Form# 1000 - Rev. C

PART OF OPW a DOVER company

LP Gas Service
REFERENCE GUIDE

Also available on the MEC App and website!

INTRODUCTION

The MEC LP-Gas Service Reference Guide has been developed for use by servicemen performing field installation, operation, and maintenance of LP-Gas equipment. The Guide provides servicemen who strive for greater efficiency and safer installations with data and answers to important questions that are relevant to installing and maintaining a propane gas system.

Although the Guide provides useful and key information, servicemen should also consult their company's procedures and policies as well as applicable federal, state and local laws and industry rules and regulations, including the National Fire Protection Association (NFPA) pamphlets 54 and 58.
MEC is not responsible for any misinterpretation of the information contained in this Guide or any improper installation, repair work, or other deviation from the procedures recommended within.

Additional information regarding regulator descriptions, specifications, installation, maintenance, and repair are provided with the instruction manuals for each regulator type. For additional copies of this guide or of the instruction manual for the regulator, please contact your local sales office or call (269)789-6700.

OPW PROPANE ENERGY SOLUTIONS a DOVER company | MEC™

PART OF OPW a DOVER company

TABLE OF CONTENTS

PROPERTIES OF PROPANE / BUTANE

Approximate Properties of LP-Gases (Inches)		
FORMULA	PROPANE	BUTANE
	C_3H_8	C_4H_{10}
Initial Boiling Point, °F	-44	31
Specific Gravity of Liquid (Water = 1.0) at 60°F	0.504	0.582
Specific Gravity of Vapor (Air = 1.0) at 60°F	1.50	2.01
Weight per Gallon of Liquid at 60°F, LB	4.2	4.81
Specific Heat of Liquid, BTU/LB at 60°F	0.630	0.549
Cubic Feet of Vapor per Gallon at 60°F	36.38	31.26
Cubic Feet of Vapor per Pound at 60°F	8.66	6.51
Ignition Temperature in Air, °F	920 to 1,120	900 to 1,000
Maximum Flame Temperature in Air, °F	3,595	3,615
Cubic Feet of Air Required to Burn One Cubic Foot of Gas	23.86	31.02
Limits of Flammability in Air, % of Vapor in Air-Gas Mix: (a) Lower (b) Upper	 2.15 9.60	 1.55 8.60
Latent Heat of Vaporization at Boiling Point: (a) BTU per Pound (b) BTU per Gallon	 184 773	 167 808
Total Heating Values After Vaporization: (a) BTU per Cubic Foot (b) BTU per Pound (c) BTU per Gallon	 2,488 21,548 91,502	 3,280 21,221 102,032

PROPERTIES OF PROPANE / BUTANE

Approximate Properties of LP-Gases (Metric)		
FORMULA	PROPANE	BUTANE
	C_3H_8	C_4H_{10}
Initial Boiling Point, °C	-42	-9
Specific Gravity of Liquid (Water = 1.0) at 15.56°C	0.504	0.582
Specific Gravity of Vapor (Air = 1.0) at 15.56°C	1.5	2.01
Weight per Cubic Meter of Liquid at 15.56°C, kg	504	582
Specific Heat of Liquid, Kilojoule/ Kilogram at 15.56°C	1.464	4.276
Cubic Meter of Vapor per Kilogram at 15.56°C	0.271	0.235
Cubic Meter of Vapor per Kilogram at 15.56°C	0.539	0.41
Ignition Temperature in Air, °C	493 to 604	482 to 538
Maximum Flame Temperature in Air, °C	1,980	1,991
Cubic Meter of Air Required to Burn One 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 PROPANE / BUTANE

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

Because the amount of pressure inside a container depends on the outside temperature of the air, lower temperatures mean less pressure and higher temperatures mean more pressure. If the container pressure is too low, not enough gas will flow from the container to the appliances. Container pressure is measured in PSIG (Pounds per Square Inch Gauge).

This table shows vapor pressures for propane and butane at various outside temperatures.

Vapor Pressure

TEMPERATURE		APPROXIMATE VAPOR PRESSURE, PSIG / bar PROPANE ----------> TO ----------> BUTANE						
°F	°C	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	23.3 / 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 / 3.9	30 / 2.1	12 / 0.83
70	21.1	127 / 8.8	95 / 6.6	78 / 5.4	68 / 5.4	59 / 4.1	38 / 2.6	17 / 1.2
80	26.7	140 / 9.7	125 / 8.6	90 / 602	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 / 116	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 / 9.1	80 / 5.5	45 / 3.1

PLANNING THE INSTALLATION

The container pressure lowers when propane vapor is withdrawn, causing the liquid to "boil" in an effect to restore pressure by generating vapor to replace what was withdrawn. The "latent heat of vaporization" required is surrendered by the liquid and causes the temperature of the liquid to drop as a result of the heat expended.

The heat surrounding the container replaces the heat lost due to the vaporization of the liquid in the container. This heat is transferred from the air through the metal surface of the container into the liquid. The heat absorbed by the vapor that is in contact with the container is negligible. The "wetted surface" is the surface area of the container that is bathed in liquid. The greater the amount of liquid in the container, or the wetted surface, the greater the vaporization capacity of the system. The larger the container, the larger the wetted surface area, therefore the greater the vaporizing capacity. If the liquid in the container receives heat for vaporization from the outside air, the higher the outside air temperature, the higher the vaporization rate of the system. See table on page 10 for how this affects the vaporization rate of 100-lbs. cylinders. This chart shows that the worst conditions for vaporization rate are when the container has a small amount of liquid in it and the outside air temperature is low.

DETERMINING TOTAL LOAD

To properly size the tank or cylinder, regulators, and piping for an installation, total load must be determined. Determining total load is the sum of all propane gas used in an installation and is expressed in BTU/Hr. (British Thermal Units per Hour).

The BTU information can be found on the nameplate of the appliance or in the manufacturer's literature. If specific appliance capacity is not available, see following table. Remember to allow for appliances which may be installed at a later date. This will eliminate the need for a later revision of piping and container.

Approximate Gas Input for Typical Appliances	
Appliance	**Input BTU / HR (Approx.)**
Space Heating Units	
Warm Air Furnace Single Family Multifamily, per unit	 100,000 60,000
Hydronic Boiler Single Family Multifamily, per unit	 100,000 60,000
Space and Water Heating Units	
Hydronic Boiler Single Family Multifamily, per unit	120,000 75,000
Water Heating Appliances	
Water Heater, Automatic Storage 30 gallon to 40 gallon tank	35,000
Water Heater, Automatic Storage 50 gallon tank	50,000
Water Heater, Automatic Instantaneous Capacity at 2 gal. / min. Capacity at 4 gal. / min. Capacity at 6 gal. / min.	 142,800 285,000 428,400
Water Heater, Domestic, Circulating or Side-Arm	35,000
Cooking Appliances	
Range, Freestanding, Domestic	65,000
Built-in Oven or Broiler Unit, Domestic	25,000
Built-in Top Unit, Domestic	40,000
Other Appliances	
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
Table reprinted from NFPA 54	

VAPORIZATION RATES

Vaporization is the rate at which liquid propane boils off and becomes vapor.

The larger the wetted surface of the container, the faster the liquid boils off into vapor. Therefore, the vaporization rate of a container is dependent upon the temperature of the liquid and the amount of wetted surface of the container.

In determining the proper size container to handle an installation's total load, the lowest winter temperature must be taken into account.

It is important to know that because of the various shapes of the containers, the wetted surface area will be different and therefore, the vaporization rates will be different. See following 2 tables for more information.

VAPORIZATION RATES FOR ASME STORAGE TANKS

The table below assumes the ASME tank is:

1. One-Half Full.
2. Relative humidity is 70%.
3. The tank is under intermittent loading.

Even though none of these conditions may apply, the following table can still serve as a reference in estimating what a certain tank size will provide under different temperatures. Under continuous loading the withdrawal rates shown should be multiplied by 0.25, though continuous loading is not a very common occurrence on domestic installations.

VAPORIZATION RATES FOR 100 LBS DOT CYLINDERS

For Continuous draws where temperatures may reach 0°F, assume the vaporization rate of a 100 LBS cylinder as approximately 50,000 BTU per hour.

$$\text{Number of Cylinders per side} = \frac{\text{Total Load in BTU}}{50{,}000}$$

Example:

Assume the Total Load is = 200,000 BTU / Hr.

Number of Cylinders Needed Per Side =

$$\frac{200{,}000}{50{,}000} = 4 \text{ Cylinders per side}$$

Maximum Intermittent Withdrawal Rate (BTU/hr.) Without Tank Frosting* IF Lowest Outdoor Temperature (Average For 24 Hours) Reaches…					
TEMPERATURE		TANK SIZE, GALLONS / LITERS			
		150 / 568	250 / 946	500 / 1,893	1,000 / 3,785
40°F	4°C	214,900	288,100	478,800	852,800
30°F	-1°C	187,000	251,800	418,600	745,600
20°F	-7°C	161,800	216,800	360,400	641,900
10°F	-12°C	148,000	198,400	329,700	587,200
0°F	-18°C	134,700	180,600	300,100	534,500
-10°F	-23°C	132,400	177,400	294,800	525,400
-20°F	-29°C	108,800	145,800	242,300	431,600
-30°F	-24°C	107,100	143,500	238,600	425,000
*Tank frosting acts as an insulator, reducing the vaporization rate.					

