
170,000	8,500
180,000	9,000
190,000	9,500
200,000	10,000
210,000	10,500
220,000	11,000
230,000	11,500
240,000	12,000
250,000	12,500
260,000	13,000
270,000	13,500
280,000	14,000
290,000	14,500
300,000	15,000

For SI units, 1 ft^3 = 0.028 m^3, 1000 Btu/hr = 0.293 kW.

Table A.9.3.2.2(a) Known Air Infiltration Rate Method: Minimum Space Volume for Appliances Other than Fan-Assisted for Specified Infiltration Rates *(ACH)*

Appliance Input (Btu/hr)	Space Volume (ft^3)		
	0.25 *ACH*	0.30 *ACH*	0.35 *ACH*
5,000	420	350	300
10,000	840	700	600
15,000	1,260	1,050	900
20,000	1,680	1,400	1,200
25,000	2,100	1,750	1,500
30,000	2,520	2,100	1,800
35,000	2,940	2,450	2,100
40,000	3,360	2,800	2,400
45,000	3,780	3,150	2,700
50,000	4,200	3,500	3,000
55,000	4,620	3,850	3,300
60,000	5,040	4,200	3,600
65,000	5,460	4,550	3,900
70,000	5,880	4,900	4,200
75,000	6,300	5,250	4,500
80,000	6,720	5,600	4,800
85,000	7,140	5,950	5,100
90,000	7,560	6,300	5,400
95,000	7,980	6,650	5,700
100,000	8,400	7,000	6,000
105,000	8,820	7,350	6,300
110,000	9,240	7,700	6,600
115,000	9,660	8,050	6,900
120,000	10,080	8,400	7,200
125,000	10,500	8,750	7,500
130,000	10,920	9,100	7,800
135,000	11,340	9,450	8,100
140,000	11,760	9,800	8,400
145,000	12,180	10,150	8,700
150,000	12,600	10,500	9,000
160,000	13,440	11,200	9,600
170,000	14,280	11,900	10,200
180,000	15,120	12,600	10,800
190,000	15,960	13,300	11,400
200,000	16,800	14,000	12,000
210,000	17,640	14,700	12,600
220,000	18,480	15,400	13,200
230,000	19,320	16,100	13,800
240,000	20,160	16,800	14,400
250,000	21,000	17,500	15,000
260,000	21,840	18,200	15,600
270,000	22,680	18,900	16,200
280,000	23,520	19,600	16,800
290,000	24,360	20,300	17,400
300,000	25,200	21,000	18,000

For SI units, 1 ft^3 = 0.028 m^3, 1000 Btu/hr = 0.293 kW.
ACH: Air change per hour.

Table A.9.3.2.2(b) Known Air Infiltration Rate Method: Minimum Space Volume for Fan-Assisted Appliance, for Specified Infiltration Rates *(ACH)*

Appliance Input (Btu/hr)	Required Volume (ft^3)		
	0.25 *ACH*	0.30 *ACH*	0.35 *ACH*
5,000	300	250	214
10,000	600	500	429
15,000	900	750	643
20,000	1,200	1,000	857
25,000	1,500	1,250	1,071
30,000	1,800	1,500	1,286
35,000	2,100	1,750	1,500
40,000	2,400	2,000	1,714
45,000	2,700	2,250	1,929
50,000	3,000	2,500	2,143
55,000	3,300	2,750	2,357
60,000	3,600	3,000	2,571
65,000	3,900	3,250	2,786
70,000	4,200	3,500	3,000
75,000	4,500	3,750	3,214
80,000	4,800	4,000	3,429
85,000	5,100	4,250	3,643
90,000	5,400	4,500	3,857
95,000	5,700	4,750	4,071
100,000	6,000	5,000	4,286
105,000	6,300	5,250	4,500
110,000	6,600	5,500	4,714
115,000	6,900	5,750	4,929
120,000	7,200	6,000	5,143
125,000	7,500	6,250	5,357
130,000	7,800	6,500	5,571
135,000	8,100	6,750	5,786
140,000	8,400	7,000	6,000
145,000	8,700	7,250	6,214
150,000	9,000	7,500	6,429
160,000	9,600	8,000	6,857
170,000	10,200	8,500	7,286
180,000	10,800	9,000	7,714
190,000	11,400	9,500	8,143
200,000	12,000	10,000	8,571
210,000	12,600	10,500	9,000
220,000	13,200	11,000	9,429
230,000	13,800	11,500	9,857
240,000	14,400	12,000	10,286
250,000	15,000	12,500	10,714
260,000	15,600	13,000	11,143
270,000	16,200	13,500	11,571
280,000	16,800	14,000	12,000
290,000	17,400	14,500	12,429
300,000	18,000	15,000	12,857

For SI units, 1 ft^3 = 0.028 m^3, 1000 Btu/hr = 0.293 kW.
ACH: Air change per hour.

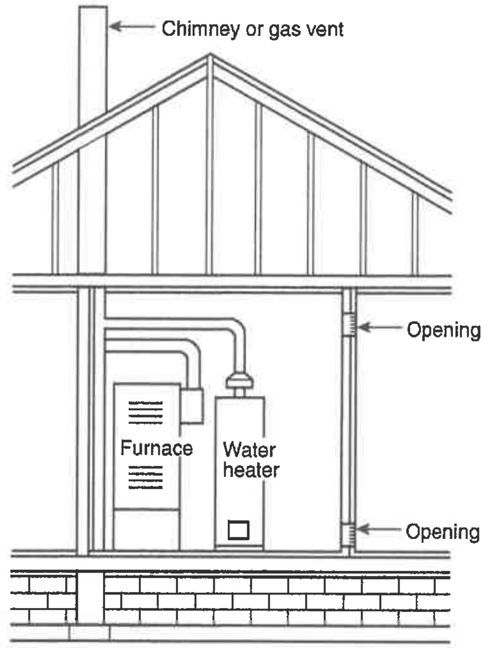


FIGURE A.9.3.2.3(1) All Combustion Air from Adjacent Indoor Spaces Through Indoor Combustion Air Openings.

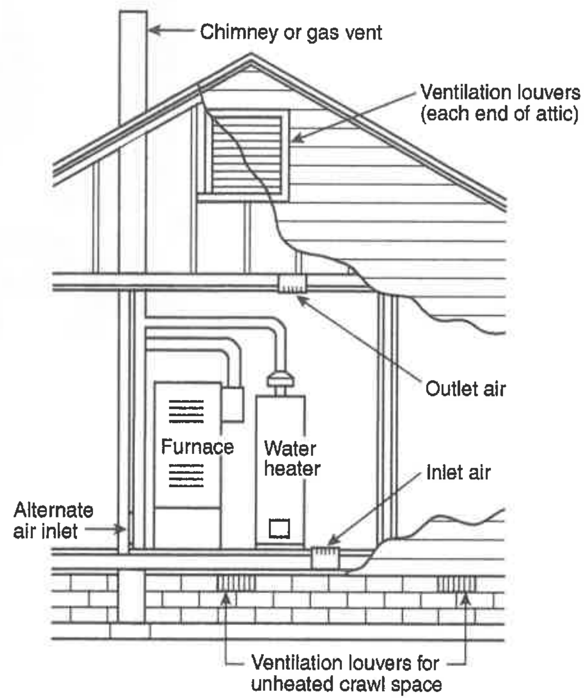


FIGURE A.9.3.3.1(1)(a) All Combustion Air from Outdoors — Inlet Air from Ventilated Crawl Space and Outlet Air to Ventilated Attic.

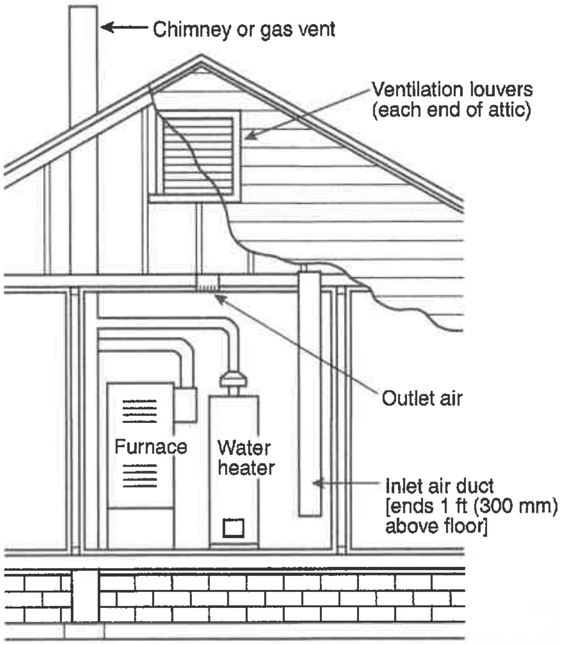


FIGURE A.9.3.3.1(1)(b) All Combustion Air from Outdoors Through Ventilated Attic.

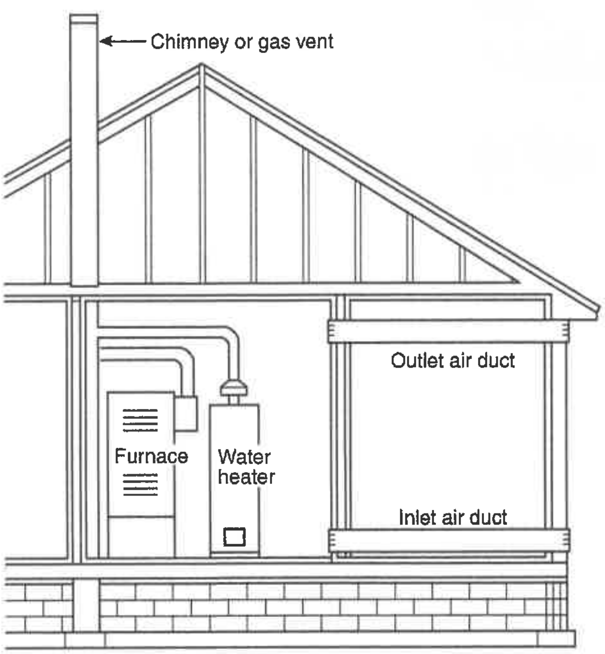


FIGURE A.9.3.3.1(2) All Combustion Air from Outdoors Through Horizontal Ducts.

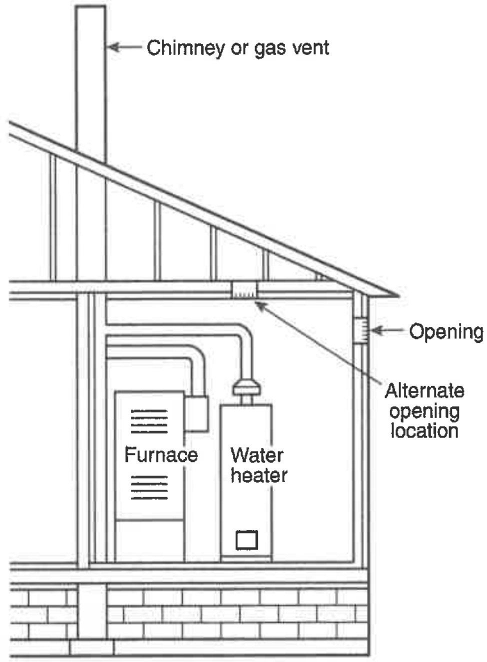


FIGURE A.9.3.3.2 All Combustion Air from Outdoors Through Single Combustion Air Opening.

N **A.10.3.1.2** Listing standards for furnaces or low-pressure boilers having input ratings greater than 400,000 Btu/hr include UL 795, *Commercial-Industrial Gas Heating Equipment,* or ANSI Z21.13/CSA 4.9, *Gas-Fired Low-Pressure Steam and Hot Water Boilers.*

A.10.3.7 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.10.3.8.3 Reference can be made to NFPA 90A or to NFPA 90B.

A.10.6.2 For information on decorative appliances for installation in vented fireplaces, see ANSI Z21.60/CSA 2.26, *Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces.*

A.10.7.2 For information on vented gas fireplaces, see ANSI Z21.50/CSA 2.22, *Vented Decorative Gas Fireplaces.*

A.10.8.2.3 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.

N **A.10.9.7.3** 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.

A.10.11.8 Where exhaust fans are used for ventilation, precautions might be necessary to avoid interference with the operation of the appliance.

A.10.13.3.1 See Figure A.10.13.3.1

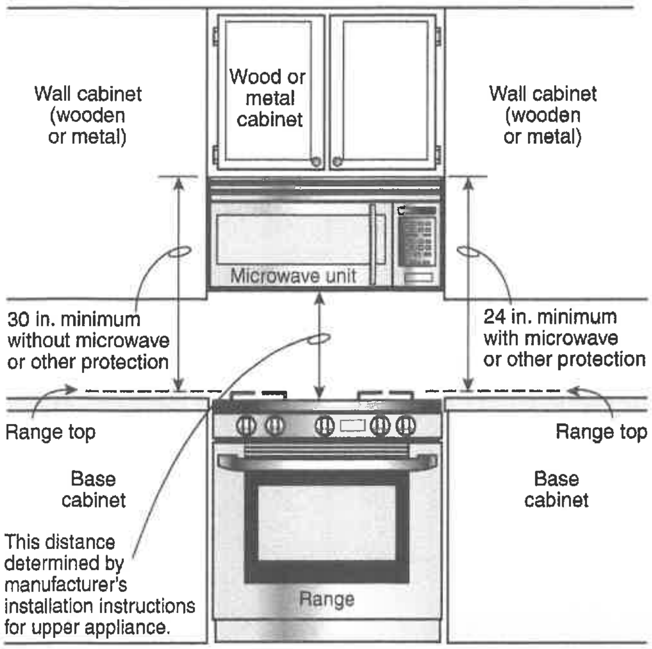


FIGURE A.10.13.3.1 Separation Requirements for Cooktops.

A.10.21.2 It is recommended that space heating appliances installed in all bedrooms or rooms generally kept closed be of the direct vent type.

A.10.26.8 A hole near the top of a cold water inlet tube that enters the top of the water heater or tank is commonly accepted for this purpose.

Δ **A.11.1.1** For most burners, the input rate can be changed only slightly by changing the input pressure. Burner input should be checked in accordance with the appliance manufacturer's installation instructions. If no appliance instructions are provided, burner input rate can be checked as follows:

(1) *Checking Burner Input Using a Meter (Clocking).* To check the Btu/hr input rate, the test hand on the gas meter should be timed for at least one revolution and the input determined from this timing. Test dials are generally marked ½, 1, 2, or 5 ft^3/revolution depending on the size of the meter. Instructions for converting the test hand readings to cubic feet per hour are given in Table A.11.1.1. This table is provided for specific gas pressures within the meters and gives gas flow rate (corrected to standard conditions) in cubic feet of gas per hour. Standard temperature is 60°F (16°C), and standard pressure is 30.00 in. of mercury. Measure the time for at least one revolution of a dial. Look up the gas flow rate in Table A.11.1.1. Gas flow rates can be calculated for meter pressures other than in these tables in the following manner. A pressure correction factor **F** should be determined for use in the gas input calculation for the gas pressure difference ΔP between the meter inlet and the atmosphere. The gas supplier can provide the pressure at the meter inlet. The pressure correction factor **F** is calculated with the following formula. Table A.11.1.1 was calculated using this formula.

[A.11.1.1a]

$$\mathbf{F} = \frac{\Delta P + (B \times 13.596)}{30.00 \times 13.596}$$

where:
F = pressure correction factor
ΔP = meter inlet pressure (in. w.c.)
B = barometric pressure, unadjusted to sea level (in. of mercury)

NOAA weather reports barometric pressure in inches of mercury, adjusted to sea level. The sea level adjustment must be subtracted from the barometric pressure reported by NOAA weather. The local sea level adjustment can be obtained from NOAA.

For example, NOAA reported barometric pressure to be 30.12 in. of mercury for a city at 250 ft elevation. The barometric pressure adjustment for 250 ft is 0.27 in. of mercury. Subtract the local sea level adjustment from the NOAA barometric pressure to get the unadjusted barometric pressure.

[A.11.1.1b]

$$30.12 - 0.27 = 29.85$$

The gas flow rate Q is calculated using the following formula:

[A.11.1.1c]

$$Q = \mathbf{F} \times C$$

where:
Q = gas flow rate at standard conditions (ft^3/hr)
F = pressure correction factor
C = timed gas flow rate (ft^3/hr)

The gas input rate I is calculated with the following formula:

[A.11.1.1d]

$$I = Q \times HHV$$

where:
I = gas input rate (Btu/hr)
Q = gas flow rate at standard conditions (ft^3/hr)
HHV = average higher heat value of the gas at standard temperature and pressure conditions (Btu/ft^3), which can be obtained from the gas supplier

Appliances can be seriously overfired if the timed meter gas flow rate used to set input rate is not adjusted for meter pressure. At 2 psi (14 kPa) meter pressure, an appliance would be 13 percent overfired if the gas flow rate is not adjusted for meter pressure.

(2) *Checking Burner Input by Using Orifice Pressure Drop and Orifice Size.* The fixed orifice size for each burner can be determined in accordance with Table E.1.1(a) for utility gases and Table E.1.1(b) for undiluted LP-Gases.

Table A.11.1.1 Gas Flow Rate to Burner in Cubic Feet per Hour at Standard Temperature and Pressure

Meter Pressure:	7.0 in. w.c. or 0.25 psi				11.0 in. w.c. or 0.40 psi				55.4 in. w.c. or 2 psi			
Seconds for One Revolution	Size of Test Meter Dial											
	½ ft^3	1 ft^3	2 ft^3	5 ft^3	½ ft^3	1 ft^3	2 ft^3	5 ft^3	½ ft^3	1 ft^3	2 ft^3	5 ft^3
10	183	366	732	1831	185	370	739	1849	204	409	818	2044
11	166	333	666	1664	168	336	672	1680	186	372	743	1859
12	153	305	610	1526	154	308	616	1540	170	341	681	1704
13	141	282	563	1408	142	284	569	1422	157	315	629	1573
14	131	262	523	1308	132	264	528	1320	146	292	584	1460
15	122	244	488	1221	123	246	493	1232	136	273	545	1363
16	114	229	458	1144	116	231	462	1155	128	256	511	1278
17	108	215	431	1077	109	217	435	1087	120	241	481	1203
18	102	203	407	1017	103	205	411	1027	114	227	454	1136
19	96	193	385	964	97	195	389	973	108	215	430	1076
20	92	183	366	915	92	185	370	924	102	204	409	1022
21	87	174	349	872	88	176	352	880	97	195	389	974
22	83	166	333	832	84	168	336	840	93	186	372	929
23	80	159	318	796	80	161	321	804	89	178	356	889
24	76	153	305	763	77	154	308	770	85	170	341	852
25	73	146	293	732	74	148	296	739	82	164	327	818
26	70	141	282	704	71	142	284	711	79	157	315	786
27	68	136	271	678	68	137	274	685	76	151	303	757
28	65	131	262	654	66	132	264	660	73	146	292	730
29	63	126	253	631	64	127	255	637	70	141	282	705
30	61	122	244	610	62	123	246	616	68	136	273	681
31	59	118	236	591	60	119	239	596	66	132	264	660
32	57	114	229	572	58	116	231	578	64	128	256	639
33	55	111	222	555	56	112	224	560	62	124	248	620
34	54	108	215	538	54	109	217	544	60	120	241	601
35	52	105	209	523	53	106	211	528	58	117	234	584
36	51	102	203	509	51	103	205	513	57	114	227	568
37	49	99	198	495	50	100	200	500	55	111	221	553
38	48	96	193	482	49	97	195	486	54	108	215	538
39	47	94	188	469	47	95	190	474	52	105	210	524
40	46	92	183	458	46	92	185	462	51	102	204	511
41	45	89	179	447	45	90	180	451	50	100	199	499
42	44	87	174	436	44	88	176	440	49	97	195	487
43	43	85	170	426	43	86	172	430	48	95	190	475
44	42	83	166	416	42	84	168	420	46	93	186	465
45	41	81	163	407	41	82	164	411	45	91	182	454
46	40	80	159	398	40	80	161	402	44	89	178	444
47	39	78	156	390	39	79	157	393	43	87	174	435
48	38	76	153	381	39	77	154	385	43	85	170	426
49	37	75	149	374	38	75	151	377	42	83	167	417
50	37	73	146	366	37	74	148	370	41	82	164	409
51	36	72	144	359	36	72	145	362	40	80	160	401
52	35	70	141	352	36	71	142	355	39	79	157	393
53	35	69	138	345	35	70	140	349	39	77	154	386
54	34	68	136	339	34	68	137	342	38	76	151	379
55	33	67	133	333	34	67	134	336	37	74	149	372
56	33	65	131	327	33	66	132	330	37	73	146	365
57	32	64	128	321	32	65	130	324	36	72	143	359
58	32	63	126	316	32	64	127	319	35	70	141	352
59	31	62	124	310	31	63	125	313	35	69	139	347
60	31	61	122	305	31	62	123	308	34	68	136	341
62	30	59	118	295	30	60	119	298	33	66	132	330
64	29	57	114	286	29	58	116	289	32	64	128	319
66	28	55	111	277	28	56	112	280	31	62	124	310
68	27	54	108	269	27	54	109	272	30	60	120	301
70	26	52	105	262	26	53	106	264	29	58	117	292

(continues)

Table A.11.1.1 *Continued*

Meter Pressure:	7.0 in. w.c. or 0.25 psi				11.0 in. w.c. or 0.40 psi				55.4 in. w.c. or 2 psi			
Seconds for One Revolution	Size of Test Meter Dial											
	½ ft³	1 ft³	2 ft³	5 ft³	½ ft³	1 ft³	2 ft³	5 ft³	½ ft³	1 ft³	2 ft³	5 ft³
72	25	51	102	254	26	51	103	257	28	57	114	284
74	25	49	99	247	25	50	100	250	28	55	111	276
76	24	48	96	241	24	49	97	243	27	54	108	269
78	23	47	94	235	24	47	95	237	26	52	105	262
80	23	46	92	229	23	46	92	231	26	51	102	256
82	22	45	89	223	23	45	90	225	25	50	100	249
84	22	44	87	218	22	44	88	220	24	49	97	243
86	21	43	85	213	21	43	86	215	24	48	95	238
88	21	42	83	208	21	42	84	210	23	46	93	232
90	20	41	81	203	21	41	82	205	23	45	91	227
94	19	39	78	195	20	39	79	197	22	43	87	217
98	19	37	75	187	19	38	75	189	21	42	83	209
100	18	37	73	183	18	37	74	185	20	41	82	204
104	18	35	70	176	18	36	71	178	20	39	79	197
108	17	34	68	170	17	34	68	171	19	38	76	189
112	16	33	65	163	17	33	66	165	18	37	73	183
116	16	32	63	158	16	32	64	159	18	35	70	176
120	15	31	61	153	15	31	62	154	17	34	68	170
130	14	28	56	141	14	28	57	142	16	31	63	157
140	13	26	52	131	13	26	53	132	15	29	58	146
150	12	24	49	122	12	25	49	123	14	27	55	136
160	11	23	46	114	12	23	46	116	13	26	51	128
170	11	22	43	108	11	22	43	109	12	24	48	120
180	10	20	41	102	10	21	41	103	11	23	45	114
190	10	19	39	96	10	19	39	97	11	22	43	108
200	9	18	37	92	9	18	37	92	10	20	41	102

Note: To convert to Btu per hour, multiply the cubic feet per hour of gas by the Btu per cubic foot heating value of the gas used.

