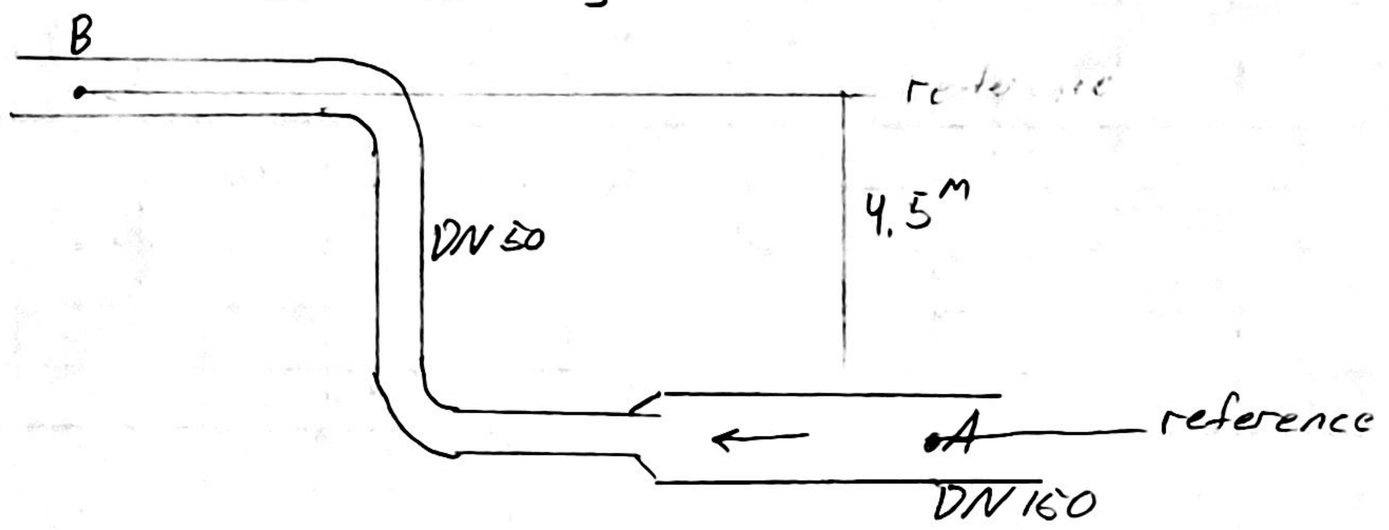
Problem 11.5

Given:
- $\gamma_{oil} = 8.8 \frac{kN}{m^3}$
- $\eta = 2.12 \times 10^{-5} \frac{m^2}{s}$
- DN 50 = 18 m $\Rightarrow A_B = 1.405 \times 10^{-3} \Rightarrow D_B = 0.0443^m$
- DN 150 = 180 m $\Rightarrow A_A = 1.682 \times 10^{-3} \Rightarrow D_A = 0.1463^m$
- long-radius elbows
- $P_B = 12.5 MPa$
- $Q = 0.015 \frac{m^3}{s}$



Find: Pressure at point A

Solution:

Bernoulli's

$$\cancel{h_A}^{0} + \frac{P_A}{\gamma} + \frac{V_A^2}{2g} + \cancel{z_A}^{0} = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_L$$

$$h_L = h_{pipe\,A} + h_{pipe\,B} + h_{elbow}$$

$$h_{pipe\,A} = f_A \cdot \frac{L}{D} \cdot \frac{V_A^2}{2g}$$

$$h_{pipe\,B} = f_B \cdot \frac{L}{D} \cdot \frac{V_B^2}{2g}$$

$$h_{elbow} = 2 \cdot k \cdot \frac{V_B^2}{2g}$$

$$V_B = \frac{Q}{A_B} = \frac{0.015}{1.405 \times 10^{-3}} = 7.87 \frac{m}{s}$$

$$V_A = \frac{Q}{A_A} = \frac{0.015}{1.682 \times 10^{-3}} = 0.891 \frac{m}{s}$$

$$Re_A = \frac{V_A D_A}{\nu} = \frac{0.891 \cdot 0.1463}{2.12 \times 10^{-6}} = 61487$$

$$\frac{D_A}{\varepsilon} = \frac{0.1463}{4.6 \times 10^{-5}} = 3180.4$$

$$f_A = 0.029$$

$$Re_B = \frac{V_B \cdot D_B}{\nu} = \frac{7.87 \cdot 0.0493}{2.12 \times 10^{-6}} = 18301.4$$

$$\frac{D_B}{\varepsilon} = \frac{0.0493}{2.12 \times 10^{-5}} = 2325.47$$

$$f_B = 0.031$$

$$f_t = \frac{0.25}{\left[\log\left(\frac{1}{3.7 \cdot \left(\frac{D_B}{\varepsilon}\right)}\right)\right]^2} = 0.0193$$

