MET 330 Pipeline Design Project

CONTINENTAL AG PIPELINE SYSTEM DESIGN

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Abstract

The company, Continental AG, is interested in a brand-new manufacturing facility located in Dayton, Ohio. The system is to be designed to handle the coolant from the time it arrives at the facility in a railroad tank until the dirty coolant is removed from the facility by a contract firm. This project covers a complete pipeline design for: the transfer of coolant between the tank car to the 15,000-gallon storage tank, the storage tank to the 1,000-gallon reservoir tank, the reservoir tank into the dirty coolant tank, and the dirty coolant tank to the truck. Several factors are considered while designing the coolant transfer system including: location, layout, flow rate, equipment selection and fitments.

Report Body

Job Location

The job will be in Dayton, Ohio.

Latitude: 39.7589°

Longitude: 84.1916°

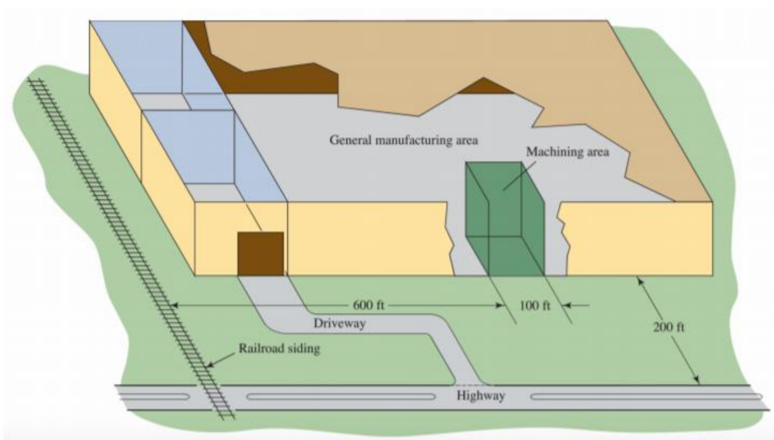


Figure 1

Specifications and Design Philosophy

The pipeline system for this will be an all pump system with the larger storage tank being outside and the rest of the tanks being inside. To accommodate for the larger tank being outside, a heating element will be installed along with it so that that liquid temperature will not go below the frostline. The three tanks that will be used for this system are a 15000-gal tank for main storage, 6000-gal tank for dirty coolant, and a 1000-gal reservoir tank. There will be a train that comes and delivers new coolant, and a truck that picks up the dirty coolant. The scheduled pick up for the dirty coolant will be once a month, and the scheduled drop off the 15000-gal tank from the train will be every 3 months. Pumps will be allocated to each storage tank and a machining system will be included along with the 1000-gal tank.

Sources

1. Mott, Robert L., and Joseph A. Untener. *Applied Fluid Mechanics*. Pearson, 2015.

Materials and Specifications

-Tank materials and Specifications:

The materials that will be used for the pipes and storage tanks will be stainless steel as the coolant has elements of water, and stainless steel is shown to handle corrosiveness of water very well. Specifically, the type of steel that will be used for the pipes and storage tank will be A36 Steel. It is expensive, yet it handles the corrosiveness of fluid very well and will be very suitable for this project. The schedule for the tanks and pipes with be 6 NPS Schedule 40 as it has high strength and properties that can resist the corrosiveness of the fluid.

-Fluid Characteristics:

The fluid being used in this project is coolant that has the properties if water. The specific gravity of the fluid is 0.94 and has the same corrosion factor as that of water. It is also known about the fluid that the viscosity and vapor and 1.5 times that of water at any temperature.

Preliminary drawings and sketches

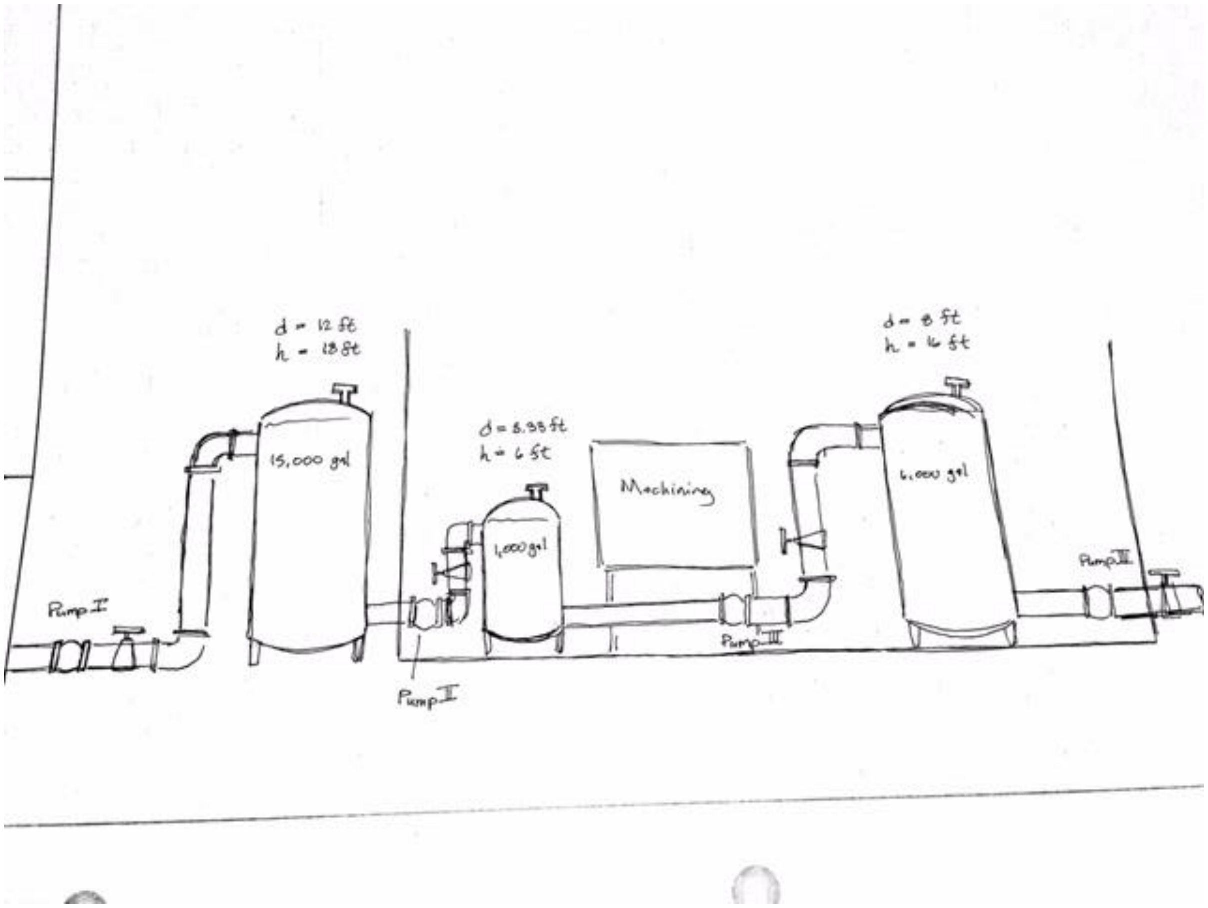


Figure 2

Design Calculations

i. Tank Specifications

-Tank Locations:

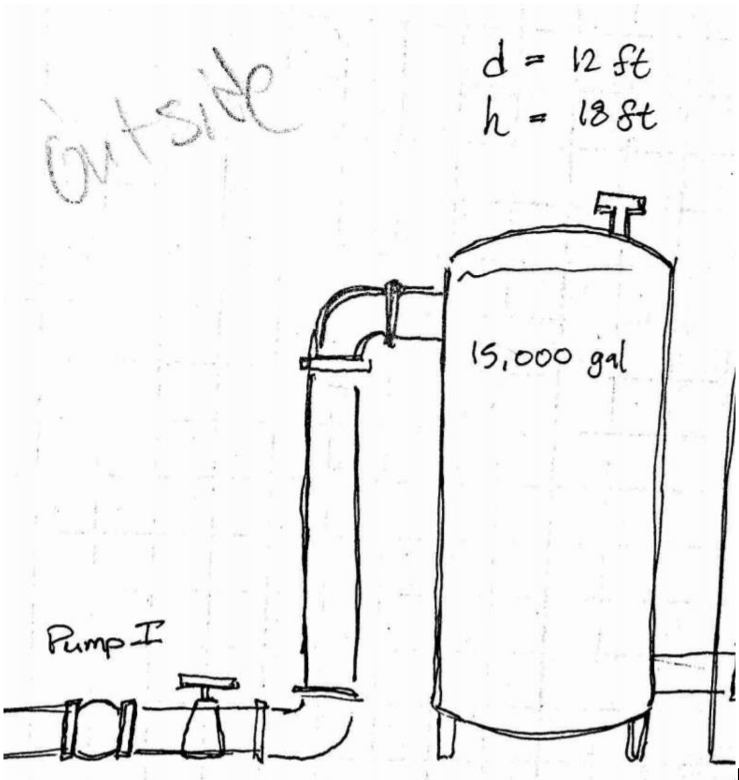


Figure 3

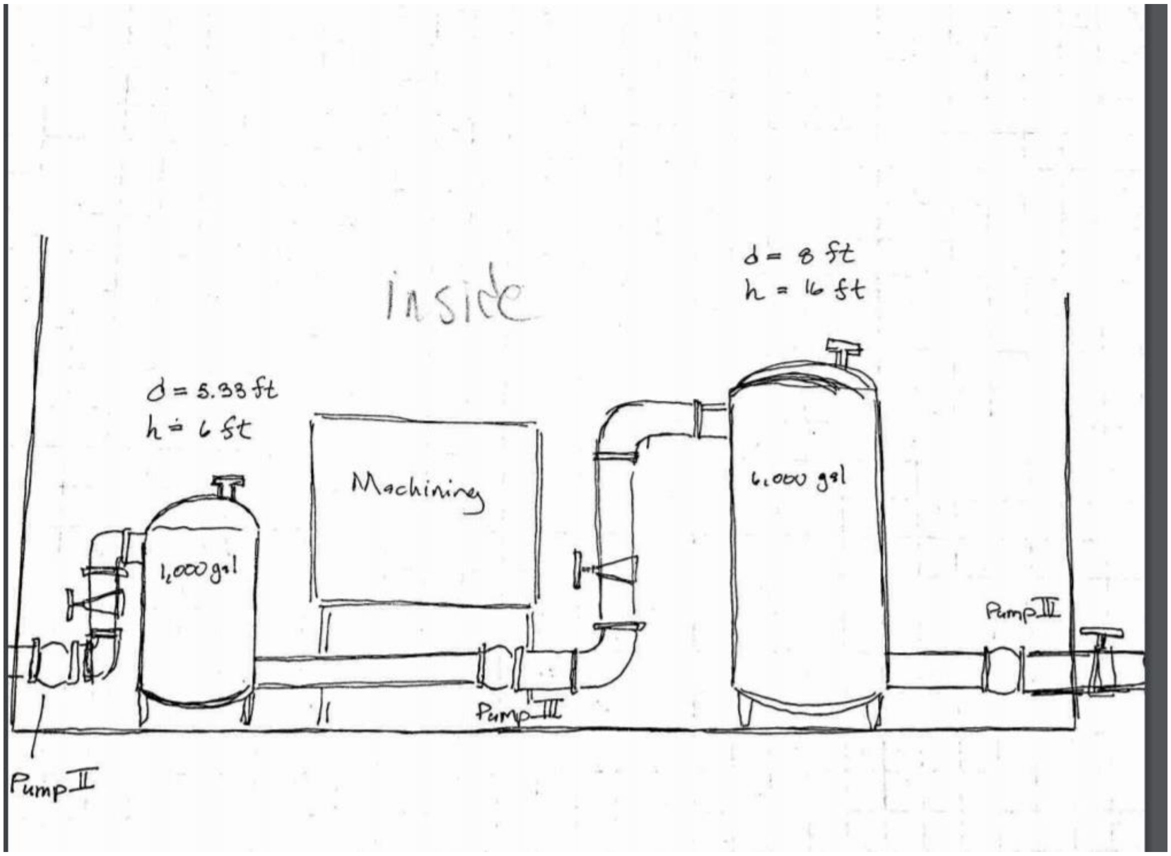

inside
d = 5.33 ft
h = 6 ft
1,000 gal
Machining
d = 8 ft
h = 16 ft
6,000 gal
Pump II
Pump III
Pump IV

Figure 4

Size Design for Tanks

From the figure provided above, the dimensions of the tanks have been given.

Tank 1 will have a volume of 15000 gallons and the diameter of the tank will be 12ft, and its height will be 18ft.

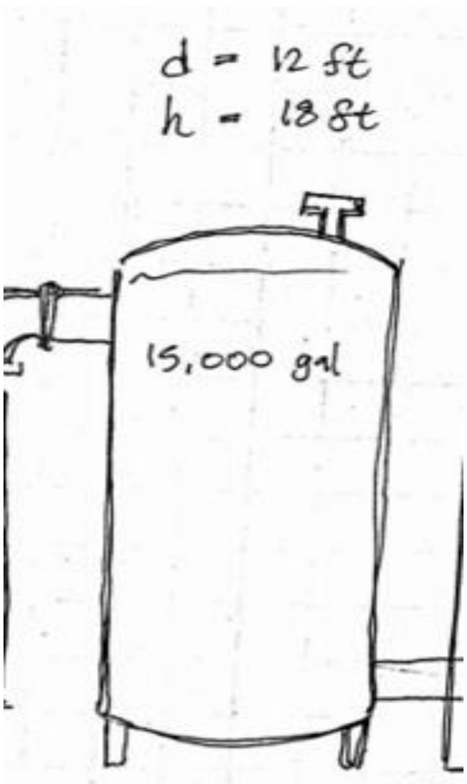


Figure 5

Tank 2 will have a volume of 6000 gallons and the diameter of the tank will be 8 ft, and the height is 16ft.

Figure 6

Tank 3 will have a volume of 1000 gallon and the diameter of the tank will be 5.38ft and the height is 6ft.

Figure 7

Tank Thickness

Purpose: Calculate the thickness

Drawings & Diagrams:

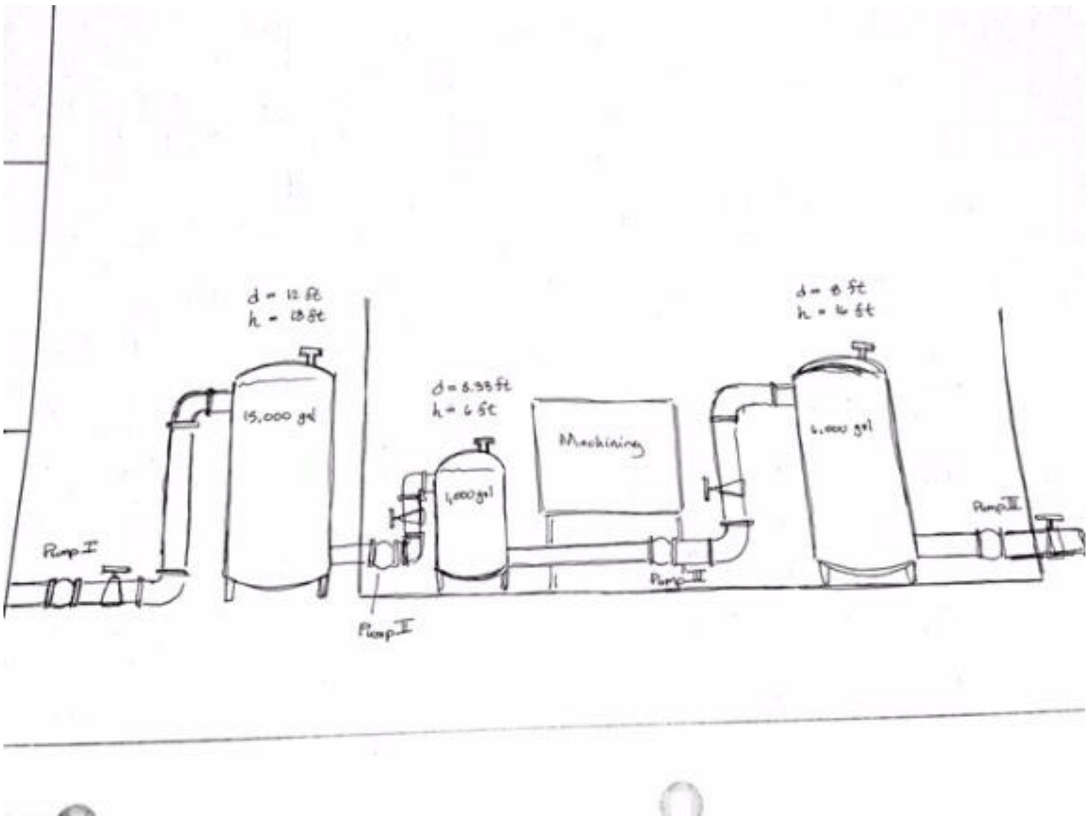


Figure 8

Sources: Mott, Robert L., and Joseph A. Untener. *Applied Fluid Mechanics*. Pearson, 2015. (Figure 8)

Design Consideration: The volume of the tank, atmospheric pressure, design stress, dimensions of tank

Data and Variables:

Tank	Height (ft)	Diameter (ft)
15000-gallon	18	12
6000-gallon	16	8
1000-gallon	6	5.33

Table 1

D(15000 gal)=12 inches, D(1000 gal)=5.85 inches, D(6000 gal)=8 inches, Y=0.4, S=248.2psi, E=1.0, P=0.5

Procedure: To solve for the wall thickness of each tanks the units of each tank must be converted form gallons to meters, and the pressure of the tanks must be calculated as well. After that, with the given dimensions of each tank and other given data such as the allowable stress, correction factor, etc., the given formula which is $t = \frac{P*D}{2(SE+PY)}$ will be used to solve for each tanks wall thickness.

