

46.36 In a counterflow heat exchanger, the cold fluid increases in temperature from $50^{\circ}F$ to $100^{\circ}F$ and the warm fluid is cooled from $180^{\circ}F$ to $145^{\circ}F$. What is the logarithmic mean temperature difference?

- A. $45^{\circ}F$
- B. $87^{\circ}F$
- C. $115^{\circ}F$
- D. $119^{\circ}F$

It is valid to use the Reference Handbook formula for **Log Mean Temperature Difference**. There is also a generalized version of the **LMTD** equation not provided in the reference handbook which is easier to remember and applies to both **Counterflow** and **Parallel Flow** heat exchangers, provided the flow directions are drawn out first. Note the opposite direction for the arrows for a counterflow heat exchanger.

$$\text{Cold Fluid : } 50^{\circ}F \longrightarrow 100^{\circ}F$$

$$\text{Hot Fluid : } 145^{\circ}F \longleftarrow 180^{\circ}F$$

Define one *physical* side of the heat exchanger as 'A' and the other side as 'B' and determine the respective temperature differences. Conveniently, the assignment of labels A and B turns out to be arbitrary. However, the *direction* of the flows is critical.

$$\Delta T_A = 145^{\circ}F - 50^{\circ}F = 95^{\circ}F$$

$$\Delta T_B = 180^{\circ}F - 100^{\circ}F = 80^{\circ}F$$

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

$$LMTD = \frac{\Delta T_A - \Delta T_B}{\ln\left(\frac{\Delta T_A}{\Delta T_B}\right)}$$
$$LMTD = \frac{95^{\circ}F - 80^{\circ}F}{\ln\left(\frac{95^{\circ}F}{80^{\circ}F}\right)} = 87.3^{\circ}F$$

Answer B

46.37 A composite wall is composed of $\frac{3}{4}$ in of stucco, 8 in normal weight concrete blocks, and $\frac{1}{2}$ in gypsum board. The inside and outside surface conductances are $6 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$ and $1.5 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$, respectively. What is the U-factor for the wall?

- A. $0.11 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$
- B. $0.41 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$
- C. $0.62 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$
- D. $2.4 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$

Sketch the **Composite Plane Wall** and label with given information. There are five sources of resistance, the two surface conductances and the three layers of building materials. The U-factor, or overall coefficient of heat transfer, is the inverse of the total resistance.

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

Write an expression for R_{total} for this specific situation.

$$R_{total} = \frac{1}{h_i} + R_{stucco} + R_{concrete} + R_{gypsum} + \frac{1}{h_o}$$

Use the table **Thermal Resistance of Building Materials** to look up the resistance values for each of the materials. In some cases the resistance may be provided per unit thickness and in others it may be given for a particular, typical thickness. Be sure to account for such nuances by ensuring correct units before taking the sum. For concrete, use the average value from the range provided for 8 in blocks.

$$R_{stucco} = \left(0.15 \frac{hr \cdot ft^2 \cdot ^\circ F}{Btu \cdot in} \right) (0.75 in) = 0.1125 \frac{hr \cdot ft^2 \cdot ^\circ F}{Btu}$$

$$R_{concrete} = 1.04 \frac{hr \cdot ft^2 \cdot ^\circ F}{Btu}$$

$$R_{gypsum} = 0.45 \frac{hr \cdot ft^2 \cdot ^\circ F}{Btu}$$

Calculate R_{total} .

$$R_{total} = \frac{1}{6 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}} + 0.1125 \frac{hr \cdot ft^2 \cdot ^\circ F}{Btu} + 1.04 \frac{hr \cdot ft^2 \cdot ^\circ F}{Btu} + 0.45 \frac{hr \cdot ft^2 \cdot ^\circ F}{Btu} + \frac{1}{1.5 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}}$$

$$R_{total} = 2.436 \frac{hr \cdot ft^2 \cdot ^\circ F}{Btu}$$

Calculate the U-factor.

$$U = \frac{1}{R_{total}} = \frac{1}{2.436 \frac{hr \cdot ft^2 \cdot ^\circ F}{Btu}} = 0.41 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$$

Answer B