Lecture -3-

2.2 Room air distribution requirements

(A) Temperature

The object of air distribution inside the conditioned spaces is to obtain the comfort conditions within the zone. These comfort conditions are measured by means of determining the ʹʻ**effective temperature**ʺ. The term comprises air temperature, air motion, relative humidity and their physiological effect on the human body. Standard limits of this effective temperature have been established and any variation from accepted standards may result in discomfort to the occupants. The discomfort may thus arise due to excessive room temperature variation (horizontally, vertically or both), excessive air motion (draft), failure to distribute the air according to the load requirements at different locations, too rapid fluctuations or due to insufficient air motion. The acceptable standard requires that the temperature variation should not be more than 2 C in the occupied zones of conditioned spaces. The average air motion around the occupants may be from 7 to 10 m/min and the maximum allowable air movement should be below 15 m/min for people at rest and 20 m/min when the people are moving.

(B) Air Direction

The following three types of air movement are preferred for the proper distribution of air inside the occupied space :

(1) Flow direction of air towards the faces of the occupants is preferred to its being of towards the back or sides.

(2) Downward flow is preferred to that of upwards flow,

(3) In order to reduce the temperature difference within acceptable limits, the entrainment of room air with the primary stream should take place outside the zone of occupancy.

(C) Velocity

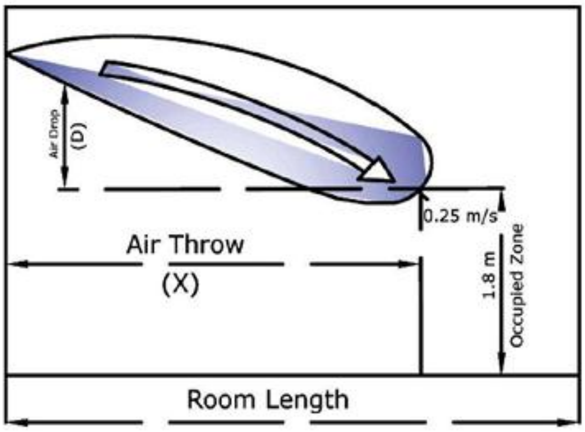
Air velocities inside the rooms must be within comfortable limits. Table 2.1 shows room air velocities and their reaction with the occupants.

TABLE 2.1 OCCUPIED ZONE ROOM AIR VELOCITIES

Room air velocity m/min	Reaction	Recommended application
0-5	Complaint about stagnation	None
8	Ideal design favorable	All commercial application
8-15	Lower range is more favorable than the higher range.	All commercial applications.
20-25	Unfavorable as papers may blow off the desk. May be favorable for the persons moving about.	Retail and departmental stores
25—100	Lower limit favorable for factory air conditioning and the higher limit becomes unfavorable.	Factory air conditioning Higher velocity for spot cooling

(D) Blow (Throw)

Blow is the horizontal distance that an air stream travels on leaving an outlet. The distance is measured from the outlet to a point at which the velocity reduces to 15 m/min (0.25 m/s). The velocity is measured at 1.8 - 2 meters above the floor. Blow is proportional to the velocity of primary air at outlet and does not depend upon the supply and room air temperatures. In general, it is not necessary to blow the entire length or width of a room. Normally, $\frac{3}{4}$ of the distances to opposite wall is the distance of blow unless there are local sources of heat nt the end of the room opposite to out let. The local source of heat may be due to the equipment, occupancy, or open doors. Under such conditions, the over blow may be required hut care must be taken to avoid uncomfortable directions.



(E) Induction

Induction is the entrainment of the room air by air ejected from the outlet and is a result of the outlet air velocity. The supply air coming from the outlet is called the primary air and the air picked and carried along by the primary air is called secondary air. The entire air, the sum of primary and secondary air is called the total air.

M1V1 + M2V2 = (M1 + M2) × V3

Where

M1 = mass of the primary air

M2 = mass of the secondary air

V1 = Velocity of the primary air

V2 = velocity of the secondary air

V3 = Velocity of the total air

Induction ratio (R) is defined as the ratio of total air to primary air;

$$R = \frac{total\ air}{primary\ air} = \frac{primary\ air + secondary\ air}{primary\ air}$$

The effect of induction is to increase or decrease the blow, as the blow, is a function of velocity. The decrease of velocity depends on the rate of induction. The amount of induction for an outlet is a direct function of the perimeter of the cross-section of primary air. Of the two outlets, having the same area, the outlet with larger perimeter has the greater induction and thug the shorter blow. Also for a given air quantity discharged into a room with a given pressure, the minimum Induction and maximum blow is obtained by a single outlet with a round cross-section. Similarly, the greatest induction and the shortest blow will be a result of single outlet in the form of long narrow

Example 2.1 Effect of Induction

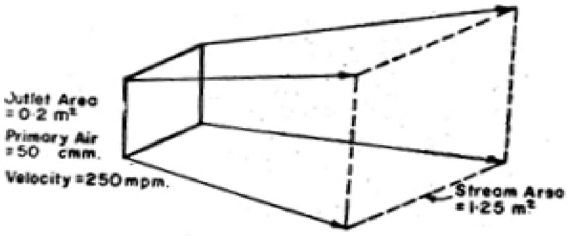
Primary air supply 50 m^3/min at a velocity of 250 m/min. Secondary air mixing with primary air 75 m^a/min at negligible velocity.