A.11.2 Normally, the primary air adjustment should first be set to give a soft blue flame having luminous tips and then increased to a point where the yellow tips just disappear. If the burner cannot be so adjusted, the manufacturer or serving gas supplier should be contacted.

Δ **A.11.6** A procedure for checking draft can be found in G.5.2.

A.12.1 This chapter recognizes that the choice of venting materials and the methods of installation of venting systems are dependent on the operating characteristics of any connected appliances. The operating characteristics of vented appliances can be categorized with respect to whether greater-than-atmospheric or sub-atmospheric pressure exists within the operating vent system and to whether an appliance generates flue or vent gases that can condense in the venting system.

Draft hood–equipped appliances require a vent design that provides a draft to draw vent products into and through the vent system. Vent design tables and the requirements within this code, both for vents and for provision of combustion air, should be used to ensure that vents will provide this draft.

Higher efficiency appliances that generate low-temperature vent gases that can condense require a venting system that can accommodate the condensate produced. Design of these venting systems is accomplished by the appliance manufacturer. Vent system installation requirements for these appliances are contained in the manufacturer's appliance installation instructions.

A.12.3.3 Information on the construction and installation of ventilating hoods can be obtained from NFPA 96.

A.12.4.4 See A.12.3.3.

A.12.6.1.3 For information on the installation of gas vents in existing masonry chimneys, see Section 12.7.

A.12.6.2.1 Chimney clearance requirements are illustrated in Figure A.12.6.2.1.

A.12.6.5.3 Reference can also be made to the chapter on chimney, gas vent, and fireplace systems of the *ASHRAE Handbook — HVAC Systems and Equipment.*

A.12.7.4.1 Additional information on sizing venting systems can be found in the following:

(1) Tables in Chapter 13
(2) The appliance manufacturer's instructions
(3) The vent system manufacturer's sizing instructions
(4) Drawings, calculations, and specifications provided by the vent system 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*

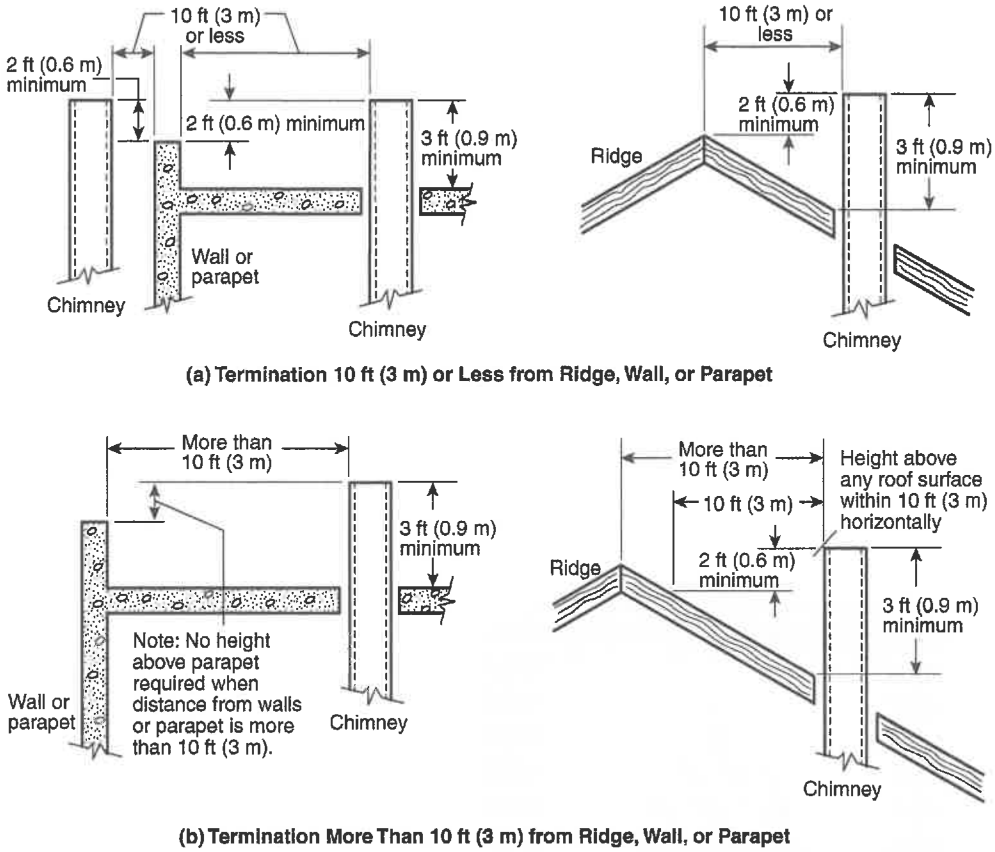


FIGURE A.12.6.2.1 Typical Termination Locations for Chimneys and Single-Wall Metal Pipes Serving Residential-Type and Low-Heat Appliances.

Category I appliances can be either draft hood–equipped or a fan-assisted combustion system in design. Different vent design methods are required for draft hood–equipped and fan-assisted combustion system appliances.

A.12.7.5.2 An example of practical separation of multistory gas venting is provided in Figure A.12.7.5.2.

Δ **A.12.8.2** Data on winter design temperature can be found in Figure F.2.4 and the *ASHRAE Handbook — Fundamentals.*

A.12.8.4.1 The prohibition only applies to a vent entirely constructed of single-wall metal pipe located in a residential occupancy. The prohibition does not apply to single-wall vent connectors used to connect an appliance to the vent as permitted in Section 12.11 and Chapter 13.

A.12.8.5(1) Reference can also be made to the chapter on chimney, gas vent, and fireplace systems of the *ASHRAE Handbook — HVAC Systems and Equipment.*

•

A.12.11.3 Reference can also be made to the chapter on chimney, gas vent, and fireplace systems of the *ASHRAE Handbook — HVAC Systems and Equipment.*

A.12.11.9 A vent connector should be installed so as to avoid turns or other construction features that create excessive resistance to flow of vent gases. A vent connector should be as short as practical, and the appliance located as close as practical, to the chimney or vent.

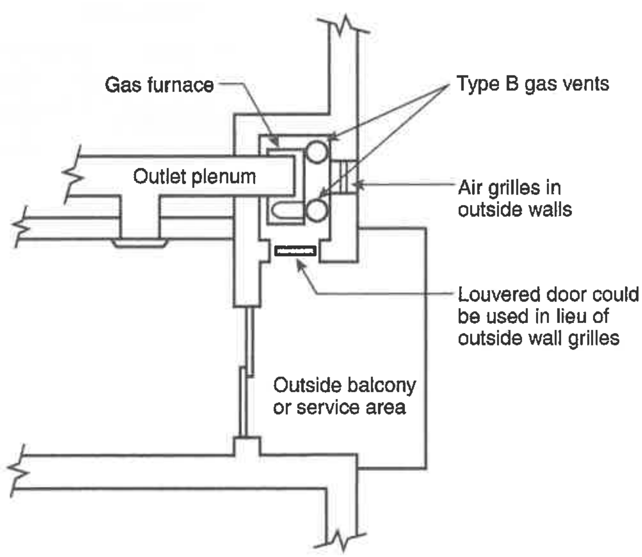


FIGURE A.12.7.5.2 Plan View of Practical Separation Method for Multistory Gas Venting.

 Shaded text = Revisions. Δ = Text deletions and figure/table revisions. • = Section deletions. *N* = New material.

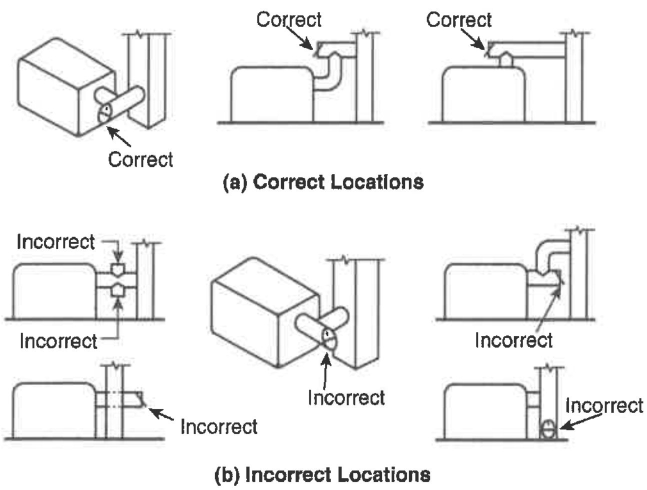


FIGURE A.12.13.4 Locations for Barometric Draft Regulators.

A.12.13.4 A device that automatically shuts 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.12.13.4 shows examples of correct and incorrect locations for barometric draft regulators.

N **A.12.14.2** Balancing baffles are typically used in engineered systems and are provided to allow draft adjustment during appliance and venting system commissioning. They are fixed in place and not adjusted after commissioning.

A.13.1.7 A long radius turn is a turn where the centerline radius is equal to or greater than 1.5 times the vent diameter.

A.13.2.20 A long radius turn is a turn where the centerline radius is equal to or greater than 1.5 times the vent diameter.

Annex B Sizing and Capacities of Gas Piping

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Sizing Factors. The first goal of determining the pipe sizing of a fuel gas piping system is to be assured that the gas pressure at the inlet to each appliance is sufficient. The majority of systems are residential, and the appliances all have the same, or nearly the same, requirement for minimum gas pressure at the appliance inlet. This pressure is about 5 in. (1.2 kPa) w.c., which is enough for proper operation of the appliance regulator to deliver about 3.5 in. (0.87 kPa) w.c. to the burner itself. The pressure drop in the piping is subtracted from the source delivery pressure to verify that the minimum is available at the appliance.

There are other systems, however, where the required inlet pressure to the different appliances could be quite varied. In such cases, the greatest inlet pressure required must be satisfied, as well as the farthest appliance, which is almost always the critical appliance in small systems.

There is an additional requirement to be observed besides the capacity of the system at 100 percent flow. That requirement is that at minimum flow, the pressure at the inlet to any appliance does not exceed the pressure rating of the appliance regulator. This factor would seldom be of concern in small systems if the source pressure is ½ psi (14 in. w.c.) (3.4 kPa) or less, but it should be verified for systems with greater gas pressure at the point of supply.

B.2 General Pipe Sizing Considerations. To determine the size of piping used in a gas piping system, the following factors must be considered:

(1) Allowable loss in pressure from point of delivery to appliance
(2) Maximum gas demand
(3) Length of piping and number of fittings
(4) Specific gravity of the gas
(5) Diversity factor

For any gas piping system, or special appliance, or for conditions other than those covered by the tables provided in this code, such as longer runs, greater gas demands, or greater pressure drops, the size of each gas piping system should be determined by standard engineering practices acceptable to the authority having jurisdiction.

B.3 Description of Tables.

B.3.1 General. The quantity of gas to be provided at each outlet should be determined, whenever possible, directly from the manufacturer's gas input Btu/hr rating of the appliance to be installed, adjusted for altitude where appropriate. In case the ratings of the appliances to be installed are not known, Table A.5.3.2.1 shows the approximate consumption (in Btu per hour) of certain types of typical household appliances.

To obtain the cubic feet per hour of gas required, divide the total Btu/hr input of all appliances by the average Btu heating value per cubic foot of the gas. The average Btu per cubic foot of the gas in the area of the installation can be obtained from the serving gas supplier.

B.3.2 Low-Pressure Natural Gas Tables. Capacities for gas at low pressure [2.0 psi (14 kPa gauge) or less] in cubic feet per hour of 0.60 specific gravity gas for different sizes and lengths are shown in Table 6.2.1(a) through Table 6.2.1(d) for iron pipe or equivalent rigid pipe, in Table 6.2.1(h) through Table 6.2.1(k) for smooth wall semirigid tubing, in Table 6.2.1(o) through Table 6.2.1(q) for corrugated stainless steel tubing, and in Table 6.2.1(t)and Table 6.2.1(u) for polyethylene plastic pipe. Table 6.2.1(a) and Table 6.2.1(h) are based on a pressure drop of 0.3 in. w.c. (75 Pa), whereas Table 6.2.1(b), Table 6.2.1(i), and Table 6.2.1(o) are based on a pressure drop of 0.5 in. w.c. (125 Pa). Table 6.2.1(j), Table 6.2.1(p), and Table 6.2.1(q) are special low-pressure applications based on pressure drops greater than 0.5 in. w.c. (125 Pa). In using Table 6.2.1(j), Table 6.2.1(p), or Table 6.2.1(q), an allowance (in equivalent length of pipe) should be considered for any piping run with four or more fittings *(see Table B.3.2)*.

Table B.3.2 Equivalent Lengths of Pipe Fittings and Valves

		Screwed Fittings[1]				90°Welding Elbows and Smooth Bends[2]					
		45°/Ell	90°/Ell	180° Close Return Bends	Tee	$R/d = 1$	$R/d = 1⅓$	$R/d = 2$	$R/d = 4$	$R/d = 6$	$R/d = 8$
	k factor =	0.42	0.90	2.00	1.80	0.48	0.36	0.27	0.21	0.27	0.36
	L/d' ratio[4] *n* =	14	30	67	60	16	12	9	7	9	12
Nominal Pipe Size (in.)	Inside Diam. *d* (in.), Sched. 40[6]										
		L = Equivalent Length in Feet of Schedule 40 (Standard Weight) Straight Pipe[6]									
½	0.622	0.73	1.55	3.47	3.10	0.83	0.62	0.47	0.36	0.47	0.62
¾	0.824	0.96	2.06	4.60	4.12	1.10	0.82	0.62	0.48	0.62	0.82
1	1.049	1.22	2.62	5.82	5.24	1.40	1.05	0.79	0.61	0.79	1.05
1¼	1.380	1.61	3.45	7.66	6.90	1.84	1.38	1.03	0.81	1.03	1.38
1½	1.610	1.88	4.02	8.95	8.04	2.14	1.61	1.21	0.94	1.21	1.61
2	2.067	2.41	5.17	11.5	10.3	2.76	2.07	1.55	1.21	1.55	2.07
2½	2.469	2.88	6.16	13.7	12.3	3.29	2.47	1.85	1.44	1.85	2.47
3	3.068	3.58	7.67	17.1	15.3	4.09	3.07	2.30	1.79	2.30	3.07
4	4.026	4.70	10.1	22.4	20.2	5.37	4.03	3.02	2.35	3.02	4.03
5	5.047	5.88	12.6	28.0	25.2	6.72	5.05	3.78	2.94	3.78	5.05
6	6.065	7.07	15.2	33.8	30.4	8.09	6.07	4.55	3.54	4.55	6.07
8	7.981	9.31	20.0	44.6	40.0	10.6	7.98	5.98	4.65	5.98	7.98
10	10.02	11.7	25.0	55.7	50.0	13.3	10.0	7.51	5.85	7.51	10.0
12	11.94	13.9	29.8	66.3	59.6	15.9	11.9	8.95	6.96	8.95	11.9
14	13.13	15.3	32.8	73.0	65.6	17.5	13.1	9.85	7.65	9.85	13.1
16	15.00	17.5	37.5	83.5	75.0	20.0	15.0	11.2	8.75	11.2	15.0
18	16.88	19.7	42.1	93.8	84.2	22.5	16.9	12.7	9.85	12.7	16.9
20	18.81	22.0	47.0	105	94.0	25.1	18.8	14.1	11.0	14.1	18.8
24	22.63	26.4	56.6	126	113	30.2	22.6	17.0	13.2	17.0	22.6

Miter Elbows[3] (No. of Miters)					Welding Tees		Valves (Screwed, Flanged, or Welded)			
1-45°	1-60°	1-90°	2-90°	3-90°	Forged	Miter[3]	Gate	Globe	Angle	Swing Check
0.45	0.90	1.80	0.60	0.45	1.35	1.80	0.21	10	5.0	2.5
15	30	60	20	15	45	60	7	333	167	83
			5	5						
L = Equivalent Length in Feet of Schedule 40 (Standard Weight) Straight Pipe[6]										
0.78	1.55	3.10	1.04	0.78	2.33	3.10	0.36	17.3	8.65	4.32
1.03	2.06	4.12	1.37	1.03	3.09	4.12	0.48	22.9	11.4	5.72
1.31	2.62	5.24	1.75	1.31	3.93	5.24	0.61	29.1	14.6	7.27
1.72	3.45	6.90	2.30	1.72	5.17	6.90	0.81	38.3	19.1	9.58
2.01	4.02	8.04	2.68	2.01	6.04	8.04	0.94	44.7	22.4	11.2
2.58	5.17	10.3	3.45	2.58	7.75	10.3	1.21	57.4	28.7	14.4
3.08	6.16	12.3	4.11	3.08	9.25	12.3	1.44	68.5	34.3	17.1
3.84	7.67	15.3	5.11	3.84	11.5	15.3	1.79	85.2	42.6	21.3
5.04	10.1	20.2	6.71	5.04	15.1	20.2	2.35	112	56.0	28.0
6.30	12.6	25.2	8.40	6.30	18.9	25.2	2.94	140	70.0	35.0

(continues)

Table B.3.2 *Continued*

Miter Elbows[3] (No. of Miters)					Welding Tees		Valves (Screwed, Flanged, or Welded)			
1-45°	1-60°	1-90°	2-90°	3-90°	Forged	Miter[3]	Gate	Globe	Angle	Swing Check
0.45	0.90	1.80	0.60	0.45	1.35	1.80	0.21	10	5.0	2.5
15	30	60	20	15	45	60	7	333	167	83
			5 	5 						
L = Equivalent Length in Feet of Schedule 40 (Standard Weight) Straight Pipe[6]										
7.58	15.2	30.4	10.1	7.58	22.8	30.4	3.54	168	84.1	42.1
9.97	20.0	40.0	13.3	9.97	29.9	40.0	4.65	222	111	55.5
12.5	25.0	50.0	16.7	12.5	37.6	50.0	5.85	278	139	69.5
14.9	29.8	59.6	19.9	14.9	44.8	59.6	6.96	332	166	83.0
16.4	32.8	65.6	21.9	16.4	49.2	65.6	7.65	364	182	91.0
18.8	37.5	75.0	25.0	18.8	56.2	75.0	8.75	417	208	104
21.1	42.1	84.2	28.1	21.1	63.2	84.2	9.85	469	234	117
23.5	47.0	94.0	31.4	23.5	70.6	94.0	11.0	522	261	131
28.3	56.6	113	37.8	28.3	85.0	113	13.2	629	314	157

For SI units, 1 ft = 0.305 m.

Note: Values for welded fittings are for conditions where bore is not obstructed by weld spatter or backing rings. If appreciably obstructed, use values for "Screwed Fittings."

[1]Flanged fittings have three-fourths the resistance of screwed elbows and tees.

[2]Tabular figures give the extra resistance due to curvature alone to which should be added the full length of travel.

[3]Small size socket-welding fittings are equivalent to miter elbows and miter tees.

[4]Equivalent resistance in number of diameters of straight pipe computed for a value of f - 0.0075 from the relation n - $k/4f$.

[5]For condition of minimum resistance where the centerline length of each miter is between d and $2\frac{1}{2}d$.

[6]For pipe having other inside diameters, the equivalent resistance may be computed from the above n values.

Source: From *Piping Handbook*, Table XIV, pp. 100–101. Used by permission of McGraw-Hill Book Company.

B.3.3 Undiluted LP-Gas Tables. Capacities in thousands of Btu per hour of undiluted LP-Gases based on a pressure drop of 0.5 in. w.c. (125 Pa) for different sizes and lengths are shown in Table 6.3.1(d) for iron pipe or equivalent rigid pipe, in Table 6.3.1(f) for smooth wall semirigid tubing, in Table 6.3.1(h) for corrugated stainless steel tubing, and in Table 6.3.1(k) and Table 6.3.1(m) for polyethylene plastic pipe and tubing. Table 6.3.1(i) and Table 6.3.1(j) for corrugated stainless steel tubing and Table 6.3.1(l) for polyethylene plastic pipe are based on operating pressures greater than 0.5 psi (3.5 kPa) and pressure drops greater than 0.5 in. w.c. (125 Pa). In using these tables, an allowance (in equivalent length of pipe) should be considered for any piping run with four or more fittings *(see Table B.3.2)*.

B.3.4 Natural Gas Specific Gravity. Gas piping systems that are to be supplied with gas of a specific gravity of 0.70 or less can be sized directly from the tables provided in this code, unless the authority having jurisdiction specifies that a gravity factor be applied. Where the specific gravity of the gas is greater than 0.70, the gravity factor should be applied.

Application of the gravity factor converts the figures given in the tables provided in this code to capacities for another gas of different specific gravity. Such application is accomplished by multiplying the capacities given in the tables by the multipliers shown in Table B.3.4. In case the exact specific gravity does not appear in the table, choose the next higher value specific gravity shown.

