

$$\dot{m} = \rho Q = \frac{Q}{v_{OA}} = \frac{\left(4167 \frac{ft^3}{min}\right) \left(\frac{60min}{1hr}\right)}{11.585 \frac{ft^3}{lb_{da}}} = 21,581 \frac{lb_{da}}{hr}$$

$$\dot{m}_w = \left(21,581 \frac{lb_{da}}{hr}\right) \left(0.0063 \frac{lb_w}{lb_{da}}\right) = 136 \frac{lb_w}{hr}$$

**Answer C**

**46.78 A 7.5hp motor is 93% efficient. How much waste heat is generated due to losses?**

- A.  $810 \frac{Btu}{hr}$
- B.  $1340 \frac{Btu}{hr}$
- C.  $1440 \frac{Btu}{hr}$
- D.  $2580 \frac{Btu}{hr}$

The heat losses from the motor result from input electrical power that is not converted into brake horsepower. Since motors are rated in *bhp*, the mechanical output power is always equal to the nominal rating of the motor, in this case *7.5hp*. Therefore, the losses do not come out of the *7.5hp*, but rather, come out of the input electrical power leaving (precisely) the *bhp* left to be delivered.

Calculate the electrical input power to the motor.

$$\dot{W}_{in} = \frac{bhp}{\eta_{motor}} = \frac{7.5hp}{0.93} = 8.065hp$$

The waste heat is the difference between the input electrical power and the output shaft power. Calculate the losses. Convert units to  $\frac{Btu}{hr}$ .

$$\dot{Q}_{losses} = (0.565hp) \left(\frac{0.7457KW}{hp}\right) \left(\frac{3412 \frac{Btu}{hr}}{KW}\right) = 1437 \frac{Btu}{hr}$$

**Answer C**

**46.79** 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. 360boiler hp
- B. 420boiler hp
- C. 460boiler hp
- D. 490boiler 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  $T_1$ .

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

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

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

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

Approximate the density at State 1 using the **Properties of Water** table and extrapolating to 250°F. The pressure is much higher than atmospheric pressure, but this approach yields a fairly accurate result since water incompressible.

$T [^\circ F]$	$\rho \left[ \frac{\text{lb}}{\text{ft}^3} \right]$
200	60.1
212	59.83
250	$\rho$

$$\frac{212^\circ F - 200^\circ F}{250^\circ F - 200^\circ F} = \frac{59.83 \frac{\text{lb}}{\text{ft}^3} - 60.1 \frac{\text{lb}}{\text{ft}^3}}{\rho - 60.1 \frac{\text{lb}}{\text{ft}^3}}$$

$$0.24 = \frac{-0.27 \frac{\text{lb}}{\text{ft}^3}}{\rho - 60.1 \frac{\text{lb}}{\text{ft}^3}}$$

$$\rho - 60.1 \frac{\text{lb}}{\text{ft}^3} = -1.125 \frac{\text{lb}}{\text{ft}^3}$$

$$\rho = 58.98 \frac{\text{lb}}{\text{ft}^3}$$