LP-10

LP-GAS SERVICEMAN'S HANDBOOK

FISHER

EMERSON Process Management

LP-GAS SERVICEMAN'S HANDBOOK

The Fisher® Controls LP-Gas Serviceman's Handbook serves as a general reference of information on LP-Gas and for the installation, operation and maintenance of LP-Gas equipment. It provides key data and answers important questions that are relevant to management and field servicemen in the LP-Gas industry.

Users of this handbook should consult applicable federal, state, and local laws as well as pertinent industry regulations, including National Fire Protection Association (NFPA) Pamphlets No. 54 and 58.

Fisher Controls shall have no responsibility for any misinterpretation of the information contained in this handbook or any improper installation or repair work or other deviation from the procedures recommended in this handbook.

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Table 1. Approximate Properties Of LP-Gases

FORMULA	PROPANE	BUTANE
	C_3H_8	C_4H_{10}
Initial Boiling Point, ºF	-44	31
Specific Gravity of Liquid (Water = 1.0) at 60ºF	0.504	0.582
Weight per Gallon of Liquid at 60ºF, LB	4.20	4.81
Specific Heat of Liquid, BTU/LB at 60ºF	0.630	0.549
Cubic feet of Vapor per Gallon at 60ºF	36.38	31.26
Cubic feet of Vapor per Pond at 60ºF	8.66	6.51
Specific Gravity of Vapor (Air = 1.0) at 60ºF	1.50	2.01
Ignition Temperature in Air, ºF	920 to 1,120	900 to 1,000
Maximum Flame Temperature in Air, ºF	3,595	3,615
Cubic feet of Air Required to Burn One Cubic Foot of Gas	23.68	31.02
Limits of Flammability in Air, % of Vapor in Air-Gas Mix		
(a) Lower	2.15	1.55
(b) Upper	9.60	8.60
Latent Heat of Vaporization at Boiling Point:		
(a) BTU per Pound	184	167
(b) BTU per Gallon	773	808
Total Heating Values After Vaporization:		
(a) BTU per Cubic Foot	2,488	3,280
(b) BTU per Pound	21,548	21,221
(c) BTU per Gallon	91,502	102,032

PROPERTIES OF LP-GASES

Table 1. Approximate Properties Of LP-Gases (Metric)		
FORMULA	PROPANE	BUTANE
	C_3H_8	C_4H_{10}
Initial Boiling Point, ºC	-42	-1
Specific Gravity of Liquid (Water = 1.0) at 15.56ºC	0.504	0.582
Weight per Cubic Meter of Liquid at 15.56ºC, kg	504	582
Specific Heat of Liquid, Kilojoule/ Kilogram at 15.56ºC	1.464	4.276
Cubic Meter of Vapor per Liter at 15.56ºC	0.271	0.235
Cubic Meter of Vapor per Kilogram at 15.56ºC	0.539	0.410
Specific Gravity of Vapor (Air = 1.0) at 15.56ºC	1.50	2.01
Iginition Temperature in Air, ºC	493 to 604	482 to 538
Maximum Flame Temperature in Air, ºC	1,980	1,991
Cubic Meters of Air Required to Burn 1 Cubic Meter of Gas	23.86	31.02
Limits of Flammability in Air, % of Vapor in Air-Gas Mix:		
(a) Lower	2.15	1.55
(b) Upper	9.60	8.60
Latent Heat of Vaporization at Boiling Point:		
(a) Kilojoule per Kilogram	428	388
(b) Kilojoule per Liter	216	226
Total Heating Values After Vaporization:		
(a) Kilojoule per Cubic Meter	92,430	121,280
(b) Kilojoule per Kilogram	49,920	49,140
(c) Kilojoule per Liter	25,140	28,100

VAPOR PRESSURE OF LP-GASES

Vapor pressure can be defined as the force exerted be a gas or liquid attempting to escape from a container. This pressure moves gas along the pipe or tubing to the appliance burner.

Outside temperature greatly affects container pressure. Lower temperature means lower container pressure. Too low a container pressure means that not enough gas is able to get to the appliance.

The Table below shows vapor pressures for propane and butane at various outside temperatures.

Table 2. Vapor Pressures

TEMPERATURE		APPROXIMATE VAPOR PRESSURE, psig / bar PROPANE ⟶ TO ⟶ BUTANE						
ºF	ºC	100%	80/20	60/40	50/50	40/60	20/80	100%
-40	-40	3.6 / 0.25	-	-	-	-	-	-
-30	-34.4	8 / 0.55	4.5 / 0.31	-	-	-	-	-
-20	-28.9	13.5 / 0.93	9.2 / 0.63	4.9 / 0.34	1.9 / 0.13	-	-	-
-10	-23.3	20 / 1.4	16 / 1.1	9 / 0.62	6 / 0.41	3.5 / 0.24	-	-
0	-17.8	28 / 1.9	22 / 1.5	15 / 1.0	11 / 0.76	7.3 / 0.50	-	-
10	-12.2	37 / 2.6	29 / 2.0	20 / 1.4	17 / 1.2	13 / 0.90	3.4 / 0.23	-
20	-6.7	47 / 3.2	36 / 2.5	28 / 1.9	23 / 1.6	18 / 1.2	7.4 / 0.51	-
30	-1.1	58 / 4.0	45 / 3.1	35 / 2.4	29 / 2.0	24 / 1.7	13 / 0.9	-
40	4.4	72 / 5.0	58 / 4.0	44 / 3.0	37 / 2.6	32 / 2.2	18 / 1.2	3 / 0.21
50	10	86 / 5.9	69 / 4.8	53 / 3.7	46 / 3.2	40 / 2.8	24 / 1.7	6.9 / 0.58
60	15.6	102 / 7.0	80 / 5.5	65 / 4.5	56 / 3.9	49 / 3.4	30 / 2.1	12 / 0.83
70	21.1	127 / 8.8	95 / 6.6	78 / 5.4	68 / 4.7	59 / 4.1	38 / 2.6	17 / 1.2
80	26.7	140 / 9.7	125 / 8.6	90 / 6.2	80 / 5.5	70 / 4.8	46 / 3.2	23 / 1.6
90	32.2	165 / 11.4	140 / 9.7	112 / 7.7	95 / 6.6	82 / 5.7	56 / 3.9	29 / 2.0
100	37.8	196 / 13.5	168 / 11.6	137 / 9.4	123 / 8.5	100 / 6.9	69 / 4.8	36 / 2.5
110	43.3	220 / 15.2	185 / 12.8	165 / 11.4	148 / 10.2	130 / 9.0	80 / 5.5	45 / 3.1

DETERMINING TOTAL LOAD

The best way to determine BTU input is from the appliance nameplate or from the manufacturer's catalog. Add the input of all the appliances for the total load. If specific appliance capacity information is not available, Table 3 below will be useful. Remember to allow for appliance which may be installed at a later date.

If the propane load in standard cubic feet per hour (SCFH) is desired, divide the BTU/hr load by 2,488 to get SCFH. Conversely, the BTU/hr capacity can be obtained from SCFH by multiplying the SCFH figure by 2,488.

Figuring the total load accurately is most important because of the size of the pipe and tubing, the tank (or the number of cylinders), and the regulator will be based on the capacity of the system to be served.

Table 3. Gas Required For Common Appliances

APPLIANCE	APPROXIMATE INPUT BTU/HR
Warm Air Furnace	
Single Family	100,000
Multifamily, per unit	60,000
Hydronic Boiler, Space Heating	
Single Family	100,000
Multifamily, per unit	60,000
Hydronic Boiler, Space and Water Heating	
Single Family	120,000
Multifamily, per unit	75,000
Range, Free Standing, Domestic	65,000
Built-In Oven or Broiler Unit, Domestic	25,000
Built-In top Unit, Domestic	40,000
Water Heater, Automatic Storage, 30 to 40 gal. Tank	35,000
Water Heater, Automatic Storage, 50 gal. Tank	50,000
Water Heater, Automatic Storage, Instantaneous	
2 GPM	142,800
4 GPM	285,000
6 GPM	428,000
Water Heater, Domestic, Circulating or Side-Arm	35,000
Refrigerator	3,000
Clothes Dryer, Type 1 (Domestic)	35,000
Gas Fireplace Direct Vent	40,000
Gas Log	80,000
Barbecue	40,000
Gas Light	2,500
Incinerator, Domestic	35,000

Table Reprinted From Table 5.4.2.1, NFPA 54, 2002 ed.

VAPORIZATION RATE

The rate of vaporization of a container is dependent upon the temperature of the liquid and the amount of “wetted surface” are of the container.

The temperature of the liquid is proportional to the outside air temperature and the wetted surface area is the tank surface are in contact with the liquid. Therefore, when the outside air temperature is lower or the container has less liquid in it, the vaporization rate of the container is a lower value.

To determine the proper size of ASME storage tanks or the proper number of DOT cylinders for carious loads, it is important to consider the lowest winter temperature at the location.

Multiple cylinders or tanks may be manifolded to give the required vaporization capacity. Withdrawal of gas from one or two containers can lower the container pressure substantially due to the refrigeration of the vaporization gas. Regulator capacity is then reduced because of the lower inlet pressure. Where any reasonably heavy gas load is expected, put sufficient cylinders on each side of an automatic changeover system.

See pages 7 and 8 for more information.

VAPORIZATION RATES FOR ASME STORAGE TANKS

A number of assumptions were made in calculating the BTU figures listed in the Table 4 below:

1) The tank is one-half full.
2) Relative humidity is 70%.
3) The tank is under intermittent loading.

Although none of these conditions may apply, Table 4 can still serve as a good rule-of-thumb in estimating what a particular tank size will provide under various temperatures. Continuous loading is not a very common occurrence on domestic installations, but under continuous loading the withdrawal rates in Table 4 should be multiplied by 0.25.

Table 4. Maximum Intermittent Withdrawal Rate (BTU/hr) Without Tank Frosting* If Lowest Outdoor Temperature (Average For 24 Hours) Reaches...

