For low velocities and long ducts of small cross-section, a somewhat more accurate formula may be used as follows:

$$t_2 = \frac{t_1 - t_3}{e^{\left(\frac{UPL}{14.4\ A\rho V}\right)}} + t_3 \qquad (15)$$

In these equations

Q = heat loss through duct walls, Btu per hour.
U = thermal transmission coefficient, Btu per square foot per hour per degree Fahrenheit.
P = perimeter of duct, feet.
L = length of duct, feet.
t_1 = temperature of air entering duct, degree Fahrenheit.
t_2 = temperature of air leaving duct, degree Fahrenheit.
t_3 = temperature of air surrounding duct, degree Fahrenheit.
M = weight of air per hour, through the duct, pounds.
A = cross-sectional area of duct, feet.
D = diameter of round duct, feet.
V = velocity of air in the duct, feet per minute, at specified temperature.
ρ = density of air, pounds per cubic foot, at the specified temperature at which V is measured.
e = naperian base of logarithms = 2.718.

In using Equations 13, 14 and 15, one of the duct air temperatures will be unknown and will be solved for by substitution of the other known or assumed values.

Heat loss coefficients for insulated ducts with various conductivities are given in Fig. 9. The conductivities of various materials, which are based on mean temperatures, ranging from about 70 to 90 F, will be found in Table 2 of Chapter 4. For cases where the mean temperature is other than that on which the test was conducted, a correction should be made. However, in most cases the effect of this factor will be small and may be neglected.

Example 4. Determine the entering air temperature and heat loss for a duct 24 × 36 in. cross-section and 70 ft in length, insulated with ½ in. of a material having a conductivity of 0.35 Btu at 86 F mean temperature, carrying air at a velocity of 1200 fpm, measured at 70 F, to deliver air at 120 F with air surrounding the duct at 40 F.

Solution. Referring to Fig. 9, the overall heat transmission coefficient is found to be 0.49 Btu. From Table 6, Chapter 1 the density of air at 70 F and 29.92 in. Hg is found to be 0.0749 lb per cubic foot. Substituting these and the other given values in Equation 13:

$$y = \frac{28.8 \times 6 \times 1200 \times 0.0749}{0.49 \times 10 \times 70} = 45.3$$

$$t_1 = \frac{120\ (45.3 + 1) - 80}{45.3 - 1} = 123.7$$

Substituting in Equation 11:

$$Q = 0.49 \times 10 \times 70 \left[\left(\frac{123.7 + 120}{2} \right) - 40 \right]$$

$$Q = 28{,}100 \text{ Btu per hour.}$$

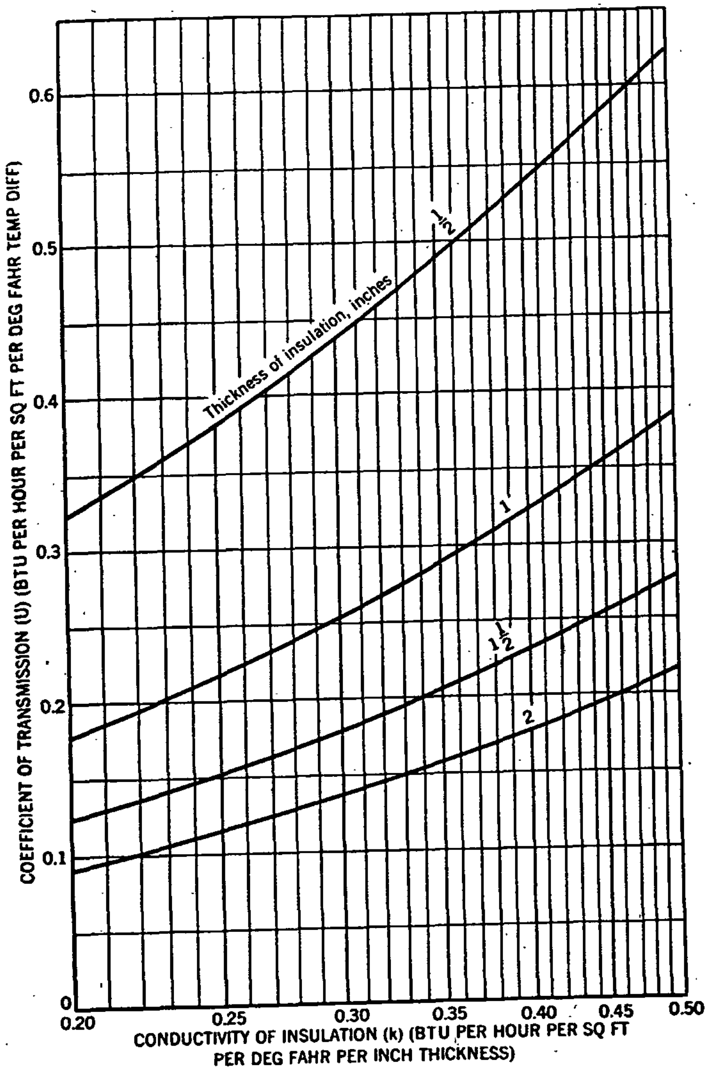

FIG. 9. HEAT LOSS COEFFICIENTS FOR INSULATED DUCTS[a]

Thickness of Insulation (Inches)	½	1	1½	2
21 to 30 in. Duct Diameter	1%	2%	3%	4%
12 to 21 in. Duct Diameter	3%	5%	7%	9%

[a]For round ducts less than 30 in. diameter, increase heat transmission values by the following percentages: