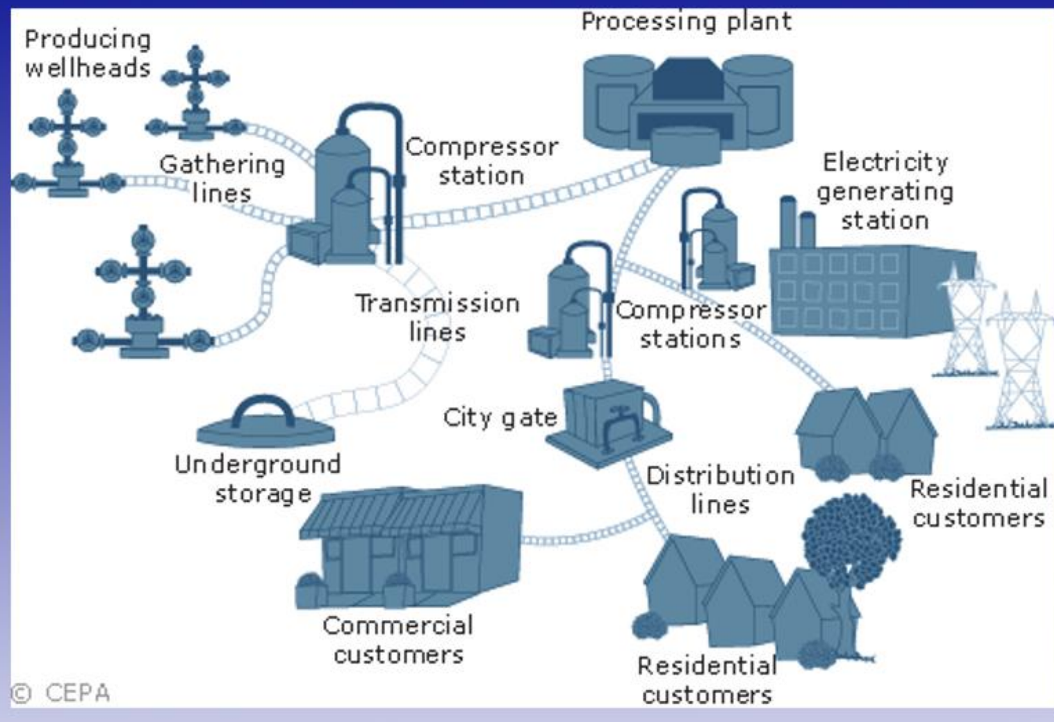


NATURAL GAS AND PROPANE SYSTEMS

Practical Hints and Tips

CONTROL SPECIALTIES, INC.

Natural Gas and Propane Systems
Practical Hints and Tips

Index

Preface

To be of help in using the information contained in this eBook, I am providing a brief summary.

Advances in the techniques to explore and extract natural gas have had a profound positive impact of the availability and prices of natural gas in the past few years. When combined with very favorable emission characteristics natural gas has become the energy source for a wide range of applications which would have been either coal or oil fired in the past. Our goal in this eBook is to cover in a quick and easy to read format the primary technical considerations of natural gas, sizing, and selecting data tables and application information we hope will be of help to you.

Chapter 1-BTU's in Natural Gas and Propane

Chapter 1 Highlights – BTU basics for natural gas, propane and other liquid and solid fuel sources.

- **Advances in the techniques to explore and extract natural gas have had a profound positive impact of the availability and prices of natural gas in the past few years.**
- **We will focus our discussions on the natural gas and propane in the book due to their common use in a wide range of applications.**

- **The definition of what became the BTU (British thermal unit) was the amount of thermal energy required to heat one pound of water one degree Fahrenheit.**
- **ENERGY DATA-ALL ARE EQUAL TO 1,000,000 BTU**
- **Natural gas is typically delivered with 1030 BTU's per cubic foot. For most calculations the figure used is 1000 BTU's per cubic foot which carries an error of 3% which in most calculations is not significant. In this book we will use the 1000 BTU per cubic foot figure in our calculations.**
- **The point of this example of cost per one million BTU's of energy is that with natural gas as a base then number 2 oil is 243% higher, propane is 455% higher and electric power 488% higher. Efficiencies of the equipment will change the delivered cost per million BTU's.**
- **Natural gas is clean burning and in most cases very cost effective.**

From Wikipedia-

"Natural gas is a fossil fuel formed when layers of buried plants, gases, and animals are exposed to intense heat and pressure over thousands of years. The energy that the plants originally obtained from the sun is stored in the form of chemical bonds in natural gas. Natural gas is a nonrenewable resource because it cannot be replenished on a human time frame. Natural gas is a hydrocarbon gas mixture consisting primarily of methane, but commonly includes varying amounts of other higher alkanes and sometimes a usually lesser percentage of carbon dioxide, nitrogen, and/or hydrogen sulfide. Natural gas is an energy source often used for heating, cooking, and electricity generation. It is also used as fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals.
Natural gas comes in various forms including –

- **Shale gas** is natural gas produced from shale. Because shale has matrix permeability too low to allow gas to flow in economical quantities, shale gas wells depend on fractures to allow the gas to flow.
- **Town gas** is a flammable gaseous fuel made by the destructive distillation of coal and contains a variety of calorific gases including hydrogen, carbon monoxide, methane, and other volatile hydrocarbons, together with small quantities of non-calorific gases such as carbon dioxide and nitrogen, and is used in a similar way to natural gas.
- **Biogas** forms when degradable organic materials are buried and react with bacteria. Methanogen archaea are responsible for all biological sources of methane. Some live in symbiotic relationships with other life forms, including termites, ruminants, and cultivated crops. Other sources of methane, the principal component of natural gas, include landfill gas, biogas, and methane hydrate. When methane-rich gases are produced by the anaerobic decay of non-fossil organic matter (biomass), these are referred to as biogas (or natural biogas).

- **Propane** is a three-carbon alkane gas which is compressible to a transportable liquid. A by-product of natural gas processing and petroleum refining, it is commonly used as a fuel for engines, oxy-gas torches, portable stoves, and residential central heating. Propane is one of a group of liquefied petroleum gases (LP gases). The others include butane, propylene, butadiene, butylene, isobutylene and mixtures thereof."

Energy is an intangible in terms of a direct measurement. As the industrial revolution took hold some few hundred years ago a definition of thermal energy was required. The definition of what became the BTU (British thermal unit) was the amount of thermal energy required to heat one pound of water one degree Fahrenheit. This simple but powerful unit of measurement worked well since all one needed to perform a lab experiment was an accurate scale, water and an accurate thermometer. A watch would provide a measurement of time which typically became one hour. The typical unit for BTU's is one million.

