

provides sufficient relief in hot weather to be acceptable to the majority of users. It should be emphasized, however, that these are borderline cases that may be acceptable largely in the interest of economy. Comprehensive studies by the A.S.H.V.E. Research Laboratory³⁰ in cooperation with office staffs in widely distributed regions, including San Antonio, Minneapolis, Washington, D. C., and New York City (see Fig. 7), show conclusively that lower effective temperatures are required for optimum comfort.

The sensation of comfort, insofar as the physical environment is concerned, is not absolute but varies considerably among certain individuals. Therefore, in applying the air conditions indicated, it should not be expected that all the occupants of a room will feel perfectly comfortable.

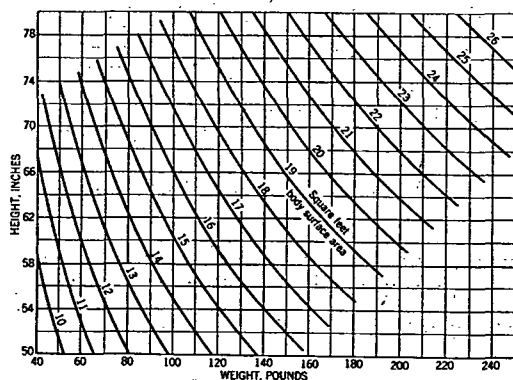


FIG. 12. CHART FOR DETERMINING SURFACE AREA OF INDIVIDUALS FOR HEIGHT AND WEIGHT GIVEN

However, when optimum comfort temperatures are applied in accordance with foregoing recommendations, the majority of the occupants should be comfortable, and it should be expected that there will be a few too warm and a few too cold. These individual differences among the minority should be counteracted by suitable clothing.

RELATION OF AIR CONDITIONING NEEDS TO METABOLISM

To maintain optimum conditions in summertime requires the removal of heat from the conditioned space. In calculating the cooling load it is always necessary to consider the heat given up by the occupants. In theaters or similarly densely populated spaces, the occupants may contribute the greater part of the total load.

The metabolic rate varies with the size of the individual, with the rate of work being performed, and at extreme conditions, with the environment. The relative proportions of sensible and latent heat given off also vary widely. The curves in Fig. 9 show the total heat loss (sensible plus latent) from the average man for four different rates of work. Heat loss in this figure is plotted against effective temperature. Figs. 10 and 11 give the sensible and latent losses for the same four work rates, plotted against dry-bulb temperature. By proper interpolation, it is possible

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 PER PERSON	
				Grains	Pounds
Basal.....	291	145	145	978	0.140
Seated at Rest.....	384	225	159	1072	0.153
Reading Aloud (Seated).....	420	225	195	1315	0.188
Standing at Rest.....	431	225	206	1389	0.198
Hand Sewing (Seated).....	441	225	216	1457	0.208
Knitting 23 stitches per minute on Sweater.....	462	225	237	1598	0.228
Dressing and Undressing.....	468	225	243	1639	0.234
Tailor.....	482	225	257	1733	0.248
Singing.....	486	225	261	1760	0.251
Office Worker Moderately Active.....	490	225	265	1787	0.255
Light Work Standing.....	549	225	324	2185	0.312
Typewriting Rapidly.....	558	225	333	2246	0.321
Ironing with 5 lb iron.....	570	225	345	2326	0.332
Dishwashing—Plates, Bowls, Cups and Saucers.....	600	225	375	2529	0.361
Clerk Moderately Active Standing at Counter.....	600	225	375	2529	0.361
Book Binder.....	626	225	401	2704	0.386
Shoemaker.....	661	225	436	2940	0.420
Sweeping Bare Floor 38 Strokes per Minute.....	672	229	443	2987	0.427
Pool Player.....	680	230	450	3055	0.434
Walking 2 mph, Light Dancing.....	761	250	511	3446	0.492
Light Metal Worker (at Bench).....	862	277	585	3945	0.564
Painter of Furniture (at Bench).....	876	280	596	4019	0.574
Carpenter.....	954	307	647	4363	0.623
Restaurant Serving.....	1000	325	675	4552	0.650
Pulling Weight.....	1041	335	708	4774	0.682
Walking 3 mph.....	1050	339	711	4795	0.685
Walking 4 mph, Active Dancing, Roller Skating.....	1390	452	938	6325	0.904
Walking Down Stairs.....	1444	467	977	6588	0.941
Stone Mason.....	1490	485	1005	6777	0.968
Bowling.....	1500	490	1010	6811	0.973
Man Sawing Wood.....	1800	590	1210	8160	1.166
Swimming.....	1986	—	—	—	—
Running 5.3 mph.....	2268	—	—	—	—
Walking 5 mph.....	2330	—	—	—	—
Walking Very Fast 5.3 mph.....	2580	—	—	—	—
Walking Upstairs.....	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.

from Figs. 9, 10 and 11, to determine the sensible and latent heat dissipation for any work rate and any environmental condition, provided the metabolic rate is known at one effective temperature. For example, if it is found that a certain type of work results in a metabolic rate of approximately 760 Btu per hour for an average person working in an atmosphere of 70 ET, then this total rate of heat dissipation to atmospheres of various temperatures will be approximately as given by the broken-line curve in Fig. 9. The broken line curves in Figs. 10 and 11 give the rate of sensible and latent heat dissipation of the person for different dry-bulb temperatures. The metabolic rates for a number of types of