

tion or depression of the mean radiant temperature above or below the air temperature requires about 0.5 deg counterchange in effective temperature of the air. Since the mean radiant temperature of the surroundings is affected by cold, uninsulated walls and windows, particularly single glazed windows, as well as by heating units placed within the room, including panel heaters, these factors must be compensated. Likewise, in densely occupied spaces, such as classrooms, theaters and auditoriums, somewhat lower temperatures may be necessary than those indicated by the comfort line on account of counter-radiation between the bodies of occupants in close proximity to each other, which also will elevate the mean radiant temperature of the room.

The sensation of comfort, insofar as the physical environment is concerned, is not absolute but varies considerably among certain individuals. Therefore, in applying the air conditions indicated, it should not be expected that all the occupants of a room will feel perfectly comfortable. The curves in Fig. 7 indicate that some persons require temperatures as much as 4 and 6 deg lower and higher than the optimum for the average. In this connection it is of interest to note that from the characteristic shape of the curves that in general people will object more quickly to a few degrees drop in temperature from the average optimum than will be the case for the same number of degrees overheating. However, when optimum comfort temperatures are applied in accordance with foregoing recommendations, the majority of the occupants should be comfortable, and it should be expected that there will be a few too warm and a few too cold. These individual differences among the minority should be counteracted by suitable clothing.

Satisfactory comfort conditions for persons at work³⁹ are found to vary depending upon the rate of work and the amount of clothing worn. In general, the greater the degree of activity, the lower the effective temperature necessary for optimum comfort. However, recent work by the A.S.H.V.E. Research Laboratory⁴⁰ indicates that under certain conditions moderate activity on the part of a person standing up and moving about may result in a slightly higher optimum effective temperature than for a person seated at rest, because of the larger body surface area exposed to heat elimination and the increase in effective air movement over his body. Where few workers occupy a large space in hot industries, recent work by the A.S.H.V.E. Research Laboratory⁴¹ shows that they may be made reasonably comfortable by blowing relatively small volumes of slightly cooled air over them or through their clothing.

For prematurely born infants, the optimum temperature varies from 100 to 75 F, depending upon the stage of development. The optimum relative humidity for these infants is placed at 65 per cent⁴². No data are yet available on the optimum air conditions for full term infants and young children up to school age. Satisfactory air conditions for these age

³⁹A.S.H.V.E. RESEARCH REPORT No. 755—Effective Temperature for Persons Lightly Clothed and Working in Still Air, by F. C. Houghten, W. W. Teague and W. E. Miller (A.S.H.V.E. TRANSACTIONS, Vol. 32, 1926, p. 315).

⁴⁰A.S.H.V.E. RESEARCH REPORT No. 1106—Air Conditioning in Industry, by W. L. Fleisher, A. E. Stacey, Jr., F. C. Houghten and M. B. Ferderber (A.S.H.V.E. TRANSACTIONS, Vol. 45, 1939, p. 59).

⁴¹Loc. Cit. Note 25.

⁴²Application of Air Conditioning to Premature Nurseries in Hospitals, by C. P. Yaglou, Philip Drinker and K. D. Blackfan (A.S.H.V.E. TRANSACTIONS, Vol. 36, 1930, p. 383).

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 movement⁴³. A great number of persons seem to be fairly content with a higher plane of indoor temperature, particularly when the matter of first cost and operating cost of a cooling plant is given due consideration. Recent studies by the University of Illinois⁴⁴ in cooperation with the A.S.H.V.E. Committee on Research indicate that effective temperatures as high as 74.5 deg are acceptable in the living quarters of a residence, and while this condition is not representative of optimum comfort it provides sufficient relief in hot weather to be acceptable to the majority of users. It should be emphasized, however, that these are borderline cases that may be acceptable largely in the interest of economy. Comprehensive studies by the A.S.H.V.E. Research Laboratory⁴⁵ in cooperation with office staffs in widely distributed regions, including San Antonio, Minneapolis, Washington, D. C., and New York City (see Fig. 7), show conclusively that lower effective temperatures are required for optimum comfort.

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.

The maintenance of such conditions as these in winter depends on three major factors, the heat produced in the occupied space, the heat absorbed from the sun and the heat loss through the walls, floor and ceiling of the structure to cold air and earth. Taking these up in the order in which they occur, in planning a new structure it is essential to remember the important effect of orientation and fenestration of the building with respect to the absorption of radiant heat from the sun. It has recently been shown that, in the vicinity of New York, effective sun-heat on a wall facing south is almost five times as great in winter as in summer, but on a wall facing west-north-west it is six times as great

⁴³Ventilation Report of the New York State Commission on Ventilation (E. P. Dutton Co., N. Y., 1923).

⁴⁴A.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).

⁴⁵Loc. Cit. Note 32.