4 Gas Line Sizing

Chapter 4
Gas Line Sizing

We now know the kind of piping which can be used for the distribution of natural gas within a building and the rules for installation. Now we will learn how to size the pipe running to each appliance so that the proper amount of gas can be delivered to each piece of equipment, including adjustments required due to elevation.

Some Important Assumptions

Before we jump into the process of calculating the correct pipe size for a given situation, we need to make a series of important assumptions. First, if you look up the heat content of natural gas you'll find a range of values from 1,000 BTUs per cubic foot to around 1,070 BTUs per cubic foot. The variation comes from formulation differences where some natural gas has slightly more ethane or propane than others. To eliminate any confusion, we're going to assume that at sea level where atmospheric pressure is 14.696 PSI that one cubic foot of natural gas contains 1,000 BTUs of heat energy.

It is important to understand the effects of increasing elevation upon the heat content of natural gas. As mentioned above, under standard conditions of one atmosphere pressure, one cubic foot of methane generates 1,000 BTH's of heat. However as elevation increases, the heat content of gas decreases. Imagine a balloon filled with exactly one cubic foot of gas at sea level in Long Beach, California. If burned, that one cubic foot of methane would yield 1,000 BTUs of heat. But if we were to take that same balloon up to Alta, Utah with an elevation of 8,600 feet, the balloon would have expanded to more than one cubic foot due to the decrease in pressure of the air surrounding the balloon. At 8,600 feet, the air pressure has dropped to 11 PSI, or only 75% of the pressure at sea level. As a result the balloon would have expanded by 25% up to 1.25 cubic feet. If we then remove exactly one cubic foot of gas from the balloon and burn it, we will obviously get less than 1,000 BTUs of heat because there are fewer molecules of methane present in a cubic foot of gas at 8,600 feet than there was at sea level. Actually we only get 755 BTUs of heat from a cubic foot of gas at Alta when compared to 1,000 at Long Beach. This must be taken into account in gas line sizing or we'll be in very serious trouble.

Now think about this for a moment. If we are installing a 100,000 BTU/hr furnace at Long Beach, to deliver 100,000 BTUs of fuel we only have to deliver 100 Ft^3 of natural gas because 100 X 1,000 = 100,000. However at Alta, to deliver 100,000 BTUs of fuel to the furnace when only 755 BTU/Ft^3 is available, we must deliver a much larger volume of gas in order to end up with the same 100,000 BTUs of fuel to this appliance. Specifically we must deliver 132.45 cubic feet of

natural gas through the pipe. As you can quickly see, if we sized the gas line to only carry 100 Ft^3 of natural gas, then we'd never be able to get 100,000 BTU/hr from the furnace because not enough fuel is arriving at the appliance. The gas line must be sized 1/3 larger to compensate for elevation.

