

APPENDIX A

SIZING AND CAPACITIES OF GAS PIPING

(This appendix is informative and is not part of the *code*. This appendix is an excerpt from the 2009 *International Fuel Gas Code*, coordinated with the section numbering of the *International Residential Code*.)

A.1 General piping considerations. The first goal of determining the *pipe* sizing for a *fuel gas piping system* is to make sure that there is sufficient gas pressure at the inlet to each *appliance*. The majority of systems are residential and the *appliances* will all have the same, or nearly the same, requirement for minimum gas pressure at the *appliance* inlet. This pressure will be about 5-inch water column (w.c.) (1.25 kPa), which is enough for proper operation of the *appliance regulator* to deliver about 3.5-inches water column (w.c.) (875 kPa) 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* may 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 would seldom be of concern in small systems if the source pressure is $\frac{1}{2}$ psi (14-inch w.c.) (3.5 kPa) or less but it should be verified for systems with greater gas pressure at the point of supply.

To determine the size of *piping* used in a *gas piping system*, the following factors must be considered:

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

For any *gas piping system*, or special *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 *code official*.

A.2 Description of tables

A.2.1 General. The quantity of gas to be provided at each *outlet* should be determined, whenever possible, directly

from the manufacturer's gas input *Btu/h* rating of the *appliance* that will be installed. In case the ratings of the *appliances* to be installed are not known, Table G2413.2 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/h* 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.

A.2.2 Low pressure natural gas tables. Capacities for gas at low pressure [less than 2.0 psig (13.8 kPa gauge)] in cubic feet per hour of 0.60 *specific gravity* gas for different sizes and lengths are shown in Table G2413.4(1) for iron *pipe* or equivalent rigid *pipe*, in Table G2413.4(3) for smooth wall semi-rigid *tubing*, in Table G2413.4(5) for corrugated stainless steel *tubing* and in Table G2413.4(7) for polyethylene plastic *pipe*. Tables G2413.4(1), G2413.4(3), G2413.4(5) and G2413.4(7) are based upon a *pressure drop* of 0.5-inch 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 A.2.2].

A.2.3 Undiluted liquefied petroleum tables. Capacities in thousands of *Btu* per hour of undiluted liquefied petroleum gases based on a *pressure drop* of 0.5-inch w.c. (125 Pa) for different sizes and lengths are shown in the *International Fuel Gas Code*. See Appendix A of that *code*.

A.2.4 Natural gas specific gravity. *Gas piping systems* that are to be supplied with gas of a *specific gravity* of 0.70 or less can be sized directly from the tables provided in this *code*, unless the *code official* 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 A.2.4. In case the exact *specific gravity* does not appear in the table, choose the next higher value *specific gravity* shown.

**TABLE A.2.2
EQUIVALENT LENGTHS OF PIPE FITTINGS AND VALVES**

		SCREWED FITTINGS ¹				90° WELDING ELBOWS AND SMOOTH BENDS ²					
		45°/EII	90°/EII	180° close return bends	Tee	R/d = 1	R/d = 1 ¹ / ₃	R/d = 2	R/d = 4	R/d = 6	R/d = 8
k factor =		0.42	0.90	2.00	1.80	0.48	0.36	0.27	0.21	0.27	0.36
L/d' ratio⁴ n =		14	30	67	60	16	12	9	7	9	12
Nominal pipe size, inches	Inside diameter <i>d</i> , inches, Schedule 40 ⁶	L = Equivalent Length In Feet of Schedule 40 (Standard-Weight) Straight Pipe⁶									
1/2	0.622	0.73	1.55	3.47	3.10	0.83	0.62	0.47	0.36	0.47	0.62
3/4	0.824	0.96	2.06	4.60	4.12	1.10	0.82	0.62	0.48	0.62	0.82
1	1.049	1.22	2.62	5.82	5.24	1.40	1.05	0.79	0.61	0.79	1.05
1 1/4	1.380	1.61	3.45	7.66	6.90	1.84	1.38	1.03	0.81	1.03	1.38
1 1/2	1.610	1.88	4.02	8.95	8.04	2.14	1.61	1.21	0.94	1.21	1.61
2	2.067	2.41	5.17	11.5	10.3	2.76	2.07	1.55	1.21	1.55	2.07
2 1/2	2.469	2.88	6.16	13.7	12.3	3.29	2.47	1.85	1.44	1.85	2.47
3	3.068	3.58	7.67	17.1	15.3	4.09	3.07	2.30	1.79	2.30	3.07
4	4.026	4.70	10.1	22.4	20.2	5.37	4.03	3.02	2.35	3.02	4.03
5	5.047	5.88	12.6	28.0	25.2	6.72	5.05	3.78	2.94	3.78	5.05
6	6.065	7.07	15.2	33.8	30.4	8.09	6.07	4.55	3.54	4.55	6.07
8	7.981	9.31	20.0	44.6	40.0	10.6	7.98	5.98	4.65	5.98	7.98
10	10.02	11.7	25.0	55.7	50.0	13.3	10.0	7.51	5.85	7.51	10.0
12	11.94	13.9	29.8	66.3	59.6	15.9	11.9	8.95	6.96	8.95	11.9
14	13.13	15.3	32.8	73.0	65.6	17.5	13.1	9.85	7.65	9.85	13.1
16	15.00	17.5	37.5	83.5	75.0	20.0	15.0	11.2	8.75	11.2	15.0
18	16.88	19.7	42.1	93.8	84.2	22.5	16.9	12.7	9.85	12.7	16.9
20	18.81	22.0	47.0	105.0	94.0	25.1	18.8	14.1	11.0	14.1	18.8
24	22.63	26.4	56.6	126.0	113.0	30.2	22.6	17.0	13.2	17.0	22.6

