Solar Sausage for Water Desalination

Interim Design Report

Team Number: 7

Submission Date: 12/8/2014

Submitted To: Dr. Scott Helzer
Nikhil Gupta

Authors: Alexandra Filardo
Joey Hamel
Alex Stringer
Crystal Wells

Team Biography

Alex Stringer

Alex double majors in Mechanical Engineering and Mathematics. He brings good leadership experience as a Kitchen Manager at Chick-fil-a to the project. His interests include thermal fluids with a focus on hypersonic flow and flight. He plans to continue studying at Florida State University to complete his double major aspirations.

Crystal Wells

Crystal is a senior in Mechanical Engineering, focusing her education on Thermal Fluids and Materials Science. She maintains position as Procurement Officer and Coordinator, handling all public relations aspects of the project. Her position as Public Relations Chair in Society of Women Engineers brings her experience in this project.

Joseph Hamel

Joseph is a Mechanical Engineer with a special track in Thermal Fluids. He's interested in alternative energy and plans on pursuing this through graduate school. He researches under Dr. Juan Ordonez and interns for ReThink Energy Florida. He is the Webmaster and works hard researching/assisting in deliverables and other tasks.

Alexandra Filardo

Alexandra has participated in many organizations at Florida State University. She's interested in thermal fluid sciences and volunteers in the CAPS building weekly. She's dedicated to a future in engineering having minimal negative impact on the environment. She has a passion for learning and using her knowledge to help others.

Table of Contents

Table of Figures

Table of Tables

Acknowledgement

The group would like to thank Dr. Helzer and Nikhil Gupta for the direction and guidance throughout the project. Also, a special thanks to Dr. Lin for his valuable input and assistance with each aspect of the project. Thank you to Dr. Devine for the assistance with the business and marketing advice of the project. Finally, the group would like to thank Ian Winger for assisting in the construction of the Solar Sausage as well as supplying the materials for it.

Abstract

The topic of this senior design project is applying the Solar Sausage, an inflatable solar concentrator, to the need of potable water in developing countries. The goal is to incorporate a desalination system with the Solar Sausage that can be deployed in underdeveloped countries in need of drinkable water. Lack of clean drinking water is a significant issue in many countries that needs to be solved to save many lives as well as improve their living conditions. The project must continue on the idea that the Solar Sausage is a cost-efficient way to concentrate solar energy. Using a decision matrix, the group decided the open trough method would be the best choice. The Solar Sausage will heat the open trough which will evaporate the saline water into the condenser dome which will then collect the potable water and be collected in a storage system. With this design, an estimated maximum output 5.125 lbm/h of potable water has been calculated. Future work includes beginning the construction, building a prototype, and beginning taking experimental data. The group will also continue research and develop a detailed instruction manual for on-site locations to best optimize the implementation of the Solar Sausage for desalination.

1 Project Overview

The group will use the Solar Sausage to desalinate saline water for applications in underdeveloped countries. This will be completed in the given time frame under constraints mentioned later on.

1.1 Sponsor and Requirements

The FAMU-FSU College of Engineering is sponsoring the project since this is entrepreneurial based. A budget of $5,000 has been allocated towards the construction of the final designed system as well as the marketing of the finished product. This project requires the use of the Solar Sausage to desalinate water and provide potable water for under-developed countries.

1.2 Needs Statement

Partnering with the College of Engineering, the team has been tasked with creating a desalination system. In the developing world, access to clean drinking water is not often available. Unclean water leads to sick children whose education suffers as they miss school and economic opportunities are lost if a parent is sick from unclean water or spends most their day in search of clean water [1]. This leads to a cycle of poverty that access to clean drinking water can break. This drives the need for a cheap system with simplistic design capable of desalinating water and supporting the potable water needs of a small village family. Thermal desalination devices currently exist but with small capacities; with the current Solar Sausage technology invented by Ian Winger a large scale thermal desalination device is possible.

“Much of the under-developed world still lacks access to clean drinking water.”

1.3 Goal Statements and Objectives

The need of this clean water is hoped to be resolved through the senior design project encompassed around the Solar Sausage which provides heat in a low cost fashion. This leads to the goal of desalinating water with the Solar Sausage’s assistance.

"The goal of this project is to create an affordable solar desalination system using the Solar Sausage."

As stated in the goal statement Team 7's goal is to create a desalination system using the solar sausage, the system must be easily transported to a small African village. With the project becoming more defined, Team's 7 objectives became clearer

- The system must provide a sufficient amount of potable water for a small family
- The group must stay within allowable budget.
- The system must be simplistic and affordable in nature so that locals could easily be trained to operate and maintain it.
- The Solar Sausage must be easily transported and installed.

