TANKLESS WATER HEATING

With any gas appliance, it is essential that the gas supply system be properly sized to support the BTU load of the system. Tankless water heaters can be a great solution to provide hot water; however, most tankless water heaters have a BTU capacity ranging from 140,000 to 200,000 or more, which makes a tankless water heater one of the largest single appliances on a typical gas system. It is necessary to ensure that the system can handle the capacity of the tankless water heater along with all other gas appliances on the system. This guide will address the fundamentals and facts of gas pipe sizing for low-pressure (under 2 psi) natural gas systems using rigid iron pipe. For other gas systems, including Propane, Hybrid Pressure, Copper Pipe, and CSST, please consult your local code or the National Fuel Gas Code, NFPA54, ANSI Z223.1 - 2012 Edition.

Will a tankless water heater work on a ½-inch gas line?

Yes and No. A typical residential gas system is a low-pressure system, meaning that the home is supplied with a gas pressure around 7 in. w.c. (inches of water column). The piping must be sized sufficiently enough so that the pressure drop is a half an inch of water column or less, when all the gas appliances are on. This can be the limiting factor when trying to use the existing piping and upgrading from a typical tank-type water heater to a tankless water heater. Typically, the gas piping has to be upgraded to support the tankless water heater due to the volume of fuel that is required. Tables 2 and 3 provide the capacity by pipe size and length based on the maximum allowable pressure drops. In all cases, a near 200,000 BTU gas appliance will require a minimum of a ¾-inch gas supply line. In specific conditions a ½-inch gas line may be used. In the 2012 National Fuel Gas Code (NFPA54. ANSI Z223.1), a 3.0 in. w.c. pressure drop chart was added for certain conditions. This chart allows a 200,000 BTU gas appliance to be installed on a ½-inch gas line up to 40 ft. in length. However, the following conditions must be met: The minimum static gas pressure must be 8 in. w.c. or greater; The calculated dropped pressure (the static pressure minus the 3.0 in. pressure drop), must be greater than the highest minimum gas pressure required by any of the gas appliances on the system. See Table 4 for pipes sizes and capacities with a 3 in. w.c. pressure drop. To select the correct diameter pipe, first determine the natural gas supply pressure for the system. The characteristics of the installation will specify the correct tables to use in ANSI Z223.1.

Will an existing regulator and meter support a tankless water heater?

Newer construction gas systems are typically a hybrid pressure system, where the incoming pressure is around 2 psi and each appliance or group of appliances are served by a single regulator. In many older areas and buildings, the system is supplied with a single, low-pressure gas system (around 7 in. w.c.) from the provider. In either case, the capacity of the regulator(s) and meter would need to be checked to ensure that the system can supply enough gas to support the addition of a tankless water heater to the system. On low-pressure systems, the pressure must be greater than the highest minimum requirement of the gas appliances plus the associated pressure drop.

What size gas line will I need for my tankless water heater?

The gas line size will depend on BTU rating of the water heater, the other gas appliances, and where they are installed on each branch from the meter and regulator. There are two methods for determining the required pipe size: the longest length method or the branch length method. See “Gas Pipe System Sizing” for more information.

How do I tell what size regulator or meter I have?

Each meter has a capacity in Cubic Feet per Hour (CFH). Locate that number regulator and multiply it by 1,024 (BTUH/CFH) to give you an approximate BTUH capacity for natural gas. The capacity of the meter and regulator must be greater than the total sum of the maximum BTU rating of all the appliances in the home. If the capacity of the system is too small, the gas appliances will not receive the volume of gas required for proper operation.

What do all these different gas pressures mean?

Gas pressure can be measured in two ways: pounds per square inch (psi) or Inches of Water Column (in. w.c.). The high-pressure side of hybrid pressure gas systems commonly measured in pounds per square inch. This pressure is around 2 psi. Inches of Water Column is typically used to measure low-pressure gas systems, which is what feeds most appliances. For example, there are 27.7 in. w.c. in 1 psi.

What is Inches of Water Column?

Inches of water column is a measurement of how much force it takes to push a column of water up by a number of inches. It is typically used to measure low-pressure gas systems.

How do you measure the gas pressure?

You will need an instrument called a Manometer. This tool allows you to measure the pressure of gas in the system. Manometers are available that measures a specific range of pressure in inches of water column or pounds per square inch. A digital Manometer can measure a broader range of pressures. See the manufacturer's instructions for using the Manometer properly

Where do you find the BTU rating on my appliances?

