Self-Contained Breathing Apparatus for Firefighter with a Permanent Stoma

A QL+ Project

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Statement of Confidentiality

The complete senior project report was submitted to the project advisor and sponsor. The results of this project are of a confidential nature and will not be published at this time.

Statement of Disclaimer

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Executive Summary

The purpose of this project was to create a unique SCBA (self-contained breathing apparatus) for a firefighter named Chris Gauer. This prototype consists of a SCBA headgear connected to a polycarbonate-formed stoma mask with a medical-grade sanitary silicone hose.

Chapter 1: Introduction

Sponsor Background & Needs

Chris Gauer is a firefighter stationed in San Francisco, CA, who has dedicated the last several years of his life to serving his local fire department. He graduated from college with an engineering degree, at which point he realized that firefighting was his real passion. After a few years on the job, he was diagnosed with pharynx cancer. He went through the appropriate chemotherapies and actually managed to go through remission. A few months later, however, the cancer returned. Chris had no choice but to undergo a laryngectomy, which requires the removal of his voice box, vocal chords, and other areas of his throat. His airway channels are separated so that he now has to breathe through a stoma (a small opening in his neck) instead of his mouth and nose. He now has to breathe through the stoma for the rest of his life.

Problem Definition

Chris is physically fit to return to work, but the current firefighter SCBA is not designed to provide oxygen to his stoma. A new SCBA must be designed that will allow him to fully perform his duties while providing enough oxygen to his stoma (see **Appendices H & I** for use cases). The purpose of this project was to create a unique SCBA (self-contained breathing apparatus) for Chris. This prototype consists of a SCBA headgear connected to a polycarbonate-formed stoma mask with a medical-grade sanitary silicone hose.

Management Plan

Table 1 below shows each member's role in the completion of the project.

Table 1: Team member roles

Client Contact, Engineer, Lab Technician	Zachary Wishbow
Engineer, Lab Technician	Jason Delgadillo
Engineer, Lab Technician	Aaron Wheeler

An agenda was created to guide the completion of this project (see **Appendix G** for full schedule). The agenda was followed until April, which is when several problems began to arise in manufacturing and assembly that hindered the progress of the project. Compartmentalization of the project was rejected as the design built upon itself. The team agreed to complete it together in order for every member to have equal knowledge of the design.

The suggested budget for this project was $2000. However, there was not a maximum budget implemented as this project directly affects an individual's quality of life. Nevertheless, the cost of this project was far less than the amount suggested.

Chapter 2: Background

Existing Products

This design does not have any competitors. The client, Chris, is in a unique position as he is most likely the first active firefighter to have a stoma. According to Chris, there is a fire chief that has a stoma but no longer fights fires. Firefighters who have throat and neck cancer usually get it from smoking, at which point they are usually too old to continue on the job, so they retire early or look for job opportunities elsewhere. Most firefighters (and victims of cancer in general) do not recover as well as Chris did, especially considering that he underwent radiation therapy, remission, relapse, and a full laryngectomy. Since Chris is the only firefighter (to date) that requires a stoma mask that is compatible with his SCOTT (brand) SCBA, there is no company interest from the manufacturer or competitors to manufacture this product.

The client created his own prototype of a stoma mask. Although his design provides air to his stoma, it considerably restricts his neck and head movement, making it completely useless for use in a firefighting situation. The prototype was analyzed for its strengths and weaknesses, although there were hardly any strengths to his design.

Applicable Standards

The mask still needs to be tested to NFPA Standards. The primary focus will be on NFPA Standard 1981: Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services. This standard provides a plethora of design requirements, including but not limited to, 1) establishing Rapid Intervention Company Universal Air Connections (RIC UAC), 2) maintaining a face piece pressure greater than 0 inches water column and less than 3.5 inches, 3) successfully passing a flame test, 4) successfully passing radiant heat tests, and 5) successfully passing brittle impact tests. This document will serve as the main guide for custom-building the mask.

The fundamental goal of this project was the completion of a working SCBA adapted for use with a stoma by a laryngectomy patient wishing to return to the Fire Fighting services. This SCBA should provide full comfort and mobility of head, neck, and shoulders while providing positive pressure air to the user. The device is required to pass the necessary NFPA testing standards for PPE in structural fire situations in order to be implemented in the field. As such, the NFPA standards discussed above must be met in order to consider this device a successful product.

Chapter 3: Design Development

As previously mentioned, the SCBA should provide full comfort and mobility of head, neck, and shoulders while providing positive pressure air to the user. The engineering specifications for the product, including current targets, can be seen in **Table 2** below.

Table 2: Design Specifications

Specification	Parameter Description	Requirement or Target	Tolerance	Risk	Compliance
1	Weight	< 5 lbs	± 1.5 lbs	L	A,T,I

2	Modularity	> 2 modular parts	± 1 part	M	S
3	Quality Fit	< 10% leak rate	± 10%	H	A,T,I
4	Implementation Time	< 20 seconds to full implementation	Max.	L	T,S
5	Communication Capability	2-way radio and person-to-person speech	± 10 dB	M	T,S,I
6	SCOTT-Pack Compatible	Fits to standard parts for air supply	Min.	L	S
7	Positive Pressure	> 14.7 psi	Min.	M	A,T,I
8	Shatter Resistance	2.4 ounce 1-inch steel ball dropped from 50 inches	-Min.	H	T,I
9	Volumetric Flow	100% flow rate when compared to original face mask	- 15%	M	A,T
10	Heat Resistance	300 Fahrenheit	Min.	H	A,T,S
11	Biocompatibility	Non-reactive with human tissue	Min.	L	A,S,I
12	Low Air Notification	33% air in tank remains	± 2.5%	L	A,T,S

Discussion of Conceptual Designs

The process began with the analysis of applicable materials and safety codes for the SCBA in a structural firefighting application. The SCOTT air pack was thoroughly tested and measured as this is the base device from which any necessary modifications were made. Individual materials were then tested for their potential viability as a solution.

The old prototype produced by the client was analyzed for its flaws and successful features. The shortcomings of this device were noted, and an iterative design process began by

making a new prototype with updated design considerations and materials. Individual components were tested independently of the combined product to ensure functionality at all levels (full decision matrix can be seen in **Appendix B**). The individual components were tested with the SCOTT air pack to ensure compatibility and proper function with the base design. This prototype still requires testing according to NFPA regulations and other applicable codes. Necessary modifications will be required before the client can return to his work. The individual sponsor was instrumental in this project as the SCBA is custom fit to a single user. Fortunately, his physical presence was not required often, as a mold of his neck was created.

Concept Selection & Justification

A decision matrix was created that divided our entire design into subsystems. The subsystems were divided as follows: stoma mask material, seal material, straps, and tubing. Each potential design solution was tested within its respective subsystem against the engineering requirements made from deliberations with the client and NFPA 1981.

Table 3 shows stoma mask seal results from the decision matrix. Silicone is the preferred material due to its high heat resistance, low reactivity with skin, and ergonomic seal.

Table 3: Decision matrix for stoma mask seal

		Best Benchmark from QFD	Less than 5 lbs	>300 degrees F	< 10% airflow lost	Needs yearly service	Relative Roughness	Weighted Sum +	Weighted Sum -	Weighted Sum S	Total Score
	Specification Weight		8	12	11	5	7				
	Silicone		S	S	+		S	11	0	27	19
Stoma Mask Seal	Natural Rubber	S	S		+		S	11	0	15	16
	Neoprene		S		+	-	+	18	5	8	15

Table 4 shows stoma mask strap results from the decision matrix. The loop and pull buckle is preferable due to its reliability, prevalence on existing SCBA systems, and low cost.

Table 4: Decision matrix for stoma mask straps

		Best Benchmark from QFD	< 5 lbs	Put on in <20 seconds	>300 degrees F	Can dissassemle	Realtive Roughness	Weighted Sum +	Weighted Sum -	Weighted Sum S	Total Score
	Specification Weight		8	7	12	8	7				
Stoma Mask Straps	Kevlar	S	S	S	+		S	12	0	22	19
	Snap Buckle		S	S	-	S	S	0	12	30	-3
	Loop & Pull Buckle		S	S	S	S	S	0	0	42	13
	Elastics		S	S	-		-	0	19	15	-15

Table 5 shows results from the tubing subsystem. The accordion style tubing lost in the decision matrix due to its heat resistance and relative roughness.

Table 5: Decision matrix for stoma mask tubing

		Best Benchmark from QFD	< 5 lbs	>300 degrees F	Realtive Roughness	Weighted Sum +	Weighted Sum -	Weighted Sum S	Total Score
	Specification Weight		8	12	7				
	Accordian	S	S			0	0	8	2
Stoma Mask Tubing	Silicone		S	S	+	7	0	20	13
	Stainless Steel		S	+	-	12	7	8	7

Table 6 shows the materials considered for the final stoma mask. Polycarbonate seems to be the best choice due to its numerous applications and familiarity as a material in comparison to Ultem 9085.

Table 6: Decision matrix for stoma mask

		Best Benchmark from QFD	< 5 lbs	>300 degrees F	< 10% airflow lost	Z88.2 ANSI	Weighted Sum +	Weighted Sum -	Weighted Sum S	Total Score
	Specification Weight		8	12	11	7				
Stoma Mask	Polycarbonate	S	S	S	+	+	18	0	20	24
	Ultem 9085		S	+	+	-	23	7	8	18

The two tubing options that were considered were the CS1 Sanitary silicone hose and FD1 silicone coated fiberglass hose. Both of these options were tested independently for verification.

Design Process: Milestones, Obstacles, Solutions & Lessons Learned

Milestones

The major milestones achieved were the successful creation of a vacuum forming device to mold the poly-carbonate, the completion of several prototype masks that the client tested, the requisition of a new hose material from the client, UL style testing of the materials used.

For the vacuum forming device a combination of lumber and silicone sealant was used to create the main body. A flange was then attached to allow for the vacuum pump to draw the air from the vacuum former box. The polycarbonate sheet was secured between an aluminum frame

in order to prevent deformation or bending when the polycarbonate was pre-treated and pre-heated. The poly-carb was heated at 350º F for 15-20 minutes depending on pre-treatment duration, the longer the pre-treatment at 250º F the less ductile the material and the more difficult it became to form. By finding a balance of 25-30 minutes pre-treatment combined with a longer pre-heat to the glass temperature a durable poly-carbonate stoma mask with minimal internal bubbles was able to be achieved. It should be noted that the internal bubbles have a minimal effect on the strength characteristics of the poly-carbonate and mainly affect the optical quality of the mask.

Through the use of the vacuum former several, prototype masks were developed and shown to the client. From these proto-types we were able to observe the necessary changes needed to complete the finalized design for the client. The sealing method will need to be further modified to allow for better contact with the clients skin, and some minor structural changes will be made to the mask design itself to better accommodate the unique dimensions of his Stoma.

The hose originally selected for the prototype was unfortunately not able to be used for the final designs. Instead a new hose material has been sourced from a competing fire-fighting safety company MSA, this new hose material has a much higher flexibility than the originally used sanitary silicone. Through the use of a better air-hose the routing of the air from the main SCOTT mask to the created Stoma mask is much more flexible and less constrictive to the user. The final attachment procedures must still be verified and tested.

For the UL style testing, the materials used for the stoma mask and seal were tested to see what sort of burn rates and patterns could be expected. In the firefighting industry it is more desirable to have a material burn rather than melt, as this helps prevent the fusion of materials to human flesh in a worst case scenario. Both the polycarbonate and the silicone burn rather than

melt, and self-extinguish with no additional aid in a manner of seconds. The visible degradation of the material also occurs near the burned area, helping to identify which sections have been damaged and should be replaced before further use of the product.

Obstacles

The earlier prototype masks will have to be modified in order to better accommodate the unique anatomy of the clients neck. In the procedure of the stoma installation the client's hyoid bone, and voice box were completely removed giving the client a unique neck anatomy. In addition to the alteration in anatomy from the removal of tissue, permanent synthetic material was added which must be accommodated for in the design. The speech valve necessary for hands free speech extended roughly an inch from the surface of the client's neck, and must be given adequate room within the mask to avoid injury or discomfort. An additional aspect of the hands free device is the possibility that the pressurized airflow may possibly force the valve closed, rendering speech impossible. Unfortunately this feature was unable to be tested as the seal on the client's neck requires additional modification.

With the neck seal, a thicker more flexible seal will have to be constructed in order to fully secure to the clients neck and prevent any leaks. Currently the seal is incomplete and air can escape in and out around the outside of the stoma mask. This will have to be remedied before any testing on the neck valve situation, or testing in the working environment can be conducted.

The original hose procured for the system, took an extended period of time to arrive severely limiting our abilities to test the hose. In addition the actual amount ordered and whether or not fittings would be attached was not. When it arrived it was shorter than expected, and roughly triple the quoted price. For these reasons, product procurement through that supplier

was halted. With the new hose arrival additional testing can begin, and the validity of the hose guaranteed.

Solutions:

In order to render better formed stoma masks, the duration of the pre-treatment has been cut down to 25-30 minutes, which allows for some moisture to be driven from the Poly-carbonate without losing the necessary ductility to form to the specified shape. In addition to the shorter pre-treatment times, the polycarbonate was allowed to deform to a greater degree before application to the mold. This allowed for better mold ability of the poly-carbonate as it had transitioned further into a semi-amorphous state. Through this technique we were able to create more exactly formed stoma masks for our client.

In order to improve and strengthen the seal, the same material will be used however additional layers will be added. This will allow for the flexible high temperature silicone to properly seal to the clients neck. By allowing for the material to run when in its liquid state, the silicone can be formed around objects rather easily. This style of application can then be used to create a U shaped edge seal, which should deform easily to the clients anatomy in order to achieve a proper seal.

Due to the difficulties with the original hose supplier, efforts are currently being undertaken to procure a better substitute from MSA, a fire-fighting safety company. This may seem slightly odd since the remainder of our system is designed around SCOTT safety systems, however since only the hose will be utilized, and modified, cross compatibility will not be an issue. The new hose will allow for a much more flexible re-routing of the air supply, due to its accordion style. This will also allow for the hose to be less intrusive to the client, as a shorter length will be able to be utilized to re-direct the air.

Lessons Learned:

In regards to the project, several valuable lessons were learned. First and foremost, the value of the iterative design process was instilled, as the project required several revisions throughout. Without the iterative design process the project would not have been able to move forward. By learning from the mistakes made, and quickly altering the design, quick revisions and new prototypes were able to be manufactured at a quick rate.

Another valuable lesson learned is the careful selection of suppliers when ordering materials. With the hose supplier HoseCraft USA, a lack of respect and communication was evident. It seemed that since the project was for a college basis and that the order was different from their common dealings with businesses, the priority given was very low and almost no positive communication was had with the company. Even when reaching out with the aid of Dr. Laiho this pattern continued, although in a somewhat more polite fashion. This experience has taught to expect some resistance when attempting unique and novel approaches to a given problem. In addition sourcing the exact same part from several suppliers is an invaluable tool for development and could have allowed this problem to be avoided. This is not always a feasible option, making multiple design choices an important option.

The amount of time a project takes is also a valuable lesson learned, as the scope and scale of engineering projects is often spread over several months or years. In the case of this project the timeframe of 10 months went by incredibly quick, and the design and implementation of the device could benefit from additional time to allow for more research and more iterative solutions.

Chapter 4: Description of the Final Design

Overall Description/Layout

The stoma mask itself has a curvilinear design to it, resembling the shape of a bifurcated teardrop. This is to allow for additional clearance of the chin and upper neck while the head is pivoted downwards. This is especially important when considering the additional distance that the face mask adds to the anteversion and retroversion of the user's chin. This shape also allows for effective mounting of straps on both the upper and lower portions in order to guarantee a tight seal.

