Department of Engineering Technology

MET 330

Fluid Mechanics

Pipeline System Design of a Manufacturing Plant for CONTINENTAL AG

Prepared by Josh Norwood, Andrew Walden, and Al McClenney

Mechanical Engineering Technology

Old Dominion University

May 1, 2019

Abstract

Continental AG of Dayton, Ohio has contracted with three Mechanical Engineers from Old Dominion University for a pipeline system design of their new manufacturing plant. Specific to the design are requirements that fluid be delivered by a Railroad Tank Car to a 1000 gallon tank ODU Engineers will provide recommendations per pipe and Sulzer pump selection, pump and fluid flow rates, efficiency losses, and location and design for all parts of the system.

Table of Contents

Table of Contents

Report Body

a. Job Site Location: Dayton, Ohio- a Bernoulli lover's dream city!

•sixth largest city in the state

Per the city's website:

Dayton, Ohio is the Birthplace of Aviation and so much more! In Dayton and Montgomery County, you will find big-city amenities with Midwestern charm and affordability. Dayton is home to the Wright Brothers, the Dayton Aviation Heritage National Historical Park, and the National Museum of the U.S. Air Force, the world's largest and oldest military aviation museum and the state's most visited free tourist attraction!

•Our building is located outside of the main town, into a small part of the city that extends into Greene County.

•Weather in Dayton can be severe, with snow and freezing weather by the end of October, lasting until March. Temperatures range from minus 20 F to 105 F and the frost line is 30 inches below the surface. Springs are cool with the threat of high winds and tornadoes, which are factored into the design. Summers are very warm.

•The manufacturing plant is only one story with a concrete floor.

•The elevation of the railroad track is the same elevation as the above concrete floor.

Report Body

b. Specifications and Design Philosophy

- Our task is only to design the pipeline of the system taking the coolant from the railroad tank to the storage tank.
- New coolant is delivered to the plant by railroad tank cars, carrying 15,000 gallons each.
- A storage tank for new coolant must be specified
- The reservoir for the automated machining system must have a capacity of 1,000 gallons
- The coolant may become contaminated and need dumping more than the regularly scheduled once per week. A truck picks up the dirty fluid, but emergency dumps are possible.
- The plant operates 24 hours per day, 7 days per week; third shift performs maintenance.

Report Body

c. Sources

" Sulzer Type OHH Pumps." Home - Because Life Is Fluid | Sulzer, www.sulzer.com/.

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

Report Body

d. Materials and Specifications

- Pipe material established to be used
  - Schedule 80 steel pipe will be used for this project

  -reasons behind selection
  - Provides additional strength for routing under driveway, where potential heavily loaded vehicles may drive or park
  - Provides better resistance to extreme weather conditions
  - Delivers endurance to higher pressure of fluids

- Fluid characteristics
  - The coolant is a solution of water and soluble oil with specific gravity of 0.94 and a freezing point 0˚F.
  - Corrosiveness is approximately the same as that of water.
  - Viscosity and vapor pressure of the coolant are 1.50 times that of water at any temperature.

