6. Sizing of piping and tubing systems

Overview

Purpose

The gas technician/fitter must be able to correctly measure and size gas piping systems for a variety of applications to ensure they perform safely and efficiently.

Objectives

At the end of this Chapter, you will be able to:

- explain pipe measurement and fitting allowance;
- describe sizing of low-pressure gas piping systems;
- describe sizing of 2 psig gas piping systems;
- describe sizing of high-pressure gas piping systems; and
- describe sizing of two-stage propane piping systems.

Terminology

Term	Abbreviation (symbol)	Definition
Code zone	CZ	Horizontal grouping of flow values according to the longest measured run
Equivalent length	EL	For bends, fittings and valves, the comparable length of pipe needed to determine the length of equivalent run (LER) To determine this, use the appropriate capacity Tables in CSA B149.1.
Fitting allowance		Space between the centre of the fitting and the end of the pipe
Length of equivalent run	LER	Measured length of pipe added to the equivalent length of pipe
Measured length	ML	Length used in determining the size of any section of gas piping or tubing The rows of the capacity Tables in CSA B149.1 shows the measured lengths in imperial and metric measurements.

Term	Abbreviation (symbol)	Definition
Pressure drop		Working pressure at the meter installation downstream of the service regulator minus working pressure at the appliance
Thread engagement		Distance the pipe screws into the fitting

Factors affecting pipe sizing

Pipe sizing is an important consideration on a gas installation. Properly sized piping or tubing helps ensure that adequate supply pressure and volume of fuel is available at all appliance connections and that the manufacturer's specifications for inlet pressure, and subsequently appliance firing rates, are achievable.

Gas piping should be large enough to meet maximum demands without undue pressure loss, i.e., a pressure drop, between the meter and the appliance.

Pressure drop is the working pressure at the meter installation downstream of the service regulator minus working pressure at the appliance. The purpose of the pipe sizing tables is to assist you in determining the pipe size suitable for the project.

Undersized piping may lead to low gas pressure at the appliances, under-fired equipment, and high lock-up pressures in gas regulators. Oversized piping inflates job costs and wastes money.

To begin understanding pipe sizing, you must consider the following factors before the installation of piping.

Factors that affect pipe sizing are as follows:

Factor	Consideration
Fuel type	Natural gas and propane have different calorific values—i.e., propane requires less fuel for the same btu rating of appliance—and different specific gravity.
Length of run	The greater the distance from the appliance to the meter, the larger the supply piping may have to be.
Allowable pressure drop	The supply pressure available will also determine pipe size.
Maximum gas consumption	You must account for the total load of all appliances firing at the same moment when sizing.
Piping configurations	The number of fittings, manifold headers, and branch lines utilized all become factors when sizing pipe.

Some piping manufacturers, such as the manufacturers of CSST products, supply their own sizing tables because the CSA B149.1 Tables do not take into account the special features and restrictive nature of corrugated piping. The required manufacturer training and certification would cover these piping specifics.

The steel piping tables in CSA B149.1 include plastic gas piping allowances, which can accommodate plastic as well as steel pipe.

Pipe measurement and fitting allowance

Pipe measuring methods

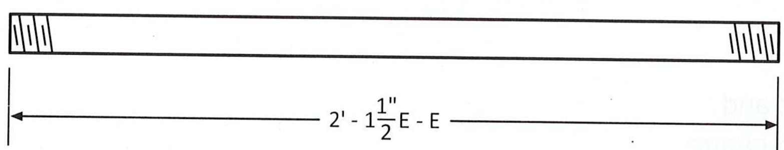
Generally, you use one of the following three methods to measure pipe lengths:

- end-to-end;
- end-to-centre; and
- centre-to-centre.

End-to-end

The "end-to-end" measurement is the measurement of the pipe without any fittings. See Figure 6-1.

Figure 6-1
End-to-end measurement

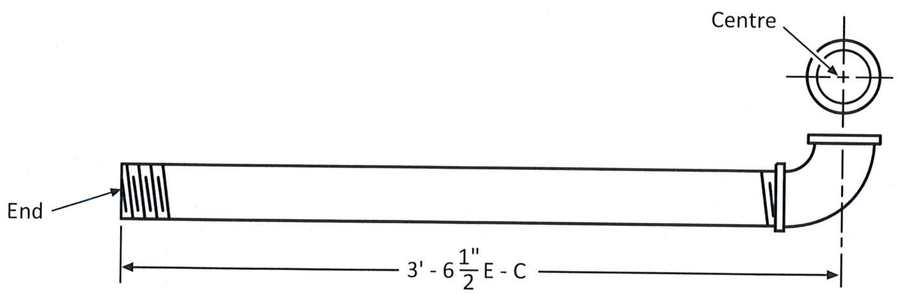


End-to-centre

You take an "end-to-centre" measurement from the centre of a fitting screwed on one end to the opposite end of the pipe. See Figure 6-2.

Make an end-to-centre measurement by first tightening a fitting on the threaded end of a pipe. Place the end of the rule exactly in the centre of the fitting, measure along the pipe, and mark at the proper distance.

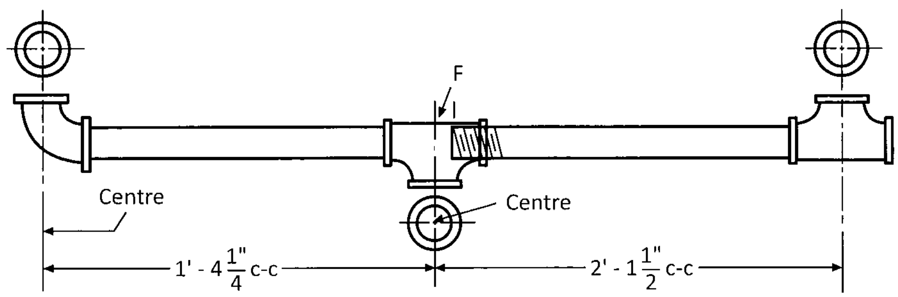
Figure 6-2
End-to-centre measurement



Centre-to-centre

Most pipe drawings are shown as "centre-to-centre" measurements. A centre-to-centre measurement is the distance between the centre of two fittings in a line of pipe. See Figure 6-3.

Figure 6-3
Centre-to-centre measurement

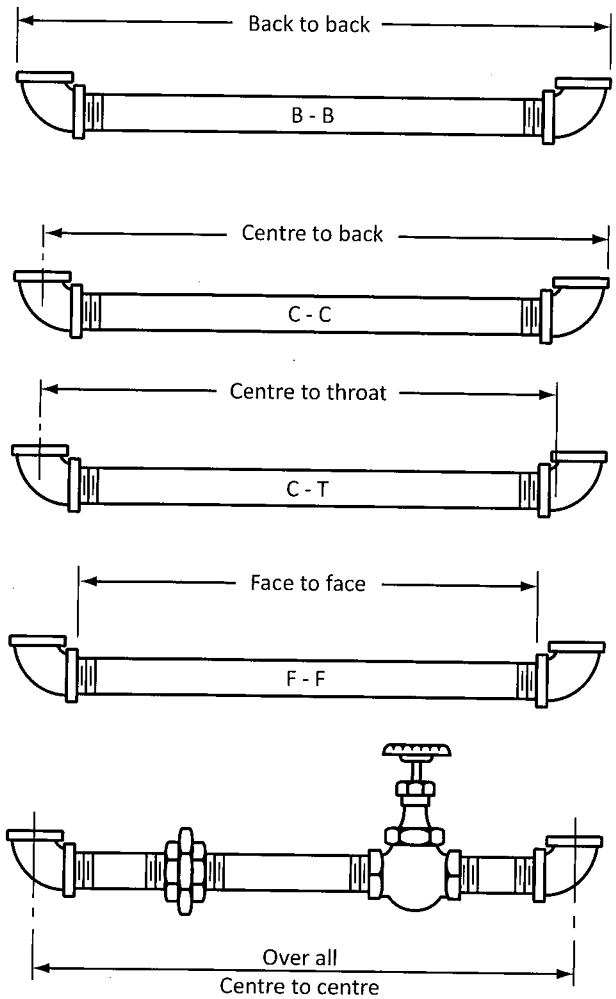


Additional measuring methods

Although not as commonly used as the preceding methods, there are additional methods of taking pipe measurements. These measurements, which you can see in Figure 6-4, are:

- back-to-back;
- centre-to-back;
- centre-to-throat; and
- overall centre-to-centre.

