MET 330 Fluid Mechanics Final Project

Full Pipeline System Design of a Manufacturing Plant for CONTINENTAL AG

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ABSTRACT

Continental AG, a manufacturing company was seeking to expand, by building an additional warehouse. The warehouse was equipped with 5 machines, which required a constant flow of coolant. As a project engineer it was our task to design a plumbing system to supply the machines with coolant. Some of the things considered in the design was the 15,000 gallons delivered by train and the removal of the dirty coolant, which occurs every month. The main goal of this project was to create a simple yet reliable and effective way to supply the machines with the coolant needed for them to run adequately.

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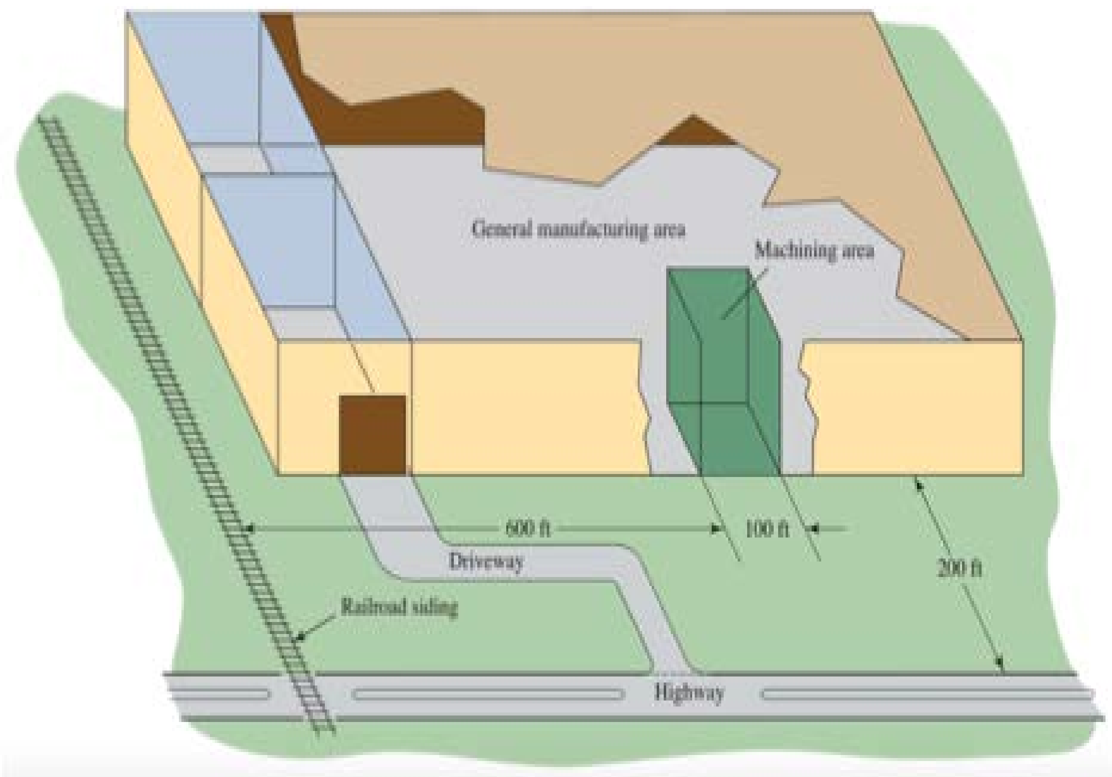
SECTION 1

JOB SITE LOCATION

The coolant plumbing system was designed for a company called continental AG, located in Dayton, Ohio. During the design phase of this project the characteristics of the location were consider, in order to design a simple yet effective way to provide manufacturing machines with coolant. The things considered were, weather, property size, railroad and highway location. The plumbing system design consisted of two steel outdoor tanks and one aluminum indoor tank.

Longitude: 39.758949 Latitude: -84.191605



SPECIFICATIONS

1) New coolant is delivered to the plant by railroad tank cars carrying 15,000 gal each. A holding tank for new coolant must be specified.
2) The reservoir for the automated machining system must have a capacity of 1000 gal.
3) The 1000-gal tank is normally emptied once per week. Emergency dumps are possible if the coolant becomes overly contaminated prior to the scheduled emptying.
4) The dirty fluid is picked up by truck only once per month.
5) A holding tank for the dirty fluid must be specified.
6) The plant is being designed to operate two shifts per day, 7 days a week.
7) Maintenance is normally performed during the third shift.
8) The building is one-story high with a concrete floor.
9) The floor level is at the same elevation as the railroad track.
10) No storage tank can be inside the plant or under the floor except the 1000-gal reservoir that supplies the machining system.
11) The rooftop is 32 ft from the floor level and the roof can be designed to support a storage tank.
12) The building is to be located in Dayton, Ohio, where the outside temperature may range from -20o F to +105 o F.
13) The frost line is 30 in below the surface.
14) The coolant is a solution of water and soluble oil with a specific gravity of 0.94 and a freezing point of 0 o F. Its corrosiveness is approximately the same as that of water.
15) Assume that the viscosity and vapor pressure of the coolant are 1.50 times that of water at any temperature.
16) You are not asked to design the system to supply the machines.
17) The basic coolant storage and delivery system is to have the functional design sketched in the block diagram in Figure 2.
18) If pumps are required, only SULZER pumps have to be selected. YOU ARE ALLOWED TO USE ONLY SULZER PUMP CATALOG PROVIDED IN CLASS!

DESIGN PHILOSOPHY

Consider yourself to be a plant engineer working for Continental AG interested on planning a new manufacturing facility. You are responsible for the design of the system to handle the coolant from the time it reaches the plant in railroad tank cars until the dirty coolant is removed from the premises by a contract firm for reclaim.

Sources

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

http://www.matweb.com/search/datasheet.aspx?bassnum=MS0001&ckck=1
http://www.academia.edu/6520039/Blind_Flange_Thickness_calculation
http://catalog.coastalflange.com/viewitems/ansi-b16-5-class-150-flanges/ansi-b16-5-class-150-blind-flanges?
https://www.grainger.com/product/DAYTON-120-240VAC-Open-Dripproof-2ZWP3?searchBar=true&searchQuery=2ZWP3
Http://documentlibrary.xylemappliedwater.com/wp-content/blogs.dir/22/files/2012/07/BeSV60-R8.pdf?_ga=2.162998143.210824565.1524715491-322419278.1524715491

Materials and Specifications

Materials for this system are based upon durable commercial applications. The equipment and materials were selected to abide by typical industry standards. The material of the tanks are carbon steel to help sustain weathered conditions, as well as the blind flange. Even the material of the pumps are made of carbon steel, along with ceramic and stainless steel. The material has been decided upon because it is found to be cheaper. Not only that but it can benefit when making the tank because it is easy to shape. Although it may not be tough, it hardness can be approved through carburizing of the tank.

SECTION 2

TANK SPECIFICATIONS

Size and Location

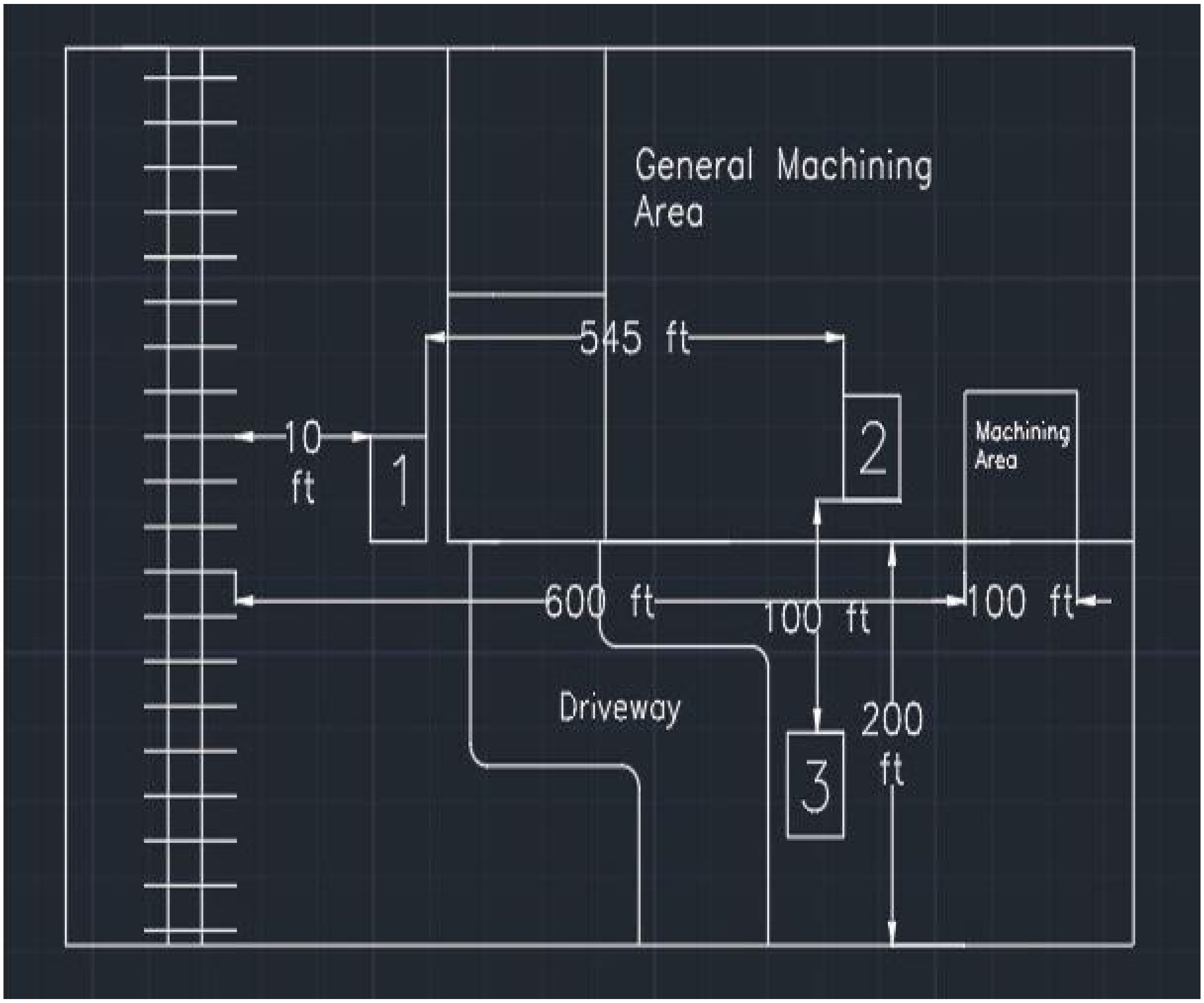


Figure2-1

Tank Weight	In. Volume(Ft3)	Fluid S.W.(lb/ft3)	Tank Height(ft)	Tank Dia.(ft)
Tank 1	2018.57	58.656	20.0416	11.4208
Tank 2	140.36	58.656	7.0416	5.2208
Tank 3	1095.52	58.656	18.0416	9.0208

Sources:

- http://www.matweb.com/search/datasheet.aspx?bassnum=MS0001&ckck=1

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

Design considerations:

- Dirty tank emptied once a month via truck
- Plant designed to run 2 shifts, 7 days per week
- 1000 gal. tank emptied once a week
- No storage tank can be in the warehouse except for the 1000 gal. tank
- Rooftop is 32 ft from floor level
- Building located in Dayton Ohio temp. Range (-20℉ to 105℉)

Data/ Variables:

- $V=\pi r^2 h$
- $P=\gamma h$
- Clean tank:15000 gallons
- Reservoir tank:1000 gallons
- Sg: .94
- Dirty tank: 8000 gallons

Calculations:

Volume of a cylinder: $V = (\pi D^2 H)/4$
Conversion of ft^3 to US gal: 1 US gal = $0.133681ft^3$
Fluid weight of coolant: $W = V*\gamma_w@4C*sg_c$

2.2.1 Tank 1 (Storage) Calculations

Volume: $V = [\pi(11.4ft)^2*20ft]/4 = 2041.41\ ft^3$
Conversion: $2041.41\ ft^3*(1\ \text{US gal}/0.133681ft^3) = 15{,}271$ US gal
Fluid Weight: $2018.57\ ft^3*58.656lb/ft^3 = 118401.2$ lb

2.2.2 Tank 2 (Reservoir) Calculations

Volume: $V = [\pi(5.2ft)^2*7ft]/4 = 148.66\ ft^3$
Conversion: $148.66\ ft^3*(1\ \text{US gal}/0.133681ft^3) = 1{,}112$ US gal
Fluid Weight: $140.36\ ft^3*58.656lb/ft^3 = 8233$ lb

2.2.3 Tank 3 (Contamination) Calculations

Volume: $V = [\pi(9ft)^2*18ft]/4 = 1145.11\ ft^3$
Conversion: $1145.11\ ft^3*(1\ \text{US gal}/0.133681ft^3) = 8{,}626$ US gal
Fluid Weight: $1095.52\ ft^3*58.656lb/ft^3 = 64258.8$ lb

Drawings:

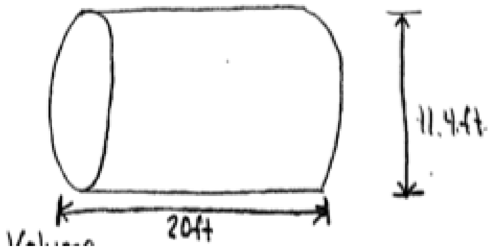


Figure 1

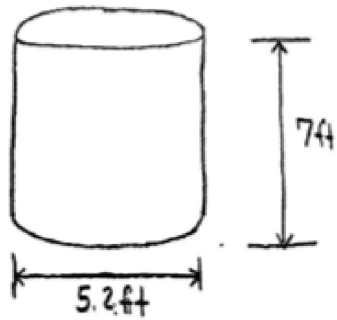


Figure 2

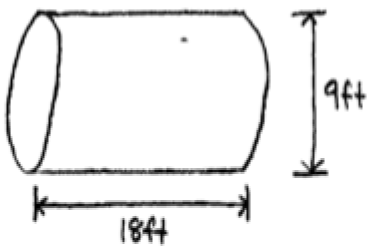


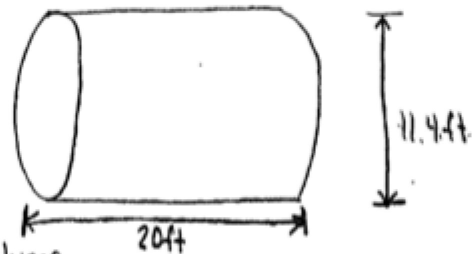
Figure 1

Storage Tank 1 (Outdoors)

Material → Carbon Steel

$15{,}000\,gal + 100\,gal = 15{,}100\,gal$

$15{,}100\,gal \times \frac{.1336\,ft^3}{1\,gal} = 2018.57\,ft^3$



Volume

$V = \pi r^2 h$

$2018.57\,ft^3 = \pi \times r^2 \times 20\,ft$

$\frac{2018.57\,ft^3}{62.8318\,ft} = \frac{62.8318\,ft\, r^2}{62.8318\,ft}$

$\sqrt{r^2} = \sqrt{32.1265}$

$r = 5.6680\,ft \rightarrow 5.7\,ft$

Pressure Calc.

$.94 = \frac{\gamma_{coolant}}{62.4\,lb/ft^3}$

$\gamma_{coolant} = 58.656$

$= \gamma h$

$= (58.656\,lb/ft^3 \times 5.7\,ft)$

$= 334.33\,lb/ft^2$

Thickness (t)

$t = (P \times D_i)/(2\sigma E - 0.2P)$

$= \frac{(334.33\,lb/ft^2 \times 11.4\,ft)}{(2 \times 1463040\,lb/ft^2 \times .85 - 0.2 \times 334.33\,lb/ft^2)}$

$= \frac{3811.36\,lb/ft}{(2487168\,lb/ft^2 - 66.866\,lb/ft^2)}$

$= \frac{3811.36\,lb/ft}{2487101.13\,lb/ft^2}$

$= .00153\,ft$

Allowable Stress

$\text{Allowable Stress} = \frac{\text{Yield Strength}}{\text{Factor Safety}}$

$= \frac{7315200\,lb/ft^2}{5.0}$

$= 1463040\,lb/ft^2$

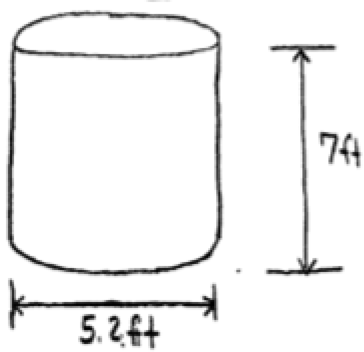
Figure 2

Storage Tank 2

Material → Carbon Steel

$1{,}000\,gal + 50\,gal = 1{,}050\,gal$

$1{,}050\,gal \times \frac{.1336\,ft^3}{1\,gal} = 140.36\,ft^3$



Pressure Calc.

$= \gamma h$

$= (58.656\,lb/ft^3 \times 7ft)$

$= 410.592\,lb/ft^2$

Volume

$V = \pi r^2 h$

$140.36\,ft^3 = \pi \times r^2 \times 7ft$

$\frac{140.36\,ft^3}{21.9911\,ft} = \frac{21.9911\,ft\, r^2}{21.9911\,ft}$

$\sqrt{r^2} = \sqrt{6.3825}$

$r = 2.5263$

Allowable Stress

$\text{Allowable Stress} = \frac{\text{Yield Strength}}{\text{Factor Safety}}$

$= \frac{7315200\,lb/ft^2}{5.0}$

$= 1463040\,lb/ft^2$

Thickness

$t = (P \times D_i)/(2\sigma E - 0.2P)$

$= \frac{(410.592\,lb/ft \times 5.2ft)}{(2 \times 1463040\,lb/ft^2 \times .85 - 0.2 \times 410.592\,lb/ft)}$

$= \frac{2135.07\,lb}{2487085.88\,lb/ft^2}$

$= 8.58 \times 10^{-4} = .000858\,ft$

Figure 3

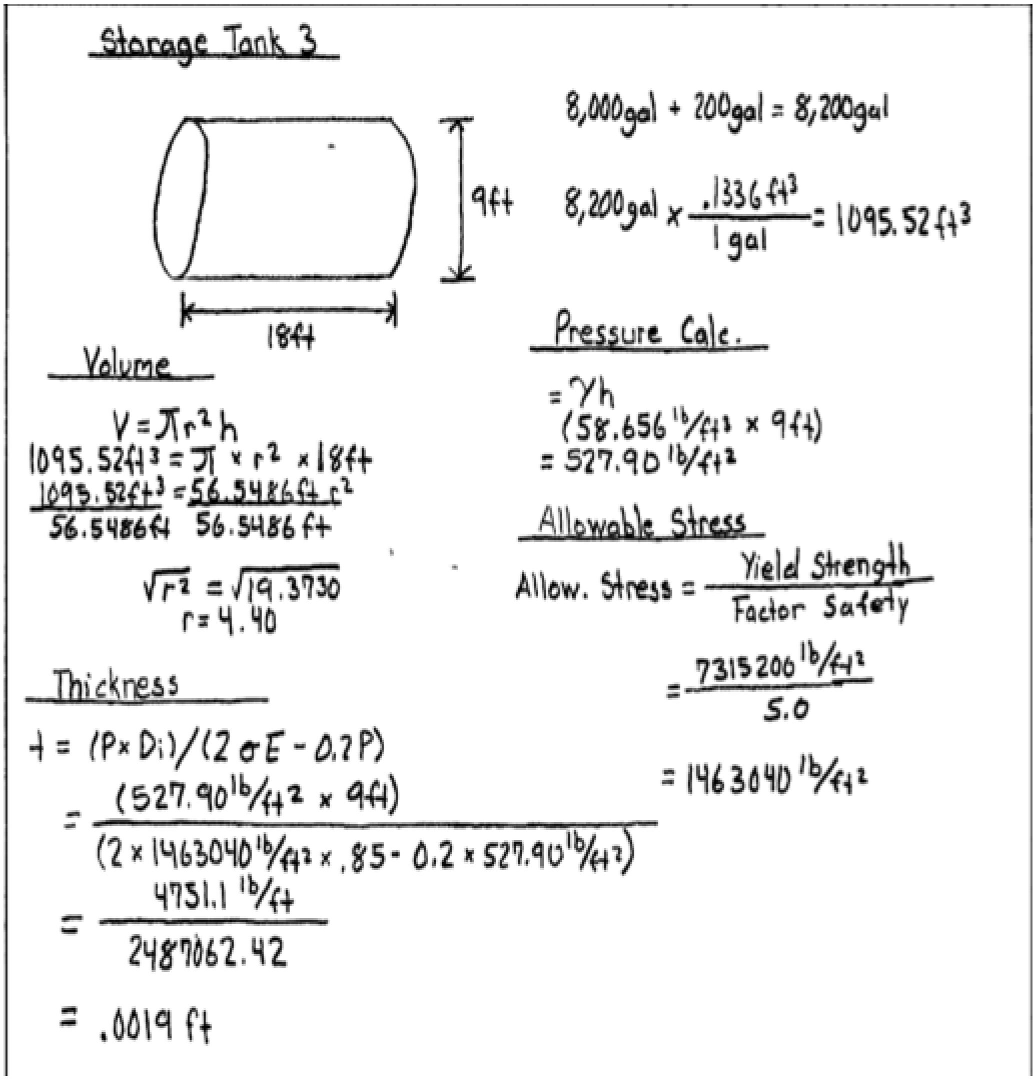


Figure 4

Materials:

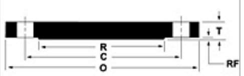
- Mild carbon steel
- Coolant

Summary:

- Clean tank: 1500 gal, (11.4 x 20)
- Dirty tank: 8000 gal, (9 x 18)
- Reservoir: 1000 gal, (5.2 x 7)

BLIND FLANGE

Manufacturer:
Coastal Precision Engineered Flanges



- All dimensions are in inches.
- These flanges will be furnished with a 1/16" raised face unless otherwise specified.
- Flat face option available.

Print PDF

SPECIFICATIONS

Flange Type	Blind
Nominal Pipe Size	3
Outside Diameter (O)	7.50
Thickness (T)	0.94
Raised Face Diameter (R)	5.00
Approximate Weight (lbs)	9
Bolt Circle (C)	6.00
Number of Holes	4
Diameter of Holes	0.75

<table>
<tr><th colspan="6">Blind Flange Specifications</th></tr>
<tr><th rowspan="2">Location</th><th rowspan="2">Size</th><th rowspan="2">Thickness</th><th colspan="3">Bolts</th></tr>
<tr><th>Size</th><th>Material</th><th>Quantity</th></tr>
<tr><td>1/2ft from the bottom of Tank 1</td><td>7.5</td><td>0.94</td><td>3/4-10UNC x 1-3/4 L</td><td>Grade 2</td><td>4</td></tr>
</table>

Sources:
http://www.academia.edu/6520039/Blind_Flange_Thickness_calculation
http://catalog.coastalflange.com/viewitems/ansi-b16-5-class-150-flanges/ansi-b16-5-class-150-blind-flanges?

Design considerations:
- Design pressure: 410.592 lb/ft³
- Flange material: Carbon steel

Data/ Variables:
- $A=\pi D^2/4$
- $P=\gamma h$
- $F=P*A$

Procedure:
- Calculated pressure on flange
- Calculated area of flange
- Calculated force on flange
- Calculated force per bolt
- Calculated bolt size

Calculations:

$A=\pi D^2/4$	$\pi(3)^2/4 = 7.069\ in^2$
$P=\gamma h$	$(58.656\ lb/ft^3)(7ft) = 381.264\ lb/ft^2 = 2.648\ psig$
$F= PxA$	$(2.648psig)(7.069in^2) = 18.719\ lb$

$$\boldsymbol{T = \sqrt{\frac{3P}{16S}}}$$

Materials:
- Flange
- 1000 gallon steel tank
- 1000 gal. coolant
- 4 nuts & bolts

Summary:
- NPS: 3in
- Outside Diameter: 7.50 in
- Thickness: .94
- Weight: 9 lbs
- Bolt circle: 6.00
- Number of holes: 4
- Diameter of holes: .75

Analysis:

The purpose of this task was to provide a future additional connection to drain one of the tanks and to design the flange required to hold the pressure of such connection. In doing so we first had to calculate the pressure at the face of the flange. Prior to finding the pressure we found the area of the connection and calculated the force on the flange. We then calculated the force on each bolt of the system.

Drawings:

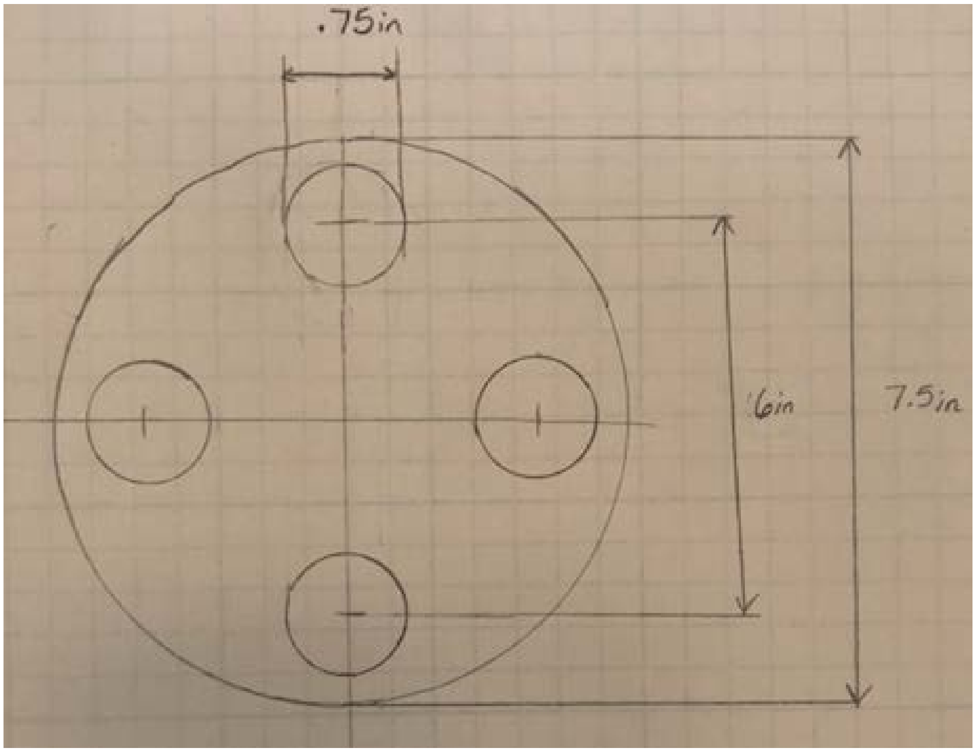


Figure 5

Sources:

http://www.academia.edu/6520039/Blind_Flange_Thickness_calculation
http://catalog.coastalflange.com/viewitems/ansi-b16-5-class-150-flanges/ansi-b16-5-class-150-blind-flanges?