$$h_{L\,pipe\,A} = 0.029 \cdot \frac{180}{0.1463} \cdot \frac{0.891^2}{2 \cdot 9.81} = 1.443^m$$

$$h_{L\,pipe\,B} = 0.031 \cdot \frac{8}{0.0493} \cdot \frac{7.87^2}{2 \cdot 9.81} = 15.88^m$$

$$h_{L\,elbow} = 2 \cdot 20 \cdot 0.031 \cdot \frac{7.87^2}{2 \cdot 9.81} = 3.91^m$$

$$h_L = 1.443 + 15.88 + 3.91 = 21.233^m$$

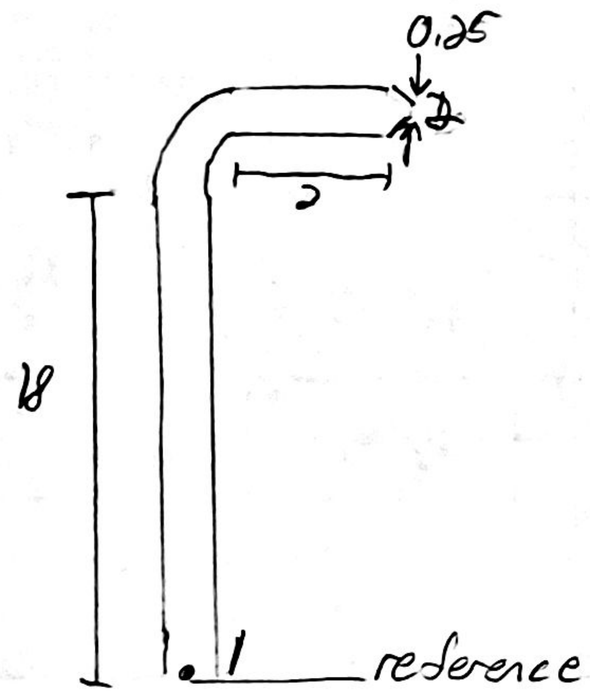
$$P_A = \gamma\left(\frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_r - \frac{V_A^2}{2g}\right)$$

$$= 8.8\left(\frac{12.5 \times 10^6}{8.8} + \frac{7.87^2}{2 \cdot 9.81} + 4.5^m + 21.233^m - \frac{0.891^2}{2 \cdot 9.81}\right)$$

$$= \underline{266.37\ MPA}$$

Problem 11.13

Given $P_A = 20$ Psig
$P_B = 80$ Psig
$K = 0.15$
$ID = 0.5$ in
90° bend at 6 in radius
Length = 20 ft
temp of water = 100°F



Find velocity at point 2 for $P_A = 20$ Psig and 80 Psig

Solution

$$\cancel{h_A}^{0} + \frac{P_1}{\delta} + \frac{V_1^2}{2g} + \cancel{z_1}^{0} = \frac{\cancel{P_2}^{0}}{\delta} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$h_L = h_{L\,pipe} + h_{L\,elbow} + h_{L\,nozzel}$$

$$h_{L\,pipe} = f\frac{L}{D}\cdot\frac{V^2}{2g}$$

$$h_{L\,elbow} = k\cdot\frac{V^2}{2g} = 20ft\,\frac{V^2}{2g}$$

$$h_{L\,nozzel} = k\,\frac{V^2}{2g} = 0.15\,\frac{V^2}{2g}$$

$$\frac{P_1}{\gamma} - z_2 = \frac{V_2^2 - V_1^2}{2g} + \frac{V^2}{2g}\left(f\frac{L}{D} + 20ft + 0.15\right)$$

$$\frac{P_1}{\gamma} - z_2 = \frac{\frac{16Q^2}{\pi^2 D_2^4} - \frac{16Q^2}{\pi^2 D_1^4}}{2g} + \frac{16Q^2}{\pi^2 D_1^4}\left(f\frac{L}{D} + 20ft + 0.15\right)$$

Based on RHS vs LHS iterative process

$Q = 0.0001 \frac{ft^3}{s}$ when $p_1 = 20 psig$

$V_2 = \frac{Q}{A_2} = \frac{0.0001 \frac{ft^3}{s}}{0.000723 ft^2} = \underline{0.1738 \frac{ft}{s}}$

Based on RHS vs LHS iterative process

$Q = 0.00008$ when $p_1 = 8 psig$

$V_2 = \frac{Q}{A_2} = \frac{0.00008 \frac{ft^3}{s}}{0.000723 ft^2} = \underline{0.1106 \frac{ft}{s}}$