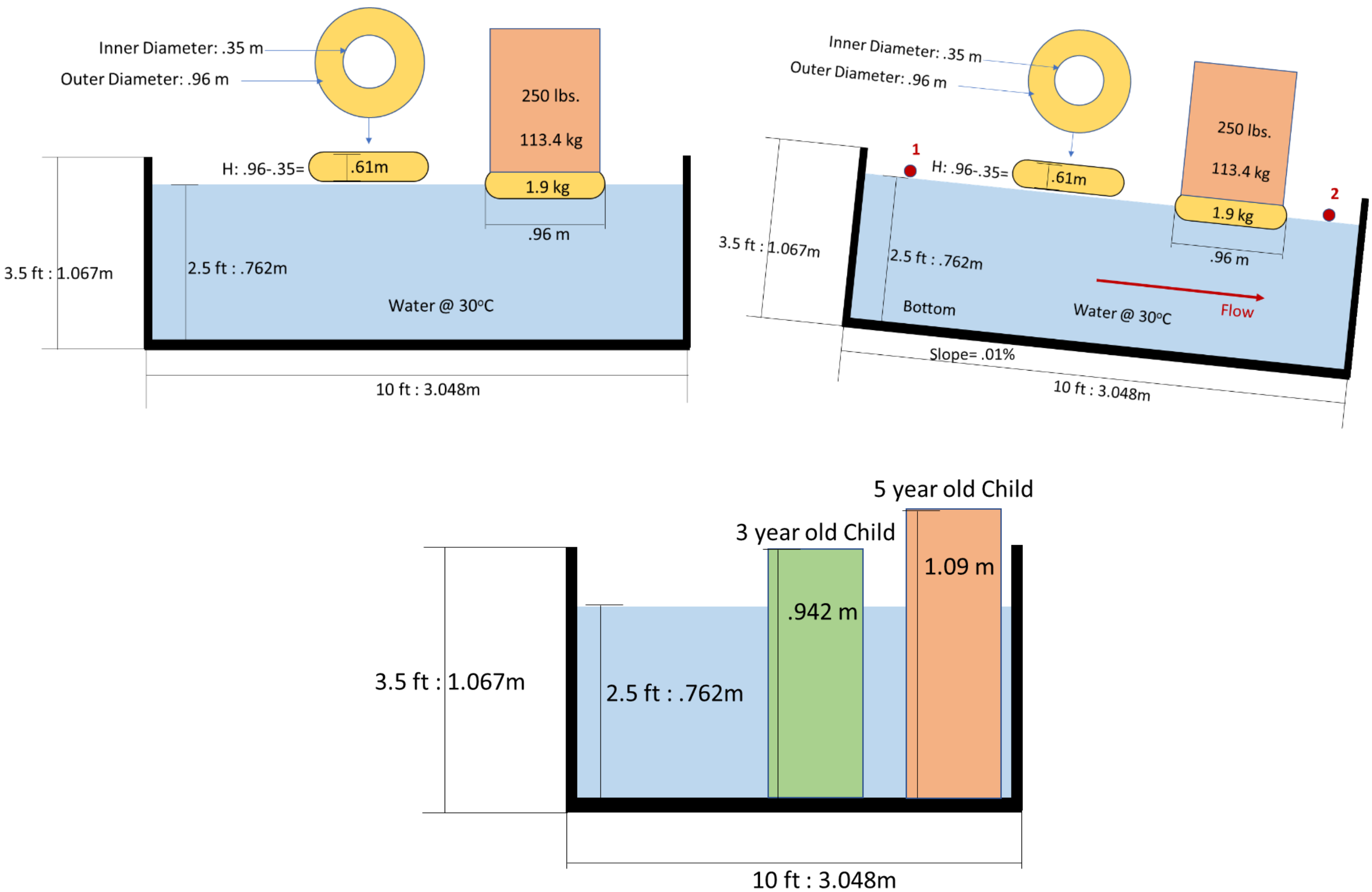
Purpose

Part A, determine design parameters for "lazy river" water park. Two ZRT42YE single hollow tubes are to be utilized within a water park. The design must also take in consideration safety precautions for younger children, as a child of three years of age must be able to stand in the "river" without danger of drowning. The Flowrate of the design must be determined to support the design parameters and the resulting velocity. Drag force on a 5-year-old child, water depth of a 250lb person using the selected float tube, stability must also be tabulated. Additionally, the force magnitude of a one-meter section of the open channel must be determined.

Drawings & Diagrams



Drawing Created in "One Note"

Sources

Mott, R., Untener, J.A. "Applied Fluid Mechanics", 7th edition Pearson Education, Inc, (2015)

"Zrt42ye - Single Tube." AQUATEC Europe, AQUANEO, https://www.aquatec-europe.com/en/waterpark/pear-tubes-and-river-tubes-for-waterparks/82-zrt42ye-single-tube.