1.4 Constraints

Team 7 was given two constraints by the instructors and mentors on this project; to use the solar sausage and a budget of $5,000. The other constraints where developed by the team based on the operating environment and the local residents using the desalination system. As the project continues to develop the constraints listed below will be subject to change:

- The system must be easily constructed/deconstructed as well as transported/stored.
- The system must be durable and able to withstand moderate weather conditions.
- The system must have low to no emissions.
- The system must be simple and easy to operate and maintain for the consumer.
- Measurements must be precise and consistent.
- The group only consists of four members so the workload for each person will be greater.
- Project must be conducted in a timely fashion, and completed by the end of the school year.
- Maximum temperature is reached during primary sunlight hours from 10 AM to 3 PM.
- A means to store fresh water after desalination must exist.
- Materials capable of operating with saline water as the working fluid must be used.
- No electricity will be used for any components in the system.

2 Design and Analysis

The designs and analysis surrounding each design are evaluated in this section. Three designs along with their respective figures are shown below and portray the group's thoughts until a final design was determined.

2.1 Functional Analysis

There are many components and specifications that are crucial for the Solar Sausage project. A water source is the first necessity in order to begin the desalination process. The components included in the design are a storage tank, inflated Solar Sausage, a heat transfer method, and a condenser. The storage tank will hold the saline water and release it into the desalination process. The Solar Sausage has a reflective film that will maximize the light that is captured by the energy receiver. Increased temperature will cause the fluid to undergo phase change. The condenser will use a heat extraction method in order to convert the vapor back to liquid and the potable water will be released and stored for later use.

2.2 System Components

The final design, discussed in sections 2.4 and 2.5, consists of a place to store and heat saline water, a method to trap water vapor and condense, and a method to collect and store condensed desalinated water. The storage tank must have a preheating stage in order to facilitate the evaporation portion of the apparatus and supply saline water already near evaporation temperature. The evaporated water must be trapped, collected, and condensed in order for the water to successfully be in liquid form and potable for the residents to drink. Finally, this potable water must then be stored so that the residents are able to remove and drink the water from the system.

2.3 System Actuators

There needs to be developed systems that regulate pressure as well as sun location. The pressure regulation system must keep the two Solar Sausage chambers well inflated and able to collect sunlight whenever in use. This calls for a pressure differential of 0.01 psi between the two chambers with the upper chamber having a larger pressure. The entire Solar Sausage must be at about 0.5 psi in total. As stated in the constraints, this system should not be using any electricity to do so. Also, the system must track the sun to gain optimum solar concentration at all times of performance. This system should also use no electricity but must be some manual system of doing so with the calculated adjustments following the sun.

2.4 Design Concepts

There are three design concepts; one of the designs incorporates a heat exchanger and the other two designs utilize direct heat transfer. Each design consists of a Solar Sausage used to concentrate sunlight, a saline water storage tank, a condenser, and a desalinated water storage tank.

