



Fuel Gas Piping Systems

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Low- to medium-pressure fuel gas systems from the property line to the final connection of the most remote gas appliance or piece of equipment, with supply pressures of 7 inches (177 millimeters) of water column to 5 pounds per square inch gauge (psig) (34 kilopascals), typically provide sufficient pressure and volume for all uses on consumer sites. (In some areas of the country, gas pressures on both sides of the meter are in inches of water column.)

The composition, specific gravity, and heating value of natural gas vary depending on the well (or field) from which the gas is extracted. Natural gas is a mixture of gases, most of which are hydrocarbons, and the predominant hydrocarbon is methane. Some natural gases contain significant quantities of nitrogen, carbon dioxide, or sulfur (usually as hydrogen sulfide). Natural gases containing sulfur or carbon dioxide typically are corrosive. These corrosive substances usually are eliminated by treating the natural gas before it is transmitted to customers. In addition, readily condensible petroleum gases usually are extracted before the natural gas is supplied to the pipeline to prevent condensation during transmission.

The physical properties of natural gas and liquefied petroleum gas (LPG) are given in Table 7-1. Natural gas and liquefied petroleum gas both are colorless and odorless, so an additive called mercaptan is injected into both types of gases for leak-detection purposes.

SYSTEM OPERATING PRESSURE

The gas pressure in the piping system downstream of the meter is usually 5 to 14 inches (125 to 356 mm) of water column, but in some cases it can be as much as 2 to 5 psi (13.8 to 34.5 kPa). Under certain conditions, engineering practice will limit the pressure losses due to friction in the piping system to a range between 0.2 and 0.5 inch (5 and 13 mm) of water column, but all model codes allow the engineer the opportunity to take a greater pressure drop. However, local codes may vary, and the engineer should consult the local AHJ prior to the design of any system.

Most appliances typically require approximately 3.5 inches (89 mm) of water column, but certain appliances such as water heaters and boilers may require higher gas pressures to operate properly. Where appliances require higher operating pressures and/or where long distribution lines are encountered, it may be necessary to select a higher pressure at the meter outlet to satisfy the appliance requirements or allow for greater pressure losses in the piping system, thereby allowing economy of pipe size. Since many appliances are selected by others (not the plumbing engineer), it is prudent for the engineer to address this issue early in the process.

Systems often are designed with meter outlet pressures of 2 to 5 psi (13.8 to 34.5 kPa), combined with pressure regulators to reduce the pressure for appliances as required. In most cases, the utility company will reduce the incoming pressure to a figure that is requested by the design engineer at the start of the project or to conform to local code requirements.

The maximum allowable operating pressure for natural gas piping systems inside a building is based on the National Fuel Gas Code (NFPA 54), except when approved by the AHJ or when insurance carriers have more stringent requirements. Natural gas system pressures generally are not permitted to exceed 5 psig (34.5 kPa) unless all of the following are met:

- The AHJ will allow a higher pressure.
- The distribution piping is welded. (Note: Some jurisdictions also may require welded joints to be x-rayed to verify continuity.)
- Pipe runs are enclosed for protection and located in a ventilated place that will not allow gas to accumulate.
- The pipe is installed within areas used specifically for industrial processes, research, warehousing, or mechanical equipment rooms.

Table 7-1 Average Physical Properties of Natural Gas and LPG

	LPG	Natural Gas (methane)
Formula	C ₃ H ₈	CH ₄
Molecular weight	44.097	16.402
Melting (or freezing) point, °F	-305.84	-300.54
Boiling point, °F	-44	-258.70
Specific gravity of gas (air = 1.00)	1.52	0.60
Specific gravity of liquid 60°F/60°F (water = 1.00)	0.588	0.30
Latent heat of vaporization at normal boiling point, Btu/lb	183	245
Vapor pressure, psig at 60°F	92	
Pounds per gallon of liquid at 60°F	4.24	2.51
Gallons per pound of liquid at 60°F	0.237	
Btu per pound of gas (gross)	21,591	23,000
Btu per ft ³ of gas at 60°F and 30 in. Hg	2,516	±1,050
Btu per gallon of gas at 60°F	91,547	
Cubic feet of gas (60°F, 30 in. Hg) per gallon of liquid	36.39	59.0
Cubic feet of gas (60°F, 30 in. Hg) per pound of liquid	8.58	23.6
Cubic feet of air required to burn 1 ft ³ of gas	23.87	9.53
Flame temperature, °F	3,595	3,416
Octane number (isooctane = 100)	125	
Flammability limit in air, upper	9.50	15.0
Flammability limit in air, lower	2.87	5.0

- The total length of the gas pipe is extremely long and the low pressure gas pipe design will include very large pipe sizes, such as in malls and sports fields.
- The volume of the consumption is so extensive that the pipes are massive.

A maximum liquefied petroleum gas pressure of 20 psig (138 kPa) generally is allowed, provided the building is used specifically for research or industrial purposes and is constructed in accordance with the Liquefied Petroleum Gas Code (NFPA 58).

PRESSURE-REGULATING VALVES

A pressure regulator is a device used to reduce a variable high inlet pressure to a constant lower outlet pressure. The line regulator is used to reduce supply line pressures. If used, this regulator usually is installed outside, upstream of the meter assembly, and it is provided by the utility company. If installed inside a building, a dedicated relief vent pipe will need to be connected at the regulator's vent connection and routed to the exterior of the building per the local AHJ. An intermediate regulator located downstream of the meter assembly may be used to further reduce pressure from 2 to 5 psig (13 to 35 kPa) or to a pressure suitable for use by terminal equipment of approximately 7 inches (178 mm) of water column.

An appliance regulator connects the supply to equipment at the point of use and may be provided by the equipment manufacturer, specifically on equipment that may include a gas train. Types of appliance regulators include the zero governor, backpressure regulator, and differential regulator.

When regulators are installed inside a building and require venting, these vents must be routed to the atmosphere, and the vents from individual regulators may not be combined. A vent to the outdoors is not required for regulators equipped with and labeled for utilization with an approved vent-limiting device installed in accordance with the manufacturer's instructions. However, the use of vent-limiting devices should be evaluated carefully for each specific project design to ensure that the proper safety measures have been accounted for and that local jurisdictional requirements have been met. Regulators with vent-limiting devices are in many cases allowed only within ventilated spaces to ensure that any gas escaping from the vent is dissipated safely.

When bottled gas is used, the tank pressure can be as high as 150 psi (1,034.6 kPa), which needs to be reduced to the burner design pressure of 11 inches (279.4 mm) of water column. The regulator typically is located at the tank for this pressure reduction.

Gas Regulator Relief Vents

Guidelines for the use of relief vents from pressure regulators, also referred to as gas-train vents, can be found in the latest editions of NFPA 54 and FM Global Loss Prevention Data Sheet 6-4: *Oil- and Gas-Fired Single-Burner Boilers*, as well as in other publications of industry standards, such as those issued by the American Gas Association.

