

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

GROUND TEMPERATURES

Ground temperatures to be assumed for estimating basement heat losses usually will differ for 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 floors¹⁰ 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.¹¹ Test observations indicate that heat losses through basement floors frequently are overestimated.¹²

Temperatures Adjacent to Basement Walls

Ground temperatures near the surface and under open spaces vary with the climate, the season 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 the ground is 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.

The ground temperature adjacent to the walls of a heated basement is greatly affected by the heat gain from the basement. Unfortunately, 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 24) and the outdoor air and ground temperatures. Heat loss through windows and walls above grade should be based on outdoor 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.

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

Ground Water Temperature	Basement Floor Loss ^a 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 Based on basement temperature of 70 F and U of 0.10.

^b Assumed twice basement floor loss.

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 that of the ground. Basement windows will, of course, lower the basement temperature when it is cold outdoors, 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 unnecessary to make an allowance for floor heat loss from rooms located over the basement.

The temperature in crawl spaces below floors will vary widely depending on the number and size of wall vents, the amount of warm piping present and type of piping insulation. It is necessary, therefore, to evaluate the conditions and to select an appropriate temperature by judgment.

HEAT LOSSES FROM FLOOR SLABS

Two types of concrete floors used in basementless houses are (a) the unheated floor, relying for warmth on heat delivered above floor level by the heating system, and (b) the heated floor containing heated pipes or ducts that constitute a radiant slab or portion thereof for complete or partial heating of the house.

For type (a), the floor heat loss, economically considered, is of minor importance since it generally comprises about 10 percent of the total heat loss of the house. From the comfort standpoint, however, it may be most important, since houses with cold floors are not successfully heated. In this connection, it should be remembered that a well insulated floor does not assure comfort if downdrafts from windows or exposed walls create pools of chilly air over considerable areas of the floor. For this reason, a floor of type (a) should not be used in a severe climate except with a heating system that delivers enough heat near the floor to counteract the downdrafts of the exterior walls and the heat transmission through the floor.

The results of some experiments^{13,14} with type (a) unheated floor slabs indicate that the heat loss from a concrete slab floor on grade is more nearly proportional to the perimeter than to the area of the floor, and that the heat loss can be estimated by means of the equation:

$$H_F = PP(t_i - t_o) \quad (3)$$

where

H_F = heat loss of the floor, Btu per hour.

P = perimeter or exposed edge of the floor, linear feet.

F = heat loss coefficient, Btu per (hour) (linear foot of exposed edge) (degree difference in temperature between the indoor air and the outdoor air). (F ranges between 0.81 for a floor with no edge insulation to 0.55 for a floor with edge insulation.)

t_i = indoor air temperature, Fahrenheit.

t_o = outdoor air temperature, Fahrenheit.

In most instances the values given in Table 5 for edge loss are of sufficient precision for use.¹⁵ The insulation shown extending under the floor horizontally for 2 ft can also be located along the foundation wall with equal effectiveness if the insulation extends 24 in. below the floor level.

Example 5: Calculate the heat loss from the floor of a 12 ft × 15 ft room with two exposures. The floor is an unheated concrete slab which is insulated at the edge with 2 in. of insulation extending horizontally for a distance of 2 ft from the edge, and the house is located in an area with an outdoor design temperature of -15 F.

Heating Load

Table 5 . . . Heat Loss of Concrete Floors at or Near Grade Level per Foot of Exposed Edge

Outdoor Design Temperature F	Heat Loss per Foot of Exposed Edge, Btu/hr	
	Recommended 2-in. Edge Insulation	1-in. Edge Insulation
-20 to -30	50	55
-10 to -20	45	50
0 to -10	40	45
Outdoor Design Temperature F	1-in. Edge Insulation	No Edge Insulation*
-20 to -30	60	75
-10 to -20	55	65
0 to -10	50	60

* This construction not recommended; shown for comparison only.

Solution: From Table 5, the heat loss per foot of exposed edge is 45 Btu per hr. The length of exposed edge is 12 ft + 15 ft = 27 ft, and the total edge loss $27 \times 45 = 1215$ Btu per hr.

Floors of type (b), containing heating pipes or ducts, are now in common use. The heat loss downward into the ground and outward through the edges of the floor slab is called the reverse loss.