ENERGY DATA-ALL ARE EQUAL TO 1,000,000 BTU

1 MCF of natural gas
1,000 cubic feet of natural gas
1 decatherm of natural gas
10 therms of natural gas
293.1 KW of electricity
7.29 gallons of # 2 oil
10.93 gallons of propane
1,000 lbs of steam
29.31 boiler horsepower

From the website Engineering Tool Box this chart allows you to compare other common heat values of liquids and solids-

Energy Source	Unit	Energy Content (*Btu*)
Electricity	1 Kilowatt-hour	3412
Butane	1 Cubic Foot (cu.ft.)	3200
Coal	1 Ton	28000000
Crude Oil	1 Barrel - 42 gallons	5800000
Fuel Oil no.1	1 Gallon	137400
Fuel Oil no.2	1 Gallon	139600
Fuel Oil no.3	1 Gallon	141800
Fuel Oil no.4	1 Gallon	145100
Fuel Oil no.5	1 Gallon	148800
Fuel Oil no.6	1 Gallon	152400
Diesel Fuel	1 Gallon	139000
Gasoline	1 Gallon	124000
Natural Gas	1 Cubic Foot (cu.ft.)	950 - 1150
Heating Oil	1 Gallon	139000
Kerosene	1 Gallon	135000
Pellets	1 Ton	16500000
Propane LPG	1 Gallon	91330
Propane gas 60^{o}F	1 Cubic Foot (cu.ft.)	2550
Residual Fuel Oil [1)]	1 Barrel - 42 gallons	6287000
Wood - air dried	1 Cord	20000000
Wood - air dried	1 pound	8000

Natural gas and propane have favorable energy densities and have the added valuable trait of very favorable emission characteristics compared to most other liquid and solid fuels.

Natural gas is typically delivered with 1030 BTU's per cubic foot. For most calculations the figure used is 1000 BTU's per cubic foot which carries an error of 3% which in most calculations is not significant. In this book we will use the 1000 BTU per cubic foot figure in our calculations.

The caveat to natural gas and propane being clean fuels rests with the burner being properly tuned. Complete combustion is stoichiometric with respect to the fuel, where there is no remaining fuel, and ideally, no remaining oxidant.

A few years ago we started up a new 200 HP steam boiler at a large hospital laundry facility. Combustion was set up properly and the boiler ran just fine. A year or so later the facility added a large propane storage tank to provide back up during natural gas curtailments which where common at the time. To burn propane as a replacement for natural gas involves a propane air mix skid which includes an evaporator to vaporize the liquid propane and an apparatus to mix the propane with air to emulate natural gas at about 1000 BTU's per cubic foot. During a curtailment we received a panic call that the boiler was making large amounts of very black smoke. When we opened the boiler we found it loaded with carbon and literally had to shovel it out in large quantities. A check by the propane supplier led to an equipment problem in the air mix skid resulting in the propane air mix being about 1250 BTU's which led to the severe carbon formation in the boiler and large smoke. The point is that any burner using natural gas or propane air mix must be regularly checked and tuned up to avoid going out of specifications on emissions.

Especially in steam and hot water boilers the burner is capable of handling different fuels. In some cases facilities will also have equivalent electric boilers. Using the chart "all are equal to one million BTU's", an illustration of how this information can be used to arrive at costs per one million BTU's of input is as follows-

- Assume the current price for natural gas is $.60 per therm. 10 therms equals one million BTU's for a cost of $6.00 per million BTU's of natural gas.
- Assume number 2 oil costs $2.00 per gallon. 7.29 gallons of number 2 oil works out to a cost of $14.58 per million BTU's.
- Assume propane costs $2.50 per gallon. 10.93 gallons of propane equals one million BTU's for a cost $27.33 per one million BTU's
- Assume electric power costs $.10 per KWH. 293.1 KWH equals one million BTU's for a cost of $29.31 per million BTU's.

The point of this example of cost per one million BTU's of energy with natural gas as a base, #2 fuel oil is 243% higher, propane is 455% higher and electric power 488% higher. Efficiencies of the equipment will change the delivered cost per million BTU's. *Natural gas is clean burning and in most cases very cost effective.*

Chapter 2-How to Calculate Natural Gas Consumption Flows

<u>Chapter 2 Highlights</u> – Many applications for natural gas involves the heating of air or water. This section has some quick estimating formulas to calculate gas flows.

- **With natural gas use on the increase we suspect that many applications for thermal energy using other fuels, steam or hot water might become candidates for conversion to natural gas.**
- **CFH=BTUH ×1000 Where CFH = Cubic per hour and BTUH = BTU's per hour**
- **Heating Air with Natural Gas CFH =<(CFM Air) ×(℉ out- ℉ in)>÷800**
- **Heating Water with Natural Gas CFH =<(GPM Water) ×(℉ out- ℉ in) ×1.1>÷2**
- **Great website for engineering information is www.engineeringtoolbox.com**

With natural gas use on the increase we suspect that many applications for thermal energy using other fuels, steam or hot water might become candidates for conversion to natural gas. With the current spread in prices between natural gas and propane, I suspect that propane will be primarily a backup fuel for possible gas curtailments.

To size gas equipment you need flow rates in cubic feet per hour so we will focus on quick calculation formats so you can select gas line sizes, pressure regulators, control valves and related equipment. We'll go from easy to more complicated calculations.

Gas Unit Ratings are provided in BTU's per Hour

New equipment for natural gas will have a BTU per hour rating. As an example, let's assume you are planning to replace a steam unit heater with a new gas fired unit rated at 100,000 BTU/HR.

$$\boldsymbol{CFH = BTUH \times 1000}$$

Where CFH = Cubic per hour
BTUH = BTU's per hour

Using our rounded safe number of 1000 BTU per cubic foot on natural gas the required flow rate for this new unit heater would be 1000 CFH (100,000 ÷ 1000)

Heating Air with Natural Gas

Many air heating applications use steam or hot water coils to heat the air. If you are considering a change to natural gas here is a quick estimating formula to calculate the gas flow rate.

$$\boldsymbol{CFH = < (CFM\ Air) \times (°\mathrm{F}\ out - °\mathrm{F}\ in) > \div 800}$$

An example-

Heat 1600 CFM (cubic per minute) of air from 50 F to 150 F

$$\boldsymbol{CFH = < (1600) \times (150 - 50) > \div 800}$$
$$\boldsymbol{CFH = 200}$$

If you are doing a retrofit to an old system finding data on air flows can become a real challenge. If you encounter this situation this formula might be of help.

$$CFM = (Face\ Area) \times (Velocity)$$

CFM is the cubic feet per minute of air to be heated
Where Face area is the length times the width of the air duct
Velocity is the air velocity in the duct

For best accuracy, measure the velocity in the air duct with an air velocity meter. If that is not possible air velocity in most HVAC heating applications is typically 500 to 700 feet per minute. For process air applications the range can be from 500 to as much as 1200 feet per minute so measuring air velocities would be a wise choice.

