elbow loss

$$h_3 = 2 \times 20 \times f_T \times \frac{v_b^2}{2 \times g} = 2 \times 20 \times 0.019 \times \frac{7.87^2}{2 \times 9.81} = 2.399187\,m$$

contraction loss

$$h_4 = 0.37 \times \frac{v_b^2}{2 \times g} = 0.37 \times \frac{7.87^2}{2 \times 9.81} = 1.168025\,m$$

total energy loss

$$h_L = h_1 + h_2 + h_3 + h_4$$

$$h_L = 1.746332 + 14.34338 + 2.399187 + 1.168025$$

$$h_L = 19.65693\ m$$

$$\frac{P_A}{\gamma} + z_A + \frac{u_A^2}{2 \times g} - h_L = \frac{P_B}{\gamma} + z_B + \frac{u_B^2}{2 \times g}$$

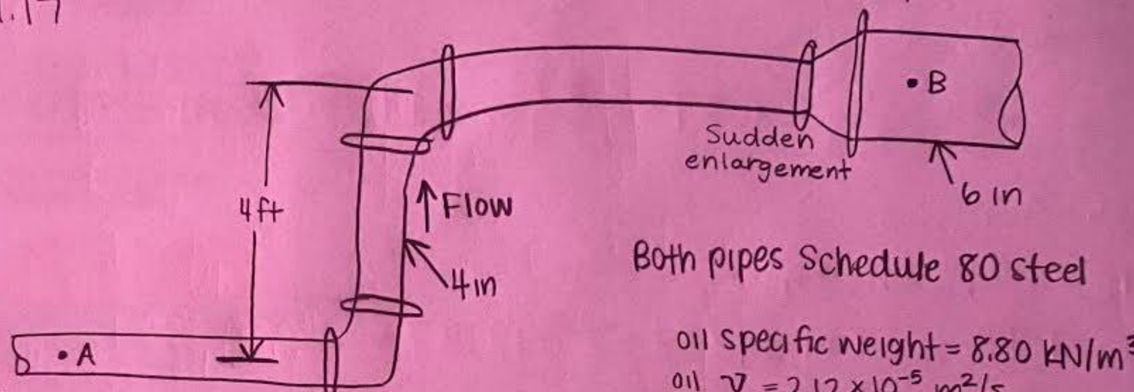
$$P_A = \gamma \left[h_L + \frac{P_B}{\gamma} + (z_B - z_A) + \left(\frac{u_B^2}{2 \times g} - \frac{u_A^2}{2 \times g} \right) \right]$$

$$P_A = 8.80 \left[19.65693 + \frac{12.5 \times 10^6}{8.80} + 4.5 + \left(\frac{0.897^2}{2 \times 9.81} - \frac{7.87^2}{2 \times 9.81} \right) \right] = \boxed{12.74\,MPa}$$

Tai Booker

Chapter 11

5. Oil is flowing at the rate of 0.015 m^3/s in the system shown in Fig. 11.17



Both pipes Schedule 80 steel

oil specific weight = 8.80 kN/m^3

oil $\nu = 2.12 \times 10^{-5}\ m^2/s$

l_a of DN 150 pipe = 180 m

l of DN 50 pipe = 8 m

pressure at B = 12.5 MPa

$$A_a = \frac{\pi \times D_a^2}{4}$$

$$A_a = \frac{\pi \times (0.1463^2)}{4} = 1.682 \times 10^{-2}\ m$$

$$A_b = \frac{\pi \times (0.0493^2)}{4} = 1.905 \times 10^{-3}\ m^2$$

$$V_a = \frac{Q_a}{A_a} = \frac{0.015}{1.682 \times 10^{-2}} = 0.892\ m/s \qquad V_b = \frac{Q_b}{A_b} = \frac{0.015}{1.905 \times 10^{-3}} = 7.87\ m/s$$

$$N_{Ra} = \frac{V_a \times D_a}{\nu} = \frac{0.892 \times 0.1463}{2.12 \times 10^{-5}} = 6.15 \times 10^3 \qquad \frac{D}{\varepsilon} = \frac{0.1463}{4.6 \times 10^{-5}} = 3180$$

friction factor

$f_{sa} = 0.035, \quad f_T = 0.019$

moody diagram & roughness equation ⇓

$$N_{Rb} = \frac{V_b \times D_b}{\nu} = \frac{7.87 \times 0.0493}{2.12 \times 10^{-5}} = 1.83 \times 10^4 \qquad \frac{D}{\varepsilon} = \frac{0.0493}{4.6 \times 10^{-5}} = 1072$$

