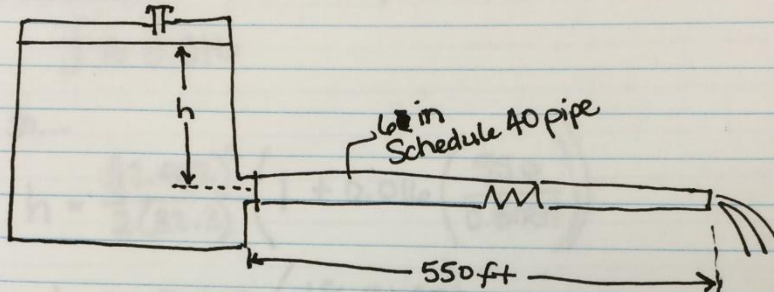
8.33 Water at 80°F flows from a storage tank through 550 ft of 6-in Schedule 40 steel pipe, as shown in the figure. Taking the energy loss due to friction into account, calculate the required head h above the pipe inlet to produce a volume flow rate of 2.50 ft^3/s.



$L = 550$ ft

Roughness $= 1.5 \times 10^{-4}$ ft

$D = 0.5054$ ft (from book)

$\gamma = 62.2 \frac{lb}{ft^3}$

$Q = 2.5\ ft^3/s$ $\quad \rho = 1.93 \frac{slugs}{ft^3}$ $\quad \nu = 9.15 \times 10^{-6} \frac{ft^2}{s}$

point 1 at top of water line, point 2 at pipe outlet

Bernoulli's $= \cancel{\frac{P_1}{\gamma}}^{\,\phi} + \cancel{\frac{V_1^2}{2g}}^{\,\phi} + z_1 = \cancel{\frac{P_2}{\gamma}}^{\,\phi} + \frac{V_2^2}{2g} + \cancel{z_2}^{\,\phi} + h_{L1-2}$ − elevation is zero

major energy losses due to friction in the pipe $= f \frac{LV^2}{D2g}$

Reynolds # $= \frac{\rho V D}{\mu} = \frac{VD}{\nu}$

Rel. Roughness $= \frac{D}{\epsilon}$

head

$$h = \frac{V_2^2}{2g} + h_{L1-2} \rightarrow \frac{V_2^2}{2g} + f \frac{LV_2^2}{D2g}$$

$$V_2 = \frac{Q}{A} = \frac{2.5}{\frac{\pi}{4}(0.5054)^2} = 12.462\ ft/s \quad \Longrightarrow$$

to find f

$$\rightarrow Re = \frac{VD}{\nu} = \frac{(12.462)(0.5054)}{9.15 \times 10^{-6}} = 688338.2$$

$$\boxed{6.88 \times 10^{5}}$$

$$\frac{D}{\epsilon} = \frac{0.5054}{1.5 \times 10^{-4}} = 3369.3$$

according to the Moody chart...

$$f \approx 0.016$$

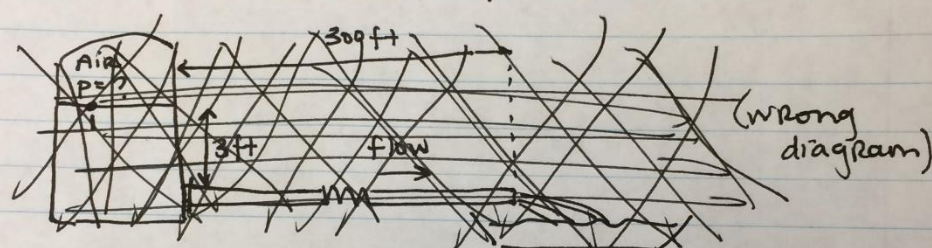
so...