Figure 6-4
Additional methods of measurement

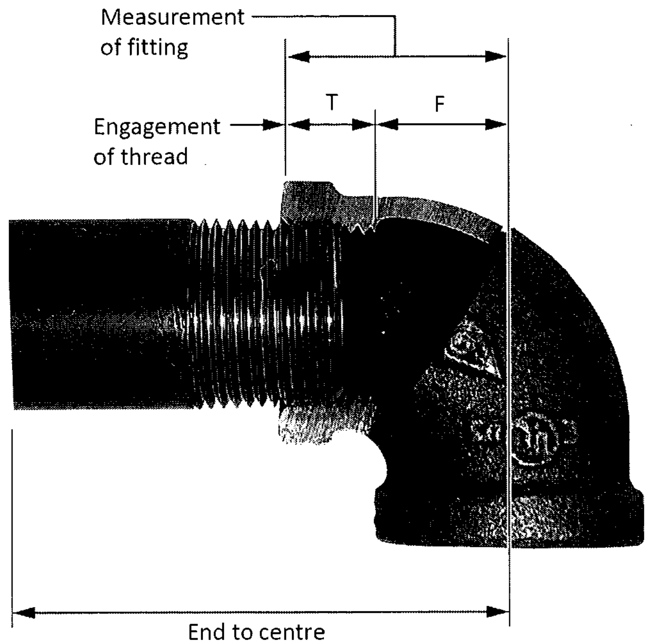


Fitting allowance

As pointed out previously, you usually make pipe measurements end-to-centre or centre-to-centre.

Using the end-to-centre measurement (see Figure 6-5), notice that the end of the pipe will not screw into the centre of the fitting. Therefore, you must make a certain allowance "F" for the fitting, and cut the pipe that much shorter.

Figure 6-5
End-to-centre measurement
Image courtesy of Terry Bell



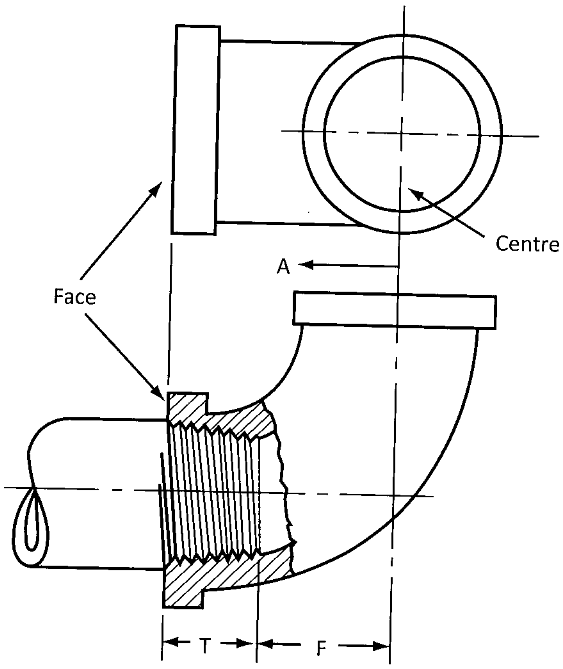
You may measure fitting allowance on the job. Otherwise, you can find it in the manufacturer's catalogue. However, since fitting measurements are not the same for all manufacturers, it is very important that you obtain the allowance from the catalogue of the manufacturer of that fitting.

Calculating fitting allowance

The measurements given are from the centre to the face of the fitting (see Figure 6-6), a standard malleable elbow.

Measurement indicated by letter	**Measured**	**Formula**
"A"	The centre-to-face measurement	Using these identifying letters, the formula for determining the fitting allowance is F = A − T.
"T"	The thread engagement or the distance the pipe screws into the fitting	
"F"	The fitting allowance, the space between the centre of the fitting and the end of the pipe	

Figure 6-6
Fitting measurement



Example

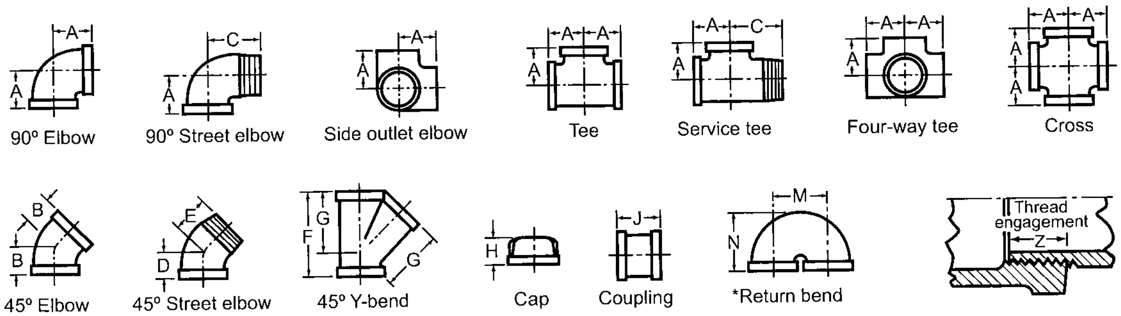
What is the fitting allowance for an NPS 3, 90°, 150-pound malleable elbow using a Crane fitting?

- "A", the centre-to-face measurement, is 3 1/8 in Table 6-1.
- "T", the thread engagement, is 1 in at the bottom of Table 6-1.
- F = A – T or 3 1/8 in – 1 in = 2 1/8 in fitting allowance.

Table 6-1
Dimensions of 150-pound malleable iron fittings and normal engagement between male and female threads

150-pound malleable iron crane fittings

Dimensions of straight sizes, in inches
banded and plain pattern

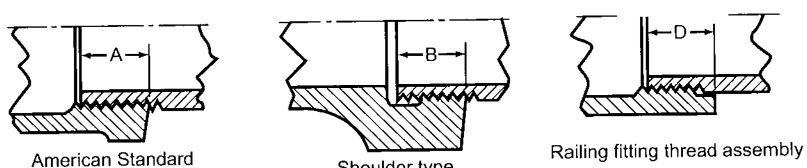


These dimensions apply to both banded and plain fittings; their centre to end dimensions are alike.

*Close pattern return bends can not be used to make up parallel coils. The centre to centre dimension is so close that the bands of adjacent bends will not clear each other.

Size	A	B	C	D	E	F	G	H	J	Return Bends						Z
										Close		Medium		Open		
										M	N	M	N	M	N	
1/8	11/16	1/2	1	11/16	13/16			9/16	15/16							1/4
1/4	13/16	3/4	1 3/16	5/8	15/16			5/8	1 1/16							3/8
3/8	15/16	13/16	1 7/16	11/16	1 1/16	2 1/8	1 7/16	3/4	1 3/16							3/8
1/2	1 1/8	7/8	1 5/8	13/16	1 3/16	2 7/16	1 11/16	7/8	1 5/16	1	1 3/4	1 1/4	1 3/8	1 1/2	1 7/8	1/2
3/4	1 5/16	1	1 7/8	15/16	1 5/16	2 7/8	2	1 1/16	1 1/2	1 1/4	2 3/16	1 1/2	1 15/16	2	2 1/4	9/16
1	1 1/2	1 1/8	2 1/8	1 1/16	1 1/2	3 3/8	2 7/16	1 3/16	1 11/16	1 1/2	2 1/2	1 7/8	2 1/4	2 1/2	2 5/8	11/16
1 1/4	1 3/4	1 5/16	2 7/16	1 1/4	1 11/16	4 1/16	2 15/16	1 1/4	1 15/16	1 3/4	2 13/16	2 1/4	2 13/16	3	3 3/16	11/16
1 1/2	1 15/16	1 7/16	2 11/16	1 3/8	1 7/8	4 1/2	3 5/16	1 5/16	2 1/8	2 3/16	3 3/16	2 1/2	3 3/16	3 1/2	3 5/8	11/16
2	2 1/4	1 11/16	3 1/4	1 11/16	2 1/4	5 7/16	4	1 7/16	2 1/2	2 5/8	3 7/8	3	3 7/8	4	4 3/8	3/4
2 1/2	2 11/16	1 15/16	3 13/16			6 1/4	4 11/16	1 13/16	2 7/8					4 1/2	4 15/16	15/16
3	3 1/8	2 3/16	4 1/2			7 1/4	5 9/16	1 15/16	3 3/16					5	5 9/16	1
3 1/2	3 7/16	2 3/8						1 15/16								1 1/16
4	3 3/4	2 5/8	5 11/16			8 7/8	6 15/16	2 1/16	3 11/16					6	6 11/16	1 1/8
5	4 1/2	3 1/16						2 5/16								1 1/4
6	5 1/8	3 7/16						2 9/16								1 5/16

Normal engagement
Between male and female threads



American Standard and API line pipe threads

Shoulder type drainage fitting threads

Railing fitting thread assembly

Size of pipe	D Length of pipe entering recessed railing fitting
1/2	1/2
3/4	1/2
1	5/8
1 1/4	11/16
1 1/2	3/4
2	3/4

Dimensions, in inches

Size	1/8	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	5	6	8	10	12	14
A	1/4	3/8	3/8	1/2	9/16	11/16	11/16	11/16	3/4	15/16	1	1 1/16	1 1/8	1 1/4	1 5/16	1 7/16	1 5/8	1 3/4	
B						9/16	5/8	5/8	5/8	7/8	15/16	1	1 1/16	1 3/16	1 1/4	1 3/8	1 9/16	1 11/16	1 7/8

Sizing of low-pressure piping systems

Factors that influence gas flow

Before you attempt to size pipe, you should clearly understand how the following six factors affect the flow rate of gas:

- type of gas;
- type of pipe;
- length of pipe;
- diameter of pipe;
- number of fittings; and
- pressure drop.

