Device Master Record

Manufacturing Process of a SCOBY Bio-Thread

FIU Engineering & Computing
Biomedical Engineering

POLARITY VENTURES

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Section 1
Design Specifications

1.1 Engineering Drawings

The objective of this project is to design a means of forming a thread 152.4 cm in length and less than 2mm in width from the by-product of the Kombucha fermentation process. To initiate this process, water, tea, sugar, and bottled Kombucha are mixed together and left to ferment. As it ferments, cellulose fibers are formed and rise to the surface of the tea. These fibers adhere together to form a pellicle called the Symbiotic Culture of Bacteria and Yeast, or SCOBY.

Due to its cellulose composition, the SCOBY demonstrates many impressive qualities such as high tensile strength, biocompatibility, and large durability. These properties allow it to be versatile, while also being cost effective and simple to create.

To manufacture the thread, the Kombucha is brewed in tubes to assist the SCOBY in forming its shape. After it has grown at a consistent width (after about 2 weeks), it is 2left to dry. Lastly, it is purifie, twisted into the thread, and stored on a spool.

Since there are many factors that contribute to the growth of the SCOBY, there are several variables that are manipulated in the project to see what may improve the process and results. The control variable uses the consistent brewing process, which is left to ferment inside an enclosed tube for a 2 week period. The first variable measures the change in mechanical properties by letting it ferment for a longer period of time. The second variable takes into account the amount of time it takes to form the SCOBY through the amount of oxygen the tea is exposed to, via an open tube.

The table below describes the market requirements and design inputs for the project:

Table 1.1 Final Market Requirements and Design Inputs

Market Requirement	Design Input
1. The Bio-thread will contain bioactive compounds.	The final product will have cellulose.
2. An uninterrupted Bio-thread with dimensions that will facilitate large scale manufacturing	The Bio-thread must present repeatability with a length of 152.4 +/- 15.24 cm and a diameter of 2 +/- 0.2 mm to allow for future large scale production.
3. The Bio-Thread must be strong and flexible for future use in wound dressings.	The Bio-thread must endure a tensile stress of 32 MPa and fit around a spool with a diameter of 1.0 cm
4. The SCOBY must not be acidic	The pH of the SCOBY must not be below 4.7.

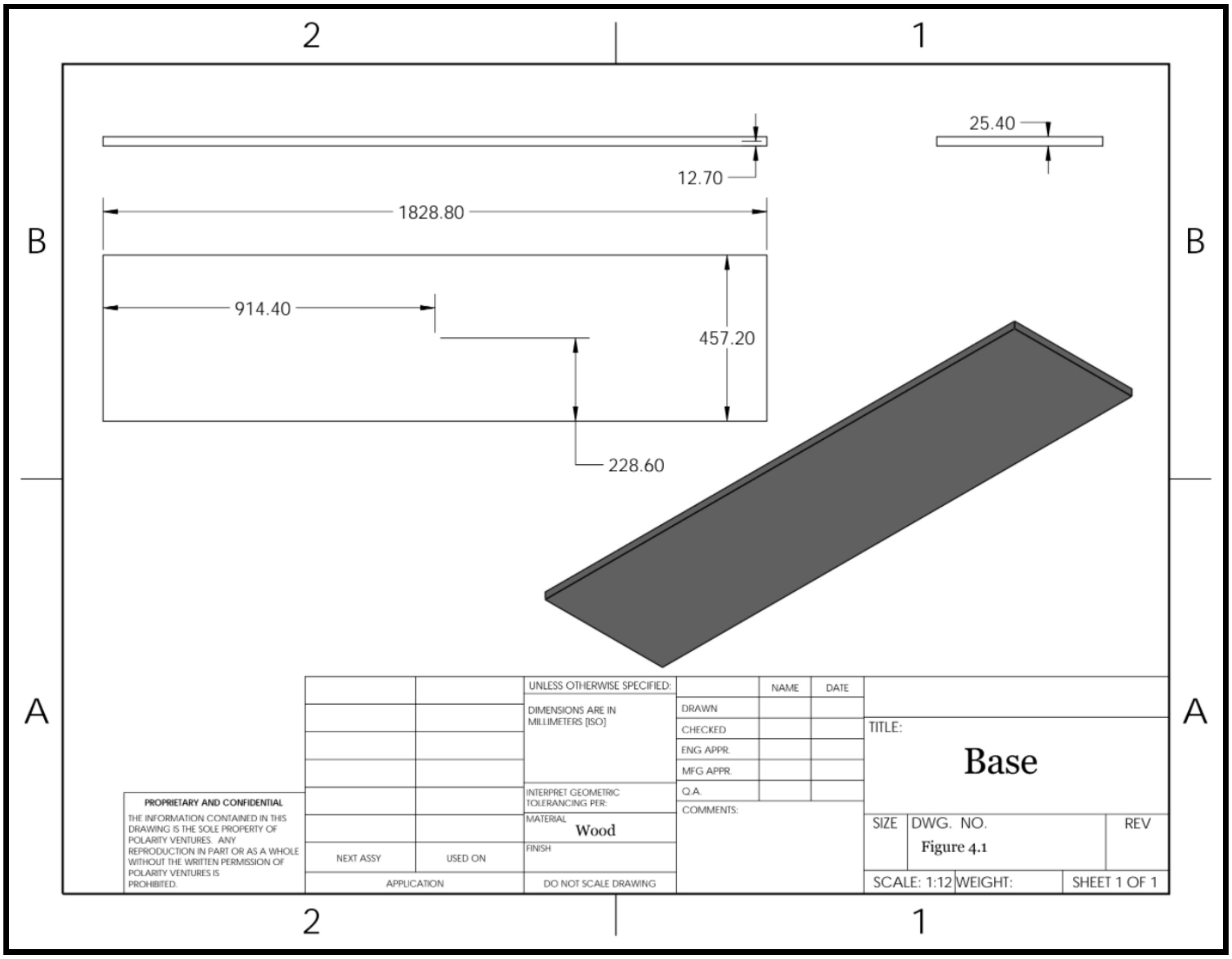

Figure 1.1 Base Design

Design drawing of the base that holds the silicone tubes. The length of the base is 6 feet and the width is 1.5 feet, with a height of 1 inch.

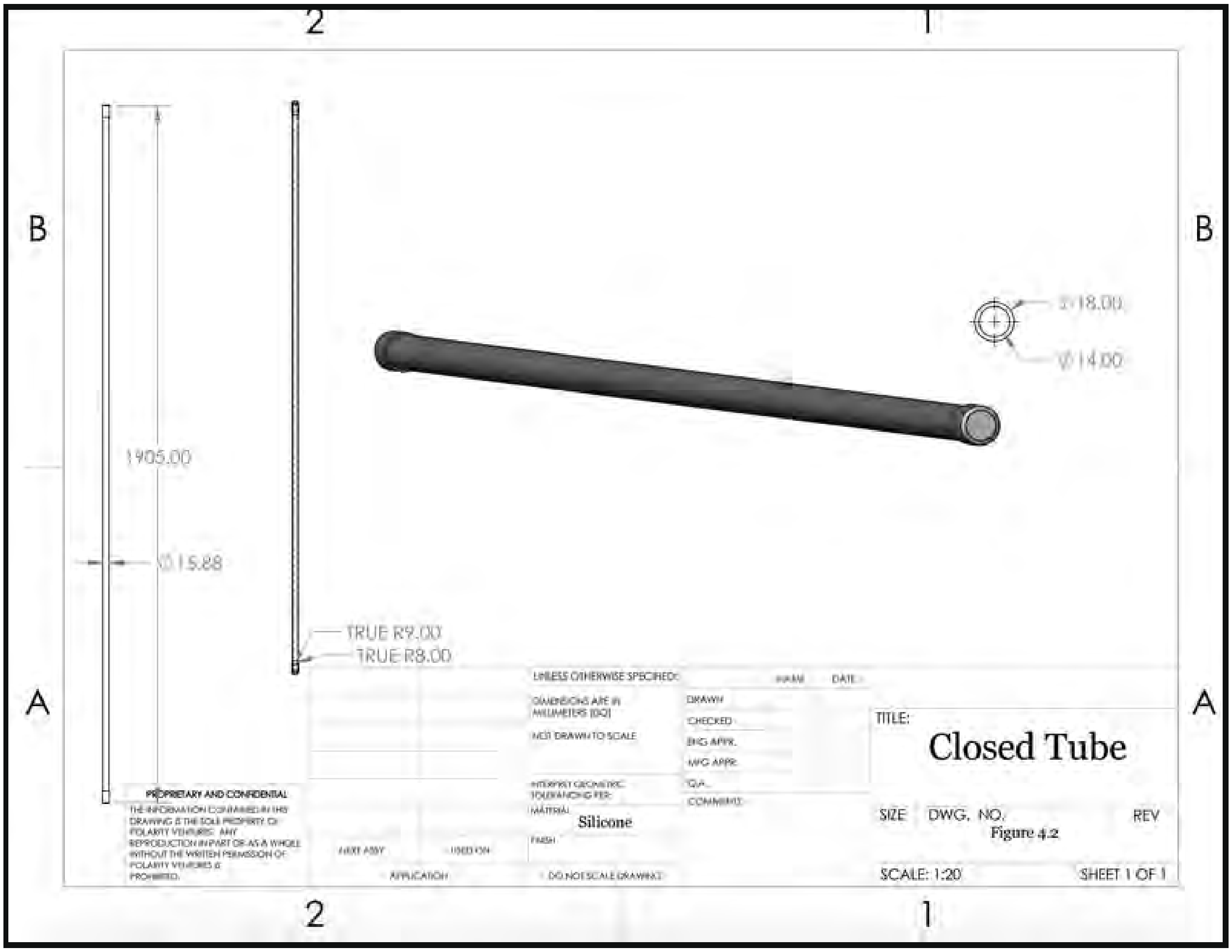

Figure 1.2 Closed Tube Design

Design drawing of closed silicone tube. The length of the tube is 6.25 feet with an ID of 12.7 mm and an OD of 15.875 mm. The cap placed on the tube has an ID of 16 mm and an OD of 18 mm.

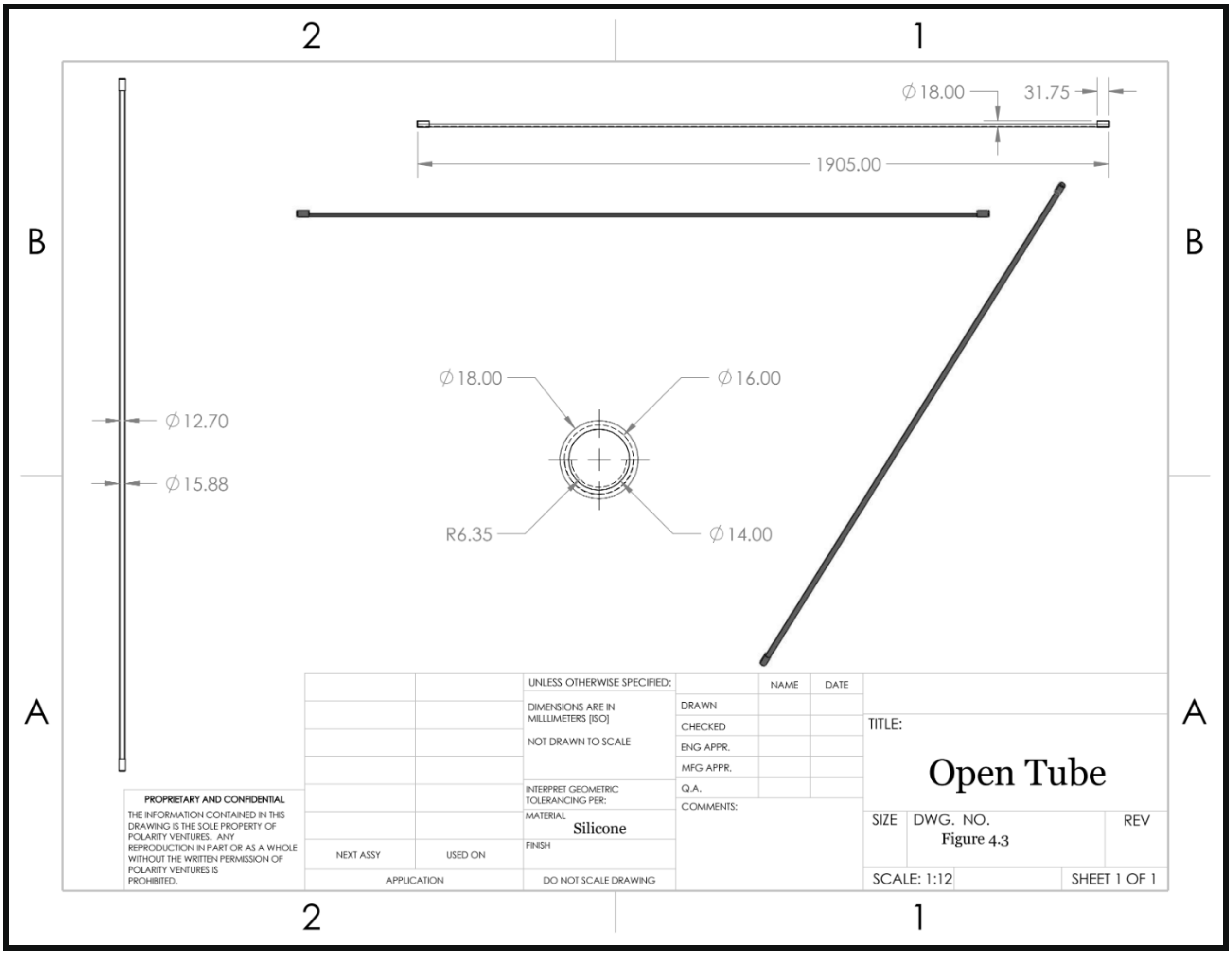

Figure 1.3 Open Tube Design

Design drawing of open silicone tube. The open tube is cut through the middle of the cross-section. The length of the tube is 6.25 feet with an ID of 12.7 mm and an OD of 15.875 mm. The cap placed on the tube has an ID of 16 mm and an OD of 18 mm.

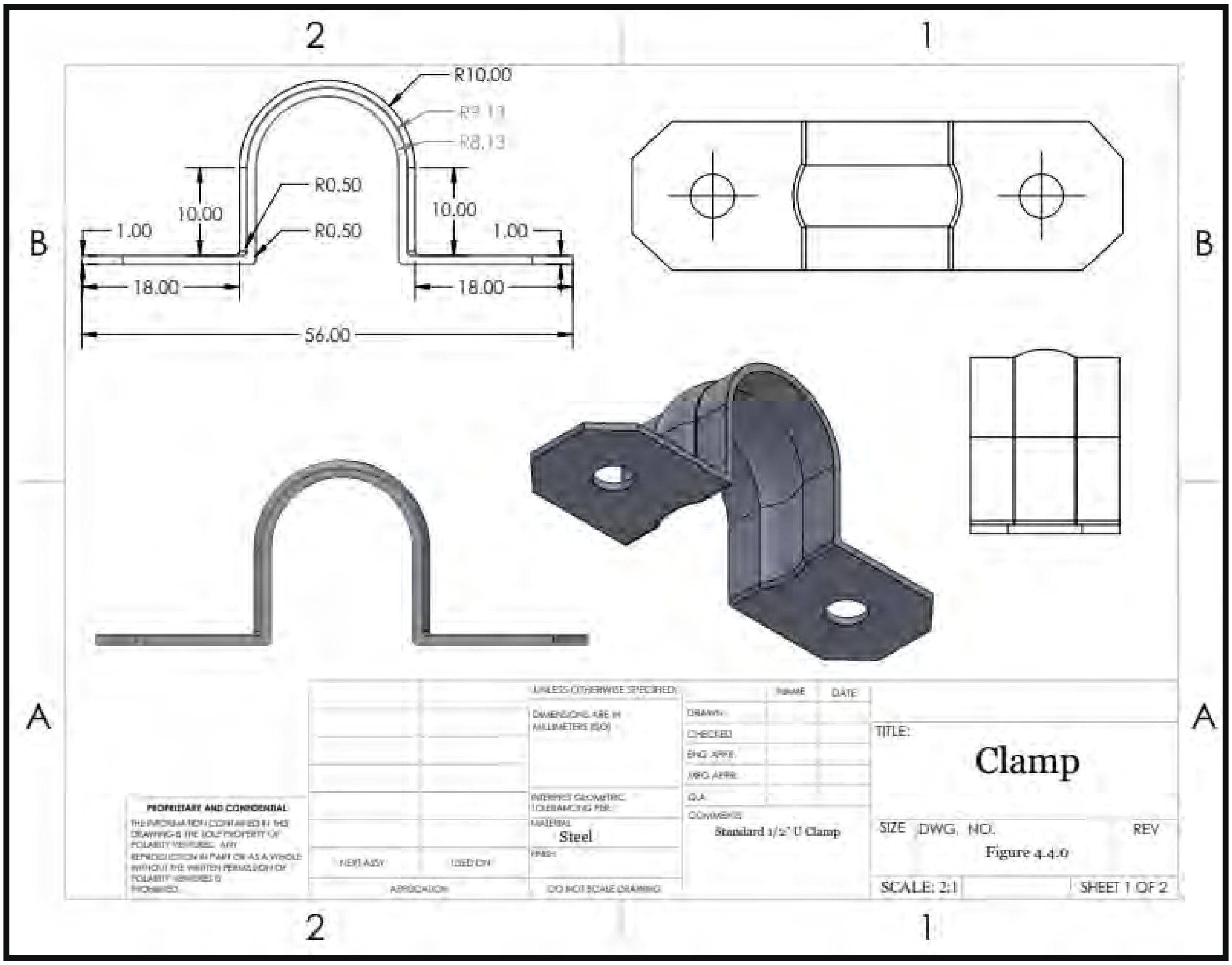

Figure 1.4.1 Clamp Design

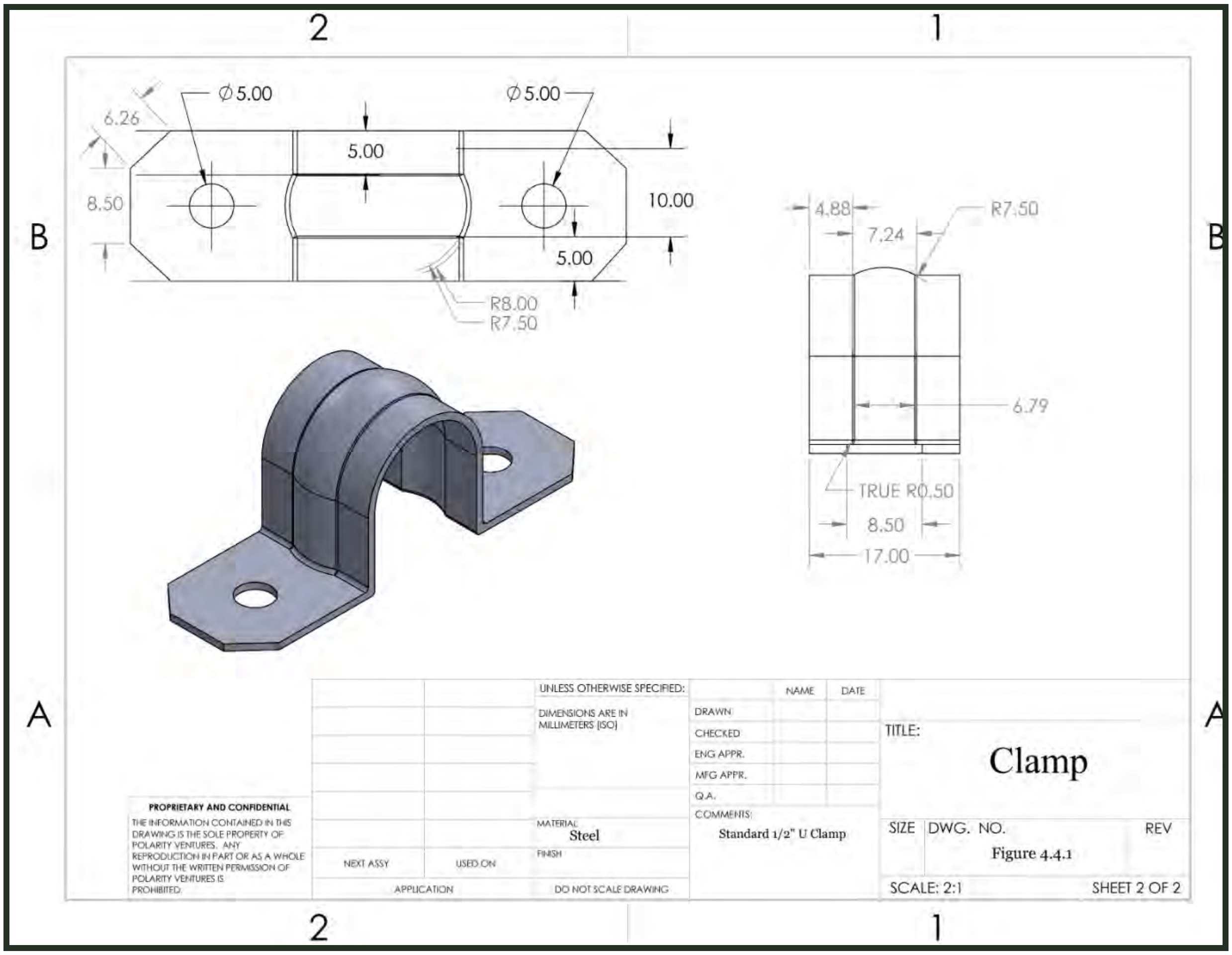

Figure 1.4.2 Clamp Design

Design drawing of the clamp. The length of the clamp is 56 mm, and the width is 17 mm. The diameter of each hole is 5 mm.

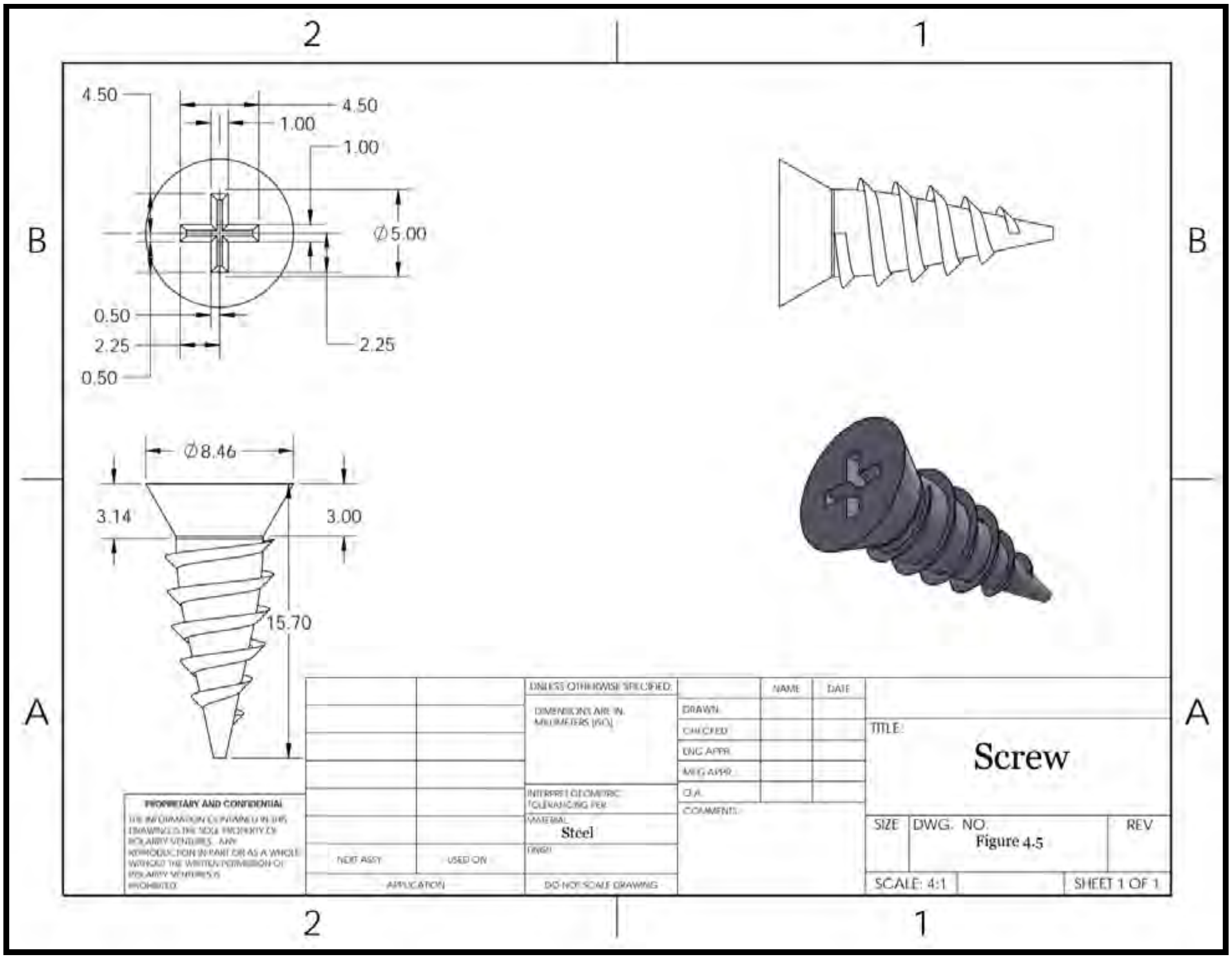

Figure 1.5 Screw Design

Design drawing of the screw. The head has a diameter of 8.46 mm and the tail has a length of 0.5 in (15.70 mm).

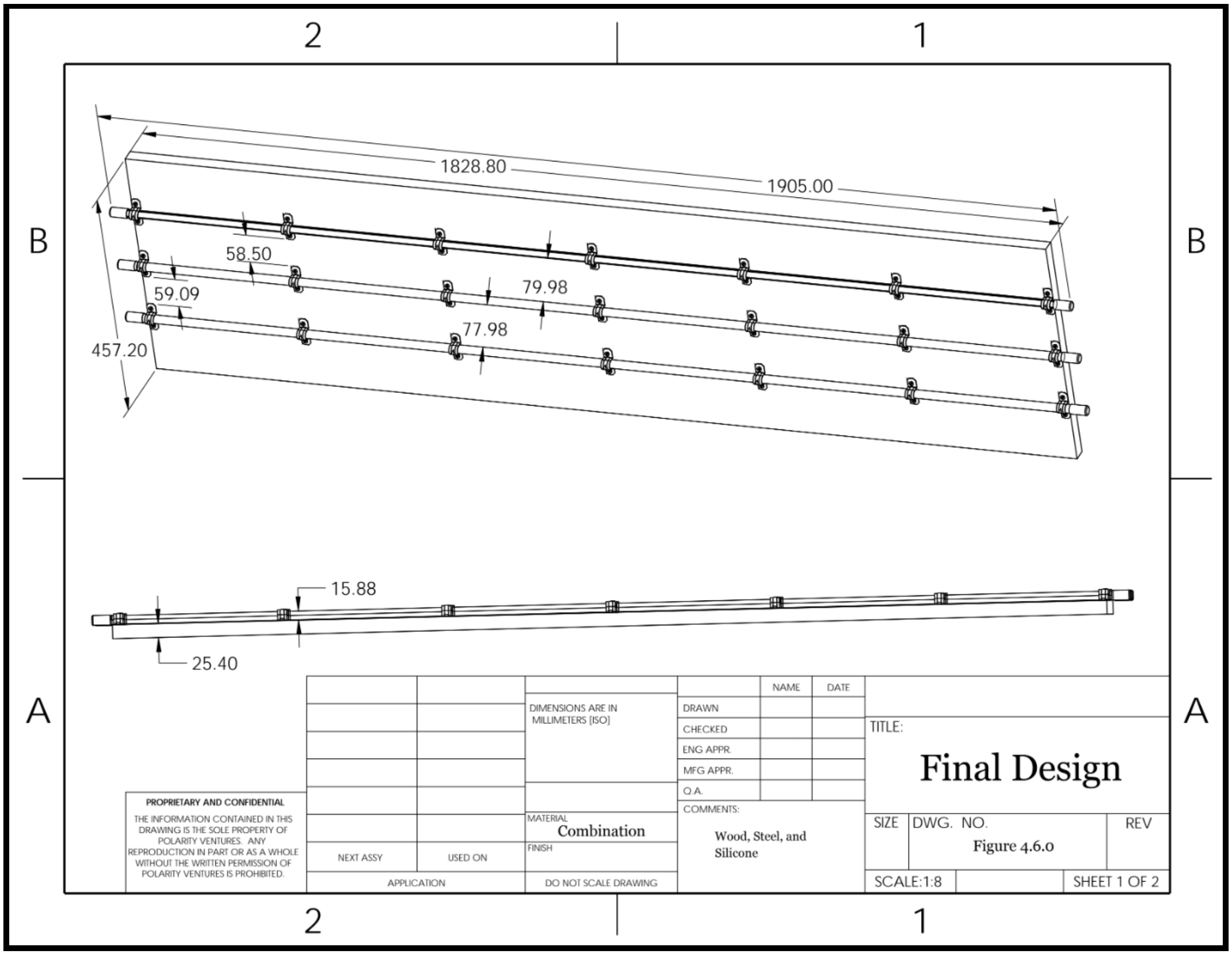

Figure 1.6.1 Completed Structure Design

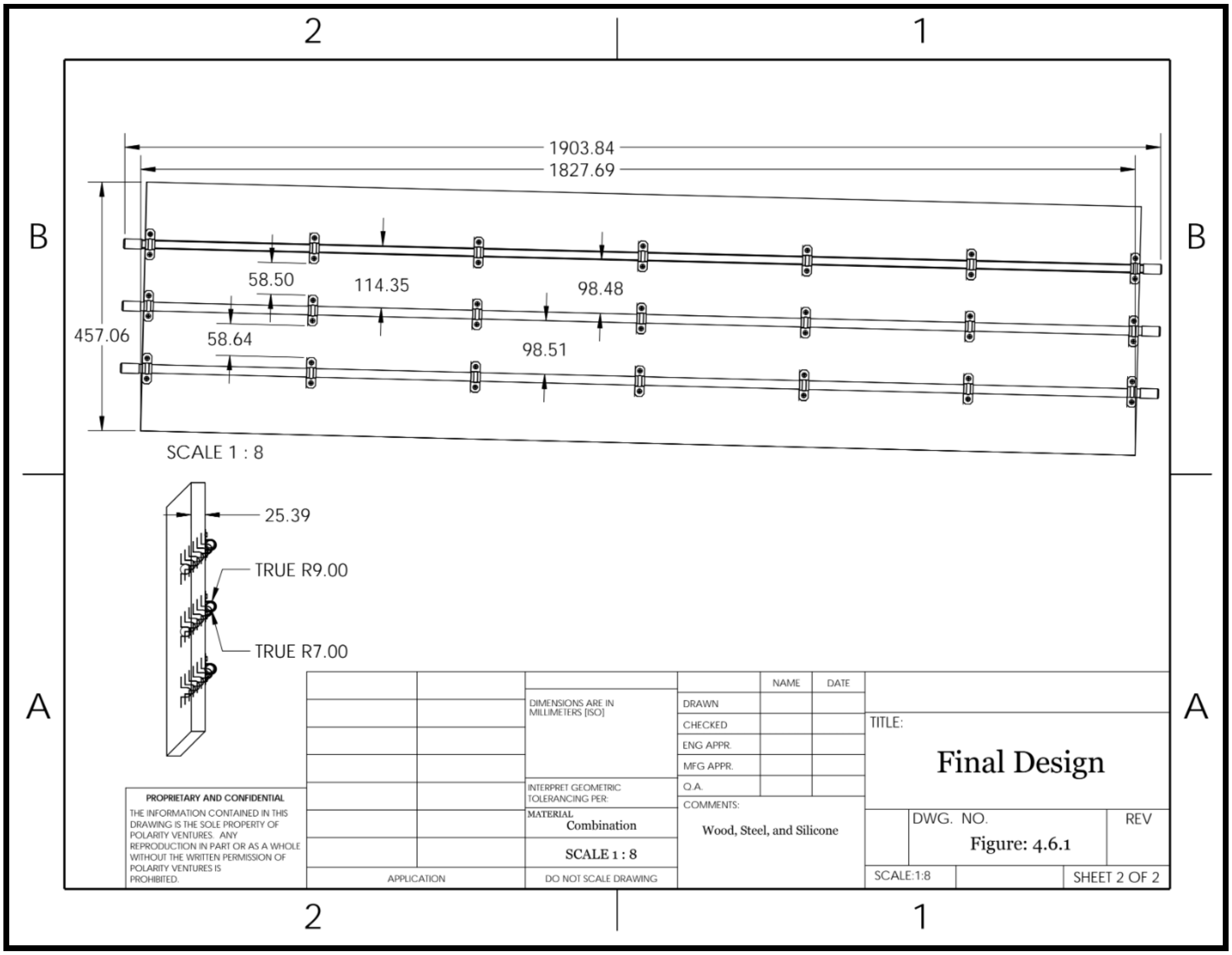

Figure 1.6.2 Completed Structure Design

Design drawing of the entire structure including two closed silicone tubes and one open silicone tube on a base. The distance between the middle of each tube is 4.5 inches.

1.2 Composition

1.2.1 Physical Design Composition

A. Silicone Tubes (Dimensions 1/2" ID x 5/8" OD; Thickness: 1.2 mm; Length:6.25 feet:

   The silicone tubes are utilized in holding the mixed ingredients. Its properties of high flexibility, suitable for food processing, and capability of being sterilized at high temperatures and pressures makes it an ideal material for growing the SCOBY. Three tubes are implemented in the design, one acts as a control and the other two represent a variable whose effects are measured.

B. Rubber End Caps (ID 16 mm):

In order to contain the components of the mixed ingredients and the grown SCOBY inside the tubes, rubber end caps are introduced to the ends. These caps provide a facilitated means of opening and closing the tubes for accessing the contents. The rubber material is a soft and elastic material that allows the cap to expand slightly to the shape of the tube, creating a tighter seal.

C. Plywood Base (Length: 6 ft; Width: 1.5 ft, Height: 1 in):

Since the silicone tubes are highly flexible and the design requires them to be fully extended, they must be secured onto a base. Plywood is a strong and lightweight material that will serve as a sturdy base to allow for the clamps to be screwed into place. It is also an inexpensive material.

D. Galvanized Steel Pipe Clamps (¾ in, 2-holes):

Galvanized Steel Clamps serve the purpose of holding the tubes down onto the base. Only requiring two screws, these clamps allow for effortless attachments to the base. Stainless steel has multiple ideal properties including high tensile strength, high durability, and low maintenance.

E. Screws (3/16 in x 1 in):

Screws work in accordance with the pipe clamps to fix the tubes to the base.

1.2.2 Procedure Design Composition

A. Spring Water (750 mL):

Water is used in the recipe to create the Kombucha tea, which will result in the SCOBY. It is recommended to use either Spring Water or Filtered water for brewing kombucha because it contains all the minerals, but no impurities.