(continued)

TABLE A.2.2—continued
EQUIVALENT LENGTHS OF PIPE FITTINGS AND VALVES

		MITER ELBOWS ³ (No. of miters)					WELDING TEES		VALVES (screwed, flanged, or welded)			
		1-45°	1-60°	1-90°	2-90° ⁵	3-90° ⁵	Forged	Miter ³	Gate	Globe	Angle	Swing Check
k factor =		0.45	0.90	1.80	0.60	0.45	1.35	1.80	0.21	10	5.0	2.5
L/d' ratio⁴ n =		15	30	60	20	15	45	60	7	333	167	83
Nominal pipe size, inches	Inside diameter <i>d</i> , inches, Schedule 40 ⁶	L = Equivalent Length In Feet of Schedule 40 (Standard-Weight) Straight Pipe⁶										
1/2	0.622	0.78	1.55	3.10	1.04	0.78	2.33	3.10	0.36	17.3	8.65	4.32
3/4	0.824	1.03	2.06	4.12	1.37	1.03	3.09	4.12	0.48	22.9	11.4	5.72
1	1.049	1.31	2.62	5.24	1.75	1.31	3.93	5.24	0.61	29.1	14.6	7.27
1 1/4	1.380	1.72	3.45	6.90	2.30	1.72	5.17	6.90	0.81	38.3	19.1	9.58
1 1/2	1.610	2.01	4.02	8.04	2.68	2.01	6.04	8.04	0.94	44.7	22.4	11.2
2	2.067	2.58	5.17	10.3	3.45	2.58	7.75	10.3	1.21	57.4	28.7	14.4
2 1/2	2.469	3.08	6.16	12.3	4.11	3.08	9.25	12.3	1.44	68.5	34.3	17.1
3	3.068	3.84	7.67	15.3	5.11	3.84	11.5	15.3	1.79	85.2	42.6	21.3
4	4.026	5.04	10.1	20.2	6.71	5.04	15.1	20.2	2.35	112.0	56.0	28.0
5	5.047	6.30	12.6	25.2	8.40	6.30	18.9	25.2	2.94	140.0	70.0	35.0
6	6.065	7.58	15.2	30.4	10.1	7.58	22.8	30.4	3.54	168.0	84.1	42.1
8	7.981	9.97	20.0	40.0	13.3	9.97	29.9	40.0	4.65	222.0	111.0	55.5
10	10.02	12.5	25.0	50.0	16.7	12.5	37.6	50.0	5.85	278.0	139.0	69.5
12	11.94	14.9	29.8	59.6	19.9	14.9	44.8	59.6	6.96	332.0	166.0	83.0
14	13.13	16.4	32.8	65.6	21.9	16.4	49.2	65.6	7.65	364.0	182.0	91.0
16	15.00	18.8	37.5	75.0	25.0	18.8	56.2	75.0	8.75	417.0	208.0	104.0
18	16.88	21.1	42.1	84.2	28.1	21.1	63.2	84.2	9.85	469.0	234.0	117.0
20	18.81	23.5	47.0	94.0	31.4	23.5	70.6	94.0	11.0	522.0	261.0	131.0
24	22.63	28.3	56.6	113.0	37.8	28.3	85.0	113.0	13.2	629.0	314.0	157.0

For SI: 1 foot = 305 mm, 1 degree = 0.01745 rad.

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: Crocker, S. *Piping Handbook*, 4th ed., Table XIV, pp. 100-101. Copyright 1945 by McGraw-Hill, Inc. Used by permission of McGraw-Hill Book Company.

TABLE A.2.4
MULTIPLIERS TO BE USED WITH TABLES G2413.4(1)
THROUGH G2413.4(8) WHERE 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

A.2.5 Higher pressure natural gas tables. Capacities for gas at pressures of 2.0 psig (13.8 kPa) or greater in cubic feet per hour of 0.60 *specific gravity* gas for different sizes and lengths are shown in Table G2413.4(2) for iron *pipe* or equivalent rigid *pipe*, Table G2413.4(4) for semi-rigid *tubing*, Table G2413.4(6) for corrugated stainless steel *tubing* and Table G2413.4(8) for polyethylene plastic *pipe*.

A.3 Use of capacity tables

A.3.1 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 *pipng* system to the maximum value.

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

- (1) Divide the *pipng 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 A.2.2 shall be considered for *pipng* segments that include four or more fittings.
- (2) Determine the gas *demand* of each *appliance* to be attached to the *pipng system*. Where Tables G2413.4(1) through G2413.4(8) are to be used to select the *pipng* size, calculate the gas *demand* in terms of cubic feet per hour for each *pipng system outlet*.
- (3) Where the *pipng system* is for use with other than undiluted liquefied petroleum gases, determine the design system pressure, the allowable loss in pressure (*pressure drop*), and *specific gravity* of the gas to be used in the *pipng system*.

