520 and 545 Btu per cubic foot, with an average of 535. A given heat value may be maintained and yet leave considerable latitude in the composition so that as distributed the composition is not necessarily the same in different districts, nor at successive times in the same district. There are limits to the variation allowable, because the specific gravity of the gas depends on the composition, and too great a change in the specific

TABLE 5. REPRESENTATIVE PROPERTIES OF GASEOUS FUELS, BASED ON GAS AT 60 F

Gas	Btu per Cu Ft		Specific Gravity, Air = 1.00	Air Required for Combustion, (Cu Ft)	Products of Combustion				Theoretical Flame Temperature, (deg Fahr)
					Cubic Feet			Per Cent CO_2 Dry Basis	
	High (Gross)	Low (Net)			CO_2	H_2O	Total with N_2		
Natural gas—Mid-Continental	967	873	0.57	9.17	0.97	1.92	10.2	11.7	3580
Natural gas—Ohio	1130	1025	0.65	10.70	1.17	2.16	11.8	12.1	3600
Natural gas—Pennsylvania	1232	1120	0.71	11.70	1.30	2.29	12.9	12.3	3620
Retort coal gas	575	510	0.42	5.00	0.50	1.21	5.7	11.2	3665
Coke oven gas	588	521	0.42	5.19	0.51	1.25	5.9	11.0	3660
Carburetted water gas	536	496	0.65	4.37	0.74	0.75	5.0	17.2	3815
Blue water gas	308	281	0.53	2.26	0.46	0.51	2.8	22.3	3800
Anthracite producer gas	134	124	0.85	1.05	0.33	0.19	1.9	19.0	3000
Bituminous producer gas	150	140	0.86	1.24	0.35	0.19	2.0	19.0	3160
Oil gas	575	510	0.35	4.91	0.47	1.21	5.6	10.7	3725

gravity necessitates a change in the adjustment of the burners of small appliances.

Combustion of Gaseous Fuels

Table 5 shows that a large proportion of the products of combustion when gas is burned, may consist of water vapor, and that the greater the proportion of water vapor, the lower the maximum attainable CO_2 by gas analysis. The table also shows that a low calorific value does not necessarily mean a low flame temperature since, for example, natural gas has a theoretical flame temperature of 3600 F and blue water gas of 3800 F, although it has a calorific value less than one-third that of natural gas.

The quantity of air given in Table 5 is that required for theoretical combustion, but with a properly designed and installed burner, the excess air can be kept low. The division of the air into primary and secondary is a matter of burner design and the pressure of gas available, and also of the type of flame desired. All the air can be made primary, and by proper pre-mixing of the gas and air the flame can be made short.

Gas Heating Appliances

For information on gas heating appliances, refer to Chapter 19.

FUEL REQUIRED FOR HEATING[1]

An estimate of the fuel which will be required for a heating season requires a knowledge of the total heat requirements of the building and an assumption of the average efficiency of utilization of the fuel. The accuracy of the estimate will depend on the ability to predict these values and on the care taken in making allowances for factors of operation not covered by the general formula. The fuel requirements are given by the following general equation:

$$F = \frac{H \times (t - t_a) \times N}{(t - t_o) \times C \times E} \qquad (1)$$

where

F = quality of fuel required for a heating season.
N = number of hours of heating season corresponding to average temperature, t_a.
t = inside temperature, degrees Fahrenheit.
t_a = average outside temperature, degrees Fahrenheit.
t_o = outside design temperature, degrees Fahrenheit.
H = calculated heat loss of building based on outside temperature of t_o, Btu per hour.
C = Calorific value of one unit of fuel, the unit being the same as that on which F is based.
E = efficiency of utilization of fuel, per cent.

Hourly Heat Loss, *H*

The hourly heat loss (H) is equal to the sum of the transmission losses (H_t) and the infiltration losses (H_i) of the various rooms or spaces to be heated and the total equivalent heating surface required is equal to $\frac{H}{240}$ sq ft. In estimating the fuel consumption of a building of more than one room divided by walls or partitions, it is not correct to use the calculated heat loss of the building without making the proper allowance for the fact that the heating load at any time does not involve the sum of the infiltration losses of all of the heated spaces of the building but only part of the infiltration losses. This is explained in Chapter 4.

It is sufficiently accurate in most cases to consider only half of the total infiltration losses of a building having interior walls and partitions, and the value of H in Equation 1 would, under these conditions, be equal to $H_t + \frac{H_i}{2}$. If a building has no interior walls or partitions, whatever air enters through the cracks on the windward side must leave through the cracks on the leeward side, and only half of the total crack should be used in computing the infiltration for each side and end of the building. Under these conditions it is sufficiently accurate to use the total calculated heat loss (H) for the building.

[1]For further information on this subject see Estimating Fuel Consumption, by Paul D. Close, *Heating, Piping and Air Conditioning*, May, 1931.