TEMPERATURE		TANK SIZE, GALLONS / l			
		150 / 568	**250 / 946**	**500 / 1,893**	**1,000 / 3,785**
40ºF	4°C	214,900	288,100	478,800	852,800
30ºF	-1°C	187,000	251,800	418,600	745,600
20ºF	-7°C	161,800	216,800	360,400	641,900
10ºF	-12°C	148,000	198,400	329,700	587,200
0ºF	-18°C	134,700	180,600	300,100	534,500
-10ºF	-23°C	132,400	177,400	294,800	525,400
-20ºF	-29°C	108,800	145,800	242,300	431,600
-30ºF	-34°C	107,100	143,500	238,600	425,000

* Tank frosting acts as an insulator, reducing the vaporization rate.

VAPORIZATION RATES FOR 100 POUNDS / 45 KG DOT CYLINDERS

“Rule of Thumb” Guide

For continuous draws, where temperatures may reach 0ºF / -18°C, assume the vaporization rate of a 100 pounds / 45 kg cylinder to be approximately 50,000 BTU/hr. Therefore the:

Number of cylinders per side = total load in BTU/hr / 50,000

Example:

If a total requirement of 20,000 BTU/hr is to be supplied from 100 pounds / 45 kg DOT cylinders and winter temperatures may drop to 0ºF / -18°C, then how many cylinders are needed per side?

Number of cylinders per side = 200,000 / 50,000 = 4

*When using a changeover regulator, 4 cylinders per side are required. Table 5 shows the vaporization rates for various temperatures and liquid levels in BTUH.

Table 5. Vaporization Rates In BTUH For Various Temperatures And Liquid Levels

POUNDS OF PROPANE IN CYLINDER	-20ºF / -29°C	0ºF / -18°C	20ºF / -6°C	40ºF / 4°C
100	65,000	71,000	79,000	94,000
90	60,000	65,000	72,000	85,000
80	54,000	59,000	66,000	77,000
70	48,000	52,000	59,000	69,000
60	43,000	46,000	52,000	61,000
50	37,000	40,000	45,000	53,000
40	31,000	34,000	38,000	45,000
30	26,000	28,000	31,000	37,000
20	20,000	22,000	25,000	29,000
10	15,000	16,000	18,000	21,000

CYLINDER AND TANK MANIFOLDING

Often it is necessary to manifold cylinders or tanks to obtain the required capacity needed for the installation. Multiple cylinder hookups are most frequently used on commercial applications and at many residential jobs, even though tank manifolding is common in certain areas.

On certain multi-cylinder or tank installations, an automatic changeover regulator can be used. These regulators change from the supply cylinder (when the gas is exhausted) to the reserve cylinder automatically without having to shutdown the system to refill.

A typical cylinder manifold using an automatic changeover regulator can be installed in line with multiple cylinders (See Figure 1).

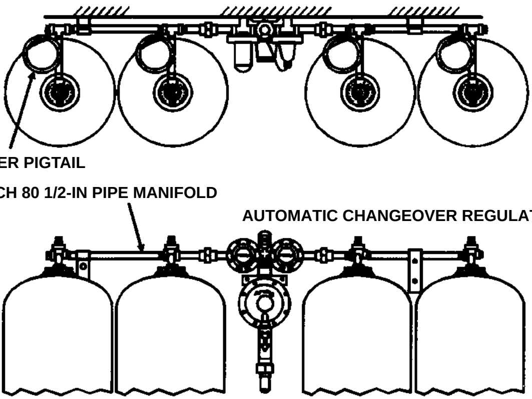


Figure 1. *Cylinder Manifold with Automatic Changeover Regulator*

CYLINDER AND TANK MANIFOLDING (Continued)

When manifolding cylinders or tanks, do not use a regulator at each container. When this is done, the required capacity for the particular installation may not be obtained. It is impossible to set all of the regulators at the same outlet pressure. The regulator delivering the highest outlet pressure will backpressure the other regulators, keeping them from operating. In effect, only one container would be supplying gas in this sort of situation.

The answer on manifold installations is to run high pressure piping from the containers into a common line, as shown in Figure 2 below. Then, install a regulator that can handle the required capacity. Two-stage regulation is the most effective system on tank manifold installations.

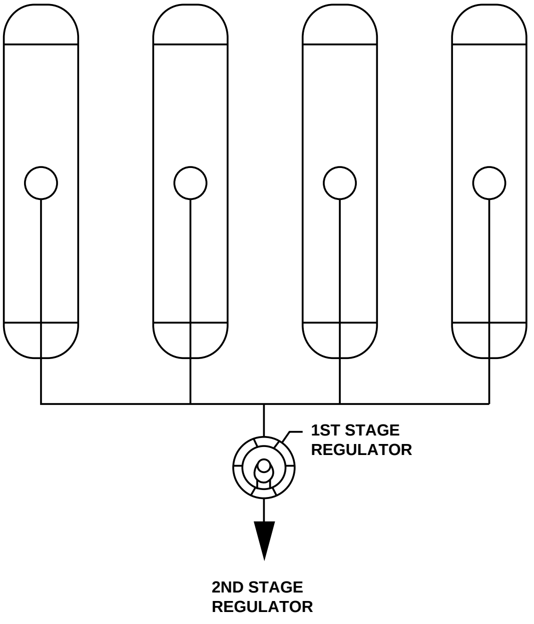


Figure 2. *Schematic of a Tank Manifold Installation*

CONTAINER LOCATION AND INSTALLATION

Once the proper size of ASME storage tank or the proper number of DOT cylinders has been determined, careful attention must be given to the most convenient, yet safe, place for their location on the customer's property.

Containers should be placed in a location pleasing to the customer that does not conflict with state and local regulations or NFPA Pamphlet No. 58, Storage and Handling of Liquefied Petroleum Gases. Refer to this standard to determine the appropriate placement of LP-Gas containers.

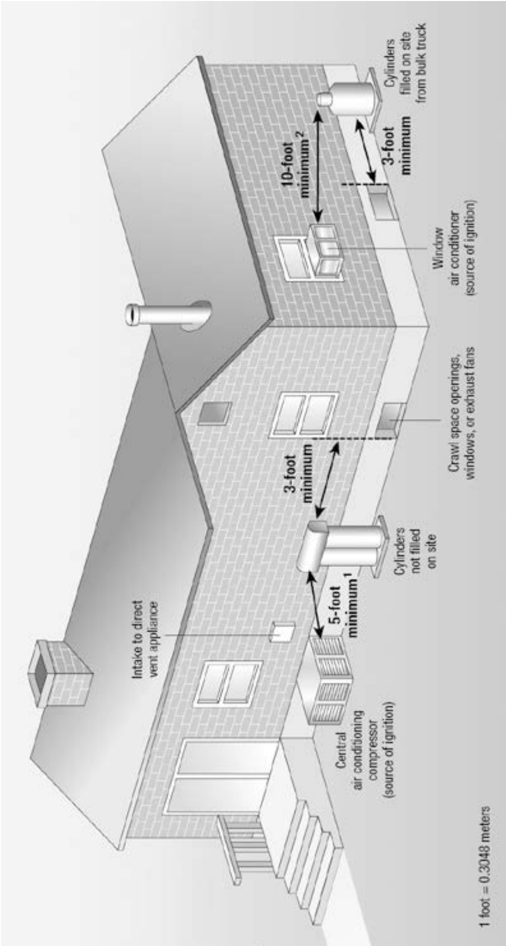
In general, storage tanks should be placed in an accessible location for filing, supported by concrete blocks of appropriate size and reinforcement, and located away from vehicular traffic.

Cylinders should be placed with ease of replacement or refilling in mind, secured on a firm base, and protected from vehicular traffic, animals and the elements.

For both ASME and DOT containers, the distance from any building openings, external sources of ignition, and intakes to direct vented gas appliances or mechanical ventilation systems are a critical consideration. See Figures 3, 4, and 5 on pages 12, 13, and 14.

Refer to NFPA No. 58 for the minimum distances that these containers must be placed from the building or other objects.

CONTAINER LOCATION (Continued)

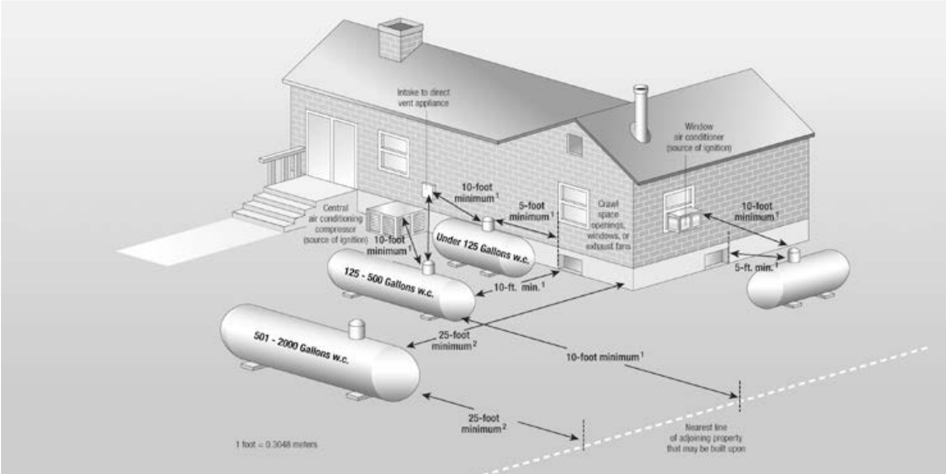


Note 1: 5-foot / 1.5 m minimum from relief valve in any direction away from any exterior source of ignition, openings into direct vent appliances, or mechanical ventilation air intakes.

Note 2: If the cylinders are filled on site from a bulk truck, the filling connection and vent valve must be at least 10-foot / 3.0 m from any exterior source of ignition, openings into direct vent appliances, or mechanical ventilation air intakes.