Calculations:

Task 2 : Tank Thickness

15,000 gallon tank

$$t = \frac{(0.5\ \text{MPa})(3657.6\ \text{mm})}{2\left[(250\text{MPa})(1) + (0.5\text{MPa})(0.4)\right]} = 3.655\ \text{mm} \Rightarrow \boxed{0.144\ \text{in.}}$$

1,000 gallon tank

$$t = \frac{(0.5\ \text{MPa})(1624.584\ \text{mm})}{2\left[(250\ \text{MPa})(1) + (0.5\text{MPa})(0.4)\right]} = 1.6233\ \text{mm} \Rightarrow \boxed{0.064\ \text{in.}}$$

6,000 gallon tank

$$t = \frac{(0.5\ \text{MPa})(2438.4\ \text{mm})}{2\left[(250\ \text{MPa})(1) + (0.5\ \text{MPa})(0.4)\right]} = 2.4365\ \text{mm} \Rightarrow \boxed{0.1\ \text{in.}}$$

Summary table:

Tank thickness for 15000-gallon tank	t= 0.144 inches

Tank thickness for 6000-gallon tank	t= 0.1 inches
Tank thickness for 1000-gallon Tank	t=0.064 inches

Table 2

Materials: Stainless steel tank, tank coolant.

Analysis: From the calculations it shows that the yield strength of the material known as stainless steel can withhold to the forces of the fluid as the forces of the fluid are not equal to the materials yield strength.

Blind Flange

Purpose: Calculate the stress that the blind flange will experience and calculate the stress and the diameter of the flanges bolt.

Drawings & Diagrams:

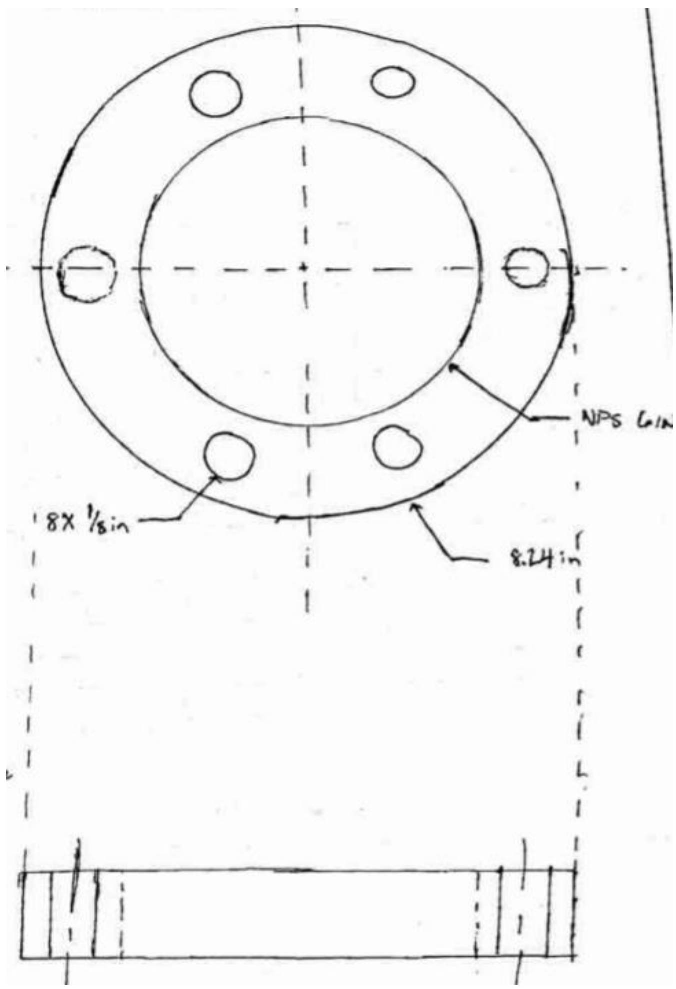


Figure 9

Sources: Mott, Robert L., and Joseph A. Untener. *Applied Fluid Mechanics*. Pearson, 2015.

Design Considerations: Bolts, Flange, pressure from fluid

Procedure: To calculate the force that the blind flange will go through, first calculate the blind flanges area then multiply it by pressure. To calculate the force that each bolt will undergo, divide the force of the blind flange by the number bolts that will be installed onto the blind flange.

Calculations:

BLIND FLANGE SYSTEM 1 15000 GALLON TANK

$P_{max} = (SG_{coolant})(\rho_{water})(h)$
$= (0.94)(62.4\ lb/ft^3)(18$
$= 1055.81\ lb/ft^2$
$= 7.33\ psi$

F(ACTING ON FLANGE)

$A = \frac{\pi}{4}(6\ in)^2$
$= 28.72\ in^2$

$F_{FLANGE} = (7.33\ psi)(28.72\ in^2)$
$= 210.57\ lbs$

$F_{BOLTS} = \frac{210.57\ lbs}{6\ BOLTS} = 35.095\ lbs$

BOLTS ARE A36 CARBON STEEL

$\gamma = 36000\ psi$

ASSUMING THE SAME THICKNESS

$A_{BOLT} = \frac{35.095\ lbs}{36{,}000\ psi} = 0.000975\ in^2$

$d^2_{bolt} = \frac{4}{\pi} \times 0.000975$
$= 0.035234\ in$

REQUIRED DIAMETER
0.035234 in

FOR HIGH FS
1/8 in DIAMETER BOLTS

THICKNESS

$0.144\ in\ (2) = 0.288\ in$
$= 7.3152\ mm$

Summary:

Force blind flange will experience	210.57lbs
Force each bolt will experience	35.095lbs
Diameter of bolts	7.3152mm

Table 12

Materials: Stainless steel, incompressible fluids

Analysis: Knowing that the amount of force the blind flange would go through is large, from the calculations it is determined that the appropriate number of bolts to go with the blind flange is 12 as it would minimize the amount of force each bolt would experience.

Wind Load and weight

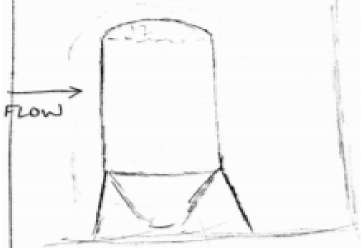
Purpose: To compute the wind load that the pipe system will experience and weight.

Drawings & Diagrams:

TASK 11

WIND LOAD

$D = 12$ ft
$h = 18$ ft



ASSUMING
TYPICAL WIND CONDITIONS
9.2 MPH
WORST CASE AVERAGE
11.7 MPH
TANK IS RECTANGULAR WHEN CALCULATING F_D
SOURCE:
https://WEATHERSPARK.COM/Y/15863/AVERAGE-WEATHER-IN-DAYTON-OHIO-UNITED-STATES-YEAR-ROUND

12 x 18

C_D = COEFFICIENT OF DRAG
V = VELOCITY = 11.7 MPH = 17.16 FT/S
DENSITY OF COOLANT = 58.67 lb/ft³
A = AREA OF TANK
D = DIAMETER
F_D = DRAG FORCE

EQUATIONS

$F_D = C_D (\rho V^2/2) A$

$C_D = \frac{(F_D/A)}{(\rho V^2/2)} = \frac{2F_D}{\rho V^2 A}$

CALCULATIONS

$A = 904.78 \text{ ft}^2$ A: 216 ft²

$\frac{L}{D} = \frac{18}{12} = 1.5$ ft $C_D = 0.88$

$F_D = C_D ((58.67)(17.16)^2)(216)$

$F_D = 3731680.098\ C_D$

$F_D = 3283878.486$ ft²

Sources: Mott, Robert L., and Joseph A. Untener. *Applied Fluid Mechanics*. Pearson, 2015.

Design Considerations: Diameter of the tank, wind velocity

Procedure: To get the wind load, calculate the coefficient of drag needed to calculate the wind load.

Summary:

Wind load(ft^2)
3283878.486

Table 9

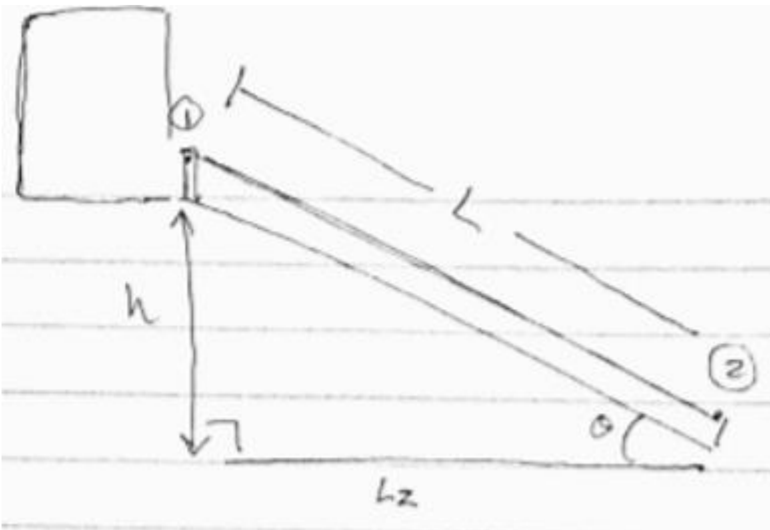
Materials: Stainless steel

Analysis: With the computed wind load, the civil engineers will take care of this task with the computed data given to them.

Open Channel for drainage tank

Purpose: To compute the open channel for draining the tanks.

Drawings & Diagrams:



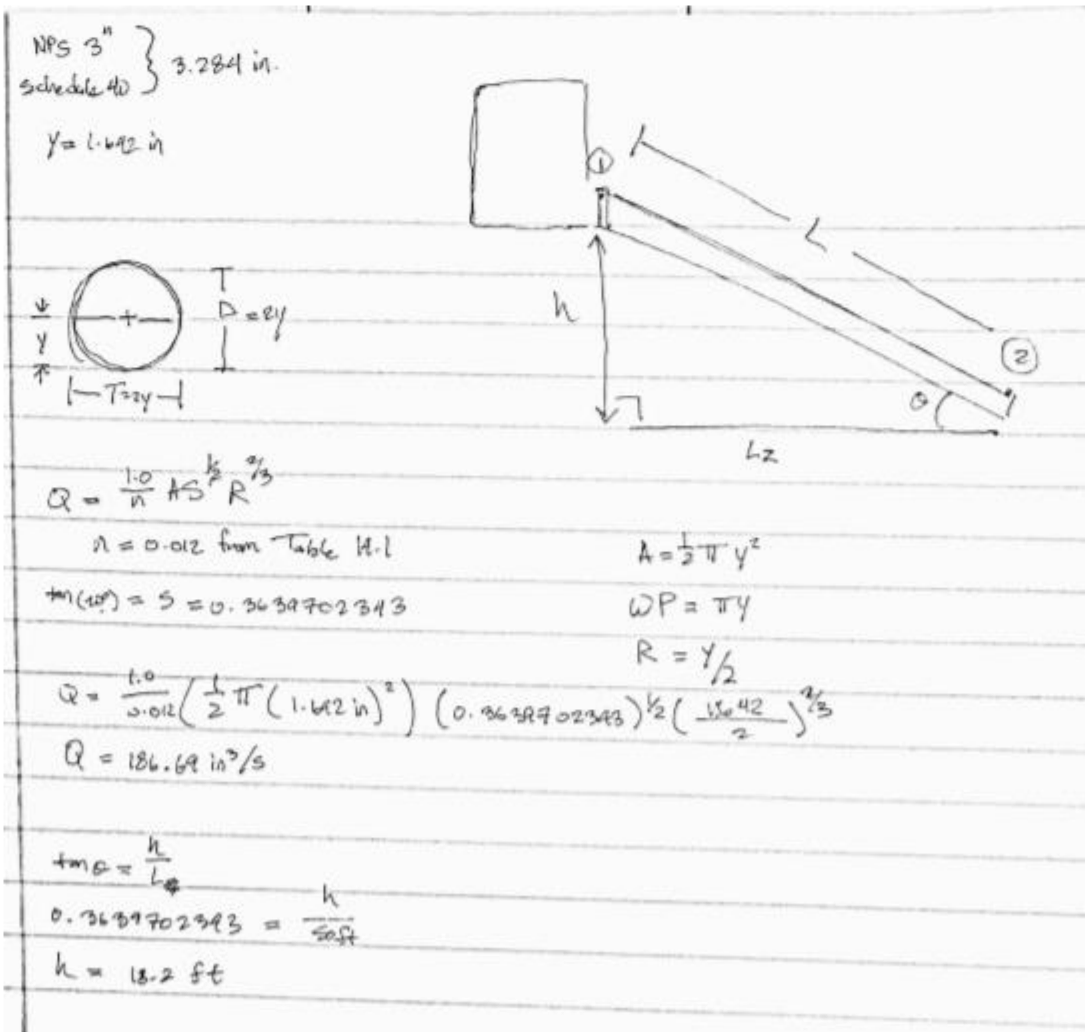
Sources: Mott, Robert L., and Joseph A. Untener. *Applied Fluid Mechanics*. Pearson, 2015.

Design Considerations: Schedule 40 pipes

Data & Variables: Specific weight=1.692 in

Procedure: To get the open channel for the tank, the flow rate must be calculated, as well as the hydraulic radius and height.

Calculations:



NPS 3" schedule 40 } 3.284 in.

$y = 1.642$ in

$$Q = \frac{1.0}{n} A S^{1/2} R^{2/3}$$

$n = 0.012$ from Table 14.1

$\tan(20°) = S = 0.3639702343$

$A = \frac{1}{2}\pi y^2$

$WP = \pi y$

$R = y/2$

$$Q = \frac{1.0}{0.012}\left(\frac{1}{2}\pi(1.642\text{ in})^2\right)(0.3639702343)^{1/2}\left(\frac{1.642}{2}\right)^{2/3}$$

$Q = 186.69\ \text{in}^3/\text{s}$

$\tan\theta = \frac{h}{L_z}$

$0.3639702343 = \frac{h}{50\text{ ft}}$

$h = 18.2$ ft

Summary:

Flow Rate(in^3/s)	186.69
Height(ft)	18.2

Table 10

Materials: Stainless steel, coolant

Analysis: With the open channel designed specifically for this tank, the same method must be used to design an open channel for the other tanks.

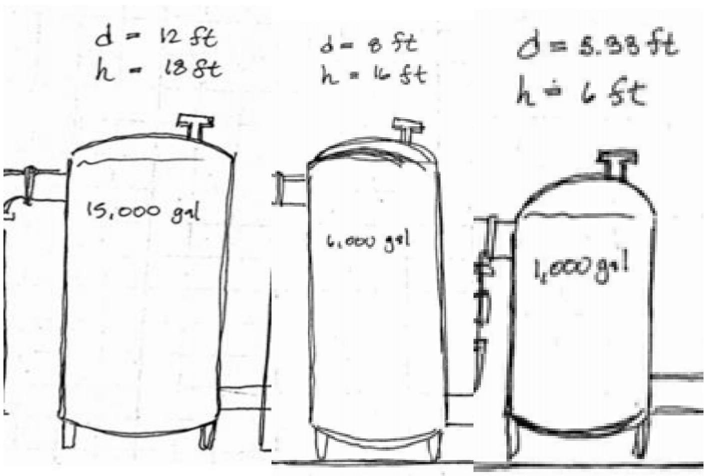
ii. Flow Rate

For the frequency of when to fill the tanks and when to empty them have been specified as the tank that is filled and delivered by the train, comes by every 3 months, and the frequency for the truck to come by and empty the dirty coolant tank is once a month.

Tank fill/empty times

Purpose: To state the fill and empty times of the tank

Drawings & Diagrams:



Sources: Mott, Robert L., and Joseph A. Untener. *Applied Fluid Mechanics*. Pearson, 2015.

Design Considerations: Volume of fluid in each tank, tank size

Data & Variables: d=12ft, 8ft, 5.33ft h=18ft, 16ft, 6ft

Procedure: To get the fill and empty times for the tanks, take the tank size and divide it by the time assumed time to drain it.

Calculations:

TIME REQUIRED

15000 GALLON TANK FROM RAIL CAR

$$\frac{15000 \text{ gallon}}{4 \text{ hrs}} \quad \frac{1 \text{ hr}}{60 \text{ min}} = 62.5 \text{ GPM}$$

65 GPM PUMP

$$\frac{15000 \text{ GAL}}{3 \text{ hrs}} \quad \frac{1 \text{ hr}}{60 \text{ min}} = 83.3 \text{ GPM}$$

85 GPM PUMP

EST. 100 GPM PUMP

PUMP FROM 15000 GAL TANK TO 1000 GAL RESEVO

$$\frac{1000 \text{ gal}}{.5 \text{ hrs}} \quad \frac{1 \text{ hr}}{60 \text{ min}} = 33.3 \text{ GPM}$$

35 GPM ?

$$\frac{1000 \text{ gal}}{10 \text{ min}} = 100 \text{ GPM}$$

-1000 GAL TO ~~MACHINERY~~ DIRTY TANK

$$\frac{6000 \text{ GAL}}{1 \text{ hr}} = 100 \text{ GPM}$$

Summary:

Tanks	Fill time(Hours)	Flow Rate(GPM)
15000 gal	4	65
6000 gal	1	100
1000 gal	0.5	35

Table 3

Materials: Steel pipes, coolant

Analysis: The time it takes to fill the 15000gal tank is 4 hours in order for the cost of it to drain to be less, and the 6000gal tank time to be filled and drain is an hour as since its volume is lesser than the 15000gal tank, it should not take more time to drain it. The 1000gal tank drain and fill time is 0.5 hour since it's the most smaller tank out of three and the dimensions allow for that time of drain and fill time without it being expensive.

Desired flow rate calculations

Purpose: Calculate the desired flow rate for each tank to understand the time to fill and empty each tank.

Drawings & Diagrams:

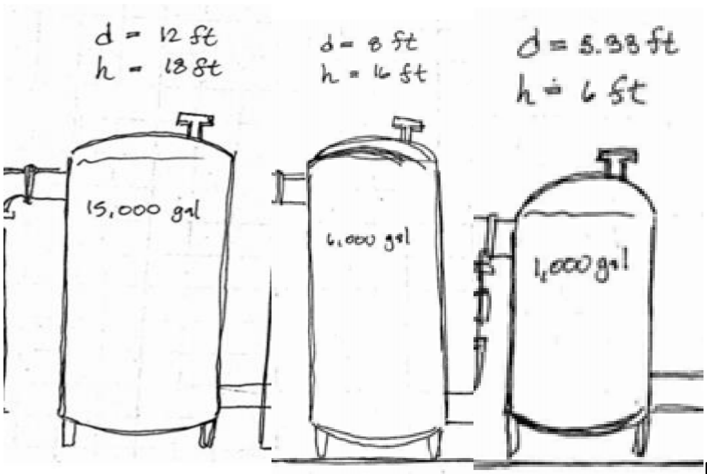


Figure 10

Sources: Figure 10

Design Considerations: Volume of fluid in each tank, pump, Incompressible fluids, constant fluid properties

Data & Variable: SG of coolant= 0.94, 15000 gallons for main storage tank, 6000 gallons for dirty coolant tank, 1000 gallons for reservoir tank

Procedure: To get the flow rate of each tank, take the volume of each tank, and divide it by the desired time for the tank(s).

Calculations:

FLOW RATE

RAIL CAR TO 15000 gallon TANK

$\frac{15000 \text{ gallon}}{4 \text{hrs}}$ (FILL)

$$\frac{15000 \text{ gallon}}{4 \text{hrs}} \cdot \frac{1 \text{hr}}{60 \text{ min}}$$

$= 62.5$ GPM

≈ 65 GPM

15000 GALLON TANK - 1000 gallon TANK (FILL)

$$\frac{1000 \text{ gal}}{.5 \text{ hr}} \cdot \frac{1 \text{hr}}{60 \text{min}} = 33.3 \text{ GPm}$$

$= 35$ GPM

1000 gal TO 6000 gal TANK (FILL)

$$\frac{6000\ \text{gal}}{3\ \text{hrs}} \quad \frac{1\ \text{hr}}{60\ \text{min}} = 33.3\ \text{GPM}$$

$= 35$ GPM

6000 gal TO TRUCK (EMPTY)

$$\frac{6000\ \text{gal}}{2\ \text{hrs}} \quad \frac{1\ \text{hr}}{60\ \text{min}} = 50\ \text{GPM}$$

$= 50$ GPM

Summary:

Systems	Empty/Fill Times
Railcar to 15000-gallon tank	65gpm
15000-gallon tank to 1000-gallon tank	35gpm
1000-gallon tank to 6000-gallon tank	35gpm
6000-gallon tank to exit	50gpm

Table 4

Material: Fluid

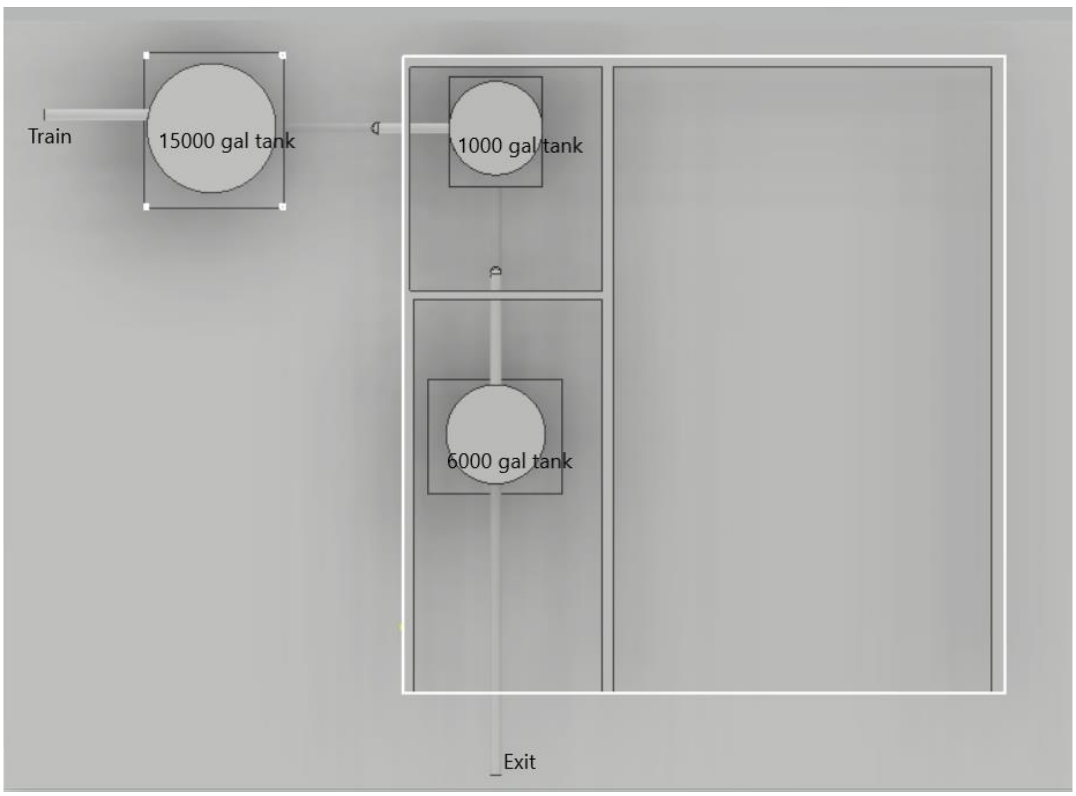
Analysis: The flow rate of each tank is different as the volume of each tank is different yet, it makes sense as the larger tanks will need more time to drain and given that it will take more time will give the chance to have countermeasure if any erros arrive while draining the tanks.

iii.Pipe Sizing

-Pipe Layout:

Purpose: Specify the entire layout of the pipe system and what the material will be used throughout the system.

Drawings & Diagrams:



Sources: Mott, Robert L., and Joseph A. Untener. *Applied Fluid Mechanics*. Pearson, 2015.

Design Considerations: All pipes are Schedule 40

Data & Variables: SG of fluid=0.94, Flow Rate of 15000-gallon tank= 65 GPM, Flow Rate of 1000-gallon tank= 35GPM, 6000-gallon tank flow rate=100 GPM, Critical Velocity =3m/s

Procedure: The layout of the pipes will be that a pipe will be attached to the train to the 15000gal tank, the 15000-gal tank to 1000 gal tank, the 1000 gal tank to the 6000 gal tank, and lastly the 6000 gal tank to the exit.

Calculations: N/A

Summary:

System	Lengths
1	80.5ft
2	25ft
3	63.5ft
4	50ft

Table 5

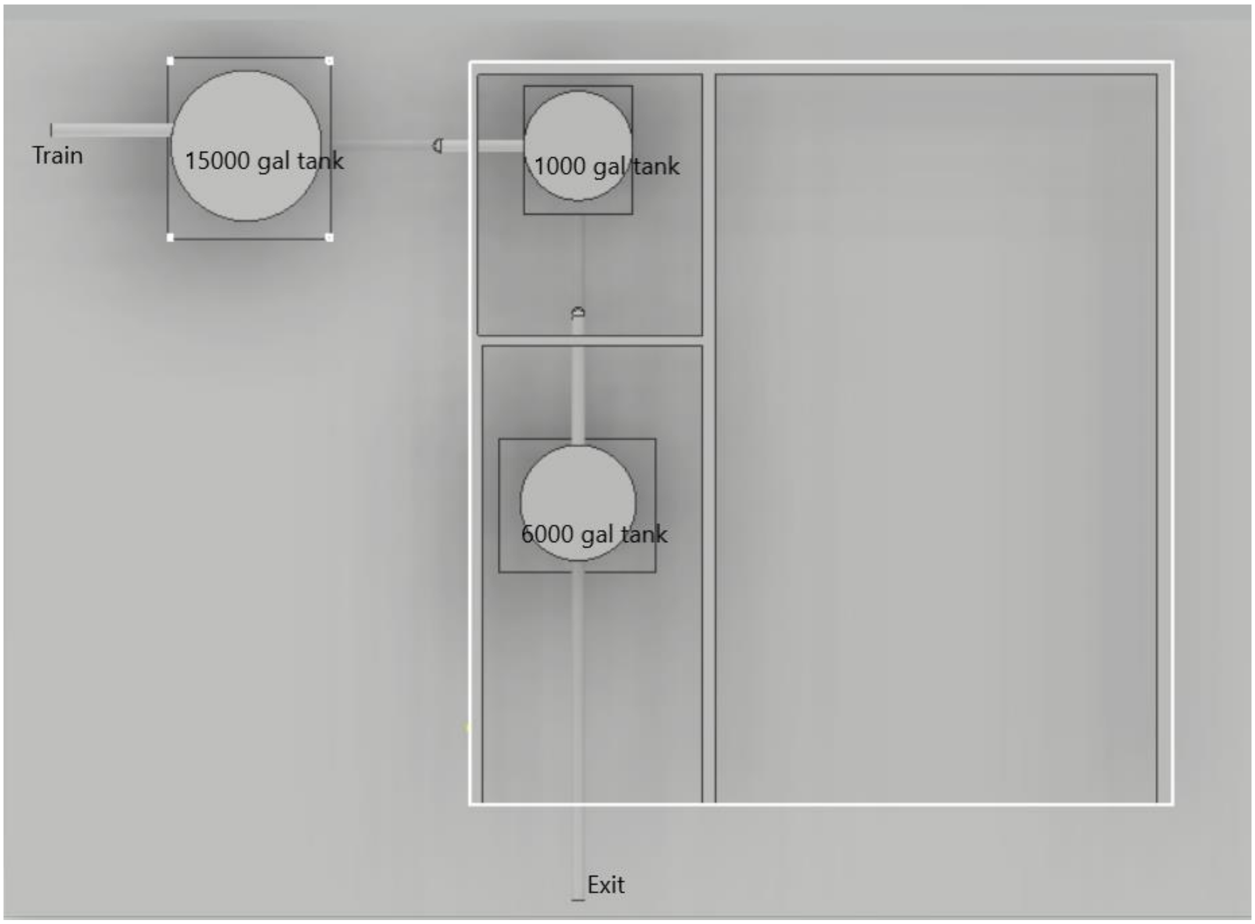
Materials: Stainless Steel pipes

Analysis: The layout chosen for this system was designed to be as simple as possible with no complications to prevent extra costs of trying to layout the pipes in the system. Furthermore, diameters of all pipes in the system were calculated to find out the measurement required to handle the flow rates of each system.

-Pipe Diameter and Lengths:

Purpose: To compute and specify the thickness of the pipes in the system and to present the lengths of the pipes.

Drawings & Diagrams:



Sources: Mott, Robert L., and Joseph A. Untener. *Applied Fluid Mechanics*. Pearson, 2015.

Design Considerations: All pipes are 40 Schedule

Data & Variables: SG of fluid=0.94, Flow Rate of 15000-gallon tank= 65 GPM, Flow Rate of 1000-gallon tank= 33.3 GPM, 6000-gallon tank flow rate=100 GPM, Critical Velocity =3m/s

Procedure: To calculate the sizes of the pipe, take the flow rates previously calculated and the critical velocity and calculate the diameter of all the pipes.

Calculations: N/A

Summary:

System	Lengths
1	80.5ft
2	25ft
3	63.5ft
4	50ft

Pipes	Diameter(ft)
System 1	0.1342
System 2	0.1150
System 3	0.1150
System 4	0.1342

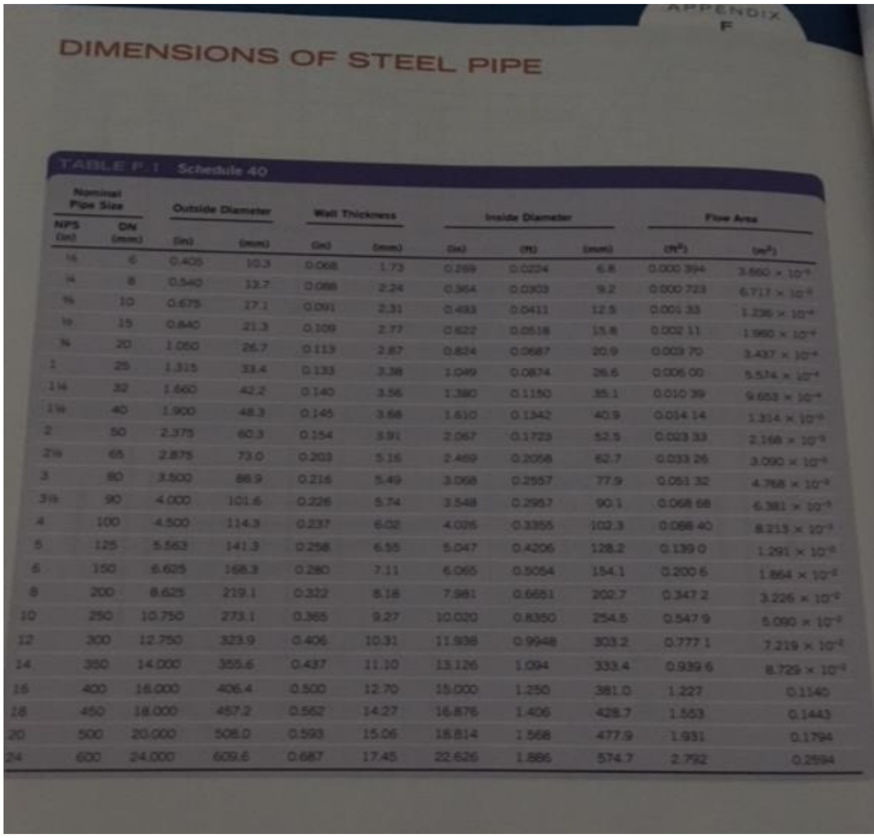
Table 6

Analysis: The diameter of the pipes are appropraites sicne the schedule makes the thickness of these pipes seems appropriate for this system.

-Pipe Thickness:

Purpose: Calculate the pipe thickness of the pipe system & maximum operating pressure.