For other air heating applications you might check the web for sites which offer engineering information such as
www.engineeringtoolbox.com/air-heating-systems-d_1136.html

Heating Water with Natural Gas

As with heating air with other sources natural gas can be a good choice to heating water and gaining the benefits offered by natural gas. A quick estimating formula to calculate gas flows is as follows-

$$\boldsymbol{CFH} = < (\boldsymbol{GPM\ Water}) \times (°\mathrm{F}\ \boldsymbol{out} - °\mathrm{F}\ \boldsymbol{in}) \times \mathbf{1.1} > \div \mathbf{2}$$

As an example-
Heat 10 GPM (gallons per minute) of water from 60° F to 180° F

$$\boldsymbol{CFH} = < (\mathbf{10}) \times (\mathbf{120}) \times \mathbf{1.1} > \div \mathbf{2}$$
$$\boldsymbol{CFH} = \mathbf{660}$$

Heating calculations are based on the rate of temperature rise. If you are heating a quantity of water from an initial to final temperature of some time period you can arrive at an equivalent gallons per minute figure with just a bit of math.

Assume you wish to heat 100 gallons of water from 60° F to 180° F in 10 minutes. Heating 100 gallons of water in 10 minutes is the same rate as 10 GPM (100 Gallons ÷10 minutes).

A great website for engineering information is www.engineeringtoolbox.com

With emphasis on green and efficient processes to opportunities to replace other fossil fuels many heating applications might be better serviced by looking at natural gas as a replacement energy source.

Chapter 3-Burners, Boilers and Other Equipment

Chapter 3 Highlights – An overview of direct and indirect fired equipment.

- **Direct fired gas burners typically have very high efficiencies in the 95-99% range.**
- **As an example, gas fired furnaces are indirect fired units. Efficiencies at the burner are typically in the 75-85% range.**

- **Infrared (IR) heating units provide an innovative and economic method of using natural gas to generate heat in an industrial setting.**
- **Direct contact water heating is an application that works by having the energy from the combustion of natural gas transferred directly from the flame into the water with efficiencies up to 99%.**
- **Gas fired unit heaters and furnaces are two good examples of indirect fired equipment to heat air.**
- **Gas fired boilers are typically used to heat hot water or produce steam.**

From http://naturalgas.org/overview/uses-industrial/

Natural gas can be burned in two basic ways-

- Direct fired into media such as air or water with the products of combustion in most cases winding up in the media. This will create problems in many cases since the products of combustion winding in the media may create problems. Direct fired gas burners typically have very high efficiencies in the 95-99% range.
- Indirect fired burners separate the flame and combustion process from the media being heated resulting in no contact between the two since the combustion by products are vented through a stack to the atmosphere. Examples include boilers of all types and vented gas air heaters of all types. As an example gas fired furnaces are indirect fired units. Efficiencies at the burner are typically in the 75-85% range.

Direct Fired Examples

A few examples of direct fired gas units include-

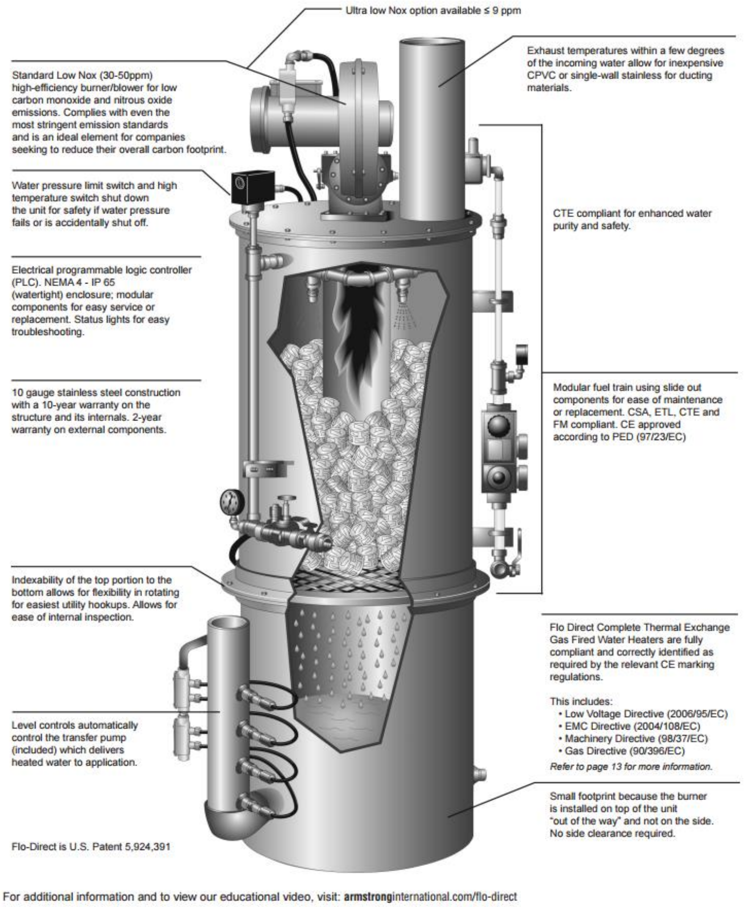
- Infrared (IR) heating units provide an innovative and economic method of using natural gas to generate heat in an industrial setting. Natural gas is combined with a panel of ceramic fibers containing a platinum catalyst, causing a reaction with oxygen to dramatically increase temperature, without even producing a flame.


Industrial


Ceiling


Fireplace

- Direct contact water heating is an application that works by having the energy from the combustion of natural gas transferred directly from the flame into the water. These systems are incredibly efficient at heating water. Normal industrial water heaters operate in the 60 – 70 percent energy efficiency range. However, direct contact water heaters can achieve efficiencies up to 99.7 percent!

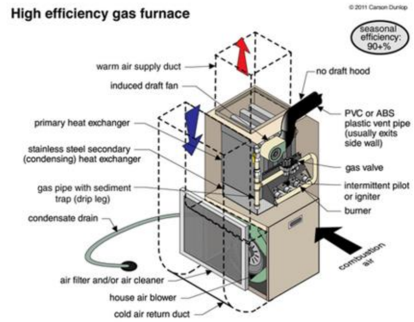


http://www.control-specialties.com/pr1174-armstrong-flo-direct-r-hot-water-heater.php?c=219

