

CHAPTER 4

GAS PIPING INSTALLATIONS

SECTION 401 (IFGC) GENERAL

401.1 Scope. This chapter shall govern the design, installation, modification and maintenance of piping systems. The applicability of this code to piping systems extends from the point of delivery to the connections with the equipment and includes the design, materials, components, fabrication, assembly, installation, testing, inspection, operation and maintenance of such piping systems.

401.1.1 Utility piping systems located within buildings. Utility service piping located within buildings shall be installed in accordance with the structural safety and fire protection provisions of the *International Building Code*.

401.2 Liquefied petroleum gas storage. The storage system for liquefied petroleum gas shall be designed and installed in accordance with the *International Fire Code* and NFPA 58.

401.3 Modifications to existing systems. In modifying or adding to existing piping systems, sizes shall be maintained in accordance with this chapter.

401.4 Additional appliances. Where an additional appliance is to be served, the existing piping shall be checked to determine if it has adequate capacity for all appliances served. If inadequate, the existing system shall be enlarged as required or separate piping of adequate capacity shall be provided.

401.5 Identification. For other than black steel pipe, exposed piping shall be identified by a yellow label marked "Gas" in black letters. The marking shall be spaced at intervals not exceeding 5 feet (1524 mm). The marking shall not be required on pipe located in the same room as the equipment served.

401.6 Interconnections. Where two or more meters are installed on the same premises but supply separate consumers, the piping systems shall not be interconnected on the outlet side of the meters.

401.7 Piping meter identification. Piping from multiple meter installations shall be marked with an approved permanent identification by the installer so that the piping system supplied by each meter is readily identifiable.

401.8 Minimum sizes. All pipe utilized for the installation, extension and alteration of any piping system shall be sized to supply the full number of outlets for the intended purpose and shall be sized in accordance with Section 402.

SECTION 402 (IFGS) 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	35,000
Capacity at 2 gal./minute	50,000
Capacity at 4 gal./minute	
Capacity at 6 gal./minute	142,800
Water heater, automatic storage, 30- to 40-gal. tank	285,000
Water heater, automatic storage, 50-gal. tank	428,400
Water heater, domestic, circulating or side-arm	35,000
Cooking Appliances	
Built-in oven or broiler unit, domestic	65,000
Built-in top unit, domestic	25,000
Range, free-standing, domestic	40,000
Other Appliances	
Barbecue	3,000
Clothes dryer, Type 1 (domestic)	35,000
Gas fireplace, direct vent	40,000
Gas light	80,000
Gas log	40,000
Refrigerator	2,500

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. Before Equations 4-1 or 4-2 are permitted to be used, plans stamped by a mechanical engineer licensed in the State of Washington shall be submitted and approved by the code official.

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

$$D = \frac{Q^{0.381}}{19.17 \left(\frac{\Delta H}{C_r \times L} \right)^{0.206}} \quad \text{(Equation 4-1)}$$

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

$$D = \frac{Q^{0.381}}{18.93 \left[\frac{(P_1^2 - P_2^2) \times Y}{C_r \times L} \right]^{0.206}} \quad \text{(Equation 4-2)}$$

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
- P₁ = Upstream pressure, psia (P₁ + 14.7)
- P₂ = Downstream pressure, psia (P₂ + 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 m³, 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.

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.

Plans for piping systems over 5 psig shall be stamped by an engineer licensed to practice in the State of Washington, and shall not be installed until approved by the code official.

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.

**TABLE 402.4(1)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	0.50 psi or less
Pressure Drop	0.3 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	32	72	132	278	520	1,050	1,600	3,050	4,800	8,500	17,500
20	22	49	92	190	350	730	1,100	2,100	3,300	5,900	12,000
30	18	40	73	152	285	590	890	1,650	2,700	4,700	9,700
40	15	34	63	130	245	500	760	1,450	2,300	4,100	8,300
50	14	30	56	115	215	440	670	1,270	2,000	3,600	7,400
60	12	27	50	105	195	400	610	1,150	1,850	3,250	6,800
70	11	25	46	96	180	370	560	1,050	1,700	3,000	6,200
80	11	23	43	90	170	350	530	990	1,600	2,800	5,800
90	10	22	40	84	160	320	490	930	1,500	2,600	5,400
100	9	21	38	79	150	305	460	870	1,400	2,500	5,100
125	8	18	34	72	130	275	410	780	1,250	2,200	4,500
150	8	17	31	64	120	250	380	710	1,130	2,000	4,100
175	7	15	28	59	110	225	350	650	1,050	1,850	3,800
200	6	14	26	55	100	210	320	610	980	1,700	3,500

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(2)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	0.50 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 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(3)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	0.60

PIPE SIZE (in.)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour								
10	1,506	3,041	5,561	11,415	17,106	32,944	52,505	92,819	189,326
20	1,065	2,150	3,932	8,072	12,096	23,295	37,127	65,633	133,873
30	869	1,756	3,211	6,591	9,876	19,020	30,314	53,589	109,307
40	753	1,521	2,781	5,708	8,553	16,472	26,253	46,410	94,663
50	673	1,360	2,487	5,105	7,650	14,733	23,481	41,510	84,669
60	615	1,241	2,270	4,660	6,983	13,449	21,435	37,893	77,292
70	569	1,150	2,102	4,315	6,465	12,452	19,845	35,082	71,558
80	532	1,075	1,966	4,036	6,048	11,647	18,563	32,817	66,937
90	502	1,014	1,854	3,805	5,702	10,981	17,502	30,940	63,109
100	462	934	1,708	3,508	5,257	10,125	16,138	28,530	58,194
125	414	836	1,528	3,138	4,702	9,056	14,434	25,518	52,050
150	372	751	1,373	2,817	4,222	8,130	12,960	22,911	46,732
175	344	695	1,271	2,608	3,909	7,527	11,999	21,211	43,265
200	318	642	1,174	2,413	3,613	6,959	11,093	19,608	39,997

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa.

**TABLE 402.4(4)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	5.0 psi
Pressure Drop	3.5 psi
Specific Gravity	0.60

PIPE SIZE (in.)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour								
10	3,185	6,434	11,766	24,161	36,206	69,727	111,133	196,468	400,732
20	2,252	4,550	8,320	17,084	25,602	49,305	78,583	138,924	283,361
30	1,839	3,715	6,793	13,949	20,904	40,257	64,162	113,431	231,363
40	1,593	3,217	5,883	12,080	18,103	34,864	55,566	98,234	200,366
50	1,425	2,878	5,262	10,805	16,192	31,183	49,700	87,863	179,213
60	1,301	2,627	4,804	9,864	14,781	28,466	45,370	80,208	163,598
70	1,204	2,432	4,447	9,132	13,685	26,354	42,004	74,258	151,463
80	1,153	2,330	4,260	8,542	12,801	24,652	39,291	69,462	141,680
90	1,062	2,145	3,922	8,054	12,069	23,242	37,044	65,489	133,577
100	979	1,978	3,617	7,427	11,128	21,433	34,159	60,387	123,173
125	876	1,769	3,235	6,643	9,953	19,170	30,553	54,012	110,169
150	786	1,589	2,905	5,964	8,937	17,211	27,431	48,494	98,911
175	728	1,471	2,690	5,522	8,274	15,934	25,396	44,897	91,574
200	673	1,360	2,487	5,104	7,649	14,729	23,478	41,504	84,656

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa.

**TABLE 402.4(5)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	1.0 psi or less
Pressure Drop	0.3 inch WC
Specific Gravity	0.60

PIPE SIZE (in.)													
Nominal	1	1 ¹ / ₄	1 ¹ / ₂	2	2 ¹ / ₂	3	3 ¹ / ₂	4	5	6	8	10	12
Actual ID	1.049	1.380	1.610	2.067	2.469	3.068	3.548	4.026	5.047	6.065	7.981	10.020	11.938
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour												
50	215	442	662	1,275	2,033	3,594	5,262	7,330	13,261	21,472	44,118	80,130	126,855
100	148	304	455	877	1,397	2,470	3,616	5,038	9,114	14,758	30,322	55,073	87,187
150	119	244	366	704	1,122	1,983	2,904	4,046	7,319	11,851	24,350	44,225	70,014
200	102	209	313	602	960	1,698	2,485	3,462	6,264	10,143	20,840	37,851	59,923
250	90	185	277	534	851	1,505	2,203	3,069	5,552	8,990	18,470	33,547	53,109
300	82	168	251	484	771	1,363	1,996	2,780	5,030	8,145	16,735	30,396	48,120
400	70	143	215	414	660	1,167	1,708	2,380	4,305	6,971	14,323	26,015	41,185
500	62	127	191	367	585	1,034	1,514	2,109	3,816	6,178	12,694	23,056	36,501
1,000	43	87	131	252	402	711	1,041	1,450	2,623	4,246	8,725	15,847	25,087
1,500	34	70	105	203	323	571	836	1,164	2,106	3,410	7,006	12,725	20,146
2,000	29	60	90	173	276	488	715	996	1,802	2,919	5,997	10,891	17,242

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(6)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	1.0 psi or less
Pressure Drop	0.5 inch WC
Specific Gravity	0.60

PIPE SIZE (in.)													
Nominal	1	1 ¹ / ₄	1 ¹ / ₂	2	2 ¹ / ₂	3	3 ¹ / ₂	4	5	6	8	10	12
Actual ID	1.049	1.380	1.610	2.067	2.469	3.068	3.548	4.026	5.047	6.065	7.981	10.020	11.938
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour												
50	284	583	873	1,681	2,680	4,738	6,937	9,663	17,482	28,308	58,161	105,636	167,236
100	195	400	600	1,156	1,842	3,256	4,767	6,641	12,015	19,456	39,974	72,603	114,940
150	157	322	482	928	1,479	2,615	3,828	5,333	9,649	15,624	32,100	58,303	92,301
200	134	275	412	794	1,266	2,238	3,277	4,565	8,258	13,372	27,474	49,900	78,998
250	119	244	366	704	1,122	1,983	2,904	4,046	7,319	11,851	24,350	44,225	70,014
300	108	221	331	638	1,017	1,797	2,631	3,666	6,632	10,738	22,062	40,071	63,438
400	92	189	283	546	870	1,538	2,252	3,137	5,676	9,190	18,883	34,296	54,295
500	82	168	251	484	771	1,363	1,996	2,780	5,030	8,145	16,735	30,396	48,120
1,000	56	115	173	333	530	937	1,372	1,911	3,457	5,598	11,502	20,891	33,073
1,500	45	93	139	267	426	752	1,102	1,535	2,776	4,496	9,237	16,776	26,559
2,000	39	79	119	229	364	644	943	1,313	2,376	3,848	7,905	14,358	22,731

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(7)
SEMI-RIGID COPPER TUBING**

Gas	Natural
Inlet Pressure	0.5 psi or less
Pressure Drop	0.3 inch WC
Specific Gravity	0.60

Nominal	K & L ACR	TUBE SIZE (in.)									
		1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
		3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		Maximum Capacity in Cubic Feet of Gas per Hour									
10		20	42	85	148	210	448	806	1,271	2,646	4,682
20		14	29	58	102	144	308	554	873	1,819	3,218
30		11	23	47	82	116	247	445	701	1,461	2,584
40		10	20	40	70	99	211	381	600	1,250	2,212
50		8.4	17	35	62	88	187	337	532	1,108	1,960
60		7.6	16	32	56	79	170	306	482	1,004	1,776
70		7.0	14	29	52	73	156	281	443	924	1,634
80		6.5	13	27	48	68	145	262	413	859	1,520
90		6.1	13	26	45	64	136	245	387	806	1,426
100		5.8	12	24	43	60	129	232	366	761	1,347
125		5.1	11	22	38	53	114	206	324	675	1,194
150		4.7	10	20	34	48	103	186	294	612	1,082
175		4.3	8.8	18	31	45	95	171	270	563	995
200		4.0	8.2	17	29	41	89	159	251	523	926
250		3.5	7.3	15	26	37	78	141	223	464	821
300		3.2	6.6	13	23	33	71	128	202	420	744

Note: Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(8)
SEMI-RIGID COPPER TUBING**

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

Nominal	K & L ACR	TUBE SIZE (in.)									
		1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
		3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		Maximum Capacity in Cubic Feet of Gas per Hour									
10		27	55	111	195	276	590	1,062	1,675	3,489	6,173
20		18	38	77	134	190	406	730	1,151	2,398	4,242
30		15	30	61	107	152	326	586	925	1,926	3,407
40		13	26	53	92	131	279	502	791	1,648	2,916
50		11	23	47	82	116	247	445	701	1,461	2,584
60		10	21	42	74	105	224	403	635	1,323	2,341
70		9.3	19	39	68	96	206	371	585	1,218	2,154
80		8.6	18	36	63	90	192	345	544	1,133	2,004
90		8.1	17	34	59	84	180	324	510	1,063	1,880
100		7.6	16	32	56	79	170	306	482	1,004	1,776
125		6.8	14	28	50	70	151	271	427	890	1,574
150		6.1	13	26	45	64	136	245	387	806	1,426
175		5.6	12	24	41	59	125	226	356	742	1,312
200		5.2	11	22	39	55	117	210	331	690	1,221
250		4.7	10	20	34	48	103	186	294	612	1,082
300		4.2	8.7	18	31	44	94	169	266	554	980

Note: Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

301.15 Prohibited location. The appliances, equipment and systems regulated by this code shall not be located in an elevator shaft.

SECTION 302 (IFGC) STRUCTURAL SAFETY

[B] 302.1 Structural safety. The building shall not be weakened by the installation of any gas piping. In the process of installing or repairing any gas piping, the finished floors, walls, ceilings, tile work or any other part of the building or premises which is required to be changed or replaced shall be left in a safe structural condition in accordance with the requirements of the *International Building Code*.

[B] 302.2 Penetrations of floor/ceiling assemblies and fire-resistance-rated assemblies. Penetrations of floor/ceiling assemblies and assemblies required to have a fire-resistance rating shall be protected in accordance with the *International Building Code*.

[B] 302.3 Cutting, notching and boring in wood members. The cutting, notching and boring of wood members shall comply with Sections 302.3.1 through 302.3.4.

[B] 302.3.1 Engineered wood products. Cuts, notches and holes bored in trusses, laminated veneer lumber, glued-laminated members and I-joists are prohibited except where the effects of such alterations are specifically considered in the design of the member.

[B] 302.3.2 Joist notching. Notching at the ends of joists shall not exceed one-fourth the joist depth. Holes bored in joists shall not be within 2 inches (51 mm) of the top and bottom of the joist and their diameter shall not exceed one-third the depth of the member. Notches in the top or bottom of the joist shall not exceed one-sixth the depth and shall not be located in the middle one-third of the span.

[B] 302.3.3 Stud cutting and notching. In exterior walls and bearing partitions, any wood stud is permitted to be cut or notched to a depth not exceeding 25 percent of its width. Cutting or notching of studs to a depth not greater than 40 percent of the width of the stud is permitted in nonload-bearing partitions supporting no loads other than the weight of the partition.

[B] 302.3.4 Bored holes. A hole not greater in diameter than 40 percent of the stud depth is permitted to be bored in any wood stud. Bored holes not greater than 60 percent of the depth of the stud are permitted in nonload-bearing partitions or in any wall where each bored stud is doubled, provided not more than two such successive doubled studs are so bored. In no case shall the edge of the bored hole be nearer than $\frac{5}{8}$ inch (15.9 mm) to the edge of the stud. Bored holes shall not be located at the same section of stud as a cut or notch.

[B] 302.4 Alterations to trusses. Truss members and components shall not be cut, drilled, notched, spliced or otherwise altered in any way without the written concurrence and approval of a registered design professional. Alterations resulting in the addition of loads to any member (e.g., HVAC equipment, water heaters) shall not be permitted without verification that the truss is capable of supporting such additional loading.

[B] 302.5 Cutting, notching and boring holes in structural steel framing. The cutting, notching and boring of holes in structural steel framing members shall be as prescribed by the registered design professional.

[B] 302.6 Cutting, notching and boring holes in cold-formed steel framing. Flanges and lips of load-bearing, cold-formed steel framing members shall not be cut or notched. Holes in webs of load-bearing, cold-formed steel framing members shall be permitted along the centerline of the web of the framing member and shall not exceed the dimensional limitations, penetration spacing or minimum hole edge distance as prescribed by the registered design professional. Cutting, notching and boring holes of steel floor/roof decking shall be as prescribed by the registered design professional.

[B] 302.7 Cutting, notching and boring holes in nonstructural cold-formed steel wall framing. Flanges and lips of nonstructural cold-formed steel wall studs shall be permitted along the centerline of the web of the framing member, shall not exceed $1\frac{1}{2}$ inches (38 mm) in width or 4 inches (102 mm) in length, and the holes shall not be spaced less than 24 inches (610 mm) center to center from another hole or less than 10 inches (254 mm) from the bearing end.

SECTION 303 (IFGC) APPLIANCE LOCATION

303.1 General. Appliances shall be located as required by this section, specific requirements elsewhere in this code and the conditions of the equipment and appliance listing.

303.2 Hazardous locations. Appliances shall not be located in a hazardous location unless listed and approved for the specific installation.

303.3 Prohibited locations. Appliances shall not be located in, or obtain combustion air from, any of the following rooms or spaces:

1. Sleeping rooms.
2. Bathrooms.
3. Toilet rooms.
4. Storage closets.
5. Surgical rooms.

Exceptions:

1. Direct-vent appliances that obtain all combustion air directly from the outdoors.
2. Vented room heaters, wall furnaces, vented decorative appliances and decorative appliances for installation in vented solid fuel-burning fireplaces, provided that the room meets the required volume criteria of Section 304.5.
3. A single wall-mounted unvented room heater equipped with an oxygen depletion safety shutoff system and installed in a bathroom, provided that the input rating does not exceed 6,000 Btu/h (1.76kW) and the bathroom meets the required volume criteria of Section 304.5.
4. A single wall-mounted unvented room heater equipped with an oxygen depletion safety shutoff sys-

tem and installed in a bedroom, provided that the input rating does not exceed 10,000 Btu/h (2.93 kW) and the bedroom meets the required volume criteria of Section 304.5.

5. Appliances installed in an enclosure in which all combustion air is taken from the outdoors, in accordance with Section 304.6. Access to such enclosure shall be through a solid weather-stripped door, equipped with an approved self-closing device.

303.4 Protection from physical damage. Appliances shall not be installed in a location where subject to physical damage unless protected by approved barriers meeting the requirements of the *International Fire Code*.

303.5 Indoor locations. Furnaces and boilers installed in closets and alcoves shall be listed for such installation.

303.6 Outdoor locations. Equipment installed in outdoor locations shall be either listed for outdoor installation or provided with protection from outdoor environmental factors that influence the operability, durability and safety of the equipment.