Table B.3.4 SPECIAL USE: Multipliers to Be Used with Tables 6.2.1(a) Through 6.2.1(x) 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

B.3.5 Higher Pressure Natural Gas Tables. Capacities for gas at pressures of 2 psi (14 kPa) and greater in cubic feet per hour of 0.60 specific gravity gas for different sizes and lengths are shown in Table 6.2.1(e) and Table 6.2.1(f) for iron pipe or equivalent rigid pipe, Table 6.2.1(l) through Table 6.2.1(n) for semirigid tubing, Table 6.2.1(r) and Table 6.2.1(s) for corrugated stainless steel tubing, and Table 6.2.1(u) and Table 6.2.1(v) for polyethylene plastic pipe.

B.4 Use of Capacity Tables.

B.4.1 The Longest Length Method. This sizing method is conservative in its approach by applying the maximum operating conditions in the system as the norm for the system and by setting the length of pipe used to size any given part of the piping system to the maximum value.

To determine the size of each section of gas piping in a system within the range of the capacity tables, proceed as follows *(also see sample calculations included in this annex)*:

(1) Divide the piping system into appropriate segments consistent with the presence of tees, branch lines, and main runs. For each segment, determine the gas load (assuming all appliances operate simultaneously) and its overall length. An allowance (in equivalent length of pipe) as determined from Table B.3.2 should be considered for piping segments that include four or more fittings.
(2) Determine the gas demand of each appliance to be attached to the piping system. Where Table 6.2.1(a) through Table 6.2.1(x) are to be used to select the piping size, calculate the gas demand in terms of cubic feet per hour for each piping system outlet. Where Table 6.3.1(a) through Table 6.3.1(m) are to be used to select the piping size, calculate the gas demand in terms of thousands of Btu per hour for each piping system outlet.
(3) Where the piping system is for use with other than undiluted LP-Gases, determine the design system pressure, the allowable loss in pressure (pressure drop), and specific gravity of the gas to be used in the piping system.
(4) Determine the length of piping from the point of delivery to the most remote outlet in the building/piping system.
(5) In the appropriate capacity table, select the row showing the measured length or the next longer length if the table does not give the exact length. This length is the only length used in determining the size of any section of gas piping. If the gravity factor is to be applied, the values in the selected row of the table are multiplied by the appropriate multiplier from Table B.3.4.
(6) Use this horizontal row to locate ALL gas demand figures for this particular system of piping.
(7) Starting at the most remote outlet, find the gas demand for that outlet in the horizontal row just selected. If the exact figure of demand is not shown, choose the next larger figure left in the row.
(8) Opposite this demand figure, in the first row at the top, the correct size of gas piping will be found.
(9) Proceed in a similar manner for each outlet and each section of gas piping. For each section of piping, determine the total gas demand supplied by that section.

When a large number of piping components (such as elbows, tees, and valves) are installed in a pipe run, additional pressure loss can be accounted for by the use of equivalent lengths. Pressure loss across any piping component can be equated to the pressure drop through a length of pipe. The equivalent length of a combination of only four elbows/tees can result in a jump to the next larger length row, resulting in a significant reduction in capacity. The equivalent lengths in feet shown in Table B.3.2 have been computed on a basis that the inside diameter corresponds to that of Schedule 40 (standard weight) steel pipe, which is close enough for most purposes involving other schedules of pipe. Where a more specific solution for equivalent length is desired, this can be made by multiplying the actual inside diameter of the pipe in inches by $n/12$, or the actual inside diameter in feet by n. N can be read from the table heading. The equivalent length values can be used with reasonable accuracy for copper or copper alloy fittings and bends, although the resistance per foot of copper or copper alloy pipe is less than that of steel. For copper or copper alloy 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.

B.4.2 The Branch Length Method. This sizing method reduces the amount of conservatism built into the traditional Longest Length Method. The longest length as measured from the meter to the farthest remote appliance is used only to size the initial parts of the overall piping system. The Branch Length Method is applied in the following manner:

(1) Determine the gas load for each of the connected appliances.
(2) Starting from the meter, divide the piping system into a number of connected segments, and determine the length and amount of gas that each segment would carry, assuming that all appliances were operated simultaneously. An allowance (in equivalent length of pipe) as determined from Table B.3.2 should be considered for piping segments that include four or more fittings.
(3) Determine the distance from the outlet of the gas meter to the appliance farthest removed from the meter.
(4) Using the longest distance (found in Step 3), size each piping segment from the meter to the most remote appliance outlet.
(5) For each of these piping segments, use the longest length and the calculated gas load for all of the connected appliances for the segment and begin the sizing process in Steps 6 through 8.
(6) Referring to the appropriate sizing table (based on operating conditions and piping material), find the longest length distance in the first column or the next larger distance if the exact distance is not listed. The use of alternative operating pressures and/or pressure drops requires the use of a different sizing table but does not alter the sizing methodology. In many cases, the use of alternative operating pressures and/or pressure drops requires the approval of both the authority having jurisdiction and the local gas serving utility.
(7) Trace across this row until the gas load is found or the closest larger capacity if the exact capacity is not listed.
(8) Read up the table column and select the appropriate pipe size in the top row. Repeat Steps 6, 7, and 8 for each pipe segment in the longest run.
(9) Size each remaining section of branch piping not previously sized by measuring the distance from the gas meter location to the most remote outlet in that branch, using the gas load of attached appliances, and follow the procedures of Steps 2 through 8.

B.4.3 Hybrid Pressure Method. The sizing of a 2 psi (14 kPa) gas piping system is performed using the traditional Longest Length Method but with modifications. The 2 psi (14 kPa) system consists of two independent pressure zones, and each zone is sized separately. The Hybrid Pressure Method is applied using the following steps.

The 2 psi (14 kPa) section (from the meter to the line regulator) is sized as follows:

(1) Calculate the gas load (by adding up the nameplate ratings) from all connected appliances. (In certain circumstances the installed gas load can be increased up to 50 percent to accommodate future addition of appliances.) Ensure that the line regulator capacity is adequate for the calculated gas load and that the required pressure drop (across the regulator) for that capacity does not exceed ¾ psi (5.2 kPa) for a 2 psi (14 kPa) system. If the pressure drop across the regulator is too high (for the connected gas load), select a larger regulator.
(2) Measure the distance from the meter to the line regulator located inside the building.
(3) If multiple line regulators are used, measure the distance from the meter to the regulator farthest removed from the meter.
(4) The maximum allowable pressure drop for the 2 psi (14 kPa) section is 1 psi (7 kPa).
(5) Referring to the appropriate sizing table (based on piping material) for 2 psi (14 kPa) systems with a 1 psi (7 kPa) pressure drop, find this distance in the first column, or the closest larger distance if the exact distance is not listed.
(6) Trace across this row until the gas load is found or the closest larger capacity if the exact capacity is not listed.
(7) Read up the table column to the top row and select the appropriate pipe size.
(8) If multiple regulators are used in this portion of the piping system, each line segment must be sized for its actual gas load, using the longest length previously determined.

The low-pressure section (all piping downstream of the line regulator) is sized as follows:

(1) Determine the gas load for each of the connected appliances.
(2) Starting from the line regulator, divide the piping system into a number of connected segments and/or independent parallel piping segments and determine the amount of gas that each segment would carry, assuming that all appliances were operated simultaneously. An allowance (in equivalent length of pipe) as determined from Table B.3.2 should be considered for piping segments that include four or more fittings.
(3) For each piping segment, use the actual length or longest length (if there are sub-branch lines) and the calculated gas load for that segment and begin the sizing process as follows:
   (a) Referring to the appropriate sizing table (based on operating pressure and piping material), find the longest length distance in the first column or the closest larger distance if the exact distance is not listed. The use of alternative operating pressures and/or pressure drops requires the use of a different sizing table but does not alter the sizing methodology. In many cases, the use of alternative operating pressures and/or pressure drops could require the approval of the authority having jurisdiction.
   (b) Trace across this row until the appliance gas load is found or the closest larger capacity if the exact capacity is not listed.
   (c) Read up the table column to the top row and select the appropriate pipe size.
   (d) Repeat this process for each segment of the piping system.

B.4.4 Pressure Drop per 100 ft Method. This sizing method is less conservative than the others, but it allows the designer to immediately see where the largest pressure drop occurs in the system. With this information, modifications can be made to bring the total drop to the critical appliance within the limitations that are presented to the designer.

Follow the procedures described in the Longest Length Method for steps (1) through (4) and step (9).

For each piping segment, calculate the pressure drop based on pipe size, length as a percentage of 100 ft, and gas flow. Table B.4.4 shows pressure drop per 100 ft for pipe sizes from ½ in. through 2 in. The sum of pressure drops to the critical appliance is subtracted from the supply pressure to verify that sufficient pressure is available. If not, the layout can be examined to find the high drop section(s), and sizing selections modified.

Table B.4.4 Thousands of Btu/hr of Natural Gas per 100 ft of Pipe at Various Pressure Drops and Pipe Diameters

Press. Drop/ 100 ft (in. w.c.)	Pipe Sizes (in.)					
	½	¾	1	1¼	1½	2
0.2	31	64	121	248	372	716
0.3	38	79	148	304	455	877
0.5	50	104	195	400	600	1160
1.0	71	147	276	566	848	1640

Note: Other values can be obtained using the following equation:

[B.4.4a]

$$\text{Desired Value} = \text{thousands of Btu/hr} \times \sqrt{\frac{\text{Desired Drop}}{\text{Table Drop}}}$$

For example, if it is desired to get flow through ¾ in. pipe at 2 in. w.c./ 100 ft, multiply the capacity of ¾ in. pipe at 1 in./100 ft by the square root of the pressure ratio:

[B.4.4b]

$$147{,}000 \text{ Btu/hr} \times \sqrt{\frac{2 \text{ in. w.c.}}{1 \text{ in. w.c.}}} = 147{,}000 \times 1.414 = 208{,}000 \text{ Btu/hr}$$

B.5 Use of Sizing Equations. Capacities of smooth wall pipe or tubing can also be determined by using the following formulas:

(1) *High Pressure* [1.5 psi (10.3 kPa) and above]:

[B.5a]

$$Q = 181.6\sqrt{\frac{D^5 \cdot \left(P_1^2 - P_2^2\right) \cdot Y}{Cr \cdot fba \cdot L}}$$

$$= 2237 D^{2.623}\left[\frac{\left(P_1^2 - P_2^2\right) \cdot Y}{Cr \cdot L}\right]^{0.541}$$

(2) *Low Pressure* [less than 1.5 psi (10.3 kPa)]:

[B.5b]

$$Q = 187.3\sqrt{\frac{D^5 \cdot \Delta H}{Cr \cdot fba \cdot L}}$$

$$= 2313 D^{2.623}\left(\frac{\Delta H}{Cr \cdot L}\right)^{0.541}$$

where:

Q = rate (cubic feet per hour at 60°F and 30 in. mercury column)
D = inside diameter of pipe (in.)
P_1 = upstream pressure (psia)
P_2 = downstream pressure (psia)
Y = superexpansibility factor = 1/supercompressibility factor
Cr = factor for viscosity, density, and temperature
fba = base friction factor for air at 60°F (CF = 1)
L = length of pipe (ft)
H = pressure drop [in. w.c. (27.7 in. H_2O = 1 psi) = $0.00354\ ST(Z/S)^{0.152}$]

See Table 6.4.2 for values of *Cr* and *Y* for natural gas and propane.

B.6 Pipe and Tube Diameters. Where the internal diameter is determined by the formulas in Section 6.4, Table B.6(a) and Table B.6(b) can be used to select the nominal or standard pipe size based on the calculated internal diameter.

B.7 Examples of Piping System Design and Sizing.

B.7.1 Example 1 — Longest Length Method. Determine the required pipe size of each section and outlet of the piping system shown in Figure B.7.1, with a designated pressure drop of 0.50 in. w.c. (125 Pa), using the Longest Length Method.

Table B.6(a) Schedule 40 Steel Pipe Standard Sizes

Nominal Size (in.)	Internal Diameter (in.)	Nominal Size (in.)	Internal Diameter (in.)
¼	0.364	1½	1.610
⅜	0.493	2	2.067
½	0.622	2½	2.469
¾	0.824	3	3.068
1	1.049	3½	3.548
1¼	1.380	4	4.026

Δ Table B.6(b) Copper Tube Standard Sizes

Tube Type	Nominal or Standard Size (in.)	Internal Diameter (in.)	Tube Type	Nominal or Standard Size (in.)	Internal Diameter (in.)
K	¼	0.305	K	1	0.995
L	¼	0.315	L	1	1.025
ACR (D)	⅜	0.315	ACR (D, A)	1⅛	1.025
ACR (A)	⅜	0.311	K	1¼	1.245
K	⅜	0.402	L	1¼	1.265
L	⅜	0.430	ACR (D, A)	1⅜	1.265
ACR (D)	½	0.430	K	1½	1.481
ACR (A)	½	0.436	L	1½	1.505
K	½	0.527	ACR (D, A)	1⅝	1.505
L	½	0.545	K	2	1.959
ACR (D)	⅝	0.545	L	2	1.985
ACR (A)	⅝	0.555	ACR (D, A)	2⅛	1.985
K	⅝	0.652	K	2½	2.435
L	⅝	0.666	L	2½	2.465
ACR (D)	¾	0.666	ACR (D, A)	2⅝	2.465
ACR (A)	¾	0.680	K	3	2.907
K	¾	0.745	L	3	2.945
L	¾	0.785	ACR (D, A)	3⅛	2.945
ACR (D, A)	⅞	0.785			

The gas to be used has 0.60 specific gravity and a heating value of 1000 Btu/ft³ (37.5 MJ/m³).

Solution

(1) Maximum gas demand for outlet A:

[B.7.1a]

$$\frac{\text{Consumption}\left(\text{rating plate input, or Table 5.4.2.1 if necessary}\right)}{\text{Btu of gas}}$$

$$= \frac{35{,}000 \text{ Btu/hr rating}}{1000 \text{ Btu/ft}} = 35 \text{ ft}^3/\text{hr} = 35 \text{ cfh}$$

Maximum gas demand for outlet B:

[B.7.1b]

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{75{,}000}{1000} = 75 \text{ cfh}$$

Maximum gas demand for outlet C:

[B.7.1c]

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{35{,}000}{1000} = 35 \text{ cfh}$$

Maximum gas demand for outlet D:

[B.7.1d]

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{100{,}000}{1000} = 100 \text{ cfh}$$

(2) The length of pipe from the point of delivery to the most remote outlet (A) is 60 ft (18.3 m). This is the only distance used.

(3) Using the row marked 60 ft (18.3 m) in Table 6.2.1(b):

(a) Outlet A, supplying 35 cfh (0.99 m^3/hr), requires ½ in. pipe.

(b) Outlet B, supplying 75 cfh (2.12 m^3/hr), requires ¾ in. pipe.

(c) Section 1, supplying outlets A and B, or 110 cfh (3.11 m^3/hr), requires ¾ in. pipe.

(d) Section 2, supplying outlets C and D, or 135 cfh (3.82 m^3/hr), requires ¾ in. pipe.

(e) Section 3, supplying outlets A, B, C, and D, or 245 cfh (6.94 m^3/hr), requires 1 in. pipe.

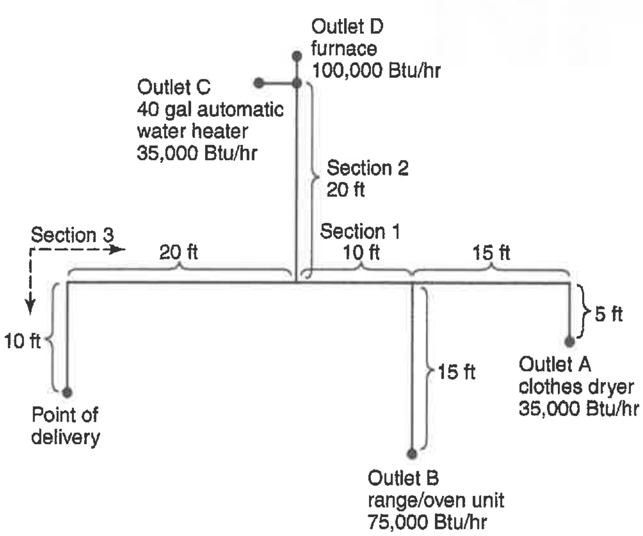
(4) If a different gravity factor is applied to this example, the values in the row marked 60 ft (18.3 m) of Table 6.2.1(b) would be multiplied by the appropriate multiplier from Table B.3.4, and the resulting cubic feet per hour values would be used to size the piping.

B.7.2 Example 2 — Hybrid or Dual Pressure Systems. Determine the required CSST size of each section of the piping system shown in Figure B.7.2, with a designated pressure drop of 1 psi (7 kPa) for the 2 psi (14 kPa) section and 3 in. w.c. (0.75 kPa) pressure drop for the 10 in. w.c. (2.49 kPa) section. The gas to be used has 0.60 specific gravity and a heating value of 1000 Btu/ft³ (37.5 MJ/m³).

Solution

(1) Size 2 psi (14 kPa) line using Table 6.2.1(r).

(2) Size 10 in. w.c. (2.5 kPa) lines using Table 6.2.1(p).



For SI units, 1 ft = 0.305 m, 1 gal = 3.785 L, 1000 Btu/hr = 0.293 kW.

FIGURE B.7.1 Piping Plan Showing a Steel Piping System.

(3) Using the following steps, determine if sizing tables can be used:

(a) Total gas load shown in Figure B.7.2 equals 110 chf (3.11 m^3/hr).

(b) Determine pressure drop across regulator [see notes in Table 6.2.1(r)].

(c) If pressure drop across regulator exceeds ¾ psi (5.2 kPa), Table 6.2.1(r) cannot be used. Note that if pressure drop exceeds ¾ psi (5.2 kPa), a larger regulator must be selected or an alternative sizing method must be used.

(d) Pressure drop across the line regulator [for 110 cfh/(3.11 m^3/hr)] is 4 in. w.c. (0.99 kPa) based on manufacturer's performance data.

(e) Assume the CSST manufacturer has tubing sizes or EHDs of 13, 18, 23, and 30.

(4) From Section A [2 psi (14 kPa) zone]:

(a) Determine distance from meter to regulator = 100 ft (30.48 m).

(b) Determine total load supplied by A = 110 cfh (3.11 m^3/hr) (furnace + water heater + dryer).

(c) Table 6.2.1(r) shows that EHD size 18 should be used. Note that it is not unusual to oversize the supply line by 25 to 50 percent of the as-installed load. EHD size 18 has a capacity of 189 cfh (5.35 m^3/hr).

(5) From Section B (low-pressure zone):

(a) Distance from regulator to furnace is 15 ft (4.57 m).

(b) Load is 60 cfh (1.70 m^3/hr).

(c) Table 6.2.1(p) shows that EHD size 13 should be used.

(6) From Section C (low-pressure zone):

(a) Distance from regulator to water heater is 10 ft (3 m).

(b) Load is 30 cfh (0.85 m^3/hr).

(c) Table 6.2.1(p) shows that EHD size 13 should be used.

(7) From Section D (low-pressure zone):

(a) Distance from regulator to dryer is 25 ft (7.62 m).

(b) Load is 20 cfh (0.57 m^3/hr).

(c) Table 6.2.1(p) shows that EHD size 13 should be used.

B.7.3 Example 3 — Branch Length Method. Determine the required semirigid copper tubing size of each section of the piping system shown in Figure B.7.3, with a designated pressure drop of 1 in. w.c. (250 Pa) (using the Branch Length Method). The gas to be used has 0.60 specific gravity and a heating value of 1000 Btu/ft³ (37.5 MJ/m³).

Solution

(1) Section A:

(a) The length of tubing from the point of delivery to the most remote appliance is 50 ft (15 m), A + C.

(b) Use this longest length to size Sections A and C.

(c) Using the row marked 50 ft (15 m) in Table 6.2.1(j), Section A supplying 220 cfh (6.23 m^3/hr) for four appliances requires 1 in. (25 mm) tubing.

(2) Section B:

(a) The length of tubing from the point of delivery to the range/oven at the end of Section B is 30 ft (9.14 m), A + B.

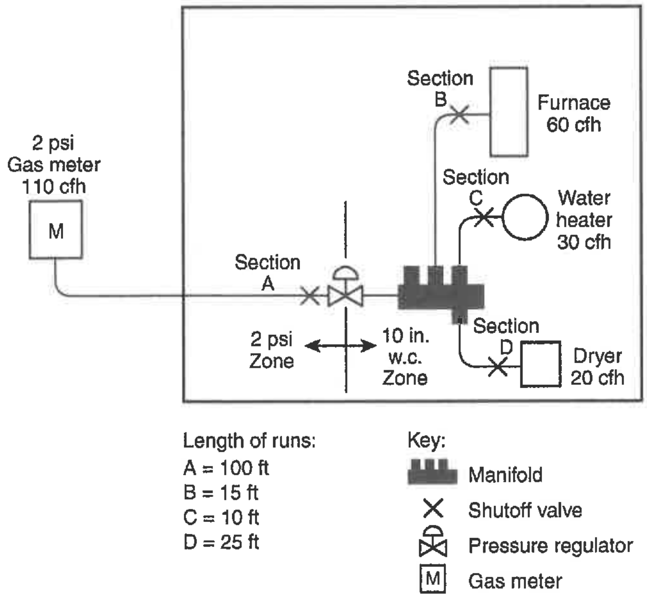


FIGURE B.7.2 Piping Plan Showing a CSST System.

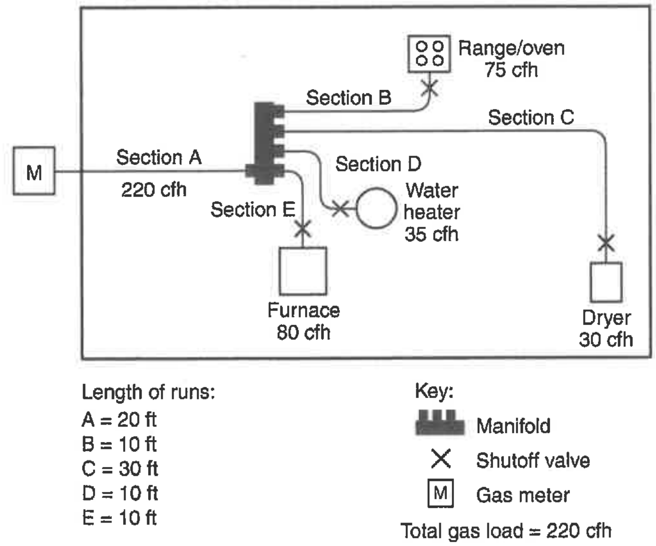


FIGURE B.7.3 Piping Plan Showing a Copper Tubing System.