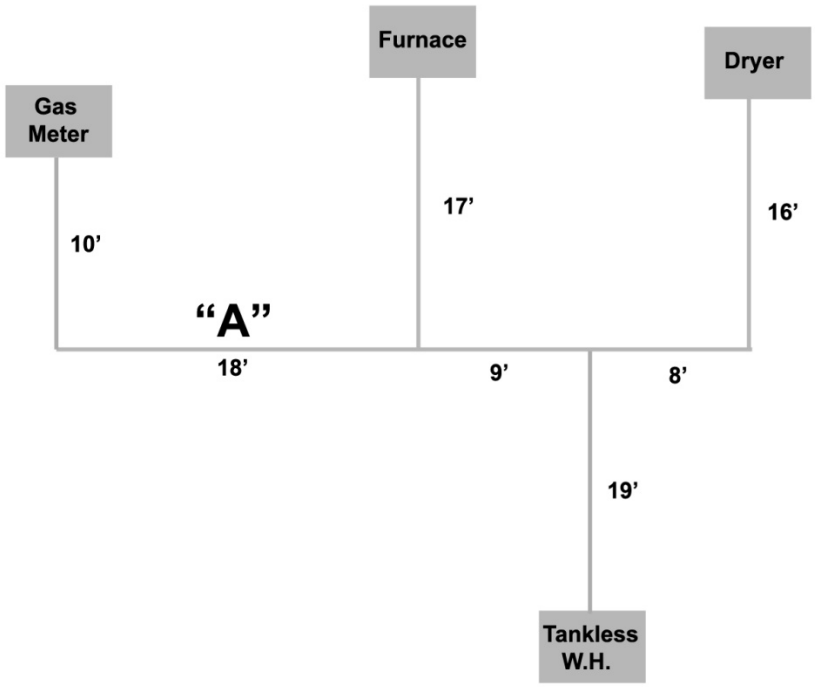
Therm and Decatherm

Before we get into the actual calculations used to compute the correct gas line size, a word (or two) is in order concerning the measurement of natural gas. Most gas bills measure gas in Therms or Decatherms. A Therm is 100,000 BTUs of heat. As we just learned, a Therm in Long Beach and a Therm in Alta is exactly the same thing, namely 100,000 BTUs of heat. However the Alta Therm will involve more cubic feet than the Long Beach Therm. That's why the gas company chooses to measure delivery of natural gas in Therms rather than cubic feet. If one Therm equals 100,000 BTU, then a Decatherm (10 Therms) equals 1 million BTUs of heat. The average home consumes 72 Decatherms of natural gas per year for heating and hot water needs, or 72 million BTUs of heat.

Now, the calculations

To determine the proper size gas line, follow this procedure:

First, calculate the distance from the meter to the farthest appliance. In the example below this would be 61 feet (from the gas meter to the dryer).



To do the required calculations you'll need a *Standard Pressure Table* or an *Elevated Pressure Table* as provided by the American Gas Association, the International Fuel Gas Code, International Residential Code, International Mechanical Code, International Plumbing Code, or local codes. A Standard Pressure Table is used for a residence with a 4 ounce meter (below), and an Elevated Pressure Table is used for a business or industrial customer with a 2 pound meter. Find the line on this table which matches your calculation. Since the farthest appliance is 61 feet, you MUST use the next larger line, namely 70 feet. ALL OF THE REMAINING PIPE CALCULATIONS FOR THIS INSTALLATION WILL COME FROM THE 70' LINE.

MAXIMUM CAPACITY OF PIPE IN
CUBIC FEET OF GAS PER HOUR

4 OUNCES

STANDARD PRESSURE

Pipe Size (inches)											
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	6
Length (ft)	Capacity in Cubic Feet of Gas per Hour										
10	172	360	678	1,390	2,000	4,020	6,400	11,300	23,100	41,800	67,600
20	118	347	466	958	1,430	2,760	4,400	7,780	15,900	28,700	46,500
30	95	199	374	768	1,150	2,220	3,530	6,350	12,700	23,000	37,300
40	81	170	320	667	985	1,900	3,020	5,300	10,900	19,700	31,900
50	72	151	284	563	873	1,680	2,680	4,700	9,660	17,500	28,300
60	66	137	257	528	791	1,520	2,430	4,290	8,760	15,800	25,600
70	60	126	237	486	728	1,400	2,230	3,950	8,050	14,600	23,600
80	56	117	220	452	677	1,300	2,080	3,670	7,490	13,600	22,000
90	52	110	207	424	635	1,220	1,950	3,450	7,030	12,700	20,600
100	50	104	195	100	300	1,160	1,840	3,260	6,640	12,000	19,500
125	44	92	173	355	532	1,020	1,630	2,890	5,890	10,600	17,200
150	40	83	157	322	482	928	1,480	2,610	5,330	9,650	15,600
175	37	77	144	296	443	854	1,360	2,410	4,910	8,880	14,400
200	34	71	134	275	412	794	1,270	2,240	4,560	8,230	13,400
250	40	63	119	244	366	704	1,120	1,980	4,050	7,320	11,900
300	27	57	108	221	331	638	1,020	1,800	3,670	6,630	10,700
350	25	53	99	203	305	587	935	1,660	3,370	6,100	9,880
400	23	49	82	189	283	546	870	1,540	3,140	5,680	9,190
450	22	46	86	177	266	512	816	1,410	2,940	5,330	8,620
500	21	43	82	168	251	484	771	1,360	2,780	5,030	8,150
550	20	41	78	159	239	459	732	1,290	2,640	4,780	7,740
600	19	39	74	152	238	438	699	1,240	2,520	4,560	7,680