303.7 Pit locations. Appliances installed in pits or excavations shall not come in direct contact with the surrounding soil. The sides of the pit or excavation shall be held back a minimum of 12 inches (305 mm) from the appliance. Where the depth exceeds 12 inches (305 mm) below adjoining grade, the walls of the pit or excavation shall be lined with concrete or masonry, such concrete or masonry shall extend a minimum of 4 inches (102 mm) above adjoining grade and shall have sufficient lateral load-bearing capacity to resist collapse. The appliance shall be protected from flooding in an approved manner.

SECTION 304 (IFGS) COMBUSTION, VENTILATION AND DILUTION AIR

304.1 General. Air for combustion, ventilation and dilution of flue gases for gas utilization equipment installed in buildings shall be provided by application of one of the methods prescribed in Sections 304.5 through 304.9. Where the requirements of Section 304.5 are not met, outdoor air shall be introduced in accordance with one of the methods prescribed in Sections 304.6 through 304.9. Direct-vent appliances, gas appliances of other than natural draft design and vented gas appliances other than Category I shall be provided with combustion, ventilation and dilution air in accordance with the equipment manufacturer's instructions.

Exception: Type 1 clothes dryers that are provided with makeup air in accordance with Section 614.5.

304.2 Appliance/equipment location. Equipment shall be located so as not to interfere with proper circulation of combustion, ventilation and dilution air.

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

304.4 Makeup air provisions. Makeup air requirements for the operation of exhaust fans, kitchen ventilation systems,

clothes dryers and fireplaces shall be considered in determining the adequacy of a space to provide combustion air requirements.

304.5 Indoor combustion air. The required volume of indoor air shall be determined in accordance with Section 304.5.1 or 304.5.2, except that where the air infiltration rate is known to be less than 0.40 air changes per hour (ACH), Section 304.5.2 shall be used. The total required volume shall be the sum of the required volume calculated for all appliances located within the space. Rooms communicating directly with the space in which the appliances are installed through openings not furnished with doors, and through combustion air openings sized and located in accordance with Section 304.5.3, are considered to be part of the required volume.

304.5.1 Standard method. The minimum required volume shall be 50 cubic feet per 1,000 Btu/h (4.8 m³/kW) of the appliance input rating.

304.5.2 Known air-infiltration-rate method. Where the air infiltration rate of a structure is known, the minimum required volume shall be determined as follows:

For appliances other than fan-assisted, calculate volume using Equation 3-1.

$$\text{Required Volume}_{\text{other}} \geq \frac{21 \text{ ft}^3}{\text{ACH}} \left(\frac{I_{\text{other}}}{1,000 \text{ Btu / hr}} \right)$$

(Equation 3-1)

For fan-assisted appliances, calculate volume using Equation 3-2.

$$\text{Required Volume}_{\text{fan}} \geq \frac{15 \text{ ft}^3}{\text{ACH}} \left(\frac{I_{\text{fan}}}{1,000 \text{ Btu / hr}} \right)$$

(Equation 3-2)

where:

I_{other} = All appliances other than fan assisted (input in Btu/h).

I_{fan} = Fan-assisted appliance (input in Btu/h).

ACH = Air change per hour (percent of volume of space exchanged per hour, expressed as a decimal).

For purposes of this calculation, an infiltration rate greater than 0.60 ACH shall not be used in Equations 3-1 and 3-2.

304.5.3 Indoor opening size and location. Openings used to connect indoor spaces shall be sized and located in accordance with Sections 304.5.3.1 and 304.5.3.2 (see Figure 304.5.3).

304.5.3.1 Combining spaces on the same story. Each opening shall have a minimum free area of 1 square inch per 1,000 Btu/h (2,200 mm²/kW) of the total input rating of all gas utilization equipment in the space, but not less than 100 square inches (0.06 m²). One opening shall commence within 12 inches (305 mm) of the top and one opening shall commence within 12 inches (305 mm) of the bottom of the enclosure. The minimum dimension of air openings shall be not less than 3 inches (76 mm).

304.5.3.2 Combining spaces in different stories. The volumes of spaces in different stories shall be considered as communicating spaces where such spaces are con-

ected by one or more openings in doors or floors having a total minimum free area of 2 square inches per 1,000 Btu/h (4402 mm²/kW) of total input rating of all gas utilization equipment.

304.6 Outdoor combustion air. Outdoor combustion air shall be provided through opening(s) to the outdoors in accordance with Section 304.6.1 or 304.6.2. The minimum dimension of air openings shall be not less than 3 inches (76 mm).

304.6.1 Two-permanent-openings method. Two permanent openings, one commencing within 12 inches (305 mm) of the top and one commencing within 12 inches (305 mm) of the bottom of the enclosure, shall be provided. The openings shall communicate directly, or by ducts, with the outdoors or spaces that freely communicate with the outdoors.

Where directly communicating with the outdoors, or where communicating with the outdoors through vertical ducts, each opening shall have a minimum free area of 1 square inch per 4,000 Btu/h (550 mm²/kW) of total input rating of all equipment in the enclosure [see Figures 304.6.1(1) and 304.6.1(2)].

Where communicating with the outdoors through horizontal ducts, each opening shall have a minimum free area of not less than 1 square inch per 2,000 Btu/h (1,100 mm²/kW) of total input rating of all equipment in the enclosure [see Figure 304.6.1(3)].

304.6.2 One-permanent-opening method. One permanent opening, commencing within 12 inches (305 mm) of the top of the enclosure, shall be provided. The equipment shall have clearances of at least 1 inch (25 mm) from the sides and back and 6 inches (152 mm) from the front of the appliance. The opening shall directly communicate with the outdoors or through a vertical or horizontal duct to the outdoors or spaces that freely communicate with the outdoors [see Figure 304.6.2] and shall have a minimum free area of 1 square inch per 3,000 Btu/h (734 mm²/kW) of the total input rating of all equipment located in the enclosure, and not less than the sum of the areas of all vent connectors in the space.

304.7 Combination indoor and outdoor combustion air. The use of a combination of indoor and outdoor combustion air shall be in accordance with Sections 304.7.1 through 304.7.3.

304.7.1 Indoor openings. Where used, openings connecting the interior spaces shall comply with Section 304.5.3.

304.7.2 Outdoor opening location. Outdoor opening(s) shall be located in accordance with Section 304.6.

304.7.3 Outdoor opening(s) size. The outdoor opening(s) size shall be calculated in accordance with the following:

1. The ratio of interior spaces shall be the available volume of all communicating spaces divided by the required volume.
2. The outdoor size reduction factor shall be one minus the ratio of interior spaces.
3. The minimum size of outdoor opening(s) shall be the full size of outdoor opening(s) calculated in accordance with Section 304.6, multiplied by the reduction factor. The minimum dimension of air openings shall be not less than 3 inches (76 mm).

304.8 Engineered installations. Engineered combustion air installations shall provide an adequate supply of combustion, ventilation and dilution air and shall be approved.

304.9 Mechanical combustion air supply. Where all combustion air is provided by a mechanical air supply system, the combustion air shall be supplied from the outdoors at a rate not less than 0.35 cubic feet per minute per 1,000 Btu/h (0.034 m³/min per kW) of total input rating of all appliances located within the space.

304.9.1 Makeup air. Where exhaust fans are installed, makeup air shall be provided to replace the exhausted air.

304.9.2 Appliance interlock. Each of the appliances served shall be interlocked with the mechanical air supply system to prevent main burner operation when the mechanical air supply system is not in operation.

304.9.3 Combined combustion air and ventilation air system. Where combustion air is provided by the building's mechanical ventilation system, the system shall provide the specified combustion air rate in addition to the required ventilation air.

304.10 Louvers and grilles. The required size of openings for combustion, ventilation and dilution air shall be based on the net free area of each opening. Where the free area through a design of louver or grille is known, it shall be used in calculating the size opening required to provide the free area specified. Where the design and free area are not known, it shall be assumed that wood louvers will have 25-percent free area and metal louvers and grilles will have 75-percent free area. Nonmotorized louvers and grilles shall be fixed in the open position. Motorized louvers shall be interlocked with the equipment so that they are proven to be in the full open position prior to main burner ignition and during main burner operation. Means shall be provided to prevent the main burner from igniting if the louvers fail to open during burner start-up and to shut down the main burner if the louvers close during operation.

304.11 Combustion air ducts. Combustion air ducts shall comply with all of the following:

1. Ducts shall be of galvanized steel complying with Chapter 6 of the *International Mechanical Code* or of equivalent corrosion-resistant material approved for this application.

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

2. Ducts shall terminate in an unobstructed space allowing free movement of combustion air to the appliances.
3. Ducts shall serve a single enclosure.
4. Ducts shall not serve both upper and lower combustion air openings where both such openings are used. The separation between ducts serving upper and lower combustion air openings shall be maintained to the source of combustion air.
5. Ducts shall not be screened where terminating in an attic space.

6. Horizontal upper combustion air ducts shall not slope downward toward the source of combustion air.
7. The remaining space surrounding a chimney liner, gas vent, special gas vent or plastic piping installed within a masonry, metal or factory-built chimney shall not be used to supply combustion air.

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

8. Combustion air intake openings located on the exterior of a building shall have the lowest side of such openings located not less than 12 inches (305 mm) vertically from the adjoining grade level.

304.12 Protection from fumes and gases. Where corrosive or flammable process fumes or gases, other than products of combustion, are present, means for the disposal of such fumes or gases shall be provided. Such fumes or gases include carbon monoxide, hydrogen sulfide, ammonia, chlorine and halogenated hydrocarbons.

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

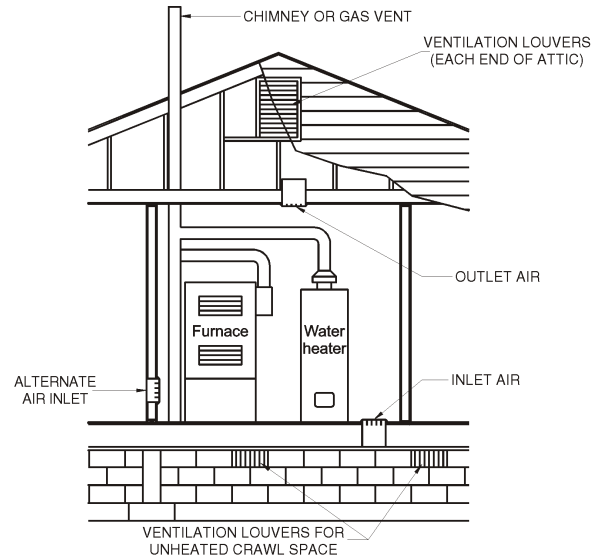


FIGURE 304.6.1(1)
ALL AIR FROM OUTDOORS—INLET AIR FROM VENTILATED CRAWL SPACE AND OUTLET AIR TO VENTILATED ATTIC
 (see Section 304.6.1)

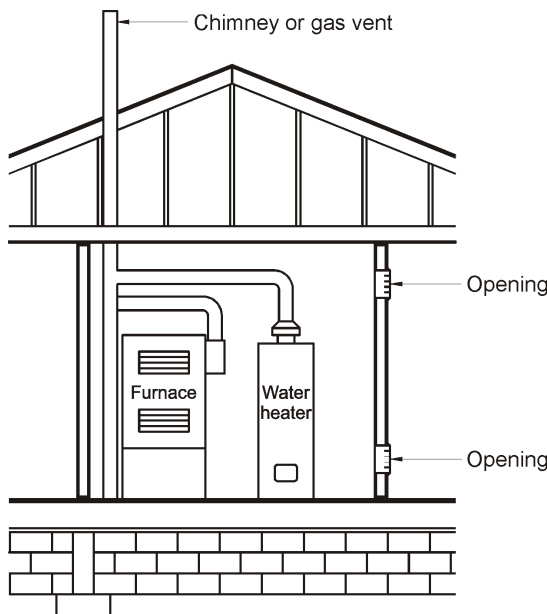
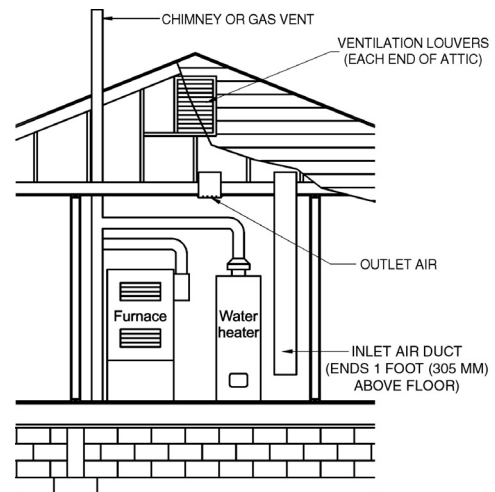


FIGURE 304.5.3
ALL AIR FROM INSIDE THE BUILDING (see Section 304.5.3)



For SI: 1 foot = 304.8 mm.

FIGURE 304.6.1(2)
ALL AIR FROM OUTDOORS THROUGH VENTILATED ATTIC
 (see Section 304.6.1)

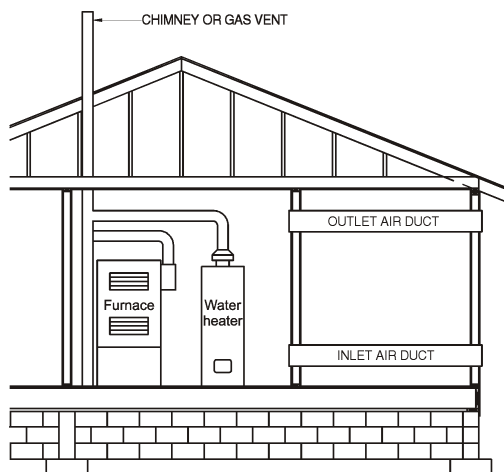


FIGURE 304.6.1(3)
ALL AIR FROM OUTDOORS
 (see Section 304.6.1)

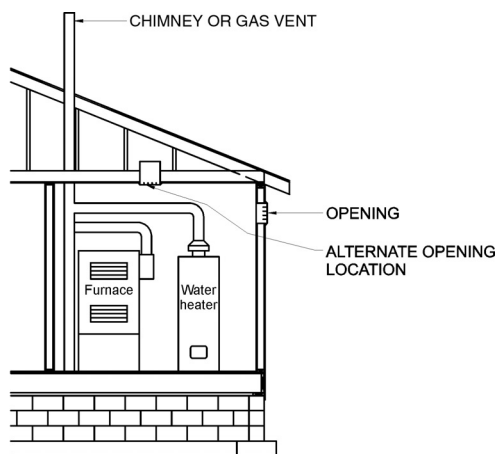


FIGURE 304.6.2
SINGLE COMBUSTION AIR OPENING,
ALL AIR FROM THE OUTDOORS
 (see Section 304.6.2)

SECTION 305 (IFGC)
INSTALLATION

305.1 General. Equipment and appliances shall be installed as required by the terms of their approval, in accordance with the conditions of listing, the manufacturer's instructions and this code. Manufacturers' installation instructions shall be available on the job site at the time of inspection. Where a code provision is less restrictive than the conditions of the listing of the equipment or appliance or the manufacturer's installation instructions, the conditions of the listing and the manufacturer's installation instructions shall apply.

Unlisted appliances approved in accordance with Section 301.3 shall be limited to uses recommended by the manufacturer and shall be installed in accordance with the manufacturer's instructions, the provisions of this code and the requirements determined by the code official.

305.2 Hazardous area. Equipment and appliances having an ignition source shall not be installed in Group H occupancies or control areas where open use, handling or dispensing of combustible, flammable or explosive materials occurs.

305.3 Elevation of ignition source. Equipment and appliances having an ignition source shall be elevated such that the source of ignition is not less than 18 inches (457 mm) above the floor in hazardous locations and public garages, private garages, repair garages, motor fuel-dispensing facilities and parking garages. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

Exception: Elevation of the ignition source is not required for appliances that are listed as flammable vapor resistant and for installation without elevation.

305.4 Public garages. Appliances located in public garages, motor fuel-dispensing facilities, repair garages or other areas frequented by motor vehicles shall be installed a minimum of 8 feet (2438 mm) above the floor. Where motor vehicles exceed 6 feet (1829 mm) in height and are capable of passing under an appliance, appliances shall be installed a minimum of 2 feet (610 mm) higher above the floor than the height of the tallest vehicle.

Exception: The requirements of this section shall not apply where the appliances are protected from motor vehicle impact and installed in accordance with Section 305.3 and NFPA 88B.

305.5 Private garages. Appliances located in private garages shall be installed with a minimum clearance of 6 feet (1829 mm) above the floor.

Exception: The requirements of this section shall not apply where the appliances are protected from motor vehicle impact and installed in accordance with Section 305.3.

305.6 Construction and protection. Boiler rooms and furnace rooms shall be protected as required by the *International Building Code*.

305.7 Clearances from grade. Equipment and appliances installed at grade level shall be supported on a level concrete slab or other approved material extending above adjoining grade or shall be suspended a minimum of 6 inches (152 mm) above adjoining grade.

305.8 Clearances to combustible construction. Heat-producing equipment and appliances shall be installed to maintain the required clearances to combustible construction as specified in the listing and manufacturer's instructions. Such clearances shall be reduced only in accordance with Section 308. Clearances to combustibles shall include such considerations as door swing, drawer pull, overhead projections or shelving and window swing. Devices, such as door stops or limits and closers, shall not be used to provide the required clearances.

SECTION 306 (IFGC) ACCESS AND SERVICE SPACE

[M] 306.1 Clearances for maintenance and replacement. Clearances around appliances to elements of permanent construction, including other installed appliances, shall be sufficient to allow inspection, service, repair or replacement without removing such elements of permanent construction or disabling the function of a required fire-resistance-rated assembly.

[M] 306.2 Appliances in rooms. Rooms containing appliances requiring access shall be provided with a door and an unobstructed passageway measuring not less than 36 inches (914 mm) wide and 80 inches (2032 mm) high.

Exception: Within a dwelling unit, appliances installed in a compartment, alcove, basement or similar space shall be provided with access by an opening or door and an unobstructed passageway measuring not less than 24 inches (610 mm) wide and large enough to allow removal of the largest appliance in the space, provided that a level service space of not less than 30 inches (762 mm) deep and the height of the appliance, but not less than 30 inches (762 mm), is present at the front or service side of the appliance with the door open.

[M] 306.3 Appliances in attics. Attics containing appliances requiring access shall be provided with an opening and unobstructed passageway large enough to allow removal of the largest component of the appliance. The passageway shall not be less than 30 inches (762 mm) high and 22 inches (559 mm) wide and not more than 20 feet (6096 mm) in length when measured along the centerline of the passageway from the opening to the equipment. The passageway shall have continuous solid flooring not less than 24 inches (610 mm) wide. A level service space not less than 30 inches (762 mm) deep and 30 inches (762 mm) wide shall be present at the front or service side of the equipment. The clear access opening dimensions shall be a minimum of 20 inches by 30 inches (508 mm by 762 mm), where such dimensions are large enough to allow removal of the largest component of the appliance.

Exceptions:

1. The passageway and level service space are not required where the appliance is capable of being serviced and removed through the required opening.
2. Where the passageway is not less than 6 feet (1829 mm) high for its entire length, the passageway shall be not greater than 50 feet (15 250 mm) in length.