It should be noted that when pressure regulators discharge (or the diaphragm in the regulator ruptures), large amounts of fuel gas may be released. It is not uncommon for a local fire department to be summoned to investigate an odor of gas caused by a gas-train vent discharge. Every attempt should be made to locate the terminal point of the vents above the line of the roof and away from doors, windows, and fresh-air intakes. They should be located on a side of the building that is not protected from the wind. Refer to NFPA 54, local utility supplier requirements, and local codes for the exact requirements for vent termination locations.

CONTROL VALVES

Excess Flow Valves

An excess flow valve is a device that shuts off the flow of gas if the flow through the pipe or service is greater than that for which it was designed. In some parts of the country, particularly in areas where earthquakes may occur, excess flow valves are necessary to guard against the possibility of a break during such an event. In other cases, where danger exists for equipment such as large boilers, installation should be considered.

A low-pressure cutoff shall be installed between the meter and the appliance where the operation of a device, such as a gas compressor, appliance, or boiler, could produce a vacuum or dangerous vacuum condition in the piping system.

Appliance Control Valves

An appliance shutoff valve shall be installed at all gas appliances. Valves at flexible hose connections are to be installed prior to the flexible connection that is used to connect the appliance to the building gas supply.

Interlocks and Solenoid Valves

An automatic interlock or gas solenoid valve can be interconnected with the automatic fire extinguishing system when required to shut off the gas supply to all equipment in a kitchen when sprinklers discharge in the event of a fire. These valves typically are provided by the fire suppression equipment contractor and installed by the plumbing or mechanical contractor.

In earthquake-prone areas, a seismic shutoff valve is necessary to shut off the supply of gas if a seismic event is of sufficient magnitude to potentially rupture the gas supply pipe or separate the pipe from equipment. The seismic shutoff valve is mandatory for restaurants. Restaurant equipment hoods also are controlled by a mechanical or electronic valve. If the fire protection system within the hood is activated, the gas shutoff valve will function.

PIPING SYSTEM MATERIALS

The International Fuel Gas Code, model plumbing codes, and standards published by NFPA (54 and 58) list the approved materials for use in natural gas and liquefied petroleum gas (propane) piping systems. The most commonly used materials for these systems (along with additional notes and cautionary statements) are listed below for reference purposes.

Metallic Pipe

Cast Iron

Cast iron pipe shall not be used.

Steel and Wrought Iron

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

- ASME B36.10M: *Welded and Seamless Wrought Steel Pipe*
- ASTM A53: *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless*: Black or carbon steel piping is generally the most commonly selected steel pipe material for natural gas and propane piping systems. Galvanized steel pipe is covered with a protective coating of zinc that greatly reduces its tendency to corrode and extends its life expectancy. However, it should be noted that galvanized steel piping is not approved for use in many jurisdictions for natural gas service. In general, it should not be used in natural gas systems because corrosivity levels in natural gas can vary over time and can cause the zinc to flake off and clog the system.
- ASTM A106: *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*

Copper and Brass

Copper and brass pipe are approved for use, but they shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet (scf) of gas (0.7 milligrams per 100 liters).

Threaded copper, brass, or aluminum alloy pipe is approved for use, but shall not be used with gases that are corrosive to such materials.

Aluminum Alloy

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

Metallic Tubing

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

Steel

Steel tubing shall comply with ASTM A254: *Standard Specification for Copper-Brazed Steel Tubing*.

Copper and Brass

Copper and brass tubing shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 scf of gas (0.7 milligrams per 100 liters). Copper tubing shall comply with standard Type K or Type L of ASTM B88: *Standard Specification for Seamless Copper Water Tube* or ASTM B280: *Specification for Seamless Copper Tube for Air-Conditioning and Refrigeration Field Service*.

Aluminum

Aluminum alloy tubing shall comply with ASTM B210: *Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes* or ASTM B 241. Aluminum alloy tubing shall be coated to protect against external corrosion where it is in contact with masonry, plaster, or insulation or is subject to repeated wettings by such liquids as water, detergent, or sewage. Aluminum alloy tubing shall not be used in exterior locations or underground.

Corrugated Stainless Steel Tubing

Corrugated stainless steel tubing (CSST) shall be listed in accordance with ANSI LC 1/CSA 6.26: *Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing*. The standard requires a contractor to be certified by the manufacturer before installing CSST. While CSST is approved by all national plumbing and gas codes, some local jurisdictions and authorities may restrict its use.

As an alternative to the installation of rigid steel or copper piping systems, CSST systems can be used from 3/8-inch up to 2-inch tube sizes. CSST systems consist of a continuous, flexible, stainless steel pipe with an exterior polyethylene (PE) jacket, which is ASTM E84: *Standard Test Method for Surface Burning Characteristics of Building Materials* rated (smoke and fire rated 25/50) to be installed in a plenum. The piping is produced in coils that are air tested for leaks. It most often is installed in a central manifold configuration (also called a parallel configuration) or extended from steel pipe mains with home run lines that extend to gas appliances (also called a hybrid system).

Flexible gas piping is lightweight and requires fewer connections than conventional gas piping because it can be bent easily and routed around obstacles. This can amount to a substantial reduction in labor costs as compared to a conventional rigid piping system installation. CSST piping systems can be a good choice for a retrofit or renovation project where existing conditions could render a rigid piping system installation very costly or disruptive to existing building occupants.

Precautions are necessary when designing, sizing, and installing CSST. Although a CSST system can be designed the same way as a rigid system, it is not the most efficient way to use this material. It's necessary to understand that the CSST industry is very proprietary, and all manufacturers have configured their systems differently. Consequently, once a CSST manufacturer is chosen either by the contractor or engineer, it would be prudent to stay the course for that project. Given the different flow characteristics between CSST and rigid pipe systems, it's important to understand that CSST cannot be sized the same way as rigid pipe systems. By using the chosen manufacturer's design and installation guide, which will include sizing criteria, the system can be sized properly. Installation, as with all natural gas and propane systems, should be done with care, but due to the flexible nature of this system, it's important to follow the strict guidelines set forth in the standard for safe routing and strike protection.

Plastic Pipe and Tubing

Plastic pipe, tubing, and fittings used to supply fuel gas shall conform to ASTM D2513: *Standard Specification for Polyethylene Gas Pressure Pipe, Tubing, and Fittings*. The pipe shall be marked “gas” and “ASTM D2513.”

Polyethylene plastic pipe may be used outside for underground installations only. In addition, PE pipe installations typically require warning tape and/or tracer wire to be installed above the installed pipe for locating purposes and to protect the pipe from damage from digging equipment.