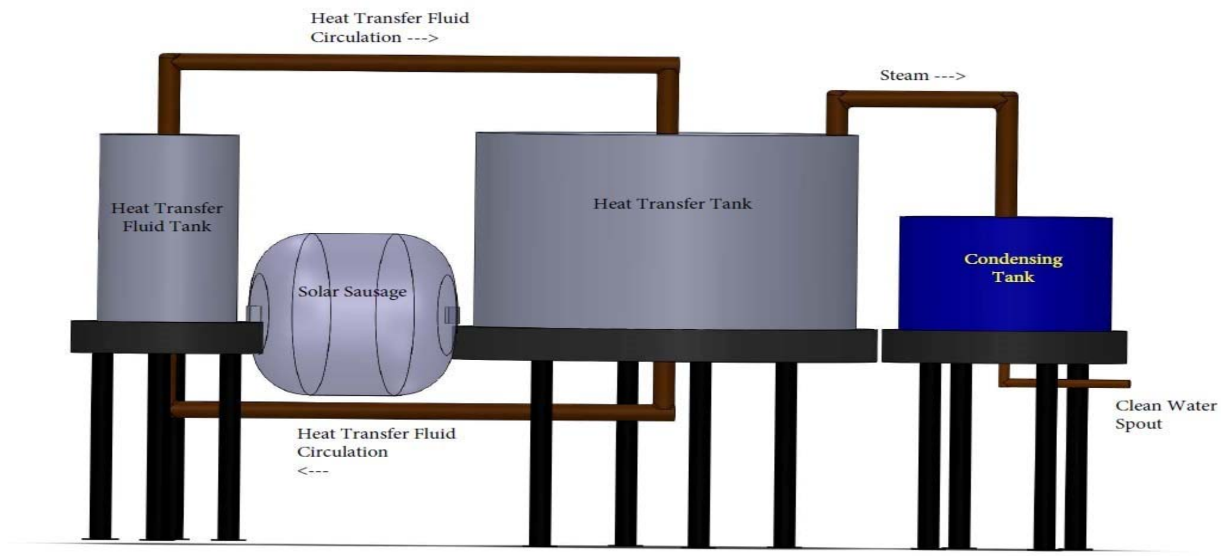


Figure 1: Design 1 - Heat Exchanger Method

The first design, shown above in Figure 1, incorporates a heat exchanger to bring the water to boiling point. Unlike the other two designs, this design requires an extra tank to store the eutectic salt. This is represented as the heat transfer fluid tank above in Figure 1. The heat transfer fluid tank not only stores the eutectic salt but induces thermal syphoning to circulate the eutectic salt. The heat transfer tank is where the heat exchanger is located. The design has the advantage in that its operating hours extend beyond 3pm. The eutectic salt will continue to circulate and stay at high temperatures far beyond peak sun hours, which would allow for an increase in the production capacity.

The disadvantages to this system include its lack of portability, cost, and use of non-environmental friendly compound. The exchanger is a closed system in itself requiring an extra tank increasing the size of the size of the system and decreasing its portability. The heat changer will requires large amounts of metal tubing with good thermal conductivity and extremely malleable, materials with these properties are expensive leading to higher cost. The utilization of a eutectic salt, introduces a corrosive element to an area where they do not have proper facilities or training to dispose of it, this increases the systems negative impact on the environment.

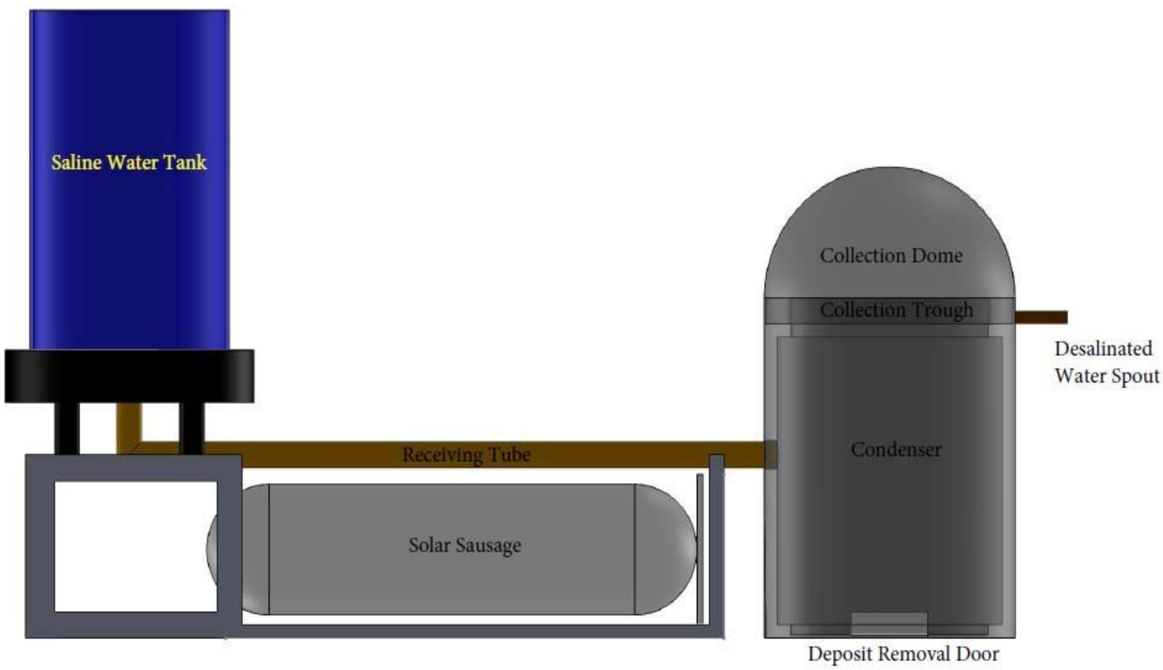


Figure 2: Design 2 - Direct Heat Transfer

The second design, shown above in Figure 2, has a saline water tank that is suspended some height in the air. The height of the water tank drives the water through the receiving tube. The focal point of the Solar Sausage is on the receiving tube and heats it to temperatures near 400°C [2]. Once the water has traversed the receiving tube, it will have reached boiling point and undergone a phase change. As the steam exits the receiving tube and enters the condenser, saline deposits drop to the bottom as steam rises into the collection dome. As the desalinated steam condenses, it drips down into the condensing trough and exits through the spout.

