atmospheric temperature of 62 F, a chimney gas temperature of 500 F, a unit chimney gas weight of 0.09 lb per cu ft, sea level atmospheric pressure, a coefficient of friction of 0.016, and a friction duct length equal to the height of the chimney above the grate level. These curves may be used for general operating conditions. For specific conditions, a new chart may be prepared from Equation 4.

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:

$$H = \frac{D_r}{2.96B_o\left(\frac{\rho_o}{T_o} - \frac{\rho_c}{T_c}\right) - \frac{0.184f\rho_c B_o V^2}{T_c d}} \quad (7)$$

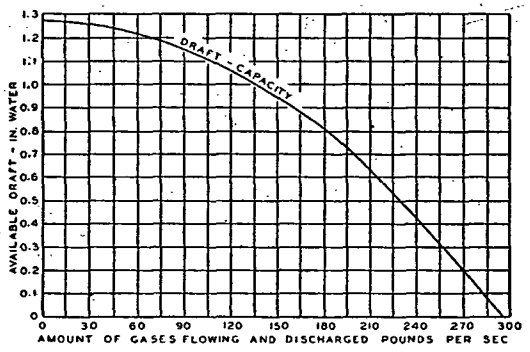

FIG. 2. TYPICAL SET OF OPERATING CHARACTERISTICS OF A NATURAL DRAFT CHIMNEY

The weight of gas per second, $W = 12.075\,\frac{dVB_o\rho_c}{T_c}$ from which

$$d = 0.288\sqrt{\frac{WT_o}{B_o\rho_c V}} \quad (8)$$

where

H = required height of chimney above inlet, 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:

$$V_e = \left(\frac{0.772T_c\left(\frac{\rho_o}{T_o} - \frac{\rho_c}{T_c}\right)\sqrt{\frac{WT_c}{B_o\rho_c}}}{f\rho_c}\right)^{2/5} \quad (9)$$

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	ρ_c = 0.09 lb per cu ft
Barometer reading, sea level	B_o = 29.92 in. Hg

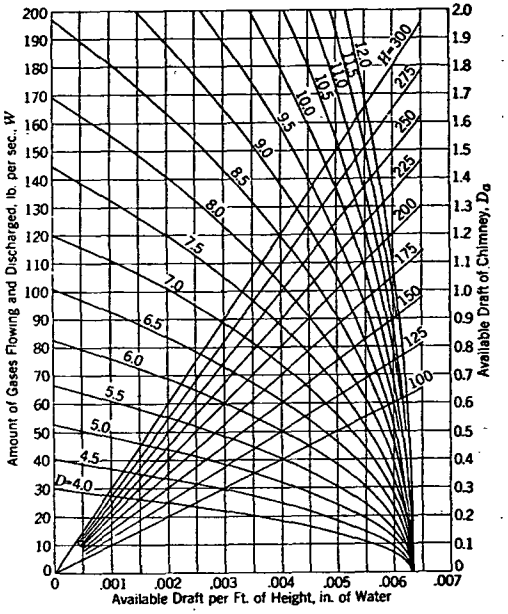

FIG. 3. CHIMNEY PERFORMANCE CHART

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.

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