Fittings and Joints

Steel pipe joints shall be threaded, flanged, brazed, or welded. Threaded connections are most commonly used for piping up to 3 inches. Welded or flanged joints become more practical above this size range as it is difficult to maneuver assembled sections of large screwed piping due to weight and space constraints. Where nonferrous pipe such as copper or brass is brazed, the brazing materials shall have a melting point in excess of 1,000°F (538°C). Brazing alloys shall not contain more than 0.05 percent phosphorus.

Steel pipe and fittings 4 inches (100 mm) and larger shall be welded. In some jurisdictions the size of the piping determines whether the piping is required to be welded and, in some cases, x-rayed at the welding points. Always verify the exact requirements with the local AHJ.

Tubing joints shall be made with approved gas tubing fittings, brazed with a material having a melting point in excess of 1,000°F (538°C), or made by press-connect fittings complying with ANSI LC4/CSA 6.32: *Press-Connect Copper and Copper Alloy Fittings for Use in Fuel Gas Distribution Systems*. (Brazing alloys shall not contain more than 0.05 percent phosphorus.)

Flexible Hose Connections

Indoor hose connectors shall be a listed connector in compliance with ANSI Z21.24/CSA 6.10: *Connectors for Gas Appliances*. The connector shall be used in accordance with the manufacturer's installation instructions and shall be located in the same room as the connected appliance. Only one connector shall be used per appliance. Indoor gas hose connectors may be used with laboratory, shop, and foodservice equipment. A shutoff valve must be installed where the connector is attached to the building piping. The connector must be of minimal length, but shall not exceed 6 feet (1.8 meters). The connector must not be concealed, must not extend from one room to another, and must not pass through wall partitions, ceilings, or floors.

Outdoor hose connectors shall be a listed connector in compliance with ANSI Z21.75/CSA 6.27: *Connectors for Outdoor Gas Appliances and Manufactured Homes*. Only one connector shall be used per appliance. They may be used to connect portable outdoor gas-fired appliances if the hose connections and appliances are listed for such applications. A shutoff valve or listed quick-disconnect device must be installed where the connector is attached to the supply piping, with piping installed in such a manner as to prevent the accumulation of water or foreign material. This connection must be made only in the outdoor area where the appliance is to be used.

Non-stationary (mobile) commercial cooking appliances and other types of appliances that may be moved for cleaning and sanitation purposes shall be connected in accordance with the connector manufacturer's installation instructions using a listed appliance connector complying with ANSI Z21.69/CSA 6.16: *Connectors for Movable Gas Appliances*. Movement of appliances with casters (in all cases) shall be limited by a restraining device installed in accordance with the connector and appliance manufacturers' installation instructions to prevent damage if the appliance should move while the gas supply is connected.

INTERIOR NATURAL GAS PIPE SIZING

Data to Be Obtained

To accurately size all elements of the piping system, calculate or obtain the following information:

- Information needed by both the utility company and the engineer
- Gas pressure available after the meter assembly
- Allowable friction loss through the piping system
- Pressure required at the equipment and/or appliance
- A piping layout that indicates all connected equipment, allowing determination of the measured length of piping to the furthest connection
- The maximum demand
- A pipe sizing method acceptable to the AHJ or local code

Information Needed by the Utility Company and the Engineer

The following are intended to be complete lists of items. Not all items will be necessary for all projects.

The following criteria and information shall be obtained in writing from the public utility company and provided to the engineer:

- Actual Btu content of the gas provided
- Minimum pressure of the gas at the outlet of the meter
- Extent of the installation work done by the utility company and the point of connection to the meter by the facility construction contractor
- Location of the utility supply main and the proposed run of pipe on the site by the utility company, in the form of a marked-up plan or description of the work, including the expected date of installation if no gas is available
- Acceptable location of the meter and/or regulator assembly or a request to locate the meter at a particular location
- Any work required by the owner/contractor to allow the meter assembly to be installed (such as a meter pit or slab on grade)
- Types of gas service available and the cost of each

For the utility company to provide this data, the following information must be provided to them:

- Total connected load: The utility will use its own diversity factor to calculate the size of the service line. For the design of the project's interior piping, the design engineer will select the diversity factor involved (as allowable by the governing code and/or local jurisdiction).

- Minimum pressure requirements for the most demanding equipment
- Site plan indicating the location of the proposed building orientation on the site and the specific area of the building where the proposed natural gas service will enter the building
- Preferred location of the meter/regulator assembly
- Expected date for the start of construction
- All specific requirements for pressure
- Two site plans, one to be marked up and returned to the engineer
- Hours of operation for the different types of equipment
- List of all future or anticipated equipment and capacities

Pressure Available After the Meter

This shall be established in writing from the utility at the start of the project. All gas-fired equipment and devices proposed for use on the project are to be submitted, and the pressure requirements and flow rates for each piece of equipment must be provided to the utility.

Allowable Friction Loss Through the Piping

This shall be established by the engineer and shall be determined by the following criteria:

- Pressure provided by the utility company, from 5 inches (125 mm) of water column to 5 psi (34.5 kPa)
- Required pressure at the equipment and/or appliance, typically a minimum 3.5 inches (89 mm) of water column for residential appliances and as much as 11 inches (280 mm) of water column for some rooftop equipment
- Allowable pressure drop either by code or the AHJ

After receiving the necessary criteria, the engineer can determine the allowable pressure drop for a particular system. This conceivably could be from 0.3 inch (7.6 mm) of water column to 6 inches (152.4 mm) of water column (for a low-pressure system) and from 1 psi (7 kPa) to 3.5 psi (24.1 kPa) for medium- to high-pressure systems).

Piping Layout

The equivalent length of piping is necessary to indicate the layout of the entire piping system and all connected appliances and equipment. The equivalent length of piping is calculated by measuring the actual length of the proposed piping from the meter to the furthest connection and then adding 50 percent (for fittings) of the measured length to obtain the total equivalent length. If a very accurate determination of the equivalent length is required, tabulate the fittings and valves and add those to the measured length. Refer to Table 7-2 for the equivalent amount of pipe length to be added for various valves and fittings.

It is common practice to omit the vertical length because natural gas is lighter than air. It expands at the rate of 1 inch (25.4 mm) of water column for each 15 feet (4.6 m) of elevation as the gas rises. The increase in pressure due to the height will offset any friction loss in the piping. For example, if a high-rise building contained 100 feet of equivalent horizontal pipe length and 200 feet of equivalent vertical pipe length, only the horizontal portion of piping (100 feet) would be considered for establishing the total equivalent length of pipe for design purposes, even though the actual equivalent pipe length in this example is 300 feet.

Natural Gas Pipe Sizing Methods

A number of formulas can be used to calculate the capacity of natural gas piping based on such variables as delivery pressure, pressure drop through the piping system, pipe size, pipe material, and length of piping. These formulas are referenced in numerous model codes as well as NFPA 54.