- (4) Determine the length of *pipng* from the point of delivery to the most remote *outlet* in the building/*pipng system*.
- (5) In the appropriate capacity table, select the row showing the measured length or the next longer length if the table does not give the exact length. This is the only length used in determining the size of any section of *gas pipng*. 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 A.2.4.
- (6) Use this horizontal row to locate ALL gas *demand* figures for this particular system of *pipng*.
- (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 pipng* will be found.
- (9) Proceed in a similar manner for each *outlet* and each section of *gas pipng*. For each section of *pipng*, determine the total gas *demand* supplied by that section.

When a large number of *pipng* 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 *pipng* 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 A.2.2 have been computed on a basis that the inside diameter corresponds to that of Schedule 40 (standard-weight) steel *pipe*, which is close enough for most purposes involving other schedules of *pipe*. Where a more specific solution for equivalent length is desired, this may be made by multiplying the actual inside diameter of the *pipe* in inches by $n/12$, or the actual inside diameter in feet by n (n can be read from the table heading). The equivalent length values can be used with reasonable accuracy for copper or brass fittings and bends although the resistance per foot of copper or brass *pipe* is less than that of steel. For copper or brass *valves*, however, the equivalent length of *pipe* should be taken as 45 percent longer than the values in the table, which are for steel *pipe*.

A.3.2 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 furthest remote *appliance* is only used to size the initial parts of the overall *pipng 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 *pipng 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 A.2.2

should be considered for *pip*ing segments that include four or more fittings.

- (3) Determine the distance from the outlet of the gas *meter* to the *appliance* furthest removed from the *meter*.
- (4) Using the longest distance (found in Step 3), size each *pip*ing segment from the *meter* to the most remote *appliance outlet*.
- (5) For each of these *pip*ing 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 *pip*ing material), find the longest length distance in the first column or the next larger distance if the exact distance is not listed. The use of alternative operating pressures and/or *pressure drops* will require the use of a different sizing table, but will not alter the sizing methodology. In many cases, the use of alternative operating pressures and/or *pressure drops* will require the approval of both the *code official* 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 *pip*ing 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 following the procedures of Steps 2 through 8.

A.3.3 Hybrid pressure method. The sizing of a 2 psi (13.8 kPa) *gas pip*ing system is performed using the traditional Longest Length Method but with modifications. The 2 psi (13.8 kPa) system consists of two independent pressure zones, and each zone is sized separately. The Hybrid Pressure Method is applied as follows.

The sizing of the 2 psi (13.8 kPa) section (from the *meter* to the line *regulator*) is as follows:

- (1) Calculate the gas load (by adding up the name plate ratings) from all connected *appliances*. (In certain circumstances the installed gas load may be increased up to 50 percent to accommodate future addition of *appliances*.) Ensure that the line *regulator* capacity is adequate for the calculated gas load and that the required *pressure drop* (across the *regulator*) for that capacity does not exceed $\frac{3}{4}$ psi (5.2 kPa) for a 2 psi (13.8 kPa) system. If the *pressure drop* across the *regulator* is too high (for the connected gas load), select a larger *regulator*.
- (2) Measure the distance from the *meter* to the line *regulator* located inside the building.
- (3) If there are multiple line *regulators*, measure the distance from the *meter* to the *regulator* furthest removed from the *meter*.

- (4) The maximum allowable *pressure drop* for the 2 psi (13.8 kPa) section is 1 psi (6.9 kPa).
- (5) Referring to the appropriate sizing table (based on *pip*ing material) for 2 psi (13.8 kPa) systems with a 1 psi (6.9 kPa) *pressure drop*, find this distance in the first column, or the closest larger distance if the exact distance is not listed.
- (6) Trace across this row until the gas load is found or the closest larger capacity if the exact capacity is not listed.
- (7) Read up the table column to the top row and select the appropriate *pipe* size.
- (8) If there are multiple *regulators* in this portion of the *pip*ing system, each line segment must be sized for its actual gas load, but using the longest length previously determined above.

The low pressure section (all *pip*ing 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 *pip*ing system into a number of connected segments and/or independent parallel *pip*ing 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 A.2.2 should be considered for *pip*ing segments that include four or more fittings.
- (3) For each *pip*ing segment, use the actual length or longest length (if there are sub-branchlines) 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 *pip*ing material), find the longest length distance in the first column or the closest larger distance if the exact distance is not listed. The use of alternative operating pressures and/or *pressure drops* will require the use of a different sizing table, but will not alter the sizing methodology. In many cases, the use of alternative operating pressures and/or *pressure drops* may require the approval of the *code official*.
 - (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 *pip*ing system.

A.3.4 Pressure drop per 100 feet 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.

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

For each *pipng* segment, calculate the *pressure drop* based on *pipe* size, length as a percentage of 100 feet (30 480 mm), and gas flow. Table A.3.4 shows *pressure drop* per 100 feet (30 480 mm) for *pipe* sizes from 1/2 inch (12.7 mm) through 2 inch (51 mm). The sum of *pressure drops* to the critical *appliance* is subtracted from the supply pressure to verify that sufficient pressure will be available. If not, the layout can be examined to find the high drop section(s) and sizing selections modified.

