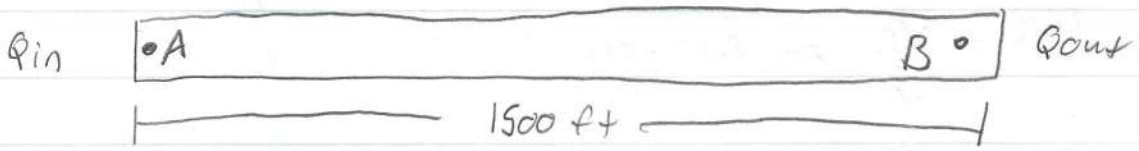
Ben Smithson Fluids test 3

Question 2:

Std 2inch steel tubing

1500 ft long

Q = 65 gpm



Bernoulis

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

$$\frac{P_A}{\gamma} = \frac{P_B}{\gamma} + h_L$$

$$\frac{P_A - P_B}{\gamma} = h_L \quad \text{prob is 1}$$

$$Q = VA = V = \frac{Q}{A} \checkmark \text{-book}$$

Steel tubing (not piping) Appendix 6.1

$$A = 1.907 \cdot 10^{-2} \text{ ft}^2$$

$$Q = 65 \text{ gpm} \rightarrow \text{ft}^3 = 0.144 \text{ ft}^3/\text{s}$$

$$V = \frac{0.144}{1.97 \cdot 10^{-2}} = 7.309 \text{ ft/s}$$

$$h_L = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

$$Re = \frac{\rho V D}{M} = \frac{VD}{V} \quad \text{for friction} \qquad \text{Relative Roughness} = \frac{D}{\epsilon}$$

$$Re = \frac{(7.309)(0.1558\ ft)}{1.89 \cdot 10^{-5}} \leftarrow \text{Appendix G.1 pg 496}$$

$\leftarrow$ appendix A.2 pg 482 (water)

$$Re = 60250.91$$

$$\text{Relative Rough} = \frac{0.1558}{1.5 \cdot 10^{-4}} = 1038.66$$

table 8.2 pg 183

Friction factor

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(D/\epsilon)} + \frac{5.74}{N_R^{0.9}}\right)\right]^2}$$ equation pg 192

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(1038.66)} + \frac{5.74}{60250.9^{0.9}}\right)\right]^2}$$

$$f = 0.023$$

$$h_L = 0.0231\left(\frac{1500}{0.1558}\right)\left(\frac{7.309^2}{2 \cdot 32.2}\right) = 183.68$$

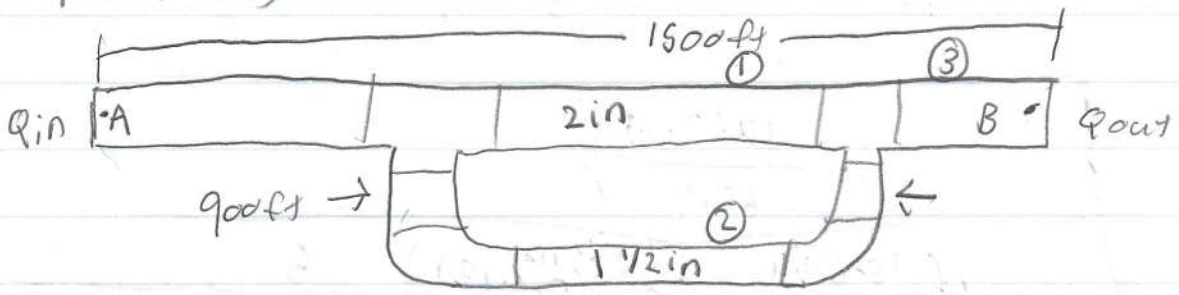
table A.2 Pg 482

$$\frac{P_A - P_B}{\gamma} = h_L \qquad \Delta P = \gamma(h_L) \qquad \Delta P = (62.4)(183.68) = \boxed{11462.15 \text{ lb/ft}^3}$$

Ben Swinson Fluids test 3

Qestion 2:

- 1 1/2 inch Standard Steel tubing
- 900 ft long



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

$$h_L = f\frac{L}{D}\frac{V^2}{2g} \qquad Re = \frac{\rho V D}{\mu} = \frac{VD}{\nu} \qquad Rang = \frac{D}{\epsilon}$$

$$\frac{P_A - P_B}{\gamma} = h_{L\,AB}$$

$$\frac{\Delta p}{\gamma} = h_{L\,AB}$$

friction factor 2inch = 0.019
K = 20 ft pg. 237 10.24

$K = L_e/D\,(ft)$

$$\frac{\Delta p}{\gamma} = f_1\left(\frac{L_1 + 2 \cdot L_{e\,tees}}{D_1}\right)\frac{V_1^2}{2g}$$

$$\frac{\Delta p}{\gamma} = f_1\left(\frac{L_1}{D_1} + 2 \cdot L_{e\,tees}\right)\frac{1}{2g}\frac{16 Q_1^2}{\pi^2 D_1^4}$$

$$Q_1 = \sqrt{\frac{\frac{\Delta p}{\gamma}}{f_1\left(\frac{L_1}{D_1} + 2 \cdot \frac{Le}{D\ tees}\right)\frac{8}{g\pi^2 D_1^4}}}$$

$$Q_1 = \sqrt{\frac{\left(\frac{11462.15}{62.4}\right)}{f_1\left(\left(\frac{1500ft}{0.1558}\right) + 2 \cdot 20(0.019)\right)\frac{8}{32.2\ \pi^2 \cdot 0.1558^4}}}$$

iteration of f_1 in excel

$Q_1 = 0.1378\ ft^3/s = 61.86\ gpm$

Q_2

$$\frac{\Delta p}{\gamma} = f_2\left(\frac{L_2}{D_2} + 2 \cdot \frac{Le}{D\ tees} + 2 \cdot \frac{Le}{elbows} + K_{reduce} + K_{expand}\right)\frac{1}{2g}\frac{16 Q_2}{\pi^2 D_2^4}$$

$$Q_2 = \sqrt{\frac{\frac{\Delta p}{\gamma}}{f_2\left(\frac{L_2}{D_2} + 2 \cdot \frac{Le}{D_{Tee}} + 2 \cdot \frac{Le}{D_{elbow}} + K_{reduce} + K_{expand}\right) \cdot \frac{8}{g\pi^2 D_2^4}}}$$

Ben Smithson Fluid mechanics Test 3

$D_2 = 0.1142$ table G.2

Le/D Tee = 60 ft since

Le/D elbow = 30 ft standard elbow

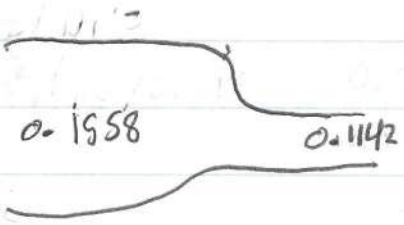
pg 237

2 inch ↓

Le/D Tee $= 60(0.019) = \underline{1.14}$

Le/D elbow $= 30(0.020) = \underline{0.6}$

↑ 1.5 inch



$D1/D2 = 1.364$

from table/graph for gradual reduction

reduction resistance $= \underline{0.04}$

30° ~~X~~ assumed - Used in example

for enlargement from table 10.2

$D_2/D_1 = 1.364$ @ 30° cone

Interpolate 1.2 } 1.4 → 1.364

0.25 } 0.36 → $\underline{0.34}$

$$Q_2 = \sqrt{\frac{\frac{11462.15}{62.4}}{f_2\left(\left(\frac{900ft}{0.1142}\right) + 2 \cdot 1.14 + 2 \cdot 0.6 + 0.04 + 0.34\right) \cdot \frac{8}{32.2\ \pi^2 \cdot 0.1142^4}}}$$

Heration of F_2

$Q_2 = 0.079\ ft^3/s$ or $35.47\ gpm$

$Q_1 + Q_2 = Q_3$

$61.86 + 35.47 = 97.33$

$97.33 - 65 =$ **32.33 gpm increase**