justifies the labor involved in making the observation[1,2]. 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 substance has not been demonstrated. The only certain fact is that expired air may be odorous and offensive, and it is capable of producing loss of appetite and a disinclination for physical activity. 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 in 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 forms of material, including volatile vapors and gases, chemical treatment for the removal or chemical reduction of the impurities have been made available through air cleaning methods, which will be discussed in Chapter 29 on Air Cleaning Devices. The A.S.H.V.E. Research Technical Advisory Committee on Air Pollution and Air Purification has outlined[3] 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 necessary 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 our other senses, is proportional to the logarithmic function of the intensity of the stimulus; or in the case of odors, the

[1]A.S.H.V.E. Research Report No. 959—Indices of Air Changes and Air Distribution, by F. C. Houghten and J. L. Blackshaw (A.S.H.V.E. Transactions, Vol. 39, 1933, p. 261).

[2]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).

[3]Report of the A.S.H.V.E. Technical Advisory Committee on Air Pollution and Air Purification (Programs of the Research Technical Advisory Committee, June, 1941).

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*[4] and the A.S.H.V.E. Research Laboratory[5]. 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 requirements for controlling temperature, air distribution and air velocity usually predominate. 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 by outside air.

It will be noted that, with adequate air space, the rate of air change indicated in Table 1 is from 10 to 30 cfm per person. In rooms occupied by only a few persons such a rate of air change will be automatically attained in cold weather by normal leakage around doors and windows while it 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 an air change of 10 cfm per person. This space allotment is essential for other reasons.

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 from heating appliances). For such conditions, the control of air temperature is the major factor to be considered.

In more crowded rooms (large offices, large workrooms, auditoriums), the whole picture changes. Cubic space per person is less and the size of the room makes it impossible to admit untempered outside air without drafts. Here, mechanical ventilation is essential, but as will be noted in a later paragraph, it is even more essential for thermal than for chemical reasons. It is control of the thermal properties of the air in order to effect the removal of the heat produced by human bodies, rather than dilution of chemical poisons, which must govern practice.

The Code of Minimum Requirements for Comfort Air Conditioning[6] prescribes definite minimum requirements which should be familiar to the designing engineer. It should be emphasized, however, that the provisions of the code aim to provide *minimum*, rather than *adequate*, requirements.

Notwithstanding the rapid advance in the field of air conditioning

[4]Loc. Cit. Note 2.

[5]Loc. Cit. Note 1.

[6]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.