Second, convert the INPUT ratings for each of the appliances from BTUs to Cubic Feet per Hour (CFH) as based upon the BTU per cubic foot rating for the area being calculated. Local tables are available showing the heat value of a cubic foot of gas for every area in the country. The formula to convert BTU to CFH is:

INPUT ÷ BTU/ ft^3 = Cubic Feet per Hour (CFH)

For example, suppose you have a 120,000 BTU furnace located in Alta, Utah. The BTU/ ft^3 rating for Alta is 755, so divide the furnace BTU/hr by 755 BTU/ ft^3 to get the CFH, i.e., 120,000 ÷ 755 = 158.94 CFH. Note that the capacity of a gas pipe is measured in CFH, not BTU. [This same appliance installed in Long Beach would only require 120 CFH because the BTU/ft^3 in this location is 1,000.]

Third, on the 70' line look up which pipe size is sufficiently large to carry 158.94 CFH. This CFH requires a 1" pipe. Notice that the 17' line to the furnace only services the furnace and no other appliances, whereas the 9' pipe section services the dryer and the tankless W.H. (you'd need to add these two appliances together in order to determine the CFH for the 9' pipe section). Notice that pipe section "A" services all the appliances; therefore you'd need to add together the CFH for all appliances to calculate this pipe section.

Let's try this for each of the appliances. Since the farthest appliance is 61 feet from the meter AND since we must use the next larger footage line (even if it's only one foot more), then all of our readings for each of the appliances must be taken from the 70 foot line even though they are not 70 feet away from the meter. It's strange, but that's how this game is played.

We've already calculated the gas line requirement for the furnace at 1", so now let's do the same thing for the rest of the appliances. As we do this, please remember that once we've calculated the distance to the farthest appliance (61 feet but using the 70 foot line in the table), we no longer care how long each individual branch is. It's irrelevant. All we need to know is how many cubic feet of gas a particular branch line is carrying. So let's start with the dryer.

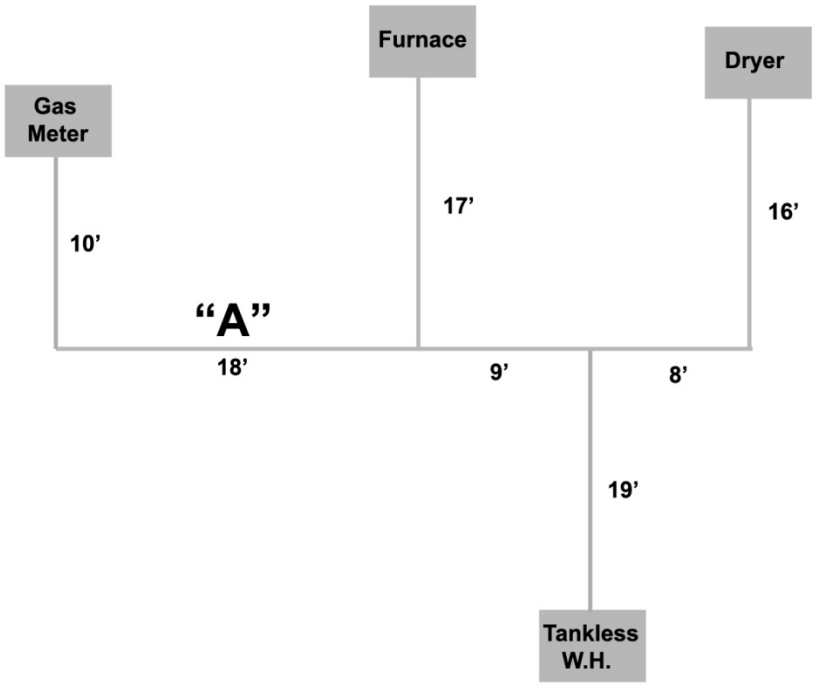
The dryer is on its own branch (the 16' line and the 8' line). No other appliance shares this branch. The input rating for the dryer is 50,000 BTU/hr. The first step is to apply our formula:

