Gorilla Glue Nitrogen System

A Baccalaureate thesis submitted to the
Department of Mechanical and Materials Engineering
College of Engineering and Applied Science
University of Cincinnati

in partial fulfillment of the
requirements for the degree of

Bachelor of Science

in Mechanical Engineering Technology

by

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April 2018

Thesis Advisor:

Professor Amir Salehpour

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SPONSOR LETTER

University of Cincinnati

College of Engineering and Applied Science

2901 Woodside Dr.

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Attn: Senior Project Review Committee

To Whom it may concern:

Andrew Haufler is currently a co-op at the Gorilla Glue Company. We have agreed to sponsor his senior project. He will be designing and overseeing the purchase and installation of a new nitrogen generator system for Gorilla Glue filling area. He will calculate the nitrogen required for each point of use in the system to determine the required capacity of the new nitrogen generator and piping. He will be responsible for generating the project schedule and managing it. He will develop drawings to show the piping routing for the nitrogen system. Andrew is also responsible for getting bids from contractors and managing those contractor's work for the project. Andrew will document the scope for the project and submit a capital request to get funding for the project.

The Gorilla Glue Company will provide the funding for the Nitrogen Generator project because it is a necessary upgrade to our existing glue filling operation. The capital request should be approved for this project by September 1, 2017. The project will be completed before the end of 2017.

Sincerely

Joe Schneider

Process Engineering Manager

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ABSTRACT

In order to graduate, the University of Cincinnati requires all seniors in the College of Engineering and Applied Science to complete a Senior Design Project. The goal of the senior design project is to apply what you've learned in the classroom to a real world application. Students are given an option to do an individual project or a group project. Regardless, the project has to be approved by the faculty so that they determine if it is applicable to your particular major. For my Senior Design Project, I had the Gorilla Glue company sponsor my project. My project was a nitrogen system which is used to purge bottles before they're filled with product and to blanket product vessel tanks by using nitrogen gas.

The Gorilla Glue Company has been operating since 1999. Gorilla Glue's mission is to make products that deliver impressive results, the company has since expanded its offerings to include Gorilla Tape, Gorilla Super Glue, Gorilla Construction Adhesive, and other premium tapes, sealants, and adhesives. My goal is to design a system for Gorilla Glue that will be able to support current and future demand, and to install flow measuring devices to monitor the flow-rate.

It was my responsibility to manage and oversee the capital project. The project involved creating a project budget and schedule, calculating the amount of nitrogen flow required at each point of use, and creating drawings of the piping and routing of the new system.

PROBLEM DEFINITION AND RESEARCH

PROBLEM STATEMENT

My project proposal pertains to the Gorilla Glue bottle filling process. Specifically, the process where nitrogen is used to purge bottles before filling, as well as the day-tank and feed tote systems in order to keep them from skimming and crusting over.

The current nitrogen generator is inadequate in supporting the current filling process. The current system's nitrogen flow cannot be monitored which introduces control variations in the process. Also there is no way to expand our current manufacturing process due to the limitations of the nitrogen generator. The purpose of this senior design project is to improve the operating efficiencies through the implementation of a mechanical and automated systems.

This project will involve: Project budget and time, calculating the amount of nitrogen required for each point of use in the system to determine the required capacity of the new generator and associated piping. This will also involve creating the drawings to show the piping, control component's, and routing for the new system.

BACKGROUND

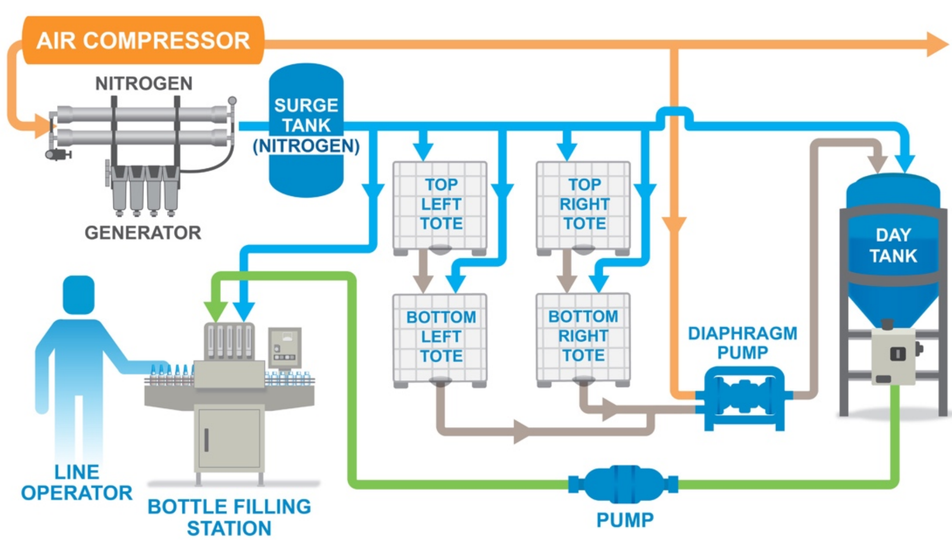

Figure 1.1. the above image shows the system rendering

Figure 1.1. shows how the system operates. The air compressor is tied into the inlet of the nitrogen generator. The compressor sends ordinary dry compressed through the series of filters that are located on the nitrogen generator the air then passes through the membrane bundles on the generator. In the membranes bundles is where the nitrogen is separated from the feed air. The walls on the membrane bundles allows the oxygen and water vapor particles to escape but it keeps in the nitrogen in. The nitrogen is then discharged under pressure into the main nitrogen line. Figure 1.1. above the blue lines are nitrogen purging lines that go to the filling lines, day-tanks, and totes. The day-tanks are polyethylene cone shaped induction tanks which holds a days worth of glue for a particular line. The totes are intermediate bulk container or (IBC) that is used to hold the bulk supply of our various glues. The nitrogen is used for the filling lines in order to purge the bottles before they are filled with product this is typically done to give the product a longer shelf life. The bottles are purged with nitrogen gas up to the neck of the bottle before they are filled with product. The nitrogen is used to replace the oxygen in the headspace of the bottle, just before being sent to the capper to be sealed. Nitrogen is used for the day-tanks and totes as a blanketing method which is a continuous supply of nitrogen into the vessel in order to keep oxygen from altering the texture of the product. The gray and lime green lines in the image above shows the glue distribution lines. When the day-tank for a particular line gets low it will send a signal over to the feed tote which will pump the glue through the diaphragm pump. The glue is forced out the other side of the diaphragm by compressed air, then the glue travels into the main glue distribution line and finally into the day-tank that called for the glue. The glue flows from the day-tank through a positive displacement and then the glue is filled in bottles by a diaphragm valve. The rendering of the system in Figure 1.1. was done by Professor Halter.

RESEARCH

SCOPE OF THE PROBLEM

This project is needed because the current system is running over-capacity on the current nitrogen generator. By the system running over-capacity we are running at a lower purity level which introduces more oxygen into the nitrogen line. The oxygen is altering the texture of the glue pretty rapidly as seen in Figure 1.2. By installing an additional nitrogen generator this will allow us to have additional nitrogen capacity for future lines and will allow for the system to run at a higher purity level thus reducing the speed at which the day-tank and product supply totes crust over. Having more compressed nitrogen in the system will allow for surges. The flow-measuring devices will allow for accurate monitoring of exactly how much nitrogen is getting to the filling lines, day-tanks, and product supply totes. We currently have no means of controlling or setting the flow of nitrogen to the lines so we could be wasting nitrogen. Calculations will be done to determine what the amount of nitrogen flow should be at each point of use in the system. This will allow for maintenance and line operators to monitor the flow measuring devices to verify that we aren't running above the calculated numbers. By having an additional nitrogen generator this will allow us to run production while the other generator is being serviced or repaired.

The project is needed for many reasons: 1. Skimming and crusting over of glue in the day-tanks and the feed tote systems 2. The current system is undersized 3. To increase the nitrogen capacity for current and future demand 4. To control the flow of nitrogen. Skimming and crusting over of the glue occurs because the current system is undersized and is running over-capacity. What this means is that the system is not running at a high purity level and more oxygen is being forced into the main distribution and altering the texture of the glue more rapidly than it should. The image below shows the skimming and crusting over that we are currently seeing in the day-tanks. The project is needed also because of future expansion with many new products on the horizon and the need for more filling lines a correctly sized system is necessary. Lastly, the project is needed to be able to control the flow of nitrogen to each machine through flow measuring devices that way we know exactly how much nitrogen we are getting to each machine. This problem has been an on-going issue that the company has dealt with over the years but one that they knew had to be eventually addressed.

Figure 1.2. shows the skimming that is occurring in the day-tanks

CURRENT STATE OF THE ART

Nitrogen purging is used across many industries such as: food, beverage, wine, pharmaceuticals, cosmetics, etc. [2] Nitrogen purging is used in order to replace the oxygen in the headspace of the bottle. Replacing the oxygen with nitrogen removes the effects that oxygen can have on a product such as: the texture, the color, and the shelf life of the product. Nitrogen is typically used to purge because it is a colorless, odorless, tasteless, and generally inert gas. The image below shows the headspace of the bottle where the oxygen is replaced with nitrogen gas. Nitrogen is also common used because of its low cost allows for a continuous purging. A drawback of nitrogen is that it is the lightest of the inert gases so it typically doesn't have good blanketing properties unless the vessel or tank is enclosed

Figure 1.3. shows the headspace of the bottle

There are a few other purging methods that are used in manufacturing other than nitrogen gas. The other two methods that are used besides nitrogen are argon gas and carbon dioxide. The pros and cons of each method are listed below:

Argon Gas

- Expensive
- Does not perform as effectively
- Complex production process
- Large carbon footprint is required

- Unreactive
- High atmospheric abundance when compared to some other inert gases.
- Improves shelf life of product

Carbon Dioxide Gas

- CO2 is soluble in aqueous products.
- It is corrosive in the presence of moisture
- Environmental regulations may apply if emitted into atmosphere.
- Capable of reacting with much larger number of substances than other inert gases.

