

V = chimney gas velocity, feet per second.

D_r = total required draft demanded by the entire installation outside of the chimney, inches of water.

Equations 5 and 6 give the required size of a natural draft chimney with all of the operating factors taken into consideration. Values for all of the factors with the exception of the chimney gas velocity may be either observed or computed. It is, of course, necessary to assume an arbitrary value for the velocity in order to arrive at some definite size. For any one set of operating conditions there will be as many sizes of chimneys as there are values of reasonable velocities to assume. Of the number of sizes corresponding to the various assumed velocities, there is one size which will cost least. Since the cost of a chimney structure, regardless of the kind of material used in the construction, varies as the volume of material in the structure, the cost criterion then may be represented by the approximate equation:

$$Q = \pi t H D \quad (7)$$

where

Q = volume of material, cubic feet.

t = average wall thickness, feet.

For all practical purposes, the value of πt may be taken as a constant regardless of the size of the structure. Hence, in general, the volume, and consequently the cost, of a chimney structure may be based on the factor HD as a criterion. Therefore, the value of the chimney gas velocity which will result in the least value of HD for any one set of operating conditions will produce a structure which will be the most economical to use, because its cost will be least.

The problem at hand is to deduce an equation for the chimney gas velocity which will result in a combination of a height and a diameter whose product HD will be least. The solution is obtained by equating the product of Equations 5 and 6 to HD , differentiating this product with respect to V and equating the resulting expression to zero. This procedure results in the following expression:

$$V_e = \left(\frac{0.772 T_c \left(\frac{W_o}{T_o} - \frac{W_c}{T_c} \right) \sqrt{\frac{W T_c}{B_o W_c}}}{f W_c} \right)^{2/5} \quad (8)$$

where V_e = economical chimney gas velocity, feet per second.

Equation 8 gives the economical velocity of the chimney gases for any set of operating conditions, and represents the velocity which will result in a chimney the size of which will cost less than that of any other size as determined by any other velocity for the same operating conditions. After the value of the economical velocity has been determined, the corresponding height and diameter can then be determined from Equations 5 and 6, respectively, and the economical size will then be attained. Equations 5, 6 and 8 may be simplified considerably for average operating conditions in an average size steam plant by assuming typical conditions.

Average chimney gas temperature, 500 F.....	$T_c = 960$
Mean atmospheric temperature, 62 F.....	$T_o = 522$
Average coefficient of friction, 0.016.....	$f = 0.016$
Average chimney gas density, 0.09.....	$W_c = 0.09$
Sea level elevation, with barometer of 29.92.....	$B_o = 29.92$

Substituting these values in Equations 8, 6 and 5, respectively, and reducing, the results are substantially:

$$V_e = 13.7 W^{1/5} \quad (9)$$

$$D = 1.5 W^{2/5} \quad (10)$$

$$H = 190 D_r \quad (11)$$

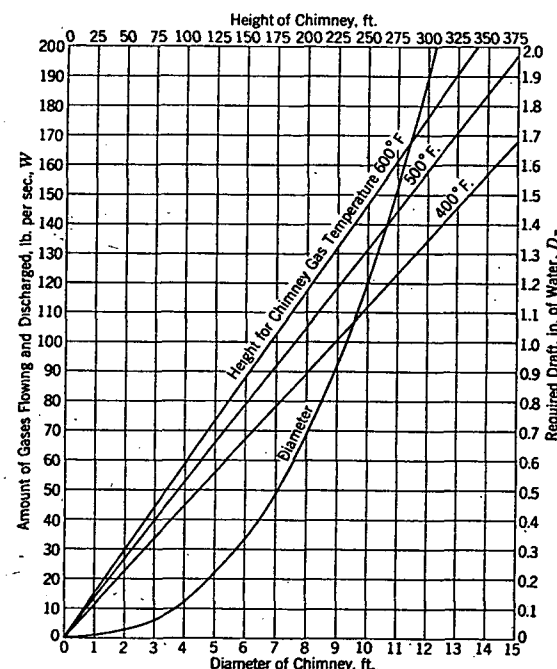


FIG. 6. ECONOMICAL CHIMNEY SIZES^a

^aDiameter values also for gas temperatures of 400, 500 and 600 F.

Fig. 6 gives the economical chimney sizes for various amounts of gases flowing and for required draft intensities as computed from Equations 9, 10 and 11. They are based on the operating factors used in reducing Equations 5, 6 and 8 to their simpler form. The sizes shown by the curves in the chart should be used for general operating conditions only, or for installations where the required data necessary for an exact determination are difficult or impossible to secure. Whenever it is possible to secure accurate data, or the anticipated operating conditions are fairly well known, the required size should be determined from Equations 5,