There are many advantages to this the design in its simplicity and portability, but the design also has its disadvantages. This design uses gravity to drive the water through the receiving tube eliminating the needs for a pumping system, lowering the cost. The direct heating method eliminated the needs for the heat transfer fluid tank as in the first design decreasing the cost. The system could be easily disassembled, due to the simplicity of its components increasing its portability.

As mentioned there are numerous disadvantages to this design including saline buildup, irregular flow, and limited operating time. Saline will build up in the receiving tube and will also corrode the tube, this will require some king of cleaning method or the inclusion of extra receiving tubes decreasing the simplicity and increasing the cost of this design. As the water level in the saline water tank decreases the velocity of the fluid in the receiving tube decreases, this will result in a higher temperature steam at the receiving tube exit changing the condensing requirement.

Since this design utilizes direct heat transfer its operating time is limited to peak sun hours.

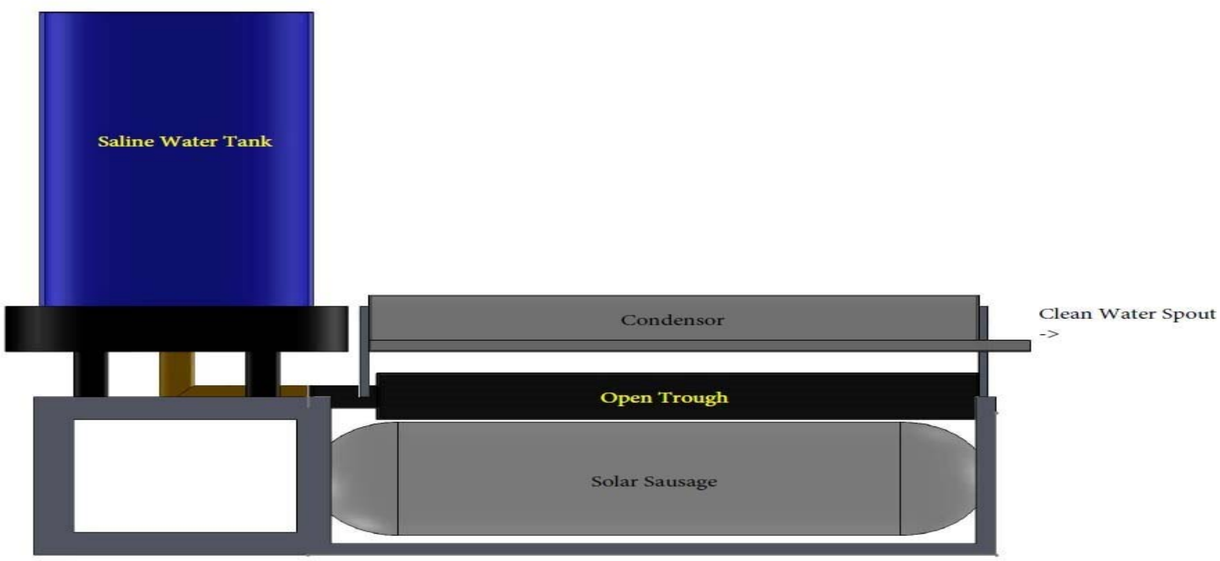


Figure 3: Design 3 - Open Trough

The third design, shown above in Figure 3 uses direct heating method like the second design. Unlike the second design, this design uses an open trough instead of a receiving tube.

The open through fills with water fed to it from the saline water tank. The Solar Sausage heats the trough surface to near 400℃ causing the water to evaporate. The steam rises into the condenser which is located right above the open trough. As the steam condenses the droplets drip down into troughs located on both sides of the condenser. As the clean water builds up in the trough it forces its way out of the clean water spout located on the one side of the condenser.

This design has many advantages, the first being that it does not have its own free standing condensing tank. By having the condensing dome, from the second design, directly over the open trough the space required for the system to operate or to be transported greatly decrease. This increases the portability and increases the simplicity. The open trough provides an easy way to remove the saline buildup, after each use someone can simply scrape the saline out of the open trough simplifying the system. As in the second design since it utilizes direct heat transfer it can only operate between peak sun hours. The second disadvantage being that the trough covers a large a large portion of the Solar Sausage's reflective material compared to the receiving tube in the second design. This would require a larger solar sausage increasing the cost and size of the system.

