ducts, and solve for t_1 and t_2:

$$t_1 = \frac{t_2\,(y + 1) - 2t_3}{(y - 1)} \qquad (13) \qquad\qquad t_2 = \frac{t_1\,(y - 1) + 2t_3}{(y + 1)} \qquad (14)$$

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

$$t_2 = \frac{t_1 - t_3}{e^{\left(\frac{UPl}{14.4\,A\,\rho_v\,V_m}\right)}} + t_3 \qquad (15)$$

Symbols used in these equations are listed at end of chapter.

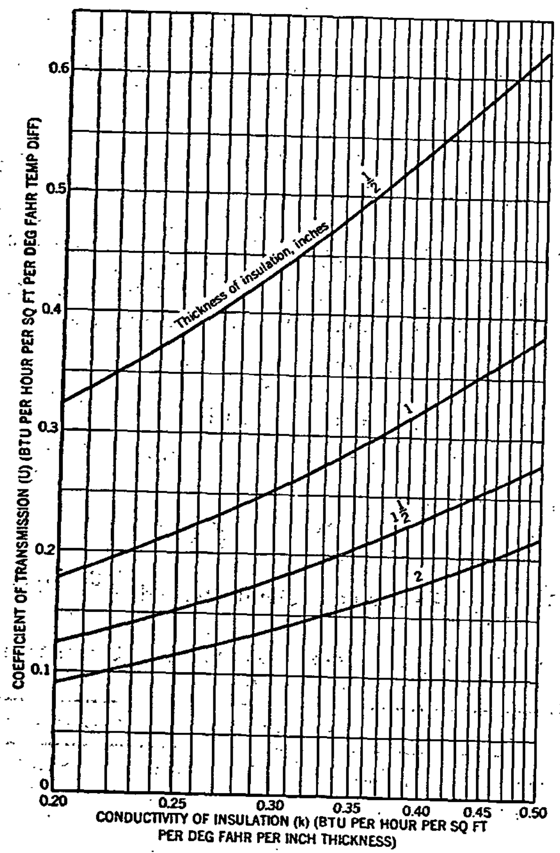

Fig. 10. Heat Loss Coefficients for Insulated Ducts[a]

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

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%

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

Heat loss coefficients for insulated ducts with various conductivities are given in Fig. 10. 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 6. For cases where the mean temperature is other than that at 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 5. 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. 10, the over-all heat transmission coefficient is found to be 0.49 Btu. From Table 1, Chapter 3 the density of air at 70 F and 29.921 in. Hg is found to be 1/13.348 = 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:

$$Q = 0.49 \times 10 \times 70 \left[\left(\frac{123.7 + 120}{2} \right) - 40 \right] = 28{,}100 \text{ Btu per hour.}$$

For special considerations which apply to insulation of ducts in marine installations see Chapter 49.

LETTER SYMBOLS USED IN CHAPTER 41

μ_o = absolute viscosity of air under actual (operating) conditions, any consistent units.
μ_s = absolute viscosity of air under standard conditions, any consistent units.
ρ_a = density of air, pounds per cubic foot.
ρ_o = density of air under actual (operating) conditions, any consistent units.
ρ_s = density of air under standard conditions, any consistent units.
ρ_v = density of air at specified temperature at which velocity, V_m, is measured, pounds per cubic foot.
A = cross-section area of duct, square feet.
a = length of one side of rectangular duct, feet or inches. (Other side is b.)
b = length of one side of rectangular duct, feet or inches. (Other side is a.)
D = inside diameter of conduit, feet.
d = equivalent diameter, feet or inches.
e = Naperian base of logarithms = 2.718.
f = non-dimensional friction coefficient.
f_i = surface conductance (inside) Btu per (hour) (square foot) (Fahrenheit degree).
f_o = surface conductance (outside) Btu per (hour) (square foot) (Fahrenheit degree).
g = acceleration due to gravity, 32.17, feet per (second) (second).
h_o = friction loss under actual (operating) conditions, any consistent units.
h_f = friction loss, feet of fluid flowing.
h_s = friction loss under standard conditions, any consistent units.
h_w = velocity head or pressure, inches of water.
l = length of conduit, feet.
P = perimeter of duct, feet.
Q = heat loss through duct walls, Btu per hour.
t_1 = temperature of air entering duct, Fahrenheit degrees.