- Less expensive when compared to argon
- Non-flammable
- Odorless
- Improves shelf life of product
- Heavier than air

A few drawbacks of using argon gas as a purging method is that it is about 4 times the cost of using nitrogen to purge bottles. This is a big factor as to why it is not really commonly used across many manufacturing processes as a purging method. Another drawback of using argon is that is a complex process, argon production and distribution creates a large carbon footprint. [3] Argon is composed of 3-5 % oxygen and 1 % nitrogen to purify the argon the mixture must first be warmed to room temperature and then compressed to 60 psi. Next hydrogen is then injected to eliminate the oxygen. The hydrogen reacts with the oxygen to form water. Finally, the argon gas becomes concentrated and is then separated from the remaining nitrogen so the resulting gas has a purity of 99.99 %. [5] Also, argon is invisible to the user so they cannot easily determine when to replenish the blanket. Therefore, nitrogen is typically used because its low cost allows for continuous purging which would be uneconomical with argon. [5] Common uses where argon gas is using the superior choice over nitrogen is in two instances: 1. Arc welding because nitrogen becomes reactive in the presence of the electric arc and 2. Window insulation because argon has a much lower thermal conductivity than compared to nitrogen. Pros for argon gas is that it improves the shelf life of the product and it is unreactive. Winemakers like to use argon gas because it’s the densest of the three gases. Being a heavier gas it has better blanketing properties. [5] Due to its heavier weight argon will tend to sit on top of a liquid column and not readily diffuse with air.

Some drawbacks to using CO2 gas is that carbon dioxide is capable of reacting with a much larger number of substances than the other inert gases, environmental regulations could come into play if too much CO2 is emitted into the atmosphere, and it can also become corrosive in the presence of moisture. For example, in the presence of water CO2 forms carbolic acid. Some pros of using CO2 is that less expensive when compared to argon, it also improves the shelf life of the product, and it is non-flammable. Also, carbon dioxide is the heaviest of the three gases and removes the oxygen by lifting it and carrying it out of the vessel. Both carbon dioxide and argon gas are very commonly used in the wine industry because of there blanketing properties. Figure 1.4. shows a breakdown of the percentage of gases that are in the atmosphere.

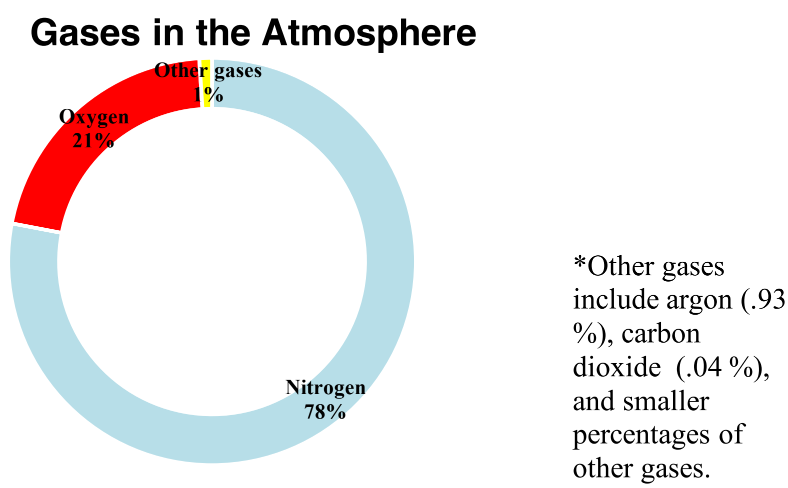

Figure 1.4. shows the concentration of gases in the atmosphere

END USER

The end user of this system would be the maintenance staff and the line operators. Maintenance staff will need to understand how the system works, do daily PM checks on the system, and monitor the flow rate for each line to verify that the flow measuring device is in the calculated flow range. The line operators will also need to monitor the flow device to verify that it is in the desired flow range and if it is not they will need to alert the maintenance staff who will adjust it to the required flow rate.

Conclusions and Summary of research

[5] Nitrogen is 88 times more abundant than argon this means that the energy to produce a pound of nitrogen is 88 times less than the energy to produce a pound of argon. I determined that the best purging method would be nitrogen for many reasons:

1. It is low cost
2. Reliable option because it uses
3. Already an air compressor on-site that could supply the generator
4. Lower carbon footprint required
5. Would allow us to run the system at a high purity level
6. Improves the shelf life of the product
7. Minimizes environmental impact

CUSTOMER FEATURES

The following features are what Gorilla Glue wants to see from the project:

1. Low cost project
2. Be able to control and set the flow rate to each machine
3. Reduce the line pressure before the machine (100 psi to 7 psi)
4. Run the system at a high purity level (97-99.5%)
5. Extend the life of the day-tank and feed tote systems
6. System that supports current and future demand
7. Safety

PRODUCT OBJECTIVES

1. Finish the project within the specified budget ($30,000)

2. Finished the project within the specified deadline (April 1st, 2018)

3. Flow measuring devices at each point of use based on the nitrogen requirements- so that the amount of flow getting to each line can be set and monitored

4. Design a system that meets all of Gorilla Glue's current and future demands

QUALITY FUNCTION DEPLOYMENT

			Engineering Requirements (units)														Customer Satisfaction Rating (0.00 - 1.00)			
		Importance wt.	Total Cost (USD)	Materials Used	Flowmeters (scfh)	Reduce pressure from 100 psi to 7 psi	Run at a 97-99.5% purity level	Continuous purging of nitrogen into totes and day-tanks	Size of nitrogen generator	Size of piping										
	Customer Requirements		1	2	3	4	5	6	7	8	9	10	11	12	13	14	CP	A	B	C
1	Be able to control and set the flowrate to each machine	0.20			9	3														
2	System supports current and future demand	0.20	3				3		9	3										
3	Run the system at a higher purity level	0.20					9	3	9											
4	Extend the life of the day-tank and feed tote systems	0.15						9	3											
5	Reduce the line pressure before the machine	0.10			3	9														
6	Safe system	0.10	1																	
7	Low Cost	0.05	9	9	3				3	3										
8																				
9																				
10	Total Importance	1.00																		
	Engineering requirement importance		1.2	0.5	2.3	1.5	2.4	1.95	4.2	0.8										

DESIGN

Project Description

This upgrade to the current nitrogen system aims to provide additional cost savings opportunities while also allowing for accurate monitoring of how much nitrogen is getting to the product supply totes, day-tanks, and filling lines by using rotameters. As part of the nitrogen system upgrade an additional nitrogen generator will be installed which will allow for additional nitrogen capacity. The existing 1/2” main nitrogen line will be replaced with a 1” line. From the main line, we will be running flexible tubing at 100 psi into an isolation valve so that flow can be stopped at a particular line for maintenance or safety purposes. The flexible tubing from the main nitrogen line will run into a push to connect fitting on the inlet of the regulator. A push to connect fitting on the outlet of the regulator will have flexible tubing running to the 90-degree swivel connect fitting on inlet of the flowmeter. The outlet on the flowmeter will also have 90-degree swivel connect fitting and the flexible tubing will then connect to the filling lines, day-tanks, or totes. The compressed air regulators will drop the pressure from 100 psi to 7 psi. This will be done on the following lines and day-tanks: Line 1 (Epoxy), Line 2 (Single-Use), Line 6 (4 oz.), Line 7 (36 oz.), Line 8 (2 oz.), Line 9 (2 oz.), and Line 10 (Pen filling). We will also be running flexible tubing to the polyurethane, dries white, and clear glue totes. Future lines are going to be run to account for clear glue running on Lines 2, 6, and 10 and dries white on Line 10.

Design Alternatives and selection

The other design alternative was to go with a single membrane nitrogen generator. Ultimately, we decided to go with a double membrane nitrogen generator because it was cheaper, could still support the current and future demand, will give us the additional nitrogen capacity that is needed, and will allow us to run at a high purity.

DESIGN OF SYSTEM DRAWINGS

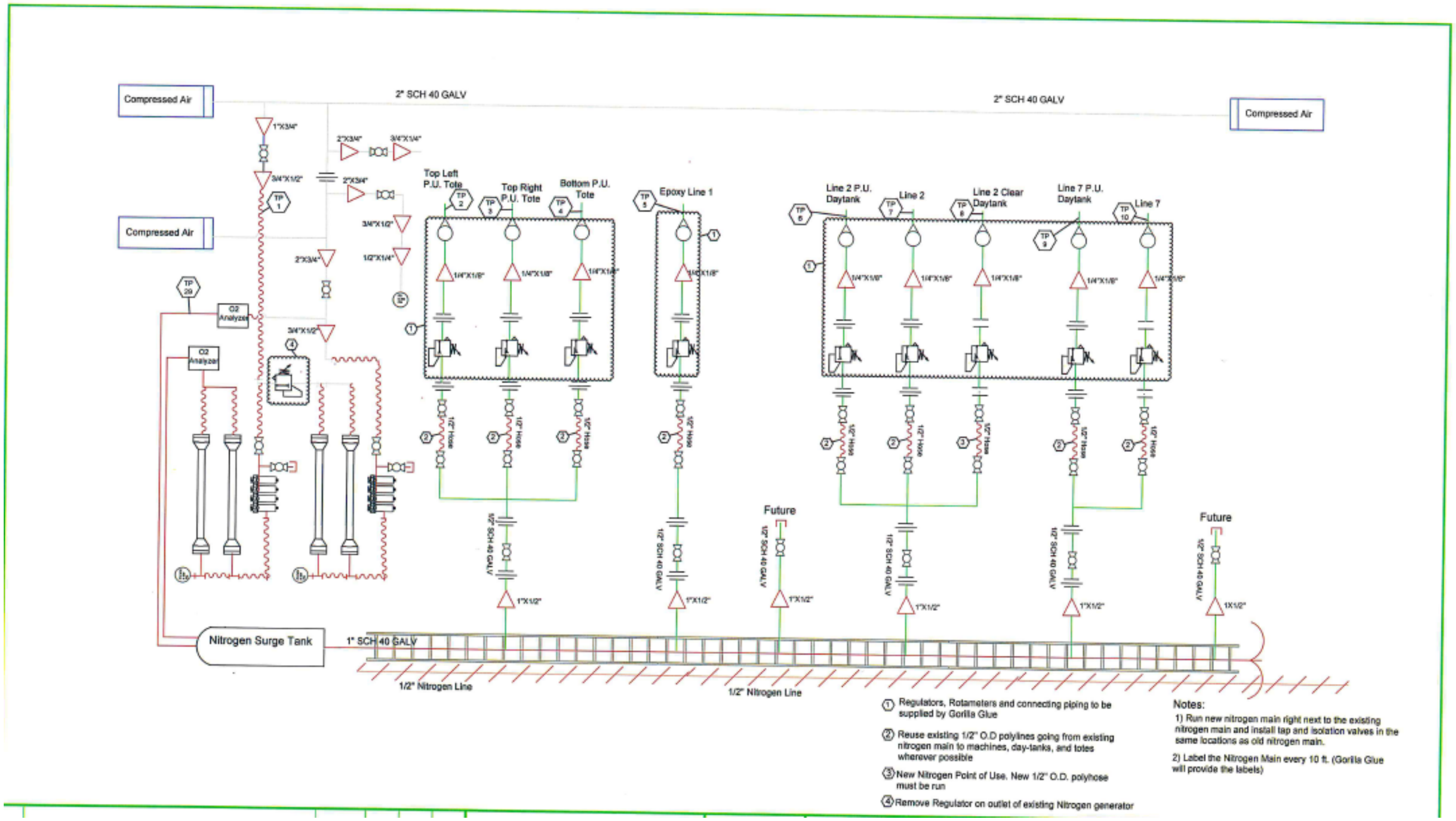

Figure 1.5. The above P&ID shows the nitrogen generators connected to the nitrogen surge tank and the main 1" nitrogen line. Also shown is the routing for the P.U. totes, Line 1, Line 2, and Line 7.

