SECTION 402
PIPE SIZING

402.1 General considerations.
Piping systems shall be of such size and so installed as to provide a supply of gas sufficient to meet the maximum demand without undue loss of pressure between the point of delivery and the gas utilization equipment.

402.2 Maximum gas demand.
The volume of gas to be provided, in cubic feet per hour, shall be determined directly from the manufacturer's input ratings of the gas utilization equipment served. Where an input rating is not indicated, the gas supplier, equipment manufacturer or a qualified agency shall be contacted, or the rating from Table 402.2 shall be used for estimating the volume of gas to be supplied.

The total connected hourly load shall be used as the basis for pipe sizing, assuming that all equipment could be operating at full capacity simultaneously. Where a diversity of load can be established, pipe sizing shall be permitted to be based on such loads.

TABLE 402.2
APPROXIMATE GAS INPUT FOR TYPICAL APPLIANCES

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

For SI: 1 British thermal unit per hour = 0.293 W, 1 gallon = 3.785 L, 1 gallon per minute = 3.785 L/m.

402.3 Sizing.

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

1. Pipe sizing tables or sizing equations in accordance with Section 402.4 .
2. The sizing tables included in a listed piping system's manufacturer's installation instructions.
3. Other approved engineering methods.

402.4 Sizing tables and equations.

Where Tables 402.4(1) through 402.4(33) are used to size piping or tubing, the pipe length shall be determined in accordance with Section 402.4.1 , 402.4.2 or 402.4.3 .

Where Equations 4-1 and 4-2 are used to size piping or tubing, the pipe or tubing shall have smooth inside walls and the pipe length shall be determined in accordance with Section 402.4.1 , 402.4.2 or 402.4.3 .

1. Low-pressure gas equation [less than 1.5 pounds per square inch (psi) (10.3 kPa)]:

$$D = \frac{Q^{0.381}}{19.17 \left(\dfrac{\Delta H}{C_r \times L} \right)^{0.206}}$$

(Equation 4-1)

2. High-pressure gas equation [1.5 psi (10.3 kPa) and above]:

$$D = \frac{Q^{0.381}}{18.93 \left[\dfrac{\left(P_1{}^2 - P_2{}^2 \right) \times Y}{C_r \times L} \right]^{0.206}}$$

(Equation 4-2)

where:

D = Inside diameter of pipe, inches (mm).

Q = Input rate appliance(s), cubic feet per hour at 60 ° F (16 ° C) and 30-inch mercury column

P_1 = Upstream pressure, psia (P_1 + 14.7)

P_2 = Downstream pressure, psia (P_2 + 14.7)

L = Equivalent length of pipe, feet

ΔH = Pressure drop, inch water column (27.7 inch water column = 1 psi)

TABLE 402.4
C_r AND Y VALUES FOR NATURAL GAS AND
UNDILUTED PROPANE AT STANDARD CONDITIONS

GAS	EQUATION FACTORS	
	C_r	Y
Natural gas	0.6094	0.9992
Undiluted propane	1.2462	0.9910

For SI: 1 cubic foot = 0.028 m ₃, 1 foot = 305 mm, 1-inch water column = 0.249 kPa, 1 pound per square inch = 6.895 kPa, 1 British thermal unit per hour = 0.293 W.

TABLE 402.4(2)
SCHEDULE 40 METALLIC PIPE

Gas	Natural
Inlet Pressure	0.5 psi or less
Pressure Drop	0.5 inch WC
Specific Gravity	0.60