Detailed Design Description

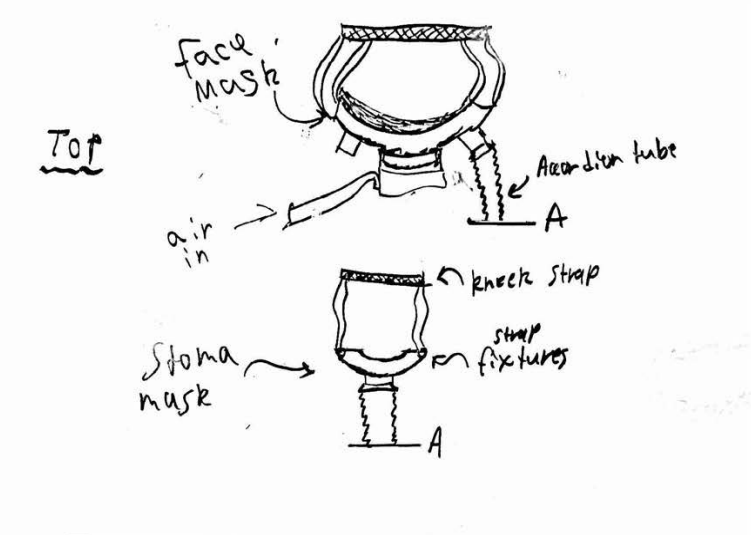


Figure 1: Top view of device design

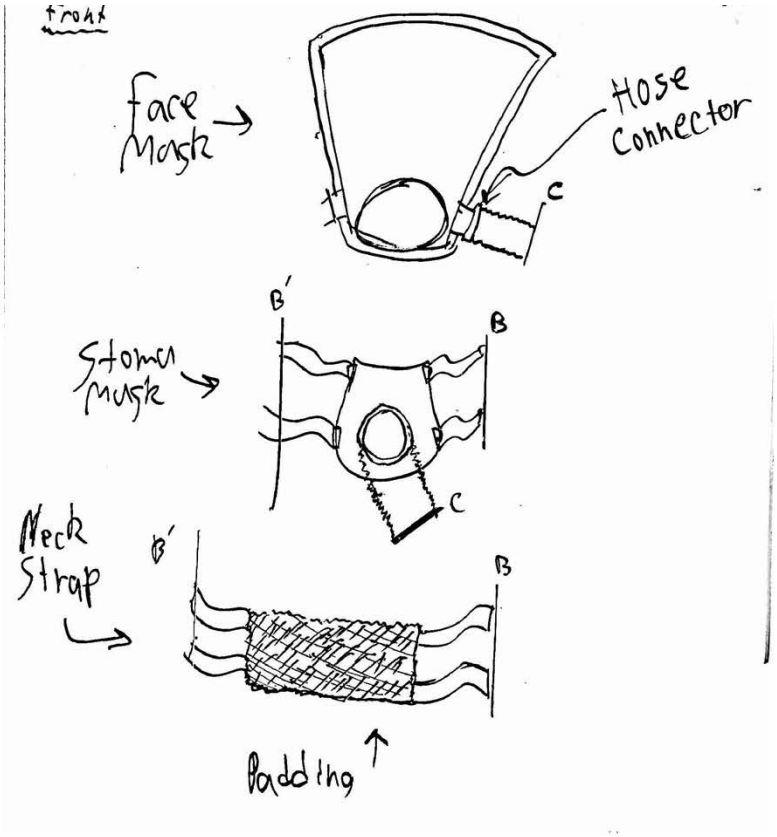


Figure 2: Front view of device design

The actual strap closure method is simply depicted as circles to allow for clarity in regards to the mask's shape and design. There is padding on the back section of the neck with the straps running internally through it in order to provide a safe and comfortable closure method. This allows for more effective padding and for the possibility of tucking any excess strapping into the padding. This method is the standard method of affixation for the SCOTT system, which the client is very familiar with.

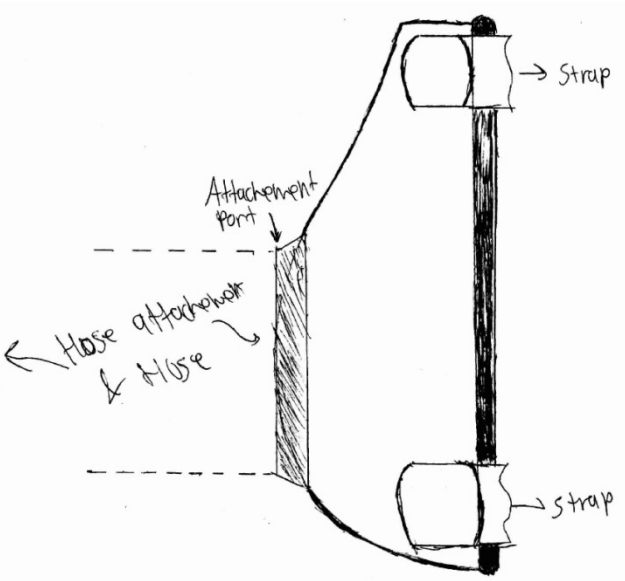


Figure 3: Side view of device design

The hose attachment method depicted is a rough representation of one of the two type of attachments, which are physically similar in dimension but involve different methods of closure. The first method of closure consists of brass NPT swivel fittings, properly sealed with Teflon tape to prevent leaks. This is the method that was employed with the CS1 sanitary hose. The second method of attachment, associated with the FD1 hose, is to use a flexible silicone sealant combined with hose clamps to securely bind the ends. Both methods extend from the mask roughly the same distance and allow for adequate hose fixation. These methods were used to affix the hose to the stoma mask. The hose attachment method may also be mounted at a 90 degree angle from the opening in order to more directly connect the hose to the facemask hose port.

Analysis & Modeling Results

The face mask itself is shown in a somewhat simplified manner since this piece of equipment is already fabricated by SCOTT manufacturing. Other than the attachment of the hose

fixation, no other modifications will be made to the face mask. A full schematic of the prototype can be seen in **Appendix C**.

Cost Breakdown

As previously mentioned, the recommended budget for this project was $2000. All of the costs associated with the completion of this project were as follows:

Item	**Cost**
Clay (25 lbs)	$20.00
Plaster Cloth	$6.00
Plaster of Paris	$6.78
Polycarbonate (3 sheets)	$59.94
Plywood	$9.00
Pegboard	$15.00
Heat Resistant Sealant (x3)	$20.91
CS1 Sanitary Hose	$400.00
Hose Clamps (x4)	$3.92
Machine Hardware (screws, nuts, etc.)	$5.23
Life Casting Platinum Silicone	$45.86
Copyflex Liquid Silicone (2 lbs)	$50.00
SCOTT air pack + mask	Donated

Total Cost: $642.64

The total cost was well under the recommended budget. The extra amount of money may be used to provide additional supplies for the client.

Special Safety Considerations

There are numerous safety considerations that must be effectively addressed for the product to be a viable solution. First and foremost, it must have a resistance to high levels of both direct and indirect heat exposure in the firefighting environment. The air itself will be at a high temperature, and objects in the environment will be at a really high temperature and should contact occur will transfer heat directly. We will address this by making sure that all materials used in the complete system will be heat resistant to at least 300 degrees Fahrenheit if not higher.

In addition to the heat resistance for burning or melting we will also try to select materials with poor heat conduction in order to better insulate the user from the heated environment.

The next main concern is that breathable air is supplied to the user at all times, and that it has not been contaminated by any smoke. This is why a quality flexible silicone seal will be used in order to prevent the entrance of smoke or other particulate matter into the users air supply. This will also serve to prevent water and other debris from entering the user's stoma, potentially blocking it or introducing unwanted foreign bodies into the lungs. The positive pressurization of the device also helps to actively prevent the entrance of smoke and particulates into the mask, however due to its relatively low gauge pressure, between 0 and 3 inches of water, this effect is somewhat minimal.

The possibility of impact is another concern for the system design. In the firefighters environment the possibility for an impact occurrence is fairly high due to the nature of the failing structure around them. It is for this reason that the polycarbonate will be used in order to withstand moderate impact force and more importantly to prevent shattering causing lacerations (see **Appendix F** for full analysis). The seal itself will also be semi-flexible serving to act as padding to the neck in the event of an impact.

The materials in use are medically safe in order to prevent the release of any toxic materials or potential bio-reactions. It is for this reason that all materials will be verified as non-toxic and skin safe, via the MSDS's and personal verification by Chris, before any implementation in the finished design. The materials must also be no-volatile and cannot release any harmful agents when heated or expose to skin , sweat, water, or any other substance the firefighter is likely to contact during their day to day routine. This will be accomplished by

using medical grade materials whenever possible, and when not available, that proper sterilization and skin contact testing have been done.

Maintenance & Repair Considerations

Ensuring that proper cleaning procedures are put in place is essential to ensure sanitary conditions (refer to **Appendix H & I**).

Chapter 5: Product Realization

Manufacturing Process

Creating the stoma mask involved creating a vacuum former that would bend polycarbonate into the desired shape. The following is a summary is how the manufacturing process worked. Full details on individual steps can be seen in **Appendix C**.

A vacuum former was created using plywood, pegboard, and heat resistant sealant. A hole was drilled in the front piece of the former in order to allow a connection to a vacuum pump.

Figure 4: Vacuum former

Several pieces of polycarbonate were cut into 12” x 12” sheets. These dimensions matched the dimensions allowed by the vacuum former.

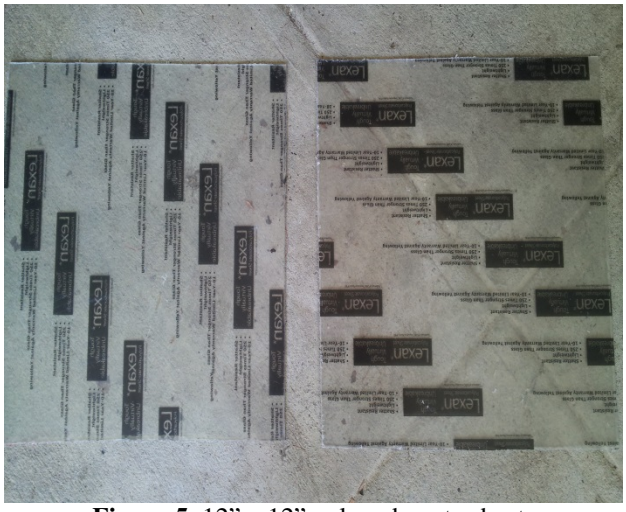


Figure 5: 12” x 12” polycarbonate sheets

A vacuum pump was then attached to the vacuum former. A mold was placed in the middle of the vacuum former to allow the polycarbonate sheet to bend over it.

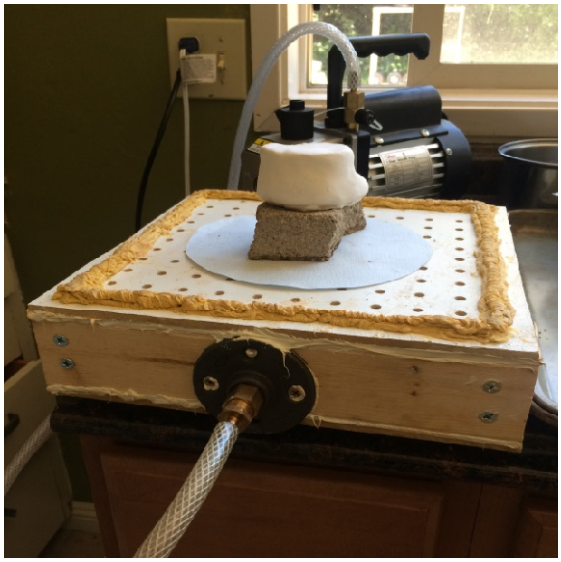


Figure 6: Vacuum pump attached to vacuum former

A polycarbonate sheet (held in place by aluminum frames and bricks) was placed in the oven at 350 degrees F.

Figure 7: Polycarbonate sheet in oven

Once the polycarbonate sheet drooped at least halfway past the bricks, the sheet was taken out and placed on top of mold, making sure to pressure-fit it into desired shape.

Figure 8: Pressure-fitting into desired shape

The polycarbonate sheet was allowed to cool once the desired shape was obtained.

Figure 9: Allowing polycarbonate sheet to cool

The desired shape was marked and cut to obtain the stoma mask.

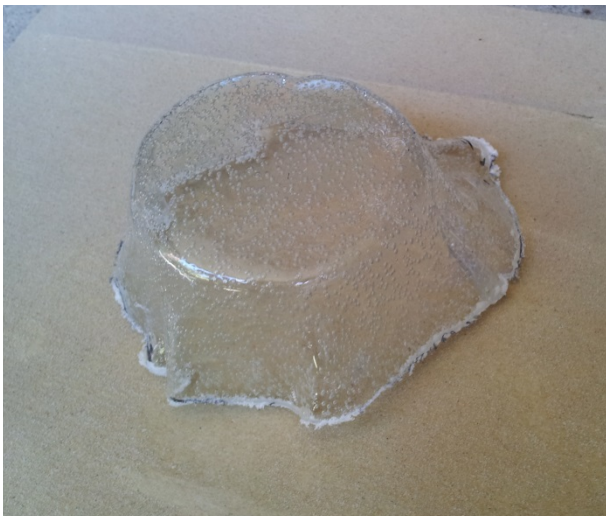


Figure 10: Stoma mask cut out

A 1 ¼" hole was then drilled in the middle of the stoma mask in order to allow hose attachment.

Figure 11: Hole drilled in stoma mask

Liquid silicone was applied around the stoma mask. The silicone was then allowed time to cure.

Figure 12: Liquid silicone around stoma mask

Figure 13: Stoma mask with cured silicone

Deviations from Initial Design

The original design of the stoma mask was a thermoformed tear-drop shaped mask with a taper towards the chin of the user. A seal was planned to be made using premixed RTV silicone sealant pressed into a mold. The idea was to connect a silicone hose from the unused accessory port of the SCOTT face piece to a hole in the stoma mask using brass fittings and hose clamps. A stainless steel reinforced silicone hose and fiberglass hose coated with silicone were both ordered for implementation to the device.

The final stoma mask shape has deviated from a tear drop shape to that of a stubby cylinder of height 1.25-1.5". The client has indicated that this is the shape that will work best with his stoma. The diameter of the cylinder is about 3" across. The silicone used to create the stoma mask seal has been swapped after unsuccessful test trials. A food-grade two part silicone mold mix (Copyflex^{TM}) that works in temperatures up to 450°F was used. The fittings have been slightly changed to include SCOTT manufactured flanges, but brass fittings may still be used. Stainless hose clamps were purchased and implemented, but the design will be upgraded to quick release clamps. The client and group members are dissatisfied with the steel enforced silicone hose and desire to swap it out with an unbraided or accordion silicone hose.

Recommendations for Future Manufacturing

It is suggested that the team spends more time with the client in order to make a final clay model of the stoma mask. There were several difficulties in finding the right geometry for the client. Once the clay model is finalized, it would be best to create a silicone negative mold of the clay model. The silicone negative mold would allow the client to pour reproducible plaster copies of the original clay model. Two important manufacturing tips for thermoforming the

polycarbonate stoma mask are to place 2” cubed spacers beneath the mask model, and to dry the polycarbonate sheet in the oven at 250°F for 30 minutes (to avoid water bubbles in the polycarbonate.)

It was only recently realized that the best method for creating a smooth and quality silicone seal is by making a clay model of it first. Once the clay model has hardened, one team member creates a plaster negative mold by coating the clay seal model with plaster infused cloth. The plaster is allowed to harden, and then the clay model is removed. The stoma mask seal negative mold is filled with silicone, and the stoma mask is pressed into the mold before the silicone cures. The stoma mask adheres to the silicone well when the outer perimeter of the mask is roughened and when small through holes are drilled along the perimeter.

The client supplied the team with an accordion style hose to replace the hose used in previous iterations. The client desires a flexible, sanitary hose; therefore, the use of a silicone hose is recommended. Once the group and client have settled on which hose to use, the stoma mask, facepiece, and hose can be assembled. Pressure fits, brass fittings, and quick release stainless hose clamps should be used to connect the pieces of the assembly.

Cost Estimate for Future Production

The following is a cost estimate for future production:

Table 7: Cost Estimate

Cost Estimate for Future Work	
Lexan	$78
Copyflex	$34
Hose	$400
Stainless Clamps	$80
Brass fittings	$50
Scott/MSA accessories*	$300
Σ	$942

*Unsure of exact accessories so high cost estimate.

Chapter 6: Design Verification & Testing

Test Descriptions

The final device underwent four tests: two melt tests, an air test, and a modified UL test. Due to time constraints, there was not enough time to perform further testing of the device. In addition, the final product will need to pass all of the ANSI and NFDA tests required by the fire department.

The first melt test involved testing the silicone mold to analyze how well it performs in extremely hot temperature conditions. A piece of cured silicone was held at a safe distance and was exposed to direct high intensity flame. The flame duration period was timed in order to determine the UL rating. Time and qualitative observations were recorded.

Figure 14: First melt test

The second melt test involved testing the stoma mask to analyze how well it performs in extremely hot temperature conditions. The stoma mask was held at a safe distance and was exposed to direct high intensity flame. The flame duration period was timed in order to determine the UL rating. Time and qualitative observations were recorded.

Figure 15: Second melt test

The air test involved testing the face mask, hose, and stoma mask for functionality and possible leaks. The face mask, hose, and stoma mask were all attached and wore by one of the group members. The air pack was turned on, and the equipment was checked for any leaks.