Claudia Boyd-Barrett|Medically reviewed byPaul Young, M.D. "Average Weight and Growth Chart for Babies, Toddlers, and Beyond." *BabyCenter*, https://www.babycenter.com/baby/baby-development/average-weight-and-growth-chart-for-babies-toddlers-and-beyo_10357633.

/author/rebecca-Robledo. (2017, September 24). *Lazy rivers in aquatics facilities: Not so lazy after all*. Aquatics International. Retrieved October 28, 2021, from https://www.aquaticsintl.com/facilities/design/lazy-rivers-in-aquatics-facilities-not-so-lazy-after-all_o.

Schedule 40 steel pipe. Steel Tubes India. (n.d.). Retrieved November 2, 2021, from https://www.steeltubesindia.net/schedule-40-steel-pipe.html.

Design Considerations

-Open Chanel Geometry: Rectangle Configuration design, 10ft : 3.048m wide by 3.5ft : 1.067m depth by

-Water Depth design: 2.5ft : .762m

-Slope .01% |.001

-Cylindrical Body "person" | Weight is to be distributed at center of tube

-Float Tube Material, PVC pas

Data Variables:

-Weight of body= 250 lbs | 113.4 kg

-Average Height of 3-year-Old Girl= 37.1 in | 3.09 ft |.942m

-Average Waist Size of 3-year-Old-Girl= 21 in | 1.75 ft 0.53m

-Average Height of 5-year-Old-Kid= 43 in | 3.7 ft | 1.13m

-Average Waist of 5-year-old-Kid= 22 in | 1.83 ft | .56m

-Float Tube, OD= 96cm| .96m | ID= 35cm| .35m |Tube Height/width: .96m - .35m = .61m

-Float Weight, 4.2 lbs. | 1.9 kg

-Manning's Value: Material- glazed brick / finished concrete *n= .013*

-Fluid, Water H_2O @ 30°C pg. 488 | γ = 9.77kN/m^3 | Ᵽ = 996 kN/m^3| Dynamic Viscosity η = 8.00x10^{-4} Pas

| Kinematic Viscosity = 8.03x10^{-7}

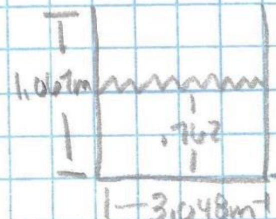
Procedure:

First, investigate provided source to identify requirements needed to configure a “lazy river” design that would allow for two of the ZRT42YE single hollow tubes, to be used side by side while occupied. Next, create a sketch / drawing of the “lazy river” design for the known parameters/requirements set forth by the problem statement. Next, use identified source for “body sizes” to document the averages of dimensional proportions to human body. The dimensions identified including average height, weights and waist sizes would be converted to proper units and utilized throughout as needed during calculations, along with the identified equations used throughout lectures/textbook source. Next, calculate velocity and flowrate needed by the lazy river design to encompass a .762m water level height and a 3.048m channel width. Next, calculate the drag force of a 5year old child is partially submerged by the .762 water level. Next, calculate how much of the float be submerged under water if a 113.4 kg load was applied to the center and also verify stability by locating metacenter and center of buoyancy. Lastly the force magnitude of a one-meter section must be calculated for the lazy canal design floor and also wall. The force magnitude location on the wall is to be determined as we’ll.

Calculations:

① Calculate Flow rate + Velocity

- Rectangular Shape design



- W = 10ft = 3.048m
- Hwalls = 3.5ft = 1.067m
- Hwater = 2.5ft = .762m
- Area wall = (1.067)(3.048) = 3.25m
- Area Flow = (.762)(3.048) = $2.32m^2$
- wp = 2(.762) + 3.048 = 4.572
- Slope = .1% = .001
- Manning = .013 Finished Concrete

*equation 14.6

① $V = \frac{1.00}{n} R^{2/3} S^{1/2}$

- $R = \frac{A}{wp} = \frac{2.32}{4.572} = .507$
- $V = \frac{1.00}{.013} (.507)^{2/3} (.001)^{1/2}$
- V = (76.92)(.636)(.032)
- **V = 1.57 m/s**

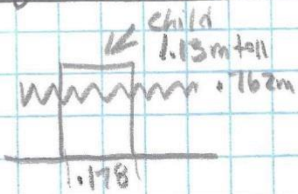
② Q = VA = (1.57m/s)($2.32m^2$)

Q = 3.64 m^3/s Flow rate Needed for design

② Calculate drag force on 5 year old Child Standing in water

pg 434 Need N_R

-Child Stats



- Height = 3.7ft = 1.13m
- Chest = 1.83ft = .56m
- Weight = 40lb = 18.14kg
- ρwater = 996 kg
- V = 1.57 m/s
- Child Diameter = .178m

