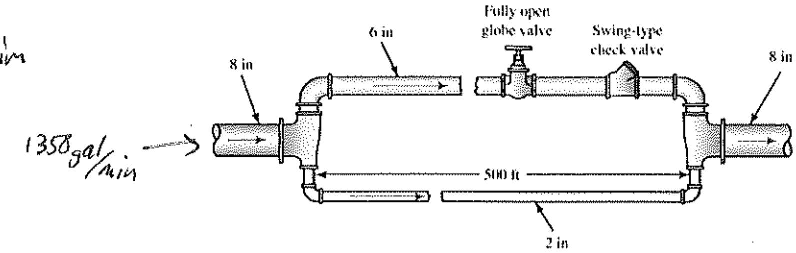
Dan Baxter

12.7)

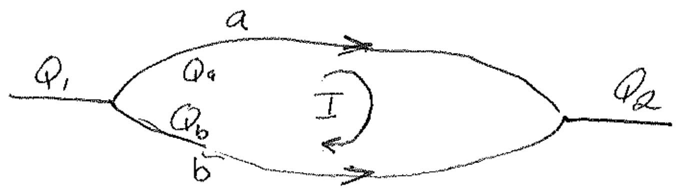
**Purpose**

Calculate volume flow rate
in 6 in pipe
in 2 in pipe
using Cross technique




**Design Consideration**

- incompressible fluid
- isothermal process
- Steady state




**Data and Variables**

Benzene

1350 gal/min = 3.007813 $ft^3/s$

$Sg = 0.87$

$D_1$ = 6in · ID = 0.5054 ft

$D_2$ = 2in ID = 0.1725 ft

$A_1 = 0.201\ ft^2$

$A_2 = 0.023\ ft^2$

$f_1 = 0.015$

$f_2 = 0.019$

$\frac{Le}{D}$ globe valve = 340

$\frac{Le}{D}$ swing valve = 100

$\frac{Le}{D}$ elbow = 30

$\nu = 7.41 \times 10^{-6}$

$\frac{D}{\varepsilon}a = 3369.33$

$\frac{D}{\varepsilon}b = 1148.67$

$$h_a = f\frac{L}{D}\frac{V^2}{2g} + f\left(\frac{Le}{D}\text{globe valve}\right)\left(\frac{V^2}{2g}\right) + f\left(\frac{Le}{D}\text{swing valve}\right)\left(\frac{V^2}{2g}\right) + 2f\left(\frac{Le}{D}\text{elbows}\right)\left(\frac{V^2}{2g}\right)$$

$$= (989.32f + 7.5)\,Q_a^2(2gA^2)$$

assumed

$Q_a = 2.5\ ft^3/s$

$Q_b = .5\ ft^3/s$

$$h_b = f\frac{L}{D}\frac{V^2}{2g} + 2f\left(\frac{Le}{D}\text{elbows}\right)\left(\frac{V^2}{2g}\right)$$

$$= (2898.55f + 1.14)\,Q_b^2(2gA^2)$$

$$N_{Ra} = \frac{Q_a D_a}{A_a \nu} = \frac{Q_a(0.5054)}{0.201(7.41\times10^{-6})} = 352160.76\,Q_a = 880401.91$$

$$N_{RB} = \frac{Q_b D_b}{A_b \nu} = \frac{Q_b(0.1725)}{0.023(7.41\times10^{-6})} = 1050420.17\,Q_b = 525210.08$$

$f = 0.016$

$f = 0.020$

$$K = \frac{f \cdot L}{D\,2gA^2}$$

$$K_a = \frac{0.016(500)}{(0.5054)(2)(32.2)(0.201)^2} = 5.64$$

$$K_b = \frac{0.020(500)}{(0.1725)(2)(32.2)(0.023)^2} = 1701.65$$

| | Q | Re | f | K | $KQ^2$ | $2KQ$ | $\Delta Q$ |
|---|---|---|---|---|---|---|---|
| Trial 1 | $Q_a = 2.5$ | 880401.91 | 0.016 | 5.64 | 35.25 | 28.2 | |
| | $Q_b = 0.5$ | 585210.08 | 0.020 | 1701.65 | 425.41 | 1701.65 | |
| | | | | | 460.66 | 1729.85 | 0.266 |
| Trial 2 | $Q_a = 2.8$ | 986050.13 | 0.016 | 5.64 | 44.22 | 31.58 | |
| | $Q_b = 0.2$ | 105042.02 | 0.022 | 1871.81 | 74.87 | 748.72 | |
| | | | | | 119.09 | 780.30 | 0.15 |

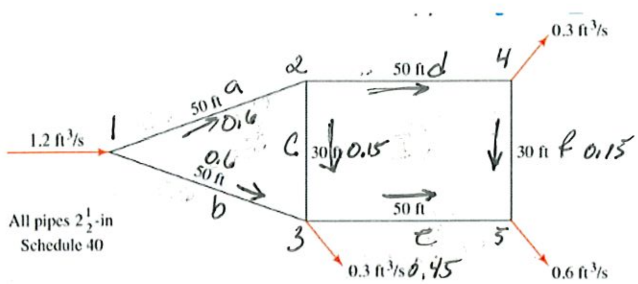
$Q = 3.008 - 0.266$
$= 2.742$

$Q = 3.008 - 0.15$
$= 2.858$

12.9)

**Purpose**

Find the flow rate of water at 60°C in each pipe.




**Design considerations**

- Incompressible fluid
- Isothermal process
- Steady state
- Neglect minor losses

$Q_a = 0.6$

$Q_b = 0.6$

$Q_c = 0.15$

$Q_d = 0.45$

$Q_e = 0.45$

$Q_f = 0.15$

**Data and Variables**

Sch 40

$D = 2.5\text{ in} = ID = 0.2058\text{ ft}$

Water at 60°F

$\gamma = 62.4\ \text{lb/ft}^3$

$\rho = 1.94\ \text{slug/ft}^3$

$\eta = 2.35\times10^{-5}\ \frac{\text{lb-s}}{\text{ft}^2}$

$\nu = 1.21\times10^{-5}\ \text{ft}^2/\text{s}$

$\varepsilon = 1.5\times10^{-4}$

$A = 0.03326\ \text{ft}^2$

$$h_L = KQ^2$$

$$f\frac{L}{D}\frac{v^2}{2g} = KQ^2$$

$$K = \frac{fL}{D\,2g\,A^2}$$

$$\frac{D}{\varepsilon} = \frac{0.2058}{1.5\times10^{-4}} = 1372$$

$$N_R = \frac{V_a D_a}{\nu} = \frac{Q_a D_a}{A_a \nu} = \frac{Q_a(0.2058)}{(0.03326)(1.21\times10^{-5})} = 511372.95\,Q_a$$

$$K_{a,b,d,e} = \frac{f(50)}{(0.2058)(2)(32.2)(0.03326)^2} = 3410.31f$$

$$K_{c,f} = \frac{f(30)}{(0.2058)(2)(32.2)(0.03326)^2} = 2046.19f$$

$$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7(D/\varepsilon)}\right)+\left(\frac{5.74}{N_R^{0.9}}\right)\right)^2}$$

| | Q | $h_L$ | f | K | $KQ^2$ | $2KQ$ | |
|---|---|---|---|---|---|---|---|
| Circuit 1 | a | 306823.77 | 0.0186 | 63.43 | 22.835 | 76.116 | |
| | b | 306823.77 | 0.0186 | 63.43 | 22.835 | 76.116 | ΔQ |
| | c | 76705.94 | 0.0194 | 39.70 | -0.893 | -11.910 | 0.300 |
| | d | 230117.83 | 0.0187 | 63.77 | 12.91 | 57.393 | |
| Circuit 2 | e | 230117.83 | 0.0187 | 63.77 | -12.91 | -57.393 | |
| | f | 76705.94 | 0.0194 | 39.70 | 0.893 | 11.910 | ΔQ |
| | | | | | 0 | 0 | 0 |

The flow rates that were assumed worked at.

$Q = 1.2 - 0$

$= 1.2\ \text{ft}^3/\text{s}$

14.6)

Purpose

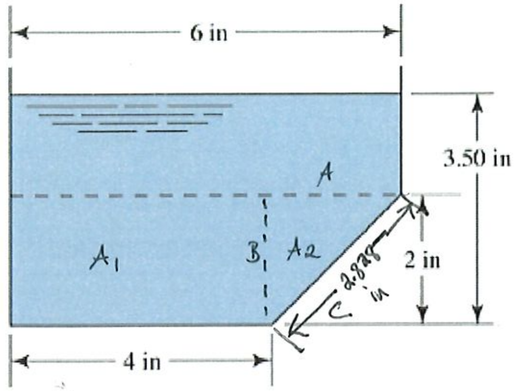
Compute hydralic Radius
if water flows at depth of 2in

Design consideration

- incompressible fluid
- isothermal process
- steady state

Data and variables

See drawing




$C = \sqrt{2+2}$
$= 2.828$

$A_1 = 8 in^2$

$A_2 = 2 in^2$

$A = 10 in^2$

$$R = \frac{A}{Wp}$$

$Wp = 4 + 2 + 2.828$

$= 8.828 in$

$$R = \frac{10 in^2}{8.828 in}$$

$= 1.133 in$

(14.15)

Purpose

Determine the normal discharge at depths of 3ft and 6ft.

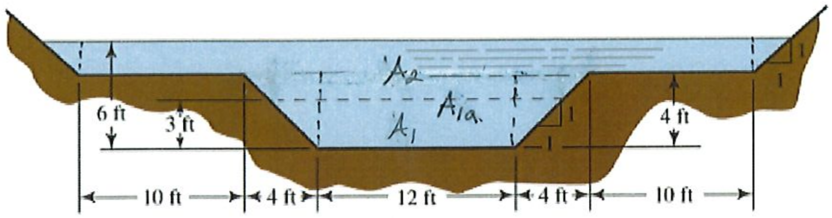
Design Considerations

- incompressible fluids
- isothermal process
- steady state

Data and variables

$n = 0.04$

average slope $= 0.00015$




at 3ft

$A_1 = (3\times12) + 2(4.5)$

$= 45 ft^2$

$R = \frac{A}{WP}$

$W_p = 12 + 4.24 + 4.24$

$= 20.48 ft$

$R = \frac{45 ft^2}{20.48 ft}$

$= 2.1973 ft$

$Q = \left(\frac{1.49}{n}\right) A R^{2/3} S^{1/2}$

$= \left(\frac{1.49}{0.04}\right)(45)(2.1973^{2/3})(0.00015^{1/2})$

$= 34.70 \ ft^3/s$

at 6ft

$A_2 = A_{1a} + A_2$

$= ((4\times12) + 2(8)) + (2\times40)$

$= 144 ft^2$

$Wp = 2(6 + 5.66 + 10 + 2)$

$= 47.32 ft$

$R = \frac{144}{47.32}$

$= 3.0431 ft$

$Q = \left(\frac{1.49}{0.04}\right)(144)(3.043^{2/3})(0.00015^{1/2})$

$= 137.94 \ ft^3/s$

15.4)

## Purpose

Calculate the deflection of a water manometer if orifice dia is 1in and 7in.