(b) Use this branch length to size Section B only.

(c) Using the row marked 30 ft (9.14 m) in Table 6.2.1(j), Section B supplying 75 cfh (2.12 m^3/hr) for the range/oven requires ½ in. (15 mm) tubing.

(3) Section C:

(a) The length of tubing from the point of delivery to the dryer at the end of Section C is 50 ft (15 m), A + C.

(b) Use this branch length (which is also the longest length) to size Section C.

(c) Using the row marked 50 ft (15 m) in Table 6.2.1(j), Section C supplying 30 cfh (0.85 m^3/hr) for the dryer requires ⅜ in. (10 mm) tubing.

(4) Section D:

(a) The length of tubing from the point of delivery to the water heater at the end of Section D is 30 ft (9.14 m), A + D.

(b) Use this branch length to size Section D only.

(c) Using the row marked 30 ft (9.14 m) in Table 6.2.1(j), Section D supplying 35 cfh (0.99 m^3/hr) for the water heater requires ⅜ in. (10 mm) tubing.

(5) Section E:

(a) The length of tubing from the point of delivery to the furnace at the end of Section E is 30 ft (9.14 m), A + E.

(b) Use this branch length to size Section E only.

(c) Using the row marked 30 ft (9.14 m) in Table 6.2.1(j), Section E supplying 80 cfh (2.26 m^3/hr) for the furnace requires ½ in. (15 mm) tubing.

B.7.4 Example 4 — Modification to Existing Piping System. Determine the required CSST size for Section G (retrofit application) of the piping system shown in Figure B.7.4, with a designated pressure drop of 0.50 in. w.c. (125 Pa) using the Branch Length Method. The gas to be used has 0.60 specific gravity and a heating value of 1000 Btu/ft^3 (37.5 MJ/m^3).

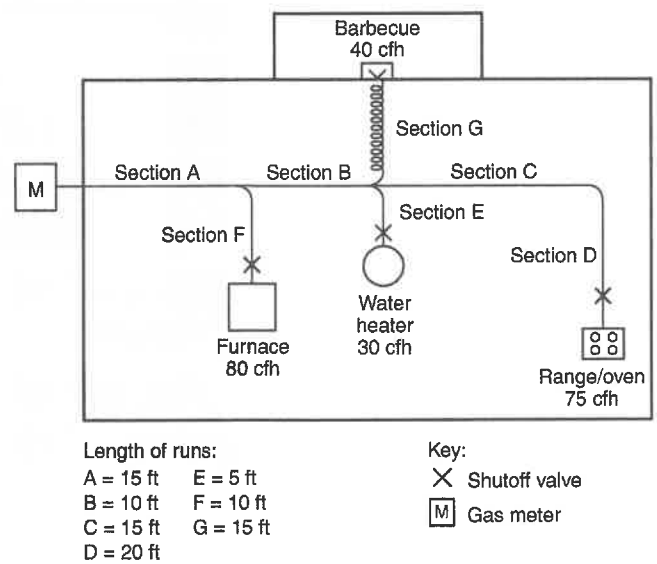


FIGURE B.7.4 Piping Plan Showing Modification to an Existing Piping System.

Solution

(1) The length of pipe and CSST from the point of delivery to the retrofit appliance (barbecue) at the end of Section G is 40 ft (12.19 m), A + B + G.

(2) Use this branch length to size Section G.

(3) Assume the CSST manufacturer has tubing sizes or EHDs of 13, 18, 23, and 30.

(4) Using the row marked 40 ft (12.19 m) in Table 6.2.1(o), Section G supplying 40 cfh (1.13 m^3/hr) for the barbecue requires EHD 18 CSST.

(5) The sizing of Sections A, B, F, and E must be checked to ensure adequate gas carrying capacity since an appliance has been added to the piping system. See B.7.1 for details.

B.7.5 Example 5 — Calculating Pressure Drops Due to Temperature Changes. A test piping system is installed on a warm autumn afternoon when the temperature is 70°F (21°C). In accordance with local custom, the new piping system is subjected to an air pressure test at 20 psi (138 kPa). Overnight, the temperature drops, and when the inspector shows up first thing in the morning the temperature is 40°F (4°C).

If the volume of the piping system is unchanged, the formula based on Boyle's and Charles' law for determining the new pressure at a reduced temperature is as follows:

(1)

[B.7.5a]

$$\frac{T_1}{T_2} = \frac{P_1}{P_2}$$

where:
T_1 = initial temperature [absolute (T_1 + 459)]
T_2 = final temperature [absolute (T_2 + 459)]
P_1 = initial pressure [psia (P_1 + 14.7)]
P_2 = final pressure [psia (P_2 + 14.7)]

(2)

[B.7.5b)]

$$\frac{(70+459)}{(40+459)} = \frac{(20+14.7)}{(P_2+14.7)}$$

(3)

[B.7.5c]

$$\frac{529}{499} = \frac{34.7}{(P_2+14.7)}$$

(4)

[B.7.5d]

$$(P_2+14.7) = \frac{34.7}{1.06}$$
$$P_2 = 32.7 - 14.7$$
$$P_2 = 18 \text{ psi}$$

Therefore, you could expect the gauge to register 18 psi (124 kPa) when the ambient temperature is 40°F (4°C).

B.7.6 Example 6 — Pressure Drop per 100 ft of Pipe Method. Using the layout shown in Figure B.7.1 and ΔH = pressure drop, in. w.c. (27.7 in. H_2O = 1 psi), proceed as follows:

(1) Length to A = 20 ft, with 35,000 Btu/hr:
For ½ in. pipe:

Δ **[B.7.6a]**

$$\Delta H = \frac{20 \text{ ft}}{100 \text{ ft}} \times 0.3 \text{ in. w.c.} = 0.06 \text{ in. w.c.}$$

(2) Length to B = 15 ft, with 75,000 Btu/hr:
For ¾ in. pipe:

Δ **[B.7.6b]**

$$\Delta H = \frac{15 \text{ ft}}{100 \text{ ft}} \times 0.3 \text{ in w.c.} = 0.045 \text{ in. w.c.}$$

(3) Section 1 = 10 ft, with 110,000 Btu/hr. Here a choice is available:
For 1 in. pipe:

Δ **[B.7.6c]**

$$\Delta H = \frac{10 \text{ ft}}{100 \text{ ft}} \times 0.\dot{2} \text{ in. w.c.} = 0.02 \text{ in. w.c.}$$

For ¾ in. pipe:

[B.7.6d]

$$\Delta H = \frac{10 \text{ ft}}{100 \text{ ft}} \times \left[0.5 \text{ in. w.c.} + \left(\frac{110{,}000 \text{ Btu/hr} - 104{,}000 \text{ Btu/hr}}{147{,}000 \text{ Btu/hr} - 104{,}000 \text{ Btu/hr}}\right) \times (1.0 \text{ in. w.c.} - 0.5 \text{ in. w.c.})\right]$$
$$= 0.1 \times 0.57 \text{ in. w.c.} \approx 0.06 \text{ in. w.c.}$$

Notice that the pressure drop for 110,000 Btu/hr between 104,000 Btu/hr and 147,000 Btu/hr has been interpolated.

(4) Section 2 = 20 ft, with 135,000 Btu/hr. Here a choice is available:
For 1 in. pipe:

[B.7.6e]

$$\Delta H = \frac{20 \text{ ft}}{100 \text{ ft}} \times \left[0.2 \text{ in. w.c.} + \frac{14{,}000 \text{ Btu/hr}}{27{,}000 \text{ Btu/hr}} \times \Delta 0.1 \text{ in. w.c.}\right]$$
$$= 0.05 \text{ in. w.c.}$$

For ¾ in. pipe:

Δ **[B.7.6f]**

$$\Delta H = \frac{20 \text{ ft}}{100 \text{ ft}} \times 1.0 \text{ in. w.c.} = 0.2 \text{ in. w.c.}$$

Notice that the pressure drop for 135,000 Btu/hr between 121,000 Btu/hr and 148,000 Btu/hr has been interpolated, but interpolation was not used for the ¾ in. pipe (trivial for 104,000 Btu/hr to 147,000 Btu/hr).

(5) Section 3 = 30 ft, with 245,000 Btu/hr. Here a choice is available:
For 1 in. pipe:

[B.7.6g]

$$\Delta H = \frac{30 \text{ ft}}{100 \text{ ft}} \times 1.0 \text{ in. w.c.} = 0.3 \text{ in. w.c.}$$

For 1¼ in. pipe:

Δ **[B.7.6h]**

$$\Delta H = \frac{30 \text{ ft}}{100 \text{ ft}} \times 0.2 \text{ in. w.c.} = 0.06 \text{ in. w.c.}$$

Notice that interpolation was not used for these options, since the table values are close to the 245,000 Btu/hr carried by that section.

(6) The total pressure drop is the sum of the section approaching A, Section 1, and Section 3, or either of the following, depending on whether an absolute minimum is required or the larger drop can be accommodated:
Minimum Pressure Drop to farthest appliance:
ΔH = 0.06 in. w.c. + 0.02 in. w.c. + 0.06 in. w.c. = 0.14 in. w.c.
Larger Pressure Drop to the farthest appliance:
ΔH = 0.06 in. w.c. + 0.06 in. w.c. + 0.3 in. w.c. = 0.42 in. w.c.
Notice that Section 2 and the run to B do not enter into this calculation, provided that the appliances have similar input pressure requirements.
For SI units, 1 Btu/hr = 0.293 W, 1 ft^3 = 0.028 m^3, 1 ft = 0.305 m, 1 in. w.c. = 249 Pa.

Annex C Suggested Method of Checking for Leakage

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.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.

C.2 Leak Check Using the Gas Meter. Immediately prior to the leak check, it should be determined that the meter is in operating condition and has not been bypassed.

The leak check 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 C.2 can be used for determining the length of observation time.

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 shows 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.

Table C.2 Observation Times for Various Meter Dials

Dial Styles (ft^3)	Test Time (min)
¼	5
½	5
1	7
2	10
5	20
10	30

For SI units, 1 ft^3 = 0.028 m^3.

C.3 Leak Check Not Using a Meter. This test can be done using one of the following methods:

(1) *For Any Gas System.*
   (a) Attach a manometer or pressure gauge between the inlet to the piping system and the first regulator in the piping system, momentarily turn on the gas supply, and observe the gauging device for pressure drop with the gas supply shut off. No discernible drop in pressure should occur during a period of 3 minutes.
   (b) Attach an in-line flow meter between the meter outlet and piping system inlet prior to the first regulator in the piping system. Slowly turn on the gas supply and observe the metering device. If flow does not drop to zero, leakage is indicated.

(2) *For Gas Systems Using Undiluted LP-Gas System Preparation for Propane.* A leak check performed on an LP-Gas system being placed back in service can be performed by using one of the following methods:
   (a) Insert a pressure gauge between the container gas shutoff valve and the first-stage regulator or integral two-stage regulator in the system, admitting full container pressure to the system and then closing the container shutoff valve. Enough gas should then be released from the system to lower the pressure gauge reading by 10 psi (69 kPa). The system should then be allowed to stand for 3 minutes without showing an increase or a decrease in the pressure gauge reading.
   (b) Insert a gauge/regulator test assembly between the container gas shutoff valve and first-stage regulator or integral two-stage regulator in the system. If a gauge/regulator test assembly with an inches water column gauge is inserted, follow the test requirements in C.3(2)(c); if a gauge/regulator test assembly with a 30 psi gauge is inserted, follow the test requirements in C.3(2)(d).
   (c) For systems with an integral two-stage, one or more second-stage, or one or more line pressure regulators serving appliances that receive gas at pressures of ½ psi (3.5 kPa) or less, insert a water manometer or inches water column gauge into the system downstream of the final stage regulator, pressurizing the system with either fuel gas or air to a test pressure of 9 in. w.c. ± ½ in. w.c. (2.2 kPa ± 0.1 kPa), and observing the device for a pressure change. If fuel gas is used as a pressure source, it is necessary to pressurize the system to full operating pressure, close the container service valve, and then release enough gas from the system through a range burner valve or other suitable means to drop the system pressure to 9 in. w.c. ± ½ in. w.c. (2.2 kPa ± 0.1 kPa). This ensures that all regulators in the system upstream of the test point 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) When testing a system that has a first-stage regulator, or an integral two-stage regulator, insert a 30 psi (207 kPa) pressure gauge on the downstream side of the first-stage regulator or at the intermediate pressure tap of an integral two-stage regulator, admitting normal operating pressure to the system and then closing the container valve. Enough gas should be released from the system to lower the pressure gauge reading by a minimum of 2 psi (13.8 kPa) so that the first-stage regulator is unlocked. The system should be allowed to stand for 3 minutes without showing an increase or a decrease in pressure gauge reading.

(e) Insert a gauge/regulator test assembly on the downstream side of the first stage regulator or at the intermediate pressure tap of an integral two stage regulator. If a gauge/regulator test assembly with an inches water column gauge is inserted, follow the test requirements in C.3(2)(c); if a gauge/regulator test assembly with a 30 psi gauge is inserted, follow the test requirements in C.3(2)(d).

C.4 When Leakage Is Indicated. If leakage is indicated by a test device, all appliances and 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 to be tight, the piping system has a leak.

Annex D Suggested Emergency Procedure for Gas Leaks

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

Δ **D.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 call 911 from an area remote from the leak.
(4) Ventilate the affected portion of the building by opening windows and doors.
(5) Shut off the supply of gas to the areas involved.
(6) Investigate other buildings in the immediate area to determine the presence of escaping gas therein.

Annex E Flow of Gas Through Fixed Orifices

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

E.1 Use of Orifice Tables.

E.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 E.1.1(a), Utility Gases (cubic feet per hour), or from Table E.1.1(b), LP-Gases (Btu per hour). When the specific gravity of the utility gas is other than 0.60, select the multiplier from Table E.1.1(c) for the specific gravity of the utility gas served and apply to the flow rate as determined from Table E.1.1(a). When the altitude is above 2000 ft (600 m), first select the equivalent orifice size at sea level using Table E.1.1(d), then determine the flow rate from Table E.1.1(a) or Table E.1.1(b) 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.

E.1.2 To Select Correct Orifice Size for Rated Burner Input. The selection of a fixed orifice size for any rated burner input is affected by many variables, including orifice coefficient, and it is recommended that the appliance manufacturer be consulted for that purpose. When the correct orifice size cannot be readily determined, the orifice flow rates, as stated in the tables in this annex, can be used to select a fixed orifice size with a flow rate to approximately equal the required rated burner input.

For gases of the specific gravity and pressure conditions stipulated at elevations under 2000 ft (600 m), Table E.1.1(a) (in cubic feet per hour) or Table E.1.1(b) (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 E.1.1(c) 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.

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 E.1.1(d) to select the equivalent orifice size for use at the higher altitude.

Table E.1.1(a) Utility Gases (cubic feet per hour at sea level)

Orifice or Drill Size	Pressure at Orifice (in. w.c.)								
	3	3.5	4	5	6	7	8	9	10
80	0.48	0.52	0.55	0.63	0.69	0.73	0.79	0.83	0.88
79	0.55	0.59	0.64	0.72	0.80	0.84	0.90	0.97	1.01
78	0.70	0.76	0.78	0.88	0.97	1.04	1.10	1.17	1.24
77	0.88	0.95	0.99	1.11	1.23	1.31	1.38	1.47	1.55
76	1.05	1.13	1.21	1.37	1.52	1.61	1.72	1.83	1.92
75	1.16	1.25	1.34	1.52	1.64	1.79	1.91	2.04	2.14
74	1.33	1.44	1.55	1.74	1.91	2.05	2.18	2.32	2.44
73	1.51	1.63	1.76	1.99	2.17	2.32	2.48	2.64	2.78
72	1.64	1.77	1.90	2.15	2.40	2.52	2.69	2.86	3.00
71	1.82	1.97	2.06	2.33	2.54	2.73	2.91	3.11	3.26
70	2.06	2.22	2.39	2.70	2.97	3.16	3.38	3.59	3.78
69	2.25	2.43	2.61	2.96	3.23	3.47	3.68	3.94	4.14
68	2.52	2.72	2.93	3.26	3.58	3.88	4.14	4.41	4.64
67	2.69	2.91	3.12	3.52	3.87	4.13	4.41	4.69	4.94
66	2.86	3.09	3.32	3.75	4.11	4.39	4.68	4.98	5.24
65	3.14	3.39	3.72	4.28	4.62	4.84	5.16	5.50	5.78
64	3.41	3.68	4.14	4.48	4.91	5.23	5.59	5.95	6.26
63	3.63	3.92	4.19	4.75	5.19	5.55	5.92	6.30	6.63
62	3.78	4.08	4.39	4.96	5.42	5.81	6.20	6.59	6.94
61	4.02	4.34	4.66	5.27	5.77	6.15	6.57	7.00	7.37
60	4.21	4.55	4.89	5.52	5.95	6.47	6.91	7.35	7.74
59	4.41	4.76	5.11	5.78	6.35	6.78	7.25	7.71	8.11
58	4.66	5.03	5.39	6.10	6.68	7.13	7.62	8.11	8.53
57	4.84	5.23	5.63	6.36	6.96	7.44	7.94	8.46	8.90
56	5.68	6.13	6.58	7.35	8.03	8.73	9.32	9.92	10.44
55	7.11	7.68	8.22	9.30	10.18	10.85	11.59	12.34	12.98
54	7.95	8.59	9.23	10.45	11.39	12.25	13.08	13.93	14.65
53	9.30	10.04	10.80	12.20	13.32	14.29	15.27	16.25	17.09
52	10.61	11.46	12.31	13.86	15.26	16.34	17.44	18.57	19.53
51	11.82	12.77	13.69	15.47	16.97	18.16	19.40	20.64	21.71
50	12.89	13.92	14.94	16.86	18.48	19.77	21.12	22.48	23.65
49	14.07	15.20	16.28	18.37	20.20	21.60	23.06	24.56	25.83
48	15.15	16.36	17.62	19.88	21.81	23.31	24.90	26.51	27.89
47	16.22	17.52	18.80	21.27	23.21	24.93	26.62	28.34	29.81
46	17.19	18.57	19.98	22.57	24.72	26.43	28.23	30.05	31.61
45	17.73	19.15	20.52	23.10	25.36	27.18	29.03	30.90	32.51
44	19.45	21.01	22.57	25.57	27.93	29.87	31.89	33.96	35.72
43	20.73	22.39	24.18	27.29	29.87	32.02	34.19	36.41	38.30
42	23.10	24.95	26.50	29.50	32.50	35.24	37.63	40.07	42.14
41	24.06	25.98	28.15	31.69	34.81	37.17	39.70	42.27	44.46
40	25.03	27.03	29.23	33.09	36.20	38.79	41.42	44.10	46.38
39	26.11	28.20	30.20	34.05	37.38	39.97	42.68	45.44	47.80
38	27.08	29.25	31.38	35.46	38.89	41.58	44.40	47.27	49.73
37	28.36	30.63	32.99	37.07	40.83	43.62	46.59	49.60	52.17
36	29.76	32.14	34.59	39.11	42.76	45.77	48.88	52.04	54.74
35	32.36	34.95	36.86	41.68	45.66	48.78	52.10	55.46	58.34
34	32.45	35.05	37.50	42.44	46.52	49.75	53.12	56.55	59.49
33	33.41	36.08	38.79	43.83	48.03	51.46	54.96	58.62	61.55
32	35.46	38.30	40.94	46.52	50.82	54.26	57.95	61.70	64.89

(continues)

Table E.1.1(a) *Continued*

Orifice or Drill Size	Pressure at Orifice (in. w.c.)								
	3	3.5	4	5	6	7	8	9	10
31	37.82	40.85	43.83	49.64	54.36	58.01	61.96	65.97	69.39
30	43.40	46.87	50.39	57.05	62.09	66.72	71.22	75.86	79.80
29	48.45	52.33	56.19	63.61	69.62	74.45	79.52	84.66	89.04
28	51.78	55.92	59.50	67.00	73.50	79.50	84.92	90.39	95.09
27	54.47	58.83	63.17	71.55	78.32	83.59	89.27	95.04	99.97
26	56.73	61.27	65.86	74.57	81.65	87.24	93.17	99.19	104.57
25	58.87	63.58	68.22	77.14	84.67	90.36	96.50	102.74	108.07
24	60.81	65.67	70.58	79.83	87.56	93.47	99.83	106.28	111.79
23	62.10	67.07	72.20	81.65	89.39	94.55	100.98	107.49	113.07
22	64.89	70.08	75.21	85.10	93.25	99.60	106.39	113.24	119.12
21	66.51	71.83	77.14	87.35	95.63	102.29	109.24	116.29	122.33
20	68.22	73.68	79.08	89.49	97.99	104.75	111.87	119.10	125.28
19	72.20	77.98	83.69	94.76	103.89	110.67	118.55	125.82	132.36
18	75.53	81.57	87.56	97.50	108.52	116.03	123.92	131.93	138.78
17	78.54	84.82	91.10	103.14	112.81	120.33	128.52	136.82	143.91
16	82.19	88.77	95.40	107.98	118.18	126.78	135.39	144.15	151.63
15	85.20	92.02	98.84	111.74	122.48	131.07	139.98	149.03	156.77
14	87.10	94.40	100.78	114.21	124.44	133.22	142.28	151.47	159.33
13	89.92	97.11	104.32	118.18	128.93	138.60	148.02	157.58	165.76
12	93.90	101.41	108.52	123.56	135.37	143.97	153.75	163.69	172.13
11	95.94	103.62	111.31	126.02	137.52	147.20	157.20	167.36	176.03
10	98.30	106.16	114.21	129.25	141.82	151.50	161.81	172.26	181.13
9	100.99	109.07	117.11	132.58	145.05	154.71	165.23	175.91	185.03
8	103.89	112.20	120.65	136.44	149.33	160.08	170.96	182.00	191.44
7	105.93	114.40	123.01	139.23	152.56	163.31	174.38	185.68	195.30
6	109.15	117.88	126.78	142.88	156.83	167.51	178.88	190.46	200.36
5	111.08	119.97	128.93	145.79	160.08	170.82	182.48	194.22	204.30
4	114.75	123.93	133.22	150.41	164.36	176.18	188.16	200.25	210.71
3	119.25	128.79	137.52	156.26	170.78	182.64	195.08	207.66	218.44
2	128.48	138.76	148.61	168.64	184.79	197.66	211.05	224.74	235.58
1	136.35	147.26	158.25	179.33	194.63	209.48	223.65	238.16	250.54

For SI units, 1 Btu/hr = 0.293 W, 1 ft^3 = 0.028 m^3, 1 ft = 0.305 m, 1 in. w.c. = 249 Pa.