2.5 Design Specifications

In order to find the solar insulation for Tallahassee, equation (1) was used. This equation includes the latitude (θ), and the solar insulation value after effects of the equator (S), which is 1000 W/m^2. The local solar insulation found for Tallahassee was found to be 866 W/m^2, which was converted to 274 Btu/h*ft^2.

$$S_{\theta} = 1000cos(30°)\frac{W}{m^2} \tag{1}$$

The solar sausage has a length of 10 feet and a diameter of 3 ft. The unobstructed reflective surface area was found by implementing these dimensions into equation (2) below. The width of the solar sausage bottom dimension is (5/12) ft. The obstructed area, or the maximum surface obstructed by the condenser was found using equation (3) below. The values for unobstructed and obstructed area were found to be 30 ft^2 and 4 ft^2 respectively. The total reflective surface area was found by subtracting the obstructed area from the unobstructed area and is shown in equation (4). The total reflective surface area was found to be 25.83 ft^2.

$$A_{surface} = LD \tag{2}$$

$$A_{obstructed} = LW \tag{3}$$

$$A_{reflective} = A_{surface} - A_{obstructed} \tag{4}$$

In order to find the heat delivered to the trough, the three points of loss had to be known. It was known that there was a 16% loss when entering the project ($\eta_{entering}$), a 10% reflective membrane ($\eta_{reflective}$), and a 12% loss when exiting the membrane ($\eta_{exiting}$). Knowing this information, the heat delivered to the trough was found using equation (5) below. The value found was 4943.48 Btu/h.

$$\dot{Q} = (S_\theta)(A_{reflective})(1 - \eta_{entering})(1 - \eta_{reflective})(1 - \eta_{exiting}) \tag{5}$$

The maximum evaporation rate was found by assuming the water source provided saline water at a temperature (T_{source}) of 77°F. The maximum temperature the body of water will be allowed to achieve (T_{max}) is 221°F. Using the enthalpy of evaporation (h_{fg}) the maximum rate of evaporation ($\dot{m}_{evap}$)was found at the T_{max} and implemented in Eqn. 6 below. The value for maximum evaporate rate was found to be 5.125 lbm/h.

$$\dot{Q} = \dot{m}_{evap} h_{fg@221°F} \tag{6}$$

$$\dot{m}_{evap} = \frac{lbm}{h}$$

Any unit conversions and work done to find the solar insulation, reflective surface areas, heat delivered, and evaporation rate can be found in Appendix A.

2.6 Evaluation of designs

Using engineering judgment, the group ranked the concepts on a weighted decision matrix. Table 1 depicts the results between the different methods and the deciding criteria.

Table 1: Design Concept Decision Matrix

Decision Making Factors	Weighting	Heat Exchanger	Direct Heat Transfer	Open Trough
Cost	9	4	8	9
Portability	8	1	7	6
Water Output	8	8	8	7
Simplicity	6	4	6	9
Eco Friendly	5	9	9	9
	Weighted Decision	**177**	**273**	**284**

2.6.1 Criteria, Method, Selection

Table 1 shows the criteria chosen, as well as the weight of each. The criteria are decreasing in weight from top to bottom and this weight is multiplied by each concept's ability to satisfy the criteria. The overall score for each concept is determined by the sum of all of the decision making factors. Cost, portability, and water output are the most important factors. Cost is crucial because the Solar Sausage is meant to be a more cost efficient alternative to harnessing solar energy. This is an entrepreneurial project that will ideally be mass produced in the most cost efficient way possible. Portability is important because these desired locations have natural disasters and other forces that may ruin the system. Therefor the mechanism must be able to be deconstructed, stored away, and then reassembled easily. Lastly, the system should be to produce a sufficient amount of water yet be simple requiring few components and can be easily maintained by the residents.

2.6.2 Design Selection

Using the weighted decision matrix, Table 1, the criteria, design and product specification to judge each design, the team selected **"Design 3: Open Through."**

2.6.3 Final Updated Design

Improvements on the final design choice have been made regarding factors already stated in the decision matrix including removing the large storage tank along with its stand. Small, lightweight stands on either side will support the system with stakes driven into the ground for support to prevent the system from moving. Figure 4 below shows these improvements.