Figure 3. *Cylinders, Reprinted from NFPA 58 Figure I.1(a), 2002 ed.*

CONTAINER LOCATION (Continued)

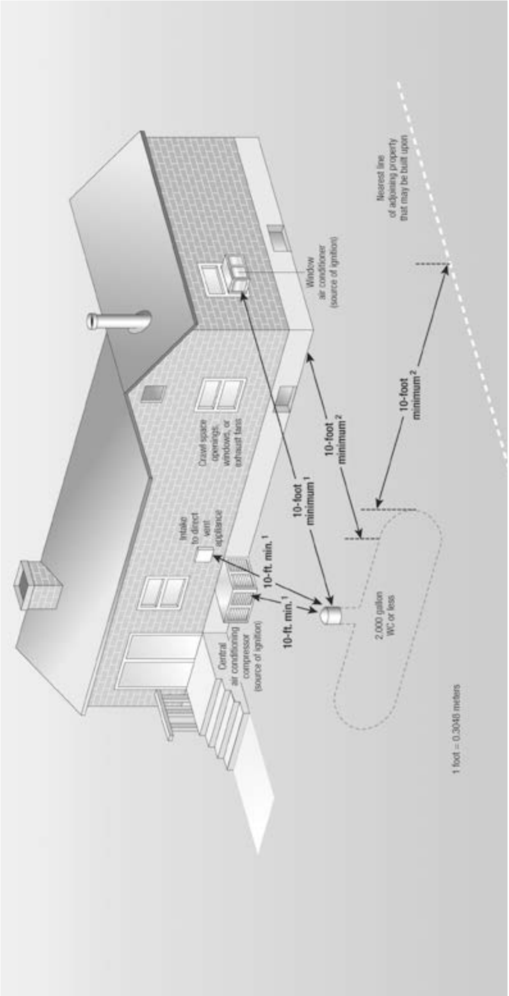


Note 1: Regardless of its size, any ASME tank filled on site must be located so that the filling connection and fixed liquid level gauge are at least 10-foot / 3.0 m away from any external source of ignition (i.e. open flame, window A/C, compressor, ect.), intake to direct vented gas appliances or intake to a mechanical ventilation system.

Note 2: The distance may be reduced to no less than 10-foot / 3.0 m for a single container of 1200 gal / 4.5 m^3 water capacity or less provided such container is at least 25-foot / 7.6 m from any other LP-Gas container of more than 125-AF6126 gal / 0.5 m^3 water capacity.

Figure 4. *Above Ground ASME Containers, Reprinted from NFPA 58 Figure I.1(b), 2002 ed.*

CONTAINER LOCATION (Continued)



Note 1: The relief valve, filling connection, and liquid fixed maximum level gauge vent connection at the container must be at least 10-foot / 3.0 m from any exterior source of ignition, openings into direct-vent appliances, or mechanical ventilation air intakes.

Note 2: If the cylinder is filled on site from a bulk truck, the filling connection and vent valve must be at least 10-foot / 3.0 m from any exterior source of ignition, openings into direct-vent appliances, or mechanical ventilation air intakes.

Figure 5. *Below Ground ASME Containers, Reprinted from NFPA 58 Figure I.1(c), 2002 ed.*

CONTAINER PREPARATION FOR REMOVAL OF WATER AND AIR CONTAMINANTS

Both water and air are contaminants that can seriously hinder the proper operation of the LP-Gas system and the connected appliances if nor effectively removed. The following procedures will help increase system performance and decrease the number of service calls.

Removing Water from Containers

Water in LP-Gas cylinders and tanks can contaminate the gas, causing regulator freezeups and erratic appliance performance. Neutralize any moisture in the container by adding anhydrous methanol (99.85% pure) according to the amount shown in Table 6.

This will minimize freeze up problems for normal amounts of water in a container. However, this water may still cause corrosion or sediment problems. Large amounts of water should be drained from the tank.

Table 6. Methanol Requirements For Water Removal

CONTAINER SIZE	MINIMUM AMOUNT OF METHANOL REQUIRED
100 pounds Cylinder	1/8 Pint (2 Fluid Ounces)
150 gallons Tank	1 Pint
250 gallons Tank	1 Quart
500 gallons Tank	2 Quarts
1,000 gallons Tank	1 Gallon

Warning: Do not substitute other alcohols in place of methanol.

PURGING AIR FROM CONTAINERS

Air in the LP-Gas can cause appliance pilot lights to be extinguished easily. It can also lead to excessive container pressure, making the safety relief valve open. Since nearly all containers are shipped from the fabricator under air pressure, it is extremely important to get rid of the air before the container is put in service.

DOT Cylinders

First, open the cylinder or service valves for several minutes to allow air to bleed to atmosphere. Then, pressure the cylinder with LP-Gas vapor and again open the cylinder or service valve (repeat this step at least two times).

ASME Storage Tanks

Depending on the type of valves in the tank, (see Figures 6a and 6b on page 17), purge the container as follows:

1) Bleed the air atmosphere by opening the multi-purpose valve or the service valve for several minutes until air pressure is exhausted. Close the valve.

2) If a pressure gauge has not been installed in the multi- purpose valve side outlet, install a 0 to 300 psig / 0 to 20.7 bar gauge (Fisher® brand Type J506). On tank with service valves, install a POL x 1/4-inch FNPT pipe coupling and 0 to 300 psig / 0 to 20.7 bar gauge in the valve service valve outlet.

3) Attach the truck vapor equalizing hose to the multi-purpose valve's vapor equalizing valve to the separate vapor-equalizing valve.

4) Slowly open the shutoff valve on the end of the hose so that the truck excess flow check valve does not slam-shut.

5) Closely watch the pressure, and when the gauge reaches 15 psig / 1.0 bar, close the shutoff valve.

PURGING AIR FROM CONTAINERS

ASME Storage Tanks (Continued)

6) Open the vapor service valve on the multi-purpose valve (or the separate service valve, after removing the adaptor). Allow all pressure to be exhausted before closing the multi-purpose valve or the service valve.
7) Repeat steps 4 through 6 at least three more times to make certain air has been purged from the tank.

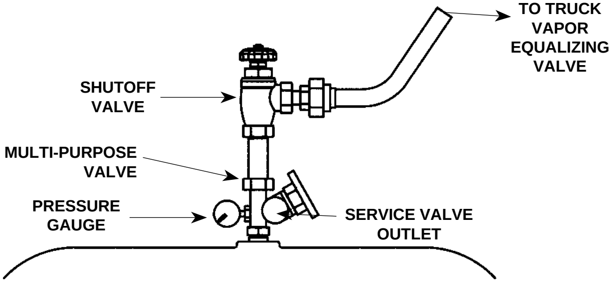
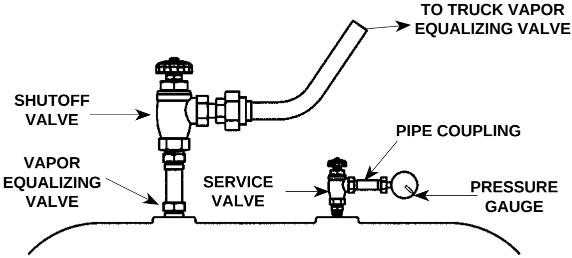


Figure 6a. *Purging Method with Multi-Purpose Valve*



Note: Do not purge tanks in this way on the customer's property. Purge them in a safe place at the bulk plant site.

Figure 6b. *Purging Method with Separate Valves*

PIPE AND TUBING SIZING

The proper selection of pipe and tubing sizes is essential for the efficient operation of the LP-Gas appliance. General consideration must be given to the maximum gas demand requirements of the system and the allowable pressure loss from the point of delivery to the inlet connection of the gas appliance.

Four different areas of sizing requirements must be addressed:

1) Sizing between First-Stage and Second-Stage Regulators

2) Sizing between Second-Stage Regulator and Appliance

3) Sizing between 2-psi / 0.14 bar Service and Line Pressure Regulators

4) Sizing between Line Pressure Regulator and Appliance

The following directions and examples, as well as Tables 7A through 8A starting on page 23, will assist in determining the proper selection of pipe and tubing sizing for these different areas. All data in the tables are calculated per NFPA Pamphlet Nos. 54 and 58.

PIPE AND TUBING SIZING (Continued)

Directions for Sizing between First-Stage and Second-Stage Regulators

(Based on NFPA 54 Hybrid Pressure Method)

1) Measure the required length of pipe or tubing from the outlet of the first-stage regulator to the inlet of the second stage regulator.

2) Determine the maximum gas demand requirements of the system by adding the BTU/HR inputs from the nameplates of all the appliances or by referring to Table 3 on page 5.

3) Select the pipe or tubing required from Tables 7A, 7B, and 7C on pages 23 through 25.

Directions for Sizing between Second-Stage Regulator and Appliance

(Based on NFPA 54 Longest Length Method)

1) Measure the length of pipe or tubing from the outlet of the second-stage regulator to the most remote appliance. (Note: This is the only length needed to size the second-stage system).

2) For each outlet and section of pipe, determine the specific gas demand requirements by adding the BTU/HR inputs from the nameplates of each appliance or by referring to Table 3 on page 5.

3) Select the pipe or tubing required for each section from Table 8A or 8B on pages 26 and 27.

PIPE AND TUBING SIZING (Continued)

Determine the sizes of pipe or tubing required for this two-stage LP-Gas installation.

Example:
A private home is to be supplied with a LP-Gas system serving a central furnace, range and water heater. The gas demand and piping lengths are shown on the sketch below.

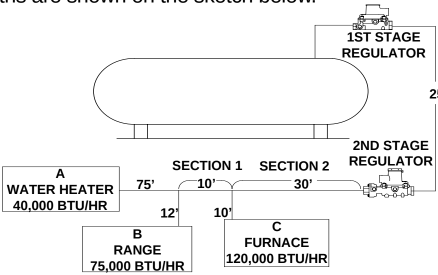


Figure 7. *LP-Gas System Serving a Central Furnace, Range, and Water Heater*

For First-Stage:

1) Length of first-stage piping = 25 feet (round up to 30 foot for use in Tables 7A, 7B, and 7C).
2) Total gas demand = 40,000 + 120,000 = 235,000 BTU/HR
3) From Tables 7A, 7B, and 7C, use 1/2-inch iron pipe; or 1/4-inch Type L or 3/8-inch ACR copper tubing or 1/2-inch plastic tubing (assume a 10 psig / 0.7 bar first-stage regulator setting and a 1 psig pressure drop).

For Second-Stage:

1) Total second-stage piping length = 30 + 10 + 15 = 55 feet (round up to 60 foot for use in Tables 8A and 8B).
2) Gas demand requirements and pipe selection from Tables 8A and 8B (assume a 11-inch w.c. setting and 1/2-inch w.c. pressure drop).

For outlet A, demand = 40,000 BTU/hr, use 1/2-inch iron pipe or 3/8-inch Type L or 5/8-inch ACR copper tubing.