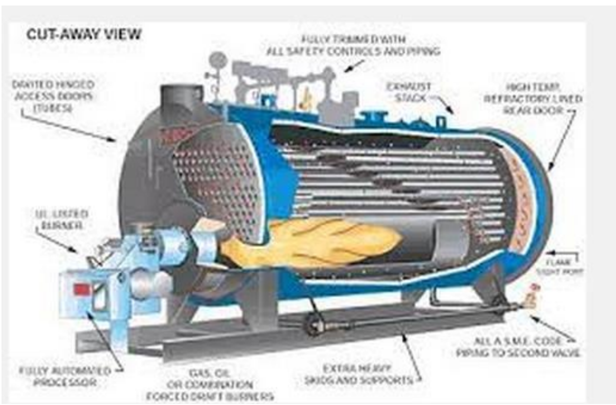
Indirect Fired Examples

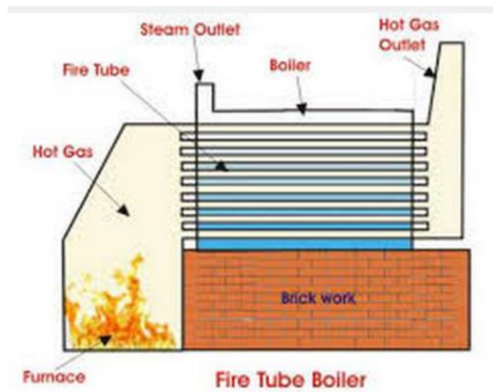
A few examples of indirect fired equipment is as follows-

- Gas fired unit heaters and furnaces are two good examples of indirect fired equipment to heat air. In both cases the gas flame is directed through a heat exchanger which separates it from the air to be heated. When heat is required, a thermostat first turns on the gas burner and when the unit is up to temperature a fan is turned on the direct air to be heated through the heat exchanger. The products of combustion are directed through a stack to outside the building space.



- Gas fired boilers are typically used to heat hot water or produce steam. Water is contained in a heat exchanger area and heated by a gas flame which passes though the exchanger but not making contact with the water being heated. Steam boilers come in two basic versions. Firetube boilers pass the flame through a large number of tubes and water which is contained in the jacket is heated. Water tube boilers maintain the fire in the box portion of the boiler and water is passed though many tubes to allow the steam to be produced. All boilers require a stack.





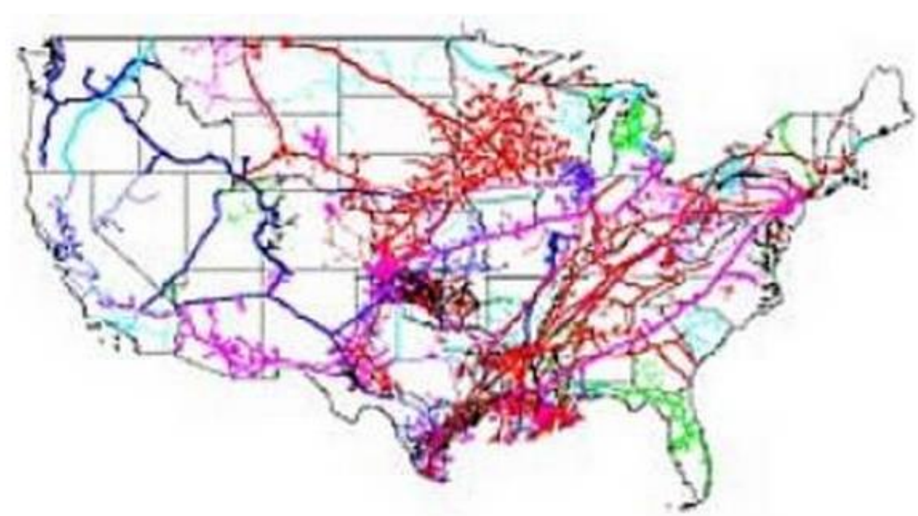
Gas fired equipment will always have a nameplate or data plate with information on the unit including the BTU input of the unit and in many cases the gas flow required for the unit. Should you encounter a unit with a BTU rating only divide the BTU/Hr rating by 1000 to arrive at the gas flow per hour in CFH. As an example a one million BTU/HR boiler would require a gas flow of 1000 cubic feet per hour (1,000,000 ÷ 1000).

Chapter 4 - Gas Regulators, controls and equipment.

Chapter 4 Highlights – An overview of Gas distribution, gas control valves and piping code requirements.

- **Natural gas is extracted from a wide number of locations in North America and transported through a vast network of pipelines to a wide range of locations for use by a wide variety of customers.**
- **Natural gas is transmitted in large primary pipelines typically at pressures anywhere from 200 to 1500 pounds per square inch.**
- **Local gas line pressures in local networks can vary widely with typical ranges of 30-60-100 psig.**
- **The most common application is to reduce the gas pressure being supplied to the facility to match the required gas pressure for the equipment firing the gas.**
- **Gas lines and associated equipment, in all cases, be installed by licensed contractor or plumbing contractor.**
- **The National Board is the governing body to set standards for installation of this equipment.**

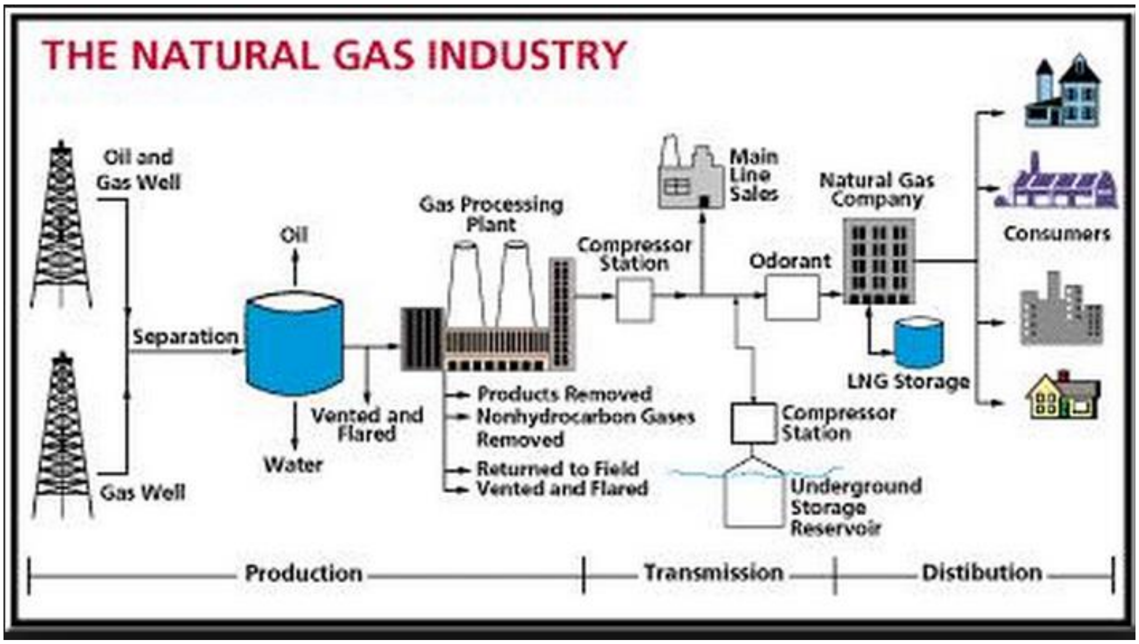
Natural gas is extracted from a wide number of locations in North America and transported through a vast network of pipelines to a wide range of locations for use by a wide variety of customers. From the Department of Energy this map shows a quick overview of the primary natural gas pipelines in the United States.



