

$$T = 85^{\circ}F$$

$$p_{ws} = 0.6psia$$

Substitute and solve for the partial pressure of water vapor at 50% relative humidity.

$$p_w = (0.5)(0.6psia) = 0.3psia$$

Answer A

47.25 2000gpm of 68°F water is transported to an open reservoir 140ft above the pump via 1500ft of 12in nominal steel pipe. Pressure on the suction side of the pump is measured as 15psig. The Darcy friction factor for this application is assumed to be approximately 0.015. What is the operating head of the pump?

- A. 20ft
- B. 120ft
- C. 220ft
- D. 240ft

Draw a sketch of the pump and reservoir and label all given information. Consider the suction side of the pump as State 1 and the top of the reservoir as State 2. Use the modified Bernoulli equation aka **Mechanical Energy Equation** arranged for total head added by a pump. Make all terms have units of ft.

$$h_A = \frac{P_2 - P_1}{\gamma} + \frac{v_2^2 - v_1^2}{2g} + z_2 - z_1 + h_f$$

The static pressure at the pump inlet, P_1 , is given in gauge pressure, 15psig. The reservoir is at atmospheric pressure which by definition is 0psig near sea level. There is no need to convert to absolute pressure, psia, in order to find the pressure difference. Convert from psia to ft by using the conversion factor rule of thumb for water, $2.31 \frac{ft}{psi}$. The velocity term may be neglected. Using the pump centerline as the datum, the Δz term may be determined.

The only unknown is the losses through the discharge piping from the pump to the reservoir, h_f . Since the friction factor is provided, use the **Darcy** equation rather than the **Steel Pipe Friction Tables**. Use the table to obtain the velocity and inside diameter.

$$h_f = \frac{fLv^2}{2Dg} = \frac{(0.015)(1500ft)\left(5.73\frac{ft}{s}\right)^2}{2\left(\frac{11.938}{12}ft\right)\left(32.2\frac{ft}{s^2}\right)} = 11.5ft$$

Solve for the total head added by the pump.

$$h_A = (0psi - 15psi)\left(2.31\frac{ft}{psi}\right) + 140ft + 11.5ft = 116.9ft$$

Answer B

47.26 $1000 \frac{Btu}{lb}$ of heat is added to $70^\circ F$, $14.7 psia$ air. What is the temperature after heating?

- A. $3665^\circ F$
- B. $3815^\circ F$
- C. $3965^\circ F$
- D. $4125^\circ F$

Consider the condition of the air before heating as State 1 and the condition of air after heating as State 2. Use the **Air at Low Pressure** tables to look up the enthalpy of air at $70^\circ F$. For low pressure air, enthalpy may be reasonably approximated as a function of temperature only.

$$h_1 \approx 126 \frac{Btu}{lb}$$

Calculate the enthalpy after heating.

$$h_2 = 126 \frac{Btu}{lb} + 1000 \frac{Btu}{lb} = 1126 \frac{Btu}{lb}$$

Return to the low pressure air table to look up the corresponding temperature for State 2. Without interpolating, notice h_2 is about halfway between two values, making the temperature straightforward to obtain.

$$T_2 \approx 3665^\circ F$$

Answer A

47.27 $400 \frac{lbm}{hr}$ of $62^\circ F$, **60%** relative humidity air is heated to $96^\circ F$ without changing the moisture content. How much heat is needed?

- A. $3300 \frac{Btu}{hr}$
- B. $6700 \frac{Btu}{hr}$
- C. $10,100 \frac{Btu}{hr}$
- D. $13,600 \frac{Btu}{hr}$

Since the moisture content is not changing, the heat transfer depends on the the mass flow rate, specific heat capacity of air, and the dry bulb temperature differential only. There is no need to account for humidity ratio or enthalpy.

$$\dot{Q} = \dot{m} c_p \Delta T$$

$$\dot{Q} = \left(400 \frac{lb}{hr}\right) \left(0.24 \frac{Btu}{lb^\circ F}\right) (96^\circ F - 62^\circ F) = 3624 \frac{Btu}{hr}$$

Answer A