For outlet B, demand = 75,000 BTU/hr, use 1/2-inch iron pipe or 1/2-inch Type L or 5/8-inch ACR copper tubing.

For outlet C, demand = 120,000 BTU/hr, use 3/4-inch iron pipe or 5/8-inch Type L or 3/4-inch ACR copper tubing.

For section 1, demand = 40,000 + 75,000 = 115,000 BTU/hr, use 3/4-inch iron pipe or 5/8-inch Type L or 3/4-inch ACR copper tubing.

For section 2, demand = 40,000 + 75,000 + 120,000 = 235,000 BTU/hr, use 1-inch iron pipe.

PIPE AND TUBING SIZING (Continued)

Directions for Sizing between 2-psi / 0.14 bar Service Regulator and Line Pressure Regulator

1) Measure the length of CSST tubing from the outlet of the 2-psi / 0.14 bar service regulator to the inlet of the line pressure regulator.
2) Determine the maximum gas demand requirements of the system be adding the BTU/hr inputs from the nameplates of all the appliances or by referring to Table 3 on page 5.
3) Use the correct footage column, or next higher column in Table 9A. Select CSST tubing size when capacity in column exceeds gas demand.

Directions for Sizing between Line Pressure Regulator and Appliance

1) Measure the length of CSST tubing from the outlet of the line pressure regulator to each of the appliances.
2) For each outlet and selection of CSST tubing, determine the specific gas demand requirements by adding the BTU/hr inputs from the nameplates of each appliance or by referring Table 3 on page 5.
3) Use the correct footage column, or next higher column in Table 11. Select CSST tubing size when capacity in column exceeds gas demand.

Example:

A typical single family home with four appliances is to be supplied with a LP-Gas system. The piping is arranged in parallel with a distribution manifold branching CSST runs to the appliances. The supply pressure (downstream of the service regulator) is 2 psig / 0.14 bar and the outlet pressure of the line pressure regulator is set to 11-inch w.c. / 27 mbar. (See next page).

PIPE AND TUBING SIZING (Continued)

Determine the sizes of pipe or tubing required for this in-house LP-Gas installation.

From 2 PSI Service Regulator to Line Regulator:

1) Length of section A tubing = 20 feet
2) Total gas demand = 80,000 + 36,000 + 28,000 + 52,000 = 196,000 BTU/hr
3) From Table 9A, use 25' column. Select 3/8-inch CSST for run A, as it has capacity over 196,000 BTU/hr (262,000) (assume a 2 psig / 0.14 bar second-stage regulator setting and 1 psig pressure drop).

From Line Pressure Regulator to Each Appliance:

1) For line B, length = 10 feet; gas demand = 80,000 BTU
   For line C, length = 10 feet; gas demand = 36,000 BTU
   For line D, length = 30 feet; gas demand = 28,000 BTU
   For line B, length = 35 feet; gas demand = 52,000 BTU
2) CSST Tubing selection from Table 11 (assume a 11-inch w.c. setting and 1/2-inch w.c. pressure drop):

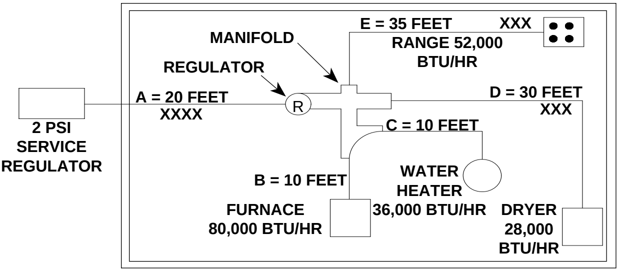


Figure 8. *Single Family Home with a LP-Gas System*

Single Family Home With LP-Gas Example				
LINE	**LENGTH (FT.)**	**LOAD, 1,000 BTU/HR**	**CSST CAPACITY, 1,000 BTU/HR**	**SELECT CSST SIZE**
B	10	80	129	1/2
C	10	36	50	3/8
D	30	28	28	3/8
E	35*	52	64	1/2
*Uses 40' column in Table 11.				

Table 7A. Pipe Sizing Between First-Stage (High Pressure Regulator) And Second-Stage (Low Pressure Regulator)

MAXIMUM UNDILUTED PROPANE CAPACITIES BASED ON 10 PSIG FIRST STAGE SETTING AND 1 PSIG PRESSURE DROP. CAPACITIES ARE IN 1,000 BTU PER HOUR.

	Schedule 40 Pipe Size, Inches (Actual Inside Diameter, Inches)								
Piping Length, Feet	**1/2 NPT (0.622-inches)**	**3/4 NPT (0.824-inches)**	**1 NPT (1.049-inches)**	**1-1/4 NPT (1.38-inches)**	**1-1/2 NPT (1.61-inches)**	**2 NPT (2.067-inches)**	**3 NPT (3.068-inches)**	**3-1/2 NPT (3.548-inches)**	**4 NPT (4.026-inches)**
30	843	3,854	7,260	14,904	22,331	43,008	121,180	177,425	247,168
40	1,577	3,298	6,213	12,756	19,113	36,809	103,714	151,853	211,544
50	1,398	2,923	5,507	11,306	16,939	32,623	91,920	134,585	187,487
60	1,267	2,649	4,989	10,244	15,348	29,559	83,286	121,943	169,877
70	1,165	2,437	4,590	9,424	14,120	27,194	76,622	112,186	156,285
80	1,084	2,267	4,270	8,767	13,136	25,299	71,282	104,368	145,393
90	1,017	2,127	4,007	8,226	12,325	23,737	66,882	97,925	136,417
100	961	2,009	3,785	7,770	11,642	22,422	63,176	92,499	128,859
150	772	1,613	3,039	6,240	9,349	18,005	50,733	74,280	103,478
200	660	1,381	2,601	5,340	8,002	15,410	43,421	63,574	88,564
250	585	1,224	2,305	4,733	7,092	13,658	38,483	56,345	78,493
300	530	1,109	2,089	5,289	6,426	12,375	34,868	51,052	71,120
350	488	1,020	1,922	3,945	5,911	11,385	32,078	46,967	65,430
400	454	949	1,788	3,670	5,499	10,591	29,843	43,694	60,870
450	426	890	1,677	3,444	5,160	9,938	28,000	40,997	57,112
500	402	841	1,584	3,253	4,874	9,387	26,449	38,725	53,948
600	364	762	1,436	2,948	4,416	8,505	23,965	35,088	48,880
700	335	701	1,321	2,712	4,063	7,825	22,047	32,280	44,969
800	312	652	1,229	2,523	3,780	7,279	20,511	30,031	41,835
900	293	612	1,153	2,367	3,546	6,830	19,245	28,177	39,253
1,000	275	578	1,089	2,236	3,350	6,452	18,178	26,616	37,078
1,500	222	464	875	1,795	2,690	5,181	14,598	21,373	29,775
2,000	190	397	748	1,537	2,302	4,434	12,494	18,293	25,483

Data taken and reprinted from Table 15.1(a) in NFPA 58, 2004 ed. Always check www.nfpa.org for the latest updates.

Table 7B. Pipe Sizing Between First-Stage (High Pressure Regulator) And Second-Stage (Low Pressure Regulator)

MAXIMUM UNDILUTED PROPANE CAPACITIES BASED ON 10 PSIG FIRST STAGE SETTING AND 1 PSIG PRESSURE DROP. CAPACITIES ARE IN 1,000 BTU PER HOUR.

Type	ACR (Refrigeration)					Type L Tubing				
Nominal	3/8-inch	1/2-inch	5/8-inch	3/4-inch	7/8-inch	3/8-inch	1/2-inch	5/8-inch	3/4-inch	7/8-inch
Outside	(0.375)	(0.500)	(0.625)	(0.750)	(0.875)	(0.500)	(0.625)	(0.750)	(0.875)	(1.000)
Inside	0.311	0.436	0.555	0.68	0.785	0.430	0.545	0.666	0.785	0.906
Length, Feet										
30	299	726	1,367	2,329	3,394	309	700	1,303	2,205	3,394
40	256	621	1,170	1,993	2,904	265	599	1,115	1,887	2,904
50	227	551	1,037	1,766	2,574	235	531	988	1,672	2,574
60	206	499	939	1,600	2,332	213	481	896	1,515	2,332
70	189	459	864	1,472	2,146	196	443	824	1,394	2,146
80	176	427	804	1,370	1,996	182	412	767	1,297	1,996
90	165	401	754	1,285	1,873	171	386	719	1,217	1,873
100	156	378	713	1,214	1,769	161	365	679	1,149	1,769
150	125	304	572	975	1,421	130	293	546	923	1,421
200	107	260	490	834	1,216	111	251	467	790	1,216
250	95	230	434	739	1,078	90	222	414	700	1,078
300	86	209	393	670	976	89	201	375	634	976
350	79	192	362	616	898	82	185	345	584	898
400	74	179	337	573	836	76	172	321	543	836
450	69	168	316	538	784	71	162	301	509	784
500	65	158	298	508	741	68	153	284	481	741
600	59	144	270	460	671	61	138	258	436	671
700	54	132	249	424	617	56	127	237	401	617
800	51	123	231	394	574	52	118	221	373	574
900	48	115	217	370	539	49	111	207	350	539
1,000	54	109	205	349	509	46	105	195	331	509
1,500	36	87	165	281	409	37	84	157	266	409
2,000	31	75	141	240	350	32	72	134	227	350

Data taken and reprinted from Table 15.1(h) and 15.1(k) in NFPA 58, 2007 ed. Always check www.nfpa.org for the latest updates.

Table 7C. Polyethylene Plastic Tube And Pipe Sizing Between First-Stage And Second-Stage Regulators

MAXIMUM UNDILUTED PROPANE CAPACITIES BASED ON 10 PSIG FIRST STAGE SETTING AND 1 PSI PRESSURE DROP. CAPACITIES ARE IN 1,000 BTU PER HOUR.