Each appliance is required to have a rating plate. This plate will list the BTU ratings of the appliance and required gas pressures for proper operation. See the manufacturer's instructions for information on locating the rating plate on each gas appliance.

Can a negative pressure gas valve solve an undersized gas system?

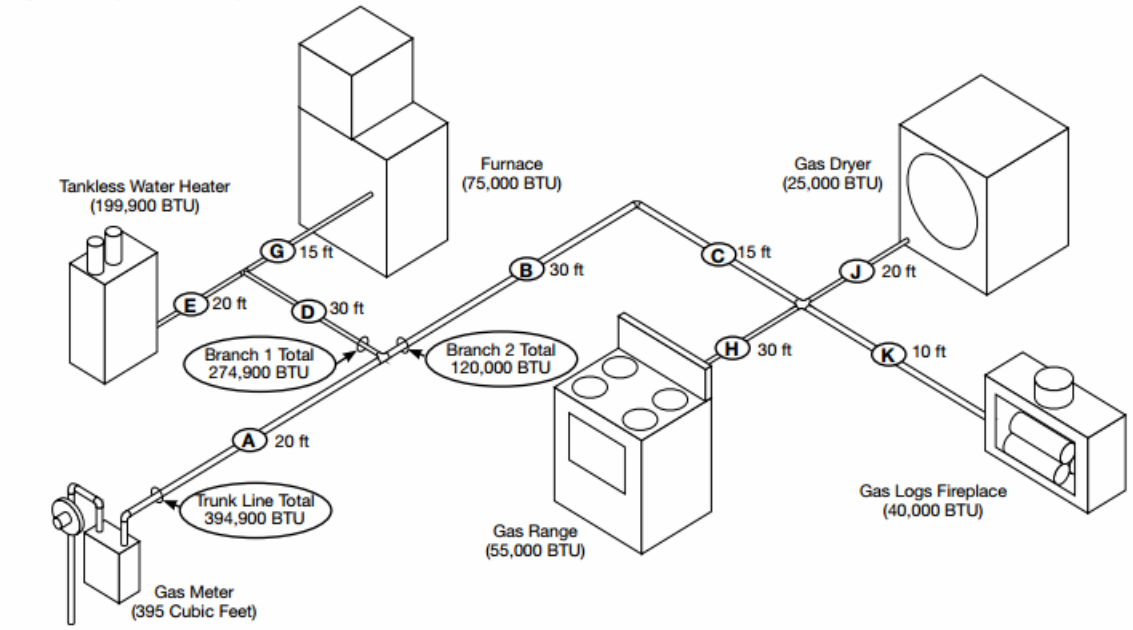
While a negative pressure gas valve in an appliance can operate at a very low gas pressure, it can have adverse effects on an undersized gas system. This style of appliance can actually rob the gas from other appliances, such as a furnace and possibly cause nuisance outages. The piping and system must be sized to pass the volume of gas, not just the pressure.

How would an undersized gas system affect the appliances?

An undersized gas system can cause poor performance in the appliances. It could cause the burners to soot, pilot lights and burners to go out, or cause condensate to form in the heat exchanger of the furnace or water heater. Condensate will cause corrosion and eventual failure in appliances not specifically designed for it. Sooting can clog burners or flues which can cause an appliance to fail or produce harmful exhaust gases such as Carbon-Monoxide.

Gas Pipe System Sizing

Figure 1 - Typical Gas System with a Tankless Water Heater



Determining the Required Meter and Regulator size.

Find the BTU requirement of each appliance in the home. In our example above, we have the following: 199,900 BTU Tankless, a 75,000 BTU Furnace, a 55,000 BTU Range, a 25,000 BTU Dryer, and a 40,000 BTU Gas Log Fireplace. The sum of these appliances is 394,900 BTU. Since most gas regulators and meters are rated in Cubic Feet per Hour, we need to convert the BTU calculation to ensure they are sized correctly. Divide total BTU by 1,024 to get the estimated Cubic Feet per Hour (CFH) requirement for the meter and regulator; 386 CFH in our example. If the water heater was a typical tank type at 40,000 BTU, then the overall system requirement would have been just 235,000 BTU with a meter and regulator rated at 235 Cubic Feet per Hour. A typical household meter and regulator is commonly rated at 250 Cubic Feet per Hour. As you can see that in the example above, when you change the water heater to a tankless, the existing regulator and meter would be potentially undersized. It is important to have a properly sized meter and regulator on the system; otherwise, the appliances on the system could experience operational issues. The local gas utility can provide more information on upgrading the meter and regulator for the home. Hybrid pressure systems, with a 2 psi static pressure with regulators at each appliance, are sized differently than in this example. Consult your local gas supplier or the National Fuel Gas Code in regards to these type systems.