Interstate Natural Gas Pipelines

Source: National Energy Technology Laboratory, DOE

A much larger network of branch lines and seconday networks then bring the natual gas to local areas for distribution to end use customers. In an electrical power grid primary transmission voltages are very high to reduce the size of wire lines and then gradually dropped to lower voltages using substations and transfomers. In a like manner, natural gas is transmitted in large primary pipelines typically at pressures anywhere from 200 to 1500 pounds per square inch (psi). This reduces the volume of the natural gas being transported (by up to 600 times), as well as propelling natural gas through the pipeline. To ensure that the natural gas flowing through any one pipeline remains pressurized, compression of this natural gas is required periodically along the pipe. This is accomplished by compressor stations, usually placed at 40 to 100 mile intervals along the pipeline. The natural gas enters the compressor station, where it is compressed by either a turbine, motor, or engine. Local gas line pressures in local networks can vary widely with typical ranges of 30-60-100 psig.



The most common application is to reduce the gas pressure being supplied to the facility to match the required gas pressure for the equipment firing the gas. To accomplish this purpose, a gas pressure reducing valve typically called a gas regulator is required to accomplish the reduction in pressure.The gas regulator along with all the required shut off and safety equipment is called the gas train. Gas lines and associated equipment must in all cases be installed by licensed contractor or plumbering contractor.

The National Board is the governing body to set standards for installation of this equipment. From their website
(http://www.nationalboard.org/index.aspx?pageID=164&ID=204)
here is a detailed explanation of the equipment required in industrial and commercial gas trains for boilers –

“The importance of fuel firing equipment cannot be over emphasized. The majority of boiler explosions occur in one of two ways: a failure of a boiler pressure part, or a furnace explosion.

Jurisdictions and insurance companies have long recognized the need for the proper installation, maintenance, repair, operation and inspection of this equipment. However, the real world shows us that there are many people involved with this equipment, including installers, maintainers, operators or inspectors who might have minimal knowledge of the maintenance and testing requirements for the different components that make up a fuel train.

There are several organizations such as UL (Underwriters Laboratory), FM (Factory Mutual), IRI (Industrial Risk Insurers), etc, that publish requirements for the various components which make up a fuel train for specific burner output. Also, several codes and standards such as NFPA and ASME publish requirements for the entire assemblies.

For now, only IRI, ASME CSD-1 (Controls and Safety Devices for Automatically Fired Boilers 1992) and NFPA 8501 (Single Burner Boiler Operation-1992) shall be considered.

A **typical** fuel train has several components, each with a specific purpose which is briefly explained below.

1. Manual shut-off valve (MSOV) - the purpose of this valve is to shut off the fuel supply so that maintenance or replacement of the fuel train may be done.
2. Gas pressure regulator (PRV) - its purpose is to maintain the fuel at a constant pressure as recommended by the burner manufacturer.
3. Low pressure gas switch - senses a low pressure in the range where the burner cannot properly operate. This switch must be equipped with safety lock-out requiring manual reset. This tells the operator to check the gas pressure, since the burner will not try to restart until the switch is reset.
4. Safety shut-off valve (SSOV) - the first of two valves in series that automatically opens and shuts off the fuel supply to the burner. On burners above 2,500,000 BTU/HR, the valve closing time is one (1) second maximum.
5. Vent valve - this is normally an open valve. It energizes to close. Whenever the SSOV's are closed, the vent valve is open, so if any gas is leaking past the first SSOV (4), it will vent this gas to the atmosphere, so that even if the second SSOV (6) may leak, no gas will go past this valve since there is no pressure differential across the SSOV
6. Safety shut-off valve (SSOV) - the second of two valves in series, automatically opens and shuts off the fuel supply to the burner. On burners above 2,500,000 BTU/HR, the valve closing time is one (1) second maximum. This SSOV in conjunction with the first SSOV (4) and the vent valve (5) comprise the double block and bleed arrangement and ensure no gas leakage into the combustion chamber during burner shutdown.

7. High gas pressure switch - the purpose of this safety device is to sense a high gas pressure and shut down the burner before an unsafe condition can occur. The high pressure is usually due to failure of the gas regulator. This switch must be equipped with a safety lock-out requiring manual reset. This tells the operator that the gas regulator failed since the burner will not restart until the switch is reset.
8. Manual shut-off valve (MSOV) - the purpose of this valve is to allow testing of all components of the fuel train under actual operating fuel pressure without firing the main burner. This testing is done after any maintenance or extended shut down to ensure all components are working properly prior to actually firing the main burner.
9. Firing rate valve - valve equipped with a modulating motor controlled by boiler pressure (steam) or temperature (hot water) and regulates the amount of fuel to the burner and through linkages, controls the air damper (like the cruise control on a car), should be located as near the burner as possible.
10. Test valves - the purpose of these valves is to allow testing of the SSOVs for leakage. This test is required by ASME CSD-l and NFPA 8501 to be done on a monthly basis.
11. Drip leg - the purpose of this piping arrangement is to trap any debris or water which may accumulate in the gas piping to prevent fouling of the fuel train components including burner orifices."

A good set of diagrams and sequence of equipment required to make up a gas train for a broad range can be found at http://www.federalcorp.com/media/TechTip13.pdf -

TECH TIP #13

GAS TRAIN BASICS

GAS TRAIN COMPONENTS..To Vent or Not To Vent

- Do I need to vent the gas pressure switches?
- The gas regulator?
- What about my V88 diaphragm gas valve?
- What about the normally open vent valve?
- Can I combine these vents so I don't have to run several lines?

A. According to UL 795, the "normally open" vent valve line must be run to a safe location outside by itself, no other vent line can be combined with it. (See below for an alternative to using normally open vent valves.)

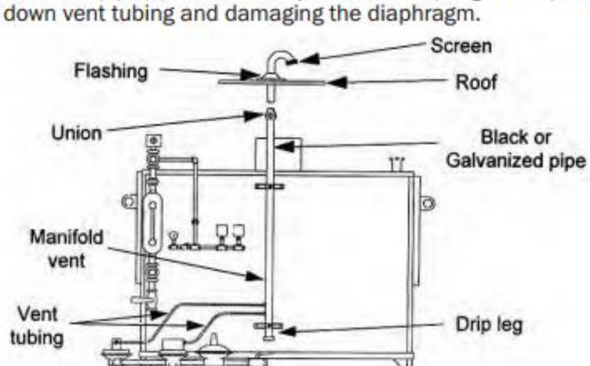
B. According to UL 795, the vent off of a gas regulator must be run to a safe location outside by itself, no other vent line can be combined with it.