[M] 306.3.1 Electrical requirements. A lighting fixture controlled by a switch located at the required passageway opening and a receptacle outlet shall be provided at or near the equipment location in accordance with the ICC *Electrical Code*.

[M] 306.4 Appliances under floors. Under-floor spaces containing appliances requiring access shall be provided with an access opening and unobstructed passageway large enough to remove the largest component of the appliance. The passageway shall not be less than 30 inches (762 mm) high and 22 inches (559 mm) wide, nor more than 20 feet (6096 mm) in length when measured along the centerline of the passageway from the opening to the equipment. A level service space not less than 30 inches (762 mm) deep and 30 inches (762 mm)

wide shall be present at the front or service side of the appliance. If the depth of the passageway or the service space exceeds 12 inches (305 mm) below the adjoining grade, the walls of the passageway shall be lined with concrete or masonry extending 4 inches (102 mm) above the adjoining grade and having sufficient lateral-bearing capacity to resist collapse. The clear access opening dimensions shall be a minimum of 22 inches by 30 inches (559 mm by 762 mm), where such dimensions are large enough to allow removal of the largest component of the appliance.

Exceptions:

1. The passageway is not required where the level service space is present when the access is open and the appliance is capable of being serviced and removed through the required opening.
2. Where the passageway is not less than 6 feet high (1829 mm) for its entire length, the passageway shall not be limited in length.

[M] 306.4.1 Electrical requirements. A lighting fixture controlled by a switch located at the required passageway opening and a receptacle outlet shall be provided at or near the equipment location in accordance with the ICC *Electrical Code*.

[M] 306.5 Appliances on roofs or elevated structures. Where appliances requiring access are installed on roofs or elevated structures at a height exceeding 16 feet (4877 mm), such access shall be provided by a permanent approved means of access, the extent of which shall be from grade or floor level to the appliance's level service space. Such access shall not require climbing over obstructions greater than 30 inches high (762 mm) or walking on roofs having a slope greater than four units vertical in 12 units horizontal (33-percent slope).

Permanent ladders installed to provide the required access shall comply with the following minimum design criteria.

1. The side railing shall extend above the parapet or roof edge not less than 30 inches (762 mm).
2. Ladders shall have a rung spacing not to exceed 14 inches (356 mm) on center.
3. Ladders shall have a toe spacing not less than 6 inches (152 mm) deep.
4. There shall be a minimum of 18 inches (457 mm) between rails.
5. Rungs shall have a minimum diameter of 0.75-inch (19 mm) and shall be capable of withstanding a 300-pound (136.1 kg) load.
6. Ladders over 30 feet (9144 mm) in height shall be provided with offset sections and landings capable of withstanding a load of 100 pounds per square foot (488.2 kg/m²).
7. Ladders shall be protected against corrosion by approved means.

Catwalks installed to provide the required access shall be not less than 24 inches wide (610 mm) and shall have railings as required for service platforms.

Exception: This section shall not apply to Group R-3 occupancies.

[M] 306.5.1 Sloped roofs. Where appliances are installed on a roof having a slope of three units vertical in 12 units horizontal (25-percent slope) or greater and having an edge more than 30 inches (762 mm) above grade at such edge, a level platform shall be provided on each side of the appliance to which access is required by the manufacturer's installation instructions for service, repair or maintenance. The platform shall not be less than 30 inches (762 mm) in any dimension and shall be provided with guards in accordance with Section 306.6.

[M] 306.5.2 Electrical requirements. A receptacle outlet shall be provided at or near the equipment location in accordance with the ICC *Electrical Code*.

[M] 306.6 Guards. Guards shall be provided where appliances, fans or other components that require service are located within 10 feet (3048 mm) of a roof edge or open side of a walking surface and such edge or open side is located more than 30 inches (762 mm) above the floor, roof or grade below. The guard shall extend not less than 30 inches (762 mm) beyond each end of such appliances, fans or other components and the top of the guard shall be located not less than 42 inches (1067 mm) above the elevated surface adjacent to the guard. The guard shall be constructed so as to prevent the passage of a 21-inch-diameter (533 mm) sphere and shall comply with the loading requirements for guards specified in the *International Building Code*.

SECTION 307 (IFGC) CONDENSATE DISPOSAL

307.1 Fuel-burning appliances. Liquid combustion by-products of condensing appliances shall be collected and discharged to an approved plumbing fixture or disposal area in accordance with the manufacturer's installation instructions. Condensate piping shall be of approved corrosion-resistant material and shall not be smaller than the drain connection on the appliance. Such piping shall maintain a minimum slope in the direction of discharge of not less than one-eighth unit vertical in 12 units horizontal (1-percent slope).

[M] 307.2 Drain pipe materials and sizes. Components of the condensate disposal system shall be cast iron, galvanized steel, copper, polybutylene, polyethylene, ABS, CPVC or PVC pipe or tubing. All components shall be selected for the pressure and temperature rating of the installation. Condensate waste and drain line size shall be not less than $\frac{3}{4}$ -inch internal diameter (19 mm) and shall not decrease in size from the drain connection to the place of condensate disposal. Where the drain pipes from more than one unit are manifolded together for condensate drainage, the pipe or tubing shall be sized in accordance with an approved method. All horizontal sections of drain piping shall be installed in uniform alignment at a uniform slope.

307.3 Traps. Condensate drains shall be trapped as required by the equipment or appliance manufacturer.

SECTION 308 (IFGS) CLEARANCE REDUCTION

308.1 Scope. This section shall govern the reduction in required clearances to combustible materials and combustible assemblies for chimneys, vents, appliances, devices and equipment. Clearance requirements for air-conditioning equipment and central heating boilers and furnaces shall comply with Sections 308.3 and 308.4.

308.2 Reduction table. The allowable clearance reduction shall be based on one of the methods specified in Table 308.2 or shall utilize an assembly listed for such application. Where required clearances are not listed in Table 308.2, the reduced clearances shall be determined by linear interpolation between the distances listed in the table. Reduced clearances shall not be derived by extrapolation below the range of the table. The reduction of the required clearances to combustibles for listed and labeled appliances and equipment shall be in accordance with the requirements of this section except that such clearances shall not be reduced where reduction is specifically prohibited by the terms of the appliance or equipment listing [see Figures 308.2(1) through 308.2(3)].

308.3 Clearances for indoor air-conditioning equipment. Clearance requirements for indoor air-conditioning equipment shall comply with Sections 308.3.1 through 308.3.5.

308.3.1 Equipment installed in rooms that are large in comparison with the size of the equipment. Air-conditioning equipment installed in rooms that are large in comparison with the size of the equipment shall be installed with clearances in accordance with the terms of their listing and the manufacturer's instructions.

308.3.2 Equipment installed in rooms that are not large in comparison with the size of the equipment. Air-conditioning equipment installed in rooms that are not large in comparison with the size of the equipment, such as alcoves and closets, shall be listed for such installations and installed in accordance with the manufacturer's instructions. Listed clearances shall not be reduced by the protection methods described in Table 308.2, regardless of whether the enclosure is of combustible or noncombustible material.

308.3.3 Clearance reduction. Air-conditioning equipment installed in rooms that are large in comparison with the size of the equipment shall be permitted to be installed with reduced clearances to combustible material provided the combustible material or equipment is protected as described in Table 308.2.

308.3.4 Plenum clearances. Where the furnace plenum is adjacent to plaster on metal lath or noncombustible material attached to combustible material, the clearance shall be measured to the surface of the plaster or other noncombustible finish where the clearance specified is 2 inches (51 mm) or less.

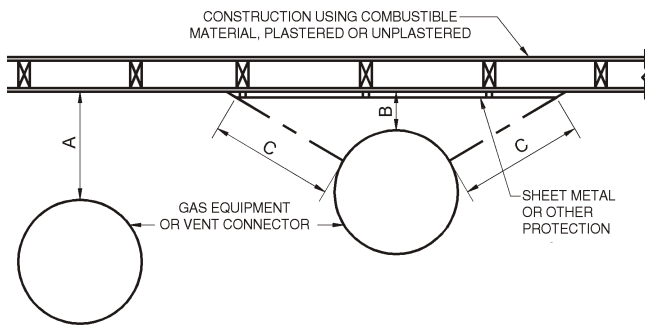
308.3.5 Clearance from supply ducts. Air-conditioning equipment shall have the clearance from supply ducts within 3 feet (914 mm) of the furnace plenum be not less than that specified from the furnace plenum. No clearance is necessary beyond this distance.

TABLE 308.2^{a-k}
REDUCTION OF CLEARANCES WITH SPECIFIED FORMS OF PROTECTION

TYPE OF PROTECTION APPLIED TO AND COVERING ALL SURFACES OF COMBUSTIBLE MATERIAL WITHIN THE DISTANCE SPECIFIED AS THE REQUIRED CLEARANCE WITH NO PROTECTION [see Figures 308.2(1), 308.2(2), and 308.2(3)]	WHERE THE REQUIRED CLEARANCE WITH NO PROTECTION FROM APPLIANCE, VENT CONNECTOR, OR SINGLE-WALL METAL PIPE IS: (inches)									
	36		18		12		9		6	
	Allowable clearances with specified protection (inches)									
	Use Column 1 for clearances above appliance or horizontal connector. Use Column 2 for clearances from appliance, vertical connector, and single-wall metal pipe.									
	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2
1. 3 1/2-inch-thick masonry wall without ventilated airspace	—	24	—	12	—	9	—	6	—	5
2. 1/2-inch insulation board over 1-inch glass fiber or mineral wool batts	24	18	12	9	9	6	6	5	4	3
3. 0.024 sheet metal over 1-inch glass fiber or mineral wool batts reinforced with wire on rear face with ventilated airspace	18	12	9	6	6	4	5	3	3	3
4. 3 1/2-inch-thick masonry wall with ventilated airspace	—	12	—	6	—	6	—	6	—	6
5. 0.024 sheet metal with ventilated airspace	18	12	9	6	6	4	5	3	3	2
6. 1/2-inch-thick insulation board with ventilated airspace	18	12	9	6	6	4	5	3	3	3
7. 0.024 sheet metal with ventilated airspace over 0.024 sheet metal with ventilated airspace	18	12	9	6	6	4	5	3	3	3
8. 1-inch glass fiber or mineral wool batts sandwiched between two sheets 0.024 sheet metal with ventilated airspace	18	12	9	6	6	4	5	3	3	3

- For SI: 1 inch = 25.4 mm, °C = [(°F - 32)/1.8], 1 pound per cubic foot = 16.02 kg/m³, 1 Btu per inch per square foot per hour per °F = 0.144 W/m² · K.
- a. Reduction of clearances from combustible materials shall not interfere with combustion air, draft hood clearance and relief, and accessibility of servicing.
 - b. All clearances shall be measured from the outer surface of the combustible material to the nearest point on the surface of the appliance, disregarding any intervening protection applied to the combustible material.
 - c. Spacers and ties shall be of noncombustible material. No spacer or tie shall be used directly opposite an appliance or connector.
 - d. For all clearance reduction systems using a ventilated airspace, adequate provision for air circulation shall be provided as described [see Figures 308.2(2) and 308.2(3)].
 - e. There shall be at least 1 inch between clearance reduction systems and combustible walls and ceilings for reduction systems using ventilated airspace.
 - f. Where a wall protector is mounted on a single flat wall away from corners, it shall have a minimum 1-inch air gap. To provide air circulation, the bottom and top edges, or only the side and top edges, or all edges shall be left open.
 - g. Mineral wool batts (blanket or board) shall have a minimum density of 8 pounds per cubic foot and a minimum melting point of 1500°F.
 - h. Insulation material used as part of a clearance reduction system shall have a thermal conductivity of 1.0 Btu per inch per square foot per hour per °F or less.
 - i. There shall be at least 1 inch between the appliance and the protector. In no case shall the clearance between the appliance and the combustible surface be reduced below that allowed in this table.
 - j. All clearances and thicknesses are minimum; larger clearances and thicknesses are acceptable.
 - k. Listed single-wall connectors shall be installed in accordance with the terms of their listing and the manufacturer’s instructions.

GENERAL REGULATIONS

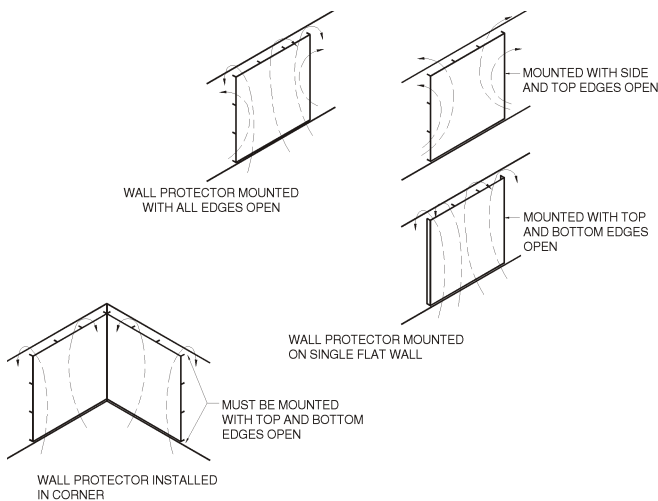


"A" equals the reduced clearance with no protection.
 "B" equals the reduced clearance permitted in accordance with Table 308.2. The protection applied to the construction using combustible material shall extend far enough in each direction to make "C" equal to "A."

**FIGURE 308.2(1)
 EXTENT OF PROTECTION NECESSARY TO
 REDUCE CLEARANCES FROM GAS EQUIPMENT OR
 VENT CONNECTIONS**

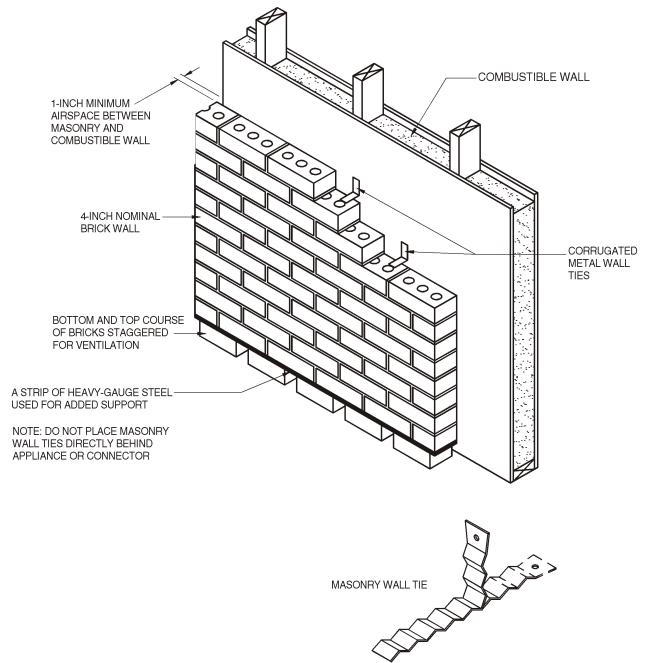
308.4 Central-heating boilers and furnaces. Clearance requirements for central-heating boilers and furnaces shall comply with Sections 308.4.1 through 308.4.6. The clearance to this equipment shall not interfere with combustion air, draft hood clearance and relief, and accessibility for servicing.

308.4.1 Equipment installed in rooms that are large in comparison with the size of the equipment. Central-heating furnaces and low-pressure boilers installed in rooms large in comparison with the size of the equipment shall be installed with clearances in accordance with the terms of their listing and the manufacturer's instructions.



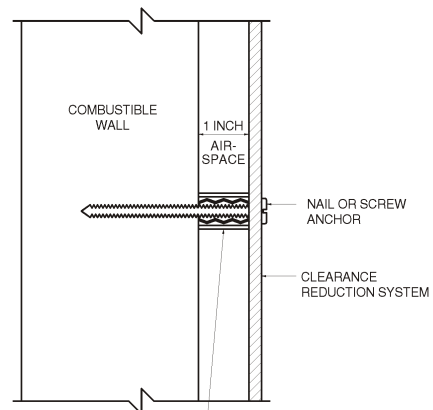
For SI: 1 inch = 25.4 mm.

**FIGURE 308.2(2)
 WALL PROTECTOR CLEARANCE REDUCTION SYSTEM**



For SI: 1 inch = 25.4 mm.

**FIGURE 308.2(3)
 MASONRY CLEARANCE REDUCTION SYSTEM**



1-INCH NONCOMBUSTIBLE SPACER SUCH AS STACKED WASHERS, SMALL-DIAMETER PIPE, TUBING OR ELECTRICAL CONDUIT.

MASONRY WALLS CAN BE ATTACHED TO COMBUSTIBLE WALLS USING WALL TIES.

DO NOT USE SPACERS DIRECTLY BEHIND APPLIANCE OR CONNECTOR.

308.4.2 Equipment installed in rooms that are not large in comparison with the size of the equipment. Central-heating furnaces and low-pressure boilers installed in rooms that are not large in comparison with the size of the equipment, such as alcoves and closets, shall be listed for such installations. Listed clearances shall not be reduced by the protection methods described in Table 308.2 and illustrated in Figures 308.2(1) through 308.2(3), regardless of whether the enclosure is of combustible or noncombustible material.

308.4.3 Clearance reduction. Central-heating furnaces and low-pressure boilers installed in rooms that are large in comparison with the size of the equipment shall be permitted to be installed with reduced clearances to combustible material provided the combustible material or equipment is protected as described in Table 308.2.

308.4.4 Clearance for servicing equipment. Front clearance shall be sufficient for servicing the burner and the furnace or boiler.

308.4.5 Plenum clearances. Where the furnace plenum is adjacent to plaster on metal lath or noncombustible material attached to combustible material, the clearance shall be measured to the surface of the plaster or other noncombustible finish where the clearance specified is 2 inches (51 mm) or less.

308.4.6 Clearance from supply ducts. Central-heating furnaces shall have the clearance from supply ducts within 3 feet (914 mm) of the furnace plenum be not less than that specified from the furnace plenum. No clearance is necessary beyond this distance.

SECTION 309 (IFGC) ELECTRICAL

309.1 Grounding. Gas piping shall not be used as a grounding electrode.

309.2 Connections. Electrical connections between equipment and the building wiring, including the grounding of the equipment, shall conform to the ICC *Electrical Code*.

SECTION 310 (IFGS) ELECTRICAL BONDING

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

CHAPTER 4

GAS PIPING INSTALLATIONS

SECTION 401 (IFGC) GENERAL

401.1 Scope. This chapter shall govern the design, installation, modification and maintenance of piping systems. The applicability of this code to piping systems extends from the point of delivery to the connections with the equipment and includes the design, materials, components, fabrication, assembly, installation, testing, inspection, operation and maintenance of such piping systems.

401.1.1 Utility piping systems located within buildings. Utility service piping located within buildings shall be installed in accordance with the structural safety and fire protection provisions of the *International Building Code*.

401.2 Liquefied petroleum gas storage. The storage system for liquefied petroleum gas shall be designed and installed in accordance with the *International Fire Code* and NFPA 58.

