

necessary for effectiveness would be likely to transcend the limit of comfort in ordinary occupied rooms. While ozone has been used in the treatment of certain diseases, there is no evidence that it has a tendency to increase comfort or to benefit health under conditions of normal human occupancy. The allowable concentrations in the breathing zone are very small, between 0.01 to 0.05 ppm parts of air. These are much too small to influence bacteria. Higher concentrations are associated with a pungent unpleasant odor and considerable discomfort to the occupants. One part per million causes respiratory discomfort, headaches, depression, a lowering of the metabolic rate and may even lead to coma¹⁰.

PHYSICAL IMPURITIES IN AIR

Dust particles of various types, when present in considerable concentrations, produce an irritant effect upon the mucous membranes of nose and throat and may be associated with high prevalence of acute respiratory diseases such as bronchitis and pneumonia. Dust which contains free silica has special harmful effects, causing a primary disease of the lungs (silicosis) and predisposing the victim in a high degree to tuberculosis. These, however, are special problems of industrial hygiene which will not be discussed in detail in this chapter.

A certain part of the dissemination of disease in confined spaces is caused by the emission of pathogenic organisms from infected persons. Droplets sprayed into the air in talking, coughing, sneezing, etc., do not all fall immediately to the ground within a few feet from the source, as was formerly believed. The large droplets fall, but minute droplets less than 0.1 mm in diameter evaporate to dryness before they fall the height of a man. Nuclear residues from such sources, which may contain infective organisms drift long distances with the air currents and the virus may remain alive long enough to be transmitted to other persons in the same room or building. Droplet nuclei have been recovered from cultures of resistant micro-organisms a week after inoculation into a tight chamber of 3000 cu ft capacity, although the majority of disease germs died out within a few hours¹¹. Practical epidemiological evidence indicates that the danger of such atmospheric transmission is slight with the bacterial diseases but may be appreciable with the diseases caused by the much smaller viruses. Avoidance of overcrowding is a major factor in avoiding such dangers. The microbic concentration in the atmosphere may be reduced by air change, but since the rate of contamination may be great at local points over short periods of time the hazardous concentration may not be eliminated quickly enough and may even be spread over larger areas by local drafts. The possibility of sterilizing the air supply at the source, or destroying the micro-organisms at their point of admission to the air by ultra-violet light is being studied and offers considerable promise¹².

While in some instances it may be possible to reduce the physical impurities of the air by dilution from a non-contaminated source, such non-contaminated sources are rarely available. Frequently the outside air contains a higher concentration of physical impurities than that within an enclosure. Therefore, it is usually desirable to reduce the concentra-

¹⁰The British Medical Journal, Editorial, June 25, 1932, p. 1182. See also Loc. Cit. Note 9.

¹¹Air-Borne Infection and Sanitary Air Control, by W. F. Wells (Journal Industrial Hygiene, November, 1935).

¹²Sanitary Ventilation in Wards, by W. F. Wells (Heating and Ventilating, April, 1939, p. 26). Measurement of Sanitary Ventilation, by W. F. Wells (American Journal of Public Health, Vol. 28, 1938, p. 343).

tion of physical impurities by air cleaning methods, as discussed in Chapter 28.

THERMAL INTERCHANGES BETWEEN THE BODY AND ITS ENVIRONMENT

The importance of the thermal factors arises from the profound influence which they exert upon body temperature, comfort and health. Body temperature depends upon the balance between heat production and heat loss. The heat resulting from the oxidation which occurs within the body (metabolism) maintains the body temperature well above that of the surrounding air in a cool or cold environment. At the same time, heat is constantly lost from the body by radiation, convection and evaporation. Since, under ordinary conditions, the body temperature is maintained at its normal level of about 98.6 F, the heat production must be balanced by the heat loss.

In conditioning air for comfort and health it is necessary to know the rate of sensible and latent heat liberation from the human body, which in conjunction with other heat loads (see Chapters 4, 6 and 7) determines the capacity required for proper conditioning. The data in common use are those of the A.S.H.V.E. Research Laboratory¹³.

The fundamental thermodynamic processes concerned in heat interchanges between the body and its environment may be described by the equation:

$$M = \pm S + E \pm R \pm C \quad (1)$$

where

M = rate of metabolism.

S = rate of storage.

E = rate of evaporative heat loss.

R = rate of radiative heat loss or gain.

C = rate of convective heat loss or gain.

Factor M , the rate of metabolism, is always positive. The storage, S , may be either positive or negative, depending upon whether heat is being stored or given off, accompanied by a rise or fall in body temperature. Under ordinary circumstances (when the dew-point of the air is below the body surface temperature) the evaporation loss, E , is always positive; that is, heat from metabolism supplies this loss. R and C are positive when the surface temperature of the body is above that of the walls and air, and negative when it is cooler.

The human body possesses remarkable powers of adaptation to a narrow range of atmospheric conditions around an ideal optimum where storage is zero, and metabolism and skin and tissue temperature are at optimum values. As skin temperature and body-tissue temperature rise or fall above or below an optimum, complex adaptive mechanisms come into play, chiefly associated with redistribution of blood supply between the skin and deeper tissues (in a cold environment) and with sweat

¹³A.S.H.V.E. RESEARCH REPORT No. 830—Heat and Moisture Losses from the Human Body and Their Relation to Air Conditioning Problems, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (A.S.H.V.E. TRANSACTIONS, Vol. 35, 1929, p. 245). Thermal Exchanges Between the Human Body and Its Atmospheric Environment, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (American Journal of Physiology, Vol. 88, 1929, p. 386). A.S.H.V.E. RESEARCH REPORT No. 908—Heat and Moisture Losses from Men at Work and Application to Air Conditioning Problems, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (A.S.H.V.E. TRANSACTIONS, Vol. 37, 1931, p. 541). Thermal Exchanges Between the Bodies of Men Working and the Atmospheric Environment, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant (American Journal of Hygiene, Vol. XIII, 1931, No. 2, p. 415). A.S.H.V.E. RESEARCH REPORT No. 1106—Air Conditioning in Industry, by W. L. Fleisher, A. E. Stacey, Jr., F. C. Houghten and M. B. Ferderber (A.S.H.V.E. TRANSACTIONS, Vol. 45, 1939, p. 59).