TRANSMISSION COEFFICIENTS BY COMPUTATION

Symbols and Definitions

The following symbols which are in agreement with the recommendations of the Committee on Heat Transmission of the *National Research Council* 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 deg 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 deg 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 deg 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 surface or film-conductance and f_o the outside surface or film-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 deg 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, 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.

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

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

x = thickness in inches.

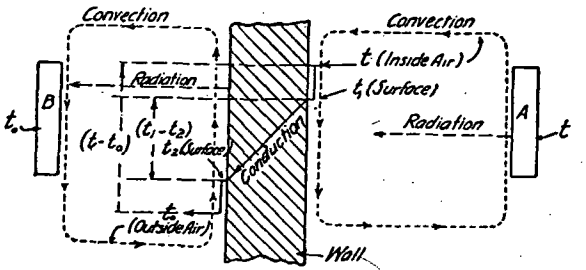
Fundamental Formulae

If heat transmission coefficients are to be computed, and in many, if not most cases, they should be computed, the following analysis of the transmission of heat through a simple, solid wall is used as the basis for such computations.

The diagram in Fig. 1 exhibits four important temperatures: *First*, the air temperature t inside of the building; *second*, the temperature t_1 of the inside surface of the wall; *third*, the temperature t_2 of the outside surface of the wall, and *fourth*, the air temperature t_o outside of the building.

Heat reaches or enters the inside surface of the wall by radiation and convection, since the air and objects A within the building are always warmer than the inside surface of the wall, when the inside air temperature t is greater than the outside air temperature t_o. This heat must then pass through the material of the wall from inside to outside surface by conduction, and is finally given off from the outside surface by radiation and convection, provided, of course, that equilibrium has been established and all four temperatures are constant.

The amount of heat reaching or entering the wall per hour depends on t and t_1 and the coefficient f_i varying with the character of the wall material. The symbol f_i may be defined as the Btu per hour entering each square foot of wall surface per degree difference between the inside air temperature t and the inside surface temperature t_1. Hence, the heat



A represents warm surfaces at temperature t of inside air;
B represents cold surfaces at temperature t_o of outside air.

FIG. 1. TEMPERATURE CURVE OR GRADIENT FROM AIR INSIDE TO AND THROUGH WALL TO AIR OUTSIDE, WALL MATERIAL ASSUMED AIR-TIGHT

received by the inner surface of the wall per hour by both radiation and convection is:

$$H_1 = f_i\,(t - t_1)\,S \tag{1}$$

where S is the inner-wall surface area in square feet and the other terms are as heretofore indicated.

Whatever amount of heat H_1 enters the inner-wall surface must be given off from the outer-wall surface, so that if H_2 represents heat emitted from outer surface,

$$H_1 = H_2 = f_o\,(t_2 - t_o)\,S \tag{2}$$

Now f_o may not equal f_i, in which case $(t_2 - t_o)$ will not equal $(t - t_1)$. Usually, in an actual wall exposed to wind on the outside, f_o (Table 2) is greater than f_i and $(t_2 - t_o)$ must be less than $(t - t_1)$. Moreover, the heat H_c passing through the wall by conduction is equal to H_1 and H_2, and if k is the thermal conductivity expressed in Btu transmitted per hour per square foot of material per 1 in. thickness per degree difference between the surface temperatures, then

$$H_1 = H_2 = H_c = \frac{k}{x}\,(t_1 - t_2)\,S \tag{3}$$

where x = wall thickness in inches.