$\frac{.56m}{\pi}$ = .178, r = .089

- projected Area of Child

A = Hwater · D = (.762)(.178) = .136m

- $N_R = \frac{\rho V D}{\eta} = \frac{(996 \frac{kg}{m^3})(1.57)(.178)}{8 \times 10^{-4}}$

N_R = 347927.7, 3.47×10^{5}

pg 434 CD = .8

① $F_D = C_D \left(\frac{\rho V^2}{2}\right) A$

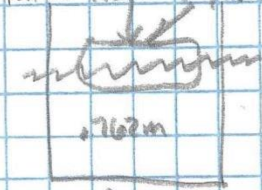
$F_D = \frac{.8 (996 \frac{kg}{m^3})(1.57^2 \frac{m}{s})(.136m)}{2}$

FD = 133.55N Friction Force on Child in Water

★ equation 5-1, HW 5.41

③ How deep in Water will float go & is it Stable

Person 113.4Kg Tube 1.9kg W_T = 113.4kg + 1.9kg = 115.3kg



d = .96m
r = .48m
h = .61m

- Tube height = .96m − .35m = .61m
- γ_{water} = 9.79 kn/m³
- Tube weight = 1.9kg
- person weight = 250lb = 113.4kg

- $W = F_b = \gamma_w V_d = \gamma_w A X$
- F_b = 1.13 kn = $\gamma_w A X$
- $X = \frac{W_T}{\gamma_w A} = \frac{1.13\ kn}{(9.79\ kn/m^3)(.628 m^2)}$ =

X = .184m under the water

① ★ $F_B = W_T$ = 115.3kg

kg → kn

$115.3kg \cdot \frac{kn}{101.97}$ = 1.13 kN

★ W_T = 1.13 kN

② Area of "tube" Float

★ $A = \frac{\pi(D^2 - d^2)}{4} = \frac{\pi(.96^2 - .35m^2)}{4}$

$A = \frac{\pi(.7991)}{4}$ = .628 m²

Stability $y_{mc} = y_{cb} + MB$

- $y_{cb} = \frac{X}{2} = \frac{.184}{2}$ = .092m
- $I = \frac{\pi D^2}{64} = \frac{\pi(.96m^2 - .35m^2)}{64}$ = .039 m⁴
- $V_d = AX \Rightarrow (.628m^2)(.184m)$ = .115m³
- $MB = \frac{I}{V_d} = \frac{.039m^4}{.115m^3}$ = .339m
- $y_{mc} = y_{cb} + MB$ = .092m + .339m = .431m

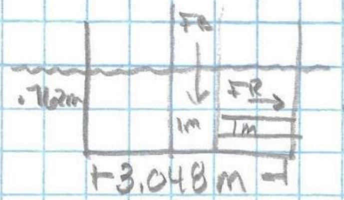
Tube height under water = $\frac{.61m}{2}$ = .305m = CB

MC .431 > CB .305

Yes Float is stable

(4) Force magnitude on 1m Section located on Floor + Wall   pg 66, 68

- Wall height = 1.067m
- Floor Width = 3.048m
- Water height = .762m
- patm = 0
- γ_w = 9.77 kN/m³
- Area of 1m Floor Section (1m x 3.048m) = 3.048m²
- Area of 1m Wall Section (1m x .762) = .762m²



$F_B = p_B A$, $F_R = \gamma(h/2)A$

(1)
- $p_B = p_{atm} + \gamma_w(.762m) =$
- $p_B = 0 + 9.77 kN/m^3(.762) = 7.44 kN/m^2$

(2) Bottom Center

$F = p_B A = (7.44 kN/m^2)(3.048 m^2)$

$F_B = 22.7$ kN, Force on Floor

(3) $F_R = \gamma(\frac{h}{2})A$

$F_R = (9.77 kN/m^3)(\frac{.762m}{2})(.762m^2)$

$F_R = 2.83$ kN, Force on Wall

(4) location on Wall

$C_p = \frac{h}{3} = \frac{.762m}{3} = .254$ m, From bottom

Summary:

A rectangular shape design for the lazy river was created with a 10ft width and a 3.5 ft wall depth. The water level selected within the design was to be held at 2.5ft. The rectangular shaped river, was also to be coated in a glazed/painted finished. The structure itself was to be of concrete allowing for the force of waterflow throughout the system. The overall specifications of the design exposed the tube riders to a water velocity of 1.52m/s and an overall system flowrate of 3.64m^3/s. Referencing external sources, showed that the flowrate and velocity of the water was in line with similar sized waterpark rivers. The flow of water through the system also created a drag force of 133.55N to a 5year old child as the water level was approximately chest high. The height of the water also allowed for the average in height 3year old of at approximately 3.09ft, the safety of water not passing about mid shoulder. Forces applied in the exterior section of the wall/floor within a one-meter section, were calculated and upon review appeared to be normal for the velocity/flowrate tabulated. The calculation for the depth of the innertubes when a 115.3kg load was applied to the 19kg wight of the tube, also appeared to be reasonable. The tubes are fairly large with a diameter of approximately .96m and a "height" of .61m, only allowed the tube to be submerged approximately half the total height of the tube. Overall, I believe the design was fair and allowed for persons within the ride to experience mild forces as found in similar lazy rivers.