Type of gas

Propane and natural gas flow through pipe at different rates because they have different relative densities. (Relative density is the weight of a gas compared to the weight of an equal volume of air. Other terms to describe relative density are specific gravity, relative weight, and specific weight.) The relative density of propane is 1.5 and natural gas is 0.6, meaning that propane is heavier than natural gas.

Since lighter gases flow through a pipe more easily than heavier gases, larger volumes of natural gas can flow through a pipe than propane (if both supply pressures are the same).

Type of pipe

An internal resistance forms as the gas molecules slide along the walls of the pipe. Pipes with smooth interior walls cause less resistance than pipes with rough interior walls.

For example, copper tubing offers less resistance (and therefore a higher flow rate) than an iron pipe with the same inside diameter.

Length of pipe

The resistance factor also applies to the length of pipe: the longer the pipe, the greater the resistance.

Diameter of pipe

The larger the pipe diameter, the greater the gas flow through the system.

Number of fittings

Each fitting on a piping system adds resistance to the gas flow. For this reason, it is important to design a system with as few fittings as possible.

If the pipe sizing table includes fittings, the figures have included a 20% allowance, which is more than enough for a normal piping system.

Pressure drop

Pressure drop is the pressure difference between the gas supply (either the gas meter or a system pressure regulator) and a gas appliance. The greater the pressure drop, the greater the resistance through a pipe.

The *Natural gas and propane installation code* specifies the maximum allowable pressure drop in a system, based on the system pressure.

You must design natural gas piping systems with pressures:
- less than 7 in w.c. (1.75 kPa), so the pressure drop does not exceed 0.5 in w.c. (125 Pa); and
- of 7 in w.c. to 14 in w.c. (1.75 kPa to 3.5 kPa), so the pressure drop does not exceed 1 in w.c. (250 Pa).

Design of propane piping systems of 11 in w.c. (2.7 kPa) must not allow the pressure drop to exceed 1 in w.c. (250 Pa).

Sizing low-pressure systems

The discussion of pipe sizing usually specifies low-pressure or high-pressure systems. Low-pressure systems, a topic of this Chapter, are those which contain gas pressures up to 0.5 psig (3.5 kPa).

Sizing a low-pressure gas piping system can consist of three steps:
1) Draw a sketch.
2) Identify the pipe sizing table.
3) Calculate the pipe size.

Drawing a sketch of the whole piping system allows you to identify and locate important system components. Knowing the details about these system components will ultimately guide you to choose the correct pipe sizing table.

System components

Information	Description
Gas supply	The gas supply may be a meter that a local utility company installed for natural gas or propane. Also, supply of propane may come from a storage container.
System pressure	After carefully considering available gas pressures, you will choose the pressure that best suits the job and conforms to local codes.
Appliance location	The building design, not the gas technician/fitter, usually fixes the appliance's location.
Appliance inputs	Appliance input is the amount of heat that can be generated in the combustion chamber every hour. This therefore determines the amount of gas that the appliance requires. The manufacturer determines each appliance's input, which is then stamped on a rating plate and permanently affixed to the equipment.

Information	Description
Piping route	You must determine the best piping route, that is, the one that uses the least amount of pipe, fittings, and valves.
Valves and other related equipment	Every piping system requires valves and other equipment such as regulators. You must know where to locate this equipment before sizing the piping system.

Identify the pipe sizing table

There are over 50 pipe sizing tables in CSA B149.1. Finding the correct table can be a complex undertaking unless you have the required information. Each table is based on the following sequence of pipe system criteria:

Information	Description
Type of gas	Determine the type of gas based on availability and cost. Natural gas is usually the cheapest fuel.
Type of pipe	Determine the type of pipe you will use after considering costs of material and labour, code restrictions, and job specifications.
System pressures	Determine system pressure after considering the following: • available pressures from the gas utility; • code restrictions; • specifications; and • cost of system installations.
Maximum pressure drop	The maximum pressure drop is the maximum allowable drop in pressure across a piping system as specified by the code and the system pressure. You must thoroughly understand system pressures and allowable pressure drops before selecting a pipe sizing table.

Selecting the table

Now that you clearly understand how to identify a pipe sizing table, identify the criteria used to create the table.

Information	Description
Type of gas	Natural gas
Type of pipe	Iron pipe
System pressures	Less than 7 in w.c.
Pressure drop	Flow rates based on a pressure drop of 0.5 in w.c.

In CSA B149.1, both imperial and metric gas tables are available. The pipe sizing tables, Tables A.1 and A.2, have two parts:

- Part "a" covers imperial measurements; and
- Part "b" covers metric measurements.

Table A.1
Maximum capacity of natural gas in thousands of Btuh for Schedule 40 pipe and plastic pipe, including fittings, for pressures of less than 7 in w.c. based on a pressure drop of 0.5 in w.c.
(See Clauses 6.3.2, 6.3.5, A.2.3, A.2.4, A.2.6, and A.3.5.)

(a) Imperial

Length of pipe, ft	Pipe size (NPS)								
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4
10	156	326	614	1 261	1 890	3 639	5 800	10 253	20 914
20	107	224	422	867	1 299	2 501	3 986	7 047	14 374
30	86	180	339	696	1 043	2 008	3 201	5 659	11 543
40	74	154	290	596	893	1 719	2 740	4 843	9 879
50	65	137	257	528	791	1 524	2 428	4 293	8 756
60	59	124	233	478	717	1 380	2 200	3 889	7 933
70	54	114	214	440	659	1 270	2 024	3 578	7 299
80	51	106	199	409	613	1 181	1 883	3 329	6 790
90	48	99	187	384	576	1 109	1 767	3 123	6 371
100	45	94	177	363	544	1 047	1 669	2 950	6 018
125	40	83	157	322	482	928	1 479	2 615	5 333
150	36	75	142	291	437	841	1 340	2 369	4 832
175	33	69	131	268	402	774	1 233	2 180	4 446
200	31	64	121	249	374	720	1 147	2 028	4 136
250	27	57	108	221	331	638	1 017	1 797	3 666
300	25	52	98	200	300	578	921	1 628	3 321
350	23	48	90	184	276	532	847	1 498	3 056
400	21	44	83	171	257	495	788	1 394	2 843
450	20	42	78	161	241	464	740	1 308	2 667
500	19	39	74	152	228	438	699	1 235	2 519
600	17	36	67	138	206	397	633	1 119	2 283
700	16	33	62	127	190	365	582	1 030	2 100
800	15	30	57	118	177	340	542	958	1 954
900	14	29	54	111	166	319	508	899	1 833
1 000	13	27	51	104	156	301	480	849	1 732
1 200	12	24	46	95	142	273	435	769	1 569
1 400	11	23	42	87	130	251	400	708	1 443
1 600	10	21	39	81	121	234	372	658	1 343
1 800	9	20	37	76	114	219	349	618	1 260
2 000	9	19	35	72	108	207	330	583	1 190

(Continued)

Table A.1 (Concluded)
Maximum capacity of natural gas in kW for Schedule 40 pipe and plastic pipe, including fittings, for pressures of less than 1.75 kPa based on a pressure drop of 125 Pa