INPUT ÷ BTU/ ft^3 = Cubic Feet per Hour (CFH)

The result is 50,000 ÷ 755 = 66.23. The second step is to look up this value on the 70' line of the table. The smallest pipe size which can carry 66.23 CFH is a 3/4" pipe.

Now for the tankless water heater. The BTU/hr input is 199,000. Plug in these values to the formula: 199,000 BTU/hr ÷ 755 BTU/ft^3 = 263.58 CFH. Now look up this value on the 70 foot line of the table. The minimum pipe size capable of carrying 263.58 CFH is a 1 ¼" pipe.

We've now calculated the pipe sizes for each of the branch lines to each individual appliance. Now we need to consider the common gas lines serving two or more appliances. The drawing is shown again below so that you can more easily see what still needs to be calculated. Notice that the 9' line supplies the dryer AND the water heater. Also notice that the 10' and the 18' lines supply all three appliances. Here's how we calculate these two pipe sections.



We've already calculated the CFH requirements for each of the three appliances:

Dryer	66.23
Furnace	158.94
Water heater	263.58
TOTAL	**488.75**

The 10' section and the 18' section will be the same size because they carry the same load. Again, once we've calculated the length to the farthest appliance (61 feet rounding up to 70 feet) we no longer need to worry about the individual branch

lengths. Turn to the table and on the 70 foot line find the size of pipe needed to carry 488.75 CFH. Notice that we barely miss the 1 ¼" pipe. When it comes to gas line sizing, you ALWAYS round up. Therefore the minimum pipe size for these two sections is 1 ½".

So to recap, follow this procedure anytime you calculate the gas line size:

First, calculate the distance from the meter to the farthest appliance. If the number is not exactly equal to one of the distances on the table, round up to the next longer distance.

Second, convert the INPUT ratings for each of the appliances from BTUs to CFH using the formula: INPUT ÷ BTU/ ft^3 = CFH (based upon the BTU/ ft^3 rating for the area being calculated)

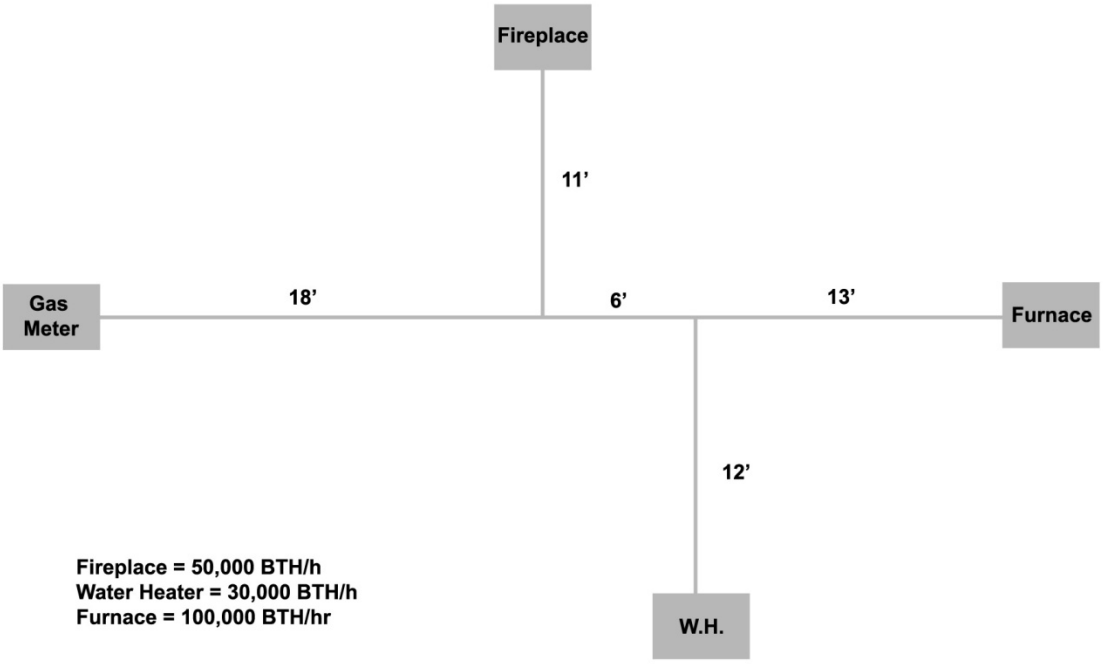
Third, look up the CFH requirement on the table for each pipe section in the installation.

