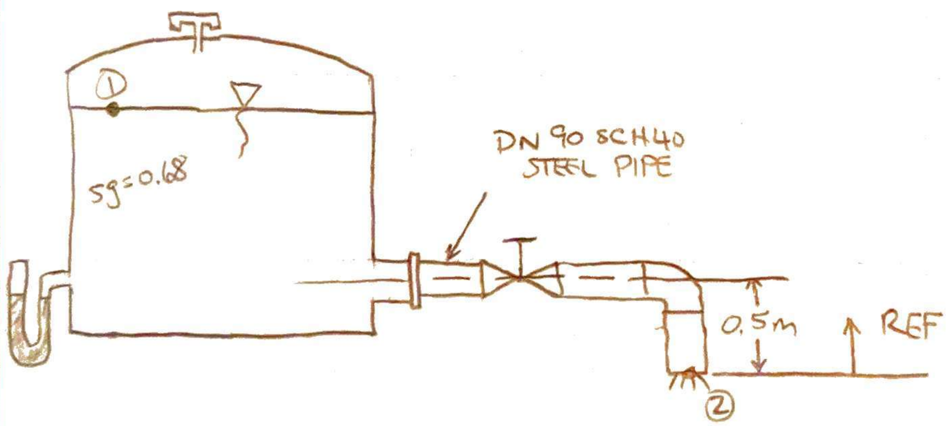
① PURPOSE

a) FOR THE SYSTEM SHOWN IN THE PROVIDED FIGURE, THE FLOW RATE IS 400 GPM WHICH CAN BE CONVERTED TO 1500 LPM. DETERMINE THE REQUIRED DEPTH "h" IN THE TANK TO PRODUCE 1500 LPM & DECIDE THE SEPERATION DISTANCE BETWEEN THE TRUCK & THE ELEVATED TANK, GATE VALVE IS HALF OPEN (MINOR LOSSES)

b) U-TUBE MANOMETER - DETERMINE MINIMUM U-TUBE MANOMETER LENGTH

c) DETERMINE TANK DIAMETER - GASOLINE SHOULD NOT DROP MORE THAN 1% OF ITS DEPTH AFTER 5 MINUTES

DRAWINGS & DIAGRAMS



SOURCES

MOTT, R; UNTENGER, J.A, "APPLIED FLUID MECHANICS, 7TH EDITION"

DESIGN CONSIDERATIONS

- CONSTANT PROPERTIES
- CONSTANT TEMPERATURE
- INCOMPRESSIBLE FLUID
- STEADY STATE

DATA & VARIABLES

DN 90 SCH40 (APPENDIX F)

$D = 90.1 \times 10^{-3}$ m

$A = 6.381 \times 10^{-3}$ m^2

GASOLINE @ 25°C (APPENDIX B)

$\upsilon = 4.22 \times 10^{-7}$ m^2/s

$\rho = 680$ kN/m^3

$\eta = 2.87 \times 10^{-4}$ Pa·S

FRICTION FACTOR

$f_T = 0.017$ (TABLE 10.5)

$K_{ENTRANCE} = 0.5 f_T$ (FIG 10.14)

$K_{VALVE} = 160 f_T$ (TABLE 10.4)

$K_{ELBOW} = 20 f_T$ (FIG 10.23b)

$K_{VALVE_{1/4}} = 900 f_T$ (TABLE 10.4)

$\varepsilon = 4.6 \times 10^{-5}$ m (TABLE 8.2)

PROCEDURE

a) FOR THIS PART, I WILL CALCULATE ENERGY LOSSES OF THE PIPE, USE THIS IN BERNOULLI'S EQUATION.

b) U-TUBE MANOMETER - USE γh TO CALCULATE MERCURY LENGTH DOUBLE LENGTH FOR TUBING LENGTH

c) USE VOLUME TO CALCULATE DIAMETER OF TANK & CALCULATE TOTAL LOSSES & MINOR LOSSES

CALCULATIONS

$$N_R = \frac{vD\rho}{\eta} = \frac{(3.9179)(90.1\times10^{-3})(680)}{2.87\times10^{-4}}$$

$Q = 400\ GPM = 1500\ LPM = 0.025\ m^3/s$

$N_R = 8.36\times10^{5}$

$$V = \frac{Q}{A} = \frac{0.025\ m^3/s}{6.381\times10^{-3}\ m^2}$$

TURBULENT

$v = 3.9179\ m/s$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(90.3\times10^{-3}/4.6\times10^{-5})} + \frac{5.74}{8.36\times10^{5}\cdot 9}\right)\right]^2}$$