WIND LOAD

<u>Purpose:</u>

The purpose of this task was to calculate the wind load and the weight of the storage tanks for the civil engineers.

Wind Load	Wind Velocity	Reynolds #	CD	Density	Area	FD	Pressure (psf)	Wind load
Tank 1(Aver.)	60	4329113.924	1.5	0.00237	228	1458.972	9.216	3151.872
Tank 3(Aver.)	60	3417721.519	1.5	0.00237	162	1036.638		2239.488

SECTION 3
PIPE SYSTEM SPECIFICATIONS

Piping Layout

Purpose:
The purpose of this task was to provide a visual layout of the piping system, connecting each of the three tank throughout the system.

Drawings & Diagrams

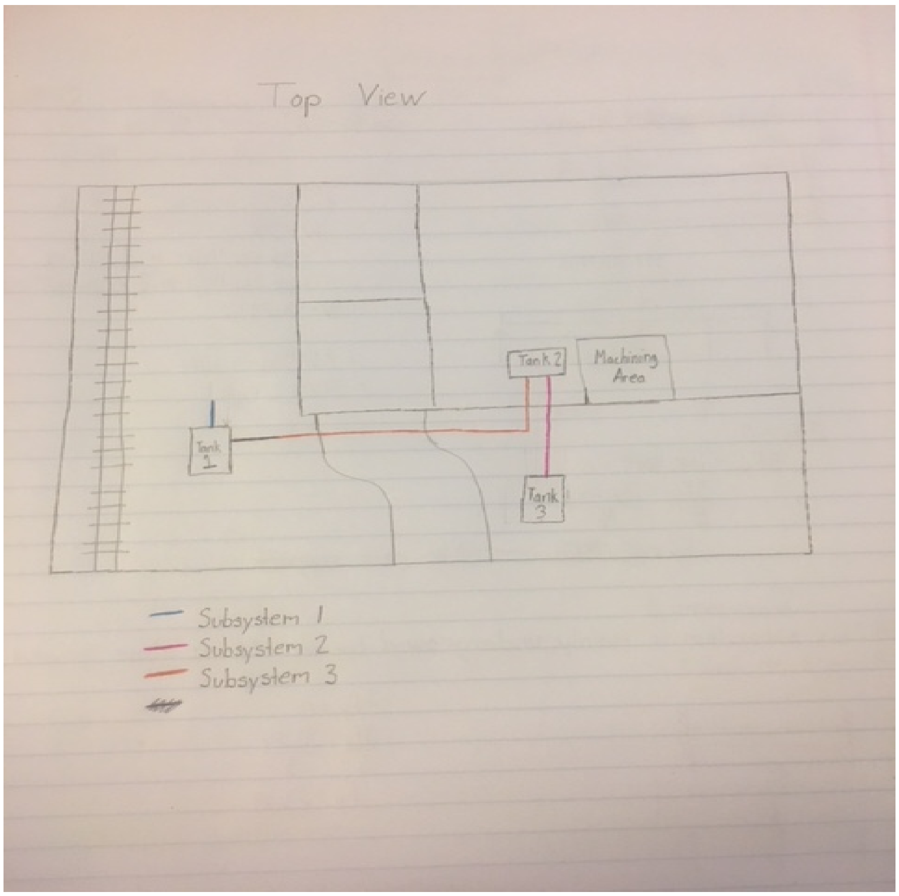


Figure 6

Design Considerations
The pipe layout was designed based on a simple, yet effective way to transfer fluid from each tank. One of the main consideration of this design was the location of the machining station, train tracks and driveway. The location of tank 1 was decided based on the location of the train tracks. By deciding to put tank 1 near the train tracks it provided easy access to the railroad car holding the coolant, with minimum head loss. Furthermore, tank 2's location was based upon the location of the machining area located in the factory. The main goal of this project was to provide the factory machines with coolant, so we assumed it would be more applicable to put a tank near the area of the machines. Also we assumed this would aid in the performance of the cycle of coolant

from machine to tank 2. In addition, tank 3's location was decided based on the driveway. This is so that when the truck comes to pick up the dirty fluid it is granted quick and easy access to the dirty fluid. Allowing the transfer truck quick and easy access to the dirty fluid (Tank 3) allows for a shorter time that the driveway is non-operational.

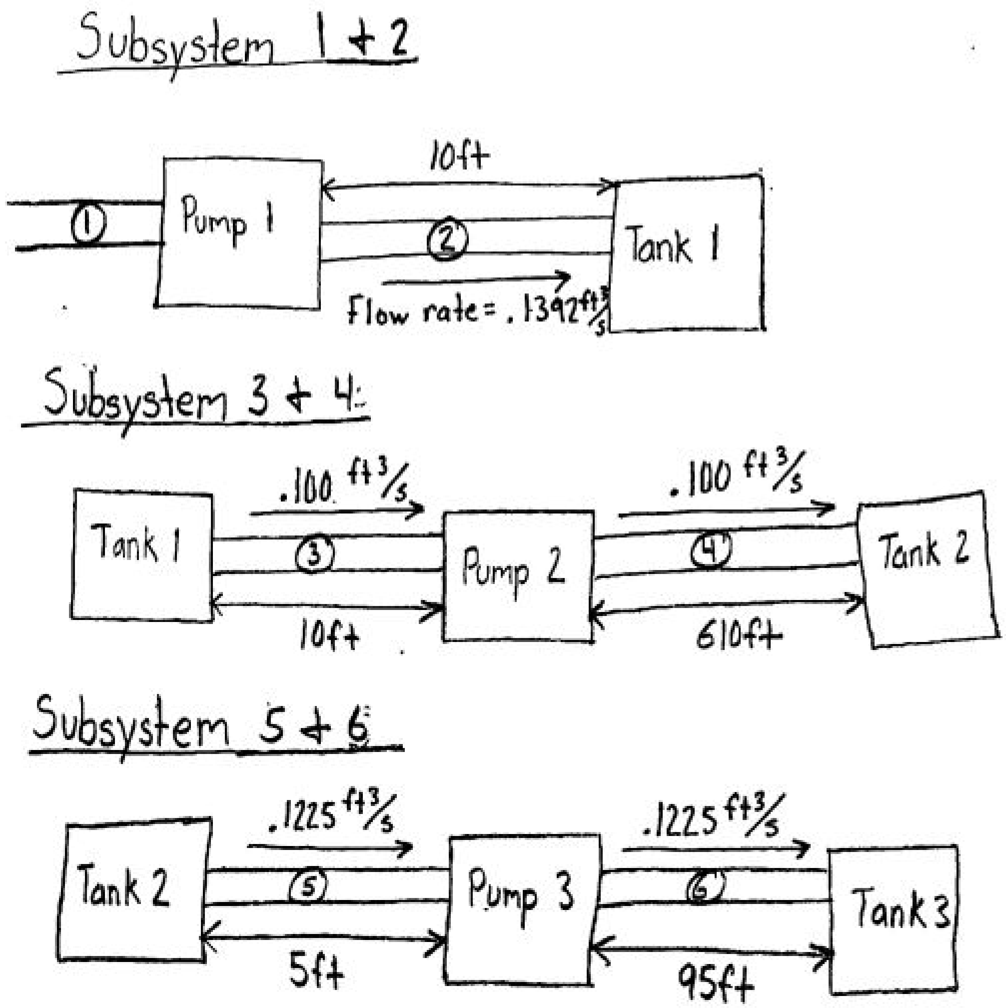
Pipe Diameter and Lengths

Purpose

The purpose of this task was to calculate the pipe sizes and lengths need to properly transfer fluid from tank to tank, based upon desired flow rates and critical velocity.

Drawings and Diagrams

*(Basic symbols and pipe sketches are used to simulate information data used to calculate Pipe diameter)



Sources

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

Design Considerations

The main consideration used to calculate pipe size was the desired flow rate, which was based on the amount of time wanted to fill and empty each tank. However, with that desired flow rate, the critical velocity needed to be within a certain limit. According the U.S. Army Corps of Engineers manual Liquid Process piping recommends that certain limit be with 3.9 ft./s to 9.8 ft./s. So, in order to maintain the velocity within the limits, the correct size needs to be chosen.

Data & Variables

- Q= Desired Flow Rate
- A= Area
- V= Velocity

Procedure

The steps to solving this task mainly consisted of hypothesizing what nominal size pipe to use. According the whether the velocity is “too high” or “too low” is how you adjust the velocity. For instance, if the velocity is too low a small diameter pipe should be used.

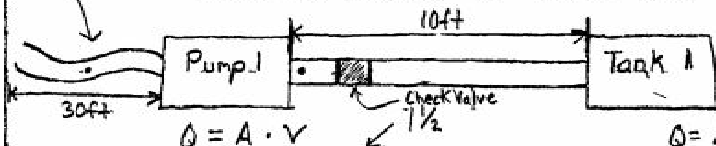
Calculations

#5

- Specify the layout of the piping system
- Material sizes of all pipes (Galvanized Steel)
- lengths required
- pipe size is chosen w/ critical Velocity criteria & desired flow rate

m 6 Subsystem 1 (From Pump 1 to Tank 1)

- Total length 10ft
- Flow rate needed of 62.5 gal/min or .1392 ft³/s



$1\frac{1}{2}$ $1\frac{1}{4}$ in

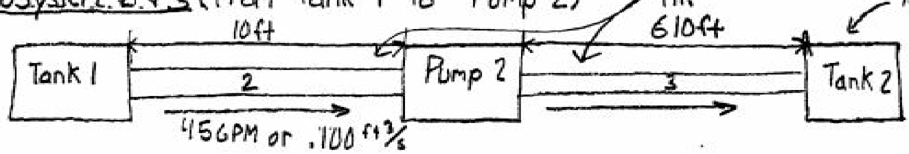
$Q = A \cdot V$ $Q = A \cdot V$

$\frac{.1392\ ft^3/s}{.01414\ ft^2} = \frac{.01414\ ft^2 \times V}{.01414\ ft^2}$ $\frac{.1392\ ft^3/s}{.01039\ ft^2} = \frac{.01039\ ft^2 \times V}{.01039\ ft^2}$

$V = 9.844\ ft/s$ $V = 13.397\ ft/s$ (Too high)

Still delivers desired flow rate
w/ lower velocity, thus creating
a safer system
"pg. 125"

Subsystem 2+3 (From Tank 1 to Pump 2) 1 in 1000gal

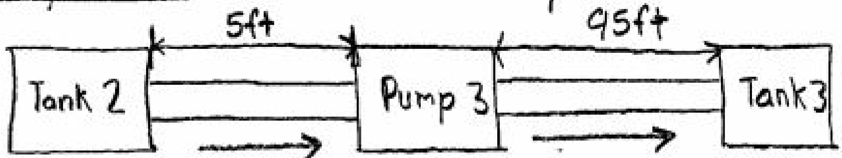


$\frac{.100\ ft^3/s}{.01039\ ft^2} = \frac{.01039\ ft^2 \times V}{.01039\ ft^2}$

$V = 9.624\ ft/s$

Calculations (continued)

Subsystem 4 & 5 (From Tank 2 to Pump 3 to Tank 3)



55 gal/min or .1225 ft³/s

$$Q = A \times V$$

$$\frac{.1225\ ft^3/s}{.01039\ ft^2} = \frac{.01039\ ft^2 \times V}{.01039\ ft^2}$$

$$V = 11.79\ ft/s \leftarrow \text{Too high}$$

$$\frac{.1225\ ft^3/s}{.01414\ ft^2} = \frac{.01414\ ft^2 \times V}{.01414\ ft^2} \leftarrow 1\tfrac{1}{2}\ \text{in.}$$

$$V = 8.6633$$

Summary

In conclusion, this task was mainly about deciding what size pipe is best for the system based on the desired flow rate. The correct size pipe was said to keep the velocity within a limit of 3.9 ft./s to 9.8 ft./s. During this task the only equation that was used was the volume flow equation.

Pipe Thickness

Purpose:

The purpose of this task is to calculate pipe thickness according to the size pipe calculated previously in task 5.