Remember that the CFH requirement for any section of pipe is equal to the total volume of gas that section will carry assuming every appliance on that line is running simultaneously. Obviously the first section of pipe attached to the gas meter will be carrying a volume of gas equal to the cumulative CFH for every gas appliance in the home. As always, if the CFH just barely misses a value, even if it's by a tenth of a cubic foot, you have to go to the next higher value (you must always round up).

Your Turn

Now it's time for you to try it yourself. On the following pages are a series of examples where you will need to calculate the values of each pipe section. The answers will follow each page. Try to do the work without looking at the answers until completed. This is the only way you will know if you have mastered the concept. If you need to refresh your memory, look back at the information previously discussed rather than looking forward at the answers. NOTE: CFH answers should be rounded to two decimal places.

Gas line sizing #1



ALTITUDE: 4,350

BTU/FT^3: 890

FORMULA: INPUT÷ BTU/ ft^3 = CFH

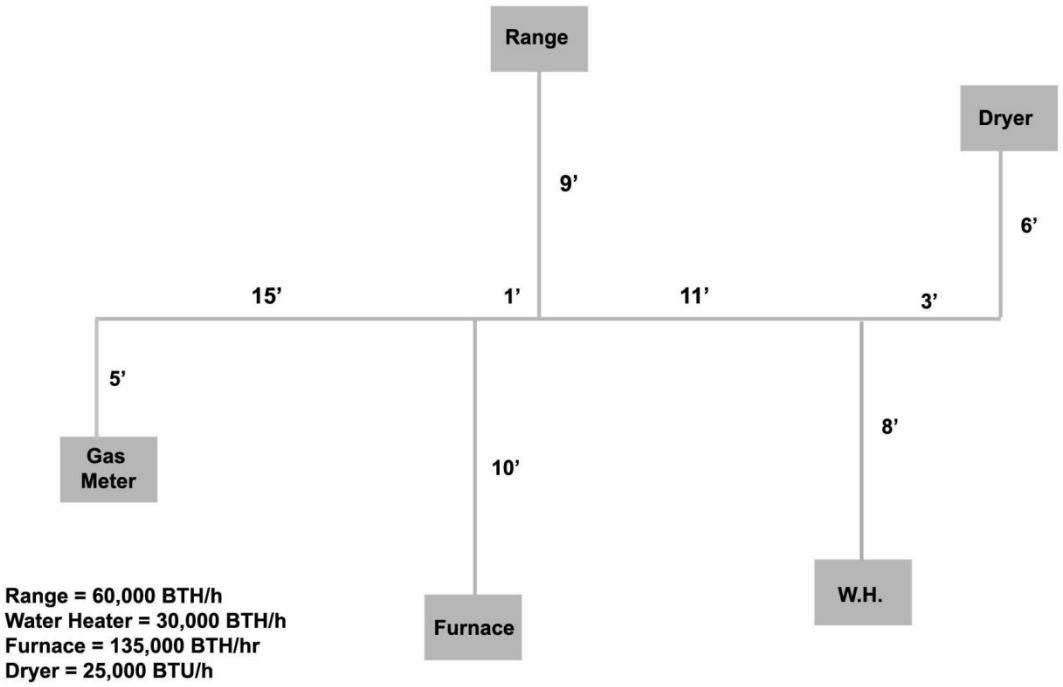
Distance from the meter to the farthest appliance = _____
Which row will you use in the table? _____
CFH for the fireplace: _____
CFH for the water heater: _____
CFH for the furnace: _____
Total CFH for all appliances: _____
Pipe size for the 13' section: _____
Pipe size for the 12' section: _____
Pipe size for the 11' section: _____
Pipe size for the 6' section: _____
Pipe size for the 18' section: _____