- friction factor

$f_{sb} = 0.028, \quad f_T = 0.019$

friction loss

$$h_1 = f_{sa} \times \frac{l_a}{D_a} \times \frac{V_a^2}{2 \times g} = 0.035 \times \frac{180}{0.1463} \times \frac{0.892^2}{2 \times 9.81} = 1.746332\ m$$

$$h_2 = f_{sb} \times \frac{l_b}{D_b} \times \frac{V_b^2}{2 \times g} = 0.028 \times \frac{8}{0.0493} \times \frac{7.87^2}{2 \times 9.81} = 14.34338\ m$$

Flip →

HW 3.1
Ch.11 #20

Team 7

Melanie Cruz Contee

20. The tank shown in Figure 11.24 is to be drained to a sewer. Determine the size of a new Sch.40 steel pipe that will carry at least 400 gal/min of water at 80°F through the system shown. The total length of pipe is 75ft.

<u>Purpose</u>

Calculate the diameter of the pipe to satisfy the required flow rate.

<u>Data & Variables</u>

$\varepsilon = 1.5 \times 10^{-4}$ ft (table 8.2)

$\nu = 9.15 \times 10^{-6}$ ft²/s (App A)

$L = 75$ ft

$g = 32.2$ ft/s²

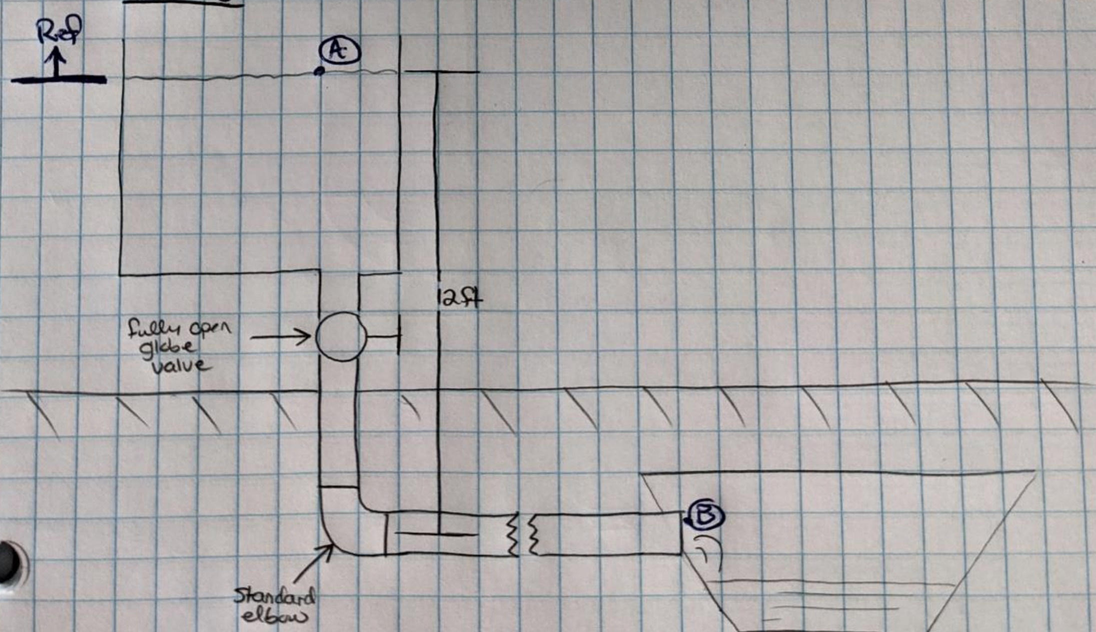
$Q = 400$ gal/min $= 0.891$ ft³/s (App K)

$T_w = 80°F$

$\gamma = 62.4$ lb/ft³ 62.2 (App A)

$z = 12$ ft

<u>Drawing</u>



→ next page

Calculation

$$\frac{P_A}{\gamma} + z_A + \frac{v_A^2}{2g} - h_L = \frac{P_B}{\gamma} + z_B + \frac{v_B^2}{2g}$$

* pressure is not given so I used $p = \gamma h$ or $\gamma \Delta z$

$$\frac{\gamma h_1}{\gamma} + z_A + \cancel{\frac{v_A^2}{2g}} - h_L = \frac{\gamma h_2}{\gamma} + z_B + \cancel{\frac{v_B^2}{2g}}$$