	Plastic Tubing Size (CTS) and Pipe Size (IPS) (Dimensions in Paranthesis are Inside Diameter)						
Length of Pipe or Tubing, Feet	**1/2-inch CTS SDR 7.00 (0.445)**	**1-inch CTS SDR 11.00 (0.927)**	**1/2-inch IPS SDR 9.33 (0.660)**	**3/4-inch IPS SDR 11.00 (0.860)**	**1-inch IPS SDR 11.00 (1.077)**	**1-1/4-inch IPS SDR 10.00 (1.328)**	**2-inch IPS SDR 11.00 (1.943)**
30	762	5,225	2,143	4,292	7,744	13,416	36,402
40	653	4,472	1,835	3,673	6,628	11,482	31,155
50	578	3,964	1,626	3,256	5,874	10,176	27,612
60	524	3,591	1,473	2,950	5,322	9,220	25,019
70	482	3,304	1,355	2,714	4,896	8,483	23,017
80	448	3,074	1,261	2,525	4,555	7,891	21,413
90	421	2,884	1,183	2,369	4,274	7,404	20,091
100	397	2,724	1,117	2,238	4,037	6,994	18,978
125	352	2,414	990	1,983	3,578	6,199	16,820
150	319	2,188	897	1,797	3,242	5,616	15,240
175	294	2,013	826	1,653	2,983	5,167	14,020
200	273	1,872	778	1,539	2,775	4,807	13,043
225	256	1,757	721	1,443	2,603	4,510	12,238
250	242	1,659	681	1,363	2,459	4,260	11,560
275	230	1,576	646	1,294	2,336	4,046	10,979
300	219	1,503	617	1,235	2,228	3,860	10,474
350	202	1,383	567	1,136	2,050	3,551	9,636
400	188	1,287	528	1,057	1,907	3,304	8,965
450	176	1,207	495	992	1,789	3,100	8,411
500	166	1,140	468	937	1,690	2,928	7,945
600	151	1,033	424	849	1,531	2,653	7,199
700	139	951	390	781	1,409	2,441	6,623
800	129	884	363	726	1,311	2,271	6,761
900	121	830	340	682	1,230	2,131	5,781
1,000	114	784	322	644	1,162	2,012	5,461
1,500	92	629	258	517	933	1,616	4,385
2,000	79	539	221	443	798	1,383	3,753

Data taken and reprinted from Table 15.1(p) and 15.1(n) in NFPA 58, 2007 ed. Always check www.nfpa.org for the latest updates.

Table 8A. Pipe Sizing Between Second-Stage (Low Pressure Regulator) And Appliance

MAXIMUM UNDILUTED PROPANE CAPACITIES BASED ON 11-INCHES W.C. SETTING AND 0.5-INCH W.C. PRESSURE DROP. CAPACITIES ARE IN 1,000 BTU PER HOUR.

	Schedule 40 Pipe Size, inches (Actual Inside Diameter, Inches)								
Piping Length, Feet	**1/2-inch NPT (0.622-inch)**	**3/4 NPT (0.824-inches)**	**1 NPT (1.049-inches)**	**1-1/4 NPT (1.38-inches)**	**1-1/2 NPT (1.61-inches)**	**2 NPT (2.067-inches)**	**3 NPT (3.068-inches)**	**3-1/2 NPT (3.548-inches)**	**4 NPT (4.026-inches)**
10	291	608	1,146	2,352	3,523	6,789	19,130	28,008	39,018
20	200	418	788	1,617	2,423	4,666	13,148	19,250	26,817
30	161	336	632	1,299	1,946	3,747	10,558	15,458	21,535
40	137	287	541	1,111	1,665	3,207	9,036	13,230	18,431
50	122	255	480	985	1,476	2,842	8,009	11,726	16,335
60	110	231	435	892	1,337	2,575	7,256	10,625	14,801
80	94	198	372	764	1,144	2,204	6,211	9,093	12,668
100	84	175	330	677	1,014	1,954	5,504	8,059	11,227
125	74	155	292	600	899	1,731	4,878	7,143	9,950
150	67	141	265	544	815	1,569	4,420	6,472	9,016
200	58	120	227	465	697	1,343	3,783	5,539	7,716
250	51	107	201	412	618	1,190	3,353	4,909	6,839
300	46	97	182	373	560	1,078	3,038	4,448	6,196
350	43	89	167	344	515	992	2,795	4,092	5,701
400	40	83	156	320	479	923	2,600	3,807	5,303

Data taken and reprinted from Table 15.1(c) in NFPA 58, 2007 ed. Always check www.nfpa.org for the latest updates.

Table 8B. Tube Sizing Between Second-Stage And Appliance

MAXIMUM UNDILUTED PROPANE CAPACITIES BASED ON 11-INCHES W.C. SETTING AND 0.5-INCH W.C. PRESSURE DROP. CAPACITIES ARE IN 1,000 BTU PER HOUR.

Type	ACR (Refrigeration)					Type L Tubing				
Nominal	**3/8-inch**	**1/2-inch**	**5/8-inch**	**3/4-inch**	**7/8-inch**	**3/8-inch**	**1/2-inch**	**5/8-inch**	**3/4-inch**	**7/8-inch**
Outside	**0.375**	**0.500**	**0.625**	**0.750**	**0.875**	**0.375**	**0.500**	**0.625**	**0.750**	**0.875**
Inside	**0.311**	**0.436**	**0.555**	**0.68**	**0.785**	**0.315**	**0.430**	**0.545**	**0.666**	**0.785**
Length, Feet										
10	47	115	216	368	536	49	110	206	348	535
20	32	79	148	253	368	34	76	141	239	368
30	26	63	119	203	296	27	61	113	192	296
40	22	54	102	174	253	23	52	97	164	253
50	20	48	90	154	224	20	46	86	146	224
60	18	43	82	139	203	19	42	78	132	203
80	15	37	70	119	174	16	36	67	113	174
100	14	33	62	106	154	14	32	59	100	154
125	12	29	55	94	137	12	28	52	89	137
150	11	26	50	85	124	11	26	48	80	124
200	9	23	43	73	106	10	22	41	69	106
250	8	20	38	64	94	9	19	36	61	94
300	8	18	34	58	85	8	18	33	55	85
350	7	17	32	54	78	7	16	30	51	78
400	6	16	29	50	73	7	15	28	47	73

Data taken and reprinted from Table 15.1(l) and 15.1(j) in NFPA 58, 2007 ed. Always check www.nfpa.org for the latest updates.

Table 9A. Maximum Capacity Of CSST*

CSST TUBE SIZE	EHD** FLOW DESIGNATION	IN THOUSANDS OF BTU/HOUR OF UNDILUTED PROPANE AT A PRESSURE OF 2 PSI AND A PRESSURE DROP OF 1 PSI (BASED ON A 1.5 SPECIFIC GRAVITY GAS). Tubing Length, Feet													
		10	25	30	40	50	75	80	100	150	200	250	300	400	500
3/8-inch	13	426	262	238	203	181	147	140	124	101	86	77	69	60	53
- - - -	15	558	347	316	271	243	196	189	169	137	118	105	96	82	72
1/2-inch	18	927	591	540	469	420	344	333	298	245	213	191	173	151	135
- - - -	19	1,106	701	640	554	496	406	393	350	287	248	222	203	175	158
3/4-inch	23	1,735	1,120	1,027	896	806	663	643	578	477	415	373	343	298	268
- - - -	25	2,168	1,384	1,266	1,100	986	809	768	703	575	501	448	411	355	319
- - - -	30	4,097	2,560	2,331	2,012	1,794	1,457	1,410	1,256	1,021	880	785	716	616	550
1-inch	31	4,720	2,954	2,692	2,323	2,072	1,685	1,629	1,454	1,182	1,019	910	829	716	638
1-1/4-inch	37	7,128	4,564	4,176	3,631	3,258	2,675	2,601	2,325	1,908	1,658	1,487	1,363	1,163	1,027
1-1/2-inch	46	15,174	9,549	8,708	7,529	6,726	5,480	5,303	4,738	3,860	3,337	2,981	2,719	2,351	2,101
2-inch	62	34,203	21,680	19,801	17,159	15,357	12,551	12,154	10,877	8,890	7,705	6,895	6,296	5,457	4,883

Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds 1/2 psi (based on 13-inch 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. CAUTION: Capacities shown in table may exceed maximum capacity for a selected regulator. Consult with regulator or tubing manufacturer for guidance.

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

** EDH - Equivalent Hydraulic Diameter - 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.

Data taken and reprinted from Table 15.1(m) in NFPA 58, 2007 ed. Always check www.nfpa.org for the latest updates.

Table 9B. Pipe Sizing Between 2 PSI Regulator And Appliance Regulator

MAXIMUM UNDILUTED PROPANE CAPACITIES BASED ON 2 PSI SETTING AND 1 PSI PRESSURE DROP. CAPACITIES ARE IN 1,000 BTU PER HOUR.

	Schedule 40 Pipe Size, inches (Actual Inside Diameter, Inches)								
Piping Length, Feet	1/2-inch NPT (0.622-inch)	3/4 NPT (0.824-inches	1 NPT (1.049-inches)	1-1/4 NPT (1.38-inches)	1-1/2 NPT (1.61-inches)	2 NPT (2.067-inches)	3 NPT (3.068-inches)	3-1/2 NPT (3.548-inches)	4 NPT (4.026-inches)
10	2,687	5,619	10,585	21,731	32,560	62,708	176,687	258,696	360,385
20	1,847	3,862	7,275	14,936	22,378	43,099	121,436	177,800	247,690
30	1,483	3,101	5,842	11,994	17,971	34,610	97,517	142,780	198,904
40	1,269	2,654	5,000	10,265	15,381	29,621	83,462	122,201	170,236
50	1,125	2,352	4,431	9,098	13,632	26,253	73,971	108,305	150,877
60	1,019	2,131	4,015	8,243	12,351	23,787	67,023	98,132	136,706
70	938	1,961	3,694	7,584	11,363	21,884	61,660	90,280	125,767
80	872	1,824	3,436	7,055	10,571	20,359	57,363	83,988	117,002
90	819	1,712	3,224	6,620	9,918	19,102	53,822	78,803	109,779
100	773	1,617	3,046	6,253	9,369	18,043	50,840	74,437	103,697
150	621	1,298	2,446	5,021	7,524	14,490	40,826	59,776	83,272
200	531	1,111	2,093	4,298	6,439	12,401	34,942	51,160	71,270

Data taken and reprinted from Table 15.1(b) in NFPA 58, 2007 ed. Always check www.nfpa.org for the latest updates.