For the Modified UL test, material samples were collected from extra scrap material or a small batch was made specifically for the testing. This allowed for the material to be tested without compromising or damaging any of the proto-type iterations. The material was suspended in a vertical configuration then set alight. The material was then extinguished and re-lit a second time in accordance with UL style testing. The time to self-extinguish was then measured, and visual observations of the burn behavior were taken. In order to pass the material could not drip and flaming material and had to self-extinguish in a maximum of 60 seconds in accordance with UL rating 3. In this case the polycarbonate self-extinguished in an average of 4 seconds with no flaming drips corresponding to a UL rating of 1. The flexible silicone seal achieved a slightly lower rating of UL 2, due to its self-extinguishing time of 20 seconds on average.

Test Results

The first melt test resulted in an absence of flaming drips, with the product burning rather than melting. It took 20 seconds for the silicone mold to self-extinguish. There was discoloration at the sites of direct flame exposure, but the rest maintained its original color.

The second melt test also resulted in an absence of flaming drips, with the product burning rather than melting. It took 3 to 5 seconds to self-extinguish. Flexural rigidity remained, but there was a slight loss of ductility.

The results for the modified UL test are shown in **Table 8** below:

Table 8: Modified UL test results

Material/Run	Time to Self-Extinguish	UL Rating for Run
Polycarbonate 1	5 Seconds	1
Polycarbonate 2	3 Seconds	1
Polycarbonate 3	4 Seconds	1
Silicone Seal 1	22 Seconds	2
Silicone Seal 2	18 Seconds	2
Silicone Seal 3	20 Seconds	2
Polycarbonate Avg.	**4 Seconds**	**1**
Silicone Avg.	**20 Seconds**	**2**

As far as the air test, all of the equipment successfully passed the air test. No leaks were detected.

Chapter 7: Conclusions and Recommendations

The most current prototype design is composed as follows: the main SCOTT SCBA, unaltered in function, is used in its regular fashion for the air supply to the main mask. The SCOTT AV 3000 series mask was modified to accept the secondary air hose by removing one of the voice transducer panels and using the open accessory port to attach the hose. The secondary air hose supplies the pressurized closed circuit air stream from the SCOTT pack to the stoma

mask. The stoma mask itself is constructed of a hard polycarbonate shell with a flexible silicone seal for the neck and a SCOTT webbing system for securing it to the neck.

In addition to our own tests, the client will have to beta test the designs in the controlled firefighting training exercises done at his firehouse. It is through this method that any flaws or features which may have not been foreseen due to lack of personal firefighting experience on behalf of the group will be identified. These beta tests should begin slowly and build in intensity and danger slowly to avoid any injury due to a potential failure during the testing stages.

Acknowledgements

We would to thank Chris Gauer, our client, for providing us with all of the equipment and material he could, but more importantly, for trusting us with this project. We would also like to thank Professor Lee McFarland for all of his help and advice on this project.

A special thanks to Dr. Lily Laiho, Jon Monett, Scott Monett, and the QL+ organization.

Appendices

Appendix A: References

National Fire Protection Association. (2014). NFPA 1: Fire Code. Retrieved from Dr. Pascual of Cal Poly FPE Dept.

National Fire Protection Association. (2014). NFPA 1500: Standard on Fire Department Occupational Safety and Health Program. Retrieved from Dr. Pascual of Cal Poly FPE Dept.

National Fire Protection Association. (2014). NFPA 1802: Standard on Personal Portable TwoWay
Radio Communications Devices for Use by Emergency Services Personnel in the Hazard Zone. Retrieved from Dr. Pascual of Cal Poly FPE Dept.

National Fire Protection Association. (2014). NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting. Retrieved from Dr. Pascual of Cal Poly FPE Dept.

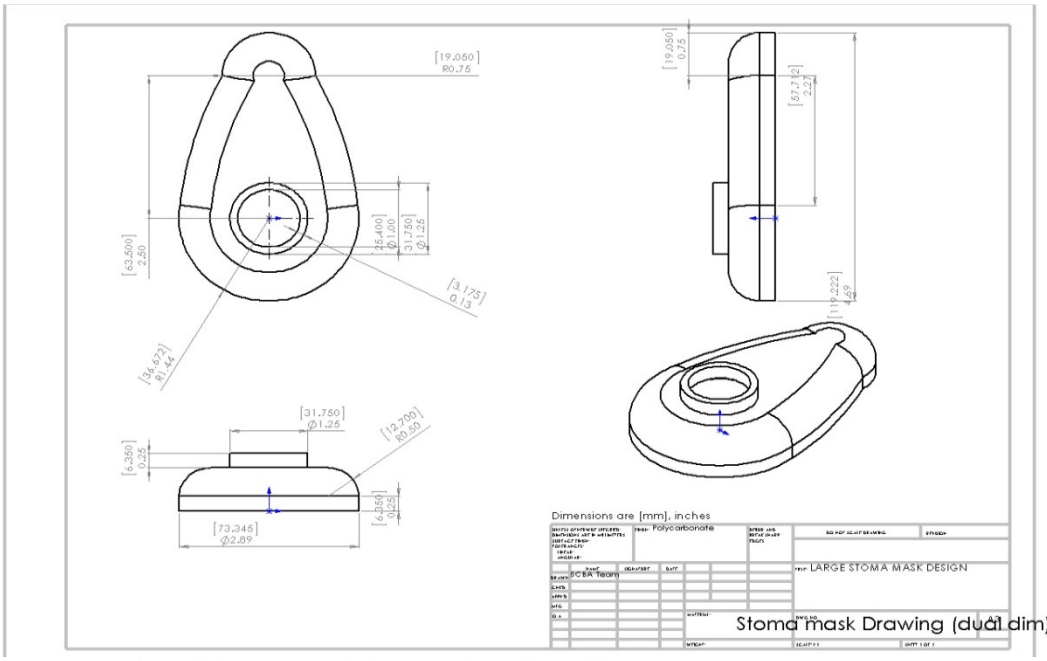
National Fire Protection Association. (2014). NFPA 1981: Standard on Open-Circuit Self Contained Breathing Apparatus (SCBA) for Emergency Services. Retrieved from Dr.Pascual of Cal Poly FPE Dept.

"SCBA." - Self Contained Breathing Apparatus for Firefighting & Rescue Teams. Marcus Media Ltd, n.d. Web. 24 Oct. 2014.

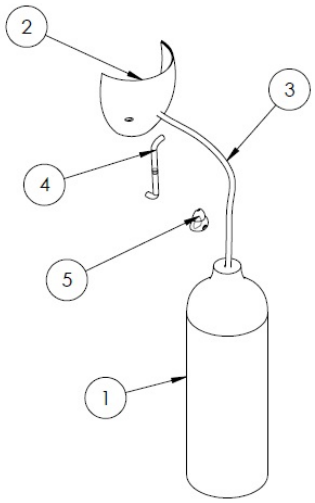
Appendix B: QFD, Decision Matrices

SCBA MOD		Engineering Requirements																			
System Functions	Potential Solutions (From Convergent Thinking Exercise)	Best Benchmark from QFD	< 5 lbs	>2 Moduar Parts	Put on in <20 seconds	>300 degrees F	< 10% airflow lost	Can dissassemle	Needs yearly service	Greater than atmospheric Pressure	Speak conversationally	Realtive Roughness	Z88.2 ANSI	Very compatible	No physical limitations		Weighted Sum +	Weighted Sum -	Weighted Sum S	Total Score	Specification Weighting Check
	Specification Weight		8	3	7	12	11	8	5	9	9	7	7	6	8						100
Stoma Mask Seal	Silicone	S	S			S	+					S					11	0	27	19	
	Natural Rubber	S	S				+					S					11	0	15	16	
	Neoprene	S	S				+		-			+					18	5	8	15	
Stoma Mask Straps	Kevlar	S	S		S	+						S					12	0	22	19	
	Snap Buckle	S	S		S	-		S				S					0	12	30	-3	
	Loop & Pull Buckle	S	S		S	S		S				S					0	0	42	13	
	Elastics	S	S		S	-						-					0	19	15	-15	
Stoma Mask	Polycarbonate	S	S			S	+						+				18	0	20	24	
	Ultem 9085	S	S			+	+						-				23	7	8	18	
Stoma Mask Tubing	Accordian	S	S														0	0	8	2	
	Silicone	S	S			S						+					7	0	20	13	
	Stainless Steel	S	S			+						-					12	7	8	7	

Appendix C: Final drawings (schematics, software diagrams, part drawings, bill of materials)



ITEM NO.	DESCRIPTION	QTY.
1	Scott-pak	1
2	Facepiece (AV2000/AV3000)	1
3	Tube (Connects Facepiece and Scott-pak)	1
4	Tube (Connects Facepiece and Stoma Mask)	1
5	Stoma Mask	1



Drawing is not final. Changes in dimensions and scaling, as well as additional parts may appear in later revisions.

UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	ZW	2/8/15
	CHECKED		
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

TITLE: First Assembley

SIZE	DWG. NO.	REV
A	00001	
SCALE 1:8	WEIGHT:	SHEET 1 OF 1

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF QL+. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.

5 4 3 2 1

	Details
Clamp	Two Clamps to attach hose (Option
02 Silicone sealant	Flex seal for Hose and Stoma mask
gas fitting	Crow foot universal fitting
anitary Silicone HP	High pressure siliconce Hose 1" ID
iberglass Coated Silicone	Coated ehxaust/vacuum tubing (12
el fitting	Brass threaded swivel
n Gas Tape	Teflon tape to seal threading
Clamp	Hose Clamp to secure tubing (see a
02 Silicon Sealant	Sealant from Same tube as before
arbonate sheeting 18X24"	0.093" thick, used for slumping mas
02 Silicone sealant	Flexible seal for polycarbonate/nec
T kevlar securing straps	Standard SCOTT Kevlar securing str
eted mounting screw	Gasketed mounting screw that secu
RNO Torch	Roofing torch used to slump and he
PEY 1.75 lb	Clay used to create general shape f
l Putty knife	Used to cut cement board
CK 3x5 sheet	Cement board for flame resistant w
2" Tile	tiles used as weight/ worksurface f
of hose and full polycarb sheet	
of hose and full polycarb sheet	

Appendix D: Manufacturing Procedure

Supplies: Earthen clay, plaster, plaster impregnated cloth, cup of water for wetting plaster cloth, 0.09" thick polycarbonate, circular saw to cut polycarbonate, oven, rectangular bricks, broken brick spacers (2-3" square), vacuum former table, leather gloves, permanent marker, rotary tool, diamond tipped cutting bits for rotary tool, sandpaper (optional), silicone mold for stoma mask seal (CopyFlex^{TM}), power drill, drill bits to cut 1.25" and 9/64th holes, Kevlar straps, Scott facepiece, knife or razorblade to cut rubber flange, brass transfer fitting, two stainless steel hose clamps, silicone hose

Safety Precautions: Always wear safety glasses when using power tools and only use them in a manner consistent with the manufacturer's instructions. Use the oven responsibly. Don't leave unattended polycarbonate in the oven. Remove objects from the oven wearing leather gloves. Keep plaster and silicone mixture from eyes.

Manufacturing Procedure:

Step 1.) Make clay or plaster model of stoma mask. Allow clay or plaster to fully dry.

Step 2.) Make a clay or plaster model of the seal intended for the stoma mask. Allow model to dry completely.

Step 3.) Using wetted plaster infused cloth coat clay/plaster mask seal. Allow plaster to dry completely.

Step 4.) Remove the clay/plaster mask seal model from plaster negative mold.

Step 5.) Smooth plaster negative mold with additional plaster. Allow plaster to dry completely. Coat internals of negative mold with silicone mold release.

Step 6.) Cut 12 inch square sheet of 0.09" thick polycarbonate.

Step 7.) Remove manufacturer's films from the sheet. Place the sheet between aluminum frames included with the vacuum former assembly.

Step 8.) Place two clay bricks in the oven spaced 13 inches apart. Preheat oven to 250^0F.

Step 9.) Once the oven is preheated place the sheet and frames in the oven for at least 30 minutes to rid the sheet of moisture.

Step 10.) After the 30 minute prebake, turn the heat up to 365^0F. Keep the sheet in the oven for 10-15 minutes. The sheet should sag until almost touching the oven's rack.

Step 11.) Place a brick riser (2-3" square) on the center of the vacuum former and then the mold on top of the riser.

Step 12.) Turn on vacuum and remove frame and sheet from oven. Line up the seal on the frame with the seal on the vacuum former. Wearing leather gloves press polycarbonate to mold. The polycarbonate will lose its flexibility within 2 minutes once removed from the oven.

Step 13.) Using a permanent marker draw an outline of the bottom edge of the clay/plaster mold of the stoma mask.

Step 14.) Remove the sheet from the frame. Using the rotary tool equipped with a diamond tipped cutting bit cut the sheet along the outline made in **Step 9.**

Step 15.) Ensure that once the polycarbonate stoma mask is cut from the sheet the mask will sit relatively flat on a level surface. Clean the cut of debris and roughen the perimeter of the cut with the rotary tool or sandpaper.

Step 16.) Drill $1/8^{th}$ inch through holes along the perimeter of the mask near the cut. There should be at least 4 holes.

Step 17.) Mix thoroughly two equal parts of silicone enough to fill plaster negative mold to a depth of 0.1". (CopyFlex^{TM}) Fill plaster negative mold with silicone and allow silicone to set for four hours.

Step 18.) Mix thoroughly two equal parts of silicone enough to fill remaining depth of plaster negative mold. Pour silicone into plaster negative. Center stoma mask with plaster negative and press the mask into the negative. Allow silicone to cure. (4 hours)

Step 19.) Remove mask and seal carefully from plaster negative mold.

Step 20.) Drill 1.25" center hole on mask. Drill four $9/64^{th}$ holes around perimeter of stoma mask to connect Kevlar straps to stoma mask.

Step 21.) Secure stoma mask and Kevlar straps utilizing the four $9/64^{th}$ holes and bolts and nuts.

Step 22.) Remove cap on unused accessory port of Scott face piece.

Step 23.) Place brass transfer fitting in accessory port and secure.

Step 24.) Collect rubber flange from removed unused accessory port. Cut rubber flange down to allow maximum clearance within stoma mask.

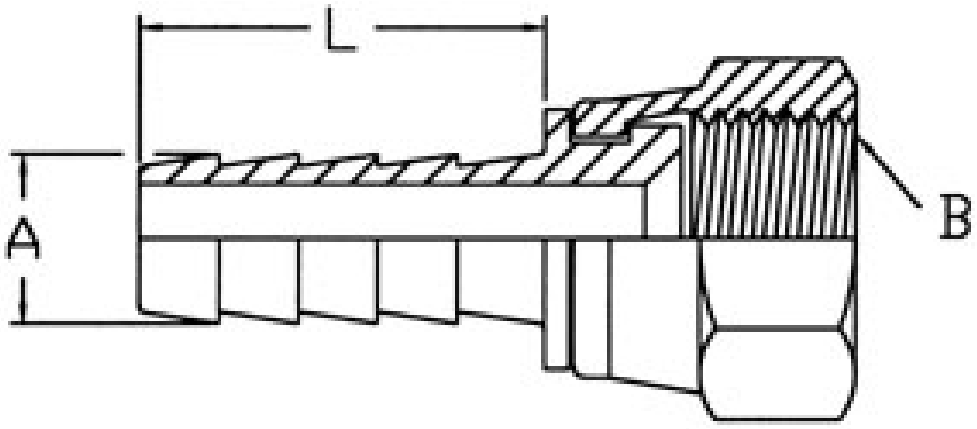
Step 25.) Pressure fit rubber flange onto 1.25" center hole on stoma mask.

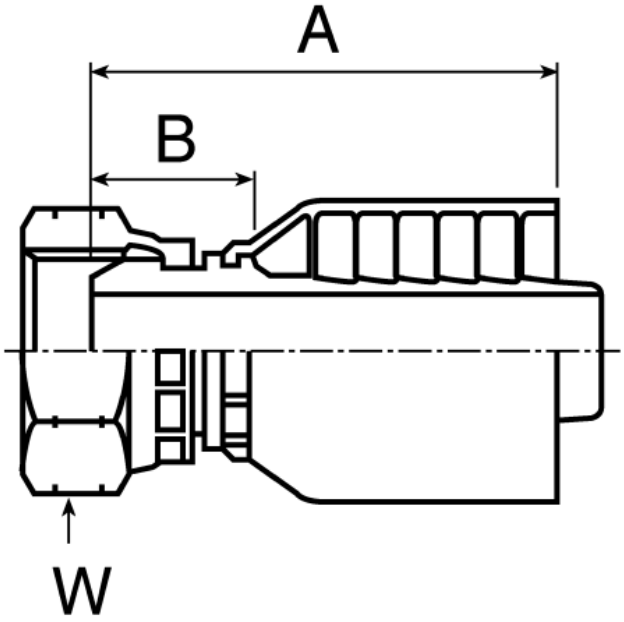
Step 26.) Pressure fit one end of silicone hose onto brass fitting on facepiece and tighten connection with stainless steel hose clamp.

