Table 4 . . . . Evaluation of Index of Heat Stress

Index of Heat Stress	Physiological and Hygienic Implications of 8-Hr Exposures to Various Heat Stresses
−20 −10	Mild cold strain. This condition frequently exists in areas where men recover from exposure to heat.
0	No thermal strain.
+10 20 30	Mild to moderate heat strain. Where a job involves higher intellectual functions, dexterity, or alertness, subtle to substantial decrements in performance may be expected. In performance of heavy physical work, little decrement expected unless ability of individuals to perform such work under no thermal stress is marginal.
40 50 60	Severe heat strain, involving a threat to health unless men are physically fit. Break-in period required for men not previously acclimatized. Some decrement in performance of physical work is to be expected. Medical selection of personnel desirable because these conditions are unsuitable for those with cardiovascular or respiratory impairment or with chronic dermatitis. These working conditions are also unsuitable for activities requiring sustained mental effort.
70 80 90	Very severe heat strain. Only a small percentage of the population may be expected to qualify for this work. Personnel should be selected (*a*) by medical examination and (*b*) by trial on the job (after acclimatization). Special measures are needed to assure adequate water and salt intake. Amelioration of working conditions by any feasible means is highly desirable, and may be expected to decrease the health hazard while increasing efficiency on the job. Slight "indisposition" which in most jobs would be insufficient to affect performance may render workers unfit for this exposure.
100	The maximum strain tolerated daily by fit, acclimatized young men.

The zone of thermal neutrality differs with clothing and season, and with activity and all of the other factors controlling heat production. The sensation of warmth or cold depends upon a number of environmental factors which include the dry-bulb temperature and humidity of the air, air motion, and the temperature of surrounding surfaces. Dry air at a relatively high temperature may feel cooler than humid air at a lower temperature. Air motion makes any moderate condition feel cooler. Radiation to cold or from hot surfaces may have a marked influence on thermal comfort.

Since no reliable objective measurement of comfort has been found, comfort studies have had to be based on the subjective reactions of trained subjects. One series of studies[39] was undertaken at the ASHRAE Laboratory a number of years ago to determine the combined effect of dry-bulb temperature, humidity and air motion. In these tests, subjects compared the relative warmth produced by many combinations of these three factors by passing back and forth between two test rooms maintained at slightly different conditions. They appraised conditions in the room just entered as being cooler, the same, or warmer than in the other room. The appraisals were made immediately after entering the space.

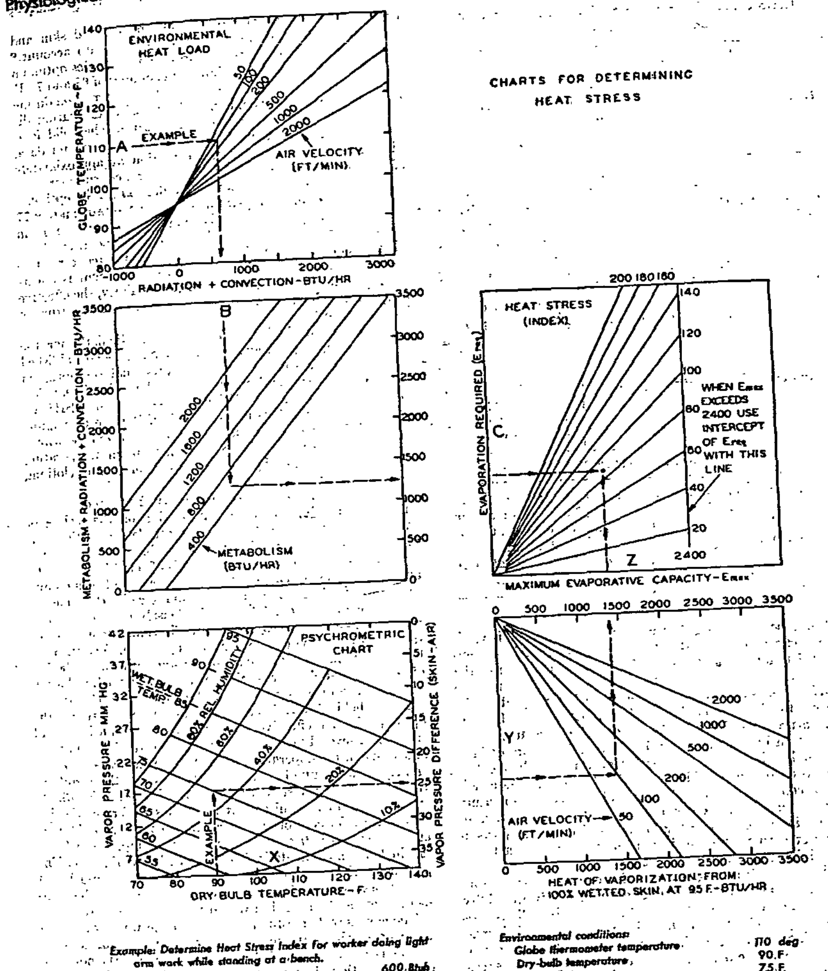
From the data thus developed, lines of thermo-equivalent conditions, *effective temperature* lines, were determined, and the original effective temperature charts were prepared by plotting these lines on the psychrometric chart. Separate charts were prepared for still air (15 to 25 fpm) and for several higher air velocities. This form of chart for still air was included in the Heating, Ventilating Air-Conditioning Guide through 1960, and in the 1961 GUIDE AND DATA BOOK. Charts for higher air velocities appeared in THE GUIDE up to 1939. Fig. 7 is another form of effective temperature chart which includes all three variables: temperature, humidity, and air motion.