B. White Sugar (100 g):

Along with water, sugar is added in the initial mixture of ingredients to brew the new batch of Kombucha. White sugar is the most widely used sugar in brewing Kombucha, leading to consistent and predictable results with regards to SCOBY growth. In the first step of the fermentation processes, the yeast present converts the sugar into ethanol, which is later converted to acids by the bacteria.

C. Black Tea (4 bags):

Tea is one of the most critical ingredients in making Kombucha. The components within the tea, such as nitrogen and caffeine, are important aspects, along with the sugar, that provides nutrients to the bacteria and yeast and leads to a healthy SCOBY. The selection of black tea originates from the fact that it contains a higher concentration of purines, which is proportional culture activity. Specifically, black tea assists in the metabolism of the microorganisms.

D. Kombucha (235 mL):

A small amount of already brewed and bottled Kombucha is used in brewing a new batch. The starting Kombucha already contains the bacteria and yeast needed to participate in the fermentation process, which facilitates the brewing process.

E. Pot (10.63 x 10.63 x 5.12 inches. Hold 4 quarts):

A pot is required to hold the ingredients while they are being mixed together.

F. Mixing Spoon (13.5 x 2.75 x 1.2 inches):

A mixing spoon is required to mix all the ingredients together.

G. Hot Plate (9.4 x 3.1 x 8.5 inches; 1000 watts):

Prior to introducing the sugar and tea to the pot, the initial water is heated to a boil. This step serves several purposes including eliminating impurities that may be found in the water and also to brew the tea and dissolve the sugar later on.

H. Dremel (5 speed 3.7V):

The dremel is used with a hook attachment to facilitate the twisting of the thread.

I. Spool (53 mm x 58 mm x 14 mm) - height x OD x ID

The final product will be spooled to meet the desired requirement. To determine the proper spool size, the reel factor and cable diameter (the diameter of the SCOBY thread) are required to calculate an estimated maximum cable length.

J. Measuring Tape (120 in (10 ft)/300 cm):

A measure tape is needed to have accurate measurements of the thread. It will also be used to measure the length of the tubes while forming them into their targeted length.

1.3 Formulation

The tables and calculations below demonstrate the measurements and calculations obtained to determine the length of the tubes. The SCOBY initially grows in a wet environment, therefore it is hydrated. One of the characteristics of the SCOBY is its high water retention, which influences the size of the SCOBY prior to drying. When it is left to dry, the SCOBY experiences a drastic change in height. Table 1.3 demonstrates the measurements (length, width, & height) taken when initially removed from the medium and when it is completely dried. Similarly, when the SCOBY will later be twisted into the thread, there will be another decrease in width, which is proposed in Table 1.4.

Table 1.3 Comparison of Length, Width, and Height from When the SCOBY is Wet and When it is Dry

Trial #	Starting Length (Wet)	Starting Width (Wet)	Starting Height (Wet)	Final Length (Dry)	Final Width (Dry)	Final Height (Dry)	Length Decrease (%)	Width Decrease (%)	Height Decrease (%)
1	8.255 cm	9.2075 cm	0.6 mm	5.3975 cm	5.715 cm	0.3 mm	34.74	37.93	50
2	7.9375 cm	7.9375 cm	0.2 mm	5.715 cm	5.715 cm	0.1 mm	28	76.378	50
3	7.62 cm	11.43 cm	0.7 mm	7.3025cm	11.1125 cm	0.3mm	4.18	2.69	57.14
4	6.6675 cm	11.7475 cm	0.4 mm	5.715 cm	11.43 cm	0.1 mm	14.29	2.7	75

Note: Calculations are found in the appendix

Table 1.4 Comparison of Length, Width, and Height from When the SCOBY is Dry and When it is Twisted

Trial #	Starting Length (Dry)	Starting Width (Dry)	Starting Height (Dry)	Final Length (Twist)	Final Width (Twist)	Final Height (Twist)	Length Decrease (%)	Width Decrease (%)	Height Decrease (%)
1	5.3975 cm	5.715 cm	0.3 mm	1.905 cm	1 mm		64.70%	98.25%	
2	5.715 cm	5.715 cm	0.1 mm	1.905 cm	1.1 mm		66.67%	98.08%	
3	7.3025cm	11.1125 cm	0.3mm	1.905 cm	1 mm		73.91%	99.1%	
4	5.715 cm	11.43 cm	0.1 mm	1.905 cm	1 mm		66.67%	99.13%	

Note: Calculations are found in the appendix

1.4 Component Specifications:

Since the SCOBY takes the shape of its container, to obtain the required dimensions of a continuous thread with a 2 mm diameter was based entirely on the length and diameter of the tubes. Ideally, to receive such results would mean to have a 5 foot tube with a 2 mm diameter, however since the tea medium is also inside the tube as the SCOBY forms, the SCOBY will not encompass the full 2mm width. To compensate for this reduction in width, the tube's inner diameter was increased to 12.7 mm (0.5 in). This allows there to be more space to be taken up by both the medium and the SCOBY. Additionally, once the SCOBY is left to dry, the width decreases significantly, approximately 27% . As for the length, the tube was measured to be 6.25 feet long to create a SCOBY of that length. This value was calculated from a reduction in length observed from manually twisting several samples and measuring approximately 20% shorter than the original dried samples.

The base on which the tube will be secured with pipe clamps and screws will measure the length of 6 feet. This is slightly shorter than the length of the tubes so that the caps can be hanging from the sides of the base, allowing for facilitated access. The clamps will be fastened at every foot of the tubes. Also, the width of the base will be 1.5 feet, allowing there to be 4.5 inches of space between the center of each tube.

Section 2
Instructions for Assembly

2.1 Component Manufacturing

For the physical design of the structure where the SCOBY will grow, the silicone tubes are originally obtained at a length of 10 feet. To form them into their 6.25 feet desired length, they are cut using a cutting wheel attachment on the dremel. Similarly, the plywood base is initially presented as a large sheet (of variable dimensions) that will have to be cut when purchased to the dimensions of 6 feet x 1.5 feet x 1 inch. The pipe clamps and rubber end caps do not have to be adjusted, and may be purchased in large quantities.

For the procedure design the measurements for the water, tea, sugar, and bottles of Kombucha are gathered by utilizing measuring cups and spoons.

2.2 Assembly protocol Base Length: 6 feet Width: 1.5 feet Tube length: 6.25 feet

1. Obtain one 6' x 1.5' x 0.5" sheet of plywood and three silicone tubes of 6.25' length and 0.5" diameter.
2. Lay the 6' x 1.5' x 0.5" sheet of plywood on a flat, even surface.
3. Mark the middle point of the plywood which will be at 36in in length and 9in in width. This is where the middle clamp of the middle tube will go and will serve as a reference point.
4. From the clamp placed at 9in in length from the base the clamp to the left will be drilled at 4.5in in width and to the right will be at 13.5in in width. Ensuring that each tube is equally spaced by 4.5 in.
5. Position 1/2 inC clamps at intervals of 12inalong the length of the tubes and mark the spots to be screwed. The clamps will also be placed at both ends of the plywood (at 0 in and 72in).
6. Pre-drill pilot holes through the plywood at every marked spot until the screw can fit tightly.
7. Screw in a ½ in long screw into each hole, through the C clamps, fastening the tube in place.

2.3 Disassembly

1. Unscrew the ½ inlong screw from each hole of the C clamps, loosening the tube.
2. Remove the tubes from their positions and stow away.

2.4 Operation

Once the brewed Kombucha is in the tubes, there is no need for manual manipulation to get the desired product until the end of its duration. The tubes serve the purpose of holding the tea in a cylindrical shape so that as it ferments and the SCOBY begins to form, it remains in that shape. Once either 2 weeks or 3 weeks of fermentation is done, the remaining medium is poured out by removing the caps and tubes from the base, and the SCOBY will also slide out.

2.5 Maintenance

Prior to each fermentation in the tubes, they will be sterilized using 2 washes of 50 ml of 90% isopropyl alcohol. The alcohol will be poured in the tubes and allowed to run down to ensure that the entire inside is covered. In addition, the alcohol will be used after each process to clean the rubber caps.

Section 3
Production Process Specification

3.1 Production Procedure

Brewing

1. In a pot, 375 ml of water will be brought to a boil (100 °C).
2. 50 g of sugar will be added and then dissolved.
3. 2 standard tea bags will be steeped for 15 minutes and then removed. *note each tea bag contains around 3g of tea.
4. 375 ml of room temperature water (around 26°C) will then be added to help decrease the cooling time.
5. Once the mixture cools to 30°C, 118 ml of unflavored, unpasteurized Kombucha can be added to the tea and then stirred.

Fermentation

6. Fill the tubes with 100ml solution.
    a. For the open tube, ensure that both of the rubber caps are tightly secured and then with a measuring cup and funnel the solution will then be poured into the mold filling it to just below the edge of the wall.
    b. For the closed tubes, secure one end of the tube with the rubber cap and then using the funnel the solution will be poured into the open end. Then secure that end with a rubber cap.
7. The solution will be left to ferment for 2 weeks (open and control tube) 0r 3 weeks.

Purifying

8. After fermentation, the remaining solution will need to be drained.
9. The thread will be rinsed with around 20ml of 1 M NaOH and then rinsed with distilled water.
10. The SCOBY will then be left to dry for 1 week.

Spooling

11. The thread will be removed from the mold after 1 week of drying.
12. The thread will be twisted upon itself after it has been dried. A dremel will aid in the twisting. One end of the thread will be secured to a hook with the other end attached to the dremel. When the dremel is turned on and in use it will twist the cord in about 5 seconds.
13. After twisting the thread will be wrapped around a spool and the ends will be fastened so that it does not untangle.

The above procedure will be slightly altered depending on which of the three variables. This can be best observed within the following flow chart. All changes will occur in the fermentation stage which can be seen within the diagram below:

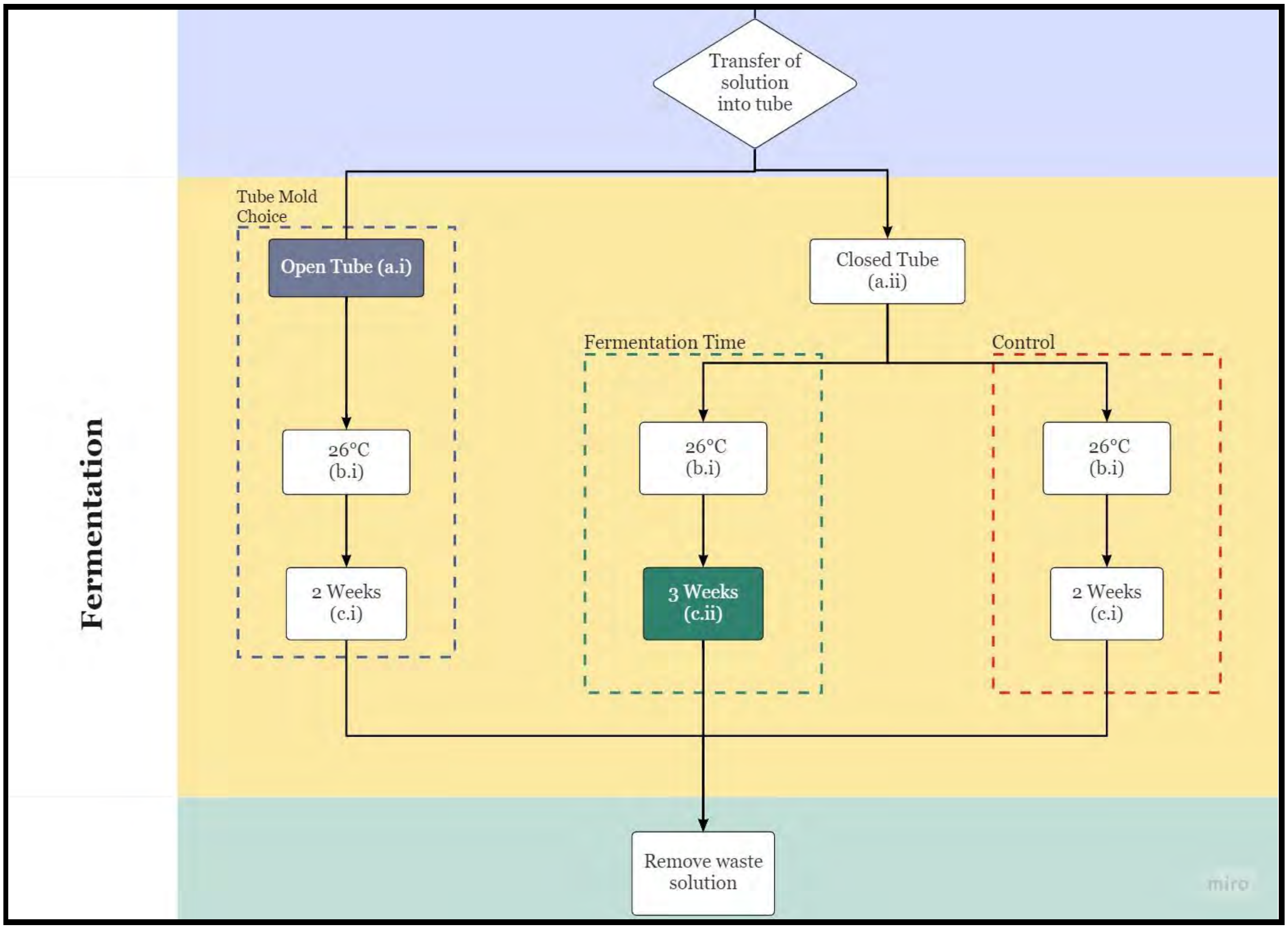

Figure 3.1 Close up of the fermentation step in the process flow chart.

3.2 Production Environment Specifications

The production of the SCOBY Biothread must be held in an indoor environment with a room temperature around 26 °C. The tube molds must also not be moved or disturbed during the fermentation period since this can disrupt the SCOBY and cause inconsistent growth.

Section 4 Manufacturing

4.1 Manufacturing

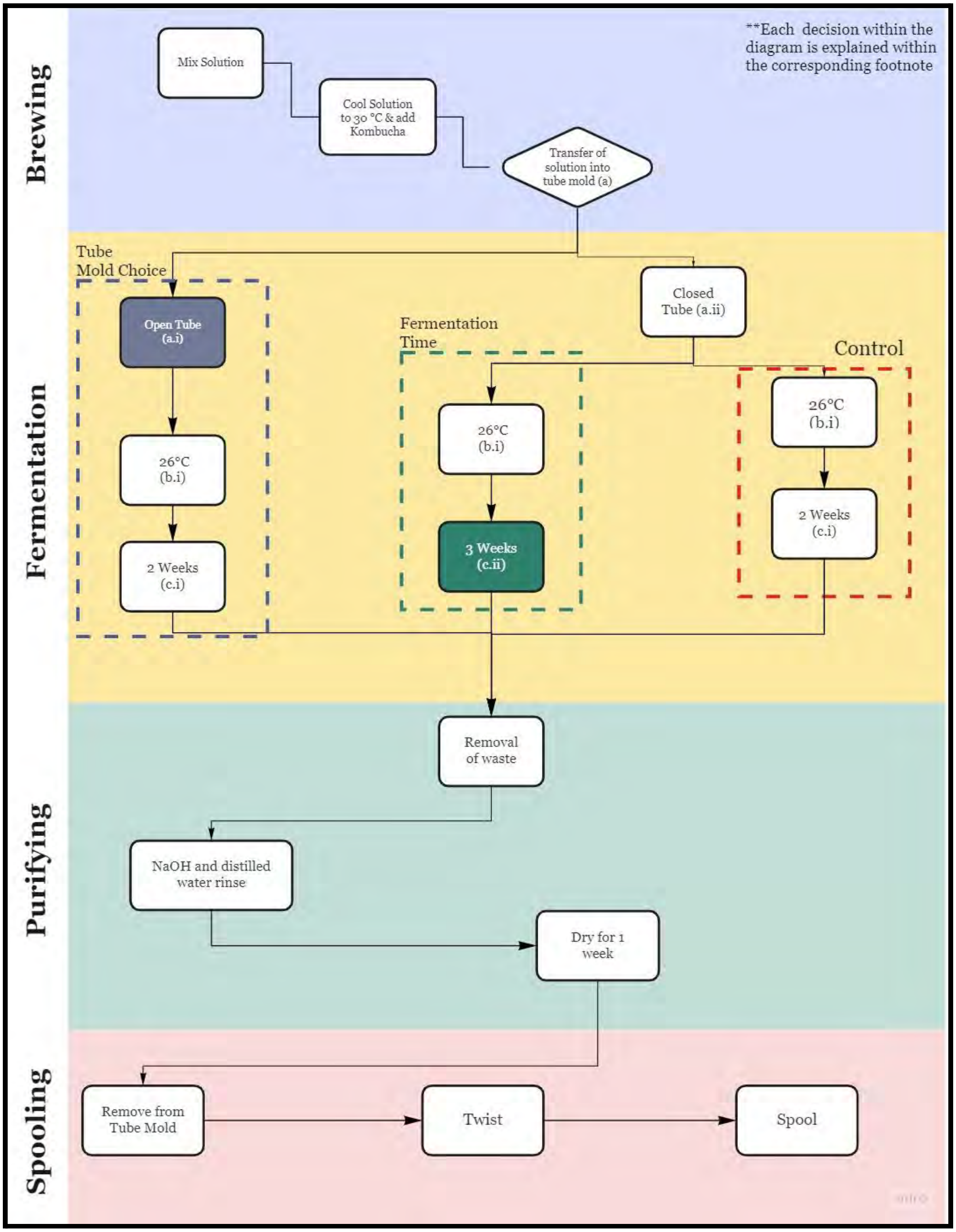

Figure 4.1 Flowchart demonstrating each step within the process.

After the thread has been produced and has gone through the brewing and fermentation stages, it will need to be purified and spooled. NaOH treatment is necessary to remove any residues from the tea solution and aidment in the shelf life of the finished product.

Twisting the thread will help in maintaining the strength and keeping a thread shape. The twisting process of the thread will be done with the hook attachment on the dremel. In order to complete this twisting, one end of the SCOBY thread will be tied around the hook on the dremel and the other end will be secured to a table. The dremel will then be turned on to a low speed and the thread will then twist.

4.2 Construction

The physical design will be constructed in an open area large enough to fit the structure. It will be built using at home power tools such as a drill. The plywood base will be trimmed to its necessary dimensions of 6 feet by 1.5 feet by the distributor. The clamps will be secured into place with a drill. The dremel will also be used to trim the silicone tubes to the desired length of 6.25 feet. The dremel will also be used to make the cross sectional cut for the open tube system.

In regards to the procedure design, those steps will be conducted within the Polarity Ventures facility located in Medley, Florida. This will include all steps including the brewing, fermentation, purifying and spooling.

4.3 Equipment Used

Table 4.1 Purpose of Equipment Used

Equipment	Purpose
Dremel	To cut the silicone tubes to desired dimensions, make the cross sectional cut and twist the thread
Drill	To screw the clamps into place on the base
Hot Plate	To heat the water during the brewing process

4.4 Bills of Lading

Table 4.2 Price Analysis

Section	Parts	Price	Per	Quantity	Total	Cash Outlay
Materials						
Final Product						
	Plywood	$66.67	Unit	1	$66.67	$66.67
	Silicone Tubes	$12.99	Unit	3	$38.97	$38.97
	Rubber Caps	$5.99	10 Units	6/10	$3.40	$3.40
	Screws	$1.28	14 Units	42	$3.84	$3.84
	Steel Clamps	$6.38	25 Unit	21/25	$5.36	$5.36
	Sugar	$1.54	1 lb (454g)	50g	$0.17	$0.17
	Black Tea	$4.65	100 Unit	2/100	$0.09	$0.09
	Kombucha	$3.65	474 ml	118ml	$0.90	$0.90
	Water	$0.98	3.78 L	750ml	$0.19	$0.19
	Spool	$22.79	20 Unit	1/20	$1.14	$1.14
	NaOH	$25.05	1 L	50ml	$1.25	$1.25
	Dremel	$23.38	Unit	1	$23.38	$23.38
Testing & Verification						
	Solids pH Meter	$97.99	Unit	1	$97.99	$97.99
	Caliper	$9.99	Unit	1	$9.99	$9.99
	Tape Measurer	$5.99	2 Unit	1	$2.99	$2.99
	Stress/Strain Apparatus	$799	1 Unit	1	$799	$0
	PASPORT Rotary Motion Sensor	$185	1 Unit	1	$185	$0.00
	PASPORT Force Sensor	$139	1 Unit	1	$139	$0.00
	Capstone Software	$695	1 Unit	1	$695	$0.00
Software	Solidworks	$3,995	Unit	1	$3,995	$0.00
	Microsoft Project Plan	$1,129.99	Unit	1	$1,129.99	$0.00
	Slack	$0	Unit	1	$0.00	$0.00

Materials Total	$7,232.31			Materials	$7,232.31	$289.32
Unit Materials Total	$256.33			Unit Materials	$7,199.32	$256.33
Labor		$15	Hour	4.5	$67.50	$0.00
Product Cost					$323.83	$256.33
Total Project Cost					$356.82	$289.32

Overhead	40% Labor + 14% Material Cost
Total	$67.50
Unit	$62.89
Total Project Price	$424.32
Total Unit Price	$386.72

Section 5 Verification

5.1 Verification Protocols

Verification and Verification Test Protocols

Table 5.1 Design Input and Verification Test for Market Requirement #1

Market Requirement	Design Input	Verification Testing
The Bio-thread will contain bioactive compounds.	The final product will have cellulose.	Schulze's Reagent. A purple color change occurs in the presence of cellulose
	Rationale: Cellulose is a biocompatible material that has the capability of promoting wound healing.	

1. Place the Scoby Bio-thread at the base of an open container.
2. Using a measuring cylinder, measure 50 mL of Schulze's reagent.
3. Using a syringe, apply Schultze's reagent along the length of the Bio-thread.
4. Record all color changes present and any other observations which may be present.
5. If the Bio-thread changes to a purple color, cellulose is present and the verification test is passed.

Table 5.2 Design Input and Verification Test for Market Requirement #2

Market Requirement	Design Input	Verification Testing
An uninterrupted Bio-thread with dimensions that will facilitate large scale manufacturing	The Bio-thread must present repeatability with a length of 152.4 +/- 15.24 cm and a diameter of 2 +/- 0.2 mm to allow for future large scale production.	Measure the final length of the Bio-thread using a tape, measure the width two dimensionally across each foot of the Bio-thread using calipers, determine the standard deviation of the width and compare it to the standard deviation across the entire length.
	Rationale: Future large scale production	

1. Place the Scoby Bio-thread along a long, flat surface and using a tape measure, record the total length of the Bio-thread.
2. Keeping the Bio-thread in the same position, measure the width two dimensionally across every 2.5 centimeters of the Bio-thread using calipers, determine the average and tabulate all results.
3. Determine the standard deviation of the width across every 2.5 centimeters of the Bio-thread and compare it to the standard deviation across the entire length.
4. Determine the standard error of the mean by dividing the standard deviation by the square root of the sample size.
5. Once the Bio-thread has a length of 152.4 +/- 15.24 cm and a diameter of no greater than 2 +/- 0.2 mm, the verification test is passed.

Table 5.3 Design Input and Verification Test for Market Requirement #3

Market Requirement	Design Input	Verification Testing
The Bio-thread must be strong and flexible for future use in wound dressings.	The Bio-thread must endure a tensile stress of 32 MPa and fit around a spool with a diameter of 1.0 cm	Tensile Strength testing: The Bio-thread must endure a minimum tensile stress of 32 MPa cycles to ensure strength. Flexibility testing: The bio-thread must spool around a spool with 1.0 cm diameter without fracturing.
	Rationale: To allow for future use in wound dressings	

1. Spool a 40 cm specimen of the SCOBY Bio-thread on a spool with 1.0 cm diameter. Observe whether any fractures occur and record results.
2. Load an 11.5 cm specimen of the SCOBY Bio-thread into a tensile stress test machine.
3. Begin the test by pulling at a constant rate of extension specified in the standard and stop the test once the tensile stress has exceeded 32 MPa.
4. Once the biothread endures a tensile stress of 32 MPa and is successfully spooled on a spool with 1.0 cm diameter without fracturing, the verification test is passed.

Table 5.4 Design Input and Verification Test for Market Requirement #4

Market Requirement	Design Input	Verification Testing
The SCOBY must not be acidic	The pH of the SCOBY must not be below 4.7	Measure the pH at every 2.5 cm and calculate the standard deviation.
	Rationale: The average pH of natural skin is 4.7. Since the SCOBY is in contact with various acids, it may adopt an acidic concentration, which will need to be measured to ensure it will not harm the skin.	

1. Place the Scoby Bio-thread along a long, flat surface.
2. Measure the pH of Bio-thread at intervals of 2.5 cm.
3. Determine the standard deviation of the pH across every 2.5 cm of the Bio-thread and compare it to the standard deviation across the entire length.
4. Determine the standard error of the mean by dividing the standard deviation by the square root of the sample size.
5. Once the Bio-thread has a pH of greater than 4.7, the verification test is passed.

5.2 Verification Results

Table 5.5 Results from the Verification Tests

Parameter	Verification Test Result	Average Measurement	Standard Error of the Mean	Average Standard deviation across every specified unit	Standard deviation across all units
Cellulose presence	Passed	Passed	N/A	N/A	N/A
Continuous Length / cm	Failed	51.5	N/A	N/A	N/A
Diameter / mm	Passed	1.073	0.019	0.044	0.088
Tensile Stress Test / MPa	Failed	6.41	N/A	N/A	N/A
Flexibility test	Passed	N/A	N/A	N/A	N/A
pH	Passed	7.311	0.008	0.023	0.037

Section 6 Quality Assurance Procedures & Specifications

6.1 Quality Objective

The objective of growing the symbiotic culture of yeast and bacteria, SCOBY, and processing it into a thread-like structure and spooling it onto a spool is to later weave the thread into a material that would be used as a wound dressing that would ideally speed up the healing process due to the presents of cellulose within the SCOBY itself.

6.2 Quality Management System

Standards:

Table 6.1 Standards

Standard	Name
ISO 21710:2020	Biotechnology — Specification on data management and publication in microbial resource centers
ISO 15882:2008	Sterilization Of Health Care Products - Chemical Indicators - Guidance For Selection, Use And Interpretation Of Results
ISO 979:1974	Sodium Hydroxide For Industrial Use -- Method Of Assay
ISO 21527-2:2008	Microbiology Of Food And Animal Feeding Stuffs - Horizontal Method For The Enumeration Of Yeasts And Moulds - Part 2: Colony Count Technique In Products With Water Activity Less Than Or Equal To 0,95
ISO 20743:2021	Determination of antibacterial activity of textiles products
ISO 4045:2018	Chemical tests- Determination of pH and difference figure.

6.3 Quality Assurance in Equipment Specifications

Part 1: Quality Assurance in the selection of shape of the mold for fermentation of Bioactive SCOBY thread

Initially, in the design of the mold for the fermentation process, we analyzed the amount of space available in which to perform the growth of the SCOBY. We then designed the mold to fit the silicone material tube in a non conformed shape. We proposed that this would lead to small distortions in the SCOBY's shape that were enough to be considered undesirable due to the need for uniformativeity of the material when taking into account the intermediate product would need to be spooled and later weaved into a final product of a wound dressing, or like shape.

With the increase of space to perform the growth of the bioactive SCOBY thread, we accommodated for the desired finished product by first analysis of the bioactive SCOBY's natural growth. When it's grown in a container, it takes the shape of its container. We observed this first by watching several videos of people growing the SCOBY for their personal purpose of digesting the Kombucha. Then, we performed small test batches of kombucha fermentation (ranging in a variety of different sizes and container shapes), to further analyze and observe the growth of the SCOBY. During the fermentation process, we analyzed the growth at different time intervals. When we removed the SCOBY from each of its respective molds, the SCOBY took the shape of its container and, depending on the amount of time it had to grow, determined the amount of compounded layer the SCOBY's thickness was capable of growing to.

We then finalized the shape of the mold to represent the final product of the thread itself.

6.4 Quality Assurance Procedures

1. **Presence of Cellulose Test**

In order to determine the final bioactive compounds of the SCOBY bio-thread, the use of Schulze's Reagent will allow us to determine if cellulose is present in the final product. The Schulze's Reagent is an oxidizing mixture consisting of aqueous solution of potassium chlorate $KClO3$ and varying amounts of concentrated nitric acid $HNO3$. This solution would be used along the length of the thread in which monitoring will occur. A color change would be observed, if the color turns to a purple color then we can guarantee that cellulose is present in the final product.

2. **Acidity Test**

Once the fermentation is successfully completed since the Kombucha culture is composed of a symbiotic growth of acid producing bacteria, the pH of the thread will be acidic.

Since our main focus is for the thread to be used in the wound dressing department. The final product must not be acidic and to achieve this methodology a pH meter would be used once the thread is created. Intervals of 3 inch would be ideally used then the standard deviation would be calculated and compared to the standard deviation of the entire length of the thread.

3. NaOH treatment/ Purification

The major components once the thread will be created are gluconic, acetic, lactic acids and ethanol and minor amounts of vitamins such as (B1, 2, 6, 12 and C). However, the main byproduct is cellulose which is the one we are interested in. In order to remove the unwanted byproducts the thread will be subjected to 1.0 M of NaOH solution. The tread will be submerged in the solution for 1.0 hour then washed with deionized water.

Section 7 Appendix

SCOBY Size Reduction

Calculations:

Equation:

$$Percentage\ Decrease = \frac{(Starting\ Value - Final\ Value)}{[Starting\ Value]} \times 100$$

Trial 1:
Length:

$$\frac{(8.255-5.3875)}{[8.255]} \times 100 = 34.74\%$$

Width:
$$\frac{(9.2075-5.715)}{[9.2075]} \times 100 = 37.93\%$$

Height:
$$\frac{(0.6-0.3)}{[0.6]} \times 100 = 50\%$$

Trial 2:
Length:

$$\frac{(7.9375-5.715)}{[7.9375]} \times 100 = 28\%$$

Width:
$$\frac{(12.7-3)}{[12.7]} \times 100 = 76.378\%$$

Height:
$$\frac{(0.2-0.1)}{[0.2]} \times 100 = 50\%$$

Trial 3:
Length:

$$\frac{(7.62-7.30125)}{[7.62]} \times 100 = 4.18\%$$

Width:
$$\frac{(11.42-11.112)}{[11.43]} \times 100 = 2.69\%$$

Height:
$\frac{(0.7-0.3)}{[0.7]} \times 100 = 57.14\%$

Trial 4:
Length:

$\frac{(6.6675-5.715)}{[6.6675]} \times 100 = 14.29\%$

Width:
$\frac{(11.7475-11.43)}{[11.7475]} \times 100 = 2.7\%$

Height:
$\frac{(0.4-0.1)}{[0.4]} \times 100 = 75\%$

Calculations:

Equation:

$$Percentage\ Decrease = \frac{(Starting\ Value - Final\ Value)}{[Starting\ Value]} \times 100$$

Trial 1:
Length:

$\frac{(5.3972-1.905)}{[5.3975]} \times 100 = 64.70\%$

Width:
$\frac{(5.715-0.1)}{[5.715]} \times 100 = 98.25\%$

Trial 2:
Length:

$\frac{(5.715-1.905)}{[5.715]} \times 100 = 66.67\%$

Width:
$\frac{(5.715-0.11)}{[5.715]} \times 100 = 98.08\%$

Trial 3:
Length:

$$\frac{(7.3025-1.905)}{[7.3025]} \times 100 = 73.91\%$$

Width:

$$\frac{(11.1125-0.1)}{[11.1125]} \times 100 = 99.1\%$$

Trial 4:

Length:

$$\frac{(5.715-1.905)}{[5.715]} \times 100 = 66.67\%$$

Width:

$$\frac{(11.43-0.1)}{[11.43]} \times 100 = 99.13\%$$

FLORIDA INTERNATIONAL UNIVERSITY

BME 4800C SENIOR DESIGN PROJECT
DESIGN HISTORY FILE

Manufacturing Process of a SCOBY Bio-Thread

Submitted in partial fulfillment of the
requirements for the degree of

BACHELOR OF SCIENCE
in
BIOMEDICAL ENGINEERING

Date: 12/8/2021

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Market Requirements

A. Clinical Research

Wound dressings was the selected application for the SCOBY Bio-Thread. A wound dressing is characterized as a sterile interface that is applied directly on a wound to aid in its healing process, while also preventing it from experiencing additional harm. A general classification of types of dressings includes natural and synthetic. The natural dressings are composed of natural polymers, proteoglycans, or proteins, whereas the synthetic ones are mostly made from synthetic polymers. Both methods demonstrate biocompatibility and biodegradability, however the components of natural dressings also demonstrate similarity in the macromolecules found within the body. Additionally, dressings can be further classified into passive, interactive, and bioactive. Passive wound dressings only cover the wounds, are non-occlusive, and are highly permeable. Interactive dressings are involved in wound healing through the production of a moist environment and are occlusive. Lastly, bioactive dressings are composed of biocompatible and biodegradable materials that contribute to the healing process. Specifically, the bacterial cellulose component of the SCOBY byproduct would characterize the wound dressing as natural and bioactive. In addition, research on bacterial cellulose has shown that it contains several special properties, such as biocompatibility, biodegradability, hydrophilicity, formation of semi-crystalline fibers, chirality, and a wide chemical-modifying capacity. Other bioactive materials used in wound dressings include collagen, hyaluronic acid, chitosan, and pectin.

Dressings are applied onto two types of wounds: acute and chronic. Acute wounds follow the duration and stages of the normal healing process, whereas chronic wounds are slow to heal and do not progress through the expected phases of the healing. Due to its association with chronic diseases, the frequency of chronic wounds is increasing annually, with the biggest contributors being diabetes and obesity. The last reviewed dataset on wound dressings was a 2018 retrospective analysis of the 2014 Medicare 5% data. The data illustrated that 8.2 million Medicare individuals were affected by Chronic, Non-healing Wounds in the United States.

B. Market Data

As mentioned in the Clinical Research section, the number of chronic wounds is increasing annually. As a result, there is an increasing demand for additional wound dressings that target chronic wounds specifically. In 2020, the global market for wound dressings was approximated at 15.25 billion USD, and it is projected to increase at a CAGR of 6.1%, reaching 24.01 billion USD in 2028. However, the general wound dressing market experienced a decrease in value in 2020 due to the repercussions of COVID-19. As the conditions of the pandemic continue to improve, the market will also improve, as depicted in its projection. In addition and more specific to our bioactive thread, the global bioactive wound dressing market is expected to grow to 14.588 billion USD by 2028. Bioactive dressings have shown to be useful in the healing process of chronic wounds. Also, chronic wounds held a dominant share in the entire wound dressing market in 2020.

Some of the top contributors to the market include Medline Industries, Inc., Smith & Nephew PLC, Mckesson Corp., Sam Medical, Coloplast Corp., and Derma Sciences, Inc.