					PIPE SIZE (in.)						
Nominal	**1 / 4**	**3 / 8**	**1 / 2**	**3 / 4**	**1**	**1 1 / 4**	**1 1 / 2**	**2**	**2 1 / 2**	**3**	**4**
Actual ID	**0.364**	**0.493**	**0.622**	**0.824**	**1.049**	**1.380**	**1.610**	**2.067**	**2.469**	**3.068**	**4.026**
Length (ft)					Maximum Capacity in Cubic Feet of Gas per Hour						
10	43	95	175	360	680	1,400	2,100	3,950	6,300	11,000	23,000
20	29	65	120	250	465	950	1,460	2,750	4,350	7,700	15,800
30	24	52	97	200	375	770	1,180	2,200	3,520	6,250	12,800
40	20	45	82	170	320	660	990	1,900	3,000	5,300	10,900
50	18	40	73	151	285	580	900	1,680	2,650	4,750	9,700
60	16	36	66	138	260	530	810	1,520	2,400	4,300	8,800
70	15	33	61	125	240	490	750	1,400	2,250	3,900	8,100
80	14	31	57	118	220	460	690	1,300	2,050	3,700	7,500
90	13	29	53	110	205	430	650	1,220	1,950	3,450	7,200
100	12	27	50	103	195	400	620	1,150	1,850	3,250	6,700
125	11	24	44	93	175	360	550	1,020	1,650	2,950	6,000
150	10	22	40	84	160	325	500	950	1,500	2,650	5,500
175	9	20	37	77	145	300	460	850	1,370	2,450	5,000
200	8	19	35	72	135	280	430	800	1,280	2,280	4,600

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m ^{3}/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

402.4.1 Longest length method.
The pipe size of each section of gas piping shall be determined using the longest length of piping from the point of delivery to the most remote outlet and the load of the section.

402.4.2 Branch length method.
Pipe shall be sized as follows:
1.   Pipe size of each section of the longest pipe run from the point of delivery to the most remote outlet shall be determined using the longest run of piping and the load of the section.
2.   The pipe size of each section of branch piping not previously sized shall be determined using the length of piping from the point of delivery to the most remote outlet in each branch and the load of the section.

402.4.3 Hybrid pressure.
The pipe size for each section of higher pressure gas piping shall be determined using the longest length of piping from the point of delivery to the most remote line pressure regulator. The pipe size from the line pressure regulator to each outlet shall be

determined using the length of piping from the regulator to the most remote outlet served by the regulator.

402.5 Allowable pressure drop.
The design pressure loss in any piping system under maximum probable flow conditions, from the point of delivery to the inlet connection of the equipment, shall be such that the supply pressure at the equipment is greater than the minimum pressure required for proper equipment operation.

402.6 Maximum design operating pressure.
The maximum design operating pressure for piping systems located inside buildings shall not exceed 5 pounds per square inch gauge (psig) (34 kPa gauge) except where one or more of the following conditions are met:
1.   The piping system is welded.
2.   The piping is located in a ventilated chase or otherwise enclosed for protection against accidental gas accumulation.
3.   The piping is located inside buildings or separate areas of buildings used exclusively for:
3.1.   Industrial processing or heating;
3.2.   Research;
3.3.   Warehousing; or
3.4.   Boiler or mechanical equipment rooms.
4.   The piping is a temporary installation for buildings under construction.

402.6.1 Liquefied petroleum gas systems.
The operating pressure for undiluted LP-gas systems shall not exceed 20 psig (140 kPa gauge). Buildings having systems designed to operate below -5°F (-21°C) or with butane or a propane-butane mix shall be designed to either accommodate liquid LP-gas or prevent LP-gas vapor from condensing into a liquid.

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

A.7 Examples of piping system design and sizing.

A.7.1 Example 1: Longest length method.

Determine the required pipe size of each section and outlet of the piping system shown in Figure A.7.1 , with a designated pressure drop of 0.5-inch w.c. (125 Pa) using the Longest Length Method. The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/ft $_3$ (37.5 MJ/m $_3$).

