line of thermal balance (see Figure 2). The reason for the lesser slope compared with the calculated value for thermal balance is that the skin temperature of Eichna's subjects did not remain constant in all environments, but increased with air temperature sufficiently that the necessary evaporation took place in the extreme environments with a higher moisture content in the air than would otherwise have been permitted. These observations lend a good deal of support to the physical basis of the heat tolerance lines.

G. LIMITS OF HEAT EXPOSURE FIXED BY THERMAL BALANCE AND MAXIMUM PERMISSIBLE SWEAT RATE

In recognition of the physiological cost of sweating as well as the necessity for maintaining heat balance during sustained periods of heat exposure, Belding and Hatch[12] have combined these two limiting requirements to define a heat stress index that has a value of 100 when $E_{req.}/E_{max.} = 1.0$. This scale holds up to $E_{req.} = 2400$ B.t.u./hr., which is just below McArdle's maximum acceptable sweat rate of 4.5 liters (equivalent to 2500 B.t.u./hr.) in 4 hours. In more severe environments, the heat stress index will be greater than 100 in proportion to the ratio: $E_{req.}/2400$. The value of the index may be obtained from the chart in Figure 3. A stress index value of 100 represents the maximum tolerable heat load for sustained (6–8 hours) exposure for acclimatized young men in good physical condition and engaged in elementary physical work. For older men or others with lowered physiological capacities, and in more demanding jobs requiring high degrees of skill and mental effort, the maximum level of heat stress must be set well below 100. The degrees of physiological and psychological stress associated with index values ranging from 0 (comfort) to 100 are suggested in Table 2, and these may be used as guides in the appraisal of heat exposures and in setting limits for industry.

TABLE 2

Physiological and Hygienic Implications of 6- to 8-Hour Exposures at Various Levels of Heat Stress[12]

Heat stress	Implications
0	No thermal strain.
10–30	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 strain is marginal.
40–60	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.
70–90	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 warranted 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	Maximum tolerable strain for fit, acclimatized young men.

[12] H. S. Belding and T. F. Hatch, Index for evaluating heat stress in terms of resulting physiological strains, *Am. Soc. Heating, Air-Conditioning Engrs. Trans.*, **62**, 213 (1956).

III. Physical Evaluation of Hot Environments

The following examples[9] illustrate the application of the method of physical analysis to the evaluation of typical heat exposures.

Example 1. An extreme heat exposure was encountered in the Forming Department of a glass plant. Measured values of globe temperature, dry- and wet-bulb temperatures, and air velocity were: $t_g = 130°$ F.; $t_a = 100°$ F.; $t_{wb} = 80°$ F.; $V = 200$ f.p.m.; calculated $t_w = 177°$ F.[9] An average work rate was assumed equivalent to 960 B.t.u./hr.

Determine: (a) relative contributions of radiation and convection to the total imposed heat load and (b) the heat stress index.

Solution:

$$R = 22(177 - 95) = 1800 \text{ B.t.u./hr.} = 62\% \text{ total heat load}$$
$$C = 2\sqrt{200}(100 - 95) = 140 \text{ B.t.u./hr.} = 5\% \text{ total heat load}$$
$$M = 960 \text{ B.t.u./hr.}$$
$$E_{req.} = M + R + C = 2900 \text{ B.t.u./hr.}$$
$$E_{max.} = 10.3\,(200)^{0.4}\,(42\text{-}21) = 1550 \text{ B.t.u./hr.}$$
$$\text{Heat stress index} = E_{req.}/E_{max.} \times 100 = 187$$

The exposure is excessive and would lead to disaster if continued. In fact, the operator does not remain in the heat more than a few minutes to complete his task and then seeks relief.

This is a hot-dry exposure with 62 per cent of the total heat load imposed by radiation. Principal heat control measures must be directed toward the radiant heat sources.

Example 2. The following conditions were found in a hot wet mine: $t_g = 98°$ F.; $t_a = 95°$ F.; $t_{wb} = 85°$ F.; $V = 200$ f.p.m.; calculated $t_w = 106°$ F.; average work rate assumed $= 800$ B.t.u./hr.

Determine: (a) contribution of radiation and convection to total heat load and (b) heat stress index value.

Solution:

$$R = 22(106 - 95) = 240 \text{ B.t.u./hr.} = 23\% \text{ total heat load}$$