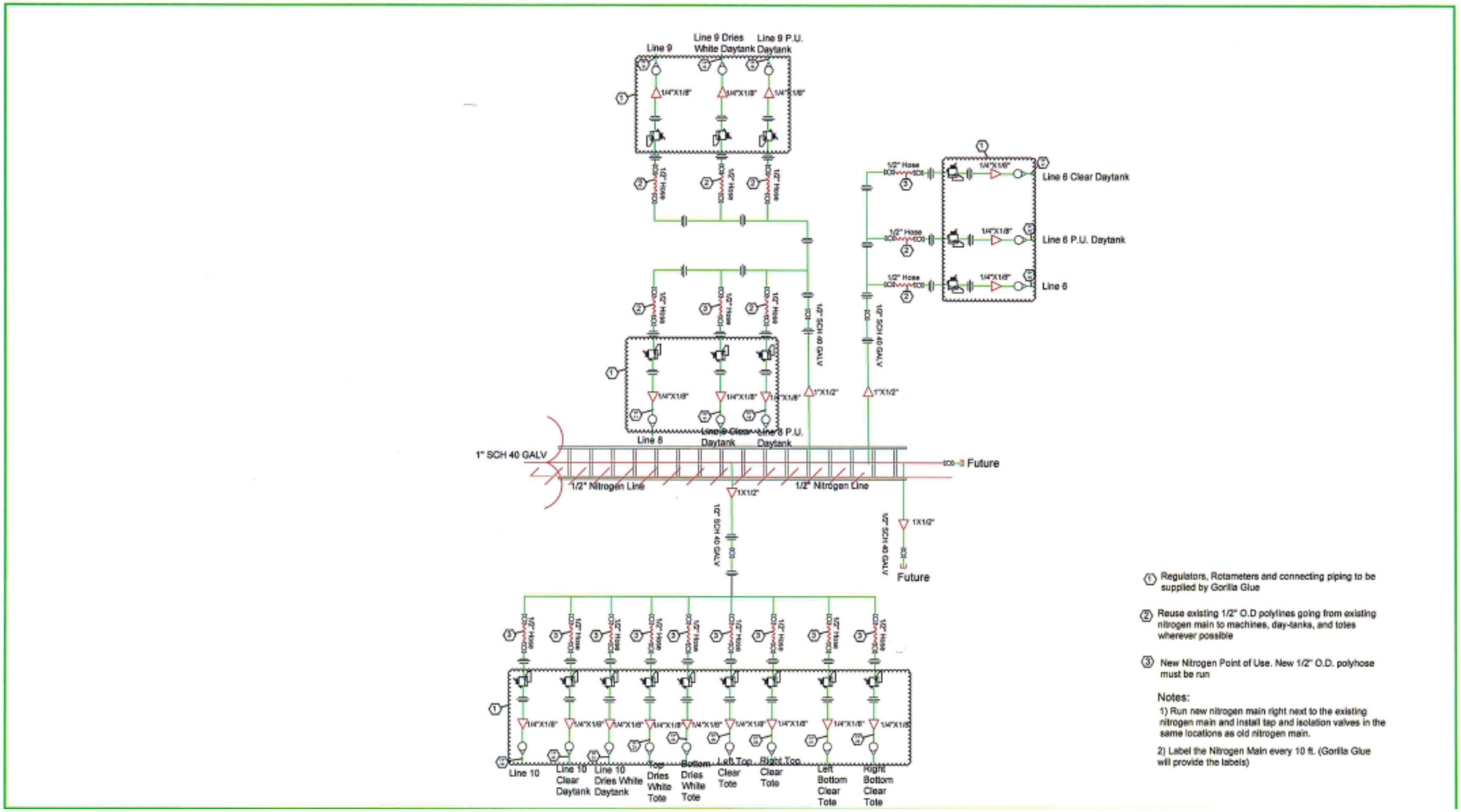

Figure 1.6. The above P&ID shows a continuation of the main 1" nitrogen line. Also shown is the routing for the Dries White and Clear Glue totes, Line 6, Line 8, and Line 9, and Line 10.

DESIGN ANALYSIS- AMOUNT OF NITROGEN REQUIRED AT EACH POINT OF USE

Machine Calculations

Below is the formula that was used to calculate the amount of nitrogen purging to each machine.

$$Amount\ of\ Nitrogen\ Used\ (CFM) = Volume\ of\ the\ container\ (oz.) * of\ pieces\ per\ minutes\ * 2$$

The equation was adjusted by adding a multiplier to account for the duty cycle.

The following are abbreviations and the filling line descriptions:

- *P.U.= Polyurethane (Brown Glue)*
- *D.W.= Dries White Glue*
- *CG= Clear Glue*

Line 1- Epoxy Syringes

Line 2- P.U. and CG

Line 6- P.U. and CG

Line 7- P.U.

Line 8- P.U., CG, and DW

Line 9- P.U. and DW

Line 10- DW and CG

-Below are specified the necessary conversion factors:

1 ml= .0338 oz.

1 gram= .0353 oz.

1 oz./min= .0010 cfm

cfm to scfh= multiply by 60

In order to calculate the above equation, the pieces per minute needed to be calculated for each filling line.

- *Line 1- 19 ppm*
- *Line 2- 59 ppm*
- *Line 6- 24 ppm*
- *Line 7- 12 ppm*
- *Line 8- 29 ppm*
- *Line 9- 48 ppm*
- *Line 10- 22 ppm*

Next I had to determine the volume of each container that the line is running and used conversion factors where necessary.

- *Line 1- 40ml*.0338= 1.352 oz.*
- *Line 2- 3 grams*.0353= .106 oz.*
- *Line 6- 4 oz.*
- *Line 7- 36 oz.*
- *Line 8- 2 oz.*
- *Line 9- 2 oz.*
- *Line 10- 20 ml.*.0338= .676 oz.*

I can now determine how much nitrogen is necessary for each line by using the following equation. Convert the oz./min to cfm by using the conversion factor above.

$$Amount\ of\ Nitrogen\ Used\ (CFM) = Volume\ of\ the\ container\ (oz.) * of\ pieces\ per\ minutes\ * 2$$

Line 1

$$Amount\ of\ nitrogen\ used\ (cfm) = 1.352 * 19 * 2 = 51.376\ oz. \frac{oz}{min} * \ .0010 = \ .054\ cfm$$

Line 2

$$Amount\ of\ nitrogen\ used\ (cfm) = .106 * 59 * 2 = 12.496\ oz. \frac{oz}{min} * \ .0010 = \ .013\ cfm$$

Line 6

$$Amount\ of\ nitrogen\ used\ (cfm) = 4 * 24 * 2 = 192\ oz. \frac{oz}{min} * \ .0010 = \ .200\ cfm$$

Line 7

$$Amount\ of\ nitrogen\ used\ (cfm) = 36 * 12 * 2 = 864\ oz. \frac{oz}{min} * \ .0010 = \ .902\ cfm$$

Line 8

$$Amount\ of\ nitrogen\ used\ (cfm) = 2 * 29 * 2 = 116\ oz.\frac{oz}{min} * \ .0010 = \ .121\ cfm$$

Line 9

$$Amount\ of\ nitrogen\ used\ (cfm) = 2 * 48 * 2 = 192\ oz.\frac{oz}{min} * \ .0010 = \ .200\ cfm$$

Line 10

$$Amount\ of\ nitrogen\ used\ (cfm) = .676 * 22 * 2 = 29.744\ oz.\frac{oz}{min} * \ .0010 = \ .031\ cfm$$

Add all the above machine line calculations to get a total cfm value for the filling lines

$$Amount\ of\ cfm = \ .054 + .013 + .200 + .902 + .121 + .200 + .121 = 1.52\ cfm$$

Day-tank Calculations

Below is the formula that was used to calculate the amount of nitrogen purging to each machine.

$$Amount\ of\ Nitrogen\ Used\ (CFM) = Volume\ of\ the\ container\ (oz.) * of\ pieces\ per\ minutes\ * 1$$

The equation was adjusted by adding a multiplier for the duty cycle which for the day-tanks is 1.

Line 2

$$Amount\ of\ nitrogen\ used\ (cfm) = .106 * 59 * 1 = 6.248\ oz.\frac{oz}{min} * \ .0010 = \ .007\ cfm$$

Line 6

$$Amount\ of\ nitrogen\ used\ (cfm) = 4 * 24 * 1 = 96\ oz.\frac{oz}{min} * \ .0010 = \ .100\ cfm$$

Line 7

$$Amount\ of\ nitrogen\ used\ (cfm) = 36 * 12 * 1 = 432\ oz.\frac{oz}{min} * \ .0010 = \ .451\ cfm$$

Line 8

$$Amount\ of\ nitrogen\ used\ (cfm) = 2 * 29 * 1 = 58\ oz.\frac{oz}{min} * \ .0010 = \ .061\ cfm$$

Line 9

$$Amount\ of\ nitrogen\ used\ (cfm) = 2 * 48 * 1 = 96\ oz.\frac{oz}{min} * \ .0010 = \ .100\ cfm$$

Line 10

$$Amount\ of\ nitrogen\ used\ (cfm) = .676 * 22 * 1 = 14.872\ oz.\frac{oz}{min} * \ .0010 = \ .016\ cfm$$

Add all the above day-tank calculations to get a total cfm value

$$Amount\ of\ cfm = \ .007 + .100 + .451 + .061 + .100 + \ .016 = \ .73\ cfm$$

Tote Calculations

The calculations for the totes were based on the total amount of glue being pumped from the totes if all the day-tanks fed from the tote would be filling at the same time.

