47.68 **A pump located $10ft$ above an open water tank at sea level transports $80gpm$ of $80°F$ water. The head loss in the suction piping is $15ft$. The net positive suction head required is $4ft$. What is the net positive suction head available?**

A. $8ft$

B. $18ft$

C. $28ft$

D. $38ft$

Net Positive Suction Head Available is a function of the physical layout of the pump, piping, and source. The Net Positive Suction Head Required is determined from the manufacturer's specifications and has no bearing on the NPSHA. The criterion for avoiding cavitation is that $NPSH_A > NPSH_R$. Since this problem only requires calculating NPSHA, the NPSHR is extra information.

Sketch and label the system. Work through each term in the NPSHA formula.

$$NPSH_A = h_p + h_z - h_{vpa} - h_f$$

The first term, h_p, is the atmospheric pressure. Use the conversion factor rule of thumb for water to convert from psi to ft.

$$h_p = (14.7psia)\left(2.31\frac{ft}{psi}\right) \approx 34ft$$

The second term, h_z, is the elevation term and is taken as negative becasue the pump is *above* the water source, thereby *reducing* the head available at the pump inlet. Sometimes the operator before this term is written as "plus or minus" $\pm$ to reflect this arrangement. It is fine to regard the value as positive as long as in the final step it is subtracted.

$$h_z = -10ft$$

The third term, h_{vpa}, is the vapor pressure and is a function of the temperature of the water. The vapor pressure is always subtracted. The higher the water temperature, the higher the vapor pressure, and the harder it will be to avoid cavitation. Use the Properties of Saturated Water and Steam (Temperature) table to look up the saturation pressure at $T = 80°F$. Use the conversion factor rule of thumb for water to convert from psi to ft.

$$T = 80°F$$

$$P_{sat} = 0.51psia\left(2.31\frac{ft}{psi}\right) = 1.178ft$$

The fourth term, h_f, is always subtracted since losses reduce the available head. The value for h_f was given.

$$h_f = 15ft$$

Calculate the NPSHA.

$$NPSH_A = 34ft - 10ft - 1.178ft - 15ft = 7.8ft$$

Answer A

47.69 Refrigerant R-410a is compressed isentropically from a saturated condition at $20psia$ to a pressure of $190psia$. What is the change in temperature during the compression process?

A. $11°F$

B. $63°F$

C. $76°F$

D. $174°F$

Sketch the compression process on a Pressure-Enthalpy diagram. Use the table for Refrigerant 410A to obtain the saturation temperature corresponding to the compressor inlet pressure, P_1. Note the table provides two temperatures, 'Bubble' and 'Dew'. Typically the values are close in magnitude and selection is of little consequence. For simplicity, use the 'Dew' temperature since this value corresponds to when the last drop of refrigerant evaporates, which should be complete prior to entering the compressor.

$$P_1 = 20psia\ (saturated)$$

$$T_1 = -49.2°F$$

Using the chart Pressure Versus Enthalpy Curves for Refrigerant 410A, draw a horizontal line across the chart for the high pressure condition, $P_2 = 190psia$. To locate the line properly, check the table for the corresponding saturation temperature which is approximately $T_3 \approx 61.6°F$. The goal is to find T_2, however, knowing T_3 will help draw the horizontal line contain the condensing process from $2 \rightarrow 3$ in the correct location on the chart. The vertical axis uses log scale so using pressure alone can be challenging. It is also essential to recognize that in the superheated region, the temperature is no longer constant along a horizontal line.

Next, draw a line of constant entropy starting from State 1 and making best effort to remain parallel with local constant entropy lines on the chart, which tend to travel north-northeast to south-southwest, but are not perfectly linear. Find the interesection of this constant entropy line from $1 \rightarrow 2$ and the horizontal line containing States 2 & 3. The interesection represents State 2. Read the temperature by following the constant temperature lines which waterfall down and to the right. Be willing to accept reduced precision when using a graphical approach.

$$T_2 \approx 125°F$$

Calculate the change in temperature between State 2 and State 1.

$$T_2 - T_1 = 125°F - (-49.2°F) = 174.2°F$$

Answer D