The most commonly referenced formula for gas pressures below 1½ psi (10.3 kPa) is the Spitzglass formula (see Equation 7-1). Another commonly referenced equation for pressures of 1½ psi (10.3 kPa) and above is the Weymouth formula (see Equation 7-2). Using these formulas for sizing can be very tedious and time consuming, so they are rarely used. However, they were used as a basis for the sizing tables that are included in the model codes and NFPA standards. These tables are regarded as the most conservative method for sizing natural gas piping systems and should be referenced specifically for each project as dictated by the governing code.

Equation 7-1

$$D = \frac{Q^{0.381}}{19.17 (\Delta H / [Cr \times L])^{0.206}}$$

where:

- D = Inside diameter of pipe, inches
- Q = Input rate appliance, cfh at 60°F
- L = Equivalent length of pipe, feet
- ΔH = Pressure drop (upstream pressure – downstream pressure), inches of water
- Cr = Natural gas: 0.6094; Undiluted propane: 1.2462
- Y = Natural gas: 0.9992; Undiluted propane: 0.9910

Equation 7-2

$$D = \frac{Q^{0.381}}{18.93 [(P_1^2 - P_2^2) * Y / (Cr \times L)]^{0.206}}$$

where:

P_1 = Upstream pressure, psia ($P_1 + 14.696$)

P_2 = Downstream pressure, psia ($P_1 + 14.696$)

The *Plumbing Engineering and Design Handbook of Tables*, published by the American Society of Plumbing Engineers, contains pipe sizing tables for many systems, including natural gas and liquefied petroleum gas (propane) systems. These tables contain sizing information for most of the commonly used piping materials including pipe sizes at various pressures and cfh requirements.

In addition, proprietary tables and calculators are available from various organizations, and popular spreadsheet programs currently available on the market also can be used.

The methods used for sizing natural gas piping systems are as follows.

Longest Length Method

This is the traditional method used to determine the longest equivalent piping length (from the meter or delivery point to the farthest outlet), which then is used in conjunction with the pipe sizing tables to determine the appropriate pipe diameter for all other sections of piping in the system. In simple terms, only the cfh quantities listed in the tables for this pipe length are used to size each and every branch and section of

Table 7-2 Equivalent Lengths for Various Valve and Fitting Sizes, ft (m)										
Fitting	Pipe Size, in. (mm)									
	¾ (19.1)	1 (25.4)	1½ (38.1)	2 (50.8)	2½ (63.5)	3 (76.2)	4 (101.6)	5 (127)	6 (152.4)	8 (203.2)
90° elbow	1 (0.3)	2 (0.61)	2.5 (0.76)	3 (0.91)	4 (1.22)	5.5 (1.68)	6.5 (1.98)	9 (2.74)	12 (3.66)	15 (4.57)
Tee (run)	0.5 (0.15)	0.75 (0.23)	1 (0.3)	1.5 (0.46)	2 (0.61)	3 (0.91)	3.5 (1.07)	4.5 (1.37)	6 (1.83)	7 (2.13)
Tee (branch)	2.5 (0.76)	3.5 (1.07)	4.5 (1.37)	5 (1.52)	6 (1.83)	11 (3.35)	13 (3.96)	18 (5.49)	24 (7.32)	30 (9.14)
Gas cock (approximate)	4 (1.22)	5 (1.52)	7.5 (2.29)	9 (2.74)	12 (3.66)	17 (5.18)	20 (6.1)	28 (8.53)	37 (11.28)	46 (14.02)
Note: The pressure drop through valves should be taken from the manufacturer's published data rather than using the equivalent lengths, since the various patterns of gas cocks can vary greatly.										

pipe. This method is the simplest to use, and it generally yields the most conservative sizing because the short runs of piping located close to the meter can be somewhat oversized. One advantage to using this method is that it can provide some cushion in the branch piping, allowing for future reconfiguration of the piping system without replacing entire branch lengths.

Branch Length Method

This is an alternate sizing method that could permit slightly smaller pipe diameters in some segments of a piping system when compared with the longest length method. The pipe size of each section of the longest pipe length (from the meter or delivery point to the farthest outlet) shall be determined using the longest equivalent length of piping and the associated cfh quantity listed in the tables for that section. Then, the pipe sizes of each section of branch piping not previously sized shall be determined using the equivalent lengths of piping from the point of delivery to the most remote outlet of each individual branch and the associated cfh quantity listed for that particular section.

Hybrid Pressure Method

This method is used when it is necessary to design a piping system that utilizes multiple supply pressures within a single distribution system. The pipe size for each section of high-pressure gas piping shall be determined using the longest equivalent length of piping from the meter or delivery point to the farthest pressure regulator. The pipe size from the pressure regulator to each outlet shall be determined using the length of piping from the regulator to the most remote outlet served by that regulator. With this method, medium-pressure gas tables (up to 5 psig) are used to size the piping upstream of the pressure regulators, and low-pressure gas tables (7 to 11 inches of water column) are used to size the piping downstream of each pressure regulator.

Sizing Tables

Table 7-3 is based on Schedule 40 steel pipe, cubic feet per hour of gas, and a specific gravity of 0.60. The friction loss allowable is indicated. The table has been provided as a supplement to the pipe sizing methods indicated, using the longest length method of pipe sizing.

To determine the size of each section of pipe in a gas supply system using the gas pipe sizing table, the following steps should be used:

1. Measure the length of the pipe from the gas meter location to the most remote outlet on the system. Add a fitting allowance of 50 percent of the measured length. This represents the total equivalent length of pipe. (For natural gas, the vertical portion of piping is not considered due to the pressure gained as gas rises. This very closely approximates the friction loss in the piping.)
2. Select the row showing the distance that is equal to or greater than the equivalent length calculated. Once chosen, it is the only row to use throughout the sizing process for all individual branches and cumulative sections of pipe.
3. Use the columns in conjunction with the row previously selected to locate all gas demand figures for this particular system. Starting at the most remote outlet, find in the table the calculated gas demand for that design point. If the exact figure is not shown, choose the figure closest to or greater than the calculated demand and select the associated pipe size.
4. With the demand figure (and corresponding length) selected, find the associated pipe size.
5. Proceed for each design point and each branch of pipe. For each section of pipe, determine the cumulative gas demand supplied by that section.

LIQUEFIED PETROLEUM GAS

Liquefied petroleum gas (propane) is a refined natural gas developed mainly for use beyond the utility's gas mains, but it has proven to be competitive in areas not covered by mains in rural areas. It is primarily a blend of propane and butane, with traces of other hydrocarbons remaining from the production method. The exact blend is controlled by the liquefied petroleum gas distributor to match the climatic conditions of the area served. For this reason, you must confirm the heating value of the supplied gas. Unlike natural gas, 100 percent propane has a specific gravity of 1.53 and a nominal rating of 2,500 Btu per cubic foot (93 megajoules per cubic meter).

