

## HEAT SOURCES WITHIN THE CONDITIONED SPACE

**People.** The rates at which heat and moisture are given off by human beings under different states of activity are given in Table 25. In many applications these sensible and latent heat gains become a large fraction of the total load. Appreciable variations in heat-emission rates must be recognized according to the age and sex of the individual, state of activity, environmental influences, and duration of occupancy (since for short occupancy the extra heat and moisture brought in by people may be a significant factor).

While Chapter 6 should be referred to for detailed information, Table

TABLE 25. RATES OF HEAT GAIN FROM OCCUPANTS OF CONDITIONED SPACES\*

| DEGREE OF ACTIVITY                           | TYPICAL APPLICATION                             | TOTAL HEAT ADULTS, MALE Btu/Hr | TOTAL HEAT ADJUSTED <sup>b</sup> Btu/Hr | SENSIBLE HEAT Btu/Hr | LATENT HEAT Btu/Hr |
|----------------------------------------------|-------------------------------------------------|--------------------------------|-----------------------------------------|----------------------|--------------------|
| Seated at Rest.....                          | Theater-Matinee.....                            | 390                            | 330                                     | 180                  | 150                |
|                                              | Theater-Evening.....                            | 390                            | 350                                     | 195                  | 155                |
| Seated, Very Light Work.....                 | Offices, Hotels, Apartments.....                | 450                            | 400                                     | 195                  | 205                |
| Moderately Active Office Work.....           | Offices, Hotels, Apartments.....                | 475                            | 450                                     | 200                  | 250                |
| Standing, Light Work; or Walking Slowly..... | Department Store, Retail Store, Dime Store..... | 550                            | 450                                     | 200                  | 250                |
| Walking; Seated.....                         | Drug Store.....                                 | 550                            | 500                                     | 200                  | 300                |
| Standing; Walking Slowly.....                | Bank.....                                       | 550                            | 550                                     | 220                  | 330                |
| Sedentary Work.....                          | Restaurant <sup>c</sup> .....                   | 490                            | 550                                     | 220                  | 330                |
| Light Bench Work.....                        | Factory.....                                    | 800                            | 750                                     | 220                  | 530                |
| Moderate Dancing.....                        | Dance Hall.....                                 | 900                            | 850                                     | 245                  | 605                |
| Walking 3 mph; Moderately Heavy Work.....    | Factory.....                                    | 1000                           | 1000                                    | 300                  | 700                |
| Bowling <sup>d</sup> .....                   | Bowling Alley.....                              |                                |                                         |                      |                    |
| Heavy Work.....                              | Factory.....                                    | 1500                           | 1450                                    | 465                  | 985                |

\* Note: Tabulated values are based on 80 F from dry-bulb temperature. For 75 F room dry-bulb, the total heat remains the same, but the sensible heat values should be increased by approximately 10 percent, and the latent heat values decreased accordingly.

<sup>b</sup> Adjusted total heat gain is based on normal percentage of men, women, and children for the application listed, with the postulate that the gain from an adult female is 85 percent of that for an adult male, and that the gain from a child is 75 percent of that for an adult male.

<sup>c</sup> Adjusted total heat value for *sedentary work, restaurant*, includes 60 Btu per hour for food per individual (30 Btu sensible and 30 Btu latent).

<sup>d</sup> For *bowling* figure one person per alley actually bowling, and all others as sitting (400 Btu per hour) or standing (550 Btu per hour).

25 in this chapter summarizes practical data representing conditions commonly encountered.

**Lighting.** In general, the instantaneous rate of heat gain from electric lighting<sup>31</sup> may be calculated from the following relation:

$$q_{el} = \left\{ \frac{\text{total light}}{\text{wattage}} \times \left\{ \frac{\text{use}}{\text{factor}} \times \left\{ \frac{\text{special allow-}}{\text{ance factor}} \right\} \times 3.41, \text{ Btu per hr.} \right. \right. \quad (15)$$

The *total light wattage* is obtained from the ratings of all fixtures installed, both for general illumination and for display use.

The *use factor* is the ratio of the wattage in use, for the conditions under which the load estimate is being made, to the total installed wattage. For commercial applications such as stores, the use factor would be unity.

The *special allowance factor* is introduced to care for fluorescent fixtures, and for fixtures which are either ventilated or installed so that only part of their heat goes to the conditioned space. For *fluorescent fixtures*, the special allowance factor is recommended to be taken as 1.20 in order to allow for power consumed in the *ballast*. For *ventilated fixtures*, *recessed fixtures*, and the like, manufacturers' or other data<sup>32</sup>

must be sought to establish the fraction of the total wattage which may be expected to enter the conditioned space.

**Power.** When equipment of any sort is operated within the conditioned space by electric motors, the heat equivalent of this operation must be considered in the cooling load. The general equation for calculating this load is:

$$q_{em} = \left( \frac{\text{Horsepower Rating}}{\text{Motor Efficiency}} \right) \times \left( \frac{\text{Load}}{\text{Factor}} \right) \times 2544, \text{ Btu per hr.} \quad (16)$$

It is assumed that both the motor and the driven equipment are within the conditioned space. If the motor is without the space, then *do not divide* by the motor efficiency in Equation 16. The *load factor* is merely the fraction of the rated load which is being delivered under the conditions of the cooling-load estimate. *Motor efficiencies* may be approximated as follows: about 50 to 60 percent at  $\frac{1}{2}$  hp rating, increasing to 80 percent at 1 hp, and to 88 percent at 10 hp and above.

**Appliances.** Care must be taken in a cooling-load estimate to take into account the heat gain from all appliances, electrical, gas, or steam. Table 26 presents recommended data.<sup>33</sup> Note that the *maintaining rate* in Table 26 is the heat input required to maintain the appliance at the normal operating temperature even though it is not being used, *i.e.*, no coffee is being made, no toast is being made, no food is being cooked in the fry kettle, etc. The maintaining rate is useful in setting up a lower limit to the heat gain to a room from the appliance when in operation.

Experienced judgment must be used in the application of data given in Table 26. Consideration must be given to the heat contributed by appliances which are in use at the time of peak load. The quantity of heat will depend upon whether products of combustion are vented to a flue, whether they escape into the space to be conditioned, or whether appliances are hooded allowing part of the heat to escape through a stack. There are no generally accepted data available on the effects of venting and shielding heating appliances, but it is believed that when they are properly hooded with a positive fan exhaust system through the hood, 50 percent of the heat will be carried away and 50 percent dissipated in the space to be conditioned. The same effectiveness of the hood should be figured for both latent and sensible heat.

## LOAD FROM MOISTURE TRANSFER THROUGH PERMEABLE BUILDING MATERIALS

The diffusion of moisture through all common building materials is a natural phenomenon which is always present to a greater or lesser degree.

The permeability and permeance values for various building materials are given in Table 2 of Chapter 10, together with an explanation of moisture transmission through these materials.

In the usual comfort air-conditioning application, it is common practice to neglect moisture transfer through walls, for the actual rate is quite small and the corresponding latent-heat load is hardly significant. So-called *vapor barriers* are frequently employed in modern construction for the purpose of keeping moisture transfer to a minimum, and reducing the deteriorating and insulation-destroying effects of moisture.

Industrial jobs, on the other hand, frequently call for a low moisture