attics, the combined ceiling and roof coefficient may be used, as described in Chapter 9.

## TEMPERATURES IN UNHEATED SPACES

The heat loss from heated rooms into unheated rooms or spaces must be based on the estimated or assumed temperature in such unheated spaces. This temperature will lie in the range between the inside and outside temperatures, depending on the relative areas of the surfaces adjacent to the heated room and those exposed to the outside. If the respective surface areas adjacent to the heated room and exposed to the outside are approximately the same, and if the coefficients of transmission are approximately equal, the temperature in the unheated space may be assumed to be the mean of the inside and outside design temperatures. If, however, the surface areas and coefficients are unequal, the temperature in the unheated space should be estimated by means of Equation 2.

$$t_u = \frac{t(A_1U_1 + A_2U_2 + A_3U_3 + \text{etc.}) + t_o(A_aU_a + A_bU_b + A_cU_c + \text{etc.})}{A_1U_1 + A_2U_2 + A_3U_3 + \text{etc.} + A_aU_a + A_bU_b + A_cU_c + \text{etc.}} \quad (2)$$

*where*

$t_u$ = temperature in unheated space, Fahrenheit degrees.

$t$ = inside design temperature of heated room, Fahrenheit degrees.

$t_o$ = outside design temperature, Fahrenheit degrees.

$A_1$, $A_2$, $A_3$, etc. = areas of surface of unheated space adjacent to heated space, square feet.

$A_a$, $A_b$, $A_c$, etc. = areas of surface of unheated space exposed to outside, square feet.

$U_1$, $U_2$, $U_3$, etc. = coefficients of transmission of surfaces of $A_1$, $A_2$, $A_3$, etc.

$U_a$, $U_b$, $U_c$, etc. = coefficients of transmission of surfaces $A_a$, $A_b$, $A_c$, etc.

*Example 2:* Calculate the temperature in an unheated space adjacent to a heated room having surface areas ($A_1$, $A_2$, and $A_3$) in contact therewith of 100, 120, and 140 sq ft and coefficients ($U_1$, $U_2$, and $U_3$) of 0.15, 0.20, and 0.25, respectively. The surface areas of the unheated space exposed to the outside ($A_a$ and $A_b$) are respectively 100 and 140 sq ft, and the corresponding coefficients are 0.10 and 0.30. The sixth surface is on the ground and is neglected in this example. Assume $t = 70$ and $t_o = -10$.

*Solution:* Substituting in Equation 2:

$$t_u = \frac{70[(100 \times 0.15) + (120 \times 0.20) + (140 \times 0.25)] + -10[(100 \times 0.10) + (140 \times 0.30)]}{(100 \times 0.15) + (120 \times 0.20) + (140 \times 0.25) + (100 \times 0.10) + (140 \times 0.30)}$$

$$t_u = \frac{4660}{126} = 37 \text{ F.}$$

The temperatures in unheated spaces having large glass areas and having two or more surfaces exposed to the outside (such as sleeping porches and sun parlors), generally are assumed to be the same as outside.

## GROUND TEMPERATURES

Ground temperatures to be assumed for estimating basement heat losses usually will differ in the case of basement walls and floors, the temperatures under the floors generally being higher than those adjacent to walls. Factors affecting these temperatures will be discussed.

### Temperatures Under Basement Floors

The temperature of the ground under basement floors[9] is affected by heat sources within the basement and is not influenced by atmospheric



conditions. In computing losses through basement floors, the ground temperatures may be assumed to be the same as water temperatures at depths of 30 to 60 ft given in Fig. 3, Chapter 35. Test observations indicate that heat losses through basement floors frequently are over-estimated.[10]

### Temperatures Adjacent to Basement Walls

Ground temperatures near the surface and under open spaces vary with the climate, the season of the year and the depth below the surface. The nearer the surface (during the cold weather) the lower will be the ground temperature. Frost will penetrate to a depth of over 4 ft in some localities if not protected by snow. A thick blanket of snow will result in a higher ground temperature near the surface. Therefore, in localities where the ground is covered with a heavy blanket of snow throughout the winter, the ground temperatures near the surface will be higher than when little or no snow is present.

Table 4. Below Grade Heat Losses for Basement Walls and Floors

| Ground Water Temperature[a] | Basement Floor Loss[b] Btu/Sq Ft | Below Grade Wall Loss[b] Btu/Sq Ft |
|---|---|---|
| 40 | 3.0 | 6.0 |
| 50 | 2.0 | 4.0 |
| 60 | 1.0 | 2.0 |

[a] See Fig. 3, Chapter 35.
[b] Based on basement temperature of 70 F and U of 0.10.

Complete data on ground temperatures adjacent to buildings are not available, but since the recommended transmission coefficient for basement walls in contact with the soil is only 0.10, any reasonable, assumed ground temperature will not materially affect the calculated heat loss.

## BASEMENT TEMPERATURES AND HEAT LOSS

The allowance to be made for basement heat loss depends on whether the basement is to be heated or not.

If the basement is *heated* to a specified temperature, the heat loss should be calculated in the usual manner, based on the proper wall and floor coefficients (see Chapter 9) and the outside air and ground temperatures. Heat loss through windows and walls above grade should be based on outside temperatures and the proper air-to-air coefficients. Heat loss through basement walls below grade should be based on the floor and wall coefficients for surfaces in contact with the soil, and on the proper ground temperature.

The heat loss values for below grade basement walls and floors given in Table 4 are sufficiently precise for general practice.

If a basement is completely below grade and is *not heated*, the temperature in the basement normally will range between that in the rooms above and the ground temperature. Basement windows will, of course, lower the basement temperature when it is cold outside, and heat given off by the heating plant will increase the basement temperature. In any case, the exact basement temperature is indeterminate if the basement is not heated. In general, it is found that the transient heat from the heating plant warms the air near the basement ceiling sufficiently to make it un-