1. **Velocity of total air stream.**
2. **Area of total air st ream after mixing of the primary and secondary air.**

Solution:

Area of primary air stream before induction

$A = M_1 / V_1 = 50/200 = 0.2 m^2$



Now from momentum equation:

$$M_1V_1 + M_2V_2 = (M_1 + M_2) \times V_3$$

$$(50 \times 250) + (75 \times 0) = (50+75) \times V_3$$

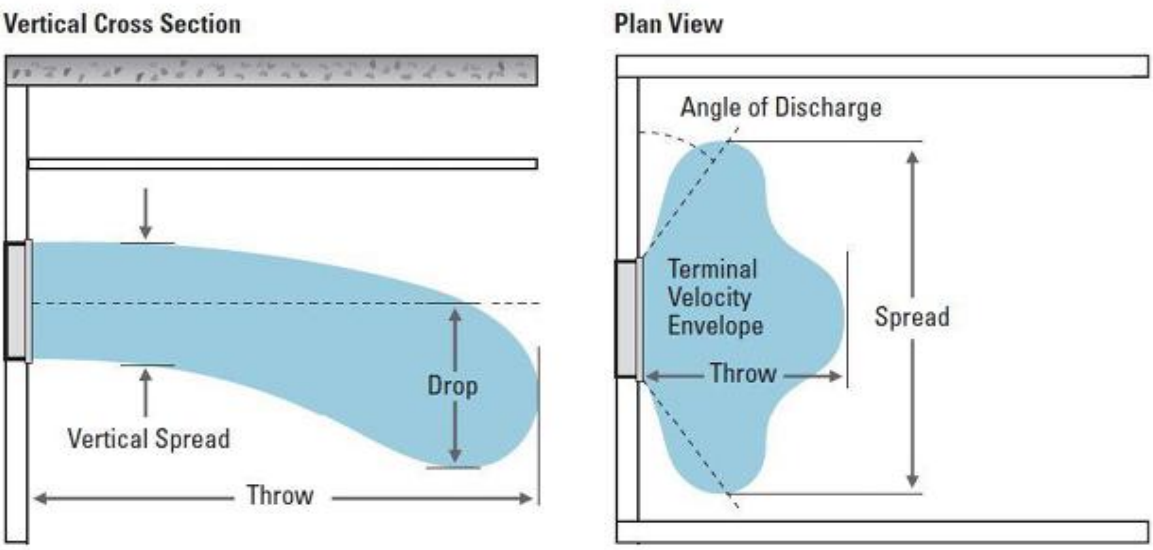
$V_3 = 100$ m/min

$$\text{Area of total air stream} = \frac{M_1+M_2}{V_3} = \frac{50+75}{100} = 1.25\ m^2$$

(F) Spread

The spread is the angle of divergence of air stream after it leaves the outlet. The spread can be either in the horizontal plane or in vertical plane. The spread is measured as the included angle in degrees in a particular plane. **Fig. 2.6** shows the spread which is the effect of induction on stream area and air velocity. Momentum law is applied to obtain the spread in example 2.1.

Normally an outlet without any converging or diverging vane setting gives a spread of about 18° to 20° in both planes. This is approximately equal to a spread of 1/6 meter per meter of blow. However, the included angle (spread) further depends upon the type of the outlet. which will be between 15° and 23 .



(G) Effect of Vanes on Outlet Performance

The straight vanes produce the spread of about 19° in both planes as shown in the **fig. 2,7 (a).**

The converging vanes shown in the **fig, 2.7 (b)** are set to direct the air to obtain longer blow. The increase in blow is about 15% and the spread remains the same of 19° as that of straight vane.

Diverging vanes are set on outlet to give a larger angular spread as shown in the **fig. 2.7 (c).** A spread of 60° can be obtained by setting the end vane at 45° angle and all other vanes at intermediate angles. Such vanes give the fanning effect and reduces the blow up to 50%. Outlets with end vane set at angles less than 45°, and all other vanes set at intermediate angles will have a lesser spread and corresponding greater blow than the 45° end vane setting.

When the vanes are used, the free outlet area is reduced. The reduction in area causes to decrease the quantity of air flow unless the pressure differential is increased. All vanes can also be set at the same angle as shown in the **fig. 2.7 (d)** in order to direct the air in a particular direction or to miss an obstruction. It can be noticed that the spread angle still remains the same and equal to approximately 19°.