C. In order to use a vent limiter on a gas regulator, the following guidelines are suggested:

1. Maximum inlet pressure to regulator 5#.
2. Maximum regulator size is 1".
3. Regulator must be mounted in upright, horizontal position.
4. Can only be used if boiler/appliance is within 6' of regulator.
5. Vent limiter must be manufactured by the regulator mfg.

D Vent outlets from gas pressure switches & diaphragm gas valves (V88) can be "ganged together" into a single vent line, provided the cross-sectional area is a least the size of the largest vent opening plus 50% of the area of all additional vent lines. See the following photo for details.

NOTICE: Always terminate vents away from air intakes or sources of ignition. Be sure that moisture and insects cannot enter the pipe(s) as well. Always utilize a drip leg to keep incidental moisture from traveling back down vent tubing and damaging the diaphragm.



How to Avoid the Need for a NORMALLY OPEN VENT VALVE

Honeywell (and possibly others) now manufacture combustion flame safeguard control systems called VPS (Valve Proving Systems) which prove the "double block" valves. We recommend this system instead of the "double block and bleed" system which has traditionally been used. This new system eliminated possible fuel leaks to the atmosphere, saves expense in installation and also increases safety.

TECH TIP #13 (Cont.)

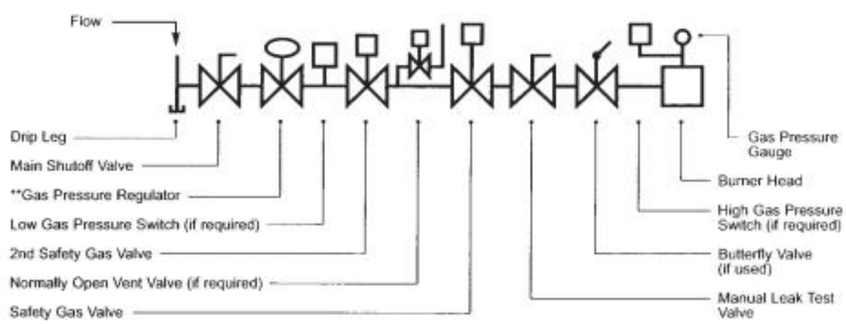
GAS TRAINS--WHAT DO THE CODES REQUIRE?

GENERAL

Proper operation of a gas or gas-fired forced draft burner is very dependent on a properly selected and assembled gas train.

The data contained in this bulletin has been compiled to assist in the selection of a UL, CSD-1, FM or IRI gas control train and the individual gas controls used in conjunction with these approval agencies. For other agency gas control trains, consult factory.

The schematic below gives the location of the various components in a typical gas train. In the interest of SAFETY, John Zink's standard policy is to supply TWO safety gas valves.



NOTE

Underwriters Laboratories (UL) regulations require that all gas or gas-oil burners bearing the UL label must be furnished with a gas train which meets UL requirements matching the input rating of the burner.

** Gas Pressure regulators with internal control require a length of five (5) pipe diameters of straight uninterupted pipe on the outlet side. Consult manufacturer's instructions for all other regulators.

Additional information on gas trains can be found in the John Zink catalog sheet 1-gen-10.53.

VENT LINE SIZING

Fuel Line size, Nominal Pipe Size, Inches	Vent Line Size, Nominal Pipe Size, Inches
Up to 1-1/2	3/4
2	1
2-1/2	1-1/4
3	1-1/4
4	2

Gordon-Piatt
Energy Group, Inc.

TECH TIP #13 (Cont.)

GAS SYSTEM SCHEMATICS

UL, FM & CSD-1 (which requires a plugged leak test cock downstream of each safety gas valve) Systems

Figure I - 400 MBh - 2500 MBh

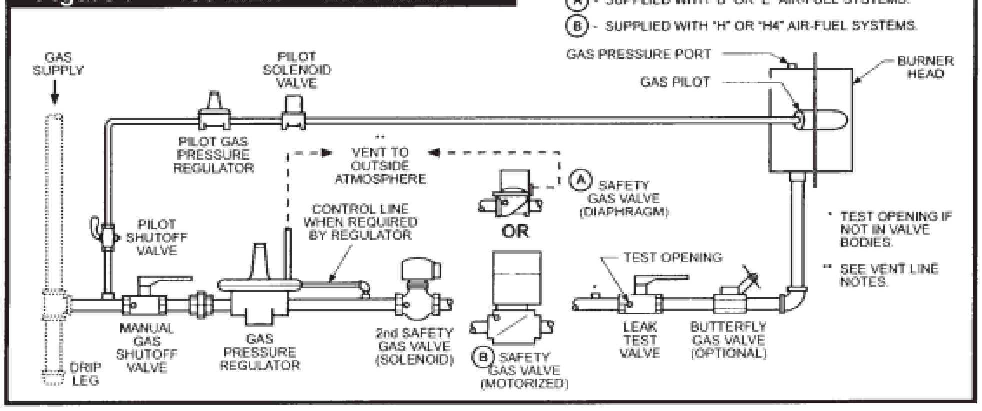


Figure II - 2501 MBh - 5000 MBh

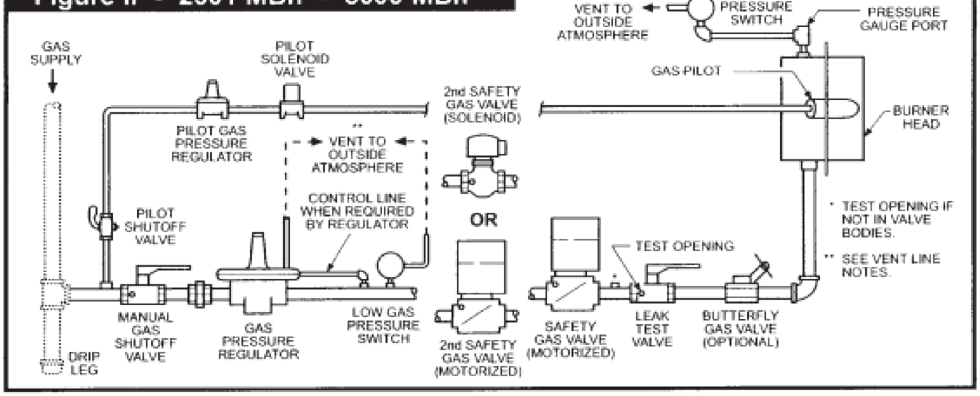
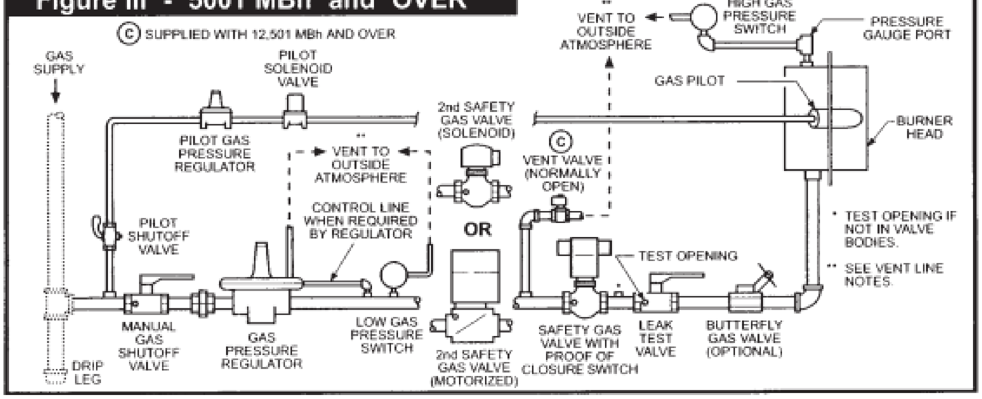