401.3 Modifications to existing systems. In modifying or adding to existing piping systems, sizes shall be maintained in accordance with this chapter.

401.4 Additional appliances. Where an additional appliance is to be served, the existing piping shall be checked to determine if it has adequate capacity for all appliances served. If inadequate, the existing system shall be enlarged as required or separate piping of adequate capacity shall be provided.

401.5 Identification. For other than black steel pipe, exposed piping shall be identified by a yellow label marked "Gas" in black letters. The marking shall be spaced at intervals not exceeding 5 feet (1524 mm). The marking shall not be required on pipe located in the same room as the equipment served.

401.6 Interconnections. Where two or more meters are installed on the same premises but supply separate consumers, the piping systems shall not be interconnected on the outlet side of the meters.

401.7 Piping meter identification. Piping from multiple meter installations shall be marked with an approved permanent identification by the installer so that the piping system supplied by each meter is readily identifiable.

401.8 Minimum sizes. All pipe utilized for the installation, extension and alteration of any piping system shall be sized to supply the full number of outlets for the intended purpose and shall be sized in accordance with Section 402.

SECTION 402 (IFGS) 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	35,000
Capacity at 2 gal./minute	50,000
Capacity at 4 gal./minute	
Capacity at 6 gal./minute	142,800
Water heater, automatic storage, 30- to 40-gal. tank	285,000
Water heater, automatic storage, 50-gal. tank	428,400
Water heater, domestic, circulating or side-arm	35,000
Cooking Appliances	
Built-in oven or broiler unit, domestic	65,000
Built-in top unit, domestic	25,000
Range, free-standing, domestic	40,000
Other Appliances	
Barbecue	3,000
Clothes dryer, Type 1 (domestic)	35,000
Gas fireplace, direct vent	40,000
Gas light	80,000
Gas log	40,000
Refrigerator	2,500

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)]:

$$D = \frac{Q^{0.381}}{19.17 \left(\frac{\Delta H}{C_r \times L} \right)^{0.206}} \quad \text{(Equation 4-1)}$$

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

$$D = \frac{Q^{0.381}}{18.93 \left[\frac{(P_1^2 - P_2^2) \times Y}{C_r \times L} \right]^{0.206}} \quad \text{(Equation 4-2)}$$

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 m³, 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.

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.

**TABLE 402.4(1)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	0.50 psi or less
Pressure Drop	0.3 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	32	72	132	278	520	1,050	1,600	3,050	4,800	8,500	17,500
20	22	49	92	190	350	730	1,100	2,100	3,300	5,900	12,000
30	18	40	73	152	285	590	890	1,650	2,700	4,700	9,700
40	15	34	63	130	245	500	760	1,450	2,300	4,100	8,300
50	14	30	56	115	215	440	670	1,270	2,000	3,600	7,400
60	12	27	50	105	195	400	610	1,150	1,850	3,250	6,800
70	11	25	46	96	180	370	560	1,050	1,700	3,000	6,200
80	11	23	43	90	170	350	530	990	1,600	2,800	5,800
90	10	22	40	84	160	320	490	930	1,500	2,600	5,400
100	9	21	38	79	150	305	460	870	1,400	2,500	5,100
125	8	18	34	72	130	275	410	780	1,250	2,200	4,500
150	8	17	31	64	120	250	380	710	1,130	2,000	4,100
175	7	15	28	59	110	225	350	650	1,050	1,850	3,800
200	6	14	26	55	100	210	320	610	980	1,700	3,500

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(2)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	0.50 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 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(3)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	0.60

PIPE SIZE (in.)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour								
10	1,506	3,041	5,561	11,415	17,106	32,944	52,505	92,819	189,326
20	1,065	2,150	3,932	8,072	12,096	23,295	37,127	65,633	133,873
30	869	1,756	3,211	6,591	9,876	19,020	30,314	53,589	109,307
40	753	1,521	2,781	5,708	8,553	16,472	26,253	46,410	94,663
50	673	1,360	2,487	5,105	7,650	14,733	23,481	41,510	84,669
60	615	1,241	2,270	4,660	6,983	13,449	21,435	37,893	77,292
70	569	1,150	2,102	4,315	6,465	12,452	19,845	35,082	71,558
80	532	1,075	1,966	4,036	6,048	11,647	18,563	32,817	66,937
90	502	1,014	1,854	3,805	5,702	10,981	17,502	30,940	63,109
100	462	934	1,708	3,508	5,257	10,125	16,138	28,530	58,194
125	414	836	1,528	3,138	4,702	9,056	14,434	25,518	52,050
150	372	751	1,373	2,817	4,222	8,130	12,960	22,911	46,732
175	344	695	1,271	2,608	3,909	7,527	11,999	21,211	43,265
200	318	642	1,174	2,413	3,613	6,959	11,093	19,608	39,997

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa.

**TABLE 402.4(4)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	5.0 psi
Pressure Drop	3.5 psi
Specific Gravity	0.60

PIPE SIZE (in.)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour								
10	3,185	6,434	11,766	24,161	36,206	69,727	111,133	196,468	400,732
20	2,252	4,550	8,320	17,084	25,602	49,305	78,583	138,924	283,361
30	1,839	3,715	6,793	13,949	20,904	40,257	64,162	113,431	231,363
40	1,593	3,217	5,883	12,080	18,103	34,864	55,566	98,234	200,366
50	1,425	2,878	5,262	10,805	16,192	31,183	49,700	87,863	179,213
60	1,301	2,627	4,804	9,864	14,781	28,466	45,370	80,208	163,598
70	1,204	2,432	4,447	9,132	13,685	26,354	42,004	74,258	151,463
80	1,153	2,330	4,260	8,542	12,801	24,652	39,291	69,462	141,680
90	1,062	2,145	3,922	8,054	12,069	23,242	37,044	65,489	133,577
100	979	1,978	3,617	7,427	11,128	21,433	34,159	60,387	123,173
125	876	1,769	3,235	6,643	9,953	19,170	30,553	54,012	110,169
150	786	1,589	2,905	5,964	8,937	17,211	27,431	48,494	98,911
175	728	1,471	2,690	5,522	8,274	15,934	25,396	44,897	91,574
200	673	1,360	2,487	5,104	7,649	14,729	23,478	41,504	84,656

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa.

**TABLE 402.4(5)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	1.0 psi or less
Pressure Drop	0.3 inch WC
Specific Gravity	0.60

PIPE SIZE (in.)													
Nominal	1	1 ¹ / ₄	1 ¹ / ₂	2	2 ¹ / ₂	3	3 ¹ / ₂	4	5	6	8	10	12
Actual ID	1.049	1.380	1.610	2.067	2.469	3.068	3.548	4.026	5.047	6.065	7.981	10.020	11.938
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour												
50	215	442	662	1,275	2,033	3,594	5,262	7,330	13,261	21,472	44,118	80,130	126,855
100	148	304	455	877	1,397	2,470	3,616	5,038	9,114	14,758	30,322	55,073	87,187
150	119	244	366	704	1,122	1,983	2,904	4,046	7,319	11,851	24,350	44,225	70,014
200	102	209	313	602	960	1,698	2,485	3,462	6,264	10,143	20,840	37,851	59,923
250	90	185	277	534	851	1,505	2,203	3,069	5,552	8,990	18,470	33,547	53,109
300	82	168	251	484	771	1,363	1,996	2,780	5,030	8,145	16,735	30,396	48,120
400	70	143	215	414	660	1,167	1,708	2,380	4,305	6,971	14,323	26,015	41,185
500	62	127	191	367	585	1,034	1,514	2,109	3,816	6,178	12,694	23,056	36,501
1,000	43	87	131	252	402	711	1,041	1,450	2,623	4,246	8,725	15,847	25,087
1,500	34	70	105	203	323	571	836	1,164	2,106	3,410	7,006	12,725	20,146
2,000	29	60	90	173	276	488	715	996	1,802	2,919	5,997	10,891	17,242

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(6)
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	1.0 psi or less
Pressure Drop	0.5 inch WC
Specific Gravity	0.60

PIPE SIZE (in.)													
Nominal	1	1 ¹ / ₄	1 ¹ / ₂	2	2 ¹ / ₂	3	3 ¹ / ₂	4	5	6	8	10	12
Actual ID	1.049	1.380	1.610	2.067	2.469	3.068	3.548	4.026	5.047	6.065	7.981	10.020	11.938
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour												
50	284	583	873	1,681	2,680	4,738	6,937	9,663	17,482	28,308	58,161	105,636	167,236
100	195	400	600	1,156	1,842	3,256	4,767	6,641	12,015	19,456	39,974	72,603	114,940
150	157	322	482	928	1,479	2,615	3,828	5,333	9,649	15,624	32,100	58,303	92,301
200	134	275	412	794	1,266	2,238	3,277	4,565	8,258	13,372	27,474	49,900	78,998
250	119	244	366	704	1,122	1,983	2,904	4,046	7,319	11,851	24,350	44,225	70,014
300	108	221	331	638	1,017	1,797	2,631	3,666	6,632	10,738	22,062	40,071	63,438
400	92	189	283	546	870	1,538	2,252	3,137	5,676	9,190	18,883	34,296	54,295
500	82	168	251	484	771	1,363	1,996	2,780	5,030	8,145	16,735	30,396	48,120
1,000	56	115	173	333	530	937	1,372	1,911	3,457	5,598	11,502	20,891	33,073
1,500	45	93	139	267	426	752	1,102	1,535	2,776	4,496	9,237	16,776	26,559
2,000	39	79	119	229	364	644	943	1,313	2,376	3,848	7,905	14,358	22,731

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

Gas	Natural
Inlet Pressure	0.5 psi or less
Pressure Drop	0.3 inch WC
Specific Gravity	0.60

**TABLE 402.4(7)
SEMI-RIGID COPPER TUBING**

Nominal	TUBE SIZE (in.)										
	K & L	1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
	ACR	3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour										
10	20	42	85	148	210	448	806	1,271	2,646	4,682	
20	14	29	58	102	144	308	554	873	1,819	3,218	
30	11	23	47	82	116	247	445	701	1,461	2,584	
40	10	20	40	70	99	211	381	600	1,250	2,212	
50	8.4	17	35	62	88	187	337	532	1,108	1,960	
60	7.6	16	32	56	79	170	306	482	1,004	1,776	
70	7.0	14	29	52	73	156	281	443	924	1,634	
80	6.5	13	27	48	68	145	262	413	859	1,520	
90	6.1	13	26	45	64	136	245	387	806	1,426	
100	5.8	12	24	43	60	129	232	366	761	1,347	
125	5.1	11	22	38	53	114	206	324	675	1,194	
150	4.7	10	20	34	48	103	186	294	612	1,082	
175	4.3	8.8	18	31	45	95	171	270	563	995	
200	4.0	8.2	17	29	41	89	159	251	523	926	
250	3.5	7.3	15	26	37	78	141	223	464	821	
300	3.2	6.6	13	23	33	71	128	202	420	744	

Note: Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(8)
SEMI-RIGID COPPER TUBING**

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

Nominal	K & L ACR	TUBE SIZE (in.)									
		1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
		3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		Maximum Capacity in Cubic Feet of Gas per Hour									
10		27	55	111	195	276	590	1,062	1,675	3,489	6,173
20		18	38	77	134	190	406	730	1,151	2,398	4,242
30		15	30	61	107	152	326	586	925	1,926	3,407
40		13	26	53	92	131	279	502	791	1,648	2,916
50		11	23	47	82	116	247	445	701	1,461	2,584
60		10	21	42	74	105	224	403	635	1,323	2,341
70		9.3	19	39	68	96	206	371	585	1,218	2,154
80		8.6	18	36	63	90	192	345	544	1,133	2,004
90		8.1	17	34	59	84	180	324	510	1,063	1,880
100		7.6	16	32	56	79	170	306	482	1,004	1,776
125		6.8	14	28	50	70	151	271	427	890	1,574
150		6.1	13	26	45	64	136	245	387	806	1,426
175		5.6	12	24	41	59	125	226	356	742	1,312
200		5.2	11	22	39	55	117	210	331	690	1,221
250		4.7	10	20	34	48	103	186	294	612	1,082
300		4.2	8.7	18	31	44	94	169	266	554	980

Note: Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
 For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(9)
SEMI-RIGID COPPER TUBING**

Use this Table to Size Tubing from House Line Regulator to the Appliance.

Gas	Natural
Inlet Pressure	0.5 psi or less
Pressure Drop	1.0 inch WC
Specific Gravity	0.60

Nominal	TUBE SIZE (in.)										
	K & L	1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
	ACR	3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour										
10	39	80	162	283	402	859	1,546	2,437	5,076	8,981	
20	27	55	111	195	276	590	1,062	1,675	3,489	6,173	
30	21	44	89	156	222	474	853	1,345	2,802	4,957	
40	18	38	77	134	190	406	730	1,151	2,398	4,242	
50	16	33	68	119	168	359	647	1,020	2,125	3,760	
60	15	30	61	107	152	326	586	925	1,926	3,407	
70	13	28	57	99	140	300	539	851	1,772	3,134	
80	13	26	53	92	131	279	502	791	1,648	2,916	
90	12	24	49	86	122	262	471	742	1,546	2,736	
100	11	23	47	82	116	247	445	701	1,461	2,584	
125	9.8	20	41	72	103	219	394	622	1,295	2,290	
150	8.9	18	37	65	93	198	357	563	1,173	2,075	
175	8.2	17	34	60	85	183	329	518	1,079	1,909	
200	7.6	16	32	56	79	170	306	482	1,004	1,776	
250	6.8	14	28	50	70	151	271	427	890	1,574	
300	6.1	13	26	45	64	136	245	387	806	1,426	

Note: Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(10)
SEMI-RIGID COPPER TUBING**

Gas	Natural
Inlet Pressure	2.0 psi or less
Pressure Drop	17.0 inch WC
Specific Gravity	0.60

		TUBE SIZE (in.)									
Nominal	K & L	1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
	ACR	3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		Maximum Capacity in Cubic Feet of Gas per Hour									
10		190	391	796	1,391	1,974	4,216	7,591	11,968	24,926	44,100
20		130	269	547	956	1,357	2,898	5,217	8,226	17,132	30,310
30		105	216	439	768	1,089	2,327	4,189	6,605	13,757	24,340
40		90	185	376	657	932	1,992	3,586	5,653	11,775	20,832
50		79	164	333	582	826	1,765	3,178	5,010	10,436	18,463
60		72	148	302	528	749	1,599	2,879	4,540	9,455	16,729
70		66	137	278	486	689	1,471	2,649	4,177	8,699	15,390
80		62	127	258	452	641	1,369	2,464	3,886	8,093	14,318
90		58	119	243	424	601	1,284	2,312	3,646	7,593	13,434
100		55	113	229	400	568	1,213	2,184	3,444	7,172	12,689
125		48	100	203	355	503	1,075	1,936	3,052	6,357	11,246
150		44	90	184	321	456	974	1,754	2,765	5,760	10,190
175		40	83	169	296	420	896	1,614	2,544	5,299	9,375
200		38	77	157	275	390	834	1,501	2,367	4,930	8,721
250		33	69	140	244	346	739	1,330	2,098	4,369	7,730
300		30	62	126	221	313	670	1,205	1,901	3,959	7,004

Note: Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
 For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(11)
SEMI-RIGID COPPER TUBING**

Gas	Natural
Inlet Pressure	2.0 psi or less
Pressure Drop	1.0 psi
Specific Gravity	0.60

Nominal	TUBE SIZE (in.)										
	K & L	1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
	ACR	3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour										
10	245	506	1,030	1,800	2,554	5,455	9,820	15,483	32,247	57,051	
20	169	348	708	1,237	1,755	3,749	6,749	10,641	22,163	39,211	
30	135	279	568	993	1,409	3,011	5,420	8,545	17,798	31,488	
40	116	239	486	850	1,206	2,577	4,639	7,314	15,232	26,949	
50	103	212	431	754	1,069	2,284	4,111	6,482	13,500	23,885	
60	93	192	391	683	969	2,069	3,725	5,873	12,232	21,641	
70	86	177	359	628	891	1,904	3,427	5,403	11,253	19,910	
80	80	164	334	584	829	1,771	3,188	5,027	10,469	18,522	
90	75	154	314	548	778	1,662	2,991	4,716	9,823	17,379	
100	71	146	296	518	735	1,570	2,826	4,455	9,279	16,416	
125	63	129	263	459	651	1,391	2,504	3,948	8,223	14,549	
150	57	117	238	416	590	1,260	2,269	3,577	7,451	13,183	
175	52	108	219	383	543	1,160	2,087	3,291	6,855	12,128	
200	49	100	204	356	505	1,079	1,942	3,062	6,377	11,283	
250	43	89	181	315	448	956	1,721	2,714	5,652	10,000	
300	39	80	164	286	406	866	1,559	2,459	5,121	9,060	

Note: Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa.

TABLE 402.4(12)
SEMI-RIGID COPPER TUBING
Pipe Sizing Between Point of Delivery and the House Line Regulator. Total Load
Supplied by a Single House Line Regulator Not Exceeding 150 Cubic Feet per Hour.²

Gas	Natural
Inlet Pressure	2.0 psi
Pressure Drop	1.5 psi
Specific Gravity	0.60

Nominal	K & L ACR	TUBE SIZE (in.)									
		1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
		3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside¹		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		Maximum Capacity in Cubic Feet of Gas per Hour									
10		303	625	1,272	2,224	3,155	6,739	12,131	19,127	39,837	70,481
20		208	430	874	1,528	2,168	4,631	8,338	13,146	27,380	48,441
30		167	345	702	1,227	1,741	3,719	6,696	10,557	21,987	38,900
40		143	295	601	1,050	1,490	3,183	5,731	9,035	18,818	33,293
50		127	262	533	931	1,321	2,821	5,079	8,008	16,678	29,507
60		115	237	483	843	1,197	2,556	4,602	7,256	15,112	26,736
70		106	218	444	776	1,101	2,352	4,234	6,675	13,903	24,597
80		98	203	413	722	1,024	2,188	3,939	6,210	12,934	22,882
90		92	191	388	677	961	2,053	3,695	5,826	12,135	21,470
100		87	180	366	640	908	1,939	3,491	5,504	11,463	20,280
125		77	159	324	567	804	1,718	3,094	4,878	10,159	17,974
150		70	145	294	514	729	1,557	2,803	4,420	9,205	16,286
175		64	133	270	473	671	1,432	2,579	4,066	8,469	14,983
200		60	124	252	440	624	1,333	2,399	3,783	7,878	13,938
250		53	110	223	390	553	1,181	2,126	3,352	6,982	12,353
300		48	99	202	353	501	1,070	1,927	3,038	6,327	11,193

Notes:

1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. When this table is used to size the tubing upstream of a line pressure regulator, the pipe or tubing downstream of the line pressure regulator shall be sized using a pressure drop no greater than 1 inch w.c.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa.

