

where

H_1 = additional drop due to temperature difference, feet.

n_1 and n_2 = constants (tentative suggested values $n_1 = 5$, $n_2 = 1.2$).

t_r = room temperature, degrees Fahrenheit.

t_{as} = supply air temperature, degrees Fahrenheit.

V_1 = jet velocity, feet per minute.

It should be remembered, that the total drop $H = H_1 + H_2$. H_1 is positive for either heating or cooling; H_2 is positive for cooling, negative for heating. In consequence, there will always be a vertical drop in cooling, and a vertical rise in heating only if $H_2 > H_1$.

Another empirical equation for the total drop is²:

$$H = \frac{m (t_r - t_{as}) L}{V_1} \quad (13)$$

where

m = constant (tentatively suggested value of $m = 16$).

In other words, for a given throw L the drop or rise increases as the temperature difference increases and the outlet velocity decreases. This equation is only valid, if a temperature difference exists between room air and supply air.

Room Air Motion (Wall Outlet)

One of the most important problems in air distribution is to achieve air motion in the occupied zone within acceptable velocity limits. Therefore, outlet performance and characteristics of the space have to be related to this air motion.

The air moving in the occupied zone is (for a side wall outlet) equal in quantity to the total air contained in the outlet stream at the end of the throw and it is generally moving in a direction opposite to the stream. Assuming that the maximum volume of air is in circulation when the air stream velocity V_s drops to 200 fpm, that the free area for return flow is 0.6 of the area of the wall in which the outlets are located, then, according to the momentum theory^{2,4}:

$$V = \frac{Q_s}{0.6 \times A_w} \quad (14)$$

where

V = average room velocity, fpm.

Q_s = Volume of room air in motion, cfm.

A_w = area of wall in which outlet is located, sq ft.

Since $Q_s = Q_1 \times r$, (by definition); and $r = \frac{V_1}{V_s}$ according to Equation 3; the average room velocity is:

$$V = \frac{Q_1 r}{0.6 A_w} = \frac{Q_1}{0.6 A_w} \left(\frac{V_1}{V_s} \right)$$

or, with $V_s = 200$ fpm

$$V = \frac{Q_1 V_1}{120 A_w} \quad (15)$$

When Q_1 , the volume of primary air, V_1 , the velocity of primary air and A_w , the wall area are known, the average room velocity may be

calculated from Equation 15 in order to determine the acceptability of the air distribution system.

OUTLET PERFORMANCE

The factors of outlet performance, throw, drop, room air motion, capacity, temperature differential, dirt and noise place considerable limitations on the design of a satisfactory distribution system.

1. *Throw*. The throw of a wall outlet must be sufficient to produce satisfactory conditions over the area to be conditioned. Underblowing may cause heated air to rise too rapidly above the occupied zone and thus create excessive vertical temperature variation (stratification); in cooling operation it may cause cold air to drop into the occupied zone before a satisfactory mixing of supply and room air has been accomplished by induction and thereby create a condition of acute discomfort (draft). On the other hand, overblowing will result in objectionable downdrafts from any surface the primary air stream may strike.

On the average it is considered most practicable to select throw as $\frac{3}{4}$ of the distance toward an exposed wall or window, as shown in A of Fig. 5.

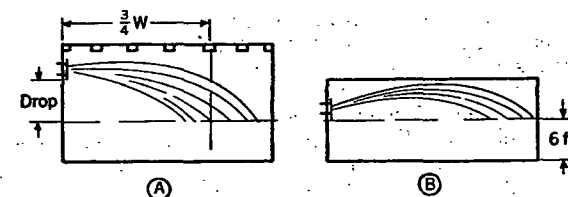


FIG. 5. THROW OF WALL OUTLETS

However, structural characteristics; mounting height, temperature differential and resultant drop or rise, or location of greatest heating or cooling loads strongly affect the selection of the optimum throw. In spaces with beamed ceilings, the outlets should be located below the bottom of the lowest beam level, and preferably low enough so that an upward or arched blow may be employed. The blow should be arched sufficiently to miss the beams and, at the same time, in such a manner as to prevent the primary or induced air stream from striking furniture and obstacles and producing objectionable drafts.

In the case of ceiling diffusers air is distributed with a spread of 360 deg horizontal. In addition there is a downward component of air motion. Therefore, both throw (radius of diffusion) and mounting height are important and interdependent factors. Due to the 360 deg spread of air diffusion the rate of induction will be higher and the throw shorter than that of a wall grille opening handling the same air quantity at the same outlet velocity. Therefore, ceiling diffusers will frequently permit the use of higher air velocities than wall outlets and consequently may be sized smaller to handle the same air volumes. If such ceiling outlets are installed flush with the ceiling, impingement of the air stream along the ceiling surface restricts induction of secondary air and the throw is increased approximately 20 per cent above that of an unrestricted air stream.

In the use of perforated ceiling plates as air distributing devices the term throw could hardly be applied in its proper meaning. Although this type of outlet can handle the greatest amount of air in proportion to room size, jet velocities must be kept low.