$v_A = v_B$

substitute $(12-x)$ for h_1

0 for h_2

x for z_A

0 for z_B

$$h_1 + z_A - h_L = h_2 + z_B$$

$$(12-x) + x - h_L = 0 + 0$$

$$h_L = 12\text{ft}$$

$$D = 0.66\left[\varepsilon^{1.25}\left(\frac{LQ^2}{gh_L}\right)^{4.75} + vQ^{9.4}\left(\frac{L}{gh_L}\right)^{5.2}\right]^{0.04}$$

$$= 0.66\left[(1.5\times10^{-4})^{1.25}\left(\frac{(75)(0.891\text{ ft}^3/\text{s})^2}{(32.2\text{ ft/s}^2)(12\text{ft})}\right)^{4.75} + (9.15\times10^{-6})(0.891\text{ ft}^3/\text{s})^{9.4}\left(\frac{75\text{ft}}{(32.2\text{ft/s}^2)(12\text{ft})}\right)^{5.2}\right]^{0.04}$$

$$= 0.66\left[(2.295\times10^{-9}) + (6.12\times10^{-10})\right]^{0.04}$$

$\boxed{D = 0.3006\text{ ft} \quad \text{diameter of pipe}}$

Minor losses

$h_1 = 1\left(\frac{v_B^2}{2g}\right)$ entrance loss

$h_2 = f\frac{L}{D}\left(\frac{v_B^2}{2g}\right)$ pipe friction loss

$$f\,\frac{75}{0.3006}\left(\frac{v_B^2}{2g}\right)$$

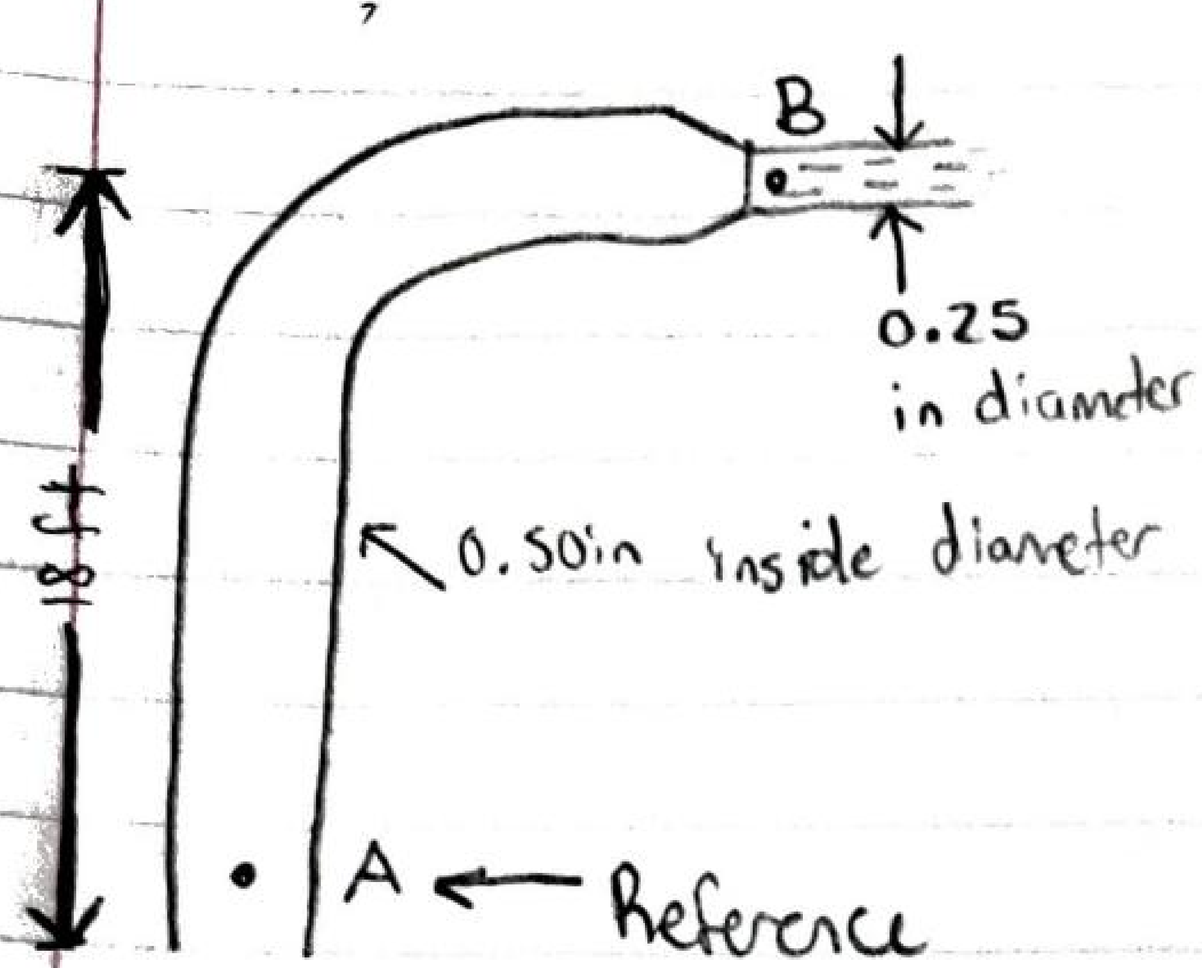
$h_3 = f_T\frac{L_e}{D}\frac{v_B^2}{2g}$ fully open globe valve (Ch. 10) $k = 340\text{ft}$