e. Preliminary drawings and sketches

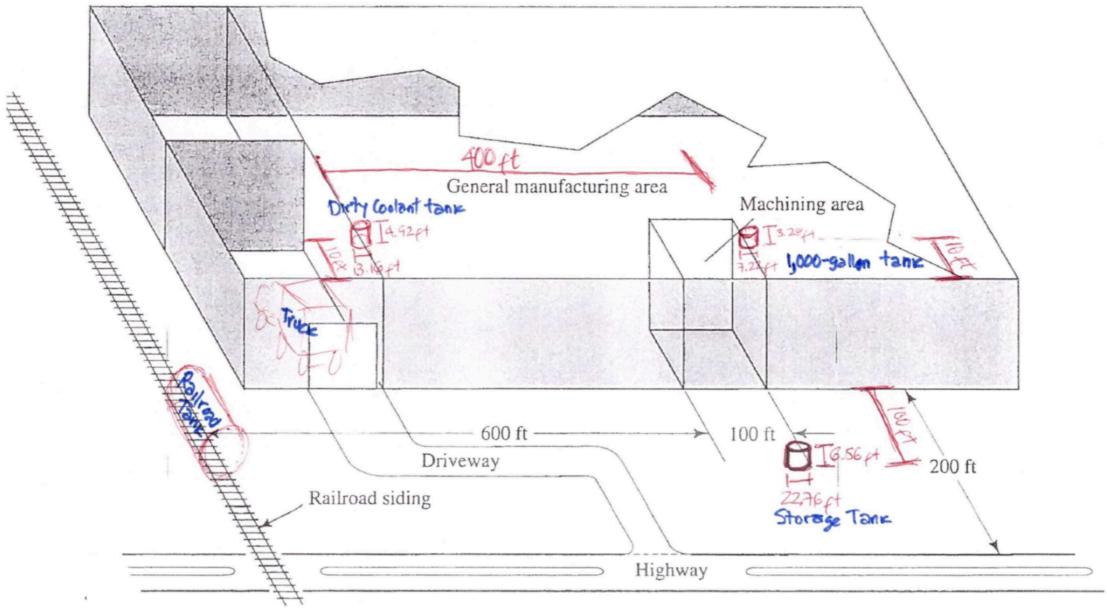
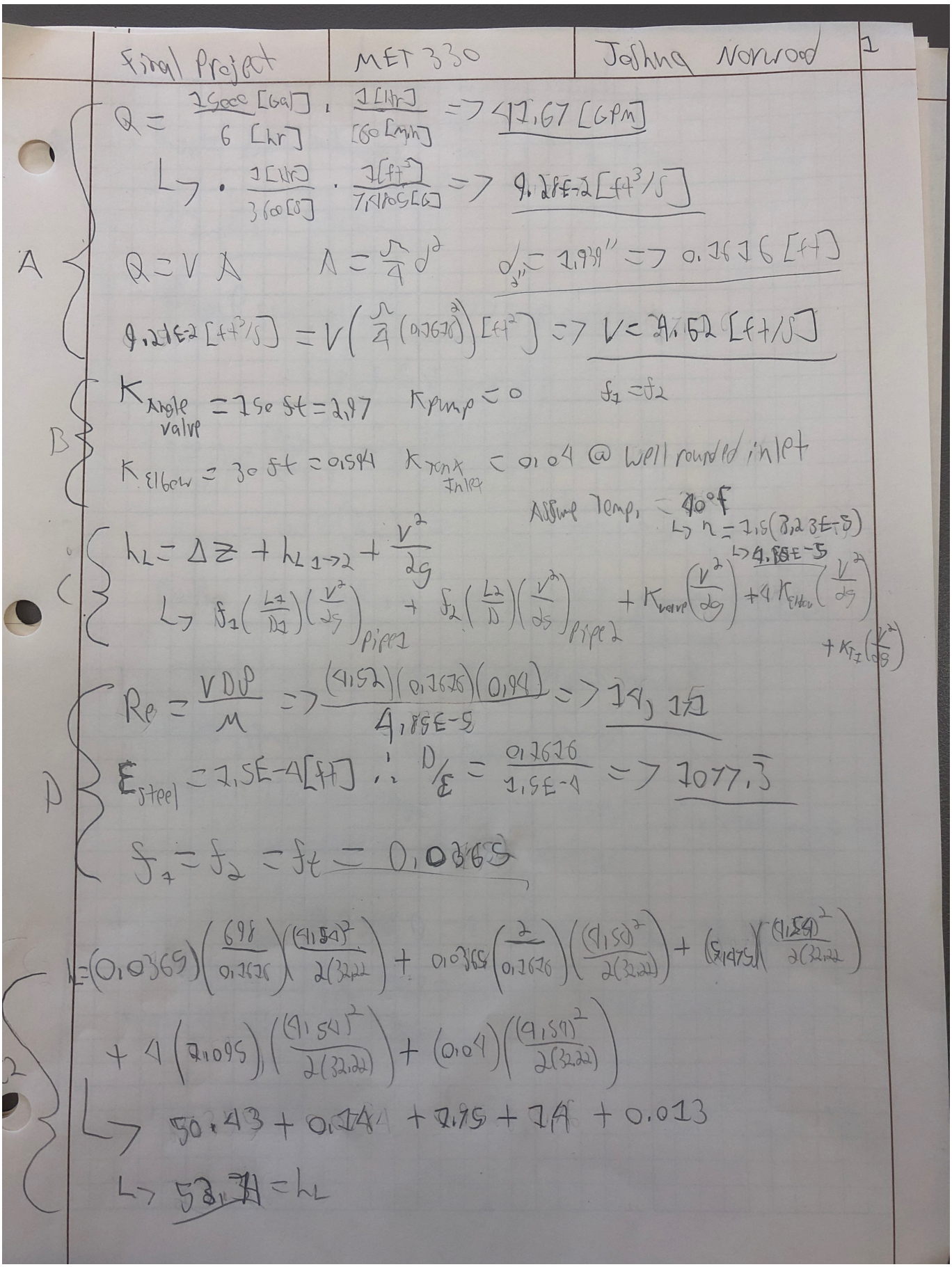