## Design Considerations

- incompressible fluid
- isothermal process
- steady state

## Data and Variables

Sharpedge orifice

Pipe dia = 10in

Volume flow rate = 25 gal/min = 0.0557002 $ft^3/s$

ammonia

$Sg = 0.83 \times 62.4 = 51.792\ lb/ft^3$

dynamic viscosity $= 2.5 \times 10^{-6}\ lb/ft^3$

Water at 70°F

$\gamma = 62.4\ lb/ft^3$

Information needed to solve problem

$A_{pipe} = \frac{\pi D^2}{4}$

$= \frac{\pi(\frac{10}{12})^2}{4}$

$= 0.5454\ ft^3$

$\frac{d_{1in}}{D} = \frac{1}{10} = 0.1$

$A_{1in\ orifice} = \frac{\pi(\frac{1}{12})^2}{4}$

$= 0.0055\ ft^2$

$\frac{d_{7in}}{D} = \frac{7}{10} = .7$

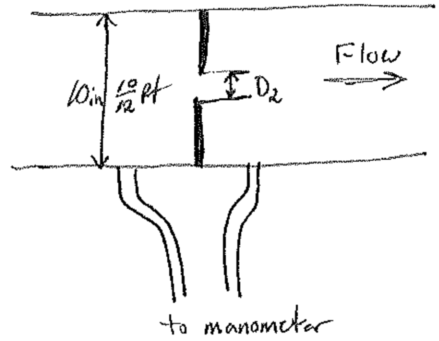
$A_{7in\ orifice} = \frac{\pi(\frac{7}{12})^2}{4}$

$= 0.2673\ ft^2$

$Re_1 = \frac{vD}{\nu}$

$= \frac{\left(\frac{0.0557002}{.5454}\right) \times \left(\frac{10}{12}\right)}{2.5 \times 10^{-6}}$

$= 34{,}042.42$




$$Q = A_1 \times C \times \sqrt{\frac{2gh\left(\frac{V_w}{V_a} - 1\right)}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$$

$$V = C\sqrt{\frac{2gh\left(\frac{V_w}{V_a} - 1\right)}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$$

$$h = \frac{\left(\frac{Q}{A_1 \times C}\right)^2 \times \left(\left(\frac{A_1}{A_2}\right)^2 - 1\right)}{2g\left(\frac{V_w}{V_a} - 1\right)}$$

from Chart

$C_{1in} = 0.592$

$C_{7in} = 0.622$

deflection of water if orifice is 1in

$$h = \frac{\left(\frac{0.0557002}{0.5454 \times 0.592}\right)^2 \times \left(\left(\frac{0.5454}{0.0055}\right)^2 - 1\right)}{2(32.2)\left(\frac{62.4}{51.792} - 1\right)}$$

$= 22.18\ ft$

deflection of water if orifice is 7in

$$h = \frac{\left(\frac{0.0557002}{0.5454 \times 0.622}\right)^2 \times \left(\left(\frac{0.5454}{0.2673}\right)^2 - 1\right)}{2(32.2)\left(\frac{62.4}{51.792} - 1\right)}$$

$= 0.0065\ ft$

15.15

Purpose

Calculate the velocity of flow

Desig Considerations

- Incompressible fluid
- Isothermic process
- Steady state

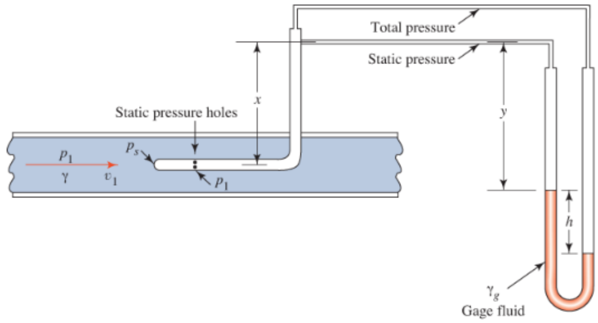
Data and Variables

Temp = 50°C

$\rho_{air} = 1.092$ kg/m³

differential manometer reads 0.24 in of water

0.24 in = 0.006096 m




$$h = h_w\left(\frac{\rho_w}{\rho_a} - 1\right)$$

$$= 0.006096\left(\frac{1000}{1.092} - 1\right)$$

$$= 5.576 m$$

$$V = \sqrt{2gh}$$

$$= \sqrt{2(9.81)(5.576)}$$

$$= 10.46 \, m/s$$