

## Gas Supply Design Guide

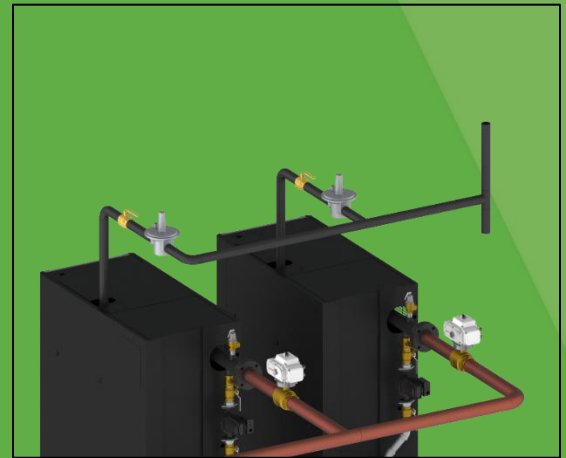
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# Innovation 1600-2000 Water Heaters with Edge<sup>®</sup> [ii] Controller

Natural Gas and Propane Gas

Modulating & Condensing Water Heater

Models INN 2000 & INN 1600



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## 1 SAFETY PRECAUTIONS

### 1. SAFETY PRECAUTIONS

AERCO Innovation water heaters are modulating input devices that require an adequate volume of natural gas at constant pressure for proper operation. The gas requirements specified in this document must be satisfied to ensure efficient combustion. Designers and installers must adhere to the PVI specifications and those of the local authorities having jurisdiction. A thorough understanding and knowledge of these guidelines is required for the successful design and installation of Innovation Low NOx series water heaters.

#### 1.1 Gas Train Components

AERCO Innovation gas-fired water heaters are equipped with standard UL approved/FM compliant gas trains. These gas trains are factory tested and fired, with a minimum number of modular components. The gas train components have been designed to operate at high combustion efficiencies by closely controlling both the volume and air/fuel mixture to the burner. The major internal gas train components are:

- \* **SAFETY SHUT OFF VALVE (SSOV) With BUILT-IN SUPPLY GAS REGULATOR** - An electro-hydraulic gas valve, containing a proof of closure switch, is utilized to stop fuel from flowing into the gas train of the water heater. This is a 100% tight shutoff device with a visible window indicator showing valve position. Reliable, and a standard industry component, this valve is factory piped with a low gas pressure switch on the inlet side of the valve which monitors the manifold pressure for minimum supply conditions. There is also a high gas pressure switch installed on the outlet side of the gas valve, which shuts down the water heater if gas manifold pressures exceed maximum conditions.

For minimum and maximum gas pressures, see Table 1, below.

- \* **AIR/FUEL VALVE** - The air/fuel valve controls the volume and mixture of air and fuel in perfect proportion throughout the entire modulation range of the water heater. The valve utilizes one common shaft to simultaneously vary the gas port area and air volume. The gas portion of the valve is a slide port type valve with linear proportion-to-position characteristics. The air side uses a butterfly type valve for adjusting the air volume. The driver of the valve shaft is a precision stepping motor which provides continuous positioning from full input to minimum fire. The air/fuel valve also contains two proof-of-position switches.
- \* **CAST ALUMINUM BLOWER ASSEMBLY** - A cast aluminum pre-mix blower ensures the precise mixing of air and fuel prior to entering the burner thereby providing controlled combustion.
- \* **LOW NOx BURNER** - The burner provides the actual point of air/fuel contact and combustion into the cylindrical combustion/heat exchanger. Fabricated from metal fiber mesh covering a stainless-steel body, the burner is stable throughout the entire input range of the water heater. The spark igniter and flame detector for the combustion supervision system are part of this assembly. The burner is easily removable from the water heater.

## 2. GAS PRESSURE REQUIREMENTS

AERCO Innovation Low NOx series water heaters require a stable natural gas and propane input pressure. A low supply gas pressure switch in each gas train prevents the water heater from operating without sufficient pressure. The allowable gas inlet pressure range when firing at maximum input for standard gas trains, such as FM is shown in Table 1. For custom gas trains, such as DBB and dual fuel, see Section 3: Custom gas Trains.

