

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 inside-outside temperature difference $(t - t_o)$ and the proper value of U :

a. *Flat roofs.* Select the coefficient of transmission of the ceiling and roof from Tables 15 or 16, Chapter 9, 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 18, Chapter 9 or calculate the combined roof and ceiling coefficient by means of Equations 4 and 5, Chapter 9, where these formulas are applicable as explained in Chapter 9.

2. By estimating the attic temperature (based on the inside and outside design temperatures) by means of Equation 1, and substituting for t_o in Equation 4, the value of t_a 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 paragraph 1a.

INFILTRATION HEAT LOSS

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

Sensible Heat Loss

The formula for the heat required to warm the outside air which enters a room by infiltration to the temperature of the room, is given in Equation 5:

$$H_s = 0.240 Qd (t - t_o) \quad (5)$$

where

H_s = heat required to raise temperature of air leaking into building from t_o to t , Btu per hour.

0.240 = specific heat of air.

Q = volume of outside air entering building, cubic feet per hour (see Chapter 10).

d = density of air at temperature t_o , pounds per cubic foot.

It is sufficiently accurate to use $d = 0.075$ in which case Equation 5 reduces to

$$H_s = 0.018 Q (t - t_o) \quad (5a)$$

The volume Q of outside air entering per hour depends on the wind velocity and direction, the width of crack or size of openings, the type of openings and other factors, as explained in Chapter 10. Where the crack method is used for estimating leakage, it is more convenient to express the air leakage heat loss in terms of the crack length:

$$H_s = B L (t - t_o) \quad (5b)$$

where

B = air leakage per (hour) (foot of crack) (Chapter 10) for the wind velocity and type of windows or door crack involved, multiplied by 0.018.

L = length of window or door crack to be taken into consideration, feet.

Example 5: What is the infiltration heat loss per hour through the crack of a 3 x 5 ft average, double-hung, non-weatherstripped, wood window, based on a wind velocity of 15 mph? Assume inside and outside temperatures to be 70 F and zero, respectively.

Solution: According to Table 2, Chapter 10, the air leakage through a window of this type (based on $\frac{1}{8}$ in. crack and $\frac{1}{4}$ in. clearance) is 39 cu ft per (ft of crack) (hour). Therefore, $B = 39 \times 0.018 = 0.70$. The length of crack L is $(2 \times 5) + (3 \times 3)$, or 19 ft; $t = 70$ and $t_o = 0$. Substituting in Equation 5b,

$$H_s = 0.70 \times 19 \times (70 - 0) = 931 \text{ Btu per hour.}$$

Crack Length to be Used for Computations

For designers who prefer to use the crack method, the basis of calculation is as follows: The amount of crack used for computing the infiltration heat loss should be not less than half of the total length of crack in the outside walls of the room. For a building having no partitions, air entering through the cracks on the windward side must leave through the cracks on the leeward side. Therefore, take one-half the total crack for computing each side and end of the building. In a room with one exposed wall, take all the crack; with two exposed walls, take the wall having the most crack; and with three or four exposed walls, take the wall having the most crack; but in no case take less than half the total crack.

In small residences the total infiltration loss of the house is generally considered to be equal to the sum of the infiltration losses of the various rooms. However, this is not necessarily accurate as at any given time infiltration will take place only on the windward side or sides and not on the leeward side. Therefore, for determining the total heat requirements of larger buildings it is more accurate to base the total infiltration loss on the wall having the most total crack, but in no case on less than half of the total crack in the building.

Number of Air Changes to be Used for Computations

Since a certain amount of judgment is required regarding quality of construction, weather conditions, use of room and other factors in estimating infiltration by any method, some designers base infiltration upon an estimated number of air changes rather than upon the length of window cracks. Table 4 of Chapter 10 indicates air changes commonly used, but should be taken only as a guide.

When calculating infiltration losses by the air change method, Equation 5a may be used by substituting for Q the volume of the room multiplied by the number of air changes obtained from Table 4, Chapter 10. For further discussion of the method see section on Air Change Method in Chapter 10.

Latent Heat Loss

When it is intended to add moisture to air leaking into a room in order to maintain proper winter comfort conditions, it is necessary to determine the heat required to evaporate the water vapor added. This heat may be calculated by the equation

$$H_l = Qd (W_i - W_o) h_{fg} \quad (6)$$

where

H_l = heat required to increase moisture content of air leaking into building from m_o to m_i , Btu per hour.

Q = volume of outside air entering building, cubic feet per hour.