

36.66 10,000 gallons per hour 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 -2.0 inches of Hg. The pressure gauge on the discharge side of the pump reads 30psi and is located 10 feet 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.

$$P_1 = -2in Hg \left(\frac{13.6in H_2O}{1in Hg} \right) \left(\frac{1ft}{12in} \right) \left(\frac{1psi}{2.31ft H_2O} \right) = -0.98psi$$

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** when finding the pressure associated with the column of fluid. Find P_2 .

$$P_2 = (30psi) + (10ft fuel) \left(\frac{0.86ft H_2O}{1ft fuel} \right) \left(\frac{1psi}{2.31ft H_2O} \right) = 33.7psi$$

Compute ΔP .

$$\Delta P = P_2 - P_1 = (33.7psi) - (-0.98psi) = 34.7psi$$

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 .

$$bhp = \frac{whp}{\eta} = \frac{3.37hp}{0.9} = 3.74hp$$

Answer D