Maximum Continuous draw in BTU per Hour At Various Temperatures In Degrees F					
LBS. of Propane in Cylinder	0°F	20°F	40°F	60°F	70°F
100	113,000	167,000	214,000	277,000	300,000
90	104,000	152,000	200,000	247,000	277,000
80	94,000	137,000	180,000	214,000	236,000
70	83,000	122,000	160,000	199,000	214,000
60	75,000	109,000	140,000	176,000	192,000
50	64,000	94,000	125,000	154,000	167,000
40	55,000	79,000	105,000	131,000	141,000
30	45,000	66,000	85,000	107,000	118,000
20	36,000	51,000	68,000	83,000	92,000
10	28,000	38,000	49,000	60,000	66,000

The table above shows the vaporization rate of containers in terms of the temperature of the liquid and the wet surface area of the container. When the temperature is lower or if the container has less liquid in it, the vaporization rate of the container is a lower value.

PURGING OF LP-GAS CONTAINERS

A very important step which must not be overlooked by LP-Gas distributors is the importance of properly purging new LP-gas containers. Attention to this important procedure will promote customer satisfaction and greatly reduce service calls on new installations. Consider the following:

- Both ASME and DOT specifications require hydrostatic testing of containers after fabrication. This is usually done with water.
- Before charging with propane, the container will contain the normal amount of air.

Water and Air Contaminants

Both water and air seriously interfere with proper operation of the system and the connected appliances. If not removed, they will result in costly service calls and needless expense far exceeding the nominal cost of proper purging.

Neutralizing Moisture from Containers

Even if a careful inspection of the tank reveals no visible moisture, the container must still be neutralized. Condensation may have formed on the interior walls and the air inside the container may have relative humidity up to 100%.

For neutralizing moisture in an ASME container, the introduction of at least one pint of genuine absolute anhydrous methanol * (99.85% pure) per 100 gal. of water capacity is required. The following table shows the minimum volumes for typical containers.

*NOTE – Avoid substitutes – they will not work. The secret of the effectiveness of methanol over all other alcohols is its high affinity of water plus a boiling point lower than all other alcohols, and most important: a boiling point lower than water.

Methanol Requirements for Water Removal	
Container Size	**Minimum Amount of Methanol Required**
100 lb. ICC Cylinder	1/8 pt. (2 fl. oz.)
420 lb. ICC Cylinder	1/2 pt. (8 fl. oz.)
500 gal. Tank	5 pts. (2 1/2 qts.)
1000 gal. Tank	10 pts. (1 1/4 gal.)

The Importance of Purging Air

The resulting issues will result if the natural volume of atmosphere in the container is not removed:

- Spring and summer installations will experience false and excessive container pressures.
  This will cause the safety relief valve to open, blowing off the excess pressure.
- The air mixture present in the vapor space will be carried to the appliances. This may result in as many as 5 or more service calls from pilot light extinguishment.
- If a vapor return equalizing hose is not used, the contained air will be compressed above the liquid level, resulting in slow filling.
- If a vapor equalizing hose is used, the air, and any moisture it containers, will be transferred from the storage tank to the transport.

Also, if atmospheric air is properly purged from the storage tank:

- The tank will fill faster,
- Appliances will perform more consistently,
- Relief valves will be less likely to pop off at consumer installations.

NEVER PURGE WITH LIQUID

The wrong way is of course the easiest way. Never purge a container with liquid propane. To do so causes the liquid to flash into vapor, chilling the container, and condensing any moisture vapor on the walls where it remains while the pressure is being blown down. Also less than 50% or as little as 25 % of the air will be removed by this easy but wrong method.

Purging Air

The natural volume of air in all containers must be removed before the first fill. The correct method for purging air is as follows. Note that purging of air MUST be done at the bulk plant site, NEVER at the customer's location.

1. Install an unloading adapter on the double check filler valve, leaving it in the closed position.
2. Install a gauge adapter assembly on the service valve pol outlet connection. Exhaust to atmosphere any air pressure in the container.
3. Attach a propane vapor equalizing hose to the vapor return valve on the container.

4. Open the valve on the outlet end of the vapor equalizing hose, throttling it to avoid slugging the excess flow valve on the truck. Carefully observe the pressure gauge.
5. When the gauge reading shows 15 PSIG, shut off the vapor valve on the hose.
6. Switch the lever on the unloading adapter to open the double check filler valve and blow down the exhaustion.
7. Close unloading adapter lever, allowing the double check filler valve to close.
8. Repeat steps 4 - 7 FOUR MORE TIMES. Total required time is 15 minutes or less.

After the previous steps have been performed, the percent of air in the container is reduced as shown in the following table:

Remaining Air and Propane After Purging		
	% Air Remaining	% Propane Remaining
1st Purging	50	50
2nd Purging	25	75
3rd Purging	12.5	87.5
4th Purging	6.25	93.75
5th Purging	3.13	96.87
6th Purging	1.56	98.44

Experience shows that reducing the residual air content to 6.25% is adequate. The mixture left will have a thermal value of about 2400 BTU. In this case, the service person can adjust the burners for a slightly richer product. The slight volume of air will to some extent dissolve in the propane if the installation stands unused for a few days.

Product Consumption

If the steps on the previous page were followed carefully and the vapor was purged 5 times, a total of 670 cu. ft. (18.4 gal) would have been used for a 1000 gallon tank. In a 500 gallon tank, a total of 9.2 gallons would have been used.

Purging DOT Cylinders

1. Exhaust to atmosphere any air pressure in the container*
2. Pressurize the cylinder to 15 PSIG propane vapor
3. Exhaust vapor to atmosphere
4. Repeat four more times

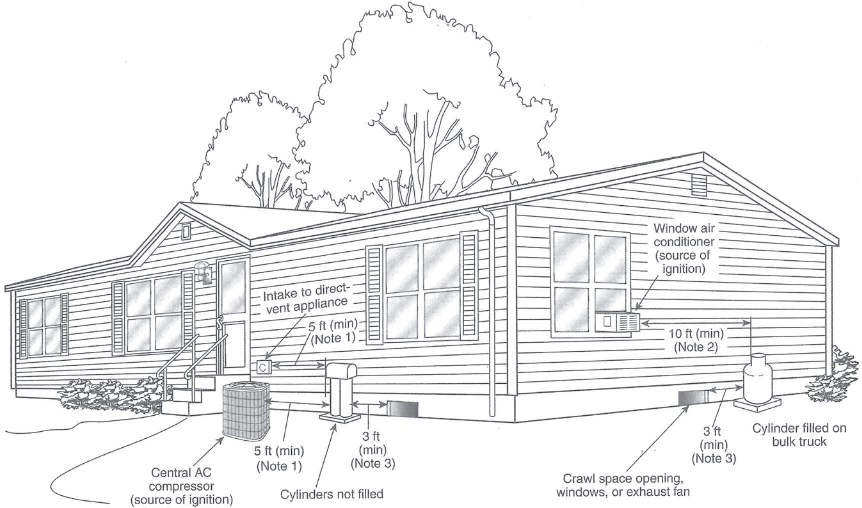
* For LP-Gas containers that are pre-purged it is not necessary to follow the purging steps above. Air and moisture have already been removed from pre-purged containers. Simply attach an adapter to the POL service connections and introduce propane vapor into the container. Allow the container pressure to reach at least 15 PSIG before disconnecting the adapter.

PROPER CYLINDER AND TANK PLACEMENT

After the correct number of DOT cylinders or correct size of ASME storage tank has been determined, carefully select the safest, most convenient site for their location.

When deciding the location for the LP-gas containers, the customer's desires and the ease of exchanging cylinders or refilling of storage tanks should be considered as long as that does not conflict with state and local regulations or NFPA 58, Liquefied Petroleum Gas Code. Refer to this standard for appropriate placement of LP-Gas containers.

The charts on the following pages are reprinted with permission of NFPA 58, LP-Gas Code, Copyright ©, National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the NFPA on the referenced subject which is represented only by the standard in its entirety.



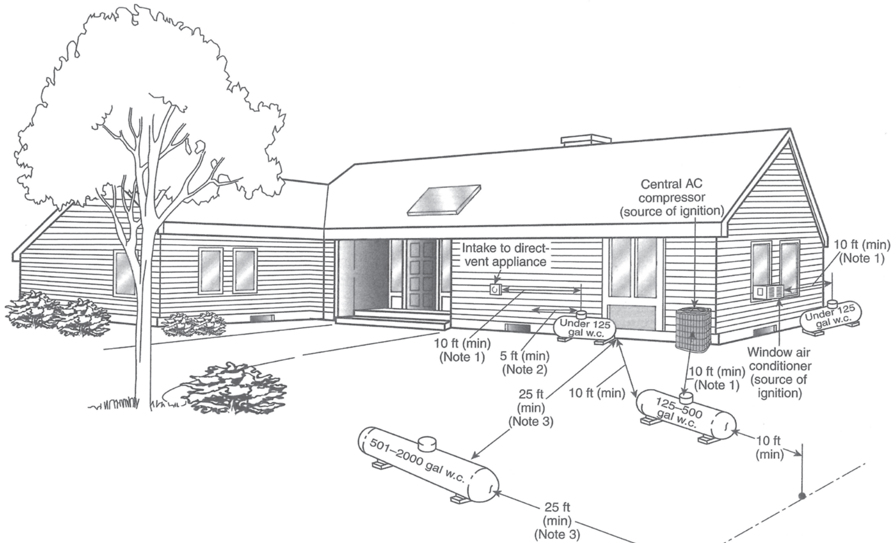
For SI units, 1 ft = 0.3048 m

Note 1: 5 ft 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 cylinder is filled on site from a bulk truck, the filling connection and vent valve must be at least 10 ft from any exterior source of ignition, openings into direct-vent appliances, or mechanical ventilation air intakes.
Refer to 6.3.9.

Note 3: Refer to 6.3.8.

FIGURE I.1(a) Cylinders. *(Figure for illustrative purposes only; code compliance required.)*

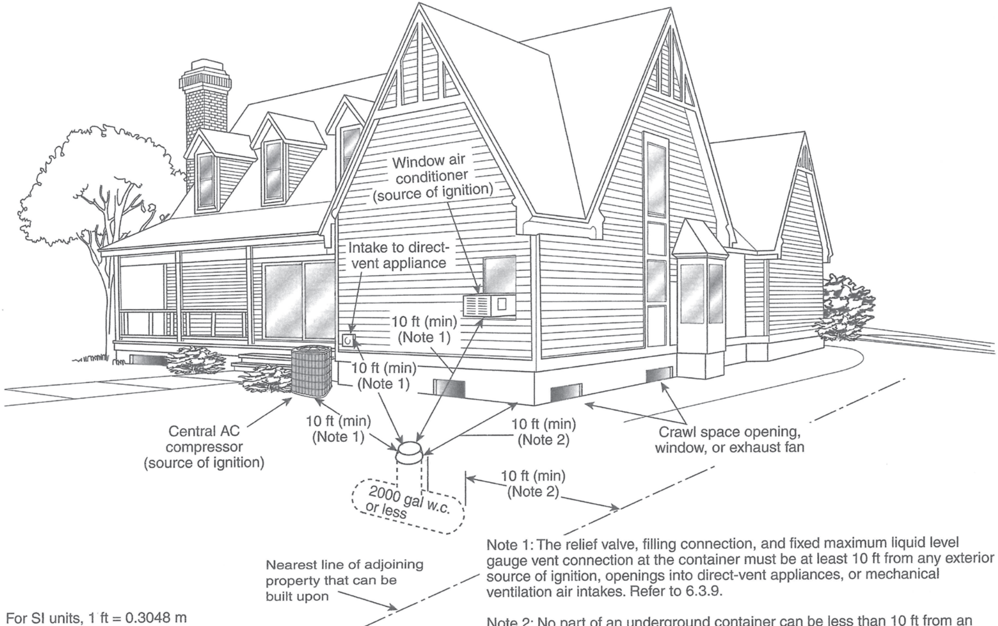


Note 1: Regardless of its size, any ASME container filled on site must be located so that the filling connection and fixed maximum liquid level gauge are at least 10 ft from any external source of ignition (e.g., open flame, window AC, compressor), intake to direct-vented gas appliance, or intake to a mechanical ventilation system. Refer to 6.3.9.

Note 2: Refer to 6.3.8.

Note 3: This distance can be reduced to no less than 10 ft for a single container of 1200 gal (4.5 m^3) water capacity or less, provided such container is at least 25 ft from any other LP-Gas container of more than 125 gal (0.5 m^3) water capacity. Refer to 6.3.3.

FIGURE I.1(b) Aboveground ASME Containers. *(Figure for illustrative purposes only; code shall govern.)*



Note 1: The relief valve, filling connection, and fixed maximum liquid level gauge vent connection at the container must be at least 10 ft from any exterior source of ignition, openings into direct-vent appliances, or mechanical ventilation air intakes. Refer to 6.3.9.

Note 2: No part of an underground container can be less than 10 ft from an important building or line of adjoining property that can be built upon. Refer to 6.3.4.2.

For SI units, 1 ft = 0.3048 m

FIGURE I.1(c) Underground ASME Containers. ***(Figure for illustrative purposes only; code shall govern.)***

Tube & Pipe Sizing

For efficient operation of the LP-gas appliances, the proper selection of tube and pipe sizes is essential. Consideration must be given to the maximum gas demand of the system and the allowable pressure loss from the point of delivery to the inlet connection of the gas appliance.

Several materials are used in propane gas installations:

1. Copper – Type L and Type K or Refrigeration
2. Schedule 40 Black Iron
3. Polyethylene – CTS and IPS
4. CSST

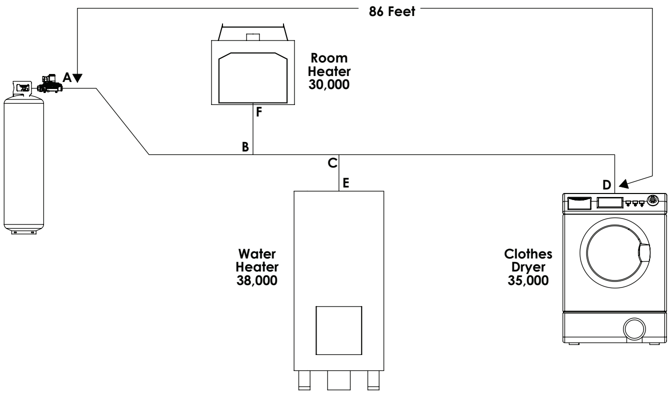
*NOTE – If metallic piping is to be utilized in propane gas installations, NFPA 58 stated underground metallic piping shall be provided with a dielectric fitting installed at building penetrations. Dielectric fittings shall not be installed underground.

Four different sizing requirements must be considered:

1. Sizing between first stage and line pressure (inches of water column) second stage regulators
2. Sizing between first stage and low pressure 2-psi second stage service regulators
3. Sizing between 2-psi second stage regulator and line pressure (inches of water column) second stage regulators
4. Sizing between line pressure (inches of water column) second stage regulators and appliances

The examples and directions that follow, as well as tables 1 to 8, will help in deciding the correct selection of tube and pipe sizing for different areas. All values in the tables are calculated per NFPA Pamphlets 54 and 58.

Example 1:
Determine the sizes of tubing and piping required for the twin-stage LP-Gas installation shown.



Total piping Length from A to D = 86 Feet (use Table 3 @ 90 feet)

From A to B, demand
= 38,000 + 35,000 + 30,000 = 103,000 BTU/hr.
Use 3/4” pipe

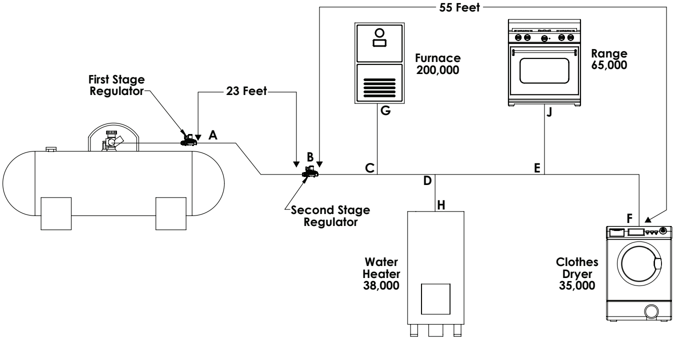
From B to C, demand
= 38,000 + 35,000 = 73,000 BTU/hr.
Use 1/2” pipe or 3/4” tubing

From C to D, demand = 35,000 BTU/hr.
Use 1/2” pipe or 5/8” tubing

From C to E, demand = 38,000 BTU/hr.
Use 1/2” pipe or 5/8” tubing

From B to F, demand = 30,000 BTU/hr.
Use 1/2” pipe or 1/2” tubing

Example 2:
To determine the sizes of tubing and piping required for the two-stage LP-Gas installation shown.



