$$T_2 = 170°F$$

$$\chi_2 = 0.9$$

$$s_f = 0.2474\frac{Btu}{lb°F}$$

$$s_{fg} = 1.5816\frac{Btu}{lb°F}$$

$$s_2 = 0.2474\frac{Btu}{lb°F} + 0.9\left(1.5816\frac{Btu}{lb°F}\right) = 1.671\frac{Btu}{lb°F}$$

Since the turbine is isentropic, the entropy for State 1 is the same as the entropy for State 2. The pressure at State 1 has been given. Use the Properties of Superheated Steam table to determine the temperature at State 1. Interpolate or estimate as appropriate.

$$s_1 = s_2 = 1.671\frac{Btu}{lb°F}$$

$$P_1 = 300psia$$

$$T_1 = 690°F$$

Answer B

47.24 Outside air conditions are $85°F$ and 50% relative humidity. What is the partial pressure of water vapor in the air?

A. $0.3psia$

B. $0.6psia$

C. $1.3psia$

D. $7.4psia$

Use the definition of Relative Humidity found under Psychrometric Properties. Relative humidity is a function of the partial pressure of water vapor in air, p_w, and the maximum possible partial pressure for water vapor in air,p_{ws}, which occurs at fully saturated conditions i.e. 100% relative humidity. The saturation pressure of water vapor in air is a function of temperature. Warmer air has a greater capacity for absorbing moisture, and therefore a higher saturation pressure.

$$\phi = \frac{p_w}{p_{ws}} \rightarrow p_w = \phi p_{ws}$$

Use the Properties of Saturated Water and Steam (Temperature) table to obtain the saturation pressure of water vapor at $85°F$.

$$T = 85°F$$

$$p_{ws} = 0.6psia$$

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