CHAPTER 2

Physiological Principles

Chemical Vitiation of Air, Physical Impurities in Air, Thermal Interchanges Between the Body and Its Environment, Adaptation to Hot Conditions, Relation of Air Conditioning Needs to Metabolism, Acclimatization, Effective Temperature Index, Physiological Objectives of Heating and Ventilation, Summer Comfort, Influence of Humidity, Influence of Air Movement, The Four Vital Factors

VENTILATION is defined in part as *the process of supplying or removing air by natural or mechanical means to or from any space.* (See Chapter 47). The word in itself implies quantity but not necessarily quality. From the standpoint of comfort and health, however, the problem is now considered to be one of securing air of the proper quality rather than of supplying only a given quantity.

The term *air conditioning* in its broadest sense implies control of any or all of the physical or chemical qualities of the air. When applied to comfort air conditioning, however, the A.S.H.V.E. Code of Minimum Requirements of Comfort Air Conditioning[1] defines it "as the process by which simultaneously the temperature, moisture content, movement and quality of the air in enclosed spaces intended for human occupancy may be maintained within required limits. If an installation cannot perform all of these functions, it shall be designated by a name that describes only the function or functions performed."

CHEMICAL VITIATION OF AIR

Under the artificial conditions of indoor life, the air undergoes certain physical and chemical changes which are brought about by the occupants themselves. The oxygen content is somewhat reduced, and the carbon dioxide slightly increased by the respiratory processes. Organic matter, which is usually perceived as odors, comes from the nose, mouth, skin and clothing. The temperature of the air is increased by the metabolic processes, and the humidity raised by the moisture emitted from the skin and lungs.

Contrary to old theories, the usual changes in oxygen and carbon dioxide are of no physiological concern because they are too small to produce appreciable effects even under the worst conditions of normal human occupancy. Only in such unusually air-tight enclosures as submarines and some air raid shelters need the increase in carbon dioxide and the reduction in oxygen be considered. The amount of carbon dioxide in air is often used as an index of odors of human origin, but the information it affords rarely justifies the labor involved in making the observation[2, 3]. Little is known of the identity and physiological effects of the organic matter given off in the process of respiration. The former belief that the discomfort experienced in confined spaces was due to some toxic volatile matter in the expired air is now limited, in the light of numerous researches, to the much less dogmatic view that the presence of such a

[1]Code of Minimum Requirements for Comfort Air Conditioning (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 27). Reprints of this code are available at $.10 a copy.

[2]A.S.H.V.E. RESEARCH REPORT No. 959—Indices of Air Change and Air Distribution, by F. C. Houghten and J. L. Blackshaw (A.S.H.V.E. TRANSACTIONS, Vol. 39, 1933, p. 261).

[3]A.S.H.V.E. RESEARCH REPORT No. 1031—Ventilation Requirements, by C. P. Yaglou, E. C. Riley and D. J. Coggins (A.S.H.V.E. TRANSACTIONS, Vol. 42, 1936, p. 133).

substance has not been demonstrated. The only certain fact is that expired air may be odorous, offensive, and capable of producing loss of appetite and a disinclination for physical activity. Objectionable body odors have the same effects. These reasons, whether esthetic or physiological, call for the introduction of a certain minimum amount of clean outdoor air to dilute odors from any source, including cooking and other processes, to a concentration which is not objectionable.

In certain industrial processes toxic fumes and gases may be produced whose removal by local exhaust ventilation is essential for the protection of human health. In the ordinary occupied spaces harmful chemical impurities may be contributed from certain types of cooking and heating appliances, including carbon monoxide from imperfect combustion, which may be a serious hazard to life and health.

The control of offensive or hazardous concentrations of chemical vitiation of the air is frequently brought about by the ventilating engineer through dilution. This method has found application when the source of contamination is the human occupant and not something of a particularly hazardous character.

In the case of vitiation by a few hazardous gases such as carbon monoxide from heating and cooking and certain industrial processes, no satisfactory chemical treatment for the elimination of the impurity has been found. The only really satisfactory solution is elimination at the source; or, if this is impossible, reduction to a safe concentration by dilution. In the case of contamination by other matter, including volatile vapors and gases, chemical treatment for the removal or chemical reduction of the impurities has been made available through air cleaning methods, which are discussed in Chapter 28 on Air Cleaning Devices. The A.S.H.V.E. Research Technical Advisory Committee on Removal of Atmospheric Impurities has outlined[4] means for the reduction of atmospheric impurities.

When the only source of contamination is the human occupant, the minimum quantity of outdoor 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 outdoor air supply, air space allowed per person, odor adsorbing capacity of air conditioning processes, and temperature and relative humidity. Perception of odor, like the perception of most of the other senses, is proportional to the logarithmic function of the intensity of the stimulus; or in the case of odors, the perception has been found to vary as the logarithmic function of the odor intensity, or inversely with the logarithmic function of the available air determined by the outdoor air supply and the air space per person.

The relation between air supply and occupancy has been reported by the *Harvard School of Public Health*[5] and the A.S.H.V.E. Research Laboratory[6]. The findings from the Harvard study are given in Table 1. Outdoor air requirements for removal of objectionable tobacco smoke odors are not accurately known but sources of information available and practice indicates the need of 15 cfm per person or more.

The total quantity of outside air to be circulated through an enclosure is governed by both chemical and physical considerations. The physical

[4]Report of the A.S.H.V.E. Technical Advisory Committee on Removal of Atmospheric Impurities (Programs of the Research Technical Advisory Committees, June, 1941, p. 7).

[5]Loc. Cit. Note 3.

[6]Loc. Cit. Note 2.