Notes:

(1) Specific gravity = 0.60; orifice coefficient = 0.90.

(2) For utility gases of another specific gravity, select multiplier from Table E.1.1(c). For altitudes above 2000 ft, first select the equivalent orifice size at sea level from Table E.1.1(d).

Table E.1.1(b) LP-Gases (Btu per hour at sea level)

Orifice or Drill Size	Propane	Butane
0.008	519	589
0.009	656	744
0.010	812	921
0.011	981	1,112
0.012	1,169	1,326
80	1,480	1,678
79	1,708	1,936
78	2,080	2,358
77	2,629	2,980
76	3,249	3,684
75	3,581	4,059
74	4,119	4,669
73	4,678	5,303
72	5,081	5,760
71	5,495	6,230
70	6,375	7,227
69	6,934	7,860
68	7,813	8,858
67	8,320	9,433
66	8,848	10,031
65	9,955	11,286
64	10,535	11,943
63	11,125	12,612
62	11,735	13,304
61	12,367	14,020
60	13,008	14,747
59	13,660	15,486
58	14,333	16,249
57	15,026	17,035
56	17,572	19,921
55	21,939	24,872
54	24,630	27,922
53	28,769	32,615
52	32,805	37,190
51	36,531	41,414
50	39,842	45,168
49	43,361	49,157
48	46,983	53,263
47	50,088	56,783
46	53,296	60,420
45	54,641	61,944
44	60,229	68,280
43	64,369	72,973
42	71,095	80,599
41	74,924	84,940
40	78,029	88,459
39	80,513	91,215
38	83,721	94,912
37	87,860	99,605
36	92,207	104,532

(continues)

Table E.1.1(b) *Continued*

Orifice or Drill Size	Propane	Butane
35	98,312	111,454
34	100,175	113,566
33	103,797	117,672
32	109,385	124,007
31	117,043	132,689
30	134,119	152,046
29	150,366	170,466
28	160,301	181,728
27	168,580	191,114
26	175,617	199,092
25	181,619	205,896
24	187,828	212,935
23	192,796	218,567
22	200,350	227,131
21	205,525	232,997
20	210,699	238,863
19	223,945	253,880
18	233,466	264,673

Notes:

	Propane	Butane
(1) Btu per cubic foot	2516	3280
(2) Specific gravity	1.52	2.01
(3) Pressure at orifice (in. w.c.)	11	11
(4) Orifice coefficient	0.9	0.9

(5) For altitudes above 2000 ft (610 m), first select the equivalent orifice size at sea level from Table E.1.1(d).

Table E.1.1(c) 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 E.1.1(d) Equivalent Orifice Sizes at High Altitudes (includes 4% input reduction for each 1000 ft above sea level)

Orifice Size at Sea Level	Orifice Size Required at Other Elevations (ft)								
	2000	3000	4000	5000	6000	7000	8000	9000	10,000
1	2	2	3	3	4	5	7	8	10
2	3	3	4	5	6	7	9	10	12
3	4	5	7	8	9	10	12	13	15
4	6	7	8	9	11	12	13	14	16
5	7	8	9	10	12	13	14	15	17
6	8	9	10	11	12	13	14	16	17
7	9	10	11	12	13	14	15	16	18
8	10	11	12	13	13	15	16	17	18
9	11	12	12	13	14	16	17	18	19
10	12	13	13	14	15	16	17	18	19
11	13	13	14	15	16	17	18	19	20
12	13	14	15	16	17	17	18	19	20
13	15	15	16	17	18	18	19	20	22
14	16	16	17	18	18	19	20	21	23
15	16	17	17	18	19	20	20	22	24
16	17	18	18	19	19	20	22	23	25
17	18	19	19	20	21	22	23	24	26
18	19	19	20	21	22	23	24	26	27
19	20	20	21	22	23	25	26	27	28
20	22	22	23	24	25	26	27	28	29
21	23	23	24	25	26	27	28	28	29
22	23	24	25	26	27	27	28	29	29
23	25	25	26	27	27	28	29	29	30
24	25	26	27	27	28	28	29	29	30
25	26	27	27	28	28	29	29	30	30
26	27	28	28	28	29	29	30	30	30
27	28	28	29	29	29	30	30	30	31
28	29	29	29	30	30	30	30	31	31
29	29	30	30	30	30	31	31	31	32
30	30	31	31	31	31	32	32	33	35
31	32	32	32	33	34	35	36	37	38
32	33	34	35	35	36	36	37	38	40
33	35	35	36	36	37	38	38	40	41
34	35	36	36	37	37	38	39	40	42
35	36	36	37	37	38	39	40	41	42
36	37	38	38	39	40	41	41	42	43
37	38	39	39	40	41	42	42	43	43
38	39	40	41	41	42	42	43	43	44
39	40	41	41	42	42	43	43	44	44
40	41	42	42	42	43	43	44	44	45
41	42	42	42	43	43	44	44	45	46
42	42	43	43	43	44	44	45	46	47
43	44	44	44	45	45	46	47	47	48
44	45	45	45	46	47	47	48	48	49
45	46	47	47	47	48	48	49	49	50
46	47	47	47	48	48	49	49	50	50
47	48	48	49	49	49	50	50	51	51
48	49	49	49	50	50	50	51	51	52

(continues)

Table E.1.1(d) *Continued*

Orifice Size at Sea Level	Orifice Size Required at Other Elevations (ft)								
	2000	3000	4000	5000	6000	7000	8000	9000	10,000
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	0.013	0.012	0.012	0.01
80	80	0.013	0.013	0.013	0.012	0.012	0.012	0.012	0.011

For SI units, 1 ft = 0.305 m.

Annex F Sizing of Venting Systems Serving Appliances Equipped with Draft Hoods, Category I Appliances, and Appliances Listed for Use with Type B Vents

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

For SI units, 1 Btu/hr = 0.293 W, 1 ft^3 = 0.028 m^3, 1 ft = 0.305 m, 1 in. w.c. = 249 Pa.

F.1 Examples Using Single Appliance Venting Tables. See Figure F.1(a) through Figure F.1(n).

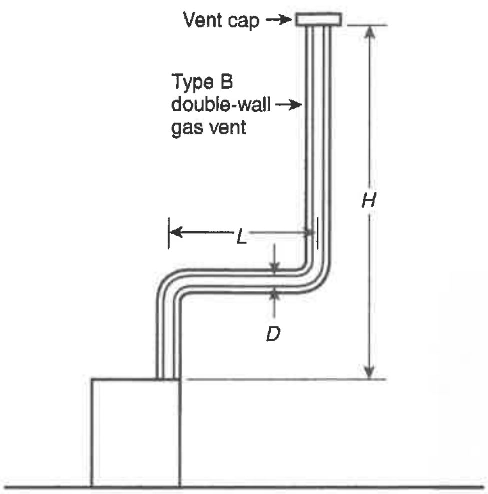


Table 13.1(a) is used when sizing Type B double-wall gas vent connected directly to the appliance.

Note: The appliance can be either Category I draft hood–equipped or fan-assisted type.

FIGURE F.1(a) Type B Double-Wall Vent System Serving a Single Appliance with a Type B Double-Wall Vent.

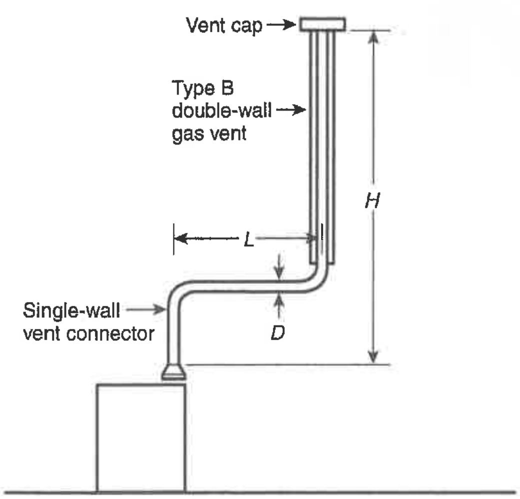


Table 13.1(b) is used when sizing a single-wall metal vent connector attached to a Type B double-wall gas vent.

Note: The appliance can be either Category I draft hood–equipped or fan-assisted type.

FIGURE F.1(b) Type B Double-Wall Vent System Serving a Single Appliance with a Single-Wall Metal Vent Connector.

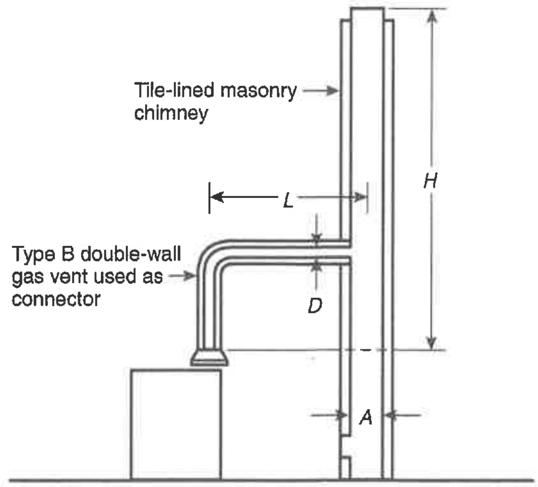


Table 13.1(c) is used when sizing a Type B double-wall gas vent connector attached to a tile-lined masonry chimney.

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 F.1(c) Vent System Serving a Single Appliance with a Masonry Chimney and a Type B Double-Wall Vent Connector.

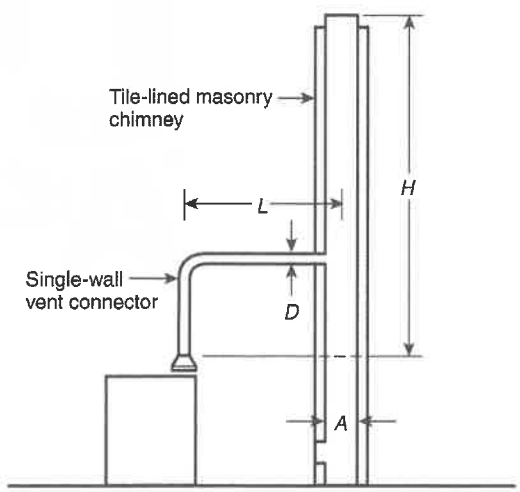
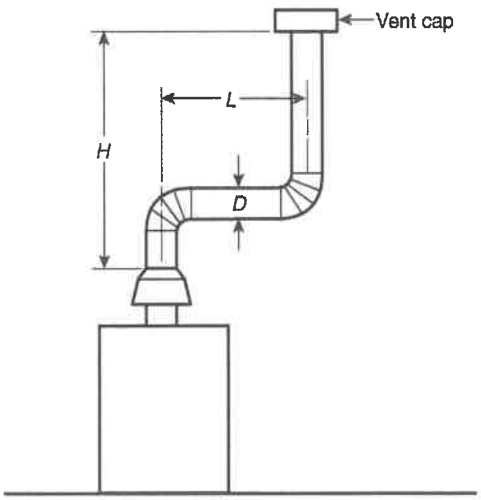


Table 13.1(d) is used when sizing a single-wall vent connector attached to a tile-lined masonry chimney.

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 F.1(d) Vent System Serving a Single Appliance Using a Masonry Chimney and a Single-Wall Metal Vent Connector.



Asbestos cement Type B or single-wall metal vent serving a single draft hood–equipped appliance. *[See Table 13.1(e).]*

FIGURE F.1(e) Asbestos Cement Type B or Single-Wall Metal Vent System Serving a Single Draft Hood–Equipped Appliance.

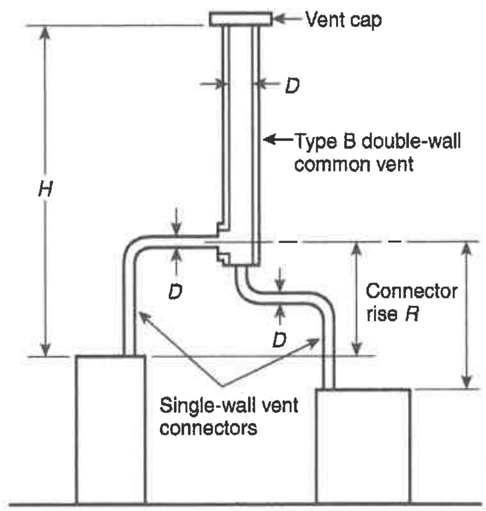


Table 13.2(b) is used when sizing single-wall vent connectors attached to a Type B double-wall common vent.

Note: Each appliance can be either Category I draft hood–equipped or fan-assisted type.

FIGURE F.1(g) Vent System Serving Two or More Appliances with Type B Double-Wall Vent and Single-Wall Metal Vent Connectors.

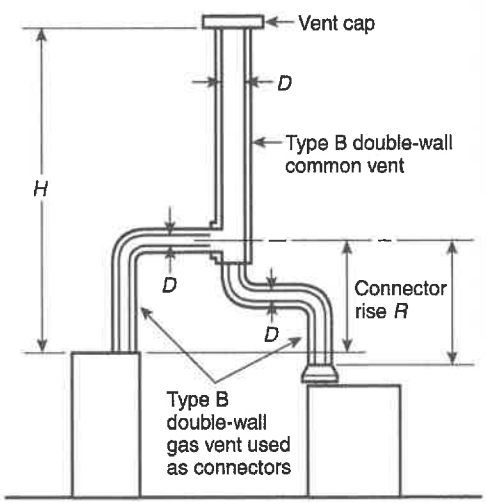


Table 13.2(a) is used when sizing Type B double-wall gas vent connectors attached to a Type B double-wall common vent.

Note: Each appliance can be either Category I draft hood–equipped or fan-assisted type.

FIGURE F.1(f) Vent System Serving Two or More Appliances with Type B Double-Wall Vent and Type B Double-Wall Vent Connectors.

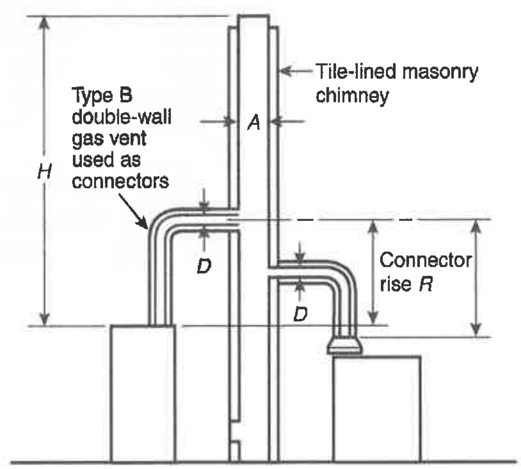


Table 13.2(c) is used when sizing Type B double-wall vent connectors attached to a tile-lined masonry chimney.

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 F.1(h) Masonry Chimney Serving Two or More Appliances with Type B Double-Wall Vent Connectors.

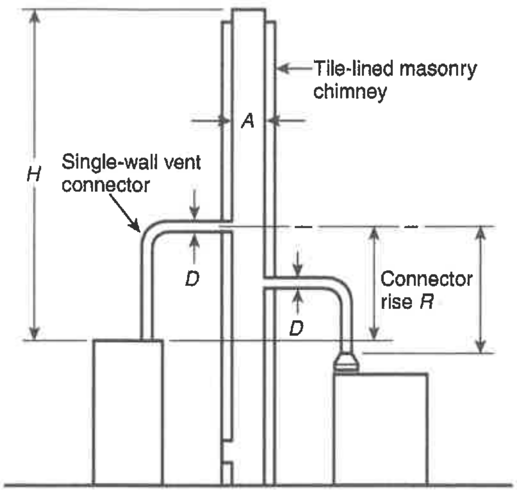
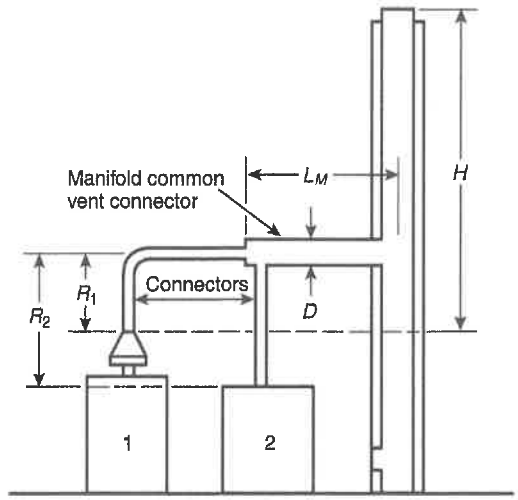


Table 13.2(d) is used when sizing single-wall metal vent connectors attached to a tile-lined masonry chimney.

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.

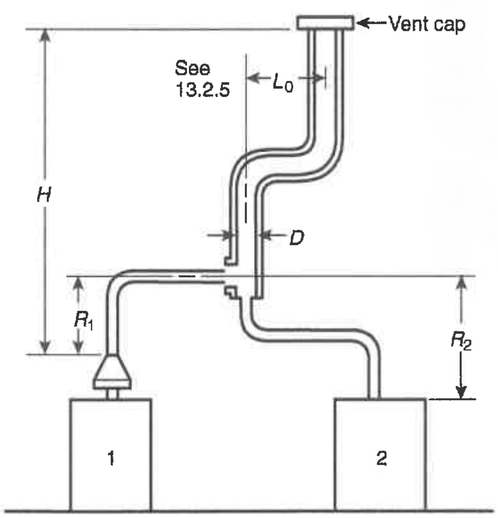
FIGURE F.1(i) Masonry Chimney Serving Two or More Appliances with Single-Wall Metal Vent Connectors.



Example: Manifolded common vent connector L_M can be no greater than 18 times the common vent connector manifold inside diameter; that is, a 4 in. (100 mm) inside diameter common vent connector manifold should not exceed 72 in. (1800 mm) in length. *(See 13.2.4.)*

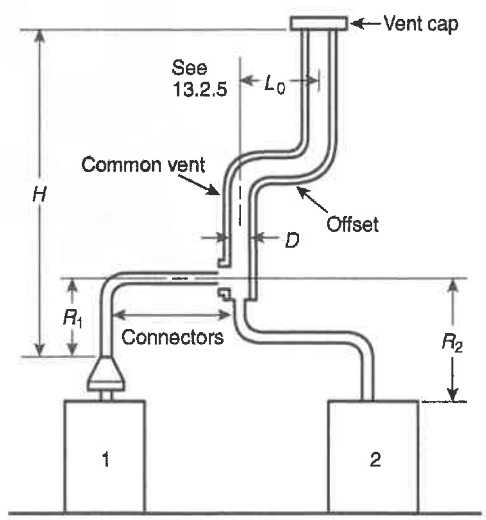
Note: This is an illustration of a typical manifolded vent connector. Different appliance, vent connector, or common vent types are possible. *(See Section 13.2.)*

FIGURE F.1(k) Use of Manifolded Common Vent Connector.



Asbestos cement Type B or single-wall metal pipe vent serving two or more draft hood–equipped appliances. *[See Table 13.2(e).]*

FIGURE F.1(j) Asbestos Cement Type B or Single-Wall Metal Vent System Serving Two or More Draft Hood–Equipped Appliances.



Example: Offset common vent.

Note: This is an illustration of a typical offset vent. Different appliance, vent connector, or vent types are possible. *(See Sections 13.1 and 13.2.)*

FIGURE F.1(l) Use of Offset Common Vent.

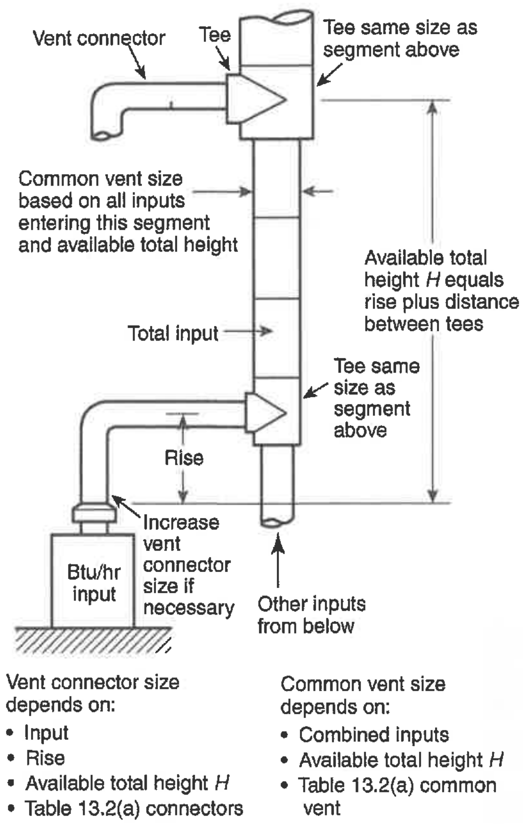


FIGURE F.1(m) Multistory Gas Vent Design Procedure for Each Segment of System.