Model	NATURAL GAS		PROPANE	
	Minimum	Maximum	Minimum	Maximum
<b>INN 1600</b>	4.0" W.C. (1.00 kPa)	14.0" W.C. (3.49 kPa)	8.0" W.C. (1.99 kPa)	14.0" W.C. (3.49 kPa)
<b>INN 2000</b>	4.0" W.C. (1.00 kPa)	14.0" W.C. (3.49 kPa)	8.0" W.C. (1.99 kPa)	14.0" W.C. (3.49 kPa)

Gas pressure must be measured when the unit is in operation at full fire. Measure the gas pressure with a manometer at the NPT ball valve provided at the SSOV inlet. In a multiple water heater installation, gas pressure must initially be set for single water heater operation, and then the remaining water heaters must be staged on at full fire, to ensure gas pressures never falls below the supply gas pressure when the single unit was firing.

### 1.2 Manual Shutoff Valves

An external manual shutoff valve must be installed at each Innovation water heater, as shown in Figure 1. This valve is supplied with the water heater.

### 1.3 Pressure Regulators

The lock-up type pressure regulator(s) must be sized as follows:

Water Heater Size (MBH)	Required Volume	
	CFH	(m <sup>3</sup> /HR)
1600	1600 – 1850	(45.3 – 52.4)
2000	2000 – 2300	(56.6 – 65.1)

An external lock-up type regulator **MUST** be installed downstream of the isolation valve at all installations where gas supply pressure will exceed 14.0" W.C. (3.49 kPa).

External gas regulators are self-contained with tapped diaphragm vent ports allowing the diaphragm to change its position as required. These vents typically require piping to the outside. For details, see Section 8: *Venting of Gas Supply Regulators*, below. The SSOV/Regulator in the gas train is factory piped and does not require any vent piping.

**CAUTION!**  
WATER HEATERS MUST BE ISOLATED FROM THE SYSTEM WHEN LEAK TESTING.

2 GAS PRESSURE REQUIREMENTS

Drip legs are typically required at the gas supply of each water heater to prevent any dirt, weld slag, or debris from entering the water heater gas train inlet pipe. When multiple water heaters are installed, some utilities and local codes require a full-size drip leg on the main gas supply line in addition to the drip leg at each unit. The bottom of the gas drip leg(s) should be removable without disassembling any gas piping. The weight of the gas pipe must not be supported from the bottom of the drip leg. The drip leg(s) must not be used to support any or part of the gas piping.

On all Innovation models it is strongly recommended that the pressure regulator be installed a minimum distance of **5 pipe diameters** between the pressure regulator and the nearest *downstream* fittings (an elbow or the unit itself), and a minimum of **10 pipe diameters** between the pressure regulator and any *upstream* fitting, such as elbow or shutoff valve, as shown in Figure 1. If the pipe is of a different size than the regulator connection, a proper tapered reducer may be used at the connection. **This recommendation applies to all gas trains on all Innovation models.**

**NOTE:** It is the responsibility of the customer to source and purchase the appropriate gas regulator as described above. However, PVI offers for sale an appropriate regulator, which may be ordered at the time of unit purchase or separately. Contact your PVI sales representative for more information.