Materials:

-Water

-Overall structure materials: concrete, glaze coating

- Two ZRT42YE Single hollow tubes

Analysis:

-The flowrate needed to move water at a velocity of 2.57 m/s was found to be 3.64m^3/s

-Innertube design provided adequate space in height for a 250lb load

-5-year-old child would be exposed to a friction force of 133.55N

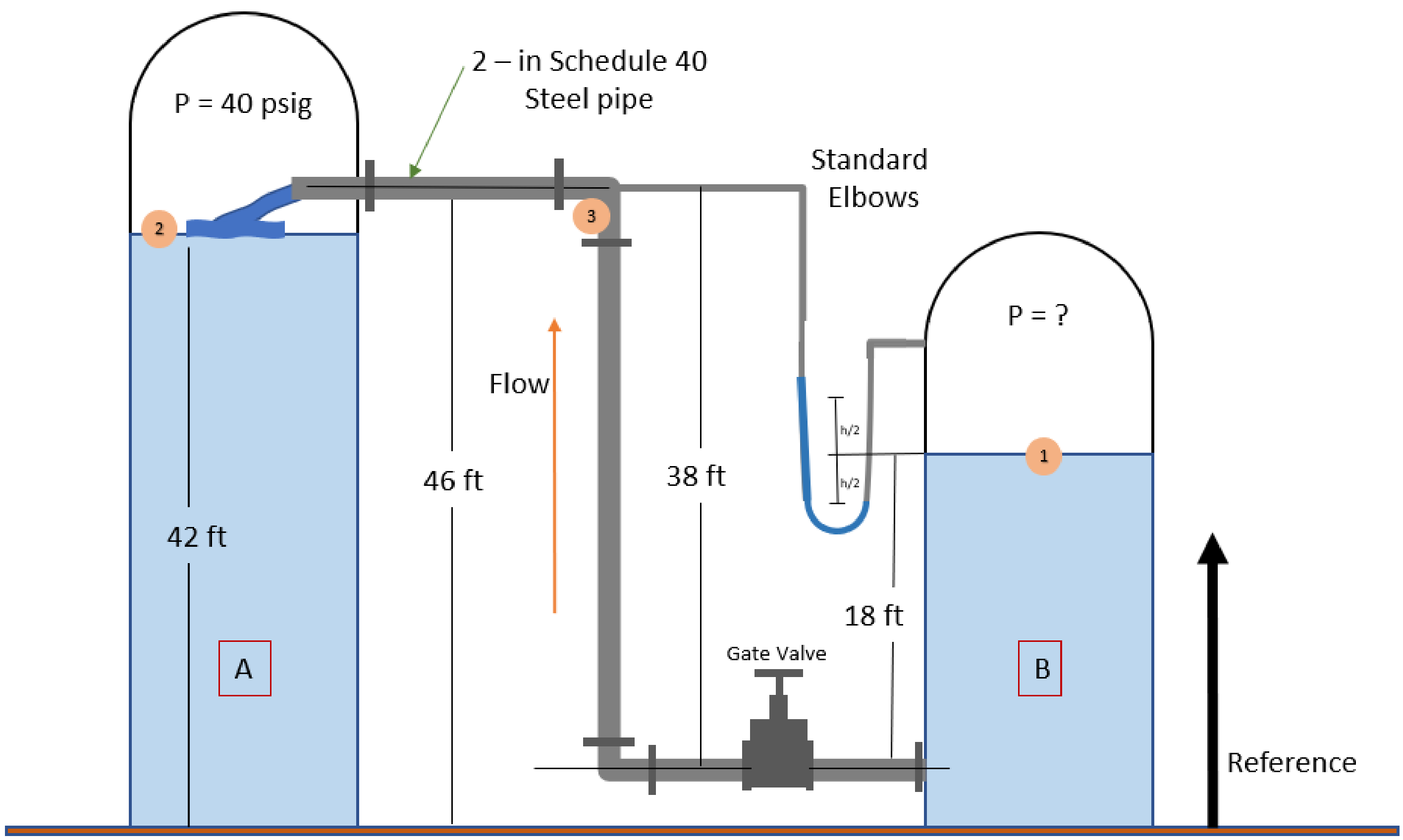
-3year old child would be able to stand within the selected water height safely

-Forces within a 1meter section of floor and walls appeared to be reasonable, allowing the concrete structure to be adequate to withstand

Purpose

Part B, determine design parameters for the test 1 ethyl alcohol system at a flow rate of 100 gallons per minute. Pipe support structures are to de designed with taking consideration of the relevant forces, the number of total horizontal and vertical forces in the whole pipe elbows valve system from tank to tank. Pressure drop is to be identified when using a 0.5 ratio from nozzle diameter to pipe diameter. Pressure it to also be identified if the valve controlling flow is to suddenly stop and review of pipe failure is needed with the given parameters.