Answers to Gas Line Sizing #1

Distance from the meter to the farthest appliance = **37'**
Which row will you use in the table? **40'**
CFH for the fireplace: **56.18**
CFH for the water heater: **33.71**
CFH for the furnace: **112.36**
Total CFH for all appliances: **202.25**
Pipe size for the 13' section: **3/4"**
Pipe size for the 12' section: **1/2"**
Pipe size for the 11' section: **1/2"**
Pipe size for the 6' section: **3/4"**
Pipe size for the 18' section: **1"**

If you missed any of the questions, please take the time to figure out what you did wrong and calculate it correctly, then move on to the next example.

Gas line sizing #2



ALTITUDE: 2,760

BTU/FT^3: 919

FORMULA: INPUT÷ BTU/ ft^3 = CFH

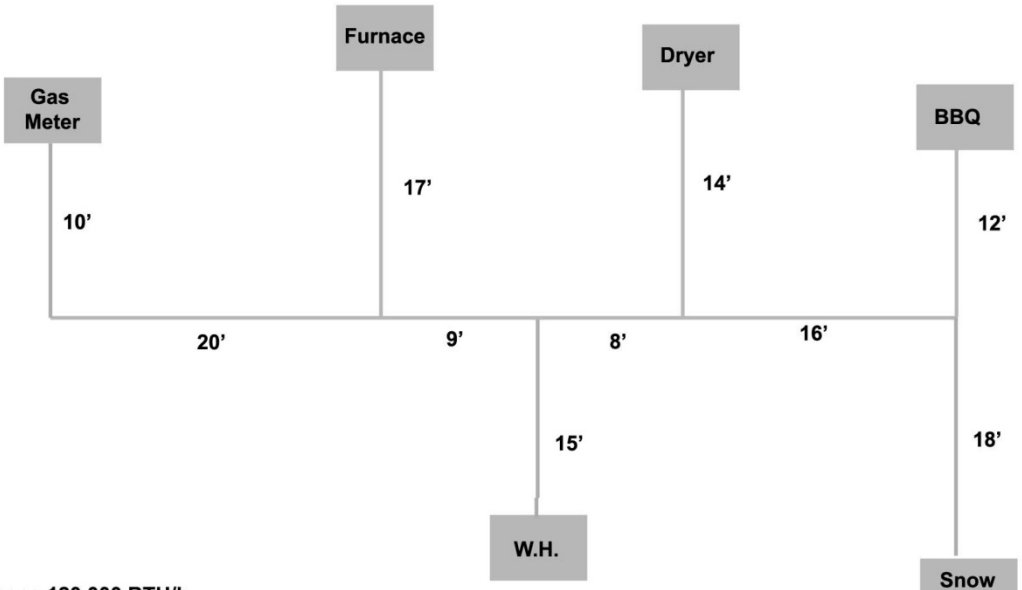
Distance from the meter to the farthest appliance = _____
Which row will you use in the table? _____
CFH for the range: _____
CFH for the water heater: _____
CFH for the furnace: _____
CFH for the dryer: _____
Total CFH for all appliances: _____
Pipe size for the 6' section: _____
Pipe size for the 3' section: _____
Pipe size for the 8' section: _____
Pipe size for the 9' section: _____
Pipe size for the 10' section: _____
Pipe size for the 11' section: _____
Pipe size for the 1' section: _____
Pipe size for the 15' section: _____
Pipe size for the 5' section: _____