Drawings & Diagrams

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)
⅛	6	0.405	10.3	0.068	1.73	0.269	0.0224	6.8	0.000 394	3.660×10^{-5}
¼	8	0.540	13.7	0.088	2.24	0.364	0.0303	9.2	0.000 723	6.717×10^{-5}
⅜	10	0.675	17.1	0.091	2.31	0.493	0.0411	12.5	0.001 33	1.236×10^{-4}
½	15	0.840	21.3	0.109	2.77	0.622	0.0518	15.8	0.002 11	1.960×10^{-4}
¾	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}
1¼	32	1.660	42.2	0.140	3.56	1.380	0.1150	35.1	0.010 39	9.653×10^{-4}
1½	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}
2½	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}
3½	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

Figure 7

O.D., I.D., & Wall Thickness Dimensions For Given Pipe Sizes									
Pipe Size	Schedule 40 Thickness			Schedule 10 Thickness			Schedule 5 Thickness		
	O.D.	I.D.	Wall Thickness	O.D.	I.D.	Wall Thickness	O.D.	I.D.	Wall Thickness
3/4	1.050	0.824	0.113	1.050	0.884	0.083	1.050	0.920	0.065
1	1.315	1.049	0.133	1.315	1.097	0.109	1.315	1.185	0.065
1-1/4	1.660	1.380	0.140	1.660	1.442	0.109	1.660	1.530	0.065
1-1/2	1.900	1.610	0.145	1.900	1.682	0.109	1.900	1.770	0.065
2	2.375	2.067	0.154	2.375	2.157	0.109	2.375	2.245	0.065
2-1/2	2.875	2.469	0.203	2.875	2.635	0.120	2.875	2.709	0.083
3	3.500	3.068	0.216	3.500	3.260	0.120	3.500	3.334	0.083
3-1/2	4.000	3.548	0.226	4.000	3.760	0.120	4.000	3.834	0.083
4	4.500	4.026	0.237	4.500	4.260	0.120	4.500	4.334	0.083
6	6.625	6.065	0.280	6.625	6.357	0.134	6.625	6.407	0.109
8	8.625	7.981	0.322	8.625	8.329	0.148	8.625	8.407	0.109

Figure 8

Sources

- Mott, R, Untener, J.A., "Applied Fluid Mechanics," 7th edition, Pearson Education, Inc, (2015)
- http://www.mcnichols.com/?pageCode=pipedims

Design Considerations

- System is in Steady State

Data & Variables

- N/A

Procedure

This task was very basic and could be completed with basic observations of the above chart. The pipe size known from task 5 and the wall thickness was stated by the chart, if read from left to right.

Summary

Subsystem Nomenclature	Pipe Size	Pipe Thickness
Subsystem 1,4,5	1 1/2in	0.145in
Subsystem 2,3	1in	0.133in

Fittings

<u>Purpose</u>

The main purpose of this task is to determine the number of fittings associated with the plumbing system.

<u>Drawings and Diagrams</u>

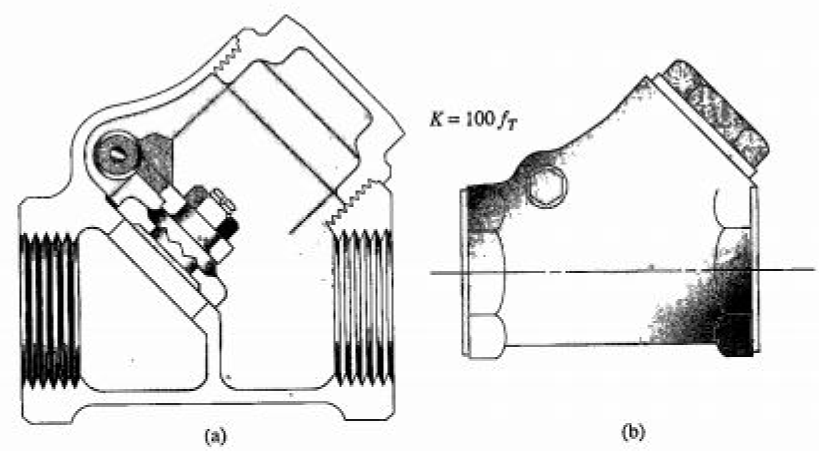


Figure 9

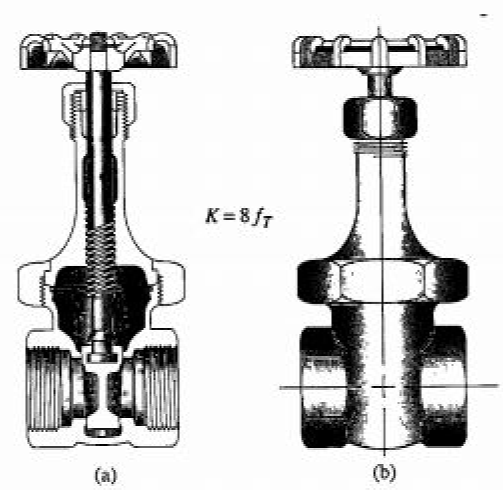
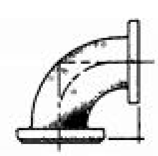


FIGURE 10.17 Gate valve. (Reprinted with permission from "Flow of Fluids Through Valves, Fittings and Pipe, Technical Paper 410" 2009. Crane Co. All Rights Reserved)

Figure 10



$K = 20f_T$
(b) 90° long radius elbow

Figure 11

Sources

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

Design Considerations

- Constant Properties
- Incompressible fluid

Subsystem 1

Fitting	Quantity
Check Valve(1-1/2in)	1

Subsystem 2

Fitting	Quantity
Gate Valve(1in)	1

Subsystem 3

Fitting	Quantity
Check Valve(1in)	1
90 degree long elbow(1in)	5
Gate Valve(1in)	1

Subsystem 4

Fitting	Quantity
Gate Valve (1-1/2in)	1

Hydraulic Analysis

Pipe System	Pipe length(ft)	Velocity	Reynolds #	Friction Factor	HL	Diameter	D/e	V^2/2*g	Delta-P
Subsystem 2	10.00	9.84	72785.94	0.02	5.79	0.13	894.67	1.50	339.62
Subsystem 3	10.00	9.62	46343.67	0.03	4.58	0.09	582.67	1.44	268.77
Subsystem 4	610.00	9.62	46343.67	0.03	267.48	0.09	582.67	1.44	15689.60
Subsystem 5	5.00	8.66	64053.70	0.02	1.24	0.13	894.67	1.17	72.62
Subsystem 6	95.00	8.66	64053.70	0.02	22.39	0.13	894.67	1.17	1313.53
Subsystem 1	30.00	9.84		0.02	5.72				

Max Pressure	P1/Y	Z1	V1/2g	HA	P2/Y	Z2	V2/2g	HL
Subsystem 1 & 2	0	11	0	21.15	16.14	3	1.50	11.51
Subsystem 3 & 4	0	11	0	276.06	11.56	2	1.44	272.06
Subsystem 5 & 6	0	7	0	21.63	5.17	9	1.17	23.63

<u>*Sources:*</u>

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

<u>*Design considerations:*</u>

- Frost depth 30 inches
- 2 hr shifts, 7 days per week
- Sg = .94
- Floor elevation level same as railroad track
- Viscosity and vapor pressure 1.50x that of water

<u>*Data/ Variables:*</u>

- $$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+Z_2$$
- K = 30fT @90° elbow

- $hL = K(v^2/2g)$
- $Q = Av$
- $M = PQ$

Procedure:

- Calculate pipe thickness
- Find NPS using chart
- Calculate area and velocity of fluid
- Calculate mass flow rate
- Calculate pressure

Calculations:

See Figure- 12, 13, 14

Materials:

- Schedule 40 pipe
- Coolant
- Pipe elbows

Summary:

- Schedule 40 pipe
- NPS: 1 ¼ in - O.D = 1.660in - I.D = 1.380in - Thickness = .140in
- NPS: 1 ½ in - O.D = 1.900in - I.D = 1.610in - Thickness = .145in

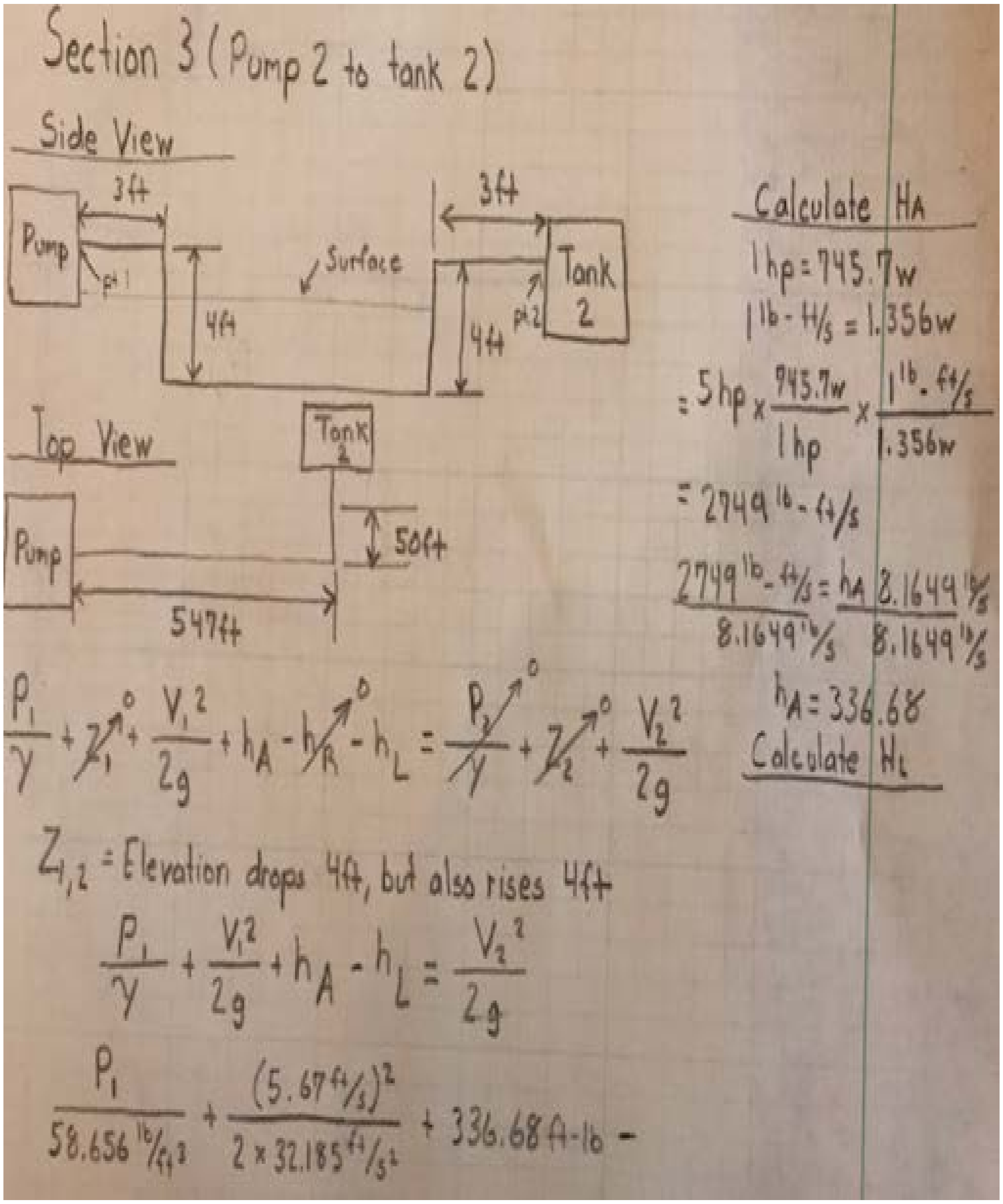

Section 3 (Pump 2 to tank 2)
Side View
3ft
3ft
Pump
pt 1
Surface
Tank 2
pt 2
4ft
4ft
Top View
Tank 2
Pump
50ft
547ft
Calculate HA
1hp = 745.7w
1lb-ft/s = 1.356w
= 5hp x 745.7w / 1hp x 1lb-ft/s / 1.356w
= 2749 lb-ft/s
2749 lb-ft/s = hA 8.1649 lb/s
8.1649 lb/s   8.1649 lb/s
hA = 336.68
Calculate HL
$\frac{P_1}{\gamma} + \cancel{z_1}^0 + \frac{V_1^2}{2g} + h_A - \cancel{h_R}^0 - h_L = \cancel{\frac{P_2}{\gamma}}^0 + \cancel{z_2}^0 + \frac{V_2^2}{2g}$
$z_{1,2}$ = Elevation drops 4ft, but also rises 4ft
$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + h_A - h_L = \frac{V_2^2}{2g}$
$\frac{P_1}{58.656\ lb/ft^3} + \frac{(5.67\ ft/s)^2}{2 \times 32.185\ ft/s^2} + 336.68\ ft\text{-}lb\ -$

Figure 12

Section 2 (From Tank 1 to pump 2)