Easy storage for relatively large quantities of energy has led to widespread acceptance and use of liquefied petroleum gas in all areas previously served by utilities providing natural gas to users, including for automotive purposes. In addition, a principal use is for heating in industrial projects. It is not a substitute for natural gas, but it provides an alternative energy source when owners want to use a low, interruptible rate for heating purposes. When used for this purpose, experience has shown that mixing it with air should produce a gas with the heating value of 1,500 Btu per cubic foot (a specific gravity of 1.30) for ease of burning and ignition.

Environmental Effects of Propane

From an environmental standpoint, propane is nontoxic and non-caustic and will not create an environmental hazard if released as a liquid or vapor into water or soil. If spilled in large quantities, the only environmental damage that may occur is the freezing of any organism or plant life in the immediate area. There are no long-term effects following a propane spill, even in large quantities. Potential damage and danger occur only if the vapor is ignited following a spill. Even then, there are no long-term effects of ignited propane that can be damaging to the environment. Propane liquid and vapor are both environmentally sound and friendly in their unused states (prior to combustion) if released.

Following are some environmental facts about propane:

- Propane is not considered a greenhouse gas.
- Propane is not damaging to freshwater or saltwater ecosystems or underwater plant or marine life.
- Propane is not harmful to soil if spilled on the ground. It will not harm drinking water supplies.
- Propane vapor will not cause air pollution, and it is not considered air pollution.
- Propane vapor is not harmful if accidentally inhaled by animals or people.
- Propane will cause bodily harm only if the liquid comes in contact with skin (boiling point -44°F).
- Propane is listed as an approved clean fuel by U.S. energy policymakers and energy administrative bodies.
- Propane engine exhaust is clean and powers forklifts operated inside warehouses throughout the world.

Propane Storage Tanks

Propane storage tanks typically are provided by the vendor for the customer and are subject to the regulations of the U.S. Department of Transportation (DOT) and the local authority, as well as NFPA standards. Tank manufacturers are required to adhere to ASME regulations for the construction of propane pressure vessels intended for use within the United States. ASME is the governing authority for all stationary propane tanks manufactured and used in the United States.

Propane tanks are considered either portable or stationary. Portable tanks, known as bottles or cylinders, are used as a fuel source for items such as gas grills and forklifts. Stationary propane tanks are located on facility sites and commercial businesses supplying multiple propane-powered appliances within the structures. Propane tanks, regardless of their size, store liquefied petroleum gas in liquid form until it is used as either a liquid or vapor. Propane tanks can be filled to only approximately 80 percent of total tank capacity and are for storing propane only.

Basic Propane Tank Function

The withdrawal of propane vapor from a tank lowers the contained pressure within the tank itself. This causes the liquid to boil, or vaporize, in an effort to restore pressure by generating vapor to replace the quantity that was removed. The required latent heat of vaporization is given up by the liquid and causes the liquid temperature to drop as a result of the expended heat.

The heat lost due to the vaporization of the liquid is replaced by the heat in the air surrounding the tank. This heat is transferred from the air, through the metal surface of the tank, into the liquid. (The area of the tank in contact with the vapor is not considered because the heat absorbed by the vapor is negligible.) The surface area of the tank that is immersed in the liquid is referred to as the wetted surface. The greater this wetted surface (or amount of liquid in the tank), the greater the vaporization capacity of the tank. Consequently, tanks that have large wetted surface areas have greater vaporization capacities. If the liquid in the tank receives heat for vaporization from the outside air, the vaporization rate of the tank will increase as the outside air temperature increases. The worst conditions for vaporization rate occur when the tank contains a small amount of liquid, and the outside air temperature is low.

Propane Tank Requirements

Listed below are tank-related safety and compliance items:

- Manufacturer's nameplate: Containers without nameplates are not permitted to be filled. The nameplates are for identification and information concerning ASME propane tanks.
- Tank color: All propane tanks are required to be painted a reflective color. It is not uncommon for facility owners to want to paint their propane tanks a color that aesthetically blends with their facility. However, this can present a safety problem (as well as a serviceability problem) if the desired tank color is dark or non-reflective. Dark colors absorb heat, while lighter colors reflect it. Therefore, propane tanks need to be painted with colors that reflect heat. Also, rust is color and will contribute to the absorption of heat. Tanks that are rusted often need to be sanded or scraped with a wire brush before they can be repainted.

Table 7-3 Pipe Sizing for Pressure Less than 2 psi and Loss of 0.3 inch of Water Column									
Pipe Length, ft	Pipe size, in. nominal (actual ID)								
	½ (0.622)	¾ (0.824)	1 (1.049)	1¼ (1.380)	1½ (1.610)	2 (2.067)	2½ (2.469)	3 (3.068)	4 (4.026)
10	131	273	514	1,060	1,580	3,050	4,860	8,580	17,500
20	90	188	353	726	1,090	2,090	3,340	5,900	12,000
30	72	151	284	583	873	1,680	2,680	4,740	9,660
40	62	129	243	499	747	1,440	2,290	4,050	8,270
50	55	114	215	442	662	1,280	2,030	3,590	7,330
60	50	104	195	400	600	1,160	1,840	3,260	6,640
70	46	95	179	368	552	1,060	1,690	3,000	6,110
80	42	89	167	343	514	989	1,580	2,790	5,680
90	40	83	157	322	482	928	1,480	2,610	5,330
100	38	79	148	304	455	877	1,400	2,470	5,040
125	33	70	131	269	403	777	1,240	2,190	4,460
150	30	63	119	244	366	704	1,120	1,980	4,050
175	28	58	109	224	336	648	1,030	1,820	3,720
200	26	54	102	209	313	602	960	1,700	3,460
250	23	48	90	185	277	534	851	1,500	3,070
300	21	43	82	168	251	484	771	1,360	2,780
350	19	40	75	154	231	445	709	1,250	2,560
400	18	37	70	143	215	414	660	1,170	2,380
450	17	35	66	135	202	389	619	1,090	2,230
500	16	33	62	127	191	367	585	1,030	2,110
550	15	31	59	121	181	349	556	982	2,000
600	14	30	56	115	173	333	530	937	1,910
650	14	29	54	110	165	318	508	897	1,830

Propane Tank Regulators

Propane tank pressures can range from less than 10 psig to more than 200 psig. The purpose of the regulator is to reduce the propane gas down to safe and usable system pressures.

A propane regulator must be covered and protected or pointed vertically down. Regulators generally are found under the tank dome (located on top of the storage tank). If located outside the tank dome, the regulator vent must be pointed down to prevent rain, ice, and debris from entering the regulator. In addition, the vent should have a screen that keeps insects out of the regulator.