Total first stage piping length = 23 feet; first stage regulator setting is 10 PSIG (use table 1 or 2 @ 30 feet)

From A to B, demand = 338,000 BTU/hr; Use 1/2” pipe, 1/2” tubing, or 1/2” T plastic pipe

Total second stage piping length from B to F = 55 feet (use Table 3 @ 60 feet)

From B to C, demand = 338,000 BTU/hr.; Use 1” pipe

From C to D, demand = 138,000 BTU/hr.; Use 3/4” pipe or 7/8” tubing

From D to E, demand = 100,000 BTU/hr.; Use 1/2” pipe or 3/4” tubing

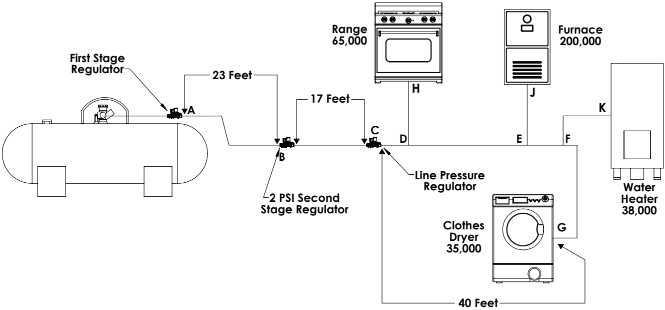
From E to F, demand = 35,000 BTU/hr.; Use 1/2” pipe or 1/2” tubing

From C to G, demand =200,000 BTU/hr.; Use 3/4” pipe or 7/8” tubing

From D to H, demand = 38,000 BTU/hr.; Use 1/2” pipe or 1/2” tubing

From E to J, demand = 65,000 BTU/hr.; Use 1/2” pipe or 5/8” tubing

Example 3:
To determine the size of piping or tubing required for the 2 PSI LP-Gas installation shown.



Total first stage piping length = 23 feet; first stage regulator setting is 10 PSIG (use table 1 and 2 @ 30 feet)

From A to B, demand = 338,000 BTU/hr.; Use 1/2” pipe, 1/2” tubing, or 1/2” T plastic pipe

Total 2 PSI piping length = 17 feet (use table 4, 5, or 6 @ 20 feet)

From B to C, demand = 338,000 BTU/hr.; Use 3/8” CSST or 1/2” copper tubing or 1/2”pipe

Total second stage piping length from C to G = 40 feet (use Table 3 @ 40 feet)

From C to D, demand = 338,000 BTU/hr.; Use 1” pipe

From D to H, demand = 65,000 BTU/hr.; Use 1/2” pipe or 5/8” tubing

From D to E, demand = 273,000 BTU/hr.; Use 3/4” pipe

From E to J, demand = 200,000 BTU/hr.; Use 3/4” pipe or 7/8” tubing

From E to F, demand = 73,000 BTU/hr.; Use 1/2” pipe or 5/8” tubing

From F to K, demand = 38,000 BTU/hr.; Use 1/2” pipe or 1/2” tubing

From F to G, demand = 35,000 BTU/hr.; Use 1/2” pipe or 1/2” tubing

Table 1: First Stage Pipe Sizing (Between First and Second Stage)											
Size of Pipe of Copper Tubing, Inches		10 PSIG Inlet with a 1 PSIG Pressure Drop Maximum Capacity of Pipe or tubing, in thousands of BTU/hr or LP-Gas									
		Copper Tubing (O.D.)				Pipe Size					
		3/8"	1/2"	5/8"	3/4"	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"
Length of Pipe or Tubing, Feet*	10	558	1387	2360	3993	3339	6982	13153	27004	40461	77924
	20	383	870	1622	2475	2295	4799	9040	18560	27809	53556
	30	309	700	1303	2205	1843	3854	7259	14904	22331	43008
	40	265	599	1115	1887	1577	3298	6213	12756	19113	36809
	50	235	531	988	1672	1398	2923	5507	11306	16939	32623
	60	213	481	896	1515	1267	2649	4989	10244	15348	29559
	70	196	443	824	1394	1165	2437	4590	9424	14120	27194
	80	182	412	767	1297	1084	2267	4270	8767	13136	25299
	90	171	386	719	1217	1017	2127	4007	8226	12325	23737
	100	161	365	679	1149	961	2009	3785	7770	11642	22422
	125	142	323	601	1018	852	1780	3354	6887	10318	19871
	150	130	293	546	923	772	1613	3039	6240	9349	18005
	175	118	269	502	843	710	1484	2796	5741	8601	16564
	200	111	251	467	790	660	1381	2601	5340	8002	15410
	225	104	235	438	740	619	1296	2441	5011	7508	14459
	250	90	222	414	700	585	1224	2350	4733	7092	13658
	275	89	211	393	664	556	1162	2190	4495	6735	12971
	300	89	201	375	634	530	1109	2089	4289	6426	12375
	350	82	185	345	584	488	1020	1922	3945	5911	11385
	400	76	172	321	543	454	949	1788	3670	5499	10591

* Total length of piping from outlet of first stage regulator to inlet of first stage regulator to inlet of second stage regulator (or inlet of second stage regulator furthest away).

Notes:

1) To allow 2 PSIG pressure drop, multiply total gas demand by .707, and use capacities from table.

2) For different first stage pressures, multiply total gas demand by the following factors, and use capacities from table.

Ex: 1,000,000 BTU load at 5 PSI: 1,000,000(1.12) = 1,200,000 BTU then use chart based on 1,200,000 BTU

First Stage Pressure PSIG	Multiply By
20	.844
15	.912
5	1.120

Data Calculated per NFPA #54 & 58

Table 2: First Stage Plastic Tubing Sizing

Size of Plastic Tubing		10 PSIG Inlet with a 1 PSIG Pressure Drop Maximum capacity of plastic tubing, in thousands of BTU/hr or LP-Gas							
		Plastic Tubing Size (CTS)		Pipe Size (IPS)					
		"1/2" SDR 7.00"	"1" SDR 11.00"	"1/2" SDR 9.33"	"3/4" SDR 11.00"	"1" SDR 11.00"	"1-1/4" SDR 10.00"	"1-1/2" SDR 11.00"	"2" SDR 11.00"
Length of Tubing, Feet*	10	1387	9510	3901	7811	14094	24416	-	66251
	20	954	6536	2681	5369	9687	16781	-	45534
	30	762	5225	2143	4292	7744	13416	20260	36402
	40	653	4472	1835	3673	6628	11482	17340	31155
	50	578	3864	1626	3256	5874	10106	15368	27612
	60	524	3591	1473	2950	5322	9220	13924	25019
	70	482	3304	1355	2714	4896	8433	12810	23017
	80	448	3074	1261	2525	4555	7891	11918	21413
	90	421	2884	1183	2369	4274	7404	11182	20091
	100	397	2724	1117	2238	4037	6994	10562	18978
	125	352	2414	990	1983	3578	6199	9361	16820
	125	319	2188	897	1797	3242	5616	8482	15240
	175	294	2013	826	1653	2983	5167	7803	14020
	200	273	1872	778	1539	2775	4807	7259	13043
	225	256	1757	721	1443	2603	4510	6811	12238
	250	242	1659	681	1363	2459	4260	6434	11560
	275	230	1576	646	1294	2336	4046	6111	10979
	300	219	1503	617	1235	2228	3860	5830	10474
	350	202	1383	567	1136	2050	3551	5363	9636
	400	188	1287	528	1057	1907	3304	4989	8965

* Total length of piping from outlet of first stage regulator to inlet of second stage regulator (or to inlet of second stage regulator furthest away).

First Stage Pressure PSIG	Multiply By
20	.844
15	.912
5	1.120

Data Calculated per NFPA #54 & 58

Table 3: Second Stage or Integral Twin Stage Pipe Sizing

Size of Pipe or Copper Tubing, Inches		11 Inches Water Column Inlet with a 1/2 Inch Water Column Drop Maximum capacity of pipe or tubing in thousands of BTU/hr or LP-Gas										
		Copper Tubing (O.D)					Pipe Size					
		3/8"	1/2”	5/8"	3/4"	7/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"
Length of Pipe or Tubing, Feet*	10	49	110	206	348	536	291	608	1146	2353	3525	6789
	20	34	76	141	239	368	200	418	788	1617	2423	4666
	30	27	61	114	192	296	161	336	632	1299	1946	3747
	40	23	52	97	164	253	137	287	541	1111	1665	3207
	50	20	46	86	146	224	122	255	480	985	1476	2842
	60	19	42	78	132	203	110	231	435	892	1337	2575
	70	-	38	71	120	185	102	212	400	821	1230	2369
	80	16	36	67	113	174	94	198	372	764	1144	2204
	90	-	33	62	105	161	87	185	349	717	1074	2068
	100	14	32	59	100	154	84	175	330	677	1014	1954
	125	12	28	52	89	137	74	155	292	600	899	1731
	125	11	26	48	80	124	67	141	265	544	815	1569
	175	-	-	-	-	-	62	129	244	500	749	1443
	200	10	22	41	69	106	58	120	227	465	697	1343
	225	-	-	-	-	-	54	113	213	437	654	1260
	250	9	19	36	61	94	51	107	201	412	618	1190
	275	-	-	-	-	-	48	101	191	392	587	1130
	300	8	18	33	55	85	46	97	182	374	560	1078
	350	7	16	30	51	78	43	89	167	344	515	992
	400	7	15	28	47	73	40	83	156	320	479	923

* Total length of piping from outlet of first stage regulator to inlet of second stage regulator (or to inlet of second stage regulator furthest away).

