32.3 An uninsulated $8inch$ 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. $3,500\frac{Btu}{hr}$

B. $4,000\frac{Btu}{hr}$

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 $\dot{Q}$ 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:

$$T_1 = 80°F + 460 = 540°R$$

$$T_2 = 55°F + 460 = 515°R$$

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:

$$\varepsilon = 0.90$$

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:

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

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

Answer A