C. Market Requirements

Market Requirements Revised 11/18

- The device must be manufactured at a low cost
- Must have the ability to spool and unspool without aggregation
- The device must be uninterrupted for its targeted length of 5 feet and 2 millimeter diameter
- The container that the SCOBY will be produced in most not interfere with the product

Market Requirements Revised 11/21
- The device must be manufactured at a low cost
- Must have the ability to spool and unspool without any form of self adhesion
- The device must be uninterrupted for its targeted length of 5 feet and 2 millimeter diameter.
- The container that the SCOBY will be produced in must not interfere with the product.

Market Requirements Revised 11/23
- The device must be manufactured at a low cost, less than $430 per unit.
- Must have the ability to spool and unspool without any form of the self adhesion, delamination or separation
- The device must be uninterrupted for its targeted length of 5 feet and 2 millimeter diameter.
- The container will not interfere with the chemical make up of the SCOBY

Market Requirements Revised 11/28
- The device must be manufactured at a low cost, less than $432 per unit.
- Must have the ability to spool an unspool without any form of self adhesion, delamination, or separation.
- The device must be uninterrupted for its targeted length of 5 feet and 2 millimeter diameter.
- The container will not interfere with the chemical makeup of the SCOBY.
- The SCOBY thread must contain bioactive compounds.

Market Requirements Revised 12/4
- The device must be manufactured at a low cost below $432 per unit.
- The device must be uninterrupted for its targeted length of 5 feet and 2 millimeters in diameter.
- The container will not interfere with the chemical makeup of the SCOBY, during manufacturing of the kombucha fermentation.
- The SCOBY thread must contain bioactive compounds.
- The SCOBY thread must be flexible and withstand bending.
- The SCOBY thread must withstand the forces of spooling and while in use.

Market Requirements Revised 2/10
- The Bio-Thread will contain bioactive compounds.
- An uninterrupted Bio-Thread with dimensions that will facilitate large scale manufacturing.
- The Bio-Thread must be flexible to be woven into future wound dressings.

- The SCOBY must not be acidic

Current Market Requirements 3/29

- The Bio-Thread will contain bioactive compounds.
- An uninterrupted Bio-Thread with dimensions that will facilitate large scale manufacturing.
- The Bio-Thread must be strong and flexible for future use in wound dressings.
- The SCOBY must not be acidic

Design Inputs

A. QFD Analysis

		1	2	3	4		Design Concepts		
Row #	Market Requirements / Design Inputs	The final product will have cellulose.	The Bio-thread must present repeatability with a length of 5' +/- 6" and a diameter of 2 mm +/- 0.2 mm to allow for future large scale production	The Bio-thread must be able to bend repeatedly 360 degrees in both directions and not exhibit shape memory	The pH of the SCOBY must not be below 4.7	MR Priority	Tubes in snake formation in bins	Wrapping tubes around a cylinder structure	Extended tubes secured on a base
1	The Bio-thread will contain bioactive compounds.	++				3	1	1	1
2	An uninterrupted Bio-thread with dimensions that will facilitate large scale manufacturing.		++	+		5	5	3	5
3	The Bio-thread must be flexible to be ultilized in future applications.		+	++		3	3	5	5
4	The SCOBY must not be acidic				++	5	1	1	1
	Total					80	42	38	48

Figure 1.1 QFD Analysis of Market Requirements, Design inputs, and Design Concepts

B. Design Inputs by Function

Design Inputs Revised 11/22/21

Table 1.1 Design Inputs 11/22/21

Market Requirement	Design Input
The device must be uninterrupted for its targeted length of 5 feet and 2 millimeters in diameter.	The SCOBY will be produced in a container that is longer than 5 feet and 2mm in diameter.
Manufactured at a low cost below $430 per unit.	The materials per unit will not cost more than $40.
Must have the ability to spool and unspool without any form of self adhesion, delamination, or separation.	The thread will not exhibit a displacement greater than 30% of its length under stress.
The container will not interfere with the	A container that neither harvests bacteria nor

chemical makeup of the SCOBY.	reacts with the acidity of the Kombucha.

The above design inputs were first formulated off of the provided scope of the project. These design inputs hit the big three characteristics that were involved in the scope such as, the required dimensions, ability to spool and low cost.

Design Inputs Revised 11/28/21

Table 1.2 Design Inputs 11/28/21

Market Requirement	Design Input
The device must be uninterrupted for its targeted length of 5 feet and 2 millimeters in diameter.	The SCOBY will be produced in a container that is longer than 5 feet and 2mm in diameter.
Manufactured at a low cost below $430 per unit.	The materials per unit will not cost more than $40.
Must have the ability to spool and unspool without any form of self adhesion, delamination, or separation.	The thread will not exhibit a displacement greater than 30% of its length under stress.
The container will not interfere with the chemical makeup of the SCOBY.	A container that neither harvests bacteria nor reacts with the acidity of the Kombucha.
The SCOBY thread must contain bioactive compounds.	The final product will contain cellulose.

The last design input was added to include more characteristics regarding the thread itself.

Design Inputs Revised 12/4/21

Table 1.3 Design Inputs 12/4/21

Market Requirement	Design Input
The device must be uninterrupted for its targeted length of 5 feet and 2 millimeters in diameter.	The SCOBY will be produced in a container that is longer than 5 feet and 2mm in diameter.
Manufactured at a low cost below $432 per unit.	The materials per unit will not cost more than $35.
The container will not interfere with the	A container that neither harvests bacteria nor

chemical makeup of the SCOBY.	reacts with the acidity of the Kombucha.
The SCOBY thread must contain bioactive compounds.	The final product will contain cellulose.
The SCOBY thread must be flexible and withstand bending	The thread must be able to bend 180 degrees without snapping and exhibit a Young's Modulus less than 1 MPa.
The SCOBY thread must withstand the forces of spooling and in use	Will be able to exhibit a tensile strength of at least 32 MPa

After the Q&A presentation it was decided that there needed to be more characteristics in regards to the thread, especially the mechanical properties of it. With that being stated more research was conducted and it was determined that flexibility, Young's Modulus as well as tensile strength will have to be incorporated within the design.

Design Inputs Revised 2/10/22

Table 1.4 Design Inputs 2/10/22

Market Requirement	Design Input
1.The Bio-thread will contain bioactive compounds.	The final product will have cellulose.
	Rationale: Cellulose is a biocompatible material that has the capability of promoting wound healing.
2. An uninterrupted Bio-thread with dimensions that will facilitate large scale manufacturing	The Bio-thread must present repeatability with a length of 152.4 +/- 15.24 cm and a diameter of 2 +/- 0.2 mm to allow for future large scale production
	Rationale Future large scale production
3. The Bio-thread must be flexible to be woven into future wound dressings.	The Bio-thread must be able to bend repeatedly 360 degrees in both directions and not exhibit shape memory
	Rationale To allow for future use in wound dressings

4. The SCOBY must not be acidic	The pH of the SCOBY must not be below 4.7
	Rationale: The average pH of natural skin is 4.7[1]. Since the SCOBY is in contact with various acids, it may adopt an acidic concentration, which will need to be measured to ensure it will not harm the skin.

Current Design Inputs 3/29/22

Table 1.5 Current Design Inputs

Market Requirement	Design Input
1. The Bio-thread will contain bioactive compounds.	The final product will have cellulose.
	Rationale: Cellulose is a biocompatible material that has the capability of promoting wound healing.
2. An uninterrupted Bio-thread with dimensions that will facilitate large scale manufacturing	The Bio-thread must present repeatability with a length of 152.4 +/- 15.24 cm and a diameter of 2 +/- 0.2 mm to allow for future large scale production.
	Rationale: Future large scale production
3. The Bio-thread must be strong and flexible for future use in wound dressings.	The Bio-thread must endure a tensile stress of 32 MPa and fit around a spool with a diameter of 1.0 cm
	Rationale: To allow for future use in wound dressings
4. The SCOBY must not be acidic	The pH of the SCOBY must not be below 4.7
	Rationale: The average pH of natural skin is 4.7. Since the SCOBY is in contact with various acids, it may adopt an acidic concentration, which will need to be measured to ensure it will not harm the skin.

C. Design Concepts

Design Concepts Revised 1/16/22

Design Concept 1 - Tubes in snake formation in bins

Four 190.5 cm silicone tubes with an ID of 1.27 cm and an OD of 1.5875 cm are acquired. Each tube represents a different condition that is being tested to see how it may improve the results from the control variable from the patent. Tube #1 is the control that will ferment at room temperature in an enclosed tube for two weeks. Tube #2 represents an open system, which has the tube cut through the center of the cross section, exposing half of the area to open air for two weeks at room temperature. Tube # 3 represents the time variable, which means it will ferment at room temperature in an enclosed tube for three weeks. Lastly, tube #4 represents the heat variable. This enclosed tube will be fermented at 27 °C for two weeks.

Four plastic bins with dimensions 23.4" x 16.9" x 6.7” would hold the tubes in a snaked configuration, as shown below. The tube would be snaked at the base of the bins, only requiring two loops inside. The rubber caps on the ends of the tubes would stand outside of the bins through holes with a diameter of 16 mm. The purpose of the bins is to keep the long tubes in a contained space, since the amount of space provided by the Sponsor was limited to a 5-foot x 5-foot workstation.

Tubes # 1 and #3 does not require any manipulation since the first one is the control, and the third one depends on time. Tube #2 needs to be cut through the center using a dremel with a cutting wheel attachment, and Tube #4 will need to have heating pads on the bottom of it to ensure it is at 27 °C.

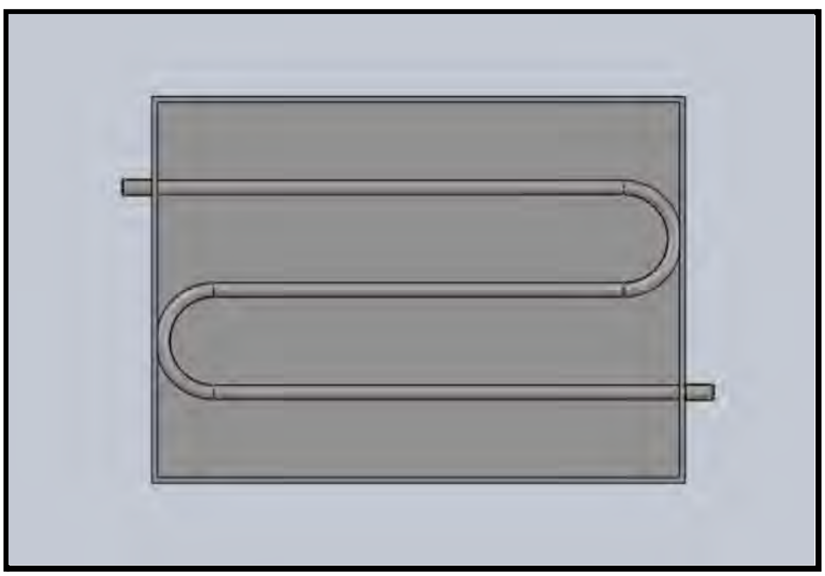


Figure 1.2 Design Concept 1

Design Concepts Revised 2/22/22

Design Concept 1 - Tubes in snake formation in bins

Four 190.5 cm silicone tubes with an ID of 1.27 cm and an OD of 1.5875 cm are acquired. Each tube represents a different condition that is being tested to see how it may improve the results from the control variable from the patent. Tube #1 is the control that will ferment at room temperature in an enclosed tube for two weeks. Tube #2 represents an open system, which has the tube cut through the center of the cross section, exposing half of the area to open air for two weeks at room temperature. Tube # 3 represents the time variable, which means it will ferment at room temperature in an enclosed tube for three weeks. Lastly, tube #4 represents the heat variable. This enclosed tube will be fermented at 27 °C for two weeks.

Four plastic bins with dimensions 23.4" x 16.9" x 6.7" would hold the tubes in a snaked configuration. The tube would be snaked at the base of the bins, only requiring two loops inside. The caps on the ends of the tubes would stand outside of the bins through holes with a diameter of 16 mm. The purpose of the bins is to keep the long tubes in a contained space, since the amount of space provided by the Sponsor was limited to a 5-foot x 5-foot workstation.

Tubes # 1 and #3 does not require any manipulation since the first one is the control, and the third one depends on time. Tube #2 needs to be cut through the center using a dremel with a cutting wheel attachment, and Tube #4 will need to have heating pads on the bottom of it to ensure it is at 27 °C.

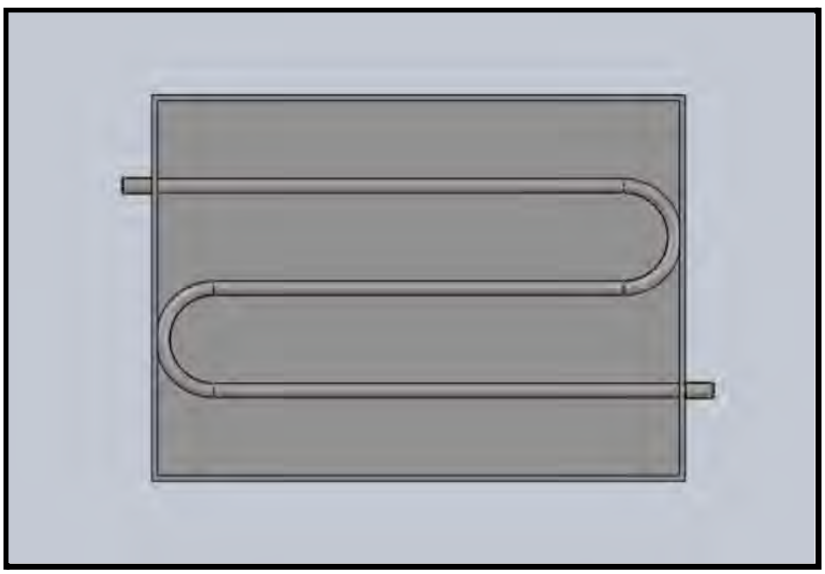


Figure 1.2 Design Concept 1

Design Concept 2 - Extended tubes secured on a base

Four 190.5 cm silicone tubes with an ID of 1.27 cm and an OD of 1.5875 cm are acquired. Each tube represents a different condition that is being tested to see how it may improve the results from the control variable from the patent. Tube #1 is the control that will ferment at room temperature in an enclosed tube for two weeks. Tube #2 represents an open system, which has the tube cut through the center of the cross section, exposing half of the area to open air for two weeks at room temperature. Tube # 3 represents the time variable, which means it will ferment at room temperature in an enclosed tube for three weeks. Lastly, tube #4 represents the heat variable. This enclosed tube will be fermented at 27 °C for two weeks.

To ensure that the SCOBY will grow uniformly throughout the tubes, they are secured onto an acrylic base with dimensions of 6 feet x 1.5 feet x 1".The caps of the tubes sit right off of the edge of the base. The distance between each tube is 3.6 inches and the distance between the end of the tube and the edge of the base is 1.5 inches. While this design does take up more space, the Sponsor agreed to accommodate to fit the structure.

Tubes # 1 and #3 does not require any manipulation since the first one is the control, and the third one depends on time. Tube #2 needs to be cut through the center using a dremel with a cutting wheel attachment, and Tube #4 will need to have heating pads on the outside of the bucket, under the tube, to ensure it is at 27 °C.

Figure 1.3 Design Concept 2

Current Design Concepts 2/26/22

Design Concept 1 - Tubes in snake formation in bins

Three 190.5 cm silicone tubes with an ID of 1.27 cm and an OD of 1.5875 cm are acquired. Each tube represents a different condition that is being tested to see how it may improve the results from the control variable from the patent. Tube #1 is the control that will ferment at room temperature in an enclosed tube for two weeks. Tube #2 represents an open system, which has the tube cut through the center of the cross section, exposing half of the area to open air for two weeks at room temperature. Lastly, tube # 3 represents the time variable, which means it will ferment at room temperature in an enclosed tube for three weeks.

Three plastic bins with dimensions 23.4" x 16.9" x 6.7" would hold the tubes in a snaked configuration. The tube would be snaked at the base of the bins, only requiring two loops inside. The caps on the ends of the tubes would stand outside of the bins through holes with a diameter of 16 mm. The purpose of the bins is to keep the long tubes in a contained space, since the amount of space provided by the Sponsor was limited to a 5-foot x 5-foot workstation.

Tubes # 1 and #3 does not require any manipulation since the first one is the control, and the third one depends on time. Tube #2 needs to be cut through the center using a dremel with a cutting wheel attachment.

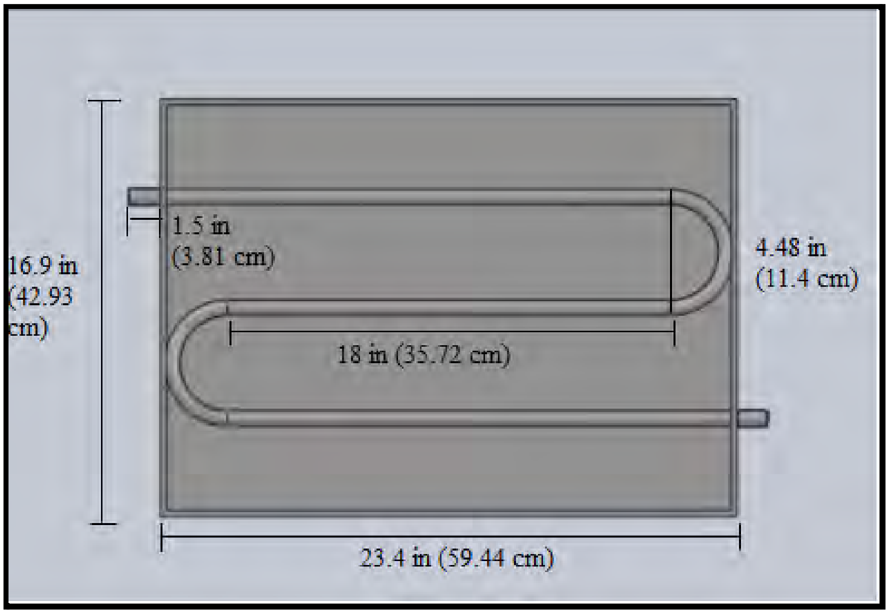


Figure 1.4 Design Concept 1

Design Concept 2 - Wrapping tubes around a cylinder structure

Three 190.5 cm silicone tubes with an ID of 1.27 cm and an OD of 1.5875 cm are acquired. Each tube represents a different condition that is being tested to see how it may improve the results from the control variable from the patent. Tube #1 is the control that will ferment at room temperature in an enclosed tube for two weeks. Tube #2 represents an open system, which has the tube cut through the center of the cross section, exposing half of the area to open air for two weeks at room temperature. Lastly, tube # 3 represents the time variable, which means it will ferment at room temperature in an enclosed tube for three weeks.

To simulate the SCOBY being in the spooled configuration, the four tubes are wrapped around the outside of four 5-gallon buckets with dimensions 12” x 13” x 14.5”. The tubes only have to be wrapped around two times to encompass the entire area, and they will be secured with zip-ties. Additionally, this design will be able to fit in the amount of space that is provided by the Sponsor.

Tubes # 1 and #3 does not require any manipulation since the first one is the control, and the third one depends on time. Tube #2 needs to be cut through the center using a dremel with a cutting wheel attachment.

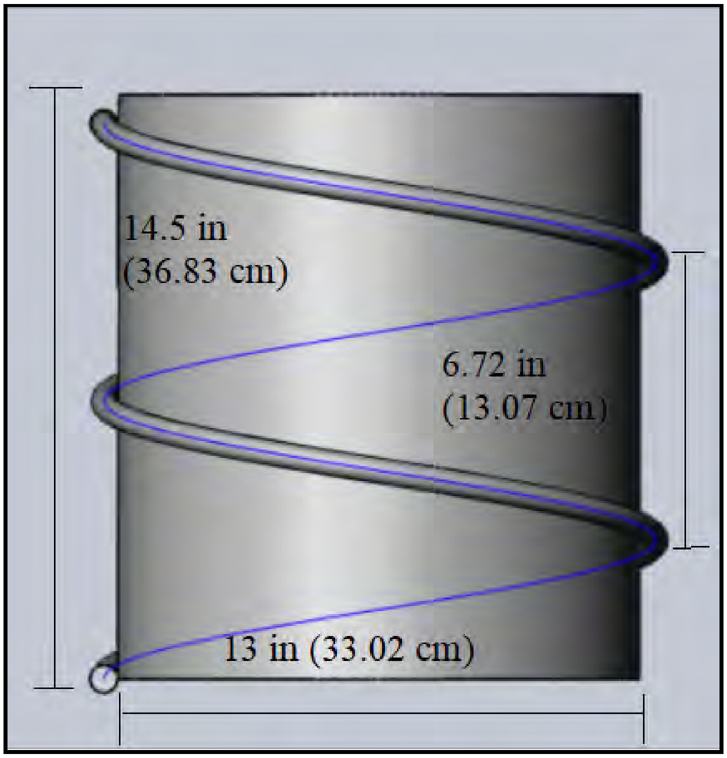


Figure 1.5 Design Concept 2

Design Concept 3 - Extended tubes secured on a base

Three 190.5 cm silicone tubes with an ID of 1.27 cm and an OD of 1.5875 cm are acquired. Each tube represents a different condition that is being tested to see how it may improve the results from the control variable from the patent. Tube #1 is the control that will ferment at room temperature in an enclosed tube for two weeks. Tube # 2 represents the time variable, which means it will ferment at room temperature in an enclosed tube for three weeks. Lastly, Tube #3 represents an open system, which has the tube cut through the center of the cross section, exposing half of the area to open air for two weeks at room temperature.

To ensure that the SCOBY will grow uniformly throughout the tubes, they are secured onto a wooden base with dimensions of 6 feet x 1.5 feet x 1''.The caps of the tubes sit right off of the edge of the base and the tubes are secured using pipe clamps. The distance between each tube is 4.5 inches and the distance between the end of the tube and the edge of the base is 1.5 inches. While this design does take up more space, the Sponsor agreed to accommodate to fit the structure.

Tubes # 1 and #2 does not require any manipulation since the first one is the control, and the second one depends on time. Tube #3 needs to be cut through the center using a dremel with a cutting wheel attachment.

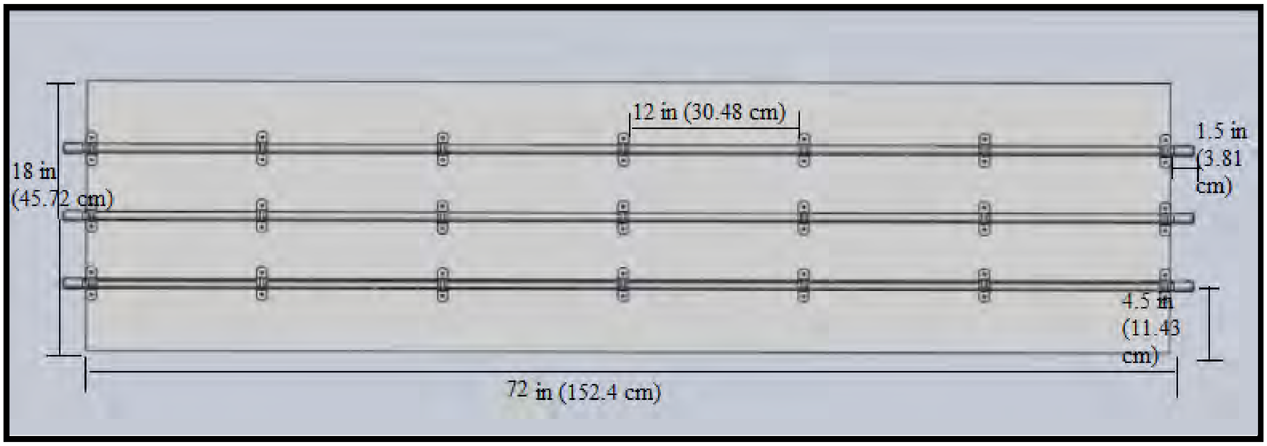


Figure 1.6 Design Concept 3

Table 1.6 Pros and Cons of the Three Design Concepts

Pros and Cons of Design Concepts		
Design Concept #	Pros	Cons
1	• Takes up less space; would fit in the original workstation • Requires minimal building	• May cause flexibility issues with the loops in the tubes • Is not the most feasible
2	• Fits SCOBY in the spooled configuration • Takes up less space; would fit in the original workstation • Requires minimal building	• Due to gravity, SCOBY may not grow consistently in thickness
3	• Allows SCOBY to grow uniformly • Easy to maintain • Requires minimal building	• Takes up more space

Feasibility Assessments

A. Technology Assessment

The consideration that we looked at for the SCOBY Bio-thread in terms of technology assessment was mainly material selection. Silicone provides a lightweight application to the tube we choose to create. Also it is flexible and easily accessible. We originally had selected ceramic, but the main challenge was maximizing the amount of oxygen that would pass through the surface. In addition, it was not ideal for our budget.

Table 2.1 Pros and Cons of Materials and Equipment Used in the Physical Design

Physical Design		
Materials		
	Pros	Cons
Silicone Tubing	Light Weight Flexible Easily Accessible	Will need to be secured to maintain a straight shape
Plywood	Easily Accessible Durable	Large in size
Rubber End Caps	Light Weight Inexpensive Flexible	Might need tape reinforcement
Galvanized Clamps	Corrosion Resistance Inexpensive	N/A
Equipment		
	Pros	Cons
Dremel	Multiple Attachments Chargeable Cordless	N/A
Drill	Chargeable Cordless Easily Accessible	N/A

Table 2.2 Pros and Cons of Materials Used in the Procedural Design

Procedural Design		
Materials	Pros	Cons
Black Tea	Food source for microorganisms Produces a stronger SCOBY	N/A
White Sugar	Necessary for Fermentation Produces a more consistent SCOBY	N/A
Raw, Unflavored, Unpasteurized Kombucha	Produces a stronger SCOBY Leads to less impurities	N/A
Spring Water	Contains minerals No impurities	N/A

B. Risk Assessment

Table 2.3 Identification and Analysis of Potential Hazards for the Project

Potential Hazard	Generic Cause	Specific Cause	Probability	Severity	Control Mode	Control Method
Allergic Reaction	Interaction between the thread and skin	Allergy to Cellulose	Remote	Critical	List of Materials	Include the caution of a cellulose allergy
Choking Hazard	The thread is small and could have pillings over time	Small dimensions of product	Remote	Critical	Listed	Recommend secure placement on the user

C. Cost Assessment

The product cost is determined by adding the cost of materials, labor and overhead. The product cost is based on the manufacturing of a single thread. The thread is composed of bioactive components one of them being cellulose which was our main focus.

Table 2.4 Breakdown of the Product Cost

Category	Item	Units per package	Units per product	Package Price	Price per product
Material	Silicone tubing	1	1.00	$20.00	$20.00
	Jumbo paper towel roll	6	1.00	$15.00	$3.00
	64oz glass jar	6	1.00	$41.00	$7.00
	16fl oz raw Kombucha	1	0.25	$4.00	$1.00
	Sugar (1lb)	1	0.11	$9.00	$1.00
	Empty Spool	10	1.00	$15.00	$2.00
	Black Tea Bags	100	4.00	$5.00	$1.00
Material total					**$35.00**
Category	**Breakdown**				**Price**
Labor	20 hours @ 14 per hour				$280.00
Labor total					**$280.00**
Overhead	40% of Labor + 14% of Materials				$117.00
Overhead total					**$117.00**
TOTAL PRODUCT COST					**$432.00**

Table 2.5 Breakdown of the Project Cost

Category	Item	Units per package	Units per Project	Package Price	Price per Project
Material	Silicone tubing	1	1	$20.00	$20.00
	Jumbo paper towel roll	6	6	$15.00	$15.00
	64oz glass jar	6	6	$41.00	$41.00
	16fl oz raw Kombucha	1	1	$4.00	$4.00

	Sugar (2lb)	1	1	$18.00	$18.00
	Empty Spool	10	10	$15.00	$15.00
	Black Tea Bags	100	100	$5.00	$5.00
Material total					**$118.00**
Category	**Breakdown**			**Original Price**	**Final Price**
Labor	3572 hours @ 14 per hour	Provided at no cost by our team		$50,008.00	$0.00
Labor total					**$0.00**
TOTAL PROJECT COST					**$118.00**

Producing a Bio-thread that is 5 feet long and 2 mm in diameter requires a tube of a particular material including metal, plastic, rubber, silicone, glass or ceramic. When the requirement that the tube must not promote bacteria growth was introduced, the potential tubing material was reduced to rubber, silicone, glass or ceramic. Silicone tubing was then selected as it was the most affordable ($20) and allowed for reusability. Within this silicone tube, raw kombucha, black tea, and sugar will be mixed and covered with a paper towel to promote SCOBY growth. After 2 weeks, adequate growth should be observed and the SCOBY is dehydrated, twisted into a thread, and spooled.

The materials used to create the bio-thread have been estimated to cost $35, and after adding labor for 20 hours at $14 per hour and an overhead cost, the total product cost was $432. This solution was the most feasible as of the date this project was analyzed. Once scaled to a commercial level with 5 or more bio-threads manufactured simultaneously, it is expected for this price to drop to less than ⅓ of the original price as labor would be spread across multiple units.

Revised 3/28/2022

Table 2.6 Cost Analysis

Section	Parts	Price	Per	Quantity	Total	Cash Outlay
Materials						
Final Product						
	Plywood	$66.67	Unit	1	$66.67	$66.67
	Silicone Tubes	$12.99	Unit	3	$38.97	$38.97

	Rubber Caps	$5.99	10 Units	6/10	$3.40	$3.40
	Screws	$1.28	14 Units	42	$3.84	$3.84
	Steel Clamps	$6.38	25 Unit	21/25	$5.36	$5.36
	Sugar	$1.54	1 lb (454g)	50g	$0.17	$0.17
	Black Tea	$4.65	100 Unit	2/100	$0.09	$0.09
	Kombucha	$3.65	474 ml	118ml	$0.90	$0.90
	Water	$0.98	3.78 L	750ml	$0.19	$0.19
	Spool	$22.79	20 Unit	1/20	$1.14	$1.14
	NaOH	$25.05	1 L	50ml	$1.25	$1.25
	Dremel	$23.38	Unit	1	$23.38	$23.38
Testing & Verification						
	Solids pH Meter	$97.99	Unit	1	$97.99	$97.99
	Caliper	$9.99	Unit	1	$9.99	$9.99
	Tape Measurer	$5.99	2 Unit	1	$2.99	$2.99
	Stress/Strain Apparatus	$799	1 Unit	1	$799	$0
	PASPORT Rotary Motion Sensor	$185	1 Unit	1	$185	$0.00
	PASPORT Force Sensor	$139	1 Unit	1	$139	$0.00
	Capstone Software	$695	1 Unit	1	$695	$0.00
Software	Solidworks	$3,995	Unit	1	$3,995	$0.00
	Microsoft Project Plan	$1,129.99	Unit	1	$1,129.99	$0.00
	Slack	$0	Unit	1	$0.00	$0.00
Materials Total	$7,232.31			Materials	$7,232.31	$289.32
Unit Materials Total	$256.33			Unit Materials	$7,199.32	$256.33
Labor		$15	Hour	4.5	$67.50	$0.00
Product Cost					$323.83	$256.33

Total Project Cost					$356.82	$289.32

Table 2.7 Price Analysis

Overhead	40% Labor + 14% Material Cost
Total	$67.50
Unit	$62.89
Total Project Price	$424.32
Total Unit Price	$386.72

A large portion of the cost for this project came from the materials that were needed. Around half of the materials went to the construction of the base and tube molds whereas the other half was for the production of the SCOBY Bio-Thread. Since the base and tube mold are reusable after the implementation of this process the overall cost should decrease and only require the materials needed to make the solution. That being the sugar, black tea, water, and Kombucha. The completion of the project remained within the budget of $500. The Project Cost was $289.32 and the product cost was $256.33. The price of the project was $424.32 with a unit price of $386.72.

Fermentation Chemical Reaction

The overall fermentation chemical reaction is described as:

$$C_6H_{12}O_6\ (glucose) \rightarrow 2C_2H_5OH\ (ethanol)\ +\ 2CO_2\ (carbon\ dioxide)$$ [2]

More specifically to Kombucha fermentation, below is the biochemical pathway of obtaining Kombucha from the inputs introduced in the procedures:

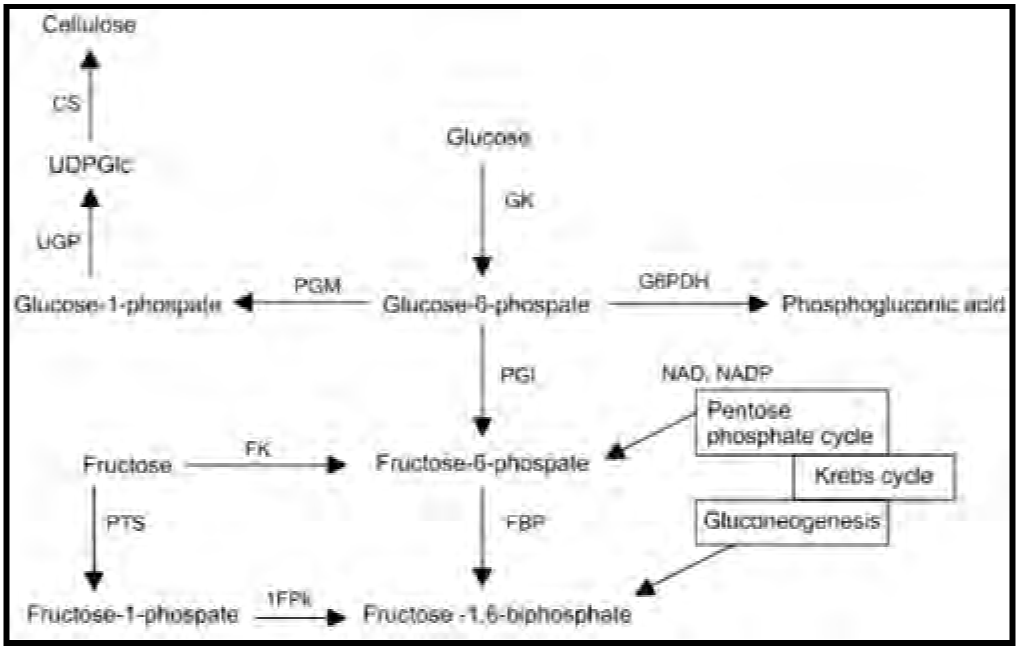


Figure 2.1 Biochemical Pathway for Kombucha Fermentation[3]

SCOBY Size Reduction

The tables and calculations below demonstrate the measurements and calculations obtained to determine the length of the tubes. The SCOBY initially grows in a wet environment, therefore it is hydrated. One of the characteristics of the SCOBY is its high water retention, which influences the size of the SCOBY prior to drying. When it is left to dry, the SCOBY experiences a drastic change in height. Table 2.8 demonstrates the measurements (length, width, & height) taken when initially removed from the medium and when it is completely dried. Similarly, when the SCOBY will later be twisted into the thread, there will be another decrease in width, which is proposed in Table 2.9.

