

cold atmospheres compensation by increased metabolism becomes inadequate. The body temperature falls and the reflex irritability of the spinal cord is markedly affected. The organism may finally pass into an unconscious state which ends in death.

A moderate amount of variability in temperature is known to be beneficial to health, comfort, and the performance of physical and mental work. On the other hand, extreme changes in temperature, such as those experienced by passing from a warm room to the cold air out-of-doors, appear to be harmful to the tissues of the nose and throat which are the portals for the entry of respiratory diseases.

Experiments show that chilling causes a constriction of the blood vessels of the palate, tonsils, throat, and nasal mucosa, which is accompanied by a fall in the temperature of the tissues. On re-warming, the palate and throat do not always regain their normal temperature and blood supply. This anaemic condition favors bacterial activity and it probably plays a part in favoring infection with common colds and other respiratory diseases. Lowered resistance may also be related to a diminution in the number and phagocytic activity of the leucocytes (white blood cells) brought about by exposure to cold and by changes in temperature.

Sickness records in industries seem to strengthen this belief. The *Industrial Fatigue Research Board* of England¹⁹ found that with the workers exposed to high temperatures and to changes in temperature, namely, steel smelters, puddlers, and general laborers, there is an excess of all sickness, the excess among the puddlers being due chiefly to respiratory diseases and rheumatism. The causative factor was not the heat itself but the sudden changes in temperature to which the workers were exposed. The tin-plate millmen who were not exposed to chills, since they work almost continuously throughout the shift, had no excess of rheumatism and respiratory diseases. On the other hand, the blast-furnacemen, who work mostly in the open, showed more respiratory sickness than the steel workers. This experience in British factories is well in accord with the findings in American industries^{20,21}. According to these data the highest pneumonia death rate is associated with dust, extreme heat, exposure to cold, and to sudden changes in temperature.

In the ordinary dwelling not equipped with a fan system during the winter season, air movement is likely to be minimal and the only air movements affecting comfort are those due to cold walls or convective heating. Below an air temperature of 77 F, for the clothed, semi-reclining body, sweat secretion is at a minimum and, even with high atmospheric humidity, all the moisture available is evaporated. Under conditions of low air movement, and with a relative humidity of 30-35 per cent, the evaporative heat loss is only 1.5 Btu per square foot of body surface greater than with a relative humidity of 75-80 per cent. This is the equivalent of decreasing the air temperature by less than 1 F.

¹⁹Fatigue and Efficiency in the Iron and Steel Industry, by H. M. Vernon (*Industrial Fatigue Research Board Report No. 5, 1920, London*).

²⁰Iron Foundry Workers Show Highest Percentage of Deaths from Pneumonia (*Statistical Bulletin, Metropolitan Life Insurance Co., New York, N. Y., 1928*).

²¹The Pneumonia Problem in the Steel Industry, by D. K. Brundage and J. J. Bloomfield (*Journal of Industrial Hygiene, 14, December, 1932*).

RELATION OF AIR CONDITIONING NEEDS TO METABOLISM

The major objective of heating and ventilation is to balance heat losses from the human body. The basic factor is human metabolism. The desirable environment, from the standpoint of heat loss, depends directly on the heat produced in the body and this heat may be five times as great when a man is exercising violently as when he is reclining and at rest.

TABLE 4. RELATION BETWEEN METABOLIC RATE AND ACTIVITY^a

ACTIVITY	HOURLY METABOLIC RATE FOR AVG PERSON OR TOTAL HEAT DISSIPATED, BTU PER HOUR	HOURLY SENSIBLE HEAT DISSIPATED, AT 79 F, BTU PER HOUR	HOURLY LATENT HEAT DISSIPATED, AT 79 F, BTU PER HOUR	MOISTURE DISSIPATED PER HOUR	
				Grains	Pounds
Basal.....	291	145	145	979	0.140
Seated at Rest.....	384	225	159	1070	0.153
Reading Aloud (Seated).....	420	225	195	1316	0.880
Standing at Rest.....	431	225	206	1390	0.199
Hand Sewing (Seated).....	441	225	216	1458	0.208
Knitting 23 stitches per minute on Sweater.....	462	225	237	1600	0.229
Dressing and Undressing.....	468	225	243	1640	0.234
Tailor.....	482	225	257	1740	0.248
Singing.....	486	225	261	1762	0.252
Office Worker Moderately Active.....	490	225	265	1790	0.256
Light Work Standing.....	549	225	324	2187	0.312
Typewriting Rapidly.....	558	225	333	2248	0.321
Ironing with 5 lb iron.....	570	225	345	2329	0.333
Dishwashing—Plates, Bowls, Cups and Saucers.....	600	225	375	2530	0.362
Clerk Moderately Active Standing at Counter.....	600	225	375	2530	0.362
Book Binder.....	626	225	401	2710	0.387
Shoemaker.....	661	225	436	2940	0.420
Sweeping Bare Floor 38 Strokes per Minute.....	672	229	443	2990	0.427
Pool Player.....	680	230	450	3040	0.434
Walking 2 mph, Light Dancing.....	761	250	511	3450	0.493
Light Metal Worker (at Bench).....	862	277	585	3950	0.564
Painter of Furniture (at Bench).....	876	280	596	4020	0.575
Carpenter.....	954	307	647	4367	0.624
Restaurant Serving.....	1000	325	675	4556	0.651
Pulling Weight.....	1041	335	708	4745	0.677
Walking 3 mph.....	1050	339	711	4750	0.679
Walking 4 mph, Active Dancing, Roller Skating.....	1390	452	938	6330	0.904
Walking Down Stairs.....	1444	467	977	6595	0.942
Stone Mason.....	1490	490	1000	6750	0.964
Bowling.....	1500	490	1010	6820	0.974
Man Sawing Wood.....	1800	590	1210	8170	1.167
Swimming.....	1986	.....	.....	.....	.....
Running 5.3 mph.....	2268	.....	.....	.....	.....
Walking 5 mph.....	2330	.....	.....	.....	.....
Walking Very Fast 5.3 mph.....	2580	.....	.....	.....	.....
Walking Up Stairs.....	4365	.....	.....	.....	.....
Maximum Exertion Different People.....	3000-4800	.....	.....	.....	.....

^aThese metabolic rates were compiled by the A.S.H.V.E. Research Laboratory from actual tests, from other authoritative sources, and from estimates based upon various considerations. Division of the total heat dissipation into latent and sensible rates is based on actual test data and on various considerations for metabolic rates up to 1250 Btu per hour and extrapolated for higher rates. Values for total heat dissipation for a person at rest apply for a dry-bulb temperature range from approximately 60 to 90 F; for other than rest conditions the values apply for a similar but lower temperature range. Below these temperature ranges metabolic rates and total rates of heat dissipation increase, while above these ranges metabolic rates increase slightly and total heat dissipation rates decrease rapidly. Division of total dissipation rates into sensible and latent heat holds only for a dry-bulb temperature of 79 F. For lower temperatures, sensible heat dissipation increases and latent heat decreases, while for higher temperatures the reverse is true.