Types of regulators include the following:

- High-pressure regulators are propane liquid or vapor service regulators designed to reduce the pressure from the tank to a lower pressure in excess of 1 psig. These regulators often are used in combination with a second-stage regulator in a two-stage regulator system. However, they also can be used independently in systems where appliance or gas equipment demands are high and the only way to satisfy demand requirements is with a high-pressure regulator.
- First-stage regulators sometimes are referred to as high-pressure regulators, but they do not reduce variable tank pressures to appliance-level pressure. They simply lower the tank pressure before it enters the gas service line. The purpose of a first-stage regulator is to deliver propane at an adequate pressure to a downstream second-stage regulator. A first-stage regulator in a two-stage regulator system is installed at the propane tank and is connected directly to the service valve with a pigtail. If a first-stage regulator is used in a propane piping system, a second-stage regulator must be installed downstream (usually at the building entrance). A first-stage regulator cannot be installed independently in a propane piping system (reference NFPA 58). A second-stage regulator also must be installed where the piping system enters the facility. The first-stage regulator will compensate for fluctuating tank pressures and will deliver into the propane gas line at a pressure of 10 psig or less. First- and second-stage regulators must be properly matched to ensure that the entire gas system is safe and functional.
- Second-stage regulators work with propane at a pressure supplied by the first-stage regulator (10 psig) and further decrease it to a pressure that can be used by the appliances (typically 11 inches of water column). Second-stage regulators are not used to decrease tank pressure and must always be installed downstream of a first-stage regulator for safe and proper operation. A regulator located at the propane entrance into a facility is always a second-stage regulator. Second-stage regulators are designed only to operate in combination with first-stage regulators. One cannot be used without the other.
- Integral two-stage regulators are a combination of both first- and second-stage regulators assembled into one unit. Integral two-stage regulators are always installed at the tank and compensate for varying tank pressures on the inlet side, while delivering steady service-line pressure and compensating for varying appliance demand on the outlet side. Integral twin-stage regulators are used in propane vapor

service only and are the most common type of regulators used in residential propane gas installations. These are used primarily when the gas service line to the facility or appliance is a relatively short distance and Btuh load requirements are not extremely high.

- Adjustable high-pressure regulators: Propane gas flow pressure adjustment in high-pressure propane systems is made possible by direct-operated regulators, another name for adjustable high-pressure regulators. The primary purpose of an adjustable regulator is to ensure that the required pressure is delivered to the appliance when the liquid level of the tank is such that vaporization is not fast enough to meet the gas demands of the appliance. Simply stated, an adjustable regulator compensates for the lack of vaporization by allowing more pressure through the outlet and into the downstream gas line. Adjustable high-pressure regulators are commonly seen attached to bottles and tanks supplying roofing tar kettles, asphalt mixers, and propane-powered torches. Direct-operated regulators are not designed to act as a service valve, but rather to allow for manual intervention in the regulation of delivery pressures as needed by the appliance.

Similar to natural gas systems, the reasoning behind having two separate regulators in a propane system is strictly for economy of the piping installation as previously explained in the natural gas section of this chapter.

Propane Tank Parts

All of the parts listed below are attached to the tank by the manufacturer with threaded fittings. These specialized propane tank parts consist of the following replaceable fittings and connections:

- Fill valve: The point at which a hose from a delivery truck is attached to the tank for refueling
- Relief valve: A safety relief assembly designed to vent propane in an over-pressure situation
- Service valve: The point at which propane is converted to vapor for use with appliances. The propane service valve is the controlling mechanism allowing propane gas to flow into the facility by way of the gas piping system. Although other gas valves may be present throughout the gas piping system, the service valve on the propane tank is the valve that controls 100 percent of the gas flow into the piping system. Propane service valves are for vapor service only.
- Fixed liquid level gauge: A gauge indicating that the level of propane is at or above 80 percent capacity
- Float gauge: A gauge that presents a visible indication of the propane volume in the tank (also referred to as a dial gauge)
- Vapor return valve: A connection used during propane delivery to remove excess tank pressure. When propane companies fill tanks in hot weather, they often will connect the vapor hose to the vapor return valve. This allows vapor to be safely recovered and contained in the delivery truck.
- Liquid withdrawal valve: A valve used to withdraw liquid propane from the tank.

Storage Tank Location

Small tanks (those for residential cooking and heating) are allowed to be located in close proximity to buildings. However, large tanks (for industrial or multiple building uses) have strict requirements governing their location in relation to buildings, public-use areas, and property lines. If large leaks occur, the heavier-than-air gas will accumulate close to ground level and form a fog, creating the potential for a hazardous condition.

Proper safety precautions and equipment, as well as good judgment, must be utilized when locating large liquefied petroleum gas storage tanks. The lines also have to be purged of air prior to the startup of the facility. Guidelines for proper clearances and placement of large, stationary propane tanks are listed in NFPA 58.

Propane Vaporization Requirements

Vaporization is the process of a liquid being converted into a gas (or vapor). Vaporization is related directly to the actual size of the propane tank as previously explained. For a propane appliance to work, vaporization must occur, and the amount of vaporization must be sufficient to deliver the required amount of propane.

Commercial and industrial propane applications using high-demand propane gas equipment need propane vaporizers to satisfy Btuh demand requirements. Vaporizers are used when equipment or appliance demands exceed the vaporizing capacity of the tank. Simply stated, vaporizers are used to supply the required amount of propane gas when the tank can't keep up with the downstream demand on its own and placing a much larger tank or multiple tanks with higher vaporization capacity would be impractical. Propane gas vaporizers work with liquid propane at a location separate from the tank, with liquid propane being piped to the vaporizing equipment for gas vaporization.

Types of propane vaporizers are as follows.

Direct-Fired Vaporizers

Direct-fired propane vaporizers contain a flame that directly heats the liquid propane, which converts it to gas for use in downstream, high vapor demand equipment. Liquid propane is piped from the tank to the vaporizer where it then is heated and, in turn, the propane gas vaporization is accelerated. What makes a direct-fired vaporizer unique is that the gas used as the heat source is supplied by the same tank supplying the liquid to be vaporized.

Note: Some jurisdictions may have regulations that prevent the installation of a direct-fired vaporizer due to location constraints and/or concerns about surrounding activities or structures. Verify such restrictions prior to the start of system design.

Indirect-Fired Propane Vaporizers

Indirect-fired propane vaporizers use heat from a supplemental source to heat liquid propane for its accelerated vaporization. Unlike direct-fired vaporizers, this type of vaporization equipment heats the liquid propane with an external source of heat, not with the propane gas from the same propane tank. However, if the liquid were heated with a flame generated from another propane tank, the equipment would still technically be

an indirect-fired vaporizer. It is not the type of fuel being used that defines whether or not a vaporizer is direct or indirect—it is the fuel source that defines a vaporizer's classification.

Liquefied Petroleum Gas System Design Considerations

Liquefied petroleum gas systems should be located in such a manner that the hazard of escaping gas is kept to a minimum.