Table 2.8 Comparison of Length, Width, and Height from When the SCOBY is Wet and When it is Dry

Trial #	Starting Length (Wet)	Starting Width (Wet)	Starting Height (Wet)	Final Length (Dry)	Final Width (Dry)	Final Height (Dry)	Length Decrease (%)	Width Decrease (%)	Height Decrease (%)
1	8.255 cm	9.2075 cm	0.6 mm	5.3975 cm	5.715 cm	0.3 mm	34.74	37.93	50
2	7.9375 cm	7.9375 cm	0.2 mm	5.715 cm	5.715 cm	0.1 mm	28	76.378	50
3	7.62 cm	11.43	0.7 mm	7.3025c	11.1125	0.3mm	4.18	2.69	57.14

		cm		m	cm				
4	6.6675 cm	11.7475 cm	0.4 mm	5.715 cm	11.43 cm	0.1 mm	14.29	2.7	75

Note: Calculations are found in the appendix

Table 2.8 Comparison of Length, Width, and Height from When the SCOBY is Wet and When it is Dry

Table 2.9 Comparison of Length, Width, and Height from When the SCOBY is Dry and When it is Twisted

Trial #	Starting Length (Dry)	Starting Width (Dry)	Starting Height (Dry)	Final Length (Twist)	Final Width (Twist)	Final Height (Twist)	Length Decrease (%)	Width Decrease (%)	Height Decrease (%)
1	5.3975 cm	5.715 cm	0.3 mm	1.905 cm	1 mm		64.70%	98.25%	
2	5.715 cm	5.715 cm	0.1 mm	1.905 cm	1.1 mm		66.67%	98.08%	
3	7.3025cm	11.1125 cm	0.3mm	1.905 cm	1 mm		73.91%	99.1%	
4	5.715 cm	11.43 cm	0.1 mm	1.905 cm	1 mm		66.67%	99.13%	

Note: Calculations are found in the appendix

Spool Size Determination

One of the requirements of the design project is that the final product should be able to spool. A variable to consider in satisfying this requirement is the size of the spool. Since the final thread will be continuous in length at a maximum of 5 feet, the spool is expected to be able to fit the entire thread, without extending from the edge of the base.

To determine the proper spool size for a desired thread length, measurements from the spool's design are used in calculating how long of a thread it can hold. A spool consists of the flanges and the barrel, as shown in Figure 6.2[4]. The formula includes multiplying the sum of area of the flange that will be occupied by the thread (H) and the diameter of the barrel (B) with the occupied area of the flange (H), the traverse distance of the flange (T), and constant 0.262 (Figure 6.3)[5]. For the design project, spools of various dimensions were searched and tested with the equation to see the length of a thread it can hold (Table 6.3). The H value was assumed as a 0.85 ratio of the entire area of the flange. This value was determined upon observations of the H/H+U ratio from examples found online that ranged from 0.83 to 0.89 (Figure 6.4, Table 6.4)[6].

Upon calculating the reel factors and length of cables for each of the spools found online, it was determined that the 2.5” x 2” spool would be best fit for the project. This spool holds approximately 7.54 ft of thread, which is slightly over the 5-feet target. However, it is important to note that these calculations are only an approximation, and do not predict the exact length of the thread it can hold. This error comes from the fact that there are assumptions when calculating the reel factor that may not be necessarily true, such as the organization of the thread on the spool[7]. Some equations assume that the thread is uniformly distributed over the spool, while others neglect the distribution.

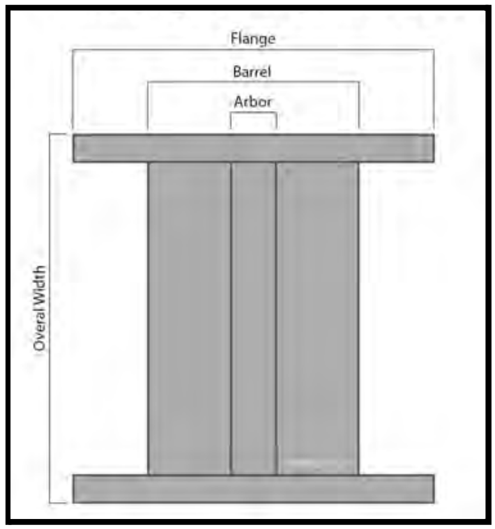


Figure 2.2 Components of a Spool including the Flange and the Barrel

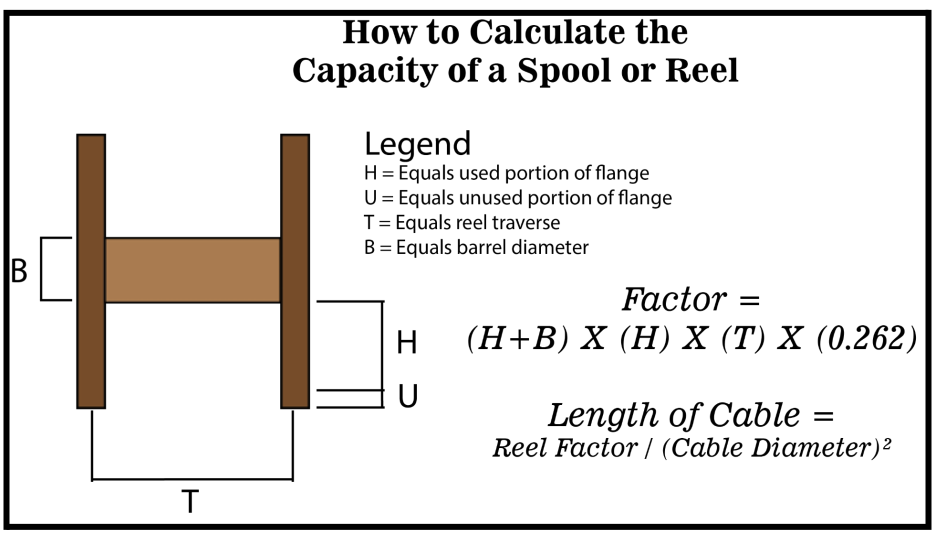


Figure 2.3 Formula for Calculating Spool Factor and Determining the Length of Cable for the Spool

Table 2.10 Sample Spools Researched to Determine Best Fit for 5-Foot Thread

Diameter	Length	H	U	T	B	Reel Factor	Length of Cable
2.5 in[8]	2 in	15.3 mm	2.7 mm	53 mm	28 mm	9199.33614	7.54 ft
2.5 in[9]	4 in	18.1356 mm	3.2004 mm	101.6 mm	20.6400 mm	18719.12112	15.33 ft
3.2 in[10]	3.3 in	26.5625 mm	4.6874 mm	84 mm	19 mm	26635.36824	21.84 ft

Note: Calculations are found in the appendix

Table 2.4 Table of Existing Spools and their Values Corresponding to the Reel Factor. The U and H Columns Were Used to Calculate the Ratio of the H Value with Respect to the Area of the Flange

Shipping Reels (Diameter")	U (inch)	H (inch)	B (inch)	T (inch)	Reel Factor
Plastic 10.5"	0.5	2.75	3.50	7.00	31.52
Plastic 10.5" (in box)	0.5	2.75	3.5	10.00	45.03
Plastic 12"	0.5	3.00	5.00	7.00	44.02
Plastic 12" (in box)	0.5	2.5	6.0	10.0	55.68
Plywood 12"	0.5	3.25	4.00	7.00	43.21
Plywood 14"	0.5	3.75	4.80	9.00	75.60
Plywood 16"	0.75	4.50	4.80	8.75	95.94
Plywood 20"	1.0	5.00	7.80	12.25	205.41
Plywood 24"	1.0	5.75	10.00	12.25	290.66
Plywood 30"	1.5	8.50	10.00	14.00	576.79
Wood 36"	1.5	10.25	11.80	18.00	1065.87
Wood 40"	1.5	12.00	11.75	17.75	1325.39

Table 2.11 Percentages of U and H for the Area of the Flange on Varying Diameters of Existing Spools

Diameter (in)	U (in)	H (in)	Percent H	Percent U
10.5	0.5	2.75	85%	15%
10.5	0.5	2.75	85%	15%
12	0.5	3.00	86%	14%
12	0.5	2.50	83%	17%
12	0.5	3.25	87%	13%
14	0.5	3.75	88%	12%

16	0.75	3.50	86%	14%
20	1.0	5.00	83%	17%
24	1.0	5.75	85%	15%
30	1.5	8.50	85%	15%
36	1.5	10.25	87%	13%
40	1.5	12.00	89%	11%

Note: Calculations are found in the appendix

D. Regulatory Assessment

Our project is creating the most efficient technique on the creation of a thread extracted from the byproduct of the fermentation process that involves the use of kombucha, sugar and tea. Once we create the thread, one of the future applications would be wound dressing. Therefore, it would need to go through the Food and Drug Administration approval as well as meet several relevant standards. Below are the Standard Organization for Standardization and FDA Regulations that our product has to meet:

- As for the FDA classification, the instrument is classified as class 1 since the risk associated with the instrument is low to moderate to the patient.
    - The device is exempted from 510k due to the tube being non-metallic.
    - The device is also exempted from PMA due to similar existing devices.

- Standards:
    - ISO 14971:2019: Application of risk management to medical devices.
    - ISO 21710:2020: Biotechnology — Specification on data management and publication in microbial resource centers
    - ISO 15882:2008: Sterilization Of Health Care Products - Chemical Indicators - Guidance For Selection, Use And Interpretation Of Results
    - ISO 979:1974: Sodium Hydroxide For Industrial Use -- Method Of Assay
    - ISO 20743:2021: Determination of antibacterial activity of textiles products
    - ISO 4045:2018: Chemical tests- Determination of pH and difference figure.

Design

A. Simulation Results

A thermal analysis of heat transfer was performed in Comsol to depict the heat transfer from the 30 °C tea inside the silicone tube through the material and to the ambient temperature of 25.4 °C. This simulation was critical in predicting the outcomes of the fermentation process. The area in which the team worked was approximately a 5 feet by 10 feet space, sealed off from the remaining environment by plastic coverings in order to keep the area controlled. During the process of creating the tea that would be held inside the silicone tubes, the sample was heated to a boil and then allowed to cool to room temperature (suggested to be approximately between 21 to 24 °C, according to a recipe that was followed[11]). However, since the sample was heated within the enclosed space, the room temperature in the area where the tea was being made also increased from an average of 25.4 °C to approximately 30 °C. By introducing the tea into the tube at a warmer temperature, it created the risk of promoting bacterial growth that may be present, which would also lead to the presence of mold, as seen in pilot trials. If the temperature of the tea was too warm and would take a long time to cool down, this would extend the period of bacterial growth. Therefore, it was important to understand how long it would take the tea to return to the 25.4 °C to predict how likely it was to see mold after the two week fermentation period. According to the recipe followed, the first stage of the kombucha fermentation process is the production of the SCOBY, which takes between one week and four weeks to complete. From pilot trials conducted by the team, it was determined that a full layer of SCOBY was produced after two weeks of fermentation. As a result, this two week period was selected as the overall time of fermentation for the desired product.

The simulation in Comsol was initiated by specifying the geometry and material of the tube and where the liquid was found at the bottom half of the cross sectional area. In addition, the boundary conditions were established as through the liquid sample the temperature was 30 °C and the tube and ambient temperature was 25.4 °C. A Surface-to-Ambient Radiation analysis was followed for this model. The results below show how long it took for the sample to reach room temperature:

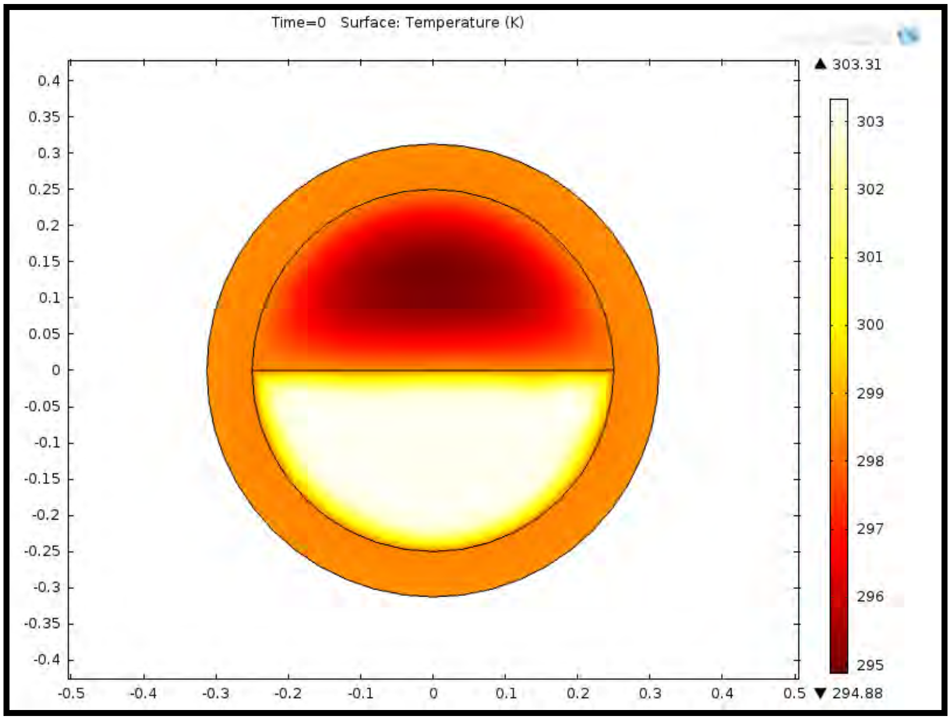


Figure 3.1 Temperature Distribution at Time=0 Seconds

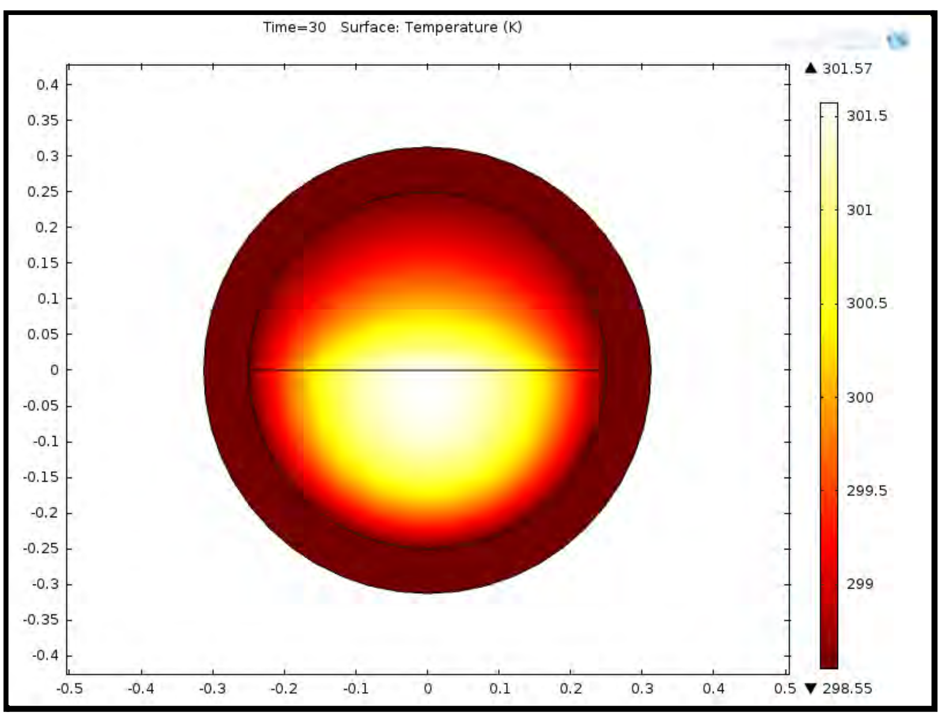


Figure 3.2 Temperature Distribution at Time=30 Seconds

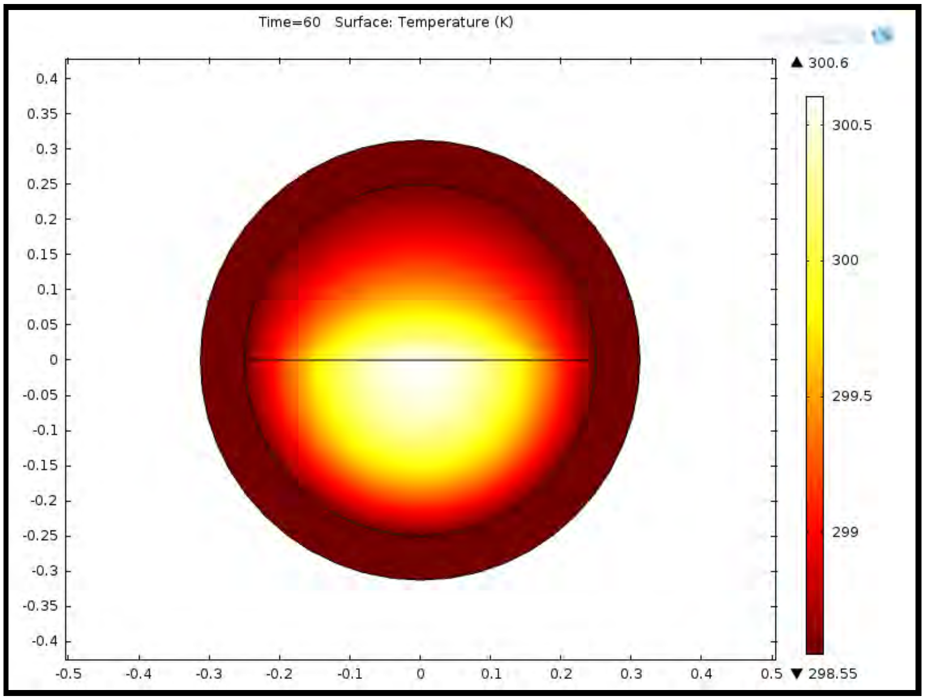


Figure 3.3 Temperature Distribution at Time=60 Seconds

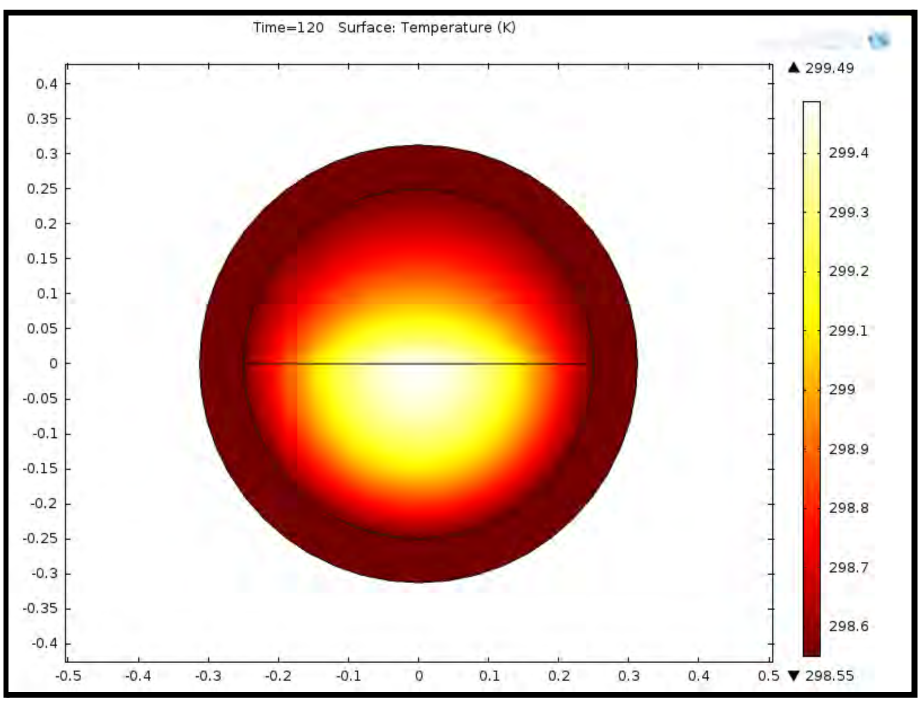


Figure 3.4 Temperature Distribution at Time=120 Seconds

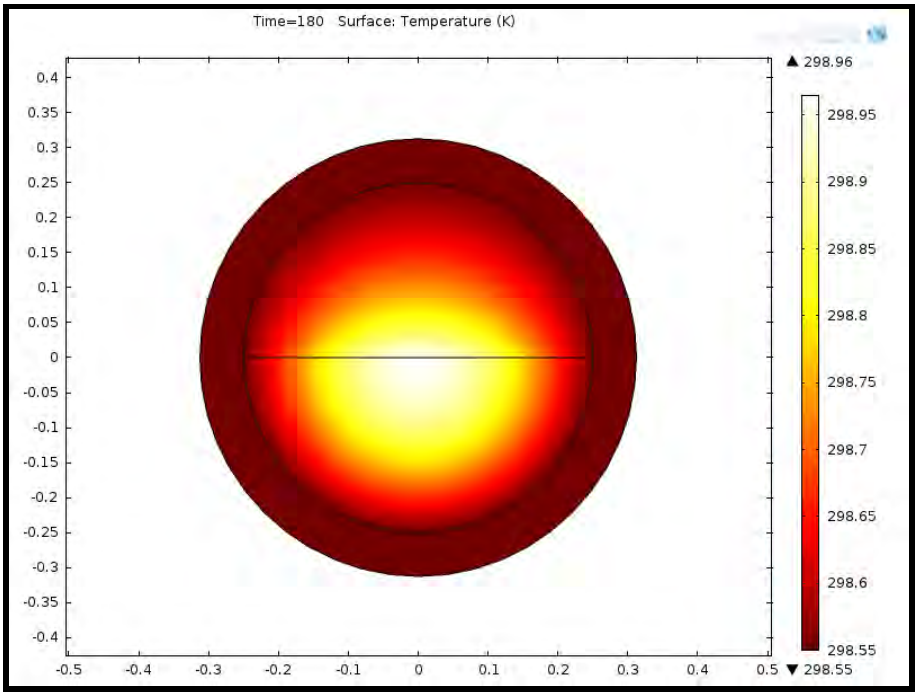


Figure 3.5 Temperature Distribution at Time=180 Seconds

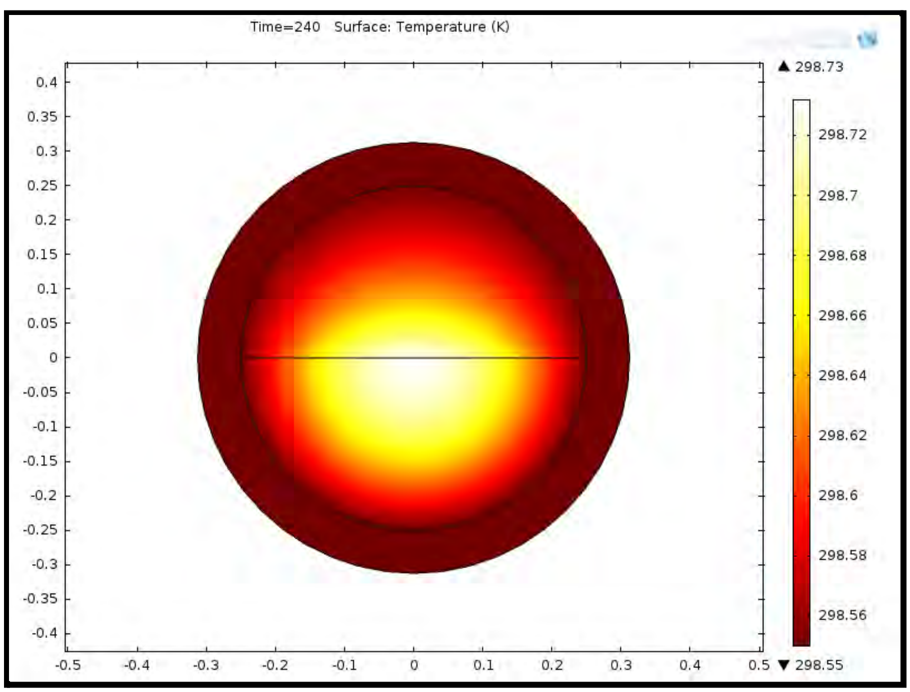


Figure 3.6 Temperature Distribution at Time=240 Seconds

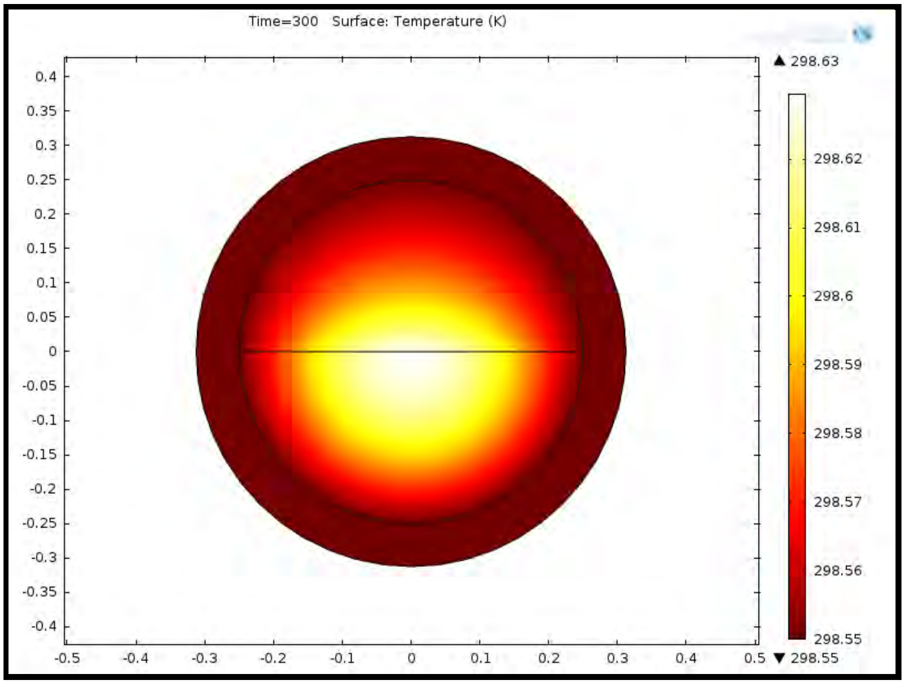


Figure 3.7 Temperature Distribution at Time=300 Seconds

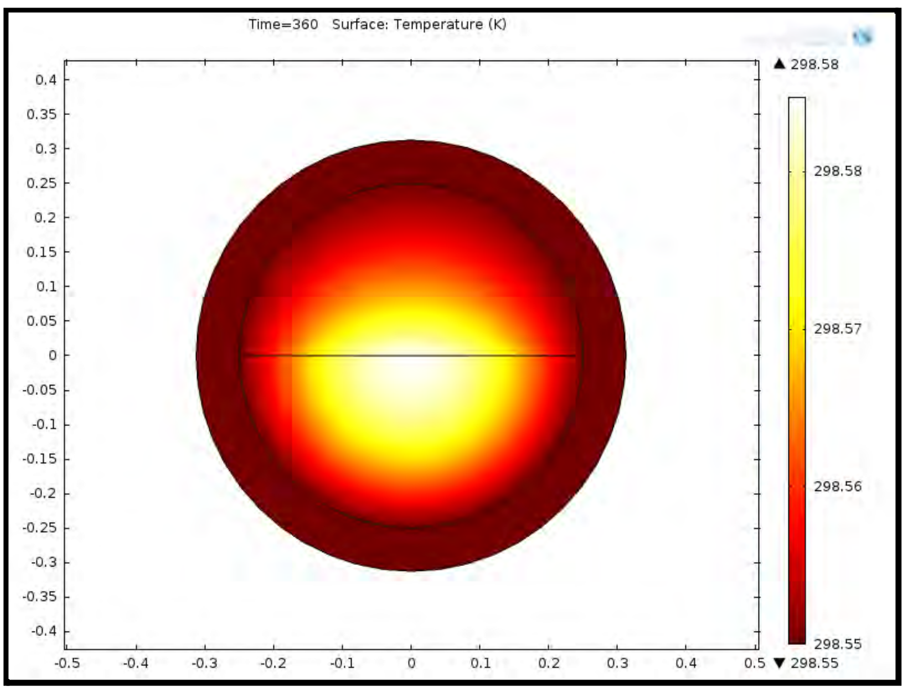


Figure 3.8 Temperature Distribution at Time=360 Seconds

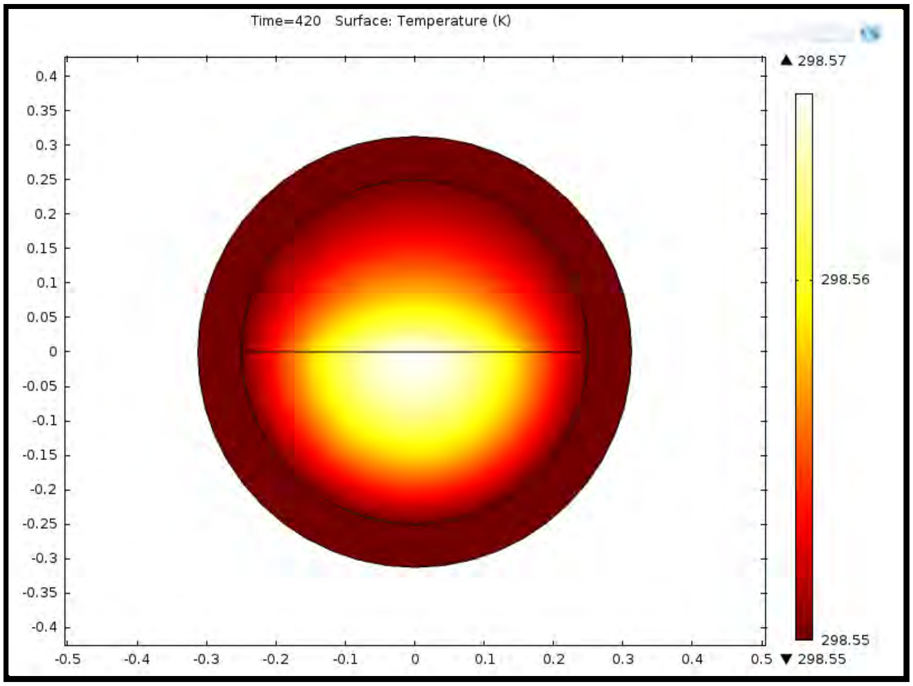


Figure 3.9 Temperature Distribution at Time=420 Seconds

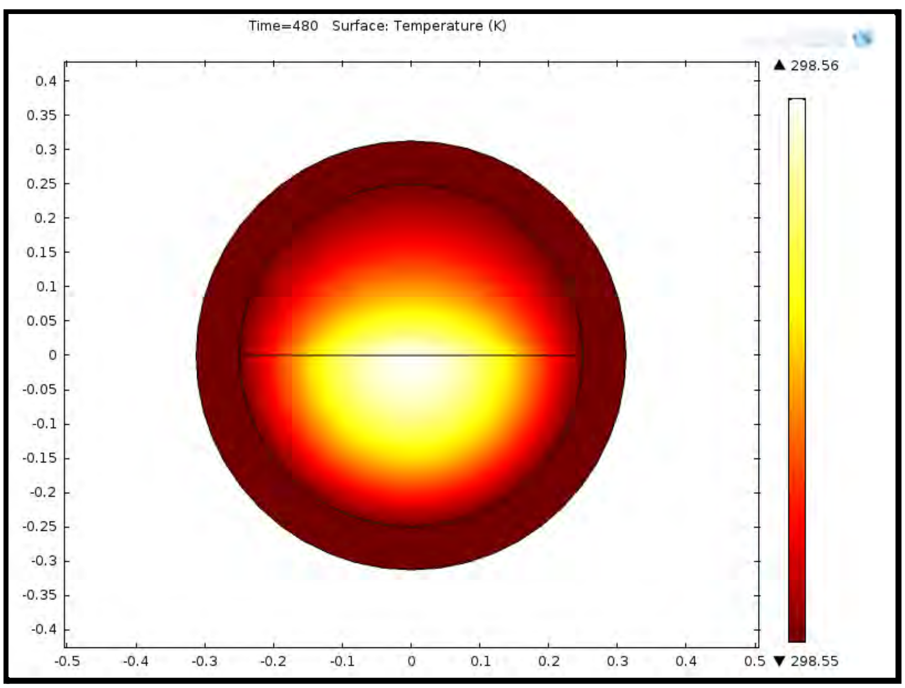


Figure 3.10 Temperature Distribution at Time=480 Seconds

The results from the simulation illustrates that after approximately 8 minutes, the content inside the tube returned to the room temperature (note that the values for the colorbar change in each figure). This concludes that out of the two week fermentation period, the sample is only at the elevated temperature for 0.0004% of the time, which allowed the team to make the assumption that any mold found in the samples was due to other factors such as sterilization and contamination.

It is important to also mention that the result from the simulation does have discrepancies with what occurred in the experiment. In the experimental scenario there were several types of heat transfer that occurred, including conduction between the sample and the tube, convection between the air and the liquid inside the tube, and convection with the air immediately outside of the tube. It was difficult to model all real-life situations, which is why the transfer of Surface-to-Ambient Radiation temperature was instead assumed. In addition, it was also assumed that the tube remained at the room temperature of 25.4 °C when the tea was introduced, which more than likely would have been slightly higher due to the convection of the warmer air. These assumptions would account for any error found in the result.

B. Patent Search Results

Patent WO 2010/031154 A2 was found that describes the same general principle for the design that the team formulated. The purpose of the design specified is to invent a process to create bacterial cellulose fibers, tapes, yarns, and threads. It consists of utilizing a controlled environment with tubes composed of gas permeable materials, such as silicone. These tubes are obtained with a desired diameter, thickness, and length that corresponds to the dimensions of the final product. Through the use of a carbon source with the microorganisms, cellulose fibers are produced which coat the inside of the tube. As the fibers compile, they create a solid layer which is extracted to form the tapes, yarns, and threads.

The microorganism used in the patent is Gluconobater Xylinum (Acetobacter xylinum) and the carbon source is a type of anhydrous glucose. The initial process is set up in the following steps:

1. The culture medium (water, sugar, and tea) is sterilized by heating it to 121 C for approximately 20 minutes.
    a. The medium is cooled down to 30 C.
2. The inoculums is prepared from either pure bacteria or from the water residuals of another fermentation.
    a. The quantity, temperature, pH, and time depends on the microorganism that is utilized.
3. The medium with the microorganism is poured in the tubes, ensuring that there is no presence of air bubbles. The medium in the tube is introduced in a way that is continuous throughout the entire length. This allows the formation of cellulose fibers to be without interruption.

