

represent current engineering practice. Some tests of infiltration through swinging and revolving doors have been reported.⁴ The data in Table 3 are indicative of what might be expected in this connection, but it should be noted that Table 3 is based on a no-wind condition, and therefore not directly applicable to heating design.

Air Change Method

The amount of air leakage may be estimated by assuming a certain number of air changes per hour for each room, the number of changes assumed being dependent upon the type, use, and location of the room, as indicated in Table 4. Where it is not possible to determine or pre-determine with accuracy the width of crack or clearance of windows, or where other sources of air leakage cannot readily be evaluated, as is often the case, the use of the air change method may be justified.⁵

The values in Table 4 may be used with reasonable accuracy for residences, and are the requirements for each room. The total infiltration allowance for the entire building should be one-half the sum of the infil-

TABLE 4. AIR CHANGES TAKING PLACE UNDER AVERAGE CONDITIONS IN RESIDENCES, EXCLUSIVE OF AIR PROVIDED FOR VENTILATION*

KIND OF ROOM OR BUILDING	NUMBER OF AIR CHANGES TAKING PLACE PER HOUR	KIND OF ROOM OR BUILDING	NUMBER OF AIR CHANGES TAKING PLACE PER HOUR
Rooms, 1 side exposed.....	1	Rooms with no windows or outside doors.....	$\frac{1}{2}$ to $\frac{3}{4}$
Rooms, 2 sides exposed.....	$1\frac{1}{2}$	Entrance Halls.....	2 to 3
Rooms, 3 sides exposed.....	2	Reception Halls.....	2
Rooms, 4 sides exposed.....	2	Bath Rooms.....	2

* For rooms with weatherstripped windows or storm sash, use $\frac{1}{2}$ these values, where applicable, but never less than $\frac{1}{2}$ air change.

tration allowances of the individual rooms, since whatever air enters on the windward side, generally leaves the building on the leeward side, and the infiltration requirements therefore do not exist simultaneously on all sides or in all rooms. An allowance of one air change per hour for all sources of air leakage for the entire volume may be considered average for a well constructed residence.

The air leakage, due to opening and closing of doors in vestibules, is sometimes based on the air change method, even though the air leakage estimates for other rooms are based on the crack method. Except for vestibules and reception halls, it is not advisable to attempt to apply the air change method to factories and industrial and commercial buildings, because of wide variations in the type and percentage of fenestration which is the principal source of air leakage in such buildings.

INFILTRATION DUE TO TEMPERATURE DIFFERENCE

The air exchange due to temperature difference, inside to outside, is a chimney effect, causing air to enter through openings at lower levels, and to leave at higher levels.⁶ Although it is not appreciable in low buildings, this loss should be considered in tall, single story buildings with openings near the ground level and near the ceiling. Also in tall, multi-story buildings it may be a considerable item, unless the sealing between various floors and rooms is quite perfect.

In tall buildings, temperature difference or chimney effect will produce

a head that will add to the effect of the wind at lower levels, and subtract from it at higher levels. On the other hand, the wind velocity at lower levels may be somewhat abated by surrounding obstructions. Furthermore, the chimney effect is reduced in multi-story buildings by the partial isolation of floors, thereby preventing free upward movement, so that wind and temperature difference may seldom cooperate to the fullest extent. Making the assumption that the *neutral zone*⁷ is located at mid-height of a building, and that the temperature difference is 70 deg, Equations 1 and 2 may be used to determine an equivalent wind velocity to be used in connection with Tables 1 and 2, that will allow for both wind velocity and temperature difference:

$$V_e = \sqrt{V^2 - 1.75a} \quad (1)$$

$$V_e = \sqrt{V^2 + 1.75b} \quad (2)$$

where

V_e = equivalent wind velocity to be used in conjunction with Tables 1 and 2, miles per hour.

V = wind velocity upon which infiltration would be determined if temperature difference were disregarded, miles per hour.

a = distance of windows under consideration from mid-height of building if above mid-height, feet.

b = distance if below mid-height, feet.

The coefficient 1.75 allows for about one-half the temperature difference head.

For buildings of unusual height, Equation 1 would indicate negative infiltration at the highest stories, which condition may, at times, actually exist.

Sealing of Vertical Openings

In tall, multi-story buildings, every effort should be made to seal off vertical openings, such as stair-wells and elevator shafts, from the remainder of the building. Stair-wells should be equipped with self-closing doors, and, in exceptionally high buildings, should be closed off into sections of not over 10 floors each. Plaster cracks should be filled. Elevator enclosures should be tight, and solid doors should be used.

If the sealing of the vertical openings is made effective, no allowance need be made for the chimney effect. Instead, the greater wind movement at the greater heights makes it advisable to install additional heating surface on the upper floors above the level of neighboring buildings, this additional surface being increased as the height is increased. One arbitrary rule is to increase the heating surface on floors above neighboring buildings by an amount ranging from 5 percent to 20 percent. This extra heating surface is required only on the windward side and on windy days, and hence, automatic temperature control is especially desirable with such installations.

In stair-wells that are open through many floor levels, although closed off from the remainder of each floor by doors and partitions, the stratification of air makes it advisable to increase the amount of heating surface at the lower levels, and to decrease the amount at higher levels. One rule is to calculate the heating surface of the entire stair-well in the usual way, and to place 50 percent of this in the bottom third, the normal amount in the middle third, and the balance in the top third.