

MET 330 Test 1 10/5/21 Hannah Wolfe

Purpose: Determine required air pressure in right tank
in order to deliver 250 gpm of ethyl alcohol
Determine manometer reading

Diagram: on separate sheet

Sources: Applied Fluid Mechanics, Seventh Edition
Robert L. Mott / Joseph A. Untener

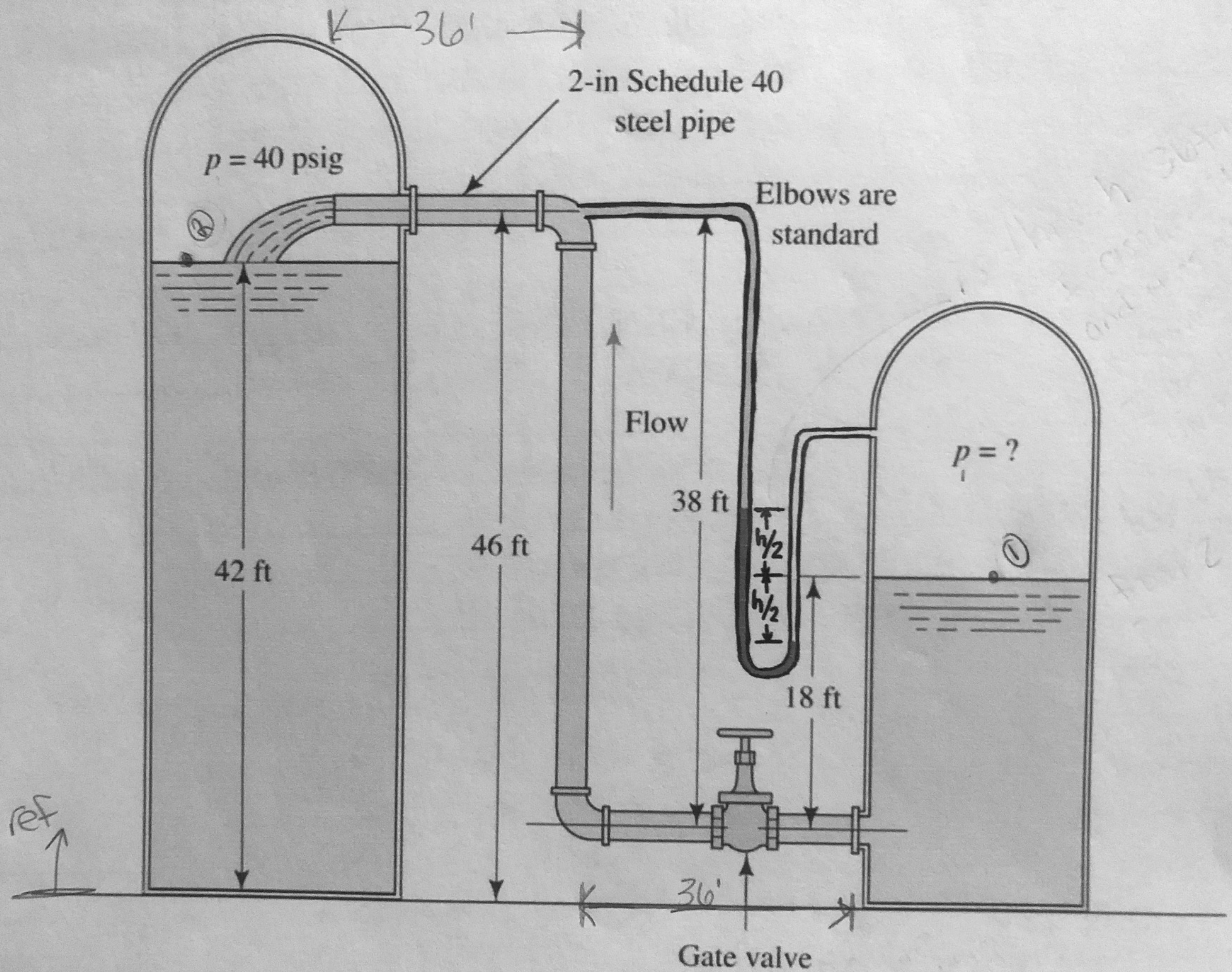
Design Considerations: 1) incompressible fluids
2) Mercury displaced by ethyl alcohol
3) isothermal, $T = 77^\circ\text{F}$ or 25°C
4) fully open gate valve

- constant
properties

Data / Variables:

- 2" Schedule 40 steel pipe
- $P_2 = 40 \text{ psig} = 5760 \text{ psf}$
- Flow area = 0.02333
- $\gamma_{\text{ethyl Alc.}} = 49.01 \text{ lb/ft}^3$
- $\epsilon = 1.5 \times 10^{-4} \text{ ft}$
- $250 \text{ gpm} = 0.557 \text{ ft}^3/\text{s}$
- $\gamma_{\text{Hg}} = 844.9 \text{ lb/ft}^3$

Procedure: 1) draw diagram
2) pick reference
3) pick points
4) use bernoulli's
5) calculate major & minor losses
6) finalize to get pressure



1. What is the required air pressure in the tank on the right?

should not have been 0.

1) Diagram w/ points on separate sheet

Solve for P_1 using Bernoulli's equation.