- *Define which lines are running each type of glue (P.U., DW, and CG) then add up the totals.*

PU Totes

- Lines 2, 6, 7, 8, and 9 run Polyurethane Glue so I took the day-tank values for those lines and added them together.

$$Amount\ of\ nitrogen\ used\ (cfm) = \ .007 + .100 + .451 + .061 + .100 = \ .72\ cfm\ \ per\ tote$$

Dries White Totes

- Lines 8, 9, and 10 run Dries White Glue so I took the day-tank values for those lines and added them together.

$$Amount\ of\ nitrogen\ used\ (cfm) = \ .061 + .100 + .016 = \ .18\ cfm\ \ per\ tote$$

Clear Glue Totes

- Lines 2, 6, 8 and 10 run Clear Glue so I took the day-tank values for those lines and added them together.

$$Amount\ of\ nitrogen\ used\ (cfm) = .007 + .100 + .061 + .016 = .18\ cfm\ \ per\ tote$$

$$total\ cfm\ for\ the\ totes = 2.16 + .36 + .72 = 3.24\ cfm$$

$$Total\ cfm\ for\ the\ entire\ system = 3.24 + .73 + 1.52 = 5.49\ cfm$$

RETURN ON INVESTMENT DATA

Table 1.1. shows what the waste disposal cost is for the day-tanks for each type of glue. The disposal cost per pound is how much it costs per pound to dispose of by glue. The disposal cost per day-tank is the typical cost to dispose of one day-tank. The last column shows what the cost savings every other year. The cost savings was determined by taking the cost disposal per day-tank and multiplying it by the number of day-tanks of the particular glue.

Day-tanks

- Polyurethane- 5
- Dries White- 2
- Clear Glue- 4

Waste Disposal Cost			
Glue Product	Disposal Cost Per Pound	Disposal Cost Per Daytank	Cost Savings every other year
Polyutherane	$ 1.10	$ 150.00	$ 750.00
Dries White	$ 1.10	$ 150.00	$ 300.00
Clear	$ 2.50	$ 300.00	$ 1,200.00
		Total:	$ 2,250.00

Table 1.1. shows the waste disposal cost for each particular glue

Table 1.2. shows the cost of the replacement plumbing for the day-tanks when they are replaced due to disposal.

Replacement Plumbing Cost		
Item	Cost per unit	Cost Savings every other year
Daytank- 10 gallon	$ 102.56	$ 410.24
Daytank- 55 gallon	$ 159.27	$ 1,114.89
Plumbing for the new	$ 500.00	$ 5,500.00
Total:	$ 602.56	$ 7,025.13

Table 1.2. shows what the cost is to replace the plumbing for the day-tanks

Table 1.3. shows the cost of labor when the day-tank and feed totes need to be changed. It typically takes two members of the maintenance staff when these are changed out.

Labor Cost	
Item	**Cost Savings every other year**
Maintenance Labor Cost changing of Day-tank	$ 2,728.00
Item	**Cost savings every year**
Maintenance Labor Cost changing of feed totes	$ 558.00

Table 1.3. labor cost to change the day-tanks and feed totes

Table 1.4. shows the cost savings for every other year and the cost savings for every year.

Cost Savings every other year
$ 12,003.13
Cost Savings every year
$ 558.00

Table 1.4. shows the cost savings of the project for every other year and the savings every year.

The data below shows the cumulative breakdown of the cost savings.

Year	Cumulative Cost Savings breakdown by year
1	$ 12,561.13
2	$ 13,119.13
3	$ 25,680.26
4	$ 26,238.26
4.5	$ 28,585.51
5	$ 38,799.39

Table 1.5. shows cumulative cost savings by year.

The data below shows the net profit. The net profit is just the cost savings for the 1st year. The cost of investment is the estimated project budget. The return on investment was calculated by dividing the net profit by the cost of the investment.

$$ROI = \frac{Net\ profit}{Cost\ of\ investment}$$

Net Profit	$ 12,561.13
Cost of Investment	$ 29,084.00
ROI	**43.19%**

Table 1.6. shown is the net profit of the project, the cost of the project, and the calculated return on investment.

Figure 1.5. shows the return on investment. In 4.5 years we will have a return on investment for the project.

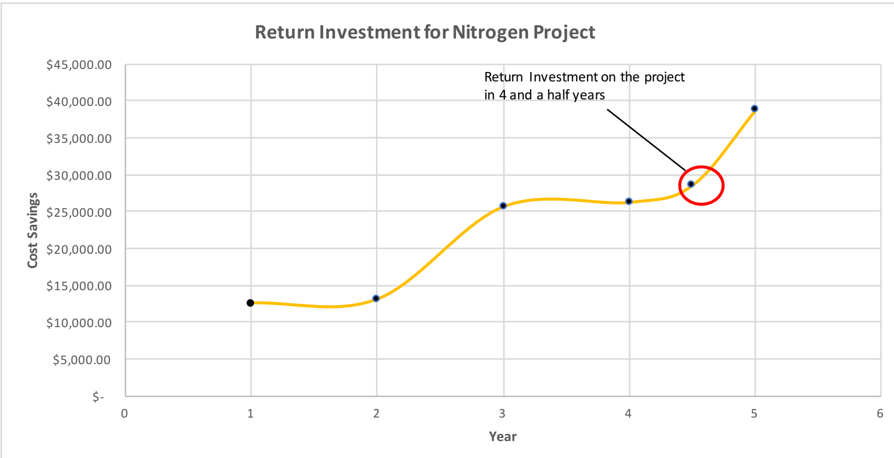

Figure 1.7 graphical representation of the cost savings by year.

SCOPE OF WORK FOR CONTRACTORS

Mechanical Contractors

An additional nitrogen generator will be installed to allow for an increase in nitrogen capacity. The new nitrogen generator will be mounted on a 5’X3’ piece of plywood above the existing generator. The new nitrogen generator will be tied into the existing open port that is located on the nitrogen surge tank. The work can be done on regular production days. The 1” SCH 40 galvanized line will be run next to the existing 2” galvanized compressed air line. The main nitrogen line will be labeled every 10 ft. Off of the main line taps will be run to each of the following locations: day-tanks, totes, and filling lines (except for the Wood Glue lines). The flowmeters and regulators will be mounted using aluminum U-channel on the filling lines, day-tanks, and totes. Demo the new 1” line that is going to be installed. Below are the responsibilities for Gorilla Glue and the mechanical contractors.

Gorilla Glue	CSL
Flowmeters	Piping
Compressed Air Regulators	Fittings
Compressed Air Regulator Brackets	Flexible Tubing
1/4"X1/8" Pipe Reducers	Isolation Valves
Pipe Marker Labels for Nitrogen	Hoses for Nitrogen Generator
Aluminum U-Channel	Plywood to Mount the Nitrogen Generator
10-32 Threaded Inserts for Flowmeters	

Table 1.7. shows the project responsibilities between Gorilla Glue and the mechanical contractor.

Electrical Contractors

An additional nitrogen generator will be installed above the existing nitrogen generator that we currently have in place. Before the new nitrogen generator is installed the electrical box and conduit will need to be moved about 2’ to the left in order for the mechanical contractor to mount the new nitrogen generator. The electrical conduit will be run to panel number EP-3 where there are already available breakers. Figure 1.6. shows the conduit and box that needs to be moved.

Figure 1.8. shows the electrical conduit and electrical box that needs to be moved

COMPONENT SELECTION AND COMPONENTS NEEDED

- Flowmeters- to set and monitor the flow-rate
- Compressed Air Regulators- to reduce the pressure before the machine
- Nitrogen generator with oxygen analyser
- Poly-hose
- Push to connect fittings for the regulators
- 90-degree swivel push to connect fittings for the flowmeters
- Aluminum U-channel to mount the regulators and flowmeters
- Brackets for the regulators
- Pipe markers
- Hoses for the nitrogen generator
- Electrical contractor (to move the conduit and electrical box)
- Mechanical contractor (mount the generator and run the piping)

Galvanized SCH 40 pipe- I chose this material because it is rust resistance due to the fact that it has a zinc coating around the piping to reduce rusting. Galvanized piping is more expensive than PVC piping but in the long run galvanized is more resistant and has a much longer life span.

Acrylic Flowmeters- I chose these flowmeters because they were affordable, easy to disassembly and assembly for maintenance staff, easy to read the flow, and acrylic is durable.

Aluminum U-Channel- The aluminum U-channel will be used to mount the regulators and flowmeters to and the bracket itself will mount to the flowmeters, day-tanks, or totes. I chose aluminum U-channel because it is light –weight and inexpensive.

INDUSTRY STANDARDS

[4] The industry standard for the piping label requirements according to ANSI/ASME A13.1, the pipe markers should comply with certain requirements. Recently, in 2007 the ANSI/ASME A13.1 standard was updated and is now recommended for all new pipe marker applications. The current version of the ANSI/ASME code uses a pipe labeling standards color code chart with 6 standard color combinations, and four user defined combinations. The color scheme is shown in the figure below:

Designation of Colors (ASME A13.1-2007)	
Classification	Letter/Background Color
Fire Quenching Fluids	White/Red
Toxic and Corrosive Fluids	Black/Orange
Flammable Fluids	Black/Yellow
Combustible Fluids	White/Brown
Potable, Cooling, Boiler Feed, and Other Water	White/Green
Compressed Air	White/Blue
To be defined by the user	White/Purple
To be defined by the user	Black/White
To be defined by the user	White/Gray
To be defined by the user	White/Black

Figure 1.9. the colors are based on the contents of the pipe and in general the most hazardous feature of the contents is used to determine the colors used.

BILL OF MATERIALS (PRICES WERE BASED ON QUOTES RECEIVED FROM VENDORS)

Item Description	Vendor	Unit Price (USD)	Quantity	Total (USD)
Nano Purification Nitrogen Generator with Oxygen Analyser	Compressed Air Technpologies	$ 15,100.00	1	$ 15,100.00
FL-2001 Rotameter, SCFH .1 to 1	Omega	$ 60.00	5	$ 300.00
FL-2031 Rotameter, SCFH .4 to 5	Omega	$ 75.00	4	$ 300.00
FL-2032 Rotameter, SCFH 1 to 10	Omega	$ 80.00	5	$ 400.00
FL-2007 Rotameter, SCFH 4 to 50	Omega	$ 60.00	3	$ 180.00
FL-2034 Rotameter, SCFH .4 to 40	Omega	$ 70.00	9	$ 630.00
FL-2035 Rotameter, SCFH 10 to 100	Omega	$ 75.00	1	$ 75.00
Compressed Air Regulators	McMaster Carr	$ 50.00	27	$ 1,350.00
Brackets for Regualtors	McMaster Carr	$ 10.00	27	$ 270.00
6061 Aluminum U-channel (5 ft.)	McMaster Carr	$ 50.00	2	$ 100.00
6061 Aluminum 1/4" thick x 3" wide (6 ft.)	McMaster Carr	$ 33.33	3	$ 100.00
Electrical Work	Hilvert&Pope	$ 500.00	1	$ 500.00
Pipe Work	CSL	$ 2,500.00	1	$ 6,900.00
Nitrogen Pipe Markers	Grainger	$ 100.00	1	$ 100.00
Stainless Steel Low Pressure Reducer 1/4"X1/8" NPT Female	McMaster Carr	$ 5.00	27	$ 135.00
10% contingency				$ 2,644.00
		Subtotal		$ 29,084.00

Table 1.8. shows a breakdown of the materials and what the cost is.