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

$$\text{Desired Value} = MBH \times \sqrt{\frac{\text{Desired Drop}}{\text{Table Drop}}}$$

For example, if it is desired to get flow through 3/4-inch (19.1 mm) *pipe* at 2 inches/100 feet, multiple the capacity of 3/4-inch *pipe* at 1 inch/100 feet by the square root of the pressure ratio:

$$147 MBH \times \sqrt{\frac{2'' \text{ w.c.}}{1'' \text{ w.c.}}} = 147 \times 1.414 = 208 MBH$$

(MBH = 1000 Btu/h)

A.4 Use of sizing equations. Capacities of smooth wall *pipe* or *tubing* can also be determined by using the following formulae:

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

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

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

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

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

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

where:

Q = Rate, cubic feet per hour at 60°F and 30-inch mercury column

D = Inside diameter of *pipe*, in.

*P*₁ = Upstream pressure, psia

*P*₂ = Downstream pressure, psia

Y = Superexpansibility factor = 1/supercompressibility factor

*C*_r = Factor for viscosity, density and temperature*

$$= 0.00354 ST \left(\frac{Z}{S} \right)^{0.152}$$

Note: See Table 402.4 for *Y* and *C*_r for natural gas and propane.

S = *Specific gravity* of gas at 60°F and 30-inch mercury column (0.60 for natural gas, 1.50 for propane), or = 1488μ

T = Absolute temperature, °F or = *t* + 460

t = Temperature, °F

Z = Viscosity of gas, centipoise (0.012 for natural gas, 0.008 for propane), or = 1488μ

fba = Base friction factor for air at 60°F (CF=1)

L = Length of *pipe*, ft

ΔH = *Pressure drop*, in. w.c. (27.7 in. H₂O = 1 psi)

(For SI, see Section G2413.4)

A.5 Pipe and tube diameters. Where the internal diameter is determined by the formulas in Section G2413.4, Tables A.5.1 and A.5.2 can be used to select the nominal or standard *pipe* size based on the calculated internal diameter.

TABLE A.3.4
THOUSANDS OF Btu/h (MBH) OF NATURAL GAS PER 100 FEET OF PIPE AT
VARIOUS PRESSURE DROPS AND PIPE DIAMETERS

PRESSURE DROP PER 100 FEET IN INCHES W.C.	PIPE SIZES (inch)					
	1/2	3/4	1	1 1/4	1 1/2	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

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

TABLE A.5.1
SCHEDULE 40 STEEL PIPE STANDARD SIZES

NOMINAL SIZE (in.)	INTERNAL DIAMETER (in.)	NOMINAL SIZE (in.)	INTERNAL DIAMETER (in.)
1/4	0.364	1 1/2	1.610
3/8	0.493	2	2.067
1/2	0.622	2 1/2	2.469
3/4	0.824	3	3.068
1	1.049	3 1/2	3.548
1 1/4	1.380	4	4.026

A.6 Use of sizing charts. A third method of sizing *gas piping* is detailed below as an option that is useful when large quantities of *piping* are involved in a job (e.g., an apartment house) and material costs are of concern. If the user is not completely familiar with this method, the resulting *pipe* sizing should be checked by a knowledgeable gas engineer. The sizing charts are applied as follows.

- (1) With the layout developed according to Section R106.1.1 of the *code*, indicate in each section the design gas flow under maximum operation conditions. For many layouts, the maximum design flow will be the sum of all connected loads. However, in some cases, certain combinations of *appliances* will not occur simultaneously (e.g., gas heating and air conditioning). For these cases, the design flow is the greatest gas flow that can occur at any one time.
- (2) Determine the inlet gas pressure for the system being designed. In most cases, the point of inlet will be the gas *meter* or service *regulator*, but in the case of a system addition, it could be the point of connection to the existing system.
- (3) Determine the minimum pressure required at the inlet to the critical *appliance*. Usually, the critical item will be the *appliance* with the highest required pressure for satisfactory operation. If several items have the same required pressure, it will be the one with the greatest length of *piping* from the system inlet.
- (4) The difference between the inlet pressure and critical item pressure is the allowable system *pressure drop*. Figures A.6(a) and A.6(b) show the relationship between gas flow, *pipe* size and *pipe* length for natural gas with 0.60 *specific gravity*.
- (5) To use Figure A.6(a) (low pressure applications), calculate the *piping* length from the inlet to the critical utilization *equipment*. Increase this length by 50 percent to allow for fittings. Divide the allowable *pressure drop* by the equivalent length (in hundreds of feet) to determine the allowable *pressure drop* per hundred feet. Select the *pipe* size from Figure A.6(a) for the required volume of flow.
- (6) To use Figure A.6(b) (high pressure applications), calculate the equivalent length as above. Calculate the index number for Figure A.6(b) by dividing the difference between the squares of the absolute values of inlet and outlet pressures by the equivalent length (in hundreds of feet). Select the *pipe* size from Figure A.6(b) for the gas volume required.