4. Fermentation of the sample is performed in a space with controlled temperature. No air filter is required for microbiologic control, since the tube functions as a filter while also allowing the passage of oxygen into the medium. Cellulose is produced when exposed to oxygen inside the internal circumference of the silicone tube. This depends on the thickness of the tube, its gas permeability, and the amount of surface area that is exposed to the air. The thickness of the wall regulates the speed at which the gas is passed from the external to the internal. Lastly, the thickness of the final product depends on the amount of time the sample is fermented.
5. The final product is collected by applying pressure on one end of the tube to push the yarn, tape, or thread out.
6. The final product is cleansed and purified by extending it and applying a hot alkaline and detergent to remove the microorganisms that may remain on it.
7. Once purified, the tapes are dried and the yarns and threads are twisted.
    a. Tapes are left to dry in the flat configuration.
    b. Threads are left to fry after twisting it upon itself.
8. The tubes are then sterilized with an alcohol of 70 GL.

Upon testing the results of the experiments, it was determined that the bacterial cellulose tapes, yarns, and threads demonstrated impressive mechanical resistance including being low weight, very durable, and having a large tension resistance. In addition, it was observed that the product had a high water retention capacity and was very resistant when humid.

C. Reliability Determination

The main objective was the production of a bio-thread composed of cellulose. To carry this project, multiple verification tests were created and tested. The first protocol, the presence of cellulose was tested. To achieve this, the bio-thread had to be created then after it was subjected to Schultz’s reagent in which an immediate color change was observed. The original color was green and then after treatment was blue which took just one trial to be accomplished. The second protocol was to have a thread with a continuous length with a 2 mm in diameter. Since the SCOBY takes the shape of its container, once the fermentation process was carried the thread was spooled, it was first noticed that the cellulose fibrils were not fully created. Time constraint was the main issue which resulted in a failed verification test because the thread was not strong enough. To mitigate this, we had to fold the thread, let it dry then twist which added more support but unfortunately the length shortened to 51.5 cm but the diameter was successfully accomplished. A 1.073 mm was obtained.

Design Outputs

A. Engineering Drawings

Engineering Drawings Revised 2/14

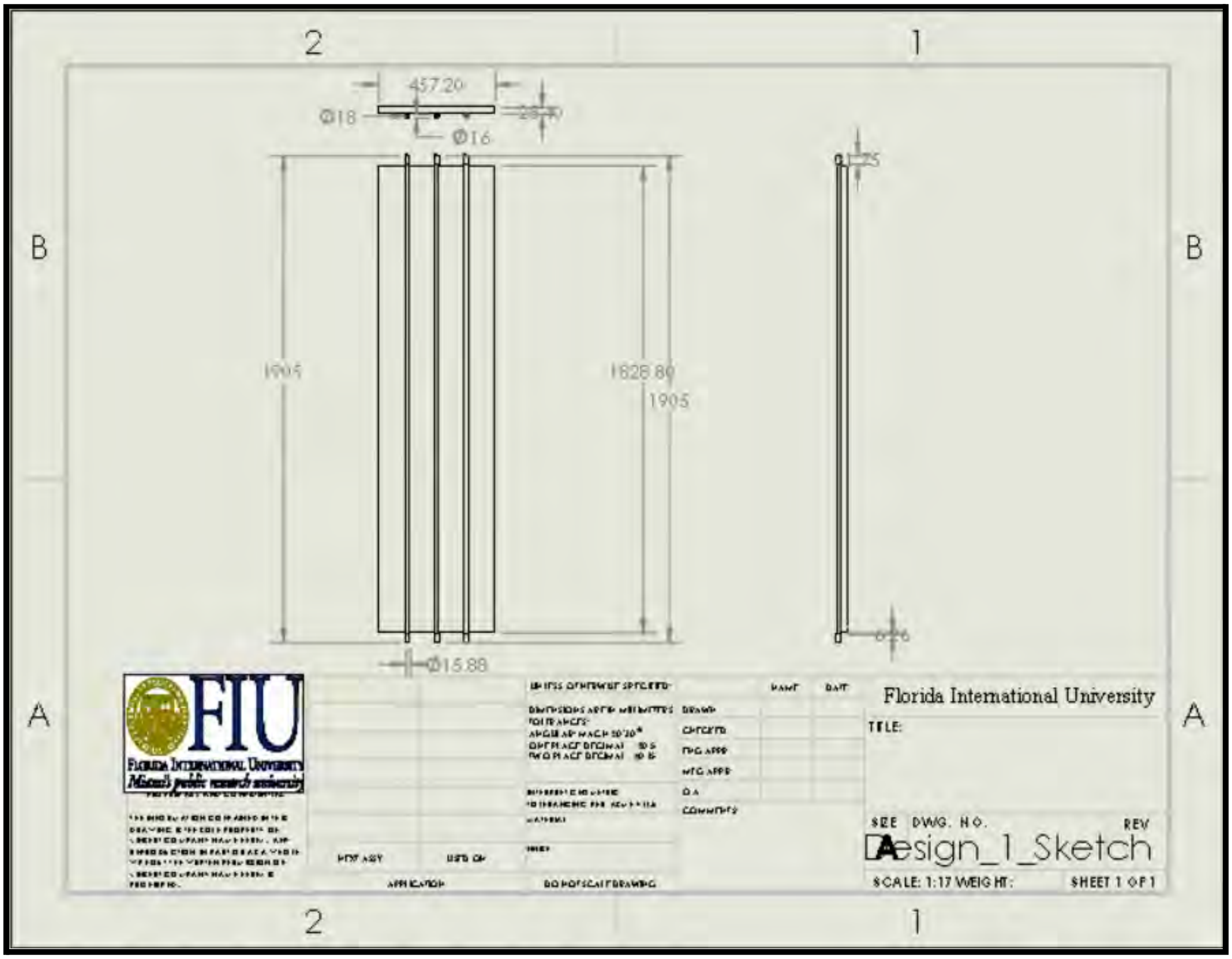


Figure 4.1 Tube & Base Structure

Design drawing of the entire structure including two closed silicone tubes and one open silicone tube on a base. The distance between the middle of each tube is 4.5 inches.

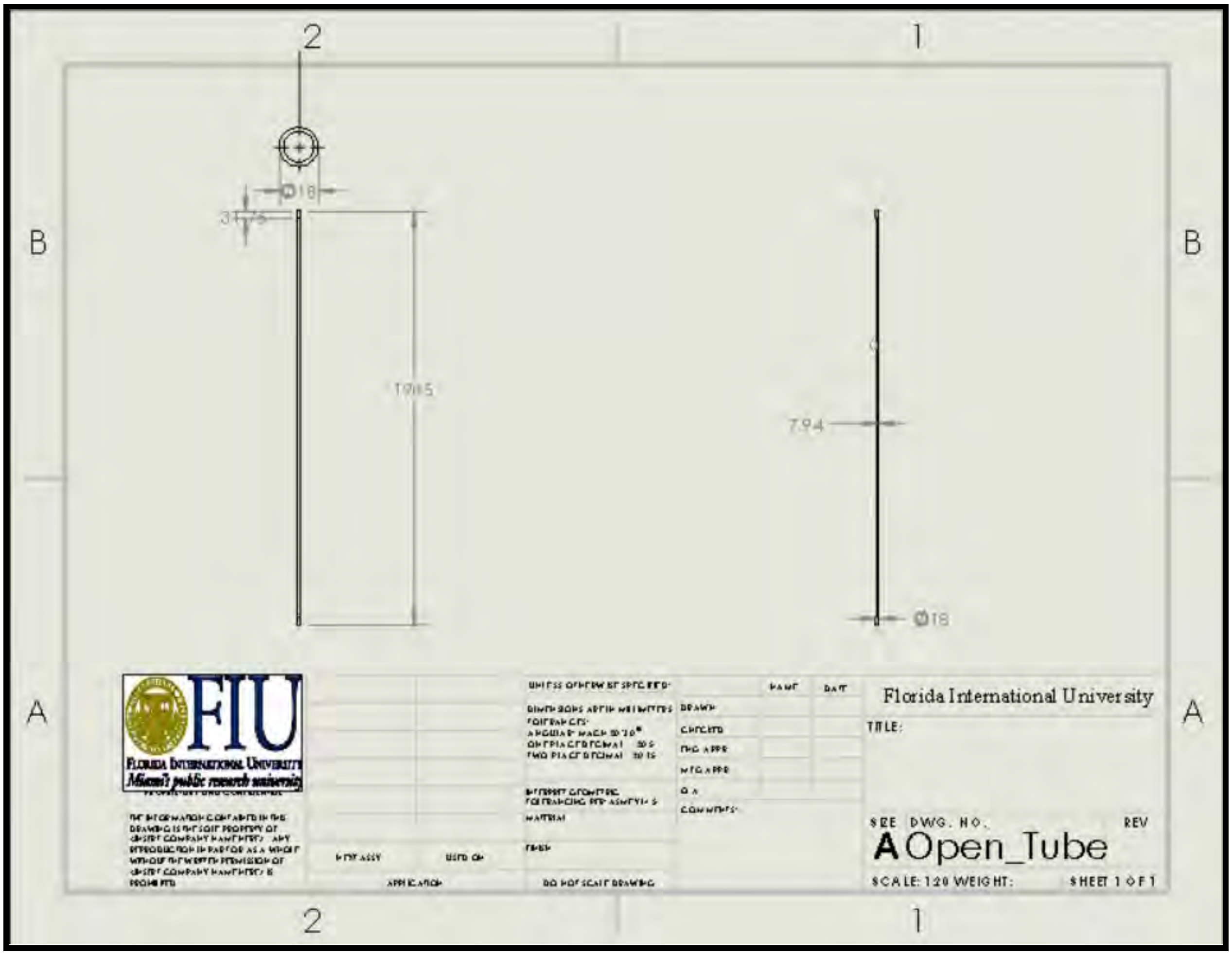


Figure 4.2 Tube Design

Design drawing of silicone tubes. The open tube is cut through the middle of the cross-section. The length of each tube is 6.25 feet with an ID of 12.7 mm and an OD of 15.875 mm. The cap placed on the tube has an ID of 16 mm and an OD of 18 mm.

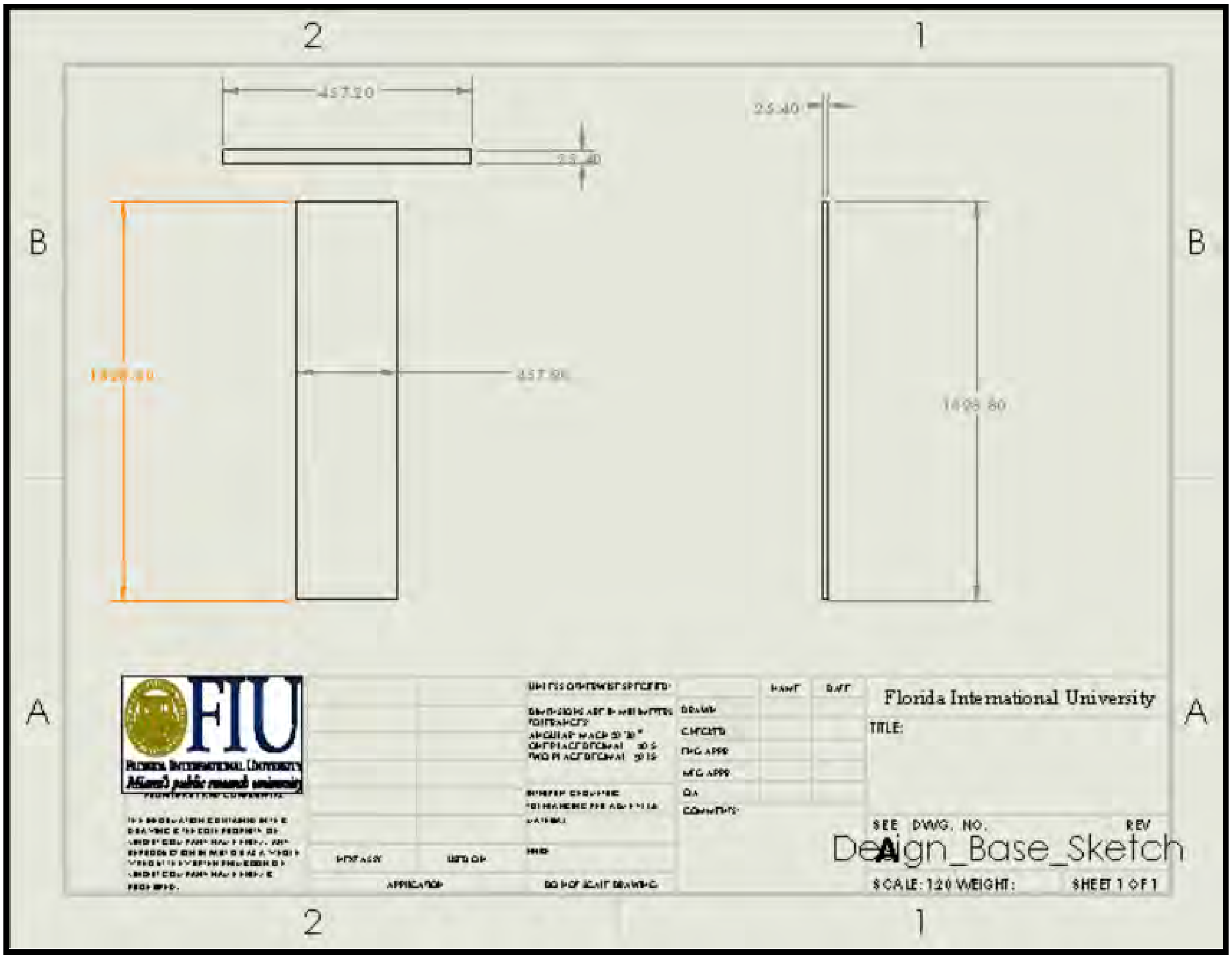
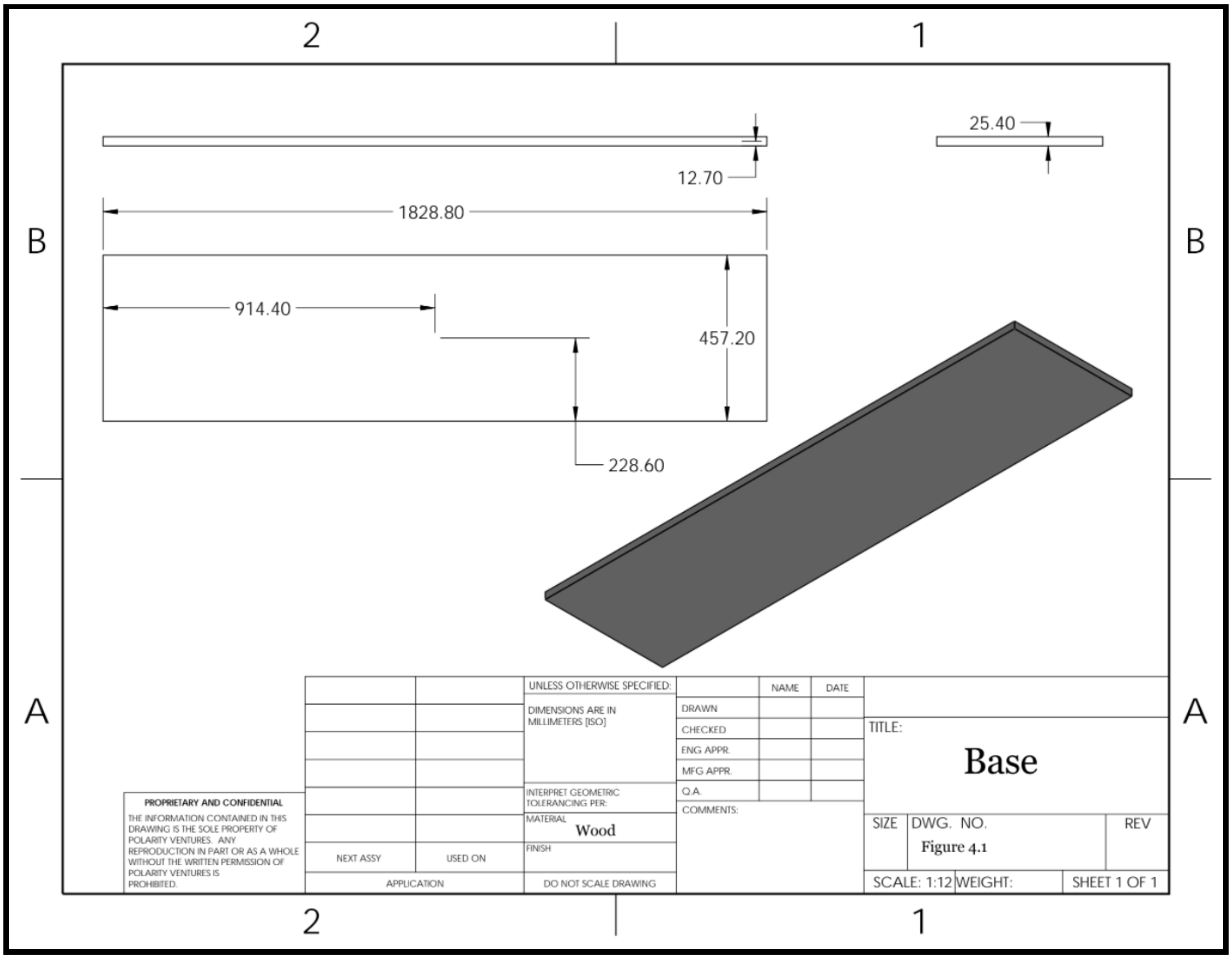


Figure 4.3 Base Design

Design drawing of the base that holds the silicone tubes. The length of the base is 6 feet and the width is 1.5 feet, with a height of 1 inch.