Since the heavier-than-air gas tends to settle in low places, the vent termination of relief valves must be located at a safe distance from openings into buildings that are below the level of such valves. With many gas systems, both the gas pressure regulator and fuel containers are installed adjacent to the buildings they serve. This distance should be at least 3 feet (0.91 m) measured horizontally. However, the required clearances vary according to the tank size and adjacent activities. Refer to local code requirements and NFPA 54 for these clearances.

When liquefied petroleum gas piping is proposed for installation within crawl spaces or utility pipe tunnels, consider secondary containment for the supply piping, whereby the gas pipe is installed within a larger pipe that is sealed and vented at both ends. A sniffer system also could be considered, which automatically shuts down the gas supply, sounds an alarm, and activates an exhaust system to purge the escaping gas from the area upon detection of gas in the space due to a breach in the piping system.

Liquefied Petroleum Gas Pipe Sizing

Propane gas piping systems shall be sized in accordance with the tables that have been developed by the model codes and NFPA 54 and 58. Tables based on an outlet pressure of 11 inches (280 mm) of water column would be suitable for interior piping. Tables based on higher outlet pressures are more suitable for site mains and distribution piping from the tank to the building entry point. Obtain or request the pressure provided by the supplier and determine the pressure drop in the piping system that would be appropriate. The AHJ shall be consulted regarding the acceptance of the pressure selected.

For stationary propane tanks, sizing is accomplished via the following steps:

1. The total Btuh demand must be determined. The total Btuh demand is the sum of all propane gas usage in the system, determined by adding all of the Btu input ratings of the connected appliances. Future appliances also must be considered during this process and added to the system demand.
2. Once the Btuh input quantities for all appliances are obtained, determine the Btu quantity used per day for each appliance. Then add up the total. The result will represent the Btu per day total for the system.
3. Using the total Btu per day established in Step 2, divide by approximately 91,502 (Btu per gallon of gas at 60°F) to obtain the gallons per day (gpd) of propane required.
4. The gpd quantity then is used to establish the tank sizes in relation to tank filling schedules. Typically, 14 days between tank fillings is acceptable; however, this figure must be based on the individual project requirements.
5. Finally, once the tank sizes have been established, use the information contained in Figure 7-1 to determine (and verify) the vaporization capacity for the tank sizes proposed for use. If the tanks proposed for use cannot provide sufficient vaporization, more tanks will need to be added or a vaporizer will need to be incorporated to accommodate the appliance demands. (Note: This step can be performed first and, in conjunction with the Btuh demand, can be used to establish an estimation of the required tank size.)

For sizing propane piping distribution systems, the process is similar to natural gas as previously explained in the natural gas section of this chapter. Unlike natural gas systems, however, propane is heavier than air. Therefore, vertical sections of piping must be considered in the calculation of equivalent pipe lengths for determining allowable pressure drops.

TYPICAL INSTALLATION REQUIREMENTS

The following requirements may vary by jurisdiction; check with the AHJ to confirm the exact requirements.

- Unions (inline couplings) are not permitted in a gas piping system except as follows:
 - a. Unions are allowed downstream of (after) appliance shutoff valves, meter locations, and immediately downstream of building shutoff valves.
 - b. The use of right/left couplings and nipples is required in lieu of unions in all other locations.
- Metallic gas piping is not allowed outdoors in or within 6 inches of the ground. Exception: Only piping that has been factory coated with approved materials is acceptable for burial in the ground.
- Appliances and UPC-approved flexible gas connectors from the gas pipe to the appliances shall be sized and installed in accordance with code requirements and manufacturer specifications.
- The gas pipe must be fire-caulked tightly where the pipe penetrates the exterior surface of the fire chamber in a factory-built fireplace. Also, the interior void shall be filled with fiberglass insulation or mineral wool. It must also be fire-caulked at any penetrations through a garage or any other fire-rated wall.
- Shutoff valve requirements are as follows:
 - a. They are required in the gas piping system ahead of all gas appliances.
 - b. They must be accessible and in the same room as the appliance.
 - c. They must not leak.
 - d. They shall be within 3 feet of the appliance, except as follows: shutoff valves may be within 6 feet of a gas dryer or freestanding oven, and shutoff valves for log lighters may be within 4 feet of the fireplace opening. (Note: Fireplace shutoff valves must be installed outside of the firebox.)
- Pipe support is based on the size of the pipe (see Table 7-4), and pipes must be protected from damage.

FIELD TEST REQUIREMENTS

Verify the following with the local AHJ's requirements.

- The entire gas piping system shall be tested, with all appliances shut off at the valve or disconnected and capped. Caution: Some of the older wedge-type shutoff valves tend to leak and then the pressure test can damage the appliances; disconnection and pre-testing are recommended.
- The inspection shall include an air pressure test. The gas piping shall stand a pressure of not less than 10 psig. The test gauge must be accurate to 1/10 of 1 pound and have a pressure range of not more than twice the test pressure applied. The test must hold for at least 15 minutes with no perceptible drop in pressure.
- Welded piping and those pipes holding gas at pressures more than 14 inches of water column shall be tested at not less than 60 psi with a gauge with 1-psi increments for at least 30 minutes. (Note that the test gauge requirements have changed slightly from prior requirements and policies.)

GLOSSARY

Boiling point The temperature of a liquid at which the internal vapor pressure is equal to the external pressure exerted on the surface of the liquid.

Btu Abbreviation for British thermal units, the quantity of heat required to raise the temperature of 1 pound of water by one degree Fahrenheit.

Burner A device used for the final conveyance of gas, or a mixture of gas and air, to the combustion zone.

Butane (C₄H₁₀) A saturated aliphatic hydrocarbon existing in two isomeric forms and used as a fuel and a chemical intermediate.

Caloric value See *heating value*.

Chimney A vertical shaft enclosing one or more flues for conveying flue gases to the outside atmosphere.

Condensate The liquid that separates from a gas (including flue gas) due to a reduction in temperature.

Cubic foot (meter) of gas The amount of gas that would occupy 1 cubic foot (cubic meter) at a temperature of 60°F (15.6°C), saturated with water vapor, and under a pressure equivalent to that of 30 inches of mercury (101.3 kPa).

Demand The maximum amount of gas per unit time, usually expressed in cubic feet per hour (liters per minute) or Btu (watts) per hour, required for the operation of the appliances supplied.

Dilution air Air that enters a draft hood or draft regulator and mixes with the flue gases.

Diversity factor The ratio of the maximum probable demand to the maximum possible demand.

Draft hood A device built into an appliance, or made a part of the vent connector from an appliance, that is designed to provide for the ready escape of the flue gases from the appliance in the event of no draft, backdraft, or stoppage beyond the draft hood; to prevent a backdraft from entering the appliance; and to neutralize the effect of stack action of the chimney or gas vent upon the operation of the appliance.

Excess air Air that passes through the combustion chamber and the appliance flues in excess of that which is theoretically required for complete combustion.

Flue gases The products of combustion plus the excess air in appliance flues or heat exchangers (before the draft hood or draft regulator).

