32.17 A run-around loop used for energy recovery pre-heats $20,000\frac{lb}{hr}$ of $20°F$ outside air. $150,000\frac{Btu}{hr}$ of heat is extracted from the same amount of exhaust air which is initially at $80°F$. The loop uses $10gpm$ of water as the heat exchange medium. Neglecting losses and pumping energy, what is the temperature range of the water in the loop?

A. $30°F - 65°F$

B. $30°F - 70°F$

C. $35°F - 65°F$

D. $35°F - 70°F$

Sketch the system. The run around loop is essentially a pair of coils and a pump connected by piping to move heat from one stream to another. Consider the $20°F$ entering outside air as State 1, the supply air after pre-heating as State 2, the $80°F$ leaving air as State 3, and the exhaust air after supplying heat to the run around loop as State 4.

$$OA_1 \longrightarrow coil_A \longrightarrow SA_2$$

$$EA_4 \longleftarrow coil_B \longleftarrow LA_3$$

The mass flow rates for the outside air stream and the exhaust air stream are same.

$$\dot{m}_{12} = \dot{m}_{34} = 20,000\frac{lb}{hr}$$

The heat extracted from the exhaust stream and supplied to coil B is equal to the quanity of heat added to the outside airsteam via coil A.

$$\dot{Q}_{12} = \dot{Q}_{34} = 150,000\frac{Btu}{hr}$$

Assume 100% efficiency. Since the the loop uses water as its heat exchange medium, use the sensible heating rule of thumb to calculate the ΔT for either coil.

$$\dot{Q} = 500gpm\Delta T$$

$$\Delta T = \frac{\dot{Q}}{500gpm} = \frac{150,000}{500\,(10)} = 30°F$$

Only one answer choice has a range of $30°F$.

By symmetry, the water ΔT will be centered within the air ΔT, which is bounded by the two entering airstreams of $T_1 = 20°F$ and $T_3 = 80°F$ for a ΔT of $80°F - 20°F = 60°F$, with its center at the average temp.

$$T_{avg} = \frac{20°F + 80°F}{2} = 50°F$$

A $30°F$ range centered @ $50°F$ is $50°F \pm 15°F = 35°F - 65°F$.

Answer C