FACTORS AFFECTING NATURAL DRAFT

As indicated in both Equations 1 and 2, the theoretical natural draft is directly proportional to the height of the flue and is dependent upon the absolute mean temperature of the gases within the flue. It is also directly proportional to the density of the air outside the flue although the effect of this factor is minor.

The formulas for theoretical natural draft are based on mean or average temperature which is one half of the sum of the entering and exit temperature. Since the difference in exit and entering temperatures, or the temperature gradient in the flue, is due to the escape of heat through the walls of the flue and chimney, the heat transfer characteristics of the chimney construction affect draft. Heat transfer is also affected by the rate of flow of the flue gases through the flue so that draft is also affected directly.

The flow of flue gases through the flue is retarded by friction which varies directly with the friction coefficient of the flue surface, and with the rate of flue gas flow. The friction loss may be estimated by means of one of the formulas for ducts such as the Fanning equation or it may be estimated with sufficient accuracy by the method used for air ducts. (See Chapter 31.)

The height of the flue is measured from the point of entrance of the flue gases to the top of the flue. With no wind to produce an aspirating effect and with no obstruction such as a rain cap at the top of the flue, the column of flue gases may extend upward above the top of the flue for several feet. The effect of this column may be sufficient to overcome the negative or retarding effect of friction and to cause the observed draft to exceed the theoretical draft. This added effect has been measured in some test work. A wind blowing across the top of the flue may also produce an aspirating effect sufficient to overcome the effect of friction and to cause the observed draft to exceed the theoretical. Both of these effects are transient and unreliable and should not be considered in determining the proper design of a chimney.

AVAILABLE DRAFT

The available draft produced by any chimney is equal to the theoretical natural draft minus the friction loss. Given the height, the heat transfer characteristics of the chimney construction, the entering temperature of the flue gases and their volume, and the friction coefficient of the flue and its dimensions, the available draft is readily calculable.

The efficiency of a chimney is defined as the ratio of the observed draft or available draft, produced by the chimney for a given inlet temperature and flow rate, to the ideal draft that would be observed if the same quantity of flue gases traversed the chimney without cooling and without friction. The chimney efficiency may be calculated as follows:

$$\text{Efficiency} = \frac{\text{final measured draft}}{\text{ideal draft calculated from the inlet temperature}}$$

REQUIRED DRAFT

Before the proper chimney for a particular installation can be selected or designed, the required draft of the combustion unit must be known. The required draft is equal to the sum of all of the resistances to gas flow from the point at which combustion air enters the unit to and including the chimney connection. This is based on the assumption that air for combustion is available without restriction (such as would be caused by tightly enclosed building construction) at that point of entrance to the unit. Particularly in residences, unrestricted supply of combustion air must be assured.

Fig. 1 presents information on the fuel-bed draft loss for various kinds of coal burned at different rates. Rough generalizations can be given for the losses in the flue passages of boiler or furnace but, on account of the great differences in such devices, more reliable data on their flue gas volume, temperature and flue resistance should be obtained for design purposes from their respective manufacturers.

Flue gases encounter resistance to flow in breechings or smoke pipes, and this can probably be treated with sufficient accuracy by means of the method used for air ducts. (See Chapter 31.) The friction in straight ducts can be estimated by means of the last term of Equations 3 and 4.

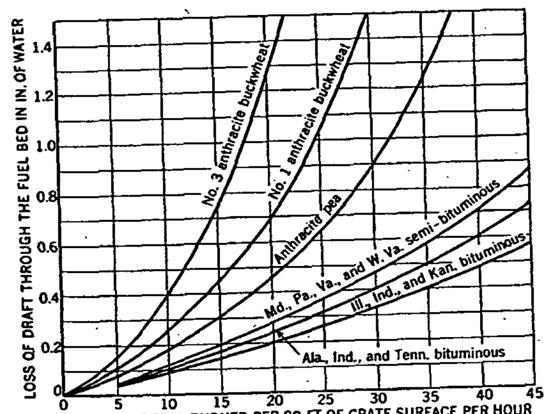

Fig. 1. Draft Required at Different Rates of Combustion for Various Kinds of Coal

Also, the temperature of flue gases falls during passage through breechings or flue pipes. For uninsulated surfaces this probably can be adequately estimated by assuming a loss of heat from the flue gas of 3 Btu per (hr) (sq ft) (Fahrenheit deg temperature difference between the gases and surrounding air).

INDUSTRIAL CHIMNEYS

Chimneys can be classified as residential and industrial, the chief difference being their sizes and the types of draft. Chimneys over approximately $1\frac{1}{2}$ ft in diameter are in the industrial chimney class, and their requirements should be treated accordingly. The majority of industrial chimneys operate under induced or forced draft, resorting to natural draft operation only in the case of emergencies. They are built of brick, concrete, or steel, depending upon economy and the type of installation needed. Proper height is of importance because of removal of waste products, inasmuch as the products of combustion are often deflected downward around