TABLE A.5.2
COPPER TUBE STANDARD SIZES

TUBE TYPE	NOMINAL OR STANDARD SIZE (inches)	INTERNAL DIAMETER (inches)
K	1/4	0.305
L	1/4	0.315
ACR (D)	3/8	0.315
ACR (A)	3/8	0.311
K	3/8	0.402
L	3/8	0.430
ACR (D)	1/2	0.430
ACR (A)	1/2	0.436
K	1/2	0.527
L	1/2	0.545
ACR (D)	5/8	0.545
ACR (A)	5/8	0.555
K	5/8	0.652
L	5/8	0.666
ACR (D)	3/4	0.666
ACR (A)	3/4	0.680
K	3/4	0.745
L	3/4	0.785
ACR	7/8	0.785
K	1	0.995
L	1	1.025
ACR	1 1/8	1.025
K	1 1/4	1.245
L	1 1/4	1.265
ACR	1 3/8	1.265
K	1 1/2	1.481
L	1 1/2	1.505
ACR	1 5/8	1.505
K	2	1.959
L	2	1.985
ACR	2 1/8	1.985
K	2 1/2	2.435
L	2 1/2	2.465
ACR	2 5/8	2.465
K	3	2.907
L	3	2.945
ACR	3 1/8	2.945

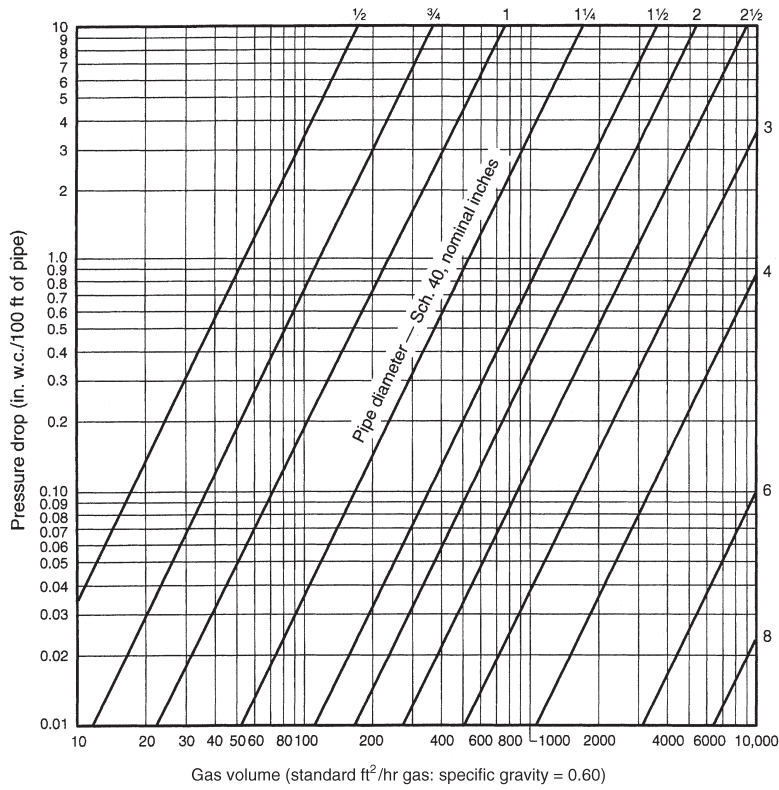


FIGURE A.6(a)
CAPACITY OF NATURAL GAS PIPING, LOW PRESSURE (0.60 WC)

