Assume the maximum heat flux as previously calculated, and use the inside and outside temperature given to calculate U:

$$U = \frac{\dot{q}_{max}}{\Delta T} = \frac{21.6\frac{Btu}{hr \cdot ft^2}}{70°F - 10°F} = .36\frac{Btu}{hr \cdot ft^2 \cdot °F}$$

The Total Resistance, R_{total}, is the inverse of the Overall Coefficient of Heat Transfer, U.

$$U = \frac{1}{R_{total}} \rightarrow R_{total} = \frac{1}{U}$$

$$R_{total} = \frac{1}{.36\frac{Btu}{hr \cdot ft^2 \cdot °F}} = 2.77\frac{hr \cdot ft^2 \cdot °F}{Btu}$$

Set the calculated value for total resistance equal to the expression for total resistance derived for the composite wall, and solve for the thermal conductivity:

$$R_{total} = 1.67\frac{hr \cdot ft^2 \cdot °F}{Btu} + \frac{1ft}{12\,(k)} = 2.77\frac{hr \cdot ft^2 \cdot °F}{Btu}$$

$$\frac{1ft}{12\,(k)} = 1.11\frac{hr \cdot ft^2 \cdot °F}{Btu}$$

$$k = \frac{\left(\frac{1ft}{12}\right)}{\left(1.11\frac{hr \cdot ft^2 \cdot °F}{Btu}\right)} = .075\frac{Btu}{hr \cdot ft \cdot °F}$$

Answer B

42.5 An uninsulated $8in$ chilled water pipe carries $55°F$ chilled water through a factory maintained at $80°F$. The length of the run is $75ft$. The pipe is painted with nonmetallic paint. What is the net heat transfer by radiation?

A. $3500\frac{Btu}{hr}$

B. $4000\frac{Btu}{hr}$

C. $40,000\frac{Btu}{hr}$

D. $120,000\frac{Btu}{hr}$

It is not unreasonable to expect there to be some heat transfer by convection in the scenario described; however, the question states that only radiation should be considered. Treat the chilled water pipe as a body that is small compared to its surroundings and select the classic radiation equation:

$$\dot{Q} = \varepsilon \sigma A \left(T_1^4 - T_2^4\right)$$

where Q is heat transfer, ε is the emissivity, σ is the Stefan-Boltzmann constant, A is the surface area, and T is for the respective temperatures of the body and the surroundings.

Treating the pipe as a cylinder (with no ends), the surface area is:

$$A = \pi DL = \pi\left(8in\right)\left(\frac{1ft}{12in}\right)\left(75ft\right) = 157ft^2$$

When calculating radiation, absolute temperature units are required. Therefore:

$$T_1 = 80^\circ F + 460 = 540^\circ R$$

$$T_2 = 55^\circ F + 460 = 515^\circ R$$

To find the emissivity, find the table in the Reference Handbook for Emissivity of Surfaces and take note of the average emissivity for nonmetallic paints:

$$\varepsilon = .90$$

The Stefan-Boltzmann constant can be found in the table Fundamental Constants:

$$\sigma = 0.1713 \times 10^{-8}\frac{Btu}{hr \cdot ft^2 \cdot R^4}$$

Solve for the net heat transfer:

$$\dot{Q} = \varepsilon\sigma A\left(T_1^4 - T_2^4\right)$$

$$\dot{Q} = (.9)\left(0.1713 \times 10^{-8}\frac{Btu}{hr \cdot ft^2 \cdot R^4}\right)\left(157ft^2\right)\left[\left(540^\circ R\right)^4 - \left(515^\circ R\right)^4\right] = 3560\frac{Btu}{hr}$$

Answer A