Table 10. Tube Sizing Between Second-Stage And Appliance

MAXIMUM UNDILUTED PROPANE CAPACITIES BASED ON 2 PSI SETTING AND 1 PSI PRESSURE DROP. CAPACITIES ARE IN 1,000 BTU PER HOUR.

Type	ACR (Refrigeration)					Type K Tubing				
Nominal	3/8-inch	1/2-inch	5/8-inch	3/4-inch	7/8-inch	3/8-inch	1/2-inch	5/8-inch	3/4-inch	7/8-inch
Outside	0.375	0.500	0.625	0.750	0.875	0.375	0.500	0.625	0.750	0.875
Inside	0.311	0.436	0.555	0.68	0.785	0.315	0.430	0.545	0.666	0.785
Length, Feet										
10	434	1,053	1,982	3,377	4,922	449	1,015	1,890	3,198	4,922
20	298	723	1,362	2,321	3,383	308	698	1,299	2,198	3,383
30	239	581	1,094	1,864	2,716	248	560	1,043	1,765	2,716
40	205	497	936	1,595	2,325	212	479	893	1,511	2,325
50	182	441	830	1,414	2,061	188	425	791	1,339	2,061
60	165	399	752	1,281	1,867	170	385	717	1,213	1,867
80	141	342	644	1,096	1,598	146	330	614	1,038	1,598
100	125	303	570	972	1,416	129	292	544	920	1,416
125	111	268	506	861	1,255	114	259	482	816	1,255
150	100	243	458	780	1,137	104	235	437	739	1,137
200	86	208	392	668	973	89	201	374	632	973
250	76	184	347	592	863	79	178	331	560	863
300	69	167	315	536	782	71	161	300	508	782
350	63	154	290	493	719	66	148	276	467	719
400	59	143	269	459	669	61	138	257	435	669

Data calculated from Formula in NFPA 54, 2002 ed.

Table 11. Maximum Capacity Of CSST*

CSST TUBE SIZE	EHD** FLOW DESIGNATION	IN THOUSANDS OF BTU/HR OF UNDILUTED PROPANE AT A PRESSURE OF 11-INCHES W.C. AND A PRESSURE DROP OF 0.5-INCH W.C. (BASED ON A 1.5 SPECIFIC GRAVITY GAS). Tubing Length, Feet																
		5	10	15	20	25	30	40	50	60	70	80	90	100	150	200	250	300
3/8-inch	13	72	50	39	34	30	28	23	20	19	17	15	15	14	11	9	8	8
- - - -	15	99	69	55	49	42	39	33	30	26	25	23	22	20	15	14	12	11
1/2-inch	18	181	129	104	91	82	74	64	58	53	49	45	44	41	31	28	25	23
- - - -	19	211	150	121	106	94	87	74	66	60	57	52	50	47	36	33	30	26
3/4-inch	23	355	254	208	183	164	151	131	118	107	99	94	90	85	66	60	53	50
- - - -	25	426	303	248	216	192	177	153	137	126	117	109	102	98	75	69	61	57
- - - -	30	744	521	422	365	325	297	256	227	207	191	178	169	159	123	112	99	90
1-inch	31	863	605	490	425	379	344	297	265	241	222	208	197	186	143	129	117	107
1-1/4-inch	37	1,415	971	775	661	583	528	449	397	359	330	307	286	270	217	183	163	147
1-1/2-inch	46	2,830	1,993	1,623	1,404	1,254	1,143	988	884	805	745	656	656	621	506	438	390	357
2-inch	62	6,547	4,638	3,791	3,285	2,940	2,684	2,327	2,082	1,902	1,761	1,554	1,554	1,475	1,205	1,045	934	854

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

** EDH - Equivalent Hydraulic Diameter - 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.

Data taken and reprinted from Table 15.1(n) in NFPA 58, 2007 ed. Always check www.nfpa.org for the latest updates.

SELECTING THE REGULATOR

Regulator performance curves show the capacity of a regulator at different inlet pressures, given the factory setting for outlet pressure.

Figure 9 shows a performance curve for a Fisher® brand Second-Stage Regulator. Gas flow rate is plotted horizontally and regulator outlet pressure vertically. The curved line represents an inlet pressure of 10 psig / 0.69 bar. For the appliance to operate efficiently, the regulator outlet pressure must not fall below 9-inch w.c. / 22 mbar.

Emerson™ rates this particular regulator at the point the 10 psig / 0.69 bar inlet curve crosses the 9-inch w.c. / 22 mbar horizontal line. Thus, the literature would rate this regulator at 1,375,000 BTU/hr or more if the inlet pressure stays above 10 psig / 0.69 bar.

What you must know to select a regulator:

1. Appliance Load
2. Pipe Size
3. Inlet Pressure
4. Outlet Pressure
5. Gas Used (Propane/Butane)
6. Select From Manufacturer Catalog

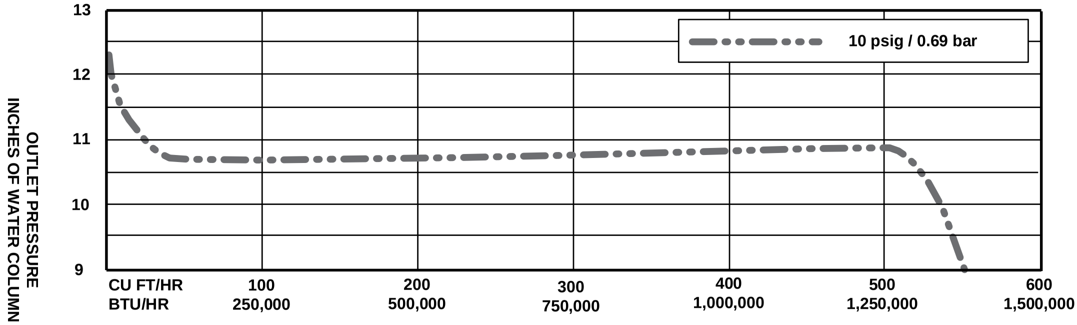


Figure 9. *Typical Capacity Curve*

REGULATOR SELECTION

TYPE OF REGULATOR OR SERVICE	CAPACITY, BTU/HR	RECOMMENDED FISHER REGULATOR
First-Stage[1] (Reduces tank pressure to 10 psig or less)	1,100,000 2,400,000	R122H R622H
Second-Stage[2] (Reduces first stage outlet pressure to 14-inch w.c. or less)	650,000 875,000 to 1,400,000 920,000 1,000,000	R222 R622 R642 R652
Integral Two-Stage[1] (Combines a high pressure and a 2nd stage regulator)	450,000 850,000	R232 R632
High Pressure[3] (Reduces tank pressure to a lower pressure in excess of 1 psig)	5,250,000 1,200,000 3,862,564	64 67C 1301F
2-psi[2] **Service** (Reduces 1st stage pressure to 2 psig)	1,680,000 1,500,000	R622E R652E

1. Based on 30 psig inlet pressure and 20% droop.
2. Based on 10 psig inlet pressure and 20% droop
3. Based on inlet pressure 20 psig greater than outlet pressure with 20% droop.

Note: The capacity BTU/HR column should be used for reference purposes only. The capacity will vary depending on the pipe size, orifice size and outlet pressure setting.

TWO-STAGE REGULATION

Advantages of Two-Stage Regulation

Uniform Appliance Pressure - Two-staging lets the first-stage regulator supply a nearly constant inlet pressure to the second-stage regulator at the house. This means the second-stage regulator has an easier time of maintaining appliance pressure at 11-inch w.c. / 27 mbar, thus improving the system efficiency.

Lower Installation Costs - Smaller pipe or tubing can be used between the first and second-stage regulators due to the higher pressure, thus reducing installation and piping material costs.

Freeze ups - Two-stage systems reduce problems due to regulator freezeups caused by excessive water in gas. Larger orifices make it more difficult for ice to form and block the passage area. The expansion of gas at two different orifices in a two-stage system greatly reduces the "refrigeration effect" that causes freezeups. See Fisher® **Bulletins LP-18 and LP-24** for more detailed information on freezing regulators.

Flexibility of Installation - A high pressure regulator can feed a number of low pressure regulators, thus enabling the addition of appliances in the future to the same pressure line without affecting there individual performances.

Fewer Trouble Calls - With two-stage regulation, you can expect fewer trouble calls due to pilot outage or burner adjustment. This means higher appliance efficiency, lower service costs and better customer relations.

REGULATOR INSTALLATION

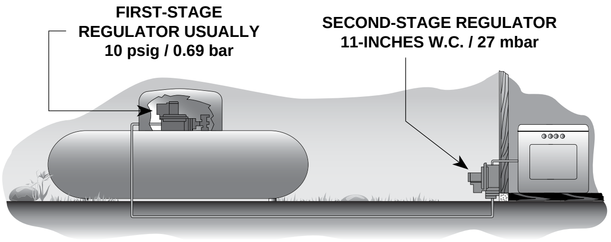


Figure 10. *Two-Stage Regulation, One at Tank and One at Building, Reduce Pressure Down to Burner Pressure (11-inches w.c.)*

A two-stage regulator system or an integral two-stage regulator shall be required on all fixed piping systems that serve appliance systems at 11-inch w.c. / 27 mbar. This includes R.V., manufactured housing and food service installations (exceptions: small portable appliances and outdoor cooking appliances with input ratings of 100,000 BTU/hr or less, certain gas distribution systems utilizing multiple second-stage regulators and systems that provide an equivalent level of overpressure protection).

This standard along with changes in UL 144 requiring increased regulator relief valve capacity or an overprotection shutoff device, results in the maximum pressure downstream of the second-stage regulator being limited to 2 psig / 0.14 bar even with a regulator seat failure.

See **Fisher® Bulletin LP-15** for more detailed information on registration operation, installation, and maintenance.

REGULATOR VENTS

Regulators should be installed in accordance with NFPA 58 and any other applicable regulations, as well as the manufacturer's instructions. The following guidelines shall be followed:

Outdoor Installations - A regulator installed outdoors without a protective hood must have its vent pointed vertically down, as shown in the drawing.

