$$\Delta T_A = 212°F - 150°F = 62°F$$

$$\Delta T_B = 195°F - 100°F = 95°F$$

Use the formula below to calculate the log mean temperature difference.

$$LMTD_{counterflow} = \frac{\Delta T_A - \Delta T_B}{ln\left(\frac{\Delta T_A}{\Delta T_B}\right)}$$

$$LMTD_{counterflow} = \frac{62°F - 95°F}{ln\left(\frac{62°F}{95°F}\right)} = 77.3°F$$

Calculate the heat transfer for the heat exchanger:

$$\dot{Q} = UA\Delta T_{lm} = \left(11\frac{Btu}{hr \cdot ft^2 \cdot °F}\right)\left(10ft^2\right)(77.3°F) = 8506\frac{Btu}{hr}$$

Answer C

47.39 An $8ft$ long, $1in$ diameter solid aluminum alloy rod with coefficient of linear thermal expansion of $12.8 \times 10^{-6}\frac{1}{°F}$ is heated from $70°F$ to $230°F$. What is the change in cross-sectional area?

A. $-3.2 \times 10^{-3}in^2$

B. $-2.1 \times 10^{-3}in^2$

C. $+2.1 \times 10^{-3}in^2$

D. $+3.2 \times 10^{-3}in^2$

The change in cross-sectional area of the rod is dependent upon the change in diameter, which is linear with the change in temperature. To obtain the change in the diameter, multiple the original diameter by the linear coefficient of thermal expansion and the ΔT.

$$\Delta D = D_0\alpha\Delta T$$

$$\Delta D = (1in)\left(12.8 \times 10^{-6}\frac{1}{°F}\right)(230°F - 70°F) = 0.00205in$$

Calculate the new diameter.

$$D_1 = D_0 + \Delta D = 1in + 0.00205in = 1.00205in$$

Calculate the new difference between the new and old cross-sectional areas.

$$A_1 - A_0 = \frac{\pi}{4}\left[D_1^2 - D_0^2\right]$$

$$A_1 - A_0 = \frac{\pi}{4}\left[(1.00205in)^2 - (1in)^2\right] = 3.2 \times 10^{-3}in^2$$

Answer D

47.40 A $25ft$ long hot water pipe with a $3in$ O.D. has an an average surface temperature of $175°F$ in a room with an ambient temperature of $60°F$. The convection coefficient is $2\frac{Btu}{hr \cdot ft^2 \cdot °F}$. What is the total heat loss from the pipe, assuming all surfaces are considered to be black, and no insulation is used?

A. $3000\frac{Btu}{hr}$

B. $4500\frac{Btu}{hr}$

C. $7500\frac{Btu}{hr}$

D. $15,000\frac{Btu}{hr}$

Consider both Convection and Radiation. The total heat loss is found by combining the two.

$$\dot{Q}_{combined} = \dot{Q}_{convection} + \dot{Q}_{radiation}$$

Write the formula for convection found by searching Newton's Law of Cooling. The convection coefficient is given. The surface area of the pipe is defined as $A = \pi DL$. The temperatures are known. Substitute and solve for the heat loss due to convection.

$$\dot{Q}_{conv} = hA\Delta T$$

$$\dot{Q}_{conv} = \left(2\frac{Btu}{hr \cdot ft^2 \cdot °F}\right)\left[\pi\left(\frac{3}{12}ft\right)(25ft)\right](175°F - 60°F) = 4516\frac{Btu}{hr}$$

Write the formula for radiation. Since all surfaces are black, assume $\varepsilon = 1$. σ is the Stefan-Boltzmann Constant. Surface area is the same as in the convection analysis. Temperatures must be in absolute terms i.e. Rankine.

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

$$\dot{Q}_{rad} = (1)\left(0.1713 \times 10^{-8}\frac{Btu}{hr \cdot ft^2 \cdot °R^4}\right)\left(\left[\pi\left(\frac{3}{12}ft\right)(25ft)\right]\right)\left[(635°R)^4 - (520°R)^4\right] = 3009\frac{Btu}{hr}$$

Solve for the combined heat loss by taking the sum of the heat loss due to convection and radiation.

$$\dot{Q}_{combined} = 4516\frac{Btu}{hr} + 3009\frac{Btu}{hr} = 7525\frac{Btu}{hr}$$

Answer C