PROJECT TASKS

1. Capital Request Submitted
2. Capital Request Approved
3. MRO's written and purchase orders provided to vendors and contractors
4. Materials received
5. Nitrogen generator installed
6. Mount nitrogen generator
7. Tie generator into the compressed air
8. Run power to the nitrogen generator
9. Connect power to the nitrogen generator
10. Run nitrogen main line
11. Tie nitrogen main line into the surge tank
12. Mount regulators and rotameters at each point of use
13. Connect points of use to the new nitrogen main line
14. Set pressure reducing valves and rotameters to correct pressure and flow
15. Write maintenance and operation procedure for the nitrogen system
16. Train maintenance staff on the procedure
17. Confirm P&ID drawings are correct
18. Release the system to maintenance

3-D MODEL OF THE MOUNTING BRACKET FOR THE SMALLER FLOWMETER

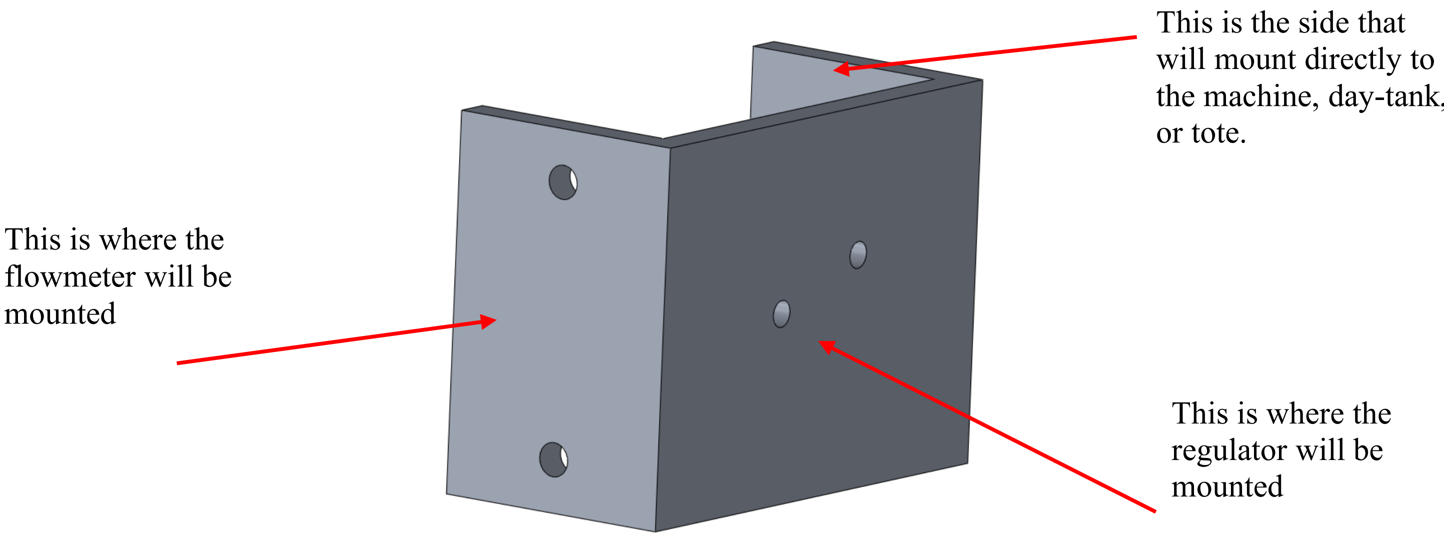

Figure 1.10. shows the Solid-works model of the mounting bracket for the smaller rotameters

3-D MODEL OF THE MOUNTING BRACKET FOR THE LARGER FLOWMETER

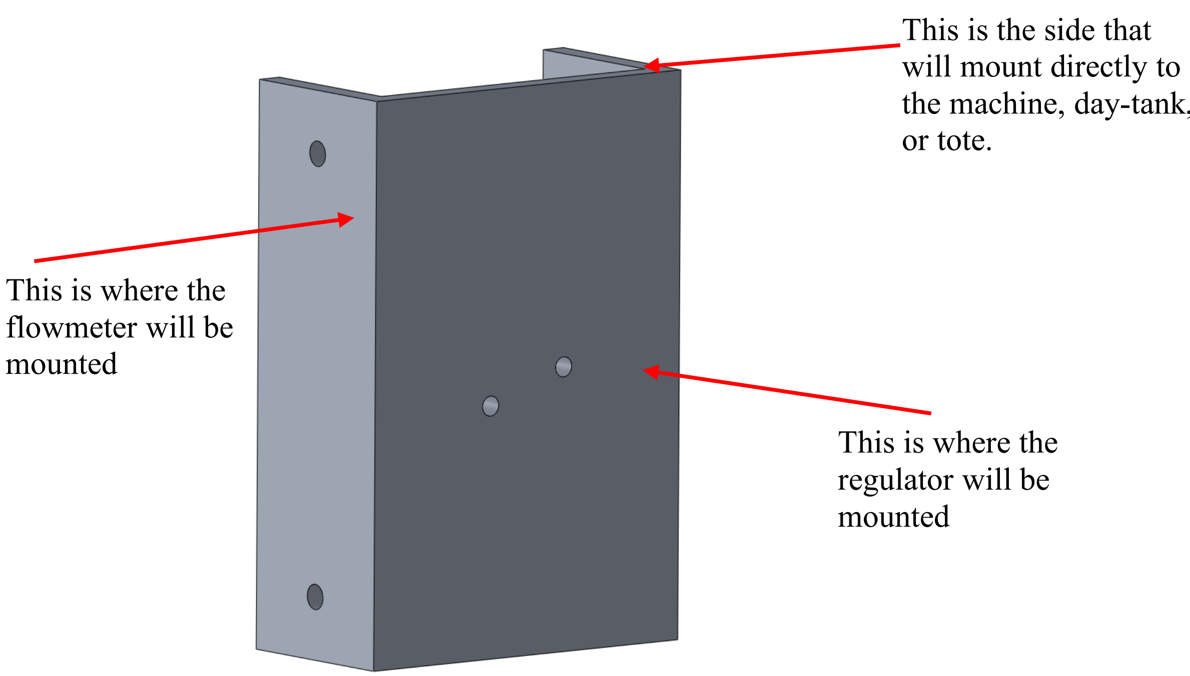

Figure 1.11. shows

the Solid-works model of the mounting bracket for the larger rotameters

BREAKDOWN OF FLOWMETER LOCATIONS AND THE SET FLOWRATES

Set Flow-rates for the Filling Lines

Machine	# of Flowmeters	Series #	Flowmeter Range (SCFH)	Set Flow-rate (SCFH)
Line 1	1	FL-2031	.4-5	3.24
Line 2	1	FL-2001	.1-1	0.78
Line 6	1	FL-2034	4-40	12.06
Line 7	1	FL-2035	10-100	54.12
Line 8	1	FL-2032	1-10	7.26
Line 9	1	FL-2034	4-40	12.06
Line 10	1	FL-2031	.4-5	1.86

Table 1.9. shows the set flow-rates for each filling line

Set Flow-rates for the Day-tanks

Day-tank	# of Flowmeters	Series #	Flowmeter Range (SCFH)	Set Flow-rate (SCFH)
Line 2	2	FL-2001	.1-1	0.42
Line 6	2	FL-2032	1-10	6
Line 7	1	FL-2034	4-40	27.06
Line 8	2	FL-2031	.4-5	3.66
Line 9	2	FL-2032	1-10	6
Line 10	2	FL-2031	.4-5	0.96

Table 1.10. shows the set flow-rates for each of the day-tanks.

Set Flow-rates for the Totes

Totes	# of Flowmeters	Series #	Flowmeter Range (SCFH)	Set Flowrate (SCFH)
Polyurethane	3	FL-2007	4-50	43.8
Dries White	2	FL-2034	4-40	10.8
Clear Glue	4	FL-2034	4-40	10.8

Table 1.11. shows the set flow-rates for each of the totes

SYSTEM PROTYPE

In order to simulate the system, I used an air compressor that was connected to 1 ½” SCH 40 PVC pipe with PVC end caps at each end of the pipe. I drilled and tapped 3 holes in the PVC pipe for the push to connect fittings. The PVC pipe with end caps represents the main nitrogen line. I also had clear plastic jars that represented a line, day-tank, and tote. I drilled 2 holes on the lids of each of the jars. One of the holes is for the push to connect fittings so I can connect the air hose from the main line to the jars. The other hole is for a 90-degree elbow to vent out air.   In line with one of the jars I will have a regulator and flowmeter to show what the set-up is like on each line. Below I have some pictures of my prototype.

Figure 1.12. the images above shows the drilled and tapped holes on the PVC pipe

Figure 1.13. the images above show the push to connect fittings and the image on the right represents the nitrogen main line.

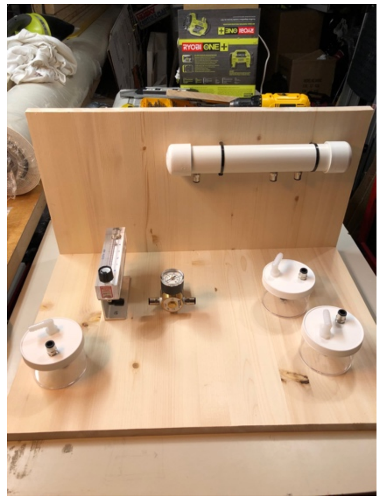

Figure 1.14. the images above show the push to connect fitting and a 90-degree elbow to vent out any air. The image on the right shows the 3 jars which represents a line, day-tank, and tote.

Figure 1.15. the images above show the completed prototype.