**TABLE 402.4(13)
SEMI-RIGID COPPER TUBING**

Gas	Natural
Inlet Pressure	5.0 psi or less
Pressure Drop	3.5 psi
Specific Gravity	0.60

Nominal	TUBE SIZE (in.)										
	K & L	1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
	ACR	3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour										
10	511	1,054	2,144	3,747	5,315	11,354	20,441	32,229	67,125	118,758	
20	351	724	1,473	2,575	3,653	7,804	14,049	22,151	46,135	81,622	
30	282	582	1,183	2,068	2,934	6,267	11,282	17,788	37,048	65,545	
40	241	498	1,013	1,770	2,511	5,364	9,656	15,224	31,708	56,098	
50	214	441	898	1,569	2,225	4,754	8,558	13,493	28,102	49,719	
60	194	400	813	1,421	2,016	4,307	7,754	12,225	25,463	45,049	
70	178	368	748	1,308	1,855	3,962	7,134	11,247	23,425	41,444	
80	166	342	696	1,216	1,726	3,686	6,636	10,463	21,793	38,556	
90	156	321	653	1,141	1,619	3,459	6,227	9,817	20,447	36,176	
100	147	303	617	1,078	1,529	3,267	5,882	9,273	19,315	34,172	
125	130	269	547	955	1,356	2,896	5,213	8,219	17,118	30,286	
150	118	243	495	866	1,228	2,624	4,723	7,447	15,510	27,441	
175	109	224	456	796	1,130	2,414	4,345	6,851	14,269	25,245	
200	101	208	424	741	1,051	2,245	4,042	6,374	13,275	23,486	
250	90	185	376	657	932	1,990	3,583	5,649	11,765	20,815	
300	81	167	340	595	844	1,803	3,246	5,118	10,660	18,860	

Note: Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa.

**TABLE 402.4(14)
CORRUGATED STAINLESS STEEL TUBING (CSST)**

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

Flow Designation	TUBE SIZE (EHD*)										
	13	15	18	19	23	25	30	31	37	46	62
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour										
5	46	63	115	134	225	270	471	546	895	1,790	4,142
10	32	44	82	95	161	192	330	383	639	1,261	2,934
15	25	35	66	77	132	157	267	310	524	1,027	2,398
20	22	31	58	67	116	137	231	269	456	888	2,078
25	19	27	52	60	104	122	206	240	409	793	1,860
30	18	25	47	55	96	112	188	218	374	723	1,698
40	15	21	41	47	83	97	162	188	325	625	1,472
50	13	19	37	42	75	87	144	168	292	559	1,317
60	12	17	34	38	68	80	131	153	267	509	1,203
70	11	16	31	36	63	74	121	141	248	471	1,114
80	10	15	29	33	60	69	113	132	232	440	1,042
90	10	14	28	32	57	65	107	125	219	415	983
100	9	13	26	30	54	62	101	118	208	393	933
150	7	10	20	23	42	48	78	91	171	320	762
200	6	9	18	21	38	44	71	82	148	277	661
250	5	8	16	19	34	39	63	74	133	247	591
300	5	7	15	17	32	36	57	67	95	226	540

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

*EHD— Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

For SI: 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 degree = 0.01745 rad.

**TABLE 402.4(15)
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Natural
Inlet Pressure	0.5 psi or less
Pressure Drop	3.0 inch WC
Specific Gravity	0.60

Flow Designation	TUBE SIZE (EHD*)										
	13	15	18	19	23	25	30	31	37	46	62
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour										
5	120	160	277	327	529	649	1,182	1,365	2,141	4,428	10,103
10	83	112	197	231	380	462	828	958	1,528	3,199	7,156
15	67	90	161	189	313	379	673	778	1,254	2,541	5,848
20	57	78	140	164	273	329	580	672	1,090	2,197	5,069
25	51	69	125	147	245	295	518	599	978	1,963	4,536
30	46	63	115	134	225	270	471	546	895	1,790	4,142
40	39	54	100	116	196	234	407	471	778	1,548	3,590
50	35	48	89	104	176	210	363	421	698	1,383	3,213
60	32	44	82	95	161	192	330	383	639	1,261	2,934
70	29	41	76	88	150	178	306	355	593	1,166	2,717
80	27	38	71	82	141	167	285	331	555	1,090	2,543
90	26	36	67	77	133	157	268	311	524	1,027	2,398
100	24	34	63	73	126	149	254	295	498	974	2,276
150	19	27	52	60	104	122	206	240	409	793	1,860
200	17	23	45	52	91	106	178	207	355	686	1,612
250	15	21	40	46	82	95	159	184	319	613	1,442
300	13	19	37	42	75	87	144	168	234	559	1,317

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

*EHD—Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

For SI: 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 degree = 0.01745 rad.

**TABLE 402.4(16)
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Natural
Inlet Pressure	0.5 psi or less
Pressure Drop	6.0 inch WC
Specific Gravity	0.60

Flow Designation	TUBE SIZE (EHD*)										
	13	15	18	19	23	25	30	31	37	46	62
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour										
5	173	229	389	461	737	911	1,687	1,946	3,000	6,282	14,263
10	120	160	277	327	529	649	1,182	1,365	2,141	4,428	10,103
15	96	130	227	267	436	532	960	1,110	1,758	3,607	8,257
20	83	112	197	231	380	462	828	958	1,528	3,119	7,156
25	74	99	176	207	342	414	739	855	1,371	2,786	6,404
30	67	90	161	189	313	379	673	778	1,254	2,541	5,848
40	57	78	140	164	273	329	580	672	1,090	2,197	5,069
50	51	69	125	147	245	295	518	599	978	1,963	4,536
60	46	63	115	134	225	270	471	546	895	1,790	4,142
70	42	58	106	124	209	250	435	505	830	1,656	3,837
80	39	54	100	116	196	234	407	471	778	1,548	3,590
90	37	51	94	109	185	221	383	444	735	1,458	3,386
100	35	48	89	104	176	210	363	421	698	1,383	3,213
150	28	39	73	85	145	172	294	342	573	1,126	2,626
200	24	34	63	73	126	149	254	295	498	974	2,276
250	21	30	57	66	114	134	226	263	447	870	2,036
300	19	27	52	60	104	122	206	240	409	793	1,860

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

*EHD— Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

For SI: 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 degree = 0.01745 rad.

**TABLE 402.4(17)
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Natural
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	0.60

Flow Designation	TUBE SIZE (EHD*)										
	13	15	18	19	23	25	30	31	37	46	62
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour										
10	270	353	587	700	1,098	1,372	2,592	2,986	4,509	9,599	21,637
25	166	220	374	444	709	876	1,620	1,869	2,887	6,041	13,715
30	151	200	342	405	650	801	1,475	1,703	2,642	5,509	12,526
40	129	172	297	351	567	696	1,273	1,470	2,297	4,763	10,855
50	115	154	266	314	510	624	1,135	1,311	2,061	4,255	9,715
75	93	124	218	257	420	512	922	1,066	1,692	3,467	7,940
80	89	120	211	249	407	496	892	1,031	1,639	3,355	7,689
100	79	107	189	222	366	445	795	920	1,471	2,997	6,881
150	64	87	155	182	302	364	646	748	1,207	2,442	5,624
200	55	75	135	157	263	317	557	645	1,049	2,111	4,874
250	49	67	121	141	236	284	497	576	941	1,886	4,362
300	44	61	110	129	217	260	453	525	862	1,720	3,983
400	38	52	96	111	189	225	390	453	749	1,487	3,452
500	34	46	86	100	170	202	348	404	552	1,329	3,089

Notes:

1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds $\frac{3}{4}$ psi, DO NOT USE THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator may vary with flow rate.
 2. CAUTION: Capacities shown in table may exceed maximum capacity for a selected regulator. Consult with regulator or tubing manufacturer for guidance.
 3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends and/or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$ where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.
- *EHD—Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

For SI: 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1 degree = 0.01745 rad.

**TABLE 402.4(18)
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Natural
Inlet Pressure	5.0 psi
Pressure Drop	3.5 psi
Specific Gravity	0.60

Flow Designation	TUBE SIZE (EHD*)										
	13	15	18	19	23	25	30	31	37	46	62
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour										
10	523	674	1,084	1,304	1,995	2,530	4,923	5,659	8,295	18,080	40,353
25	322	420	691	827	1,289	1,616	3,077	3,543	5,311	11,378	25,580
30	292	382	632	755	1,181	1,478	2,803	3,228	4,860	10,377	23,361
40	251	329	549	654	1,031	1,284	2,418	2,786	4,225	8,972	20,246
50	223	293	492	586	926	1,151	2,157	2,486	3,791	8,015	18,119
75	180	238	403	479	763	944	1,752	2,021	3,112	6,530	14,809
80	174	230	391	463	740	915	1,694	1,955	3,016	6,320	14,341
100	154	205	350	415	665	820	1,511	1,744	2,705	5,646	12,834
150	124	166	287	339	548	672	1,228	1,418	2,221	4,600	10,489
200	107	143	249	294	478	584	1,060	1,224	1,931	3,977	9,090
250	95	128	223	263	430	524	945	1,092	1,732	3,553	8,135
300	86	116	204	240	394	479	860	995	1,585	3,240	7,430
400	74	100	177	208	343	416	742	858	1,378	2,802	6,439
500	66	89	159	186	309	373	662	766	1,035	2,503	5,762

Notes:

1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds $\frac{3}{4}$ psi, DO NOT USE THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator may vary with flow rate.
 2. CAUTION: Capacities shown in table may exceed maximum capacity for a selected regulator. Consult with regulator or tubing manufacturer for guidance.
 3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends and/or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$ where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.
- *EHD— Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

For SI: 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1 degree = 0.01745 rad.

**TABLE 402.4(19)
POLYETHYLENE PLASTIC PIPE**

Gas	Natural
Inlet Pressure	1.0 psi or less
Pressure Drop	0.3 inch WC
Specific Gravity	0.60

Nominal OD	PIPE SIZE (in.)					
	1/2	3/4	1	1 1/4	1 1/2	2
Designation	SDR 9.33	SDR 11.0	SDR 11.00	SDR 10.00	SDR 11.00	SDR 11.00
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour					
10	153	305	551	955	1,442	2,590
20	105	210	379	656	991	1,780
30	84	169	304	527	796	1,430
40	72	144	260	451	681	1,224
50	64	128	231	400	604	1,084
60	58	116	209	362	547	983
70	53	107	192	333	503	904
80	50	99	179	310	468	841
90	46	93	168	291	439	789
100	44	88	159	275	415	745
125	39	78	141	243	368	661
150	35	71	127	221	333	598
175	32	65	117	203	306	551
200	30	60	109	189	285	512

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(20)
POLYETHYLENE PLASTIC PIPE**

Gas	Natural
Inlet Pressure	1.0 psi or less
Pressure Drop	0.5 inch WC
Specific Gravity	0.60

Nominal OD	PIPE SIZE (in.)					
	1/2	3/4	1	1 1/4	1 1/2	2
Designation	SDR 9.33	SDR 11.0	SDR 11.00	SDR 10.00	SDR 11.00	SDR 11.00
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour					
10	201	403	726	1,258	1,900	3,415
20	138	277	499	865	1,306	2,347
30	111	222	401	695	1,049	1,885
40	95	190	343	594	898	1,613
50	84	169	304	527	796	1,430
60	76	153	276	477	721	1,295
70	70	140	254	439	663	1,192
80	65	131	236	409	617	1,109
90	61	123	221	383	579	1,040
100	58	116	209	362	547	983
125	51	103	185	321	485	871
150	46	93	168	291	439	789
175	43	86	154	268	404	726
200	40	80	144	249	376	675

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa.

**TABLE 402.4(21)
POLYETHYLENE PLASTIC PIPE**

Gas	Natural
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	0.60

Nominal OD	PIPE SIZE (in.)					
	1/2	3/4	1	1 1/4	1 1/2	2
Designation	SDR 9.33	SDR 11.0	SDR 11.00	SDR 10.00	SDR 11.00	SDR 11.00
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	Maximum Capacity in Cubic Feet of Gas per Hour					
10	1,858	3,721	6,714	11,631	17,565	31,560
20	1,277	2,557	4,614	7,994	12,072	21,691
30	1,026	2,054	3,706	6,420	9,695	17,419
40	878	1,758	3,172	5,494	8,297	14,908
50	778	1,558	2,811	4,869	7,354	13,213
60	705	1,412	2,547	4,412	6,663	11,972
70	649	1,299	2,343	4,059	6,130	11,014
80	603	1,208	2,180	3,776	5,703	10,246
90	566	1,134	2,045	3,543	5,351	9,614
100	535	1,071	1,932	3,347	5,054	9,081
125	474	949	1,712	2,966	4,479	8,048
150	429	860	1,551	2,688	4,059	7,292
175	395	791	1,427	2,473	3,734	6,709
200	368	736	1,328	2,300	3,474	6,241

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound per square inch = 6.895 kPa.

TABLE 402.4(22)
SCHEDULE 40 METALLIC PIPE
Pipe Sizing Between First Stage (High Pressure Regulator)
and Second Stage (Low Pressure Regulator)

Gas	Undiluted propane
Inlet Pressure	10.0 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

Nominal Inside	PIPE SIZE (in.)								
	1/2	3/4	1	1 1/4	1 1/2	2	3	3 1/2	4
Actual	0.622	0.824	1.049	1.38	1.61	2.067	3.068	3.548	4.026
Length (ft)	Maximum Capacity in Thousands of Btu/h								
30	1,834	3,835	7,225	14,834	22,225	42,804	120,604	176,583	245,995
40	1,570	3,283	6,184	12,696	19,022	36,634	103,222	151,132	210,539
50	1,391	2,909	5,480	11,252	16,859	32,468	91,484	133,946	186,597
60	1,261	2,636	4,966	10,195	15,275	29,419	82,891	121,364	169,071
70	1,160	2,425	4,568	9,379	14,053	27,065	76,258	111,654	155,543
80	1,079	2,256	4,250	8,726	13,074	25,179	70,944	103,872	144,703
90	1,012	2,117	3,988	8,187	12,267	23,624	66,564	97,460	135,770
100	956	2,000	3,767	7,733	11,587	22,315	62,876	92,060	128,247
150	768	1,606	3,025	6,210	9,305	17,920	50,492	73,927	102,987
200	657	1,374	2,589	5,315	7,964	15,337	43,214	63,272	88,144
250	582	1,218	2,294	4,711	7,058	13,593	38,300	56,077	78,120
300	528	1,104	2,079	4,268	6,395	12,316	34,703	50,810	70,782
350	486	1,015	1,913	3,927	5,883	11,331	31,926	46,744	65,119
400	452	945	1,779	3,653	5,473	10,541	29,701	43,487	60,581
450	424	886	1,669	3,428	5,135	9,890	27,867	40,802	56,841
500	400	837	1,577	3,238	4,851	9,342	26,323	38,541	53,691
600	363	759	1,429	2,934	4,395	8,465	23,851	34,921	48,648
700	334	698	1,314	2,699	4,044	7,788	21,943	32,127	44,756
800	310	649	1,223	2,511	3,762	7,245	20,413	29,888	41,637
900	291	609	1,147	2,356	3,530	6,798	19,153	28,043	39,066
1,000	275	575	1,084	2,225	3,334	6,421	18,092	26,489	36,902
1,500	221	462	870	1,787	2,677	5,156	14,528	21,272	29,633
2,000	189	395	745	1,529	2,291	4,413	12,435	18,206	25,362

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 British thermal unit per hour = 0.2931 W.

**TABLE 402.4(23)
SCHEDULE 40 METALLIC PIPE**

Gas	Undiluted propane
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

Nominal	PIPE SIZE (in.)								
	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	Maximum Capacity in Thousands of Btu/h								
10	2,676	5,595	10,539	21,638	32,420	62,438	99,516	175,927	358,835
20	1,839	3,845	7,243	14,872	22,282	42,913	68,397	120,914	246,625
30	1,477	3,088	5,817	11,942	17,893	34,461	54,925	97,098	198,049
40	1,264	2,643	4,978	10,221	15,314	29,494	47,009	83,103	169,504
50	1,120	2,342	4,412	9,059	13,573	26,140	41,663	73,653	150,229
60	1,015	2,122	3,998	8,208	12,298	23,685	37,750	66,735	136,118
70	934	1,952	3,678	7,551	11,314	21,790	34,729	61,395	125,227
80	869	1,816	3,422	7,025	10,526	20,271	32,309	57,116	116,499
90	815	1,704	3,210	6,591	9,876	19,020	30,314	53,590	109,307
100	770	1,610	3,033	6,226	9,329	17,966	28,635	50,621	103,251
125	682	1,427	2,688	5,518	8,268	15,923	25,378	44,865	91,510
150	618	1,293	2,435	5,000	7,491	14,427	22,995	40,651	82,914
175	569	1,189	2,240	4,600	6,892	13,273	21,155	37,398	76,280
200	529	1,106	2,084	4,279	6,411	12,348	19,681	34,792	70,964

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 British thermal unit per hour = 0.2931 W.

TABLE 402.4(24)
SCHEDULE 40 METALLIC PIPE
Pipe Sizing Between Single or Second Stage
(Low Pressure Regulator) and Appliance

Gas	Undiluted propane
Inlet Pressure	11.0 inch WC
Pressure Drop	0.5 inch WC
Specific Gravity	1.50

	PIPE SIZE (in.)								
Nominal Inside	1/2	3/4	1	1 1/4	1 1/2	2	3	3 1/2	4
Actual	0.622	0.824	1.049	1.38	1.61	2.067	3.068	3.548	4.026
Length (ft)	Maximum Capacity in Thousands of Btu/h								
10	291	608	1,145	2,352	3,523	6,786	19,119	27,993	38,997
20	200	418	787	1,616	2,422	4,664	13,141	19,240	26,802
30	160	336	632	1,298	1,945	3,745	10,552	15,450	21,523
40	137	287	541	1,111	1,664	3,205	9,031	13,223	18,421
50	122	255	480	984	1,475	2,841	8,004	11,720	16,326
60	110	231	434	892	1,337	2,574	7,253	10,619	14,793
80	94	197	372	763	1,144	2,203	6,207	9,088	12,661
100	84	175	330	677	1,014	1,952	5,501	8,055	11,221
125	74	155	292	600	899	1,730	4,876	7,139	9,945
150	67	140	265	543	814	1,568	4,418	6,468	9,011
200	58	120	227	465	697	1,342	3,781	5,536	7,712
250	51	107	201	412	618	1,189	3,351	4,906	6,835
300	46	97	182	373	560	1,078	3,036	4,446	6,193
350	42	89	167	344	515	991	2,793	4,090	5,698
400	40	83	156	320	479	922	2,599	3,805	5,301

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W.