The results¹⁶ of an investigation in which a warm air perimeter duct was embedded in four types of concrete floor-slab and foundation constructions has verified the indication that Equation 3 can be used to calculate the reverse loss when warm air perimeter heating ducts are used. To make the results of this application more usable, values corresponding to those shown in Table 5 for unheated floors are given in Table 6 for concrete floors with a warm air perimeter duct.

The desirability of edge insulation is apparent. One inch of water-resistant material is the minimum thickness of edge insulation that should be used, but a 2-in. thickness is recom-

Table 6 . . . Floor Heat Loss to be Used When Warm Air Perimeter Heating Ducts Are Embedded in Slabs^a

Outdoor Design Temperature, F	Edge Insulation		
	1-in. Vertical Extending Down 18 in. Below Floor Surface	1-in. 1-Type Extending at least 12 in. Deep and 12 in. Under	2-in. 1-Type Extending at least 12 in. Down and 12 in. Under
-20	105	100	85
-10	95	90	75
0	85	80	65
10	75	70	55
20	62	57	45

^a Factors include loss downward through inner area of slab.

mended.^{16,17,18} The values of edge loss in Table 6 indicate that the reverse heat loss of heated slabs is likely to be about 20 percent of the total heat loss of many types of present day houses, and may exceed 20 percent if only one inch of insulation is used at the edge of the floor.

The concrete floor slab is usually placed on a gravel fill 4 in. thick or more, both to insulate the floor from the earth and to retard the rise of ground water by capillarity. A waterproof membrane should be installed over the gravel fill. Obviously, it is important that such floors be laid several inches above grade, and that effective subsoil drainage be provided to avoid slabs soaked by rain or melting snow, and consequent excessive heat loss.

TRANSMISSION HEAT LOSS

The basic formula for the loss of heat by transmission through any surface is given in Equation 4:

$$H_t = AU(t_i - t_o) \quad (4)$$

where

H_t = heat loss transmitted through the wall, roof, ceiling, floor, or glass, Btu per hour.

A = area of wall, glass, roof, ceiling, floor, or other exposed surface, square feet.

U = coefficient of transmission, air-to-air, Btu per (hour) (square foot) (Fahrenheit degree temperature difference).

t_i = indoor temperature near surface involved (this may not necessarily be the so-called breathing-line temperature), Fahrenheit degrees.

t_o = outdoor temperature, or temperature of adjacent unheated space or of the ground, Fahrenheit degrees.

Example 4: Calculate the transmission loss through an 8-in. brick wall having an area of 150 sq ft, if the indoor temperature t_i is 70 F, and the outdoor temperature t_o is -10 F.

Solution: The coefficient of transmission U of a plain 8-in. brick wall is 0.41 (Chapter 24, Table 6). The area A is 150 sq ft. Substituting in Equation 4:

$$H_t = 150 \times 0.41 \times [70 - (-10)] = 4,920 \text{ Btu per hour.}$$

Transmission Loss Through Ceilings and Roofs

The transmission heat loss through top floor ceilings, attics, and roofs may be estimated by either of two methods:

1. By substituting in Equation 4 the ceiling area A , the indoor-outdoor temperature difference ($t_i - t_o$), and the proper value of U :
 - a. **Flat roofs.** Select the coefficient of transmission of the ceiling and roof from Tables 11 to 14, Chapter 24, or use appropriate coefficients in Equation 1 if side walls extend appreciably above the ceiling of the floor below.
 - b. **Pitched roofs.** Select the combined roof and ceiling coefficient from Table 15, Chapter 24, or calculate the combined roof and ceiling coefficient by means of Equations 4 and 5, Chapter 24, where these formulas are applicable, as explained in Chapter 24.
2. By estimating the attic temperature (based on the indoor and outdoor design temperatures) by means of Equation 1, and substituting for t_i in Equation 4, the value of t_i thus obtained, together with the ceiling area A and the ceiling coefficient U . This applies to pitched roofs. In the case of flat roofs it is not necessary to calculate the attic temperatures, as the ceiling-roof heat loss can be determined as suggested in preceding paragraph 1a.

INFILTRATION HEAT LOSS

The infiltration heat loss includes (1) the *sensible heat loss*, or the heat required to warm the outdoor air entering by infiltration, and (2) the *latent heat loss*, or the heat equivalent of any moisture which must be added.