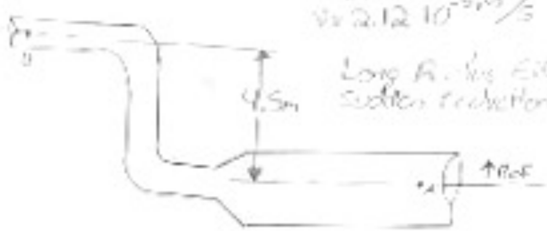
Fluids	Homework 31	Andrew Bresnahan

Problem 11.5

$p_B = 12500\ kN/m^2$ $Q = 0.015\ m^3/s$

$\gamma = 8.80\ kN/m^3$ $L_{150} = 180m$

$\nu = 2.12 \cdot 10^{-5}\ m^2/s$ $L_{50} = 8m$



Long Radius Elbow
Sudden reduction

$V = \frac{Q}{A}$ ∴ $\begin{cases} \text{in DN150 Pipe: } V_{150} = \frac{0.015\ m^3/s}{1.864 \cdot 10^{-2}\ m^2} = \boxed{0.805\ m/s} \\ \text{in DN50 Pipe: } V_{50} = \frac{0.015\ m^3/s}{2.168 \cdot 10^{-3}\ m^2} = \boxed{6.92\ m/s} \end{cases}$

$Re = \frac{VD}{\nu}$ ∴ $Re_{150} = \frac{0.805\frac{m}{s} \cdot 0.1541m}{2.12 \cdot 10^{-5}\ m^2/s} = \boxed{5848}$

$Re_{50} = \frac{6.92\frac{m}{s} \cdot 0.0525m}{2.12 \cdot 10^{-5}\ m^2/s} = \boxed{17137}$

$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7\frac{D}{\epsilon}} + \frac{5.74}{Re^{0.9}}\right)\right)^2}$ ∴ $f_{150} = \frac{.25}{\left(\log\left(\frac{1}{3.7\left(\frac{.1541}{1.5 \cdot 10^{-6}}\right)} + \frac{5.74}{5848^{0.9}}\right)\right)^2} = \boxed{0.036}$

$\boxed{f_{50} = 0.027}$

Losses Due to friction

$h_{Lf150} = f_{150}\left(\frac{L_{150}}{D}\right)\left(\frac{V_{150}^2}{2g}\right) = 0.036\left(\frac{180m}{0.1541m}\right)\left(\frac{(0.805\ m/s)^2}{19.62\ m/s^2}\right) = \boxed{1.39m}$

$h_{Lf50} = f_{50}\left(\frac{L_{50}}{D}\right)\left(\frac{V_{50}^2}{2g}\right) = 0.027\left(\frac{8m}{0.0525m}\right)\left(\frac{6.92^2\ m^2/s^2}{19.62\ m/s^2}\right) = \boxed{10.04m}$

Loss In Sudden Reduction

$\frac{D_2}{D_1} = \left(\frac{.0525}{.1541}\right)^{-1} = 3$ + $V = 6.92$ ∴ $K = 0.4$

$h_{LR} = K\left(\frac{V^2}{2g}\right) = 0.4\left(\frac{6.92^2}{19.62}\right) = \boxed{0.98m}$

(Problem 11.5 cont)

Energy losses in Elbows

$h_{LE} = 2K\left(\frac{V^2}{2g}\right)$ $\quad K = 20f_T = 20(0.027) = 0.54$

$h_{LE} = 2(0.54)\left(\frac{6.92^2}{19.62}\right) = \boxed{2.64m}$

Bernoulli's

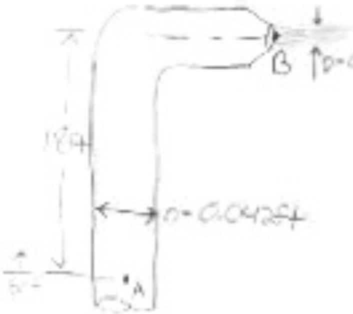
$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + \cancel{z_A} = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_L$

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

$P_A = 8.80\frac{kN}{m^3}\left(\frac{12600\,kN/m^2}{8.80\,kN/m^3} + \frac{6.92^2 - 0.8058^2}{19.62} + 4.5m + 15.05m\right)$

$\boxed{P_A = 1442.41\,kN/m^2}$

Problem 11.13



Water @ 100F :