PREVENTATIVE MAINTENANCE FOR THE SYSTEM

1. Verify the flowmeters are running at the specified flow-rate- Daily
2. Ensure that flowmeters are not broken/cracked- Daily
3. Verify that the regulators are running between 7-10 psi- Daily
4. Inspect the 1.0 and 0.1 Micron filters, and the carbon filter for water or oil- Daily
5. Check all piping for leaks- Weekly
6. Replace the 1.0 Micron filter elements- Semi-Annually
7. Replace 0.1 Micron filter elements- Semi-Annually
8. Replace Activated carbon filter elements- Semi-Annually
9. Replace 1.0 Micron filter float drain- Yearly
10. Replace 0.1 Micron filter float drain- Yearly
11. Replace Nitrogen generator membranes- 15 years

TESTING

1. **Phase Implementation-** the system was brought on-line in phases one line at a time. This was done because in case there was a problem I could focus on that one line instead of having issues at multiple lines at once.

2. **Requirement Verification-** once a line was moved over onto the new line I set the regulators and flowmeters to the exact flow and pressure.

3. **Monitoring the System-** I walked through the system making sure all the flows were correct, that there were no problems, and that everything was running properly.
4. **System Approval-** the system was approved and the maintenance staff was trained on the new system procedure

PROJECT MANAGEMENT

BUDGET, PROPOSED/ACTUAL

Equipment Purchases (net of Rebates/Customer Contribution)						
Item Description	**Vendor**		**Unit Price**		**Quantity**	**Total**
Nano Purification Nitrogen Generator with Ouput Analyzer	Compressed Air Technologies		$ 15,100.00		1	$ 15,100.00
FL-2001 Rotameter, SCFH .1 to 1 SCFH	Omega		$ 60.00		5	$ 300.00
FL-2031 Rotameter, .4 to 5 SCFH	Omega		$ 75.00		4	$ 300.00
FL-2032 Rotameter, 1 to 10 SCFH	Omega		$ 80.00		5	$ 400.00
FL-2007 Rotameter 4-50 SCFH	Omega		$ 60.00		3	$ 180.00
FL-2034 Rotameter, .4 to 40 SCFH	Omega		$ 70.00		9	$ 630.00
FL-2035 Rotamer, 10 to 100 SCFH	Omega		$ 75.00		1	$ 75.00
Compressed Air Regulator Relieving Brass Housing	McMaster Carr		$ 50.00		27	$ 1,350.00
Mounting Bracket for Air Regulators	McMaster Carr		$ 10.00		27	$ 270.00
Stainless Steel Low Pressure Reducer 1/4"x1/8"NPT Female	McMaster Carr		$ 5.00		27	$ 135.00
6061 Aluminum U-Channel (5 ft.)	McMaster Carr		$ 50.00		2	$ 100.00
6061 Aluminum 1/4" Thick x 3" Wide (6 ft.)	McMaster Carr		$ 33.33		3	$ 100.00
Electrical Work	Hilvert & Pope		$ 500.00		1	$ 500.00
Pipe Work	CSL		$ 2,500.00		1	$ 6,900.00
Nitrogen Pipe Markers	Brady		$ 100.00		1	$ 100.00
10% Contingency						$ 2,644.00
						-
		SubTotal of Capital Items				$ 29,084.00

Figure 1.16. The above shows the proposed budget breakdown of the materials

- Proposed Project Budget: $29,084.00

- Actual Project Budget: $27,531.88
  - Nitrogen generator cost was $15,100.00

- $29,084.00-$27,531.88= $1,552.12

- Rate of Change: $1,552.12/$29,084.00= .053

- .053*100= 5.3 % under budget

Figure 1.17. shows the proposed budget vs. the actual project budget. As you can see the project came in 5.3% under budget.

SCHEDULE, PROPOSED /ACTUAL

#	Task	Start Date	Duration (days)	End Date	Status
1	Capital Request Submitted	9/15/17	1	9/15/17	Completed
2	Capital Request Approved	9/18/17	5	9/22/17	Completed
3	MRO's written and purchase orders provided to vendors and contractors	10/9/17	60	12/29/17	Completed
4	Materials received	12/18/17	52	2/28/18	Completed
5	Phase 1	2/28/18	0	2/28/18	Completed
6	Run Power to the nitrogen generator	1/15/18	1	1/15/18	Completed
7	Connect the power to the nitrogen generator	3/5/18	3	3/7/18	Completed
8	Nitrogen Generator Installed	3/5/18	3	3/7/18	Completed
9	Mount nitrogen generator	3/5/18	3	3/7/18	Completed
10	Tie the Nitrogen Generator to the compressed air	3/5/18	3	3/7/18	Completed
11	Run the Nitrogen main line	1/15/18	12	2/1/18	Completed
12	Tie the nitrogen main line into the surge tank	1/15/18	12	2/1/18	Completed
13	Mount regulators and rotameters at each point of use	1/15/18	12	2/1/18	Completed
14	Connect the points of use to the new nitrogen main	1/15/18	12	2/1/18	Completed
15	Set pressure reducing valves and rotameters to correct pressure flow based on calculations	3/15/18	1	3/15/18	Completed
16	Phase 2	3/15/18	0	3/15/18	Completed
17	Write the maintenance and operation procedure for the nitrogen generator	3/8/18	11	3/22/18	Completed
18	Train maintenance on the procedure	3/28/18	1	3/28/18	Completed
19	Confirm P&ID drawings are correct and make any necessary adjustments	2/8/18	1	2/8/18	Completed
20	Release system to maintenance	3/28/18	1	3/28/18	Completed
21	Phase 3	3/28/18	0	3/28/18	Completed

Figure 1.18. shows the project schedule and the status of each of the tasks.

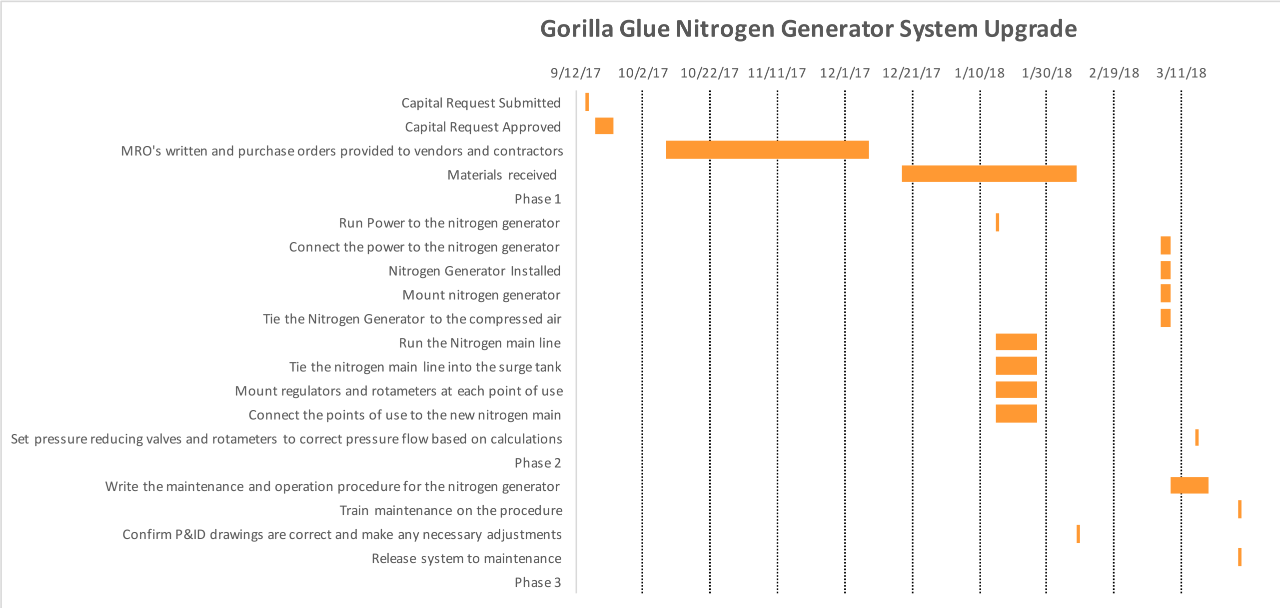

Figure 1.19. *The bar chart above is a Gantt chart that illustrates the project schedule. As you can see the tasks are listed on the vertical axis and the time intervals on the horizontal axis. The width of each of the horizontal bars shows the duration of each task.*

PROJECT PHOTOS

Figure 1.20. the image on the left shows the electrical conduit and electrical box above the existing nitrogen generator. The image on the right shows the conduit and electrical moved.

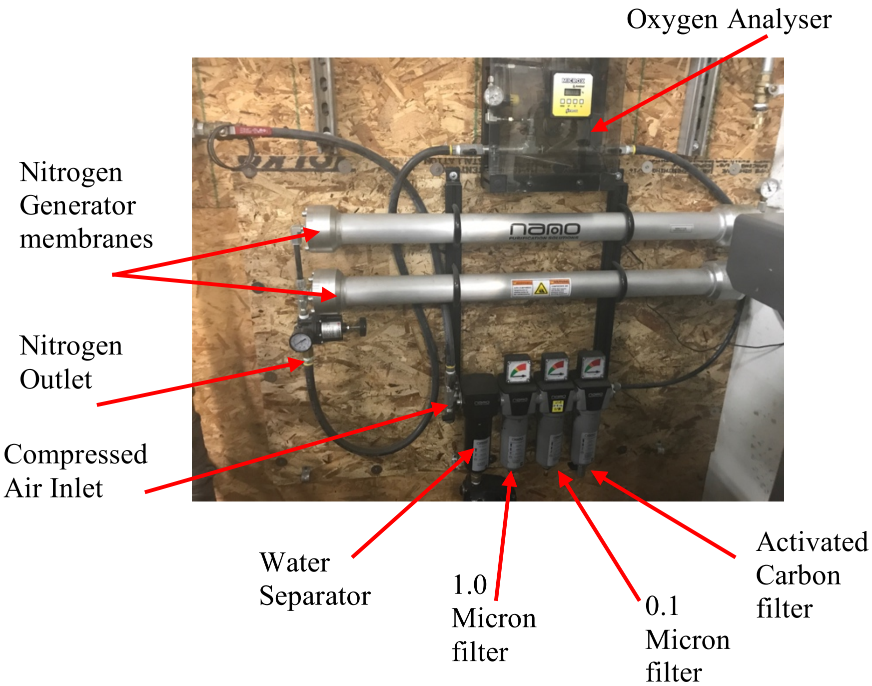

Figure 1.21. the image on the left shows the existing nitrogen generator and identifies the parts of the generator. The image on the right shows the newly installed nitrogen generator in parallel with the existing generator.