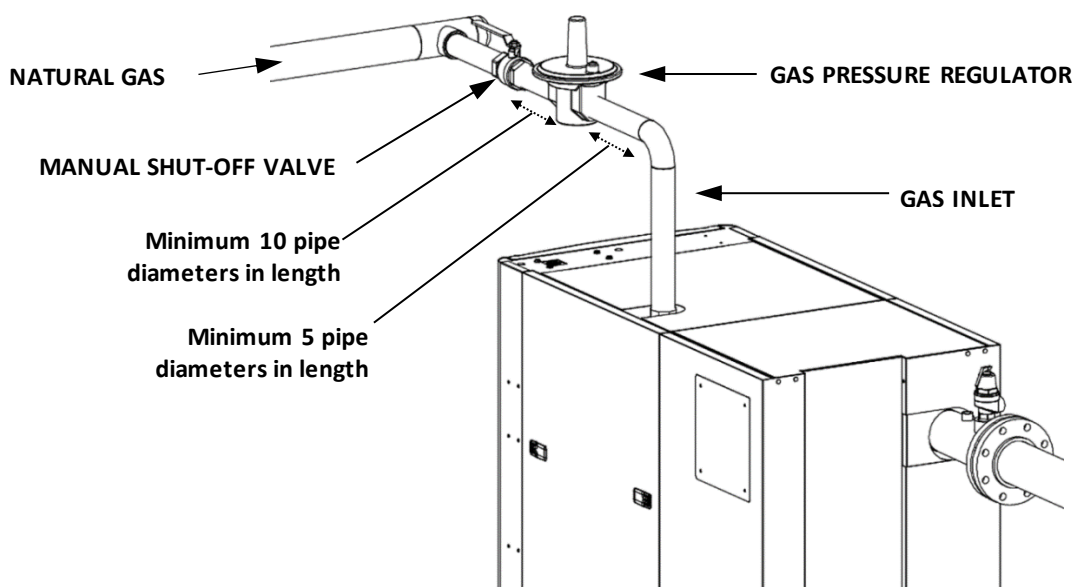


Figure 1: Gas Regulator and Manual Shut-Off Valve

2.3 Massachusetts Installations Only

For Massachusetts installations, a mandatory external gas supply regulator must be positioned as shown in Figure 1, regardless of supply gas pressure. The gas supply regulator must be properly vented to the outside. Consult the local gas utility for detailed requirements concerning venting of the supply gas regulator.

2 GAS PRESSURE REQUIREMENTS

2.4 Multiple Unit Installations

The following points apply to sites that have multiple Innovation units installed:

- If inlet pressures are between 7" W.C. (1.74kPa) and 14" W.C. (3.49kPa) a gas pressure regulator is *highly recommended*. Consult your PVI representative or the factory.
- If inlet pressures are above 14" W.C. (3.49 kPa) a gas pressure regulator is **mandatory**.

