

be completely evaporated below 680 F are likely to undergo cracking in vaporizing type burners, with the resulting possibilities of smoky combustion and residues in the oil burner. A complete distillation curve cannot usually be determined for fuel oils containing fractions that evaporate above 680 F.

Since No. 1 grade fuel oil in *Commercial Standard* CS12-48 has a maximum end point of 625 F, it can in most cases be completely evaporated in atmospheric vaporizing burners without cracking, although occasionally an oil is found that undergoes cracking at temperatures below 625 F. By the same criterion, No. 2 grade fuel oil in the *Commercial Standard*, which can have a maximum distillation temperature of 675 F at the 90 percent point, would frequently be cracked in a vaporizing burner. However some No. 2 fuel oils do not crack before complete evaporation takes place. Vaporizing-type burners can generally use only No. 1 fuel oil with assurance that thermal decomposition will not occur during combustion. On the other hand either No. 1 or No. 2 fuel oils may be employed in high or low pressure atomizing burners when the temperatures developed in the combustion chamber are high enough to assure complete combustion, even if the fuel oil is thermally decomposed.

In vaporizing burners, preheating of the combustion air and fuel, complete evaporation of fuel before it is exposed to intense heat, and thorough mixing of the air and gasified fuel promote complete combustion without smoke and with a minimum of excess air. In pressure-type burners preheating of the combustion air, a maximum of air turbulence, good atomization of the fuel, and high combustion chamber temperatures (preferably red hot) promote smokeless combustion with a minimum of excess air.

Natural draft burners depend on the motivating force of a chimney to induce enough air into the burner for complete combustion. Forced draft burners are supplied with combustion air by means of a blower or fan; the chimney merely conducts the flue gases outdoors and prevents leakage of flue gases inside the building. More details on the operation of the different kinds of oil burners and on chimneys and draft will be found in Chapters 15 and 17 respectively.

FUEL GASES

Fuel gases employed for various heating and air conditioning processes throughout the United States fall into three broad classifications: natural, manufactured, and liquefied petroleum. Natural gas is a mixture of several combustible gases and, usually, a small percentage of inert gases obtained from geologic formations. Natural gas is produced in significant amounts in 20 states. Texas is by far the largest producer, followed by Louisiana, Oklahoma, California, Kansas, and West Virginia. Manufactured gas is made by the distillation or cracking of oil or coal, by the steam carbon reaction, or by combinations of these processes. Liquefied petroleum gases (propane and butane) are higher hydrocarbon gases normally obtained as a by-product of oil refineries or by stripping natural gas. These two compounds are generally gaseous under usual atmospheric conditions although they can be liquefied by the application of moderate pressures at normal temperatures.

The demand for gaseous fuels has increased so tremendously during the past 25 years that few cities now can be said to depend solely on one source of supply. During peak load periods, heating demands on natural gas distribution systems may necessitate augmenting the base supply with supplemental fuels such as high Btu oil gas or liquefied petroleum gas-

air mixtures. The supply of manufactured gases may be similarly increased by adding natural gas, reformed refinery gases, or relatively low heating value mixtures of liquefied petroleum gas and air.

In American gas practice the heating value of a gas and appliance efficiencies are based on the gross heating value. This value is the number of Btu liberated by complete combustion, at constant pressure, of one cubic foot of gas saturated with water vapor and measured at 60 F and 30 in. of mercury, with air at the same temperature and pressure. Products of combustion are cooled to the initial temperature of the gas and air and the water formed by combustion of free and combined hydrogen is condensed to the liquid state.

Classification of Gases

Representative properties of gaseous fuels commonly employed for domestic heating processes are shown in Table 6.^{15, 16, 17, 18}

Natural gas contains from 55 to 98 percent methane with various percentages of higher hydrocarbons, chiefly ethane. In addition to these components, small quantities of non-combustible gases such as carbon dioxide, nitrogen, and helium are sometimes present. Percentages of the different components vary with the area from which natural gas is withdrawn. They may even vary slightly from any given well during its lifetime but these variations are inconsequential insofar as the utilization of the gas is concerned. Heating values of natural gases vary from 900 to 1400 Btu per cu ft but the usual range for use is from 1000 to 1050 Btu (gross) per cu ft. A typical analysis is given in Table 6.

Manufactured gases commonly produced are listed in Table 6. Gross, or higher, calorific values of typical send-out gases made from these manufactured gases generally range from 500 to 600 Btu per cu ft. Due largely to the greatly increased demand for city gases the tendency during recent years has been to increase rather than to decrease heat content of manufactured gases, thus making it possible to serve more customers through the existing distribution system.

Mixed gases are a result of increased distribution of natural gas, through transcontinental transmission lines, into areas having existing manufactured gas facilities. In such instances some gas companies supply a 600 to 800 Btu mixture (See Table 6). In some territories these mixtures are distributed as an intermediate step in changing over from manufactured gas to natural gas. Although the burden of adjusting installed heating and air conditioning equipment and supplying new orifices and burner equipment is generally assumed by the gas companies when the gas is changed, it is advisable to consult the local gas company to insure that equipment is provided with proper orifices and burners when installed.

Most states enforce legislation through their public service commissions to require delivery of a gas of specified average or minimum heating value within their respective limits. Any given heating value within reason fortunately may be maintained and yet permit considerable latitude in the composition of the gas distributed. Hence the constituents of city gases are not necessarily the same in different districts nor even at successive stations in the same district. In every community, however, the objective is to maintain variations in composition and gas pressure within limits which will provide satisfactory operation and performance of all common types of gas burning equipment.

Liquefied petroleum gases, such as propane and butane or mixtures thereof have calorific values ranging from 2500 to 3200 Btu per cu ft. These