

The density value obtained from compressed water tables not available in the Reference Handbook is $58.8 \frac{lb}{ft^3}$ for a deviation of only 0.3%.

Find the heat load for the boiler. Replace mass flow rate with the product of density and volume flow rate. Convert units to $\frac{Btu}{hr}$, then finally to *boiler hp*.

$$\dot{Q} = \dot{m}\Delta h = \rho Q\Delta h$$

$$\dot{Q} = \left(58.98 \frac{lb}{ft^3}\right) \left(25 \frac{gal}{min}\right) \left(\frac{1ft^3}{7.48gal}\right) \left(\frac{60min}{1hr}\right) \left(1521 \frac{Btu}{lb} - 226.6 \frac{Btu}{lb}\right) = 1.53 \times 10^7 \frac{Btu}{hr}$$

$$\dot{Q} = \frac{1.53 \times 10^7 \frac{Btu}{hr}}{33,470 \frac{Btu}{hr \cdot boiler\ hp}} = 457 \text{boiler hp}$$

Answer C

46.80 $1 \frac{lb_m}{s}$ of saturated liquid water at $50psia$ enters a mixing chamber along with $1 \frac{lb_m}{s}$ of superheated steam at $50psia$ and $500^\circ F$. $2 \frac{lb_m}{s}$ of the resulting mixture is discharged after thorough mixing. What is the quality of the mixture?

- A. 0.44
- B. 0.50
- C. 0.56
- D. 0.62

Sketch the mixing chamber. Let State 1 represent the entering saturated liquid, State 2 represent the entering saturated steam, and State 3 represent the exiting mixture. Write the energy balance for the mixing process.

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

All mass flow rates are known. Use the [Properties of Saturated Water and Steam](#) (Pressure) table to obtain the enthalpy at State 1, h_1 .

$$P_1 = 50psia$$

$$h_1 = h_f = 250.2 \frac{Btu}{lb}$$

Use the [Properties of Superheated Steam](#) table to obtain the enthalpy at State 2.

$$P_2 = 50psia$$

$$T_2 = 500^\circ F$$

$$h_2 = 1284.1 \frac{\text{Btu}}{\text{lb}}$$

Solve for h_3 .

$$h_3 = \frac{\dot{m}_1 h_1 + \dot{m}_2 h_2}{\dot{m}_3} = \frac{(1 \frac{\text{lb}}{\text{s}}) (250.2 \frac{\text{Btu}}{\text{lb}}) + (1 \frac{\text{lb}}{\text{s}}) (1284.1 \frac{\text{Btu}}{\text{lb}})}{(2 \frac{\text{lb}}{\text{s}})} = 767.15 \frac{\text{Btu}}{\text{lb}}$$

Return to the **Properties of Saturated Water and Steam** (Pressure) table to obtain the enthalpy of vaporization, h_{fg} , at 50psia .

$$h_{fg} = 924.03 \frac{\text{Btu}}{\text{lb}}$$

Find the quality at State 3 using the equation from **Properties for Two-Phase (Vapor-Liquid) Systems**.

$$h_3 = h_f + \chi h_{fg} \rightarrow \chi = \frac{h_3 - h_f}{h_{fg}}$$
$$\chi = \frac{767.15 \frac{\text{Btu}}{\text{lb}} - 250.2 \frac{\text{Btu}}{\text{lb}}}{924.03 \frac{\text{Btu}}{\text{lb}}} = 0.56$$

Answer C