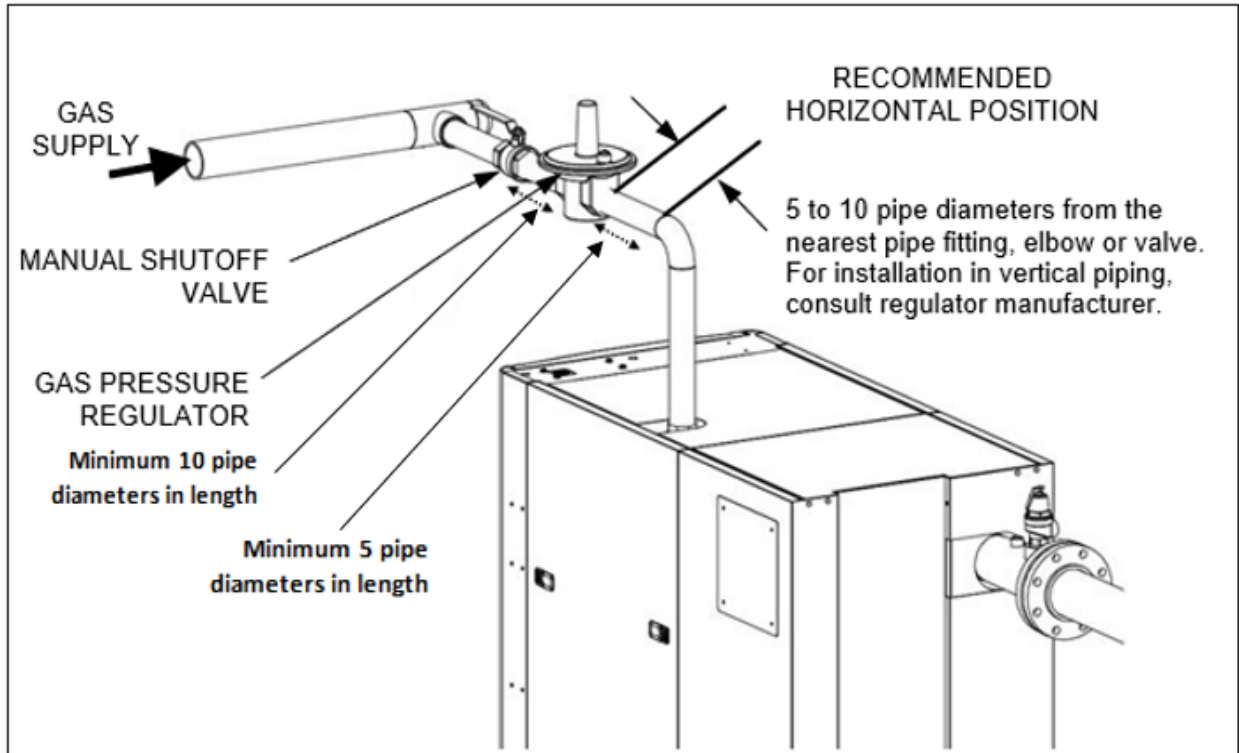


Figure 2: Multiple Water Heater Gas Pipe Connections Guidelines

The following are PVI's recommendations for installation of gas pressure regulator, unless superseded by state and local codes and the regulator manufacturer's specifications:

- Horizontal installation of gas pressure regulators is recommended unless stated otherwise by the regulator manufacturer. Consult the manufacturer for additional recommendations and installation options.
- When installed horizontally, the required distance between the gas pressure regulator and the nearest pipe fitting, elbow or valve is **5 pipe diameters upstream, and 10 pipe diameters downstream**, as shown above.
- When pipe size reduction is required, use only bell reducers.

### 3. CUSTOM GAS TRAINS

Some utilities, insurance carriers, and industrial customers have special requirement gas components on high input devices that are beyond what is normally supplied with PVI water heaters. Secondary shutoffs, high- or low-pressure operators, and external regulators are typical of the requirements of gas utilities. It is mandatory that a designer or installer comply with these requirements. PVI assumes no liability when these requirements are not satisfied for any location or installation. Contact your local gas utility for their specific requirements before installing PVI equipment. A special gas train with **Double Block and Bleed (DBB)** configuration (formerly **IRI**) is available from PVI.

Table 3 lists the gas inlet pressure requirements for custom **Natural Gas** and **Propane** gas trains:

TABLE 3: Gas Inlet Pressure Requirements for Custom DBB Gas Trains			
Model	Fuel	Minimum	Maximum
INN 1600	Natural Gas	4.5" W.C. (1.12 kPa)	14.0" W.C. (3.49 kPa)
	Propane	8" W.C. (1.99 kPa)	14.0" W.C. (3.49 kPa)
INN 2000	Natural Gas	4.5" W.C. (1.12 kPa)	14.0" W.C. (3.49 kPa)
	Propane	8" W.C. (1.99 kPa)	14.0" W.C. (3.49 kPa)



4 GAS PIPING

**4. GAS PIPING**

All gas piping and components must comply with NFPA local codes, and utility requirements minimum. Only gas approved fittings, valves, or pipe should be utilized.

Standard industry practice for gas piping is Schedule 40 iron pipe and fittings. All high and low gas pressure piping systems must comply with local utility and building codes.

Assembled piping must be clean of all debris, pipe chips and foreign material to prevent any from entering the water heater’s gas train. Piping must be tested as prescribed in NFPA 54. Equipment must be isolated before testing any piping system over the allowable pressure. DO NOT EXCEED 14.0” W.C. (3.49 kPa) on the inlet side of the Innovation water heater at any time.

The diameter of the gas inlet pipes is as follows:

TABLE 4: Inlet Pipe Diameter		
INN Model	Natural Gas	Propane
1600	2 Inch	1.5 Inch
2000	2 Inch	1.5 Inch

