34.3 $1000\frac{lb}{min}$ **of saturated liquid water at atmospheric pressure enters a closed feedwater heater and exits as saturated steam after being heated at constant pressure. The heat source is superheated steam at** $100psia$ **and** $500°F$**, which exits as a saturated liquid after constant pressure cooling. What is the volume flow rate of saturated liquid water exiting the feedwater heater from the heating stream?**

A. $17gpm$

B. $131gpm$

C. $680gpm$

D. $1300gpm$

Consider the entering saturated liquid as State 1, the leaving saturated steam as State 2, the entering superheated steam as State 3, and the leaving saturated liquid as State 4. Since the feedwater heater is *closed*, there is no mixing between of the stream from 1 to 2 with the stream from 3 to 4. All states are fully defined. Write the energy balance for the feedwater heater.

$$\dot{Q}_{in} = \dot{Q}_{out}$$

$$\dot{m}_1 h_1 + \dot{m}_3 h_3 = \dot{m}_2 h_2 + \dot{m}_4 h_4$$

Since the streams are kept separate, $\dot{m}_1 = \dot{m}_2$, and $\dot{m}_3 = \dot{m}_4$. Substitute for $\dot{m}_2$ and $\dot{m}_3$. Then solve for $\dot{m}_4$.

$$\dot{m}_1 h_1 + \dot{m}_4 h_3 = \dot{m}_1 h_2 + \dot{m}_4 h_4$$

$$\dot{m}_4 = \dot{m}_1 \left(\frac{h_2 - h_1}{h_3 - h_4} \right)$$

Use the Saturated Water and Steam table to obtain the enthalpies at States 1, 2, and 4. Also obtain the specific volume for State 4 for use in the subsequent step. Use the Superheated Steam table the obtain the enthalpy for State 3. Evaluate $\dot{m}_4$.

$$\dot{m}_4 = 1000\frac{lb}{min}\left(\frac{1150.25\frac{Btu}{lb} - 180.18\frac{Btu}{lb}}{1279.5\frac{Btu}{lb} - 298.51\frac{Btu}{lb}} \right) = 989\frac{lb}{min}$$

Use the specific volume to find the volume flow rate at State 4. Convert units to gpm.

$$Q_4 = \dot{m}_4 v_4 = 989\frac{lb}{min}\left(0.0177\frac{ft^3}{lb} \right)\left(\frac{7.48gal}{ft^3} \right) = 130.9gpm$$

Answer B