Drawings & Diagrams **“””Additional supporting FBDs to be created as needed in calculations sections”””**



Drawing Created in “One Note”

Sources

Mott, R., Untener, J.A. "Applied Fluid Mechanics", 7th edition Pearson Education, Inc, (2015)

Design Considerations

-2 in Schedule 40 Steel Pipe

-Horizontal Pipe section 36ft

-Temperature 77°F

-System Fluid = Ethyl alcohol

Data Variables:

-Tank A, pressure = 40 lb/in^2

-Volume Flow Rate Q= 100gal/min = 0.223 ft^3/s

-Modulus of elasticity= 200GPa

-Pipe Nozzle Raito= 0.5

-Pipe Roughness E = $1.5x10^{-4}$

-Ethyl Alcohol @ 77°F pg. 490 | SG = .787 | γ = 49.01 lb/ft^3 | Ƿ = 1.53lb $slug/ft^3$ | Dynamic Viscosity η = $2.10x10^{-5}$

| Kinematic Viscosity = $1.37x10^{-5}$

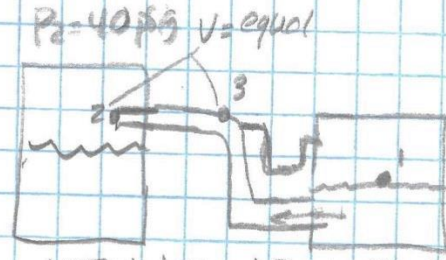
-2in Schedule Pipe 40 pg. 500 | OD = 2.375in | Wall Thickness = 0.154in | ID = .1723ft, 2.067in | Flow Area = 0.02333 ft^2

Procedure:

Reference my sketch drawing for the known variables and identified any needed key areas. Next, solved new pressure at tank B, utilizing Bernoulli's equations throughout the system, solving for energy losses. Then attempted to calculate the vertical and horizontal forces of the identified areas. Attempted to calculate pressure drop of the system, as a nozzle with a .05 ratio diameter was used to measure flow. Lastly attempted to utilize equation 11-9 within the text book to calculate the pressure increment after the sudden stop of flow within the system. Lastly, attempted to calculate pipe failure and cavitation are to be reviewed and verified.

Calculations:

(5) Relevant Forces for Support design



$\gamma = 49.01\ lb/ft^3$

$\Delta Z = 20$

* Test 1 spread sheet also used

Flow Rate $Q = 100\ gal/min = 100/449$

$Q = .223\ ft^3/s$

Pipe

$A = \frac{\pi D^2}{4} = \frac{\pi(.172\ ft)^2}{4} = .023\ ft^2$

Velocity $V_2 = V_3$

$V_2 = \frac{Q}{A} = \frac{.223\ ft^3/s}{.023} = 9.60\ ft/s$ $\frac{V_2^2}{2g} = \frac{(9.60^2)}{2(32.2)} = 1.42$

$P_1 = P_2 + \gamma\left(\frac{V_1^2 - V_2^2}{2g}\right) - Z_2 - Z_1 + h_{L\ total}$

pg 185 table 10.5

$f_t = 0.019$

$Re = \frac{VD}{\nu} = \frac{(9.55)(.1723)}{1.37 \times 10^{-5}} = 1.2 \times 10^5$ $\frac{D}{\varepsilon} = \frac{.1723}{1.5 \times 10^{-4}} = 1148.7$

Energy losses + P1

h_L entrance $= k\frac{V^2}{2g} = \frac{(.5)(9.6^2)}{2(32.2)} = .708\ ft$

$h_{L\ total} = .708 + 1.613 + .215 + 19.44$

$= 21.97\ ft$

h_L Elbow $= 2k\frac{V^2}{2g} = \frac{2(30)(9.6^2)}{2(32.2)} = 1.613\ ft$

h_L Valve $= k\frac{V^2}{2g} = \frac{(8)(9.6^2)}{2(32.2)} = .215\ ft$

h_L Pipe $= f\frac{L}{D} \times \frac{V^2}{2g} = (.0215)\frac{(110)}{(.1723)}\frac{(9.6^2)}{2(32.2)} = 19.44\ ft$

$P_1 = 40 + 49.01\left(20 + \frac{(9.6)^2}{2(32.2)} + 21.97\right) \Rightarrow 40 + 49.01(20 + 1.43 + 21.97) \cdot \left(\frac{1}{144}\right)$