$\gamma = 62 \, lb/ft^3$ $\rho = 1.93 \frac{slugs}{ft^3}$

$\nu = 1.42 \cdot 10^{-5} \frac{ft^2}{s}$

$P_B = 0$ $Z_A = 0$

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

$$\frac{P_A}{\gamma} - Z_B = \frac{V_B^2 - V_A^2}{2g} + h_L$$

$V_B^2 = \frac{16Q^2}{\pi^2 D_B^4}$

$V_B^2 = 8335718.85 Q^2$

$V_A^2 = 520982.43 Q^2$

$\therefore V_B^2 - V_A^2 = 7814736 Q^2$

$$h_L = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) + 0.15\left(\frac{V^2}{2g}\right) + 20f\frac{V^2}{2g}$$

$$\therefore h_L = \frac{V^2}{2g}\left(f\left(\frac{L}{D}\right) + 0.15 + 20f\right)$$

$$h_L = \frac{8Q^2}{g\pi^2 D^4}\left(f\frac{L}{D} + 0.15 + 20f\right)$$

$$= 8089.8Q^2(496.2f + 0.15)$$

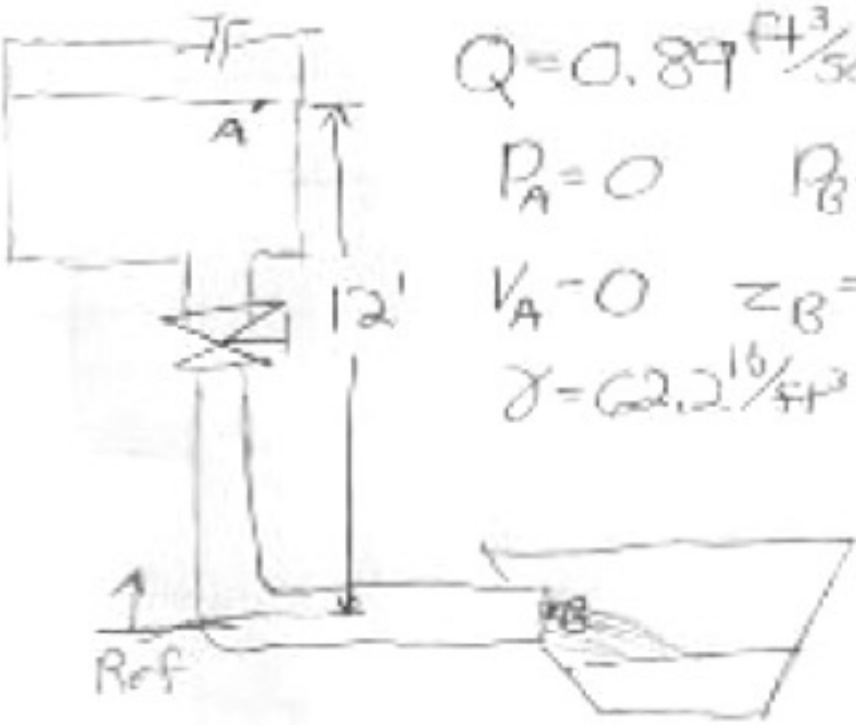
$$\frac{P_A}{62} - 18 = 121347Q^2 + 8089.8Q^2(4926.2f + 0.15)$$

$$\frac{P_A}{62} - 18 = Q^2(121347 + 8089.8(4926.2f + 0.15))$$

$$Q = \sqrt{\frac{\frac{P_A}{62} - 18}{121347 + 8089.8(4926.2f + 0.15)}}$$

1) $V = 3.58 \, ft/s$
2) $V = 9.58 \, ft/s$ } From Excel

$\boxed{11.20}$



$Q = 0.89\ ft^3/sec \quad L_{pipe} = 75'$

$P_A = 0 \quad P_B = 0 \quad \eta = 1.77 \cdot 10^{-5}\ lb \cdot s/ft^2$

$V_A = 0 \quad z_B = 0$

$\gamma = 62.2\ lb/ft^3 \quad \rho = 1.93\ slugs/ft^3$

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

$$12ft = \frac{V_B^2}{2g} + h_L$$

Energy Losses

$$h_L = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) + 340f\left(\frac{V^2}{2g}\right) + 30f\left(\frac{V^2}{2g}\right) + 0.5\left(\frac{V^2}{2g}\right)$$

$$h_L = \frac{V^2}{2g}\left(f\frac{L}{D} + 340f + 30f + 0.5\right)$$

$$h_L = \frac{8Q^2}{\pi^2 D^4}\left(75fD + 370f + 0.5\right)$$

$$12ft = \frac{0.64}{D^4}\left(1 + 75fD + 370f + 0.5\right)$$

$\boxed{D \approx 2ft \text{ Schedule 40 Pipe}}$ ← from excel