

2-67 The gage pressure of air in a pressurized water tank is measured simultaneously by both a pressure gage and a manometer. The differential height h of the mercury column is to be determined.

Assumptions The air pressure in the tank is uniform (i.e., its variation with elevation is negligible due to its low density), and thus the pressure at the air-water interface is the same as the indicated gage pressure.

Properties We take the density of water to be $\rho_w = 1000 \text{ kg/m}^3$. The specific gravities of oil and mercury are given to be 0.72 and 13.6, respectively.

Analysis Starting with the pressure of air in the tank (point 1), and moving along the tube by adding (as we go down) or subtracting (as we go up) the ρgh terms until we reach the free surface of oil where the oil tube is exposed to the atmosphere, and setting the result equal to P_{atm} gives

$$P_1 + \rho_w gh_w - \rho_{\text{Hg}} gh_{\text{Hg}} - \rho_{\text{oil}} gh_{\text{oil}} = P_{\text{atm}}$$

Rearranging,

$$P_1 - P_{\text{atm}} = \rho_{\text{oil}} gh_{\text{oil}} + \rho_{\text{Hg}} gh_{\text{Hg}} - \rho_w gh_w$$

or,

$$\frac{P_{1,\text{gage}}}{\rho_w g} = \text{SG}_{\text{oil}} h_{\text{oil}} + \text{SG}_{\text{Hg}} h_{\text{Hg}} - h_w$$

Substituting,

$$\left(\frac{80 \text{ kPa}}{(1000 \text{ kg/m}^3)(9.81 \text{ m/s}^2)} \right) \left(\frac{1000 \text{ kg} \cdot \text{m/s}^2}{1 \text{ kPa} \cdot \text{m}^2} \right) = 0.72 \times (0.75 \text{ m}) + 13.6 \times h_{\text{Hg}} - 0.3 \text{ m}$$

Solving for h_{Hg} gives $h_{\text{Hg}} = \mathbf{0.582 \text{ m}}$. Therefore, the differential height of the mercury column must be 58.2 cm.

Discussion Double instrumentation like this allows one to verify the measurement of one of the instruments by the measurement of another instrument.