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

Velocities cancel out

$$P_1 = P_2 + \cancel{\gamma \left(\frac{V_2^2 - V_1^2}{2g} \right)} + \gamma(z_2 - z_1) + \gamma h_L$$

Plug in P_2 , γ of ethyl alcohol, and height

$$P_1 = 5760 \text{ psf} + 49.01 \text{ lb/ft}^3 (42 - 26) + \gamma h_L$$

$$P_1 = 5760 \text{ psf} + 49.01 \text{ lb/ft}^3 (16) + \gamma h_L$$

Major Losses

actual pipe ID = 0.17225 ft

$$V = Q/A = 0.557 / 0.02333 = 23.87 \text{ ft/s}$$

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

Straight pipe: $36(2) + 38 = 110 \text{ ft}$

$$h_L = 0.0207 \left(\frac{110}{0.17225} \right) \left(\frac{23.87^2}{2(32.2)} \right)$$

$$Re = \frac{VD}{\nu} = \frac{(23.87 \text{ ft/s})(0.17225 \text{ ft})}{14.73 \times 10^{-6} \text{ ft}^2/\text{s}} = 2.79 \times 10^5$$

$$h_L = 116.96 \text{ ft}$$

$$D/\epsilon = 0.17225 / 1.5 \times 10^{-4} = 1148.33$$

Minor losses

should have been $f = 0.01899$

$$f = 0.0207$$

0.02019

$$h_L = 30 \left(\underset{\text{elbow}}{0.0207} \right) \left(\frac{23.87^2}{2(32.2)} \right) + \underset{\text{inlet}}{(0.78)} \left(\frac{23.87^2}{2(32.2)} \right) + \underset{\text{gate valve}}{(8)} (0.0207) \left(\frac{23.87^2}{2(32.2)} \right)$$

$K = 8 \text{ ft} \leftarrow \text{gate valve}$

$K = 30 \text{ ft} \leftarrow \text{short elbow}$

$K = 0.78 \leftarrow \text{inward pipe inlet}$

$$h_L = 5.49(2) + 6.9 + 1.47$$

$$h_L = 19.35 \text{ ft}$$

$$h_L = 116.96 + 19.35 = 136.31 \text{ ft}$$

$$P_1 = 5760 + 49.01(16) + 49.01(136.31)$$

$$P_1 = 13224.71 \text{ psf}$$

$$P_1 = 91.84 \text{ psi}$$

- Find Reynolds number
- Find relative roughness
- Use to find friction factor on Moody's chart
- Use K values with minor loss equation
- find major losses for 110' of pipe
- Use established h_L in Bernoulli's to find P_1

~~P_3 was needed~~

$$P_3 = P_1 - \gamma_{alc} \left[(z_3 - z_1) + \frac{v_3^2}{2g} + h_{1-3} \right]$$

$\xrightarrow{20ft}$

$\xrightarrow{8.817}$

$$h_{1-3} = 90.083 ft$$

$$P_3 = 53.566 \text{ psi}$$

find manometer reading:

$$\Delta P = \gamma h$$

$$13224.71 - 5760 = (\gamma_{Hg} - \gamma_{ethyl})h$$

$$7464.71 = (844.9 - 49.01)h$$

$$7464.71 = 795.89h$$

$$h = 9.38 ft$$

h is found using the specific weight difference and pressure difference

$$h = \frac{(94.045 - 53.566) \left(\frac{144}{1} \right) - 49.01}{795.89} \times 20$$

Summary:

$$h = 9.38 ft$$

$$P_1 = 13224.71 \text{ psf} = 91.84 \text{ psi}$$

$$\frac{844.9 - 49.01}{2}$$

$$h = 5.91 ft$$

Analysis: Pressure of the right tank is a little over double the pressure of the left tank. It is appropriate for the right pressure to be more because it is lower than the left tank and pressure increases the further down the tank goes. The manometer deflection is due to the movement of mercury with ethyl alcohol.

Purpose: Determine at what air pressure the flow of Ethyl Alcohol in the system stops.
Determine new manometer deflection

Diagram: on separate sheet

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Design Considerations:

- 1) incompressible fluids
- 2) fluids do not combine
- 3) Isothermal, $T = 77^{\circ}\text{F}$ or 25°C
- 4) open gate valve
- 5) no flow

Data / Variables:

$$P_A = 40 \text{ psi} = 5760 \text{ psf}$$
$$2" \text{ schedule 40 steel pipe}$$
$$\gamma_{\text{ethyl}} = 49.4 \text{ lb/ft}^3$$
$$Z_2 = 42 \text{ ft}$$
$$Z_1 = 26 \text{ ft}$$

Procedure:

- 1) draw diagram
- 2) pick reference, then points
- 3) use Bernoulli's and cancel
- 4) use $\Delta P = \gamma h$ for manometer

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

$$P_1 = P_2 + \gamma \left(\frac{V_2^2 - V_1^2}{2g} \right) + \gamma(z_2 - z_1)$$

$$P_1 = 5760 + 49.01(16)$$

$$P_1 = 6544.16 \text{ psf}$$

$$= 45.45 \text{ psi}$$

Bernoulli is used to find P_1 . Velocity is zero and there is no h_L because the fluid is not moving.

right concept
slightly different numbers

$$\Delta P = \gamma h$$

$$6544.16 - 5760 = (784.9 - 49.01)h$$

$$784.16 = 795.89h$$

$$h = 0.99 \text{ ft}$$

$$h = 11.88 \text{ in}$$

h is found using the difference of pressures and specific weights of the fluids

Use previous manometer equation and come up with $h = 0 \text{ ft}$

Summary: The pressure at point 1 when the flow of Ethyl Alcohol stops is 45.45 psi. The new manometer reading would be 11.88 in.

Analysis: The pressure of the left tank is slightly higher than the right tank. The pressure and height are both less than the previous problem because there are no losses to account for.