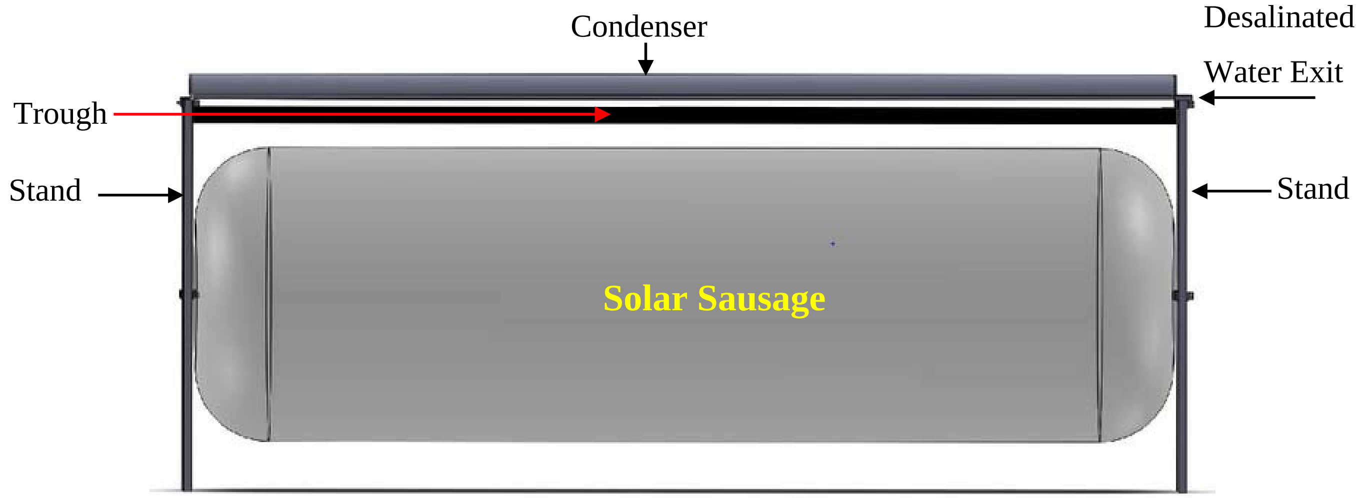


Figure 4: Final Updated Design

The bottom of the trough will be painted black for maximum heat transfer, and the sides will be lined with some type of insulation so heat transfer moves vertically only. Fins will be attached to the condenser to increase heat transfer and a reflective material will be placed over the condenser in order to minimize heat accumulation in this component which functions on the basis of removing heat from the water. Additional work being considered to improve the system is explained later in section 10: Future Plans for Prototype and Others.

3 Detailed Design and Design for Manufacturing

This section explains the design and materials of our system and provides detailed information to describe the specifics of each. This allows one to analyze each decision made by the group if replication of the project is desired.

3.1 Detailed Design

The final updated design was displaced in Figure 4. The design consist of thirteen parts, most of which will require minimum machining. The trough and the condenser will require welding, making the parts more complicated. A more detailed design is provided in Appendix B, it presented in drawing produced by SolidWorks. The drawings, located in Appendix B, provide dimensions manufacturing notes for each component.

3.2 Materials

Aluminum 6061 and 6063 will be used for the majority of the project materials including the trough, supporting side stands, and condenser. This material was chosen based on its high thermal conductivity as well as its inexpensive cost relative to most other metals. It is also rigid and provides a good support for the sides. The trough and condenser will be thin in order to have heat transfer maximized while still being thick enough to support the weight of the design. These characteristics are shown and weighted in the Tables 2 and 3 below

Table 2: Side Support Material Choice

Structural Material Decision Matrix								
	Density		**Machinability**	**Tensile Strength**		**Cost**		
	kg/m^3	Rating	Rating	Mpa	Rating	$/ton		**Total**
Aluminum	2770	8	10	276	4	$2,017.50	8	204
Steel	7854	3	7	415	9	$766.00	10	175
Weight		9	6		4		7	

Table 3: Condenser and Trough Material Choice

Condenser and Trough Material Decision Matrix							
	Emissivity		**Machinability**	**Cost**		**Availability**	
	ε	Rating	Rating	$/ton	Rating	Rating	Total
Aluminum	0.09	6	10	$ 2,017.50	8	10	240
Copper	0.15	9	9	$ 6,621.00	4	6	178
Weight		4	6		7	10	

4 Commercial Viability

With this project being entrepreneurial, commercial viability is vital. This section outlines each aspect of being commercially viability and defines factors for the project such as the consumer, cost, and advantages offered by the system.

