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.

A wide range of infiltration rates would be expected for swinging doors because of variations in the indoor-outdoor pressure difference caused by wind, temperature differences, and the degree to which a heating or an air-conditioning system tended to raise or lower the inside pressure by blower action. The frequency of door usage would also affect the amount of leakage per passage.

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

TABLE 3. INFILTRATION THROUGH 72-INCH REVOLVING DOOR AND 36-INCH SWINGING DOOR[a,b]

(Cubic Feet per Person per Passage)

USAGE	FREELY-REVOLVING DOOR	DOOR EQUIPPED WITH BRAKE
Infrequent	75	60
Average	60	50
Heavy	40	40
36-Inch Swinging Door		20 to 100

[a] These figures are based on the assumption that there is no wind pressure and that swinging doors are in use in one wall only. Any swinging doors in other walls should be kept closed to insure air conditioning in accordance with these recommended standards.

[b] From Application Engineering Standards for Air Conditioning for Comfort 1947, *Air Conditioning & Refrigerating Machinery Association, Inc.*, Washington, D. C. and from experimental data of *National Bureau of Standards*. Used by permission.

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 infiltration 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] when the building is heated or causing flow in the reverse direction when the building is cooled. This air exchange is usually of considerable importance in tall, single-story buildings with openings near the ground level and near the ceiling; it should also be considered in tall, multi-story buildings unless the sealing between various floors is nearly perfect; and may be appreciable in one-story buildings with basements and attics.

The flow of air through a building under the influence of indoor-outdoor temperature difference is quite complex except for single-story structures without a basement or attic. It can best be understood by visualizing the building as a complex chimney with a number of passages and a number of restrictions. The basement represents the lower section of this imaginary chimney with air moving inward through cracks in the walls and around

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

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	½ to ¾
Rooms, 2 sides exposed	1½	Entrance Halls	2 to 3
Rooms, 3 sides exposed	2	Reception Halls	2
Rooms, 4 sides exposed	2	Bath Rooms	2

[a] For rooms with weatherstripped windows or storm sash, use ½ these values, where applicable, but never less than ½ air change.

windows and doors. The air then moves upward through cracks and openings in the floor which acts like a damper in the chimney. Above the floor the chimney has many parallel passages consisting of the several rooms and the hollow wall spaces in certain types of construction. These separate passages are all interconnected by cracks and also communicate with the outside through cracks and fissures. The ceiling acts as another damper with air flowing upward through various cracks and openings. This condition is repeated in every story of a multi-story building and can be further complicated by open stairways, elevator shafts, and utility ducts. The attic finally represents the union of all the parallel passages in the chimney with the outward flow of air being again restricted by the roof construction.

Since the chimney effect in a building produces a negative pressure and an inward flow of air at the lower levels and positive pressure and outward flow at the higher levels, a neutral zone[7] exists near midheight where there is no pressure difference between indoors and outdoors, if the openings are about uniformly distributed in a vertical direction. At the neutral zone there would be no air flow through openings in the outside walls as a result of temperature differences.

The infiltration caused by the indoor-outdoor temperature differences can be calculated by means of the crack method described earlier in this chapter for determining the infiltration caused by wind pressure. This is done by determining the equivalent wind velocity that would produce the same rate of infiltration as was caused by the prevailing temperature difference. It is recommended that one-half the total crack length of the