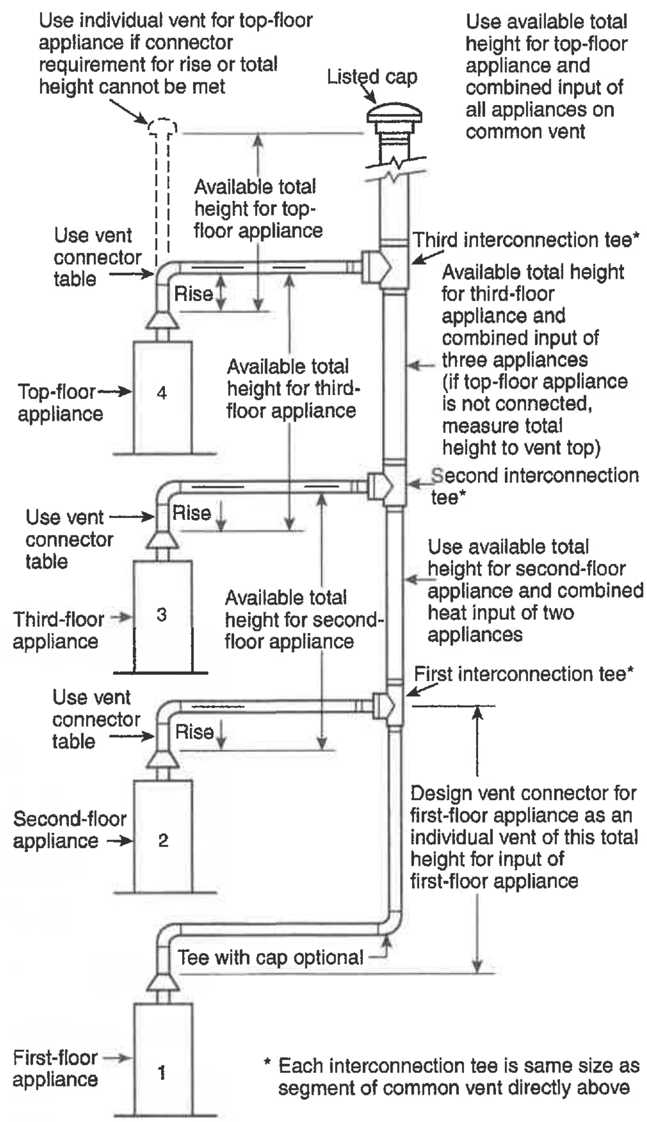


FIGURE F.1(n) Principles of Design of Multistory Vents Using Vent Connector and Common Vent Design Tables. ***(See 13.2.14 through 13.2.17.)***

F.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 F.1.1.

Solution

Table 13.1(b) should be used to solve this problem, because single-wall metal vent connectors are being used with a Type B vent, as follows:

(1) Read down the first column in Table 13.1(b) until the row associated with a 10 ft height and 5 ft lateral is found. Read across this row until a vent capacity greater than 120,000 Btu/hr is located in the shaded columns labeled NAT Max for draft hood–equipped appliances. In this case, a 5 in. diameter vent has a capacity of 122,000 Btu/hr and can be used for this application.

(2) If three 90 degree elbows are used in the vent system, the maximum vent capacity listed in the tables must be reduced by 10 percent. 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:

[F.1.1a]

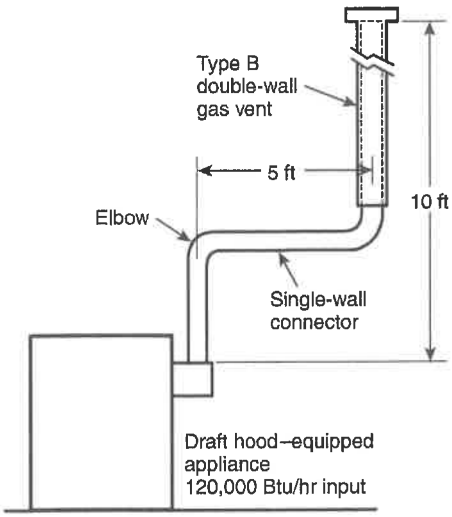
$$122{,}000 \times 0.90 = 110{,}000 \text{ for 5 in. vent}$$

From Table 13.1(b), select 6 in. vent.

[F.1.1b]

$$186{,}000 \times 0.90 = 167{,}000$$

This figure is greater than the required 120,000. Therefore, use a 6 in. vent and connector where three elbows are used.



For SI units, 1 ft = 0.305 m.

FIGURE F.1.1 Single Draft Hood–Equipped Appliance— Example 1.

F.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 F.1.2.

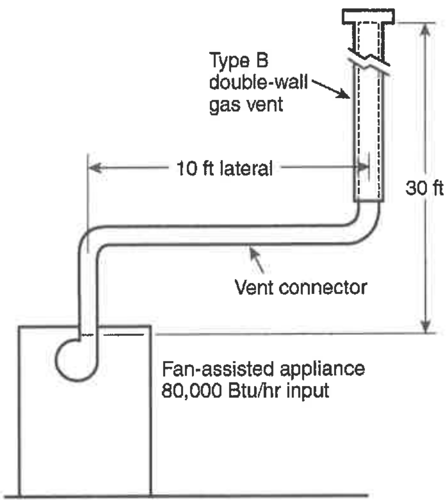
Solution

Table 13.1(b) 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, a 4 in. single-wall metal connector could be used to vent the appliance. Table 13.1(b) 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, a Type B vent could be used as the connector material. In this case, Table 13.1(a) 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.

F.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



For SI units, 1 ft = 0.305 m.

FIGURE F.1.2 Single Fan-Assisted Appliance — Example 2.

and is also Type B. Can this appliance be vented using a 4 in. diameter vent?

Solution

Table 13.1(a) is used in the case of an all Type B vent system. However, Table 13.1(a) does not have an entry for a height of 12 ft, and interpolation must be used. Read down the 4 in. diameter NAT Max column to the row associated with 10 ft height and 5 ft lateral to find the capacity value of 77,000 Btu/hr. Read further down to the 15 ft height, 5 ft lateral row to find the capacity value of 87,000 Btu/hr. The difference between the 15 ft height capacity value and the 10 ft height capacity value is 10,000 Btu/hr. The capacity for a vent system with a 12 ft height is equal to the capacity for a 10 ft height plus ⅖ of the difference between the 10 ft and 15 ft height values, or 77,000 + ⅖ × 10,000 = 81,000 Btu/hr. Therefore, a 4 in. diameter vent can be used in the installation.

F.2 Examples Using Common Venting Tables.

F.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 F.2.1.

Solution

Table 13.2(b) should be used to size single-wall metal vent connectors attached to Type B vertical vents. In the vent connector capacity portion of Table 13.2(b), 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/hr furnace. Because both vent connector horizontal lengths are less than the maximum lengths listed in 13.2.2, the table values can be used without adjustments.

In the common vent capacity portion of Table 13.2(b), 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.

F.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 F.2.2.

Solution

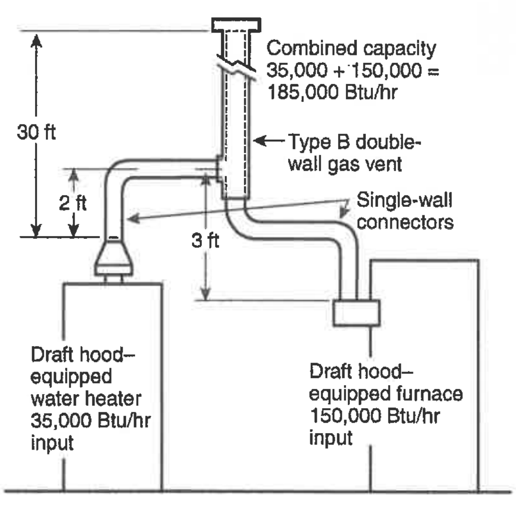
Water Heater Vent Connector Diameter. Since the water heater vent connector horizontal length of 4 ft is less than the maximum value listed in Table 13.2(b), the venting table values can be used without adjustments. Using the Vent Connector Capacity portion of Table 13.2(b), read down the Total Vent Height (*H*) column to 30 ft and read across the 2 ft Connector Rise (*R*) row to the first Btu/hr rating in the NAT Max column that is equal to or greater than the water heater input rating. The table shows that a 3 in. vent connector has a maximum input rating of 37,000 Btu/hr. Although this rating is greater than the water heater input rating, a 3 in. vent connector is prohibited by 13.2.24. A 4 in. vent connector has a maximum input rating of 67,000 Btu/hr and is equal to the draft hood outlet diameter. A 4 in. vent connector is selected. Since the water heater is equipped with a draft hood, there are no minimum input rating restrictions.

Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 13.2(b), read down the Total Vent Height (*H*) column to 30 ft and across the 3 ft Connector Rise (*R*) row. Because the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu/hr rating greater than the furnace input rating. The 4 in. vent connector has a maximum input rating of 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. Because the furnace vent connector horizontal length of 6 ft is less than the maximum value listed in 13.2.2, the venting table values can be used without adjustment. If the furnace had an input rating of 80,000 Btu/hr, a Type B vent connector would be needed in order to meet the minimum capacity limit.

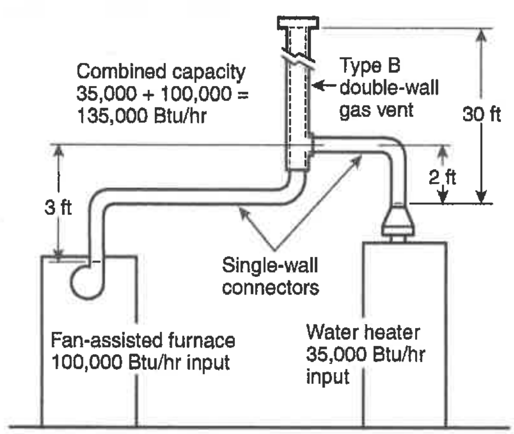
Common Vent Diameter. The total input to the common vent is 135,000 Btu/hr. Using the Common Vent Capacity portion of Table 13.2(b), read down the Total Vent Height (*H*) column to 30 ft and across this row to find the smallest vent diameter in the FAN + NAT column that has a Btu/hr rating equal to or 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.



For SI units, 1000 Btu/hr = 0.293 kW, 1 ft = 0.305 m.

FIGURE F.2.1 Common Venting Two Draft Hood–Equipped Appliances — Example 4.



For SI units, 1000 Btu/hr = 0.293 kW, 1 ft = 0.305 m.

FIGURE F.2.2 Common Venting a Draft Hood–Equipped Water Heater with a Fan-Assisted Furnace into a Type B Double-Wall Common Vent — Example 5(a).

Δ F.2.3 Example 5(b): Common Venting into an Interior Masonry Chimney. In this case, the water heater and fan-assisted furnace of Example 5(a) are to be common-vented into a clay-tile-lined masonry chimney with a 30 ft height. The chimney is not exposed to the outdoors below the roof line. The internal dimensions of the clay tile liner are nominally 8 in. × 12 in. Assuming the same vent connector heights, laterals, and materials found in Example 5(a), what are the recommended vent connector diameters, and is this an acceptable installation?

Solution

Table 13.2(d) is used to size common venting installations involving single-wall connectors into masonry chimneys.

Water Heater Vent Connector Diameter. Using Table 13.2(d), Vent Connector Capacity, read down the Total Vent Height (*H*) column to 30 ft, and read across the 2 ft Connector Rise (*R*) row to the first Btu/hr rating in the NAT Max column that is equal to or greater than the water heater input rating. The table shows that a 3 in. vent connector has a maximum input of only 31,000 Btu/hr, while a 4 in. vent connector has a maximum input of 57,000 Btu/hr. A 4 in. vent connector must therefore be used.

Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 13.2(d), read down the Total Vent Height (*H*) column to 30 ft and across the 3 ft Connector Rise (*R*) row. Because the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu/hr rating greater than the furnace input rating. The 4 in. vent connector has a maximum input rating of 127,000 Btu/hr and a minimum input rating of 95,000 Btu/hr. The 100,000 Btu/hr furnace in this example falls within this range, so a 4 in. connector is adequate.

Masonry Chimney. From Table F.2.3, the Equivalent Area for a Nominal Liner size of 8 in. × 12 in. is 63.6 in.^{2}. Using Table 13.2(d), 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.

Subsection 13.2.18 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 F.2.3, the equivalent area for an inside diameter of 4 in. is 12.2 in.^{2}. Seven times 12.2 equals 85.4, which is greater than 63.6, so this configuration is acceptable.

Table F.2.3 Masonry Chimney Liner Dimensions with Circular Equivalents

Nominal Liner Size (in.)	Inside Dimensions of Liner (in.)	Inside Diameter or Equivalent Diameter (in.)	Equivalent Area (in.^{2})
4 × 8	2½ × 6½	4.0	12.2
		5.0	19.6
		6.0	28.3
		7.0	38.3
8 × 8	6¾ × 6¾	7.4	42.7
		8.0	50.3
8 × 12	6½ × 10½	9.0	63.6
		10.0	78.5
12 × 12	9¾ × 9¾	10.4	83.3
		11.0	95.0
12 × 16	9½ × 13½	11.8	107.5
		12.0	113.0
		14.0	153.9
16 × 16	13¼ × 13¼	14.5	162.9
		15.0	176.7
16 × 20	13 × 17	16.2	206.1
		18.0	254.4
20 × 20	16½ × 16¾	18.2	260.2
		20.0	314.1
20 × 24	16½ × 20½	20.1	314.2
		22.0	380.1
24 × 24	20¼ × 20¼	22.1	380.1
		24.0	452.3
24 × 28	20¼ × 24¼	24.1	456.2
28 × 28	24¼ × 24¼	26.4	543.3
		27.0	572.5
30 × 30	25½ × 25½	27.9	607.0
		30.0	706.8
30 × 36	25½ × 31½	30.9	749.9
		33.0	855.3
36 × 36	31½ × 31½	34.4	929.4
		36.0	1017.9

For SI units, 1 in. = 25.4 mm, 1 in.^{2} = 645 mm^2.

Note: When liner sizes differ dimensionally from those shown in this table, equivalent diameters can be determined from published tables for square and rectangular ducts of equivalent carrying capacity or by other engineering methods.

F.2.4 Example 5(c): Common Venting into an Exterior Masonry Chimney. In this case, the water heater and fan-assisted furnace of Examples 5(a) and 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 F.2.3 and Figure F.2.4.

Solution

According to 13.2.22, Type B vent connectors are required to be used with exterior masonry chimneys. Use Table 13.2(h) and Table 13.2(i) to size FAN+NAT common venting installations involving Type B double-wall connectors into exterior masonry chimneys.

The local 99 percent winter design temperature needed to use Table 13.2(h) and Table 13.2(i) can be found in *ASHRAE Handbook — Fundamentals.* For Charlotte, North Carolina, this design temperature is 19°F.

Chimney Liner Requirement. As in Example 5(b), use the 63 in.^{2} Internal Area columns for this size clay tile liner. Read down the 63 in.^{2} column of Table 13.2(h) to the 30 ft height row to find that the Combined Appliance Maximum Input is 747,000 Btu/hr. The combined input rating of the appliances in this installation, 135,000 Btu/hr, is less than the maximum value, so this criterion is satisfied. Table 13.2(i), at a 19°F

Design Temperature, and at the same Vent Height and Internal Area used earlier, shows that the minimum allowable input rating of a space-heating appliance is 470,000 Btu/hr. The furnace input rating of 100,000 Btu/hr is less than this minimum value. So this criterion is not satisfied, and an alternative venting design needs to be used, such as a Type B vent shown in Example 5(a) or a listed chimney liner system shown in the remainder of the example.

According to 13.2.20, Table 13.2(a) or Table 13.2(b) is used for sizing corrugated metallic liners in masonry chimneys, with the maximum common vent capacities reduced by 20 percent. This example will be continued assuming Type B vent connectors.

Water Heater Vent Connector Diameter. Using Table 13.2(a), Vent Connector Capacity, read down the Total Vent Height (*H*) column to 30 ft, and read across the 2 ft Connector Rise (*R*) row to the first Btu/hour rating in the NAT Max column that is equal to or greater than the water heater input rating. The table shows that a 3 in. vent connector has a maximum capacity of 39,000 Btu/hr. Although this rating is greater than the water heater input rating, a 3 in. vent connector is prohibited by 13.2.24. A 4 in. vent connector has a maximum input rating of 70,000 Btu/hr and is equal to the draft hood outlet diameter. A 4 in. vent connector is selected.

Furnace Vent Connector Diameter. Using Table 13.2(a), Vent Connector Capacity, read down the Total Vent Height (*H*) column to 30 ft, and read across the 3 ft Connector Rise (*R*) row to the first Btu/hr rating in the FAN Max column that is equal to or greater than the furnace input rating. The 100,000 Btu/hr furnace in this example falls within this range, so a 4 in. connector is adequate.

Chimney Liner Diameter. The total input to the common vent is 135,000 Btu/hr. Using the Common Vent Capacity portion of Table 13.2(a), 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 results in a maximum capacity for a 4 in. corrugated liner of 110,000 Btu/hr, less than the total input of 135,000 Btu/hr. So a larger liner is needed. The 5 in. common vent capacity listed in Table 13.2(a) is 210,000 Btu/hr, and after reducing by 20 percent is 168,000 Btu/hr. Therefore, a 5 in. corrugated metal liner should be used in this example.

Single-Wall Connectors. Once it has been established that relining the chimney is necessary, Type B double-wall vent connectors are not specifically required. This example could be redone using Table 13.2(b) 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.

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 are not necessarily accurate. The climate data used to develop this map are from the *ASHRAE Handbook—Fundamentals* (Climate Conditions for the United States).

For 99% winter design temperatures in Alaska, consult the *ASHRAE Handbook—Fundamentals.*

99% winter design temperatures for Hawaii are greater than 37°F.

Δ FIGURE F.2.4 Range of Winter Design Temperatures Used in Analyzing Exterior Masonry Chimneys in the United States.

Annex G Recommended Procedure for Safety Inspection of an Existing Appliance Installation

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

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

G.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 continued use. Where a gas supplier performs an inspection, their written procedures should be followed.

G.1.1 Application. This procedure is intended for existing residential installations of a furnace, boiler, room heater, water heater, cooking appliance, fireplace appliance, and clothes dryer. This procedure should be performed prior to any attempt to modify the appliance installation or building envelope.

G.1.2 Weatherization Programs. Before a building envelope is to be modified as part of a weatherization program, the existing appliance installation should be inspected in accordance with these procedures. After all unsafe conditions are repaired, and immediately after the weatherization is complete, the appliance inspections in G.5.2 are to be repeated.

G.1.3 Inspection Procedure. The safety of the building occupant and inspector are to be determined as the first step as described in Section G.2. Only after the ambient environment is found to be safe should inspections of gas piping and appliances be undertaken. It is recommended that all inspections described in Sections G.3, G.4, and G.6, where the appliance is in the off mode, be completed and any unsafe conditions repaired or corrected before continuing with inspections of an operating appliance described in Sections G.5 and G.6.

G.1.4 Manufacturer Instructions. Where available, the manufacturer's installation and operating instructions for the installed appliance should be used as part of these inspection procedures to determine if the appliance is installed correctly and is operating properly.

G.1.5 Instruments. The inspection procedures include measuring for fuel gas and carbon monoxide (CO) and will require the use of a combustible gas detector (CGD) and a CO detector. It is recommended that both types of detectors be listed. Prior to any inspection, the detectors should be calibrated or tested in accordance with the manufacturer's instructions. In addition, it is recommended that the detectors have the following minimum specifications:

(1) Gas Detector: The CGD should be capable of indicating the presence of the type of fuel gas for which it is to be used (e.g. natural gas or propane). The combustible gas detector should be capable of the following:
   (a) *PPM:* Numeric display with a parts per million (ppm) scale from 1 ppm to 900 ppm in 1 ppm increments
   (b) *LEL:* Numeric display with a percent lower explosive limit (% LEL) scale from 0 percent to 100 percent in 1 percent increments
   (c) *Audio:* An audio sound feature to locate leaks
(2) CO Detector: The CO detector should be capable of the following functions and have a numeric display scale as follows:
   (a) *PPM:* For measuring ambient room and appliance emissions a display scale in parts per million (ppm) from 0 to 1,000 ppm in 1 ppm increments
   (b) *Alarm:* A sound alarm function where hazardous levels of ambient CO is found (*see Section G.2 for alarm levels*)
   (c) *Air Free:* Capable of converting CO measurements to an air-free level in ppm. Where a CO detector is used without an air-free conversion function, the CO air free can be calculated in accordance with Footnote 3 in Table G.6.

G.2 Occupant and Inspector Safety. Prior to entering a building, the inspector should have both a combustible gas detector (CGD) and CO detector turned on, calibrated, and operating. Immediately upon entering the building, a sample of the ambient atmosphere should be taken. Based on CGD and CO detector readings, the inspector should take the following actions:

(1) Where the CO detector indicates a carbon monoxide level of 70 ppm or greater, the inspector should immediately notify the occupant of the need for themselves and any building occupant to evacuate; the inspector should immediately evacuate and call 911.
(2) Where the CO detector indicates a reading between 30 ppm and 70 ppm, the inspector should advise the occupant that high CO levels have been found and recommend that all possible sources of CO be turned off immediately and windows and doors be opened. Where it appears that the source of CO is a permanently installed appliance, advise the occupant to shut the appliance off and have the appliance serviced by a qualified servicing agent.
(3) Where the CO detector indicates CO below 30 ppm, the inspection can continue. (See U.S. Consumer Product Safety Commission, *Responding to Residential Carbon Monoxide Incidents, Guidelines For Fire and Other Emergency Response Personnel*)
(4) Where the CGD indicates a combustible gas level of 20 percent LEL or greater, the inspector should immediately notify the occupant of the need for themselves and any building occupant to evacuate; the inspector should immediately evacuate and call 911.
(5) Where the CGD indicates a combustible gas level below 20 percent LEL, the inspection can continue.

If during the inspection process it is determined a condition exists that could result in unsafe appliance operation, shut off the appliance and advise the owner of the unsafe condition. Where a gas leak is found that may result in an unsafe condition, advise the owner of the unsafe condition and call the gas supplier to turn off the gas supply. The inspector should not continue a safety inspection on an operating appliance, venting system, and piping system until repairs have been made.

G.3 Gas Piping and Connection Inspections.

G.3.1 Leak Checks. Conduct a test for gas leakage using either a noncorrosive leak detection solution or a CGD confirmed with a leak detection solution.

The preferred method for leak checking is by use of gas leak detection solution applied to all joints. This method provides a reliable visual indication of significant leaks.

