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

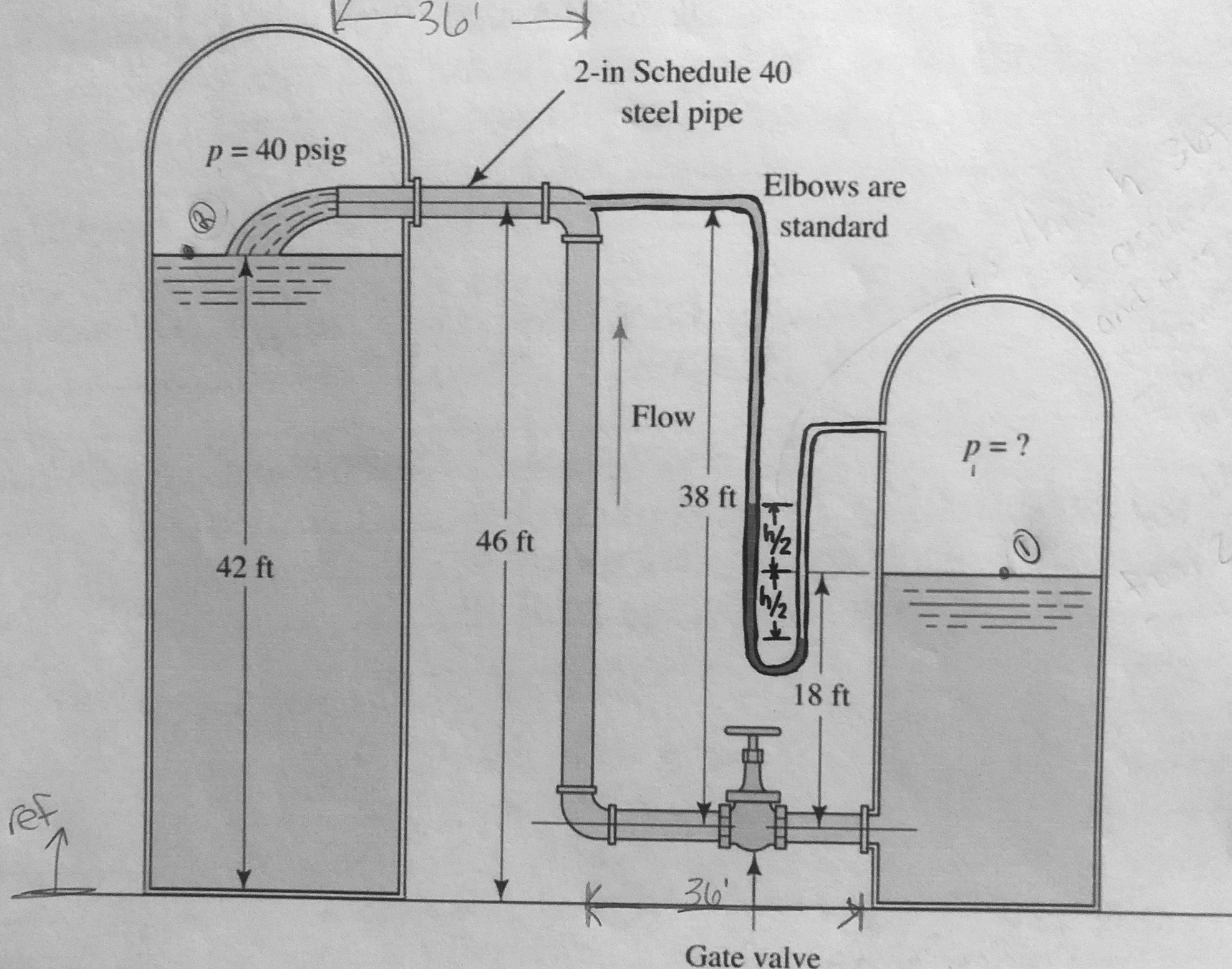
Diagram: on separate sheet

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, $T = 77^{\circ}F$ or $25^{\circ}C$
4) fully open gate valve

Data/Variables:
- 2" Schedule 40 steel pipe
- $P_2 = 40 psig = 5760 psf$
- flow area = 0.02333
- $\gamma_{Ethyl\ Alc.} = 49.01\ lb/ft^3$
- $\varepsilon = 1.5 \times 10^{-4}\ ft$
- $250 gpm = 0.557\ ft^3/s$
- $\gamma_{Hg} = 844.9\ lb/ft^3$

Procedure: 1) draw diagram
2) pick reference
3) pick points
4) use bernoullis
5) calculate major & minor losses
6) finalize to get Pressure



1. What is the required air pressure in the tank ...

1) Diagram w/ points on separate sheet

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

$$P_1 = P_2 + \gamma\left(\frac{V_2^2 - V_1^2}{2g}\right) + \gamma(z_2 - z_1) + \gamma h_L \quad (V_2 \to 0)$$

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

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

Solve for P_1 using bernoullis equation.

Velocities cancel out

Plug in P_2, γ of Ethyl alcohol, and height

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

actual pipe ID = 0.17225ft

Major Losses

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

Straight pipe: 36(2) + 38 = 110 ft

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

$h_L = 116.96$ ft

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

$D/\varepsilon = {}^{0.17225}/_{1.5\times10^{-4}} = 1148.33$

$f = 0.0207$

Minor losses

$K = 8$ ← gate valve

$K = 30$ ← short elbow

$K = 0.78$ ← inward pipe inlet

$h_L = 30(0.0207)\left(\frac{23.87^2}{2(32.2)}\right) + (0.78)\left(\frac{23.87^2}{2(32.2)}\right) + (8)(0.0207)\left(\frac{23.87^2}{2(32.2)}\right)$

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

$h_L = 19.35$ ft

$h_L = 116.96 + 19.35 = 136.31$ ft

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

$P_1 = 13224.71$ psf

$P_1 = 91.84$ 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 bernoullis to find P_1

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

Summary: $h = 9.38 ft$
$P_1 = 13224.71 psf = 91.84 psi$

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, $T = 77^{\circ}F$ or $25^{\circ}C$
4) open gate valve
5) no flow

Data / Variables:

$P_2 = 40 psi = 5760 psf$
2" schedule 40 steel pipe
$\gamma_{ethyl} = 49.0 \, lb/ft^3$
$Z_2 = 42 ft$
$Z_1 = 26 ft$

Procedure: 1) draw diagram
2) pick reference, then points
3) use bernoullis and cancel
4) use $\Delta P = \gamma h$ for manometer

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

$P_1 = P_2 + \gamma\left(\frac{V_2^2 - V_1^2}{2g}\right) + \gamma(z_2 - z_1)$ ($V_2 = 0$)

$P_1 = 5760 + 49.01(16)$

$P_1 = 6544.16 \text{ psf}$
$= 45.45 \text{ psi}$

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

$\Delta P = \gamma h$

$6544.16 - 5760 = (844.9 - 49.01)h$

$784.16 = 795.89h$

$h = 0.99 \text{ ft}$

$h = 11.88 \text{ in}$

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

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.