**5. GAS SUPPLY MAIN SIZING**

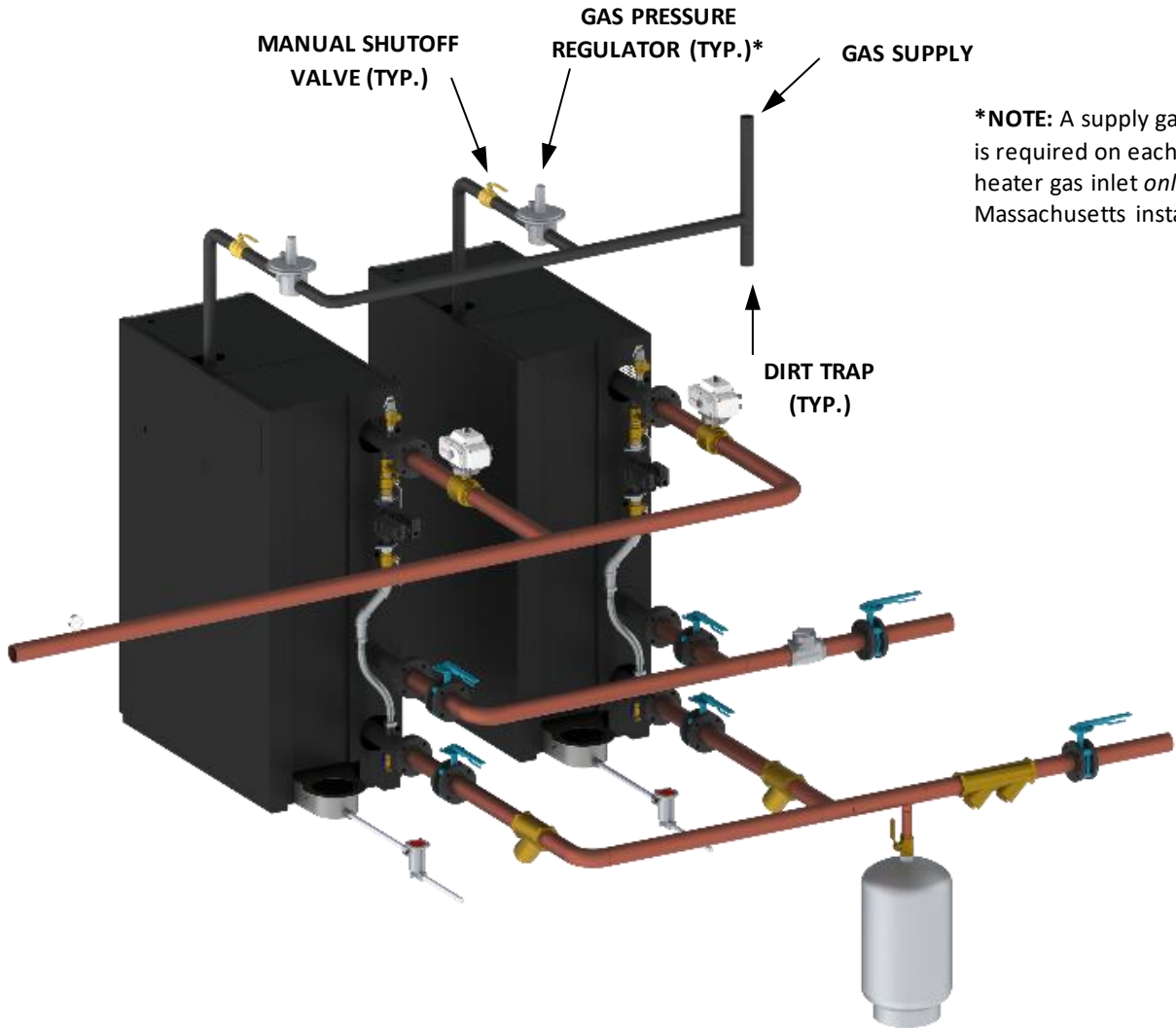
Gas pipe sizing, for either a single or multiple water heater installation, must be sized for a **maximum pressure drop of 0.3” W.C. (75 Pa) from the source to the final water heater.** The maximum gas flow rate required is the sum of the maximum inputs of each unit divided by the heat of combustion of the fuel supplied at the location, (approximately 1,030 BTU per cubic foot [38.35 megajoule/cubic meter] for natural gas or 2,520 BTU per cubic foot [93.83 megajoule/cubic meter] for propane gas). The fuel supplier or utility should be consulted to confirm that sufficient volume and normal pressure is provided to the building at the discharge side of the gas meter or supply pipe. For existing installations with gas equipment, gas pressure must be measured with a manometer to be certain sufficient pressure is available. Before sizing gas piping, a survey of all connected gas devices must be made. Gas piping supplying more than one gas device must be able to handle the total connected input within the allowable gas pressure drop. The allowable minimum and maximum gas pressure for each device must be considered. Whenever the minimum and maximum gas pressures vary between devices, gas pressure regulators at each unit must be installed to allow regulation at any individual unit. Gas pressure must never exceed the maximum allowable rating of any connected device.

