AREAS WHERE TRANSMISSION LOSSES OCCUR

Heat is lost from a building by transmission through all of those surfaces which separate heated spaces from the outside air or from unheated colder spaces within the building. In general, five kinds of surfaces are involved: (1) outside walls; (2) outside glass; (3) inside walls or partitions next to unheated spaces; (4) ceilings of upper floors, either below a cold attic space or as the underside of a roof slab; and (5) floors of heated rooms above an unheated space.

The net outside wall surface is usually determined by reference to the scale plans and elevations of the building concerned. In some cases, of course, the actual building may have to be measured. The total area of all outside openings which are occupied by windows and doors is accurately measured and listed as *glass*. The *glass* area is then deducted from the total outside wall area for each room and the difference is the net wall area. The outside wall areas for any floor should be based on the vertical floor-to-floor heights and the horizontal distance from center to center of partitions separating different rooms. If there are no partitions, measure from inside face of one wall to inside face of next wall. The areas of walls, ceilings and floors next to cold or unheated spaces are found, of course, by taking the inside dimensions of such areas, measured on the heated side.

COEFFICIENTS OF TRANSMISSION

The coefficients of transmission may be determined by means of the guarded hot box or the Nicholls Heat Meter described in Chapter 40, or they may be calculated from fundamental constants. On account of the unlimited number of combinations of building materials, it would be impractical to attempt to determine by test the heat transmission coefficients of every type of construction in use; consequently, in most cases it is advisable to calculate these coefficients.

Symbols

The following symbols are used in the heat transmission formulae in this chapter:

U = Thermal transmittance or over-all coefficient of heat transmission and is the amount of heat expressed in Btu transmitted in one hour per square foot of the wall, floor, roof or ceiling for a difference in temperature of 1 F between the air on the inside and outside of the wall, floor, roof or ceiling.

k = Thermal conductivity and is the amount of heat expressed in Btu transmitted in one hour through 1 sq ft of a homogeneous material 1 in. thick for a difference in temperature of 1 F between the two surfaces of the material. The conductivity of any material depends on the structure of the material and its density. Heavy or dense materials, the weight of which per cubic foot is high, usually transmit more heat than light or less dense materials, the weight of which per cubic foot is low.

C = Thermal conductance and is the amount of heat expressed in Btu transmitted in one hour through 1 sq ft of a non-homogeneous material for the thickness or type under consideration for a difference in temperature of 1 F between the two surfaces of the material. Conductance is usually used to designate the heat transmitted through such heterogeneous materials as plaster board and hollow clay tile.

f = Film or surface conductance and is the amount of heat expressed in Btu transmitted by radiation, conduction and convection from a surface to the air surrounding it, or vice versa, in one hour per square foot of the surface for a difference in temperature

of 1 deg between the surface and the surrounding air. To differentiate between inside and outside wall (or floor, roof or ceiling) surfaces, f_i is used to designate the inside film or surface conductance and f_o the outside film or surface conductance.

a = Thermal conductance of an air space and is the amount of heat expressed in Btu transmitted by radiation, conduction and convection in one hour through an area of 1 sq ft of an air space for a temperature difference of 1 F. The conductance of an air space depends on the mean absolute temperature, the width, the position and the character of the materials enclosing it.

R = Resistance or resistivity which is the reciprocal of transmission, conductance, or conductivity, *i.e.:*

$\frac{1}{U}$ = over-all or air-to-air resistance.

$\frac{1}{k}$ = internal resistivity.

$\frac{1}{C}$ = internal resistance.

$\frac{1}{f}$ = film or surface resistance.

$\frac{1}{a}$ = air-space resistance.

Fundamental Formulae

The formula of the over-all coefficient for a simple wall x inches thick is:

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{x}{k}} \qquad (2)$$

and for a compound wall of several materials having thicknesses in inches of x_1, x_2, x_3, etc., the coefficient is:

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3} + etc.} \qquad (3)$$

In the case of air-space construction, an air-space coefficient for each air space must be inserted in either Equation 2 or 3. Thus for a simple wall with one air space,

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{1}{a} + \frac{x}{k}} \qquad (4)$$

and for a simple wall of several air spaces having conductances of a_1, a_2, a_3, etc., the coefficient is:

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{x}{k} + \frac{1}{a_1} + \frac{1}{a_2} + \frac{1}{a_3} + etc.} \qquad (5)$$

With certain special forms of materials which have irregular air spaces (such as hollow tile) or are otherwise non-homogeneous, it is necessary to use the conductance (C) for the unit construction, in which case $\frac{x}{k}$ is replaced by $\frac{1}{C}$.