trol of the system later. In general, it is safe to say that where audiences are involved, the heating installation must have sufficient capacity to bring the building up to the stipulated inside temperature before the audience arrives. In industrial plants, quite a different condition exists, and heat sources, if they are always available during the period of human occupancy, may be substituted for a portion of the heating installation. In no case should the actual heating installation (exclusive of heat sources) be reduced below that required to maintain at least 40 deg. fahr. in the building. The following allowances may be made when required:

TABLE 44. HEAT EMITTED BY PERSONS PER HOUR AT DIFFERENT ROOM TEMPERATURES

$H$ = Heat emitted by man at rest per hour.
$Hl$ = Heat emitted by man at light labor per hour.
$Ha$ = Heat emitted by man at average labor per hour.
$Hh$ = Heat emitted by man at hard labor per hour.

$H\,E$ = Heat Energy = $\left(\frac{\text{Foot-Pounds per hour}}{778}\right)$ = 84 B.t.u., 168 B.t.u. and 252 B.t.u. respectively for light, average and hard labor.

$T$ = Room Temperature.

$H = 13.2\,(98.6 - T)$ Heat due labor = $\frac{T \times H\,E}{100}$

$Hl$, $Ha$, or $Hh = 13.2\,(98.6 - T)$ plus $\frac{T \times H\,E}{100}$

| Room Temp. Deg. Fahr. | Rest | Heat Emitted by Man B.t.u. per Hour at | | | Condition Required to Balance Excess and Shortage in Heat Emission |
|---|---|---|---|---|---|
| | | 84 B.t.u. Light Labor | 168 B.t.u. Average Labor | 252 B.t.u. Hard Labor | |
| 30 | 905 | 931 | 954 | 981 | Increasing Humidity. |
| 40 | 773 | 807 | 838 | 874 | Heavy Clothing for Reduction or Prevention of Radiation. |
| 50 | 642 | 684 | 723 | 768 | |
| 60 | 509 | 559 | 606 | 660 | |
| 68 | 404 | 461 | 518 | 575 | Normal Condition. |
| 70 | 378 | 436 | 491 | 554 | |
| 75 | 312 | 375 | 438 | 501 | Decreasing Humidity. |
| 80 | 246 | 313 | 375 | 447 | Air Currents for Producing Evaporation of Perspiration. |
| 85 | 180 | 251 | 322 | 394 | |
| 90 | 114 | 189 | 259 | 342 | |

*For children use one-half of table values.

Motors and the machinery which they drive, if both are located in the room, convert all of the electrical energy supplied into heat, which is retained in the room if the product being manufactured is not removed until its temperature is the same as the room temperature.

If power is transmitted to the machinery from the outside, then only the heat equivalent of the brake horsepower supplied is used. In the first case the B.t.u. supplied per hour = $\frac{\text{Motor horsepower}}{\text{Efficiency of motor}} \times 2{,}546$, and in the second case B.t.u. per hr. = b.hp. × 2,546, in which 2,546 is the B.t.u. equivalent of 1 hp. hour. In high-powered mills this is the chief source of heating and is frequently sufficient to overheat the building even in zero weather, thus requiring cooling by ventilation the year round.

For intermittent heating allow 10 per cent additional for rooms heated





in the day time only, and for longer intervals of several days or more, add 25 per cent in determining minimum heating requirements, and size of plant.

### *EXAMPLES OF HEAT LOSS COMPUTATIONS*

FACTORY BUILDING. (See Fig. 9).

1. LOCATION.....Philadelphia, Pa.
2. LOWEST OUTSIDE TEMPERATURE. (Table 3).....— 6 deg. fahr.
3. BASE TEMPERATURE:

   *In this example* a design temperature 10 deg. fahr. above lowest on record instead of 15 deg. fahr. is used. Hence the base temperature = (— 6 + 10) = + 4 deg. fahr.

4. DIRECTION OF PREVAILING WIND (during Dec., Jan., Feb.).....Northwest
5. BREATHING-LINE TEMPERATURE (5 ft. from floor).....60 deg. fahr.
6. INSIDE AIR TEMPERATURE AT ROOF:

   *The air temperature* just below *roof* is higher than at the breathing line. Height of roof is 16 ft., or it is 16 — 5 = 11 ft. above breathing line. Allowing 2 per cent per foot above 5 ft., or 2 × 11 = 22 per cent, makes the temperature of the air under the roof = 1.22 × 60 = 73.3 deg. fahr.

7. INSIDE TEMPERATURE AT WALLS:

   *The air temperature* at the mean height of the *walls* is greater than at the breathing line. The mean height of the walls is 8 ft. and allowing 2 per cent per foot above 5 ft., the average mean temperature of the walls is 1.06 + 60 = 63.6 deg. fahr. By similar assumptions and calculations, the mean temperature of the *glass* will be found to be 64.2 deg. fahr. and that of the *doors* 61.2 deg. fahr.

8. AVERAGE WIND VELOCITY (Table 3).....11.0 miles per hour
9. OVERALL DIMENSIONS (See Fig. 9).....120 x 50 x 16 ft.
10. CONSTRUCTION:

   *Walls*—12-in. brick, with ½-in. plaster applied directly to inside surface.
   *Roof*—3-in. stone concrete and built-up roofing.
   *Floor*—5-in. stone concrete on 3-in. cinder concrete on dirt.
   *Doors*—One 12 ft. x 12 ft. wood door (2 in. thick) at each end.
   *Windows*—Fifteen, 9 ft. x 16 ft. single glass double-hung windows on each side.

11. TRANSMISSION COEFFICIENTS:

   *Walls*—(Table 12)..... $U = 0.277$
   *Roof*—(Table 32)..... $U = 0.610$
   *Floor*—(Table 31)..... $U = 0.521$
   *Doors*—(Table 36)..... $U = 0.382$
   *Windows*—(Table 36)..... $U = 1.13$

12. INFILTRATION COEFFICIENTS:

   *Windows*—Crack assumed $\frac{1}{16}$ in. The leakage per foot of crack for an 11-mile wind velocity is 92.7 cu. ft. per hour, for a plain window. (By interpolation from Table 39, Part II.) The heat equivalent per hour per degree is

   $92.7 \times 0.075 \times 0.24 = 1.67$ B.t.u.

   *Doors*—Assume infiltration loss through door crack twice that of windows or

   $2 \times 1.67 = 3.34$ B.t.u.