

V_e = nominal velocity of discharge based on the core area, feet per minute.

C_d = coefficient of discharge (usually between 0.65 and 0.90).

R_{fa} = ratio of free area to gross (core) area.

X = distance from face of outlet, feet.

K and K' = proportionality constants, with $K' = 1.13 K$.

D_0 = effective or equivalent diameter of stream at discharge from open-end duct or at a contracted section, feet.

$A_0 = A_e \times C_d \times R_{fa}$ = effective area of stream at discharge from an open-end duct or at a contracted section, square feet.

A_e = measured gross (core) area of outlet, square feet.

Q = discharge from outlet, cubic feet per minute.

Equation 1 is nondimensional and requires only that consistent units be used, as in the above nomenclature. Values of K and K' are listed in Table 1.^{2, 4}

TABLE 1. RECOMMENDED VALUES OF THE CENTERLINE VELOCITY CONSTANT K OR K' (See Equation 1)

TYPE OF OUTLET	K		K'	
	$V_e = 500$ to 1000	$V_e = 2000$ to 10,000	$V_e = 500$ to 1000	$V_e = 2000$ to 10,000
Free Openings				
Round or Square	5.0	6.2	5.7	7.0
Rectangular, large aspect ratio (<40)	4.3	5.3	4.9	6.0
Annular slots axial or radial ^a	—	—	3.9	4.8
Grilles and Grids				
Free area 40% or more	4.1	5.0	4.7	5.7
Perforated Panels				
Free area 3 to 5%	2.7	3.3	3.0	3.7
Free area 10 to 20%	3.5	4.3	4.0	4.9

^a For radial slots use X/H instead of $X/(A)^{1/2}$. H is the height or width of the slot.

Note: K and K' are indexes of loss in axial kinetic energy. Interpolate as required. Departures from maximum value indicate losses in first and second zones when compared with the jet from a rounded-entrance, circular nozzle.

Low velocity test results, in the range $V_x < 150$ fpm, indicate that the normal values of K and K' should be reduced about 20 percent for $V_x = 50$ fpm, as used in later Equation 4b for throw. Fig. 2 gives the effective diameter D_0 in inches for single openings and includes the coefficient of discharge.⁵ Similar values for grilles are available in the literature or can be experimentally determined. Values of C_d and R_{fa} are required for determining V_0 , D_0 and A_0 for orifice-type and multiple-opening outlets, and should, therefore, be included in catalog data of these outlets.

In the case of multiple-opening outlets and annular-ring outlets (see diagram A of Fig. 1), the streams coalesce into a solid jet before actual jet expansion takes place. This coalescence affects the experimentally determined proportionality constants K or K' and accounts for some of the divergence in reported values for similar outlets.

Centerline Velocities in Zones 1 and 2

Experimental evidence indicates that in Zone 2

$$\frac{V_x}{V_0} = \sqrt{\frac{K'H_0}{X}} \quad (3)$$

where

H_0 = width of jet at outlet or at vena contracta.

Approximately the same values of K' apply as for Zone 3 expansion from axial outlets.

In Zone 1, the ratio V_x/V_0 is constant and equal to the ratio of the cen-

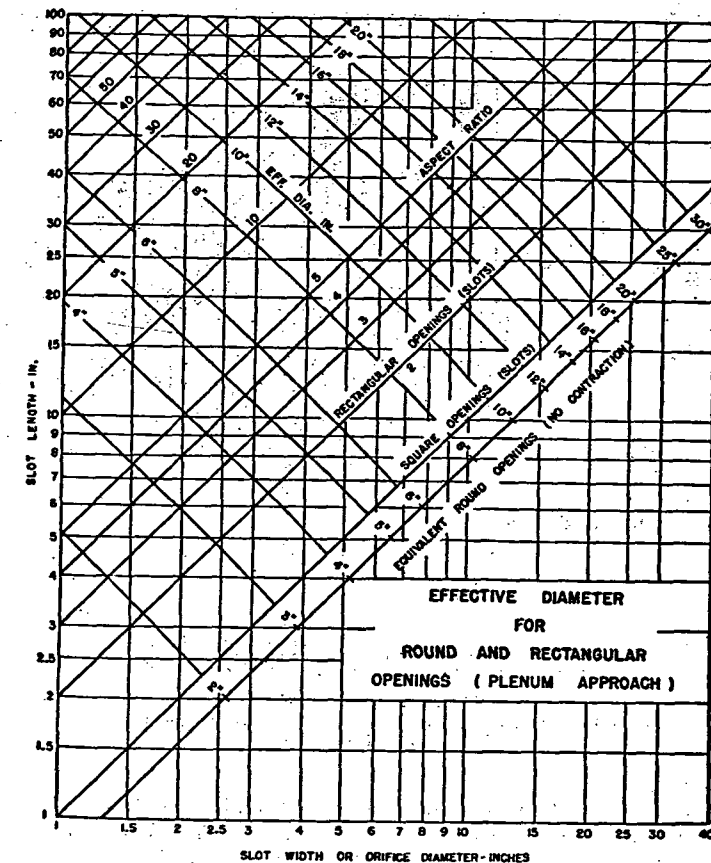


FIG. 2. EFFECTIVE DIAMETERS FOR ROUND AND RECTANGULAR OPENINGS (PLENUM APPROACH)

ter velocity of the jet at start of expansion to the average velocity, ranging from approximately 1.0 for rounded-entrance nozzles to about 1.2 for straight pipe discharge, but with much higher values for diverging-discharge outlets.

Determining Centerline Velocities

To permit correlation of data from all four zones, centerline velocity ratios are plotted against distance from outlet in Fig. 3 in accordance with