Pipe Sizing Methods

There are two basic pipe sizing methods: longest length and branch length. Proper sizing will allow the system to maintain the required minimum pressure drop. In the longest length method, the pipe size of each section should be determined by using the longest length of piping from the point of delivery, the gas meter or regulator, to the most remote outlet and the load of the section. In the branch length method, the pipe size of each section of the longest pipe run, from the point of delivery to the most

remote outlet, should be determined by the longest run of piping and the load of the section. The pipe size of each section of branch piping should be determined using the length of piping from the point of delivery to the most remote outlet in each branch and the load of the section. Branch length sizing is the most common method.

Determining Pipe Size by Length and Capacity

We will need to calculate the total load of the system and each branch. In our sample system, Figure 1, measure and add the lengths of pipes at each section. Total the BTU of the appliances for each branch line and the main trunk line back to the gas meter. Select the appropriate sized gas line based on length, BTU capacity, and pressure drop from Table 2, Table 3, or Table 4.

Gas Pipe System Sizing

Table 1 - Gas System Branch Sizing Example based on Figure 1

Line Segment		Appliance	BTU Required	Line Length	Minimum Pipe Size Required	
					0.3 w.c. drop	3.0 w.c. drop
Branch 1	E	Tankless Water Heater	199,900	20 ft	1"	½"
	G	Gas Furnace	75,000	15 ft	½"	½"
	D	Branch Main Line	274.900	30 ft	1"	¾"
Branch 2	J	Gas Dryer	25,000	20 ft	½"	½"
	H	Gas Range	55,000	30 ft	½"	½"
	K	Gas Logs	40,000	10 ft	½"	½"
	B + C	Branch Main Line	120,000	45 ft	¾"	½"
Main Trunk	A	Main Trunk Line	394,900	20 ft	1 ¼"	¾"

You can see that, in a typical gas system, a tankless water heater with a capacity of 199,900 BTU will require a 1-inch pipe size for a 20 ft branch length (based on the 0.3 in w.c. pressure drop in Table 2). The same appliance would require just a ½" pipe size based on Table 4 the 3.0 in w.c. pressure drop. A branch line is a pipe off the main line that feeds a group of appliances. In our example, we have two branch lines. The pipe size of the main pipe on the branch must be sized based on the total BTU of all the appliances on that branch line and pipe length. The trunk line pipe is the main pipe from the meter/regulator that feeds the different branches. The trunk line must be sized based on the total BTU from each branch-line system or the sum of the total BTU of all the appliances on the system and pipe length. Items such as elbows, tees, and valves are not included in these sample calculations. Their equivalent pipe length should be included when sizing gas systems. It is recommend that a licensed gas tradesman size, design, and install the gas system.

Pipe Sizing Formula and Factors

You can calculate the required inside diameter of the piping required for a specific appliance/system capacity and length. This formula is from the National Fuel Gas Code (NFPA 54, ANSI Z223.1, Section 6.4.1). Calculate Q by dividing the BTU capacity of the appliance(s) by 1,024. To determine the allowable

pressure drop, find the system static input gas pressure using a Manometer. Then, find the highest minimum gas pressure from all the appliances, usually listed on the appliances rating label. Subtract the highest minimum gas pressure from the static input gas pressure to get the difference. For example, the input static pressure is 7 in. w.c.; the highest minimum pressure is 6 in. w.c.; leaving a difference of 1 in. w.c. In this example the system can have a .5 in. w.c. pressure drop based on Table 3. If the input pressure was 9 in. w.c., in this example, then a 3.0 in. w.c. pressure drop based on Table 4 would be allowable.

$$D = \frac{Q^{0.381}}{19.17\left(\frac{\Delta H}{Cr \times L}\right)^{0.206}}$$

D = inside diameter of pipe (in.)
Q = input rate of appliance (s) (cubic feet)
(divide the BTU by 1,000 to get the cubic feet)
ΔH = pressure drop [in. w.c.]
L = equivalent length of pipe
Cr = gas formula factor 0.6094 for Natural Gas

For additional sizing information for Hybrid Pressure Systems, Propane Gas Systems, and Corrugated Stainless Steel Tubing, see the 2012 Edition of the National Fuel Gas Code, NFPA 54, ANSI Z223.1, or consult with your local gas utility or code officials.