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

No pressure coming from tank

No Elevation

Velocity

$$Q = Av$$

$$\frac{.0802\ ft^3/s}{.01414\ ft^2} = \frac{.01414\ ft^2\ V}{.01414\ ft^2}$$

$$V = 5.67\ ft/s$$

Calc h_L

$$k = f \times \frac{L}{D}$$

$$= .020 \times \frac{3ft}{.1342ft}$$

$$K = .4470$$

$$h_L = k\left(\frac{v^2}{2g}\right)$$

$$= .4470 \times \left(\frac{(5.67\ ft/s)^2}{2 \times 32.185\ ft/s^2}\right)$$

$$= .2232\ ft$$

$$h_A + \frac{V_1^2}{2g} - h_L = \frac{P_2}{\gamma} + \frac{V_2^2}{2g}$$

$$\frac{(5.67\ ft/s)^2}{2 \times 32.185\ ft/s^2} - .2232\ ft = \frac{P_2}{58.656\ lb/ft^3} + \frac{(5.67\ ft/s)^2}{2 \times 32.185\ ft/s}$$

$$58.656\ lb/ft^3 \times (.4994ft - .2232ft - .4994ft + .5ft) = P_2$$

$$P_2 = 16.23\ lb/ft^2$$

Figure 13

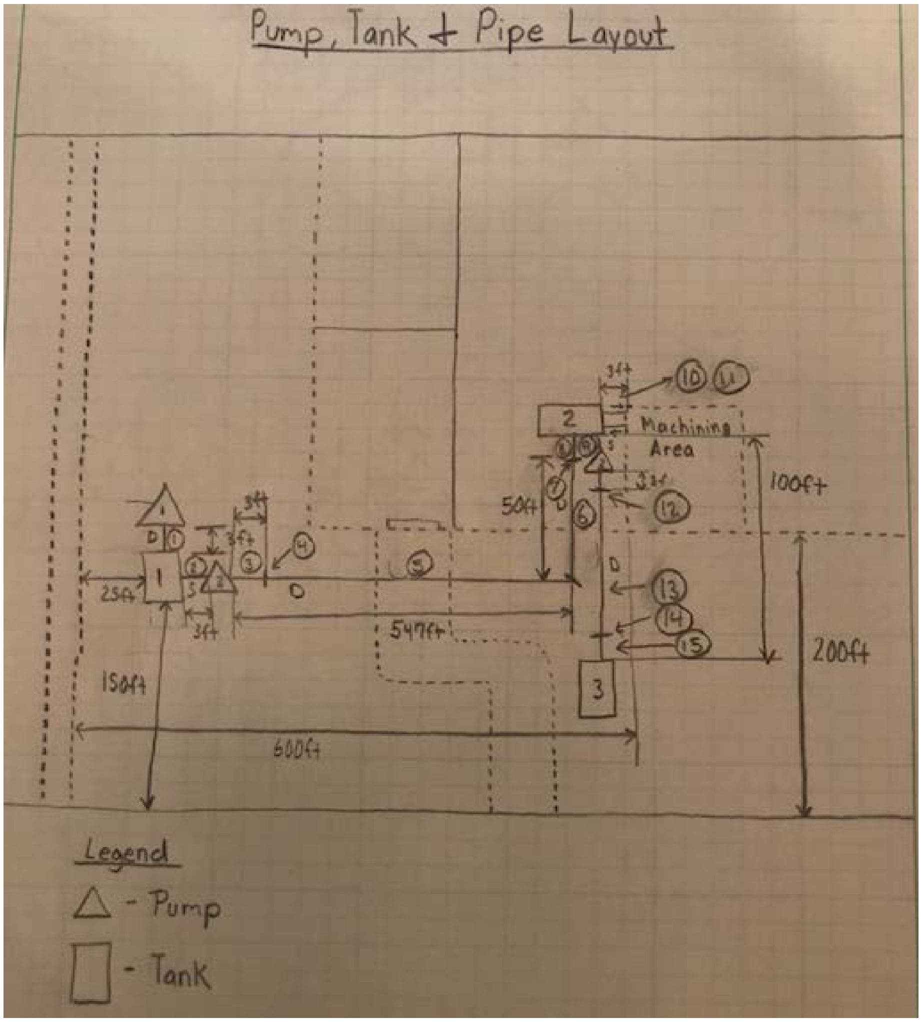

Pump, Tank + Pipe Layout
Machining Area
100ft
200ft
50ft
547ft
25ft
3ft
150ft
600ft
Legend
- Pump
- Tank

Figure 14

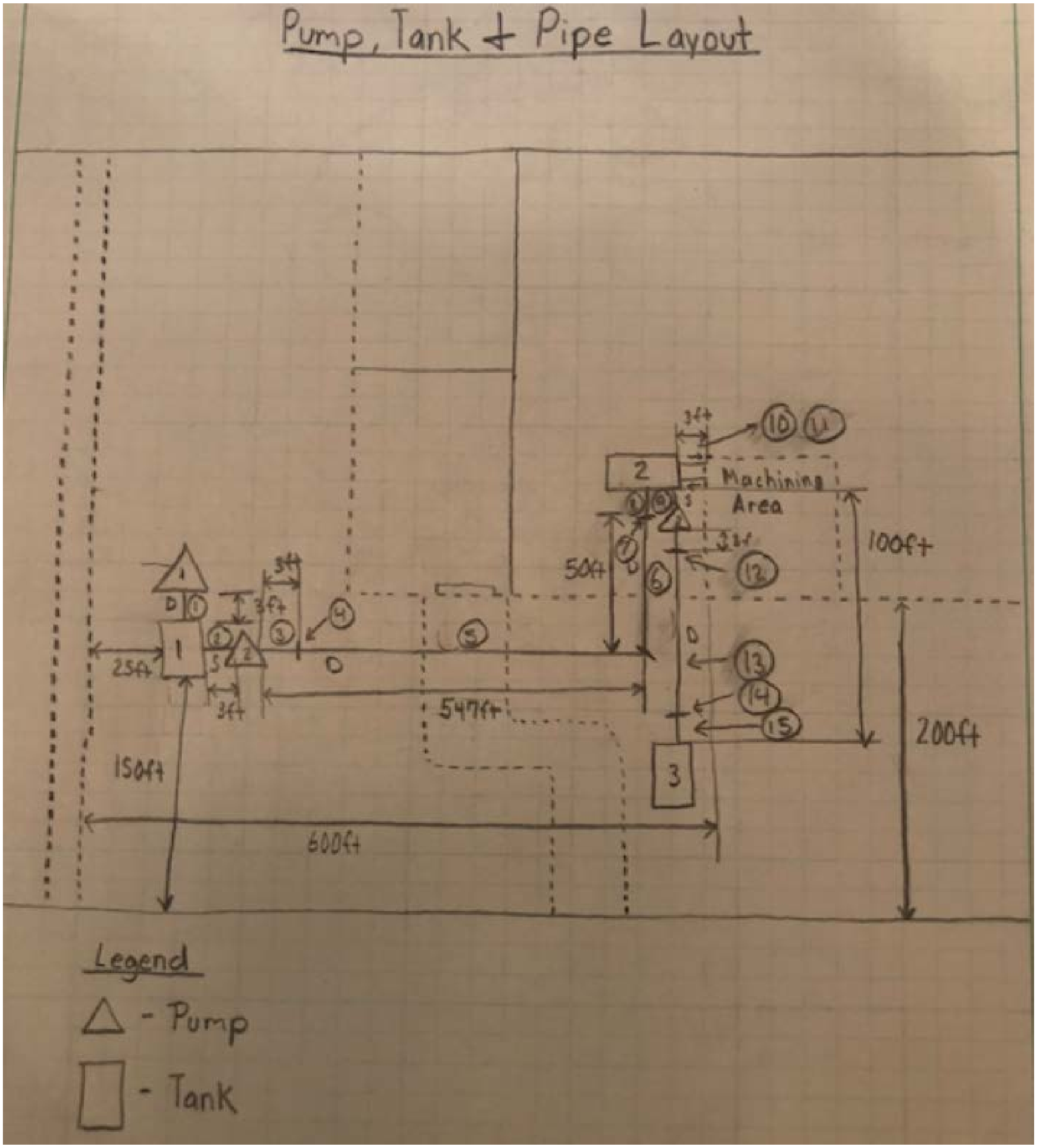
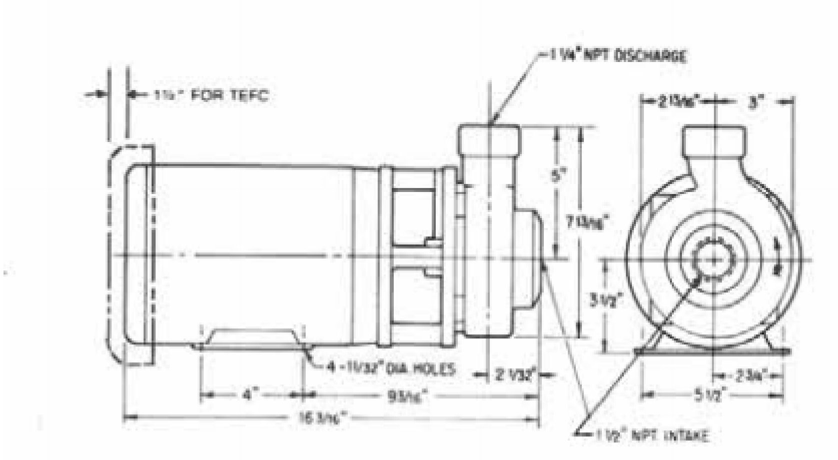

Pump, Tank + Pipe Layout
2
Machining Area
3ft
3ft
3ft
3ft
3ft
50ft
100ft
200ft
25ft
150ft
600ft
547ft
1
3
Legend
- Pump
- Tank

Figure 15

SECTION 4
Flow Rate

Purpose:
- Specify the the pump size and flow rate specs

Drawings:



Sources:
- Mott, R, Untener, J.A., *Applied Fluid Mechanics,* 7th edition, Pearson Education, Inc, (2015)

Design considerations:
- Necessary (gpm)
- 2 hr shifts, 7 days per week
- Sg = .94
- Floor elevation level same as railroad track
- Viscosity and vapor pressure 1.50x that of water

Data/ Variables:
- M = PQ
- Ɣcoolant = 58.656lb/ft□³
- 1hr = 60min

$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\gamma}+\frac{V_2^2}{2g}+Z_2+h_{exit}+h_{entrance}+h_{friction}$$

Calculations:

Modifications

* Time to drain tank 1 raised from 36 Gal/min to 45 Gal/min

$$15{,}000 \text{ gal} \times \frac{1 \text{ min}}{45 \text{ gall}} = 5\tfrac{1}{2} \text{ hrs}$$ To completly empty

Tank 2 (Time to fill)

$$1{,}000 \text{gal} \times \frac{1 \text{ min}}{45 \text{ gal}} = 22.2 \text{min}$$ To completly fill

Tank 2 (Empty)

$$1{,}000 \text{gal} \times \frac{1 \text{ min}}{55 \text{ gal}} = 18.2 \text{min}$$ To completly Empty

Materials:

- Schedule 40 pipe
- Coolant
- Pipe elbows

Summary:

- Tank 1 flow rate = 45 gpm
- Tank 2 flow rate = 45 gpm
- Tank 3 flow rate = 55 gpm

Analysis:

The flow rate was set to have tank 1 fill with 15,000, while tank 2 and 3 is going to be fill with 1,000 gallons each.

SECTION 5

Pipe line Support

<u>Purpose:</u>

The purpose of this task was to decide the type of supports and determine the force acting upon each support.