Effective Temperature is defined as an arbitrary index which combines into a single value the effects of temperature, humidity and air motion on the sensation of warmth or cold felt by the human body. The numerical value of the index for any given combination of conditions is the temperature of still, saturated air which would induce an identical feeling of warmth.

The ASHRAE Comfort Chart,[40] with effective temperatures plotted on dry- and wet-bulb coordinates, has been widely used. This chart, as revised in 1950, is reproduced in Fig. 12, but with effective temperature lines shown dashed. The distribution curve in the upper part of this figure indicates that the maximum percentage of people should be comfortable in summer at 71 ET. Similarly, the partial distribution curve in the lower part of the figure indicates a maximum percentage of people comfortable in winter at 68 ET.

As previously stated, effective temperature is an index of the degree of *warmth* experienced by the body. An effective temperature line is, therefore, a line defining the various combinations of conditions which will induce like sensations of warmth. It does not necessarily follow that like sensations of *comfort* will also be experienced along the entire length of an effective temperature line. Some degree of discomfort is likely to be experienced at very high or very low relative humidities, regardless of the effective temperature.

Although the effective temperature scale has served as a useful guide to the air-conditioning engineer for many years, there was increasing evidence that the predictions of the scale did not entirely agree with operating experience in the field. To obtain additional information on the subject of human comfort, a series of tests[41] was recently conducted in the environmental test room at the ASHRAE Research Laboratory. In these studies, subjects wore light indoor clothing and were seated and at rest. Room surfaces were held at the same temperature as the room air in all tests, and the air motion in the space was 20 fpm or less. The thermal sensation votes used in analyzing the test data were those which were cast after approximately three hour occupancy. The results of the recent study are shown by the four solid lines in Fig. 12. These lines show the conditions under which subjects cast votes of 3, 4, 5, or 6, indicating sensations of *slightly cool*, *comfortable*, *slightly warm*, and *warm*. It is shown in Reference 41 that the slope of these lines agrees well with the results of several other laboratory studies.[42–44] It might be noted at this point that the comfort line 4 shown in Fig. 12 differs slightly from the line as shown in Reference 41. It has been replotted from the original data shown in Fig. 5 of the reference, to bring it into better agreement with the data and to make it more consistent with lines 5 and 6.



Example: Determine Heat Stress Index for worker doing light arm work while standing at a bench.

Metabolism	*600 Btuh*
Environmental conditions:	
Globe thermometer temperature	*110 deg*
Dry-bulb temperature	*90 F*
Wet-bulb temperature	*75 F*
Air velocity	*100 fpm*

Solution: Follow the broken lines from the globe thermometer temperature and from dry-bulb temperature to their intersection on above diagram C to read a heat stress index of 90.

Fig. 11 . . . . Charts for Determining Heat Stress