First Stage Pressure PSIG	Multiply By
20	.844
15	.912
5	1.120

Data Calculated per NFPA #54 & 58

Table 4: Maximum Capacity of CSST									
In thousands of BTU/hr of undiluted LP-Gases Pressure of 2 psi and a pressure drop of 1 psi (Based on a 1.52 Specific Gravity Gas)*									
Size		3/8"		1/2"		3/4"		1"	
EHD** Flow Designation		13	15	18	19	23	25	30	31
Length of Pipe or Tubing, Feet	10	426	558	927	1106	1735	2168	4097	4720
	20	262	347	591	701	1120	1384	2560	2954
	30	238	316	540	640	1027	1266	2331	2692
	40	203	271	469	554	896	1100	2012	2323
	50	181	243	420	496	806	986	1794	2072
	75	147	196	344	406	663	809	1457	1685
	80	140	189	333	393	643	768	1410	1629
	110	124	169	298	350	578	703	1256	1454
	150	101	137	245	287	477	575	1021	1182
	200	86	118	213	248	415	501	880	1019
	250	77	105	191	222	373	448	785	910
	300	69	96	173	203	343	411	716	829
	400	60	82	151	175	298	355	616	716
	500	53	72	135	158	268	319	550	638

Table does not include effect of pressure drop across the line regulator. If regulator loss exceeds 1/2 psi (based on 13in. water column 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 number of bends and / or fittings shall be increased by an equivalent length of tubing according to the following equation: L-1.3n where L is additional length (ft.) of tubing and n is the number of additional fittings and / or bends.

** EHD - equivalent Hydraulic Diameter - A measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of

Table 5: Maximum Capacity of CSST*									
In thousands of BTU/hr of undiluted LP-Gases Pressure of 11 Inch Water Column and a pressure drop of .5 Inch Water Column (Based on a 1.50 Specific Gravity Gas)									
Size		3/8"		1/2"		3/4"		1"	
EHD** Flow Designation		13	15	18	19	23	25	30	31
Length of Pipe or Tubing, Feet	5	72	99	181	211	355	426	744	863
	10	50	69	129	150	254	303	521	605
	15	39	55	104	121	208	248	422	490
	20	34	49	91	106	183	216	365	425
	25	30	42	82	94	164	192	325	379
	30	28	39	74	87	151	177	297	344
	40	23	33	64	74	131	153	256	297
	50	20	30	58	66	118	137	227	265
	60	19	26	53	60	107	126	207	241
	70	17	25	49	57	99	117	191	222
	80	15	23	45	52	94	109	178	208
	90	15	22	44	50	90	102	169	197
	100	14	20	41	47	85	98	159	186
	150	11	15	31	36	66	75	123	143
	200	9	14	28	33	60	69	112	129
	250	8	12	25	30	53	61	99	117
	300	8	11	23	26	50	57	90	107

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

** EHD - 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.

Table 6: Copper Tube Sizing or Schedule 40 Pipe Sizing*										
Size of Pipe of Copper Tubing, Inches	In thousands of BTU/hr of undiluted LP-Gases 2 PSIG Inlet with a 1 PSIG Pressure Drop									
	Copper Tubing (O.D.)				Pipe Size					
	3/8"	1/2"	5/8"	3/4"	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"
Length of Pipe or Tubing, Inches: 10	413	852	1,730	3,030	2,680	5,590	10,500	21,600	32,400	62,400
20	284	585	1,190	2,080	1,840	3,850	7,240	14,900	22,300	42,900
30	228	470	956	1,670	1,480	3,090	5,820	11,900	17,900	34,500
40	195	402	818	1,430	1,260	2,640	4,980	10,200	15,300	29,500
50	173	356	725	1,270	1,120	2,340	4,410	9,060	13,600	26,100
60	157	323	657	1,150	1,010	2,120	4,000	8,210	12,300	23,700
70	144	297	605	1,060	934	1,950	3,680	7,550	11,300	21,800
80	134	276	562	983	869	1,820	3,420	7,020	10,500	20,300
90	126	259	528	922	815	1,700	3,210	6,590	9,880	19,000
100	119	245	498	871	770	1,610	3,030	6,230	9,330	18,000
125	105	217	442	772	682	1,430	2,690	5,520	8,270	15,900
150	95	197	400	700	618	1,290	2,440	5,000	7,490	14,400
175	88	181	368	644	569	1,190	2,240	4,600	6,890	13,300
200	82	168	343	599	529	1,110	2,080	4,280	6,410	12,300
250	72	149	304	531	469	981	1,850	3,790	5,680	10,900
300	66	135	275	481	425	889	1,670	3,440	5,150	9,920
350	60	124	253	442	391	817	1,540	3,160	4,740	9,120
400	56	116	235	411	364	760	1,430	2,940	4,410	8,490
450	53	109	221	386	341	714	1,340	2,760	4,130	7,960
500	50	103	209	365	322	674	1,270	2,610	3,910	7,520

*Note: Maximum undiluted propane capacities listed are based on a 2-psig setting and a 1-psi pressure drop. Data Calculated per NFPA #54 and NFPA #58

Table 7: Second stage or Integral Twin Stage Polyethylene tubing or pipe sizing*									
Size of Plastic Tubing		In thousands of BTU/hr of undiluted LP-Gases Pressure of 11 Inch Water Column and a pressure drop of .5 Inch Water Column (Based on a 1.50 Specific Gravity Gas)							
		Plastic Tubing Size (CTS)		Pipe Size (IPS)					
		1/2" SDR 7.00"	1" SDR 11.00"	1/2" SDR 9.33"	3/4" SDR 11.00"	1" SDR 11.00"	1-1/4" SDR 11.00"	1-1/2" SDR 11.00"	2" SDR 11.00"
Length of Pipe or Tubing, Feet*	10	121	828	340	680	1,230	2,130	3,210	5,770
	20	83	569	233	468	844	1,460	2,210	3,970
	30	67	457	187	375	677	1,170	1,770	3,180
	40	57	391	160	321	580	1,000	1,520	2,730
	50	51	347	142	285	514	890	1,340	2,420
	60	46	314	129	258	466	807	1,220	2,190
	70	42	289	119	237	428	742	1,120	2,010
	80	39	269	110	221	398	690	1,040	1,870
	90	37	252	103	207	374	648	978	1,760
	100	35	238	98	196	353	612	924	1,660
	125	31	211	87	173	313	542	819	1,470
	150	28	191	78	157	284	491	742	1,330
	175	26	176	72	145	261	452	683	1,230
	200	24	164	67	135	243	420	635	1,140
	250	21	145	60	119	215	373	563	1,010
	300	19	132	54	108	195	338	510	916
	350	18	121	50	99	179	311	469	843
	400	16	113	46	92	167	289	436	784
	450	15	106	43	87	157	271	409	736
	500	15	100	41	82	148	256	387	695
*Note: Total length of piping from the outlet of regulator to appliance furthest away. Data Calculated per NFPA #58 & NFPA #54.									

Table 8: Polyethylene Tubing or Pipe Sizing									
Size of Plastic Tubing or Pipe**		2 PSIG Inlet with a 1 PSIG Pressure Drop (Between 2 PSIG Service and Line Pressure Regulator Tubing in thousands of BTU/hr of undiluted LP-Gases (Based on 1.50 Specific Gravity Gas)							
		Pipe Size (NPS)							
		1/2" SDR 9.33"	3/4" SDR 11.00"	1" SDR 11.00"	1-1/4" SDR 10.00"	1-1/2" SDR 11.00"	2" SDR 11.00"	3" SDR 11.00"	4" SDR 11.00"
Length of Pipe or Tubing, Feet*	10	3,130	6,260	11,300	19,600	29,500	53,100	147,000	284,000
	20	2,150	4,300	7,760	13,400	20,300	36,500	101,000	195,000
	30	1,730	3,450	6,230	10,800	16,300	29,300	81,100	157,000
	40	1,480	2,960	5,330	9,240	14,000	25,100	69,400	134,100
	50	1,310	2,620	4,730	8,190	12,400	22,200	61,500	119,000
	60	1,190	2,370	4,280	7,420	11,200	20,100	55,700	108,000
	70	1,090	2,180	3,940	6,830	10,300	18,500	51,300	99,100
	80	1,010	2,030	3,670	6,350	9,590	17,200	47,700	92,200
	90	952	1,910	3,440	5,960	9,000	16,200	44,700	86,500
	100	899	1,800	3,250	5,630	8,500	15,300	42,300	81,700
	125	797	1,600	2,880	4,990	7,530	13,500	37,500	72,400
	150	722	1,450	2,610	4,520	6,830	12,300	33,900	65,600
	175	664	1,330	2,400	4,160	6,280	11,300	31,200	60,300
	200	618	1,240	2,230	3,870	5,840	10,500	29,000	56,100
	250	548	1,100	1,980	3,430	5,180	9,300	25,700	49,800
	300	496	994	1,790	3,110	4,690	8,430	23,300	45,100
	350	457	914	1,650	2,860	4,320	7,760	21,500	41,500
	400	425	851	1,530	2,660	4,020	7,220	12,000	38,600
	450	399	798	1,440	2,500	3,770	6,770	18,700	36,200
	500	377	754	1,360	2,360	3,560	6,390	17,700	34,200

*Total length of piping from outlet of regulator to inlet of 2 psig Service/Line Pressure Regulator (or to inlet of regulator furthest away)

**Data reference from NFPA 54 2018

REGULATOR SELECTION

The regulator is the center of any LP-Gas installation. It compensates for variation in tank pressure from as low as 8 PSIG to 220 PSIG and still delivers a steady flow of LP-Gas at 11” W.C. to running appliances.

