in which these appliances are installed but the extent to which they must be equipped with reliable safety devices. For example, connection to an effective flue is mandatory. Furthermore, all such heating equipment must incorporate an automatic ignition pilot that will shut off gas supply to the main burner or burners in the event of pilot outage. If liquefied petroleum gas is used, the automatic pilot must cut off all gas supply to the appliance, including the pilot burner, in case the pilot flame becomes extinguished.

Rating and Sizing Gas Appliances

Input rating for a gas appliance is established by demonstrating that the appliance can meet the Approval Requirements of the ASA. The tests are conducted at the A.G.A. Testing Laboratories. Output rating is determined from the approved input and a minimum required efficiency stated in the Approval Requirements, and is the heat available at the outlet.

Although gas-burning equipment usually is completely automatic, maintaining the temperature of rooms at a predetermined figure, there are some manually controlled installations. In order to overcome effectively the starting load and losses in piping, a manually-controlled gas boiler should have an output as much as 100 percent greater than the equivalent standard radiation which it is expected to serve.

Boilers under thermostatic control, however, are not subject to such severe pick-up loads and consequently, it is possible to use a lower selection factor. For a gas-fired boiler or furnace under thermostatic control, a factor of 20 to 25 percent is usually sufficient for pick-up allowance.

In those installations, in mild climates where 100 percent outdoor air is used, furnaces should be of larger size in order to provide adequate capacity and quick pickup under intermittent heating conditions.

The factor to be allowed for loss of heat from piping will vary somewhat, the proportionate amount of piping installed being greater for small installations than for large ones. For selection factors to be added to installed radiation under thermostatic control, see Chapter 35.

Appliances used for heating with gas should bear the approval seal of the A.G.A. Testing Laboratories on the manufacturer's nameplate, together with the official input and output ratings. It is not permissible to operate a gas heating unit above its stated rating. It is necessary to reduce ratings at the rate of 4 percent for each 1000 ft elevation above sea level when appliances are installed in localities above 2000 ft elevation. Installations should be made in accordance with recommendations of the American Gas Association, as shown in current *American Standard for Installation of Gas Appliances and Gas Piping*, ASA Z21.30, and in accordance with local regulations.

Sizing of Gas Piping

Piping for gas appliances should be of adequate size, and so installed as to provide a supply of gas sufficient to meet the maximum demand without undue loss of pressure between the point of supply (the meter) and the burner. The size of gas pipe required depends upon the following:

1. Maximum gas consumption to be provided.
2. Length of pipe and number of fittings.
3. Allowable loss in pressure from the outlet of the meter to the burner.
4. Specific gravity of the gas.

To obtain the cubic feet per hour of gas required by the burner, divide the Btu input rate at which the burner will be adjusted, by the average Btu heating value per cubic foot of the gas.

Capacities of different sizes and lengths of pipe, in cubic feet per hour, with a pressure drop of 0.3 in. of water column for a gas of 0.60 specific gravity, are shown in Table 3. In adopting a 0.3 in. pressure drop, due allowance for an ordinary number of fittings was made.

To convert the values given in Table 3 to capacities for another gas of different specific gravity, multiply the tabular values by the multipliers shown in Table 4.

Pipe capacities for gas flow up to 100,000 cfh for various lengths of pipe are given in Fig. 16 which is based on a specific gravity of 0.60. The capacity at a given pressure loss for a different specific gravity may be obtained by multiplying Fig. 6 capacities by a multiplier obtained from Table 4.

Table 3 .... Capacity of Gas Piping—Cu Ft Per Hr
(At pressure drop of 0.3 in. water. Specific gravity = 0.60)

Length of Pipe Ft	Iron Pipe Size (IPS) Inches									Length of Pipe Ft
	½	¾	1	1¼	1½	2	2½	3	4	
10	132	278	520	1,050	1,600	3,050	4,800	8,500	17,500	10
20	92	190	350	730	1,100	2,100	3,300	5,900	12,000	20
30	73	152	285	590	890	1,650	2,700	4,700	9,700	30
40	63	130	245	500	760	1,450	2,300	4,100	8,300	40
50	56	115	215	440	670	1,270	2,000	3,600	7,400	50
60	50	105	195	400	610	1,150	1,850	3,250	6,800	60
70	46	96	180	370	560	1,050	1,700	3,000	6,200	70
80	43	90	170	350	530	990	1,600	2,800	5,800	80
90	40	84	160	320	490	930	1,500	2,600	5,400	90
100	38	79	150	305	460	870	1,400	2,500	5,100	100
125	34	72	130	275	410	780	1,250	2,200	4,500	125
150	31	64	120	250	380	710	1,130	2,000	4,100	150
175	28	59	110	225	350	650	1,050	1,850	3,800	175
200	26	55	100	210	320	610	980	1,700	3,500	200

From *American Standard Installation of Gas Appliances and Gas Piping*, ASA Z21.30-1959.