(b) Metric

Length of pipe, m	Pipe size (NPS) 1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4
3	46	97	182	374	560	1078	1718	3038	6196
6	32	66	125	257	385	741	1181	2088	4259
9	25	53	100	206	309	595	948	1677	3420
12	22	46	86	176	264	509	812	1435	2927
15	19	40	76	156	234	451	719	1272	2594
18	18	37	69	142	212	409	652	1152	2350
21	16	34	64	130	195	376	600	1060	2162
24	15	31	59	121	182	350	558	986	2012
27	14	29	55	114	171	328	523	925	1887
30	13	28	52	108	161	310	494	874	1783
35	12	26	48	99	148	285	455	804	1640
40	11	24	45	92	138	266	423	748	1526
45	11	22	42	86	129	249	397	702	1432
50	10	21	40	82	122	235	375	663	1352
60	9	19	36	74	111	213	340	601	1225
70	8	18	33	68	102	196	313	553	1127
80	8	16	31	63	95	182	291	514	1049
90	7	15	29	59	89	171	273	482	984
100	7	14	27	56	84	162	258	456	929
125	6	13	24	50	74	143	228	404	824
150	6	12	22	45	67	130	207	366	746
175	5	11	20	41	62	119	190	337	687
200	5	10	19	39	58	111	177	313	639
250	4	9	17	34	51	99	157	278	566
300	4	8	15	31	46	89	142	252	513
350	4	7	14	28	43	82	131	231	472
400	3	7	13	26	40	76	122	215	439
500	3	6	11	23	35	68	108	191	389
600	3	5	10	21	32	61	98	173	353

Notice that the table title includes all the necessary criteria: Schedule 40 pipe, system pressure of 1.75 kPa to 3.5 kPa and a pressure drop of 250 Pa. The volume of gas flow is expressed in metric Units (kW).

Table A.2
Maximum capacity of natural gas in thousands of Btuh for Schedule 40 pipe and plastic pipe, including fittings, for pressures of 7 in w.c. up to 14 in w.c. based on a pressure drop of 1 in w.c.

(See Clauses 6.3.2, 6.3.4, 6.3.5, A.2.3, A.2.4, A.2.6, A.3.5, E.1.2, and E.2.2.)

(a) Imperial

Length of pipe, ft	Pipe size (NPS)								
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4
10	227	474	894	1 835	2 749	5 295	8 439	14 919	30 429
20	156	326	614	1 261	1 890	3 639	5 800	10 253	20 914
30	125	262	493	1 013	1 517	2 922	4 658	8 234	16 795
40	107	224	422	867	1 299	2 501	3 986	7 047	14 374
50	95	199	374	768	1 151	2 217	3 533	6 246	12 739
60	86	180	339	696	1 043	2 008	3 201	5 659	11 543
70	79	166	312	640	959	1 848	2 945	5 206	10 619
80	74	154	290	596	893	1 719	2 740	4 843	9 879
90	69	145	272	559	837	1 613	2 571	4 544	9 269
100	65	137	257	528	791	1 524	2 428	4 293	8 756
125	58	121	228	468	701	1 350	2 152	3 805	7 760
150	52	110	207	424	635	1 223	1 950	3 447	7 031
175	48	101	190	390	584	1 126	1 794	3 171	6 469
200	45	94	177	363	544	1 047	1 669	2 950	6 018
250	40	83	157	322	482	928	1 479	2 615	5 333
300	36	75	142	291	437	841	1 340	2 369	4 832
350	33	69	131	268	402	774	1 233	2 180	4 446
400	31	64	121	249	374	720	1 147	2 028	4 136
450	29	61	114	234	351	675	1 076	1 903	3 881
500	27	57	108	221	331	638	1 017	1 797	3 666
600	25	52	98	200	300	578	921	1 628	3 321
700	23	48	90	184	276	532	847	1 498	3 056
800	21	44	83	171	257	495	788	1 394	2 843
900	20	42	78	161	241	464	740	1 308	2 667
1 000	19	39	74	152	228	438	699	1 235	2 519
1 200	17	36	67	138	206	397	633	1 119	2 283
1 400	16	33	62	127	190	365	582	1 030	2 100
1 600	15	30	57	118	177	340	542	958	1 954
1 800	14	29	54	111	166	319	508	899	1 833
2 000	13	27	51	104	156	301	480	849	1 732

(Continued)

Table A.2 (Concluded)
Maximum capacity of natural gas in kW for Schedule 40 pipe and plastic pipe, including fittings, for pressures of 1.75 kPa up to 3.50 kPa based on a pressure drop of 250 Pa

(b) Metric

Length of pipe, m	Pipe size (NPS) 1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4
3	67	141	265	544	815	1569	2500	4420	9015
6	46	97	182	374	560	1078	1718	3038	6196
9	37	78	146	300	450	866	1380	2439	4976
12	32	66	125	257	385	741	1181	2088	4259
15	28	59	111	228	341	657	1047	1850	3774
18	25	53	100	206	309	595	948	1677	3420
21	23	49	92	190	284	547	873	1542	3146
24	22	46	86	176	264	509	812	1435	2927
27	20	43	81	166	248	478	762	1346	2746
30	19	40	76	156	234	451	719	1272	2594
35	18	37	70	144	216	415	662	1170	2386
40	17	35	65	134	201	386	616	1088	2220
45	16	32	61	126	188	362	578	1021	2083
50	15	31	58	119	178	342	546	965	1968
60	13	28	52	108	161	310	494	874	1783
70	12	26	48	99	148	285	455	804	1640
80	11	24	45	92	138	266	423	748	1526
90	11	22	42	86	129	249	397	702	1432
100	10	21	40	82	122	235	375	663	1352
125	9	19	35	72	108	209	332	588	1199
150	8	17	32	65	98	189	301	532	1086
175	7	16	29	60	90	174	277	490	999
200	7	14	27	56	84	162	258	456	929
250	6	13	24	50	74	143	228	404	824
300	6	12	22	45	67	130	207	366	746
350	5	11	20	41	62	119	190	337	687
400	5	10	19	39	58	111	177	313	639
500	4	9	17	34	51	99	157	278	566
600	4	8	15	31	46	89	142	252	513

Once you have drawn the sketch and selected the correct table, you are ready to size the piping system. Sizing the piping system is just a matter of correctly reading the table.

Reading the table

In order to correctly read a table, you would have to identify the following information:

- piping loads;
- longest measured supply run; and
- code zone.

Information	Description
Piping loads	This term expresses the volume of fuel that must pass through a pipe each hour. Determine this volume using the appliance load connected to that pipe. Each section of pipe has its own piping load.
Longest measured supply run	This is the distance from the point of gas supply (gas meter or system regulator) to the manifold of the furthest appliance. This measurement must be the actual length of pipe as installed. It may be expressed in feet or metres, depending on the Units of measurement in the pipe sizing table.
Code zone	The code zone (CZ) is a horizontal grouping of flow values according to the longest measured run. Choosing the code zone is based on selecting the length of pipe that is exactly the same, or larger, than the longest measured run. You may use only the flow values in the code zone to size the piping system.

Example

Using Figure 6-7 as a guide, assume a longest measured run (LMR) of 65 ft. Identify the pipe size required to carry a flow rate of 300 000 Btu/h (expressed as 300 MBtu/h for the purpose of the table) and proceed as follows:

1) Look down the Length of Pipe column and identify the code zone (CZ) that is exactly the same or larger than the longest measured run. You will find all load values in the 70 ft code zone.
2) Move across the code zone until you find an equal or greater value than 300 MBtu/h. In this case, you locate 440 MBtu/h.
3) Move up to the top of the column and identify that a NPS 1-1/4 iron pipe size is required.

Figure 6-7
Reading the pipe sizing table

Maximum Capacity in Thousands of Btu/h for Schedule 40 Pipe, Including Fittings, for Pressures of Less than 7 inches w.c. Based on a Pressure Drop of 0.5 inches w.c.