The total length of gas piping as well as fitting pressure drop must be considered when sizing the gas piping. Total equivalent length must be calculated from the meter or source location to the last water heater connected on the header. The values in the Gas Piping Tables 4, 5 and 6 (in Section 7: *Gas Piping Tables*, below), which contain data extracted from NFPA 54, must be used as a *minimum guideline*. Gas pipe size must be selected on the total *equivalent* length from the appropriate pressure table. The gas volume for CFH (m<sup>3</sup>/hr.) flow will be the input divided by the calorific value of the fuel to be supplied.



**6. GAS HEADER SIZING**

Main supply gas pipe sizing must be developed for the total plant. Water heater gas manifold piping must be sized based on the volume requirements and lengths between water heaters and the fuel main. Header sizes can be either full size or stepped in size as units are connected. A typical gas piping header diagram for a 2-module Innovation Water Heater Plant is illustrated in Figure 3.



**\*NOTE:** A supply gas regulator is required on each water heater gas inlet *only* for Massachusetts installations.

**Figure 3: Typical Multiple Water Heater Manifold Construction**

\* Based on Table 4 on the following pages for natural gas, 0.6 specific gravity, 1,000 CFH (28 m<sup>3</sup>/hr.) / unit, actual header sizes will vary with length of pipe run and fittings employed. For propane gas (1.6 specific gravity, 2,520 BTU/FT<sup>3</sup>) header sizing, consult NFPA 54.

If supply gas pressure exceeds 14.0" W.C. (3.49 kPa), a single lock-up regulator in the header, or individual lock-up regulators in each unit must be used to bring the gas pressure down to 14.0" W.C. (3.49 kPa). The header should be located above or behind the water heater. Gas piping should not be installed directly over top or front of any part of the water heater. Sufficient clearances for maintenance are required.

**7. GAS PIPING TABLES**

The data in the following pipe and vent sizing tables have been extracted from the National Fire Protection Association Article 54 (NFPA 54).

<b>TABLE 5: Maximum Capacity of Pipe for 0.5 PSI or Less (Imperial Units)</b>														
<b>In Cubic Feet of Gas per Hour for a Pressure Drop of 0.3-inch Water Column</b>														
Nominal Iron Pipe Size in Inches	Internal Diameter in Inches	Total Equivalent Length of Pipe (Feet)												
		10	20	30	40	50	60	70	80	90	125	150	175	200
<b>2.00</b>	<b>2.067</b>	3,050	2,100	1,650	1,450	1,270	1,150	1,050	990	930	780	710	650	610
<b>2.50</b>	<b>2.469</b>	4,800	3,300	2,700	2,300	2,000	1,850	1,700	1,600	1,500	1,250	1,130	1,050	980
<b>3.00</b>	<b>3.068</b>	8,500	5,900	4,700	4,100	3,600	3,250	3,000	2,800	2,600	2,200	2,000	1,850	1,700
<b>4.00</b>	<b>4.026</b>	17,500	12,000	9,700	8,300	7,400	6,800	6,200	5,800	5,400	4,500	4,100	3,800	3,500

<b>TABLE 6: Maximum Capacity of Pipe for 3.45 kPa or Less (Metric Units)</b>														
<b>In Cubic Meters of Gas per Hour (m3/hr.) for a Pressure Drop of 75 Pa</b>														
Nominal Iron Pipe Size in mm	Internal Diam. in mm	Total Equivalent Length of Pipe (Meters)												
		3.05	6.1	9.14	12.19	15.24	18.28	21.33	24.38	27.43	38.1	45.72	53.34	60.96
<b>50.80</b>	<b>52.50</b>	86.37	59.47	46.72	41.06	35.96	32.56	29.73	28.03	26.33	22.09	20.10	18.41	17.27
<b>63.50</b>	<b>62.71</b>	135.92	93.45	76.46	65.13	56.63	52.39	48.14	45.31	42.48	35.40	32.00	29.73	27.75
<b>76.20</b>	<b>77.93</b>	240.69	167.07	133.09	116.10	101.94	92.03	84.95	79.29	73.62	62.30	56.63	52.39	48.14
<b>101.60</b>	<b>102.26</b>	495.54	339.80	274.67	235.03	209.54	192.55	175.56	164.24	152.91	127.43	116.10	107.60	99.11