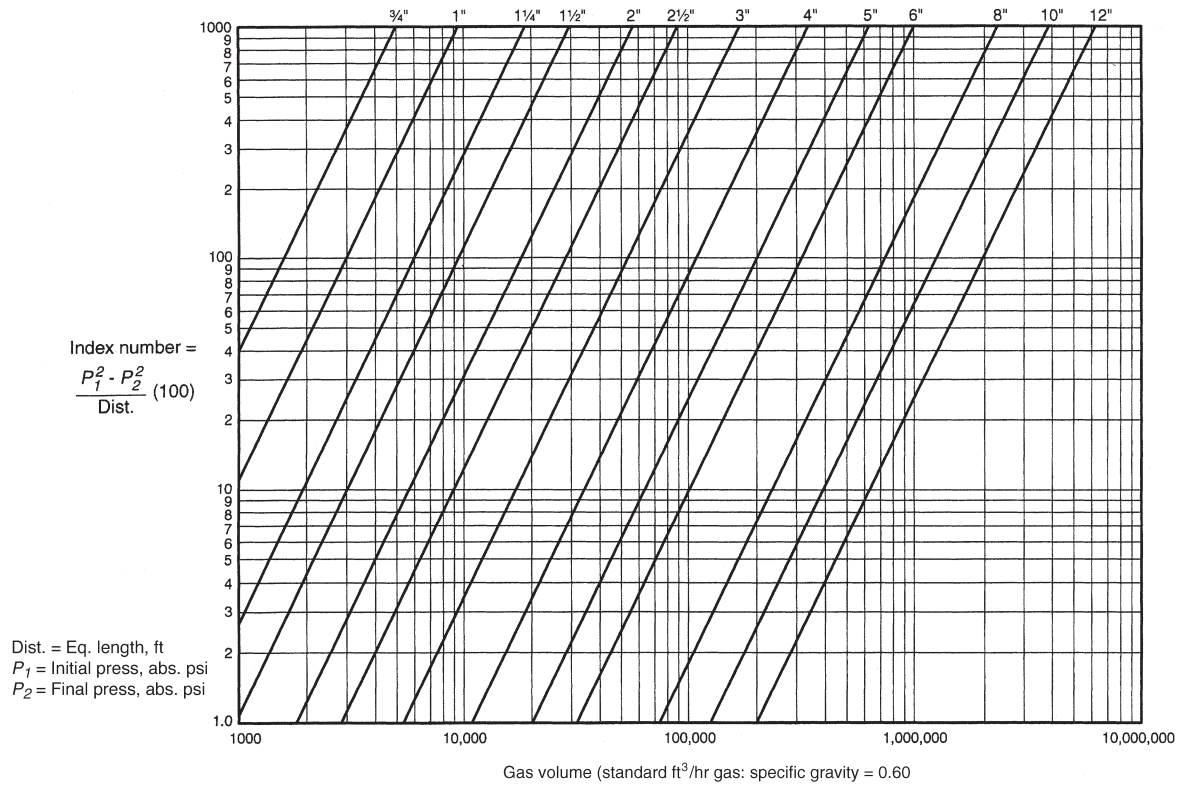


FIGURE A.6 (b)
CAPACITY OF NATURAL GAS PIPING, HIGH PRESSURE (1.5 psi and above)

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/ft³* (37.5 MJ/m³).

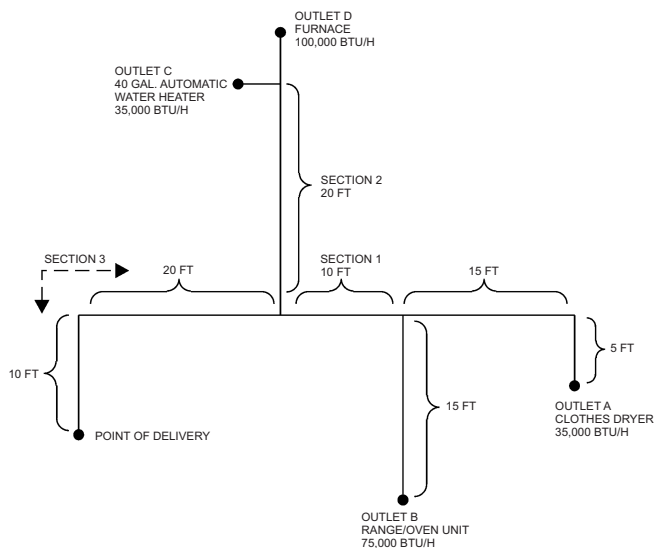


FIGURE A.7.1
PIPING PLAN SHOWING A STEEL PIPING SYSTEM

Solution:

(1) Maximum gas demand for Outlet A:

$$\frac{\text{Consumption (rating plate input, or Table G 2413.2 if necessary)}}{\text{Btu of gas}} =$$

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

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 G2413.4(1):

(a) *Outlet A*, supplying 35 cfh (0.99 m³/hr), requires ³/₈-inch *pipe*.

(b) *Outlet B*, supplying 75 cfh (2.12 m³/hr), requires ³/₄-inch *pipe*.

(c) Section 1, supplying *Outlets A* and *B*, or 110 cfh (3.11 m³/hr), requires ³/₄-inch *pipe*.

(d) Section 2, supplying *Outlets C* and *D*, or 135 cfh (3.82 m³/hr), requires ³/₄-inch *pipe*.

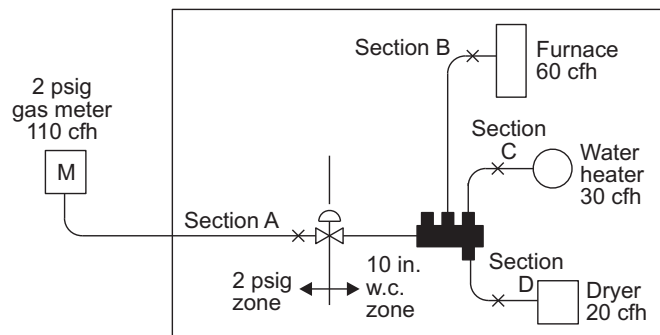
(e) Section 3, supplying *Outlets A, B, C* and *D*, or 245 cfh (6.94 m³/hr), requires 1-inch *pipe*.

(4) If a different gravity factor is applied to this example, the values in the row marked 60 feet (18 288 mm) of Table G2413.4(1) 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 *pipe*.

Section A.7.2 through A7.4 note: These examples are based on tables found in the International Fuel Gas Code.

A.7.2 Example 2: Hybrid or dual pressure systems.

Determine the required CSST size of each section of the *piping system* shown in Figure A.7.2, with a designated *pressure drop* of 1 psi (6.9 kPa) for the 2 psi (13.8 kPa) section and 3-inch w.c. (0.75 kPa) *pressure drop* for the 13-inch w.c. (2.49 kPa) section. The gas to be used has 0.60 *specific gravity* and a heating value of 1,000 *Btu/ft³* (37.5 MJ/m³).



- Length of runs:
 A = 100 ft
 B = 15 ft
 C = 10 ft
 D = 25 ft
- Key:
 Manifold
 Shut-off valve
 Pressure regulator
 Gas meter

FIGURE A.7.2
PIPING PLAN SHOWING A CSST SYSTEM

Solution

(1) Size 2 psi (13.8 kPa) line using Table 402.4(16).