Longest measured run

Code zone

Piping loads

Length of pipe (feet)	Pipe sizes 1/2	3/4	1	1 1/4	1 1/2	2	2 1/2
10	156	326	614	1261	1890	3639	5800
20	107	224	422	867	1299	2501	3986
30	86	180	339	696	1043	2008	3201
40	74	154	290	596	893	1719	2740
50	65	137	257	528	791	1524	2428
60	59	124	233	478	717	1380	2200
70	54	114	214	440	659	1270	2024
80	51	106	199	409	613	1181	1883
90	48	99	187	384	576	1109	1767
100	45	94	177	363	544	1047	1669
125	40	83	157	322	482	928	1479
150	36	75	142	291	437	841	1340
175	33	69	131	268	402	774	1233
200	31	64	121	249	374	720	1147
250	27	57	108	221	331	638	1017
300	25	52	98	200	300	578	921
350	23	48	90	184	276	532	847
400	21	44	83	171	257	495	788
450	20	42	78	161	241	464	740
500	19	39	74	152	228	438	699
550	18	37	70	144	216	416	664
600	17	36	67	138	206	397	633

Sizing a low-pressure system steps summary

The following is a summary of the steps required to size a piping system:

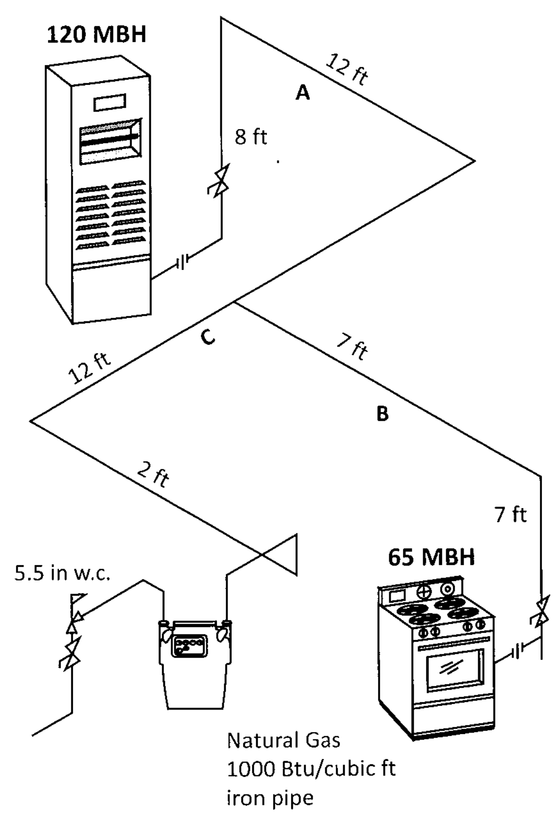
1) Sketch the piping system and dimension all pipe sections.
2) Identify the gas (natural gas, propane, etc.).
3) Identify the piping material (iron pipe or copper tubing).
4) Identify the pressure system and the allowable pressure drop.
5) Select the correct pipe sizing table.
6) Calculate the gas load in Btu/h (or kW) on each section of pipe and list each load.
7) Calculate the longest measured run (LMR) in the system.
8) Locate the appropriate code zone (CZ).
9) Size each pipe in the system from the selected code zone.

Refer to Figure 6-8 for a dimensioned sketch of the piping system for this example. Go through each step to identify the required pipe size.

Information based on Figure 6-8	Description
Type of gas	Natural gas
Type of pipe	Black iron pipe
System pressure	Less than 7 in w.c.

Information based on Figure 6-8	Description
Allowable pressure drop	0.5 in w.c.
Table	From information in steps 1, 2, and 3, determine that Table A.1 a) in CSA B149.1 is the appropriate table.
Calculate loads	Line A = 120 MBtu/h Line B = 65 MBtu/h Line C (A + B) = 185 MBtu/h
LMR	34 ft (branch "A")
CZ	40 ft
Size each pipe	[Start with the furthest appliance and pick up loads as you approach the meter. Line A = 3/4 in Line B = 1/2 in Line C = 1 in

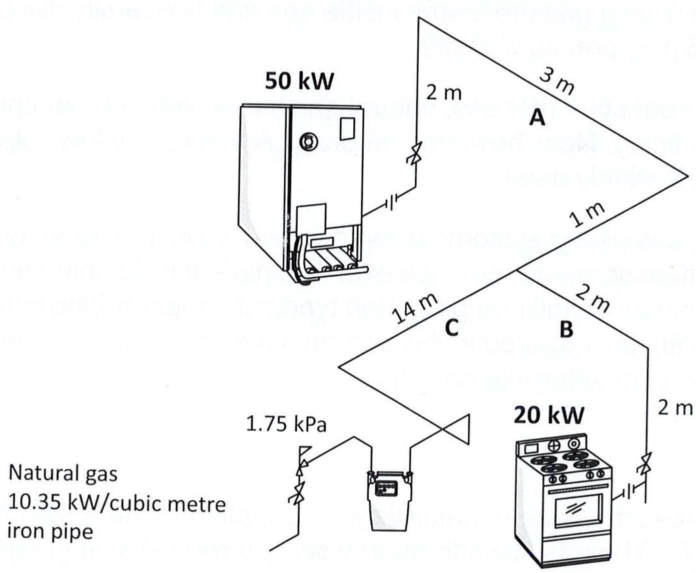
Figure 6-8
Sketch of piping system with imperial Units of measure



Refer to Figure 6-9 for a dimensioned sketch of the piping system for the following example.

Information based on Figure 6-9	**Description**
Type of gas	Natural gas
Type of pipe	Black iron pipe
System pressure	1.75 kPa
Allowable pressure drop	250 Pa
Table	Table A.2 b) in CSA B149.1
LMR	20 m
CZ	21 m
Calculate loads	Line A = 50 kW Line B = 20 kW Line C = 70 kW
Size each pipe	Start with the furthest appliance and pick up loads as you approach the meter. Line A = 1 in Line B = 1/2 in Line C = 1 in

Figure 6-9
Sketch of piping system with metric Units



Converting between metric and imperial measures

With the installation of new appliances and meters, you may have to mix imperial with metric values. For example, you may hook an appliance rated in Btu/h into a meter delivering its gas in m^3. Similarly, you may hook an appliance rated in kilowatts into an older type of gas meter, delivering gas in ft^3.

You cannot perform pipe sizing unless all values are imperial or metric. The following conversion factors are what you use for converting between imperial and metric Units of measure.

Conversion factors for gas pressure Units:

Gas Pressure Unit	Conversion
1 kW	3,412 Btu/h
1 Btu/h	0.00029295 kW
1 m^3	35.31 ft^3
1 ft^3	0.028317 m^3
1 psi	28 in w.c. 2 inHg 6895 Pa 6.895 kPa

Sizing of 2 psig gas piping systems

Traditionally, the gas utility companies in Canada have offered natural gas to customers at either 7 in w.c. for low-pressure applications (domestic) or at 5 psig for high-pressure applications (industrial). Additionally, 2 psig gas pressures inside one and two family dwellings are permitted with both 1 psig and 1.5 psig pressure drops.

Before changes in the production process, natural gas had a high sulphur content and copper tubing had to have a tin-lining. Now, however, natural gas has a very low sulphur content and standard copper tubing is widely used.

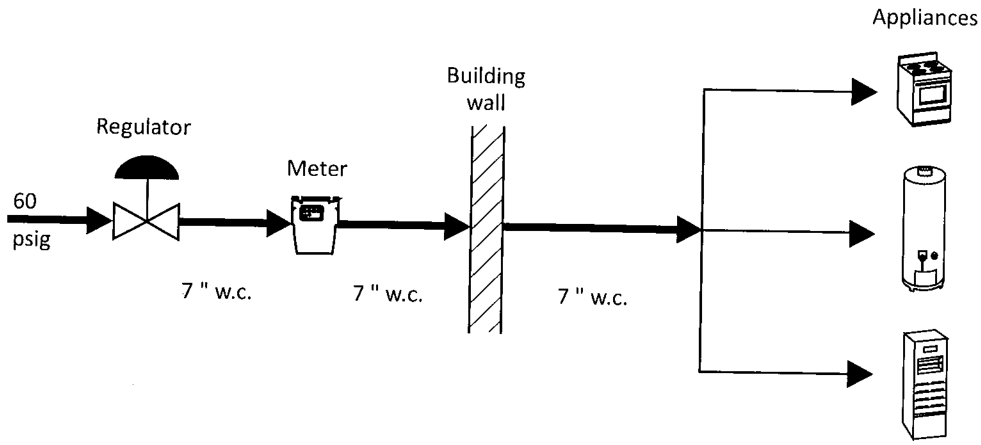
You can install two psig gas piping systems using copper tubing, iron pipe, or a combination of these. Copper tubing offers some advantages over iron pipe. It is flexible and you can often install it in places where you cannot install iron pipe. Soft types of copper tubing come in long coils, reducing the number of fittings required in the system. Overall, a copper tube system can be quicker to install, allowing considerable savings.

Characteristics

In a conventional low pressure system, natural gas is supplied to the residential property at about 60 psig (see Figure 6-10). The gas flows through a service regulator at the gas meter, which reduces the pressure to 7 in w.c. The gas then flows to the appliances at the same 7 in w.c. pressure.

Notice in Figure 6-10 that the size of the pipe leaving the meter is comparatively larger than the pipe entering the appliance. The larger pipe size is required to supply enough volume to all three appliances.