Drawings & Diagrams:



APPENDIX F

DIMENSIONS OF STEEL PIPE

TABLE F.1 Schedule 40

Nominal Pipe Size		Outside Diameter		Wall Thickness		Inside Diameter			Flow Area	
NPS (in)	DN (mm)	(in)	(mm)	(in)	(mm)	(in)	(ft)	(mm)	(ft^2)	(m^2)
1/8	6	0.405	10.3	0.068	1.73	0.269	0.0224	6.8	0.000 394	3.660×10^{-5}
1/4	8	0.540	13.7	0.088	2.24	0.364	0.0303	9.2	0.000 723	6.717×10^{-5}
3/8	10	0.675	17.1	0.091	2.31	0.493	0.0411	12.5	0.001 33	1.236×10^{-4}
1/2	15	0.840	21.3	0.109	2.77	0.622	0.0518	15.8	0.002 11	1.960×10^{-4}
3/4	20	1.050	26.7	0.113	2.87	0.824	0.0687	20.9	0.003 70	3.437×10^{-4}
1	25	1.315	33.4	0.133	3.38	1.049	0.0874	26.6	0.006 00	5.574×10^{-4}
1 1/4	32	1.660	42.2	0.140	3.56	1.380	0.1150	35.1	0.010 39	9.653×10^{-4}
1 1/2	40	1.900	48.3	0.145	3.68	1.610	0.1342	40.9	0.014 14	1.314×10^{-3}
2	50	2.375	60.3	0.154	3.91	2.067	0.1723	52.5	0.023 33	2.168×10^{-3}
2 1/2	65	2.875	73.0	0.203	5.16	2.469	0.2058	62.7	0.033 26	3.090×10^{-3}
3	80	3.500	88.9	0.216	5.49	3.068	0.2557	77.9	0.051 32	4.768×10^{-3}
3 1/2	90	4.000	101.6	0.226	5.74	3.548	0.2957	90.1	0.068 68	6.381×10^{-3}
4	100	4.500	114.3	0.237	6.02	4.026	0.3355	102.3	0.088 40	8.213×10^{-3}
5	125	5.563	141.3	0.258	6.55	5.047	0.4206	128.2	0.139 0	1.291×10^{-2}
6	150	6.625	168.3	0.280	7.11	6.065	0.5054	154.1	0.200 6	1.864×10^{-2}
8	200	8.625	219.1	0.322	8.18	7.981	0.6651	202.7	0.347 2	3.226×10^{-2}
10	250	10.750	273.1	0.365	9.27	10.020	0.8350	254.5	0.547 9	5.090×10^{-2}
12	300	12.750	323.9	0.406	10.31	11.938	0.9948	303.2	0.777 1	7.219×10^{-2}
14	350	14.000	355.6	0.437	11.10	13.126	1.094	333.4	0.939 6	8.729×10^{-2}
16	400	16.000	406.4	0.500	12.70	15.000	1.250	381.0	1.227	0.1140
18	450	18.000	457.2	0.562	14.27	16.876	1.406	428.7	1.553	0.1443
20	500	20.000	508.0	0.593	15.06	18.814	1.568	477.9	1.931	0.1794
24	600	24.000	609.6	0.687	17.45	22.626	1.886	574.7	2.792	0.2594

Table 3

Sources: Mott, Robert L., and Joseph A. Untener. *Applied Fluid Mechanics*. Pearson, 2015.

Design Considerations: Pipes diameter measurements are all Schedule 40 Pipe

Data & Variables: Y=0.4, S=248.2Mpa, E=1.0, P=0.5

Procedure: To obtain the thickness of the pipes, use the formula used previously: $t = \frac{P*D}{2(SE+PY)}$ we must also use the diameters calculated previously for the pipes.

Calculations:

PIPE WALL THICKNESS

SYSTEM 1

$\frac{65 \text{ gal}}{\text{min}} \quad \frac{1 \text{ min}}{60 \text{ sec}} \quad \frac{0.0.0378 \text{ m}^3}{\text{gal}} = 0.004095 \text{ m}^3/\text{s}$

$0.004095 \text{ m}^3/\text{s} = (3 \text{ m/s})(\pi/4 \, d^2)$

$$\sqrt{\frac{\left(\frac{0.004095 \text{ m}^3/\text{s}}{3 \text{ m/s}}\right)}{\pi/4}} = d$$

$d = 0.041689 \text{ m}$

$= 41.689 \text{ mm}$

NPS $1\frac{1}{2}$ SCH 40

SYSTEM 2

$\frac{35 \text{ gal}}{\text{min}} \quad \frac{1 \text{ min}}{60 \text{ sec}} \quad \frac{0.0.0378 \text{ m}^3}{\text{gal}} = 0.0.02205 \text{ m}^3/\text{s}$

$$d = \sqrt{\frac{\left(\frac{0.002205 \text{ m}^3/\text{s}}{3 \text{ m/s}}\right)}{\pi/4}}$$

$= 0.030091 \text{ m}$

$= 30.5 \text{ mm}$

NPS $1\frac{1}{4}$ SCH 40

SYSTEM 3

35 gpm

SYSTEM 4

$$\frac{50\ \text{gal}}{\text{min}} \cdot \frac{1}{60\ \text{sec}} \cdot \frac{0.00378\ m^3}{\text{gal}} \approx 0.00315\ m^3/s$$

$$d = \sqrt{\frac{\left(\frac{0.00315\ m^3/s}{3\ m/s}\right)}{\pi/4}}$$

$$= 0.036564\ m$$
$$= 36.5\ mm$$

NPS 1½ SCH 40

Summary:

System	Thickness(mm)
1	41.68
2	30.5
3	30.5
4	36.5

Table7

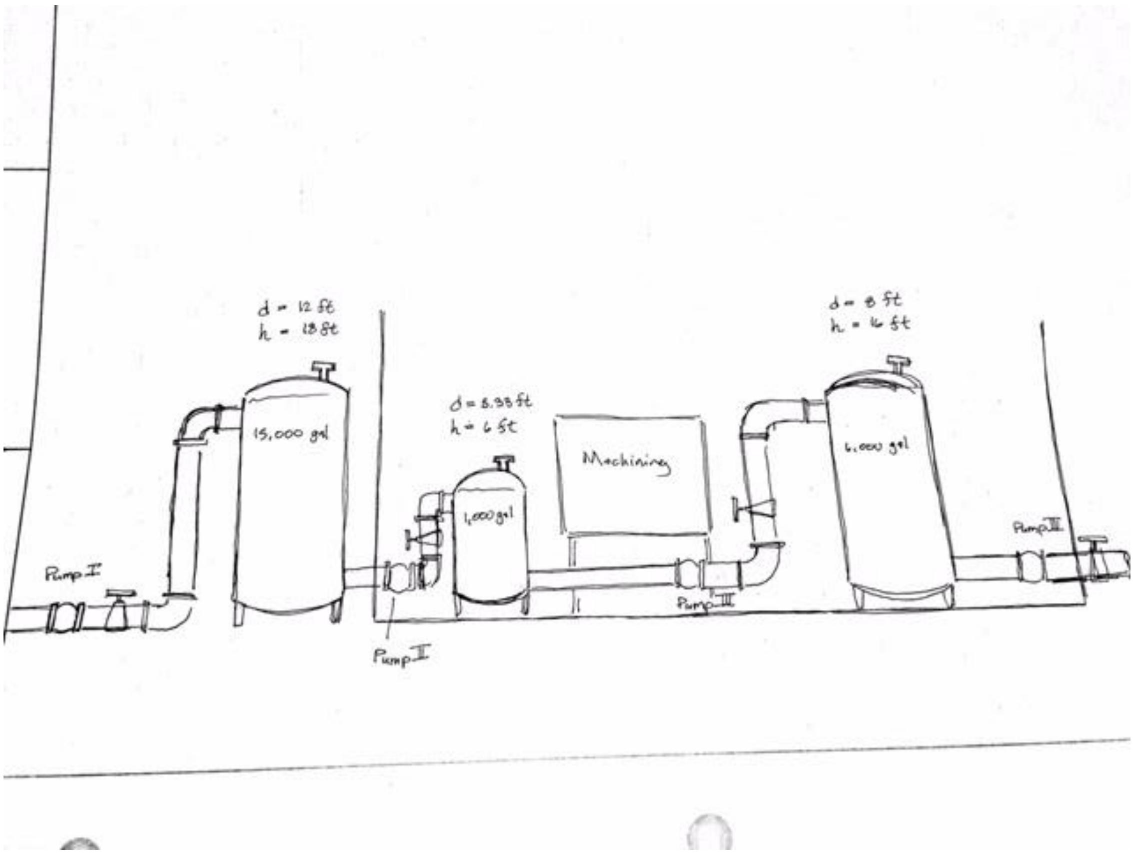
Materials: Stainless steel pipes.

Analysis: While the calculated thickness may not be the same to the actual thickness to the other pipes in the system, we're still using the thickness measurement in case of failure were to happen in the pipeline system.

Pipe Fittings

Purpose: State the fittings of the pipes, such as the valves, and pumps.

Drawings & Diagrams:



Sources: Figure11

Design Considerations: All the pipes, valves, and pumps are made from A36 stainless steel. They all have the thickness and diameter of 3 NPS Schedule 40.

Data & Variables: The flow rate of the 15000-gal tank pump is 65 GPM, flow rate of 6000-gal tank pump is 100 GPM, and the flow rate of the 1000-gal tank pump is 33.3 GPM.

Procedure: With the figure representing the pipe layout for the storage tanks, valves, and pumps have been designated to each pump regarding the needs to pump the fluid inside the tanks and valves included to prevent substantial energy loss and to control the flow rate as well.

Calculations: N/A

Summary: There are a total of 6 elbow pipes in the system and a total of 4 gate valves included onto the pipeline system.

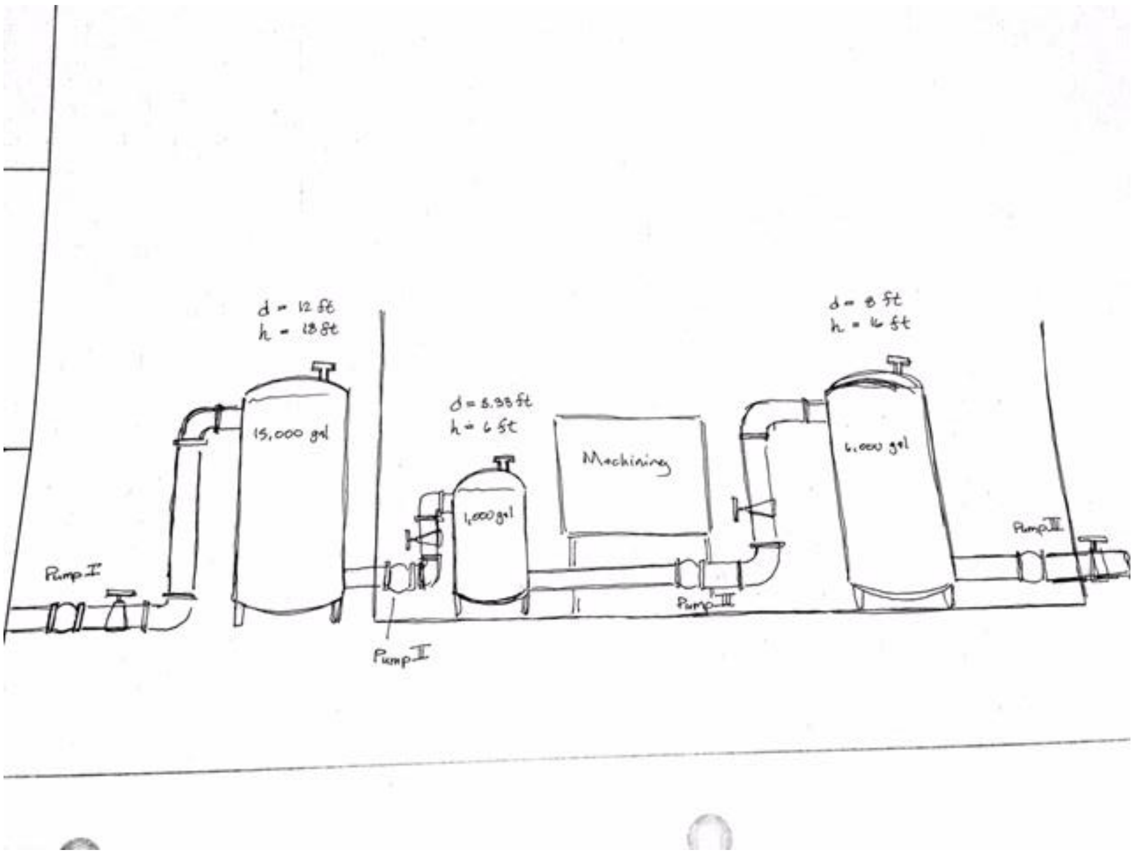
Materials: Stainless steel pipes, Coolant

Analysis. The inclusion of the valves and unique elbow pipes that are on the pipe system was included to control the energy flowing through the system, and to prevent any mistake or problem that could happen in the system. Furthermore, they were also included so that the fluids can get around the inside of the building without making any complication during shifts.

Water Hammer

Purpose: To calculate and show if there is any water hammer happening on one of the systems.

Drawings and diagrams:



Sources: Mott, Robert L., and Joseph A. Untener. Applied Fluid Mechanics. Pearson, 2015

Design Considerations: Steel pipes are Schedule 40

Data and Variables: P= 22.5psi

Calculations:

WATER HAMMER

$$c = \frac{\sqrt{\frac{E_v}{\rho}}}{\sqrt{1 + \frac{E_v D}{E \delta}}}$$

$$= \frac{\sqrt{\frac{6.34E7}{1.8234}}}{\sqrt{1 + \frac{6.3467(0.2657)}{4.789(0.216)}}}$$

$c = 5858.84$

65 GPM

$\Delta P = \rho c V$

$(1.8234)(5858.84)(8.79251)$

$\frac{\pi}{4} d^2$

$= 93941.1$ psf $= 652.369$ psi

$A = \frac{\pi}{4}(3.068)^2$

$= 7.39264$

$P_{op} =$

$P_{op} = 22.5$ psi

$= 3240$ psf

$\frac{65}{7.39265} = 8.79251$

NO WATER HAMMER ON SECTION 1

TRAIN TO PUMP TO 15000 - gallon TANK

Summary: From the calculations, there will be no water hammer occuring on section 1

Materials: Stainless steel. Coolant

Analysis: From the given pressure of the 15000 gal tank, water hammer shouldn't occur as the value for water hammer to happen is not near to the pressure emmited by the tank.

iv. Pipeline supports:

Purpose: Given information needed for the supports to be added to the pipeline system

Drawings & Diagrams:

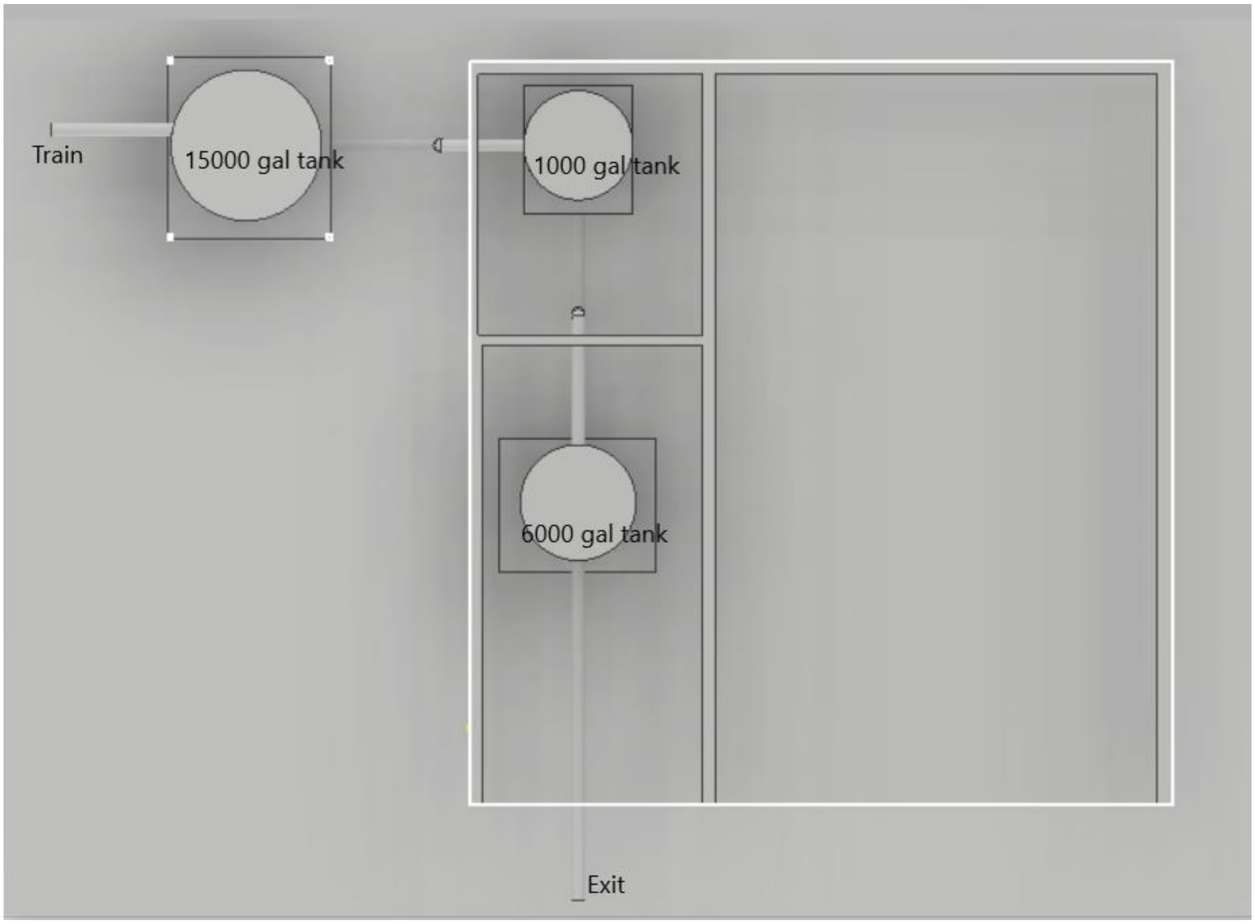


Figure 12

Sources: Figure 12

Design Considerations: 1.25 NPS Schedule 40,

Data & Variables: E= 29,000,000

Procedure; To obtain the deflection of the support, the weight of the pipe and fluid must be calculated, as well as converting the diameter to 1% to reduce the computed deflection

