

$$D = 0.288 \sqrt{\frac{WT_c}{B_o W_c V}} \quad (7)$$

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.

For large chimneys, it is usual to assume that total construction cost is least when the product HD (height $\times$ diameter) is minimum. On this assumption, the product of Equations 6 and 7 can be differentiated and the differential set equal to zero to find the minimum. Solution for velocity then yields the following equation:

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

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

Equations 6, 7 and 8 can of course be simplified if values are assumed for some of the factors in it. Some typical figures for boiler plants are as follows:

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.....	$W_c = 0.09$ lb per cubic foot
Barometer reading, sea level.....	$B_o = 29.92$ in. Hg

When these values are substituted in Equations 8, 7 and 6 respectively, the results are:

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

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

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

Fig. 3 gives the economical chimney sizes for various amounts of gases flowing and for required draft intensities computed from Equations 9, 10 and 11. They are based on the operating factors used in reducing Equations 6, 7 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 6, 7 and 8.

The recommended minimum inside dimensions and heights of chimneys for small and medium size installations are given in Table 1.

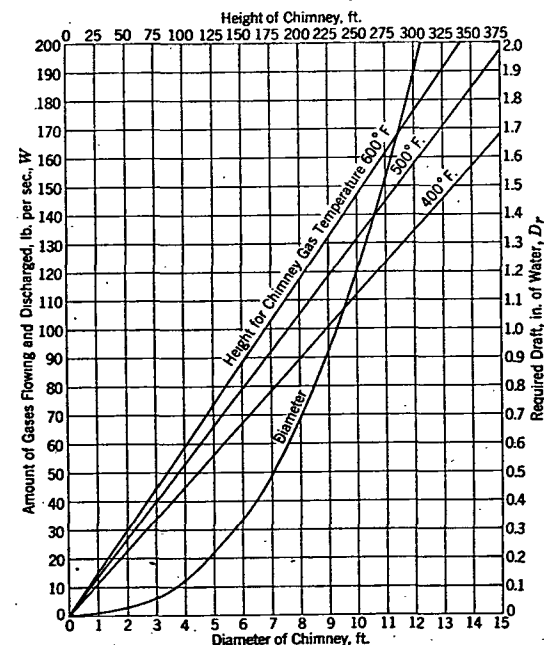
FACTORS AFFECTING REQUIRED DRAFT

The foregoing considerations deal with chimney size selection when the required draft and flue gas volume and temperature are known. The

CHAPTER 9. CHIMNEYS AND DRAFT CALCULATIONS

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. 4 presents information on the fuel-bed draft loss for various kinds of coal burned at different rates and rough generalizations can be given for the losses in the flue passages of boiler or furnace, but, on account of



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

FIG. 3. ECONOMICAL CHIMNEY SIZES

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 terms of foregoing Equations 2 and 3.

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