$f = 0.01746$

a)

BERNOULLI'S EQUATION

$$\frac{\cancel{P_1}^{0}}{\gamma} + \frac{\cancel{V_1^2}^{0}}{2g} + z_1 = \frac{\cancel{P_2}^{0}}{\gamma} + \frac{V_2^2}{2g} + \cancel{z_2}^{0} + h_L$$

$$z_1 = \frac{V_2^2}{2g} + h_L$$

$$h_L = (K_{ENTRANCE} + K_{VALVE_{1/2}} + K_{ELBOW})\frac{V_2^2}{2g}$$

$$\frac{V_2^2}{2g} = \frac{3.9179^2}{2(9.81)} = 0.782$$

$K = (0.5 + 160 + 20)(0.01746)$

$K = 3.15$

$h_L = 3.15(0.782) =$

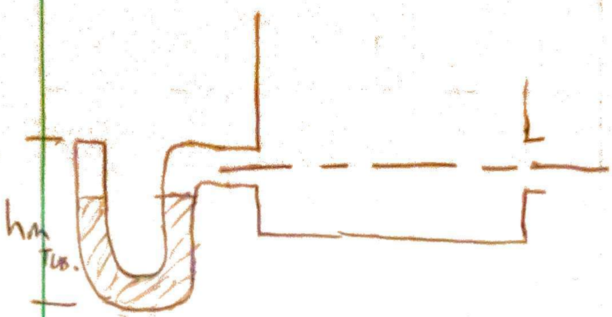
$h_L = 2.46\ m$
MINOR

$z_1 = ((0.782) + 2.46) - 0.5m$

$h = 3.24 - 0.5m$

$$\boxed{h = 2.742m}$$

b) U-TUBE MANOMETER



$A = 3.530 \times 10^{-4}$

$P = 16$ BAR

(1600 kPa)

(232 psi)

APPENDIX G (TABLE G.3)

O.D. = 25mm

I.D. = 21.2mm

$\gamma_m = 13.54$ (APPENDIX B)

$h_m = \gamma_m h = (13.54)(2.742)$

$h_m = 37.13\,m$

$h_{m_{TUBING}} = 37.13 \times 2$ $\quad h_{m_{TUBING}} = 74.25\,m$

c) 1500 LPM • 5 MIN = 7500 L

7500 L = 7.5 m^3

7.5 m^3 × 100 = 750 m^3

$V = \pi r^2 h$

$750\,m^3 = \pi r^2 (2.742)$

$\frac{750\,m^3}{\pi(2.742)} = r^2$

$r^2 = 87.01$

$r = 9.33$

$D = 18.66$

$\boxed{D = 19\,m}$

$h_{L_{PIPE}} = 0.01746\left(\frac{1}{90.3 \times 10^{-3}}\right) \times (0.782)$

$h_{L_{PIPE}} = 0.1512\,m$

$\frac{h_{L_{PIPE}}}{h_{L_{MINOR}}} = \frac{0.1512\,m}{2.46\,m} = 0.061$

$\boxed{\text{MINOR LOSSES ARE LARGER}}$

$0.061 \times 100 = \underline{6.1\%}$

$\frac{h_{L_{PIPE}}}{h_{L_{TOTAL}}} = \frac{0.1512}{2.742} = 0.055$

$0.055 \times 100 = 5.5\%$

SUMMARY

a) THE TANK ELEVATION IS 2.742m IN HEIGHT PLUS THE 0.5m OF PIPE

b) THE DESIGNED MANOMETER IS 74.25m TOTAL LENGTH MADE FROM A 25mm OD CLEAR PVC PLASTIC TUBING

c) THE TANK DIAMETER IS 19m & WE LEARNED THAT PIPE MINOR LOSSES ARE LARGER THAN PIPE TOTAL LOSSES

MATERIALS

- GASOLINE
- MERCURY

ANALYSIS

- THIS GRAVITY FED SYSTEM CAN BE CONTROLLED WITH A GATE VALVE
- WITH SHORT DISTANCES USING FITTINGS IN A SYSTEM LIKE THIS, THE ENERGY LOSSE ARE NEGLIGIBLE.