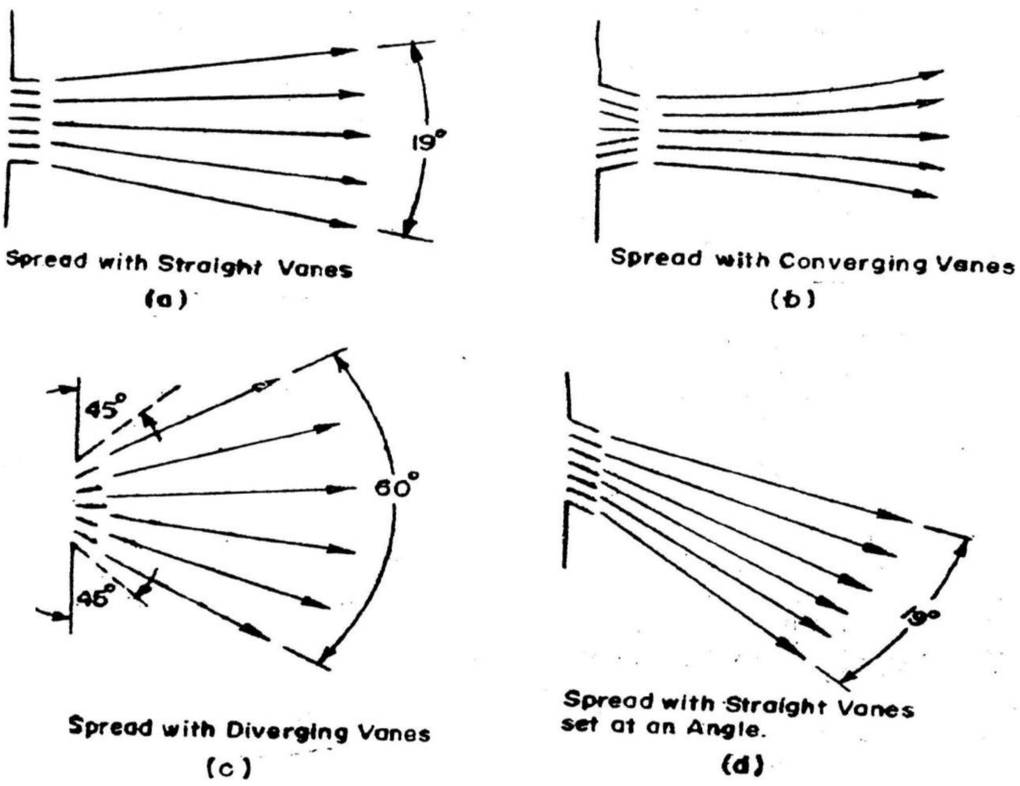
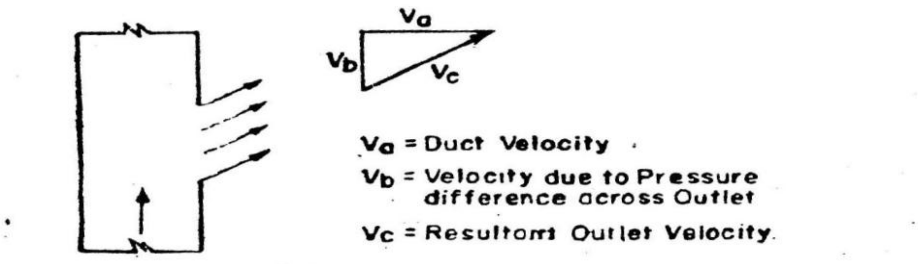


Fig. 2.7 Spread of Different Types of Vane

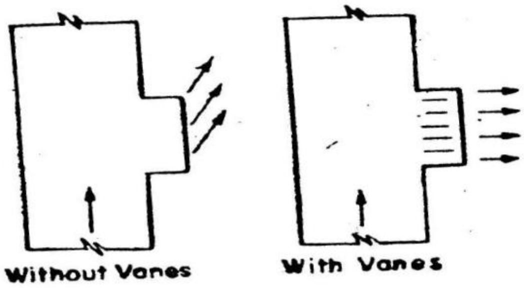
(H) Effect of Duct Velocity on Outlet Performance

Fig. 2.8 shows a simple outlet without vanes. The direction of blow of the air is the sum vector of the duct velocity and the outlet velocity m the direction as shown in the **fig. 2.8 (a).** In order to make the resultant velocity V_e perpendicular to the direction of air flow in the duct, the short collars are provided with straight vanes as shown in **fig. 2.8 (b).** In case the divergence is required than the vane angles can be set occasionally.



(a)

Fig. 2.8 (a) Discharge of Air from Simple Outlet without Vane



(b)

Fig. 2.8 (b) Discharge of Air from a Collared Outlet with Straight Va

(I) Room Air Movement

Satisfactory room air motion can only be obtained by proper air distribution in the room. The room air distribution depends upon the outlet performance.

The common terms in usage are explained below :—

1. Total air in circulation = Outlet cmm × Induction ratio.
2. Average room velocity $= \dfrac{1.4 \times \text{total cmm in circulation}}{\text{Area of wall opposite outlets}}$
3. Room Circulation Factor $K = \dfrac{\text{Average room velocity}}{1.4 \times \text{Induction ratio}}$

$= \text{Primary air cmm/m}^2 \text{ of wall opposite outlet}$

$= \dfrac{\text{outlet cmm}}{\text{Clear area of wall opposite outlets}}$