Definitions

1. *Supply Opening or Outlet:* Any opening through which air is delivered into a space which is being heated, or cooled, or humidified, or dehumidified, or ventilated.
2. *Exhaust Opening:* Any opening through which air is removed from a space which is being heated, or cooled, or humidified, or dehumidified, or ventilated.
3. *Outside Air Opening:* Any opening used as an entry for air from outdoors.
4. *Grille:* A covering for any opening and through which air passes.
5. *Damper:* A device used to vary the volume of air passing through a confined cross-section by varying the cross-sectional area.
6. *Multiple Louver Damper:* A damper having a number of adjustable blades.
7. *Single Louver Damper:* A damper having one adjustable blade.
8. *Face:* A grille with provision for attaching a damper.
9. *Register:* A face with a damper attached.
10. *Flange:* The portion (either integral or separate) of a grille, face, or register extending into the duct opening for the purpose of mounting.
11. *Frame:* The portion (either integral or separate) of a grille, face, or register extending around the duct opening for the purpose of mounting.
12. *Margin:* The margin of a grille, face, or register is one-half of the difference between the duct dimension and overall dimension measured either horizontally or vertically.
13. *Fret:* The member separating the openings of a grille, face, or register.
14. *Free Area:* The total minimum area of the openings in the grille, face, or register through which air can pass.
15. *Core Area:* The total plane area of the portion of a grille, face, or register bounded by a line tangent to the outer edges of the outer openings through which air can pass.
16. *Mean Area:* The total of the core and free areas divided by two.
17. *Duct Area:* The area of a cross-section of the duct based on the inside dimensions at the point where the grille, face or register is mounted.
18. *Percentage Free Area:* The ratio of the free area to the core area expressed in percentage.
19. *Aspect Ratio:* The ratio of length of the core of a grille, face or register to the width.
20. *Throw:* The distance air will carry measured along the axis of an air stream from the supply opening to the position in the stream at which air motion reduces to 50 fpm.
21. *Envelope:* The outer boundary of an air stream.
22. *Drop:* The vertical distance the lower edge of the air stream drops between the time it leaves the outlet and reaches the end of its throw (h in ft).
23. *Rise:* The converse of drop.
24. *Induction:* The entrainment of room air by the air ejected from the outlet.
25. *Primary Air:* The air leaving an outlet (Q_1 in cfm).
26. *Secondary Air:* The room air picked up by the primary air through induction (Q_2 in cfm).
27. *Total Air:* The mixture of primary and secondary air (Q_3 in cfm).
28. *Induction Ratio:* The total air divided by the primary air equals r, or Q_3/Q_1.
29. *Outlet Velocity:* The average air velocity emerging from the outlet (V_1 in fpm) measured at the plane of the opening.
30. *Terminal Velocity:* The average air stream velocity at the end of the throw (V_T in fpm).
31. *Horizontal Spread:* The divergence of the air stream in the horizontal plane after it leaves the outlet (Degrees).
32. *Vertical Spread:* The divergence in the vertical plane (Degrees).
33. *Temperature Differential:* Temperature difference between primary and room air ($t_r - t_{as}$).
34. *Vane Ratio:* The ratio of depth of vane to shortest opening width between two adjacent grille bars.

MECHANICS OF AIR DISTRIBUTION

In the mechanics of air distribution, two major problems are involved: (1) complete mixing of the primary air and room air outside of the zone of occupancy and (2) counteraction of the natural convection and radiation effects within the room.

Induction

When air is discharged from an outlet into a free open space, the primary air stream entrains room air as it traverses the space. This entraining effect increases the cross-sectional area and reduces the velocity of the resulting air stream. Induction takes place with the conservation of linear momentum; this has been confirmed by tests which indicate that the momentum remains almost constant throughout the entire measureable length of the air stream. This relationship may be expressed by the Equation 1:

$$M_1 V_1 + M_2 V_2 = (M_1 + M_2) V_3 \qquad (1)$$

where

M_1 = mass of primary air.
M_2 = mass of secondary air.
V_1 = velocity of primary air.
V_2 = velocity of secondary air (normally = 0).
V_3 = velocity of the mixture.

Substituting zero for V_2 and the volume rate Q for the mass (M), and solving for the induction ratio (r):

$$r = \frac{V_1}{V_3} = \frac{Q_1 + Q_2}{Q_1} \qquad (2)$$

The total air entrained by an air stream is in direct proportion to the distance from the discharge of the outlet. For a given blow from a wall in which a number of outlets are located, the induction ratio may be increased by increasing the aspect ratio, diverging the vanes of the outlet, or by simultaneously increasing the number of outlets, reducing their size, and increasing the velocity but maintaining a constant blow. The aspect ratio must be increased considerably from that of a rectangle to a slot before marked changes in the entrainment ratio take place.

Spread

The induction effect results in the spreading of the air stream. Equation 3 derived from induction Equation 1 gives spread or cross-sectional area of the stream as a function of induction ratio, volume of primary air, and primary air velocity.

$$A = \frac{r^2 Q_1}{V_1} = \frac{V_1 Q_1}{(V_3)^2} \qquad (3)$$

where

Q_1 = primary air quantity, cubic feet per minute.
V_1 = primary air velocity, feet per minute.
V_3 = air velocity of mixture, feet per minute.
r = induction ratio.