TABLE 402.4(25)
SEMI-RIGID COPPER TUBING
Sizing Between First Stage (High Pressure Regulator)
and Second Stage (Low Pressure Regulator)

Gas	Undiluted propane
Inlet Pressure	10.0 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

Nominal	K & L ACR	TUBE SIZE (in.)									
		1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
		3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		Maximum Capacity in Thousands of Btu/h									
10		513	1,058	2,152	3,760	5,335	11,396	20,516	32,347	67,371	119,193
20		352	727	1,479	2,585	3,667	7,832	14,101	22,232	46,303	81,921
30		283	584	1,188	2,075	2,944	6,290	11,323	17,853	37,183	65,785
40		242	500	1,016	1,776	2,520	5,383	9,691	15,280	31,824	56,304
50		215	443	901	1,574	2,234	4,771	8,589	13,542	28,205	49,901
60		194	401	816	1,426	2,024	4,323	7,782	12,270	25,556	45,214
70		179	369	751	1,312	1,862	3,977	7,160	11,288	23,511	41,596
80		166	343	699	1,221	1,732	3,700	6,661	10,502	21,873	38,697
90		156	322	655	1,145	1,625	3,471	6,250	9,853	20,522	36,308
100		147	304	619	1,082	1,535	3,279	5,903	9,307	19,385	34,297
125		131	270	549	959	1,361	2,906	5,232	8,249	17,181	30,396
150		118	244	497	869	1,233	2,633	4,741	7,474	15,567	27,541
175		109	225	457	799	1,134	2,423	4,361	6,876	14,321	25,338
200		101	209	426	744	1,055	2,254	4,057	6,397	13,323	23,572
225		95	196	399	698	990	2,115	3,807	6,002	12,501	22,117
250		90	185	377	659	935	1,997	3,596	5,669	11,808	20,891
275		85	176	358	626	888	1,897	3,415	5,385	11,215	19,841
300		81	168	342	597	847	1,810	3,258	5,137	10,699	18,929

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 British thermal unit per hour = 0.2931 W.

Note: Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

TABLE 402.4(26)
SEMI-RIGID COPPER TUBING
Sizing Between Single or Second Stage
(Low Pressure Regulator) and Appliance

Gas	Undiluted propane
Inlet Pressure	11.0 inch WC
Pressure Drop	0.5 inch WC
Specific Gravity	1.50

Nominal	K & L ACR	TUBE SIZE (in.)									
		1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
		3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside		0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside		0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		Maximum Capacity in Thousands of Btu/h									
10		45	93	188	329	467	997	1,795	2,830	5,895	10,429
20		31	64	129	226	321	685	1,234	1,945	4,051	7,168
30		25	51	104	182	258	550	991	1,562	3,253	5,756
40		21	44	89	155	220	471	848	1,337	2,784	4,926
50		19	39	79	138	195	417	752	1,185	2,468	4,366
60		17	35	71	125	177	378	681	1,074	2,236	3,956
70		16	32	66	115	163	348	626	988	2,057	3,639
80		15	30	61	107	152	324	583	919	1,914	3,386
90		14	28	57	100	142	304	547	862	1,796	3,177
100		13	27	54	95	134	287	517	814	1,696	3,001
125		11	24	48	84	119	254	458	722	1,503	2,660
150		10	21	44	76	108	230	415	654	1,362	2,410
175		10	20	40	70	99	212	382	602	1,253	2,217
200		8.9	18	37	65	92	197	355	560	1,166	2,062
225		8.3	17	35	61	87	185	333	525	1,094	1,935
250		7.9	16	33	58	82	175	315	496	1,033	1,828
275		7.5	15	31	55	78	166	299	471	981	1,736
300		7.1	15	30	52	74	158	285	449	936	1,656

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W.

Note: Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

**TABLE 402.4(27)
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Undiluted propane
Inlet Pressure	2.0. psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

Nominal		TUBE SIZE (in.)										
		K & L	1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2
		ACR	3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	1 5/8	2 1/8	2 5/8
Outside			0.375	0.500	0.625	0.750	0.875	1.125	1.375	1.625	2.125	2.625
Inside			0.305	0.402	0.527	0.652	0.745	0.995	1.245	1.481	1.959	2.435
Length (ft)		Maximum Capacity in Thousands of Btu/h										
10		413	852	1,732	3,027	4,295	9,175	16,517	26,042	54,240	95,962	
20		284	585	1,191	2,081	2,952	6,306	11,352	17,899	37,279	65,954	
30		228	470	956	1,671	2,371	5,064	9,116	14,373	29,936	52,963	
40		195	402	818	1,430	2,029	4,334	7,802	12,302	25,621	45,330	
50		173	356	725	1,267	1,798	3,841	6,915	10,903	22,708	40,175	
60		157	323	657	1,148	1,629	3,480	6,266	9,879	20,575	36,401	
70		144	297	605	1,057	1,499	3,202	5,764	9,088	18,929	33,489	
80		134	276	562	983	1,394	2,979	5,363	8,455	17,609	31,155	
90		126	259	528	922	1,308	2,795	5,031	7,933	16,522	29,232	
100		119	245	498	871	1,236	2,640	4,753	7,493	15,607	27,612	
125		105	217	442	772	1,095	2,340	4,212	6,641	13,832	24,472	
150		95	197	400	700	992	2,120	3,817	6,017	12,533	22,173	
175		88	181	368	644	913	1,950	3,511	5,536	11,530	20,399	
200		82	168	343	599	849	1,814	3,267	5,150	10,727	18,978	
225		77	158	321	562	797	1,702	3,065	4,832	10,064	17,806	
250		72	149	304	531	753	1,608	2,895	4,564	9,507	16,819	
275		69	142	288	504	715	1,527	2,750	4,335	9,029	15,974	
300		66	135	275	481	682	1,457	2,623	4,136	8,614	15,240	

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 British thermal unit per hour = 0.2931 W.

Note: Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

**TABLE 402.4(28)
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Undiluted propane
Inlet Pressure	11.0 inch WC
Pressure Drop	0.5 inch WC
Specific Gravity	1.50

Flow Designation	TUBE SIZE (EHD*)										
	13	15	18	19	23	25	30	31	37	46	62
Length (ft)	Maximum Capacity in Thousands of Btu/h										
5	72	99	181	211	355	426	744	863	1,415	2,830	6,547
10	50	69	129	150	254	303	521	605	971	1,993	4,638
15	39	55	104	121	208	248	422	490	775	1,623	3,791
20	34	49	91	106	183	216	365	425	661	1,404	3,285
25	30	42	82	94	164	192	325	379	583	1,254	2,940
30	28	39	74	87	151	177	297	344	528	1,143	2,684
40	23	33	64	74	131	153	256	297	449	988	2,327
50	20	30	58	66	118	137	227	265	397	884	2,082
60	19	26	53	60	107	126	207	241	359	805	1,902
70	17	25	49	57	99	117	191	222	330	745	1,761
80	15	23	45	52	94	109	178	208	307	696	1,647
90	15	22	44	50	90	102	169	197	286	656	1,554
100	14	20	41	47	85	98	159	186	270	621	1,475
150	11	15	31	36	66	75	123	143	217	506	1,205
200	9	14	28	33	60	69	112	129	183	438	1,045
250	8	12	25	30	53	61	99	117	163	390	934
300	8	11	23	26	50	57	90	107	147	357	854

For SI: 1 foot = 304.8 mm, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W, 1 degree = 0.01745 rad.

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

*EHD—Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

**TABLE 402.4(29)
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Undiluted propane
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

Flow Designation	TUBE SIZE (EHD*)										
	13	15	18	19	23	25	30	31	37	46	62
Length (ft)	Maximum Capacity in Thousands of Btu/h										
10	426	558	927	1,106	1,735	2,168	4,097	4,720	7,128	15,174	34,203
25	262	347	591	701	1,120	1,384	2,560	2,954	4,564	9,549	21,680
30	238	316	540	640	1,027	1,266	2,331	2,692	4,176	8,708	19,801
40	203	271	469	554	896	1,100	2,012	2,323	3,631	7,529	17,159
50	181	243	420	496	806	986	1,794	2,072	3,258	6,726	15,357
75	147	196	344	406	663	809	1,457	1,685	2,675	5,480	12,551
80	140	189	333	393	643	768	1,410	1,629	2,591	5,303	12,154
100	124	169	298	350	578	703	1,256	1,454	2,325	4,738	10,877
150	101	137	245	287	477	575	1,021	1,182	1,908	3,860	8,890
200	86	118	213	248	415	501	880	1,019	1,658	3,337	7,705
250	77	105	191	222	373	448	785	910	1,487	2,981	6,895
300	69	96	173	203	343	411	716	829	1,363	2,719	6,296
400	60	82	151	175	298	355	616	716	1,163	2,351	5,457
500	53	72	135	158	268	319	550	638	1,027	2,101	4,883

For SI: 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W, 1 degree = 0.01745 rad.

Notes:

1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds 1/2 psi (based on 13 in. w.c. outlet pressure), DO NOT USE THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator may vary with flow rate.
2. CAUTION: Capacities shown in table may exceed maximum capacity for a selected regulator. Consult with regulator or tubing manufacturer for guidance.
3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends and/or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$ where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.

*EHD—Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

**TABLE 402.4(30)
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Undiluted propane
Inlet Pressure	5.0 psi
Pressure Drop	3.5 psi
Specific Gravity	1.50

Flow Designation	TUBE SIZE (EHD*)										
	13	15	18	19	23	25	30	31	37	46	62
Length (ft)	Maximum Capacity in Thousands of Btu/h										
10	826	1,065	1,713	2,061	3,153	3,999	7,829	8,945	13,112	28,580	63,788
25	509	664	1,092	1,307	2,037	2,554	4,864	5,600	8,395	17,986	40,436
30	461	603	999	1,193	1,866	2,336	4,430	5,102	7,682	16,403	36,928
40	396	520	867	1,033	1,629	2,029	3,822	4,404	6,679	14,183	32,004
50	352	463	777	926	1,463	1,819	3,409	3,929	5,993	12,670	28,642
75	284	376	637	757	1,206	1,492	2,769	3,194	4,919	10,322	23,409
80	275	363	618	731	1,169	1,446	2,677	3,090	4,768	9,990	22,670
100	243	324	553	656	1,051	1,296	2,388	2,756	4,276	8,925	20,287
150	196	262	453	535	866	1,062	1,941	2,241	3,511	7,271	16,581
200	169	226	393	464	755	923	1,675	1,934	3,052	6,287	14,369
250	150	202	352	415	679	828	1,493	1,726	2,738	5,616	12,859
300	136	183	322	379	622	757	1,359	1,572	2,505	5,122	11,745
400	117	158	279	328	542	657	1,173	1,356	2,178	4,429	10,178
500	104	140	251	294	488	589	1,046	1,210	1,954	3,957	9,108

For SI: 1 foot = 305 mm, 1 pound per square inch = 6.895 kPa, 1 British thermal unit per hour = 0.2931 W, 1 degree = 0.01745 rad.

Notes:

1. Table does not include effect of pressure drop across line regulator. Where regulator loss exceeds 1 psi, DO NOT USE THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator may vary with flow rate.
2. CAUTION: Capacities shown in table may exceed maximum capacity of selected regulator. Consult with tubing manufacturer for guidance.
3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends and/or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$ where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.

*EHD—Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

**TABLE 402.4(31)
POLYETHYLENE PLASTIC PIPE**

Gas	Undiluted propane
Inlet Pressure	11.0 inch WC
Pressure Drop	0.5 inch WC
Specific Gravity	1.50

Nominal OD	PIPE SIZE (in.)					
	1/2	3/4	1	1 1/4	1 1/2	2
Designation	SDR 9.33	SDR 11.0	SDR 11.00	SDR 10.00	SDR 11.00	SDR 11.00
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	Maximum Capacity in Thousands of Btu/h					
10	340	680	1,227	2,126	3,211	5,769
20	233	467	844	1,461	2,207	3,965
30	187	375	677	1,173	1,772	3,184
40	160	321	580	1,004	1,517	2,725
50	142	285	514	890	1,344	2,415
60	129	258	466	807	1,218	2,188
70	119	237	428	742	1,121	2,013
80	110	221	398	690	1,042	1,873
90	103	207	374	648	978	1,757
100	98	196	353	612	924	1,660
125	87	173	313	542	819	1,471
150	78	157	284	491	742	1,333
175	72	145	261	452	683	1,226
200	67	135	243	420	635	1,141

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W, 1 degree = 0.01745 rad.

Notes:

1. Table does not include effect of pressure drop across line regulator. If regulator loss exceeds 1 psi, **DO NOT USE THIS TABLE**. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drop across regulator may vary with the flow rate.
2. CAUTION: Capacities shown in table may exceed maximum capacity of selected regulator. Consult with tubing manufacturer for guidance.
3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends and/or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$ where L is additional length (feet) of tubing and n is the number of additional fittings and/or bends.

*EHD—Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

**TABLE 402.4(32)
POLYETHYLENE PLASTIC PIPE**

Gas	Undiluted propane
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

Nominal OD	PIPE SIZE (in.)					
	1/2	3/4	1	1 1/4	1 1/2	2
Designation	SDR 9.33	SDR 11.0	SDR 11.00	SDR 10.00	SDR 11.00	SDR 11.00
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	Maximum Capacity in Thousands of Btu/h					
10	3,126	6,259	11,293	19,564	29,545	53,085
20	2,148	4,302	7,762	13,446	20,306	36,485
30	1,725	3,454	6,233	10,798	16,307	29,299
40	1,477	2,957	5,335	9,242	13,956	25,076
50	1,309	2,620	4,728	8,191	12,369	22,225
60	1,186	2,374	4,284	7,421	11,207	20,137
70	1,091	2,184	3,941	6,828	10,311	18,526
80	1,015	2,032	3,666	6,352	9,592	17,235
90	952	1,907	3,440	5,960	9,000	16,171
100	899	1,801	3,249	5,629	8,501	15,275
125	797	1,596	2,880	4,989	7,535	13,538
150	722	1,446	2,609	4,521	6,827	12,266
175	664	1,331	2,401	4,159	6,281	11,285
200	618	1,238	2,233	3,869	5,843	10,498

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 British thermal unit per hour = 0.2931 W.

**TABLE 402.4(33)
POLYETHYLENE PLASTIC TUBING**

Gas	Undiluted propane
Inlet pressure	11.0 inch WC
Pressure Drop	0.5 inch WC
Specific Gravity	1.50

Nominal OD	PLASTIC TUBING SIZE (CTS) (in.)	
	$\frac{1}{2}$	$\frac{3}{4}$
Designation	SDR 7.00	SDR 11.00
Actual ID	0.445	0.927
Length (ft)	Maximum Capacity in Thousands of Btu/h	
10	121	828
20	83	569
30	67	457
40	57	391
50	51	347
60	46	314
70	42	289
80	39	269
90	37	252
100	35	238
125	31	211
150	28	191
175	26	176
200	24	164
225	22	154
250	21	145
275	20	138
300	19	132
350	18	121
400	16	113

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W, 1-inch water column = 0.2488 kPa.

**SECTION 403 (IFGS)
PIPING MATERIALS**

403.1 General. Materials used for piping systems shall comply with the requirements of this chapter or shall be approved.

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

403.3 Other materials. Material not covered by the standards specifications listed herein shall be investigated and tested to determine that it is safe and suitable for the proposed service, and, in addition, shall be recommended for that service by the manufacturer and shall be approved by the code official.

403.4 Metallic pipe. Metallic pipe shall comply with Sections 403.4.1 through 403.4.4.

403.4.1 Cast iron. Cast-iron pipe shall not be used.

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

1. ASME B 36.10, 10M
2. ASTM A 53; or
3. ASTM A 106.

403.4.3 Copper and brass. Copper and brass pipe shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet of gas (0.7 milligrams per 100 liters). Threaded copper, brass and aluminum-alloy pipe shall not be used with gases corrosive to such materials.

403.4.4 Aluminum. Aluminum-alloy pipe shall comply with ASTM B241 (except that the use of alloy 5456 is prohibited), and shall be marked at each end of each length indicating compliance. Aluminum-alloy pipe shall be coated to protect against external corrosion where it is in contact with masonry, plaster, or insulation, or is subject to repeated wettings by such liquids as water, detergents, or sewage. Aluminum-alloy pipe shall not be used in exterior locations or underground.

403.5 Metallic tubing. Seamless copper, aluminum alloy and steel tubing shall not be used with gases corrosive to such materials.

403.5.1 Steel tubing. Steel tubing shall comply with ASTM A 254 or ASTM A 539.

403.5.2 Copper and brass tubing. Copper tubing shall comply with Standard Type K or L of ASTM B 88 or ASTM B 280.

Copper and brass tubing shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet of gas (0.7 milligrams per 100 liters).

403.5.3 Aluminum tubing. Aluminum-alloy tubing shall comply with ASTM B 210 or ASTM B 241. Aluminum-alloy tubing shall be coated to protect against external corrosion where it is in contact with masonry, plaster or insulation, or is subject to repeated wettings by such liquids as water, detergent or sewage.

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

403.5.4 Corrugated stainless steel tubing. Corrugated stainless steel tubing shall be tested and listed in compliance with the construction, installation and performance requirements of ANSI LC 1/CSA 6.26.

403.6 Plastic pipe, tubing and fittings. Plastic pipe, tubing and fittings shall be used outside, underground, only, and shall conform

to ASTM D 2513. Pipe shall be marked “gas” and “ASTM D 2513.”

403.6.1 Anodeless risers. Plastic pipe, tubing and anodeless risers shall comply with the following:

1. Factory-assembled anodeless risers shall be recommended by the manufacturer for the gas used and shall be leak tested by the manufacturer in accordance with written procedures.
2. Service head adapters and field-assembled anodeless risers incorporating service head adapters shall be recommended by the manufacturer for the gas used, and shall be designed and certified to meet the requirements of Category I of ASTM D 2513, and U.S. Department of Transportation, Code of Federal Regulations, Title 49, Part 192.281(e). The manufacturer shall provide the user with qualified installation instructions as prescribed by the U.S. Department of Transportation, Code of Federal Regulations, Title 49, Part 192.283(b).

403.6.2 LP-gas systems. The use of plastic pipe, tubing and fittings in undiluted liquefied petroleum gas piping systems shall be in accordance with NFPA 58.

403.7 Workmanship and defects. Pipe, tubing and fittings shall be clear and free from cutting burrs and defects in structure or threading, and shall be thoroughly brushed, and chip and scale blawn.

Defects in pipe, tubing and fittings shall not be repaired. Defective pipe, tubing and fittings shall be replaced (see Section 406.1.2).

No gas piping shall be strained or pinched, and no appliance shall be supported by, or develop any strain or stress on its supply piping.

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

403.9 Metallic pipe threads. Metallic pipe and fitting threads shall be taper pipe threads and shall comply with ASME B1.20.1.

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

403.9.2 Number of threads. Field threading of metallic pipe shall be in accordance with Table 403.9.2.

**TABLE 403.9.2
SPECIFICATIONS FOR THREADING METALLIC PIPE**

IRON PIPE SIZE (inches)	APPROXIMATE LENGTH OF THREADED PORTION (inches)	APPROXIMATE NUMBER OF THREADS TO BE CUT
1/2	3/4	10
3/4	3/4	10
1	7/8	10
1 1/4	1	11
1 1/2	1	11
2	1	11
2 1/2	1 1/2	12
3	1 1/2	12
4	1 5/8	13

For SI: 1 inch = 25.4 mm.

