36.35 **A variable frequnecy drive producing $100W$ of waste heat during continuous operation is housed in an insulated sheet matal enclosure mounted in a machine room. The insulation is $\frac{1}{8}in$ thick with a thermal conductivity of $0.2\frac{Btu}{hr \cdot ft \cdot ^\circ F}$. The thermal resistance of the sheet metal is negligible. The surface area of the enclosure is $8ft^2$. The machine room is maintained at $76^\circ F$. The film coefficients both inside and outside the enclosure are $4\frac{Btu}{hr \cdot ft^{2} \cdot ^\circ F}$. What is the steady state temperature inside the enclosure?**

A. $52^\circ F$

B. $88^\circ F$

C. $100^\circ F$

D. $112^\circ F$

Model the enclosure as a Composite Wall with 3 layers: 2 films and the insulation. Negligible thermal resistance is provided by the sheet metal. The total heat transfer through the composite wall may be described by the equation $\dot{Q} = UA\Delta T$, where the overall coefficient of heat transfer, $U = \frac{1}{R_T}$, and where R_T is the total thermal resistance. Determine the total thermal resistance by adding the individual thermal resistenaces in series.

$$R_T = \frac{1}{h_i} + \frac{L_{ins}}{k_{ins}} + \frac{1}{h_o}$$

$$R_T = \frac{1}{\left(4\frac{Btu}{hr \cdot ft^{2} \cdot ^\circ F}\right)} + \frac{\left(\frac{1}{8}in\right)\left(\frac{1ft}{12in}\right)}{0.2\frac{Btu}{hr \cdot ft \cdot ^\circ F}} + \frac{1}{\left(4\frac{Btu}{hr \cdot ft^{2} \cdot ^\circ F}\right)} = 0.55\frac{hr \cdot ft^2 \cdot ^\circ F}{Btu}$$

Calculate the overall heat transfer coefficient from the total thermal resistance.

$$U = \frac{1}{R_T} = \frac{1}{0.55\frac{hr \cdot ft^{2} \cdot ^\circ F}{Btu}} = 1.8\frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$$

Calculate the temperature differential using the total heat transfer, the overall heat transfer coefficient, and the surface area.

$$\Delta T = \frac{\dot{Q}}{UA} = \frac{(100W)\left(3.412\frac{Btu}{hr \cdot W}\right)}{\left(1.8\frac{Btu}{hr \cdot ft^{2} \cdot ^\circ F}\right)(8ft^2)} = 23.7^\circ F$$

Use the temperature differential to calculate the temperature inside the encolsure based on the room temperature.

$$\Delta T = T_{enclosure} - T_{room}$$

$$T_{enclosure} = \Delta T + T_{room} = 23.7^\circ F + 76^\circ F = 99.7^\circ F$$

Answer C