Calculations:

$\delta_o = 1.660 in \rightarrow 0.1383 ft$

$d_i = 0.1150 ft$

Pipeline support for system C

$$W_P = \frac{7700\pi(0.1383^2 - 0.1150^2)}{4} = 35.6916$$

$$W_F = \frac{1.940\pi(0.1383^2 - 0.1150^2)}{4} + \frac{(1.940\pi\ 0.1383^2)}{4} = .0381316$$

$$35.6916 + .0381316 = 35.7216$$

$$I = \frac{\pi(0.1383^2 - 0.1150^2)}{64} = 2.89 \times 10^{-4}$$

$$\delta_{max} = \frac{35.7216(63.5 ft)}{\frac{\pi(0.001383^2 - 0.001150^2)}{4}(29{,}000{,}000 psi)}$$

$$\underline{\delta_{max} = 171.13 ft}$$

Summary:

Deflection(ft)	171.13ft

Table 11

Materials: Stainless steel, coolant

Analysis: The deflection seems necessary for the support as it won't bend as much when the fluid reaches to that part of the pipe where the support is at.

v. Energy Losses

Purpose: Develop a hydraulic analysis of the pipe system showing the minor losses, and the friction losses.

Drawings & Diagrams:

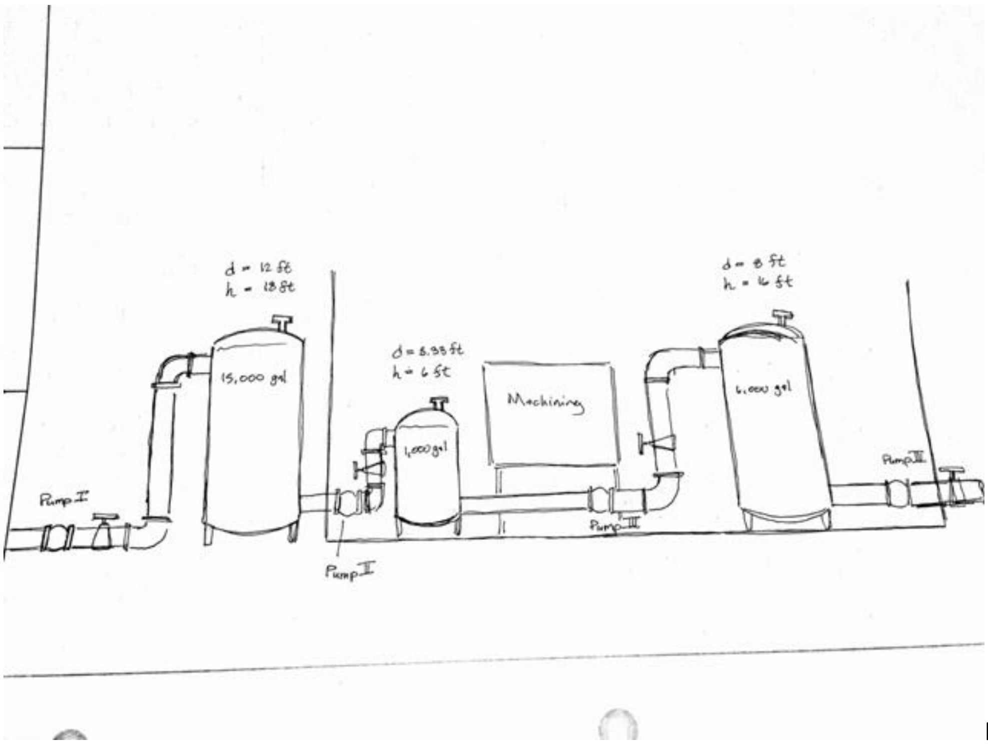


Figure 11

Sources: Figure 11

Design Considerations: Schedule 40 pipe, Flow rate, Incompressible fluids. Valves, elbow pipes

Data & Variables: Height of 1000gal tank=6ft, Height of 6000gal tank=16ft

Procedure: To get the energy losses in the system, Bernoulli's equation must be used and manipulated to get the energy losses. Also included to the equation are the valves, and elbow pips as they affect the flow of the fluid in the system.

Calculations:

15000gal tank to pump (System 1):

PIPE DIAMETER

$Q = VA \quad A = \frac{\pi}{4} d^2 \quad V = \frac{Q}{A}$

$$\frac{65 \text{ gal}}{\text{min}} \left| \frac{1 \text{ min}}{60 \text{ sec}} \right| \frac{0.0378 m^3}{\text{gal}} = 0.004095 \ m^3/s$$

$0.004095 \ m^3/s = (3 m/s)(\pi/4 \, d^2)$

$\frac{0.004095 m^3/s}{3 m/s} = \frac{\pi}{4} d^2$

$0.001365 m^2 = \frac{\pi}{4} \cdot d^2$

$\sqrt{\frac{0.001365 m^2}{\pi/4}} = d$

$d = 0.041689 m$
$= 41.689 mm$

NPS $1 \cdot \frac{1}{2}$ SCH 40

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

$$h_A = (z_2 - z_1) - \frac{V_1^2}{2g} + h_L$$

$$A = \frac{\pi}{4} (\overset{40.9}{\cancel{0.1342}} mm)^2$$

$= 1313.82 \ mm^2$

$V = \frac{0.004098 m^3/s}{0.00131382 m^2}$
$= 3.11687 \ m/s$

$$h_A = (23\,ft - 2.5\,ft) - \left(\frac{3.11687\,m/s}{2(9.81\,m/s)}\right) + h_L$$
$$= (7.0104\,m - 0.762\,m) - 0.158862\,m + h_L$$
$$= 6.2484\,m - 0.158862 + h_L$$
$$= 6.08984\,m + h_L$$

$$h_L = f \frac{L}{D} \frac{V^2}{2g} + 2(K_v f_t) + K_{exit}$$

ASSUMING FULLY OPEN GATE VALVE + STANDARD 90° ELBOW + NEW, CLEAN, COMMERCIAL STEEL PIPE

$$f\left(\frac{24.5424\,m}{0.0409\,m}\right)\left(\frac{3.11687^2}{2(9.81)}\right) + 2(8(0.019))\frac{3.11687^2}{2(9.81)} + 30(0.019)\frac{3.11687^2}{2(9.81)}$$

$$297.12f + 0.150526 + 0.282237$$
$$297.12f + 0.432763\,m$$

$$\frac{0.0409\,m}{4.6\times10^{-5}\,m} = 889.13$$

$$\frac{D}{\varepsilon} = 889.13$$

$$R_e = \frac{VD\rho}{\eta}$$

$$\rho = (0.94)(1000\,kg\cdot m^3)$$
$$= 940\,kg$$

$$\eta = (1.75\times10^{-3}\,Pa\cdot s)(1.5)$$
$$= 0.002625\,Pa\cdot s$$

$D = 0.0409\,m$
$V = 3.11687\,m/s$

$$R_e = 45650$$

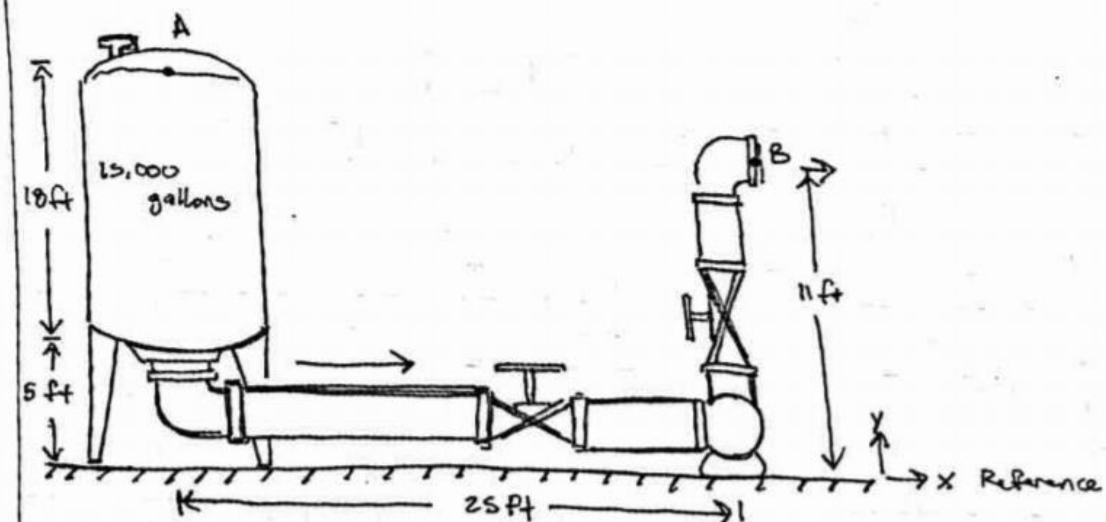
$f = 0.0246$ FROM MOODY CHART

$$h_L = (0.0246)(297.12\ m) + 0.432763$$
$$= 7.74\ m = 25.39\ ft$$

$$h_A = 6.08954\ m + 7.74\ m$$
$$= 13.83\ m = 45.374\ ft$$

15000gal tank to 1000gal tank (System 2):

System 2



NPS $1\frac{1}{4}$

$D_i = 1.3052 \text{ in} \Rightarrow 0.0351 \text{ m}$

$Q = 35 \text{ gal/min} \Rightarrow 0.00220816 \text{ m}^3/\text{s}$

$A = 9.68 \times 10^{-4} \text{ m}^2$

$$\cancel{\frac{P_A}{\gamma}}^{0} + \cancel{\frac{v_A^2}{2g}}^{0} + z_A + h_A = \cancel{\frac{P_B}{\gamma}}^{0} + \frac{v_B^2}{2g} + z_B + h_{L_{A-B}}$$

$$h_A = (z_A - z_B) - \frac{v_B^2}{2g} + h_{L_{A-B}}$$

$z_A = 7.0104 \text{ m}$

$z_B = 3.3528 \text{ m}$

$$v_B = \frac{Q}{A} = \frac{0.00220816}{9.68 \times 10^{-4}} = 2.281157025 \text{ m/s}$$

$$h_{L_{A-B}} = f \frac{L}{D} \frac{v_B^2}{2g} + 2(8 f_T) + 2(30 f_T)$$

System 2

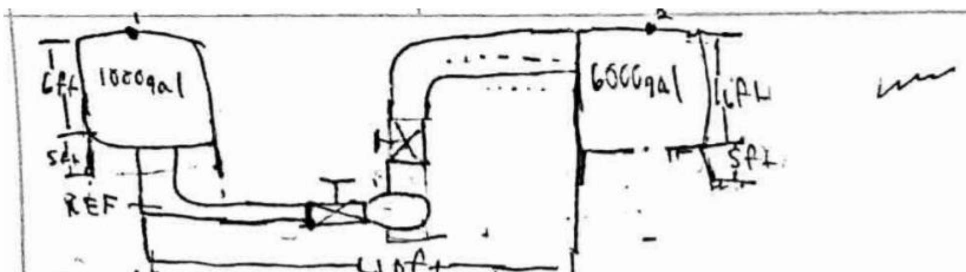
$$h_{L_{A-B}} = (0.0268005226)\frac{7.62m}{0.0351}\left(\frac{2.28457025^2}{2(9.81)}\right) + 2(8(0.015)) + 2(30(0.018))$$

$$h_{L_{A-B}} = 2.674312987 \text{ m}$$

$$h_A = (7.0104 - 3.3528) - \frac{2.28457025^2}{2(9.81)} + 2.674312987$$

$$h_A = 6.066689879 \text{ m} \Rightarrow \boxed{19.903888 \text{ ft}}$$

1000gal tank to 6000gal tank (System 3):



$$\frac{35\text{gal}}{\text{min}}\left|\frac{1\text{min}}{60\text{sec}}\right|\frac{0.00378}{\text{gal}} = 0.02205 \text{ m}^3/\text{s}$$

$$0.02205/3 = 7.35\times10^{-4}/(\pi/4) = \sqrt{9.35\times10^{-4}} = .0305 \text{ m} = 30.5 \text{ mm}^2$$

So NPS is 1¼ NPS schedule 40

$$\frac{35\text{gal}}{\text{min}}\left|\frac{1\text{min}}{60\text{sec}}\right|\frac{0.133\text{ft}^3}{\text{gal}} = 0.0775 \text{ ft}^3/\text{s}$$

$$Q = VA \rightarrow V = \frac{0.0775 \text{ ft}^3/\text{s}}{\pi/4 \cdot 0.1150^2} = 7.46 \text{ ft}^3/\text{s}$$

$$R_E = \frac{(7.46 \text{ ft}/\text{s})(0.1150)(940)}{(1.75\times10^{-3} \text{ Pa}\cdot\text{s})(1.5)} = 3.07\times10^5$$

$$D/\varepsilon = \frac{0.1150 \text{ ft}}{1.5\times10^{-4}} = 766.6 \text{ ft}$$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(766.6\text{ft})} + \frac{5.74}{(3.07\times10^5)^{0.9}}\right)^2\right]} = 0.021$$

$K_{valve} = 8(.021) = 0.175 \quad K_{elbow} = 1.89$

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

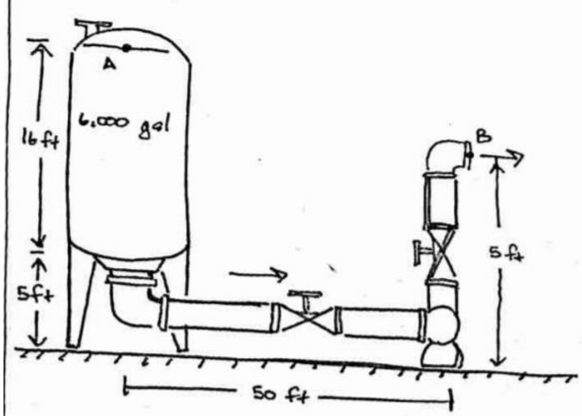
$$h_L = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g} + K_{elbow}\frac{V^2}{2g} + K_{valve}\frac{V^2}{2g} + K_{valve}\frac{V^2}{2g} + K_{elbow}\frac{V^2}{2g}$$

$$h_L = 0.021 \cdot \frac{63.5}{0.1150} \times \frac{7.46^2}{2(32.2)} + (1.89)\left(\frac{7.46^2}{2(32.2)}\right) + (0.175)\left(\frac{7.46^2}{2(32.2)}\right) + (0.175)\left(\frac{7.4}{2(3}\right.$$
$$+ (1.89)\left(\frac{7.46^2}{2(32.2)}\right)$$

$$h_L = 13.5894\,ft$$

6000 to exit (System 4):

