

building be used for this computation. To determine the infiltration caused by the temperature difference, one-half the crack length of the building is multiplied by the infiltration coefficient from Table 2 corresponding to the equivalent wind velocity computed from the following equation developed from basic relationships between velocity, pressure, density and temperature.

$$V_o = B\sqrt{h(t_i - t_o)} \quad (1)$$

where

- V_o = equivalent wind velocity corresponding to the temperature difference ($t_i - t_o$), miles per hour.
 h = height of rooms, feet.
 t_i = inside temperature, Fahrenheit.
 t_o = outside temperature, Fahrenheit.
 B = a constant to account for leakage through floor and ceiling and for the number of stories in the building.

The constant B would be 0.12 for a single-story building or for any story of a multi-story building whose floor and ceiling were impervious to air, whereas the value of B was found to be approximately unity for a single-story frame building with basement and attic having double wood flooring, plastered ceiling, and the walls finished with plasterboard on the inside. The value of this constant would increase as the the number of stories increased and for stories farther removed from the neutral zone in either direction in buildings that lacked perfect sealing between stories.

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 per cent of this in the bottom third, the normal amount in the middle third, and the balance in the top third.

INFILTRATION MEASUREMENT

The total air leakage into an existing building caused by wind and temperature difference forces can be determined with considerable accuracy by determining the decrease in concentration of a tracer gas. Such measurements have been made using water vapor or carbon dioxide as the tracer gas, but such experiments have not been too successful because both of these gases are absorbed by many building materials. However, hydrogen and helium have both been used quite successfully as tracer gases in conjunction with a sensitive thermal conductivity comparator.⁸ About one percent of tracer gas by volume is introduced into the room or building for which the infiltration is to be determined and the tracer gas is thoroughly mixed with the air. The decrease in concentration of the tracer gas is then observed at regular time intervals with a thermal conductivity meter as fresh air leakage dilutes the mixture. The following formula developed from fundamental considerations is used to calculate the infiltration from the observed concentration measurements:

$$C = C_o e^{-\frac{kt}{v}} \quad (2)$$

where

- C_o = initial tracer gas concentration, percent.
 C = concentration of tracer gas after t minutes, percent.
 v = volume of room or building, cubic feet.
 k = infiltration rate, cubic feet per minute.
 e = 2.718, base for natural logarithms.

Partly enclosed spaces, such as closets and cupboards, should be left open during such infiltration tests so the entire space will have the same rate of change of tracer-gas concentration.

Infiltration and Air for Combustion

Infiltration in buildings normally supplies the air required for combustion by fuel-burning appliances, but in some cases weatherstripping, sealing and caulking may reduce infiltration to the point that special openings must be provided to supply adequate air to the heating appliances.

NATURAL VENTILATION

Ventilation by natural forces finds application in industrial plants, public buildings, schools, dwellings, garages, and in farm buildings.

The natural forces available for moving air into, through, and out of buildings are: (a) wind forces, and (b) the difference in temperature between the air inside and outside a building. The air movement may be caused by either of these forces acting alone, or by a combination of the two, depending upon atmospheric conditions, building design, and location. The ventilating results obtained will vary, from time to time, due to variation in the velocity and direction of the wind, and the temperature difference. The arrangement, location, and control of the ventilating openings should be such that the two forces act cooperatively rather than in opposition.

WIND FORCES

In considering the use of natural wind forces for producing ventilation, account must be taken of: (1) average wind velocity; (2) prevailing wind direction; (3) seasonal and daily variations in velocity and direction; and