Table 4 .... Multipliers for Various Specific Gravities
(For Use With Table 3 and Fig. 16)

Specific Gravity	Multiplier	Specific Gravity	Multiplier
0.35	1.31	1.00	0.775
0.40	1.23	1.10	0.740
0.45	1.16	1.20	0.707
0.50	1.10	1.30	0.680
0.55	1.04	1.40	0.655
0.60	1.00	1.50	0.633
0.65	0.962	1.60	0.612
0.70	0.926	1.70	0.594
0.75	0.895	1.80	0.577
0.80	0.867	1.90	0.565
0.85	0.841	2.00	0.547
0.90	0.817	2.10	0.535

COMMERCIAL AND INDUSTRIAL GAS EQUIPMENT

No attempt can be made, due to space limitation, to describe or classify the varied types of equipment used for commercial and industrial applications. Much of the equipment utilized is custom built to suit a particular process. Certain standard parts such as venturi and burner head sets, ring burners, proportional mixers, or compressors, are purchased for assembly in existing equipment, usually by the installer. Furnaces to provide particular atmospheres or for annealing, soaking pits, metal melting, etc. are usually engineered by industrial gas-equipment manufacturers.

Burners utilized in industrial equipment often operate at gas pressures higher than encountered in domestic usage. High-pressure gas provides flexibility of control required in the production of constant temperatures. In addition, air-gas ratios can be closely maintained under throttling conditions, and heat liberation per cubic foot of combustion space is considerably greater than can be achieved with lower pressures.

A few of the many basic types of burners used are as follows: single-pipe high-pressure, proportional mixing, pre-mix, two-pipe high-pressure, and atmospheric.

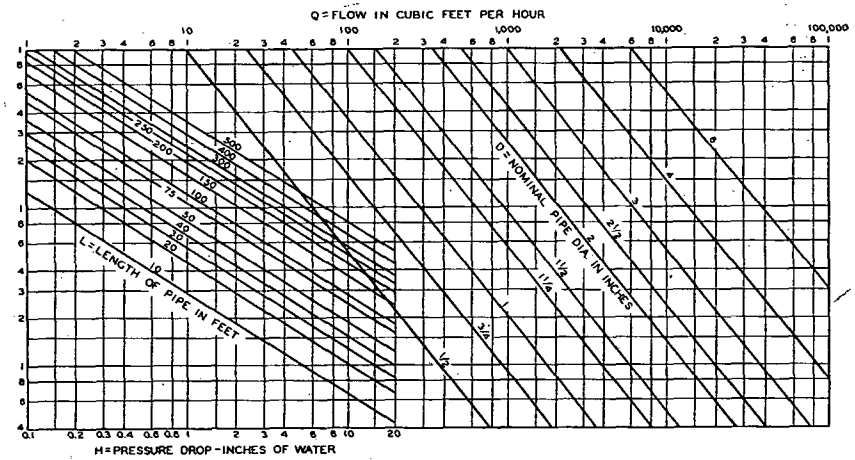
The *single-pipe high-pressure burner* system utilizes gas delivered to the orifice of a venturi at pressures from 10 to 50 psig. A constant pressure compressor, sometimes remotely placed, is occasionally used to increase the gas pressure. The velocity of the gas issuing from the orifice entrains primary air which is controlled by an air shutter on the venturi tube. An advantage of this system is that when the gas pressure is reduced (lowering the input) the air-gas ratio will remain constant over a fairly wide range.

In the *proportional mixing burner*, an enclosed type venturi is used and high-pressure air is delivered through an orifice. The resulting partial vacuum entrains the gas which is supplied through a zero pressure governor. When the air pressure is reduced, the amount of gas entrained is similarly reduced, thus maintaining a constant air-gas ratio over a wide fuel capacity range.

The *pre-mix burner* system embodies a compressor which mixes air and gas intimately and discharges the mixture through pipes to the burners where it is discharged through orifices and burned. The pre-mix compressor can be remotely installed and the mixture can be closely controlled.

The *two-pipe high-pressure burner* system utilizes both air and gas under pressure, both being delivered through orifices and mixed prior to delivery to the burner.

The *atmospheric burner* system is not commonly used. It consists of a burner supplied with gas at a pressure of 2



Based on Spitzglass Friction Factor and 0.60 Specific Gravity. To convert for other specific gravity see Table 4.

Fig. 16 .... Flow vs. Pressure Drop for Low Pressure Natural Gas