Step 27.) Pressure fit other end of silicone hose onto rubber flange on stoma mask and tighten connection with a stainless steel hose clamp.

Appendix E: Vendor supplied component specifications and data sheets

Pictures below models anticipated brass fittings.





REDWOOD PLASTICS CORPORATION

Revised October 23, 2006

POLYCARBONATE

MSDS
MATERIAL SAFETY DATA SHEET

I. PRODUCT IDENTIFICATION

PRODUCT NAME: Polycarbonate

PHONE NUMBERS:

BAYER EMERGENCY:	(412) 923-1800
BAYER INFORMATION:	1-800-628-5084
CHEMTREC:	1-800-424-9300

II. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE:	Solid tint
ODOR:	Slight
PERCENT VOLATILES:	N/A
MELTING POINT:	428 – 446°F (220-230°C)
SOLUBILITY IN WATER:	Insoluble
SPECIFIC GRAVITY:	1.2

III. STABILITY AND REACTIVITY

STABILITY: Stable

MATERIALS TO AVOID: None known

IV. EXPOSURE CONTROLS/PERSONAL PROTECTION

VENTILATION: Provide natural or mechanical ventilation to control exposure levels below airborne exposure limits. Local mechanical exhaust ventilation should be used at sources of air contamination, such as open process equipment, or during purging operations, to capture gases and fumes that may be emitted. Standard reference sources regarding industrial ventilation should be consulted for guidance about adequate ventilation. In the event of thermal decomposition from overheating the product, evacuate the work area, shut down equipment and provide general ventilation to the room prior to reoccupying.

PROTECTIVE EQUIPMENT

SKIN: None required but fabric gloves are recommended when handling molten material

REDWOOD PLASTICS CORPORATION

IV. EXPOSURE CONTROLS/PERSONAL PROTECTION - continued

EYE: Safety glasses are recommended as a good industrial hygiene and safety practice.

RESPIRATOR: NIOSH/MSHA – approved dust respirator recommended if the airborne dust concentration is near or exceeds the nuisance dust exposure limits.

ADDITIONAL PROTECTIVE MEASURES:

The greatest potential for injury occurs when working with molten polymeric resins. During this type of operation it is essential that all workers in the immediate area wear eye and skin protection as protection from thermal burns. Purgings should be collected as small flat thin shapes or thin strands to allow for rapid cooling. Precautions should be taken against auto-ignition of hot, thick masses of the plastic. Quench with water. Grinder dust is an exposure hazard.

EXPOSURE GUIDELINES:

INGREDIENT	AGENCY	VALUE
Nuisance Dust	OSHA-PEL	15mg/m^3
Respirable Dust	OSHA-PEL	5mg/m^3

V. HEALTH HAZARDS IDENTIFICATION

ACUTE OR IMMEDIATE EFFECTS

SKIN: Contact with hot material will cause thermal burns

EYES: Mechanical irritation to the eyes may occur due to exposure to fines. Eyes may become red and scratchy and may tear.

INHALATION: Toxic gases/fumes given off during burning or thermal decomposition cause respiratory irritation

CHRONIC/CARCINOGENICITY: Not listed as a carcinogen

VI. FIRST AID MEASURES

SKIN: Wash affected areas with soap and water. See a physician if thermal burn occurs

EYES: Flush with plenty of lukewarm water. See a physician or ophthalmologist for follow-up if irritation is present and persists

INHALATION: Move to an area free from risk of further exposure. Give oxygen or artificial respiration as needed. Obtain medical attention

VII. FIRE FIGHTING MEASURES

AUTOIGNITION TEMPERATURE: Above 842°F (450°C) ASTM D-1929B

REDWOOD PLASTICS CORPORATION

VII. FIRE FIGHTING MEASURES - continued

HAZARDOUS PRODUCTS OF COMBUSTION:
Carbon monoxide, carbon dioxide, bisphenol A, diphenyl carbonate, phenol and phenol derivatives. Traces of aliphatic and aromatic hydrocarbons, aldehydes and acids.

EXTINGUISHING MEDIA: Water; carbon dioxide, dry chemical, foam

SPECIAL FIRE FIGHTING INSTRUCTIONS/PRECAUTIONS:
Full emergency equipment with self-contained breathing apparatus must be worn by firefighters

VIII. ACCIDENTAL RELEASE MEASURES

SPILL OR RELEASE:
If molten material is spilled, allow it to solidify. Remove material mechanically by a method which minimizes the generation of airborne dust and place in appropriately marked containers.

IX. HANDLING AND STORAGE

HANDLING:
When handling flaked material or during secondary operations, vent storage bins, conveyors, dust collectors, etc. ground handling equipment, keep open flames, sparks and heat away from dusty areas. Maintain highest standards of housekeeping to prevent accumulation of dust.

STORAGE:
Max 200°F (93°C) material should be stored in a clean, dry environment in sealed containers. Material must be dried before processing

X. DISPOSAL CONSIDERATIONS

DISPOSAL: Material may be incinerated or landfilled in compliance with Federal, State, Provincial and Local environmental control regulations.

XI. DISCLAIMER OF EXPRESSED AND IMPLIED WARRANTIES

The information presented in the Material Safety Data Sheet is based on data believed to be accurate as of the date this Material Safety Data Sheet was prepared. HOWEVER, NO WARRANTY OF MERCHANTABILITY, FITNESS FOR ANY PARTICULAR PURPOSE, OR ANY OTHER WARRANTY IS EXPRESSED OR IS TO BE IMPLIED REGARDING THE ACCURACY OR COMPLETENESS OF THE INFORMATION PROVIDED ABOVE, THE RESULTS TO BE OBTAINED FROM THE USE OF THIS INFORMATION OR THE PRODUCT, THE SAFETY OF THIS PRODUCT, OR THE HAZARDS RELATED TO ITS USE. No responsibility is assumed for any damage or injury resulting from abnormal use or from any failure to adhere to recommended practices. The information provided above, and the product, are furnished on the condition that the person receiving them shall make their own determination as to the suitability of the product for their particular purpose and on the condition that they assume the risk of their use. In addition, no authorization is given nor implied to practice any patented invention without a license.

MATERIAL SAFETY DATA SHEET

1. Chemical Product and Company Identification

PRODUCT: ASI 502

Supplier: American Sealants, Inc
3806 Option Pass
Fort Wayne, IN 46818

Phone: 260-489-0728
Fax: 260-489-0519
Emergency (InfoTrac): 800-535-5053

Revised: 02/01/2011
Reviewed:

Generic Description: Silicone elastomer
Physical Form: Paste
Color: All Colors
Odor: Acetic acid odor
NFPA Profile: Health 2 Flammability 1 Instability/Reactivity 0

Note: NFPA = National Fire Protection Association

2. Composition/Information of Ingredients

CAS Number	Wt %	Component Name
17689-77-9	1.0 - 5.0	Ethyltriacetoxysilane
4253-34-3	1.0 - 5.0	Methyltriacetoxysilane

The above components are hazardous as defined in 29 CFR 1910.1200

3. Hazards Identification

POTENTIAL HEALTH EFFECTS

Acute Effects

Eye: Direct contact may cause moderate irritation.

Skin: May cause moderate irritation.

Inhalation: Material is not likely to present an inhalation hazard at ambient conditions. However, if material is heated or high vapor concentration is attained, central nervous system depression may occur, which is characterized by drowsiness, dizziness, confusion or loss of coordination.

Oral: Low ingestion hazard in normal use.

Prolonged/Repeated Exposure Effects

Skin: No known applicable information.

Inhalation: No known applicable information.

Oral: Repeated ingestion or swallowing large amounts may injure internally.

Signs and Symptoms of Overexposure

No known applicable information.

Medical Conditions Aggravated by Exposure

No known applicable information.

The above listed potential effects of overexposure are based on actual data, results of studies performed upon similar compositions, component data and/or expert review of the product. Please refer to Section 11 for the detailed toxicology information.

4. FIRST AID MEASURES

Eye: Immediately flush with water for 15 minutes. Get medical attention.

Skin: Remove from skin and wash thoroughly with soap and water or waterless cleanser. Get medical attention if irritation or other ill effects develop or persist.

Inhalation: Material is not likely to present an inhalation hazard at ambient conditions. If material is heated or vapor is generated, care should be taken to prevent inhalation. In case of exposure to vapor, move to fresh air.

Oral: Get medical attention.

Notes to Physician: Treat according to person's condition and specifics of exposure.

5. FIRE FIGHTING MEASURES

Flash Point: > 212 ˚F / > 100 ˚C (Closed Cup)

Autoignition Temperature: Not determined.

Flammability Limits in Air: Not determined.

Extinguishing Media: On large fires use dry chemical, foam or water spray. On small fires use carbon dioxide (CO2), dry chemical or water spray. Water can be used to cool fire exposed containers.

Fire Fighting Measures Self-contained breathing apparatus and protective clothing should be worn in fighting large fires involving chemicals. Determine the need to evacuate or isolate the area according to your local emergency plan. Use water spray to keep fire exposed containers cool.

Unusual Fire Hazards: None.

6. ACCIDENTAL RELEASE MEASURES

Containment/Clean up: Observe all personal protection equipment recommendations described in Sections 5 and 8. Wipe up or scrape up and contain for salvage or disposal. Clean area as appropriate since spilled materials, even in small quantities, may present a slip hazard. Final cleaning may require use of steam, solvents or detergents. Dispose of saturated absorbant or cleaning materials appropriately, since spontaneous heating may occur. Local, state and federal laws and regulations may apply to releases and disposal of this material, as well as those

materials and items employed in the cleanup of releases. You will need to determine which federal, state and local laws and regulations are applicable.

Sections 13 and 15 of this MSDS provide nformation regarding certain federal and state requirements.

Note: See section 8 for Personal Protective Equipment for Spills.

7. HANDLING AND STORAGE

Use with adequate ventilation. Product evolves acetic acid (HOAc) when exposed to water or humid air. Provide ventilation during use to control HOAc within exposure guidelines or use respiratory protection. Avoid eye contact. Avoid skin contact. Do not take internally. Avoid breathing vapor. Keep container closed.

Use reasonable care and store away from oxidizing materials. Keep container closed and store away from water or moisture..

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Component Exposure Limits

CAS Number	Component Name	Exposure Limits
17689-77-9	Ethyltriacetoxysilane	See acetic acid comments.
4253-34-3	Methyltriacetoxysilane	See acetic acid comments.

Acetic acid is formed upon contact with water or humid air. Provide adequate ventilation to control exposures within guidelines of OSHA PEL: TWA 10 ppm and ACGIH TLV: TWA 10 ppm, STEL 15 ppm.

Engineering Controls

Local Ventilation: Recommended.
General Ventilation: Recommended.

Personal Protective Equipment for Routine Handling

Eyes: Use proper protection - safety glasses as a minimum.

Skin: Wash at mealtime and end of shift. Contaminated clothing and shoes should be removed as soon as practical and thoroughly cleaned before reuse. Chemical protective gloves are recommended.

Suitable Gloves: Butyl Rubber. Nitrile Rubber.

Inhalation: Use respiratory protection unless adequate local exhaust ventilation is provided or exposure assessment demonstrates that exposures are within recommended exposure guidelines. IH personnel can assist in judging the adequacy of existing engineering controls.

Suitable Respirator: Respiratory protection is not needed under ambient conditions. If vapor is generated when material is heated or handled, the following is advised.

General and local exhaust ventilation is recommended to maintain vapor exposures below recommended limits. Where concentrations are above recommended limits or are unknown, appropriate respiratory protection should be worn. Follow OSHA respirator regulations (29 CFR 1910.134) and use NIOSH/MSHA approved respirators.

Personal Protective Equipment for Spills

Eyes: Use full face respirator.

Skin: Wash at mealtime and end of shift. Contaminated clothing and shoes should be removed as soon as practical and thoroughly cleaned before reuse. Chemical protective gloves are recommended.

Inhalation/Suitable Respirator: Respiratory protection recommended. Follow OSHA Respirator Regulations (29 CFR 1910.134) and use NIOSH/MHSA approved respirators. Protection provided by air purifying respirators against exposure to any hazardous chemical is limited. Use a positive pressure air supplied respirator if there is any potential for uncontrolled release, exposure levels are unknown, or any other circumstance where air purifying respirators may not provide adequate protection.

Precautionary Measures: Avoid eye contact. Avoid skin contact. Do not take internally. Avoid breathing vapor. Keep container closed. Use reasonable care.

Comments: Product evolves acetic acid (HOAc) when exposed to water or humid air. Provide ventilation during use to control HOAc within exposure guidelines or use respiratory protection.

When heated to temperatures above 150 C (300 F) in the presence of air, product may form formaldehyde vapors.

Note: These precautions are for room temperature handling. Use at elevated temperature or aerosol/spray applications may require added precautions.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical Form:	Paste
Color:	See product name
Odor:	Acetic acid odor
Specific Gravity @ 25˚C:	1.007
Viscosity:	Not determined.
Freezing/Melting Point:	Not determined.
Boiling Point:	Not determined.
Vapor Pressure @ 25˚C:	Not determined.
Vapor Density:	Not determined.
Solubility in Water:	Not determined.
pH:	Not determined.
Volatile Content:	Not determined.
Flash Point:	> 212 ˚F / > 100 ˚C (Closed Cup)
Autoignition Temperature:	Not determined.
Flammability Limits in Air:	Not determined.

Note: The above information is not intended for use in preparing product specifications.

10. STABILITY AND REACTIVITY

Chemical Stability:	Stable.
Hazardous Polymerization:	Hazardous polymerization will not occur.
Conditions to Avoid:	None.
Materials to Avoid:	Oxidizing material can cause a reaction. Water, moisture, or humid air can cause hazardous vapors to form as described in Section 8.

Hazardous Decomposition Products

Thermal breakdown of this product during fire or very high heat conditions may evolve the following decomposition products: Carbon oxides and traces of incompletely burned carbon compounds. Silicon dioxide. Formaldehyde. Metal oxides. Nitrogen oxides. Sulfur oxides. Chlorine compounds.

11. TOXILOGICAL INFORMATION

Component Toxicology Information

Inhalation of fumes may result in metal fume fever, a flu-like illness with symptoms of metallic taste, fever and chills, aches, chest tightness, and cough.

Special Hazard Information on Components

No known applicable information.

12. ECOLOGICA11L INFORMATION

Environmental Fate and Distribution

Complete information is not yet available.

Environmental Effects

Complete information is not yet available.

Fate and Effects in Waste Water Treatment Plants

Complete information is not yet available.

	Ecotoxicity Classification Criteria		
Hazard Parameters (LC50 or EC50)	High	Medium	Low
Acute Aquatic Toxicity (mg/L)	<=1	>1 and <=100	>100
Acute Terrestrial Toxicity	<=100	>100 and <= 2000	>2000

This table is adapted from "Environmental Toxicology and Risk Assessment", ASTM STP 1179, p.34, 1993.

This table can be used to classify the ecotoxicity of this product when ecotoxicity data is listed above. Please read the other information presented in the section concerning the overall ecological safety of this material.

13. DISPOSAL CONSIDERATIONS

RCRA Hazard Class (40 CFR 261)

When a decision is made to discard this material, as received, is it classified as a hazardous waste? No State or local laws may impose additional regulatory requirements regarding disposal.

14. TRANSPORT INFORMATION

DOT Road Shipment Information (49 CFR 172.101)

Not subject to DOT.

Ocean Shipment (IMDG)

Not subject to IMDG code.

Air Shipment (IATA)

Not subject to IATA regulations.

15. REGULATORY INFORMATION

Contents of this MSDS comply with the OSHA Hazard Communication Standard 29 CFR 1910.1200.

TSCA Status: All chemical substances in this material are included on or exempted from listing on the TSCA Inventory of Chemical Substances.

EPA SARA Title III Chemical Listings

Section 302 Extremely Hazardous Substances (40 CFR 355):
None.

Section 304 CERCLA Hazardous Substances (40 CFR 302):
None.

Section 311/312 Hazard Class (40 CFR 370):

Acute: Yes
Chronic: No
Fire: No
Pressure: No
Reactive: No

Section 313 Toxic Chemicals (40 CFR 372):

None present or none present in regulated quantities.

