DETERMINING INDUSTRIAL CHIMNEY SIZES

If the required performance for a proposed chimney is known, and *if a chimney-gas velocity is assumed,* Equation 3 can be transposed to yield the necessary height, and an equation can be developed for the required diameter. These operations result in the following equations:

$$H = \frac{D_r}{2.96B_o\left(\frac{W_o}{T_o} - \frac{W_c}{T_c}\right) - \frac{0.184fW_cB_oV^2}{T_cD}} \qquad (7)$$

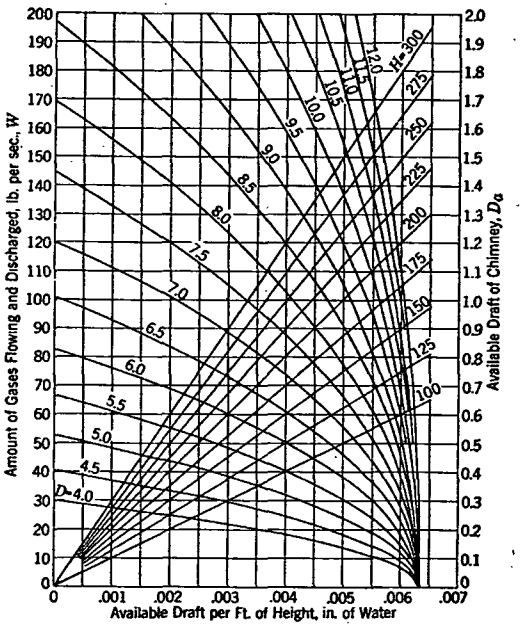

FIG. 3. CHIMNEY PERFORMANCE CHART

To solve a typical example: Proceed horizontally from a Weight Flow Rate point to intersection with diameter line; from this intersection follow vertically to chimney height line; from this intersection follow horizontally to the right to Available Draft scale. Starting from a point of Available Draft, take steps in reverse order.

The weight of gas per second, $W = 12.075\,\frac{D^2VB_oW_c}{T_c}$ from which

$$D = 0.288\sqrt{\frac{WT_c}{B_oW_cV}} \qquad (8)$$

where

H = required height of chimney above grate, feet.

D = required minimum diameter of chimney, feet.

V = chimney gas velocity, feet per second.

D_r = total required draft, inches of water.

For large chimneys, it is usual to assume that total construction cost

is least when the product HD (height × diameter) is minimum. On this assumption, the product of Equations 7 and 8 can be differentiated, and the differential set equal to zero to find the minimum. Solution for velocity then yields the following equation:

$$V_e = \left(\frac{0.772T_c\left(\frac{W_o}{T_o} - \frac{W_c}{T_c}\right)\sqrt{\frac{WT_c}{B_oW_c}}}{fW_c}\right)^{2/5} \qquad (9)$$

where

V_e = economical chimney gas velocity, feet per second.

Equations 7, 8 and 9 can of course be simplified if values are assumed for some of the factors in it. Some typical figures for boiler plants are:

Average chimney gas temperature 500 F ..... T_c = 960 F absolute
Average atmospheric temperature 62 F ..... T_o = 522 F absolute
Average coefficient of friction 0.016 ..... f = 0.016
Average chimney, gas density, 0 F, 1 Atmosphere ..... W_o = 0.09 lb per cu ft
Barometer reading, sea level ..... B_o = 29.92 in. Hg

When these values are substituted in Equations 7, 8 and 9, respectively, the results are:

$H = 190D_r$ (10) $\qquad D = 1.5W^{2/5}$ (11) $\qquad V_e = 13.7W^{1/5}$ (12)

These equations should be used for general operating conditions only, or where the required data necessary for an exact determination are difficult or impossible to secure. Whenever it is possible to obtain accurate data, or the anticipated operating conditions are fairly well known, the required size should be determined from Equations 7, 8, and 9.

Additional construction data for large industrial chimneys, whether brick, concrete, or steel, may be found in *Kent's Mechanical Engineers' Handbook*[4] or the *Handbook of Building Construction.*[5]

RESIDENTIAL CHIMNEYS

A residential chimney, to provide satisfactory performance, must have adequate height and area, be of permanently tight construction, be as smooth as practicable internally, and be of such construction as to present no fire hazard to the building. The height of a residence or apartment chimney is usually limited by the height of the building, and by cost. The chimney height and location that are best suited to a building from an architectural standpoint, will sometimes be unsatisfactory for the proper operation of the heating equipment. Chimney height is likely to be critical in one-story ranch-type or rambler-type houses, and therefore, it is important to compare carefully the available draft of the chimney and the required draft of the heating appliance to determine whether or not they will operate together satisfactorily.

Most residential chimneys are constructed of brick with a clay flue liner, but recently several lightweight, prefabricated chimneys have been marketed. These chimneys were primarily designed for use with gas equipment, but recently several have been approved by the *National Board of Fire Underwriters* for use with all types of fuels. The advantages of the lightweight, prefabricated chimney are ease of installation, somewhat lower cost, and reduced weight on the supporting structure.