There are four things to consider when selecting a regulator:

1. Appliance Load – This is the sum of all propane gas used in the installation and is expressed in BTU’s/ hour (British Thermal Units = per hour)

2. Pipe Size – Decide on the right pipe, tubing material, and dimensions for a propane gas installation. Refer to piping selection for dielectric requirements

3. Inlet Pressure – The pressure measured in PSIG.

4. Outlet Pressure – The pressure measured from any of the regulators (in PSIG for first stage and 2 psi service regulators and inches of water column for second stage and integral twin stage regulators).



First Stage Regulators

First-stage regulators are located at the propane storage tank on medium to large BTU/H demand systems. This type of regulator reduces the high inlet pressure from the tank or cylinder to 10 psi.
First-Stage Regulators must be:

1. Designated as a first-stage regulator suitable for residential applications. DO NOT use high-pressure regulators designed for commercial or industrial applications as a first-stage regulator.
2. Rated with an output capacity in excess of total system demand.
3. Designed to supply outlet pressures within the range needed for the second-stage regulator(s) inlet pressures, typically 5 PSIG to 10 PSIG.
4. Equipped with adequate relief capacity to meet the requirements of NFPA codes.

Two first-stage regulators can be used in a parallel installation in unusually high-demand systems.

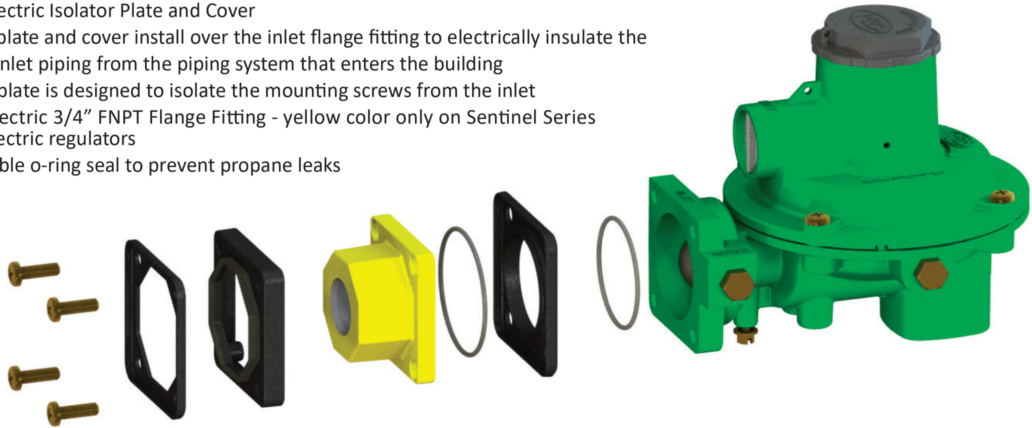


Second Stage Regulators

Second-stage regulators are used at building service entrance(s) to reduce the approximately 10 PSIG vapor pressure supplied by the first-stage regulator to approximately 11 inches water column supply to the half-pound distribution piping.

SENTINEL™ SERIES DIELECTRIC INLET CONSTRUCTION

1. Mounting Screws
2. Reinforcement Plate
    a. distributes mounting screw loads across plate
    b. drip-lip to prevent water and condensation collection
3. Dielectric Isolator Plate and Cover
    a. plate and cover install over the inlet flange fitting to electrically insulate the inlet piping from the piping system that enters the building
    b. plate is designed to isolate the mounting screws from the inlet
4. Dielectric 3/4” FNPT Flange Fitting - yellow color only on Sentinel Series dielectric regulators
5. Double o-ring seal to prevent propane leaks



Integral Two Stage Regulators

Integral 2-stage regulators are for half-pound systems. The regulator is most frequently used for manufactured homes and other installations with relatively small demands loads and short piping runs.

2 PSI Service Regulators

When selecting a 2 PSI regulator:

1. Ensure that the first-stage regulator has sufficient BTU/H capacity to supply all installed and anticipated future appliances total BTU/H demand.
2. Select a 2-PSI service regulator for each required service entrance that has sufficient BTU/H capacity to supply all installed and anticipated future appliances the regulator services.
3. Ensure that suitable line regulators are selected and properly located to supply connected appliances with adequate gas volume (BTU/H) and pressure.


2 PSI Integral Two Stage Regulators

When selecting a 2 PSI Two-Stage regulator:

1. Select a 2-PSI Integral Two Stage service regulator for each required service entrance that has sufficient BTU/H capacity to supply all installed and anticipated future appliances the regulator services.
2. Ensure that suitable line regulators are selected and properly located to supply connected appliances with adequate gas volume (BTU/H) and pressure.



Automatic Changeover Regulators

Two Stage Automatic Changeover regulators combine the first and second stage regulator into one unit, converting full tank pressure to 11” WC. MEC ***Excela-Flo***™ Automatic Changeover regulators prevent gas outages by switching supply cylinders over to the reserve cylinder automatically when the primary cylinder is near empty. When the primary cylinder is depleted, causing the changeover to occur, a red indicator will appear signifying the reserve cylinder is now in use and the primary cylinder can be refilled without loss of service.

TYPE OF REGULATOR OR SERVICE	CAPACITY, BTU/HR	RECOMMENDED MEC REGULATOR
First - Stage(1) (Reduces tank pressure to 10 psig or less)	1,100,000 - 1,700,000	MEGR-1122H MEGR-1222HT MEGR-1252H MEGR-1622H MEGR-1622HT
	2,100,000 - 2,750,000	
Second - Stage(2) (Reduces first stage outlet pressure to 14" w.c. or less)	450,000 -800,000	MEGR-1222 MEGR-1222D MEGR-1252 MEGR-1252D
	710,000 - 1,300,000	MEGR-1622 MEGR-1622D MEGR-1642 MEGR-1642D MEGR-1652 MEGR-1652D
Integral Two - Stage(1) (Combines a high pressure and a 2nd stage regulator)	450,000 - 650,000	MEGR-1232 MEGR-1232T
	700,000 - 950,000	MEGR-1632 MEGR-1632T
High Pressure(3) (Reduces tank pressure to a lower pressure in excess of 1 psig)	2,700,000 - 5,300,000	MEGR-164
2 - PSI(2) **Service** (Reduces 1st stage pressure to 2 psig)	1,100,000 - 1,400,000	MEGR-1622E MEGR-1622ED MEGR-1652E MEGR-1652ED
2 - PSI Integral Two Stage(2) (Combines a high pressure and 2 PSI regulator)	500,000	MEGR-1232E
	850,000 - 1,400,000	MEGR-1632E

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.

*Refer to piping selection for dielectric requirements

Single Stage / Twin Stage Regulation

NFPA 58 States that single stage regulators shall not be installed in fixed piping systems. This requirement includes systems for appliances on RVs, motor homes, manufactured housing, and food service vehicles. In these cases a twin stage regulator must be used. The requirements do not apply to small outdoor cooking appliances, such as gas grills, provided the input rating is 100,000 Btu/h or less.

Two Stage Regulation

There are several advantages of having two stage regulation:

Uniform Appliance Pressures – Installing a two stage system – one high pressure regulator to compensate for varied inlet pressure at the container and one low pressure regulator to supply a constant delivery of pressure to the appliances at the building – helps to ensure a maximum efficiency and keeps pressure variations within 1” W.C. at the appliances.

Freeze up and Service call Reductions – When moisture in the gas condenses and freezes on the cold surfaces of the regulator nozzle, regulator freeze ups occur. The nozzle becomes chilled when high pressure gas expands across it into the regulator body. In a two stage system the expansion of gas at two different orifices greatly reduce the refrigeration effect that causes freeze ups.

Economy of Installation – Transmission line piping between the container and the appliances in a twin stage system must be large enough to accommodate the required volume of gas at the 11” W.C. In contrast, the two stage system line between the first and second stage regulators can be much smaller as it delivers gas at 10 PSIG to the second stage regulator. In many cases the savings in piping cost will pay for the second regulator.

In locations where winter temperatures are extremely low, attention should be given to the first stage regulator setting to avoid the possibility of propane vapors re-condensing into liquid in the line downstream of the first stage regulator.

For example, if the temperature in the area reaches as low as -20°F, the first stage regulator should not be set higher than 10 PSIG. If the temperature in the area reaches as low as -35°F, the first stage regulator should not be set higher than 5 PSIG.

An additional benefit of two stage systems is that older single stage systems can be easily converted using existing supply lines when they prove inadequate to meet added loads.