Figure 1. Plot plan of manufacturing plant for design problem

g. Design Calculations



$h_A = \Delta z + h_{L1\to2} + \frac{V^2}{2g} \Rightarrow 7 + 52.3 + \frac{(9.50)^2}{64.194}$

$\hookrightarrow h_A = 53.62$

D

Pump selected off 1775 RPM @ 60Hz

$\hookrightarrow$ 1.5 x 3 x 8

$\left(\frac{h_{A2}}{h_{A1}}\right) = \left(\frac{N_2}{N_1}\right)^2 \Rightarrow \left(\frac{1775}{3550}\right)^2 \Rightarrow (0.5)^2 = 0.25$

$h_{A2} = 0.25(h_{A1}) \Rightarrow h_{A1} = \frac{h_{A2}}{0.25} \Rightarrow 214.48$ ✓

Both Line up in 1.5 x 3 x 8 pump section

Part (1) • Why kinetic pump instead of positive displacement?

- Cheaper, smaller, and can control "Q"
  - ↳ Radial flow (centrifugal) due to constant state of substance and speed needed of delivery of fluid

$Q_1 = 0 \therefore h_{A1} = 0.95$ [ft] $Q_2 = 47.67$ [GPM] $\therefore h_{A2} = 53.3$ [ft]

$Q_3 = 10$ [GPM] $h_{A3} = 47.5 + 0.41 + 4.91 + 3.93 + 0.36$

$V_3 = 7.16$ [ft/s] $\hookrightarrow$ 156.76

$h_{A5} = 156.76$ $Q_3 = 10$ [GPM] $\therefore$ 6150" Line

7.) $P_{ower_{pump}} = \frac{\gamma Q h_w}{\eta} \Rightarrow \frac{(0.99)(9.28E-2)(53.79)}{\eta}$

$\eta = P_E \times M_E \qquad M_E = 1.1(P_E)$

$\hookrightarrow \eta = P_E \times 1.1(P_E) \Rightarrow 1.1 P_E^2$

@ 47.67 [GPM] $\Rightarrow P_{ower} = 5.5$ [BHP]

@ 70 [GPM] $\Rightarrow P_{ower} = 6.5$ [BHP]

