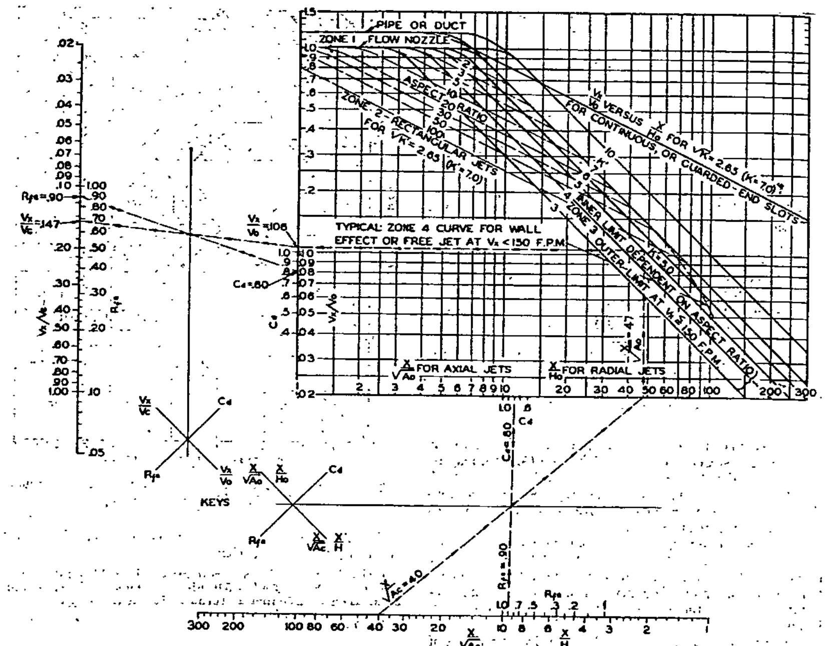


Fig. 8 .... Chart for Determining Centerline Velocities of Axial and Radial Jets

outlet, if the discharge volume and the center velocity are known.

$$X = \frac{K'}{V_x} \cdot \frac{Q}{\sqrt{A_c \times C_d \times R_{fe}}} \tag{7}$$

or, if

$$Z = \sqrt{C_d \times R_{fe}}$$

$$X = \frac{K'}{V_x} \cdot \frac{Q}{Z\sqrt{A_c}} \tag{8}$$

The maximum throw L is usually defined as the distance from the outlet face where the centerline velocity is 50 fpm. Therefore, for $V_x = 50$ fpm,

$$L = X = \frac{K'}{50} \cdot \frac{Q}{Z\sqrt{A_c}} \tag{9}$$

Any other terminal centerline velocity e.g., 100, 150, 200, etc., fpm could be inserted in Equation 8 for V_x.

Velocity Profiles of Jets

In Zone 3 of both axial and radial jets, the velocity distribution may be expressed by a single curve (Fig. 9) in terms of dimensionless coordinates, and this same curve can be used as a good approximation for adjacent portions of Zones 2 and 4. Experiments have shown that temperature and density differences have but a small effect on cross-sectional velocity profiles.

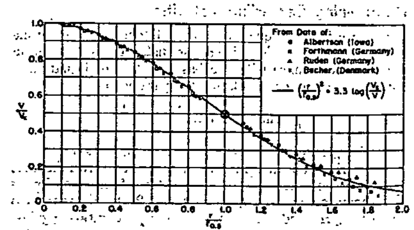


Fig. 9 .... Cross-Sectional Velocity Profiles for Straightflow Turbulent Jets

Velocity distribution in Zone 3 can be expressed by the Gauss error-function or probability curve which is approximated by a simple equation using common logarithms

$$\left(\frac{r}{r_{0.5}}\right)^2 = 3.3 \log \frac{V_x}{V} \tag{10}$$

where

r = the radial distance of the point under consideration from the centerline of the jet.

$r_{0.5}$ = the radial distance in the same cross-sectional plane from the axis to the point where the velocity is half the centerline velocity. ($V = 0.5\ V_x$).

V_x = the centerline velocity in the same cross-sectional plane, feet per minute.

V = the actual velocity at the point being considered, feet per minute.

