

36.73 A boiler produces saturated steam at atmospheric pressure. 20gpm of feedwater enters at 160°F and 14.7psia. What is the boiler horsepower rating?

- A. 270boiler hp
- B. 280boiler hp
- C. 290boiler hp
- D. 300boiler hp

Consider the feedwater entering the boiler as State 1 and the steam leaving the boiler as State 2. To find the enthalpy at State 1, recall from Thermodynamics that the change in enthalpy is the product of the specific heat capacity and the change in temperature. State 1 is compressed water which has been cooled sensibly past the saturation temperature of 212°F. Use the properties of **Saturated Water and Steam** table to obtain the enthalpy for a saturated liquid at 14.7psia, and determine h_1 .

$$P_1 = 14.7psia$$

$$T_1 = 160^\circ F$$

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

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

$$h_1 = h_{sat} - c_p (T_{sat} - T_1) = 180.18 \frac{Btu}{lb} - \left(1 \frac{Btu}{lb \cdot ^\circ F} \right) (212^\circ F - 160^\circ F) = 128.2 \frac{Btu}{lb}$$

Use the properties of **Saturated Water and Steam** table again to obtain the enthalpy for State 2.

$$P_2 = 14.7psia \text{ (saturated)}$$

$$h_2 = 1150.25 \frac{Btu}{lb}$$

Find the mass flow rate in $\frac{lb}{hr}$. Use the **Properties of Water** table to obtain the density at State 1.

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

$$\dot{m} = \left(61 \frac{lb}{ft^3} \right) \left(20 \frac{gal}{min} \right) \left(\frac{1ft^3}{7.48gal} \right) \left(\frac{60min}{1hr} \right) = 9786 \frac{lb}{hr}$$

Determine the heat added by the boiler. Find the conversion factor from $\frac{Btu}{hr}$ to *boiler hp* in the **Measurement Relationships** table.

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

$$\dot{Q} = \frac{(9786 \frac{lb}{hr}) (1150.25 \frac{Btu}{lb} - 128.2 \frac{Btu}{lb})}{(33,470 \frac{Btu}{hp \cdot boiler \ hp})} = 299 \text{ boiler hp}$$

Answer D