<u>Drawings:</u>

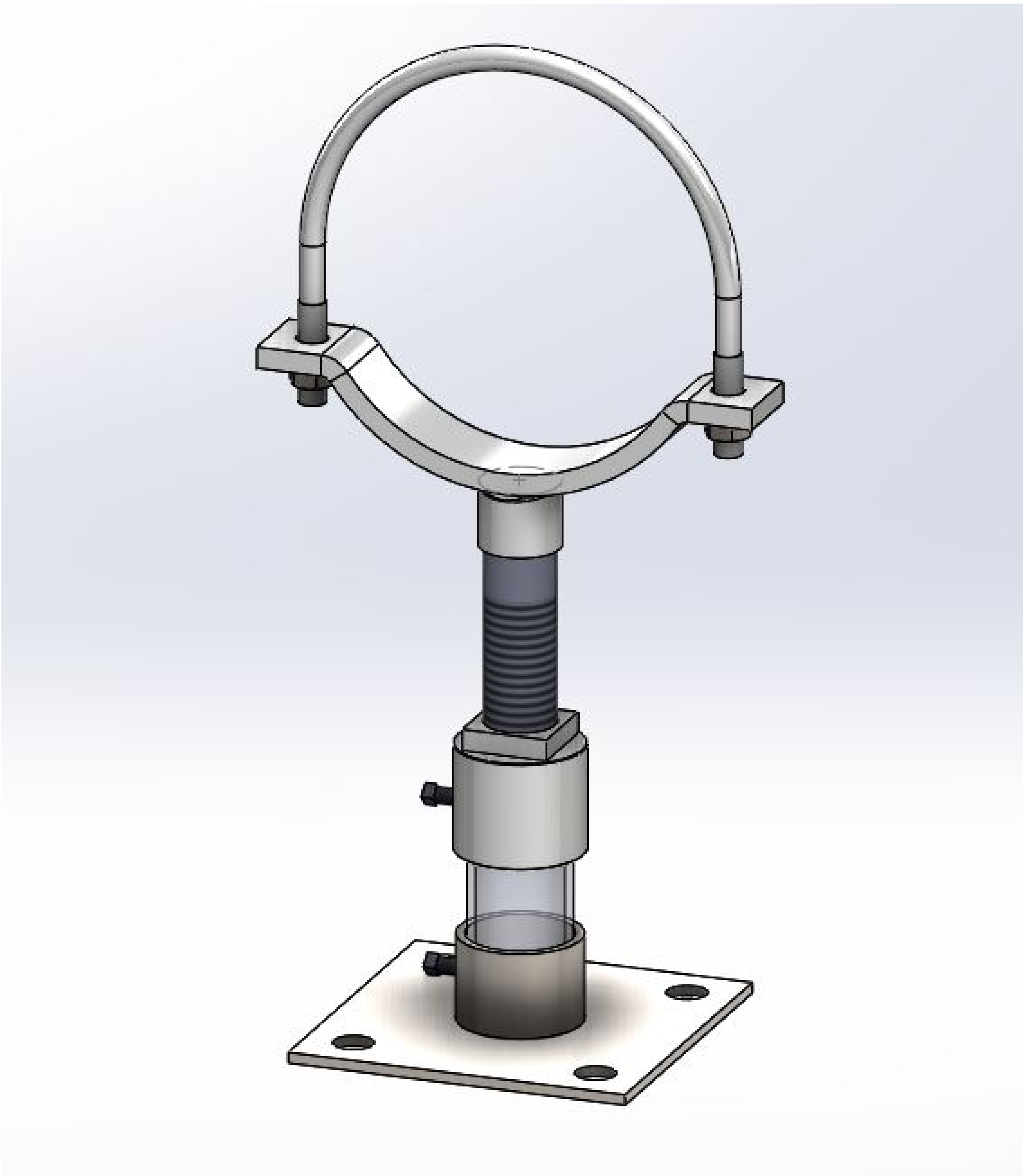


Figure 16

Moment of Inertia

$$I = \frac{\pi(1.9^4 - 1.610^4)}{64}$$

$$= .3098\,in^4$$

$$Y = 1\%\, D_o$$

$$= .01 \times 1.9in$$

$$= .019$$

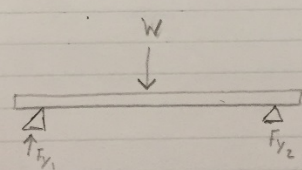
$$Y = -\frac{PL^3}{48EI}$$

$$.019 = -\frac{(4.7642L)L^3}{48(29\times10^6)(.3098)}$$

$$.019 = -(1.6\times10^{-8})L^4$$

$$L = \left(\frac{.019}{1.6\times10^{-8}}\right)^{1/4}$$ Spacing of support

$$= 33.01in \quad or \quad \boxed{2.75ft}$$



$$W = 4.7642 \times 33.01in$$

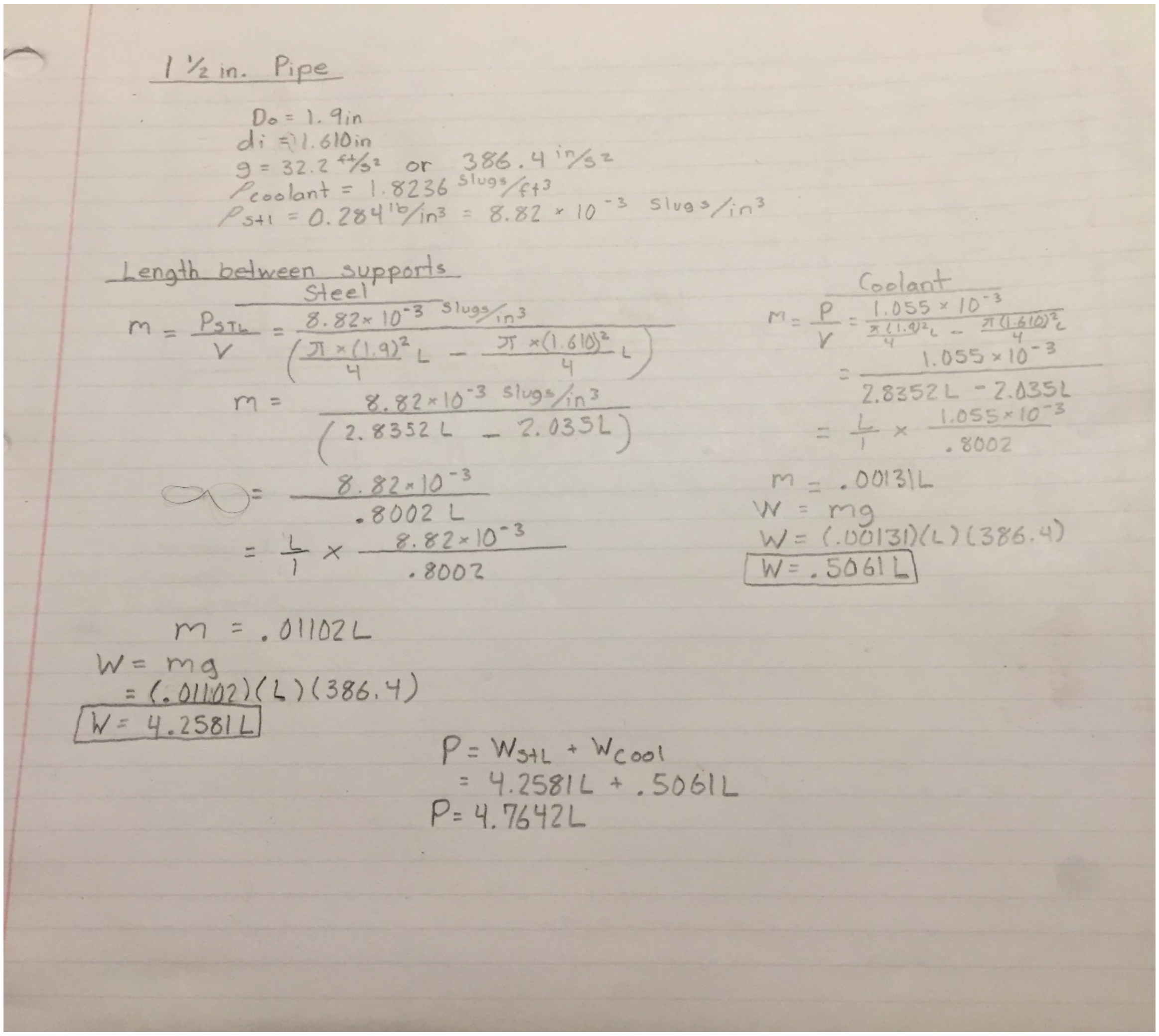
$$= 157.26lb\text{-}in$$

$$\Sigma F_y = 0$$

$$F_{y_1} + F_{y_2} = 157.26$$

$$\frac{2F_y}{2} = \frac{157.26}{2}$$

$$\boxed{F_y = 78.633}$$ Force on each support



1 ½ in. Pipe

$D_o = 1.9 in$
$d_i = 1.610 in$
$g = 32.2\ ft/s^2$ or $386.4\ in/s^2$
$\rho_{coolant} = 1.8236\ slugs/ft^3$
$\rho_{stl} = 0.284\ lb/in^3 = 8.82 \times 10^{-3}\ slugs/in^3$

Length between supports

Steel

$$m = \frac{\rho_{STL}}{V} = \frac{8.82 \times 10^{-3}\ slugs/in^3}{\left(\frac{\pi \times (1.9)^2}{4} L - \frac{\pi \times (1.610)^2}{4} L\right)}$$

$$m = \frac{8.82 \times 10^{-3}\ slugs/in^3}{(2.8352 L - 2.035 L)}$$

$$= \frac{8.82 \times 10^{-3}}{.8002 L}$$

$$= \frac{L}{1} \times \frac{8.82 \times 10^{-3}}{.8002}$$

$$m = .01102 L$$

$$W = mg$$

$$= (.01102)(L)(386.4)$$

$$\boxed{W = 4.2581 L}$$

Coolant

$$m = \frac{\rho}{V} = \frac{1.055 \times 10^{-3}}{\frac{\pi (1.9)^2}{4} L - \frac{\pi (1.610)^2}{4} L}$$

$$= \frac{1.055 \times 10^{-3}}{2.8352 L - 2.035 L}$$

$$= \frac{L}{1} \times \frac{1.055 \times 10^{-3}}{.8002}$$

$$m = .00131 L$$

$$W = mg$$

$$W = (.00131)(L)(386.4)$$

$$\boxed{W = .5061 L}$$

$$P = W_{StL} + W_{cool}$$

$$= 4.2581 L + .5061 L$$

$$P = 4.7642 L$$

<u>Design Considerations:</u>

For the pipes that are ran underground there will be no pipe supports. For the above ground pipes we will use a U bolt saddle support to hold the weight of the pipes and keep them steady.

<u>Summary:</u>

This task required us to decide on a pipe support and to determine the force acting on each support.

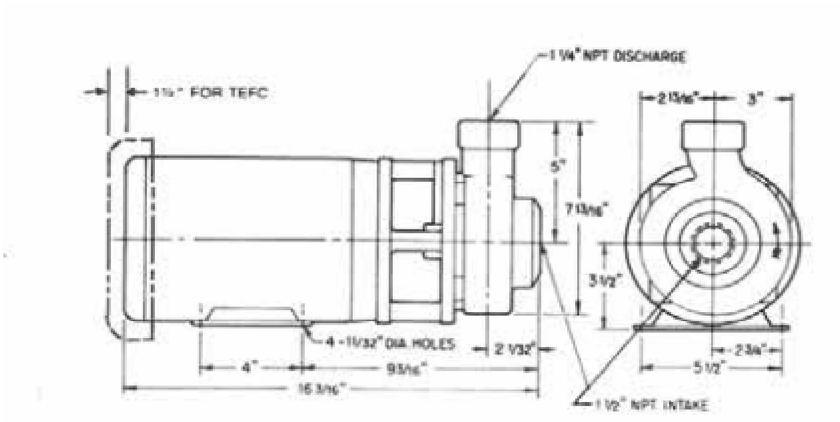
SECTION 6

PUMP SPECIFICATIONS

<u>Purpose:</u> To specify the number of pumps, flow capacities, head capacities, and power requirements

<u>Sources:</u>
http://goulds.com/centrifugal-pumps-boosters/multi-stage-pumps/
https://www.grainger.com/product/DAYTON-120-240VAC-Open-Dripproof-2ZWP3?searchQuery=2zwp3&suggestConfigId=1&searchBar=true

<u>Diagram:</u>



<u>Design Considerations:</u>
- Flow rate
- Pressure
- Pipe inlet and outlet diameters
- Volume

<u>Data/Variables:</u>
- Flow rates = 45 gpm and 55 gpm
- Pipe sizes = 1", 1-½ in, 2 in
- Volume= 15,000 gallons and 1,000 gallons for last 2 pumps

<u>Procedure:</u>
Account for volume that each pump will hold. Find pumps that will accommodate piping sizes and flow rate needed, while keeping pressure low.

<u>Calculations Used:</u>

<u>Summary:</u>
There are 3 total pumps throughout the system:

- Pump 1 will transfer the coolant from the railroad car to tank 1.
- Pump 2 will transfer the coolant from tank 1 to tank 2 inside the building.
- Pump 3 will transfer the coolant from tank 2 to tank 3.

The types of pumps are as followed:

- Pump 1: Open Drip-proof Centrifugal Pump, 1-Phrase
- Pump 2: Vertical In-Line (6) multistage pump
- Pump 3: Open Drip-proof Centrifugal Pump, 1-Phrase

Flow capacities:

- Pump 1: Max. is 72 gpm / Min. is 22 gpm
- Pump 2: Max. is Max. is 75 gpm / Min. is 9 gpm
- Pump 3: Max. is 67 gpm / Min. is 10 gpm

Head Requirements:

- Pump 1: Max head is 55 feet.
- Pump 2: Max head is 1150 feet.
- Pump 3: Max head is 44 feet.

Power Requirements:

- Pump 1: 120/240VAC
- Pump 2: ¾/20 HP
- Pump 3: 120/240VAC

We chose these based upon what would accommodate our calculations for the transferring of the coolant, the inlet/outlet and the head size for the pump. For pump 1 we know a flow rate of 45 gpm was needed, along with a head size of 21.149 ft. Pump 2 was a struggle because we needed a head with a size of 276.0633 ft and flow rate of 45 gpm also. Due to head size requirement, we had to outreach to a commercial retailer to obtain the specific pump we needed. Pump 3 is very similar to pump 1 because the head size requirement is 21.6134 and the flow rate is 55 gpm. One main reason we felt a centrifugal pump was necessary was because they reduce the pressure at the inlet. The was extremely importantly for pump 2 due the size of the head needed. A positive displacement pump wouldn't be able to adjust to the pressure inlet as well as the centrifugal.

Characteristics of the tanks:

-Pump 1:

- "This pump is designed for continuous low-pressure circulation and transfer of nonflammable liquids, utility, boiler feed, general transfer, filtration, cooling towers, condensate return, marine applications, fountains, boosters, water circulation, irrigation, spraying systems, jockey pump service, chemical processing, aggressive liquid applications, and other general-purpose pumping compatible with pump component materials where no suction lift or self-priming is required. It pumps nonstop while producing high flow rates under low head conditions."