<u>Future Appliance Allowances</u> – New installations of two stage systems offer a high degree of flexibility. Appliances can be added later to the present load by the addition of a second low pressure regulator as long as the high pressure regulator can handle the increase. Since appliances can be regulated independently, demands from the other parts of the installations will not affect their individual performances.

Regulator Vent

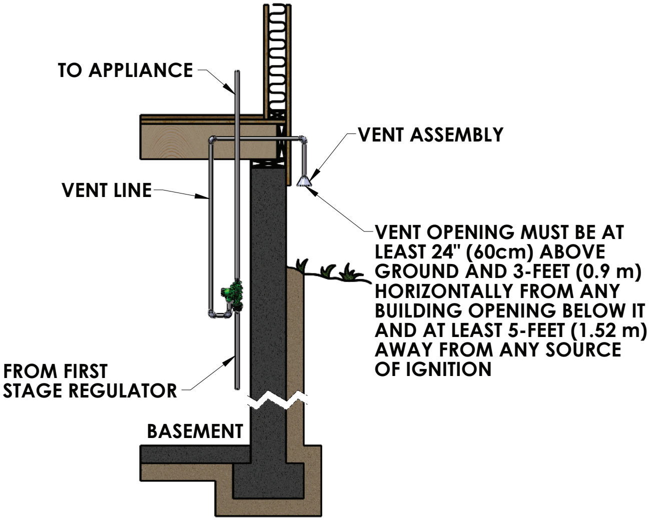
Obstructions of the regulator vent, caused by snow, sleet, freezing rain, ice, mud, or other debris, can prevent the regulator from operating properly. This can result in high pressure gas at the appliances resulting in explosion or fire.

Regulator vents must be clear and fully open at all times. Regulators installed in accordance with NFPA#58 will meet these requirements. The regulator should be installed with the vent facing down or under a protective cover. Screened vents must have the screen in place at all times. If missing or clogged, cleaning of the vent and screen replacement is necessary. If foreign material is evident in the vent, the regulator should be replaced.

Indoor Installations

The first stage and integral regulators are not recommended for indoor installations. The second stage regulator may be installed indoors as follows.

By code, regulators installed indoors have limited inlet pressure, and they require a vent line to the outside of the building. A vent assembly, such as MEC ME960 or at least 3/4” NPT pipe, Gray PVC Schedule 40 Rigid Non-Metallic Electrical Conduit for above Ground Service, per UL 651, should be used. The same installation precautions, previously discussed throughout this manual for the regulator vent, apply to the end of the vent tube assembly. Vent lines must not restrict the gas flow from the regulator’s internal relief valve. To install the vent line, remove the vent screen and apply a good grade of pipe compound to the male threads of the line. Vent lines should be as straight as possible with a minimum number of bends.



Underground Installations

The integral two-stage regulators require 2 vent lines, one for the first stage vent (1/4” OD copper tube inverted flare connection: 7/16-24 UN thread) and the other for the second stage vent (3/8” NPT) of the regulator. Failure to use 2 separate vent tubes can result in early regulator failure and / or over pressuring the second stage that could result in fire or personal injury.

A regulator installed in the dome of an underground container requires a vent line to prevent water from entering the regulator spring case.

Remove the vent screen(s) and install a vent line(s). The vent line must be run from the regulator vent(s) to above the maximum water table. The vent line opening(s) must terminate at the extreme top inside of the dome cover. Make sure the regulator’s closing cap is on tightly, and maintain drainage away from the dome at all times.

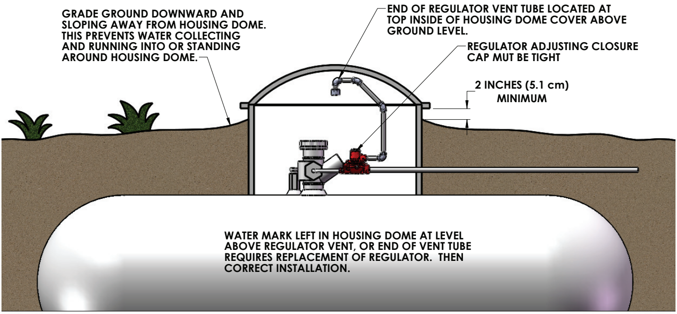


Figure 5: Underground Installation

Testing for Leaks in the Installation

According to NFPA 54 the definition of a leak check is an operation performed on a gas piping system to verify that the system does not leak. This means that all leak test should be performed on both new and existing systems that are being placed into service. All piping, fittings, regulators, and control valves in the system should be included in the test.

There are several methods to conducting a leak test. The two basic methods are low pressure testing and high pressure testing.

Low Pressure Testing

When using this method a low pressure test gauge (ME50P-2 or ME60P-2) or a water manometer (ME1328, ME1331, or ME1332) is used to detect loss due to leaks.

1. Inspect all connections and appliance valves to be sure they are tightly closed, including the pilot valves and any line shutoff valves.
2. Connect the low pressure test gauge or a manometer to a range top burner orifice. If a range is not available, install a special tee between the appliance shutoff and inlet to the appliance. The pressure tap port can also be used if available on the shutoff valve.
3. Open container valve to pressurize the piping system. Leave system open five to six seconds then tightly close valve. Return to the appliances and open each appliance shutoff valve slowly. If the pressure drops below 10” W.C. repeat step 3.
4. The reading on the low pressure test set or the manometer should be at least 11” W.C. Slowly open one burner valve on an appliance or bleed through a pilot valve just enough gas to reduce the pressure reading on the test set or the manometer to 9” W.C.

A leak tight system is indicated by a constant pressure for 3 minutes. If a drop in pressure occurs, check joints and other possible leakage points with an approved leak detector, such as MEC leak detector, soap and water, or an approved mechanical leak detector.

CAUTION: Some leak test solutions, including soap and water, can cause corrosion or stress cracking. Rinse the piping with water after testing unless the leak test solution is noncorrosive. Never use an open flame to test. An increase in pressure indicates that the container valve is not shut off tightly. Tightly shutoff container valve and repeat step 4.

High Pressure Testing

1. Inspect all connections and appliance valves to be sure they are tightly closed, including the pilot valves.
2. Install the pressure test gauge on the test port upstream side of the regulator but downstream of the tank service valve seat.
3. While observing the pressure on the 300 psi test gauge open the container valve to allow the system to pressure.
4. Tightly close the service valve. Make note of the pressure reading on the pressure gauge, slowly bleed gas between service valve and gauge adapter, reduce pressure to 10 PSIG less than the original reading on the gauge and re-tighten gauge adapter into service valve or close bleeder port. Make note of reading on gauge.

The system is assumed leak tight if gauge reading remains constant for at least 3 minutes. If the pressure reading drops, it indicates a leak someplace in the high or low pressure piping system. **NOTE**: A drop in pressure of 15 PSIG in 10 minutes indicates a leak as little as 10 BTU of gas per hour. Check joints and other possible leakage points with an approved leak detector, such as MEC leak detector, soap and water, or an approved mechanical leak detector. **CAUTION**: Some leak test solutions, including soap and water, can cause corrosion or stress cracking. Rinse the piping with water after testing unless the leak test solution is noncorrosive. Never use an open flame to test. An increase in pressure indicates that the container valve is not shut off tightly. Tightly shutoff container valve and repeat step 4.

5. The test gauge can either be left in place or disconnected from the service shutoff valve. If disconnected plug opening and check for leaks with an appropriate leak detector solution (see caution in step 4).

Corrective Actions to take when a leak is detected

If a leak is found, go through these steps to correct the leak.

1. To locate the leak use an approved leak detector, such as MEC leak detector solution, soap and water, or an approved mechanical leak detector. Never use an open flame.
2. Apply solution over every joint in the piping or tubing checking for bubbles that expand. This indicates a leak. A large leak will blow away the solution before bubbles can form.
3. For Flared Tubing: If a leak is found try tightening the connection. If this doesn't work, re-flare tubing.
4. For Threaded Piping: If a leak is found, try tightening or redoing the connection. If leak persists the threads on the connection are bad and will need to be re cut.
5. If steps 3 and 4 don't fix the leakage, look for sand-holes in the pipe or fittings, and splits in tubing. Defective material needs to be replaced.

NOTE: If leaks are caused by equipment that is faulty, that equipment must be replaced.

Troubleshooting ASME Tank Fittings

Hose End and Filling Valves

Follow this procedure on every filling application in order to prevent hazardous conditions:

- Check hose end valve and filler valve for foreign materials and, if present, remove with extreme care. If foreign material cannot be safely removed, do not proceed with filling and replace valve.
- Make sure the acme connector easily spins on by hand. Never use hammers or pipe wrenches to tighten acme connections.
- If a leak is detected when filling is started, immediately stop the operation and follow procedures to correct the leaking condition.
- Before disconnecting a filler valve, close both the filler and hose end valve tightly and vent the trapped gas by (a) using the vent on the hose end valve or (b) slightly loosening coupling nut to vent the gas before disconnecting. Loosen the filler valve very slowly. If the gas does not stop venting, then there is a leak in the filler valve or hose end valve. Do not disconnect the filling connector. Make sure you are familiar with your companies' procedure for handling this hazardous situation and follow it carefully.

