2 ● Find the value of U for a 6-in. concrete wall with plaster on metal lath attached to 2-in. furring strips with flanged ½-in. blanket insulation.

0.23 (Table 3, Wall 12L).

3 ● A wall is built with two layers of ½-in. insulating material spaced 1 in. apart; the air space is lined on one side with bright aluminum foil; mean temperature is 40 F; still air on both sides of wall; k for insulating material is 0.34. Calculate the value of U.

$$f_i = 1.65; f_o = 1.65; a = 0.46$$

$$R = \frac{1}{1.65} + \frac{0.5}{0.34} + \frac{1}{0.46} + \frac{0.5}{0.34} + \frac{1}{1.65} = 6.327$$

$$U = \frac{1}{R} = 0.158$$

4 ● What is the inside surface temperature of a 6-in. solid concrete wall? Inside air, 70 F; outside air, −20 F with 15 mph wind.

The temperature drop from point to point through a wall is directly proportional to the heat resistance.

$$f_i = 1.65; k \text{ for concrete} = 12.62; f_o = 6.0$$

$$\text{Over-all resistance } R = \frac{1}{1.65} + \frac{6}{12.62} + \frac{1}{6.0} = 1.27$$

$$\frac{\text{Temperature drop, inside air to surface}}{\text{Temperature drop, air to air}} = \frac{\frac{1}{1.65}}{1.27}$$

$$\text{Temperature drop, inside air to surface} = \frac{90}{1.27 \times 1.65} = 43$$

$70 - 43 = 27$ F, inside surface temperature of wall.

5 ● How many inches of insulating material having a conductivity of 0.30 would be required, for the wall of Question 4, to raise the inside surface temperature to 60 F?

Temperature drop, air to inside surface = 10 F; temperature drop, inside surface to outside air = 80 F. Therefore, the heat resistance from inside wall surface to outside air must be eight times that from inside air to inside wall surface, or $8 \times \frac{1}{1.65} = 4.85$. The resistance for added material is, therefore,

$$4.85 - \left(\frac{6}{12.62} + \frac{1}{6}\right) = 4.19$$

$4.19 \times 0.30 = 1.25$ in. of insulation.

6 ● An unheated attic space in a residence has an equivalent pitched roof area of 1560 sq ft and a ceiling area of 1200 sq ft. If 15 per cent of the roof area is composed of vertical wall spaces having a value of U = 0.52, determine the total heat loss per hour through the ceiling and roof for a temperature difference of 85 F, if U = 0.46 for the roof and U = 0.38 for the ceiling.

An approximate value of U for the roof is equivalent to the summation of coefficients for each individual section times its percentage of total area.

$U_r = (0.52 \times 0.15) + (0.46 \times 0.85) = 0.47.$

Ratio of roof area to ceiling = $1560 \div 1200 = 1.3$.

Substituting in Formula 6:

$$U = \frac{0.47 \times 0.38}{0.47 + \frac{0.38}{1.3}} = 0.235$$

$H = A\,U\,(t_i - t_o) = 1200 \times 0.235 \times 85 = 23{,}900$ Btu per hour.

Chapter 6

AIR LEAKAGE

Nature of Air Infiltration, Infiltration Through Walls, Window Leakage, Door Leakage, Selection of Wind Velocity, Crack Length used for Computations, Multi-Story Buildings, Heat Equivalent of Air Infiltration

AIR leakage losses are those resulting from the displacement of heated air in a building by unheated outside air, the interchange taking place through various apertures in the building, such as cracks around doors and windows, fireplaces and chimneys. This leakage of air must be considered in heating and cooling calculations. (See Chapters 7 and 8.)

NATURE OF AIR INFILTRATION

The natural movement of air through building construction is due to two causes. One is the pressure exerted by the wind; the other is the difference in density of outside and inside air because of differences in temperature.

The wind causes a pressure to be exerted on one or two sides of a building. As a result, air comes into the building on the windward side through cracks or porous construction, and a similar quantity of air leaves on the leeward side through like openings. In general the resistance to air movement is similar on the windward to that on the leeward side. This causes a building up of pressure within the building and a lesser air leakage than that experienced in single wall tests as determined in the laboratory. It is assumed that actual building leakages owing to this building up of pressure will be 80 per cent of laboratory test values. While there are cases where this is not true, tests in actual buildings substantiate the factor for the general case. Tests on mechanically ventilated classrooms of average construction have shown that air infiltration acts quite independently of the planned air supply. Accordingly, the heating or cooling load owing to air infiltration from natural causes should be considered in addition to the ventilating load.

The air exchange owing to temperature difference, inside to outside, is not appreciable in low buildings. In tall, single story buildings with openings near the ground level and near the ceiling, this loss must be considered. Also in multi-story buildings it is a large item unless the sealing between various floors and rooms is quite perfect. This temperature effect is a *chimney action*, causing air to enter through openings at lower levels and to leave at higher levels.

A complete study of all of the factors involved in air movement through building constructions would be very complex. Some of the complicating