403.9.3 Thread compounds. Thread (joint) compounds (pipe dope) shall be resistant to the action of liquefied petroleum gas

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or to any other chemical constituents of the gases to be conducted through the piping.

403.10 Metallic piping joints and fittings. The type of piping joint used shall be suitable for the pressure-temperature conditions and shall be selected giving consideration to joint tightness and mechanical strength under the service conditions. The joint shall be able to sustain the maximum end force caused by the internal pressure and any additional forces caused by temperature expansion or contraction, vibration, fatigue or the weight of the pipe and its contents.

403.10.1 Pipe joints. Pipe joints shall be threaded, flanged, brazed or welded. Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1,000°F (538°C). Brazing alloys shall not contain more than 0.05-percent phosphorus.

403.10.1.1 All welding in the piping system shall be done in accordance with ASME Boiler and Pressure Vessel Code Section IX.

403.10.2 Tubing joints. Tubing joints shall be either made with approved gas tubing fittings or brazed with a material having a melting point in excess of 1,000°F (538°C). Brazing alloys shall not contain more than 0.05-percent phosphorus.

403.10.3 Flared joints. Flared joints shall be used only in systems constructed from nonferrous pipe and tubing where experience or tests have demonstrated that the joint is suitable for the conditions and where provisions are made in the design to prevent separation of the joints.

403.10.4 Metallic fittings. Metallic fittings, including valves, strainers and filters, shall comply with the following:

1. Threaded fittings in sizes larger than 4 inches (102 mm) shall not be used except where approved.
2. Fittings used with steel or wrought-iron pipe shall be steel, brass, bronze, malleable iron or cast iron.
3. Fittings used with copper or brass pipe shall be copper, brass or bronze.
4. Fittings used with aluminum-alloy pipe shall be of aluminum alloy.
5. Cast-iron fittings:
 - 5.1. Flanges shall be permitted.
 - 5.2. Bushings shall not be used.
 - 5.3. Fittings shall not be used in systems containing flammable gas-air mixtures.
 - 5.4. Fittings in sizes 4 inches (102 mm) and larger shall not be used indoors except where approved.
 - 5.5. Fittings in sizes 6 inches (152 mm) and larger shall not be used except where approved.
6. Aluminum-alloy fittings. Threads shall not form the joint seal.
7. Zinc aluminum-alloy fittings. Fittings shall not be used in systems containing flammable gas-air mixtures.
8. Special fittings. Fittings such as couplings, proprietary-type joints, saddle tees, gland-type compression fittings, and flared, flareless or compression-type tubing fittings shall be: used within the fitting manufacturer's pressure-temperature recommendations; used within the service conditions anticipated with respect to vibration, fatigue, thermal expansion or contraction; installed or braced to prevent separation of the joint by gas pressure or external physical damage; and shall be approved.

403.11 Plastic pipe, joints and fittings. Plastic pipe, tubing and fittings shall be joined in accordance with the manufacturer's instructions. Such joint shall comply with the following:

1. The joint shall be designed and installed so that the longitudinal pull-out resistance of the joint will be at least equal to the tensile strength of the plastic piping material.
2. Heat-fusion joints shall be made in accordance with qualified procedures that have been established and proven by test to produce gas-tight joints at least as strong as the pipe or tubing being joined. Joints shall be made with the joining method recommended by the pipe manufacturer. Heat fusion fittings shall be marked "ASTM D 2513."
3. Where compression-type mechanical joints are used, the gasket material in the fitting shall be compatible with the plastic piping and with the gas distributed by the system. An internal tubular rigid stiffener shall be used in conjunction with the fitting. The stiffener shall be flush with the end of the pipe or tubing and shall extend at least to the outside end of the pipe or tubing and at least to the outside end of the compression fitting when installed. The stiffener shall be free of rough or sharp edges and shall not be a force fit in the plastic. Split tubular stiffeners shall not be used.
4. Plastic piping joints and fittings for use in liquefied petroleum gas piping systems shall be in accordance with NFPA 58.

403.12 Flanges. All flanges shall comply with ASME B16.1, ASME B16.20, AWWA C111/A21.11 or MSS SP-6. The pressure-temperature ratings shall equal or exceed that required by the application.

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

403.12.2 Lapped flanges. Lapped flanges shall be used only above ground or in exposed locations accessible for inspection.

403.13 Flange gaskets. Material for gaskets shall be capable of withstanding the design temperature and pressure of the piping system, and the chemical constituents of the gas being conducted, without change to its chemical and physical properties. The effects of fire exposure to the joint shall be considered in choosing material. Acceptable materials include metal or metal-jacketed asbestos (plain or corrugated), asbestos, and aluminum "O" rings and spiral wound metal gaskets. When a flanged joint is opened, the gasket shall be replaced. Full-face gaskets shall be used with all bronze and cast-iron flanges.

SECTION 404 (IFGC) PIPING SYSTEM INSTALLATION

404.1 Prohibited locations. Piping shall not be installed in or through a circulating air duct, clothes chute, chimney or gas vent, ventilating duct, dumbwaiter or elevator shaft.

404.2 Piping in solid partitions and walls. Concealed piping shall not be located in solid partitions and solid walls, unless installed in a chase or casing.

404.3 Piping in concealed locations. Portions of a piping system installed in concealed locations shall not have unions, tubing fittings, right and left couplings, bushings, compression couplings and swing joints made by combinations of fittings.

Exceptions:

1. Tubing joined by brazing.
2. Fittings listed for use in concealed locations.

404.4 Piping through foundation wall. Underground piping, where installed below grade through the outer foundation or basement wall of a building, shall be encased in a protective pipe

sleeve. The annular space between the gas piping and the sleeve shall be sealed.

404.5 Protection against physical damage. In concealed locations, where piping other than black or galvanized steel is installed through holes or notches in wood studs, joists, rafters or similar members less than 1 inch (25 mm) from the nearest edge of the member, the pipe shall be protected by shield plates. Shield plates shall be a minimum of 1/16-inch-thick (1.6 mm) steel, shall cover the area of the pipe where the member is notched or bored, and shall extend a minimum of 4 inches (102 mm) above sole plates, below top plates and to each side of a stud, joist or rafter.

404.6 Piping in solid floors. Piping in solid floors shall be laid in channels in the floor and covered in a manner that will allow access to the piping with a minimum amount of damage to the building. Where such piping is subject to exposure to excessive moisture or corrosive substances, the piping shall be protected in an approved manner. As an alternative to installation in channels, the piping shall be installed in a casing of Schedule 40 steel, wrought iron, PVC or ABS pipe with tightly sealed ends and joints. Both ends of such casing shall extend not less than 2 inches (51 mm) beyond the point where the pipe emerges from the floor. Piping shall not be installed in solid floors without prior approval of the code official.

404.7 Above-ground outdoor piping. All piping installed outdoors shall be elevated not less than 31/2 inches (152 mm) above ground and where installed across roof surfaces, shall be elevated not less than 31/2 inches (152 mm) above the roof surface. Piping installed above ground, outdoors, and installed across the surface of roofs shall be securely supported and located where it will be protected from physical damage. Where passing through an outside wall, the piping shall also be protected against corrosion by coating or wrapping with an inert material. Where piping is encased in a protective pipe sleeve, the annular space between the piping and the sleeve shall be sealed.

404.8 Protection against corrosion. Metallic pipe or tubing exposed to corrosive action, such as soil condition or moisture, shall be protected in an approved manner. Zinc coatings (galvanizing) shall not be deemed adequate protection for gas piping underground. Ferrous metal exposed in exterior locations shall be protected from corrosion in a manner satisfactory to the code official. Where dissimilar metals are joined underground, an insulating coupling or fitting shall be used. Piping shall not be laid in contact with cinders.

404.8.1 Prohibited use. Uncoated threaded or socket welded joints shall not be used in piping in contact with soil or where internal or external crevice corrosion is known to occur.

404.8.2 Protective coatings and wrapping. Pipe protective coatings and wrappings shall be approved for the application and shall be factory applied.

Exception: Where installed in accordance with the manufacturer's installation instructions, field application of coatings and wrappings shall be permitted for pipe nipples, fittings and locations where the factory coating or wrapping has been damaged or necessarily removed at joints.

404.9 Minimum burial depth. Underground piping systems shall be installed a minimum depth of 12 inches (305 mm) below grade, except as provided for in Section 404.9.1.

404.9.1 Individual outside appliances. Individual lines to outside lights, grills or other appliances shall be installed a minimum of 8 inches (203 mm) below finished grade, provided that such installation is approved and is installed in locations not susceptible to physical damage.

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

404.11 Piping underground beneath buildings. ~~Piping installed underground beneath buildings is prohibited except where the piping is encased in a conduit of wrought iron, plastic pipe, or steel pipe designed to withstand the superimposed loads. Such conduit shall extend into an occupiable portion of the building and, at the point where the conduit terminates in the building, the space between the conduit and the gas piping shall be sealed to prevent the possible entrance of any gas leakage. Where the end sealing is capable of withstanding the full pressure of the gas pipe, the conduit shall be designed for the same pressure as the pipe. Such conduit shall extend not less than 4 inches (102 mm) outside the building, shall be vented above grade to the outdoors, and shall be installed so as to prevent the entrance of water and insects. The conduit shall be protected from corrosion in accordance with Section 404.8.~~

Where the installation of gas piping underground beneath buildings is unavoidable, the piping shall be encased in Schedule 40 steel, wrought iron, PVC or ABS pipe or other material approved by the building official. The casing shall be designed to withstand the superimposed loads. The casing shall extend into a normally usable and accessible portion of the building and, at the point where the casing terminates in the building, the space between the casing and the gas piping shall be sealed to prevent the possible entrance of any gas leakage. Where the end sealing is of a type that will retain the full pressure of the pipe, the casing shall be designed for the same pressure as the pipe. The casing shall extend at least 4 in. (100 mm) outside the building, be vented above grade to the outside, and be installed so as to prevent the entrance of water and insects. Piping shall not be installed underground beneath buildings without prior approval of the code official.

404.12 Outlet closures. Gas outlets that do not connect to appliances shall be capped gas tight.

Exception: Listed and labeled flush-mounted-type quick-disconnect devices and listed and labeled gas convenience outlets shall be installed in accordance with the manufacturer's installation instructions.

404.13 Location of outlets. The unthreaded portion of piping outlets shall extend not less than 1 inch (25 mm) through finished ceilings and walls and where extending through floors or outdoor patios and slabs, shall not be less than 2 inches (51 mm) above them. The outlet fitting or piping shall be securely supported. Outlets shall not be placed behind doors. Outlets shall be located in the room or space where the appliance is installed.

Exception: Listed and labeled flush-mounted-type quick-disconnect devices and listed and labeled gas convenience outlets shall be installed in accordance with the manufacturer's installation instructions.

404.14 Plastic pipe. The installation of plastic pipe shall comply with Sections 404.14.1 through 404.14.3.

404.14.1 Limitations. Plastic pipe shall be installed outside underground only. Plastic pipe shall not be used within or under any building or slab or be operated at pressures greater than 100 psig (689 kPa) for natural gas or 30 psig (207 kPa) for LP-gas.

Exceptions:

- ± Plastic pipe shall be permitted to terminate above ground outside of buildings where installed in premanufactured anodeless risers or service head adapter risers that are installed in accordance with the manufacturer's installation instructions.

~~2. Plastic pipe shall be permitted to terminate with a wall head adapter within buildings where the plastic pipe is inserted in a piping material for fuel gas use in buildings.~~

404.14.2 Connections. Connections made outside and underground between metallic and plastic piping shall be made only with transition fittings categorized as Category I in accordance with ASTM D 2513.

404.14.3 Tracer. A yellow insulated copper tracer wire or other approved conductor shall be installed adjacent to underground nonmetallic piping. Access shall be provided to the tracer wire or the tracer wire shall terminate above ground at each end of the nonmetallic piping. The tracer wire size shall not be less than 18 AWG and the insulation type shall be suitable for direct burial.

404.15 Prohibited devices. A device shall not be placed inside the piping or fittings that will reduce the cross-sectional area or otherwise obstruct the free flow of gas.

Exception: Approved gas filters.

404.16 Testing of piping. Before any system of piping is put in service or concealed, it shall be tested to ensure that it is gas tight. Testing, inspection and purging of piping systems shall comply with Section 406.

SECTION 405 (IFGS)

PIPING BENDS AND CHANGES IN DIRECTION

405.1 General. Changes in direction of pipe shall be permitted to be made by the use of fittings, factory bends, or field bends.

405.2 Metallic pipe. Metallic pipe bends shall comply with the following:

1. Bends shall be made only with bending equipment and procedures intended for that purpose.
2. All bends shall be smooth and free from buckling, cracks, or other evidence of mechanical damage.
3. The longitudinal weld of the pipe shall be near the neutral axis of the bend.
4. Pipe shall not be bent through an arc of more than 90 degrees (1.6 rad).
5. The inside radius of a bend shall be not less than six times the outside diameter of the pipe.

405.3 Plastic pipe. Plastic pipe bends shall comply with the following:

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

405.4 Mitered bends. Mitered bends are permitted subject to the following limitations:

1. Miters shall not be used in systems having a design pressure greater than 50 psig (340 kPa gauge). Deflections caused by misalignments up to 3 degrees (0.05 rad) shall not be considered as miters.
2. The total deflection angle at each miter shall not exceed 90 degrees (1.6 rad).

405.5 Elbows. Factory-made welding elbows or transverse segments cut therefrom shall have an arc length measured along the crotch at least 1 inch (25 mm) in pipe sizes 2 inches (51 mm) and larger.

SECTION 406 (IFGS)

INSPECTION, TESTING AND PURGING

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

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

406.1.2 Repairs and additions. In the event repairs or additions are made after the pressure test, the affected piping shall be tested.

Minor repairs and additions, as determined by the building official, are not required to be pressure tested provided that the work is inspected and connections are tested with a noncorrosive leak-detecting fluid or other approved leak-detecting methods.

406.1.3 New branches. Where new branches are installed from the point of delivery to new appliances, only the newly installed branches shall be required to be pressure tested. Connections between the new piping and the existing piping shall be tested with a noncorrosive leak-detecting fluid or other approved leak-detecting methods.

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

406.1.5 Regulators and valve assemblies. Regulator and valve assemblies fabricated independently of the piping system in which they are to be installed shall be permitted to be tested with inert gas or air at the time of fabrication.

406.2 Test medium. The test medium shall be air, nitrogen, carbon dioxide or an inert gas. Oxygen shall not be used.

406.3 Test preparation. Pipe joints, including welds, shall be left exposed for examination during the test.

Exception: Covered or concealed pipe end joints that have been previously tested in accordance with this code.

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

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

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

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

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

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

406.4.1 Test pressure. ~~The test pressure to be used shall be no less than 1 1/2 times the proposed maximum working pressure, but not less than 3 psig (20 kPa gauge), irrespective of design pressure. Where the test pressure exceeds 125 psig (862 kPa gauge), the test pressure shall not exceed a value that produces a hoop stress in the piping greater than 50 percent of the specified minimum yield strength of the pipe.~~

406.4.2 Test duration. ~~Test duration shall be not less than 1/2 hour for each 500 cubic feet (14 m³) of pipe volume or fraction thereof. When testing a system having a volume less than 10 cubic feet (0.28m³) or a system in a single family dwelling, the test duration shall be not less than 10 minutes. The duration of the test shall not be required to exceed 24 hours.~~

The test pressure for gas piping systems less than 14 inch (356 mm) water column shall be fifteen psig. The test gauge shall have a pressure range of 30 psig. The test pressure shall be held for a length of time satisfactory to the code official, but in no case less than fifteen minutes, with no perceptible drop in pressure.

For welded pipe and for pipe carrying gas at pressures in excess of 14 inch (356 mm) water column, the test pressure shall be 60 psig (413.4 mm). The test gauge shall have a pressure range of 100 psig. The test pressure shall be held for a length of time satisfactory to the code official, but in no case less than 30 minutes.

406.5 Detection of leaks and defects. The piping system shall withstand the test pressure specified without showing any evidence of leakage or other defects.

Any reduction of test pressures as indicated by pressure gauges shall be deemed to indicate the presence of a leak unless such reduction can be readily attributed to some other cause.

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

406.5.2 Corrections. Where leakage or other defects are located, the affected portion of the piping system shall be repaired or replaced and retested.

406.6 System and equipment leakage test. Leakage testing of systems and equipment shall be in accordance with Sections 406.6.1 through 406.6.4.

406.6.1 Test gases. Leak checks using fuel gas shall be permitted in piping systems that have been pressure tested in accordance with Section 406.

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

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

406.6.4 Placing equipment in operation. Gas utilization equipment shall be permitted to be placed in operation after the piping system has been tested and determined to be free of leakage and purged in accordance with Section 406.7.2.

406.7 Purging. Purging of piping shall comply with Sections 406.7.1 through 406.7.4.

406.7.1 Removal from service. Where gas piping is to be opened for servicing, addition, or modification, the section to be worked on shall be turned off from the gas supply at the nearest convenient point, and the line pressure vented to the outdoors, or to ventilated areas of sufficient size to prevent accumulation of flammable mixtures.

The remaining gas in this section of pipe shall be displaced with an inert gas as required by Table 406.7.1.

**TABLE 406.7.1
LENGTH OF PIPING REQUIRING PURGING WITH INERT GAS
FOR SERVICING OR MODIFICATION**

NOMINAL PIPE SIZE (inches)	LENGTH OF PIPING REQUIRING PURGING
2 1/2	> 50 feet
3	> 30 feet
4	> 15 feet
6	> 10 feet
8 or larger	Any length

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

406.7.2 Placing in operation. Where piping full of air is placed in operation, the air in the piping shall be displaced with fuel gas, except where such piping is required by Table 406.7.2 to be purged with an inert gas prior to introduction of fuel gas. The air can be safely displaced with fuel gas provided that a moderately rapid and continuous flow of fuel gas is introduced at one end of the line and air is vented out at the other end. The fuel gas flow shall be continued without interruption until the vented gas is free of air. The point of discharge shall not be left unattended during purging. After purging, the vent shall then be closed. Where required by Table 406.7.2, the air in the piping shall first be displaced with an inert gas, and the inert gas shall then be displaced with fuel gas.

**TABLE 406.7.2
LENGTH OF PIPING REQUIRING PURGING WITH INERT GAS
BEFORE PLACING IN OPERATION**

NOMINAL PIPE SIZE (inches)	LENGTH OF PIPING REQUIRING PURGING
3	> 30 feet
4	> 15 feet
6	> 10 feet
8 or larger	Any length

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

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

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

SECTION 407 (IFGC) PIPING SUPPORT

407.1 General. Piping shall be provided with support in accordance with Section 407.2.

407.2 Design and installation. Piping shall be supported with pipe hooks, metal pipe straps, bands, brackets, or hangers suitable for the size of piping, of adequate strength and quality, and located at intervals so as to prevent or damp out excessive vibration. Piping shall be anchored to prevent undue strains on connected equipment and shall not be supported by other piping. Pipe hangers and supports shall conform to the requirements of MSS SP-58 and shall be spaced in accordance with Section 415. Supports, hangers, and anchors shall be installed so as not to interfere with the free expansion and contraction of the piping between anchors. All parts of the supporting equipment shall be designed and installed so they will not be disengaged by movement of the supported piping.