$P_1 = 54.77\ psig$

Energy Loss + P3 * Done in Excel

- $h_{L\,elbow}$ = 1.213 ft
- $h_{L\,entrance}$ = .709 ft
- $h_{L\,to\ elbow}$ = 16.45 ft
- $h_{L\,valve}$ = .216 ft
- $h_{L\,pipe}$ = 18.01 ft

- $P_3 = P_1 - \gamma\left(\frac{V_2^2 - V_3^2}{2g}\right) + Z_3 - Z_1\ h_{L\,total}$

$P_3 = 55.32 - 49.01\left(20 + \frac{9.6^2}{2(32.2)} + 16.45\right) \Rightarrow 55.32 - 49.01(20 + 1.43 + 16.45)(1/144)$

P_3 = 42.43 psig

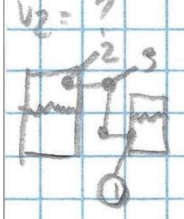
Reaction Forces P_1 = 55.318 psig, P_2 = 40 psig, P_3 42.43 psig

* Pg 424 Equation 16-8

Forces in Rx

- $R_x = \rho Q v_1 + P_1 A_1$

ρ = 1.37×10^{-5}
Q = .223 ft^3/s
V_1 = 9.6 ft/s
A_1 = .023 ft^2
A_2 = .023 ft^2
V_2 = ?



- $R_{x\,P1} = \rho Q v_1 + P_1 A_1 = (1.37\times10^{-5})(.223)(9.6) + (55.318)(.023) =$ 1.28 lb, $R_{x\,P1}$
- $R_{y\,P1} = \rho Q v_2 + P_1 A_2 = (1.37\times10^{-5})(.223)(0) + (55.318)(.023) =$ 1.27 lb $R_{y\,P1}$
- $R_{x\,P2} = \rho Q v_1 + P_1 A_1 = (1.37\times10^{-5})(.223)(9.6) + (40)(.023) =$ 1.28 $P_2\ R_x$
- $R_{y\,P2}$ $\rho Q v_2 + P_1 A_2 = (1.37\times10^{-5})(.223)(0) + (40)(.023) =$ .92 $P_2\ R_y$
- $R_{x\,P3} = \rho Q v_1 + P_1 A_1 = (1.37\times10^{-5})(.223)(0) + (42.43)(.023) =$ .976 $P_3\ R_y$
- $R_{y\,P3} = \rho Q v_2 + P A_2 = (1.37\times10^{-5})(.223)(9.6) + (42.43)(.023) =$ .976

* I'm missing something or not using correct method or both numbers are off and just changing the velocity does not seem correct.

(6) What is the Pressure Drop across a flow nozzle with pipe D = .5 Ratio

* pg 401 Equation 15-7 β = .5 Ratio , Diameter pipe = .1723 ft (.5) = Nozzle = .0862

$C = .9975 - 6.53\sqrt{\beta / N_R}$

(1) • $N_R = \frac{vD}{\eta} = \frac{(9.6 ft/s)(.1723)}{2.10 \times 10^{-5} lb/ft} = 78765.7$

Ethyl

(2) $C = .9975 - 6.53\sqrt{\frac{.5}{78765.7}}$

$C = .981$

Change in Pressure p1 - p2   * pg 398 Equation 15-4

(3) $V_1 = C\sqrt{\frac{2g(p_1 - p_2)/\gamma}{(A_1 - A_2)^2 - 1}} = 9.6 ft/s = .981\sqrt{\frac{\frac{2(32.2 ft/s^2)(p_1 - p_2)}{49.1 lb/ft^3}}{\left(\frac{.023 ft^2}{.0058 ft^2}\right)^2 - 1}}$

• $\gamma = 49.1\ lb/ft^3$

• Area of pipe = .023 ft²

• Area of Nozzle $= \frac{\pi D^2}{4} = \frac{\pi(.0862)^2}{4}$

A = .0058 ft²

• g = 32.2 ft/s²

• $\frac{9.6 ft/s}{.981} = .981\sqrt{\frac{\frac{(64.4 ft/s^2)(p_1 - p_2)}{49.01 lb/ft^3}}{16.14}}$

• $9.78 ft/s = \sqrt{\frac{(1.31 \frac{s^3}{ft})(p_1 - p_2)}{16.14}}$

• $9.78 ft/s = \sqrt{.0812 \frac{s^3}{ft}(p_1 - p_2)}$

• $9.78^2 = .0812\ (p_1 - p_2)$

• $95.65 = .0812\ (p_1 - p_2)$

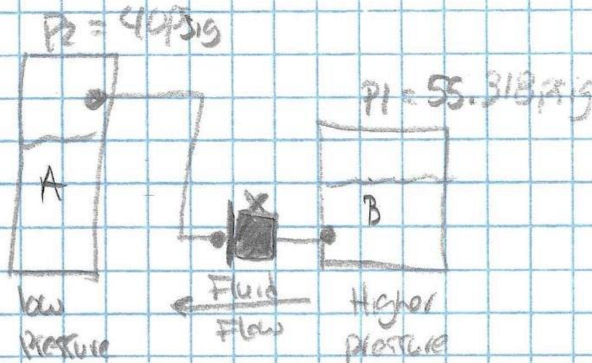
$(p_1 - p_2) = 1177.93$ * lost in units or math was done incorrectly

