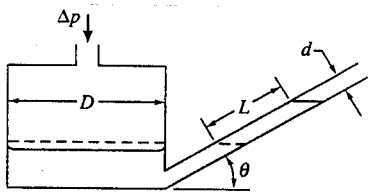
Problem 3.29



Given: Inclined manometer as shown filled with oil, SG = 0.897

Find: Angle, θ, such that applied pressure of 1 in. H_2O gage gives 5" oil deflection along incline. Also determine sensitivity

Solution:

Basic equation: $\frac{dp}{dz} = -\gamma$

Assumptions: (1) static fluid
(2) gravity is only body force
(3) z axis directed vertically

$dp = -\gamma\, dz$

For constant γ, $\Delta p = p_1 - p_2 = -\gamma(z_1 - z_2)$

Under applied pressure $\Delta p = \gamma_{oil}(L\sin\theta + x)$

where $\Delta p = 1\text{ in } H_2O = \gamma_{H_2O} h = 62.4 \frac{lbf}{ft^3} \times 1\text{ in} \times \frac{ft}{12\text{ in}} = 5.2 \frac{lbf}{ft^2}$.

Since the volume of the oil must remain constant

$$x A_{res} = L A_{tube}$$

$$\therefore x = L \frac{A_{tube}}{A_{res}}$$

and

$$\Delta p = \gamma_{oil}\left(L\sin\theta + L\frac{A_t}{A_r}\right) = \gamma_{oil}\left[L\sin\theta + L\left(\frac{d}{D}\right)^2\right]$$

Solving for $\sin\theta$,

$$\sin\theta = \frac{\Delta p}{\gamma_{oil} L} - \left(\frac{d}{D}\right)^2$$

$$= 5.2 \frac{lbf}{ft^2} \times \frac{ft^3}{0.897(62.4)lbf} \times \frac{1}{5\text{ in}} \times \frac{12\text{ in}}{ft} - \left(\frac{1}{4(3)}\right)^2$$

$$\sin\theta = 0.2161$$

$$\theta = 12.5° \quad \leftarrow \theta$$

The manometer sensitivity, $S = \frac{L}{\Delta h_e} = \frac{5\text{ in}}{1\text{ in}} = 5$ ← S