The use of a CGD in its audio sensing mode can quickly locate suspect leaks but can be overly sensitive indicating insignificant and false leaks. All suspect leaks found through the use of a CGD should be confirmed using a leak detection solution.

Where gas leakage is confirmed, the owner should be notified that repairs must be made. The inspection should include the following components:

(1) All gas piping fittings located within the appliance space
(2) Appliance connector fittings
(3) Appliance gas valve/regulator housing and connections

Δ **G.3.2 Appliance Connector.** Verify that the appliance connection type is compliant with Section 9.6. Inspect flexible appliance connections to determine if they are free of cracks, corrosion, and signs of damage. Verify that there are no uncoated copper alloy connectors. Where connectors are determined to be unsafe or where an uncoated copper alloy connector is found, the appliance shutoff valve should be placed in the off position and the owner notified that the connector must be replaced.

G.3.3 Piping Support. Inspect piping to determine that it is adequately supported, that there is no undue stress on the piping, and if there are any improperly capped pipe openings.

Δ **G.3.4 Bonding.** Verify that the electrical bonding of gas piping is compliant with Section 7.12.

G.4 Inspections to Be Performed with the Appliance Not Operating. The following safety inspection procedures are performed on appliances that are not operating. These inspections are applicable to all appliance installations.

G.4.1 Preparing for Inspection. Shut off all gas and electrical power to the appliances located in the same room being inspected. For gas supply, use the shutoff valve in the supply line or at the manifold serving each appliance. For electrical power, place the circuit breaker in the off position or remove the fuse that serves each appliance. A lock type device or tag should be installed on each gas shutoff valve and at the electrical panel to indicate that the service has been shut off for inspection purposes.

Δ **G.4.2 Vent System Size and Installation.** Verify that the existing venting system size and installation are compliant with Chapters 12 and 13. The size and installation of venting systems for other than natural draft and Category I appliances should be in compliance with the manufacturer's installation instructions. Inspect the venting system to determine that it is free of blockage, restriction, leakage, corrosion, and other deficiencies that could cause an unsafe condition. Inspect masonry chimneys to determine if they are lined. Inspect plastic venting system to determine that it is free of sagging and it is sloped in an upward direction to the outdoor vent termination.

Δ **G.4.3 Combustion Air Supply.** Inspect provisions for combustion air as follows:

(1) *Non-Direct Vent Appliances.* Determine that non-direct vent appliance installations are compliant with the combustion air requirements in Section 9.3. Inspect any interior and exterior combustion air openings and any connected combustion air ducts to determine that there is no blockage, restriction, corrosion, or damage. Inspect to determine if horizontal combustion air ducts are sloped upward toward the air supply source.
(2) *Direct Vent Appliances.* Verify that the combustion air supply ducts and pipes are securely fastened to direct vent appliance and determine that there are no separations, blockage, restriction, corrosion, or other damage. Determine that the combustion air source is located in the outdoors or to areas that freely communicate to the outdoors.
(3) *Unvented Appliances.* Verify that the total input of all unvented room heaters and gas-fired refrigerators installed in the same room or rooms that freely communicate with each other does not exceed 20 Btu/hr/ft^3.

Δ **G.4.4 Flooded Appliances.** Inspect the appliance for signs that the appliance has been damaged by flooding. Signs of flooding include a visible water submerge line on the appliance housing, excessive surface or component rust, deposited debris on internal components, and mildew-like odor. Inform the owner that flood-damaged appliances should be replaced.

G.4.5 Flammable Vapors. Inspect the room/space where the appliance is installed to determine if the area is free of the storage of gasoline or any flammable products such as oil-based solvents, varnishes or adhesives. Where the appliance is installed where flammable products will be stored or used, such as a garage, verify that the appliances burner is a minimum of 18 in. above the floor unless the appliance is listed as flammable vapor ignition–resistant.

Δ **G.4.6 Clearances to Combustibles.** Inspect the immediate location where the appliance is installed to determine if the area is free of rags, paper, or other combustibles. Verify that the appliance and venting system is compliant with clearances to combustible building components in 9.2.2.

G.4.7 Appliance Components. Inspect internal components by removing access panels or other components for the following:

(1) Inspect burners and crossovers for blockage and corrosion. The presence of soot, debris, and signs of excessive heating could indicate incomplete combustion due to blockage or improper burner adjustments.
(2) Metallic and non-metallic hoses for signs of cracks, splitting, corrosion, and loose connections
(3) Signs of improper or incomplete repairs
(4) Modifications that override controls and safety systems
(5) Electrical wiring for loose connections; cracked, missing, or worn electrical insulation; and indications of excessive heat or electrical shorting. Appliances requiring an external electrical supply should be inspected for proper electrical connection in accordance with *NFPA 70.*

G.4.8 Placing Appliances Back in Operation. Return all inspected appliances and systems to their pre-existing state by reinstalling any removed access panels and components. Turn on the gas supply and electricity to each appliance found in safe condition. Proceed to the operating inspections in Section G.5 through Section G.6.

G.5 Inspections to Be Performed with the Appliance Operating. The following safety inspection procedures are to be performed on appliances that are operating where there are no unsafe conditions or where corrective repairs have been completed.

G.5.1 General Appliance Operation.

(1) *Initial Startup.* Adjust the thermostat or other control device to start the appliance. Verify that the appliance starts up normally and is operating properly.

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 all pilot safety devices to determine whether they are 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.
(2) *Flame Appearance.* Visually inspect the flame appearance for proper color and appearance. Visually determine that the main burner gas is burning properly (i.e., no floating, lifting, or flashback). Adjust the primary air shutter 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.
(3) *Appliance Shutdown.* Adjust the thermostat or other control device to shut down the appliance. Verify that the appliance shuts off properly.

Δ **G.5.2 Test for Combustion Air and Vent Drafting for Natural Draft and Category I Appliances.** Combustion air and vent draft procedures are for natural draft and category I appliances equipped with a draft hood and connected to a natural draft venting system.

(1) *Preparing for Inspection.* Close all exterior building doors and windows and all interior doors between the space in which the appliance is located and other spaces of the building that can be closed. Turn on any clothes dryer. 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 and any fireplace doors.
(2) *Placing the Appliance in Operation.* Place the appliance being inspected in operation. Adjust the thermostat or control so the appliance will operate continuously.
(3) *Spillage Test.* Verify that all appliances located within the same room are in their standby mode and ready for operation. Follow lighting instructions for each appliance as necessary. Test for spillage at the draft hood relief opening as follows:
    (a) After 5 minutes of main burner operation, check for spillage using smoke.

(b) Immediately after the first check, turn on all other fuel gas burning appliances within the same room so they will operate at their full inputs and repeat the spillage test.
(c) Shut down all appliances to their standby mode and wait for 15 minutes.
(d) Repeat the spillage test steps (a) through (c) on each appliance being inspected.

(4) *Additional Spillage Tests:* Determine if the appliance venting is impacted by other door and air handler settings by performing the following tests:
(a) Set initial test condition in accordance with G.5.2(1).
(b) Place the appliance(s) being inspected in operation. Adjust the thermostat or control so the appliance(s) will operate continuously.
(c) Open the door between the space in which the appliance(s) is located and the rest of the building. After 5 minutes of main burner operation, check for spillage at each appliance using smoke.
(d) Turn on any other central heating or cooling air handler fan that is located outside of the area where the appliances are being inspected. After 5 minutes of main burner operation, check for spillage at each appliance using smoke. The test should be conducted with the door between the space in which the appliance(s) is located and the rest of the building in the open and in the closed position.

(5) Return doors, windows, exhaust fans, fireplace dampers, and any other fuel gas burning appliance to their previous conditions of use.

(6) If spillage occurs during testing, the owner should be notified, be instructed as to which configuration of the home would lessen its impact, and arrange for corrective action by an HVAC or venting professional. Where it is believed that the venting system performance is inadequate, the owner should be notified that alternative vent sizing, design, or configuration is needed in accordance with Chapters 12 and 13. Where it is believed that sufficient combustion air is not available, the owner should be notified that additional combustion air is needed in accordance with Section 9.3.

G.6 Appliance-Specific Inspections. The following appliance-specific inspections are to be performed as part of a complete inspection. These inspections are performed either with the appliance in the off or standby mode (indicated by "*OFF*") or on an appliance that is operating (indicated by "*ON*"). The CO measurements are to be taken only after the appliance is determined to be venting properly. The CO detector should be capable of calculating CO emissions in ppm air free. Table G.6 contains CO thresholds for specific appliances.

G.6.1 Forced Air Furnaces.

(1) *OFF.* Verify that an air filter is installed and that it is not excessively blocked with dust.
(2) *OFF.* Inspect visible portions of the furnace combustion chamber for cracks, ruptures, holes, and corrosion. A heat exchanger leakage test should be conducted.
(3) *ON.* Verify that both the limit and fan controls are operating properly. 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.

Δ Table G.6 CO Thresholds

Appliance	Threshold Limit
Central furnace (all categories)	400 ppm[a] air free[b,c]
Floor furnace	400 ppm air free
Gravity furnace	400 ppm air free
Wall furnace	200 ppm air free
Wall furnace (direct vent)	400 ppm air free
Vented room heater	200 ppm air free
Vent-free room heater	200 ppm air free
Boilers (all categories)	400 ppm air free
Water heater	200 ppm air free
Oven/Broiler	225 ppm as measured
Top burner	25 ppm as measured (per burner)
Clothes dryer	400 ppm air free
Refrigerator	25 ppm as measured
Gas log (gas fireplace)	25 ppm as measured in vent
Gas log (installed in wood-burning fireplace)	400 ppm air free in firebox

Notes:
[a]Parts per million
[b]Air-free emission levels are based on a mathematical equation (involving carbon monoxide and oxygen or carbon dioxide readings) to convert an actual diluted flue gas carbon monoxide testing sample to an undiluted air-free flue gas carbon monoxide level utilized in the appliance certification standards. For natural gas or propane, using as-measured CO ppm and O_2 percentage:

[G.6a]

$$CO_{AFppm} = \left(\frac{20.9}{20.9 - O_2} \right) \times CO_{ppm}$$

where:
CO_{AFppm} = Carbon monoxide, air-free ppm
CO_{ppm} = As-measured combustion gas carbon monoxide
O_2 = Percentage of oxygen in combustion gas, as a percentage

[c]An alternate method of calculating the CO air-free when access to an oxygen meter is not available:

[G.6b]

$$CO_{(air-free)} = \frac{UCO_2}{CO_2}(CO)$$

where:
UCO_2 = Ultimate concentration of carbon dioxide for the fuel being burned in percent for natural gas (12.2 percent) and propane (14.0 percent)
CO_2 = Measured concentration of carbon dioxide in combustion products in percent
CO = Measured concentration of carbon monoxide in combustion products in percent

(4) *ON.* Verify that the blower compartment door is installed properly and can be resecured properly if opened. Verify that the blower compartment door safety switch operates properly.
(5) *ON.* Check for flame disturbance before and after blower comes on, which can indicate heat exchanger leaks.
(6) *ON.* Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table G.6.

G.6.2 Boilers.

(1) *OFF and ON.* Inspect for evidence of water leaks around boiler and connected piping.
(2) *ON.* Verify 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.
(3) *ON.* Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table G.6.

G.6.3 Water Heaters.

(1) *OFF.* Verify that the pressure-temperature relief valve is in operating condition. Water in the heater should be at operating temperature.
(2) *OFF.* Verify that inspection covers, glass, and gaskets are intact and in place on a flammable vapor ignition resistant (FVIR)–type water heater.
(3) *ON.* Verify that the thermostat is set in accordance with the manufacturer's operating instructions and measure the water temperature at the closest tub or sink to verify that it is no greater than 120°F.
(4) *OFF.* Where required by the local building code in earthquake-prone locations, inspect that the water heater is secured to the wall studs in two locations (high and low) using appropriate metal strapping and bolts.
(5) *ON.* Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table G.6.

G.6.4 Cooking Appliances.

(1) *OFF.* Inspect oven cavity and range-top exhaust vent for blockage with aluminum foil or other materials.
(2) *OFF.* Inspect cook top to verify that it is free from a build-up of grease.
(3) *ON.* Measure the CO above each burner and at the oven exhaust vents after 5 minutes of burner operation. The CO should not exceed threshold in Table G.6.

G.6.5 Vented Room Heaters.

(1) *OFF.* For built-in room heaters and wall furnaces, inspect that the burner compartment is free of lint and debris.
(2) *OFF.* Inspect that furnishings and combustible building components are not blocking the heater.
(3) *ON.* Measure the CO in the vent after 5 minutes of main burner operation. The CO should not exceed threshold in Table G.6.

G.6.6 Vent-Free Heaters.

(1) *OFF.* Verify that the heater input is a maximum of 40,000 Btu/hr input, but not more than 10,000 Btu/hr where installed in a bedroom, and 6,000 Btu/hr where installed in a bathroom.
(2) *OFF.* Inspect the ceramic logs provided with gas log–type vent-free heaters to verify that they are located and aligned properly.
(3) *OFF.* Inspect the heater to verify that it is free of excess lint build-up and debris.
(4) *OFF.* Verify that the oxygen depletion safety shutoff system has not been altered or bypassed.
(5) *ON.* Verify that the main burner shuts down within 3 minutes by extinguishing the pilot light. The test is meant to simulate the operation of the oxygen depletion system (ODS).
(6) *ON.* Measure the CO after 5 minutes of main burner operation. The CO should not exceed threshold in Table G.6.

G.6.7 Gas Log Sets and Gas Fireplaces.

(1) *OFF.* For gas logs installed in wood-burning fireplaces equipped with a damper, verify that the fireplace damper is in a fixed open position.
(2) *ON.* Measure the CO in the firebox (log sets installed in wood burning fireplaces or in the vent [gas fireplace]) after 5 minutes of main burner operation. The CO should not exceed threshold in Table G.6.

G.6.8 Gas Clothes Dryer.

(1) *OFF.* Where installed in a closet, verify that a source of make-up air is provided and inspect that any make-up air openings, louvers, and ducts are free of blockage.
(2) *OFF.* Inspect for excess amounts of lint around the dryer and on dryer components. Verify that the lint trap is installed properly and that it does not have holes or tears. Verify that it is in a clean condition.
(3) *OFF.* Inspect visible portions of the exhaust duct and connections for loose fittings and connections, blockage, and signs of corrosion. Verify that the duct termination is not blocked and that it terminates in an outdoor location. Verify that only approved metal vent ducting material is installed (plastic and vinyl materials are not approved for gas dryers).
(4) *ON.* Verify mechanical components, including drum and blower, are operating properly.
(5) *ON.* Operate the clothes dryer and verify that exhaust system is intact and exhaust is exiting the termination.
(6) *ON.* Measure the CO at the exhaust duct or termination after 5 minutes of main burner operation. The CO should not exceed threshold in Table G.6.

Annex H Indoor Combustion Air Calculation Examples

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

For SI units, 1 Btu/hr = 0.293 W, 1 ft^3 = 0.028 m^3, 1 ft = 0.305 m, 1 in. w.c. = 249 Pa.

H.1 New Installation. Determine if the indoor volume is sufficient to supply combustion air for the following new installation example.

Example Installation 1: A 100,000 Btu/hr fan-assisted furnace and a 40,000 Btu/hr draft hood–equipped water heater are being installed in a basement of a new single-family home. The basement measures 25 ft × 40 ft with an 8 ft ceiling.

Solution

(1) *Determine the total required volume:* Because the air infiltration rate is unknown, the standard method to determine combustion air is used to calculate the required volume.

(a) The combined input for the appliances located in the basement is calculated as follows: 100,000 Btu/hr + 40,000 Btu/hr = 140,000 Btu/hr

(b) The Standard Method requires that the required volume be determined based on 50 cubic feet per 1000 Btu/hour.

(c) Using Table A.9.3.2.1, the required volume for a 140,000 Btu/hr combined input is 7000 ft^3.

(2) *Determine available volume:* The available volume is the total basement volume:

Available Volume: 25 ft × 40 ft × 8 ft ceiling = 8000 ft^3

Conclusion: The installation can use indoor air because the available volume of 8000 ft^3 exceeds the total required volume of 7000 ft^3. No outdoor air openings are required.

Δ H.2 New Installation, Known Air Infiltration Rate Method. Determine if the indoor volume is sufficient to supply combustion air for the following replacement installation example.

Example Installation 2: A 100,000 Btu/hr fan-assisted furnace and a 40,000 Btu/hr draft hood–equipped water heater are being installed in a new single-family house. It was determined (either by use of the ASHRAE calculation method or blower door test) that the house has 0.65 air changes per hour (ACH). The furnace and water heater are being installed in a 20 ft × 35 ft basement with an 8 ft ceiling height.

Solution

(1) *Determine the required volume:* Because two types of appliances are located in the space — a fan-assisted furnace and a draft hood–equipped water heater — the required volume must be determined for each appliance and then combined to determine the total required volume:

(a) *Fan-assisted furnace:* For structures for which the air infiltration rate is known, the method shown in 9.3.2.2 permits the use of Equation 9.3.2.2b to determine the required volume for a fan-assisted appliance. Paragraph 9.3.2.2(3) limits the use of the equation to air change rates equal to or less than 0.60 *ACH.* While the house was determined to have a 0.65 *ACH,* 0.60 is used to calculate the required volume. Using Equation 9.3.2.2b, the required volume for a 100,000 Btu/hr fan-assisted furnace is calculated as follows:

[H.2a]

$$= \frac{15\ \text{ft}^3}{0.60}\left(\frac{100{,}000\ \text{Btu/hr}}{1000\ \text{Btu/hr}}\right)$$

$$= 2500\ \text{ft}^3$$

Paragraph 9.3.2.2 specifies a lower required volume limitation for fan-assisted appliances at no smaller than 25 ft^3 per 1000 Btu/hr. From Table A.9.3.2.2(b), the lower limit is 2500 ft^3.

Because the calculated required volume of 2308 ft^3 falls below the lower required volume limit, the lower limit of 2500 ft^3 must be used as the minimum required volume.

(b) *Draft hood–equipped water heater:* For structures for which the air infiltration rate is known, the method shown in 9.3.2.2 permits the use Equation 9.3.2.2a to determine the required volume for a draft hood–equipped appliance. Paragraph 9.3.2.2(3) limits the use of the equation to air change rates equal to or less than 0.60 *ACH.* While the house was determined to have a 0.65 *ACH,* 0.60 is used to calculate the required volume. Using Equation 9.3.2.2a, the required volume for the 40,000 Btu/hr water heater is calculated as follows:

[H.2b]

$$= \frac{21\ \text{ft}^3}{0.60}\left(\frac{40{,}000\ \text{Btu/hr}}{1000\ \text{Btu/hr}}\right)$$

$$= 1400\ \text{ft}^3$$

Paragraph 9.3.2.2 specifies a lower required volume limitation for appliances other than fan-assisted at no smaller than 35 ft^3 per 1000 Btu/hr. From Table A.9.3.2.2(a), the lower limit is 1400 ft^3.

Because the calculated required volume of 1292 ft^3 falls below the lower required volume limit, the lower limit of 1400 ft^3 must be used as the minimum required volume.

(c) *Total required volume:* Subsection 9.3.2 states that the total required volume of indoor air is the sum of the required volumes for all appliances located in the space:

Total Required = 2500 ft^3+ 1400 ft^3 = 3900 ft^3

(2) *Determine available volume:* The available volume is determined as follows:

[H.2c]

$$(20\ \text{ft} \times 35\ \text{ft}) \times 8\ \text{ft} = 5600\ \text{ft}^3$$

Conclusion: The installation can use indoor air because the available volume of 5600 ft^3 exceeds the total required volume of 3900 ft^3. No outdoor air openings are required.

Δ H.3 New Installation, Known Air Infiltration Rate Method. Determine if the indoor volume is sufficient to supply combustion air for the following replacement installation example.

Example Installation 3: A 100,000 Btu/hr fan-assisted furnace and a 40,000 Btu/hr draft hood–equipped water heater are being installed in a new single-family house. It was determined (either by use of the ASHRAE calculation method or blower door test) that the house has 0.30 air changes per hour (ACH). The furnace and water heater are being installed in a 20 ft × 35 ft basement with an 8 ft ceiling height.

Solution

(1) *Determine the required volume:* Because two types of appliances are located in the space — a fan-assisted furnace and a draft hood–equipped water heater — the required volume must be determined for each appliance and then combined to determine the total required volume:

(a) *Fan-assisted furnace:* For structures for which the air infiltration rate is known, the method shown in 9.3.2.2 permits the use of Equation 9.3.2.2b to determine the required volume for a fan-assisted appliance. Paragraph 9.3.2.2(3) limits the use of the equation to air change rates equal to or less than 0.60 *ACH.* Because 0.30 *ACH* is less than 0.60 *ACH,* 0.30 can be used to calculate the required volume. Using Equation 9.3.2.2b, the required volume for a 100,000 Btu/hr fan-assisted furnace is calculated as follows:

[H.3a]

$$=\frac{15\text{ ft}^3}{0.30}\left(\frac{100{,}000\text{ Btu/hr}}{1000\text{ Btu/hr}}\right)$$

$$=5000\text{ ft}^3$$

Paragraph 9.3.2.2 specifies a lower required volume limitation for fan-assisted appliances at no smaller than 25 ft^3 per 1000 Btu/hr. From Table A.9.3.2.2(b), the lower limit is 2500 ft^3.

Because the calculated required volume of 5000 ft^3 is above the lower required volume limit, use this amount as the minimum required volume.

(b) *Draft hood–equipped water heater:* For structures for which the air infiltration rate is known, the method shown in 9.3.2.2 permits the use of Equation 9.3.2.2a to determine the required volume for a draft hood–equipped appliance. Paragraph 9.3.2.2(3) limits the use of the equation to air change rates equal to or less than 0.60 *ACH.* Because 0.30 *ACH* is less than 0.60 *ACH,* 0.30 *ACH* is used to calculate the required volume. Using Equation 9.3.2.2a, the required volume for the 40,000 Btu/hr water heater is calculated as follows:

[H.3b]

$$=\frac{21\text{ ft}^3}{0.30}\left(\frac{40{,}000\text{ Btu/hr}}{1000\text{ Btu/hr}}\right)$$

$$=2800\text{ ft}^3$$

Paragraph 9.3.2.2 specifies a lower required volume limitation for appliances other than fan-assisted at no smaller than 35 ft^3 per 1000 Btu/hr. From Table A.9.3.2.2(a), the lower limit is 1400 ft^3.