Answers to Gas Line Sizing #2

Distance from the meter to the farthest appliance = **41**
Which row will you use in the table? **50**
CFH for the range: **65.29**
CFH for the water heater: **32.64**
CFH for the furnace: **146.90**
CFH for the dryer: **27.20**
Total CFH for all appliances: **272.03**
Pipe size for the 6' section: **1/2"**
Pipe size for the 3' section: **1/2"**
Pipe size for the 8' section: **1/2"**
Pipe size for the 9' section: **1/2"**
Pipe size for the 10' section: **3/4"**
Pipe size for the 11' section: **1/2"**
Pipe size for the 1' section: **3/4"**
Pipe size for the 15' section: **1"**
Pipe size for the 5' section: **1"**

If you missed any of the questions, please take the time to figure out what you did wrong and calculate it correctly, then move on to the next example.

Gas line sizing #3



Furnace 120,000 BTH/h
Water Heater = 30,000 BTH/h
Dryer = 35,000 BTH/hr
BBQ = 125,000 BTU/h
Snow Melt = 250,000 BTH/h

ALTITUDE: 3,250

BTU/FT^3: 903

FORMULA: INPUT÷ BTU/ ft^3 = CFH

Distance from the meter to the farthest appliance = _____
Which row will you use in the table? _____
CFH for the furnace: _____
CFH for the water heater: _____
CFH for the dryer: _____
CFH for the BBQ: _____
CFH for the snow melt: _____
Total CFH for all appliances: _____

Pipe size for the 18' section: _____
Pipe side for the 12' section: _____
Pipe size for the 14' section: _____
Pipe size for the 15' section: _____
Pipe size for the 17' section: _____

Pipe size for the 16' section: _____
Pipe size for the 8' section: _____
Pipe size for the 9' section: _____
Pipe size for the 20' section: _____
Pipe size for the 10' section: _____

Answers to Gas Line Sizing #3

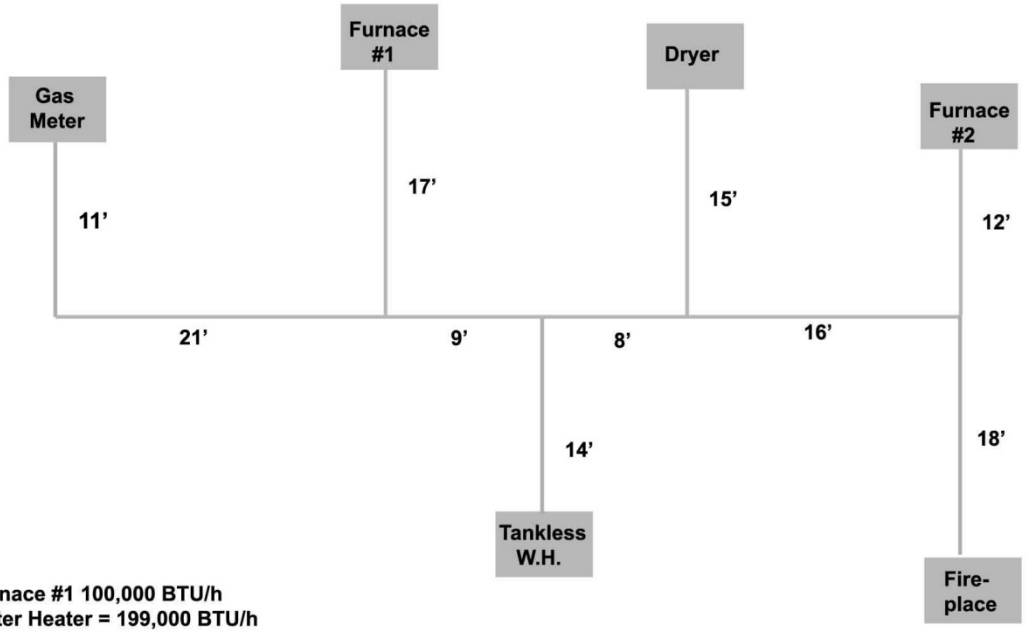
Distance from the meter to the farthest appliance = **81'**
Which row will you use in the table? **90'**
CFH for the furnace: **132.89**
CFH for the water heater: **32.22**
CFH for the dryer: **38.76**
CFH for the BBQ: **138.43**
CFH for the Snow Melt: **276.85**
Total CFH for all appliances: **619.15**