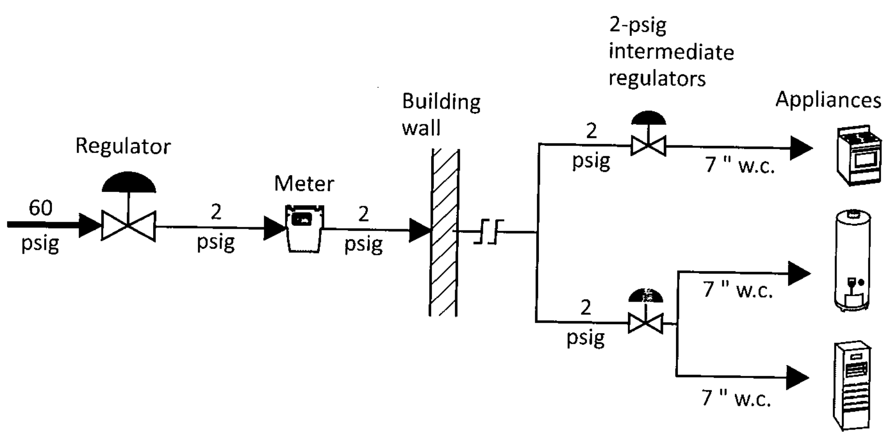
Figure 6-10
Conventional low-pressure piping system



In a 2 psig system, natural gas is also supplied to the residential property at about 60 psig (see Figure 6-11). The service regulator reduces the gas to 2 psig until it reaches the second regulator in the system. The second regulator reduces the gas pressure to 7 in w.c.

Notice in Figure 6-11 that a smaller-diameter piping than the conventional piping delivers the gas to the 2 psig regulators. Note also that supplying two or more appliances from a single 2 psig regulator is possible.

Figure 6-11
psig gas tubing system



2 psig regulators

Because most gas appliances require gas at low pressure, the installation of a regulator is a must to reduce the pressure. You can locate 2-psig regulators anywhere in a building, but their location should be close to the appliances, and they must be accessible.

Shut-off valves

Each regulator must have a shut off valve on the high pressure side for the regulator to be serviced.

Sizing regulators

Take care when sizing regulators, particularly with respect to the inlet pressure:

Inlet pressure = system pressure – pressure drop

As CSA B149.1 tables allow for 1.5 psig pressure drop, the regulator will be sized accordingly:

0.5 psig = 2 psig – 1.5 psig

Sizing a 2 psig system

Sizing a 2 psig piping system can consist of three steps:

1) Draw a sketch.
2) Identify the 2 psig pipe sizing table.
3) Calculate the pipe size.

The sketch of the whole piping system identifies and locates important system components such as:

- gas supply;
- piping route;
- appliance locations; and
- 2 psig regulator locations.

This sketch also allows you to identify the different pressure zones in the piping system:

- psig pressure zone—the piping from the meter to the regulator; and
- low-pressure zone—the piping from the regulator to the appliances.

Size each pressure zone separately

For the next two steps (identifying the table and sizing the pipe), you must size each pressure zone separately. It is advisable to first size the low-pressure zone, followed by the 2 psig zone.

You can size any low-pressure zones according to information in the *Pipe measurement and fitting allowance* section. Remember, you will measure the LMR for the low-pressure zone from the 2 psig regulator to the appliance.

Identify 2 psig pipe sizing tables

The sizing tables for 2 psig gas pressure also have a 20% allowance for fittings. You do not have to add an extra allowance unless the system has an unusually large number of fittings. ("Including fittings" is found in the table title if fitting allowance is included.)

Correctly identifying the table for a 2 psig system requires the following information:

Information	Description
Type of gas	Natural gas or propane
Type of pipe	Iron pipe or copper tubing
System pressure	2 psig
Pressure drop	1.5 psig

Calculate pipe size

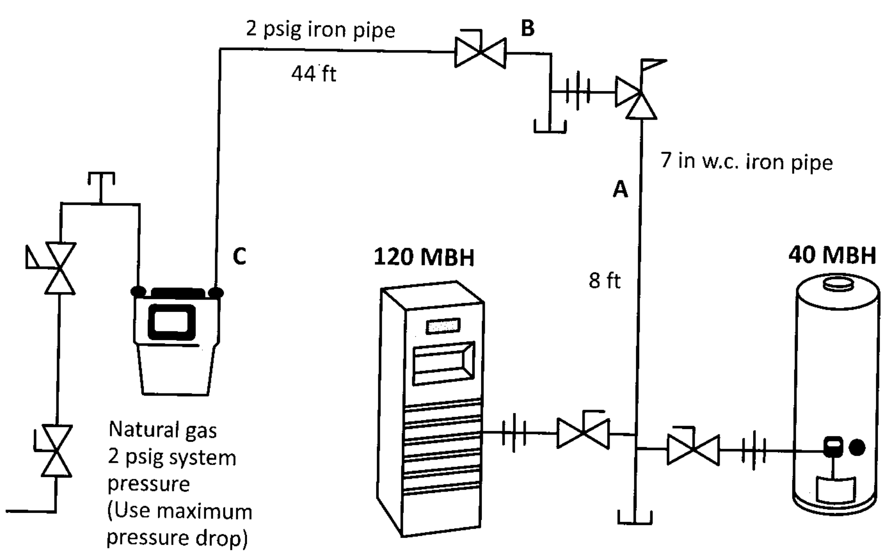
After selecting the correct pipe sizing table for the 2 psig pressure zone, follow this procedure:

Information	Description
Type of gas	Natural gas or propane
Type of pipe	Iron pipe or copper tubing
System pressure	2 psig
Pressure drop	1.5 psig
Pipe loads	Calculate the load in MBtu/h or kW, depending on the table values.
LMR	Remember, you will measure the longest measured run of the 2 psig zone from the meter to the 2 psig regulator, not the appliance.
CZ	Size all pipes in the same code zone.

Example

Refer to Figure 6-12 for a dimensioned sketch of the piping system for this example. Start with the furthest appliance and pick up loads as you approach the meter.

Figure 6-12
Sketch of piping system with imperial Units of measure



Step 1—Calculate low pressure zone

Information	Description
Type of gas	Natural gas
Type of pipe	Black iron pipe
System pressure	7 in w.c.
Allowable pressure drop	1 in w.c.
Table	Table A.2 a) in CSA B149.1 is the appropriate table.
Calculate loads	Line A = 160 MBtu/h
LMR	8 ft (branch "A")
CZ	10 ft
Size each pipe	Line A = 1/2 in

Step 2—Calculate 2 psig zone

Information	Description
Type of gas	Natural gas
Type of pipe	Black iron pipe
System pressure	2 psig
Allowable pressure drop	1 psig
Table	Table A.3 a) in CSA B149.1 is the appropriate table
Calculate loads	Line B = 160 MBtu/h Line C = 160 MBtu/h
LMR	44 ft (branch "A")
CZ	50 ft
Size each pipe	Line B = 1/2 in Line C = 1/2 in

Sizing of high-pressure natural gas piping systems

High-pressure gas is any gas pressure over 1/2 psig. Two psig gas piping systems (as discussed in the *Sizing of low-pressure piping systems* section) are also classified as high-pressure systems, but the pipe sizing tables include fittings. This section will discuss only high-pressure pipe sizing systems for which the pipe sizing table does not allow for fittings.

CSA B149.1 specifies the maximum gas pressure allowed inside different classes of buildings. Single family dwellings are limited to a maximum of 2 psig. Because commercial and industrial buildings may have heavy flow rates and long pipe runs, it is more economical to design piping systems with small-diameter pipes. As a result of the smaller pipe size, gas pressure in industrial and commercial applications ranges from 5 to 20 psig.

Characteristics

In a conventional low pressure system, natural gas is supplied to the building site at about 60 psig. The gas flows through a service regulator at the gas meter that reduces the pressure either to 2 psig or to 7 in w.c. These pressures are well-suited to applications where the flow rates are low and the pipe runs are relatively short.

As the flow rates and the pipe length increases, it becomes more economical to design piping systems with higher gas pressures. This keeps the pipe sizes small. The most common high pressures are 5, 10, and sometimes 20 psig (34, 70, and 140 kPa).

High-pressure regulators

Because most appliances require gas at low pressure, a regulator is installed to reduce the pressure. You must locate the high-pressure regulators where they are accessible and make provisions to install a vent to the outdoors.

Shut-off valves

Each regulator must have a shut off valve on the high pressure side so that you can service the regulator. It is also good piping practice to have a shut-off valve on the downstream side to save time and money when servicing the regulator.