7 GAS PIPING TABLES

**TABLE 7: Pipe Sizing Table for 1 Pound Pressure (Imperial Units)**  
Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour with a 10% Pressure Drop and a Gas of 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe in Inches	Internal Diameter in Inches	Total Equivalent Length of Pipe (Feet)							
		50	100	150	200	250	300	400	500
2.00	2.067	4245	2918	2343	2005	1777	1610	1378	1222
2.50	2.469	6766	4651	3735	3196	2833	2567	2197	1947
3.00	3.068	11962	8221	6602	5650	5008	4538	3884	3442
3.50	3.548	17514	12037	9666	8273	7332	6644	5686	5039
4.00	4.026	24398	16769	13466	11525	10214	9255	7921	7020
5.00	5.047	44140	30337	24362	20851	18479	16744	14330	12701
6.00	6.065	71473	49123	39447	33762	29923	27112	23204	20566
8.00	7.981	146849	100929	81049	69368	61479	55705	47676	42254

**TABLE 8: Pipe Sizing Table for 6.89 kPa Pressure: (Metric Units)**  
Capacity of Pipes of Different Diameters and Lengths in Cubic Meters per Hour with a 10% Pressure Drop and a Gas of 0.6 Specific Gravity

Pipe Size of Schedule 40 Standard Pipe in mm	Internal Diam. in mm	Total Equivalent Length of Pipe (Meters)							
		15.24	30.48	45.72	60.96	76.2	91.44	121.92	152.4
50.80	52.50	120.21	82.63	66.35	56.78	50.32	45.59	39.02	34.60
63.50	62.71	191.59	131.70	105.76	90.50	80.22	72.69	62.21	55.13
76.20	77.93	338.73	232.79	186.95	159.99	141.81	128.50	109.98	97.47
88.90	90.12	495.94	340.85	273.71	234.27	207.62	188.14	161.01	142.69
101.60	102.26	690.88	474.85	381.32	326.35	289.23	262.07	224.30	198.79
127.00	128.19	1249.91	859.05	689.86	590.44	523.27	474.14	405.78	359.65
152.40	154.05	2023.90	1391.02	1117.02	956.04	847.33	767.73	657.07	582.37
203.20	202.72	4158.32	2858.01	2295.06	1964.29	1740.90	1577.40	1350.04	1196.51

7 GAS PIPING TABLES

<b>TABLE 9: Pipe Sizing Table for an Initial Pressure of 2.0 PSI (Imperial Units)</b> Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour with a 10% Pressure Drop and a Gas of 0.6 Specific Gravity									
Pipe Size of Schedule 40 Standard Pipe in Inches	Internal Diameter in Inches	Total Equivalent Length of Pipe (Feet)							
		50	100	150	200	250	300	400	500
2.00	2.067	6589	4528	3636	3112	2758	2499	2139	1896
2.50	2.469	10501	7217	5796	4961	4396	3983	3409	3022
3.00	3.068	18564	12759	10246	8769	7772	7042	6027	5342
3.50	3.548	27181	18681	15002	12840	11379	10311	8825	7821
4.00	4.026	37865	26025	20899	17887	15853	14364	12293	10895
5.00	5.047	68504	47082	37809	32359	28680	25986	22240	19711
6.00	6.065	110924	76237	61221	52397	46439	42077	36012	31917

<b>TABLE 10: Pipe Sizing Table for an Initial Pressure of 13.79 kPa: (Metric Units)</b> Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour with a 10% Pressure Drop and a Gas of 0.6 Specific Gravity									
Pipe Size of Schedule 40 Standard Pipe in mm	Internal Diameter in mm	Total Equivalent Length of Pipe (Meters)							
		15.24	30.48	45.72	60.96	76.2	91.44	121.92	152.4
50.80	52.50	186.58	128.22	102.96	88.12	78.10	70.76	60.57	53.69
63.50	62.71	297.36	204.36	164.13	140.48	124.48	112.79	96.53	85.57
76.20	77.93	525.68	361.30	290.14	248.31	220.08	199.41	170.67	151.27
88.90	90.12	769.68	528.99	424.81	363.59	322.22	291.98	249.90	221.47
101.60	102.26	1072.22	736.95	591.80	506.51	448.91	406.75	348.10	308.51
127.00	128.19	1939.83	1333.22	1070.64	916.31	812.13	735.85	629.77	558.16
152.40	154.05	3141.03	2158.80	1733.60	1483.73	1315.01	1191.49	1019.75	903.79