4.1 Target Consumer

The target consumer will be the under-developed countries that have easy access to saline water while lacking clean, potable water. Most likely the primary audience will be under-developed countries such as Madagascar which has become the top choice of location for implementation of the final design. Other countries with similar conditions to Madagascar like Somalia will also be of primary interest since the design will be easily translated. With the module design, single Solar Sausages could be purchased along with the other materials that compose the entire system. Those purchased could be donated to specific areas across the world by organizations and individuals.

4.2 Cost

The budget of the entrepreneurial project is $5,000 however the cost of the entire system including packaging should be as inexpensive as possible in order to make the final product most marketable for these under-developed countries. Considering the developing nature of the countries with inadequate access to clean drinking water, this system must be at a price that the consumer can afford. This means more product can be sold and distributed, furthering the amount of people benefitting from this technology to obtain clean water.

4.3 System Advantages

The system offers advantages since it is light weight and portable compared to other desalination systems. Also, it is easy to manufacture due to its use of simple, commercially available components that are assembled without the need of welding or any serious machining (bolts and nuts assembly).

5 Risk and Reliability

This section provides an overview of risks that consumers and workers of the final product should be aware of. Also, the reliability of the system is defined for clarification.

5.1 Risk

Associated risks are ensuring water does not become contaminated by any of the materials being used in the project. For instance, the aluminum cannot corrode or else the chemicals from the rust will enter the water and make it unsafe for drinking. A noncorrosive spray may be necessary if this becomes an issue. Also, there is potential for getting burned due to the large heating capacity of the Solar Sausage concentrating solar energy onto the trough made of good thermal absorbing metal. Local workers maintaining this system must take caution and wear protective gloves for safety.

5.2 Reliability

The system developed must be able to resist moderate weather interactions although it can be easily disassembled and stored in case of severe weather conditions. The system also will work only with a fair amount of sun and decent weather so the reliability of this system during a wet season should be accounted for. Residents may want to properly store potable water in case of hurricane seasons or longer periods of inclement weather.

6 Procurement

Purchase orders have been created and will be submitted to the project's advisor. All purchase orders to date can be found attached in the appendix C of this document. The purchase orders attached include materials and components for the solar sausage's construction and will be purchased by large, national vendors such as Metals Supermarket and McMaster Carr. Additional purchase orders will be created for local vendors.

Currently, the allocated funds total to a value of $1,367.52. This will be taken from the $5,000.00 budget from the College of Engineering for the Solar Sausage for Desalination project. A summary of the number of items and the total amount of money spent for each vendor is shown below in Table 4. An itemized breakdown, along with a copy of the submitted procurement forms, is available in Appendix C.

Table 4: Procurement Table

Purchase Analysis		
Vendor	**Number of Line Items**	**Total**
Metals Supermarket	8	$ 264.01
McMaster Carr	4	$ 240.51
Grand Total		**504.52**

7 Communications

Communication within the group has been conducted through group texting and has been excellent. Thus far, there have been no miscommunications between the group members and everyone has been on the same track for allocated tasks and deadlines. Communication with advisers and mentors have been performed through email. Arranging meeting times to talk in person with these personnel have been done through email as well. There has been only very minor issues when dealing with meeting with these personnel due to schedule conflicts between the group and adviser/mentor. To this point in the project, there have been no real concerns in this area.

8 Environmental and Safety Issues and Ethics

There are no environmental issues associated with the design since it is a zero emissions design and will only be used in residential areas. The previously mentioned safety issues associated with the system are contaminated water due to metal corrosion and workers being burned by touching the hot trough while in use without wearing thermal protective gloves. One ethic associated with this project includes not using unsafe materials due to cost reductions. Another is not cutting corners out of laziness and then lying about the cleanliness of the potable water. This water must truly be clean and drinkable for the consumers.

9 Project Management

The schedule along with resources and time allocations are listed in this section. This breaks down the individual as well as group contributions. An analysis of expected expenditures is also included.

9.1 Gantt Chart

Work for the fall semester is complete and the team has accomplished the task in the Gantt Chart. This can be found in Appendix D. The team has a final design with the necessary CAD drawings for construction. As the team moves forward into the spring semester construction of the base model will begin during the month of January, weather conditions do not permit any testing during this time. The base model will allow for proof of concept for the team, the base model is shown in Figure 4.

While the base model is being constructed research will be conducted on a water storage tank, a pressure regulation system and a sun tracking system. The systems will be constructed and added on to the base model in the month February. These systems are meant to improve the function of the system but are not necessary to proof of concept. Once these systems are implemented, the team will begin testing in the month of March.

