active work[14], limits which are, of course, much lower than those cited for subjects at rest. The upper limit of effective temperature to which the human organism is capable of adapting itself without serious discomfort or injury to health is 90 deg ET (Effective Temperature) for men at rest and between 80 and 90 deg ET for men at work depending upon the rate of work. Within these limits a new equilibrium is established at a higher body temperature level through a chain of physiological adjustments. The heat regulating center fails when the external temperature is so abnormally high that bodily heat cannot be eliminated as fast as it is produced. Part of it is retained in the body, causing a rise in skin and deep tissue temperature, an increase in the heart rate, and accelerated respiration. (See Table 3.) In extreme heat the metabolic rate is markedly increased owing to the excessive rise in body temperature, and a vicious cycle results which may eventually lead to serious physiologic damage or heat exhaustion[15].

TABLE 3. PHYSIOLOGICAL RESPONSES TO HEAT OF MEN AT REST AND AT WORK[a]

Effective Temp	Actual Cheek Temp (Deg Fahr)	Men at Rest			Men at Work 90,000 ft-lb of Work per Hour			
		Rise in Rectal Temp (Deg Fahr per Hr)	Increase in Pulse Rate (Beats per Min per Hr)	Approximate Loss in Body Weight by Perspiration (Lb per Hr)	Total Work Accomplished (Ft-Lb)	Rise in Body Temp (Deg Fahr per Hr)	Increase in Pulse Rate (Beats per Min per Hr)	Approximate Loss in Body Wt by Perspiration (Lb per Hr)
60	.....	.....	.....	.....	225,000	0.0	6	0.5
70	.....	0.0	0	0.2	225,000	0.1	7	0.6
80	96.1	0.0	0	0.3	209,000	0.3	11	0.8
85	96.6	0.1	1	0.4	190,000	0.6	17	1.1
90	97.0	0.3	4	0.5	153,000	1.2	31	1.5
95	97.6	0.9	15	0.9	102,000	2.3	61	2.0
100	99.6	2.2	40	1.7	67,000	4.0	103[b]	2.7
105	104.7	4.0	83	2.7	49,000	6.0[b]	158[b]	3.5[b]
110	.....	5.9[b]	137[b]	4.0[b]	37,000	8.5[b]	237[b]	4.4[b]

[a]Data by A.S.H.V.E. Research Laboratory.
[b]Computed value from exposures lasting less than one hour.

Examples of this are met with in unusually hot summer weather and in hot industries where heat loss from the body by radiation and convection is impossible. Consequently, the workers depend entirely on evaporation for the elimination of body heat. They stream with perspiration and drink liquids abundantly to replace the loss.

One of the deleterious effects of high temperatures is that the blood is diverted from the internal organs to the surface capillaries, in order to serve in the process of cooling. This affects the stomach, heart, lungs and other vital organs, and it is suggested that the feeling of lassitude and discomfort experienced is due in part to the anaemic condition of the

[14]A.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).

[15]A.S.H.V.E. RESEARCH REPORT No. 719—Basal Metabolism Before and After Exposure to High Temperatures and Various Humidities, by W. J. McConnell, C. P. Yaglou and W. B. Fulton (A.S.H.V.E. TRANSACTIONS, Vol. 31, 1925, p. 123). A.S.H.V.E. Research Paper—The Peripheral Type of Circulatory Failure in Experimental Heat Exhaustion (The Role of Posture), by R. W. Keeton, F. K. Hick, Nathaniel Glickman and M. M. Montgomery (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, February, 1940, p. 122).

brain. The stomach loses some of its power to act upon the food, owing to a diminished secretion of gastric juice, and there is a corresponding loss in the antiseptic and antifermentive action which favors the growth of bacteria in the intestinal tract[16]. These are considered to be the potent factors in the increased susceptibility to gastro-intestinal disorders in hot summer weather.

In warm atmospheres, particularly during physical work, a considerable amount of chloride is lost from the system through sweating. The loss of this substance may lead to attacks of cramps, unless the salts are replaced in the drinking water. In order to relieve both cramps and fatigue, it is recommended that 6 g of sodium chloride and 4 g of potassium chloride be added to a gallon of water[17].

The deleterious physiologic effects of high temperatures exert a powerful influence upon physical activity, accidents, sickness and mortality. Both laboratory and field data show that physical work in warm atmospheres is a great effort, and that production falls progressively as the temperature rises. The incidence of industrial accidents reaches a minimum at about 68 F, increasing above and below that temperature. Sickness and mortality rates increase progressively as the temperature rises.

The control of hot conditions by chilling the walls of an occupied space has only limited application in practice. Either air-cooling, increase in air movement, or dehumidification, or any combination of these procedures may be used in practice to keep a space cool in summer.

ADAPTATION TO COLD CONDITIONS

When the heat demand of the environment exceeds the metabolic output, the chief changes which occur, as external temperature decreases, are (1) increased heat loss due to radiation plus convection, and (2) increased positive storage or cooling of the body tissues. It will be noted in Fig. 1 that the slope of the line representing heat loss due to radiation plus convection changes as one passes from the *zone of evaporative regulation* to the *zone of body cooling*. The less abrupt slope in the latter zone is due to a progressive fall in skin temperature which is the only mechanism the body calls into play in this region to adapt to a cool environment. Under colder conditions, or after longer periods of time, a second mechanism, increased metabolism, may become operative but this does not appear in the experiments here reviewed.

For a fall in operative temperature from 88 to 68 F the mean skin temperature decreases from 94 to 84 F. The temperature of the lower extremities falls most rapidly while that of the head or trunk may decrease less. This type of regulation is, however, as pointed out previously, incomplete; and positive storage (cooling of the body) increases progressively as external temperature falls. Chilling, then, imposes an extra load upon the heat-producing organs to maintain body temperature. The strain falls largely upon digestion, metabolism, blood circulation, and the kidneys, and indirectly upon the nervous system[18]. In extremely

[16]Influence of Effective Temperature upon Bactericidal Action of Gastro-Intestinal Tract, by Arnold and Brody (*Proceedings Society Exp. Biol. Med.*, Vol. 24, 1927, p. 832).

[17]Some Effects of High Air Temperatures Upon the Miner, by K. N. Moss (*Transactions Institute of Mining Engineers*, Vol. 66, 1924, p. 284).

[18]Preventive Medicine and Hygiene, by M. J. Rosenau (6th Edition, p. 909).