SECTION 408 (IFGC) DRIPS AND SLOPED PIPING

408.1 Slopes. Piping for other than dry gas conditions shall be sloped not less than 1/4 inch in 15 feet (6.3 mm in 4572 mm) to prevent traps.

408.2 Drips. Where wet gas exists, a drip shall be provided at any point in the line of pipe where condensate could collect. A drip shall also be provided at the outlet of the meter and shall be installed so as to constitute a trap wherein an accumulation of condensate will shut off the flow of gas before the condensate will run back into the meter.

408.3 Location of drips. Drips shall be provided with ready access to permit cleaning or emptying. A drip shall not be located where the condensate is subject to freezing.

408.4 Sediment trap. Where a sediment trap is not incorporated as part of the gas utilization equipment, a sediment trap shall be installed downstream of the equipment shutoff valve as close to the inlet of the equipment as practical. The sediment trap shall be either a tee fitting with a capped nipple in the bottom opening of the run of the tee or other device approved as an effective sediment trap. Illuminating appliances, ranges, clothes dryers and outdoor grills need not be so equipped.

SECTION 409 (IFGC) SHUTOFF VALVES

409.1 General. Piping systems shall be provided with shutoff valves in accordance with this section.

409.1.1 Valve approval. Shutoff valves shall be of an approved type. Shutoff valves shall be constructed of materials compatible with the piping. Shutoff valves installed in a portion of a piping system operating above 0.5 psig shall comply with ASME B 16.33. Shutoff valves installed in a portion of a piping system operating at 0.5 psig or less shall comply with ANSI Z 21.15 or ASME B 16.33.

409.1.2 Prohibited locations. Shutoff valves shall be prohibited in concealed locations and furnace plenums.

409.1.3 Access to shutoff valves. Shutoff valves shall be located in places so as to provide access for operation and shall be installed so as to be protected from damage.

409.2 Meter valve. Every meter shall be equipped with a shutoff valve located on the supply side of the meter.

409.3 Shutoff valves for multiple-house line systems. Where a single meter is used to supply gas to more than one building or tenant, a separate shutoff valve shall be provided for each building or tenant.

409.3.1 Multiple tenant buildings. In multiple tenant buildings, where a common piping system is installed to supply other than

one- and two-family dwellings, shutoff valves shall be provided for each tenant. Each tenant shall have access to the shutoff valve serving that tenant's space.

409.3.2 Individual buildings. In a common system serving more than one building, shutoff valves shall be installed outdoors at each building.

409.3.3 Identification of shutoff valves. Each house line shutoff valve shall be plainly marked with an identification tag attached by the installer so that the piping systems supplied by such valves are readily identified.

409.4 MP Regulator valves. A listed shutoff valve shall be installed immediately ahead of each MP regulator.

409.5 Equipment shutoff valve. Each appliance shall be provided with a shutoff valve separate from the appliance. The shutoff valve shall be located in the same room as the appliance, not further than 6 feet (1829 mm) from the appliance, and shall be installed upstream from the union, connector or quick disconnect device it serves. Such shutoff valves shall be provided with access.

Exception: Shutoff valves for vented decorative appliances and decorative appliances for installation in vented fireplaces shall not be prohibited from being installed in an area remote from the appliance where such valves are provided with ready access. Such valves shall be permanently identified and shall serve no other equipment. Piping from the shutoff valve to within 3 feet (914 mm) of the appliance connection shall be sized in accordance with Section 402.

409.5.1 Shutoff valve in fireplace. Equipment shutoff valves located in the firebox of a fireplace shall be installed in accordance with the appliance manufacturer's instructions.

SECTION 410 (IFGC) FLOW CONTROLS

410.1 Pressure regulators. A line pressure regulator shall be installed where the appliance is designed to operate at a lower pressure than the supply pressure. Access shall be provided to pressure regulators. Pressure regulators shall be protected from physical damage. Regulators installed on the exterior of the building shall be approved for outdoor installation.

410.2 MP regulators. MP pressure regulators shall comply with the following:

1. The MP regulator shall be approved and shall be suitable for the inlet and outlet gas pressures for the application.
2. The MP regulator shall maintain a reduced outlet pressure under lockup (no-flow) conditions.
3. The capacity of the MP regulator, determined by published ratings of its manufacturer, shall be adequate to supply the appliances served.
4. The MP pressure regulator shall be provided with access. Where located indoors, the regulator shall be vented to the outdoors or shall be equipped with a leak-limiting device, in either case complying with Section 410.3.
5. A tee fitting with one opening capped or plugged shall be installed between the MP regulator and its upstream shutoff valve. Such tee fitting shall be positioned to allow connection of a pressure-measuring instrument and to serve as a sediment trap.
6. A tee fitting with one opening capped or plugged shall be installed not less than 10 pipe diameters downstream of the MP regulator outlet. Such tee fitting shall be positioned to allow connection of a pressure-measuring instrument.

410.3 Venting of regulators. Pressure regulators that require a vent shall have an independent vent to the outside of the building.

The vent shall be designed to prevent the entry of water or foreign objects.

Exception: ~~A vent to the outside of the building is not required for regulators equipped with and labeled for utilization with approved vent limiting devices installed in accordance with the manufacturer's instructions.~~

Regulators equipped with limiting orifices capable of releasing not more than 5 cubic feet of gas per hour (0.04 L/sec), when supplied with medium pressure, need not be vented to an outside location when the regulators have been approved by the code official. The regulators shall:

1. Have an approved gas valve in the line upstream of the regulator;
2. Be accessible;
3. Have upstream pressure identified by a metal tag permanently attached to the regulator that states: "WARNING 1/2 to 5 pounds (3.4- 34.5 kPa) natural gas pressure. DO NOT REMOVE"; and
4. Be in an area approved by the code official that communicates with a naturally ventilated area.

SECTION 411 (IFGC) APPLIANCE CONNECTIONS

411.1 Connecting appliances. Appliances shall be connected to the piping system by one of the following:

1. Rigid metallic pipe and fittings.
2. Semirigid metallic tubing and metallic fittings. Lengths shall not exceed 6 feet (1829 mm) and shall be located entirely in the same room as the appliance. Semirigid metallic tubing shall not enter a motor-operated appliance through an unprotected knockout opening.
3. Listed and labeled appliance connectors installed in accordance with the manufacturer's installation instructions and located entirely in the same room as the appliance.
4. Listed and labeled quick-disconnect devices used in conjunction with listed and labeled appliance connectors.
5. Listed and labeled convenience outlets used in conjunction with listed and labeled appliance connectors.
6. Listed and labeled appliance connectors complying with ANSI Z21.69 and listed for use with food service equipment having casters, or that is otherwise subject to movement for cleaning, and other large movable equipment.

411.1.1 Protection from damage. Connectors and tubing shall be installed so as to be protected against physical damage.

411.1.2 Appliance fuel connectors. Connectors shall have an overall length not to exceed 3 feet (914 mm), except for range and domestic clothes dryer connectors, which shall not exceed 6 feet (1829 mm) in length. Connectors shall not be concealed within, or extended through, walls, floors, partitions, ceilings or appliance housings. A shutoff valve not less than the nominal size of the connector shall be installed ahead of the connector in accordance with Section 409.5. Connectors shall be sized to provide the total demand of the connected appliance.

Exception: Fireplace inserts factory equipped with grommets, sleeves, or other means of protection in accordance with the listing of the appliance.

Note: This exception applies to grommets that are included in the listing of the appliance.

411.1.3 Movable appliances. Where appliances are equipped with casters or are otherwise subject to periodic movement or relocation for purposes such as routine cleaning and maintenance, such appliances shall be connected to the supply system piping by means of an approved flexible connector

designed and labeled for the application. Such flexible connectors shall be installed and protected against physical damage in accordance with the manufacturer's installation instructions.

SECTION 412 (IFGC) LIQUEFIED PETROLEUM GAS MOTOR VEHICLE FUEL- DISPENSING STATIONS

412.1 General. Motor fuel-dispensing facilities for LP-gas fuel shall be in accordance with this section and the *International Fire Code*. The operation of LP-gas motor fuel-dispensing facilities shall be regulated by the *International Fire Code*.

412.2 Storage and dispensing. Storage vessels and equipment used for the storage or dispensing of LP-gas shall be approved or listed in accordance with Sections 412.3 and 412.4.

412.3 Approved equipment. Containers; pressure-relief devices, including pressure-relief valves; and pressure regulators and piping used for LP-gas shall be approved.

412.4 Listed equipment. Hoses, hose connections, vehicle fuel connections, dispensers, LP-gas pumps and electrical equipment used for LP-gas shall be listed.

412.5 Attendants. Motor vehicle fueling operations shall be conducted by qualified attendants or in accordance with Section 412.8 by persons trained in the proper handling of LP-gas.

412.6 Location. In addition to the fuel dispensing requirements of the *International Fire Code*, the point of transfer for dispensing operations shall be 25 feet (7620 mm) or more from buildings having combustible exterior wall surfaces, buildings having noncombustible exterior wall surfaces that are not part of a 1-hour fire-resistance-rated assembly or buildings having combustible overhangs, property which could be built on public streets, or sidewalks and railroads; and at least 10 feet (3048 mm) from driveways and buildings having noncombustible exterior wall surfaces that are part of a fire-resistance-rated assembly having a rating of 1 hour or more.

Exception: The point of transfer for dispensing operations need not be separated from canopies providing weather protection for the dispensing equipment constructed in accordance with the *International Building Code*.

Liquefied petroleum gas containers shall be located in accordance with the *International Fire Code*. Liquefied petroleum gas storage and dispensing equipment shall be located outdoors and in accordance with the *International Fire Code*.

412.7 Installation of dispensing devices and equipment. The installation and operation of LP-gas dispensing systems shall be in accordance with this section and the *International Fire Code*. Liquefied petroleum gas dispensers and dispensing stations shall be installed in accordance with manufacturers' specifications and their listing.

412.7.1 Valves. A manual shutoff valve and an excess flow-control check valve shall be located in the liquid line between the pump and the dispenser inlet where the dispensing device is installed at a remote location and is not part of a complete storage and dispensing unit mounted on a common base.

An excess flow-control check valve or an emergency shutoff valve shall be installed in or on the dispenser at the point at which the dispenser hose is connected to the liquid piping. A differential backpressure valve shall be considered equivalent protection. A listed shutoff valve shall be located at the discharge end of the transfer hose.

412.7.2 Hoses. Hoses and piping for the dispensing of LP-gas shall be provided with hydrostatic relief valves. The hose length

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shall not exceed 18 feet (5486 mm). An approved method shall be provided to protect the hose against mechanical damage.

412.7.3 Vehicle impact protection. Vehicle impact protection for LP-gas storage containers, pumps and dispensers shall be provided in accordance with the *International Fire Code*.

412.8 Private fueling of motor vehicles. Self-service LP-gas dispensing systems, including key, code and card lock dispensing systems, shall not be open to the public and shall be limited to the filling of permanently mounted fuel containers on LP-gas powered vehicles. In addition to the requirements in the *International Fire Code*, self-service LP-gas dispensing systems shall be provided with an emergency shutoff switch located within 100 feet (30 480 mm) of, but not less than 20 feet (6096 mm) from, dispensers and the owner of the dispensing facility shall ensure the safe operation of the system and the training of users.

SECTION 413 (IFGC)

COMPRESSED NATURAL GAS MOTOR VEHICLE FUEL-DISPENSING STATIONS

413.1 General. Motor fuel-dispensing facilities for CNG fuel shall be in accordance with this section and the *International Fire Code*. The operation of CNG motor fuel-dispensing facilities shall be regulated by the *International Fire Code*.

413.2 General. Storage vessels and equipment used for the storage, compression or dispensing of CNG shall be approved or listed in accordance with Sections 413.2.1 and 413.2.2.

413.2.1 Approved equipment. Containers; compressors; pressure-relief devices, including pressure-relief valves; and pressure regulators and piping used for CNG shall be approved.

413.2.2 Listed equipment. Hoses, hose connections, dispensers, gas detection systems and electrical equipment used for CNG shall be listed. Vehicle fueling connections shall be listed and labeled.

413.3 Location of dispensing operations and equipment. Compression, storage and dispensing equipment shall be located above ground outside.

Exceptions:

1. Compression, storage or dispensing equipment is allowed in buildings of noncombustible construction, as set forth in the *International Building Code*, which are unenclosed for three-quarters or more of the perimeter.
2. Compression, storage and dispensing equipment is allowed to be located indoors in accordance with the *International Fire Code*.

413.3.1 Location on property. In addition to the fuel-dispensing requirements of the *International Fire Code*, compression, storage and dispensing equipment shall not be installed:

1. Beneath power lines,
2. Less than 10 feet (3048 mm) from the nearest building or property line which could be built on, public street, sidewalk, or source of ignition.

Exception: Dispensing equipment need not be separated from canopies providing weather protection for the dispensing equipment constructed in accordance with the *International Building Code*.

3. Less than 25 feet (7620 mm) from the nearest rail of any railroad track.
4. Less than 50 feet (15 240 mm) from the nearest rail of any railroad main track or any railroad or transit line where power for train propulsion is provided by an outside electrical source such as third rail or overhead catenary.

5. Less than 50 feet (15 240 mm) from the vertical plane below the nearest overhead wire of a trolley bus line.

413.4 Private fueling of motor vehicles. Self-service CNG-dispensing systems, including key, code and card lock dispensing systems, shall be limited to the filling of permanently mounted fuel containers on CNG-powered vehicles.

In addition to the requirements in the *International Fire Code*, the owner of a self-service CNG-dispensing facility shall ensure the safe operation of the system and the training of users.

413.5 Pressure regulators. Pressure regulators shall be designed, installed or protected so their operation will not be affected by the elements (freezing rain, sleet, snow, ice, mud or debris). This protection is allowed to be integral with the regulator.

413.6 Valves. Piping to equipment shall be provided with a manual shutoff valve. Such valve shall be provided with ready access.

413.7 Emergency shutdown equipment. An emergency shutdown device shall be located within 75 feet (22 860 mm) of, but not less than 25 feet (7620 mm) from, dispensers and shall also be provided in the compressor area. Upon activation, the emergency shutdown shall automatically shut off the power supply to the compressor and close valves between the main gas supply and the compressor and between the storage containers and dispensers.

413.8 Discharge of CNG from motor vehicle fuel storage containers. The discharge of CNG from motor vehicle fuel cylinders for the purposes of maintenance, cylinder certification, calibration of dispensers or other activities shall be in accordance with this section. The discharge of CNG from motor vehicle fuel cylinders shall be accomplished through a closed transfer system or an approved method of atmospheric venting in accordance with Section 413.8.1 or 413.8.2.

413.8.1 Closed transfer system. A documented procedure which explains the logical sequence for discharging the cylinder shall be provided to the code official for review and approval. The procedure shall include what actions the operator will take in the event of a low-pressure or high-pressure natural gas release during the discharging activity. A drawing illustrating the arrangement of piping, regulators and equipment settings shall be provided to the code official for review and approval. The drawing shall illustrate the piping and regulator arrangement and shall be shown in spatial relation to the location of the compressor, storage vessels and emergency shutdown devices.

413.8.2 Atmospheric venting. Atmospheric venting of motor vehicle fuel cylinders shall be in accordance with Sections 413.8.2.1 through 413.8.2.6.

413.8.2.1 Plans and specifications. A drawing illustrating the location of the vessel support, piping, the method of grounding and bonding, and other requirements specified herein shall be provided to the code official for review and approval.

413.8.2.2 Cylinder stability. A method of rigidly supporting the vessel during the venting of CNG shall be provided. The selected method shall provide not less than two points of support and shall prevent the horizontal and lateral movement of the vessel. The system shall be designed to prevent the movement of the vessel based on the highest gas-release velocity through valve orifices at the vessel's rated pressure and volume. The structure or appurtenance shall be constructed of noncombustible materials.

413.8.2.3 Separation. The structure or appurtenance used for stabilizing the cylinder shall be separated from the site

equipment, features and exposures and shall be located in accordance with Table 413.8.2.3.

**TABLE 413.8.2.3
SEPARATION DISTANCE FOR ATMOSPHERIC VENTING OF CNG**

EQUIPMENT OR FEATURE	MINIMUM SEPARATION (feet)
Buildings	25
Building openings	25
Lot lines	15
Public ways	15
Vehicles	25
CNG compressor and storage vessels	25
CNG dispensers	25

For SI: 1 foot = 304.8 mm.

413.8.2.4 Grounding and bonding. The structure or appurtenance used for supporting the cylinder shall be grounded in accordance with the ~~ICC~~ *Seattle Electrical Code*. The cylinder valve shall be bonded prior to the commencement of venting operations.

413.8.2.5 Vent tube. A vent tube that will divert the gas flow to the atmosphere shall be installed on the cylinder prior to the commencement of the venting and purging operation. The vent tube shall be constructed of pipe or tubing materials approved for use with CNG in accordance with the *International Fire Code*.

The vent tube shall be capable of dispersing the gas a minimum of 10 feet (3048 mm) above grade level. The vent tube shall not be provided with a rain cap or other feature which would limit or obstruct the gas flow.

At the connection fitting of the vent tube and the CNG cylinder, a listed bidirectional detonation flame arrester shall be provided.

413.8.2.6 Signage. Approved NO SMOKING signs shall be posted within 10 feet (3048 mm) of the cylinder support structure or appurtenance. Approved CYLINDER SHALL BE BONDED signs shall be posted on the cylinder support structure or appurtenance.

**SECTION 414 (IFGC)
SUPPLEMENTAL AND STANDBY GAS SUPPLY**

414.1 Use of air or oxygen under pressure. Where air or oxygen under pressure is used in connection with the gas supply, effective means such as a backpressure regulator and relief valve shall be provided to prevent air or oxygen from passing back into the gas piping. Where oxygen is used, installation shall be in accordance with NFPA 51.

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

**SECTION 415 (IFGS)
PIPING SUPPORT INTERVALS**

415.1 Interval of support. Piping shall be supported at intervals not exceeding the spacing specified in Table 415.1. Spacing of supports for CSST shall be in accordance with the CSST manufacturer's instructions.

**TABLE 415.1
SUPPORT OF PIPING**

STEEL PIPE, NOMINAL SIZE OF PIPE (inches)	SPACING OF SUPPORTS (feet)	NOMINAL SIZE OF TUBING (SMOOTH-WALL) (inch O.D.)	SPACING OF SUPPORTS (feet)
1/2	6	1/2	4
3/4 or 1	8	5/8 or 3/4	6
1 1/4 or larger (horizontal)	10	7/8 or 1 (Horizontal)	8
1 1/4 or larger (vertical)	Every floor level	1 or Larger (vertical)	Every floor level

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

