32.14 Water enters a closed feedwater heater at $100°F$ and $200psia$. After being heated at constant pressure, the water exits as superheated steam at $500°F$. What heat transfer per unit mass is required?

A. $844\frac{Btu}{lb}$

B. $914\frac{Btu}{lb}$

C. $1124\frac{Btu}{lb}$

D. $1194\frac{Btu}{lb}$

Consider the entering condition for the water as State 1 and the exit condition for the superheated steam as State 2. The heat transfer per unit mass is the difference in enthalpy between the two states. Use the Properties of Saturated Water and Steam table to look up the saturation temperature and enthalpy of a saturated liquid at $P = 200psia$.

$$T_1 = 100°F$$

$$P_1 = 200psia$$

$$T_{sat} = 381.8°F$$

$$h_f = 355.5\frac{Btu}{lb}$$

Notice the temperature is lower than the saturation temperature; therefore, the water is a compressed liquid. To find the enthalpy, h_1, use the specific heat capacity, temperature differential, and enthalpy at saturation.

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

$$h_f - h_1 = c_p \left(T_{sat} - T_1\right)$$

$$h_1 = h_f - c_p \left(T_{sat} - T_1\right)$$

$$h_1 = 355.5\frac{Btu}{lb} - \left(1\frac{Btu}{lb°F}\right)(381.8°F - 100°F) = 74.5\frac{Btu}{lb}$$

Use the Properties of Superheated Steam table to look up the enthalpy for State 2. Since the heating is done at constant pressure, $P_2 = P_1$.

$$T_2 = 500°F$$

$$P_2 = 200psia$$

$$h_2 = 1269\frac{Btu}{lb}$$

Calculate the difference in enthalpy between the two states. This is the amount of heat transfer required per unit mass.

$$\Delta h = h_2 - h_1$$

$$\Delta h = 1269\frac{Btu}{lb} - 74.5\frac{Btu}{lb} = 1194.5\frac{Btu}{lb}$$

Answer D