Sizing regulators

Take care when sizing regulators, particularly with respect to the inlet pressure.

System pressure – Pressure drop = Inlet pressure

Since the Code tables come with large pressure drops, the regulators are sized with the following inlet pressures:

System pressure	Pressure drop	Inlet pressure
2 psig	1.5 psig	1/2 psig
5 psig	50%	2-1/2 psig
10 psig	50%	5 psig
20 psig	50%	10 psig

Sizing a high-pressure system

Sizing a high-pressure piping system can consist of three steps:

1) Draw a sketch.
2) Identify the pipe sizing table.
3) Calculate the pipe size.

Drawing a sketch of the whole piping system allows you to identify and locate important system components such as:

- gas supply;
- piping route;
- system regulator locations; and
- appliance locations.

This sketch also allows you to identify the different pressure zones in the piping system:

Zone	Description
High-pressure zone	Piping from the meter to the system regulators or piping between system regulators
Low-pressure zone	Piping from the system regulators to the appliances

Size each pressure zone separately

For the next two steps (identifying the table and sizing the pipe), you must size each pressure zone separately. It is advisable to first size the low-pressure zone, followed by the high-pressure zone.

You can size all low-pressure zones according to the information in *Pipe measurement and fitting allowance* section. Remember, you measure the LMR for the low-pressure zone from the system regulator to the appliance.

Identify pipe sizing table

To correctly identify the table for a high-pressure piping system, you need the following information:

Information	Description
Type of gas	Natural gas or propane
Type of pipe	Iron pipe or copper tubing
System pressure	High pressure
Pressure drop	50%

You should now be able to identify a pipe sizing table for your specific piping project.

Calculate pipe size

Before listing the steps to sizing the high-pressure piping system, it is important to understand how fittings are allowed for in the calculations. As discussed previously, there are six factors that influence the flow rate through a pipe. One of these factors, the number of fittings, is particularly relevant to sizing high-pressure systems.

Number of fittings

Fittings and valves create resistance to gas flow. Most low-pressure and 2 psig pipe sizing tables allow for this resistance by including a reasonable number of pipe fittings in the table calculations. Most high-pressure pipe sizing tables, however, do not allow for fittings. You must, therefore, include fitting resistance in your pipe sizing calculations. Make sure you check whether fittings are included or not.

The formula for deriving Tables A.1 to A.4 and A.8 to A.11, B.1, B.2, B.6, and B.7 contains a factor, (F = 1.2), which is used to multiply the piping or tubing length to allow for a reasonable number of fittings. Tables A.5 to A.7, A.12 to A.14, B.3 to B.5 and B.8 to B.10 do not contain a fitting allowance (F = 1), and Table A.16 or B.11 should be utilized to determine equivalent lengths of fittings.

How do you allow for fittings in high-pressure pipe sizing calculations? The resistance through a fitting is expressed as the resistance through a specific length of straight pipe. In other words, each pipe fitting is equal, in resistance, to an equivalent length of straight pipe.

To make your job easier, Table A.16 in CSA B149.1 lists the equivalent length values. This table lists values for threaded or welded fittings and valves.

Notes: Keep the following points in mind when calculating the number of fittings:

The equivalent length of pipe run includes only tees that change the direction of flow 90°. Do not include fittings that do not change the direction of flow (tees on the run, pipe couplings, unions, reducing couplings).

Calculate reducing tees or bull-headed tees that change flow direction by the largest inlet size of the tee.

Table A.16 does not show NPS 3.5 fittings. You will have to use a value between the NPS 3 and NPS 4 fittings.

Where a regulator reduces the pressure on a section of pipe, calculate each section separately.

Sizing a high-pressure system steps summary

Sizing a high-pressure system is similar to sizing a low-pressure system, except for Steps 8 and 10:

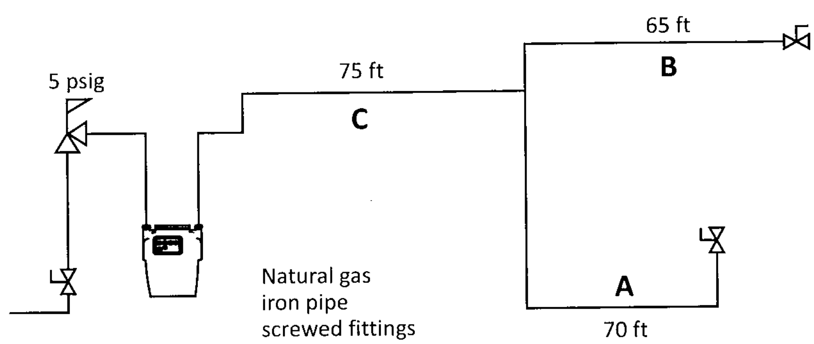
1) type of gas;
2) type of pipe;
3) system pressure;
4) pressure drop;
5) pipe sizing table;
6) pipe loads;
7) longest measured run;
8) guess code zone;
9) size pipe; and
10) prove code zone.

Information	Description
Step 8	Requires you to guess the code zone, based on the measured length of the piping run and an allowance of equivalent length for the fittings
Step 9	Sizes the pipe based on that code zone
Step 10	A check to see whether you chose the correct code zone. This is very important because since you have guessed at the code zone, you must check whether that pipe size will actually carry the gas load. You do this by checking whether the measured length added to the equivalent length exceeds the code zone length.

Example (imperial)

Referring to Figure 6-13, go through the pipe sizing procedure.

Figure 6-13
Schematic diagram for sizing high-pressure gas piping system



Information	Description
Type of gas	Natural gas
Type of pipe	Iron pipe (screwed fittings)
System pressure	5 psig
Pressure drop	2.5 psig
Pipe sizing table	Table A.5 a) in CSA B149.1
Pipe loads	Pipe A carries a load of 1000 MBtu/h Pipe B carries a load of 750 MBtu/h Pipe C (A + B) carries a load of 1750 MBtu/h
LMR	145 ft (Pipe "A")
Code zone (CZ)	Choose a code zone equal to, or longer than, the equivalent length of all pipe runs in the system. At this point, you do not know the size of the fittings, so you must estimate their

Information	Description
	equivalent length. If you refer to Table A 1.5, you can see that the choice of code zones is limited to 150 ft, 175 ft, and 200 ft. Making an allowance for a reasonable number of fittings, the 175 ft code zone is the best choice. (This allows an extra 30 ft of pipe as an allowance for the fittings.)
Size pipe	On 175 ft code zone: Pipe A 1000 MBtu/h = NPS 3/4 Pipe B 750 MBtu/h = NPS 3/4 Pipe C 1750 MBtu/h = NPS 1
Proof length of pipe runs	To proof the length of pipe runs, add the measured length of pipe with the equivalent length of pipe to find the length of equivalent run (LER). The LER of any pipe run must not exceed the code zone used to size the piping system.

Procedure:

1) List all fittings on the run, starting with the longest measured run.
2) Look up their equivalent lengths from Table A.16.

Proof pipe A

3 –1 in screwed 90 @ 2.62 ft	7.86 ft
1 – 1 in screwed T @ 5.24 ft	5.24 ft
2 – 3/4 in screwed 90 @ 2.06 ft	4.12 ft
1 – 3/4 in valve @ 2.06 ft	2.06 ft
Equivalent length	19.28 ft

Equivalent length (EL)	19.28 ft
Measured length (ML)	145.00 ft
Length of equivalent run (LER)	164.28 ft

Proof pipe B

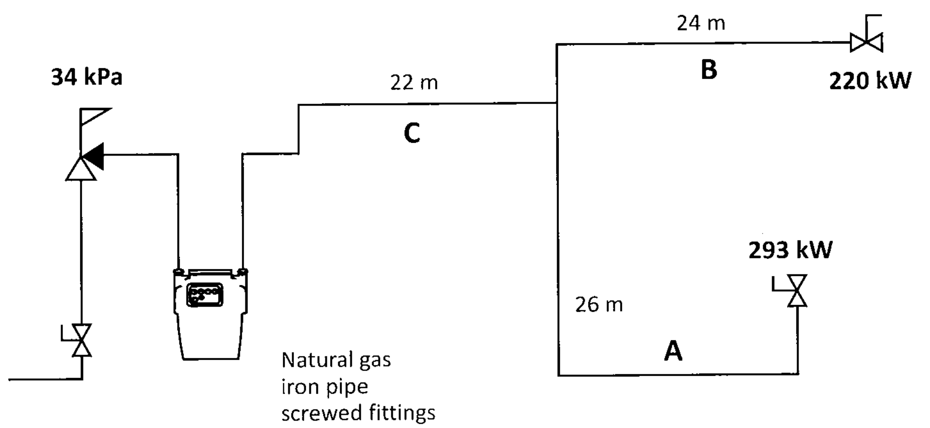
3 – 1 in screwed 90 @ 2.62 ft	7.86 ft
1 – 1 in screwed T @ 5.24 ft	5.24 ft
1 – 3/4 in screwed 90 @ 2.06 ft	2.06 ft
1 – 3/4 in valve @ 2.06 ft	2.06 ft
	Equivalent length 17.22 ft

Equivalent length (EL)	17.22 ft
Measured length (ML)	140.00 ft
Length of equivalent run (LER)	157.22 ft

If both Pipe A and Pipe B's length of equivalent runs are less than the selected code zone, the code zone is okay. In neither case does the LER exceed the selected code zone of 175 ft. Therefore, the 175 ft code zone is okay and the pipe is sized correctly.