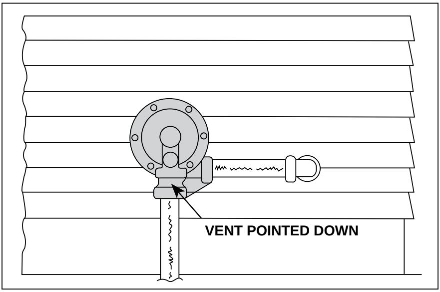


Figure 11. *Vent Pointing Vertically Down*

The regulator should be at least 18-inch / 457 mm above the ground. Do not install the regulator where there can be excessive water accumulation or ice formation, such as directly beneath a downspout, gutter or roof line. All vent openings must be at least three horizontal feet in any building opening and not less than five feet in any direction from any source of ignition, openings into direct vent appliances or mechanical ventilation intakes.

Horizontally mounted regulators, such as on single cylinder installations, must be installed underneath a protective cover. On ASME tank installations with the regulator installed under the tank dome, the regulator vent should slope slightly down enough to allow any condensation to drain from the spring case. The regulator vent should be positioned far enough back from the tank dome slot so that it is protected from the weather. The hood should be kept closed.

Regulators without "drip lip" vents must be installed under a protective cover.

REGULATOR VENTS (Continued)

Indoor Installations - In a fixed pipe system, regulators installed indoors require a vent line to the outside air. A screened vent assembly (Fisher® brand Y602 Series or equivalent) must be used at the end of the vent line. The vent assembly position and location precautions are the same as for regulator vents. The vent line must be the same size as the regulator vent and adequately supported. See Figure 12.

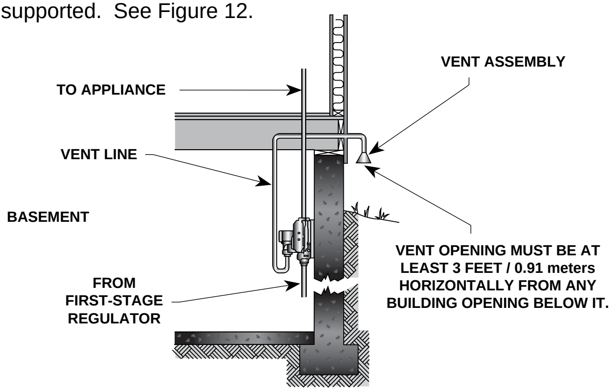


Figure 12. *Indoor Installation*

Underground Tanks - A vent tube is required on these installations to prevent water from entering the regulator's spring case. The vent tube connects to the regulator's spring case. The vent tube connects to the regulator vent and terminates above any possible water level, see Figure 13. Be sure that the ground slopes away from the tank dome as illustrated.

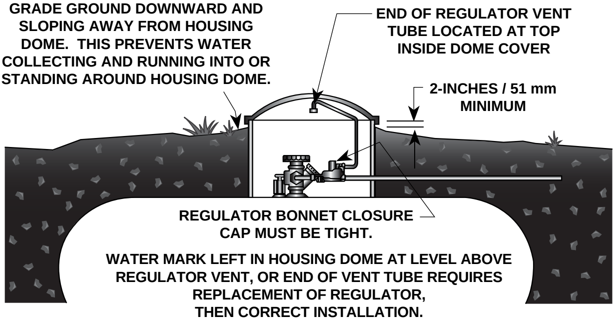


Figure 13. *Underground Tank*

LEAK TESTING METHODS

There are two primary methods for testing leaks in installations:

Low Pressure Method

1) Inspect all connections and appliance valves to be sure they are tight or closed. This includes pilot valves.
2) Connect a low pressure gauge (Fisher® brand Type 50P-2 or equivalent) to the burner orifice and open the valve.
3) Open the service valve at the tank to pressure the system. Close the service valve tightly.
4) The low pressure gauge should read at least 11-inch w.c. / 27 mbar. Slowly bleed off pressure by opening burner valve on the appliance to vent enough gas to reduce the pressure to exactly 9-inch w.c. / 22 mbar.
5) If the pressure remains at 9-inch w.c. / 22 mbar for 3 minute you can assume the system is leak tight. If the pressure drops, refer to the leak detection procedures below.
6) After the leak is repaired, repeat steps 3, 4, and 5.

High Pressure Method

1) Inspect all connections and appliance valves to be sure they are tight or closed. This includes pilot valves.
2) Connect a test block (Fisher brand Type J600 or equivalent in the service valve outlet at the tank, between the valve's outlet and the first regulator in the system).
3) Open the service valve at the tank to pressure the system. Close the service valve tightly.
4) Open an appliance valve until the test block's pressure gauge drops to 10 psig / 0.69 bar.
5) The system should stand for 3 minutes without an increase or decrease in the 10 psig / 0.69 bar reading. If pressure drops, refer to the leak detection procedure section. If pressure increases, then the service valve is leaking.
6) After any leaks are repaired, repeat steps 2, 3, and 4.

LEAK TESTING METHODS

Leak Detection and Correction Procedures

1) Use a bubble leak detection solution, to mechanical leak detector, (never a match or an open flame) when checking for leaks.

2) Apply the solution over every pipe or tubing joint and observe carefully to see if the bubbles expand, indicating a leak is present. A large leak can blow the solution away before bubble have a chance to form.

3) To correct a leak on flaring tubing, first try to tighten the connection. If this does not work, reflare.

4) On threaded piping, try tightening or redoping first. If the leak continues, take the connection apart and inspect the threads. Cut new thread if necessary.

5) If step 3 and 4 fail to correct the problem, look for sandholes in the pipe or fittings and check for splits in the tubing. Replace whatever material is defective.

   Note: Leaks caused by equipment such as gas cocks, appliances, valves, act., will require repair of the faulty part or replacement of the entire device.

REGULATOR INSPECTION

The following items should be checked at each gas delivery and at regularly scheduled testing and maintenance program intervals.

The customer should be instructed to turn off the tank service valve if gas can be smelled, pilot lights fail to stay on, or any other abnormal situation takes place.

Improper Installation

The regulator vent must be pointed down or under a protective cover. Regulators without “drip lip” vents (Figure 14) must be under a protective cover. Proper installation also minimizes weather related vent blockage and internal corrosion.

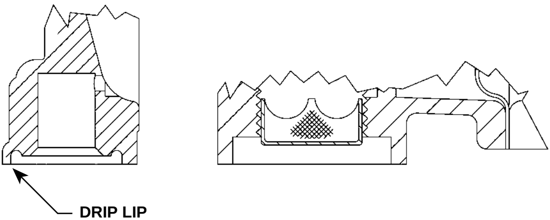


Figure 14. *Drip Lip*

Vent Blockage

Make sure the regulator vent, vent assembly, or vent tube is not blocked with mud, insect nests, ice, snow, paint, etc. The screen should be clean and properly installed.

Internal and External Corrosion

Replace any regulator that has had water in the spring case to shows evidence of external or internal corrosion. Regulators that have been flooded or that have been installed horizontally which minimizes moisture drainage, or on underground tanks, or in coastal areas are more susceptible to internal corrosion.

To inspect for internal corrosion:

1) Remove the regulator’s closing cap and look down into the spring case (a flashlight may be needed).
2) On some regulators it may be necessary to shut down the system and remove the adjusting screw and main spring to adequately see any internal corrosion.

REGULATOR INSPECTION

Internal and External Corrosion (Continued)

3) Look for visible corrosion or water marks on the relief valve area and chimney (shaded area in the picture below).
4) Replace the regulator if corrosion is present.

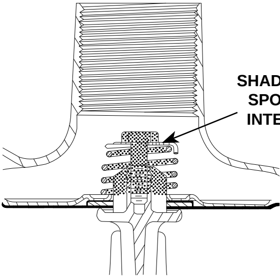


Figure 15. *Corrosion Area*

Regulator Age

Locate and replace old regulators. R600, R122H, R232, R222, and HSRL Series regulators have a recommended replacement life of 20 years. All other regulators have a recommended replacement life of 15 years. Replace regulators that are over the recommended replacement life or that have experienced conditions (corrosion, underground systems, flooding, etc.) that would shorten their service life. Older regulators are more likely to fail because of worn or corroded parts. Replace with a two-stage regulator system.

Regulator disk wear (especially on older regulators) or foreign material (dirt, pipe scale, etc.) lodged between the regulator disk and orifice can cause higher than normal outlet pressure to the appliances at lock up or extremely low flows. A pressure test of the system will be required to verify the outlet pressure under these conditions. Replace the regulator if pressure is high. Check the system for foreign material and clean out or replace pigtails as needed.

Always reset the system after replacing a regulator. See **Fisher® Bulletin LP-32** and the instruction manual for more detailed information on inspecting LP-Gas regulators.

TROUBLESHOOTING DOMESTIC TANK FITTINGS

A periodic inspection and maintenance program is recommended for domestic tank fittings. The following briefly discusses ways to avoid and correct potential safety problems with the most common domestic fittings.

A more complete examination of this subject can be found in NPGA Safety Bulletin 306.

Filler Valves

Always use a filling hose adaptor on the end of the hose end valve during the filling process. After filling the tank, do not disconnect the Acme coupling from the filler valve until the fill valve is closed and all pressure between the hose end valve and the fill valve has been bled off. If pressure discharge continues, the filler valve may have malfunctioned. Do not remove the fill hose as the internal parts may be blown out. If light tapping does not close the fill valve, disconnect the filling hose adaptor from the hose end valve, leaving the filling hose adaptor on the fill valve. The tank will probably have to be emptied to replace the fill valve.

Some fill valve designs allow the seat disk to be replaced while the tank is pressurized. On these designs, make sure the lower back check is still functioning by forcing open the upper back check with an adaptor. Take care to dislodge only the upper back check and not both back checks. If there is little leakage with the upper back check open, then the lower back check is in place and the disk can be replaced by following the manufacturer's instructions.

Relief Valves

Do not stand over a relief valve when tank pressure is high. A relief valve's purpose is to relieve excessive tank pressure which can be caused by overfilling, improper purging of air from the container, overheating of the tank, improper paint color, or high vapor pressure, to list just a few reasons. Check the tank pressure gauge if the relief valve is leaking.

TROUBLESHOOTING DOMESTIC TANK FITTINGS

Relief Valves (Continued)

On a 250 psi / 17.2 bar design pressure tank for example, if the relief valve is discharging between the 240 to 260 psig / 16.5 to 17.9 bar range, the relief valve is working properly as long as it reseats.