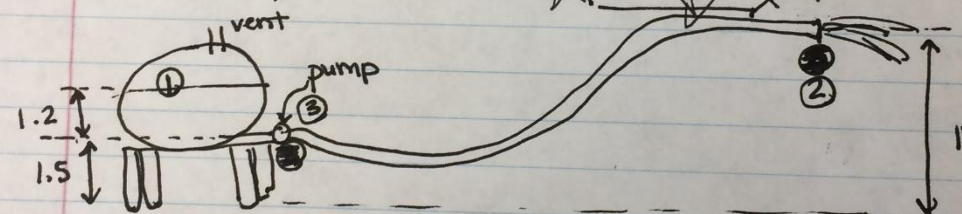
$$h = \frac{(12.462)^2}{2(32.2)}\left(1 + 0.016\left(\frac{550}{0.5054}\right)\right)$$

$$h = 2.4115\,(18.41195)$$

$$h = 44.4 \text{ ft}$$

8.38 Figure shows a system for delivering lawn fertilizer in liquid form. The nozzle on the end of the hose requires 140 kPa of pressure to operate effectively. The hose is smooth plastic with an ID of 25mm. The fertitizer solution has a specific gravity of 1.10 & a dynamic viscosity of 2.0×10^{-3} Pa·s. If the length of the hose is 85 m, determine a) the power delivered by the pump to the solution & b) the pressure at the outlet of the pump. Neglect the energy losses on the suction side of the pump. The flow rate is 95L/min.





$P_1 = \phi \quad V_2 = V_3$

$V_1 = \phi$

$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} + h_A - h_L = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$$

$$V = \frac{Q}{A} = \frac{95\,L/min}{\pi(0.025m)^2/4} \times \frac{1\,m^3/s}{60000\,L/min} = \boxed{3.23\,m/s} \rightarrow \frac{V^2}{2g} = \frac{(3.23)^2}{2(9.81)} = \boxed{0.532m}^{*}$$

$$h_A = \frac{P_2}{\gamma} + (z_2 - z_1) + \frac{V_2^2}{2g} + h_L$$

$$N_R = \frac{(3.23)(0.025)(1100)}{2.0 \times 10^{-3}} = 4.44 \times 10^4 \Rightarrow f = 0.021^{**}$$

$$h_L = f\frac{L}{D}\frac{V^2}{2g} = 0.021^{**}\left(\frac{85}{0.025}\right)(0.530^{*}) = 37.84m$$

$$h_A = \frac{140\,kN/m^2}{1.10\,(9.81\,kN/m^3)} + 7.3m + 0.530 + 37.84m = 58.64m$$

$$P_A = h_A \gamma Q = (58.64\,m)(1.10)(9.81\,kN/m^3)(95/60{,}000\,m^3/s) = 1.00$$

$$\boxed{\text{Power} = 1.00\,kW}$$

b) $$\frac{P_3}{\gamma} + z_3 + \frac{V_3^2}{2g} - h_L = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$$

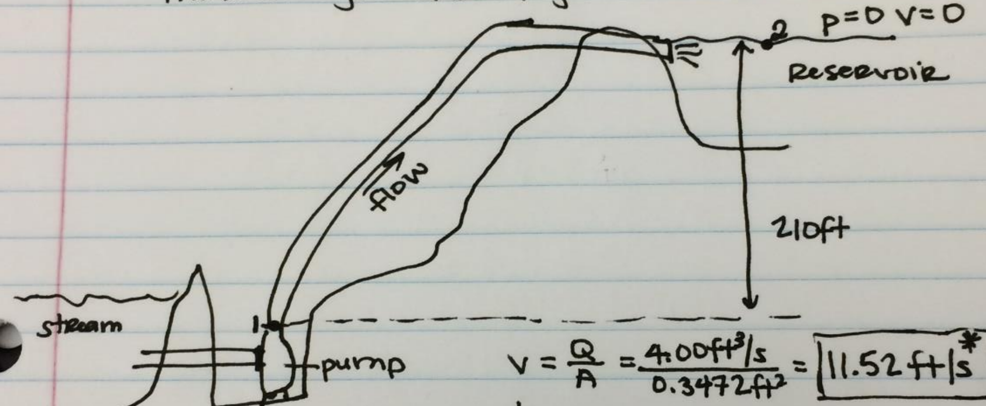
$$P_3 = \underbrace{P_2}_{140\,kPa} + \left[\underbrace{(z_2 - z_3)}_{8.5} + \underbrace{h_L}_{37.84}\right]\underbrace{\gamma}_{1.10 \times 9.81}$$

