Table 2. Condition of Sensible Perspiration for Persons Seated at Rest for Various Atmospheric Conditions[b]

| Degree of Perspiration[a] | Atmospheric Condition | | | | | |
|---|---|---|---|---|---|---|
| | 95 per cent R. H. | | | 20 per cent R. H. | | |
| | E. T. | D. B. | W. B. | E. T. | D. B. | W. B. |
| Forehead clammy | 73.0 | 73.6 | 72.4 | 75.0 | 87.0 | 60.7 |
| Body clammy | 73.0 | 73.6 | 72.4 | 75.0 | 87.0 | 60.7 |
| Body damp | 79.0 | 79.7 | 78.4 | 81.0 | 97.5 | 67.5 |
| Beads on forehead | 80.0 | 80.8 | 79.4 | 87.0 | 109.4 | 75.2 |
| Body wet | 84.5 | 85.4 | 84.0 | 86.5 | 108.5 | 74.6 |
| Perspiration on forehead runs and drips | 88.0 | 89.0 | 87.6 | 94.0 | 125.2 | 85.4 |
| Perspiration runs down body | 88.5 | 89.5 | 88.1 | 90.0 | 116.0 | 79.5 |

[a]Forty per cent of subjects registered degree of perspiration equal to or greater than indicated.

[b]"Thermal Exchanges between the Human Body and its Atmospheric Environment," by F. C. Houghten, W. W. Teague, W. E. Miller, W. P. Yant (*American Journal Physiology*, Vol. 88, No. 3, April, 1929, pp. 386–406).

134,000 B.t.u. latent heat and 1,000 × 905 = 905,000 grains or 129 lb. of water vapor will be added per hour to the air in the auditorium.

These sensible and latent heat loss additions may also be found as follows: The effective temperature of the condition 75 deg. dry-bulb and 63.5 deg. wet-bulb is 70.3 deg. effective temperature. From Fig. 6 find 403 B.t.u. as the total heat added to the air by a person for 70.3 deg. effective temperature. From Fig. 9 find the percentage of sensible and latent heat at 75 deg. dry-bulb to be 66.5 per cent and 33.5 per cent. The sensible heat added to the air in the auditorium is 1,000 × 0.665 × 403 = 267,995 B.t.u. per hour. The latent heat added is 1,000 × 0.335 × 403 = 135,005 B.t.u. per hour.

*Solution—Problem 1-B:* From Figs. 7 and 8, respectively, the sensible and latent heat losses per person for 85 deg. dry-bulb are found to be 164 and 225 B.t.u. per hour. The water vapor added to atmosphere is 1,520 grains per hour. The audience will then add 164,000 B.t.u. sensible heat, 225,000 B.t.u. latent heat and 1,520,000 grains or 217 lb. of water vapor to the air in the auditorium per hour.

*Problem 2:* Neglecting the gain or loss of heat to an auditorium by transmission or infiltration through the walls, windows and doors, how many cubic feet of outside air, with 65 deg. dry-bulb, 59 deg. wet-bulb and 63.1 deg. effective temperature must be added per hour to an auditorium containing 1,000 people in order that the inside shall not exceed 75 deg. dry and 65 deg. wet-bulb, respectively?

Table 3. Condition of Sensible Perspiration for Persons Working at Hard Labor for Various Atmospheric Conditions

| Degree of Perspiration[a] | Atmospheric Condition | | | | | |
|---|---|---|---|---|---|---|
| | 95 Per Cent Relative Humidity | | | 20 Per Cent Relative Humidity | | |
| | E. T. | D. B. | W. B. | E. T. | D. B. | W. B. |
| Forehead clammy | 59.0 | 59.4 | 58.3 | 69.5 | 80.5 | 56.5 |
| Body clammy | 50.0 | 50.2 | 49.3 | 57.0 | 61.6 | 44.2 |
| Body damp | 60.0 | 60.3 | 59.3 | 62.5 | 69.6 | 49.5 |
| Beads on forehead | 68.0 | 68.5 | 67.5 | 76.0 | 91.0 | 63.4 |
| Body wet | 69.0 | 69.6 | 68.5 | 71.0 | 82.8 | 53.0 |
| Perspiration on forehead runs and drips | 78.5 | 79.3 | 78.0 | 82.0 | 100.5 | 70.2 |
| Perspiration runs down body | 79.0 | 79.8 | 78.5 | 81.0 | 99.8 | 69.0 |

