40.14 $10,000\frac{gal}{hr}$ **of fuel oil with a specific gravity of 0.86 is delivered to an emergency generator by a 90% efficient pump. The pressure gauge near the pump inlet reads** $-2.0in\,Hg$**. The pressure gauge on the discharge side of the pump reads** $30psig$ **and is located** $10ft$ **above the pump. What is the input power to the pump?**

A. $1.6hp$

B. $3.2hp$

C. $3.4hp$

D. $3.8hp$

Input power to the pump, bhp i.e. brake hp depends on the hydraulic horsepower of the pump, whp, which can be determined from the volume flow rate, Q, and pressure difference, ΔP. The pump efficiency should also be accounted for:

$$bhp = \frac{whp}{\eta}$$

$$whp = \frac{Q_{[gpm]}\Delta P_{[psi]}}{1714}$$

Convert the volume flow rate units to gpm:

$$Q = \left(10,000\frac{gal}{hr}\right)\left(\frac{1hr}{60min}\right) = 166.66gpm$$

Express the pressure differential across the pump as $\Delta P = P_2 - P_1$. Note that P_1 is a local measurement on the suction side of the pump and only requires unit conversion to psi. Lookup measurement relationships to get any necessary conversion factors. The rule of thumb conversion factor for water $2.31\frac{ft}{psi}$ may also be used.

$$P_1 = -2in\,Hg\left(\frac{13.6in\,H_2O}{1in\,Hg}\right)\left(\frac{1ft}{12in}\right)\left(\frac{1psi}{2.31ft\,H_2O}\right) = -.98psi$$

P_2 has a static pressure measurement via gauge and is at a higher elevation, so a Δz term must be included to account for the additional pressure associated with the increase in height. Note we have neglected velocity on both the suction and discharge side of the pump under the premise that the pipe size is constant and that any differences in velocity are not likely to be significant. Because the fluid being pumped is fuel, we must account for the specific gravity i.e. sg, when finding the pressure associated with the column of fluid. Find P_2:

$$P_2 = (30psi) + (10ft\,fuel)\left(\frac{.86ft\,H_2O}{1ft\,fuel}\right)\left(\frac{1psi}{2.31ft\,H_2O}\right) = 33.7psi$$

Compute ΔP:

$$\Delta P = P_2 - P_1 = (33.7psi) - (-.98psi) = 34.7psi$$

Find whp. Note the formula is already arranged to produce horsepower units provided the input units are as shown. Therefore, it is not necessary to write the units as long they are known to be correct.

$$whp = \frac{Q_{[gpm]}\Delta P_{[psi]}}{1714} = \frac{(166.66)\,(34.7)}{1714} = 3.37hp$$

Apply the pump efficiency to solve for the bhp:

$$bhp = \frac{whp}{\eta} = \frac{3.37hp}{.9} = 3.74hp$$

Answer D

40.15 $20,000gpm$ **of water flows through a turbine in a hydroelectric power application. The inlet pressure is** $50psig$ **and the exit pressure is** $1atm$**. The turbines have an overall efficiency of 80%. What is the electrical capacity of the hydroelectric plant?**

A. $350KW$

B. $435KW$

C. $470KW$

D. $540KW$

A hydroelectric turbine performs the opposite function of a pump. Pumps consume mechanical *brake* horsepower and produce *hydraulic* horsepower; hydroelectric turbines consume *hydraulic* horsepower and produce *brake* horsepower — the power of a rotating shaft. Therefore, we can start by writing the formula for whp, then express the electrical power as a fraction of the whp. Any losses are accounted for by the efficiency of the turbine (and since it is an *overall* efficiency can be assumed to include any generators that may be part of the electricity producing system downstream.)

$$whp = \frac{Q_{[gpm]}\Delta P_{[psi]}}{1714}$$

$$P_{elec} = \eta_t \cdot whp$$

Since the inlet pressure was given as $50psig$ and the outlet pressure is atmospheric pressure, $\Delta P = 50psi$. The volume flow rate was given in gpm. Combine the two formulas above, substitute, solve, and convert to KW:

$$P_{elec} = \frac{\eta_t Q_{[gpm]}\Delta P_{[psi]}}{1714} = \frac{(.8)\,(20,000)\,(50)}{1714} = 466.7hp\left(\frac{.7457KW}{1hp}\right)$$

$$P_{elec} = 348KW$$

Answer A