-Pump 2:

- This pump is a vertical multistage centrifugal pump. Everything that touch the liquid is stainless steel. It also has a mechanical seal according to EN 12756 and ISO 3069. It has an innovative axial load compensation system to accommodate higher heads, such as ours. It is sustainable through temperatures such from -20F to 250F. To avoid critical mechanical areas being exposed to air, the tank has a seal housing chamber.

-Pump 3:

- "Designed for continuous low-pressure circulation and transfer of nonflammable liquids, utility, boiler feed, general transfer, filtration, cooling towers, condensate return, marine applications, fountains, boosters, water circulation, irrigation, spraying systems, jockey pump service, chemical processing, aggressive liquid applications, and other general-purpose pumping compatible with pump component materials where no suction"

<u>Pump Size and Weight:</u>

Pump 1:

- Frame = 56J
- Length = 13-1/2"
- Width = 6-5/8"
- Height = 5-7/8"
- Weight= 34.5 lbs.

Pump 2:

- Frame = 184TC
- Length = 21.71"
- Width = 6.87"
- Weight = 119"

Pump 3:

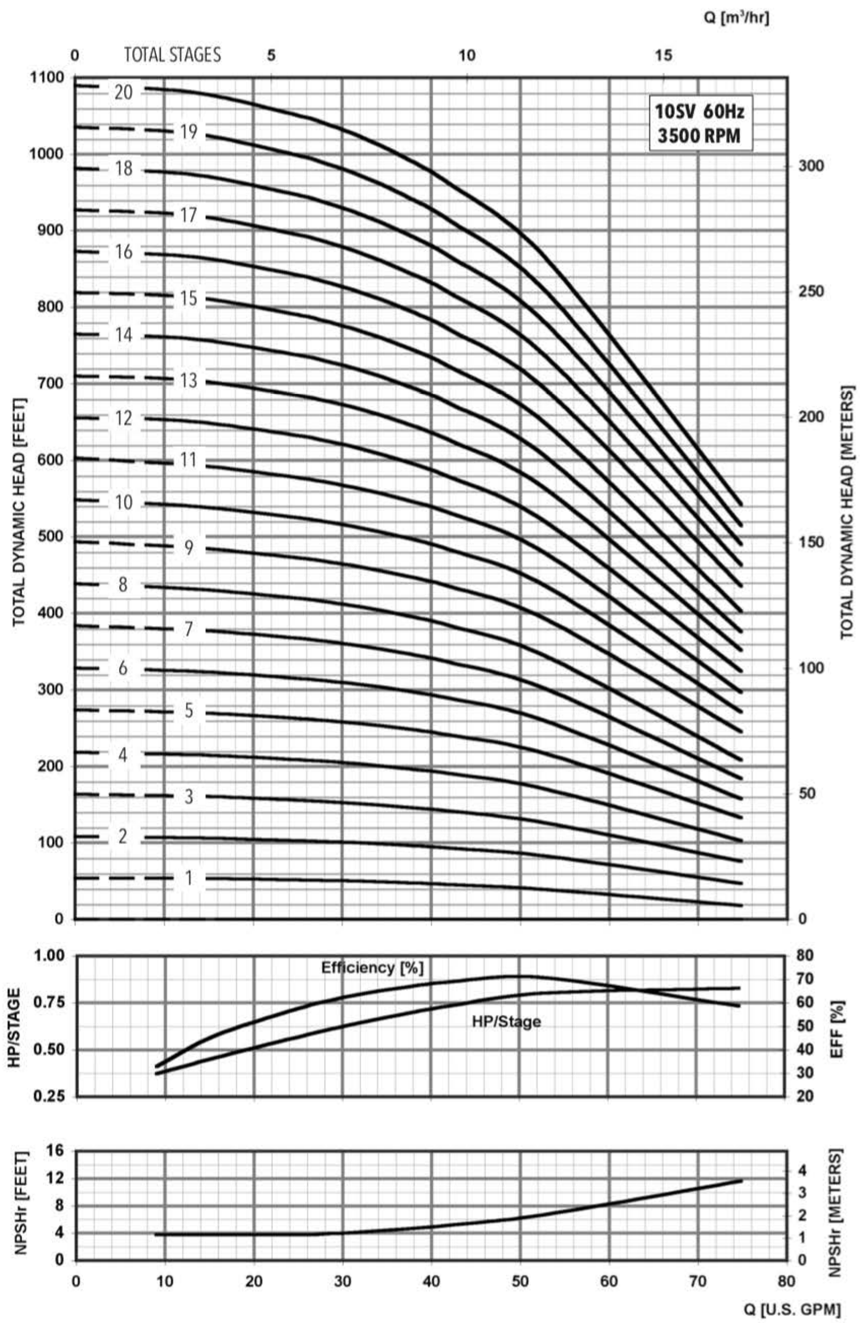
- Frame = 56J
- Length = 13-1/2"

- Width = 6-5/8”
- Height = 5-7/8”
- Weight= 35 lbs.

Goulds Water Technology

Commercial Water

Performance Curve **10SV 3500 RPM** **60 Hz**



MINIMUM FLOW RATE: 9 GPM [2 m³/hr]

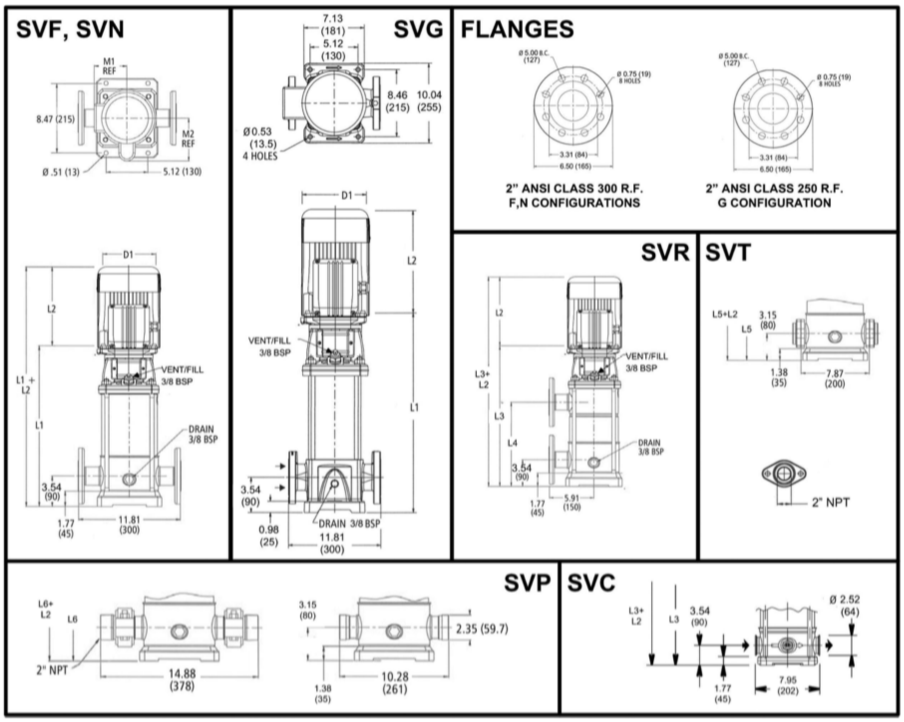
Item	Centrifugal Pump	Motor Type	Capacitor Start
Item - Straight Centrifugal Pumps	Straight Centrifugal High Flow Pump	Wetted Materials	Cast Iron, Buna-N, Carbon, Ceramic, Stainless Steel
HP - Pumps	3/4	Max. Liquid Temp.	200 Degrees F
Voltage - Pumps	120/240VAC	GPM of Water @ 20 Ft. of Head	63
Phase - Pumps	1	GPM of Water @ 25 Ft. of Head	58
Housing Material - Pumps	Cast Iron	GPM of Water @ 30 Ft. of Head	53
Inlet Size - Pumps	1-1/4" NPT	GPM of Water @ 40 Ft. of Head	41
Outlet Size - Pumps	1" NPT	GPM of Water @ 50 Ft. of Head	22
Max. Pressure - Pumps	24 psi	Max. Specific Gravity	1.0
Max. Head	55	Max. Case Pressure	200 psi
Motor Enclosure - Pumps	Open Dripproof	Inlet Pressure	200 psi
Best Efficiency Range GPM @ Head	35 to 63 gpm @ 45 to 20 ft.	Bearing Type	Ball
Amps	11.3/5.6	Max. Dia. Solids	1/2"
Impeller Type	Semi Open	Manufacturers Warranty Length	1 yr.
Impeller Material	Cast Iron	Includes	Manual
GPM of Water @ 10 Ft. of Head	72	Agency Compliance	c UL us
GPM of Water @ 15 Ft. of Head	67	Duty	Continuous
Seal Material	Buna-N, Carbon, Ceramic, Stainless Steel	Frame	56J
Length	13-1/2"	Port Rotation	4 Position Increments
Width	6-5/8"	Max. GPM @ Head	72 gpm @ 10 ft.
Height	5-7/8"	Best Efficiency GPM @ Head	47 gpm @ 36 ft.
Motor RPM	3450		

Item	Centrifugal Pump	Hz	60
Item - Straight Centrifugal Pumps	Straight Centrifugal High Flow Pump	Motor Type	Capacitor Start
HP - Pumps	1/2	Wetted Materials	Cast Iron, Buna-N, Carbon, Ceramic, Stainless Steel
Voltage - Pumps	120/240VAC	Max. Liquid Temp.	200 Degrees F
Phase - Pumps	1	GPM of Water @ 20 Ft. of Head	57
Housing Material - Pumps	Cast Iron	GPM of Water @ 25 Ft. of Head	48
Inlet Size - Pumps	1-1/4" NPT	GPM of Water @ 30 Ft. of Head	40
Outlet Size - Pumps	1" NPT	GPM of Water @ 40 Ft. of Head	10
Max. Pressure - Pumps	19 psi	Max. Specific Gravity	1.0
Max. Head	44	Max. Case Pressure	200 psi
Motor Enclosure - Pumps	Open Dripproof	Inlet Pressure	200 psi
Best Efficiency Range GPM @ Head	19 to 63 gpm @ 35 to 15 ft.	Bearing Type	Ball
Amps	8.4/4.8	Max. Dia. Solids	7/16"
Impeller Type	Semi Open	Manufacturers Warranty Length	1 yr.
Impeller Material	Cast Iron	Includes	Manual
GPM of Water @ 10 Ft. of Head	67	Agency Compliance	c UL us
GPM of Water @ 15 Ft. of Head	63	Duty	Continuous
Seal Material	Buna-N, Carbon, Ceramic, Stainless Steel	Frame	56J
Length	13-1/2"	Port Rotation	4 Position Increments
Width	6-5/8"	Max. GPM @ Head	67 gpm @ 10 ft.
Height	5-7/8"	Best Efficiency GPM @ Head	38 gpm @ 27 ft.
Motor RPM	3450	Min. GPM @ Head	10 gpm @ 40 ft.

Goulds Water Technology

Commercial Water

Dimensions and Weights | **10SV Series 3500 RPM** | **60 Hz**



All dimensions are in inches (mm).

