$$T_f = \frac{T_s + T_\infty}{2} = \frac{140°F + 60°F}{2} = 100°F$$

$$Ra_L = \frac{\left(32.2\frac{ft}{s^2}\right)\left(\frac{2\times10^{-4}}{°F}\right)(140°F - 60°F)(0.5ft)^3(4.52)}{\left(0.74\times10^{-5}\frac{ft^2}{s}\right)^2} = 5.32\times10^9$$

Based on the range of Ra_L select the appropriate constants C and n:

$$10^9 < Ra_L < 10^{13}$$

$$C = 0.10$$

$$n = 1/3$$

Calculate $\bar{h}$:

$$\bar{h} = C\left(\frac{k}{L}\right)Ra_L^n = (.1)\left(\frac{\left(0.364\frac{Btu}{hr\cdot ft^2\cdot °F}\right)}{(.5ft)}\right)\left(5.32\times10^9\right)^{\frac{1}{3}} = 127\frac{Btu}{hr\cdot ft^2\cdot °F}$$

Determine the rate of heat transfer, $\dot{Q}$:

$$\dot{Q} = hA\Delta T = \left(127\frac{Btu}{hr\cdot ft^2\cdot °F}\right)(0.5ft)^2(140°F - 60°F) = 2541\frac{Btu}{hr}$$

Answer A

42.17 Cold water initially at $55°F$ is heated to $120°F$ to make potable hot water using a parallel flow shell and tube heat exchanger. Low temperature hot water from a boiler enters the heat exchanger at $160°F$ and leaves at $130°F$. What is the log mean temperature difference?

A. $40°F$

B. $45°F$

C. $56°F$

D. $58°F$

In a parallel flow heat exchanger, the temperature of the cold and hot stream will approach but never reach one another. The smallest temperature differential between the two streams will be observed at the outlet and the highest temperature differential will be observed at the inlet.

Call the inlet temperature differential ΔT_A and the outlet temperature differential ΔT_B:

$$\Delta T_A = 160°F - 55°F = 105°F$$

$$\Delta T_B = 130°F - 120°F = 10°F$$

Recall the simplified LMTD equation offered in solution 10.2. Substitute and solve for the log mean temperature difference:

$$\Delta T_{lm} = \frac{\Delta T_A - \Delta T_B}{ln\left(\frac{\Delta T_A}{\Delta T_B}\right)} = \frac{105°F - 10°F}{ln\left(\frac{105°F}{10°F}\right)} = 40.4°F$$

Answer A

42.18 In the summer, a warehouse is maintained at $72°F$ by several chilled beams supplied with $58°F$ chilled water which returns at $65°F$. Treating the chilled beam coil as a heat exchanger, what is the log mean temperature difference?

A. $7°F$

B. $10°F$

C. $11°F$

D. $14°F$

To treat the chilled beam coil as a heat exchanger, consider the chilled water to be the cold stream, entering at 58°F and leaving at 65°F. The air side will represent the warm stream, however, we do not know the supply and return temperature. We could assume the return temperature is representative of the room and guess that the supply air temperature is somewhat lower. This would not be unreasonable, although the supply air temperature chosen would be an outright guess.

Thinking about the way a ceiling mounted chilled beam works, in particular the *passive* style, the stratification of the air naturally brings warm air into contact with the chilled beam, which cools the air which gently falls away, promoting mixing vertically throughout the space without the use of a fan. Also since the chilled water is supplied at a higher temperature, there is an opportunity to capture savings not only by omitting the fan, but also by raising the chilled water setpoint for the system.

As an approximation, suppose the passive chilled beam is holding the space in equilibrium, and the supply and return temperatures are nearly equal. Note this is is *not strictly* true,

$$SAT \approx RAT = 72°F$$

To find the LMTD, calculate ΔT_A at the inlet and ΔT_B at the outlet:

$$\Delta T_A = 72°F - 58°F = 14°F$$

$$\Delta T_B = 72°F - 65°F = 7°F$$

Substitute and solve for the log mean temperature difference: