37.41 Saturated steam at $300psia$ enters a closed feedwater heater and heats entering water with a temperature of $60°F$. The steam leaves as a saturated liquid. If the mass flow rate of water is 10 times the mass flow rate of steam, what is the exit temperature of the water?

A. $99°F$

B. $101°F$

C. $139°F$

D. $141°F$

Assuming 100% efficiency, all of the heat provided by the steam is added to the water. Set the heat removed from the steam equal to the heat gained by the water.

$$\dot{Q}_{steam} = \dot{Q}_{water}$$

Write an expression for the steam based on mass flow rate and the change in enthalpy, and express the heat gain by the water using mass flow rate, specific heat capacity, and change in temperature.

$$\dot{m}_{steam}\Delta h = \dot{m}_{water}c_p\Delta T$$

Since the mass flow rate of water is 10 times the mass flow rate of steam, substitute for the mass flow rate of water, then cancel $\dot{m}_{steam}$ on both sides.

$$\dot{m}_{water} = 10\dot{m}_{steam}$$

$$\dot{m}_{steam}\Delta h = 10\dot{m}_{steam}c_p\Delta T$$

$$\Delta h = 10c_p\Delta T$$

Solve for ΔT. Use the Properties of Saturated Water and Steam table by pressure to obtain the change in enthalpy for $300psia$ steam. The steam enters as saturated steam and therefore has enthalpy h_g, and leaves as saturated liquid and therefore has enthalpy h_f. For convenience, recall that the change in enthalpy is provided in the table directly, and $h_{fg} = h_g - h_f$.

$$\Delta T = \frac{\Delta h}{10c_p} = \frac{h_g - h_f}{10c_p} = \frac{h_{fg}}{10c_p} = \frac{809.42\frac{Btu}{lb}}{10\left(1\frac{Btu}{lb\cdot°F}\right)} = 80.9°F$$

Expand the water ΔT and solve for the leaving water temperature, T_2.

$$\Delta T = T_2 - T_1$$

$$T_2 = T_1 + \Delta T$$

$$T_2 = 60°F + 80.9°F = 140.9°F$$

Answer D