System 4



NPS $1\frac{1}{5}$
$D_i = 0.0409\,m$
$Q = 0.00315451\ m^3/s$
$A = 1.31 \times 10^{-3}\ m^2$

$$\cancel{\frac{P_A}{\gamma}}^{0} + \cancel{\frac{V_A^2}{2g}}^{0} + z_A + h_A = \cancel{\frac{P_B}{\gamma}}^{0} + \frac{V_B^2}{2g} + z_B + h_{L_{A-B}}$$

$$h_A = (z_A - z_B) - \frac{V_B^2}{2g} + h_{L_{A-B}}$$

$z_A = 21ft \Rightarrow 6.4008\,m$
$z_B = 5ft \Rightarrow 1.524\,m$

$$V = \frac{Q}{A} = \frac{0.00315451}{1.31\times10^{-3}} = 2.408022901\ m/s$$

$$h_{L_{A-B}} = f\frac{L}{D}\frac{V_B^2}{2g} + 2(8f_T) + 2(30f_T) \Rightarrow (0.0318)\frac{15.24}{0.0409}\left(\frac{2.408^2}{2(9.81)}\right) + 2(8(0.02)) +$$

$$h_{L_{A-B}} = f\frac{L}{D}\frac{V_B^2}{2g} + 2(8f_T) + 2(30f_T) \Rightarrow (0.0318)\frac{15.24}{0.0409}\left(\frac{2.408^2}{2(9.81)}\right) + 2(8(0.02)) + 2(30(0.02))$$

$$Re = \frac{\rho V D}{\mu} \ @ T = 0°C$$

$$\rho = 1000\ kg/m^3$$

$$\mu = (1.75 \times 10^{-3} Pa\cdot s) \times 1.5 = 0.002625\ Pa\cdot s$$

$$h_{L_{A-B}} = 5.016732408\ m$$

$$Re = \frac{(1000)(2.408022901)(0.0409)}{0.002625} = 37519.29015$$

$$\varepsilon = 4.6 \times 10^{-5}\ m$$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(D/\varepsilon)} + \frac{5.74}{Re^{0.9}}\right)\right]^2} = 0.0317525433$$

$$f_T = 0.02$$

$$h_A = (6.4008 - 1.524) - \frac{2.408022901^2}{2(9.81)} + 5.016732408$$

$$4.8768 - 0.2955440816 + 5.016732408$$

$$h_A = 9.597988356\ m \Rightarrow \boxed{31.48946\ ft}$$

Summary:

System	Energy Losses
1	45.57ft
2	19.90ft
3	13.58ft
4	31.48ft

Table 8

Materials: Stainless steel pipes and elbows

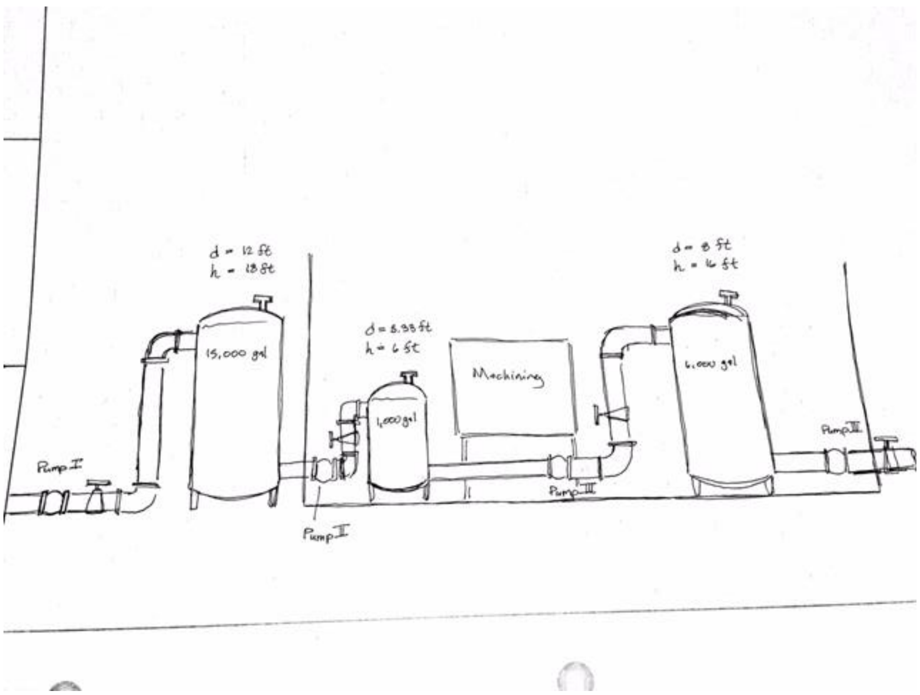
Analysis: All the data in the calculations are necessary for obtaining the energy losses in the system. The values are obtained through conversion. Bernoulli's equation is very useful in this problem as it sets up the procedure to solve for the energy losses in the system.

vi. Pump Selection:

-Pump requirements

Purpose: Provide the required information such as number of pumps required, pump head and flow rate.

Drawing & Diagrams:



Sources: Figure 11

Design Considerations: Schedule 40 pipe

Data & Variables: sg=0.94, flow rate of 15000-gal tank=65 GPM, flow rate of 6000-gal tank=100 GPM, flow rate of 1000-gal tank= 33.3 GPM.

Procedure: To get the pump head, must use the Bernoulli's equation, however a modified version of the equation must be used to calculate the pump head. $hA = hl + Z$ is the equation we'll be using, and the Z's are the height of the pipes that are connected to the pumps.

Calculations:

System 1:

$$h_A = 6.08954\,m + 7.74\,m$$
$$= 13.83\,m = 45.374\,ft$$

System 2:

$$h_A = (7.0104 - 8.3528) - \frac{2.26157025^2}{2(9.81)} + 2.674312987$$
$$h_A = 6.066689879\,m \Rightarrow \boxed{19.903838\,ft}$$

System 3:

$$h_A = h_L + (Z_A - Z_B)$$
$$19.5 + 13.58$$
$$h_A = 33.08\,ft$$

System 4:

$$h_A = (6.4008 - 1.524) - \frac{2.408022901^2}{2(9.81)} + 5.016732408$$
$$4.8768 - 0.2955440516 + 5.016732408$$
$$h_A = 9.597988356\,m \Rightarrow \boxed{31.48946\,ft}$$

Summary:

System #	Pump head(ft)
1	45.37

2	19.90
3	33.08
4	31.48

Table 9

Materials: Pumps, Valves

Analysis: Pumps were added to our pipeline system to prevent the case of a significant loss in energy in the flow of the fluids. Valves were added as well to help circulate the flow of the coolant and make sure that there is no extra loss in energy.

Selection of Pump Type

Purpose: Specify the number of pumps, their types, flow capacities, head requirements, and the power required

Drawings and Diagrams:

Figure 12

Sources: Mott, Robert L., and Joseph A. Untener. Applied Fluid Mechanics. Pearson, 2015.

Design Considerations: Schedule 40 pipes, fixed speed

Data & Variables: N=1775rpm, Specific weight= 58.656

Procedure. To obtain the power, multiply the flow rate by the head loss of which specific system, and the specific weight of the fluid. To obtain speed, multiply the desired speed by the square root of the flow rate, then divide the result by the pump head of the system to the power ¾. The type of pump we will be using is a kinetic pump, and the radial version will be the best type to do the job.

Calculations:

Train to 15000gal tank (System 1):

$h_A = 45.374$ ft $Q = 65$ gpm $\rightarrow \frac{65 \text{gal}}{\text{min}} \left| \frac{1 \text{min}}{60 \text{sec}} \right| \frac{0.133 ft^3}{1 \text{gal}} = 0.144 ft^3/s$

$N = 1775$ rpm $\gamma = 58.656$

$P = \gamma Q h_A \rightarrow (45.374 \text{ ft})(0.144 ft^3/s)(58.656) = 383.25$ lb/s

$N_S = \frac{N\sqrt{Q}}{h_A} = \frac{1775 \text{rpm} \sqrt{0.144 ft^3/s}}{(45.374 ft)^{3/4}} = 38.52$ rpm

15000 gal tank to 1000 gal tank (System 2):

$h_A = 23.2$ ft $Q = 0.07798$ ft^3/s

$P = (23.2 ft)(0.07798 ft^3/s)(58.656) = 91.022$ lb/s

$N_s = \frac{1775 \text{rpm} \sqrt{0.07798 ft^3/s}}{(23.2 ft)^{3/4}} = 46.88$ rpm

1000 gal tank to 6000 gal tank (System 3):

$h_A = 33.08$ ft $Q = 0.0649$ ft^3/s

$P = (33.08 ft)(0.0649 ft^3/s)(58.656) = 125.92$ lb/s

$N_s = \frac{1775 \text{rpm} \sqrt{0.0649 ft^3/s}}{(33.08)^{3/4}} = 32.78$ rpm

6000 gal tank to truck (System 4):

$h_A = \cancel{29.54}$ ft $Q = 50$ GPM $\rightarrow 0.1114$ ft^3/s
31.48

$P = (\cancel{29.54}$ 31.48 ft$)(0.1114 ft^3/s)(58.656) = \cancel{193.02}$ lb/s 205.69

$N_s = \frac{1775 \text{rpm} \sqrt{0.1114 ft^3/s}}{(\cancel{29.54} ft)^{3/4}} = \cancel{46.75 \text{rpm}}$
31.48
44.5774 rpm

Summary:

Systems	Power(lb/s)	Speed(rpm)
1	383.25	38.52
2	91.022	46.88
3	125.92	32.78
4	205.69	44.57

Table 13

Materials: Pumps, stainless steels

Analysis; The power, and speed calculated seem appropriate for the pumps since the speed desired was implemented onto one of the equations. Our reasoning for using a kinetic energy pump over a positive displacement pump is because positive displacement pumps are mainly used for very viscous fluids, and for multiphase flows, for which this project has neither of those requirements for a positive displacement pump. We're using a radial pump because the speed that is desired for this system is where the radial pump can maintain.

Pump Curves, System Curves, operating task point

Purpose: Specify the characteristics of the chosen pumps, point of operations, and the actual pump size and the weight.

Drawings & Diagrams:

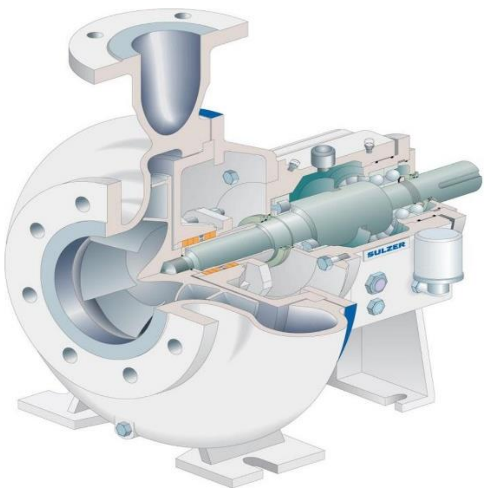


Figure 13

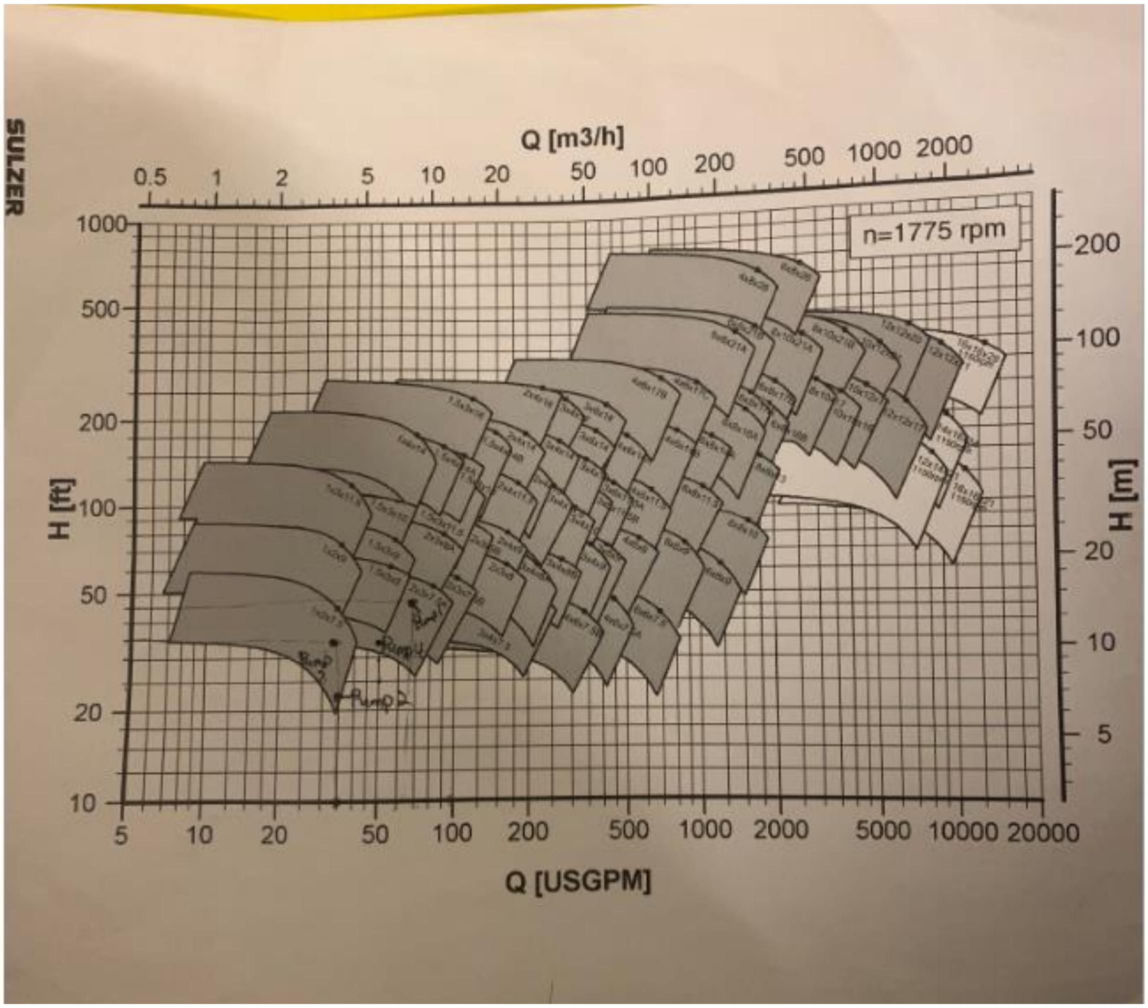
Sources: Mott, Robert L., and Joseph A. Untener. Applied Fluid Mechanics. Pearson, 2015.

Design Considerations: Schedule 40 pipe, Pump head

Data & Variables: Impeller= 4.50in, hA= 45.37ft, 31.49ft, 19.9ft, 33.08ft

Procedure: To select our pumps, we used our flowrate of the tanks, and the pump head from them as well to indicate from the Sulzer pump catalogue on which pump is the best to use for our system.