(2) Size 10-inch w.c. (2.5 kPa) lines using Table 402.4(14).

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

(a) Total gas load shown in Figure A.7.2 equals 110 cfh (3.11 m³/hr).

(b) Determine *pressure drop* across *regulator* [see notes in Table 402.4 (16)].

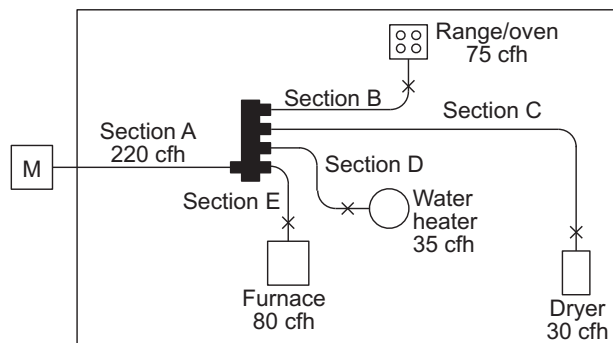
- (c) If *pressure drop across regulator* exceeds $3/4$ psig (5.2 kPa), Table 402.4 (16) cannot be used. Note: If *pressure drop* exceeds $3/4$ psi (5.2 kPa), then a larger *regulator* must be selected or an alternative sizing method must be used.
 - (d) *Pressure drop across the line regulator* [for 110 cfh (3.11 m³/hr)] is 4-inch 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) Section A [2 psi (13.8 kPa) zone]
- (a) Distance from *meter* to *regulator* = 100 feet (30 480 mm).
 - (b) Total load supplied by A = 110 cfh (3.11 m³/hr) (*furnace* + *water heater* + *dryer*).
 - (c) Table 402.4 (16) shows that EHD size 18 should be used.
- Note: 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 m³/hr).
- (5) Section B (low pressure zone)
- (a) Distance from *regulator* to *furnace* is 15 feet (4572 mm).
 - (b) Load is 60 cfh (1.70 m³/hr).
 - (c) Table 402.4 (14) shows that EHD size 13 should be used.
- (6) Section C (low pressure zone)
- (a) Distance from *regulator* to *water heater* is 10 feet (3048 mm).
 - (b) Load is 30 cfh (0.85 m³/hr).
 - (c) Table 402.4 (14) shows that EHD size 13 should be used.
- (7) Section D (low pressure zone)
- (a) Distance from *regulator* to *dryer* is 25 feet (7620 mm).
 - (b) Load is 20 cfh (0.57 m³/hr).
 - (c) Table 402.4(14) shows that EHD size 13 should be used.

A.7.3 Example 3: Branch length method. Determine the required semi-rigid copper *tubing* size of each section of the *pipng system* shown in Figure A.7.3, with a designated *pressure drop* of 1-inch w.c. (250 Pa) (using the Branch Length Method). The gas to be used has 0.60 *specific gravity* and a heating value of 1,000 *Btu/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 feet (15 240 mm), A + C.

- (b) Use this longest length to size Sections A and C.
 - (c) Using the row marked 50 feet (15 240 mm) in Table 402.4(8), Section A, supplying 220 cfh (6.2 m³/hr) for four *appliances* requires 1-inch *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 feet (9144 mm), A + B.
 - (b) Use this branch length to size Section B only.
 - (c) Using the row marked 30 feet (9144 mm) in Table 402.4(8), Section B, supplying 75 cfh (2.12 m³/hr) for the range/oven requires $1/2$ -inch *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 feet (15 240 mm), A + C.
 - (b) Use this branch length (which is also the longest length) to size Section C.
 - (c) Using the row marked 50 feet (15 240 mm) in Table 402.4(8), Section C, supplying 30 cfh (0.85 m³/hr) for the dryer requires $3/8$ -inch *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 feet (9144 mm), A + D.
 - (b) Use this branch length to size Section D only.
 - (c) Using the row marked 30 feet (9144 mm) in Table 402.4(8), Section D, supplying 35 cfh (0.99 m³/hr) for the *water heater* requires $3/8$ -inch *tubing*.



- Length of runs:
- A = 20 ft
 - B = 10 ft
 - C = 30 ft
 - D = 10 ft
 - E = 10 ft
- Key:
- Manifold
 - Shut-off valve
 - Gas meter
- Total gas load = 220 cfh

FIGURE A.7.3
PIPING PLAN SHOWING A COPPER TUBING SYSTEM

- (5) Section E
 - (a) The length of *tubing* from the point of delivery to the *furnace* at the end of Section E is 30 feet (9144 mm), A + E.
 - (b) Use this branch length to size Section E only.
 - (c) Using the row marked 30 feet (9144 mm) in Table 402.4(8), Section E, supplying 80 cfh (2.26 m³/hr) for the *furnace* requires 1/2-inch *tubing*.

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/ft³* (37.5 MJ/m³).