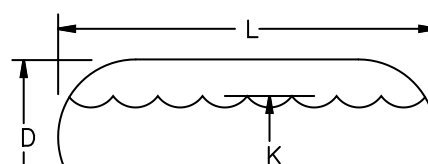
Fuel gas A gaseous compound used as fuel to generate heat. It may be known variously as utility gas, natural gas, liquefied petroleum gas, propane, butane, methane, or a combination of the above. It has a caloric value that corresponds to the specific compound or combination of compounds. Care must be exercised in determining the caloric value for design purposes.

Gas log An unvented, open-flame room heater consisting of a metal frame or base supporting simulated logs designed for installation in a fireplace.

Gas train A series of devices pertaining to a fuel gas appliance located on the upstream side of the unit. Typically, it consists of a combination of devices and may include pipe, fittings, fuel, air-supervisory switches (pressure regulators), and safety shutoff valves.

Gas-train vent A piped vent to atmosphere from a device on a gas train.

Gas vent Factory-built vent piping and vent fittings listed by a nationally recognized testing agency, assembled and used in accordance with the terms of their listings, used for conveying flue gases to the outside atmosphere.



Where:
D=Outside diameter (inches)
L=Overall length, (inches)
K=Constant for percent volume of propane liquid in tank

Percentage of Container Filled (%)	K Equals	Propane Vaporization Capacity at 0°F (BTU/H)*
60-18	100	DxLx100
50	90	DxLx90
40	80	DxLx80
30	70	DxLx70
20	60	DxLx60
10	45	DxLx45

*This formula allows for the temperature of the propane liquid to refrigerate to -20°F (below zero), producing a temperature differential of 20°F for the transfer of heat from the surrounding air, to the tank's "wetted" surface, and then into the propane liquid. (The vapor space area of the tank is not considered, as its effect is negligible).

Vaporization Capacities for Other Air Temperatures			
Prevailing Air Temperature	Multiplier	Prevailing Air Temperature	Multiplier
-15°F	0.25	+5°F	1.25
-10°F	0.50	+10°F	1.50
-5°F	0.75	+15°F	1.75
0°F	1.00	+20°F	2.00

Figure 7-1 Determining the Vaporization Capacity of a Propane Tank

Type B gas vent A gas vent for venting gas appliances with draft hoods and other gas appliances listed for use with type B gas vents.

Type B-W gas vent A gas vent for venting listed gas-fired vented wall furnaces.

Type L gas vent A gas vent for venting gas appliances listed for use with type L vents.

Heating value (total) The number of British thermal units produced by the combustion, at constant pressure, of 1 cubic foot (cubic meter) of gas when the products of combustion are cooled to the initial temperature of the gas and air, the water vapor formed during combustion is condensed, and all the necessary corrections have been applied.

LPG Liquefied petroleum gas, a mixture of propane and butane.

Loads connected The sum of the rated Btu input to individual gas utilization equipment connected to a piping system. It may be expressed in cubic feet (cubic meters) per hour.

Meter set assembly The piping and fittings installed by the gas supplier to connect the inlet side of the meter to the gas service and the outlet side of the meter to the customer's building or yard piping.

Pipe, equivalent length The resistance of valves, controls, and fittings to gas flow, expressed as equivalent length of straight pipe. In some cases, it is referred to as the developed pipe length.

Pressure drop The loss in static pressure due to friction or obstruction during flow through pipes, valves, fittings, regulators, and burners.

Propane (C₃H₈) A gaseous hydrocarbon of the methane series, found in petroleum.

Regulator, gas pressure A device for controlling and maintaining a uniform gas pressure. This pressure is always lower than the supply pressure at the inlet of the regulator.

Safety shutoff device A device that is designed to shut off the gas supply to the controlled burner or appliance if the source of ignition fails. This device may interrupt the flow of gas to the main burner only or to the pilot and main burner under its supervision.

Specific gravity The ratio of the weight of a given volume of gas to that of the same volume of air, both measured under the same conditions.

Vent connector The portion of a venting system that connects the gas appliance to the gas vent, chimney, or single-wall metal pipe.

Vent gases The products of combustion from a gas appliance plus the excess air and the dilution air in the venting system above the draft hood or draft regulator.

Table 7-4 Maximum Pipe Support Distances

Pipe Size, in.	Maximum Support Distance, ft
1/2	6
3/4 to 1	8
1 1/4 and larger	Horizontal: 10 Vertical: every floor

ASPE Read, Learn, Earn Continuing Education

You may submit your answers to the following questions online at aspe.org/readlearnearn. If you score 90 percent or higher on the test, you will be notified that you have earned 0.1 CEU, which can be applied toward CPD renewal or numerous regulatory-agency CE programs. (Please note that it is your responsibility to determine the acceptance policy of a particular agency.) CEU information will be kept on file at the ASPE office for three years.

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Expiration date: Continuing education credit will be given for this examination through **October 31, 2017**.

CE Questions — "Fuel Gas Piping Systems" (CEU 240)

- Which of the following materials shall not be used in a fuel gas piping system if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 scf of gas?
 - cast iron
 - brass
 - wrought iron
 - aluminum
- The Liquefied Petroleum Gas Code is _____.
 - NFPA 30
 - NFPA 54
 - NFPA 58
 - UL 144
- The required pressure at residential appliances is typically a minimum of _____.
 - 0.3 in. wc
 - 3.5 in. wc
 - 5 in. wc
 - 11 in. wc
- LPG is a mixture of propane and _____.
 - natural gas
 - methane
 - butane
 - mercaptan
- A _____ is a connection used during propane delivery to remove excess tank pressure.
 - relief valve
 - service valve
 - liquid withdrawal valve
 - vapor return valve
- What is the Btu per cubic foot of liquefied petroleum gas at 60°F and 30 in. Hg?
 - 2,516
 - 21,591
 - 23,000
 - 91,547
- What is the maximum support distance for 1-inch gas pipe?
 - 4 feet
 - 6 feet
 - 8 feet
 - 10 feet
- Which of the following is a type of appliance regulator?
 - backpressure regulator
 - differential regulator
 - zero governor
 - all of the above
- Mixing LPG with air should produce a gas with the heating value of _____.
 - 1,500 Btu/ft³
 - 2,000 Btu/ft³
 - 2,500 Btu/ft³
 - 3,000 Btu/ft³
- The most commonly referenced formula for gas pressures below 1½ psi is the _____.
 - Weymouth formula
 - Manning formula
 - Darcy-Weisbach formula
 - Spitzglass formula
- A liquefied petroleum gas tank should be located at least _____ measured horizontally from the building it serves.
 - 3 feet
 - 10 feet
 - 13 feet
 - 30 feet
- To accurately size all elements of the gas piping system, which of the following must be known?
 - maximum demand
 - pressure required at the appliance
 - allowable friction loss through the piping system
 - all of the above