According to Table, $P_E = 42\%$

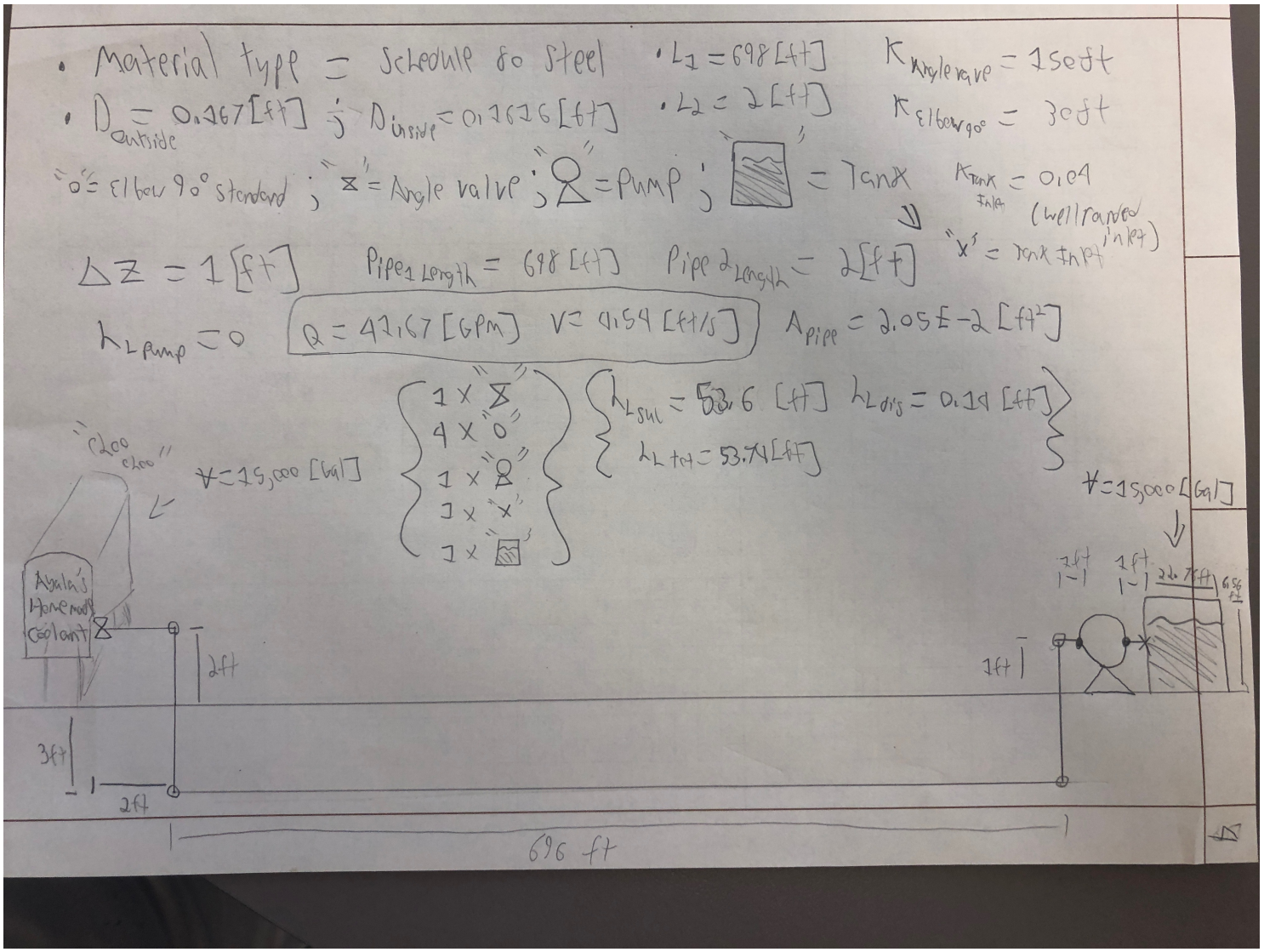
$\eta = 1.1(0.42)^2 \Rightarrow 0.185 \times 100 \Rightarrow$ **18.5%**

8) According to Table, Cavitation = 4[ft] @ 47.67 [GPM]

