

the A.S.H.V.E. Research Laboratory⁵⁵ and at the John-B. Pierce Laboratory of Hygiene⁵⁶ give data on the effect of air movement on heat dissipation for normally clothed, standing and seated subjects, and for lightly clothed and semi-reclining subjects, respectively. Fig. 9, resulting from A.S.H.V.E. research, shows the increase in dry-bulb and wet-bulb temperatures for the same effective temperature with air velocities ranging from 20 to 700 fpm.

Air velocities may be used for effective cooling; however, great care must be exercised to avoid drafts due to uneven cooling of the body surface. During the heating season air velocities in excess of 25 to 30 fpm usually give undesirable effects. With summer cooling and air conditioning higher velocities up to 40 or 50 fpm, if properly controlled, seem to give satisfactory conditions free from sensation of draft, while with higher ambient temperatures even higher air velocities may be used. In this connection it may be emphasized that drafts are interpreted⁵⁷ as local sensations of excessive coolness, and that even while very high air movement in relatively warm air increases the rate of heat loss from local parts of the body, it may improve the comfort of the occupant, so long as that part of his body surface is not excessively cooled.

THE FOUR VITAL FACTORS

From the preceding discussion it is clear that thermal environment cannot properly be adjusted to the requirements of human health and comfort without control of all the four basic factors:

1. Air temperature (free from radiation effects).
2. Air movement.
3. Humidity.
4. Mean radiant temperature of surrounding surfaces.

According to the recommendations of the Sub-Committee on the Hygiene of Environmental Conditions in the Dwelling⁵⁸, it is of great importance in all research studies to make an accurate record of each of the four independent factors governing bodily heat exchanges, temperature, movement and humidity of the air, and mean radiant temperature of the surrounding surfaces. For this purpose the committee suggested in the interest of comparability the use of the following four types of instruments or others yielding similar data:

1. Silvered dry-bulb thermometers or hair-pin thermometers (Bergeboer).
2. Silvered dry Kata thermometers or the hot-wire anemometer.
3. Psychrometer, wet- and dry-bulb, whirling or ventilated.
4. Globe thermometer (Vernon) or the dry resultant thermometer (Missenard).

In this country, the shielded thermometer, or a very fine wire thermocouple, has been found more convenient for determining the true dry-

⁵⁵A.S.H.V.E. RESEARCH REPORT No. 691—Cooling Effects on Human Beings Produced by Various Air Velocities, by F. C. Houghten and C. P. Yaglou (A.S.H.V.E. TRANSACTIONS, Vol. 30, 1924, p. 193). A.S.H.V.E. RESEARCH REPORT No. 717—Effective Temperature with Clothing, by C. P. Yaglou and W. E. Miller (A.S.H.V.E. TRANSACTIONS, Vol. 31, 1925, p. 89). A.S.H.V.E. RESEARCH REPORT No. 690—Air Motion, High Temperatures and Various Humidities—Reactions on Human Beings, by W. J. McConnell, F. C. Houghten and C. P. Yaglou (A.S.H.V.E. TRANSACTIONS, Vol. 30, 1924, p. 167). A.S.H.V.E. RESEARCH REPORT No. 718—Work Tests Conducted in Atmospheres of High Temperatures and Various Humidities in Still and Moving Air, by W. J. McConnell and C. P. Yaglou (A.S.H.V.E. TRANSACTIONS, Vol. 31, 1925, p. 101).

⁵⁶The Influence of Air Movement on Heat Losses for the Clothed Human Body, by C.-E. A. Winslow, A. P. Gage and L. P. Herrington (*American Journal of Physiology*, October, 1939, Vol. 127, p. 505).

⁵⁷A.S.H.V.E. RESEARCH REPORT No. 1088—Draft Temperatures and Velocities in Relation to Skin Temperature and Feeling of Warmth, by F. C. Houghten, Carl Gutberlet and Edward Witkowski (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 289).

⁵⁸Housing Commission of the League of Nations, adopted at Geneva, June 25, 1937.

bulb temperature. Fine, hot-wire anemometers are rapidly replacing the use of the Kata thermometer for measuring low air velocities, while some adaptations of the Vernon Globe thermometer, incorporating thermocouples rather than mercury thermometers, have been found more satisfactory and convenient.

Such instruments as these, when properly calibrated and their readings are compared, can be used for determining the four basic physical factors concerned separately or in certain combinations. The results of the four physical measurements thus determined can generally be translated into the terms of any special instrument combining two or more of them.

The work of the A.S.H.V.E. Research Laboratory has made available psychrometric charts with effective temperature scale superimposed thereon, including Figs. 8 and 9, and others⁵⁹, while recent studies⁶⁰ have indicated the degree to which mean radiant temperature of the surroundings modifies the effective temperature index.

In some instances it may be important to record not only the movement and temperature of the air at various levels, but also the temperature of each wall and window, of the flooring, and of the ceiling; and to measure the total effective radiation of the surroundings in 6 directions; in order to trace the exact causes of defects in the building which have an unfavorable influence on the heat exchanges of its inhabitants. Facts of this type are of great practical importance.

⁵⁹A.S.H.V.E. RESEARCH REPORT No. 691—Cooling Effects on Human Beings Produced by Various Air Velocities, by F. C. Houghten and C. P. Yaglou (A.S.H.V.E. TRANSACTIONS, Vol. 30, 1924, p. 193).

⁶⁰Loc. Cit. Note 31.