the head-capacity curve of the pump and also to the dynamic-head capacity curve of the fan.

When the gases in the chimney are stationary, the draft created is termed the *theoretical draft*. When the gases are flowing, the theoretical intensity is diminished by the draft loss due to friction, the difference between the two being termed the total *available draft*. The general equation for this net total available draft intensity of a natural draft chimney with a circular section is as follows:

$$D_a = 2.96 H B_o \left(\frac{W_o}{T_o} - \frac{W_c}{T_c}\right) - \frac{0.00126 W^2 T_c f L}{D^5 B_o W_c} \qquad (1)$$

*where*

$D_a$ = available draft, inches of water.
$H$ = height of chimney above grate bars, feet.
$B_o$ = barometric pressure corresponding to altitude, inches of mercury.
$W_o$ = unit weight of a cubic foot of air at 0 F and sea level atmospheric pressure, pounds per cubic foot.
$W_c$ = unit weight of a cubic foot of chimney gases at 0 F and sea level atmospheric pressure, pounds per cubic foot.
$T_o$ = absolute temperature of atmosphere, degrees Fahrenheit.
$T_c$ = absolute temperature of chimney gases, degrees Fahrenheit.
$W$ = amount of gases generated in the combustion chamber of the boiler and passing through the chimney, pounds per second.
$f$ = coefficient of friction.
$L$ = length of friction duct of the chimney, feet.
$D$ = minimum diameter of chimney, feet.

The first term of the right hand expression of Equation 1 represents the theoretical draft intensity, and the second term, the loss due to friction.

*Example 1.* Determine the available draft of a natural draft chimney 200 ft in height and 10 ft in diameter operating under the following conditions: atmospheric temperature, 62 F; chimney gas temperature, 500 F; sea level atmospheric pressure, $B_o$ = 29.92 in. of mercury; atmospheric and chimney gas density, 0.0863 and 0.09, respectively; coefficient of friction, 0.016; length of friction duct, 200 ft. The chimney discharges 100 lb of gases per second.

Substituting these values in Equation 1 and reducing:

$$D_a = 2.96 \times 200 \times 29.92 \times \left(\frac{0.0863}{522} - \frac{0.09}{960}\right) - \frac{0.00126 \times 100^2 \times 960 \times 0.016 \times 200}{10^5 \times 29.92 \times 0.09}$$

$$= 1.27 - 0.14 = 1.13 \text{ in.}$$

Fig. 3 shows the variation in the available draft of a typical 200 ft by 10 ft chimney operating under the general conditions noted in Example 1. When the chimney is under static conditions and no gases are flowing, the available draft is equal to 1.27 in. of water, the theoretical intensity. As the amount of gases flowing increases, the available intensity decreases until it becomes zero at a gas flow of 297 lb per second, at which point the draft loss due to friction is equal to the theoretical intensity. The draft-capacity curve corresponds to the head-capacity curve of centrifugal pump characteristics and the dynamic-head-capacity curve of a fan. The point of maximum draft and zero capacity is called shut-off draft, or point of impending delivery, and corresponds to the point of shut-off head of a centrifugal pump. The point of zero draft and maximum capacity is





called the wide open point and corresponds to the wide open point of a centrifugal pump. A set of operating characteristics may be developed for any size chimney operating under any set of conditions by substituting the proper values in Equation 1 and then plotting the results in the manner shown in Fig. 3.

In substituting the values for the various factors in Equation 1, care should be exercised that the selections be as near the actual conditions as is practically possible. The following notes will serve as a guide for these selections:

1. The *barometric pressure* varies inversely as the altitude of the plant above sea level. Fig. 4 gives the barometric pressure corresponding to various elevations as computed from the equation:

$$E_1 = 62{,}737 \log_{10} \frac{29.92}{B_o} \qquad (2)$$

*where*

$E_1$ = altitude of plant above sea level, feet.

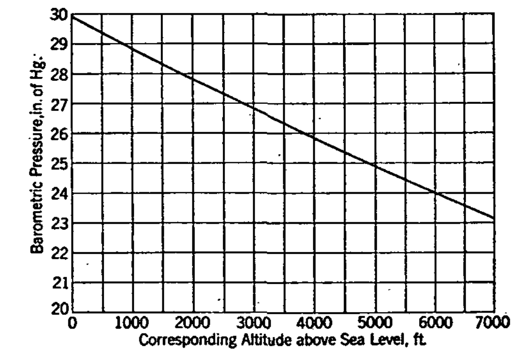


FIG. 4. RELATION BETWEEN BAROMETRIC PRESSURE AND ALTITUDE

In general, the barometric pressure decreases approximately 0.1 in. of mercury per 100 ft increase in elevation.

2. The *unit weight of a cubic foot* of chimney gases at 0 F and sea level barometric pressure is given by the equation:

$$W_c = 0.131 CO_2 + 0.095\, O_2 + 0.083\, N_2 \qquad (3)$$

In this equation $CO_2$, $O_2$ and $N_2$ represent the percentages of the parts by volume of the carbon dioxide, oxygen and nitrogen content, respectively, of the gas analysis. For ordinary operating conditions, the value of $W_c$ may be assumed at 0.09.

The density effect on the chimney gases due to superheated water vapor resulting from moisture and hydrogen in the fuel, or due to any air infiltrations in the chimney proper are here disregarded. Though water vapor content is not disclosed by Orsat analysis, its presence tends to reduce the actual weight per cubic foot of chimney gases.

3. The *atmospheric temperature* is the actual observed temperature of the outside air at the time the analysis of the operating chimney is made. The mean atmospheric temperature in the temperate zone is approximately 62 F.

4. The *chimney gas temperature* does not vary appreciably from the gas temperature as it leaves the breeching and enters the chimney. For average operating conditions, the chimney gas temperature will vary between 500 F and 650 F except in the case when