Note: Chemicals are listed under the 313 Toxic Chemicals section only if they meet or exceed a reporting threshold.

Supplemental State Compliance Information

California

Warning: This product contains the following chemical(s) listed by the State of California under the Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) as being known to cause cancer, birth defects or other reproductive harm.

None known.

Massachusetts

CAS Number	Wt %	Component Name
7631-86-9	7.0 - 13.0	Silica, amorphous

1333-86-4	<=2.0	Carbon black
13463-67-7	<=1.8	Titanium dioxide
1309-37-1	<=1.0	Iron oxide

New Jersey

CAS Number	Wt %	Component Name
70131-67-8	> 60.0	Dimethyl siloxane, hydroxy-terminated
7631-86-9 7	.0 - 13.0	Silica, amorphous
64742-46-7	<=6.9	Hydrotreated middle petroleum distillates
17689-77-9	1.0 - 5.0	Ethyltriacetoxysilane
63148-62-9	1.0 - 5.0	Polydimethylsiloxane
1333-86-4	<=2.0	Carbon black
1332-37-2	<=2.0	Iron oxide
147-14-8	<=2.0	Tetrabenzo-5,10,15,20-diazaporphyrinephthalocyanine (Pigment blue 15)
4253-34-3	1.0 - 5.0	Methyltriacetoxysilane
13463-67-7	<=1.8	Titanium dioxide
1309-37-1		<=1.0 Iron oxide

Pennsylvania

CAS Number	Wt %	Component Name
70131-67-8	> 60.0	Dimethyl siloxane, hydroxy-terminated
7631-86-9 7	.0 - 13.0	Silica, amorphous
64742-46-7	<=6.9	Hydrotreated middle petroleum distillates
1333-86-4	<=2.0	Carbon black
13463-67-7	<=1.8	Titanium dioxide
1309-37-1	<=1.0	Iron oxide

16. OTHER INFORMATION

These data are offered in good faith as typical values and not as product specifications. No warranty, either expressed or implied, is hereby made. The recommended industrial hygiene and safe handling procedures are believed to be generally applicable. However, each user should review these recommendations in the specific context of the intended use and determine whether they are appropriate.

Material Safety Data Sheet

Silicone Coated Fiberglass – Cloth, Tape, Rope & Tubing
McAllister Mills, Inc.
Revised: April 26, 2014

Section 1 – Chemical Product and Company Identification

Product Name: Style 3170 and 3220
Chemical Name: *Fibrous Glass*
CAS Number: *65997-17-3*
Product Use: *Thermal Insulation*
Manufacturer Information: McAllister Mills, Inc.
McAllister Mills, Inc.
173 Rainbow Circle
Independence, VA 24348
(276) 773-3114
Emergency Contacts: Gary Burris
Prepared By
Torri Nichols
(276) 773-3114
Preparation Date: *April 26, 2014*
Supercedes: July 6, 2011

Section 2 – Composition/Ingredient Information

CAS #	Component/Ingredient	Percent by Weight
65997-17-3	Fibrous Glass	30
	Silicone Coating	70

See Section 8 of this MSDS for exposure limit data for these ingredients

Section 3 – Hazards Identification

Appearance and Odor: Silver-Gray colored cloth */ no odor*

Potential Health Effects:
Acute Inhalation: *Mechanical irritation of the mouth, nose and throat*

Skin Contact: *Exposure to this product may cause temporary irritation to the skin. Itching and possible inflammation are a mechanical reaction to the fibers and are not damaging in the way that chemical irritants may be.*
Eye Contact: *Dust from this product may cause temporary mechanical irritation to the eyes.*

Ingestion: *Ingestion of this product is unlikely. However ingestion may produce gastro-intestinal irritation and disturbances.*

Medical Conditions Aggravated by Exposure: *Chronic respiratory or skin conditions will not improve and may worsen with exposure to this product.*

Ingredient: *Fibrous Glass*
IARC: *Group 3, not classifiable as carcinogenic to humans*
OSHA: *Not listed*

Section 4 – First Aid Measures

Inhalation: *Remove from further exposure. If Cough or other symptoms develop, seek medical attention.*
Skin Contact: *If skin becomes irritated, do not rub or scratch. Wash the affected area with soap and water.*
Eye Contact: *If eyes become irritated, flush immediately with lukewarm water for 15 minutes.*
Ingestion: *Drink plenty of water to reduce irritation. If irritation persists, seek medical attention.*

Section 5 – Fire Fighting Measures

Is this product flammable?	No	**Lower Flammability Limit**	Not Available
Flash Point	>250°C by TOC	**Flammability Classification**	Not Determined
Upper Flammable Limit	Not Applicable	**Explosion Data – Sensitivity to mechanical impact**	Not Available
Auto Ignition Temperature	700°F	**Explosion Data – Sensitivity to static discharge**	Not Available
Flash Point Method	Not Applicable	**Hazardous Combustion Products Data**	Not Available

General Fire Hazards: *There is no potential for fire or explosion.*
Extinguishing Media: *Dry chemical, foam, carbon dioxide, and water fog.*

Fire Fighting Instructions: *No special procedures necessary. Use normal fire fighting procedures.*

Section 6 – Accidental Release Measures

Containment Procedures: *Pick up any large pieces. Use high efficiency vacuum to clean up spilled material. Use wet sweeping where sweeping is necessary. Do not use compressed air for clean up.*
Clean-Up Procedures: *Collect material and place in a suitable container for disposal as non-hazardous waste.*

Section 7 – Handling and Storage

General Storage: *Use good and safe workplace practices when handling this material.*
Handling: *Handling and use in a manner consistent with good industrial & manufacturing techniques and practices.*
Storage: *Store in un-opened containers under cool and dry conditions.*
Storage Temperature: *Not Determined*
Loading Temperature: *Not Applicable*

Section 8 – Exposure Controls / Personal Protection

Engineering Controls: *If dust is generated, provide local exhaust ventilation to control airborne levels below ACGIH TLV-TWA exposure limit for Particulates Not Otherwise Classified of 10mg/m^3 for inhalable particles and 3mg/m^3 for respirable.*

Personal Protective Equipment:
Eyes and Face: *Wear safety glasses with side shields or goggles when handling this material.*
Skin: *Use appropriate workplace clothing and procedures when using this material*
Respiratory: *If airborne dust is present, use a NIOSH approved particulate respirator. (3M 8710)*
Comments *This product contains no known OSHA hazardous ingredients per 29 CFR 1910.1200*

Hazardous Ingredients	**OSHA PEL**	**ACGIH TLV**	**Other**
Fibrous Glass (respirable nuisance dust) (NIOSH)	5mg/M³	10 mg/M³	3x10(6)/M³

Particular care should be taken when working with material that has been in service to minimize dust. If exposure limits are exceeded or if irritation is experienced, approved respiratory protection should be worn.

Section 9 – Physical and Chemical Properties

Appearance	Silver-Gray Colored	**Odor**	Odorless
Physical State	Fibrous	**pH in water**	Not Applicable
Vapor Density	Not Applicable	**Melting Point**	1000 ° F +
Vapor Pressure	Not Applicable	**Freezing Point**	Not Applicable
Specific Gravity	2.40	**Solubility**	Insoluble
Odor Threshold	Not Applicable	**Boiling Point**	Not Applicable
Evaporation Rate	Not Applicable	**Coefficient of Water/Oil Distribution**	Not Applicable

Section 10 – Chemical Stability & Reactivity Information

Stability: *This is a stable material*
Reactivity: *Not reactive.*
Hazardous Decomposition: *In a fire, product produces small amounts of incompletely burned Hydrocarbon gases.*
Incompatible Material: *Fabric strength is destroyed in strong bases and Hydrofluoric acid*
Hazardous Polymerization: *Will not occur*

Section 11 – Toxicological Information

Acute Toxicity:
A) General Product Information: *Dusts may cause mechanical irritation to skin and eyes. Inhalation may cause coughing, nose and throat irritation or sneezing.*
B) Component Analysis:

Component Carcinogenicity: *None known*

Irritancy of the Product:
Acute Inhalation: *Dust from this product may cause mechanical irritation of the nose, throat and respiratory tract.*
Skin Contact: *Dust from this product may cause temporary irritation to the skin.*
Eye Contact: *Dust from this product may cause temporary mechanical irritation to the eyes.*

Section 12 – Ecological Information

No ecological concerns can be identified with this product

Section 13 – Disposal Considerations

US EPA Waste Number and Descriptions:
A) General Product Information: *This product is not expected to be a characteristic waste under RCRA.*
B) Component Waste Numbers: *No EPA Numbers are applicable for this product's components.*
Disposal Instructions: *This product can be disposed of in a normal manner. Local regulations may apply.*

Section 14 – Transportation Information

US DOT Regulations:
Primary Hazard Class / Division: *This product has no classification.*
Other Shipping Information: *Product should remain in a proper container during transportation.*

Section 15 – Regulatory Information

US Federal Regulations:
A) General Product Information: *No additional information available*
B) Component Analysis: *None of the components of this product are listed under SARA Section 302 (40 CFR 355 Appendix A), SARA Section 313 (40 CFR 372.65) and/or CERCLA (40 CFR 302.4).*
State Regulations:

A) General Product Information: *No Additional Information available.*
B) Component Analysis – State: *The Following Components appear on one or more of the state hazardous substance list:*

Component	CAS#	CA	FL	MA	MN	NJ	PA
Fibrous Glass	65997-17-3	No	No	No	No	No	No

Other Regulations:
A) General Product Information: *No additional Information available.*
***B)* TSCA Status:** *This Product and its components are listed on the TSCA 8(b) inventory. None of the components listed on the TSCA Export Notification 12(b) list.*
C) Component Analysis - Inventory

Component	CAS#	TSCA	DSL	ELNCS
Fibrous Glass	65997-17-3	No	No	No

D) Canada Workplace Hazardous Materials Information System (WHMIS)
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all of the information required by the Controlled Products Regulations.

Section 16 – Other Information

MATERIAL SAFETY DATA SHEET Product: MAHTTR50-2

Manufacturers Name: ***SAINT-GOBAIN PPL***

Address:
3910 Terry Diane Drive
Beaverton, MI 48612-0481

Product Information Call: (989)435-9533

Date Prepared: 09/26/11

SECTION 1 - IDENTITY

1.1 Common Name (used on label):	Tygon 3350
1.2 CAS No.....:	Mixture
1.3 Chemical Name.....:	N/A
1.4 Chemical Family.....:	Functional Polydimethylsiloxanes with filler and auxiliaries.
1.5 Formula.....:	The specific chemical identity of the ingredients is considered a trade secret.

SECTION 2 - HAZARDOUS INGREDIENTS

Principal Hazardous Component(s) (Chemical & Common Names)	Threshold Limit Value
A. None Found	
B. Non-Hazardous:	
1. Functional Polydimethylsiloxanes	N/E

SECTION 3 - PHYSICAL & CHEMICAL CHARACTERISTICS

3.1 Boiling Point.....:	N/A
3.2 Specific Gravity (H2O=1).....:	Approximately 1.13
3.3 Vapor Pressure.....:	N/D
3.4 Percent Volatile by Volume.....:	N/A
3.5 Vapor Density (Air=1).....:	N/A
3.6 Evaporation Rate.....:	N/A
3.7 Solubility in Water.....:	Negligible
3.8 Reactivity in Water.....:	None
3.9 Appearance and Odor.....:	TRANS, Solid Elastomer, no odor.
3.10 Flash Point.....:	> 200 Celsius/392 Fahrenheit

3.11 Flammable Limits in Air by Volume.....:	Lower: **N/A** Upper: **N/A**
3.12 Auto-Ignition Temperature..:	> 400 Celsius/752 Fahrenheit
3.13 Extinguisher Media.....:	Sand, Carbon Dioxide, Dry Chemical or Foam type extinguishing media.
3.14 Special Fire Fighting Procedures:	Fire fighters should wear full protective clothing including a self-contained breathing apparatus.
3.15 Unusual Fire & Explosion Hazards.....:	None Known

SECTION 4 - PHYSICAL HAZARDS

4.1 Stability.....:	Stable: **X** Unstable:
Conditions to Avoid.....:	None Known. Stable at ambient temperatures and atmospheric pressure.
4.2 Incompatibility.....:	(Materials to Avoid) None Known
4.3 Hazardous Decomposition Products.....:	SiO_2, CO_2, CO and traces of incompletely burned hydrocarbons at combustion. At temperatures of approx. 150 C/302 F a small amount of Formaldehyde can be released by oxidative degradation.
4.4 Hazardous Polymerization....:	Will Not Occur.
Conditions to Avoid.....:	None Known

SECTION 5 - HEALTH HAZARDS

5.1 Threshold Limit Value.....:	**N/E**
5.2 Sign & Symptoms of Exposure:	
1. Acute Overexposure.....:	Toxicological testing has not been conducted with this material.
Route of Entry:	Eye Contact: No toxic effects are expected. Skin Contact: No toxic effects are expected. Inhalation: Not expected in industrial use. Ingestion: Not expected in industrial use.
2. Chronic Overexposure..:	None Known

5.3 Medical Conditions Generally Aggravated by Exposure...:	There is no data available which address medical conditions which are generally recognized as being aggravated by exposure to this product.
5.4 Chemical Listed as Carcinogen or Potential Carcinogen.....:	National Toxicology Program: **No** I.A.R.C. Monographs: **No** OSHA: **No**
5.5 OSHA Permissible Exposure Limit.....:	**N/E**
5.6 ACGIH Threshold Limit Value:	**N/E**
5.7 Other Exposure Limit Used...:	Unknown
5.8 Emergency & First-Aid Procedures.....:	Inhalation: **N/A** Eyes: If contact with eyes, immediately flush eyes with plenty of water. Seek medical attention if irritation occurs. Skin: If contact with skin, wash skin with water and soap. Seek medical attention if irritation occurs. Ingestion: If swallowed, allow affected person to vomit naturally, seek medical attention.

SECTION 6 - SPECIAL PROTECTION INFORMATION

6.1 Respiratory Protection.....:	**N/R**
6.2 Ventilation.....:	Local Exhaust: **N/R** Mechanical-General: **N/R** Mechanical-Special: **N/R** Mechanical-Other: **N/R**
6.3 Protective Gloves.....:	Recommended
6.4 Eye Protection.....:	**N/R**
6.5 Other Protective Clothing or Equipment.....:	Not Necessary

SECTION 7 - SPECIAL PRECAUTIONS AND SPILL/LEAK PROCEDURES

7.1 Precautions to be taken in Handling & Storage.....:	Store cool and dry.
7.2 Other Precautions.....:	**N/A**
7.3 Steps to be Taken in Case Material is Released or Spilled.....:	Take up by mechanical means and place in an appropriate chemical waste container. Observe all Local, State and Federal Laws and Regulations regarding disposal, spill, clean up, removal or discharge.
7.4 Waste Disposal Methods.....:	According to Local, State and Federal Regulations.

SECTION 8 - OTHER INFORMATION

8.1 Transportation Information...:	DOT Shipping Name:	**N/A**
	DOT Hazard Class:	**N/A**
	DOT Label(s):	**N/A**
	UN/NA Number:	**N/A**
	Placards:	None
	IATA:	**N/A**
	IMO IMDG-Code:	**N/A**
	European Class:	
	RID (OCTI):	**N/A**
	ADR (ECE):	**N/A**
	RAR (IATA):	**N/A**

8.2 These data are offered in good faith as typical values and not as a product specification. No warranty, either expressed or implied, is made. The recommended handling procedures are believed to be generally applicable. However, each user should review these recommendations in the specific content of the intended use.

MATERIAL SAFETY DATA SHEET

HMIS CODES:	H	F	R	P
	0	0	0	A

May be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Standard must be consulted for specific requirements.