Back Checks and Valves with Back Checks

Back checks limit flow to one direction. They are not intended to be a primary shut-off. Always fully close shut-off valves equipped with back checks when not in use.

Excess Flows and Valves with Excess Flows

Excess flows check closed when their rated flow is exceeded. Always fully open a shut-off valve with an excess flow when in use.

Quick Acting Filling Valves

Inspect valves daily to ensure locking mechanism is working properly.

Orifice Capacities for LP-Gases (BTU/HR at Sea Level)					
ORIFICE OR DRILL SIZE	PROPANE	BUTANE	ORIFICE OR DRILL SIZE	PROPANE	BUTANE
0.008	519	589	51	36531	41414
0.009	656	744	50	39842	45168
0.010	812	921	49	43361	49157
0.011	981	1112	48	46983	53263
0.012	1169	1326	47	50088	56783
80	1480	1678	46	53296	60420
79	1708	1936	45	54641	61944
78	2080	2358	44	60229	68280
77	2629	2980	43	64369	72973
76	3249	3684	42	71095	80599
75	3581	4059	41	74924	84940
74	4119	4669	40	78029	88459
73	4678	5303	39	80513	91215
72	5081	5760	38	83721	94912
71	5495	6230	37	87860	99605
70	6375	7227	36	92207	104532
69	6934	7860	35	98312	111454
68	7813	8858	34	100175	113566
67	8320	9433	33	103797	117672
66	8848	10031	32	109385	124007
65	9955	11286	31	117043	132689
64	10535	11943	30	134119	152046
63	11123	12612	29	150366	170466
62	11735	13304	28	160301	181728
61	12367	14020	27	168580	191114
60	13008	14747	26	175617	199092
59	13660	15486	25	181619	205896
58	14333	16249	24	187828	212935
57	15026	17035	23	192796	218567
56	17572	19921	22	200350	227131
55	21939	24872	21	205525	232997
54	24630	27922	20	210699	238863
53	28769	32615	19	223945	253880
52	32805	37190	18	233466	264673
Data reprinted from Table E.1.1(b) in NFPA 54, 2012 Ed. Always check www.nfpa.org for the latest updates.					

	PROPANE	BUTANE
BTU per Cubic Foot	2516	3280
Specific Gravity	1.52	2.01
Pressure at Orifice, Inches w.c.	11	11
Orifice Coefficient	0.9	0.9

Liquid Propane Flow GPH	Iron Pipe (Feet)															
	1/4"		3/8"		1/2"		3/4"		1"		1-1/4"		1-1/2"		2"	
	Schedule		Schedule		Schedule		Schedule		Schedule		Schedule		Schedule		Schedule	
	40	80	40	80	40	80	40	80	40	80	40	80	40	80	40	80
10	729	416														
15	324	185														
20	182	104	825	521												
40	46	26	205	129	745	504										
60	20	11	92	58	331	224										
80	11	6	51	32	187	127	735	537								
100	7	4	33	21	119	81	470	343								
120			23	15	83	56	326	238								
140			15	9	61	41	240	175	813	618						
160			13	8	47	32	184	134	623	473						
180					37	25	145	106	491	373						
200					30	20	118	86	399	303						
240					21	14	81	59	277	211						
280					15	10	60	44	204	155						
300					13	9	52	38	177	135	785	623				
350							38	28	130	99	578	459				
400							30	22	99	75	433	344	980	794		
500							19	14	64	49	283	225	627	508		
600									44	33	197	156	435	352		
700									32	24	144	114	320	259		
800									25	19	110	87	245	198	965	795
900									19	14	87	69	194	157	764	630
1000									16	12	71	56	157	127	618	509
1500											31	25	70	57	275	227
2000											18	14	39	32	154	127
3000											8	6	17	14	69	57
4000													10	8	39	32
5000															25	21
10000															6	5

To Use Chart

1. Having determined the required flow at point of use, locate this flow in the left hand column. If this falls between two figures, use the larger of the two.
2. Determine total length of piping required from source to point of use.
3. Read across chart from left (required flow) to right to find the total length which is equal to or exceeds the distance from source to use.
4. From this point read up to find the correct size of pipe required.

CONVERSION UNITS		
Multiply	**By**	**To Obtain**
LENGTH AND AREA		
Centimeters	0.3937	Inches
Feet	0.3048	Meters
Feet	30.48	Centimeters
Feet	304.8	Millimeters
Inches	2.540	Centimeters
Inches	25.40	Millimeters
Kilometer	0.6214	Miles
Meters	1.094	Yards
Meters	3.281	Feet
Meters	39.37	Inches
Miles (nautical)	1853	Meters
Miles (Statute)	1609	Meters
Millimeters	0.0394	Inches
Sq. Centimeters	0.1550	Sq. Inches
Sq. Feet	0.0929	Sq. Meters
Sq. Inches	6.4516	Sq. Centimeters
Sq. Meters	10.764	Sq. Feet
Yards	0.9144	Meters
Yards	91.44	Centimeters
VOLUME AND MASS		
Cubic Centimeters	0.06103	Cubic Inches
Cubic Feet	7.48	Gallons (US)
Cubic Feet	28.316	Liters
Cubic Feet	1728	Cubic Inches
Cubic Feet	0.03704	Cubic Yards
Cubic Feet	0.02832	Cubic Meters
Cubic Inches	16.387	Cubic Centimeters
Cubic Meters	35.315	Cubic Feet
Gallons (Imperial)	1.201	Gallons (US)
Gallons (US)	0.1337	Cubic Feet
Gallons (US)	0.8326	Gallons (Inperial)
Gallons (US)	3.785	Liters
Gallons (US)	231	Cubic Inches
Kilograms	2.2046	Pounds
Liters	0.0353	Cubic Feet
Liters	0.2642	Gallons (US)
Liters	1.057	Quarts (US)
Liters	2.113	Pints (US)
Pints (US)	0.4732	Liters
Pounds	0.4535	Kilograms
Tonnes	1.1024	Tons (US)
Tons (US)	0.9071	Tonnes

CONVERSION UNITS		
Multiply	**By**	**To Obtain**
PRESSURE AND FLOW RATE		
Atmospheres	1.0332	Kilograms / Sq. Centimeters
Atmospheres	14.70	Pounds / Sq. Inch
Atmospheres	407.14	Inches W.C.
Bars	14.50	Pounds / Sq. Inch
Bars	100	Kilopascals (kPa)
Cubic Feet / hr.	28.316	Liters / hr.
Cubic Meters / hr.	4.403	Gallons / min.
Gallons / min.	0.2271	Cubic Meters / hr.
Grams / Sq. Centimeters	0.0142	Pounds / Sq. Inch
Inches of Mercury	0.4912	Pounds / Sq. Inch
Inches of Mercury	1.133	Feet of Water
Inches W.C.	0.0361	Pounds / Sq. Inch
Inches W.C.	0.0735	Inches of Mercury
Inches W.C.	0.5781	Ounces / Sq. Inch
Inches W.C.	5.2040	Pounds / Sq. Foot
Inches W.C.	2.488	Millibars
Kilograms / Sq. Centimeters	14.22	Pounds / Sq. Inch
Kilograms / Sq. Meter	0.2048	Pounds / Sq. Foot
Kilopascals (kPa)	0.145	Pounds / Sq. Inch
Liters / hr.	0.0353	Cubic Feet / hr.
Millibars	0.4018	Inches W.C.
Ounces / Sq. Inch	1.733	Inches W.C.
Pounds / Sq. Inch	0.068	Atmospheres
Pounds / Sq. Inch	0.07031	Kilograms / Sq. Centimeters
Pounds / Sq. Inch	6.89	Kilopascals (kPa)
Pounds / Sq. Inch	2.036	Inches of Mercury
Pounds / Sq. Inch	2.307	Feet of Water
Pounds / Sq. Inch	0.06897	Bars
Pounds / Sq. Inch	27.67	Inches W.C.
MISCELLANEOUS		
API Bbls	42	Gallons (US)
BTU	0.252	Calories, kg.
BTU	1.055	Kilojoules
BTU	0.00001	Therms
BTU / hr.	0.293	Watts
Calories, kg.	3.968	BTU
Kilograms	2.205	Pounds
Kilojoules	0.9478	BTU
Kilowatt Hour	3412	BTU
Megajoules	0.00948	Therms
Ounces	28.35	Grams
Pounds	0.4536	Kilograms
Pounds	453.5924	Grams
Therms	100,000	BTU
Therms	105.5	Megajoules
Ton (US)	2000	Pounds
Ton (US)	0.908	Tonnes
Watts	3.414	BTU / hr.

Form# 1000 - Rev. C

PART OF OPW a DOVER company

MARSHALL EXCELSIOR COMPANY
1506 George Brown Drive Marshall, MI 49068
Phone (269) 789-6700 | www.marshallexcelsior.com

LP-GAS SERVICE REFERENCE GUIDE