10SV SERIES – 60Hz, 3500 RPM ODP/TEFC Enclosures

Pump Type Stages	Motor					Dimensions (in)															Weight (lbs.)								
	HP	NEMA Frame				L1	L2				L3	L4	L5	L6	M (Ref.)	D1 (max.)				D2	Pump Only	Motor				Pump/Motor			
		ODP 1Ø	TEFC 1Ø	ODP 3Ø	TEFC 3Ø		ODP 1Ø	TEFC 1Ø	ODP 3Ø	TEFC 3Ø						ODP 1Ø	TEFC 1Ø	ODP 3Ø	TEFC 3Ø			ODP 1Ø	TEFC 1Ø	ODP 3Ø	TEFC 3Ø	ODP 1Ø	TEFC 1Ø	ODP 3Ø	TEFC 3Ø
10SV-01	0.75	56C				16.56	10.79	9.91	9.16	9.29	-	-	16.17	16.17	5.19	6.19	6.19	6.19	6.19	4.13	36	27	29	21	21	63	65	57	57
10SV-02	2					16.56	11.18	12.06	11.16	10.79	-	-	16.17	16.17	5.74	7.19	7.19	6.19	6.19	4.72	38	43	51	32	33	81	89	70	71
10SV-03	3					17.82	11.57	13.44	11.18	11.16	-	-	17.43	17.43	5.75	6.50	7.19	7.16	7.19	5.51	40	49	64	41	44	89	104	81	84
10SV-04	5	184TC		182TC	184TC	19.58	13.93	15.43	12.55	13.93	-	-	19.19	19.19	6.87	8.88	8.86	9.02	8.86	5.51	46	81	92	62	69	127	138	108	115
10SV-05						20.84	13.93	15.43	12.55	13.93	20.84	10.20	20.45	20.45	6.87	8.88	8.86	9.02	8.86	5.51	48	81	92	62	69	129	140	110	117
10SV-06						22.10	13.93	15.43	12.55	13.93	22.10	11.46	21.71	21.71	6.87	8.88	8.86	9.02	8.86	5.51	50	81	92	62	69	131	142	112	119
10SV-07	7.5	213TC		184TC		23.36	13.88	15.53	13.93	15.43	23.36	12.72	22.97	22.97	8.05	8.89	10.62	8.88	8.86	5.51	52	100	120	75	85	152	172	127	137
10SV-08						24.62	13.88	15.53	13.93	15.43	24.62	13.98	24.22	24.22	8.05	8.89	10.62	8.88	8.86	5.51	54	100	120	75	85	154	174	129	139
10SV-09				184TC/213TC*		25.88	13.88	15.53	13.93	15.43	25.88	15.24	25.48	25.48	8.05	8.89	10.62	8.88	8.86	5.51	56	100	120	75	85	156	176	131	141
10SV-10	10	215TC		213TC	215TC	27.71	16.63	16.68	15.55	15.51	27.71	16.50	-	27.31	8.77	10.62	10.18	10.18	10.28	5.51	66	132	145	107	122	198	211	173	188
10SV-11						28.97	16.63	16.68	15.55	15.51	28.97	17.76	-	28.57	8.77	10.62	10.18	10.18	10.28	5.51	68	132	145	107	122	200	213	175	190
10SV-12						29.44	16.63	16.68	15.55	15.51	29.44	19.02	-	29.05	8.77	10.62	10.18	10.18	10.28	5.51	70	132	145	107	122	202	215	177	192
10SV-13						31.51	16.63	16.68	15.55	15.51	31.51	20.28	-	31.11	8.77	10.62	10.18	10.18	10.28	5.51	75	132	145	107	122	207	220	182	197
10SV-14						32.85	16.63	16.68	15.55	15.51	32.85	21.54	-	32.45	8.77	10.62	10.18	10.18	10.28	5.51	77	132	145	107	122	209	222	184	199
10SV-15	15	-		215TC	254TC	34.66	-	-	15.55	16.57	-	-	-	34.26	9.22	-	-	10.18	10.28	5.51	84	-	-	125	195	-	-	209	279
10SV-16						35.92	-	-	15.55	16.57	-	-	-	35.52	9.22	-	-	10.18	10.28	5.51	86	-	-	125	195	-	-	211	281
10SV-17						37.18	-	-	15.55	16.57	-	-	-	36.78	9.22	-	-	10.18	10.28	5.51	88	-	-	125	195	-	-	213	283
10SV-18						38.44	-	-	15.55	16.57	-	-	-	38.04	9.22	-	-	10.18	10.28	5.51	90	-	-	125	195	-	-	215	285
10SV-19						39.78	-	-	15.55	16.57	-	-	-	39.38	9.22	-	-	10.18	10.28	5.51	92	-	-	125	195	-	-	217	287
10SV-20	20			254TC	256TC	40.96	-	-	16.66	20.08	-	-	-	40.56	9.5	-	-	10.18	13.13	5.51	94	-	-	144	285	-	-	238	379

* Please refer to motor table for frame size

Task 17

Electrical Motor Requirements:

Pump 1:

- ¾ HP
- 1-phrase

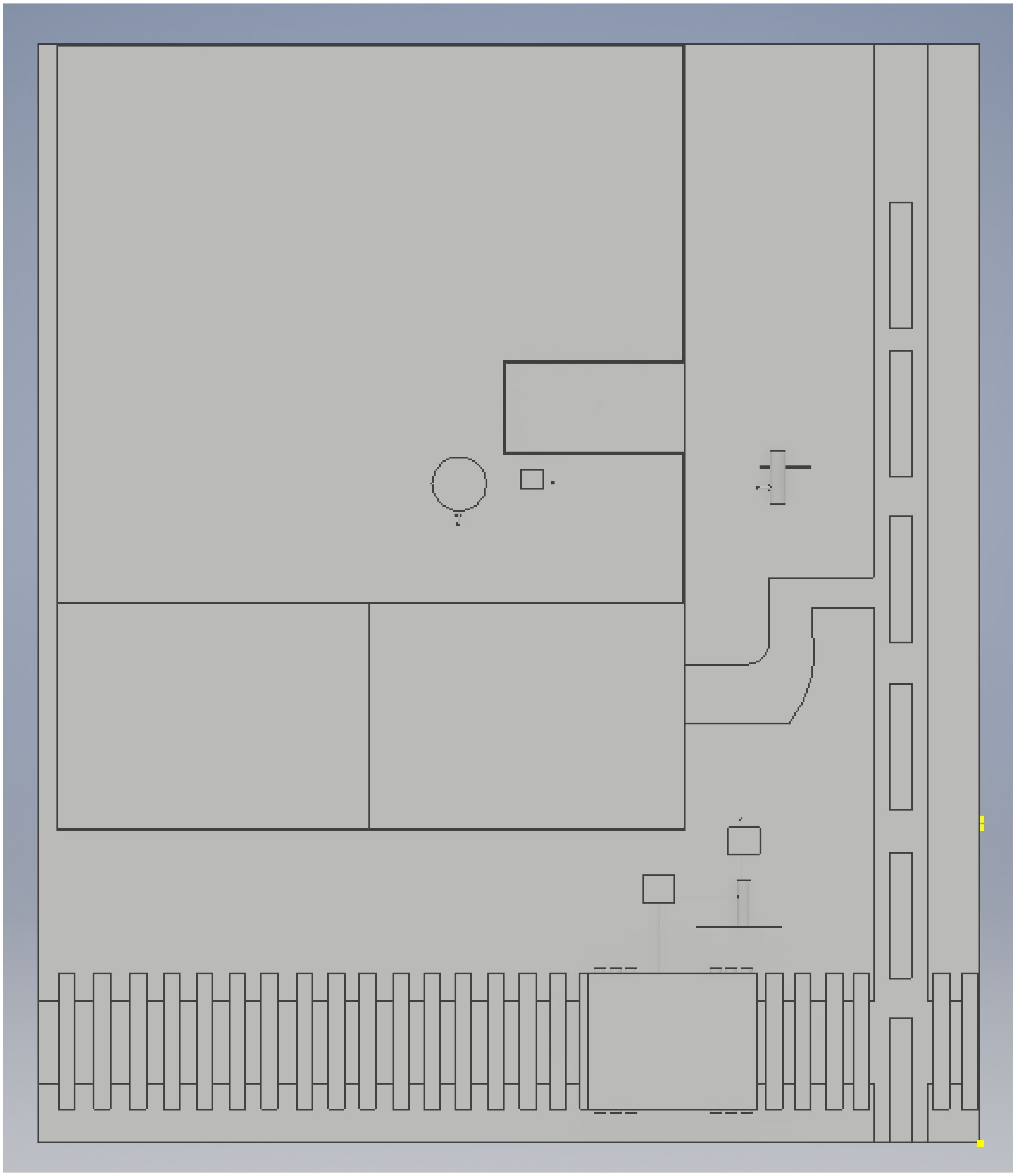
Pump 2:

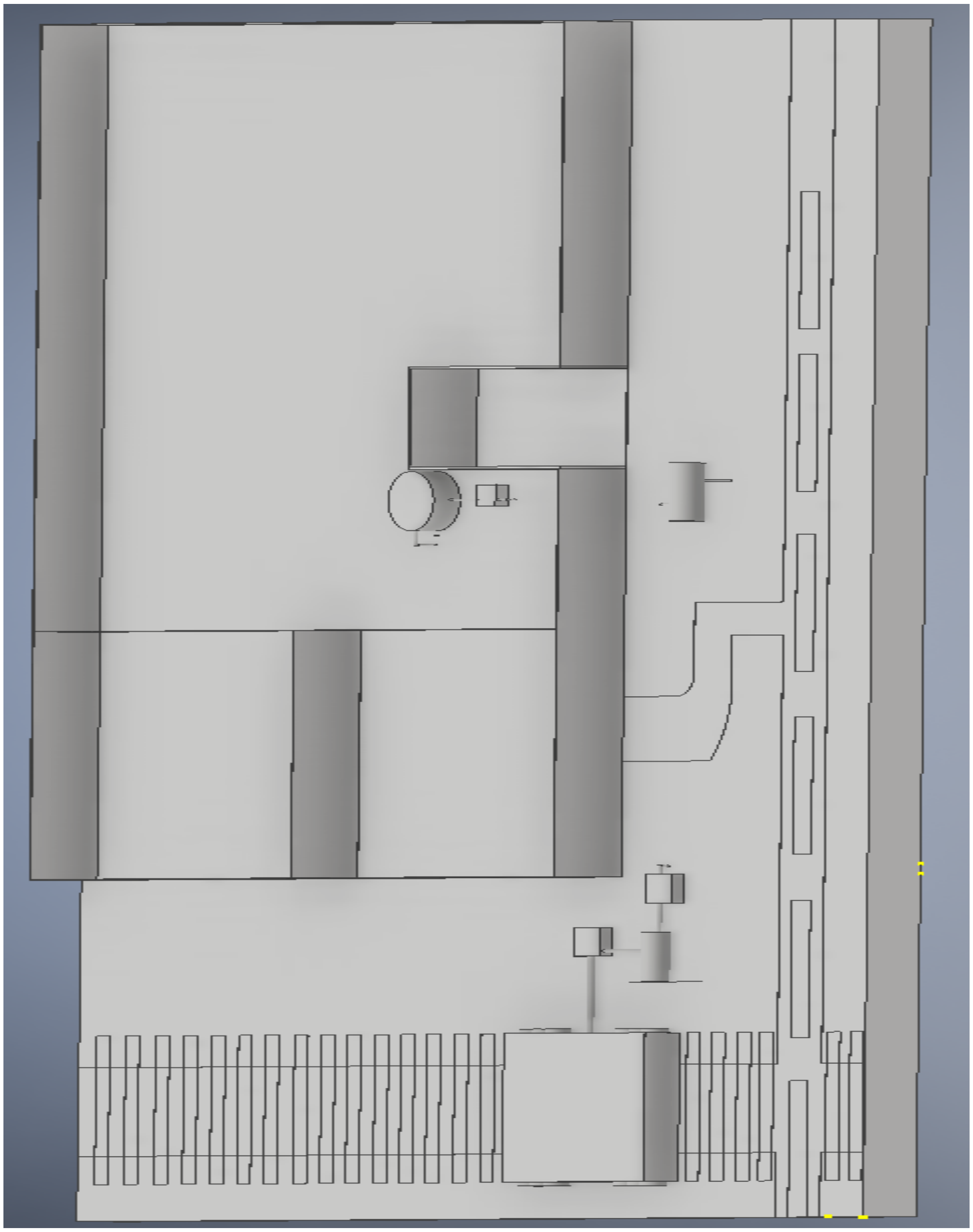
- 0.5 HP – 75 HP
- Multistage

Pump 3:

- ½ HP
- 1-phase

Final Drawings





BILL OF MATERIALS

Nomenclature	Manufacturer	Rating	Material	Qty
Tank 1	Southern Tanks	15,310 gal	Carbon Steel	1
Tank 2	Southern Tanks	1,128 gal	Carbon Steel	1
Tank 3	Southern Tanks	8,626 gal	Carbon Steel	1
Blind Flange	Coastal Precision Engineered Flanges		ANSI B16.5 Class 150	1
Bolts	Fastenal	33,000 psi	Grade 2	4
Nuts	Fastenal	33,000 psi	Grade 2	4
Washers	Fastenal	33,000 psi	Grade 2	8
System Piping	BMG Metals		1-1/2in Schedule 40 Steel Pipe	7
System Piping	BMG Metals		1in Schedule 40 Steel Pipe	6
90° long radius elbow 1-1/2in	Grainger, Inc.		Schedule 40 Steel	5
90° long radius elbow 1in	Grainger, Inc.		Schedule 40 Steel	5
Gate valve 1in	Powell Valves		Schedule 40 Steel	3
Gate valve 1-1/2in	Powell Valves		Schedule 40 Steel	1
Pump 1	Sulzer		N/A	1
Pump 2	Sulzer		N/A	1
Pump 3	Sulzer		N/A	1
Pump 4	Sulzer		N/A	1

GROUP REFLECTIONS

Dezmond Banks:

Going into the semester I can honestly say that I underestimated this project and I truly regret it. I spent a lot of days and nights cursing your name (Ayala), but obviously you aren't the one to blame. I now look at the project and your motives differently. When I first began this project I thought your only sole purpose of this project was to teach us fluids from a real life perspective. Now that it has come to an end I feel that you not only created this assignment to teach us about fluids but to teach us about ourselves and what it's like to work with a team of peers. From everything that has happened this semester I have learned a great deal about myself and my peers. I now understand how important everyone's role is in a team and how each role plays into the next. For this project I was the leader, and unfortunately I feel like I failed as a leader to keep the ship up and running smooth. Throughout the project there were many unfortunate circumstances that could have possibly been avoided with better time management skills and delegation of tasks. In conclusion, I will take this as a lesson learned and apply it to all of my future endeavors.

- Dezmond Banks

Ricky Scott:

Throughout this project I was met by many obstacles that really challenged my knowledge dealing with fluid mechanics. Through perseverance of me and my team members we were able to overcome most of those obstacles and formulate a simple yet effective design. By participating in this project I was able to gain more knowledge about the subject matter than I ever though I would. I am 100% confident in my ability to solve any problem pertaining to fluid mechanics. In conclusion, I must say this project was the most time consuming thing I have ever faced in all of my academic career.

- Ricky Scott