A relief valve that discharges substantially below 240 psig / 16.5 bar or that does not reseat when the tank pressure is lowered, will have to be replaced. Do not attempt to force the valve closed. Lower the tank pressure by withdrawing gas or cooling the outside of the tank.

Always keep a rain cap on the relief valve to help keep out dirt, debris, and moisture.

Relief valves, like other pieces of equipment, will not last forever. Emerson™ recommends that a Fisher® brand relief valves not be used for over 15 years. Earlier replacement may be required because of severe service conditions or applicable federal, state, or local codes.

Liquid Withdrawal Valves

A damaged seat or missing internal parts may allow an excessive amount of liquid discharge when the closing cap is loosened. These valves have a bleed hole in the closing cap to vent liquid before the cap is completely unscrewed. If a significant amount of the liquid continues to vent from beneath the cap after 30 seconds, do not remove the cap. Should only vapor be leaking from under the cap, the connection to the withdrawal valve can usually be made.

There is the possibility of liquid spray while opening the withdrawal valve with an angle valve-special adaptor. For this reason, protective clothing should be worn and extreme care taken throughout the entire process.

Service Valves

Show the customer this valve and tell him to shut it off if gas is escaping into the house or any other abnormal situation takes place. Check the stem seal and shutoff seats periodically for leakage and replace them if necessary (empty the tank first).

Table 12. LP-Gas Orifice Capacities LP-Gases (BTU/hr at Sea Level)

ORIFICE OR DRILL SIZE	PROPANE	BUTANE	ORIFICE OR DRILL SIZE	PROPANE	BUTANE
0.008	519	589	51	36,531	41,414
0.009	656	744	50	39,842	45,168
0.01	812	921	49	43,361	49,157
0.011	981	1,112	48	46,983	53,263
0.012	1,169	1,326	47	50,088	56,783
80	1,480	1,678	46	53,296	60,420
79	1,708	1,936	45	54,641	61,944
78	2,080	2,358	44	602,229	68,280
77	2,629	2,980	43	64,369	72,973
76	3,249	3,684	42	71,095	80,599
75	2,581	4,059	41	74,924	84,940
74	4,119	4,669	40	78,029	88,459
73	4,678	5,303	39	80,513	91,215
72	5,081	5,760	38	83,721	94,912
71	5,495	6,230	37	87,860	99,605
70	6,375	7,227	36	92,207	104,532
69	6,934	7,860	35	98,312	111,454
68	7,813	8,858	34	100,175	113,566
67	8,320	9,433	33	103,797	117,672
66	8,848	10,031	32	109,385	124,007
65	9,955	11,286	31	117,043	132,689
64	10,535	11,943	30	134,119	152,046
63	11,125	12,612	29	150,366	170,466
62	11,735	13,304	28	160,301	181,728
61	12,367	14,020	27	168,580	191,114
60	13,008	14,747	26	175,617	199,092
59	13,660	15,846	25	181,619	205,896
58	14,333	16,249	24	187,828	212,935
57	15,026	17,035	23	192,796	218,567
56	17,572	19,921	22	200,350	227,131
55	21,939	24,872	21	205,525	232,997
54	24,630	27,922	20	210,699	238,863
53	28,769	32,615	19	223,945	253,880
52	32,805	37,190	18	233,466	264,673

Reprinted from Table F.2 in NFPA 54, 2002 ed. Always check www.nfpa.org for the latest updates.

	PROPANE	BUTANE
BTU per cubic foot	2,516	3,280
Specific Gravity	1.52	2.01
Pressure at Orifice, Inches w.c.	11	11
Orifice Coefficient	0.9	0.9

Table 13. Line Sizing Chart For Liquid Propane In GPM

BASED ON 1 PSIG PRESSURE DROP. PROPANE AT 60ºF. BASED ON SCHEDULE 40/80 STEEL/IRON PIPE

Piping Length, Feet	1/2-inch		3/4-inch		1-inch		1-1/4-inch		1-1/2-inch		2-inch		2-1/2-inch		3-inch		4-inch	
	40	80	40	80	40	80	40	80	40	80	40	80	40	80	40	80	40	80
10	7.1	5.0	15.0	11.3	28.3	22.2	58	47.6	87	73	169	143	269	229	475	410	967	846
15	5.8	4.1	12.2	9.2	23.0	18.1	47.5	38.8	71	59	137	116	219	187	387	334	789	690
20	5.0	3.5	10.5	8.0	19.9	15.6	41.0	33.5	62	51	119	100	189	161	335	289	682	597
30	4.1	2.9	8.5	6.5	16.2	12.7	33.4	27.3	50.1	41.6	97	82	154	131	283	235	556	486
40	3.5	2.5	7.4	5.6	14.0	11.0	28.8	23.5	43.3	35.9	84	71	133	114	236	203	481	421
50	3.1	2.2	6.6	5.0	12.5	9.8	25.7	21.0	36.3	32.1	75	63	119	101	211	182	429	376
60	2.8	2.0	6.0	4.5	11.3	8.9	23.4	19.1	35.2	29.2	68	57	109	92	192	166	391	343
70	2.6	1.8	5.5	4.2	10.5	8.2	21.6	17.7	32.5	27.0	63	53	100	85	177	153	362	317
80	2.4	1.7	5.2	3.9	9.8	7.7	20.2	16.5	30.4	25.2	59	49.6	94	80	166	143	338	296
90	2.3	1.6	4.8	3.7	9.2	7.2	19.0	15.5	28.6	23.7	55	46.7	88	75	156	135	319	279
100	2.2	1.5	4.6	3.5	8.7	6.8	18.0	14.7	27.1	22.5	52	44.2	84	71	148	128	302	264
150	1.8	1.2	3.7	2.8	7.1	5.5	14.6	11.9	22.0	18.2	42.5	35.9	68	58	120	104	246	215
200	1.5	1.1	3.2	2.4	6.1	4.8	12.6	10.3	18.9	15.7	36.7	31.0	59	49.9	104	89	212	185
300	1.2	0.9	2.6	1.9	4.9	3.8	10.2	8.3	15.3	12.7	29.7	25.1	47.5	40.4	84	73	172	151
400	1.0	0.7	2.2	1.7	4.2	3.8	8.8	7.1	13.2	10.9	25.6	21.6	40.9	34.8	73	66	149	130

CONVERSION FACTORS

Multiply	By	To Obtain
LENGTH AND AREA		
Millimeters	0.0394	Inches
Meters	3.2808	Feet
Sq. Centimeters	0.1550	Sq. Inches
Sq. Meters	10.764	Sq. Feet
VOLUME AND MASS		
Cubic Meters	35.315	Cubic Feet
Liters	0.0353	Cubic Feet
Gallons	0.1337	Cubic Feet
Cubic cm.	0.061	Cubic Inches
Liters	2.114	Pints (US)
Liters	0.2642	Gallons (US)
Kilograms	2.2046	Pounds
Tonnes	1.1024	Tons (US)
PRESSURE AND FLOW RATE		
Millibars	0.4018	Inches w.c.
Ounces/sq. in.	1.733	Inches w.c.
Inches w.c.	0.0361	Pounds/sq. in.
Bars	14.50	Pounds/sq. in.
Kilopascals	0.1450	Pounds/sq. in.
Kilograms/sq. cm.	14.222	Pounds/sq. in.
Pounds/sq. in.	0.068	Atmospheres
Liters/hr.	0.0353	Cubic Feet/hr.
Cubic Meters/hr.	4.403	Gallons/min.
MISCELLANEOUS		
Kilojoules	0.9478	BTU
Calories, kg	3.968	BTU
Watts	3.414	BTU/HR
BTU	0.00001	Therms
Megajoules	0.00948	Therms

CONVERSION FACTORS

Multiply	By	To Obtain
LENGTH AND AREA		
Inches	25.4	Millimeters
Feet	0.3048	Meters
Sq. Inches	6.4516	Sq. Centimeters
Sq. Feet	0.0929	Sq. Meters
VOLUME AND MASS		
Cubic Feet	0.0283	Cubic Meters
Cubic Feet	28.316	Liters
Cubic Feet	7.481	Gallons
Cubic Inches	16.387	Cubic cm.
Pints (US)	0.473	Liters
Gallons (US)	3.785	Liters
Pounds	0.4535	Kilograms
Tons (US)	0.9071	Tonnes
PRESSURE AND FLOW RATE		
Inches w.c.	2.488	Millibars
Inches w.c.	0.577	Ounces/sq. in.
Pounds/sq. in.	27.71	Inches w.c.
Pounds/sq. in.	0.0689	Bars
Pounds/sq. in.	6.895	Kilopascals
Pounds/sq. in.	0.0703	Kilograms/sq. cm.
Atmospheres	14.696	Pounds/sq. in.
Cubic Feet/hr.	28.316	Liters/hr.
Gallons/min.	0.2271	Cubic Meters/hr.
MISCELLANEOUS		
BTU	1.055	Kilojoules
BTU	0.252	Calories, kg
BTU/HR	0.293	Watts
Therms	100,000	BTU
Therms	105.5	Megajoules

FLOW EQUIVALENTS AND TEMPERATURE CONVERSION

Table 14. Flow Equivalents

To convert flow capacities of one kind of gas to flow capacities of a different kind of gas

		MULTIPLY BY:
If you have a flow capacity (CFH, etc.) in NATURAL GAS and want to know equivalent flow capacity of—	Propane: Butane: Air:	0.63 0.55 0.77
If you have BUTANE and want to know equivalent flow capacity of—	Propane: Natural Gas: Air:	1.15 1.83 1.42
If you have AIR and want to know equivalent flow capacity of—	Propane: Butane: Natural Gas:	0.81 0.71 1.29
If you have PROPANE and want to know equivalent flow capacity of—	Butane: Natural Gas: Air:	0.87 1.59 1.23

Table 15. Temperature Conversion

°F	°C	°F	°C	°F	°C
-40	-40	30	-1.1	90	32.2
-30	-34.4	32	0	100	37.8
-20	-28.9	40	4.4	110	43.3
-10	-23.3	50	10.0	120	48.9
0	-17.8	60	15.6	130	54.4
10	-12.2	70	21.1	140	60.0
20	-6.7	80	26.7	150	65.6

Serviceman's Handbook

LP-10

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