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PHYSIOLOGICAL PRINCIPLES

Chemical Vitiating of Air, Physical Impurities in Air, Thermal Interchanges Between the Body and Its Environment, Low- and High-Temperature Hazards, Acclimatization, Upper Limits of Heat for Men at Work, Hot Spaces, Assessment of Heat Stress, Dry-bulb Temperature, Effective Temperature, Wet-bulb Globe-Temperature Index, Index of Physiological Effect, The Predicted Four-Hour Sweat Rate, Heat Stress Index, Environmental Conditions and Comfort

An understanding of physiological principles is essential in the proper design of air conditioning systems for spaces intended for human occupancy. The term *air conditioning*, in its broadest sense, implies control of any or all of the physical and chemical qualities of the air. As defined in Chapter 67, *comfort air conditioning* is the process of treating air so as to control simultaneously its temperature, humidity, cleanliness, and distribution, to meet the comfort requirements of the occupants of the conditioned space.

CHEMICAL VITIATING OF AIR

People living indoors bring about certain physical and chemical changes in the air about them. The oxygen content of the air diminishes and the carbon dioxide increases, but these changes are too slight to be significant except in airtight spaces as in submarines. Organic matter which is usually perceived as odors, comes from the body or clothes. Moisture and heat are given off by the body. There is no evidence of any toxic volatile material given off by man to the ambient air. Stale air may be offensive because of odors and may induce loss of appetite and loss of energy. Objectionable body odors have the same effects. These reasons, whether esthetic or physiological, usually make it desirable in the design of air-conditioning systems to provide for the elimination or control of odors arising from occupancy, cooking, or other sources. This may be accomplished by introducing odor-free air in sufficient quantities to reduce odor concentrations by dilution to a level which is not objectionable. Odor-free air may be outdoor air or air which has been cleared of odors by sorption, washing, or other appropriate means.

In the case of vitiation by a few hazardous gases such as carbon monoxide from heating, cooking, and certain industrial processes, no satisfactory chemical treatment for the elimination of the impurity has been found. The only satisfactory solution is elimination at the source by local exhaust ventilation, or, if this is impossible, reduction to a safe concentration by dilution. (See Chapter 11). In the case of contamination by other matter, including volatile vapors and gases, chemical treatment for the removal or reduction of the impurities has been made available through air cleaning methods, which are discussed in Chapter 36.

The general responsibility for this chapter is assigned to TC 1.4, Physiology and Human Environment.

When the only source of contamination is the human occupant, and overheating is not a problem, the minimum quantity of odor-free air needed appears to be that required to remove objectionable body odors or tobacco smoke. The concentration of body odor in a room, in turn, depends upon a number of factors, including the dietary and hygienic habits of the occupants (frequently reflecting their socio-economic status), the odor-free air supply, air space allowed per person, odor adsorbing capacity of air-conditioning processes, and temperature and relative humidity. The intensity of odor sensation has been found to vary as the logarithm of the concentration of the odoriferous substance in the air, or inversely with the logarithmic function of the amount of odor-free air supplied and the air space per person.

The relation between air supply and occupancy has been studied by the Harvard School of Public Health¹ and by the ASHRAE Research Laboratory.² The data in Table 1 are for the removal of body odors under laboratory conditions.³ Table 3 of Chapter 27 gives minimum and recommended ventilation rates for various types of occupancies, and includes requirements for the removal of tobacco smoke.⁴

The total quantity of outdoor air to be circulated through an enclosure is often governed chiefly by the physical considerations for controlling temperature, air distribution, and air velocity. Other factors which must be taken into consideration include the type and usage of the building, locality, climate, height of rooms, floor area, window area, extent of occupancy, and the operation of the system distributing the air supply. Frequently, some of these factors, particularly the need for air movement and good distribution, may be satisfied by recirculation of inside air rather than outdoor air.

It will be noted that, with adequate air space, the rate of air change indicated in Table 1 is from 4 to 30 cfm per person. In rooms occupied by only a few persons, such an air change will be automatically attained in cold weather by normal leakage around doors and windows, and can easily be secured in warm weather by the opening of windows. With a space allotment of 400 cu ft per person, only 1½ air changes per hour are necessary to provide a ventilation rate of 10 cfm per person.

Therefore, in the ordinary dwelling with adequate cubic space allotment, no special provision for controlling chemical purity of the air is necessary (aside from removal of fumes