

Throw

Equations for the throw of straight flow side wall outlets have been developed on the basis of the momentum theory. Equation 4 states the throw in terms of the area of the outlet and the primary air volume:²

$$L = 0.82 \frac{Q_1}{\sqrt{A_1}} \quad (4)$$

where

L = throw, feet.

A_1 = effective outlet area, in square inches = (gross measured area) $\times$ (percentage of free area/100) $\times$ (discharge coefficient).

The discharge coefficient is approximately 0.8.

Equation 4 has been developed under the assumption that the temperature of the supply air is the same as the temperature of the room air. It applies only to straight flow outlets with aspect ratios less than 16.

Equation 5 for the performance of straight flow outlets evolved from research¹ allows the calculation of the maximum residual velocity at any distance perpendicular to the outlet face. It applies for aspect ratios up to 50.

$$V_r = K \frac{V_1 \sqrt{A_1}}{X} = K \frac{Q_1}{X \sqrt{A_1}} \quad (5)$$

where

V_r = maximum residual velocity in air stream, i.e., the highest maintained velocity at the given cross section in the room, feet per minute.

V_1 = average initial velocity across outlet, feet per minute.

K = constant of proportionality.

A_1 = effective outlet area in square feet = (gross measured area) $\times$ (percentage of free area/100) $\times$ (discharge coefficient).

X = normal distance from outlet face, feet.

Equation 5 together with Equation 6 (which reduces to Equation 7 if the jet angle is 20 deg) for the entrainment ratio,

$$\text{Entrainment Ratio} = \frac{0.785 K}{R X \sqrt{A_1}} \left(\sqrt{\frac{A_1}{0.785}} + 2 X \tan \frac{\theta}{2} \right)^2 - 1 \quad (6)$$

where

R = ratio of maximum residual velocity to average residual velocity.

θ = jet angle or spread angle in degrees.

$$\text{Entrainment Ratio} = \frac{0.785 K}{R X \sqrt{A_1}} \left(\sqrt{\frac{A_1}{0.785}} + 0.35 X \right)^2 - 1 \quad (7)$$

has been used to develop charts² which provide the graphical solution of problems involving the determination of the throw of air from slots and jets, the residual velocity, and the size of openings. (See Figs. 2 and 3). The charts apply only to air discharging into room air of same temperature as the stream. They can be used to determine the throw of air and entrainment

ratios up to 40:1 with initial velocities of 1000 to 6000 fpm, and with residual velocities of 100 to 1000 fpm. The charts furthermore are for use with sharp-edged orifices or slots, and include the coefficient of discharge. If air is discharged from an orifice with a well-rounded entrance or from a length of straight duct, the coefficient of discharge is unity and the actual area of the opening is the effective area. For such rectangular openings the effective diameter is the diameter of a circle with an area equal to the actual area of the rectangle. The following examples will illustrate the use of the charts:

Example 1: Air is delivered to a cooler through independent slots each 24 in. $\times$ 2 in.

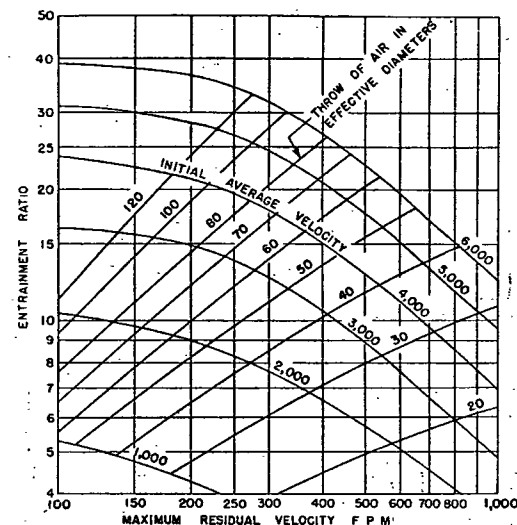


FIG. 2. RELATION BETWEEN INITIAL VELOCITY, RESIDUAL VELOCITY, ENTRAINMENT RATIO AND THROW OF AIR FROM JETS AND SLOTS

with an initial velocity of 2000 fpm. Determine the maximum residual velocity and the entrainment ratio at a distance of 15 ft from the slot.

From Fig. 3 the effective diameter = 6.2 in. = 0.52 ft. The number of effective diameters in 15 ft = $15/0.52 = 28.8$.

From Fig. 2 at 2000 ft initial velocity read entrainment ratio = 6.6 and maximum residual velocity = 390 fpm. From tests it has been shown that the average residual velocity may be taken as $\frac{1}{3}$ of the maximum or 130 fpm in this case.

Example 2: Using the data from Example 1 determine the distance at which the maximum residual velocity will be 150 fpm.

From Fig. 2 at $V_1 = 2000$ and $V_r = 150$, the number of effective diameters is read directly as 73 and the throw of the air is therefore $73 \times 0.52 = 38$ ft.

Example 3: Air issues from a round orifice plate with an initial average velocity of 4000 fpm. It is to have a maximum residual velocity of 400 fpm at a distance of 30 ft from the opening. Calculate the size of the opening required and the entrainment ratio.

On Fig. 2 at the intersection of the curve of 4000 fpm, the entrainment ratio is read directly as 15 and the effective diameters of throw = 55.