where

H = height of chimney, feet.

B_o = existing barometric pressure, inches of mercury.

W_o = density of air at 0 F and 1 atmosphere pressure, pounds per cubic foot.

W_c = density of flue gas at 0 F and 1 atmosphere pressure, pounds per cubic foot.

T_o = temperature of air surrounding the chimney, Fahrenheit degrees absolute.

T_c = average or effective temperature of the gases in the chimney, Fahrenheit degrees absolute.

The quantity D_t, found by the formula, is the pressure difference between the gas inside and air outside of the chimney, in inches of water, when no flow occurs in the chimney. The quantity is variously known as

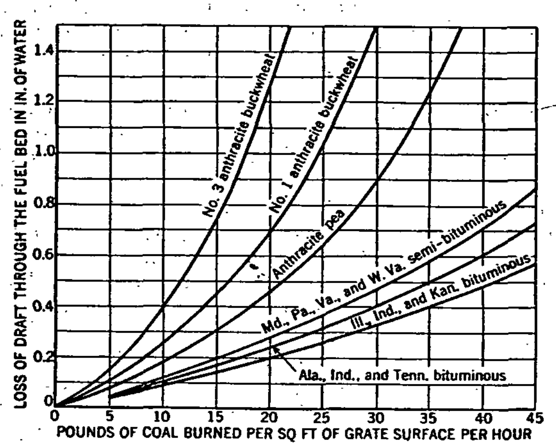

FIG. 1. DRAFT REQUIRED AT DIFFERENT RATES OF COMBUSTION FOR VARIOUS KINDS OF COAL

the theoretical draft, the static draft, or the computed draft. It is very useful in predicting and analyzing chimney performance, but it is seldom, if ever, attained in an actual chimney because of the friction incident to gas flow and the effects of wind.

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 flue gases traversed the chimney without cooling and without friction. The chimney efficiency may be calculated as follows:

$$\text{Efficiency} = \frac{\text{final measured draft}}{\text{ideal draft calculated from the inlet temperature}} \tag{2}$$

FACTORS AFFECTING REQUIRED DRAFT

Before the proper chimney can be selected for an installation, the required draft of the combustion unit must be known. The required draft is, of course, equal to the sum of all the resistances to gas flow from the ash pit door to, and including, the chimney connection.

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 32.) The friction in straight ducts can be estimated by means of the last term of Equations 3 and 4.

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 the chimney and, with the large amount of gases that are exhausted to the atmosphere through the industrial chimney, downwash can be very objectionable.[1]

AVAILABLE DRAFT FOR THE INDUSTRIAL CHIMNEY

The available draft, D_a, *for large chimneys and stacks* has been estimated with apparent satisfaction in the past by means of formulas which in effect deduct an estimated friction loss from a theoretical draft determined as in Equation 1. The friction loss can be estimated by means of one of the formulas available for ducts, such as the Fanning equation. This procedure results in formulas for the available draft as follows:

For a *cylindrical* stack:

$$D_a = 2.96\,HB_o\left(\frac{W_o}{T_o} - \frac{W_c}{T_c}\right) - \frac{0.00126W^2T_cfL}{D^5B_oW_c} \tag{3}$$

and for a *rectangular* stack:

$$D_a = 2.96\,HB_o\left(\frac{W_o}{T_o} - \frac{W_c}{T_c}\right) - \frac{0.000388W^2T_cfL(x+y)}{(xy)^3B_oW_c} \tag{4}$$

where

D_a = available draft, inches water gage.

H = height of chimney above inlet, feet.

B_o = existing barometric pressure, inches of mercury.

W_o = density of air at 0 F, 1 atmosphere pressure.

W_c = density of flue gas at 0 F, 1 atmosphere pressure.

T_o = temperature of atmosphere, Fahrenheit, absolute.