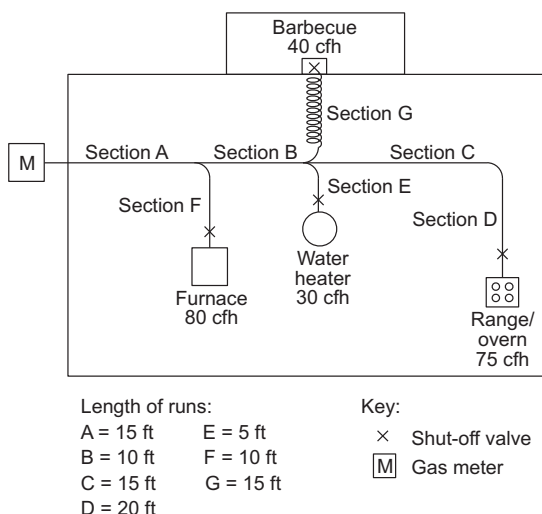


FIGURE A.7.4
PIPING PLAN SHOWING A MODIFICATION TO EXISTING PIPING SYSTEM

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 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(13), Section G, supplying 40 cfh (1.13 m³/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).

A.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 psig (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, then the formula based on Boyle's and Charles' law for determining the new pressure at a reduced temperature is as follows:

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

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 ($P_2 + 14.7$)

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

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

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

$$(P_2 + 14.7) = \frac{34.7}{1.060}$$

$$P_2 = 32.7 - 14.7$$

$$P_2 = 18 \text{ psig}$$

Therefore, the gauge could be expected to register 18 psig (124 kPa) when the ambient temperature is 40°F (4°C).

A.7.6 Example 6: Pressure drop per 100 feet of pipe method.

Using the layout shown in Figure A.7.1 and $\Delta H = \text{pressure drop}$, in w.c. (27.7 in. H₂O = 1 psi), proceed as follows:

- (1) Length to A = 20 feet, with 35,000 *Btu/hr*.
For 1/2-inch *pipe*, $\Delta H = \frac{20 \text{ feet}}{100 \text{ feet}} \times 0.3 \text{ inch w.c.} = 0.06 \text{ in. w.c.}$
- (2) Length to B = 15 feet, with 75,000 *Btu/hr*.
For 3/4-inch *pipe*, $\Delta H = \frac{15 \text{ feet}}{100 \text{ feet}} \times 0.3 \text{ inch w.c.} = 0.045 \text{ in. w.c.}$
- (3) Section 1 = 10 feet, with 110,000 *Btu/hr*. Here there is a choice:
For 1 inch *pipe*: $\Delta H = \frac{10 \text{ feet}}{100 \text{ feet}} \times 0.2 \text{ inch w.c.} = 0.02 \text{ in w.c.}$
For 3/4-inch *pipe*: $\Delta H = \frac{10 \text{ feet}}{100 \text{ feet}} \times [0.5 \text{ inch w.c.} + \frac{(110,000 \text{ Btu/hr} - 104,000 \text{ Btu/hr})}{(147,000 \text{ Btu/hr} - 104,000 \text{ Btu/hr})} \times (1.0 \text{ inches w.c.} - 0.5 \text{ inch w.c.})] = 0.1 \times 0.57 \text{ inch w.c.} = 0.06 \text{ inch w.c.}$
Note that the pressure drop between 104,000 Btu/hr and 147,000 Btu/hr has been interpolated as 110,000 Btu/hr.
- (4) Section 2 = 20 feet, with 135,000 *Btu/hr*. Here there is a choice:
For 1-inch *pipe*: $\Delta H = \frac{20 \text{ feet}}{100 \text{ feet}} \times [0.2 \text{ inch w.c.} + \frac{(14,000 \text{ Btu/hr})}{(27,000 \text{ Btu/hr})} \times 0.1 \text{ inch w.c.}] = 0.05 \text{ inch w.c.}]$

For $\frac{3}{4}$ -inch pipe: $\Delta H = \frac{20 \text{ feet}}{100 \text{ feet}} \times 1.0 \text{ inch w.c.} = 0.2 \text{ inch w.c.}$

Note that the pressure drop between 121,000 Btu/hr and 148,000 Btu/hr has been interpolated as 135,000 Btu/hr, but interpolation for the $\frac{3}{4}$ -inch pipe (trivial for 104,000 Btu/hr to 147,000 Btu/hr) was not used.

- (5) Section 3 = 30 feet, with 245,000 Btu/hr. Here there is a choice:

For 1-inch pipe: $\Delta H = \frac{30 \text{ feet}}{100 \text{ feet}} \times 1.0 \text{ inches w.c.} = 0.3 \text{ inch w.c.}$

For $1\frac{1}{4}$ -inch pipe: $\Delta H = \frac{30 \text{ feet}}{100 \text{ feet}} \times 0.2 \text{ inch w.c.} = 0.06 \text{ inch w.c.}$

Note that interpolation for these options is ignored 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, Sections 1 and 3, or either of the following, depending on whether an absolute minimum is needed or the larger drop can be accommodated.

Minimum *pressure drop* to farthest *appliance*:

$\Delta H = 0.06 \text{ inch w.c.} + 0.02 \text{ inch w.c.} + 0.06 \text{ inch w.c.} = 0.14 \text{ inch w.c.}$

Larger *pressure drop* to the farthest *appliance*:

$\Delta H = 0.06 \text{ inch w.c.} + 0.06 \text{ inch w.c.} + 0.3 \text{ inch w.c.} = 0.42 \text{ inch w.c.}$

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 cubic foot = 0.028 m³, 1 foot = 0.305 m, 1 inch w.c. = 249 Pa.