Figure 1.22. the image on the left and right shows the oxygen analyser on the nitrogen generator. This device displays the amount of oxygen that is contained in the main line, the lower the number the better. If the oxygen is low that means the system is running at a higher purity level. The image on the left is before the system was implemented the line contained 17.3% oxygen (82.7 % purity level). The image on the right is after the system was implemented the line contained 2.29% oxygen (97.69% purity level).

Figure 1.23. shows flowmeter and regulator mounted to the bracket. The bracket is mounted to one of the filling lines.

Figure 1.24. shows flowmeter and regulator mounted to the bracket. The bracket is mounted to one of the totes.

Figure 1.25. shows flowmeter and regulator mounted to the bracket. The bracket is mounted to one of the day-tanks.

CONCLUSION

I finished the nitrogen system project a week before the technical expo due to a delay in the shipment of the nitrogen generator. Since the system has been implemented we are running at the desired range of 97-99.5% purity level (previously it was between 80-83% purity). This is good because we now have less oxygen in the main nitrogen line thus the system is running at a higher purity level. Also, running at a higher purity will increase the life of the day-tank and product supply totes because there isn't as much oxygen in the line to alter the texture of the glue like before. With less oxygen the texture of the glue won't crust over as rapidly. Flowmeters and regulators have been installed at each point of use so now the flow-rate can be monitored and adjusted if necessary. The day-tanks are now continuously blanketed with nitrogen gas as opposed to every 10 minutes this keeps the oxygen from altering the texture of the product. The feed tote life has been increased by 200% instead of changing the feed totes every 6 months the totes are changed every year now. With the implementation of this system the quality of the glue has improved because the crusting over of the product supply has been reduced.

Overall, I didn't run into any difficulties with the project. I did experience a problem when the manufacturer of the nitrogen generator delayed the project by a month due to not be able to get the membrane bundles on the generator. I handled this issue by speaking with a member of Nano- Purification Solutions and they gave us a free set of filters for the nitrogen generator and expedited the shipment of the generator when it was ready.

WORKS CITED

[1] Nitrogen Generators How It Works - Compressed Gas Technologies. Nitrogen Generators - Compressed Gas Technologies [online]. [Accessed 5 October 2017]. Available from: http://www.nitrogen-generators.com/nitrogen-generators-how-it-works/

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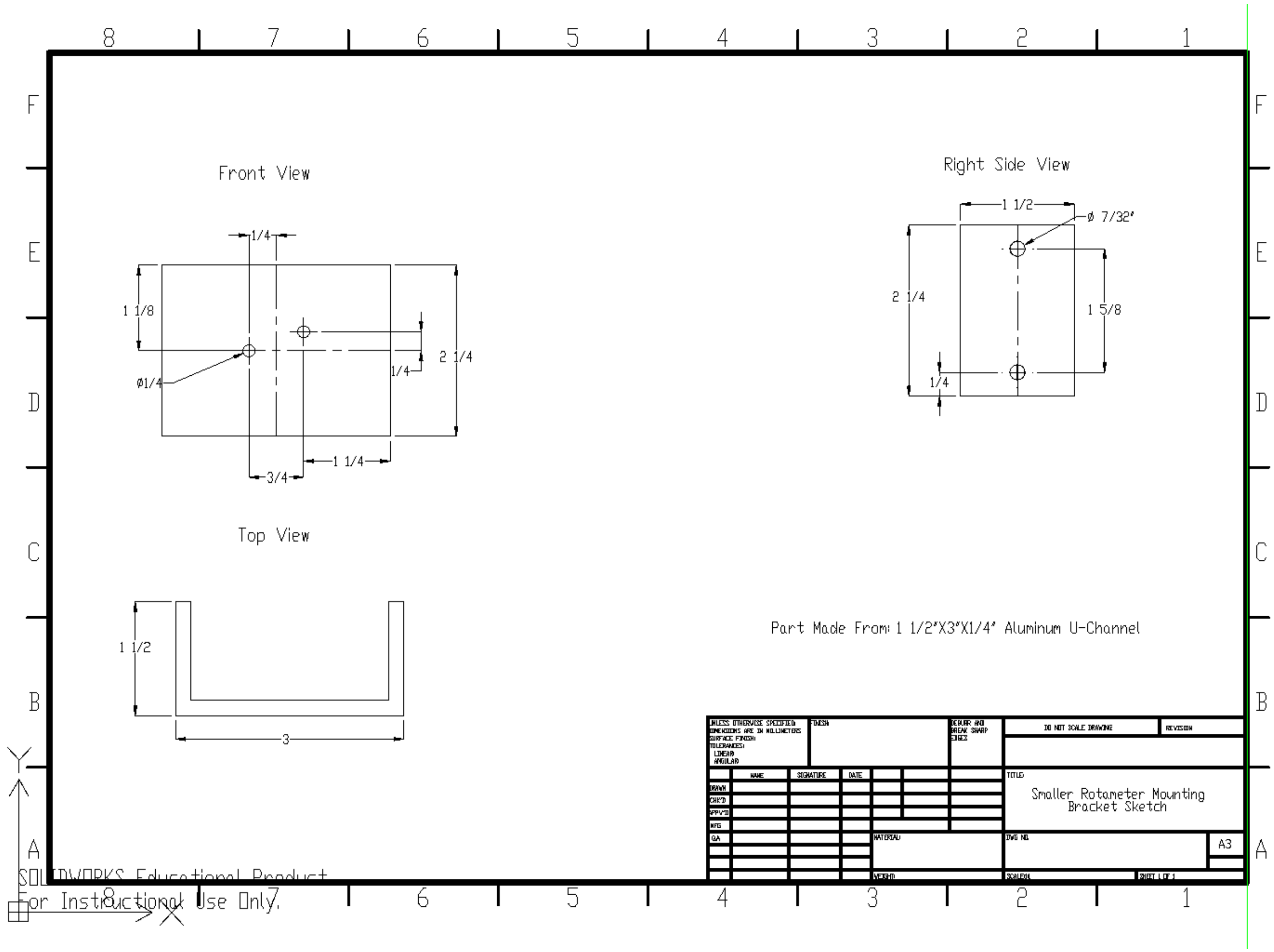
[3] Reinhardt, D., Himmen, D. and Kaltenegger, D. (2017). Overview of inert gas production methods. [online] Boconline.co.uk. Available at: https://www.boconline.co.uk/internet.lg.lg.gbr/en/images/Inerting-in-the-chemical-industry410_166975.pdf?v=1.0 [Accessed 6 Oct. 2017].

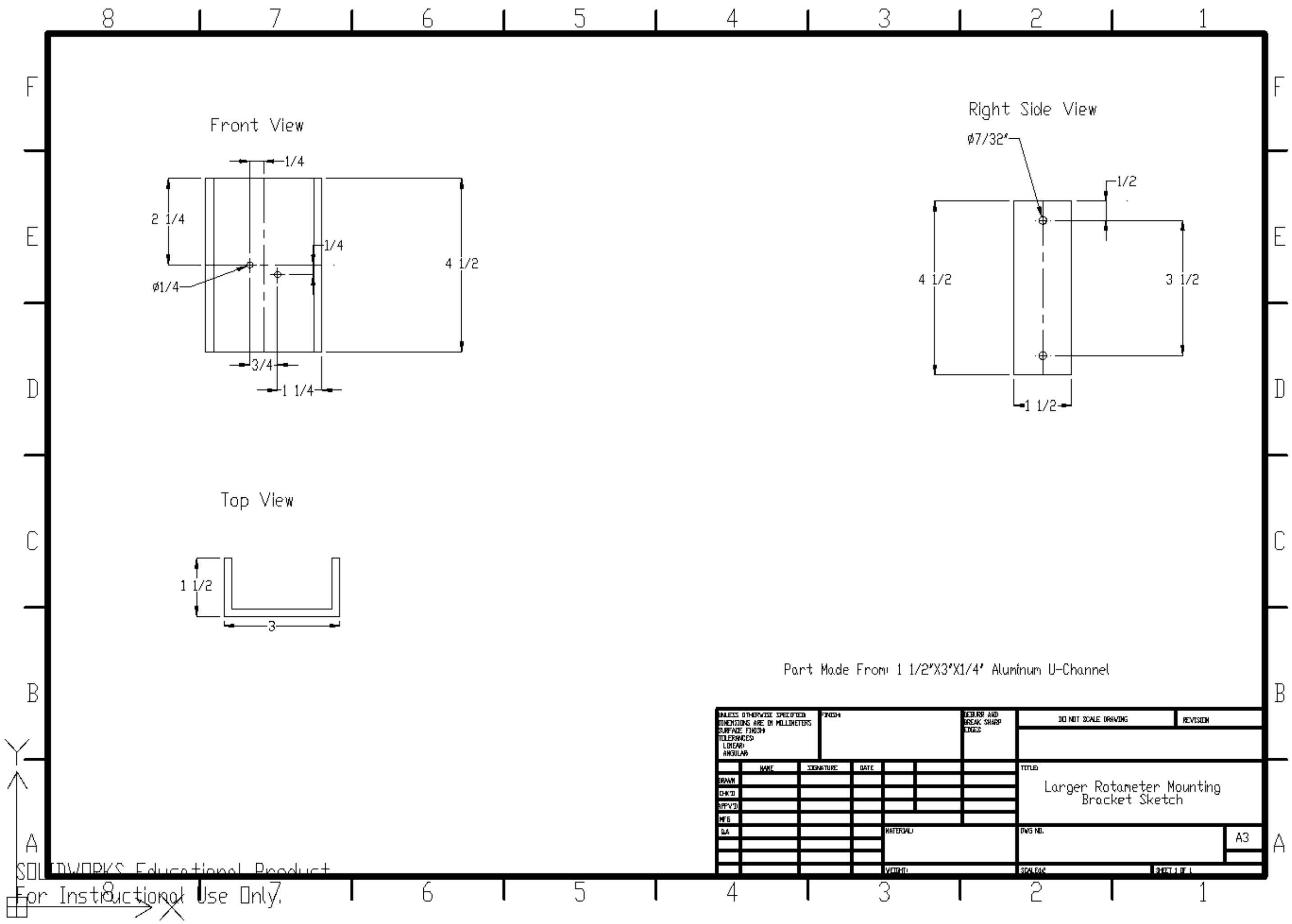
[4] "ANSI/ASME A13.1 Pipe Labeling Requirements." ANSI/ASME A13.1 Pipe Labeling Requirements, Graphic Products, 7 Feb. 2018, www.graphicproducts.com/articles/ansi-asme-a131-pipe-labeling-requirements/.