Experiments show that the conical angle for $0.5\ V_x$ and $r_{0.5}$ is approximately one-half of the total angle of divergence of a jet. The velocity profile curve for one-half of a straight-flow turbulent jet (the other half being a symmetrical duplicate) is shown in Fig. 9. For multiple-opening outlets, such as grilles, or perforated panels, the velocity profiles are similar, but the angles of divergence are smaller.

Entrainment Ratios

Equations for the entrainment of circular jets and of jets from long slots have been mathematically derived.[14] They are:

For third zone expansion of circular jets,

$$\frac{Q_x}{Q_0} = \frac{2}{K'} \cdot \frac{X}{\sqrt{A_0}} \tag{11}$$

By substituting from Equation 4.

$$\frac{Q_x}{Q_0} = 2\ \frac{V_0}{V_x} \tag{12}$$

For a long slot

$$\frac{Q_x}{Q_0} = \sqrt{\frac{2}{K'}} \cdot \sqrt{\frac{X}{H_0}} \tag{13}$$

And by substituting from Equation 2 at the beginning of Zone 3

$$\frac{Q_x}{Q_0} = \sqrt{2}\ \frac{V_0}{V_x} \tag{14}$$

where

Q_x = total volume flow rate at distance X from face of outlet, cubic feet per minute.

Q_0 = discharge from outlet, cubic feet per minute.

X = distance from face of outlet, feet.

K' = proportionality constant.

A_0 = effective area of stream at discharge from an open-end duct or at a contracted section, square feet.

H_0 = width of slot, feet.

Entrainment ratios are important from the standpoint of the total air movement at a given distance from an outlet. It will be noted that with a given outlet, the entrainment ratio is proportional to the distance X (Equation 11) or proportional to the square root of the distance X (Equation 13) from the outlet. From Equations 12 and 14, it will be noted that for a fixed centerline velocity, the entrainment ratio is directly proportional to the outlet velocity. They also show that at the same centerline and outlet velocity, a circular jet will have a greater entrainment and total air movement than will a long slot. Comparing Equations 11 and 13 shows that the long slot should have a greater rate of induction. It should also be noted that the entrainment ratio at a given distance is less with a large K' than with a small K'.

Effect of Walls and Ceilings

Jets discharging parallel to a wall with one edge of the outlet coinciding with the wall, take the form of one-half of an axial jet discharging from an outlet twice as large, similar to radial jets from ceiling plaques. Entrainment takes place practically only along the surface of a half cone and the maximum velocity remains close to the wall.[7]

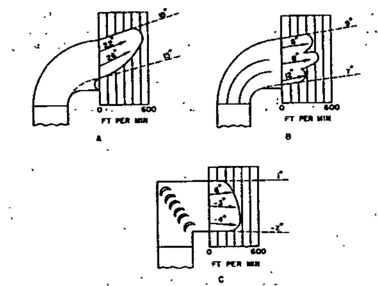
Values of K and K' are approximately those for a free jet multiplied by $\sqrt{2}$, that is to say, the normal maximum of 7.0 for K' for free jets becomes 9.9 for a similar jet adjacent to, and discharged parallel to, a wall, and $X/\sqrt{2A_0}$ should be used in place of $X\sqrt{A_0}$ in Fig. 8.

When a jet is discharged parallel to, but at some distance from a wall, its expansion in the direction of the wall is reduced and entrained air must be obtained by recirculation from the jet itself instead of from ambient air.[9,15] The jet expands normally to within a short distance from the wall, which nearer to the outlet only affects velocity distribution in the outer shell of the jet, but further on also affects centerline velocities. This happens at some distance from a plane where the jet outline becomes parallel to the wall, and where the jet enters its fourth or terminal zone. Few engineering data are available on this important phase of jet expansion.[9]

Air Velocities in Two Parallel Ventilating Jets

In each air jet of twin parallel air jets, there is a maximum velocity core and the jet behaves independently until the point is reached at which the two interfere. The point of interference and its distance out from the outlets varies with the distance between the outlets.

From the outlets to the point of interference the maximum velocity, as for a single jet, will be on the centerline of each jet. Then the velocity on a line midway between and parallel



Stack 14 in. x 6 in. Outlets 14 x 9 in. Stack Velocity 500 fpm
A. Rounded Throat and Rounded Back.
B. Rounded Throat and Back and 2 Splitters.
C. Square Throat and Back and 6 Guide Vanes.

Fig. 10 .... Outlet Velocity and Air Direction Diagrams for Stack Heads with Expanding Outlets