U.S. Department of Labor
Occupational Safety and Health Administrator
(Non-Mandatory Form)
Form Approved OMB No. 1218-0072

IDENTITY (AS USED ON LABEL AND LIST):	NOTE: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.
YELLOW GAS LINE PTFE TAPE GT-TAPE	

Section I

Manufacturer's Name: J.C. WHITLAM MANUFACTURING COMPANY	Emergency Telephone Number: (330) 334 - 2524
Address (Number, Street, City, State, and ZIP Code): 200 WEST WALNUT STREET	Telephone Number for Information: (330) 334 - 2524
P.O. BOX 380	Date Prepared: January 24, 2014
WADSWORTH, OHIO 44282-0380	Signature of Preparer (optional):

Section II - Hazardous Ingredients/Identity Information

HAZARDOUS COMPONENTS (SPECIFIC CHEMICAL IDENTITY: COMMON NAME(S)	OSHA PEL	ACGIH TLV	OTHER LIMITS Recommended	% (optional)
NONE	N/A	N/A	N/A	

Section III - Physical/Chemical Characteristics

Boiling Point:	N/A	Specific Gravity (H20 =1):	.8 (BULK DENSITY)
Vapor Pressure (mm Hg):	N/A	Melting Point:	N/A
Vapor Density (AIR = 1):	N/A	Evaporation Rate (Butyl Acetate = 1):	N/A

Solubility in Water: N/A

Appearance and Odor: YELLOW TAPE

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used): N/A	Flammable Limits:	LEL: N/A	UEL: N/A

Extinguishing Media: N/A

Special Fire Fighting Procedures: N/A

Unusual Fire and Explosion Hazards: N/A

Section V - Reactivity Data		**YELLOW GAS LINE PTFE TAPE**	**GT-TAPE**
Stability:	Unstable:		Conditions to Avoid: N/A
	Stable:	X	
Incompatibility (Materials to Avoid):			
Hazardous Decomposition or Byproducts:			
Hazardous Polymerization:	May Occur:		Conditions to Avoid: N/A
	Will Not Occur:	X	

Section VI - Health Hazard Data			
Route(s) of Entry:	Inhalation? NO	Skin? NO	Ingestion? NO
Health Hazards (Acute and Chronic): N/A			
Carcinogenicity:	NTP? NO	IARC Monographs? NO	OSHA Regulated? NO
Signs and Symptoms of Exposure: N/A			
Medical Conditions Generally Aggravated by Exposure: N/A			
Emergency and First Aid Procedures: N/A			

Section VII - Precautions for Safe Handling and Use		
Steps to Be Taken in Case Material is Released or Spilled: DISPOSE OF IN A PROPER WASTE CONTAINER.		
Waste Disposal Method: FOLLOW LOCAL, STATE, AND FEDERAL RESTRICTIONS.		
Precautions to Be Taken in Handling and Storing: N/A		
Other Precautions: DO NOT USE IN TEMPERATURES EXCEEDING 260°C.		

Section VIII - Control Measures		
Respiratory Protection (Specify Type): N/A		
Ventilation:	Local Exhaust: N/A	Special: N/A
	Mechanical (General): N/A	Other: N/A
Protective Gloves: N/A	Eye Protection: N/A	
Other Protective Clothing or Equipment: N/A		
Work/Hygienic Practices: N/A		

COPY FLEX PART A

MATERIAL SAFETY DATA SHEET

SECTION I

MANUFACTURERED FOR: CULINART, INC. DBA MakeYourOwnMolds.com
ADDRESS: 7609 Production Dr – CINCINNATI, OH 45237
EMERGENCY TELEPHONE #: (513) 244-2999
CHEMICAL NAME AND SYNONYMS: ORGANOPOLYSILOXANE MIXTURE
TRADE NAME AND SYNONYMS: COPY FLEX A
CEMICAL FAMILY: 2 PART RTV SILICONE
FORMULATION: PROPRIETARY MIXTURE, NON HAZARDOUS
EMERGENCY # 1-800-262-8200 (CHEM TREC)

SECTION II HAZARDOUS INGREDIENTS

CHEMICAL	CAS#	AMOUNT
VINYL DIMETHYL TERMINATED POLYDIMETHYLSILOXANE	68083-19-2	75%
SILICON DIOXIDE	7631-86-9	25%
PLATINUM DICARBONYL DICHLORIDE	73018-55	0.01%

SECTION III PHYSICAL DATA

BOILING POINT (F): >260C
SPECIFIC GRAVITY: (WATER = 1): 1.15
VAPOR PRESSURE (mm Hg): >1 mm Hg - ESSENTIALLY NON-VOLATILE /CROSSLINKER: NEGLIGIBLE
VAPOR DENSITY (AIR=1): N/A
EVAPORATION RATE (nBuAc=1): NIL
SOLUBILITY IN WATER: NIL
APPEARANCE AND ODOR: VISCOUS, ODORLESS PASTE, TAN

SECTION IV FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED): BASE: 190C; CROSSLINKER: 150C
FLAMMABLE LIMITS: NOT MEASURED
EXTINGUISHING MEDIA: WATER FOG, DRY CHEMICAL, FOAM, OR CO2
SPECIAL FIRE FIGHTING PROCEDURES: FIRE FIGHTERS SHOULD WEAR SELF- CONTAINED BREATHING APPARATUS AND FULL PROTECTIVE CLOTHING. USE WATER SPRAY TO COOL NEARBY CONTAINERS.
UNUSUAL FIRE AND EXPLOSION HAZARDS: NONE

SECTION V HEALTH HAZARD DATA

PERSONAL PROTECTION RECOMMENDED: WEAR PROTECTIVE GOGGLES TO PREVENT EYE CONTACT. UNDER RECOMMENDED CONDITIONS OF USE, NO OTHER PROTECTION SHOULD BE REQUIRED.

SIGNS AND SYMPTOMS OF EXPOSURE: THE PRIMARY ROUTE OF EXPOSURE IS EYE CONTACT. DIRECT EYE CONTACT CAN CAUSE A TRANSITORY IRRITATION, BUT IT IS NOT INJURIOUS. THIS IRRITATION MAY PERSIST FOR UP TO 24 HOURS.
EXPERIENCE WITH THIS MATERIAL HAS NOT INDICATED ANY SERIOUS EFFECTS RELATED TO EXPOSURE BY ANY ROUTE.
FIRST AID FOR EXPOSURE:
EYE CONTACT: FLUSH WITH WATER. GET MEDICAL ATTENTION IF IRRITATION PERSISTS.
SKIN CONTACT: WASH THOROUGHLY WITH SOAP AND WATER
INGESTION: GET MEDICAL ATTENTION
INHALATION: REMOVE TO FRESH AIR. GIVE OXYGEN OR ARTIFICIAL RESPIRATION IF NOT BREATHING. GET IMMEDIATE MEDICAL ATTENTION.
OCCUPATIONAL EXPOSURE LIMITS: BECAUSE OF THE LOW HEALTH HAZARD, NO EXPOSURE LIMITS HAVE BEEN ESTABLISHED.
TOXICITY: BECAUSE OF THE LOW TOXICITY, SPECIFIC TOXICITY DATA IS UNAVAILABLE.
MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE: PRE-EXISTING EYE DISORDERS.

SECTION VI REACTIVITY DATA

STABILITY: STABLE
INCOMPATABILITY (MATERIALS TO AVOID): NONE
HAZARDOUS DECOMPOSITION PRODUCTS: BURNING MAY LIBERATE CARBON MONOXIDE, CARBON DIOXIDE, AND SILICON DIOXIDE.
HAZARDOUS POLYMERIZATION: WILL NOT OCCUR

SECTION VII SPILL OR LEAK PROCEDURES

USE PERSONAL PROTECTION TO PREVENT PERSONAL EXPOSURE.
AS REQUIRED DIKE WITH SOIL OR OTHER ABSORBENT MATERIALS TO PREVENT SPREAD OF SPILL. WIPE UP AND PLACE IN APPROPRIATE CONTAINERS AND/OR PLACE ABSORBENT MATERIAL ON SPILL AND TRANSFER ABSORBED SOLVENT TO APPROPRIATE CONTAINERS.
CONSULT AND COMPLY WITH FEDERAL, STATE, AND LOCAL REGULATIONS CONCERNING ANY RELEASE OF HAZARDOUS MATERIALS INTO THE WATER, WATER PIPING SYSTEMS, GROUND, OR AIR. CONSULT AND COMPLY WITH FEDERAL, STATE, AND LOCAL REGULATIONS CONCERNING REMOVAL OF WASTE.

SECTION VIII SHIPPING INFORMATION

NFPA - HEALTH – 0 , FIRE- 1 , REACTIVITY 0
SARA 313- NOT LISTED

The recommendations given here serve only as a guide. Each user should thoroughly test the material to determine the suitability of the product for an intended use and independently conclude satisfactory performance before commercializing. User assumes all risk and liability whatsoever in connection with the use of this product. Our liability is limited to the replacement price of the product.

COPY FLEX PART B

MATERIAL SAFETY DATA SHEET

SECTION I

MANUFACTURERED FOR: CULINART, INC. DBA MakeYourOwnMolds.com
ADDRESS: 7609 Production Dr – CINCINNATI, OH 45237
EMERGENCY TELEPHONE #: (513) 244-2999
CHEMICAL NAME AND SYNONYMS: ORGANOPOLYSILOXANE MIXTURE
TRADE NAME AND SYNONYMS: COPY FLEX B
CEMICAL FAMILY: 2 PART RTV SILICONE
FORMULATION: PROPRIETARY MIXTURE, NON HAZARDOUS
EMERGENCY # 1-800-262-8200 (CHEM TREC)

SECTION II HAZARDOUS INGREDIENTS

CHEMICAL	CAS #	AMOUNT
VINYL DIMETHYL TERMINATED POLYDIMETHYLSILOXANE	68083-19-2	58.5 %
DIMETHLY SILOXANE FLUID	63148-62-9	13%
DIATOMACEOUS EARTH	86855-54-9	5%
SILICON DIOXIDE	7631-86-9	17.5 %
POLYMETHYHYDROGEN SILOXANE	63148-57-2	5%
CUSTOM ORANGE SILICONE PIGMENT	PROPRIETARY	1%

SECTION III PHYSICAL DATA

BOILING POINT (F): >260C
SPECIFIC GRAVITY: (WATER = 1): 1.15
VAPOR PRESSURE (mm Hg): >1 mm Hg - ESSENTIALLY NON-VOLATILE /CROSSLINKER: NEGLIGIBLE
VAPOR DENSITY (AIR=1): N/A
EVAPORATION RATE (nBuAc=1): NIL
SOLUBILITY IN WATER: NIL
APPEARANCE AND ODOR: VISCOUS, ODORLESS PASTE, TAN

SECTION IV FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED): BASE: 190C; CROSSLINKER: 150C
FLAMMABLE LIMITS: NOT MEASURED
EXTINGUISHING MEDIA: WATER FOG, DRY CHEMICAL, FOAM, OR CO2
SPECIAL FIRE FIGHTING PROCEDURES: FIRE FIGHTERS SHOULD WEAR SELF- CONTAINED BREATHING APPARATUS AND FULL PROTECTIVE CLOTHING. USE WATER SPRAY TO COOL NEARBY CONTAINERS.
UNUSUAL FIRE AND EXPLOSION HAZARDS: NONE

SECTION V HEALTH HAZARD DATA

PERSONAL PROTECTION RECOMMENDED: WEAR PROTECTIVE GOGGLES TO PREVENT EYE CONTACT. UNDER RECOMMENDED CONDITIONS OF USE,
NO OTHER PROTECTION SHOULD BE REQUIRED.
SIGNS AND SYMPTOMS OF EXPOSURE: THE PRIMARY ROUTE OF EXPOSURE IS EYE CONTACT. DIRECT EYE CONTACT CAN CAUSE A TRANSITORY IRRITATION, BUT IT IS NOT INJURIOUS. THIS IRRITATION MAY PERSIST FOR UP TO 24 HOURS.
EXPERIENCE WITH THIS MATERIAL HAS NOT INDICATED ANY SERIOUS EFFECTS RELATED TO EXPOSURE BY ANY ROUTE.
FIRST AID FOR EXPOSURE:
EYE CONTACT: FLUSH WITH WATER. GET MEDICAL ATTENTION IF IRRITATION PERSISTS.
SKIN CONTACT: WASH THOROUGHLY WITH SOAP AND WATER
INGESTION: GET MEDICAL ATTENTION
INHALATION: REMOVE TO FRESH AIR. GIVE OXYGEN OR ARTIFICIAL RESPIRATION IF NOT BREATHING. GET IMMEDIATE MEDICAL ATTENTION.
OCCUPATIONAL EXPOSURE LIMITS: BECAUSE OF THE LOW HEALTH HAZARD, NO EXPOSURE LIMITS HAVE BEEN ESTABLISHED.
TOXICITY: BECAUSE OF THE LOW TOXICITY, SPECIFIC TOXICITY DATA IS UNAVAILABLE.
MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE: PRE-EXISTING EYE DISORDERS.

SECTION VI REACTIVITY DATA

STABILITY: STABLE
INCOMPATABILITY (MATERIALS TO AVOID): NONE
HAZARDOUS DECOMPOSITION PRODUCTS: BURNING MAY LIBERATE CARBON MONOXIDE, CARBON DIOXIDE, AND SILICON DIOXIDE.
HAZARDOUS POLYMERIZATION: WILL NOT OCCUR

SECTION VII SPILL OR LEAK PROCEDURES

USE PERSONAL PROTECTION TO PREVENT PERSONAL EXPOSURE.
AS REQUIRED DIKE WITH SOIL OR OTHER ABSORBENT MATERIALS TO PREVENT SPREAD OF SPILL. WIPE UP AND PLACE IN APPROPRIATE CONTAINERS AND/OR PLACE ABSORBENT MATERIAL ON SPILL AND TRANSFER ABSORBED SOLVENT TO APPROPRIATE CONTAINERS.
CONSULT AND COMPLY WITH FEDERAL, STATE, AND LOCAL REGULATIONS CONCERNING ANY RELEASE OF HAZARDOUS MATERIALS INTO THE WATER, WATER PIPING SYSTEMS, GROUND, OR AIR. CONSULT AND COMPLY WITH FEDERAL, STATE, AND LOCAL REGULATIONS CONCERNING REMOVAL OF WASTE.

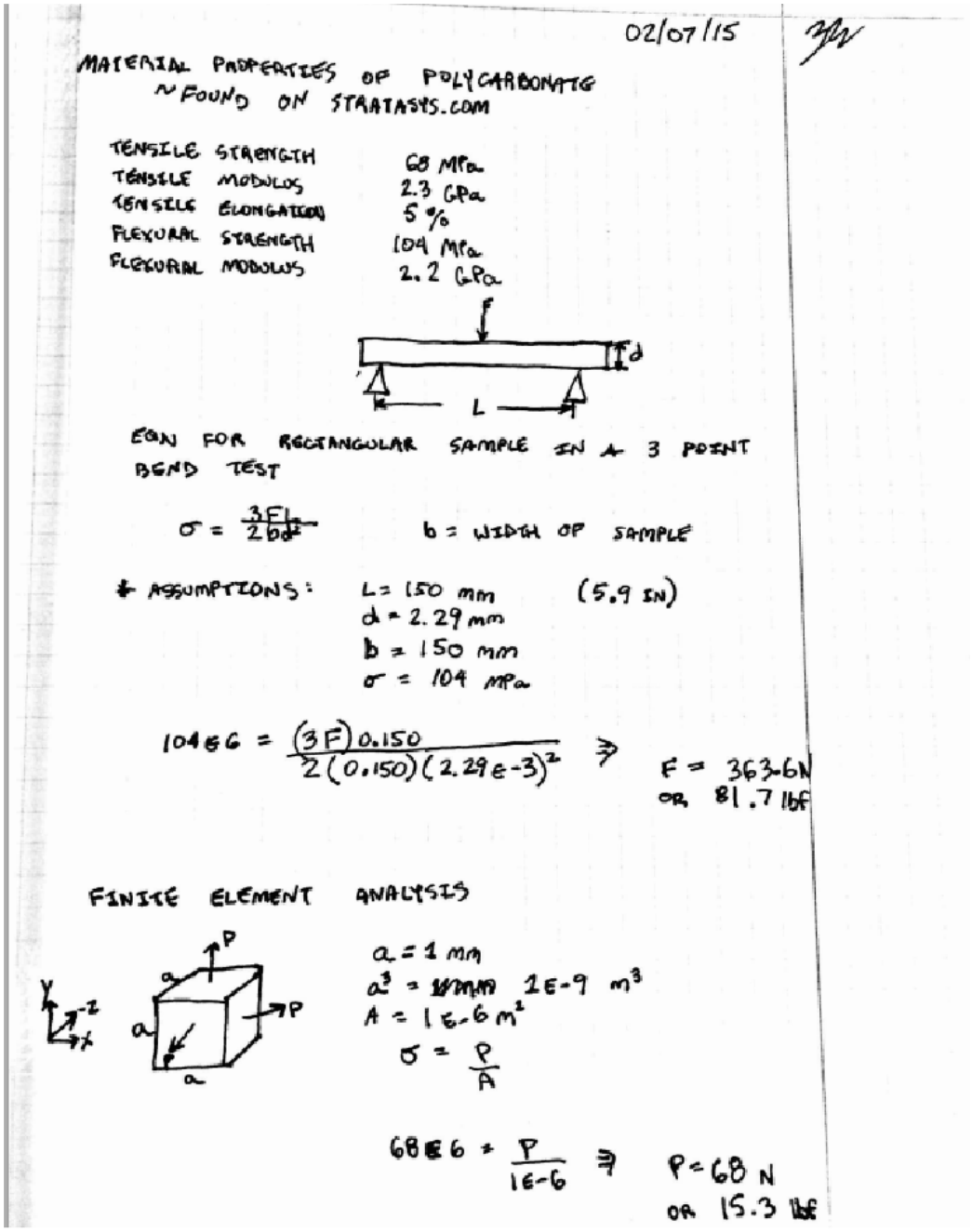
SECTION VIII SHIPPING INFORMATION

NFPA - HEALTH – 0 , FIRE- 1 , REACTIVITY 0
SARA 313- NOT LISTED
CALIFORNIA PROP 65 – NOT LISTED
DOT SHIPPING CLASSIFACATION – NON- HAZARDOUS
OTHER PRECAUTIONS: STORE IN A COOL, DRY PLACE. KEEP CONTAINER CLOSED AND KEEP AWAY FROM

HEAT AND FLAME. DO NOT LAY CONTAINER ON ITS SIDE.