Pipe size for the 18' section: **1 1/4"**
Pipe side for the 12' section: **1"**
Pipe size for the 14' section: **1/2"**
Pipe size for the 15' section: **1/2"**
Pipe size for the 17' section: **1"**
Pipe size for the 16' section: **1 1/4"**
Pipe size for the 8' section: **1 1/2"**
Pipe size for the 9' section: **1 1/2"**
Pipe size for the 20' section: **1 1/2"**
Pipe size for the 10' section: **1 1/2"**

With this example you can see the impact a long distance between meter and the farthest appliance has on the calculations for even small appliances.

If you missed any of the questions, please take the time to figure out what you did wrong and calculate it correctly, then move on to the next example.

Gas line sizing #4



Furnace #1 100,000 BTU/h
Water Heater = 199,000 BTU/h
Dryer = 45,000 BTU/hr
Furnace #2 = 150,000 BTU/h
Fireplace = 50,000 BTU/h

ALTITUDE: 6,000

BTU/FT^3: 818

FORMULA: INPUT÷ BTU/ ft^3 = CFH

Distance from the meter to the farthest appliance = _____
Which row will you use in the table? _____
CFH for furnace #1: _____
CFH for the water heater: _____
CFH for the dryer: _____
CFH for furnace #2: _____
CFH for the fireplace: _____
Total CFH for all appliances: _____
Pipe size for the 12' section: _____
Pipe side for the 18' section: _____
Pipe size for the 15' section: _____
Pipe size for the 14' section: _____
Pipe size for the 17' section: _____
Pipe size for the 16' section: _____
Pipe size for the 8' section: _____
Pipe size for the 9' section: _____
Pipe size for the 21' section: _____
Pipe size for the 11' section: _____

Answers to Gas Line Sizing #4

Distance from the meter to the farthest appliance = **83'**
Which row will you use in the table? **90'**
CFH for furnace #1: **122.25**
CFH for the water heater: **243.28**
CFH for the dryer: **55.01**
CFH for furnace #2: **183.37**
CFH for the fireplace: **61.12**
Total CFH for all appliances: **665.03**

Pipe size for the 12' section: **1"**
Pipe side for the 18' section: **3/4"**
Pipe size for the 15' section: **3/4"**
Pipe size for the 14' section: **1 1/4"**
Pipe size for the 17' section: **1"**
Pipe size for the 16' section: **1 1/4"**
Pipe size for the 8' section: **1 1/4"**
Pipe size for the 9' section: **1 1/2"**
Pipe size for the 21' section: **2"**
Pipe size for the 11' section: **2"**

Chapter 4 Summary

Gas Pipe Sizing

To determine the proper size pipe section, follow this procedure:

First, calculate the distance from the meter to the farthest appliance. Find the line on the table which matches your calculation. You must have an exact match or you are required to use the next larger line. ALL OF THE REMAINING PIPE CALCULATIONS WILL COME FROM THIS LINE regardless of the length of the individual pipe sections.

Second, convert the INPUT ratings for each of the appliances from BTUs to cubic feet per hour (CFH) based upon the BTU/ ft^3 rating for the area being calculated. Local tables are available showing the heat value of a cubic foot of gas for every area in the country. The formula to convert BTU to CFH is:

$$\text{INPUT} \div \text{BTU}/\,ft^3 = \text{CFH}$$

Third, look up the CFH requirement on the table for each pipe section in the installation.

Remember that the CFH requirement for any section of pipe is equal to the total volume of gas that pipe section might be called upon to carry assuming every appliance on that line is running simultaneously. Obviously the first section of pipe attached to the gas meter might be required to carry a volume of gas equal to the cumulative CFH for every gas appliance in the home. As always, if the CFH just barely misses a value, even if it's by a tenth of a cubic foot, you have to go to the next higher value (you must always round up with gas line sizing).