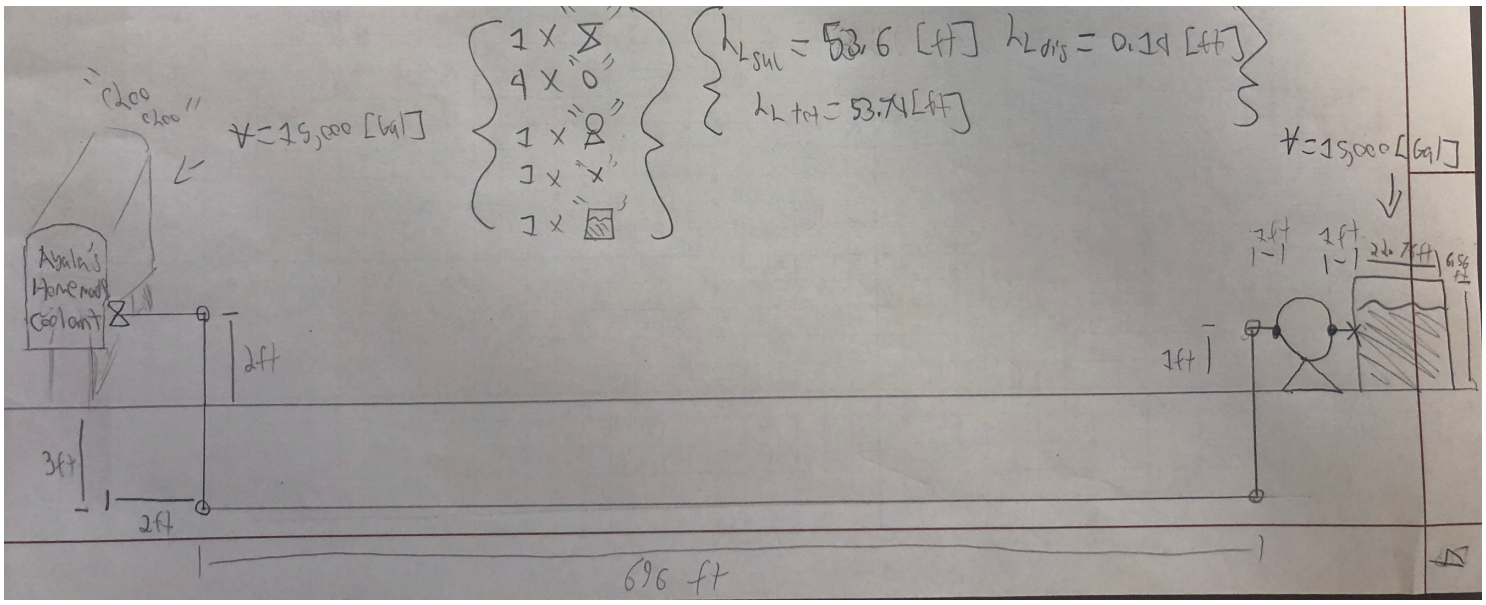
$\hookrightarrow$ 4[ft] @ 70 [GPM]

Tables used

Pg. E0.11 , E0.5, E0.1)


• Material type = Schedule 80 Steel
• $D_{outside} = 0.167$ [ft] ; $D_{inside} = 0.1626$ [ft]
• $L_1 = 698$ [ft]
• $L_2 = 2$ [ft]
$K_{Angle\ valve} = 150$ ft
$K_{Elbow\ 90°} = 30$ ft
"O" = Elbow 90° standard ; "⧖" = Angle valve ; "⧖" = Pump ; = Tank
$K_{Tank\ Inlet} = 0.04$ (well rounded inlet)
"X" = Tank Inlet
$\Delta Z = 1$ [ft]
Pipe 1 Length = 698 [ft]
Pipe 2 Length = 2 [ft]
$h_{L\ Pump} = 0$
Q = 47.67 [GPM]
V = 0.54 [ft/s]
$A_{Pipe} = 2.05E-2$ [ft²]
1 x ⧖
4 x O
1 x ⧖
1 x X
1 x
$h_{L\ Suc} = 53.6$ [ft]
$h_{L\ dis} = 0.14$ [ft]
$h_{L\ tot} = 53.74$ [ft]
"Cool Cool"
V = 15,000 [Gal]
Ayala's Homemade Coolant
2ft
3ft
2ft
696 ft
V = 15,000 [Gal]
2ft
1ft
1ft
22.74ft
696 ft
1ft

4. Final Drawings



a. Elevation view of final pipeline design

5. Materials and equipment list

Schedule 80 steel pipe	700 ft
Elbows, 90° standard	4
Angle valve	1
Sulzer pump	1
Storage tank	1000 gal
Pipe supports	4

6. Final remarks

The pump chosen for this project was selected from the Sulzer, Curves-Type OHH chart for pumps operating at 60 Hertz and 1775 rpm, Series 2.0

The Sulzer pump selected was 1.5 x 3 x 8

The reason for selecting this particular kinetic pump instead of a positive displacement pump is due to the following:

- Cheaper, smaller, and can control the flow rate
- Radial flow (centrifugal) due to constant state of substance and speed needed of delivery of fluid.

7. Appendix

Al McClenney: Reflections on the final Pipeline Project

As you can probably tell, if you have visited my MET 330 webpage, pipelines truly intrigue me. I was very excited to be a part of this mini-engineering project about a pipeline design for a manufacturer in the small town of Dayton, Ohio. It was a challenge to get the group together for one last hurrah, that is for sure. It was also a challenge trying to decipher calculations from my two great teammates-they both will admit that their handwriting is not the easiest to understand! I know that it is a true team effort, however, and I know that we all worked as well as we could with the time given.