Solution:

(1) Maximum gas demand for Outlet A:

$$\frac{\text{Consumption (rating plate input, or Table 402.2 if necessary)}}{\text{Btu of gas}} =$$

$$\frac{35,000 \text{ Btu per hour rating}}{1,000 \text{ Btu per cubic foot}} = 35 \text{ cubic feet per hour} = 35 \text{ cfh}$$

Maximum gas demand for Outlet B:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{75,000}{1,000} = 75 \text{ cfh}$$

Maximum gas demand for Outlet C:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{35,000}{1,000} = 35 \text{ cfh}$$
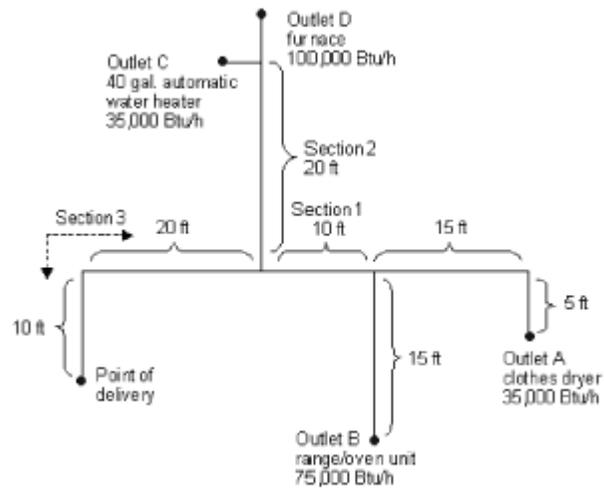
Maximum gas demand for Outlet D:

$$\frac{\text{Consumption}}{\text{Btu of gas}} = \frac{100,000}{1,000} = 100 \text{ cfh}$$

(2)   The length of pipe from the point of delivery to the most remote outlet (A) is 60 feet (18 288 mm). This is the only distance used.

(3)   Using the row marked 60 feet (18 288 mm) in Table 402.4(2) :

(a)   Outlet A, supplying 35 cfh (0.99 m$_3$/hr), requires $3/8$-inch pipe.

(b)   Outlet B, supplying 75 cfh (2.12 m$_3$/hr), requires ¾-inch pipe.

(c)   Section 1, supplying Outlets A and B, or 110 cfh (3.11 m$_3$/hr), requires ¾-inch pipe.

(d)   Section 2, supplying Outlets C and D, or 135 cfh (3.82 m$_3$/hr), requires ¾-inch pipe.

(e)   Section 3, supplying Outlets A, B, C and D, or 245 cfh (6.94 m$_3$/hr), requires 1-inch pipe.

(4)   If a different gravity factor is applied to this example, the values in the row marked 60 feet (18 288 mm) of Table 402.4(2) would be multiplied by the appropriate multiplier from Table A.2.4 and the resulting cubic feet per hour values would be used to size the piping.

FIGURE A.7.1
PIPING PLAN SHOWING A STEEL PIPING SYSTEM

Outlet D
furnace
100,000 Btu/h

Outlet C
40 gal. automatic
water heater
35,000 Btu/h

Section 2
20 ft

Section 3   20 ft   Section 1   15 ft
                             10 ft

5 ft

10 ft

15 ft   Outlet A
             clothes dryer
             35,000 Btu/h

Point of
delivery

Outlet B
range/oven unit
75,000 Btu/h

A.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 A.7.4 , with a designated pressure drop of 0.5-inch w.c. (125 Pa) using the branch length method. The gas to be used has 0.60 specific gravity and a heating value of 1,000 Btu/ft $_3$ (37.5 MJ/m $_3$).

Solution

(1)   The length of pipe and CSST from the point of delivery to the retrofit appliance (barbecue) at the end of Section G is 40 feet (12 192 mm), 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 feet (12 192 mm) in Table 402.4(14) , Section G, supplying 40 cfh (1.13 m $_3$/hr) for the barbecue requires EHD 18 CSST.

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

FIGURE A.7.4
PIPING PLAN SHOWING A MODIFICATION TO EXISTING PIPING SYSTEM