The recommendations given here serve only as a guide. Each user should thoroughly test the material to determine the suitability of the product for an intended use and independently conclude satisfactory performance before commercializing. User assumes all risk and liability whatsoever in connection with the use of this product. Our liability is limited to the replacement price of the product.

Appendix F: Detailed Supporting Analysis



02/07/15

MATERIAL PROPERTIES OF POLYCARBONATE FOUND ON STRATASYS.COM

TENSILE STRENGTH	68 MPa
TENSILE MODULUS	2.3 GPa
TENSILE ELONGATION	5 %
FLEXURAL STRENGTH	104 MPa
FLEXURAL MODULUS	2.2 GPa

EQN FOR RECTANGULAR SAMPLE IN A 3 POINT BEND TEST

$$\sigma = \frac{3FL}{2bd^2}$$ b = WIDTH OF SAMPLE

ASSUMPTIONS: L = 150 mm (5.9 IN)
d = 2.29 mm
b = 150 mm
σ = 104 MPa

$$104E6 = \frac{(3F)0.150}{2(0.150)(2.29e-3)^2} \Rightarrow$$ F = 363.6N OR 81.7 lbf

FINITE ELEMENT ANALYSIS

a = 1 mm
a^3 = 1E-9 m^3
A = 1E-6 m^2

$$\sigma = \frac{P}{A}$$

$$68E6 = \frac{P}{1E-6} \Rightarrow$$ P = 68 N OR 15.3 lbf

ANALYZE WEAK AREA (PROTUSION FOR AIRHOSE FROM STOMA MASK)

CUT SECTION JUST AFTER PROTOSION

ASSUME: PROTUSION IS 0.5 IN OR 12.7 mm

σ_y = 68 MPa

ϕ = 3/8" OR 9.525mm

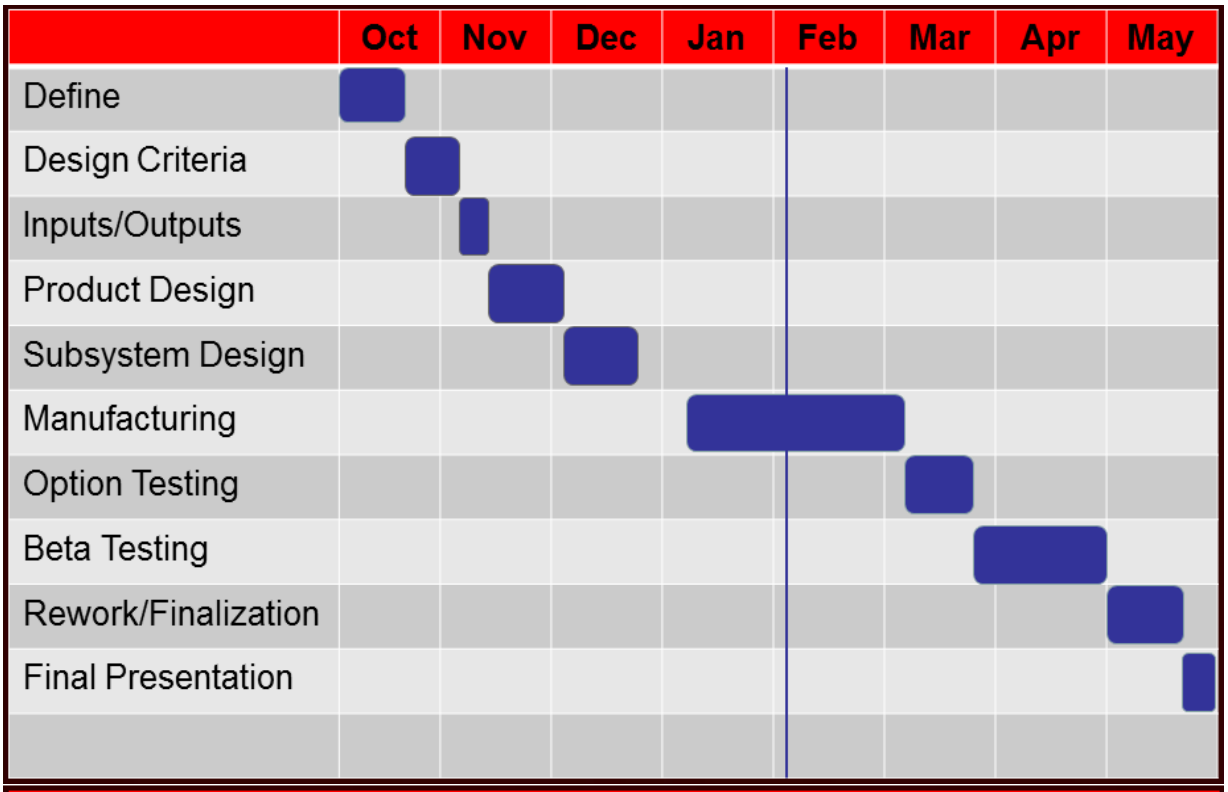
$M = F(0.0127)$

$$\sigma = \frac{-My}{I}$$

$$68\ EG\ P_a = \frac{F(0.0127\ m)(0.009525\ m)\ 1/2}{1/4\ \pi\ (0.0047625)^4}$$

$F = 454.25\ N$ OR 102.12 lbf

Appendix G: Gantt Chart & Management Plan



Major Milestone	Target	Completed	Completed
Project Definition	October	October	100%
Design Criteria	October	November	100%
Inputs/Outputs Defined	November	November	100%
Product Design	December	December	100%
Manufacturing	March	N/A	50%
Option/ Feasibility Testing	March	N/A	0%
Beta Testing (Limited field use)	April	N/A	0%
Rework/Finalization	May	N/A	0%
Final Presentation	May/June	N/A	0%

Appendix H: Use Cases

USE Case #1

Case: Initial Donning, Pre-air hookup

Step 1.) Make Sure Stoma is ready/ unobstructed
Step 2.) Make Sure Stoma Mask is ready/unobstructed
Step 3.) Loosen Straps pulling mask and over-head until proper placement on neck is achieved
Step 4.) Adjust straps to desired tension

Pre-Condition: Stoma Mask is NOT connected to airflow yet, ambient air drawn through opening/hose
Post-Condition: Attach hose to main Mask/ activate pressurized air supply

USE Case #2

Case: Cleaning/Maintenance

Step1.) Detach hose and check connection threads/ tape
Step2.) Inspect threads and hose for signs of wear
Step 3.) Look through length of hose to ensure no obstructions
Step 4.) Using "Cleaning solution" gently wipe clean inside and outside of mask and hose
Step 5.) Allow all pieces to dry completely before re-assembly

EXCEPTIONS:
EX Step 3.) Should wear be evident replace fittings, hose, or necessary part immediately.

Pre-condition: Dirty/ post use scenario
Post-condition: Store and use as needed

USE Case #3

Case: Emergency Response to Chris

Step 1.) Remove Chris from immediate harm (I.E. trapping object/situation) and extricate from building
Step 2.) Once in a safe area loosen neck straps of stoma mask allowing stoma to be uncovered and natural airflow to occur
Step 3.) Shut off SCOTT Pak air supply valve
Step 4.) Remove SCOTT face mask from Chris, followed by stoma face mask by pulling up and overhead carefully
Step 5.) Perform CPR and first aid as necessary, keep in mind only air route to lungs is through stoma

EXCEPTIONS:

EX Step 2.) If straps unable to be loosened/are bound, cut free using safety belt cutter or

EMT shears

Pre-condition: Chris is injured/disabled and in need of rescue
Post-Condition: Receive any necessary medical care

USE Case #4

Case: Air Supply from SCOTT Pak is interrupted

Step 1.) Signal to fellow firefighter that Air supply is interrupted
Step 2.) Join SCOTT tanks together using rescue air attachment
Step 3.) Extricate from building/situation as soon as possible
Step 4.) Once clear of Danger remove Stoma mask, begin to breathe normally and remove remaining SCOTT Gear.
Step 5.) Inspect all equipment and establish cause for sir supply failure
Step 6.) Repair/replace damaged parts or equipment, proceed to clean and inspect all other equipment in order to ensure no other failure will occur in the near future.

Pre-condition: In use
Post-Condition: In need of repair/replacement

USE Case #5

Case: Air Supply sharing to another firefighter *DO NOT ATTEMPT UNTIL TESTED FOR SAFETY*

Step 1.) Signal to fellow firefighter that you can supply him rescue air.
Step 2.) Attach SCOTT rescue hose from your tank to his
Step 3.) Extricate firefighter from building As soon as possible
Step 4.) Remove stoma mask when in safe location, breathe normally
Step 5.) Detach rescue hose and check remaining oxygen supply
Step 6.) Assess with other firefighter health and medical needs

Pre-condition: Firefighter in need of assistance due to SCOTT Pak failure
Post-condition: Return to normal duty/ refill tank as necessary

Appendix I: Use and Assembly/Disassembly Instructions

Phase 1: Preparing the SCOTT Mask and Stoma Mask

Step 1.) Take SCOTT face mask and remove voice transducer from preferred side, Note: if a Radio connection is present on mask use other port.
Step 2.) Once voice transducer is removed ensure that airpath into inner nose/mouthcup is unobstructed and clean.
Step 3.) Ensure that the stoma mask is clean and that the flexible silicone seal is not cracked or showing signs of wear, if it is replace the flexible seal (See: Seal replacement below)
Step 4.) If the neck webbing is not already installed, place the gasketed screw male ends through the webbing D rings, or attachement holes and place threaded portion through hole in Stoma mask. Note: make sure to align the straps so they do not cross.
Step 5.) Place the female ends of the gasketed screw attachments onto the male ends and tighten with fingers initially, then using a Torx bit tighten until the gaskets are firmly seated. Note: DO NOT overtighten, this may cause damage to the gasket and shorten its lifespan.
Step 6.) Depending on Hose to be used, and affixation method see desired section below

Phase 2A: attaching the CS1 Hose

Step 1.) Place the brass male stud end of the threading firmly into the SCOTT accessory port opening, ensure that you feel the stud grip the rubber housing. Note: a small amount of silicone may be applied to the stud to help ensure an airtight seal, if so make sure to let silicone cure before proceeding.
Step 2.) Place the brass swivel fittings into the hose ends and secure according to manufactures instructions.
Step 3.) If stoma mask is not already tapped with male NPT threads do so, matching the standard TPI for the 1” fittings.
Step 4.) Apply Teflon gas tape to the threads of the brass fittings according to Teflon tape manufacturer specifications (Normally 3 wraps for a 1” diameter).
Step 5.) Secure the brass fittings together using hand tension at first, followed by a wrench until fittings are firmly seated. Note: DO NOT OVERTIGHTEN, doing so can cause damage to the brass fittings resulting in leaks.

Phase 2B: attaching the FD1 Hose

Step 1.) Ensure that the hose mounting section of the stoma mask and SCOTT mask are both clean and dry.
Step 2.) Loosely place hose clamp onto both hoses and slide inward one to two inches initially.
Step 3.) Place a small amount of Silicone sealant around the openings and firmly press hose over protrusion and into Sealant.

Step 4.) Slide the hose clamps down to the section of hose covering the protrusion and firmly secure the hose clamp.
Step 5.) Place an additional bead of silicone sealant around the end of the hose to ensure a tight seal to the mask.
Step 6.) Allow the silicone to fully cure, then check for any leak. Should a leak be found fill the gap with additional silicone sealant and allow to fully cure.

Maintenance and repair:

Seal Replacement:

Step 1.) Using a sharp hobby knife make cuts perpendicular to the masks face in 1-2 inch increments. Note: Caution should be used when handling the hobby knife
Step 2.) Using a firm grip or pliers, grasp the segments and peel them off of the polycarbonate
Step 3.) Should any fragments remain carefully place the flat of the blade against the mask and carefully slice away the remaining silicone.
Step 4.) Using a padded vice, or stand place the stoma mask with the side to be sealed face up, and carefully apply the silicone sealant to the edge of the polycarbonate. Note: Ensure that the bead runs onto both sides of the polycarbonate in order to ensure a quality seal.
Step 5.) Allow sealant to cure fully, then perform a qualitative leak test before returning the mask to service

Appendix J: FMEA

Quality Tools

Failure Mode and Effects Analysis

Description

This template illustrates a Failure Mode and Effects Analysis (FMEA), also referred to as a Potential Failure Mode and Effects Analysis (PFMEA) or Failure Modes, Effects and Criticality Analysis (FMECA). A detailed discussion can be found at www.ASQ.org

Learn About FMEA

Instructions

- Please follow the link for detailed instructions for data entry
- Initiate action to reduce the RPN
- Re-evaluate the RPN value after completion of the recommended actions

Learn More

To learn more about other quality tools, visit the ASQ Learn About Quality web site.

Learn About Quality

FAILURE MODE AND EFFECTS ANALYSIS

Item:	Firfighting SCBA	Responsibility:	Core Team	FMEA number:	123456
Model:	Current	Prepared by:	Core Team	Page :	1 of 1
Core Team:	Jason Delgadillo, Aaron Wheeler, Zachary Wishbow			FMEA Date (Orig)	2/24/2015 Rev: 0

Process Function	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Class	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Process Controls	Detec	RPN	Recommended Action(s)	Responsibility and Target Completion Date	Action Results				
												Actions Taken	Sev	Occ	Det	RPN
Hose Attachment providing Air	*Looseing and Leaking*	*Client Suffocates or has limited air intake*	*9*		*Use over time*	*2*	*Regular maintenace and checks*	*3*	*54*	*Check for secure fit before each use*	*Jun-15*	*Instructions to check before each use will be included in user manual*	*9*	*2*	*1*	*18*
Hose Attachment providing Air	*Looseing and Leaking*	*Client Suffocates or has limited air intake*	*9*		*user error*	*2*	*Instructions in use given*	*3*	*54*	*Check for secure fit before each use*	*Jun-15*	*Instructions to check before each use will be included in user manual*	*9*	*2*	*1*	*18*