* Not sure if it can be used but reviewing the Chpt 15.9 figure shows pg 405 a Diameter Ratio β = .5 has a 65% decrease in Pressure. If p1 = 55.13 psi = 65% decrease = 19.31 psi   (6)

(7) Pressure After Closing Pipe Suddenly, Check for Pipe Failure + Cavitation

* lecture 10-26-21

$p_{max} = \rho C V$, $p_{max} = p_{operating} + \Delta p_{max}$



• ρ = 1.53 lbs slug/ft³
• V = 9.559 ft/s Fully open
• $p = p_1$ = 55.318psig operating

(1) $\Delta p_{max} = \rho C V$

$$C = \frac{\sqrt{\frac{E_0}{\rho}}}{\sqrt{1 + \frac{E_0 D}{E \delta}}}$$

* Chpt 11 table 1-3 @68°F
E_0 = 130,000 psi
D = 2 in Schedule 40
E = 200 GPa ⇒ to psi
200(145038)
= 2.901 × 10⁷ psi
δ = pg 500 2" Schedule 40
= .154 in

ρ = 1.53 slug/ft³ to PSI
= 1.53(223.43 psi) / 1000 =
= 341.84 psi/1000 ft * google Calculator used

(2)
$$C = \frac{\sqrt{\frac{130{,}000\ psi}{341.84\ psi/ft}}}{\sqrt{1 + \frac{(130000\,psi)(2\,in)}{(2.901\times10^7\,psi)(.154\,in)}}}$$

$= \frac{19.50\,ft}{1.0287} = 18.96\,ft$?

Wave velocity
$= 18\,ft \cdot \frac{1}{60\,sec} = .3\,ft/sec$

* My conversions are wrong somewhere can't find it, just moving on

(3) $\Delta p_{max} = \rho C V = \left(1.53\ \frac{slug}{ft^3}\right)\left(.3\ \frac{ft}{sec}\right)\left(9.559\ \frac{ft}{sec}\right)$

Δp_{max} = 4.39 slug/ft·sec pressure   to psi = 980.86 psig   Wrong WAY High

(4) $p_{max} = p_{1\,operating} + \Delta p_{max}$

p_{max} = 55.318psig + 980.86psig = 1036.178 psig   Total MAX Pressure

p_{max} = 1036.178 psig

Units off / math wrong Not sure where

Continue to equation 11-9

Wall thickness $t = \frac{pD}{2(SE + py)}$

11-9 Basic Wall thickness Calculations pg 285

$t = \frac{PD}{2(SE + Py)}$, $t_{min} = t + A$, $t_{nom} = 1.143$

*pg 560
2" schedule pipe 40
Wall thickness = .154 in
O.D = 2.375 in
= .1979 ft

equation 11-9

- P_{max} = 1036.178 psig
- S = 200GPa = 200(1450308) = PSI
- GPA → PSI = 2.9×10^{-7}
- pg 285
- E = 1 = seemless steel
- y = .4 for steel
- D = O.D. = 2.375 in
- A = Corrosion Allowance .08 in

(1) $t = \frac{1036.178 \, lb/in (2.375 in)}{2[(2.9 \times 10^{-7} lb/in)(1) + (1036.178 \, lb/in)(.4 in)]}$

$t = \frac{2462.316}{2(2.9 \times 10^{-7} lb/in + 414.47 \, lb)}$

t = 828.9424006 in = Definitley off....

* I know I am to compare design pipe thickness of (2.375 in) with the found thickness with my pressure but I'm off somewhere in units / conversions, reworked a few times but no luck / Time

* As for Cavitation, the movement of the Ethyl Alcohol is being done due to Tank B, being the highest of pressures. If gate valve is closed rapidly, I do not believe cavitation would occur due to the Alcohol going into Tank A. Since the only pressure through Kinetic in Tank A in the system, I do not believe the temperature given would change.

Summary:

The calculated pressure needed for tank B (right) to deliver 100 gal/min of ethyl alcohol to tank A, I believe was calculated. Energy losses throughout the system was also calculated with the new flowrate of fluid. Upon reviewing steps, I believe I miss calculated the location of the pressure and was unable to establish the correct reaction forces within the system to allow for the establishment of support structures. Flowrate calculation utilizing a flow nozzle for measurement also was not tabulated correctly. I believe I followed the correct equation in the source text but I also believe I miscalculated in overall math steps or unit conversion. Upon reviewing chapter 15, figure 15-9 provided a chart with values pertaining to flow nozzle/pressure drop ratios. Per chart 15-9, a nozzle with a ratio of .5, would create a decrease in pressure of 65%. Unfortunately, I was not able to properly calculate the values depicting the change in pressure. Lastly, water hammer was to tabulated as fluid in the system was to be "stopped suddenly". Cavitation was also to be determined if it was present within the system. Due to miscalculations values did not appear to be correct, as mathematical errors were present.