Current Engineering Drawings 4/1



4.1 Base Design

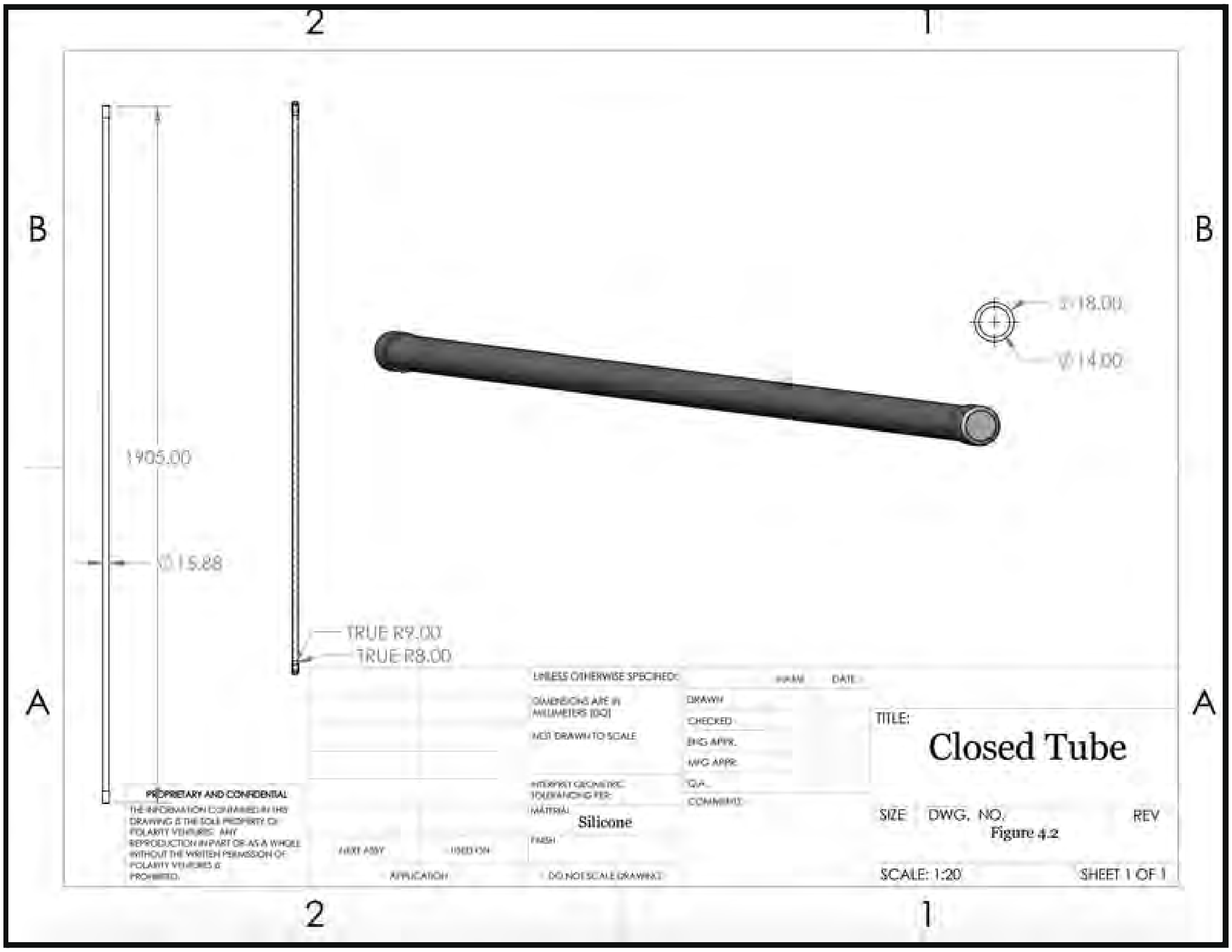


Figure 4.2 Closed Tube Design

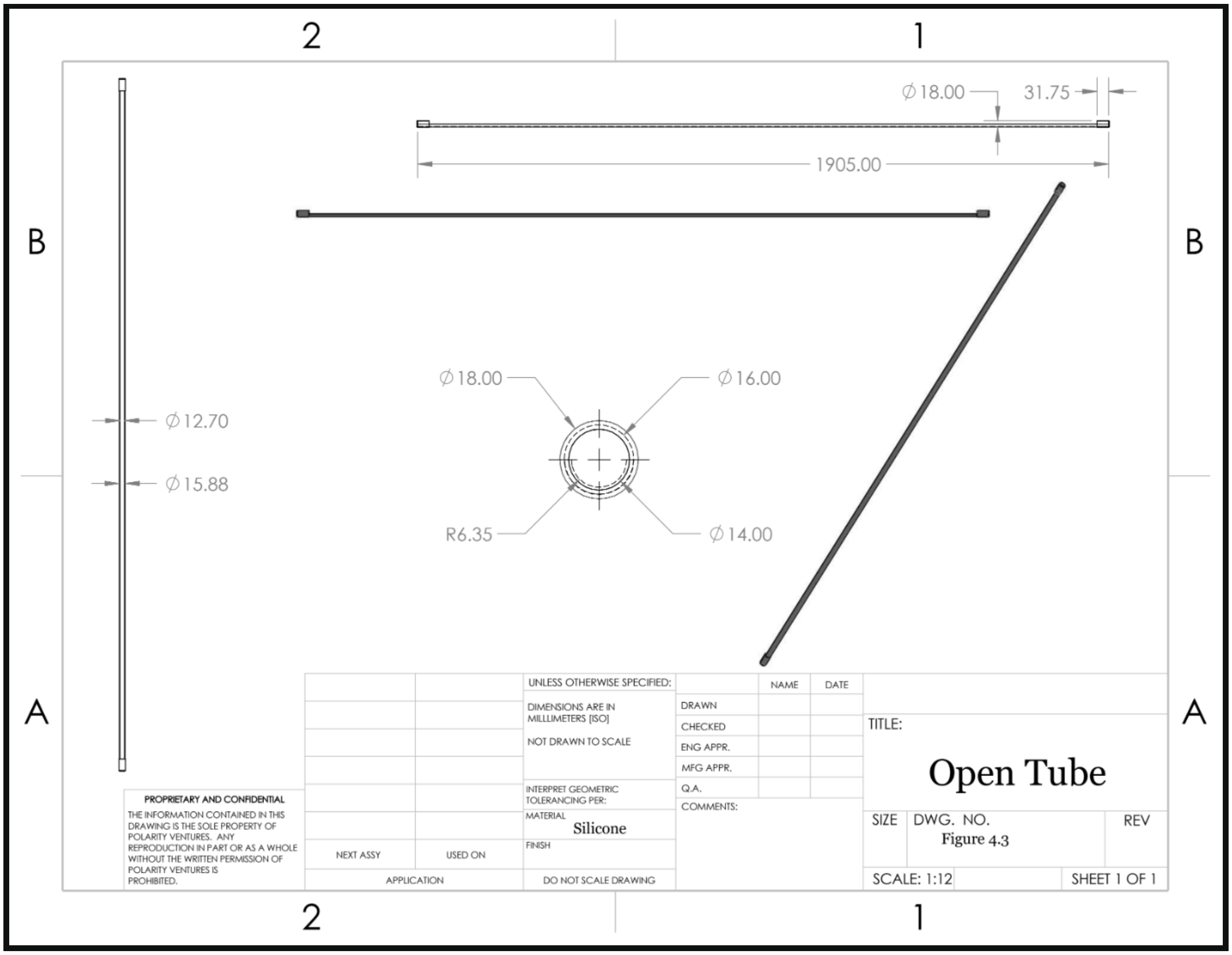


Figure 4.3 Open Tube Design

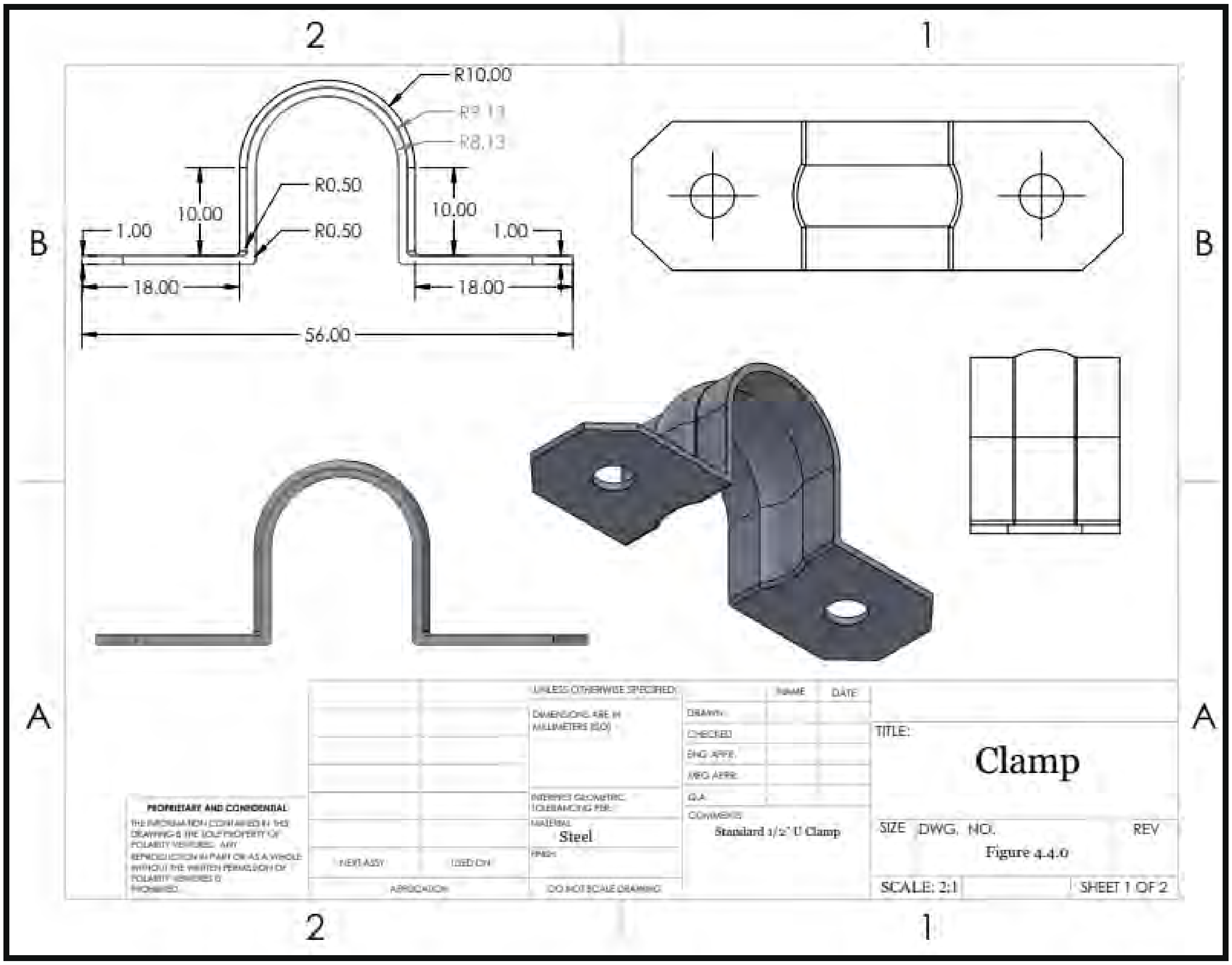


Figure 4.4.1 Clamp Design

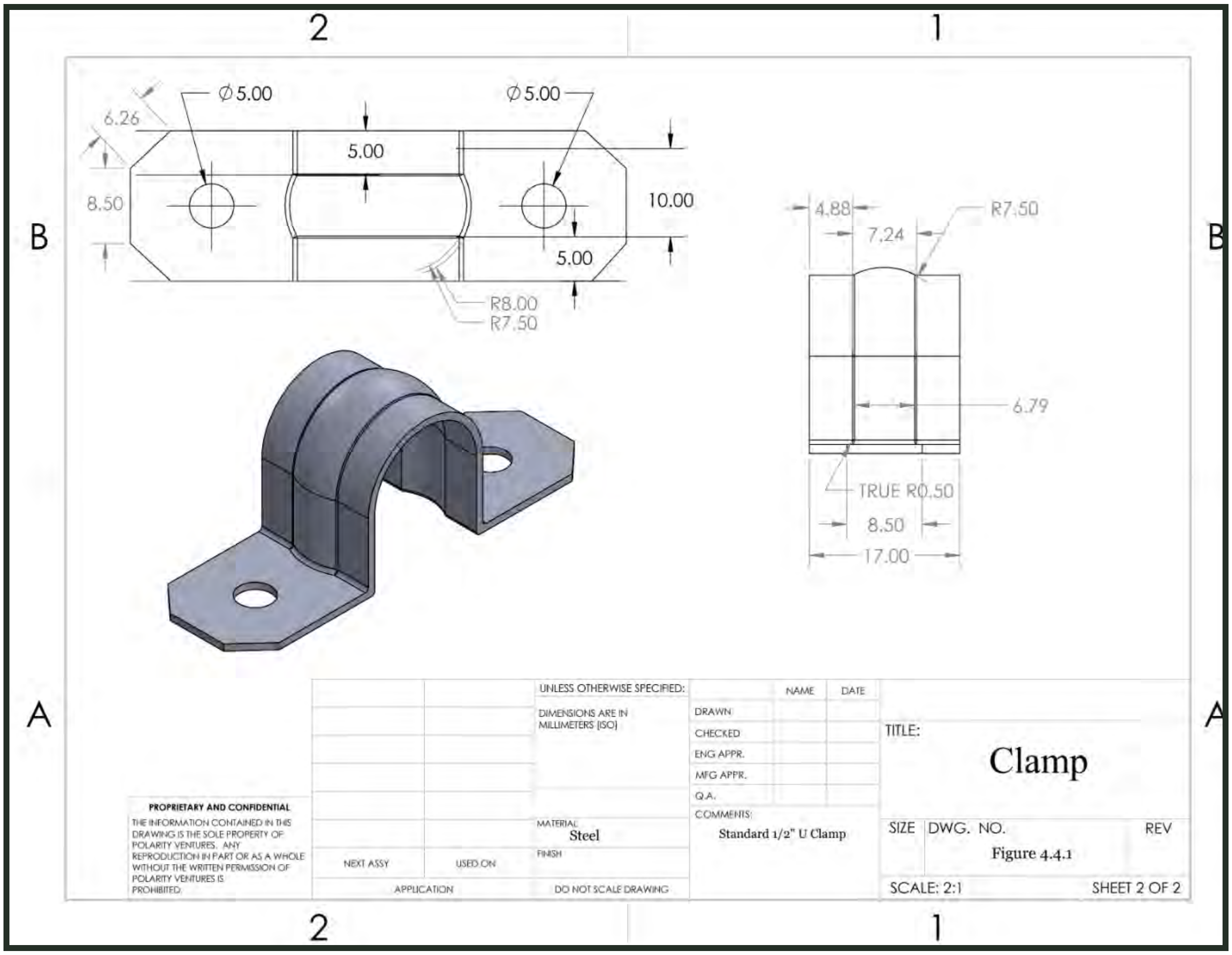


Figure 4.4.2 Clamp Design

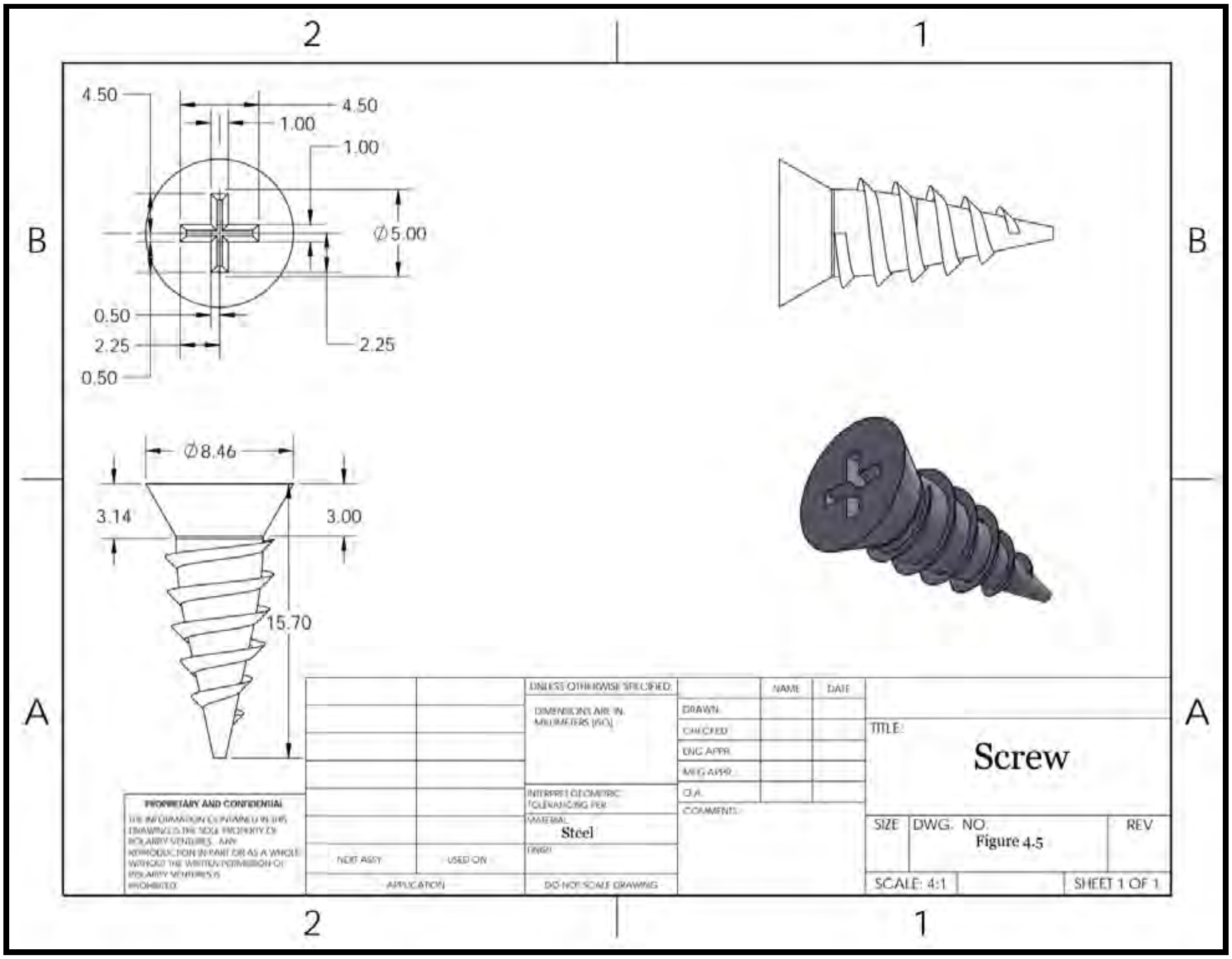


Figure 4.5 Screw Design

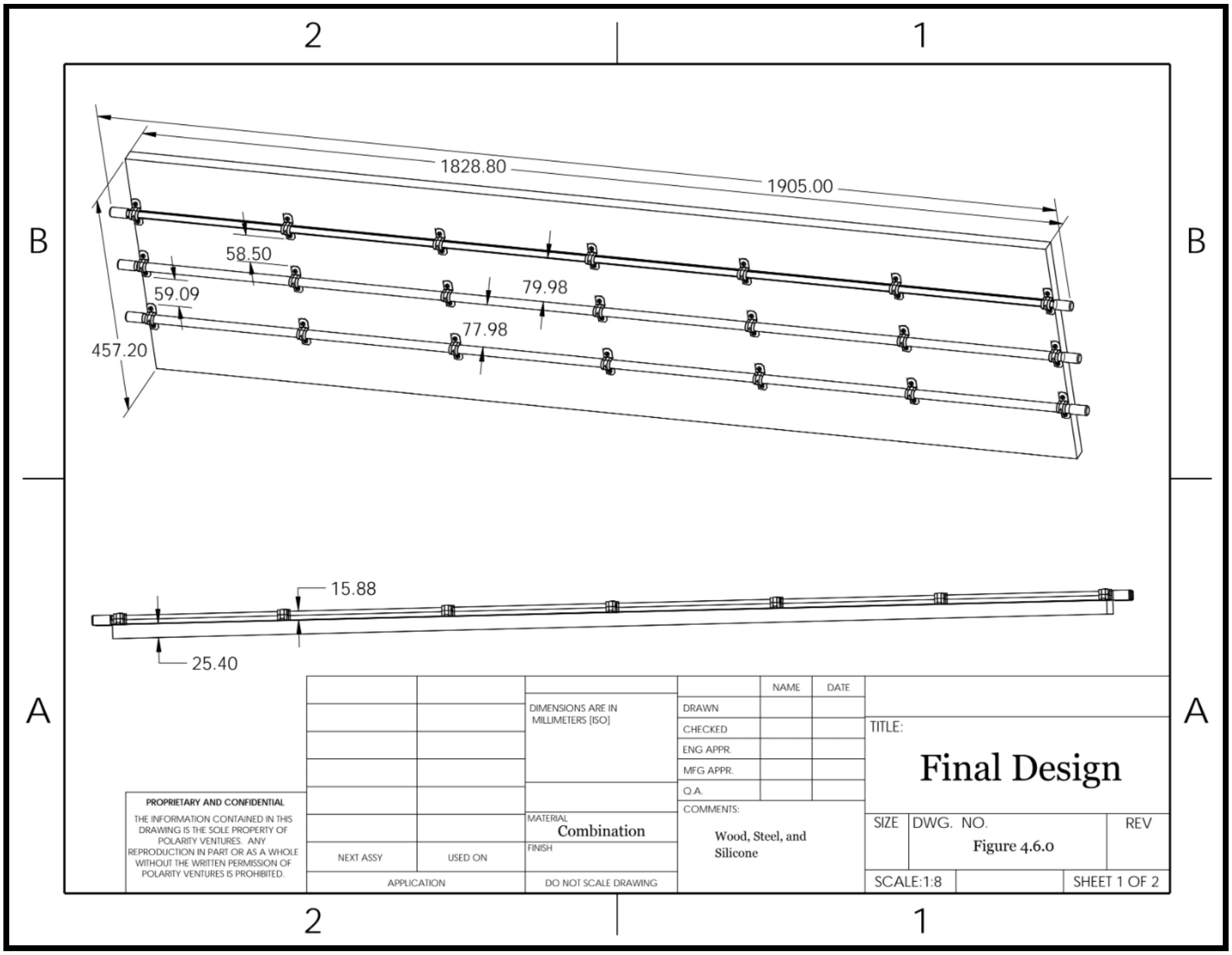


Figure 4.6.1 Completed Structure Design

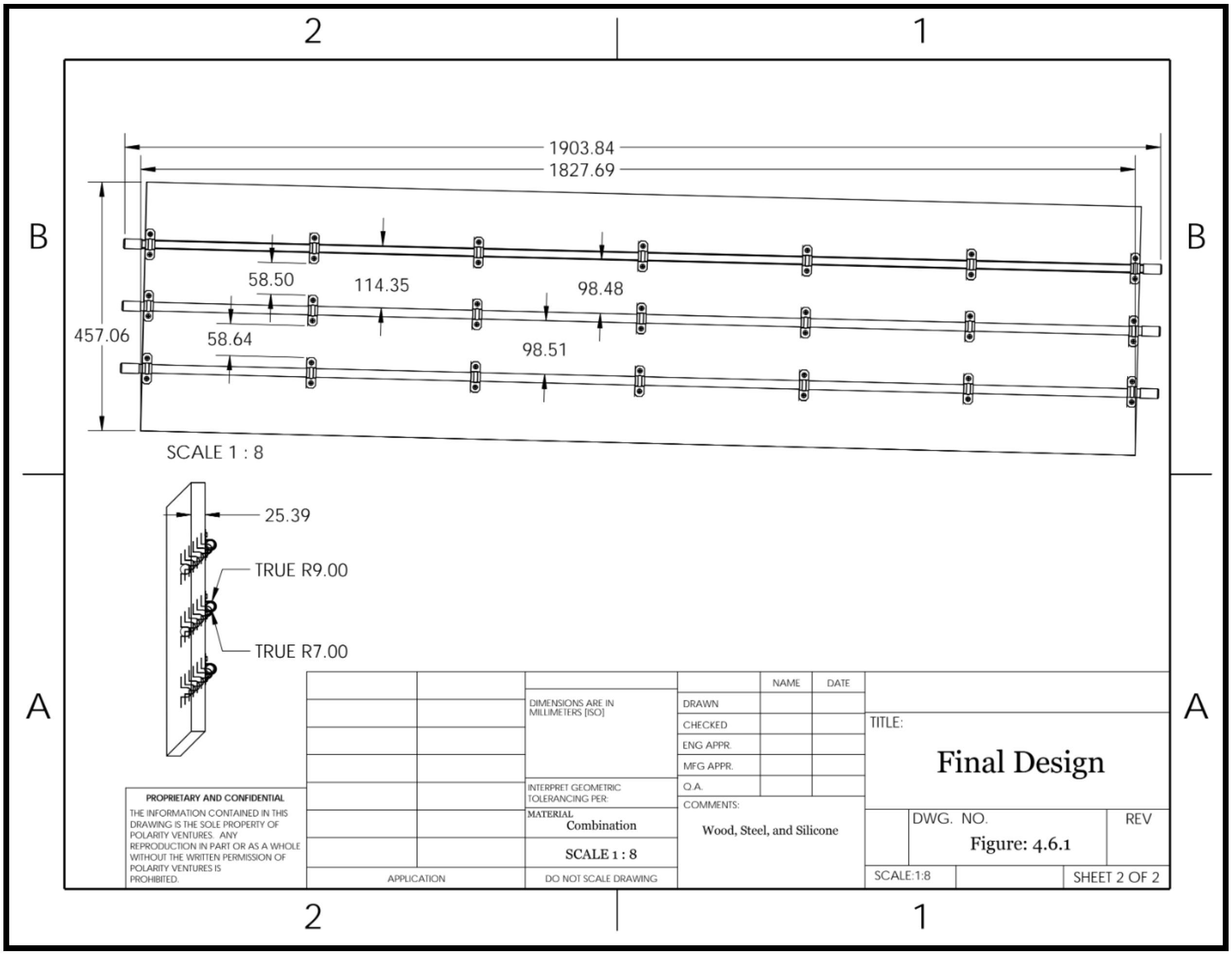


Figure 4.6.2 Completed Structure Design

B. Material Specifications

1. Silicone Tubes (Dimensions 1/2" ID x 5/8" OD; Thickness: 1.2 mm; Length: 6.25 feet:

   The silicone tubes are utilized in holding the mixed ingredients. Its properties of high flexibility, suitable for food processing, and capability of being sterilized at high temperatures and pressures makes it an ideal material for growing the SCOBY. Three tubes are implemented in the design, one acts as a control and the other two represent a variable whose effects are measured.

2. Rubber End Caps (ID 16 mm):

   In order to contain the components of the mixed ingredients and the grown SCOBY inside the tubes, rubber end caps are introduced to the ends. These caps provide a facilitated means of opening and closing the tubes for accessing the contents. The rubber material is a soft and elastic material that allows the cap to expand slightly to the shape of the tube, creating a tighter seal.

3. Plywood Base (Length: 6 ft; Width: 1.5 ft, Height: 1 in):

   Since the silicone tubes are highly flexible and the design requires them to be fully extended, they must be secured onto a base. Plywood is a strong and lightweight material that will serve as a sturdy base to allow for the clamps to be screwed into place. It is also an inexpensive material.

4. Galvanized Steel Pipe Clamps (¾ in, 2-holes):

   Galvanized Steel Clamps serve the purpose of holding the tubes down onto the base. Only requiring two screws, these clamps allow for effortless attachments to the base. Stainless steel has multiple ideal properties including high tensile strength, high durability, and low maintenance.

5. Screws (3/16 in x 1 in):

   Screws work in accordance with the pipe clamps to fix the tubes to the base.

6. Spring Water (750 mL):

Water is used in the recipe to create the Kombucha tea, which will result in the SCOBY. It is recommended to use either Spring Water or Filtered water for brewing kombucha because it contains all the minerals, but no impurities.

7. White Sugar (100 g):

   Along with water, sugar is added in the initial mixture of ingredients to brew the new batch of Kombucha. White sugar is the most widely used sugar in brewing Kombucha, leading to consistent and predictable results with regards to SCOBY growth. In the first step of the fermentation processes, the yeast present converts the sugar into ethanol, which is later converted to acids by the bacteria.

8. Black Tea (4 bags):

   Tea is one of the most critical ingredients in making Kombucha. The components within the tea, such as nitrogen and caffeine, are important aspects, along with the sugar, that provides nutrients to the bacteria and yeast and leads to a healthy SCOBY. The selection of black tea originates from the fact that it contains a higher concentration of purines, which is proportional culture activity. Specifically, black tea assists in the metabolism of the microorganisms.

9. Kombucha (235 mL):

   A small amount of already brewed and bottled Kombucha is used in brewing a new batch. The starting Kombucha already contains the bacteria and yeast needed to participate in the fermentation process, which facilitates the brewing process.

10. Pot (10.63 x 10.63 x 5.12 inches. Hold 4 quarts):

    A pot is required to hold the ingredients while they are being mixed together.

11. Mixing Spoon (13.5 x 2.75 x 1.2 inches):

    A mixing spoon is required to mix all the ingredients together.

12. Hot Plate (9.4 x 3.1 x 8.5 inches; 1000 watts):

    Prior to introducing the sugar and tea to the pot, the initial water is heated to a boil. This step serves several purposes including eliminating impurities that may be found in the water and also to brew the tea and dissolve the sugar later on.

13. Dremel (5 speed 3.7V):

    The dremel is used with a hook attachment to facilitate the twisting of the thread.

14. Spool (53 mm x 58 mm x 14 mm) - height x OD x ID

    The final product will be spooled to meet the desired requirement. To determine the proper spool size, the reel factor and cable diameter (the diameter of the SCOBY thread) are required to calculate an estimated maximum cable length.

15. Measuring Tape (120 in (10 ft)/300 cm):

    A measure tape is needed to have accurate measurements of the thread. It will also be used to measure the length of the tubes while forming them into their targeted length.

C. Procedures

Current Procedures 4/1

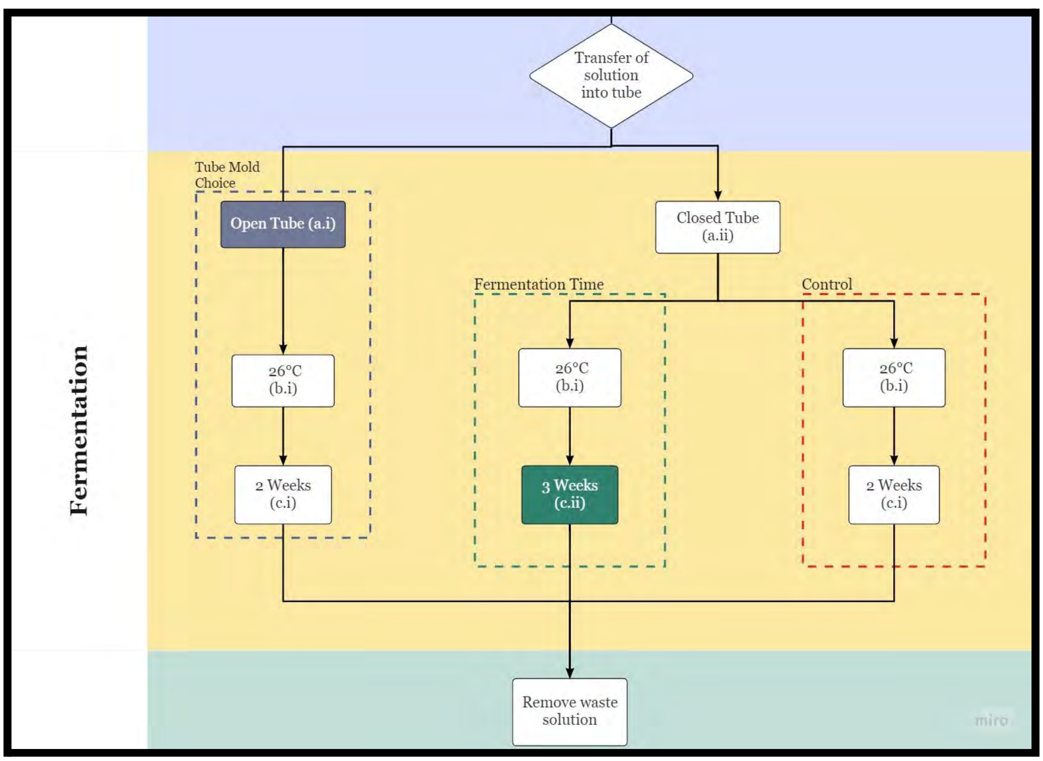


Figure 4.7 Conditions Being Tested in the Procedures

Procedures Revised 1/26

a. Tube Mold Choice

i. Open Tube

The tube mold will be one made out of silicone due to its high capacity of oxygen permeability. Since the fermentation process of SCOBY requires the presence of oxygen, having the tube be open in a horizontal cross section will allow for a greater presence of oxygen. Allowing for a decrease in the overall production of a SCOBY thread.

Zare, M., Ghomi, E. R., Venkatraman, P. D., & Ramakrishna, S. (2021). Silicone‐based biomaterials for biomedical applications: Antimicrobial strategies and 3D printing technologies. *Journal of Applied Polymer Science*, *138*(38), 50969. https://doi.org/10.1002/app.50969

ii. Closed Tube (C0ntrol)

The closed tube mold still allows for the oxygen permeability however, it will be entering the fermentation system at a much lower rate when compared to the open tube.

b. Temperature

i. 22 Degrees Celsius (control)

Kombucha tea is traditionally fermented at room temperature which is why this will serve as the control.

Laavanya, D., Shirkole, S., & Balasubramanian, P. (2021). Current challenges, applications and future perspectives of SCOBY cellulose of Kombucha fermentation. Journal of Cleaner Production, 295, 126–454. https://doi.org/10.1016/j.jclepro.2021.126454

c. Fermentation Time

i. 2 Weeks (Control)

This is considered the general fermentation time for SCOBY regardless of what its final intentions are. It will serve as the control fermentation time when testing the effectiveness of altering the remaining variables.

ii. 3 Weeks
The longer the SCOBY is left to ferment the thicker it will become. By setting the fermentation time for an extra week this will allow for the thread to be more uniform in its consistency and thickness.

Current Procedures 4/1

d. Tube Mold Choice

i. Open Tube

The tube mold will be one made out of silicone due to its high capacity of oxygen permeability. Since the fermentation process of SCOBY requires the presence of oxygen, having the tube be open in a horizontal cross section will allow for a greater presence of oxygen. Allowing for a decrease in the overall production of a SCOBY thread.

Zare, M., Ghomi, E. R., Venkatraman, P. D., & Ramakrishna, S. (2021). Silicone‐based biomaterials for biomedical applications: Antimicrobial strategies and 3D printing technologies. *Journal of Applied Polymer Science*, *138*(38), 50969. https://doi.org/10.1002/app.50969

ii. Closed Tube (C0ntrol)

The closed tube mold still allows for the oxygen permeability however, it will be entering the fermentation system at a much lower rate when compared to the open tube.

e. Temperature

i. 26 Degrees Celsius (Control)
Kombucha tea is traditionally fermented at room temperature which is why this will serve as the control.

Laavanya, D., Shirkole, S., & Balasubramanian, P. (2021). Current challenges, applications and future perspectives of SCOBY cellulose of Kombucha fermentation. Journal of Cleaner Production, 295, 126–454. https://doi.org/10.1016/j.jclepro.2021.126454

f. Fermentation Time

i. 2 Weeks (Control)

This is considered the general fermentation time for SCOBY regardless of what its final intentions are. It will serve as the control fermentation time when testing the effectiveness of altering the remaining variables.

ii. 3 Weeks

The longer the SCOBY is left to ferment the thicker it will become. By setting the fermentation time for an extra week this will allow for the thread to be more uniform in its consistency and thickness.

Revised Procedures 3/6/2022

Brewing

1. In a pot, 750ml of water will be brought to a boil (100 °C).
2. 100g of sugar will be added and then dissolved.
3. 4 standard tea bags will be steeped for 15 minutes and then removed. *note each tea bag contains around 3g of tea.
4. 750ml of room temperature water (around 20°C) will then be added to help decrease the cooling time.
5. Once the mixture cools to 22°C, 235ml of unflavored, unpasteurized Kombucha can be added to the tea and then stirred.

Fermentation

6. Fill the tubes with solution.
    a. For the open tube, ensure that both of the rubber caps are tightly secured and then with a measuring cup and funnel the solution will then be poured into the mold filling it to just below the edge of the wall.
    b. For the closed tubes, secure one end of the tube with the rubber cap and then using the funnel the solution will be poured into the open end. Then secure that end with a rubber cap.
7. The solution will be left to ferment for 2 weeks (open and control tube) 0r 3 weeks.

Purifying

8. After fermentation, the remaining solution will need to be drained.
9. The thread will be rinsed with around 20ml of 1 M NaOH and then rinsed with distilled water.
10. The SCOBY will then be left to dry for 1 week.

Spooling

11. The thread will be removed from the mold after 1 week of drying.

12. The thread will be twisted upon itself after it has been dried. A dremel will aid in the twisting. One end of the thread will be secured to a hook with the other end attached to the dremel. When the dremel is turned on and in use it will twist the cord in about 5 seconds.
13. After twisting the thread will be wrapped around a spool and the ends will be fastened so that it does not untangle.

Current Procedures 3/9/2022

Brewing

1. In a pot, 375 ml of water will be brought to a boil (100 °C).
2. 50g of sugar will be added and then dissolved.
3. 2 standard tea bags will be steeped for 15 minutes and then removed. *note each tea bag contains around 3g of tea.
4. 375ml of room temperature water (around 26°C) will then be added to help decrease the cooling time.
5. Once the mixture cools to 30°C, 118 ml of unflavored, unpasteurized Kombucha can be added to the tea and then stirred.

Fermentation

6. Fill the tubes with 100ml solution
    a. For the open tube, ensure that both of the rubber caps are tightly secured and then with a measuring cup and funnel the solution will then be poured into the mold filling it to just below the edge of the wall.
    b. For the closed tubes, secure one end of the tube with the rubber cap and then using the funnel the solution will be poured into the open end. Then secure that end with a rubber cap.
7. The solution will be left to ferment for 2 weeks (open and control tube) 0r 3 weeks.

Purifying

8. After fermentation, the remaining solution will need to be drained.
9. The thread will be rinsed with around 20ml of 1 M NaOH and then rinsed with distilled water.
10. The SCOBY will then be left to dry for 1 week.

Spooling

11. The thread will be removed from the mold after 1 week of drying.

12. The thread will be twisted upon itself after it has been dried. A dremel will aid in the twisting. One end of the thread will be secured to a hook with the other end attached to the dremel. When the dremel is turned on and in use it will twist the cord in about 5 seconds.
13. After twisting the thread will be wrapped around a spool and the ends will be fastened so that it does not untangle.

Between the first and the finalized procedures two changes were made; the dimensions of the ingredients and the temperature at which the solution cools to. The dimensions were cut in half due to the determination of only 100ml of solution being needed in each tube. Beforehand there was a large amount of excess that ended up being wasted. The solution is also now cooled down to 30°C which is to still be considered room temperature. This decision was changed since the temperature within the room of the facility was around 26°C.

D. Test Procedures

Test Protocol	
Project Description: Manufacturing Process of a SCOBY Bio-Thread	**REVISION NO.:**
Team: Nathaniel Alexander, Megan Boge, Rene Elvir, Catalina Zambrano, Sydney Zamorano	**Page** 1 of 3
TITLE: *SCOBY Bio-thread Tensile Strength and Shape Memory Verification Test*	

1. PURPOSE

The overall purpose of the protocol is to confirm that the final product meets all the specifications or requirements defined in the phase zero of the project. To verify that the thread is strong, the tensile test will be used to provide measurable data such as tensile strength. To verify that the thread is flexible, the spooling test will be used to determine whether the thread can be spooled on a spool with a diameter of 1.0 cm.

2. SCOPE

The overall scope of all the protocols is to verify that the design inputs drawn from the market requirements are developed in the correct way. The intent from all the verification tests is to ensure that the final product does what it is supposed to do which in our case is the wound dressing aspect. The only part that we are not going to cover is the actual wound dressing itself since we are only focused on producing the thread.

3. REFERENCE DOCUMENTS

ASTM D5035 Textile Break and Elongation Testing- which is typically used in different types of fabrics which requires the use of a specific machine.

4. **OVERVIEW/BACKGROUND**

This protocol is necessary due to the fact that this will promote credibility and reliability to our project. Having verification and validation protocols will give the confirmation that the product we are trying to deliver is built to the stated specifications and validation confirms that the product meets the customer's needs.

5. **OBJECTIVES**

We will be comparing our result to collagen fibers

Tensile strength: 32MPa

Flexibility: Capacity to be spooled on a spool with a diameter of 1.0 cm.

6. **TEST EQUIPMENT**

In order to measure the tensile strength of the thread we are trying to deliver we must use a testing machine which will measure the overall strength or the maximum load the thread can withstand. A spool of diameter 1.0 cm will be used to determine whether or not the bio-thread is flexible.

7. **MATERIAL**

Tensile strength machine, 0.5 cm diameter spool.

8. **SETUP**

For the tensile test the thread created will be placed in the tensile testing machine having a gap in between then through the use of the computer software the load will be applied in small increments until failure or when the thread breaks. Furthermore, for the flexibility test, the thread will be spooled on a spool with a diameter of 1.0 cm.

9. **SAMPLE SIZE**

We will be using 1 thread created from the fermentation process.

10. **EXPECTED RESULTS/HYPOTHESIS**

If we create a microbial thread containing nanofibers derived from bacteria and yeast through fermentation processes then the thread will have similar characteristics to collagen fibers.

11. **PROCEDURE**

For the tensile test using the standard the steps are as follows:

1. Using the ASTM D5035 standard a width of 1 in. is common
2. Secure both ends of the sample in grips that are wider than the sample.
3. A slight preload may be applied to align the grips along a universal joint and remove slack.
4. Begin the test by pulling at a Constant Rate of Extension specified in the standard.
5. Stop the test once the sample has been ripped apart
6. After gathering this information the tensile strength of the bio-thread can be determined and a tensile strength of greater than 32 MPa will suggest that the bio-thread is strong.
7. Additionally, the flexibility test procedure is to have the bio-thread spooled on a spool with a diameter of 1.0 cm. If the bio-thread does not fracture, it will be considered flexible.

12. **DATA COLLECTION SHEET**

Specimen	Tensile Stress Test result	Flexibility test
SCOBY Bio-thread	passed/failed	Passed/failed

E. Patent Opportunities

The manufacturing of a SCOBY Bio-Thread is a process that can be adopted as a new patent. The aforementioned patent discovered after initially designing this process includes the key components of utilizing a closed silicone tube of a desired length and width for an unmentioned amount of time depending on factors such as tube material, wall thickness, and bacteria. The design created by the team includes growing the SCOBY Bio-Thread under different conditions, showing the addition of variables not mentioned in the original patent contributing to either the efficiency of its production or to the enhancing of its mechanical properties. Such variables include a longer fermentation time (3-weeks vs 2-weeks) and rate of fermentation due to amount of gas exposure (opened tube vs closed tube). The results of the updated design are organized at the end of the project and made available to the sponsor, Polarity Ventures, who own the rights to the findings and may apply for a patent with additional research. The team was tasked to create a process that would result in the acquisition of a thread composed of the SCOBY byproduct from the Kombucha fermentation. Polarity Ventures is in the position to continue into the next phase of the product development, and later into design validation and commercialization. They also hold the rights to capitalize on the process as the sole manufacturer and distributor of the SCOBY Bio-Thread.

Design Verification

A. Design Verification Protocols

Design Verification Revised 2/18/2022

Verification and Verification Test Protocols

Table 5.1 Design Input and Verification Test for Market Requirement #1

<table>
<tr><td rowspan="2">1.The Bio-thread will contain bioactive compounds.</td><td>The final product will have cellulose.</td><td rowspan="2">Schulze's Reagent. A purple color change occurs in the presence of cellulose</td></tr>
<tr><td>Rationale: Cellulose is a biocompatible material that has the capability of promoting wound healing.</td></tr>
</table>

1. Place the Scoby Bio-thread at the base of an open container.
2. Using a measuring cylinder, measure 50 mL of Schulze's reagent.
3. Using a syringe, apply Schultze's reagent along the length of the Bio-thread.
4. Record all color changes present and any other observations which may be present.
5. If the Bio-thread changes to a purple color, cellulose is present and the verification test is passed.

Table 5.2 Design Input and Verification Test for Market Requirement #2

<table>
<tr><td rowspan="2">2. An uninterrupted Bio-thread with dimensions that will facilitate large scale manufacturing</td><td>The Bio-thread must present repeatability with a length of 152.4 +/- 15.24 cm and a diameter of 2 +/- 0.2 mm to allow for future large scale production</td><td rowspan="2">Measure the final length of the Bio-thread using a tape, measure the width two dimensionally across each foot of the Bio-thread using calipers, determine the standard deviation of the width and compare it to the standard deviation across the entire length.</td></tr>
<tr><td>Rationale

Future large scale production</td></tr>
</table>

1. Place the Scoby Bio-thread along a long, flat surface and using a tape measure, record the total length of the Bio-thread.
2. Keeping the Bio-thread in the same position, measure the width two dimensionally across every 7.5 centimeters of the Bio-thread using calipers and tabulate all results.
3. Determine the standard deviation of the width across every 7.5 centimeters of the Bio-thread and compare it to the standard deviation across the entire length.

4. Determine the standard error of the mean by dividing the standard deviation by the square root of the sample size.
5. Once the Bio-thread has a length of 152.4 +/- 15.24 cm and a diameter of 2 +/- 0.2 mm, the verification test is passed.

Table 5.3 Design Input and Verification Test for Market Requirement #3

3. The Bio-thread must be flexible to be woven into future wound dressings.	The Bio-thread must be able to bend repeatedly 360 degrees in both directions and not exhibit shape memory	Fatigue testing: The Bio-thread must endure a minimum of 1000 cycles to ensure flexibility. Shape memory: The bio-thread must return to its original shape after deformation.
	Rationale To allow for future use in wound dressings	

1. Load a 17.75 cm specimen of the SCOBY Bio-thread into a fatigue tester.
2. Set the tensile stress to ___ MPa and perform 1000 cycles.
3. Take another 17.75 cm specimen of the SCOBY Bio-thread and bend it 360 degrees. When released, observe whether it returns to its original shape or exhibits shape memory by holding the bent shape.
4. Once the biothread endures 1000 cycles in the fatigue tester and does not exhibit shape memory, the verification test is passed.

Table 5.4 Design Input and Verification Test for Market Requirement #4

4. The SCOBY must not be acidic	The pH of the SCOBY must not be below 4.7	pH meter for soft solids. Measure the pH at every 3 inches and calculate the standard deviation.
	Rationale: The average pH of natural skin is 4.7. Since the SCOBY is in contact with various acids, it may adopt an acidic concentration, which will need to be measured to ensure it will not harm the skin.	

1. Place the Scoby Bio-thread along a long, flat surface.
2. Measure the pH of Bio-thread at intervals of 3 inches.
3. Determine the standard deviation of the pH across every 3 inches of the Bio-thread and compare it to the standard deviation across the entire length.

4. Determine the standard error of the mean by dividing the standard deviation by the square root of the sample size.
5. Once the Bio-thread has a pH of greater than 4.7, the verification test is passed.

Verification Results

Table 5.5 Results from the Verification Tests

Parameter	Average Measurement	Standard Error of the Mean	Standard deviation across every specified length	Standard deviation across entire specimen
Cellulose presence	present/absent	N/A	N/A	N/A
Length / cm				
Diameter / mm				
Fatigue test endurance / cycles	Number of cycles	N/A	N/A	N/A
Shape memory	present/absent	N/A	N/A	N/A
pH				

Design Verification Revised 3/29/2022

Verification and Verification Test Protocols

Table 5.1 Design Input and Verification Test for Market Requirement #1

Market Requirement	Design Input	Verification Testing
The Bio-thread will contain bioactive compounds.	The final product will have cellulose.	Schulze's Reagent. A purple color change occurs in the presence of cellulose
	Rationale: Cellulose is a biocompatible material that has the capability of promoting wound healing.	

1. Place the Scoby Bio-thread at the base of an open container.
2. Using a measuring cylinder, measure 50 mL of Schulze's reagent.
3. Using a syringe, apply Schultze's reagent along the length of the Bio-thread.
4. Record all color changes present and any other observations which may be present.
5. If the Bio-thread changes to a purple color, cellulose is present and the verification test is passed.

Table 5.2 Design Input and Verification Test for Market Requirement #2

Market Requirement	Design Input	Verification Testing
An uninterrupted Bio-thread with dimensions that will facilitate large scale manufacturing	The Bio-thread must present repeatability with a length of 152.4 +/- 15.24 cm and a diameter of 2 +/- 0.2 mm to allow for future large scale production.	Measure the final length of the Bio-thread using a tape, measure the width two dimensionally across each foot of the Bio-thread using calipers, determine the standard deviation of the width and compare it to the standard deviation across the entire length.
	Rationale: Future large scale production	

1. Place the Scoby Bio-thread along a long, flat surface and using a tape measure, record the total length of the Bio-thread.
2. Keeping the Bio-thread in the same position, measure the width two dimensionally across every 2.5 centimeters of the Bio-thread using calipers, determine the average and tabulate all results.
3. Determine the standard deviation of the width across every 2.5 centimeters of the Bio-thread and compare it to the standard deviation across the entire length.
4. Determine the standard error of the mean by dividing the standard deviation by the square root of the sample size.
5. Once the Bio-thread has a length of 152.4 +/- 15.24 cm and a diameter of no greater than 2 +/- 0.2 mm, the verification test is passed.

Table 5.3 Design Input and Verification Test for Market Requirement #3

Market Requirement	Design Input	Verification Testing
The Bio-thread must be strong and flexible for future use in wound dressings.	The Bio-thread must endure a tensile stress of 32 MPa and fit around a spool with a diameter of 1.0 cm	Tensile Strength testing: The Bio-thread must endure a minimum tensile stress of 32 MPa cycles to ensure strength.
	Rationale: To allow for future	

	use in wound dressings	Flexibility testing: The bio-thread must spool around a spool with 1.0 cm diameter without fracturing.

1. Spool a 40 cm specimen of the SCOBY Bio-thread on a spool with 1.0 cm diameter. Observe whether any fractures occur and record results.
2. Load an 11.5 cm specimen of the SCOBY Bio-thread into a tensile stress test machine.
3. Begin the test by pulling at a constant rate of extension specified in the standard and stop the test once the tensile stress has exceeded 32 MPa.
4. Once the biothread endures a tensile stress of 32 MPa and is successfully spooled on a spool with 1.0 cm diameter without fracturing, the verification test is passed.

Table 5.4 Design Input and Verification Test for Market Requirement #4

Market Requirement	Design Input	Verification Testing
The SCOBY must not be acidic	The pH of the SCOBY must not be below 4.7	pH meter for soft solids. Measure the pH at every 2.5 cm and calculate the standard deviation.
	Rationale: The average pH of natural skin is 4.7. Since the SCOBY is in contact with various acids, it may adopt an acidic concentration, which will need to be measured to ensure it will not harm the skin.	

1. Place the Scoby Bio-thread along a long, flat surface.
2. Measure the pH of Bio-thread at intervals of 2.5 cm.
3. Determine the standard deviation of the pH across every 2.5 cm of the Bio-thread and compare it to the standard deviation across the entire length.
4. Determine the standard error of the mean by dividing the standard deviation by the square root of the sample size.
5. Once the Bio-thread has a pH of greater than 4.7, the verification test is passed.

5.2 Verification Results

Table 5.5 Results from the Verification Tests

Parameter	Verification	Average	Standard	Average	Standard

	Test Result	Measurement	Error of the Mean	Standard deviation across every specified unit	deviation across all units
Cellulose presence	Passed	Passed	N/A	N/A	N/A
Continuous Length / cm	Failed	51.5	N/A	N/A	N/A
Diameter / mm	Passed	1.073	0.019	0.044	0.088
Tensile Stress Test / MPa	Failed	6.41	N/A	N/A	N/A
Flexibility test	Passed	N/A	N/A	N/A	N/A
pH	Passed	7.311	0.008	0.023	0.037

B. Test Data & Data Evaluation

To evaluate the final results, test protocols were designed to confirm all design inputs. The final SCOBY Bio-thread was required to contain cellulose, have a continuous length of 152.4 +/- 15.42 cm with a diameter of 2 +/- 0.2 mm, endure a tensile stress of 32 MPa, be spooled on a 1.0 cm diameter spool, and have a pH of greater than 4.7. The PASCO Capstone hardware and software were used to perform the tensile stress verification test, an electronic caliper was used to measure the width of the Bio-thread along its entire length, a solid pH meter was used to determine the pH of the Bio-thread along its entire length and Microsoft Excel was used to determine any averages, standard deviations and standard errors of the means.