Hose Attachment providing Air	*Broken via impact*	*Broken during use*	*9*		*falling debris*	*4*	*Previous firefighting safety taught to client*	*10*	*360*	*practice avoiding falling objects while wearing system*	*Jun-15*	*developing practice techniques*	*9*	*4*	*9*	*324*
Hose Attachment providing Air	*Broken via impact*	Broken during use	9		Snag on stationary Debris	4	Previous firefighting safety taught to client	10	360	avoid potential snag situations	*Jun-15*	developing snag avoidance measures	9	4	9	324
Hose Attachment providing Air	*Broken via impact*	Broken during storage or transport	7		Dropped or crushed by foreign object	2	Proper storage methods used	10	140	Addition of a padded case	*Jun-15*	Planning to include padded case with final product	7	1	10	70
Hose Attachment providing Air	Cross threaded fittings	Client Suffocates or has limited air intake	10		user or assembly error	1	Use proper threading techniques and do not overtorque	3	30	Set initially with fingers before using tools to tighten	*Jun-15*	Including assembly instructions	10	1	1	10
Hose Attachment providing Air	Cross threaded fittings	Damage to mask	9		user or assembly error	1	Use proper threading techniques and do not overtorque	3	27	Set initially with fingers before using tools to tighten	*Jun-15*	Including assembly instructions	9	1	1	9
Polycarbonate stoma mask providng protection and air	Crack or break	Air leak and possible exposure to smoke	10		Severe impact	3	impact resistance of material used	1	30	Verify through test	*Jun-15*	Plan to ANSI test	10	3	1	30
Polycarbonate stoma mask providing stoma mask and air	Crack or break	cuts or lacerations	10		Severe impact	3	impact resistance of material used	1	30	Verify through test	*Jun-15*	Plan to ANSI test	10	3	1	30
Polycarbonate stoma mask providing stoma mask and air	Chemical damge or degredation	mask becomes unusable	7		direct exposure to corrosive chemicals	1	Previous firefighting safety taught to client to avoid these situations	4	28	Include list of chemicals to be avoided in instructions	*Jun-15*	Including proper storage and use instructions	7	1	1	7
Flexible neck seal to contain air and exclude smoke	tear or rupture due to impact or accident in use	Client Suffocates or has limited air intake	10		falling debris or other accident	4	Previous firefighting safety methods taught	10	400	Ensure neck seal is made of durable material	*Jun-15*	Using tough seal material and making seal replacable	10	4	9	360
Flexible neck seal to contain air and exclude smoke	Tear or rupture due to improper storage, cleaning, or assembly	mask is in need of repair	7		accident during storage or cleaning	3	Flexible tough seal material used	3	63	Check for cracks or tears before use	*Jun-15*	Including seal check as part of regular maintenance	7	3	1	21
Flexible neck seal to contain air and exclude smoke	Chemical damge or degredation	Seal needs repair or replaceme nt	7		direct exposure to corrosive chemicals	1	Previous firefighting safety traingin	4	28	Include list of chemicals to be avoided in instructions	*Jun-15*	Advise regular seal replacement in addition to training	7	1	1	7
Neck Strap attachement system	Cut or torn during use	Client Suffocates or has limited air intake	10		Snag on sharp object	3	previous firefighting training	3	90	ensure proper trainging	*Jun-15*	Ensure proper training	10	2	2	40
Neck Strap attachement system	Wear through over time	Straps need repair	7		excessive use between repairs	3	Regular maintenace and checks	1	21	ensure regular maintenance	*Jun-15*	Advise regular strap replacement	7	1	1	7
Neck Strap attachement system	Tangles in storage	Needs to be untangled	4		Improper storage methods	2	Proper storage methods used	1	8	ensure proper storage techniques used	*Jun-15*	Include storage instructions	4	1	1	4
Hose Body	Leakage through tear during use	Client Suffocates or has limited air intake	10		foreign object impact	4	previous firefighting training	3	120	additional object avoidance training	*Jun-15*	Development of further training	10	3	3	90

Hose Body	leakage through wear	hose needs repair or replacement	4		overuse and improper care	2	Regular maintenace and checks	3	24	ensure proper maintenance and care	*Jun-15*	Including maintenace instructions	4	1	1	4
Hose Body	Kink in the hose during use	hose must be unkinked immediately	9		repeated akward motions	3	previous firefighting training	2	54	avoid movements that could cause kink	*Jun-15*	Visually inpect regularly	9	3	1	27
Air supply from SCOTT abruptly terminated	Client suffocates or has limited air supply	Needs resuce air immediately	10		Manufacturing defect in SCOTT system	2	Ensure SCOTT pak is working properly before attachement to system	2	40	Inspect SCOTT pak regularly	*Jun-15*	Visually inpect regularly	10	1	1	10
Air supply exhausted through use	Client suffocates or has limited air supply	Needs resuce air immediately	10		Low air alarm fails to activate	2	Regularly check low air alarm	2	40	Inspect low air alarm regularly	*Jun-15*	Function test reglarly by bleeding test tank till alarm activate	10	1	1	10

Appendix K: DVP&R and Test Procedures

ENGR459-461 DESIGN VE

TEST PLAN

Report Date		Sponsor	

Item No	Specification	Test Description	Acceptance Criteria	Test Responsibility
1	Weight	Measurement of Mass	5± 1.5 lbs	Zack
2	Modularity	Modular Analysis	2± 1 parts	Zack
3	Air Loss	Air Loss from Stoma Mask Detect.	10± 10% Air Loss	Zack
4	Donning/Doffing Time	Donning/Doffing Time Trials	<20 sec	Zack
5	Communication	Loudness Measurement	60± 10 dB	Aaron
6	Compatibility	Fit Test of Scott-pak	Fits Scott-pak	Aaron
7	Positive Pressure	Pressure Gage Test	14.7<P>15.5 psi	Aaron
8	Shatter Resistance	ANSI Z87.1	Pass	Aaron
9	Volum. Flow Loss	Flowrate Comparision Test	85-100% Airflow	Aaron
10	Heat Resistance	Heat Test	>300° F	Jason
11	Biocompatibility	Human Exposure Test	Nonreactive	Jason
12	Low Air Notification	Low Air Test	Notifies user	Jason
15	Hose Abrasion	Abrasion Test	>50 Cycles	Jason
16	Hose Ductility	Cyclical Tensile Loading	>1000 Cycles	Jason

ERIFICATION PLAN AND REPORT

				Component/Assembly		REPORTING ENGINEER:		
					TEST REPORT			
Test Stage (% Completed)	SAMPLES		TIMING		TEST RESULTS			NOTES
	Quantity	Type	Start date	Finish date	Test Result	Quantity Pass	Quantity Fail	
0	3	B	5/20/2015	5/27/2105				
50	1	B	1/21/2015	5/28/2105				
0	5	B	5/22/2015	5/29/2105				
70	2	B	5/23/2015	5/30/2105				
0	3	B	5/24/2015	5/31/2105				
50	3	B	1/1/2015	6/1/2105				
50	5	B	12/12/2014	6/2/2105				
0	1	C	5/27/2015	6/3/2105				
0	1	B	5/28/2015	6/4/2105				
10	5	C	2/7/2015	6/5/2105				
18	1	C	12/2/2014	6/6/2105				
0	2	B	5/31/2015	6/7/2105				
0	1	C	6/1/2015	6/8/2105				
0	1	C	6/2/2015	6/9/2105				

Testing Verification Procedure

Firefighting SCBA team: Aaron Wheeler, Jason Delgadillo, Zachary Wishbow

Verification Plan 1: Measurement of Mass

Supplies: Digital or spring scale with a loading capacity of at least 6.5 LBS and sensitivity of 0.5 LBS, appropriately sized weighing boat (6 inch square at least)

Safety Precautions: Do not breathe on scale, wind will affect data collected.

Test Procedure:

Step 1.) Collect assembly

A. Stoma mask B. Stoma tube C. Brass fittings (2)

Step 2.) Locate dry, level, low-wind surface.

Step 3.) Turn on scale.

Step 4.) Tare scale if scale doesn't auto-tare.

Step 5.) Place assembly on weighing platform.

Step 6.) Check overhang of assembly. Assembly should only be in contact with only weighing platform.

Step 7.) If overhang is in contact with a surface that isn't the weighing platform remove assembly from platform. Place weigh boat on platform and tare. Place assembly in weigh boat and check for overhang.

Step 8.) Wait for scale to settle on a reading.

Step 9.) Wait 3 seconds and record weight to the tenths place.

Step 10.) Pick up assembly from weighing platform and return it to its previous location. Check overhang

Step 11.) Repeat steps 8-9

Step 12.) Repeat steps 12

Step 13.) Repeat steps 8-9

Analysis: Record identifying features of scale (serial number). Record 3 weight samples.

Cleanup/Disposal: Stow assembly and scale in a safe place.

Testing Verification Procedure

Firefighting SCBA team: Aaron Wheeler, Jason Delgadillo, Zachary Wishbow

Verification Plan 15: Hose abrasion Test

Supplies: Leather gloves, Safety Glasses, 80 grit sandpaper, 1" Diameter dowel rod, Camera, Paper and pencil,1ft Hose sample, Clamping method, Designated work surface.

Safety Precautions: Always wear leather gloves when handling the sandpaper and abraded hose. Wear safety glasses at all times during the test. Check the manufacturers MSDS before any testing in order to ensure no hazardous materials will be released during the test. IF Hazardous material will be released follow manufacturer or OSHA guidelines for handling if risk is minor (I.E. minor skin irritation, minor particulate release). Should the risk be higher, re-develop this test plan to control the hazards of the specific hose to be tested.

Test Procedure:

Step 1.) Select the hose to be tested and acquire a 1 foot section. If cutting is required follow manufacturers recommendation for proper cutting.

Step 2.) Inspect the hose section for signs of wear, fatigue, or damage. If any are present select another 1 foot section of hose for testing.

Step 3.) Firmly secure the hose sample on both ends such that there is less than 1" slack in the one foot length.

Step 4.) Photograph hose sample before any further testing for future comparison.

Step 5.) Put on the leather gloves and safety goggles. Ensure that the work area is clear of any objects or people that could potentially be harmed.

Step 6.) Wrap 80 grit sand paper around the Dowel rod, and using moderate force abrade the center of the hose pulling towards yourself for 5 passes. The amount of force and physical mechanism is similar to that of opening a door.

Step 7.) Record the number of total passes and photograph if significant visual change in the hose.

Step 8.) Repeat steps 6 and 7 until the hose is abraded through.

Step 9.) Record the number of passes to achieve failure for the section of the hose.

Step 10.) Repeat steps 6 through 9, 3 inches from the center on both sides. Record these values.

Step 11.) Average the 3 values to find the average number of passes to failure, and compare to selection criteria.

Analysis: Record all pictures and the average number of passes to cause failure in the particular hose section. In addition keep the abraded section of the hose and label it with the test # and date conducted. Compare the sample tested to the required limit and other hoses being considered.

Cleanup/Disposal: Sweep or vacuum all dust from the work area when finished with testing. Ensure that the waste material does not need to be disposed of in a special manner by consulting the MSDS for the product. Remove the used 80 grit sandpaper from the Dowel rod and dispose of in trash. Keep the Dowel rod for future sample testing, if the rod has become damaged place in an available wood scrap bin or trash can. Once the area is clean remove the leather gloves and safety goggles and store them properly.

Test Procedures: Impact testing (Modified ANSI Z87.1 2010)

Supplies: Object to be impact tested, safety glasses for all conducting experiment, secondary impact barrier, such as a face shield, also recommended. Leather gloves, long pants, durable closed toe shoes, 500 g pointed steel weight, 1" diameter steel ball, tape measure, mounting surface preferably model head, 200g weight tipped with needle, 0.25" steel ball, slingshot or air cannon capable of 150 fps, camera, safe work area away from public, shop blankets or towels, cardboard box.

Safety Considerations: Since all of the impact test involve weighted or high velocity object moving it is important to observe all safety procedures. First and foremost ensure that the testing area is free of bystanders and any equipment that could potentially be damaged by the moving objects. Make sure to wear safety glasses at all times, and the secondary protection when conducting the velocity impact tests. Hang the shop blankets around the model during impact testing in order to catch any possible ricochet from projectiles. Inspect any firing mechanism such as slingshot or air cannon before use to ensure that it is completely operational. Before release of any object whether dropped or fired make sure there is no individual downrange of the object and to clearly and loudly state "Planning to test all clear" make sure any other testers are clear of the area. Then declare "Firing One" when release is occurring, and "All clear" once projectile has ceased motion completely. If projectile testing is too dangerous for conditions conduct drop testing only.

Testing Procedure 1: High Mass

Step 1.) Firmly secure the Stoma mask to the mounting surface, preferably a model mannequin head. Place the mounting surface on the ground or other firm flat surface close to ground level (< 1').

Step 2.) Place shop blankets around the mounting surface to help catch the weight after impact.

Step 3.) Measure 50" from the surface of the stoma mask vertically, and hold the 500g pointed weight at this position. If possible mark this location for future reference.

Step 4.) Proceed with release declarations stated in safety consideration section and drop weight.

Step 5.) Once weight has stopped moving remove from impact area and inspect Stoma mask.

Step 6.) Stoma mask has passed high mass test if no piece detaches, no fracture occurs, and all pieces are retained in their place.

Step 7.) Photograph results for later reference highlighting the impact area.

Step 8.) Repeat test additional 9 times (10 runs total) and compare results for any deviations. Additional runs can be performed if desired.

Testing Procedure 2: Drop Ball

Step 1.) Firmly secure the Stoma mask to the mounting surface, preferably a model mannequin head. Place the mounting surface on the ground or other firm flat surface close to ground level (< 1').

Step 2.) Hang shop blankets around the mounting surface in order to help catch the steel ball after impact.

Step 3.) Measure 50" from Stoma mask surface, and bring the 1" steel ball to this height.

Step 4.) Proceed with release declarations stated in safety considerations section and proceed to drop steel ball.

Step 5.) Once steel ball has stopped moving remove from impact area and inspect stoma mask.

Step 6.) Mask has passed drop ball test if the material does not fracture, and all elements of the mask remain in place.

Step 7.) Photograph results for later reference highlighting the impact area.

Step 8.) Repeat test additional 9 times (10 runs total) and compare results for any deviations. Additional runs can be performed if desired.

Testing Procedure 3: Low mass piercing weight

Step 1.) Firmly secure the Stoma mask to the mounting surface, preferably a model mannequin head. Place the mounting surface on the ground or other firm flat surface close to ground level (< 1').

Step 2.) Hang shop blankets around the mounting surface in order to help catch the piercing weight after impact. **NOTE:** The piercing weight is tipped with a sharp needle, be extremely careful when dropping.

Step 3.) Measure 50" from Stoma mask surface, and bring the piercing weight to this height.

Step 4.) Proceed with release declarations stated in safety considerations section and proceed to drop piercing weight.

Step 5.) Once piercing weight has stopped moving remove from impact area and inspect stoma mask.

Step 6.) Mask has passed piercing test if the material remains un-penetrated.

Step 7.) Photograph results for later reference highlighting the impact area.

Step 8.) Repeat test additional 9 times (10 runs total) and compare results for any deviations. Additional runs can be performed if desired.

Testing Procedure 4: High velocity test

Step 1.) Firmly secure the stoma mask to the mounting surface, preferably a mannequin head. Place the mounting surface on the cardboard box.

Step 2.) Hang shop blankets behind, and to the sides of the mannequin head in order to help catch the 0.25" steel ball.

Step 3.) Set up air cannon ensuring that manufacturer's instructions are followed, or prepare slingshot arrangement 10' from the stoma mask. Ensure all testers are wearing secondary protection and if possible are also behind a physical barrier. This is done in order to help prevent ricochet from reaching the testers in the event the ball bounces back towards the testers after impact.

Step 4.) Proceed with the release declarations stated in safety considerations section and proceed to release high velocity projectile.

Step 5.) Once steel ball has ceased moving approach stoma mask and inspect.

Step 6.) Stoma mask has passed the high velocity test if no fracture occurs, all pieces remain in place, and the steel ball does not reach the area of the stoma through ricochet or other means.

Step 7.) Photograph results for later reference highlighting the impact area.

Step 8.) Repeat test additional 9 times (10 runs total) and compare results for any deviations. Additional runs can be performed if desired.

Analysis: Compiling the data from all the tests ensure that the mask passes all tests a minimum of 9 of the 10 times. If any failures did occur closely inspect and try to determine cause of failure. Record all photographs for future reference along with recorded data from testing.

Cleanup: Sweep and clean testing area ensuring that no material was left behind in the event of mask failure. Return all tools to proper locations. Recycle of store cardboard box as desired.

Testing Verification Procedure Cyclic loading

Verification Plan 16: Cyclical Tensile Loading

Supplies: 2 Skate wheel bearing, 1 ft. Hose sample, Clamping method, wood board, dowel rod, bolts sized for skate bearings and matching thread nuts.

Safety Precautions: Be careful when rotating the hose on the mount, if it slips loose it could cause injury

Test Procedure:

Step 1.) Select the hose to be tested and acquire a 1 foot section. If cutting is required follow manufacturers recommendation for proper cutting.

Step 2.) Inspect the hose section for signs of wear, fatigue, or damage. If any are present select another 1 foot section of hose for testing. Photograph hose section for future reference before testing proceeds.

Step 3.) Firmly secure the hose sample on one end in the clamp securely, ensuring not to crush the hose in the process.

Step 4.) Attach the other end of the hose to one of the bearings using a pressure fit method, it may be necessary to temporarily embed the bearing into a dowel rod in order to match the inner diameter.

Step 5.) Attach this bearing surface to the outer edge of the wood board cut into a circular pattern, then support the wooden disk on the second bearing mounted in the center.

Step 5.) Rotate the wheel for approximately 1000 revolutions observing the hose while doing so for any signs of wear or failure.

Step 6.) Observe the hose after 1000 revolutions. Record any signs of wear or damage to it. Photograph the hose to catalog for later review

Analysis: Record all pictures and any signs of wear or damage to it. Make sure to inspect it carefully for any sign of wear throughout the hose

Cleanup/Disposal: Remove the hose section from the clamp, and sweep the testing area. Return all tools used to their proper place.