

ments of the majority of people consist of temperatures between 68 and 72 F in winter and between 70 and 85 F in summer, the latter depending largely upon the prevailing outdoor temperature. The most desirable relative humidity range seems to be between 30 and 60 per cent.

3 • Are the optimum conditions for comfort identical with those for health?

There are no absolute criteria of the prolonged effects of various air conditions on health. For the present it can be only inferred that bodily discomfort may be an indication of adverse conditions leading to poor health.

4 • Given dry-bulb and wet-bulb temperatures of 76 F and 62 F, respectively, and an air velocity of 100 fpm, determine: (1) effective temperature of the condition; (2) effective temperature with calm air; (3) cooling produced by the movement of the air.

(1) In Fig. 1 draw line *AB* through given dry- and wet-bulb temperatures. Its intersection with the 100 ft velocity curve gives 69 deg for the effective temperature of the condition. (2) Follow line *AB* to the right to its intersection with the 20 fpm velocity line, and read 70.4 deg for the effective temperature for this velocity or so-called still air. (3) The cooling produced by the movement of the air is $70.4 - 69 = 1.4$ deg ET.

5 • Assume that the design of an air conditioning system for a theater is to be based on an outdoor dry-bulb temperature of 95 F and a wet-bulb temperature of 78 F with an indoor relative humidity of 50 per cent. According to Table 2, the dry-bulb temperature in the auditorium should be 80 F. Estimate the sensible and latent heat given up per person.

The sensible heat given up per person per hour may be obtained from Fig. 9. With an abscissa value of 80 F, Curve *D* for men seated at rest gives a value (on the ordinate scale) of 220 Btu per person per hour as the sensible heat loss. The latent heat given up by a person seated at rest may be obtained from Fig. 10. With an abscissa value of 80 F, Curve *D* indicates a latent heat loss of 175 Btu per hour (left hand scale) or a moisture loss of 1190 grains per hour (right hand scale).

6 • Neglecting the gain or loss of heat by transmission or infiltration through walls, windows and doors, how many cubic feet of outside air, with dry- and wet-bulb temperatures of 65 F and 59 F, respectively, (63.1 deg ET) must be supplied per hour to an auditorium containing 1000 people in order that the inside temperature shall not exceed 75 F dry-bulb and 65 F wet-bulb?

Figs. 9 and 10 give 265 Btu sensible heat and 905 grains of moisture per person with a dry-bulb temperature of 75 F in the auditorium. Therefore, 265,000 Btu of sensible heat and 905,000 grains of moisture will be added to the air in the auditorium per hour.

Taking 0.24 as the specific heat of air, 2.4 Btu per pound of air will be absorbed in raising the dry-bulb temperature from 65 to 75 F, and $\frac{265,000}{2.4} = 110,400$ lb of air or

$110,400 \times 13.4 = 1,479,000$ cfh of air will be required. This is equivalent to $\frac{1,479,000}{1000 \times 60} = 24.7$ cfm per person.

The moisture content of the inside air is 76 grains per pound of dry air and that of the outside condition is 65 grains. From a psychrometric chart the increase in moisture content will therefore be 11 grains per pound of dry air. Hence $\frac{905,000}{11.0} = 82,300$ lb of air at the specified condition will be required. This is equivalent to $82,300 \times 13.4 = 1,103,000$ cfh of air or $\frac{1,103,000}{1000 \times 60} = 18.4$ cfm of air per person.

The higher volume of 24.7 cfm per person will be required to keep the dry-bulb temperature from rising above the 75 F specified. The wet-bulb temperature will therefore not rise to the maximum of 65 F.

Chapter 4

NATURAL VENTILATION

Wind Forces, Stack Effect, Openings, Windows, Doors, Skylights, Roof Ventilators, Stacks, Principles of Control, General Rules, Measurements, Dairy Barn Ventilation, Garage Ventilation

VENTILATION by natural forces, supplemented in certain cases with mechanical forces, finds extensive application in industrial plants, public buildings, schools, dwellings, garages, and in farm buildings.

The natural forces available for the displacement of air in buildings are the wind and the difference in temperature of the air inside and outside the building. The arrangement and control of ventilating openings should be such that the two forces act cooperatively and not in opposition.

Wind Forces

In considering the use of natural wind forces for the operation of a ventilating system, account must be taken of (1) average and minimum wind velocities, (2) wind direction, (3) seasonal, daily and hourly variations in wind velocity and direction, and (4) local wind interference by buildings and trees.

Table 1, Chapter 8, gives values for the average summer wind velocities and the prevailing wind directions in various localities throughout the United States, while Table 2, Chapter 7, lists similar values for the winter. In almost all localities the summer wind velocities are lower than those in the winter, and in about two-thirds of the localities the prevailing direction is different during the summer and winter. While average wind velocities are seldom below 5 mph, there are many hours in each month during which the wind velocity is from 3 to 5 mph, even in localities where the seasonal average is considerably above 5 mph. There are relatively few places where the hourly wind velocity falls much below 3 mph for more than 10 daylight hours per month. Usually a natural ventilating system should be designed to operate satisfactorily with a wind velocity of 3 to 6 mph, depending on locality.

The following formula may be used for calculating the quantity of air forced through ventilation openings by the wind, or for determining the proper size of such openings:

$$Q = EAV \quad (1)$$

where

Q = air flow in cubic feet per minute.

A = free area of inlet (or outlet) openings in square feet.

V = wind velocity in feet per minute,

= miles per hour $\times 88$.

E = effectiveness of openings.

(*E* should be taken at from 50 to 60 per cent if the inlet openings face the wind and from 25 to 35 per cent if the inlet openings receive the wind at an angle.)