Materials:

-Ethyl alcohol

-Overall system components, 2-in Schedule 40 steel pipe (tanks, piping sections, valve and fittings)

Analysis:

- Pressure in the system was found, along with energy losses, pressures did not appear correct for reaction forces calculations

- Reaction forces were tabulated, did not appear to be correct to verify for support structure needed

-Flow nozzle ration equation calculation did not appear correct due to mathematical errors, 65% decrease in pressure throughout the system was established, referencing chart 15-9

-Waterhammer, cavitation and pressure after the flow of alcohol was suddenly stopped was not verified, as mathematical errors are present

Variable	Value	Unit
P_1	55.318	lb/in^2
V_1	0.000	ft/s
$V_1^2/2g$	0.000	ft/s
Z_1	22.000	ft
P_2	40.000	lb/in^2
V_2	9.559	ft/s
$V_2^2/2g$	1.419	ft/s
Z_2	42.000	ft
$h_{L\ Gate\ Valve}$	0.216	ft
$h_{L\ Pipe\ Bend\ 1}$	1.617	ft
$h_{L\ Pipe\ Bend\ 2}$	1.617	ft
$h_{L\ Overall\ Pipe}$	19.474	ft
$h_{L\ Entrance\ Loss}$	0.709	ft
h_L Total	23.634	ft
γ Ethyl	49.010	$slugs/ft^3$
γ Ethyl	0.340	ft
g	32.200	ft/s^2
$Q_{Flow\ Rate}$	0.223	ft^3/s
$Q_{Flow\ Rate}$	100.000	gal/min
Area	0.023	ft^2
$K_{Pipe\ Bend}$	0.570	30
$K_{Gate\ Valve}$	0.152	8
$K_{Entrance\ Loss}$	0.500	_
$Friction_{Factor}$	0.019	_
$Length_{of\ Pipe}$	110.000	ft
$Diameter_{of\ Pipe}$	0.172	ft
Friction Pipe Factor	0.0215	ft
Pipe Vertical	38	ft
Pipe Horizontal	36	ft
Delta Z	20	ft
ρ	0.0000137	

Variable	Equation	Value	Unit
Bernullis Equation	$P1/y + V^2{}_1/2g + Z_1 = P2/y + V^1{}_2/2g + Z_2$		_
Bernullis Equation for P1 =	$P2 + y(V^2{}_1 - V^1{}_2 /2g + Z_2 - Z_1 + hL_{total})$	55.318	psig lb/in^2
$h_{L\ Pipe\ Bend\ 1\&2}$ $h_L = K_{Pipe\ Bend}(V2^2/2g)$	$K*(V2^2/2g)$	1.617	ft
$h_{L\ Gate\ Valve}$ $h_L = K_{Gate\ Valve}(V2^2/g)$	$K*(V2^2/2g)$	0.216	ft
$h_{L\ Overall\ Pipe}$ $h_L = f_f*(L/D)*(V2^2/2g)$	$h_L = f_f*(L/D)*(V2^2/2g)$	19.474	ft
$h_{L\ Entrance\ Loss}$ $h_L = K_{Square\ Inlet}(V2^2/2g)$	$h_L = K_{Entrance\ Loss}(V2^2/2g)$	0.709	ft
h_L Total Energy Loss	$(h_{L\ Gate\ Valve} + h_{L\ Pipe\ Bend\ 1} + h_{L\ Pipe\ Bend\ 2} + h_{L\ Overall\ Pipe} + h_{L\ Tank\ Inlet})$	23.634	ft

Bernullis Equation for P3 =	$P1 - y(V^2{}_1 - V^1{}_2 /2g + Z_3 - Z_1 + hL_{total})$	42.429	psig lb/in^2
$h_{L\ Pipe\ Bend\ 1\&2}$ $h_L = K_{Pipe\ Bend}(V2^2/2g)$	$K*(V2^2/2g)$	1.213	ft
$h_{L\ Gate\ Valve}$ $h_L = K_{Gate\ Valve}(V2^2/g)$	$K*(V2^2/2g)$	0.216	ft
$h_{L\ Overall\ Pipe}$ $h_L = f_f*(L/D)*(V2^2/2g)$	$h_L = f_f*(L/D)*(V2^2/2g)$	13.101	ft
$h_{L\ Entrance\ Loss}$ $h_L = K_{Square\ Inlet}(V2^2/2g)$	$h_L = K_{Entrance\ Loss}(V2^2/2g)$	0.709	ft
h_L Total Energy Loss	h_L to Pipe Bend	16.452	ft