Figure III - 5001 MBh and OVER



Gas Regulators are common in all gas trains. When sizing a gas regulator you must first know the following four parameters:

Inlet Pressure
(Sometimes called P in) This is important in order to select the proper pressure rating of the valve as well as being necessary to determine the allowable pressure drop across the valve. Here in the United States, Pressure is commonly expressed in Inches of Water (" wc) for low pressure applications and Pounds per Square Inch (PSI) for higher pressure applications. (Note: 1 PSI equals 28" wc.)

Outlet Pressure
(Sometimes called P out) This is necessary to select the proper spring range of the regulator along with the other piece in the puzzle for determining the allowable pressure drop. The smaller the allowable pressure drop is the bigger the valve must become, and vice versa. An application with a large drop across the regulator will have a much smaller regulator size.

Flow
This coupled with the allowable pressure drop (P out minus P in) and determines the actual size of the regulator body and valve orifice. The flow is commonly expressed in CFH or CFM (cubic feet per hour or minute respectively) for gaseous applications and GPH or GPM (gallons per hour or minute respectively) for liquid applications. When dealing with combustion or plumbing & heating, it is also very common to speak in BTUH, which is British Thermal Units per hour, or MBH which is thousands of BTUs per hour. Any of these can tie your flow back to a specific rate of gas flow.

Application
It is important to define the application with all of its special expectations. The materials of construction in a High Pressure Steam application would differ significantly when compared to a Low Pressure Natural Gas application. Also, if you're locating the regulator in the wall next to your boss's office, noise may be a consideration. Is it indoor or outdoor? Issues like that are worthwhile considering in defining your needs.

The important part is to provide your supplier or the engineer who is going to size the regulator with the above criteria. Anyone who advises you that this information is NOT necessary is misinformed and mistaken.

Typical Gas Controls Using Fisher as an Example

“Fisher natural gas pressure control regulator products are used in transmission and distribution stations, city gate and farm taps, residential, commercial, and industrial applications.”

Pressure Reducing
Fisher pressure reducing regulators maintain desired outlet pressure providing the required flow to satisfy a variable downstream demand. The level at which the reduced pressure is maintained is the outlet pressure setting of the regulator.

Relief / Backpressure
Fisher backpressure regulators maintain desired upstream pressure by varying the flow in response to changes in upstream pressure. Pressure relief valves provide overpressure protection in case of unexpected pressure buildup.

Shutoff Devices
Fisher pressure shutoff or slam-shut devices shut off the gas flow when the sensed control pressure passes a set limit in response to a low-pressure condition, a high-pressure condition, or both."

http://www.control-specialties.com/c80-gas-valves.php

Chapter 5 – Sizing Charts.

Chapter 5 Highlights – An overview

The web is a great source for sizing natural gas and propane lines. The charts can be complex if you are dealing with long gas lines, high flows and many other variables. A great set of data and charts can be found at the Engineering Tool Box website

http://www.engineeringtoolbox.com/natural-gas-pipe-sizing-d_826.html

For a quick reference, we have included pipe sizing charts as well as a chart comparing the different types of natural gas flow meters and their usable ranges.

Liquid Propane Gas Pipe Sizing Chart

Length of Pipe in Feet	Size of Pipe in Inches								
	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
10	275	567	1071	2205	3307	6221	10140	17990	35710
20	^ 189	393	732	1496	2299	4331	7046	12510	25520
30	152	315	590	1212	1858	3465	5695	10110	20620
40	129	267	504	1039	1559	2992	4778	8481	17300
50	114	237	448	913	1417	2646	4343	7708	15730
60	103	217	409	834	1275	2394	3908	6936	14150
80	89	185	346	724	1086	2047	3329	5908	12050
100	78	162	307	630	976	1811	2991	5309	10830
125	69	146	275	567	866	1606	2654	4711	9613
150	63	132	252	511	787	1496	2412	4281	8736
200	54	112	209	439	665	1282	2083	3618	7382
250	48	100	185	390	590	1138	1808	3210	6549
300	43	90	168	353	534	1030	1637	2905	5927
350	40	83	155	325	491	947	1505	2671	5450
400	37	77	144	303	458	887	1404	2492	5084

LP Gas flow is given in thousands of BTU/hr. - One cubic foot of LP gas - 2516 BTU

This chart refers to low pressure LP, after regulation Standard nominal pressure at the burner for Liquid Propane Gas is 11" of water column.

Pipe length must include additional length for all fittings. Add approximately 5 feet of pipe per fitting

LP Example: A machine with a burner that requires 440,000 BTU would need a 1" pipe for a 20' long run.

Natural Gas Pipe Sizing Chart

Length of Pipe In Feet	Size of Pipe in Inches								
	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
10	108	230	387	793	1237	2259	3640	6434	
20	75	160	280	569	877	1610	2613	5236	9521
30	61	129	224	471	719	1335	2165	4107	7859
40	52	110	196	401	635	1143	1867	3258	6795
50	46	98	177	364	560	1041	1680	2936	6142
60	42	89	159	336	513	957	1559	2684	5647
70	38	82	149	317	476	896	1447	2492	5250
80	36	76	140	239	443	840	1353	2315	4900
90	33	71	133	275	420	793	1288	2203	4667
100	32	68	126	266	411	775	1246	2128	4518
125	28	60	117	243	369	700	1143	1904	4065
150	25	54	105	215	327	625	1008	1689	3645
175	23	50	93	196	303	583	993	1554	3370
200	22	47	84	182	280	541	877	1437	3160
300	17	37	70	145	224	439	686	1139	2539

Natural Gas flow is given in thousands of BTU/hr. - One cubic foot of LP gas = 1000 BTU

Nominal pressure at the burner for Natural Gas is 3.5" of water column. (Typical machine supply 5"-7")

Pipe length must include additional length for all fittings. Add approximately 5 feet of pipe per fitting

Natural Gas Example: A machine with a burner that requires 440,000 BTU would need a 1 -1/4" pipe for a 20' long run.