Because the calculated required volume of 2800 ft^3 is above the lower required volume limit, use this amount as the minimum required volume.

(c) *Total required volume:* Subsection 9.3.2 states that the total required volume to use indoor air is the sum of the required volumes for all appliances located in the space:

Total Required = 5000 ft^3+ 2800 ft^3 = 7800 ft^3

(2) *Determine available volume:* The available volume is determined as follows:

[H.3c]

$$(20\text{ ft}\times 35\text{ ft})\times 8\text{ ft}=5600\text{ ft}^3$$

Conclusion: The installation cannot use indoor air alone, because the available volume of 5600 ft^3 is less than the total required volume of 7800 ft^3. Outdoor air openings can be sized in accordance with all air from the outdoors or by use of the combination of indoor/outdoor air method.

Annex I Example of Combination of Indoor and Outdoor Combustion and Ventilation Opening Design

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

For SI units, 1 Btu/hr = 0.293 W, 1 ft^3 = 0.028 m^3, 1 ft = 0.305 m, 1 in. w.c. = 249 Pa.

I.1 Example of Combination Indoor and Outdoor Combustion Air Opening Design. Determine the required combination of indoor and outdoor combustion air opening sizes for the following appliance installation example.

Example Installation: A fan-assisted furnace and a draft hood–equipped water heater with the following inputs are located in a 15 ft × 30 ft basement with an 8 ft ceiling. No additional indoor spaces can be used to help meet the appliance combustion air needs.

Fan-Assisted Furnace Input: 100,000 Btu/hr

Draft Hood–Equipped Water Heater Input: 40,000 Btu/hr

Solution

(1) *Determine the total available room volume:* Appliance room volume: 15 ft × 30 ft with an 8 ft ceiling = 3600 ft^3

(2) *Determine the total required volume:* The Standard Method to determine combustion air is used to calculate the required volume. The combined input for the appliances located in the basement is calculated as follows:

[I.1a]

$$100{,}000\text{ Btu/hr}+40{,}000\text{ Btu/hr}=140{,}000\text{ Btu/hr}$$

The Standard Method requires that the required volume be determined based on 50 ft^3 per 1000 Btu/hr. Using Table A.9.3.2.1, the required volume for a 140,000 Btu/hr combined input is 7000 ft^3.

Conclusion: The indoor volume is insufficient to supply combustion air since the total of 3600 ft^3 does not meet the required volume of 7000 ft^3. Therefore, additional combustion air must be provided from the outdoors.

(3) Determine the ratio of the available volume to the required volume:

[I.1b]

$$\frac{3600 \text{ ft}^3}{7000 \text{ ft}^3} = 0.51$$

(4) Determine the reduction factor to be used to reduce the full outdoor air opening size to the minimum required based on ratio of indoor spaces:
1.00 - 0.51 (from Step 3) = 0.49

(5) Determine the single outdoor combustion air opening size as though all combustion air is to come from outdoors. In this example, the combustion air opening directly communicates with the outdoors:

[I.1c]

$$\frac{140{,}000 \text{ Btu/hr}}{3000 \text{ Btu/in.}^2} = 47 \text{ in.}^2$$

(6) Determine the minimum outdoor combustion air opening area:

Outdoor opening area = 0.49 (from Step 4) × 47 in.^{2} = 23 in.^{2}
Paragraph 9.3.4(3)(c) requires the minimum dimension of the air opening should not be less than 3 in.

Annex J Enforcement

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

J.1 The following sample ordinance is provided to assist a jurisdiction in the adoption of this code and is not part of this code.

ORDINANCE NO.________________

An ordinance of the *[jurisdiction]* adopting the 2021 edition of NFPA 54/ANSI Z223.1, *National Fuel Gas Code*, documents listed in Chapter 2 of that code; prescribing regulations governing conditions hazardous to life and property from fire or explosion; providing for the issuance of permits and collection of fees; repealing Ordinance No.______ of the *[jurisdiction]* and all other ordinances and parts of ordinances in conflict therewith; providing a penalty; providing a severability clause; and providing for publication; and providing an effective date.

BE IT ORDAINED BY THE *[governing body]* OF THE *[jurisdiction]*:

SECTION 1 That the *National Fuel Gas Code* and documents adopted by Chapter 2, three (3) copies of which are on file and are open to inspection by the public in the office of the *[jurisdiction's keeper of records]* of the *[jurisdiction]*, are hereby adopted and incorporated into this ordinance as fully as if set out at length herein, and from the date on which this ordinance shall take effect, the provisions thereof shall be controlling within the limits of the *[jurisdiction]*. The same are hereby adopted as the code of the *[jurisdiction]* for the purpose of prescribing regulations governing conditions hazardous to life and property from fire or explosion and providing for issuance of permits and collection of fees.

SECTION 2 Any person who shall violate any provision of this code or standard hereby adopted or fail to comply therewith; or who shall violate or fail to comply with any order made thereunder; or who shall build in violation of any detailed statement of specifications or plans submitted and approved thereunder; or failed to operate in accordance with any certificate or permit issued thereunder; and from which no appeal has been taken; or who shall fail to comply with such an order as affirmed or modified by or by a court of competent jurisdiction, within the time fixed herein, shall severally for each and every such violation and noncompliance, respectively, be guilty of a misdemeanor, punishable by a fine of not less than $ ________ nor more than $________ or by imprisonment for not less than________ days nor more than_________ days or by both such fine and imprisonment. The imposition of one penalty for any violation shall not excuse the violation or permit it to continue; and all such persons shall be required to correct or remedy such violations or defects within a reasonable time; and when not otherwise specified the application of the above penalty shall not be held to prevent the enforced removal of prohibited conditions. Each day that prohibited conditions are maintained shall constitute a separate offense.

SECTION 3 Additions, insertions, and changes — that the 2021 edition of NFPA 54/ANSI Z223.1, *National Fuel Gas Code*, is amended and changed in the following respects:

List Amendments

SECTION 4 That ordinance No.___________ of *[jurisdiction]* entitled *[fill in the title of the ordinance or ordinances in effect at the present time]* and all other ordinances or parts of ordinances in conflict herewith are hereby repealed.

SECTION 5 That if any section, subsection, sentence, clause, or phrase of this ordinance is, for any reason, held to be invalid or unconstitutional, such decision shall not affect the validity or constitutionality of the remaining portions of this ordinance. The *[governing body]* hereby declares that it would have passed this ordinance, and each section, subsection, clause, or phrase hereof, irrespective of the fact that any one or more sections, subsections, sentences, clauses, and phrases be declared unconstitutional.

SECTION 6 That the *[jurisdiction's keeper of records]* is hereby ordered and directed to cause this ordinance to be published. [NOTE: An additional provision may be required to direct the number of times the ordinance is to be published and to specify that it is to be in a newspaper in general circulation. Posting may also be required.]

SECTION 7 That this ordinance and the rules, regulations, provisions, requirements, orders, and matters established and adopted hereby shall take effect and be in full force and effect *[time period]* from and after the date of its final passage and adoption.

Annex K Informational References

K.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this code and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

K.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 56, *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems,* 2020 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 2020 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting,* 2018 edition.

NFPA 70®, National Electrical Code®, 2020 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* 2021 edition.

NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems,* 2021 edition.

NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations,* 2021 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems,* 2020 edition.

National Fuel Gas Code Handbook, 2018 edition.

K.1.2 Other Publications.

K.1.2.1 API Publications. American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005-4070.

API STD 1104, *Welding Pipelines and Related Facilities,* 2013.

K.1.2.2 ASHRAE Publications. ASHRAE, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305, (404) 636-8400, www.ashrae.org.

ASHRAE Handbook — Fundamentals, 2017.

ASHRAE Handbook — HVAC Systems and Equipment, 2016.

Δ **K.1.2.3 ASME Publications.** American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990, (800) 843-2763. www.asme.org

Boiler and Pressure Vessel Code, Section IX and Section IV, 2015.

Δ **K.1.2.4 ASTM Publications.** ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, (610) 833-9585. www.astm.org

ASTM D2385, *Test Method for Hydrogen Sulfide and Mercaptan Sulfur in Natural Gas (Cadmium Sulfate — Iodometric Titration Method),* 1981, reaffirmed 1990 (withdrawn 1995).

ASTM D2420, *Test Method of for Hydrogen Sulfide in Liquefied Petroleum (LP) Gases (Lead Acetate Method),* 2013, reaffirmed 2018.

Δ **K.1.2.5 AWS Publications.** American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166-6672, (800) 443-9353. www.aws.org

AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification,* 2014.

AWS B2.2/B2.2M, *Specification for Brazing Procedure and Performance Qualification,* 2016.

Δ **K.1.2.6 CSA Group Publications.** CSA Group, 178 Rexdale Boulevard, Toronto, ON M9W 1R3, Canada, (216) 524-4990. www.csagroup.org

ANSI Z21.13/CSA 4.9, *Gas-Fired Low Pressure Steam and Hot Water Boilers,* 2017.

ANSI Z21.50/CSA 2.22, *Vented Decorative Gas Appliances,* 2019.

ANSI Z21.60/CSA 2.26, *Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces,* 2017.

Δ **K.1.2.7 NACE Publications.** NACE International, 15835 Park Ten Place, Houston, TX 77084-4906. www.nace.org

NACE SP0169, *Control of External Corrosion on Underground or Submerged Metallic Piping Systems,* 2013.

Δ **K.1.2.8 UL Publications.** Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096. www.ul.com

UL 651, *Schedule 40 and 80 Rigid PVC Conduit and Fittings,* 2011, revised 2018.

UL 795, *Commercial-Industrial Gas Heating Equipment,* 2016.

K.1.2.9 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001. www.gpo.gov

Responding to Residential Carbon Monoxide Incidents, Guidelines for Fire and Other Emergency Response Personnel, U.S. Consumer Product Safety Commission, July 23, 2002.

K.1.2.10 Other Publications.

Piping Handbook, 2000, New York: McGraw-Hill Book Company.

Project Number 21323, *Validation of Installation Methods for CSST Gas Piping to Mitigate Indirect Lightning Related Damage,* Gas Technology Institute 2015.

K.2 Informational References. The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.

K.2.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 30, *Flammable and Combustible Liquids Code,* 2021 edition.

NFPA 59, *Utility LP-Gas Plant Code,* 2021 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities,* 2020 edition.

NFPA 86, *Standard for Ovens and Furnaces,* 2019 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel–Burning Appliances,* 2019 edition.

NFPA 501A, *Standard for Fire Safety Criteria for Manufactured Home Installations, Sites, and Communities,* 2017 edition.

Δ **K.2.2 CSA Group Publications.** CSA Group, 178 Rexdale Boulevard, Toronto, ON M9W 1R3, Canada, (216) 524-4990. www.csagroup.org

ANSI/AGA NGV 3.1/CSA 12.3, *Fuel System Components for Compressed Natural Gas Powered Vehicles,* 2014, reaffirmed 2019.

AGA/CSA NGV 1, *Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices,* 2017.

ANSI/CSA FC 1, *Fuel Cell Technologies — Part 3-100: Stationary fuel cell power systems — Safety,* 2014, reaffirmed 2018.

ANSI/CSA NGV 2, *Natural Gas Vehicle Fuel Containers,* 2016.

ANSI/LC 2A, *Direct Gas-Fired Circulating Heaters for Agricultural Animal Confinement Buildings,* 1998, reaffirmed 2015.

ANSI/LC 2, *Direct Gas-Fired Circulating Heaters for Agricultural Animal Confinement Buildings,* 1996, reaffirmed 2015.

ANSI Z21.1/CSA 1.1, *Household Cooking Gas Appliances,* 2018.

ANSI Z21.5.1/CSA 7.1, *Gas Clothes Dryers — Volume I — Type 1 Clothes Dryers,* 2017.

ANSI Z21.5.2/CSA 7.2, *Gas Clothes Dryers — Volume II — Type 2 Clothes Dryers,* 2016.

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,* 2017.

ANSI Z21.10.3/CSA 4.3, *Gas Water Heaters — Volume III — Storage Water Heaters with Input Ratings above 75,000 Btu per Hour, Circulating and Instantaneous,* 2017.

ANSI Z21.11.2, *Gas-Fired Room Heaters — Volume II — Unvented Room Heaters,* 2016.

ANSI Z21.12, *Draft Hoods,* 1990 reaffirmed 2015.

ANSI Z21.13/CSA 4.9, *Gas-Fired Low-Pressure Steam and Hot Water Boilers,* 2017.

ANSI Z21.15/CSA 9.1, *Manually Operated Gas Valves for Appliances, Appliance Connector Valves, and Hose End Valves,* 2009, reaffirmed 2014.

ANSI Z21.17/CSA 2.7, *Domestic Gas Conversion Burners,* 1998, reaffirmed 2014.

ANSI Z21.18/CSA 6.3, *Gas Appliance Pressure Regulators,* 2007, reaffirmed 2016.

ANSI Z21.19/CSA 1.4, *Refrigerators Using Gas Fuel,* 2014.

ANSI Z21.20/CSA C22.2 — No. 60730-2-5, *Automatic Electrical Controls for Household and Similar Use — Part 2: Particular Requirements for Automatic Burner Ignition Systems and Components,* 2014, reaffirmed 2019.

ANSI Z21.21/CSA 6.5, *Automatic Valves for Gas Appliances,* 2019.

ANSI Z21.22/CSA 4.4, *Relief Valves for Hot Water Supply Systems,* 2015.

ANSI Z21.23, *Gas Appliance Thermostats,* 2010, reaffirmed 2015.

ANSI Z21.24/CSA 6.10, *Connectors for Gas Appliances,* 2015.

ANSI Z21.35/CSA 6.8, *Pilot Gas Filters,* 2005, reaffirmed 2015.

ANSI Z21.40.1/CSA 2.91, *Gas-Fired, Heat Activated Air-Conditioning and Heat Pump Appliances,* 1996, reaffirmed 2017.

ANSI Z21.40.2/CSA 2.92, *Gas-Fired, Work Activated Air-Conditioning and Heat Pump Appliances (Internal Combustion),* 1996, reaffirmed 2017.

ANSI Z21.40.4/CSA 2.94, *Performance Testing and Rating of Gas-Fired, Air-Conditioning and Heat Pump Appliances,* 1996, reaffirmed 2017.

ANSI Z21.42, *Gas-Fired Illuminating Appliances,* 2013, reaffirmed 2018.

ANSI Z21.47/CSA 2.3, *Gas-Fired Central Furnaces,* 2016.

ANSI Z21.54/CSA 8.4, *Gas Hose Connectors for Portable Outdoor Gas-Fired Appliances,* 2019.

ANSI Z21.56/CSA 4.7, *Gas-Fired Pool Heaters,* 2017.

ANSI Z21.57, *Recreational Vehicle Cooking Gas Appliances,* 2010.

ANSI Z21.58/CSA 1.6, *Outdoor Cooking Gas Appliances,* 2018.

ANSI Z21.60/CSA 2.26, *Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces,* 2017.

ANSI Z21.61, *Gas-Fired Toilets,* 1993, reaffirmed 2013.

ANSI Z21.66/CSA 6.14, *Automatic Vent Damper Devices for Use with Gas-Fired Appliances,* 2015.

ANSI Z21.69/CSA 6.16, *Connectors for Movable Gas Appliances,* 2015.

ANSI Z21.71, *Automatic Intermittent Pilot Ignition Systems for Field Installations,* 1993 reaffirmed 2016.

ANSI Z21.77/CSA 6.23, *Manually-Operated Piezo-Electric Spark Gas Ignition Systems and Components,* 2005, reaffirmed 2015.

ANSI Z21.78/CSA 6.20, *Combination Gas Controls for Gas Appliances,* 2010, reaffirmed 2015.

ANSI Z21.84, *Manually Lighted, Natural Gas Decorative Gas Appliances for Installation in Solid-Fuel Burning Appliances,* 2017.

ANSI Z21.86/CSA 2.32, *Vented Gas-Fired Space Heating Appliances,* 2016.

ANSI Z21.87/CSA 4.6, *Automatic Gas Shutoff Devices for Hot Water Supply Systems,* 2007, reaffirmed 2016.

ANSI Z21.88/CSA 2.33, *Vented Gas Fireplace Heaters,* 2017.

ANSI Z21.91, *Ventless Firebox Enclosures for Gas-Fired Unvented Decorative Room Heaters,* 2017.

ANSI Z83.4/CSA 3.7, *Non-Recirculating Direct Gas-Fired Industrial Air Heaters,* 2017.

ANSI Z83.8/CSA 2.6, *Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters, and Gas-Fired Duct Furnaces,* 2016.

ANSI Z83.11/CSA 1.8, *Gas Food Service Equipment,* 2016.

ANSI Z83.19/CSA 2.35, *Gas-Fired High-Intensity Infrared Heaters*, 2017.

ANSI Z83.20/CSA 2.34, *Gas-Fired tubular and Low-Intensity Infrared Heaters*, 2016.

ANSI Z83.21/CSA C 22.2 No.168, *Commercial Dishwashers*, 2016.

K.2.3 MSS Publications. Manufacturers Standardization Society of the Valve and Fittings Industry, 127 Park Street, NE, Vienna, VA 22180-4602. www.msshq.org

MSS SP-6, *Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings*, 2017.

ANSI/MSS SP-58, *Pipe Hangers and Supports — Materials, Design and Manufacture*, 2018.

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Δ **K.2.4 UL Publications.** Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096. www.ul.com

UL 103, *Chimneys, Factory-Built, Residential Type and Building Heating Appliances*, 2010, revised 2017.

UL 441, *Gas Vents*, 2016.

UL 641, *Type L Low-Temperature Venting Systems*, 2010, revised 2018.

UL 1738, *Venting Systems for Gas Burning Appliances, Categories II, III and IV*, 2010, revised 2014.

UL 1777, *Chimney Liners*, 2015, revised 2019.

Δ **K.2.5 US Government Publications.** US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001. www.gpo.gov

Title 24, Code of Federal Regulations, Part 3280, "*Manufactured Home Construction and Safety Standard.*"

K.3 References for Extracts in Informational Sections. (Reserved)

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Sequence of Events for the Standards Development Process

Once the current edition is published, a Standard is opened for Public Input.

Step 1 – Input Stage

- Input accepted from the public or other committees for consideration to develop the First Draft
- Technical Committee holds First Draft Meeting to revise Standard (23 weeks); Technical Committee(s) with Correlating Committee (10 weeks)
- Technical Committee ballots on First Draft (12 weeks); Technical Committee(s) with Correlating Committee (11 weeks)
- Correlating Committee First Draft Meeting (9 weeks)
- Correlating Committee ballots on First Draft (5 weeks)
- First Draft Report posted on the document information page

Step 2 – Comment Stage

- Public Comments accepted on First Draft (10 weeks) following posting of First Draft Report
- If Standard does not receive Public Comments and the Technical Committee chooses not to hold a Second Draft meeting, the Standard becomes a Consent Standard and is sent directly to the Standards Council for issuance (see Step 4) or
- Technical Committee holds Second Draft Meeting (21 weeks); Technical Committee(s) with Correlating Committee (7 weeks)
- Technical Committee ballots on Second Draft (11 weeks); Technical Committee(s) with Correlating Committee (10 weeks)
- Correlating Committee Second Draft Meeting (9 weeks)
- Correlating Committee ballots on Second Draft (8 weeks)
- Second Draft Report posted on the document information page

Step 3 – NFPA Technical Meeting

- Notice of Intent to Make a Motion (NITMAM) accepted (5 weeks) following the posting of Second Draft Report
- NITMAMs are reviewed and valid motions are certified by the Motions Committee for presentation at the NFPA Technical Meeting
- NFPA membership meets each June at the NFPA Technical Meeting to act on Standards with "Certified Amending Motions" (certified NITMAMs)
- Committee(s) vote on any successful amendments to the Technical Committee Reports made by the NFPA membership at the NFPA Technical Meeting

Step 4 – Council Appeals and Issuance of Standard

- Notification of intent to file an appeal to the Standards Council on Technical Meeting action must be filed within 20 days of the NFPA Technical Meeting
- Standards Council decides, based on all evidence, whether to issue the standard or to take other action

Notes:

1. Time periods are approximate; refer to published schedules for actual dates.
2. Annual revision cycle documents with certified amending motions take approximately 101 weeks to complete.
3. Fall revision cycle documents receiving certified amending motions take approximately 141 weeks to complete.

Committee Membership Classifications[1,2,3,4]

The following classifications apply to Committee members and represent their principal interest in the activity of the Committee.

1. M *Manufacturer:* A representative of a maker or marketer of a product, assembly, or system, or portion thereof, that is affected by the standard.
2. U *User:* A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.
3. IM *Installer/Maintainer:* A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the standard.
4. L *Labor:* A labor representative or employee concerned with safety in the workplace.
5. RT *Applied Research/Testing Laboratory:* A representative of an independent testing laboratory or independent applied research organization that promulgates and/or enforces standards.
6. E *Enforcing Authority:* A representative of an agency or an organization that promulgates and/or enforces standards.
7. I *Insurance:* A representative of an insurance company, broker, agent, bureau, or inspection agency.
8. C *Consumer:* A person who is or represents the ultimate purchaser of a product, system, or service affected by the standard, but who is not included in (2).
9. SE *Special Expert:* A person not representing (1) through (8) and who has special expertise in the scope of the standard or portion thereof.

NOTE 1: "Standard" connotes code, standard, recommended practice, or guide.

NOTE 2: A representative includes an employee.

NOTE 3: While these classifications will be used by the Standards Council to achieve a balance for Technical Committees, the Standards Council may determine that new classifications of member or unique interests need representation in order to foster the best possible Committee deliberations on any project. In this connection, the Standards Council may make such appointments as it deems appropriate in the public interest, such as the classification of "Utilities" in the National Electrical Code Committee.

NOTE 4: Representatives of subsidiaries of any group are generally considered to have the same classification as the parent organization.