

36.79 25gpm of water at 300psia and 250°F goes through a boiler where it is converted to 500psia steam at 1000°F. What is the heat load being delivered by the boiler?

- A. 363boiler hp
- B. 416boiler hp
- C. 428boiler hp
- D. 491boiler hp

Consider the water entering the boiler as a State 1 and the superheated steam exiting the boiler as State 2. Determine the enthalpy at State 1. Use the properties of **Saturated Water and Steam** table by pressure and obtain h_f at $P_1 = 300\text{psia}$. Since $T_1 < T_{sat}$, the water is subcooled. Solve for the enthalpy at T_1 .

$$T_{sat@300\text{psia}} = 417.33^\circ F$$

$$h_{sat} = h_{f@300\text{psia}} = 393.93 \frac{\text{Btu}}{\text{lb}}$$

$$h_{sat} - h_1 = c_p (T_{sat} - T_1)$$

$$h_1 = h_{sat} - c_p (T_{sat} - T_1) = 393.93 \frac{\text{Btu}}{\text{lb}} - \left(1 \frac{\text{Btu}}{\text{lb}^\circ F}\right) (417.33^\circ F - 250^\circ F) = 226.6 \frac{\text{Btu}}{\text{lb}}$$

Obtain the specific volume from the same table and calculate the density, to be used later when changing volume flow rate to mass flow rate.

$$v = 0.0189 \frac{\text{ft}^3}{\text{lb}}$$

$$\rho = \frac{1}{v} = 52.9 \frac{\text{lb}}{\text{ft}^3}$$

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

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

$$\dot{Q} = \left(52.9 \frac{\text{lb}}{\text{ft}^3}\right) \left(25 \frac{\text{gal}}{\text{min}}\right) \left(\frac{1\text{ft}^3}{7.48\text{gal}}\right) \left(\frac{60\text{min}}{1\text{hr}}\right) \left(1521 \frac{\text{Btu}}{\text{lb}} - 226.6 \frac{\text{Btu}}{\text{lb}}\right) = 1.37 \times 10^7 \frac{\text{Btu}}{\text{hr}}$$

$$\dot{Q} = \frac{1.37 \times 10^7 \frac{\text{Btu}}{\text{hr}}}{33,000 \frac{\text{Btu}}{\text{hr}\cdot\text{boiler hp}}} = 416\text{boiler hp}$$

Answer B