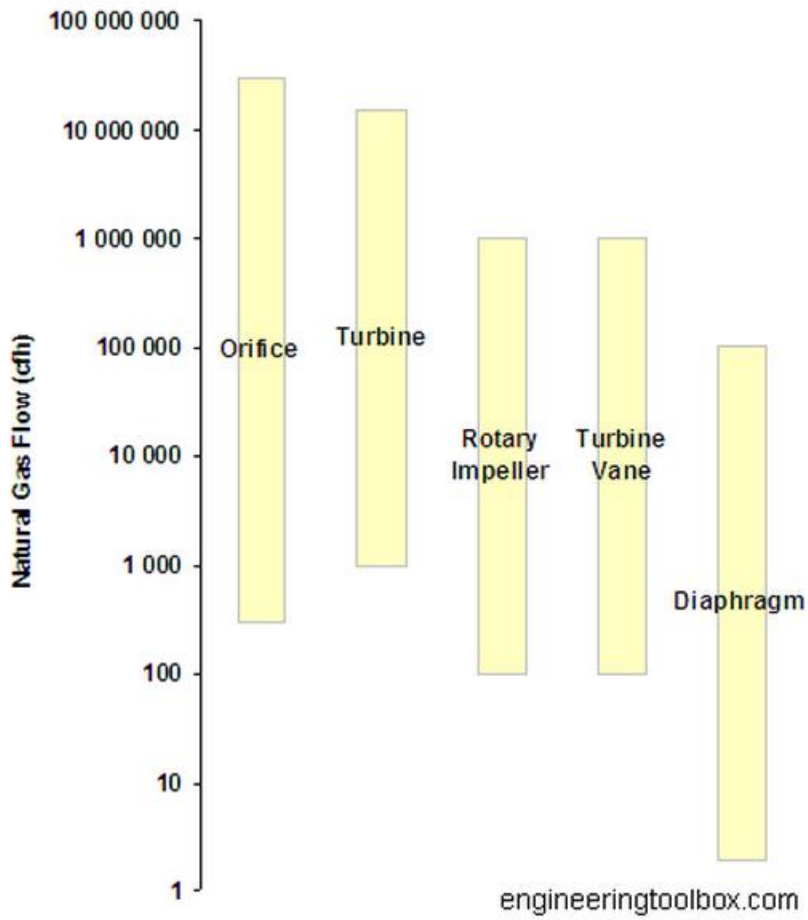
Table I4-1. Gas Line Capacities, Natural Gas

IINITIAL GAS PRESSURE	TOTAL PRESS. DROP	GAS LINE CAPACITIES (CU-FT/HR THROUGH 100 FT LENGTH)											
		DIAMETER OF PIPE IN INCHES											
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6	8
4" water	0.2"	23	52	104	230	358	724	1180	2150	4510	8210	13400	27300
5" water	0.25"	26	58	117	257	400	811	1320	2410	5050	9190	14900	30600
6" water	0.30"	28	64	128	282	439	889	1450	2640	5540	10100	16400	33500
7" water	0.35"	31	69	139	305	475	962	1570	2860	5990	10900	17700	36300
8" water	0.40"	33	74	148	327	508	1030	1680	3060	6410	11700	19000	38800
9" water	0.45"	35	79	158	347	540	1090	1780	3250	6810	12400	20200	41200
10" water	0.50"	37	83	166	366	569	1150	1880	3430	7180	13100	21300	43500
11" water	0.55"	38	87	175	385	598	1210	1980	3600	7550	13700	22300	45700
12" water	0.6"	40	91	183	402	625	1280	2060	3760	7890	14300	23300	47700
1/2 psi	.025 psi	43	98	197	433	673	1360	2220	4050	8590	15400	25100	51400
3/4 psi	.038 psi	53	121	243	534	831	1680	2750	5000	10500	19100	31100	63500
1 psi	.050 psi	62	141	282	622	967	1960	3190	5820	12200	22200	36100	73800
1-1/4 psi	.062 psi	70	159	319	702	1090	2210	3600	6570	13800	25000	40800	83300
1-1/2 psi	.075 psi	77	175	351	773	1200	2440	3970	7240	15200	27600	44900	91800
1-3/4 psi	.088 psi	84	191	382	842	1310	2650	4320	7870	16500	30000	48900	99900
2 psi	.100 psi	91	205	412	906	1410	2850	4660	8480	17800	32300	52600	108000
2-1/2 psi	.125 psi	103	233	467	1030	1600	3240	5280	9620	20200	36700	59000	122000
3 psi	.150 psi	114	259	519	1140	1780	3600	5870	10700	22400	40800	66300	136000
3-1/2 psi	.175 psi	125	283	568	1250	1940	3940	6420	11700	24500	44600	72600	148000
4 psi	.200 psi	135	307	615	1350	2110	4270	6960	12700	26600	48300	78700	161000
4-1/2 psi	.225 psi	146	330	661	1460	2260	4580	7480	13600	28500	51900	84500	173000
5 psi	.250 psi	155	352	706	1550	2420	4890	7980	14500	30500	55400	90200	184000
6 psi	.300 psi	174	395	792	1740	2710	5490	8960	16300	34200	62200	101000	207000
8 psi	.400 psi	211	477	957	2110	3280	6640	10800	19700	41300	75200	122000	250000
10 psi	.500 psi	246	556	1120	2460	3820	7730	12600	23000	48200	87600	143000	292000
For total lengths other than 100 ft, multiply the capacity shown in the table by the factor corresponding to the desired length as follows:													
Length of pipe in ft		10	15	25	50	100	150	200	250	300	350	400	500
Multiplier		3.16	2.58	2.00	1.41	1.00	.817	.707	.632	.577	.535	.500	.447
For pressures and diameters not shown, consult you local Cleaver-Brooks authorized representative.													

This table shows gas flow capacities of pipes from 1/2" to 8" diameter, based upon a pressure drop of 5% of the initial gas pressure for 100-ft length of pipe. Turbulent flow is assumed, hence the non-linear ratio of length to capacity.

Natural Gas Flow Meters

Natural gas meters are offered in a number of types and operating principals. Each type has a usable range. This chart from the Engineering Tool Box site provides a great comparion of meter types and usable ranges.



Final Thoughts

In closing, we hope this eBook on Natural Gas and Propane Systems has provided some practical data to enable you to make the decision on which type of energy source provides the most cost efficient results for your facility. The solution lies in the calculations and ultimate payback. For industry to remain competitive in this worldwide marketplace, we hope you will consider all energy sources and use our Natural Gas and Propane Hints and Tips to make those decisions.