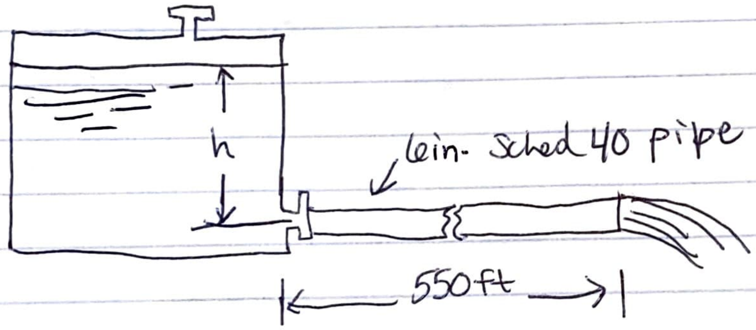
Feb 10 HW 1.4
Chapter 8

#33 Water at 80° F flows from a storage tank through 550 ft of 6in schedule 40 pipe, Taking the energy loss due to friction into acount, calculate the required head h above the pipe inlet to produce a volume flow rate of 2.50 ft³/s.




$Q_{in} = Q_{out}$

$V_{in} A_{in} = V_{out} A_{out}$

$\cancel{h_A} + \cancel{\frac{P_1}{\gamma}} + \cancel{\frac{V_A^2}{2g}} + z_A = \cancel{\frac{P_2}{\gamma}} + \frac{V_B^2}{2g} + \cancel{z_2} + h_L$

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

Shed 40 steel = ID = .5054 ft
Flow area = .2006 ~~ft~~ ft²
$\varepsilon$ = [redacted] $5.0 \times 10^{-6}$ ft

$Q = VA$

$V = \frac{Q}{A}$

$V = \frac{2.50 \text{ ft}^3/s}{.2006 \text{ ft}^2} = 12.46 \text{ ft}/s$

$N_R = \frac{VD}{\nu}$

$N_R = \frac{(12.46 \frac{ft}{s})(.5054 \text{ ft})}{(9.15 \times 10^{-6} \text{ ft}^2)}$

$N_R = 688{,}227.76$

$F_T = \frac{.25}{\left[\log\left(\left(\frac{1}{3.7\left(\frac{ID}{\varepsilon}\right)}\right) + \left(\frac{5.74}{(N_R)^{.9}}\right)\right)\right]^2}$

$F_T = \frac{.25}{\left[\log\left(\left(\frac{1}{3.7\left(\frac{.5054}{5.0 \times 10^{-6} \text{ ft}}\right)}\right) + \left(\frac{5.74}{(688{,}227.76)^{.9}}\right)\right)\right]^2}$ [redacted]

$h_L = F_T \left(\frac{L}{ID} \cdot \frac{V_B^2}{2g}\right)$

$h_L = .01256 \left(\frac{550}{.5054}\right) \cdot \left(\frac{12}{6}\right.$

$= .01256$

$h_L = 32.95$

$\boxed{z_A = 35.36 \text{ ft}}$ ANS

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$$h_A + \frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + Z_B + h_r + h_L$$

#4 System used to spray polluted water into the air to increase the water's $O_2$ content and to cause volatile solvents in the water to vaporize. Pressure @ point B just ahead of nozzle must be 25 PSIG for proper performance. Volume flow rate is .5 ft³/s. Dynamic Viscosity is $4\times10^{-5}$ lb·s/ft². Specific gravity is 1.026. Pressure @ A is −3.5 PSIG

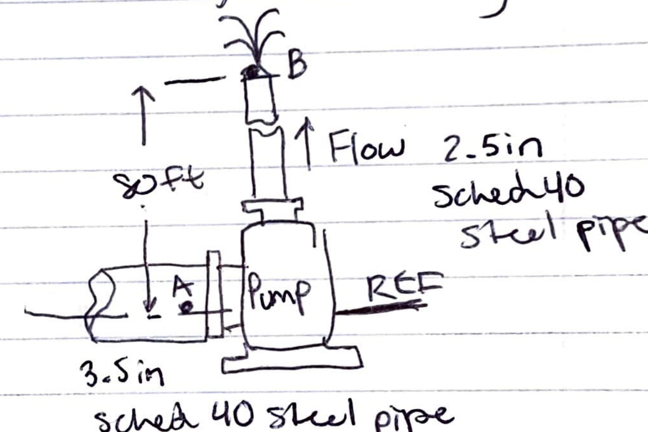
→ Compute power delivered by pump to the fluid, considering energy loss in discharge line.

Sched 40 steel pipe $\varepsilon = 1.5\times10^{-4}$

$ID_A = .2957$ ft   $A_A = .06868$ ft²

$ID_B = .2058$ ft   $A_B = .03326$ ft²

Density = 1.99 slug/ft




$Q = VA \rightarrow V_A = \frac{Q}{A_A}$   $V_B = \frac{Q}{A_B}$

$V_A = \frac{.5 \text{ ft}^3/s}{.06868 \text{ ft}^2}$   $V_B = \frac{.5 \text{ ft}^3/s}{.03326 \text{ ft}^2}$

$V_A = 7.28$ ft/s   $V_B = 15.03$ ft/s

$N_R = \frac{VD}{\nu} = \frac{15.03(.2058)}{2\times10^{-5}}$

$N_R = 1.54\times10^{-5}$

$KV = \frac{D_v}{\text{Density}} = \frac{4\times10^{-5}}{1.99} \frac{\text{lb·s/ft}^2}{\text{lb·s}^2\text{/ft}} = 2\times10^{-5}$

$$F_T = \frac{.25}{\left[\log\left(\frac{1}{3.7\left(\frac{.2058}{1.5\times10^{-4}}\right)} + \left(\frac{5.74}{1.54(10^5)^{.9}}\right)\right)\right]^2}$$

$F_T = .02046$

$$h_L = F_T\left(\frac{L}{ID_B}\cdot\frac{V_B^2}{2g}\right) = .02046\left(\frac{80 \text{ ft}}{.2058}\cdot\frac{15.03^2}{64.4}\right) = 27.89 \text{ ft}$$

$$h_A + \frac{(-3.5)(12^2)}{64.4} + \frac{7.28^2}{64.4} + 0 = \frac{25(12^2)}{64.4} + \frac{15.03^2}{64.4} + 80 + 27.89 \text{ ft}$$

$h_A = 55.9 + 3.5 + 80 + 27.89 + 7.82 - .8229 = 174.29$ ft

$P = h_A \cdot \gamma \cdot Q = (174.29)(64.4)(.5) = 5612.138$ ft·lb/s or $\boxed{10.2 \text{ HP}}$