Calculations:


SULZER
Q [m3/h]
0.5 1 2 5 10 20 50 100 200 500 1000 2000
n=1775 rpm
H [ft]
1000 500 200 100 50 20 10
H [m]
200 100 50 20 10 5
5 10 20 50 100 200 500 1000 2000 5000 10000 20000
Q [USGPM]

CHARACTERISTICS OF PUMP

PUMP 1 + PUMP 4

2x 3 x 7.5a

332 lbs

BASE = 800 lbs

PUMP 2 + PUMP 3

1x 2 x 7.5

311lbs

BASE = 800lbs

2 x 3 x 7.5A Graph

Pump 1 : 4.50 in

$h_A = 45.374$ ft

$Q = 65$ gal/min $\Rightarrow$ 14.7631 m^3/h

IMPELLER = 4.50 in

Efficiency = 35%

Pump 4

$h_A = 31.49$ ft

$Q = 50$ gal/min $\Rightarrow$ 11.3562 m^3/h

impeller = 4.50 in

Efficiency = 35%

1 x 2 x 7.5-1

Pump 2

h_A = 19.9 ft

Q = 35 gal/min

Impeller = 4.50 in

effeciency = 25%

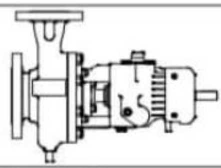
Pump 3

h_A = 33.08 ft

Q = 35 gal/min

impeller = 4.50 in

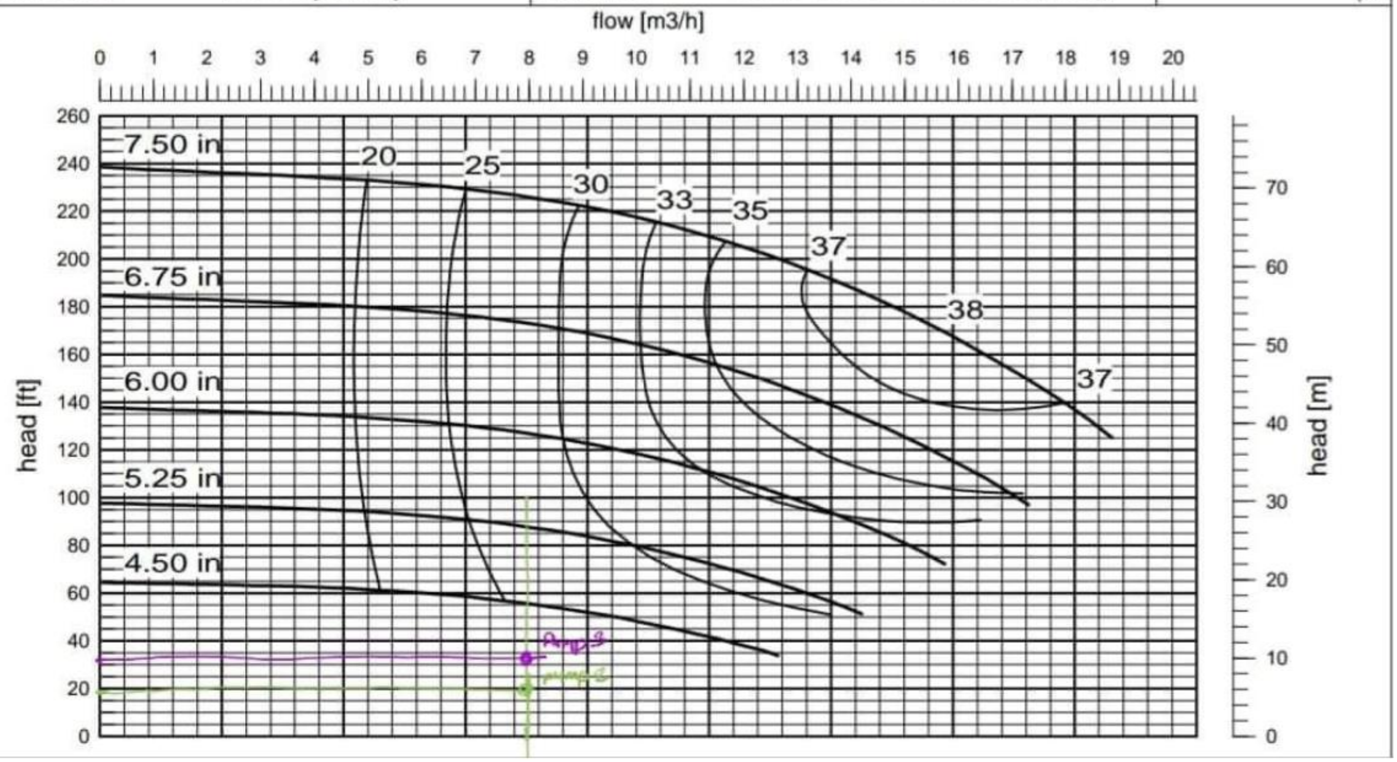
effeciency = 25%

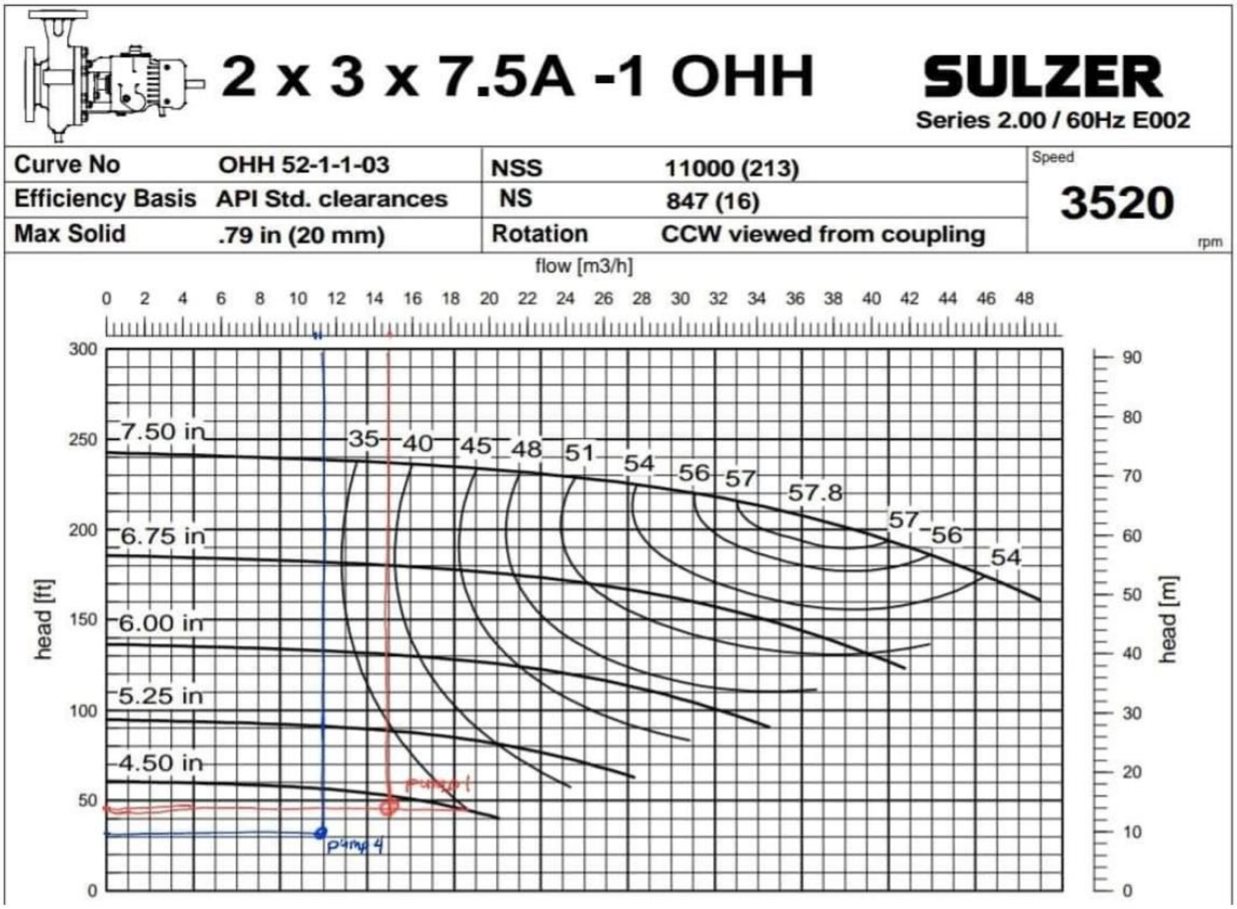


1 x 2 x 7.5 -1 OHH

SULZER
Series 2.00 / 60Hz E001

Curve No	OHH 53-1-1-02	**NSS**	10190 (197)	Speed
Efficiency Basis	API Std. clearances	**NS**	560 (11)	**3520**
Max Solid	.20 in (5 mm)	**Rotation**	CCW viewed from coupling	rpm





Summary:

Pump#	Pump head(ft)	Efficiency (%)	Impeller(in)	Flow Rate(gpm)
1	45.374	35	4.5	65
2	19.9	25	4.5	35
3	33.08	25	4.5	35
4	31.49	35	4.5	50

Table 14

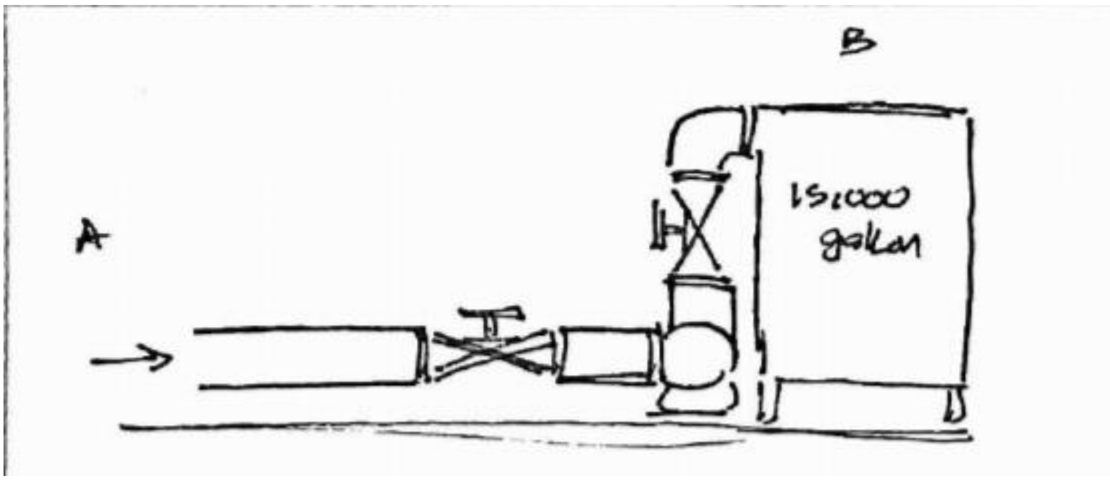
Materials: Stainless steel pipes, Sulzer pumps

Analysis: With the already known information given to use by previous tasks, the selection of the pumps wasn't too difficult to choose, as well as obtaining curves.

Cavitation

Purpose: To indicate if there is any cavitation occurring within the system.

Drawings & Diagrams:



Sources: Mott, Robert L., and Joseph A. Untener. Applied Fluid Mechanics. Pearson, 2015.

Design Considerations: Schedule 40 pipe, NPSHA, NPSH Required

Data & Variables: hA=13.83m, hL=7.74m

Procedure: To compute the NPSH, we needed information from the pump and our system to see if the NPSH from either one of them will give us cavitation.

Calculations:

$$\frac{P_A}{\gamma} + \cancel{\frac{V_A^2}{2g}}^{\,0} + z_A + h_A = \frac{P_B}{\gamma} + \cancel{\frac{V_B^2}{2g}}^{\,0} + z_B + h_{L_{A-B}}$$

$$\frac{P_A - P_V}{\gamma} + z_A + h_A = \frac{P_B - P_V}{\gamma} + z_B + h_{L_{A-B}}$$

$$NPSH_A = \frac{P_A - P_V}{\gamma}$$

$$NPSH_A = \frac{P_B - P_V}{\gamma} + (z_B - z_A) + h_{L_{A-B}} - h_A$$

$P_B = 21.7 \text{ psi} \Rightarrow 15256.6 \text{ Kg/m}^2$

$P_V = 0.6105 \text{ KPa} \Rightarrow 62.255675 \text{ Kg/m}^2$

$\gamma = 9.806 \text{ KN/m}^3$

$z_B = 7.0104 \text{ m}$

$z_A = 0.762 \text{ m}$

$h_{L_{A-B}} = 7.74 \text{m}$

$h_A = 13.83 \text{ m}$

$$NPSH_A = \frac{15256.6 - 62.255675}{9.806} + (7.0104 - 0.762) + 7.74 - 13.83$$

$$NPSH_A = 1549.659028 \text{m}$$

$$NPSH_R = 0.9144$$

$$NPSH_A > NPSH_R$$

Summary:

NPSHA:	1599.65m
NPSH Required:	0.9144m

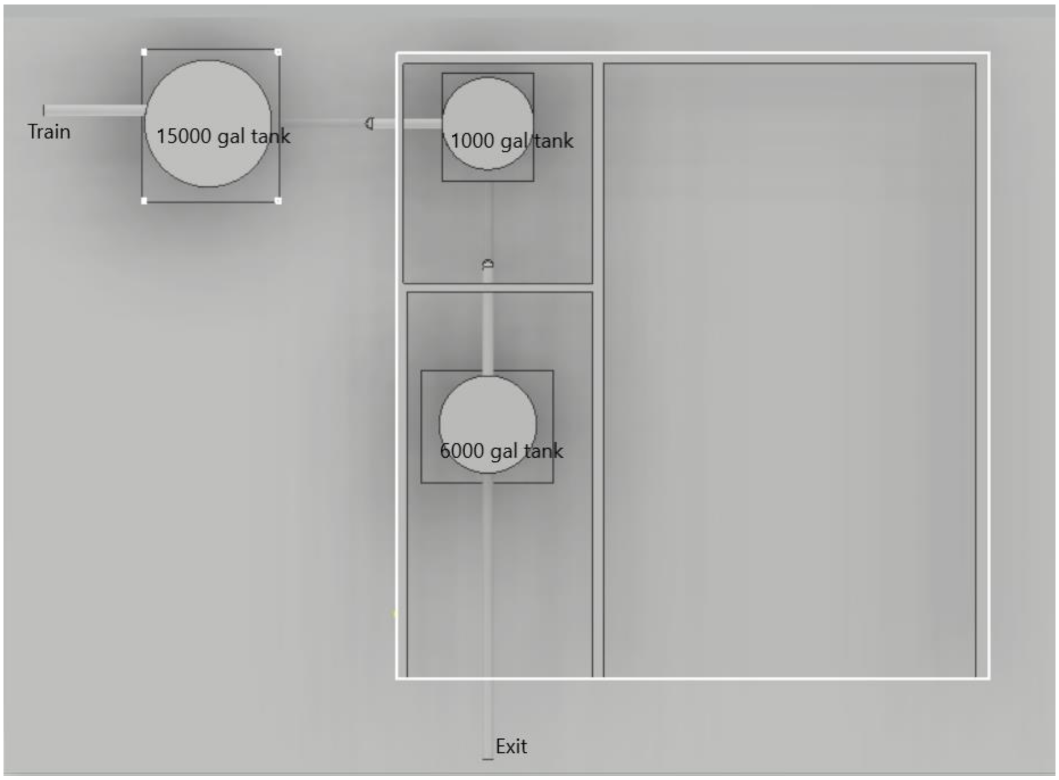
Materials: Stainless Steel pipes, Sulzer pumps

Analysis: There is no cavitation going on within the system as the NPSHA is greater than the NPSH required.

Summary of selected pumps

Purpose: To specify the power output of the electrical motor power requirement for our electrical engineer colleagues, the NPSH required, and the pump weight, pump required power

Drawings & Diagrams:



Sources: Mott, Robert L., and Joseph A. Untener. Applied Fluid Mechanics. Pearson, 2015.

Design Considerations: Sulzer Pumps, Electric pumps

Data & Variables: Power of System 1: 421.57 lb/s, Power of System 2: 91.022 lb/s, Power of System 3: 125.92 lb/s, Power of System 4: 205.69 lb/s

Procedure: Multiply the current power output of the pumps by the required output for the electrical motor requirement which is 1.10.

Calculations:

Task 17		
System 1 P=383.25 lb/s Electrical motor requirement: 383.25 lb/s(1.10)= 421.57 lb/s		
System2 P=91.022 lb/s Electrical motor requirement! 91.022 lb/s(1.10) = 100.124 lb/s		
System 3 P=125.92 lb/s Electrical motor requirement: 125.92 lb/s(1.10)= 138.51 lb/s		
System 4 P=205.69 lb/s Electrical motor requirement: 205.69 lb/s (1.10) = 226.25 lb/s		

CHARACTERISTICS OF PUMP

PUMP 1 + PUMP 4
2x3x7.5a
332 lbs
BASE = 800 lbs

PUMP 2 + PUMP 3
1x2x7.5
311 lbs
BASE = 800 lbs

Summary:

System	Power(lb/s)	Electrical Power Requirement(lb/s)
1	383.25	421.57
2	91.022	100.124
3	125.92	138.56
4	205.69	226.25

Table 16

Pump	Weight
1	332lbs
2	311lbs
3	311lbs
4	332lbs
NPSH Required:	0.9144m

Materials: Electric Pump

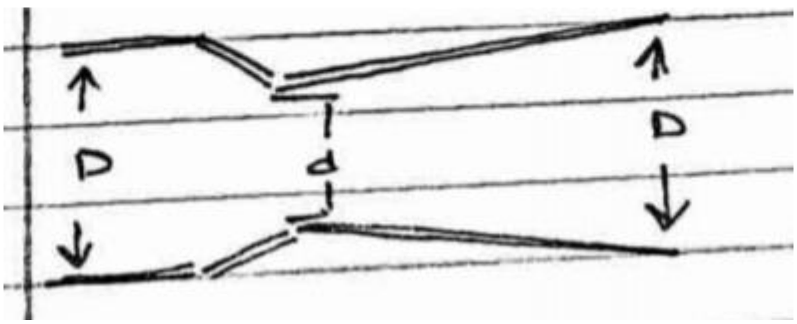
Analysis: The power requirement for the electrical pump seems appropriate since the calculations were of the original power were computed to that result, as well as the pump weights seem appropriate as that is what the catalog displayed, and the NPSH required is appropriate as well because it was computed from the previous task known as cavitation.

vii. Instrumentation Selection

Flow Rate

Purpose: Specify the flow rate that the digital manometer will measure

Drawings & Diagrams:



Sources: Mott, Robert L., and Joseph A. Untener. Applied Fluid Mechanics. Pearson, 2015.