The information in this brochure is for educational purposes only, it is not meant to be an engineering guide or supplement any national or local code. All national and local codes muse be followed. The information in this brochure was obtained from the National Fuel Gas Code, NFPA54, ANSI Z223.1 2012 Edition. Refer to the National Fuel Gas Code, your local gas supplier, or your local code official for information. Gas systems should be designed, installed, and inspected by a certified and licensed gas fitter, engineer, or tradesman. The information in this guide does not apply for installations in Canada, see CAN/CSA B149.1 for details or consult with your local code official.

Gas Pipe Capacity Charts

Table 2 - 0.3 Inch Water Column Pressure Drop for Black Iron - Schedule 40 Metallic Pipe						
	Pipe Size (in.)					
Nominal Dia.	½	¾	1	1¼	1½	2
Length (ft)	Capacity in BTU per Hour**					
10	134,144	279,552	526,336	1,085,440	1,617,920	3,123,200
20	92,160	192,512	363,520	743,424	1,116,160	2,140,160
30	73,728	154,624	290,816	596,992	893,952	1,720,320
40	63,488	132,096	248,832	510,976	764,928	1,474,560
50	56,320	116,736	220,160	452,608	677,888	1,310,720
60	51,200	106,496	199,680	409,600	614,400	1,187,840
70	47,104	97,280	183,296	376,832	565,248	1,085,440
80	43,008	91,136	171,008	351,232	526,336	1,012,736
90	40,960	84,992	160,768	329,728	493,568	950,272
100	38,912	80,896	151,552	311,296	465,920	898,048
** Calculated based ANSI Z223.1-2012 Table 6.2(a) using 1,024 BTU per Cubic Foot of Gas						

Table 3 - 0.5 Inch Water Column Pressure Drop for Black Iron - Schedule 40 Metallic Pipe						
	Pipe Size (in.)					
Nominal Dia.	½	¾	1	1¼	1½	2
Length (ft)	Capacity in BTU per Hour**					
10	176,128	368,640	694,272	1,423,360	2,140,160	4,116,480
20	120,832	252,928	477,184	979,968	1,464,320	2,826,240
30	97,280	203,776	382,976	786,432	1,177,600	2,273,280
40	82,944	174,080	327,680	672,768	1,008,640	1,945,600
50	73,728	154,624	290,816	596,992	893,952	1,720,320
60	66,560	140,288	263,168	540,672	809,984	1,556,480
70	61,440	129,024	242,688	497,664	745,472	1,433,600
80	57,344	119,808	225,280	462,848	693,248	1,331,200
90	53,248	112,640	211,968	434,176	650,240	1,249,280
100	51,200	106,496	199,680	409,600	614,400	1,187,840
** Calculated based ANSI Z223.1-2012 Table 6.2(b) using 1,024 BTU per Cubic Foot of Gas						

Table 4 - 3 Inch Water Column Pressure Drop for Black Iron - Schedule 40 Metallic Pipe Initial gas supply pressure must be 8.0 inches of water column or greater						
	Pipe Size (in.)					
Nominal Dia.	½	¾	1	1¼	1½	2
Length (ft)	Capacity in BTU per Hour**					
10	464,896	971,776	1,829,888	3,757,056	5,628,928	10,842,112
20	319,488	667,648	1,257,472	2,582,528	3,868,672	7,451,648
30	256,000	536,576	1,009,664	2,073,600	3,868,672	5,984,256
40	219,136	458,752	864,256	1,774,592	2,659,328	5,121,024
50	194,560	396,288	765,952	1,572,864	2,357,248	4,539,392
60	176,128	368,640	694,272	1,425,408	2,135,040	4,112,384
70	161,792	338,944	638,976	1,310,720	1,965,056	3,783,680
80	150,528	315,392	593,920	1,219,584	1,827,840	3,519,488
90	141,312	295,936	557,056	1,144,832	1,715,200	3,302,400
100	134,144	279,552	526,336	1,081,344	1,619,968	3,119,104
** Calculated based ANSI Z223.1-2012 Table 6.2(c) using 1,024 BTU per Cubic Foot of Gas						