[5] Hannifin, Parker. "Argon or Nitrogen. Which Is Best for Your Application?" Should I Use Argon or Nitrogen?, 15 Sept. 2016, blog.parker.com/argon-or-nitrogen-which-is-best-for-your-application

APPENDIX A- DRAWING FOR SMALLER MOUNTING BRACKET



APPENDIX B- DRAWING FOR LARGER BRACKET



APPENDIX C- MANUFACTURER SPEC SHEET FOR NITROGEN GENERATOR

sizing & specifications

Model	Inlet Air Pressure	Rated Outlet Flow	Nitrogen Purity at the Outlet (Maximum Oxygen Content)							Dimensions (inches)			Approx. Weight
	psig		99.9% (0.1%)	99.5% (0.5%)	99% (1%)	98% (2%)	97% (3%)	96% (4%)	95% (5%)	A	B	C	lbs
NMG 1126	100	scfh	63	126	168	260	330	408	486	40	48	5.5	51
		m^3/hr	1.8	3.6	4.8	7.4	9.3	11.6	13.8	40	48	5.5	51
	125	scfh	87	174	232	352	452	556	656	40	48	5.5	51
		m^3/hr	2.5	4.9	6.6	10.0	12.8	15.7	18.6	40	48	5.5	51
	150	scfh	100	200	268	394	514	628	776	40	48	5.5	51
		m^3/hr	2.8	5.7	7.6	11.2	14.6	17.8	22.0	40	48	5.5	51
	200	scfh	145	290	388	586	776	918	1058	40	48	5.5	51
		m^3/hr	4.1	8.2	11.0	16.6	22.0	26.0	30.0	40	48	5.5	51
NMG 1317	100	scfh	159	317	423	600	777	953	1130	34	53	8.0	69
		m^3/hr	4.5	9.0	12.0	17.0	22.0	27.0	32.0	34	53	8.0	69
	125	scfh	212	423	565	812	1059	1306	1518	34	53	8.0	69
		m^3/hr	6.0	12.0	16.0	23.0	30.0	37.0	43.0	34	53	8.0	69
	150	scfh	238	476	635	918	1200	1447	1730	34	53	8.0	69
		m^3/hr	6.7	13.5	18.0	26.0	34.0	41.0	49.0	34	53	8.0	69
	200	scfh	393	714	953	1341	1765	2154	2500	34	53	8.0	69
		m^3/hr	11.1	20.2	27.0	38.0	50.0	61.0	70.8	34	53	8.0	69

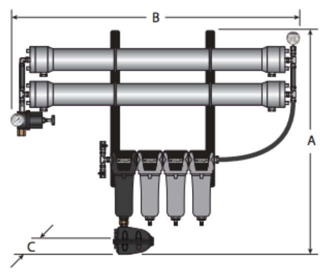
specifications

inlet & outlet connections	1/2" NPT
design operating pressure range	100 - 200 psig
design operating temperature range	41 - 113°F
pressure drop	7 - 10 psig

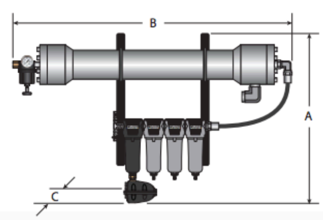
inlet air to outlet Nitrogen ratio (1)

Nitrogen Purity	99.9%	99.5%	99%	98%	97%	96%	95%
NMG 1126	7.5	4.7	3.8	2.9	2.5	2.3	2.1
NMG 1317	4.9	4.6	3.6	2.8	2.5	2.2	2.1

(1) The amount of compressed air required at the inlet as a function of the Nitrogen flow at the outlet. Values are approximate. Contact us for detailed compressed air inlet requirements.



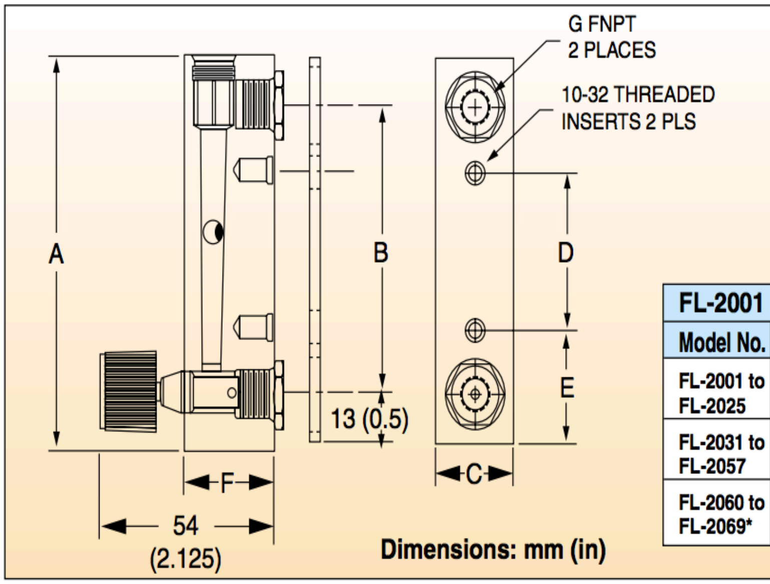
NMG 1126



NMG 1317

Experience. Customer. Service...n-psi

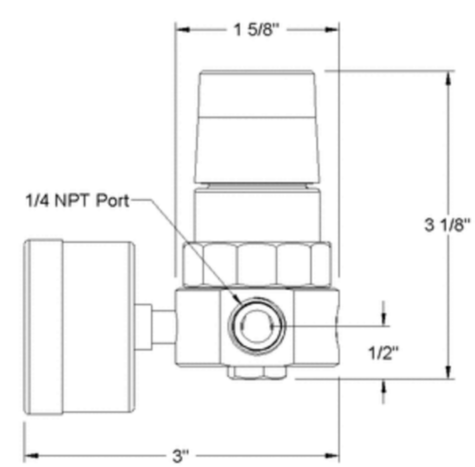
APPENDIX D- DIMENSIONS FOR THE FLOWMETERS AND REGULATORS



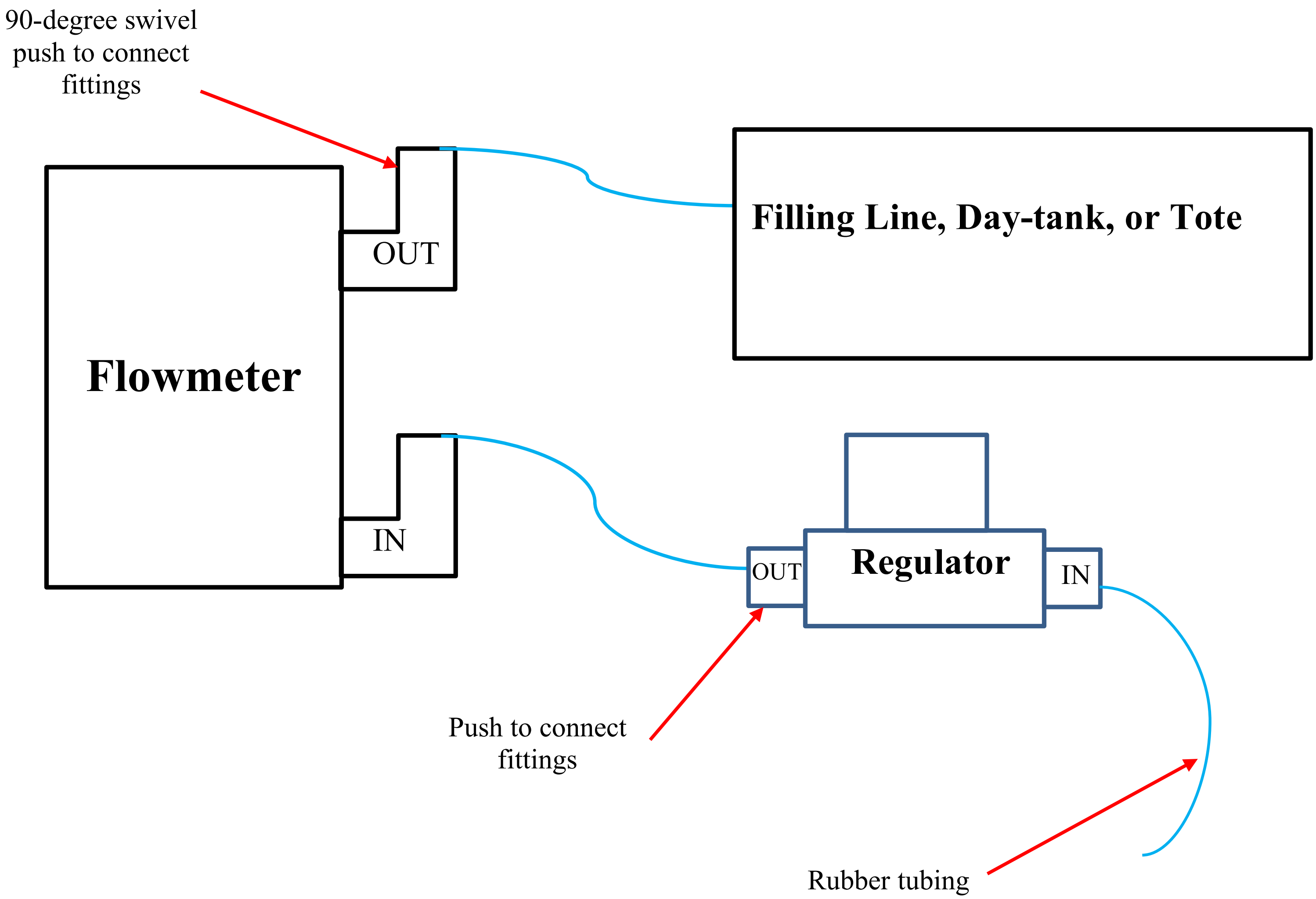
FL-2001 through FL-2069 Dimensions mm (inch)

Model No.	A	B	C	D	E	F	G
FL-2001 to FL-2025	102.0 (4.0)	76.2 (3.0)	25.4 (1)	41.3 (1.6)	30.2 (1.2)	28.6 (1.1)	⅛
FL-2031 to FL-2057	165.0 (6.5)	140.0 (5.5)	34.9 (1.4)	88.9 (3.5)	38.1 (1.5)	28.6 (1.1)	⅛
FL-2060 to FL-2069*	168.0 (6.6)	140.0 (5.5)	28.6 (1.1)	88.9 (3.5)	38.1 (1.5)	34.9 (1.4)	¼

All in this range do not include a ⅛" back plate



APPENDIX E- THE REGULATOR AND FLOWMETER CONNECTIONS



APPENDIX F- SPONSOR

This project would not have been possible without my fantastic sponsor. I greatly appreciate everything that the company did for me.