Design Considerations: Digital Manometer

Data & Variables: Specific weight of water: 9.81(kN/m^3), Specific weight of mercury: 132.8(kN/m^3)

Procedure: To obtain the flow rate that the manometer will measure, the equation that'll be used is Reynold number, and the equation that was used in a previous lecture such as the Flow Measurement.

Calculations:

Digital Manometr for 6000gal to truck

$C = 0.9975 - 6.53\sqrt{\beta / Re}$ $\qquad Q = CA_1\sqrt{\frac{2g(P_1 - P_2)/\gamma}{(A_1/A_2)^2 - 1}}$

$P_1 = 21.2\text{psi}$

$\beta = d/D$

$Re = \frac{VD}{\nu} = \frac{(2.408022901\ m/s)(0.0409m)}{(1.75 \times 10^{-6})(1.5)} = 37519.29017$

digital manometr from 6,000gal to truck

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

$Q = 0.0031541\ m^3/s$

$D_1 = 0.0409\ m$

$A_1 = 1.31 \times 10^{-3} m^2$

$\gamma_w = 9.81\ kN/m^3$

$\gamma_m = 132.8\ kN/m^3$

$g = 9.81\ m/s^2$

Assume $D_2 = 0.02045m$

$A_2 = 3.28 \times 10^{-4} m^2$

$\frac{D_2}{D_1} = \frac{d}{D} = \frac{\cancel{3.28 \times 10^{-4}}\ 0.02045m}{0.0409m} = 0.5$

$C = 0.9975 - 6.53\sqrt{(0.5)/37519.29017} = 0.9736619418$

$0.0031541 = (1.31 \times 10^{-3})(0.9736619418)\sqrt{\frac{2(9.81)h\left(\frac{132.8}{9.81} - 1\right)}{\left(\frac{1.31 \times 10^{-3}}{3.28 \times 10^{-4}}\right)^2 - 1}}$

$0.0031541 = (0.0012754471)\left(\sqrt{\frac{245.98h}{14.9512569}}\right)$ $\qquad h = 0.3716805767m$

$2.472839805 = \sqrt{\frac{245.98h}{14.95}}$

Summary:

Flow Rate(m^3/s)	0.0031541

Table 17

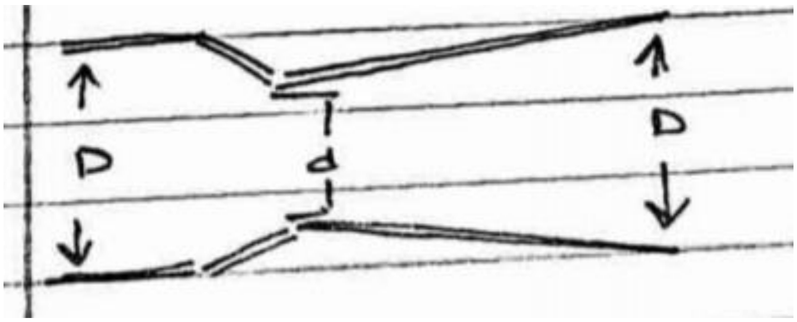
Materials: Manometer

Analysis: The flow rate that the manometer is reading seems appropriate for the system as the reading doesn’t seem like it would break anything in the system.

Pressure

Purpose: Specify the pressure that the manometer will read on the system

Drawings & Diagrams:



Sources: Mott, Robert L., and Joseph A. Untener. Applied Fluid Mechanics. Pearson, 2015.

Design Considerations: Digital Manometer

Data & Variables: Specific weight of water: 9.81(kN/m^3), Specific weight of mercury: 132.8(kN/m^3)

Procedure: To obtain the flow rate that the manometer will measure, the equation that'll be used is Reynold number, and the equation that was used in a previous lecture such as the Flow Measurement.

Calculations:

Digital Manometr for 6000gal to truck

$C = 0.9975 - 6.53\sqrt{\beta/Re}$ $\qquad Q = CA_1\sqrt{\frac{2g(P_1 - P_2)/\gamma}{(A_1/A_2)^2 - 1}}$

$P_1 = 21.2\,psi$

$\beta = d/D$

$Re = \frac{VD}{N} = \frac{(2.408022901\,m/s)(0.0409m)}{(1.75\times10^{-6})(1.5)} = 37519.29017$

digital manometr from 6,000gal to truck

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

$Q = 0.0031541\ m^3/s$

$D_1 = 0.0409\,m$

$A_1 = 1.31\times10^{-3}\,m^2$

$\gamma_w = 9.81\,kN/m^3$

$\gamma_m = 132.8\,kN/m^3$

$g = 9.81\,m/s^2$

Assume $D_2 = 0.02045m$

$A_2 = 3.28\times10^{-4}\,m^2$

$\frac{D_2}{D_1} = \frac{d}{D} = \frac{\cancel{3.28\times10^{-4}}\ 0.02045m}{0.0409m} = 0.5$

$C = 0.9975 - 6.53\sqrt{(0.5)/37519.29017} = 0.9736619418$

$0.0031541 = (1.31\times10^{-3})(0.9736619418)\sqrt{\frac{2(9.81)h\left(\frac{132.8}{9.81} - 1\right)}{\left(\frac{1.31\times10^{-3}}{3.28\times10^{-4}}\right)^2 - 1}}$

$0.0031541 = (0.0012754471)\left(\sqrt{\frac{245.98\,h}{14.9512566\,9}}\right)$ $\qquad h = 0.3716805767m$

$2.47283980 5 = \sqrt{\frac{245.98h}{14.95}}$

Summary:

Pressure Reading(psi)	21.2

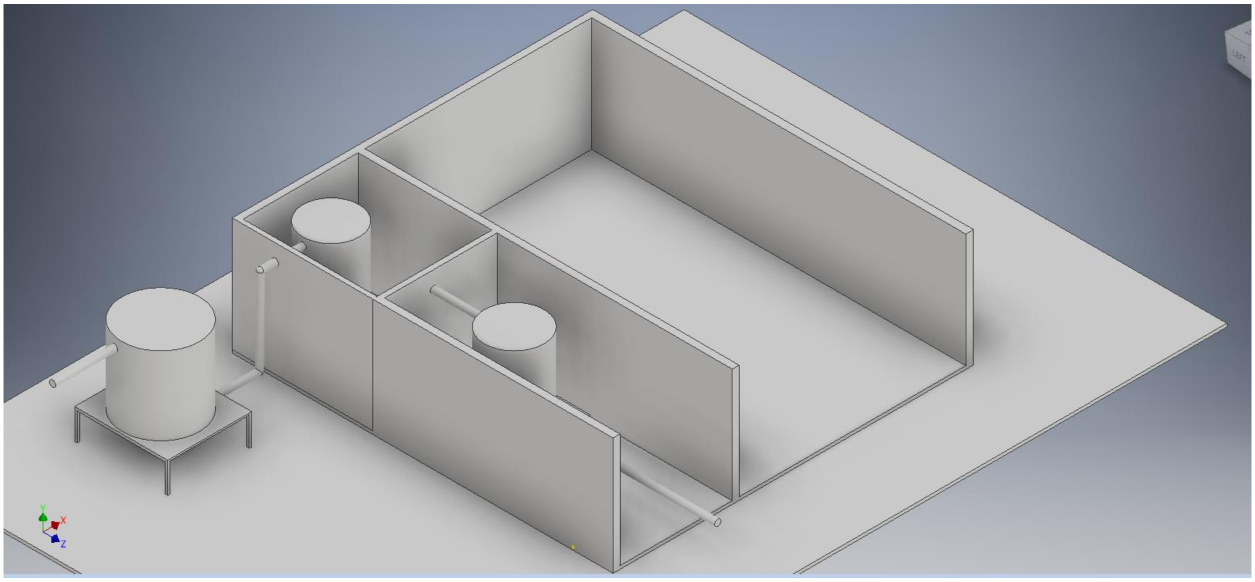
Table 17

Materials: Stainless steel pipes, coolant

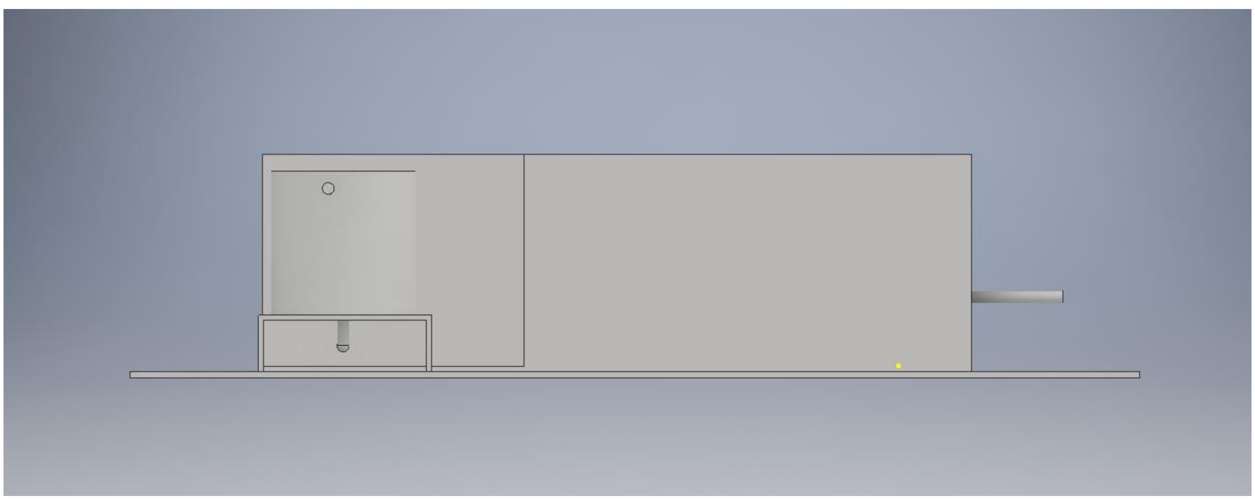
Analysis: The pressure that the manometer will read seems appropriate as it was obtained from the calculations.

Final Drawings:

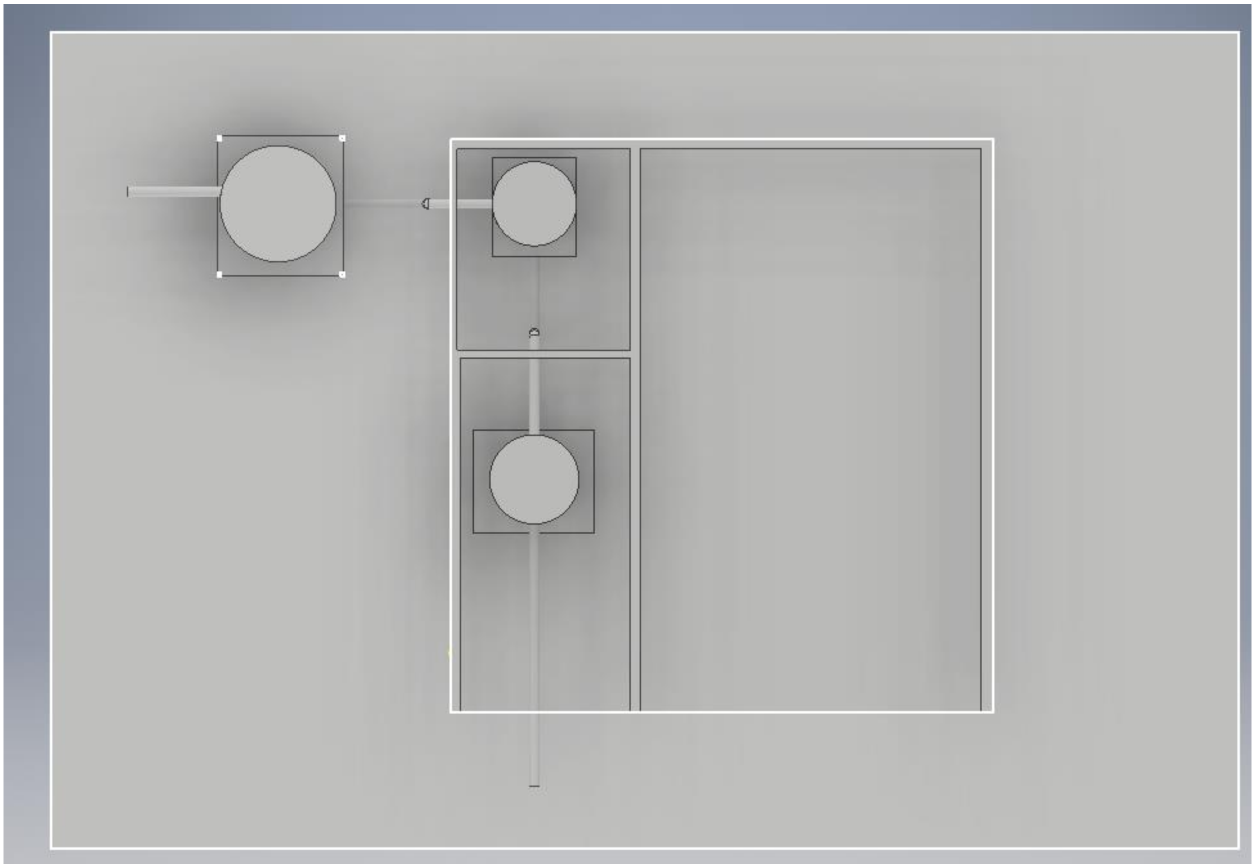
Plot Plan:



Elevations View:



Top View:



Bill of Materials, and Equipment

Total Length of Schedule 40 Pipes	219ft
# of elbows	7
# of gate valves	8
# of pumps	4

Table 18

Tanks	# of
15000	x1
6000	x1
1000	x1

Table 19

Final Remarks

The design of our project is to be simple and cost effective as not as much piping was used and the entire layout is simple with no complications included with the installation of the layout. The tanks that were selected were to be allocated to near the train and the garage exit, allowing the design to be simple.

Appendix

William Gemo:

The project, and the class itself taught me a great deal of needed information that I will needed later in my engineering career. The project taught me so much about time management and the process of creating solutions for each of the task that I believe that I will be using these methods later at my future workspace at the Naval Shipyard. Furthermore, if I were to be approached at an interview and this project was to be pulled up during it and I was asked about my strengths and weaknesses during the project, I would state that my strengths for the project was my time management, and being resourceful with the given resources I am given from my class such as the notes and the book, however the weaknesses I encountered during the project was lack of clarity given through each tasks and how I addressed it was asking assistance from my fellow team mates and the professor on how to approach these tasks. Overall I believe this project was a great way to get a feeling of how my career will be after graduation, and I highly recommend any student to take it, however if I were to start all over again yet give advice to myself before this, my advice to myself would be to relax and plan ahead of time when doing this project.

Michael Delacruz:

This project has showed me the real world applications of what we learned in class. This project gave me a wider view of what being a mechanical engineer would be like. I believe that not only did we learn how to do the project, but we learned key skills. These skills involved time management, leadership and how to work as a team. These key skills will be carried on throughout my career and my life. If I was to be interviewed for about this project, I believe this project will showcase my skills as well as show the employers how far I have come. I believe that regarding my strengths, it came out in terms of bringing the group together, time management and observation skills. My weaknesses in using the resources around me in the beginning of the project. I addressed this by asking my professor and my teammates in times of need. I believe this project helped me figure out how my career will look in the future. I would recommend that any student fortunate enough to take this class should not feel overwhelmed by the work. Professor Ayala once said "It is not difficult, it is just very long." If I were to take this class again, I would tell myself that tough times don't last, but tough people do. I would tell myself take your time and don't get overwhelmed as this is just one step in what is hopefully a successful career.

Daniel Tamayo:

The project was interesting in that the design process seemed like an impossible task in the beginning, but as each individual step was completed, the project itself was simple. The hardest part was determining a design that the entire group would agree on and fixing mistakes that my teammates and I would make. I learned how to cooperate and deal with my teammates from this project. If I were interviewed for a job application that involved this project, I would highlight the team management aspect of the project, where the roles of each member was clearly defined and each individual task was completed in a timely manner. One problem that did occur from the project was miscommunication. There would be times were the data we calculated did not make it to the project summary and the group would have to take time to fix that problem. In terms of technical strength, I was able to complete my assigned tasks within the assigned time limit but a critical weakness was that I was over reliant on my team mates for certain pieces of data. Overall, I believe that the project was a success and my advice for any new students would be: don't be afraid to ask the professor for help.