[a]Forty per cent of subjects registered degree of perspiration equal to or greater than indicated.





*Solution—Problem 2:* Figs. 7 and 8 give 265 B.t.u. sensible heat and 905 grains of moisture as the additions per person with 75 deg. dry-bulb in the auditorium. Therefore 265,000 B.t.u. of sensible heat and 905,000 grains of moisture will be added to the air in the auditorium per hour.

Taking 0.24 as the specific heat of air, 2.4 B.t.u. per pound of air will be required to raise the dry-bulb temperature from 65 to 75 deg. and $\frac{265,000}{2.4}$ = 110,400 lb. of air or $110,400 \times 13.4 = 1,479,000$ cu. ft. of air per hour will be required. This is equivalent to $\frac{1,479,000}{1,000 \times 60} = 24.7$ cu. ft. per person per minute.

The moisture content of the inside air as taken from a psychrometric chart is 76 grains per pound of dry air and that of the outside condition is 65 grains so the increase in moisture content will be 11 grains per pound of dry air. $\frac{905,000}{11.0}$ = 82,300 lb. of dry air or approximately 83,000 lb. of air at the specified condition will be required. This is equivalent to 83,000 × 13.4 = 1,112,000 cu. ft. of air per hour or $\frac{1,112,000}{1,000 \times 60} = 18.5$ cu. ft. of air per minute per person.

The higher volume of 24.7 cu. ft. per person per minute will be required to keep the dry-bulb from rising above the 75 deg. specified. The wet-bulb will, therefore, not rise to the maximum of 65 deg.

Examples 1-A and 1-B demonstrate that while the effective temperature, and, hence, the feeling of warmth and rate of total heat loss, does not differ greatly in the two cases, the relative proportion of sensible and latent heat loss is reversed. In order to maintain the air conditions stipulated the air conditioning equipment must remove 61.6 per cent more sensible heat in (1-A) than in (1-B); and 67.8 per cent more latent heat or water vapor in (1-B) than in (1-A). In (1-A) 66.5 per cent of the total heat loss is sensible while in (1-B) only 42.5 per cent of the total loss is sensible.

## SYNTHETIC AIR CHART

The form of the Synthetic Air Chart has been slightly modified since it was originally adopted by the Society and the form here presented is the one in use at the present time. (See Synthetic Air Chart, by E. Vernon Hill, A.S.H.V.E., Transactions, Vol. 23, 1917).

### *Description of the Chart*

The Synthetic Air Chart is designed for measuring the air conditions maintained in a room. Instead of speaking of the ventilation of a room as good, bad or indifferent, the results of tests are plotted on a chart, and the air conditions as a whole determined on a percentage basis. (Fig. 10).

This is done by plotting test data for all known factors that make up the air conditions. These factors with their proper weights are arranged in vertical columns across the chart.

The base of each column represents ideal conditions, or 100 per cent perfect. The columns are seven in number, and the first six are indicated by the capital letters, *A*, *B*, *C*, *D*, *E*, *F*.

*A* = the Effective Temperature Difference, or the amount of variation from the ideal effective temperature.
*B* = Dust Particles per Cu. Ft.
*C* = Bacteria.
*D* = Percentage of freedom from objectionable odors.
*E* = Carbon Dioxide, parts per 10,000.
*F* = the Distribution Percent.

The last column is the Percent of Perfect column used for plotting the final percentage.