Verification Test for Cellulose:

The presence of cellulose within the SCOBY bio-thread was examined for one trial. Once the bio-thread was spooled, it was subjected to the Schultze's reagent, an oxidizing solution consisting of potassium chlorate $KClO_3$ and nitric acid HNO_3. If a blue color change were observed, cellulose would be deemed present.

Results:

Once there was contact between Schultze's reagent and the SCOBY Bio-thread, a color change was observed from dark green to blue, indicating the presence of cellulose.

Figure 5.1 Original Bio-thread Figure 5.2 Bio-thread treated with Schultze's reagent.

Dimensional Verification Test:

In order to test the continuous length of the Bio-thread, a measuring tape positioned alongside the Bio-thread and results were recorded for one specimen. Initially, the dried SCOBY was 193 cm long but if twisted, fracturing would have occurred. As a result, the SCOBY was folded in thirds and twisted, providing the Bio-thread with much greater strength and stability. In order to test the diameter of the Bio-thread along its entire length, a caliper was used at every 2.5 cm. Further analysis was performed using Microsoft Excel to determine the average width, standard deviation and standard error of the mean.

Results:

The Bio-thread, analyzed for one specimen, was continuous in length for 51.5 cm, falling short of the desired length of 152.4 cm. However, the Bio-thread had an average width of 1.073 +/- 0.019 mm, satisfying the design input requiring the thread to be no greater than 2 +/- 0.2 mm in diameter, and passing the verification test.

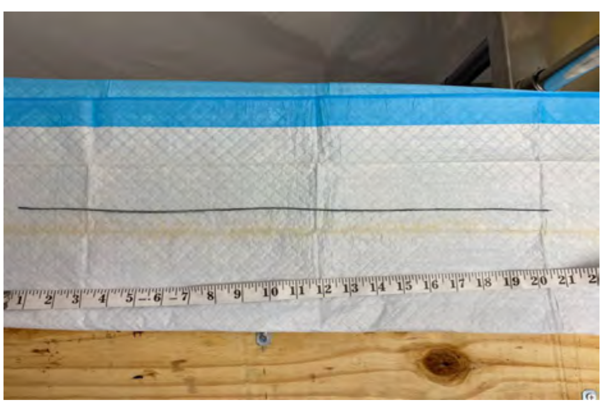


Figure 5.3 Final Bio-thread

Table 5.6 Results from the Dimensional Verification Test

Trial	Position/cm	Two Dimensional Diameter Average/ mm	Overall Average Diameter/ mm	SD Between Successive Points/ mm	SD Across Entire Specimen/ mm	SEM Across Entire Specimen
1	0	1.2	1.073	0.071	0.088	0.019
2	2.5	1.1		0.000		
3	5	1.1		0.071		
4	7.5	1.2		0.000		
5	10	1.2		0.071		
6	12.5	1.1		0.000		
7	15	1.1		0.071		
8	17.5	1.2		0.071		
9	20	1.1		0.000		
10	22.5	1.1		0.000		
11	25	1.1		0.071		
12	27.5	1		0.000		
13	30	1		0.000		
14	32.5	1		0.071		
15	35	1.1		0.141		
16	37.5	0.9		0.000		
17	40	0.9		0.071		
18	42.5	1		0.071		
19	45	1.1		0.071		
20	47.5	1		0.000		
21	50	1		0.071		
22	51.5	1.1		N/A		

Equations:

$$Standard\ deviation\ (SD)\ =\ \sqrt{\frac{\Sigma(x-\bar{x})^2}{n}}$$

$$Standard\ Error\ of\ the\ Mean\ (SEM)\ =\ \frac{SD}{\sqrt{n}}$$

Tensile Stress and Flexibility Verification Tests:

For the tensile stress test, an 11.5 cm sample of the SCOBY Bio-thread was secured at both ends of the PASCO Capstone tensile stress tester. This Bio-thread specimen was from a 2 week old SCOBY, with a diameter of 1.073 mm. The Bio-thread was slowly pulled apart until the point of fracture. The maximum endured force was recorded and the tensile stress was calculated. For the flexibility verification test, the 51.5 cm long Bio-thread was spooled on a spool with a diameter of 1 cm. If spooled without fracture, the Bio-thread would be deemed flexible.

Results:

The 1.073 diameter Bio-thread endured a force of 5.8 N, corresponding to a tensile stress of 6.41 MPa. This was much lower than the desired 32 MPa and therefore failed the tensile stress verification test. However, the Bio-thread was successfully spooled on a 1.0 cm diameter spool, deeming the Bio-thread flexible.

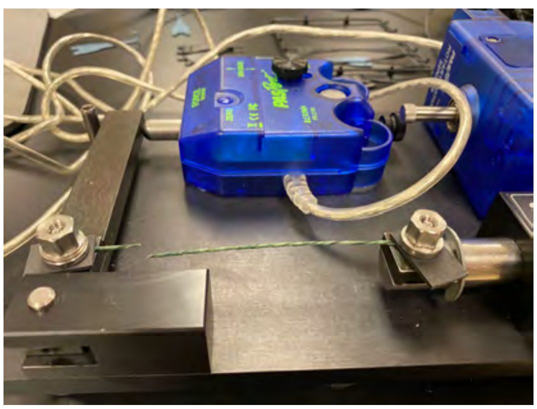


Figure 5.4 PASCO Capstone Tensile Stress Test

Table 5.7 Data Collected from the Tensile Stress Test

Maximum Force / N	Area / m^2	Ultimate Tensile Stress / MPa
5.8	9.04E-07	6.41

Figure 5.5 Spool Flexibility Test

pH Verification Test:

In order to test the pH of one Bio-thread specimen along its entire length, a solid pH meter was used at every 2.5 cm. Further analysis was performed using Microsoft Excel to determine the average pH, standard deviation and standard error of the mean.

Results:

The Bio-thread, analyzed for one specimen, had an average pH of 7.311 +/- 0.008, satisfying the design input requiring the thread pH to be no less than 4.7, and passing the verification test.

Table 5.8 Results from the pH Verification Test

Trial	Position/ cm	pH	Average pH	SD Between Successive Points	SD Across Entire Specimen	SEM Across Entire Specimen
1	0	7.31	7.311	0.007	0.037	0.008
2	2.5	7.3		0.035		
3	5	7.35		0.042		
4	7.5	7.29		0.007		
5	10	7.3		0.000		
6	12.5	7.3		0.042		
7	15	7.24		0.042		
8	17.5	7.3		0.007		
9	20	7.29		0.071		
10	22.5	7.39		0.007		
11	25	7.38		0.000		

12	27.5	7.38		0.049		
13	30	7.31		0.000		
14	32.5	7.31		0.000		
15	35	7.31		0.007		
16	37.5	7.32		0.035		
17	40	7.27		0.014		
18	42.5	7.29		0.014		
19	45	7.27		0.035		
20	47.5	7.32		0.028		
21	50	7.28		0.035		
22	51.5	7.33		N/A		

Equations:

$$Standard\ deviation\ (SD) \ = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n}}$$

$$Standard\ Error\ of\ the\ Mean\ (SEM) \ = \frac{SD}{\sqrt{n}}$$

Engineering Analysis

1. SolidWorks Design

SolidWorks was utilized to depict the design for the three proposed design concepts. For Design Concept 1, three parts were created: the curved tube, the straight tube, and the bin. Firstly, the bin was formed by creating the rectangular shape and following the dimensions from a plastic bin it was based on. Using the length from inside the bin, the dimensions of the curved tube was formulated. This part was duplicated and connected with the other curved tube via a straight tube component. With this assembly, it was then added to the bin part, making another assembly, and the final design, as seen in Figure 6.1.

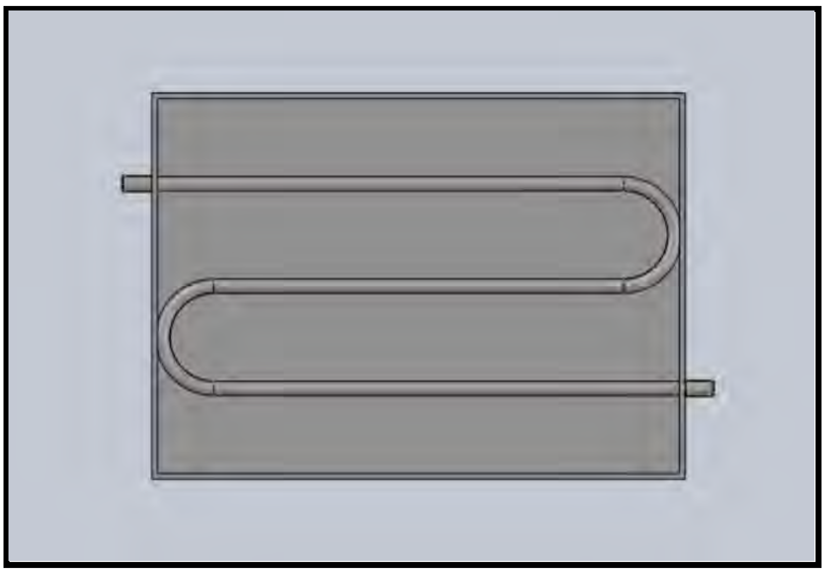


Figure 6.1 Design Concept 1

Design Concept 2 did not consist of an assembly, but rather of a singular part. The cylindrical structure was modeled after a 5-gallon bucket, and its dimensions were used to create the component. Next, using the Helix and Spiral option in Solidworks, the tube was formed in the wrapped configuration around the structure, finalizing the second design concept, shown in Figure 6.2.

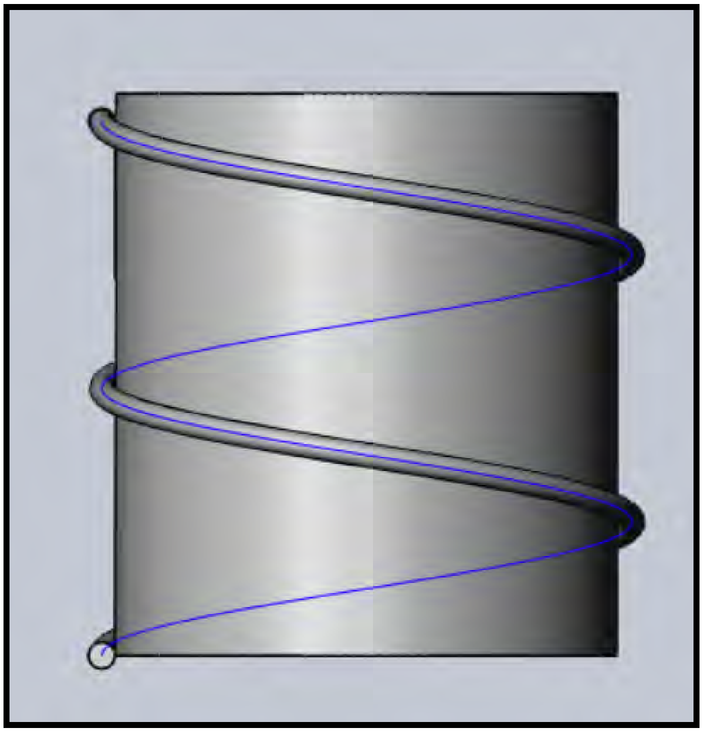


Figure 6.2 Design Concept 2

Lastly, Design Concept 3 was initiated by the design of the plywood base. Its dimensions were determined from the length of the tubes, allowing for a section of them from extending off of the edge. Next, the enclosed tube was made along with the rubber end caps, along with the opened tube, which served with the same design process only differing in cutting the cross-sectional area through the center. The clamp and screw was created based on previously formed templates. Lastly, all components were placed on an assembly and mated to remain secured on a structure, as it would in process (Figure 6.3)

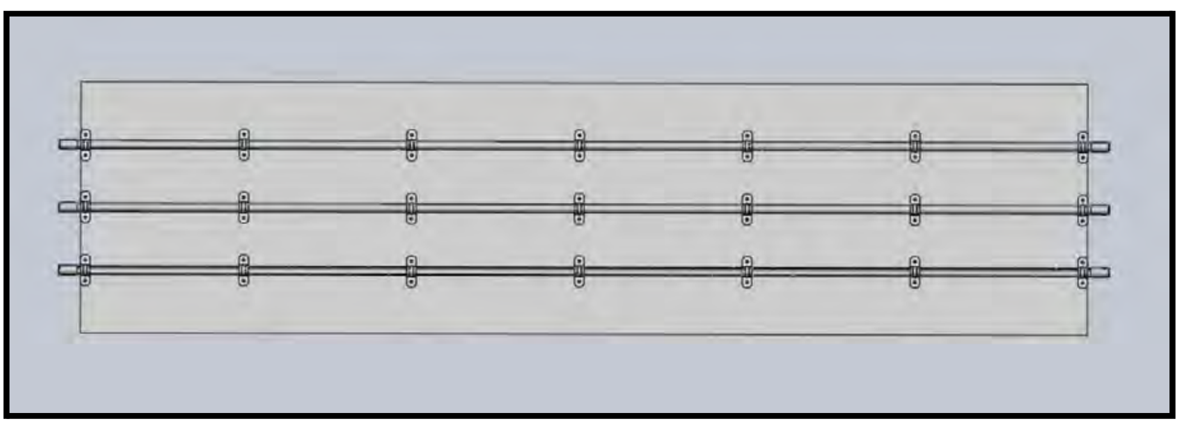


Figure 6.3 Design Concept 3

2. Heat Transfer Simulation

The Surface-to-Ambient Radiation analysis in Comsol describes the radiation of defined boundaries to the ambient[15]. The equation used to perform the analysis involves the net inward heat flux, as shown below:

$$-n \times q = \varepsilon\sigma(T^4_{amb} - T^4)$$

In this equation, ε represents the surface emissivity, which is selected from the material specified. This value ranges from 0 to 1, where 0 means that no radiation is emitted from the surface and 1 means that the surface is a perfect emitter, or a blackbody. The σ variable represents the predefined Stefan-Boltzmann constant, which is $5.6704*10^{-8}$ W/m^2*K. Lastly, T_{amb} is the ambient temperature in Kelvin, which is manually inputted by the user.

This simulation was performed on the project to determine how long it would take the tea within the tubes to return to room temperature. The temperature of the tea (T) was inputted as 30 °C, and the ambient temperature (T_{amb}) was 25.5 °C. The results demonstrated that it would take approximately 8 minutes for the temperature to return to the modified room temperature.

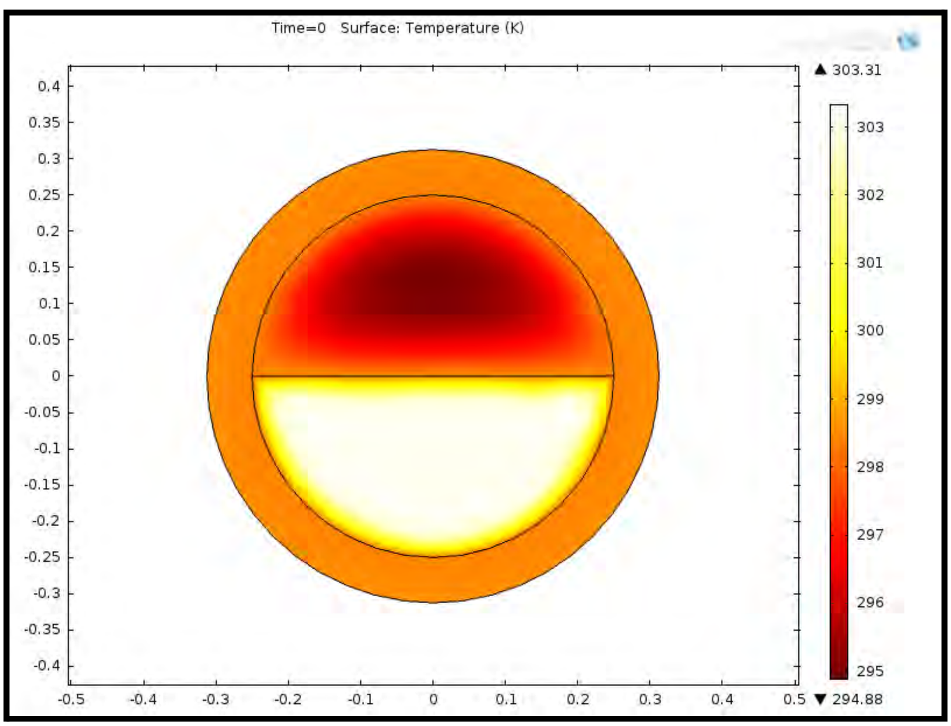


Figure 6.4 Temperature Distribution at Time=0 Seconds

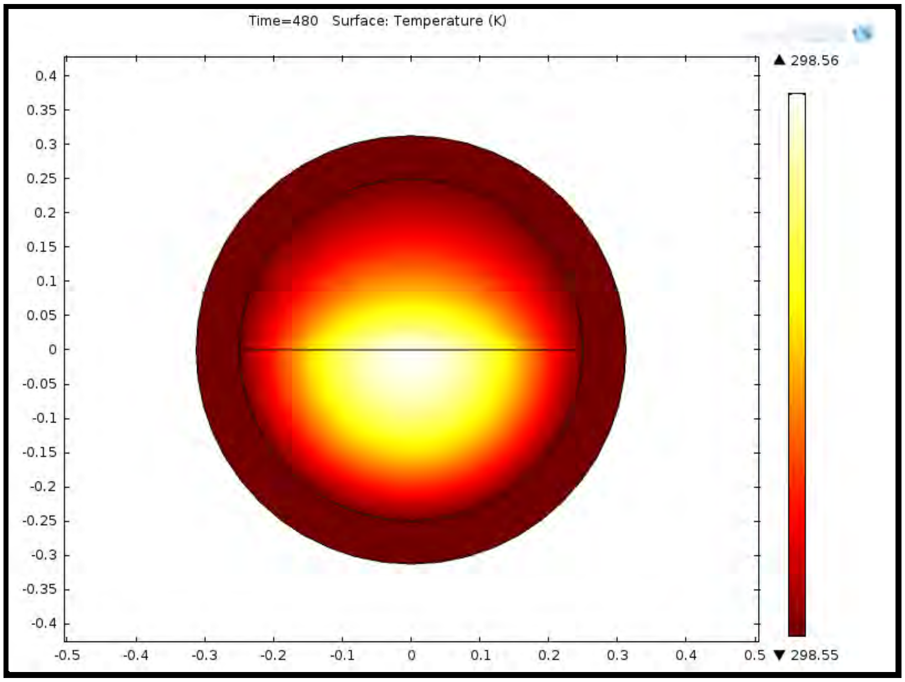


Figure 6.5 Temperature Distribution at Time=480 Seconds

3. NaOH Solution Preparation and Reaction Kinetics

Calculation of NaOH Solution (Prior to Preparation of Solution)
Used in Industry: Chlor-Alkali Process: **Electrolysis Process** of Sodium Chloride Solutions to Manufacture Chlorine, Molecular Hydrogen and Sodium Hydroxide
Half Reactions

$ClO^{-} + H_2O + 2e^{-} \leftrightarrow Cl^{-} + 2OH^{-}$ Reduction

$H_2O + 2e^{-} + 2Na^{+} \leftrightarrow H_2 + 2NaOH$ Oxidation

Whole Reaction **Exothermic Reaction**

$2Na^{+}Cl^{-}(s) + H_2O\,(l) \rightarrow 2Na^{+}OH^{-}(aq) + H_2(g)\uparrow + Cl^{-}(g)\uparrow$

n = number of moles

Molarity $\mathcal{M} = \frac{number\ of\ moles}{Liters}$

Molecular Weight (M) $= \frac{grams}{number\ of\ moles}$

Knowns:

$M_{Na} = 23.00\ [\frac{g}{mol}]$

$M_{O} = 16.00\ [\frac{g}{mol}]$

$M_H = 1.01 \left[\frac{g}{mol}\right]$

Therefore,

$M_{NaOH} = 40.00 \left[\frac{g}{mol}\right]$

Density, $\rho = \frac{mass}{volume}$

$\rho_{H2O} = 1.00 \left[\frac{g}{mL}\right]$

Desired: $\boldsymbol{\mathcal{M}}_{NaOH} = 1\ [mol/L]$

Volume of Solvent (Water) = 100 mL

Therefore: n_{NaOH} = 1 [mol/L] NaOH * 100 [mL] * 10^{-3} [L/mL] = 1 [mol] NaOH

g_{NaOH} = 1 [mol] * $40.00 \left[\frac{g}{mol}\right]$ = 4 $[g]$

Preparation of NaOH Solution

Pre-prep: Calculate solution measurements then put on protective eyewear and gloves. NaOH pellets and NaOH solution will burn the skin if in immediate contact. High Density Polyethylene, HDPE, containers are highly recommended as over time the sodium hydroxide can react with glass to form sodium silicate, that may result in etched or shattered glass. Be sure to use a container that is twice the size of the total desired volume collected in preparation of any unforeseen accidents.

- Using a scale with a resolution of at least tenths to the gram precision: In **separate** containers weigh out each component, Water and Sodium Hydroxide, with their respective amount previously calculated.
- <u>Slowly</u>, add the **NaOH** to the **WATER**. Continuously, mix the solution until all NaOH flakes have been added to the solution and dissolved completely. Container will be hot. Do not cover the container until the solution has cooled to room temperature.

4. **Thread Dimensions Calculations**

The table and calculations below demonstrate the measurements and calculations obtained to determine the SCOBY Bio-Thread diameter, standard deviation and standard error of the mean. The Bio-Thread is a result of the twisted dehydrated SCOBY, influencing the consistency of the diameter across the entire length. To investigate this, Table 6.1 demonstrates the measurements (diameter,standard deviation (SD), & standard error of the mean (SEM)) taken at every 2.5 cm along the length of the Bio-Thread.

Table 6.1 Results from the Dimensional Verification Test

Trial	Position/cm	Two Dimensional Diameter Average/ mm	Overall Average Diameter/ mm	SD Between Successive Points/ mm	SD Across Entire Specimen/ mm	SEM Across Entire Specimen
1	0	1.2	1.073	0.071	0.088	0.019
2	2.5	1.1		0.000		
3	5	1.1		0.071		
4	7.5	1.2		0.000		
5	10	1.2		0.071		
6	12.5	1.1		0.000		
7	15	1.1		0.071		
8	17.5	1.2		0.071		
9	20	1.1		0.000		
10	22.5	1.1		0.000		
11	25	1.1		0.071		
12	27.5	1		0.000		
13	30	1		0.000		
14	32.5	1		0.071		
15	35	1.1		0.141		
16	37.5	0.9		0.000		
17	40	0.9		0.071		
18	42.5	1		0.071		
19	45	1.1		0.071		
20	47.5	1		0.000		
21	50	1		0.071		
22	51.5	1.1		N/A		

Equations:

$$Standard\ deviation\ (SD)\ =\ \sqrt{\frac{\Sigma(x-\bar{x})^2}{n}}$$

$$Standard\ Error\ of\ the\ Mean\ (SEM) = \frac{SD}{\sqrt{n}}$$

5. **Thread pH Calculations**

The table and calculations below demonstrate the measurements and calculations obtained to determine the SCOBY Bio-Thread pH, standard deviation and standard error of the mean. The Bio-Thread is a result of the twisted dehydrated SCOBY, from a fermentation process. The fermentation consistency across the entire length of the tube influences the consistency of the pH across the entire length. To investigate this, and to ensure the Bio-Thread is not acidic, Table 6.2 demonstrates the measurements (pH, standard deviation (SD), & standard error of the mean) taken at every 2.5 cm along the length of the Bio-Thread.

Table 6.2 Results from the pH Verification Test

Trial	Position/ cm	pH	Average pH	SD Between Successive Points	SD Across Entire Specimen	SEM Across Entire Specimen
1	0	7.31	7.311	0.007	0.037	0.008
2	2.5	7.3		0.035		
3	5	7.35		0.042		
4	7.5	7.29		0.007		
5	10	7.3		0.000		
6	12.5	7.3		0.042		
7	15	7.24		0.042		
8	17.5	7.3		0.007		
9	20	7.29		0.071		
10	22.5	7.39		0.007		
11	25	7.38		0.000		
12	27.5	7.38		0.049		
13	30	7.31		0.000		
14	32.5	7.31		0.000		
15	35	7.31		0.007		
16	37.5	7.32		0.035		

17	40	7.27		0.014		
18	42.5	7.29		0.014		
19	45	7.27		0.035		
20	47.5	7.32		0.028		
21	50	7.28		0.035		
22	51.5	7.33		N/A		

Equations:

$$Standard\ deviation\ (SD)\ =\ \sqrt{\frac{\Sigma(x-\bar{x})^2}{n}}$$

$$Standard\ Error\ of\ the\ Mean\ (SEM)\ =\ \frac{SD}{\sqrt{n}}$$

6. Thread Stress Measurements

The table below shows the measurements obtained to determine the SCOBY bio-thread Ultimate Tensile Stress. The Bio-Thread is a result of the twisted dehydrated SCOBY, from a fermentation process. The fermentation consistency across the entire length of the tube influences the strength of the Bio-Thread across the entire length. Table 6.3 demonstrates the maximum force applied in tension to the Bio-Thread, the average cross-sectional area of the Bio-Thread and the Ultimate Tensile Stress of the Bio-Thread.

Table 6.3 Results from the Tensile Stress Verification Test

Maximum Force (N)	Cross-sectional Area (m^2)	Ultimate Tensile Stress (MPa)
5.8	9.04E-07	6.41

Meeting Minutes

“SCOBY Bio-thread” **Report Date: 11/8/2021**

Team Meeting

Attendees	Meeting Date	Attendance	Time Start	Time End
Nathaniel Alexander	11/8	**P**	**8:10**	**9:10**
Megan Boge	11/8	**P**	**8:10**	**9:10**
Rene Elivir	11/8	**P**	**8:10**	**9:10**
Catalina Zambrano	11/8	**P**	**8:10**	**9:10**
Sydney Zamorano	11/8	**P**	**8:10**	**9:10**

P = Present L = Late AE = Absent (Excused) A = Absent
Cc: Attendees

Facilitator: Sydney Zamorano
Note Taker: Catalina Zambrano
Time Keeper: Catalina Zambrano

Agenda

Discussion Points	Comments
Assign the slides for the presentation	● Sydney led the discussion going through the slides, assigning them to whichever member volunteered. ● The order of the presentation went as follows: 1. Intro – Nathaniel 2. Problem Statement – Nathaniel 3. Problem Solution – Nathaniel 4. BME Acumen – Megan 5. Clinical Background – Catalina 6. Marketing Background – Catalina 7. Marketing Background (cont.) – Catalina 8. Market Requirement – Megan 9. Current Modalities – Rene 10. Scope – Sydney 11. Applied Sciences – Catalina 12. Inclusion/Exclusion – Catalina 13. Success Factor – Catalina 14. Design Input – Sydney 15. Hazard – Sydney 16. Design Concept – Sydney 17. Technology – Megan 18. Product Cost – Nathaniel 19. Project Budget – Nathaniel 20. Regulatory Assessment – Megan

	21. Standards – Rene 22. Verification Tests – Rene 23. Accomplishments – Sydney 24. Critical Milestone – Sydney ● The team went over the first 10 slides to prepare for the preliminary presentation.
Begin looking at the written proposal	● Sydney showed the team the template for the written proposal. ● We discussed that this is due in the upcoming weeks and that we will need to work on it in the meantime.

Action Item	Person Responsible	Date	Status
Begin populating information on slides	All members	11/8/2021	In progress
Prepare talking points for the presentation	All members	11/8/2021	In progress

"SCOBY Bio-thread"

Report Date: 11/15/2021

Team Meeting

Attendees	Meeting Date	Attendance	Time Start	Time End
Nathaniel Alexander	11/15	**P**	**8:15**	**9:15**
Megan Boge	11/15	**P**	**8:15**	**9:15**
Rene Elivir	11/15	**P**	**8:15**	**9:15**
Catalina Zambrano	11/15	**P**	**8:15**	**9:15**
Sydney Zamorano	11/15	**P**	**8:15**	**9:15**

P = Present L = Late AE = Absent (Excused) A = Absent
Cc: Attendees

Facilitator: Sydney Zamorano
Note Taker: Catalina Zambrano
Time Keeper: Catalina Zambrano

Agenda

Discussion Points	Comments

Discuss the slides that were assigned	• Each member spoke about the slides they worked on for the preliminary presentation. • The team also discussed how long would be spent talking on each slide in order to meet the 5 minute time limit.
Run through preliminary presentation	• The team practiced presenting their slides all together to see where there could be corrections. • The members began mapping out the information they would discuss so that they could practice it in the upcoming days.

Action Item	**Person Responsible**	**Date**	**Status**
Practice presenting slides	All members	11/15/2021	In progress
Continue to work on slides for the full presentation	All members	11/19/2021	In progress

"SCOBY Bio-Thread"

Report Date: 11/17/2021

Team Meeting

Attendees	**Meeting Date**	**Attendance**	**Time Start**	**Time End**
Nathaniel Alexander	11/17/2021	P	**8:15**	**10:10**
Megan Boge	11/17/2021	P	**8:!5**	**10:10**
Rene Elivir	11/17/2021	P	**8:15**	**10:10**
Catalina Zambrano	11/17/2021	P	**8:15**	**10:10**
Sydney Zamorano	11/17/2021	P	**8:15**	**10:10**

P = Present L = Late AE = Absent (Excused) A = Absent
Cc: Attendees

Facilitator: Sydney Zamorano
Note Taker: Catalina Zambrano
Time Keeper: Catalina Zambrano

Agenda

Discussion Points	**Comments**

Conditions of the SCOBY	● Megan had questions about how we would apply the thread to the wound dressing if it has many acids. o We mentioned that we will have to keep that in mind when we start designing, and that we can measure pH using the probe that measures pH in solid foods ● She also asked how we would prevent the sticking of the threads when they are spooled. o Again, we discussed that we would speak about that when testing, but that we might have to add another material or oil to prevent that. ● We also discussed that we need to do further research for determining the optimal conditions for the process. o Ex. Container material, type of bacteria, type of yeast, light source, etc.
Run through of presentation	● The team ran through the presentation 3 times to ensure that the presentation was under 5 minutes. o We spoke with individual members about projecting and organizing their presentation so that it flows better o We also discussed how to introduce the next person presenting.
Assign full presentation slides	● Sydney created a document that assigned each member to slides on the full presentation o The document was uploaded on the Google Drive. o Nathaniel will present 5 Megan will present 5 Rene will present 4 Catalina will present 4 Sydney will present 6 ● It was discussed that everyone will have their parts due by Friday night
Meeting with sponsor	● What materials are going to be supplied? o We will need to get tubing that is permeable to gasses o The sponsor orders everything from eBay and Amazon ● Types of solutions o Get a bottle of kombucha, add water, tea, and sugar (table sugar), and let it grow for a week o Dip a needle in the liquid and slowly raise it. Research nylon process o Take top layer of kombucha where nanofibers are and pour that into a tube ● Add heat to the thread to remove moisture before spooling o How can moisture be removed for future applications? ▪ Moisture can be reintroduced through antibiotics o Moisture is being removed for product formation ● Silicone surface ● New project proposal o Is not required for our project scope

Action Item	Person Responsible	Date	Status

Practice presentation	All members	11/19/2021	In Progress
Finish presentation slides	All members	11/19/2021	In Progress

"SCOBY Bio-thread" **Report Date: 11/28/2021**

Team Meeting

Attendees	Meeting Date	Attendance	Time Start	Time End
Nathaniel Alexander	11/28	**AE**	**1:22**	**3:05**
Megan Boge	11/28	**P**	**1:22**	**3:05**
Rene Elivir	11/28	**AE**	**1:22**	**3:05**
Catalina Zambrano	11/28	**P**	**1:22**	**3:05**
Sydney Zamorano	11/28	**P**	**1:22**	**3:05**

P = Present L = Late AE = Absent (Excused) A = Absent
Cc: Attendees

Facilitator: Sydney Zamorano
Note Taker: Catalina Zambrano
Time Keeper: Catalina Zambrano

Agenda

Discussion Points	Comments
Go over corrections for assigned slides	● Participants went over their the corrections for their assigned slides. ● The members discussed the addition of market requirement: The thread will contain bioactive compounds - A bioactive compound is one that is delivered to the wound and aids in epithelialization and overall wound healing. ● A design input of the thread must contain cellulose in its final form was added due to the new market requirement. ● The design concepts were kept the same and it was emphasized that Sydney mention that the line of SCOBY forms due to the design of the container. - As for the nylon concept, it was added that the process is similar to the conditions in our project ● The technology assessment was also adjusted for the new market requirement. ● The regulatory assessment slide was left the same, and a disclaimer was added that spoke about how the classification would be if once the thread is made into the wound dressing. ● Notes were left for Rene to adjust his slides for the new market requirement

	• The adjustment on the marketing background was left the same and will be fixed once the professor responds to the email.

Action Item	Person Responsible	Date	Status
Practice presenting slides	All members	11/28/2021	In progress
Prepare for presentation after class on Monday	All members	11/28/2021	In progress
Finish presentation slides	All members	11/28/2021	Completed

Team 7 – SCOBY Bio-Thread
Meeting Minutes

January 6th, 2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 1:15 PM on January 6th, 2022 on Zoom.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Nathaniel Alexander, Megan Boge, Rene Elvir, Catalina Zambrano, and Sydney Zamorano

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

V. New business

a) Going to the Facility – As an entire team, we need to establish a day to go to the facility once a week for at least 1 hour based on the availability of ALL team members. Its location is approximately 25 minutes away from EC and there is sufficient parking available. Sydney and Catalina first visited the facility on January 3rd and informed the team that all the preliminary and basic supplies are already there. Our first meeting next week will consist of making a test batch that will serve for manipulation. We will also be doing inventory of what the sponsor currently has that we may use for the project, and deciding what we will need to purchase.

b) Design Concept – Sydney explained Obdulio's input in regards to having the decided tube be snaked into a large plastic bin to allow for ventilation, but also a limited rate of evaporation. Nathaniel and Megan expressed their concerns in regards to the tube moving, but those were resolved by Sydney and Catalina explaining how the bin will be in a secured area.

c) Material List – Conducting an inventory of what is available from the sponsor will aid in deciding the finalized purchased list. We will need to determine the dimensions of the bin we will be using. Nathaniel brought up the idea of using a Dremel to cut the tube which is approximately $20 on Amazon.