> **Note:** *If any LER had exceeded the chosen code zone, it would indicate the chosen code zone is too short and you would have to resize and reproof the piping on the next longest code zone.*

Figure 6-14
Schematic diagram for sizing high-pressure gas piping system



Information	Description
Type of gas	Natural gas
Type of pipe	Iron pipe (screwed fittings)
System pressure	34 kPa
Pressure drop	17 kPa
Pipe sizing table	Table A.5 b) in CSA B149.1
Pipe loads	Pipe A carries a load of 293 kW Pipe B carries a load of 220 kW

Information	Description
	Pipe C (A + B) carries a load of 513 kW
LMR	48 m (Pipe A)
Code zone (CZ)	CZ chosen is 60 m
Size pipe	On 60 m code zone: Pipe A: 293 kW = 3/4 inch Pipe B: 220 kW = 3/4 inch Pipe C: 513 kW = 1 inch
Proof length of pipe runs	At this point, the pipe has been sized but you do not know if the length of the pipe runs—including fittings—will exceed the length of the 60 m code zone. To proof the length of each pipe run, add the measured length of pipe with the equivalent length of pipe to find the length of equivalent run. Starting with the longest measured run, list all fittings on that run. Look up their equivalent lengths from Table A.16 b) Metric in CSA B149.1.

Proof pipe A

3 – 1 in screwed 90 @ 0.8 m	2.40 m
1 – 1 in screwed T @ 1.6 m	1.60 m
2 – 3/4 in screwed 90 @ 0.63 m	1.26 m
1 –3/4 in valve @ 0.63 m	0.63 m
Equivalent length	5.89 m

Equivalent length (EL)	5.89 m
Measured length (ML)	48.00 m
Length of equivalent run (LER)	53.89 m

Proof pipe B

3 – 1 in screwed 90 @ 0.8 m	2.40 m
1 – 1 in screwed T @ 1.6 m	1.60 m
1 – 3/4 in screwed 90 @ 0.63 m	0.63 m
1 –3/4 in valve @ 0.63 m	0.63 m
Equivalent length	5.26 m

Equivalent length (EL)	5.26 m
Measured length (ML)	46.00 m
Length of equivalent run (LER)	51.26 m

If both Pipe A and Pipe B's length of equivalent runs are less than the selected code zone, the code zone is okay. In neither case does the LER exceed the selected code zone of 60 m. Therefore, the 60 m code zone is okay and the pipe is sized correctly.

Sizing of propane piping systems

Propane systems, like natural gas systems, may have more than one pressure zone due to the fact that the supply pressure to propane appliances is normally 11 in w.c. However, the propane supplied from a tank or cylinder, under most conditions, is much higher. (The vapour pressure in the tank is related to the temperature of the propane liquid in the tank. See the Unit *3 Properties, characteristics, and safe handling of fuel gases* for temperature/pressure relationships.)

You can carry out the pressure reduction from the tank to the appliance either in a single stage or in two stages:

System	Description
Single-stage system	Reduction of tank pressure immediately to 11 in w.c. with a regulator at the outlet valve
Two-stage system	Reduction of tank pressure to an intermediate pressure (usually 10 psig) in the first stage, and then to 11 in w.c. in the second stage

Sizing propane systems

Once you have determined whether it is a single- or two-stage system, you can size it using the same procedure as natural gas low-pressure sizing or high-pressure sizing. Annex B of CSA B149.1 provides the tables used for sizing propane systems.

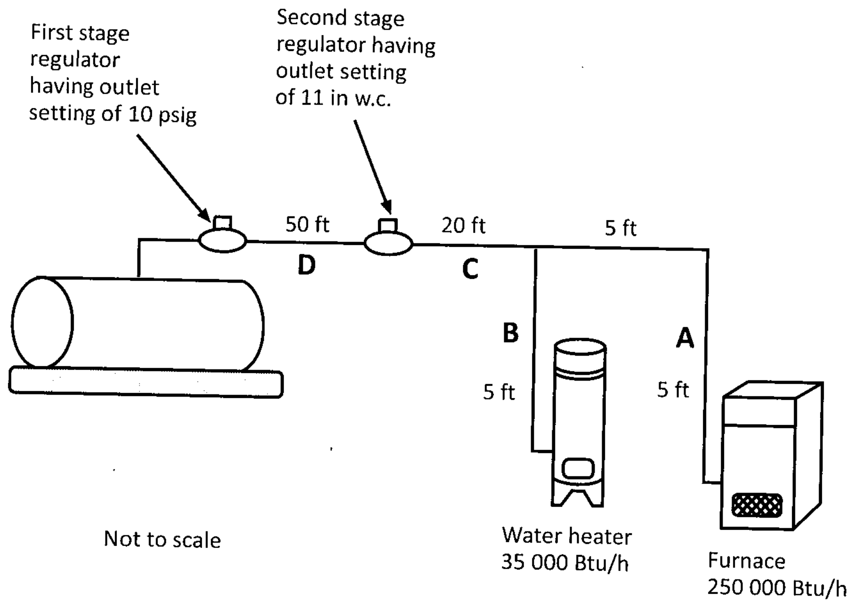
Example

The following example sizes a two-stage system using the high and low pressure methods previously reviewed for natural gas.

If you need to size a single-stage system, only use the low-pressure sizing method.

Refer to Figure 6-15 for a dimensioned sketch of the piping system for this example. Start with the farthest appliance and pick up loads as you approach the propane container.

Figure 6-15
Sketch of two-stage propane piping system



Step 1—Calculate low pressure zone

Information	**Description**
Type of gas	Propane
Type of pipe	Copper tubing
System pressure	11 in w.c.
Allowable pressure drop	1 in w.c.
Table	Table B.6 a) in CSA B149.1
Calculate loads	Line A = 250 MBtu/h Line B = 35 MBtu/h Line C = 285 MBtu/h
LMR	30 ft
CZ	30 ft
Size each pipe	Line A = 7/8 in Line B = 1/2 in Line C = 7/8 in

Step 2—Calculate high pressure zone

Information	Description
Type of gas	Propane
Type of pipe	Copper tubing
System pressure	10 psig
Allowable pressure drop	5 psig
Table	From Table B.9 a) in CSA B149.1
Calculate loads	Line D = 285 MBtu/h
LMR	50 ft
CZ	50 ft
Size each pipe	Line D = 3/8 in

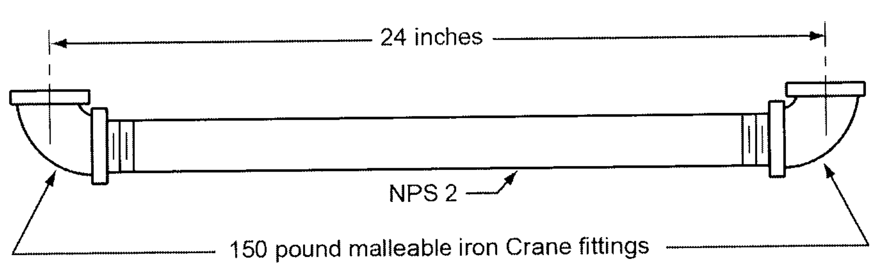
Assignment Questions – Chapter 6

1) Indicate True or False:
   One method of measuring pipe length is to measure the pipe from end to centre.
   a) True
   b) False

2) Are fitting allowances for a specific diameter and type of fitting the same for all manufacturers?
   a) Yes
   b) No

3) What length should the pipe be cut to be properly sized for the application shown in Illustration 1?

Illustration 1



   a) 21 Inches
   b) 23 inches
   c) 20 Inches