

contrasts upon entering and leaving the *cooled* space and to keep the clothing and skin dry. This second scheme requires more refrigeration with the present conventional type of apparatus.

Current practice in theaters, restaurants, etc., follows a schedule similar to that shown in Table 2. This schedule has been the subject of much discussion and criticism but so far no satisfactory substitute has been offered. It is, in fact questionable whether entirely satisfactory air conditions could be adduced for practical use to meet the changing requirements of patrons from the time they enter to the time they leave a cooled space. Too many uncontrollable variables enter into the problem. Work now going on at the A.S.H.V.E. Laboratories and other interested institutions may throw considerable light on this complex problem.

For cooled banks and stores where the customers come and go spending but a few minutes in the cooled space, observations³⁷ indicate a schedule about 1 deg dry-bulb or effective temperature higher than that shown in Table 2. Laboratory experiments with exposures of 2 to 10 min indicate temperatures 2 to 10 F higher than those in Table 2 but with much lower relative humidities.

It should be kept in mind that southern people, with their more sluggish heat production and lack of adaptability, will demand a comfort zone several degrees higher than that for the more active people of northern climates. Instead of the summer comfort line standing at 71 deg as here given, it was found to be much higher for foreigners in Shanghai where climatic conditions are similar to those of our gulf states. This difference in adaptability of people forms a very real problem for air conditioning engineers. Cooling of theaters, restaurants, and other public buildings in southern climates cannot be based on northern standards without considerable modification.

Optimum Humidity

Just what the optimum range of humidity is, is a matter of conjecture. There seems to exist a general opinion, supported by some experimental and statistical data, that warm, dry air is less pleasant than air of a moderate humidity, and that it dries up the mucous membranes in such a way as to increase susceptibility to colds and other respiratory disorders^{37, 38, 39}. Owing to the cooling effect of evaporation, higher temperatures are necessary, and this condition may lead to discomfort and lassitude. Moist air, on the other hand, interferes with the normal evaporation of moisture from the skin, and again may cause a feeling of oppression and lassitude, especially when the temperature is also high. For the premature infant, a high relative humidity of about 65 per cent is demonstrably beneficial to health and growth⁴⁰ until the infants reach a

³⁷How Cool? Inside Temperature should Depend upon Type of Occupancy, by J. H. Walker (*Heating and Ventilating*, October, 1932).

³⁸Reactions of the Nasal Cavity and Post-Nasal Space to Chilling of the Body Surface, by Mudd, Stuart, et al (*Journal Experimental Medicine*, 1921, Vol. 34, p. 11).

³⁹Reactions of the Nasal Cavity and Post-Nasal Space to Chilling of the Body Surfaces, by A. Goldman, et al and Concurrent Study of Bacteriology of Nose and Throat (*Journal Infectious Diseases*, 1921, Vol. 29, p. 151).

⁴⁰The Etiology of Acute Inflammations of the Nose, Pharynx and Tonsils, by Mudd, Stuart, et al (*Am. Otol., Rhinol. and Laryngol.*, 1921).

⁴¹Loc. Cit. Note 24.

weight of about 5 lb. No such clear-cut evidence exists in the case of adult persons. In the comfort zone experiments of the A.S.H.V.E. Research Laboratory, the relative humidity was varied between the limits of 30 and 70 per cent approximately, but the most comfortable range has not been determined. In similar experiments at the Harvard School of Public Health, the majority of the subjects were unable to detect sensations of humidity (*i.e.*, too high, too low, or medium) when the relative humidity was between 30 per cent and 60 per cent with ordinary room temperatures. This is in accord with studies by Howell⁴¹, Miura⁴² and others.

The limitation of the comfort zones in Fig. 6 with respect to humidity must not be taken too seriously. Relative humidities below 30 per cent may prove satisfactory from the standpoint of comfort, so long as extremely low humidities are avoided. From the standpoint of health, however, the consensus seems to favor a relative humidity between 40 and 60 per cent. In mild weather such comparatively high relative humidities are entirely feasible, but in cold or sub-freezing weather they are objectionable on account of condensation and frosting on the windows. They may even cause serious damage to certain building materials of the exposed walls by condensation and freezing of the moisture accumulating inside these materials. Unless special precautions are taken to properly insulate the affected surfaces, it will be necessary to reduce the degree of artificial humidification in sub-freezing weather to less than 40 per cent, according to the outdoor temperature. Information on the prevention of condensation on building surfaces is given in Chapter 7. The principles underlying humidity requirements and limitations are discussed more fully elsewhere⁴³.

The purpose of artificial humidification may be easily defeated by failure to change the spray water of the humidifier at least daily. Where this condition occurs, the air is characterized by a *lack of freshness*, and under extreme conditions by a musty sour odor in the conditioned space.

AIR QUALITY AND QUANTITY

Air Quality

In occupied spaces in which the vitiation is entirely of human origin, the chemical composition of the air, the dust, and often the bacteria content may be dismissed from consideration so that the problem consists in maintaining a suitable temperature with a moderate humidity, and in keeping the atmosphere free from objectionable odors. Such unpleasant odors, human or otherwise, can be easily detected by persons entering the room from clean, odorless air.

In industrial rooms where the primary consideration is the control of air pollution (dusts, fumes, gases, etc.), or contamination not removable at the source of production, the clean air supply must be sufficient to dilute the polluting elements to a concentration below the physiological threshold (See Chapters 15 and 16).

⁴¹Humidity and Comfort, by W. H. Howell (*The Science Press*, April, 1931).

⁴²Effect of Variation in Relative Humidity upon Skin Temperature and Sense of Comfort, by U. Miura (*American Journal of Hygiene*, Vol. 13, 1931, p. 432).

⁴³Humidification for Residences, by A. P. Kratz (*University of Illinois Engineering Experiment Station Bulletin No. 230*, July 28, 1931).