$$340\text{ft}\left(\frac{v_B^2}{2g}\right)$$

$h_4 = f_T\frac{L_e}{D}\left(\frac{v_B^2}{2g}\right)$ standard elbow (Table 10.4) $\rightarrow 30\text{ft}\,\frac{v_B^2}{2g}$

I learned that ALL sources of energy losses have to be considered between points A & B if working with Class II or III systems. I also learned that to find the friction factor (f), the Reynold's number and relative roughness need to be calculated. If velocities @ pt A & B are different, then the volume flow rate equation, $Q = VA$ can be used to solve for it.
When calculating Class III systems, I learned that pressure drop is directly related to the energy loss in the system and that energy losses are typically proportional to the velocity head as it flows through the system.

Team 7, Chris Betton #13



Determine the velocity of flow from the nozzle if the pressure at the bottom is

(a) 20 psig $\cdot \frac{12^2}{1ft^2} = 2880 \frac{lb}{ft^2}$

(b) 80 psig $\cdot \frac{12^2}{1ft^2} = 11520 \frac{lb}{ft^2}$

Data & Variables

$K_{nozzle} = 0.15$ Table A.2: Water @ 100°F, $\gamma = 62.0 \frac{lb}{ft^3}$, $\rho = 1.93 \frac{slugs}{ft^3}$, $\nu = 7.37 \times 10^{-6} \frac{ft^2}{s}$

$\eta = 1.42 \times 10^{-5} \frac{lb \cdot s}{ft^2}$

$D = 0.50in = 0.0416 ft$, $L_{bend} = 20.0 ft$ $L_{pipe} = 18 ft$

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + z_B + h_{L_{A-B}} \quad \textcircled{1} \therefore \frac{P_A}{\gamma} = \frac{P_B}{\gamma} + z_B + h_{L_{A-B}}$$

$$\textcircled{2}\; h_L = f \frac{L}{D} \frac{v^2}{2g} + \frac{kv^2}{2g} \qquad 1 \to 2 \to \; f \frac{L}{D} \frac{v^2}{2g} + \frac{kv^2}{2g} = \frac{P_A - P_B}{\gamma} - z_B$$

$$V = \sqrt{\frac{\frac{P_A - P_B}{\gamma} - z_B}{f \frac{L}{D} \cdot \frac{1}{2g} + \frac{k}{2g}}}, \qquad f = \frac{0.25}{\log\left[\frac{1}{3.7}\left(\frac{D}{\varepsilon}\right) + \frac{5.74}{N_R^{0.9}}\right]^2}$$

$$\frac{D}{\varepsilon} = \frac{0.0416 ft}{1.5 \times 10^{-4} ft} = 277.3\overline{3}$$

$$N_R = \frac{\nu D \rho}{\eta} = \frac{7.37e^{-6} \,|\, 0.0416 \,|\, 1.93}{1.42e}$$

$\hookrightarrow f = 0.062433$

$N_R = 0.041670603$

(a)

$$v = \sqrt{\frac{\frac{2880}{62.0} - 18}{0.062437\left(\frac{18}{0.0416}\right) \cdot \frac{0.15}{4g^2}}} = \boxed{170.65 \frac{ft^2}{s}}$$

(b)

$$v = \sqrt{\frac{\frac{11520}{62.0} - 18}{0.062433\left(\frac{18}{0.0416}\right) \cdot \frac{0.15}{4g^2}}} = \boxed{414.43 \frac{ft^2}{s}}$$