$$P_3 = 140 + 10.791\,(8.5 + 37.84)$$

$$P_3 = 140 + (10.791)(46.34)$$

$$P_3 = 640.05 \sim \boxed{640\,kPa}$$

8.46 Water at 60°F is being pumped from a stream to a reservoir whose surface is 210 ft. above the pump. See the figure below. The pipe from the pump to the reservoir is an 8-in. Schedule 40 steel pipe, 2500 ft long. If 4.00 ft³/s is being pumped, compute the pressure at the outlet of the pump. Consider the friction loss in the discharge line, but neglect other losses.



$$V = \frac{Q}{A} = \frac{4.00\,ft^3/s}{0.3472\,ft^2} = \boxed{11.52\,ft/s}^{*}$$

$$\frac{P_1}{\gamma_w} + z_1 + \frac{V_1^2}{2g} - h_L = \frac{\cancel{P_2}^{\,\phi}}{\gamma_w} + z_2 + \frac{V_2^2}{2g}$$

210ft

$$210-\phi$$

$$P_1 = \gamma_w\left((z_2 - z_1) - \frac{V_1^2}{2g} + h_L\right)$$

$$N_R = \frac{^{*}(11.52)(0.6651)}{1.21\times10^{-5}} = \boxed{6.33\times10^5} \rightarrow \frac{0.6651}{1.5\times10^{-4}} = \boxed{4434} \Rightarrow \boxed{f = 0.0155}$$

$$h_L = f\,\frac{L}{D}\,\frac{v^2}{2g} = (0.0155)\left(\frac{2500}{0.6651}\right)\left(\frac{11.52^2}{2(32.2)}\right) = 120.06\,ft$$

$$P_1 = \frac{62.4\,lb}{ft^3}\left(210 - \frac{(11.52)^2}{64.4} + 120.06\right)\frac{ft \cdot 1\,ft^2}{144\,in^2} = \boxed{142.13\,lb/in^2}$$

10.20 Sudden contraction ~~in a pi~~ from a DN 125 Schedule 80 steel pipe to a DN 50 schedule 80 pipe. Flow rate = 500 L/min. Determine energy loss.

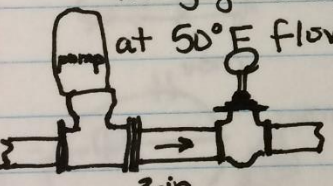
$$h_L = K\left(v_2^2/2g\right) \qquad \frac{D_1}{D_2} = \frac{122.3\,mm}{49.3\,mm} = 2.48$$

$$v_2 = \frac{Q}{A_2} = \frac{500\,L/min}{1.905\times10^{-3}\,m^2}\left(\frac{1\,m^3/s}{60000\,L/min}\right) = 4.37\,m/s$$

so, $K = 0.38$

$$\therefore h_L = (0.38)\left(\frac{4.37^2}{2\cdot 9.81}\right) = \boxed{0.370\,m}$$

10.39 A piping system for a pump contains a tee, see figure, to permit the pressure at the outlet of the pump to be measured. However, there is no flow into the line leading to the gage. Compute the energy loss as 0.40 ft³/s of water at 50°F flows through the tee.



3-in Schedule 40 pipe

$$v = \frac{Q}{A} = \frac{0.40\,ft^3/s}{0.05132\,ft^2} = 7.79\,ft/s$$

$$\frac{L_e}{D} = 20 \qquad f_T = 0.018$$

$$h_L = (0.018)(20)\left(\frac{7.79^2}{64.4}\right) = \boxed{0.339\,ft}$$