VI. Actions

a) Fill out Google Form to determine availability for going to the facility – ALL MEMBERS – By January 7th, 2022

VII. Adjournment

Sydney Zamorano adjourned the meeting at 2:06 PM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

January 12th, 2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Organization/Committee Name at time on date at location.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Nathaniel Alexander, Megan Boge, Rene Elvir, Catalina Zambrano, and Sydney Zamorano.

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

V. **New business**

a) Start Making Batches of Kombucha – Three batches were made as test samples to understand how the SCOBY grows. We will check on it next week to note its progress and determine if any changes need to be made.

b) Check Material Closets to Do Inventory – Megan and Rene checked the three rooms filled with equipment to see what can be gathered and used from there and what we need to buy.

c) Additional Research on Thread Processes – Catalina did some research to see if there were anymore possible methods to produce the thread in case our design does not work. A Google patent was found that described nearly an identical method as the group came up with. We will talk with Dr. Christie in today's meeting to see if this will be a problem.

d) Meet with Dr. Christie – Dr. Christie explained that for every meeting with him, the team is expected to tell him four topics that will presented in a PowerPoint. The four topics are 1) What was accomplished from last meeting 2) Next steps 3) Risks that were found in the project 4) How those will be mitigated. Dr. Christie also mentioned how we need to establish a value of how much cellulose will be present and establish an upper and lower level for when its presence is beneficial and then not. He also suggested that the team have "content experts" on the following topics: cellulose and how it aids wound healing, Kombucha fermentation, and then current modalities of ointments. They were assigned to Megan, Nathaniel, and Catalina respectively. He also request an article that shows how cellulose aids in wound healing.

VI. **Actions**

a) Send Dr. Christie the articles he requested – Catalina – By January 19th, 2022

b) Read the patent – ALL MEMBERS – By January 19th, 2022

c) Work on research for assigned topics – ALL MEMBERS – By January 19th, 2022

VII. **Adjournment**

Sydney Zamorano adjourned the meeting at 2:00 PM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

January 19th, 2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 1:15 PM on January 19th, 2022 on Google Meet.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Nathaniel Alexander, Megan Boge, Rene Elvir, Catalina Zambrano, and Sydney Zamorano.

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

a) Going Over Patent – Each person went over their research from reading the patent and presented any questions they had. Rene spoke about "Step 1 – Preparation of the fermentation environment dissolution of the substrates in water". He pointed out that this was a sterilization step that we did not follow in our test batches. Nathaniel added that when we cooled our samples, as in step 1b, we cooled down to a temperature much lower than the one highlighted in the patent. We agreed that we would ask Dr. Christie for his advice on what this step entails: a sterilization or brewing of tea. Megan then spoke about the "Step 6 – Cleansing of the threads and tapes". There needs to be additional research to see if our thread will have to be sterilized after production. Lastly, Catalina addressed a section in the patent that highlighted the structure of the tube used. In this experiment, the tube is fully in tact when the thread is produced, however in the team's design the thread is cut through the middle, allowing the mixture to be exposed to more oxygen, and also allowing it to grow faster. The team then decided that they would speak with Dr. Christie to see if this is enough of a difference to proceed with the design.

b) Checking SCOBY Batches – Sydney visited the facility to check on the three batches of Kombucha. She saw that there had been growth of the SCOBY that appeared very thin at the top of the containers. She took one of them out to inspect the consistency and noted that it was very elastic and had a high tensile strength. Pictures were sent to the group and Sydney decided to leave the SCOBY out to dry for a few hours to see how it would react. She noticed that it started to get very hard and brittle. Lastly, she returned the SCOBY into its container.

V. New business

VI. Actions

a) Continue to research assigned topics – ALL MEMBERS – By January 26th, 2022

VII. Adjournment

Sydney Zamorano adjourned the meeting at 2:00 PM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

January 26th, 2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Tread at 9:00 AM and 1:30 PM on January 26, 2022 at Polarity Ventures.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Nathaniel Alexander, Rene Elvir, Catalina Zambrano, and Sydney Zamorano

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

a) Look at the first two batches of SCOBY that have been growing for two weeks – The two batches grew to a thickness of 0.2 cm and had a smooth, skin-like texture on the surface exposed to the air, and had a bumpy, darker color texture on the surface exposed to the liquid. The thickness of the SCOBYs were inconsistent throughout the area, making some sections thinner than others.

b) Meeting with Dr. Christie –

1. Dr. Christie reviewed the patent with the team and heard their pitch on how their design differs from the one detailed in the patent. He would like the team to determine the benefits of the design by replicating the one in the patent as well. In addition, he would like proof of how the team's open tube idea would improve oxygenation. He also stated that

at the end of the semester the team delivers the project to the sponsor with the patent so that they can design how to proceed.

2. He wants additional research on types of wounds and which type of product is needed to maintain cell growth and improve healing

V. New business

a) Make three new batches – Three new batches were made. One was the same recipe but a quarter of the amount originally made. The second was the same as originally made, and the third (control) placed one of the initial SCOBYs back into fresh media to see how it would continue to grow.

b) Meeting with Dr. Christie –

1. He would like the team to add a slide in the beginning of the PowerPoints that outlines everything that will be presented.
2. All links should be put on the bottom of the slides
3. Our currently template of the meeting minutes is exactly how he wants it, so there does not have to be any modifications.

c) Presentation preparation – To prepare for our presentation at the end of the semester, it was suggested that all members write out an answer to, "What is your project?", and memorize it. This will assist in providing a consistent and clear response to anyone who asks about the project.

VI. Actions

a) Continue research - ALL MEMBERS - By February 8th, 2022

b) Create summary of what the project is and begin to memorize it - ALL MEMBERS

VII. Adjournment

Sydney Zamorano adjourned the meeting at 10:20 AM, 2:10 PM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

January 28th, 2022

I. **Call to order**

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 8:30 AM on January 28th, 2022 on Zoom.

II. **Roll call**

Sydney Zamorano conducted a roll call. The following persons were present: Nathaniel Alexander, Rene Elvir, Catalina Zambrano, and Sydney Zamorano

III. **Approval of minutes from last meeting**

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. **Open issues**

a) Meeting with Dr. Godavarty – Dr. Godavarty was assigned as the team's faculty advisor. She wanted to meet to discuss her expectations of the team, however she ran late and could not attend. Sydney mentioned that she will reach out to Dr. Godavarty to reschedule the meeting and will keep the team posted.

V. **Adjournment**

Sydney Zamorano adjourned the meeting at 8:56 AM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

February 2, 2022

I. **Call to order**

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 9:00 AM & 1:30 PM on 2/2/2022 at Polarity Ventures.

II. **Roll call**

Sydney Zamorano conducted a roll call. The following persons were present: Nathaniel Alexander, Rene Elvir, Megan Boge, Catalina Zambrano, and Sydney Zamorano

III. **Approval of minutes from last meeting**

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

a) Look at batches – The old SCOBY that was left to continue to grow, grew a thin new layer. However, the layer was not consistent or even throughout the surface area. The new batches showed the normal SCOBY growth. The SCOBY that was left to dry demonstrated incredible strength. Lastly, the part of the dry SCOBY was put in a container with 3.7 mL of water to initiate the rehydration. After a few minutes of being in the water, the SCOBY began to exhibit its previous properties.

V. New Business

a) Go over MRs, DIs, and Verification Tests – The team was assigned to review the MRs, DIs, and Verification Tests developed in Senior 1, as well as think of new ones. Nathaniel, Sydney, Catalina, and Rene each went over the ones they worked on, and provided rational for their requirements, along with the research that was done. These MRs were sent to Dr. Godavarty, and we will be going over them at our next meeting.

VI. Actions

a) Continue working on research for the meeting with Dr. Christie next Wednesday – ALL MEMBERS – By February 8th, 2022

VII. Adjournment

Sydney Zamorano adjourned the meeting at 10:10 AM & 1:56 PM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

February 4th, 2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 8:00 on February 4th, 2022 on Zoom.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Rene Elvir, Nathaniel Alexander, Megan Boge, Catalina Zambrano, Sydney Zamorano.

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

a) Go over MRs, DIs, and Verification Tests with Dr. Godavarty –

(1) What does "produced in the container" mean for the requirement? The team explained that the container acts as a <u>mold</u> where the solution will take up its space. Therefore, the market requirement should be the output (i.e. the SCOBY) not the input (i.e. the tube). Instead of testing the length and width with a ruler and caliper (this is not engineering), investigate breaking the cross-sectional area into dimensions and show that it is 2 mm uniformly. Do the same concept for length and measure standard deviation. Another method could be to take a picture and measure it digitally to avoid error. <u>Statistically validate the length under different conditions</u>.

Why 5 feet long and why 2 mm in diameter? **Ask the sponsor the engineering purpose for these parameters**

(2) What does low cost? Do not compare final product cost and initial cost. **Do not make a requirement.** Instead, mention that it is inexpensive as an advantage for the design.

(3) Remove requirement because it is an input.

(4) Find percentage of cellulose. The verification test provided is valid.

(5) Test this market requirement under different conditions. Young's modulus is only stress and strain and bending is a different requirement. The angle of bending is 360 degrees in both directions, not 180 degrees These are two different requirements. **Find engineering verification tests for bending.**

(6) Tensile strength is part of Young's modulus, so remove it from this requirement. The forces in spooling value depend on the modality it will be used with. So ask the sponsor what they want to do with this thread, if it's wound dressing, then buy a wound dressing and compare with its test values.

(7) At what stage do we test for pH? Find how to test for a solid. Determine how to standardize it.

(8) Moisture is different from water. Do more research.

(9) Design: Consider different designs, and determine which creates a consistently reproducible product. Validate why each factor is being used.

(10) The patent can be used to obtain the values to test against. Replicate the design in the patent and compare with the design the team has created. A faster production time can also be considered cost-effective.

V. New business

VI. Actions

a) Correct market requirements that were worked on (Megan work with Rene on his market requirement) – ALL MEMBERS – BY February 6th at 11:59 PM

b) Develop a short script of what the project is about and what the design is – ALL MEMBERS – By February 9th at 11:59 PM

c) Reread patent and note the procedures to replicate as well as the results – ALL MEMBERS – By February 6th at 11:59 PM

VII. Adjournment

Sydney Zamorano adjourned the meeting at 9:00 AM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

February 9, 2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 9:00 AM & 1:30 PM on February 9, 2022 at Polarity Ventures.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Nathaniel Alexander, Rene Elvir, Megan Boge, Sydney Zamorano, Catalina Zambrano.

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

a) View the SCOBYs' left in the facility – The team went into the facility to check on the SCOBYs that were left to grow for two weeks. Both SCOBYs had formed a thicker, solid layer similar to the first trial that was performed. They were then left to see how they would progress in a third week

V. New business

a) Going over MR/DI/VT with Dr. Christie –

(1) Market Requirement #1:

- Dr. Christie stated to include a rationale for all DIs that are formed. This can be written below the DIs.
- He also asked for clarification on the MR.
- For the DI, continue to look for a value for cellulose. The team can also consider determining a percentage for how much cellulose should retain during the process. Also, the team can look at cellulose- containing wound dressing to see composition and use that value instead.
- Add the "Method of Verification" in brackets under "verification testing" header.
- For all MRs look for standards.

(2) Market Requirement #2

- Adjust MR to say something along the lines of, "The bio-thread must have dimensions that will facilitate [reason]"
- For the DI, include the values and rationale, "These are the sponsor's requirements for scaling…"

(3) Market Requirement #3

- MR is good. Include "…flexible in order to…"

- Look up compliance for DI.

(4) Market Requirements #4

- MR and DI are good.

(5) In the patent specifications included in the DRM, the resistance limit is the ultimate stress.

(6) For the three protocols, make a process flow diagram.

(7) We can get started with the design once we organize the purchasing of supplies.

Look into the SOP for ordering material and tax exempt form, which will be given to the supplier and sponsor.

b) Determining the list of supplies to purchase – The team put together a list of all the supplies that should be purchased to complete the design. Sydney assigned responsibilities so that members can research specific specifications for certain supplies. Nathaniel will look into dimensions of the tubing and plastic bin, as well as confirmation of using the Dremel for cutting the tube. Rene will continue to look into how much NaOH would be needed to sterilize the final product, while not disrupting the mechanical properties. Sydney will confirm with Kevin at Polarity Ventures about using a heating pad that he may already have. She will also confirm about having access to DI water in the facility. Catalina will look into software to measure objects digitally. Lastly, Megan will try to acquire pots and mixing spoons for brewing the medium.

VI. Actions

Create three Process Flow Chart for the protocols – ALL MEMBERS – Due by February 10, 2022 by 11:59 PM

Find Electronic Measuring Software – Catalina – Due by February 16th, 2022 by 9:00 AM

Complete Summary of Project – Megan, Sydney, & Rene – Due February 13th, 2022 by 11:59 PM

Find Flow Chart Template – Megan – Due February 10th, 2022 by 11:59 PM

Organize information for Dr. Godavarty – Sydney – Due February 10th, 2022 by 11:59 PM

Create Excel with material information needed for Claudia Estrada – Sydney – Due February 13th, 2022 by 11:59 PM

Research NaOH amount and concentration for sterilization and provide document with information – Rene – Due February 12th, 2022 by 11:59 PM

VII. Adjournment

Sydney Zamorano adjourned the meeting at 10:00 AM & 2:00 PM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

Date: 2/11/2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 8:00 AM on February 11, 2022 on Zoom.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Nathaniel Alexander, Rene Elvir, Megan Boge, Sydney Zamorano, and Catalina Zambrano

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

a) Go over Protocols with Dr. Godavarty –

(1) Design Protocol 1: Fermentation time is an intermediate step, whereas thickness of the SCOBY is the dependent variable.

(2) Design Protocol 2: The fermentation time means making one case for 2 weeks and 3 week.

(3) Variables being modified:

Temperature: 22 degrees C, 27 degrees C

Fermentation time: 2 week and 3 week

Oxygen permeability: Open and closed system

(4) Create a clear table of the existing variables in the patent and the proposed changes in each design case.

(a) Only change one variable in each case..

(b) Put rationale for each variable change under each case.

(c) For cases where the value of the independent variable is not stated, "In the patent there were no specific values for … so we came up with a design to make it more efficient by changing variables to … from additional research on the its impact on …"

(5) Question Nathaniel's MR –

(a) Look into Fatigue test as the verification test and make it large scale.

(b) Another aspect to consider is that flexibility should not shape memory.

V. New business

a) Divide topics of responsibilities in a table and list each person to do under it.

VI. Actions

VII. Adjournment

Sydney Zamorano adjourned the meeting at 8:45 AM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

February 17, 2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 8:00 AM on February 17th, 2022 on Zoom.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Nathaniel Alexander, Rene Elvir, Catalina Zambrano, Sydney Zamorano

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

V. New business

a) Everyone go over their new assigned section of the DMR:

(1) **Everyone: Add additional documents to back up information when presented to Dr. Godavarty.**

(2) Catalina discussed the purchasing of materials. Dr. Godavarty wants a design that makes more sense as opposed to coiling a tube in a container. She proposed coiling the tube around a large cylindrical container to already give the shape it will have when coiled.

(3) Megan needs to put what standards she finalized. Do not just put that something was researched. Include all findings and if possible put information in a table so that it is easier to understand.

(4) Nathaniel: The topic of why we need the container was brought up. The team explained that they do not have the space, however Dr. Godavarty proposed that we change our design to simply incorporate the tubes in a wooden structure and ask the sponsor to either provide us more space or to allow us to carry out the project somewhere else. Additionally, Dr. Godavarty asked for the calculations to account for the shrinkage of the SCOBY, which influences the tube length. For the verification tests, Dr. Godavarty stated that the team should ask the sponsor on how each test will be carried out, i.e. if they had the resources to perform them or know where we can (specifically, fatigue test).

(5) Sydney: Dr. Godavarty explained that she would like all formulas with references added to the slides (spooling formula).

In regards to the flowcharts:

(i) Add how the setup looks for each step in the flow chart.

(ii) Look into if the temperature has to be 27 C uniformly or just approximated. She mentioned that heating pads fluctuate in temperature (heat transport).

(iii) Make the distinction between the open vs close system clear on the chart.

(iv) Adjust the flow chart to add why the steps were selected and back it up with research (Add the references).

(6) Rene: Identify two or three purification processes and include the pros and cons of each one, as well as which you selected the best one. Convert each process into flow charts.

VI. Actions

(1) Create new designs for the thread: - Catalina – By February 23rd

1. Tube is elongated and held in a wooden box (would need more space for it).
2. Tube is coiled around a cylindrical bucket so that it is already in the desired shape.
    a. Look into the dimensions needed once again for the tube to get the desired length and diameter of the thread. Perform calculations from trials completed to see how much is reduced in shrinkage.
    b. Determine how to heat up one of the trials for each design.
    c. Also determine how to secure the tube in each design (possibly zip-tie).

(2) Finish finding standards and organize them in an appropriate manner – Megan & Rene – By February 23rd

(3) Make the aforementioned adjustments to the flowchart – Sydney – By February 23rd, 2022

(4) Tabulate the pros and cons for each purification method – Rene – By February 23rd, 2022

(5) Create flow charts for the purification processes – Rene – By February 23rd, 2022

VII. Adjournment

Sydney Zamorano adjourned the meeting at 9:00 AM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

February 25th, 2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Team 7 -SCOBY Bio-Thread at 8:10 AM on February 25th on Zoom.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Rene Elvir, Catalina Zambrano, Sydney Zamorano

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

a) Design Concepts – Now that we have three physical design concepts we can use the methodology design concepts as supplemental information to improve our project. For the three physical design concepts, draft up better explanations for the pros and cons for each one (focusing on gravity). Also, modify the current design concept to remove the box and only adhere the tubes to a surface using stainless steel clamps. For Design Concept 3, perform a pilot trial to provide evidence as to why it will not work. For the methodology design concepts, write about all three and look into not using the heat variable since it will be difficult to control.

b) Flow Charts – Highlight the variable that is changing so that it is easily viewed by the audience. Also, include larger titles for each variable that is being changed (Time, System, Temperature). When presenting the flow chart, give a summary of the parts that does not include the variables that are changed, and only show the section of the flow chart that has the variables since it does not all fit together on a slide.

c) Purification Pros and Cons – Change “Portion” in the document to “Technique”. This is also included in the methodology design concept section.

d) Standards: You need to find standards within the scope such as biocompatible, purity, look into fermentation (contamination), and material. This should be done by next week.

V. New business

a) Megan & Nathaniel need to submit more work weekly.

b) Simulation – Examples of possible simulations: The outside temperature of the tube compared to the inside of the tube (heat transport). Finding how long the reaction occurs in the given volume (time variable).

c) Prototype Sub-System Test Heading in the DHF – Little testing done to make sure the prototype works. Pilot studies.

VI. Actions

a) Continue working on DHF & DMR – ALL MEMBERS – By February 27th

VII. Adjournment

Sydney Zamorano adjourned the meeting at 9:15 AM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

March 11th, 2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 9:00 AM on March 11, 2022 on Zoom.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Megan Boge, Rene Elvir, Nathaniel Alexander, Catalina Zambrano, Sydney Zamorano.

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

V. New business

a) Starting Design Process – Catalina, Nathaniel, and Sydney briefly spoke about the final construction and the commencement of the design process. This week the design structure was brought in the lab and used to carry out the beginning of the process. The tea was brewed and added to two tubes, while discussions of cutting the third tube was occurred between Nathaniel, Rene, Megan, and Catalina. At the end, the tubes had to be twisted to ensure that they were completely straight so that the liquid would evenly distribute. Rene did not have the opportunity to talk about his contribution.

b) Team Conflict – Dr. Godavarty mediated a discussion on group conflict where Megan expressed her concerns about not being involved in assignments. Each member spoke about their thoughts and at the end Dr. Godvarty made the executive decision to have every member work on two aspects of the project so that there is collaboration between individuals.

c) Project Tasks For Each Member – As a result from the discussion, Dr. Godvarty asked that everyone select two areas that they are strong in to work on for the project. She asked that Sydney send her a document with everyone's tasks.

VI. Actions

Work on Engineering Analysis for respective section – ALL MEMBERS – By 3/18

Select tasks to work on and let Sydney know – ALL MEMBERS – By 3/14

VII. Adjournment

Sydney Zamorano adjourned the meeting at 10:00 AM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

March 21st, 2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 8:00 AM on March 21, 2022 on Zoom.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Megan Boge, Rene Elvir, Catalina Zambrano, Sydney Zamorano.

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

V. New business

a) Communication Issues - Megan explained her issues in regards to not completing her contribution to the solidworks yet. Dr. Godavarty suggested that Megan move forward and is best to take advantage of the computer labs on campus. She reminded the group that they are in the final stages of the project and can not afford to lose time.

b) Time Constraint - Dr. Godavarty stated how the team is starting to run out of time until the design expo. In regards to the NaOH treatment she asked if it can be performed on a previously made batch to ensure that it will not destroy the final product. She asked if the team had any current "back ups" for our threads and the team does not. In conclusion, she stressed how it is important that the team pays very close attention with the current threads that are fermenting to ensure minimal errors that can jeopardize the project.

c) Written Report Drafts – Dr. Godavarty requested that each section of the written report have a draft by Friday for her to review. She mentioned how each section can be broken down into smaller parts if need be to fit the multiple aspects of the project. The recognition of need and problem formulation sections need to be updated and can not remain the same from last semester. Dr. Godavarty stressed the importance of the report.

VI. Actions

Drafts of respective sections of the Written Report - ALL MEMBERS - by 3/25

Continuing working on respective tasks - ALL MEMBERS - by 3/25

Have a write up in regards to the NaOH treatment - Megan - by 3/25

VII. **Adjournment**

Sydney Zamorano adjourned the meeting at 8:45 AM.

Minutes submitted by: Sydney Zamorano

Minutes approved by: Catalina Zambrano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

March 25th, 2022

I. **Call to order**

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 7:45 AM on March 25th, on Zoom.

II. **Roll call**

Sydney Zamorano conducted a roll call. The following persons were present: Rene Elvir, Sydney Zamorano, Nathaniel Alexander, Catalina Zambrano, Megan Boge.

III. **Approval of minutes from last meeting**

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. **Open issues**

a) Number of cycles – Rene mentioned how him and Nathaniel still do not have a value defined for the number of cycles the thread should withstand. Dr. Godavarty stated that the value comes from putting the sample into the machine. She also said to double check the length of sample needed in order to conduct the test.

b) Engineering analysis/ simulation – Catalina spoke about the progress on the Engineering Analysis and how all that has to be done is the population of all of the tables. As for the heat transfer simulation, Dr. Godavarty advised that it goes under the Simulation section of the DHF and the Solution Formulation section of the report. All of the assumptions and additional information about the model will go in the Engineering Analysis section.

V. New business

a) Appearance of sample obtained – After Nathaniel, Sydney, and Megan went into the facility on Thursday they were able to do the purification treatment on the sample in the control tube. Dr. Godavarty saw a picture of the sample and stated that it does not look uniform. Nathaniel confirmed that some sections are bigger than others but we will be able to see a better result once it is dried. Dr. Godavarty responded stating that she wants more pictures as we continue the process

b) Purification of sample – Megan spoke about how she did the washing of the sample with the NaOH solution that she had made. All of the calculations and instructions on preparation were added to the DHF

c) Question:

   (a) Where do we put the things we have adjusted due to error in the DHF?

      (i) Dr. Godavarty stated that every updated factor is added to the DHF as a revised version of the section. She stressed that nothing should be deleted because the point of the DHF is to show everything that was worked on so that others can see what worked and what did not work. However, the final version of each section goes into the DMR and the report.

   (b) What do we present at the final presentation?

      (i) The final version of each section is presented. Do not discuss the errors or difficulties encountered in detail, simply state that after several pilot trials, the time variable and open vs closed system variable were adjusted, and here are their results.

   (c) Do we take the whole structure at the final presentation or just the thread?

      (i) For the final presentation, just take the thread and present it on the spool. Do not take the entire wooden structure.

VI. Actions

Finalize the DCs in Solidworks – MEGAN – By April 1st

Finish sections in the report – SYDNEY – By March 25th

Update Lab Notebook – SYDNEY – By April 1st

Do heat transfer simulation – CATALINA – By April 1st

Assign presentation slides – NATHANIEL – By April 1st

Collect data and do analysis – RENE & NATHANIEL – By April 1st

Look over assigned sections in DHF, DMR, and report – EVERYONE – By April 8th

VII. Adjournment

Sydney Zamorano adjourned the meeting at 8:20 AM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Team 7 – SCOBY Bio-Thread
Meeting Minutes

April 1st, 2022

I. Call to order

Sydney Zamorano called to order the regular meeting of the Team 7 – SCOBY Bio-Thread at 1:15 PM on April 1st, 2022 on Zoom.

II. Roll call

Sydney Zamorano conducted a roll call. The following persons were present: Nathaniel Alexander, Megan Boge, Rene Elvir, and Sydney Zamorano

III. Approval of minutes from last meeting

Sydney Zamorano read the minutes from the last meeting. The minutes were approved as read.

IV. Open issues

a) Tests – Dr. Godavarty went through what was remaining to be tested including: measuring diameter of the long thread, the length after twisting of the long thread, and the pH across different sections of the washed samples.

b) Switching fatigue test to tensile stress machine – Dr. Godavarty said that the tensile stress test would only test to see how stretchable it is, whereas the fatigue test measures how much bending the thread can withstand. She stressed to speak to the Sponsor and to Mr.

Zicarelli in the machine shop to locate a fatigue test machine. If neither work, try to find an location that has that this machine and pay to have the sample tested. Do a rudimentary technique just bending the samples to see if they break, but also conducted

c) Simulation – Add equations for heat transfer to Engineering Analysis section.

d) Abstract – The revised version is too wordy. Dr. Godvarty suggested to make it more simple so that it is easy for anyone to understand.

V. New business

VI. Actions

a) Finalize fatigue test and tensile stress test machine inquiry – Nathaniel & Rene – By April 2nd, 2022

b) Finalize all documents – EVERYONE – By April 5th, 2022

c) Finalize engineering drawings and screw – Megan – By April 4th, 2022

VII. Adjournment

Sydney Zamorano adjourned the meeting at 9:00 AM.

Minutes submitted by: Catalina Zambrano

Minutes approved by: Sydney Zamorano

Appendix

Tea Volume Determination

Once the tea was brewed, it was ready to be introduced into the tubes. To determine the volume that would be poured in the tubes the volume of a half cylinder with the proper dimensions was calculated (Figure 6.5)[12]. Using the radius of 0.25 in and the height of 75 in, the volume needed to fill up half of the tube was determined to be 116.89 cm^3. The team, however, decided to fill only 100 mL to account for the growth of the SCOBY in the container.

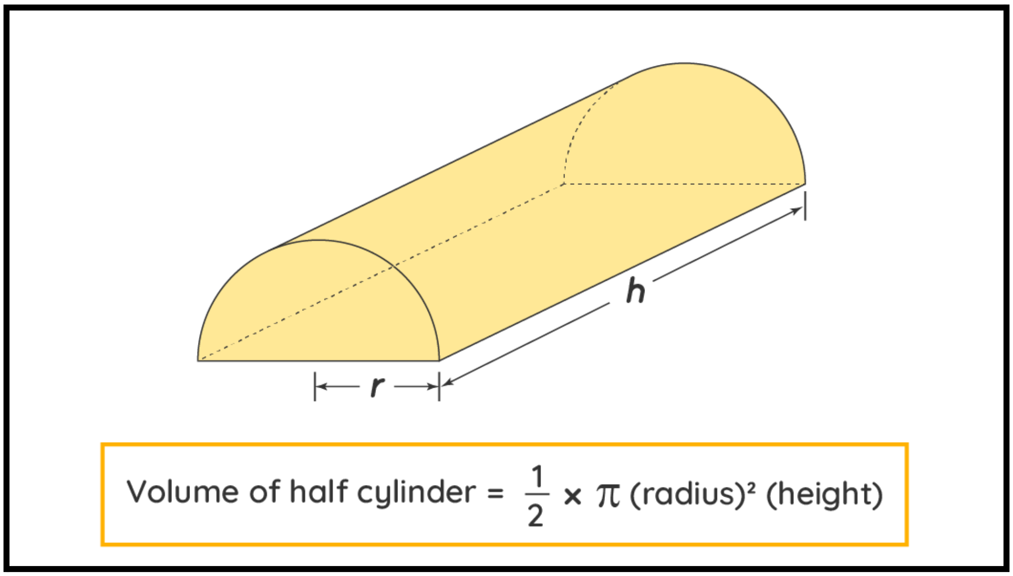


Figure 6.5 Formula for Volume of a Half Cylinder

Calculations:

$Radius:\ 0.25\ in\ >\ 0.625\ cm$
$Height:\ 75\ in\ >\ 190.5\ cm$
$\frac{1}{2} \times \pi \times (1.27)^2 \times 190.5 = 116.89\ cm^3$

SCOBY Size Reduction

Calculations:

Equation:

$$Percentage\ Decrease = \frac{(Starting\ Value - Final\ Value)}{[Starting\ Value]} \times 100$$

Trial 1:
Length:

$$\frac{(8.255-5.3875)}{[8.255]} \times 100 = 34.74\%$$

Width:
$$\frac{(9.2075-5.715)}{[9.2075]} \times 100 = 37.93\%$$

Height:
$$\frac{(0.6-0.3)}{[0.6]} \times 100 = 50\%$$

Trial 2:
Length:

$$\frac{(7.9375-5.715)}{[7.9375]} \times 100 = 28\%$$

Width:
$$\frac{(12.7-3)}{[12.7]} \times 100 = 76.378\%$$

Height:
$$\frac{(0.2-0.1)}{[0.2]} \times 100 = 50\%$$

Trial 3:
Length:

$$\frac{(7.62-7.30125)}{[7.62]} \times 100 = 4.18\%$$

Width:
$$\frac{(11.42-11.112)}{[11.43]} \times 100 = 2.69\%$$

Height:
$$\frac{(0.7-0.3)}{[0.7]} \times 100 = 57.14\%$$

Trial 4:
Length:

$$\frac{(6.6675-5.715)}{[6.6675]} \times 100 = 14.29\%$$

Width:
$$\frac{(11.7475-11.43)}{[11.7475]} \times 100 = 2.7\%$$

Height:
$\frac{(0.4-0.1)}{[0.4]} \times 100 = 75\%$

Calculations:

Equation:

$$Percentage\ Decrease = \frac{(Starting\ Value - Final\ Value)}{[Starting\ Value]} \times 100$$

Trial 1:
Length:

$\frac{(5.3972-1.905)}{[5.3975]} \times 100 = 64.70\%$

Width:
$\frac{(5.715-0.1)}{[5.715]} \times 100 = 98.25\%$

Trial 2:
Length:

$\frac{(5.715-1.905)}{[5.715]} \times 100 = 66.67\%$

Width:
$\frac{(5.715-0.11)}{[5.715]} \times 100 = 98.08\%$

Trial 3:
Length:

$\frac{(7.3025-1.905)}{[7.3025]} \times 100 = 73.91\%$

Width:
$\frac{(11.1125-0.1)}{[11.1125]} \times 100 = 99.1\%$

Trial 4:
Length:

$\frac{(5.715-1.905)}{[5.715]} \times 100 = 66.67\%$

Width:
$\frac{(11.43-0.1)}{[11.43]} \times 100 = 99.13\%$

Spool Size Determination

Calculations:

$$Diameter = 64\,mm$$
$$Barrel = 28\,mm$$
$$\frac{64\,mm - 28mm}{2} = 18\,mm\,(flange)$$
$$18 \times 0.85 = 15.3\,mm\,(H\,Value)$$
$$18 - 15.3 = 2.7\,mm\,(U\,value)$$
$$(15.3 + 28) \times (15.3) \times (53) \times (0.262) = 9199.33614\,(Reel\,Factor)$$
$$\frac{9199.33614}{2^2} = 2299.83\,mm = 7.54\,ft\,(Length\,of\,Cable)$$
$$Diameter = 2.5\,in$$
$$Barrel = 0.8126\,in = 20.6400\,mm$$
$$\frac{2.5 - 0.8126}{2} = 0.8437\,in = 21.336\,mm\,(flange)$$
$$21.336 \times 0.85 = 18.1356\,mm\,(H\,Value)$$
$$21.336 - 18.1356 = 3.2004\,mm\,(U\,value)$$
$$(18.1356 + 20.6400) \times (18.1356) \times (101.6) \times (0.262) = 18719.12112\,(Reel\,Factor)$$
$$\frac{18719.12112}{2^2} = 4679.78\,mm = 15.33\,ft\,(Length\,of\,Cable)$$
$$Diameter = 81.5\,mm$$
$$Barrel = 19\,mm$$
$$\frac{81.5 - 19}{2} = 31.25\,mm\,(flange)$$
$$31.25 \times 0.85 = 26.5625\,mm\,(H\,Value)$$
$$21.336 - 25.5625 = 4.6874\,mm\,(U\,value)$$
$$(26.5625 + 19) \times (26.5625) \times (84) \times (0.262) = 26635.36824\,(Reel\,Factor)$$
$$\frac{26635.36824}{2^2} = 6658.84\,mm = 21.84\,ft\,(Length\,of\,Cable)$$

CALCULATIONS:

$$\frac{2.75}{0.5+2.75} = 0.85 * 100 = 85\% \quad ; \quad 100 - 85 = 15\%$$

$$\frac{2.75}{0.5+2.75} = 0.85 * 100 = 85\% \quad ; \quad 100 - 85 = 15\%$$

$$\frac{3.00}{0.5+3.00} = 0.86 * 100 = 86\% \quad ; \quad 100 - 86 = 14\%$$

$$\frac{2.50}{0.5+2.50} = 0.83 * 100 = 83\% \quad ; \quad 100 - 83 = 17\%$$

$$\frac{3.25}{0.5+3.25} = 0.87 * 100 = 87\% \quad ; \quad 100 - 87 = 13\%$$

$$\frac{3.75}{0.5+3.75} = 0.88 * 100 = 88\% \quad ; \quad 100 - 88 = 12\%$$

$$\frac{3.50}{0.75+3.50} = 0.86 * 100 = 86\% \quad ; \quad 100 - 86 = 14\%$$

$$\frac{5.00}{1.0+5.00} = 0.83 * 100 = 83\% \quad ; \quad 100 - 83 = 17\%$$

$$\frac{5.75}{1.0+5.75} = 0.85 * 100 = 85\% \quad ; \quad 100 - 85 = 15\%$$

$$\frac{8.50}{1.5+8.5} = 0.85 * 100 = 85\% \quad ; \quad 100 - 85 = 15\%$$

$$\frac{2.75}{0.5+2.75} = 0.85 * 100 = 85\% \quad ; \quad 100 - 85 = 15\%$$

$$\frac{10.25}{1.5+10.25} = 0.87 * 100 = 87\% \quad ; \quad 100 - 87 = 13\%$$

$$\frac{12,00}{1.5+12.00} = 0.89 * 100 = 89\% \quad ; \quad 100 - 89 = 11\%$$

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