young children up to school age. Satisfactory air conditions for these age groups are assumed to vary from 75 to 68 F with natural indoor humidities. For school children, the studies of the *New York State Commission on Ventilation* place the optimum air conditions at 66 to 68 F temperature with a moderate humidity and a moderate but not excessive amount of air movement[35].

Satisfactory comfort conditions for men at work are found to vary from 40 to 70 deg ET, depending upon the rate or work and amount of clothing worn[36]. In hot industries, 80 deg ET is considered the upper limit compatible with efficiency, and, whenever possible, this should be reduced to 70 deg ET or less.

The summer comfort zone is much more difficult to fix than the winter zone owing to the complicating factor of sweating in warm weather. A given air condition which is comfortable for persons with dry skin and clothing may prove too cold for those perspiring, as is the case, for instance, with employees and customers in a cooled store, restaurant, or theater, on a warm summer day. The conditions to be maintained in different types of public buildings depend to a large extent upon the occupant's length of stay and upon the prevailing outdoor condition.

In Fig. 6 is shown the summer comfort zone for exposures of 3 hours or more, after adaptation has taken place. The average zone extends from 66 to 75 deg ET, with a comfort line at 71 deg ET, as determined at the *Harvard School of Public Health*[37]. These effective temperatures average about 4 deg higher than those found in winter when customary winter clothing was worn. The variation from winter to summer is probably due partly to adaptation to seasonal weather and partly to differences in the clothing worn in the two seasons.

The basic summer comfort zone presented in Fig. 6 prescribes conditions of choice for continuous exposures, as in homes, offices, etc., without regard to costs, prevailing outdoor air conditions, and temperature contrasts upon entering or leaving the cooled space. A great number of persons seem to be content with a higher plane of indoor temperature, particularly when the matter of first cost and cost of operation of a cooling plant is given due consideration.

According to previous investigations[38], an indoor temperature of about 80 F with relative humidities below 55 per cent, or 74.5 deg ET and lower, results in satisfactory comfort conditions in the living quarters of a residence, and while this condition is not representative of optimum comfort it provides for sufficient relief in hot weather to be acceptable to the majority of users. Experience in a number of air conditioned office buildings, including the *New Metropolitan Life Building in New York*[39], indicates that a temperature of about 80 F with a relative humidity between 45 and 55 per cent (73 to 74.5 deg ET) is generally satisfactory in meeting the requirements of the employees.

[35]Loc. Cit. Note 12.

[36]Loc. Cit. Note 28.

[37]Loc. Cit. Note 31.

[38]A.S.H.V.E. RESEARCH REPORT No. 1012—Study of Summer Cooling in the Research Residence for the Summer of 1934, by A. P. Kratz, S. Konzo, M. K. Fahnestock and E. L. Broderick (A.S.H.V.E. TRANSACTIONS, Vol. 41, 1935, p. 207).

[39]The Air Conditioned System of the New Metropolitan Building—First Summer's Experience, by W. J. McConnell and I. B. Kagey (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 217).

Recent studies carried out under the auspices of the Society have shown that effective temperatures of 71 F in Toronto, 72 F in Pittsburgh and Minneapolis, and 73 F in Texas, were generally found most comfortable by sedentary workers during the summer months[40]. The preferred indoor optimum varied with outdoor temperature during successive summer months[41]; and interesting data were obtained as to contrast effects between indoor and outdoor situations[42].

In artificially cooled theaters, restaurants, and other public buildings where the period of occupancy is short, the contrast between outdoor and indoor air conditions becomes the deciding factor in regards to the temperature and humidity to be maintained. The object of cooling such places in the summer is to provide sufficient relief from the heat without causing sensations of chill or intense heat on entering and leaving the building.

The Comfort Chart has proved one of the most valuable tools of the heating and ventilating engineer. Research in other laboratories[43] has shown somewhat different quantitative relationships but these are easily accounted for by differences in metabolic activity and clothing. It appears from this other work that the Comfort Chart may perhaps exaggerate somewhat the influence of relative humidity at low temperatures and underestimate it at high temperatures; but the chart gives an essentially correct picture of those relations which exist where radiant influences and high air movement are not important factors.

PHYSIOLOGICAL OBJECTIVES OF HEATING AND VENTILATION

Aside from the removal of toxic fumes and dusts from heating appliances and industrial processes, the chief task of the heating and ventilating engineer is to keep his clients warm in winter and cool in summer.

For the normally vigorous person, normally clothed, and at rest, an air temperature of 65 F should be provided at knee-height, 18 in. in order to prevent chilling of the legs and feet. With some heating systems, this will correspond to 70 F at a 5 ft height. Air temperature may be increased or decreased in order to compensate for deviations of *mean radiant temperature* above or below air temperature.

In rooms occupied by persons of sub-normal vitality, knee-height temperatures must be higher than 65 F. Since dwellings are designed for occupancy by old people and children, the heating system should be able to provide a temperature of 70 F at knee-height under ordinary winter conditions.

[40]A.S.H.V.E. RESEARCH REPORT No. 1035—Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet (A.S.H.V.E. TRANSACTIONS, Vol. 42, 1936, p. 215). A.S.H.V.E. RESEARCH REPORT No. 1055—Cooling Requirements for Summer Comfort Air Conditioning, by F. C. Houghten, F. E. Giesecke, C. Tasker and Carl Gutberlet (A.S.H.V.E. TRANSACTIONS, Vol. 43, 1937, p. 145). A.S.H.V.E. RESEARCH REPORT No. 1088—Summer Cooling Requirements of 275 Workers in an Air Conditioned Office, by A. B. Newton, F. C. Houghten, Carl Gutberlet, and R. W. Qualley (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 337). Cooling Requirements for Summer Comfort Air Conditioning in Toronto, by C. Tasker (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 549).

[41]A.S.H.V.E. RESEARCH REPORT No. 1088—Summer Cooling Requirements of 275 Workers in an Air Conditioned Office, by A. B. Newton, F. C. Houghten, Carl Gutberlet and R. W. Qualley (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 337).

[42]A.S.H.V.E. RESEARCH REPORT No. 1102—Shock Experiences of 275 Workers After Entering and Leaving Cooled and Air-Conditioned Offices, by A. B. Newton, F. C. Houghten, C. Gutberlet, R. W. Qualley, and M. C. W. Tomlinson (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 571).

[43]Loc. Cit. Note 9.