7 GAS PIPING TABLES

<b>TABLE 11: Pipe Sizing Table for an Initial Pressure of 5.0 PSI (Imperial Units)</b>									
<b>Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour with a 10% Pressure Drop and a Gas of 0.6 Specific Gravity</b>									
Pipe Size of Schedule 40 Standard Pipe in Inches	Internal Diameter in Inches	Total Equivalent Length of Pipe (Feet)							
		15.24	30.48	45.72	60.96	76.2	91.44	121.92	152.4
2.00	2.067	11786	8101	6505	5567	4934	4471	3827	3391
2.50	2.469	18785	12911	10368	8874	7865	7126	6099	5405
3.00	3.068	33209	22824	18329	15687	13903	12597	10782	9556
3.50	3.548	48623	33418	26836	22968	20365	18444	15786	13991
4.00	4.026	67736	46555	37385	31997	28358	25694	21991	19490
5.00	5.047	122544	84224	67635	57887	51304	46485	39785	35261
6.00	6.065	198427	136378	109516	93732	83073	75270	64421	57095

<b>TABLE 12: Pipe Sizing Table for an Initial Pressure of 34.47 kPa: (Metric Units)</b>									
<b>Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour with a 10% Pressure Drop and a Gas of 0.6 Specific Gravity</b>									
Pipe Size of Schedule 40 Standard Pipe in mm	Internal Diameter in mm	Total Equivalent Length of Pipe (Meters)							
		15.24	30.48	45.72	60.96	76.2	91.44	121.92	152.4
<b>50.80</b>	<b>52.50</b>	333.74	229.40	184.20	157.64	139.72	126.61	108.37	96.02
<b>63.50</b>	<b>62.71</b>	531.93	365.60	293.59	251.29	222.71	201.79	172.71	153.05
<b>76.20</b>	<b>77.93</b>	940.38	646.31	519.02	444.21	393.69	356.71	305.31	270.60
<b>88.90</b>	<b>90.12</b>	1376.86	946.30	759.92	650.38	576.68	522.28	447.01	396.18
<b>101.60</b>	<b>102.26</b>	1918.08	1318.30	1058.63	906.06	803.01	727.58	622.72	551.90
<b>127.00</b>	<b>128.19</b>	3470.08	2384.97	1915.22	1639.19	1452.78	1316.32	1126.59	998.49
<b>152.40</b>	<b>154.05</b>	5618.86	3861.82	3101.16	2654.21	2352.38	2131.42	1824.21	1616.76

## 8. VENTING OF GAS SUPPLY REGULATORS

PVI's general guidelines for venting of gas regulators are listed below. These guidelines must be followed to ensure reliable and proper operation. You must also consult local codes and the gas regulator manufacturer for additional details. Always follow the most stringent guidelines available, including those below.

- When venting a gas supply regulator, the vent pipe must be no smaller than the regulator vent.
- In a multiple unit installation, each regulator must have a separate vent line.
- Vent lines must not be manifolded together or with any other equipment at the site that also requires atmospheric vents.
- When sizing the vent, pipe diameters must be increased by one pipe diameter every 20 equivalent feet of pipe.

Each 90° elbow is equivalent to approximately:

- ⇒ 2.5 feet (0.76 m) for nominal pipe sizes of up to 3/4" (19 mm)
- ⇒ 4.5 feet (1.37 m) for nominal pipe sizes of up to 1-1/2" (38 mm)
- ⇒ 10.5 feet (3.2 m) for nominal pipe sizes of up to 4" (101 mm)

Each 45° elbow is equivalent to approximately:

- ⇒ 1 foot (0.3 m) for nominal pipe sizes of up to 3/4" (19 mm)
- ⇒ 2 feet (0.61 m) for nominal pipe sizes of up to 1-1/2" (38 mm)
- ⇒ 5 feet (1.52 m) for nominal pipe sizes of up to 4" (101 mm)

