46.25 A steam boiler uses $50\frac{lb}{hr}$ of $40psia$ saturated steam to heat $10gpm$ of water. What is the expected increase in temperature for the water?

A. $7°F$

B. $8°F$

C. $9°F$

D. $10°F$

There is no mention of any losses in the problem statement, so assume the heat exchange process is 100% efficient. Set the heat provided by the steam equal to the heat gained by the water. Ensuring both sides of the equation have units of $\frac{Btu}{hr}$, it is valid to use the sensible heating rule of thumb for water on the right side.

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

$$\dot{m}_{steam}\Delta h = 500gpm\Delta T$$

The change in enthalpy for the steam may be assumed as the latent heat of vaporization for steam at 40psia. Since no quality or leaving enthalpy was given, it is reasonable to assume the steam condenses fully and gives up all of its latent heat in the process.

$$\dot{m}_{steam}h_{fg} = 500gpm\Delta T$$

Use the Properties of Saturated Water and Steam table to obtain the latent heat of vaporization.

$$P = 40psia$$

$$h_{fg} = 933.68\frac{Btu}{lb}$$

Solve the left side of the equation and confirm the units are $\frac{Btu}{hr}$.

$$\dot{m}_{steam}h_{fg} = \left(50\frac{lb}{hr}\right)\left(933.68\frac{Btu}{lb}\right) = 46,684\frac{Btu}{hr}$$

Since the units are confirmed and the right side of the equation is a "rule of thumb," it is implied that the change in temperature will be in degrees Farenheit, as desired. Solve for ΔT.

$$46,684 = (500)(10)\Delta T$$

$$\Delta T = \frac{46,684}{(500)(10)} = 9.3°F$$

Answer C

46.26 $200\frac{lb}{hr}$ **of** $5psig$ **saturated steam enters a heating coil which supplies** $100MBH$**. What percent of the exiting steam is in a liquid phase?**

A. 44%

B. 48%

C. 52%

D. 56%

Consider the saturated steam entering the coil as State 1 and the saturated mixture leaving the coil as State 2.

Use the Properties of Saturated Water and Steam table to obtain the enthalpy at State 1.

$$P_1 = 5psig \approx 20psia$$

$$h_1 = h_g = 1156.19\frac{Btu}{lb}$$

The total heat transfer and mass flow rate are given. Determine the enthalpy at State 2.

$$\dot{Q} = \dot{m}\Delta h = \dot{m}\left(h_1 - h_2\right)$$

$$h_2 = h_1 - \frac{\dot{Q}}{\dot{m}} = 1156.19\frac{Btu}{lb} - \frac{100,000\frac{Btu}{hr}}{200\frac{lb}{hr}} = 656.19\frac{Btu}{lb}$$

Determine the quality at State 2. Use the steam table to obtain enthalpy values h_f and h_{fg}. The quality is the fraction of the saturated mixture that is in a *vapor* phase.

$$h_f = 196.25\frac{Btu}{lb}$$

$$h_{fg} = 959.94\frac{Btu}{lb}$$

$$\chi_2 = \frac{h_2 - h_f}{h_{fg}} = \frac{656.19\frac{Btu}{lb} - 196.25\frac{Btu}{lb}}{959.94\frac{Btu}{lb}} = 0.479$$

The fraction of the water that is in a *liquid* phase is the complement of the quality.

$$1 - \chi_2 = 1 - 0.479 = 0.521 \approx 52\%$$

Answer C