9.2 Resources

There are four team members in the design group that will be responsible for completing the required task. The task allocated to each team member is displayed in the table for each member. The labor hours for task not yet completed and will be updated with the actual labor hours as the project progresses. The task, resource type, and labor hours for each task are shown for each team member in Tables 5-8 on the subsequent page.

Table 5: Tasks Allocated to Alex Filardo

Task	Resource Type	Labor Hours	Expected Completion Date
Design Specifications	Intellectual	4	Oct. 8, 2014
Saline Water Corrosiveness	Research	3	Oct. 15, 2014
Evaporation Input Energy	Intellectual	2	Oct. 21, 2014
Solar Sausage Length Analysis	Intellectual	5	Oct. 29, 2014
Condensing Techniques	Research	4	Oct. 31, 2014
CAD Drawings	Intellectual	10	Nov. 24, 2014
Pipe Selection	Material/Fiscal	2	Dec 5, 2014
Total Labor Hours		**30**	

Table 6: Tasks Allocated to Joseph Hamel

Task	Resource Type	Labor Hours	Expected Completion Date
Performance Specifications	Intellectual	4	Oct. 8, 2014
Heat Exchanger	Research	5	Oct. 15, 2014
Condensation Energy	Intellectual	2	Oct. 21, 2014
Head Loss Calculations	Intellectual	3	Nov. 2, 2014
Condensation System Requirements	Intellectual	7	Nov. 2, 2014
CAD Drawings	Intellectual	10	Nov. 24, 2014
Total Labor Hours		**31**	

Table 7: Tasks Allocated to Alex Stringer

Task	Resource Type	Labor Hours	Expected Completion Date
Design Specifications	Intellectual	5	Oct. 8, 2014
Conduction Research	Research	3	Oct. 15, 2014
Solar Intensity Research	Research	4	Oct. 15, 2014
Solar Concentration Analysis	Intellectual	5	Oct. 24, 2014
Temperature Regulations	Research/Material	2	Nov. 4, 2014
CAD Drawings	Intellectual	10	Nov. 24, 2014
Storage Tank Selection	Material/Fiscal	2	Dec 5, 2014
Total Labor Hours		**31**	

Table 8: Tasks Allocated to Crystal Wells

Task	Resource Type	Labor Hours	Expected Completion Date
Performance Specifications	Intellectual	4	Oct. 8, 2014
Madagascar Demographics	Research	2	Oct. 12, 2014
Heat Transfer Fluids	Research	3	Oct. 15, 2014
Trough Materials	Material	5	Oct. 21, 2014
Minimum Diameter Calculations	Intellectual	1	Oct. 31, 2014
Water Storage	Material	3	Nov. 4, 2014
CAD Drawings	Intellectual	10	Nov. 24, 2014
Structural Material	Research	2	Dec. 5, 2014
Purchase Orders	Administrative	5	Dec.5, 2014
Total Labor Hours		**35**	

9.3 Budget

The budget along with projected costs of different components of the project is shown in Table 9 below.

Table 9: Budget with Projected Costs to Date

Master Budget			
	Estimated		
Category	**Cost**	**% of Tot. Spent**	**% of Tot. Budget**
Raw Material	$ 287.86	21%	6%
Fastners	$ 30.91	2%	1%
Accessories	$ 244.00	18%	5%
Labor	$ 750.00	55%	15%
Shipping	$ 54.75	4%	1%
Total	$ 1,367.52		
Total Budget	$ 5,000.00		
% Budget Spent	27%		

As seen above, only about 27% of the budget so far has been allocated which is consistent with the concept of a cheap desalination system for underdeveloped countries. This leaves a sufficient amount of funds left for design optimization. Also, it leaves much money for marketing and other costs associated with an entrepreneurial project.

10 Conclusion

At the conclusion of this semester, the group has a final design concept that has been conceptually and numerically proven successful in absorbing sunlight through the Solar Sausage while desalinating water through the open trough. Engineering detailed sketches have been made of the design providing these features. The Solar Sausage has already been constructed with the help of the raw materials and guidance given by Ian Winger. The purchase of the materials will most likely be completed by the end of the semester and the construction of the system should be completed early in the spring semester. The maximum distillate water flow output of 5.125 lbm/h will hopefully be achieved in the testing of the system later in the spring. This will be a scalable technology that ideally will be translated from the prototype to a larger scale in order to provide potable water for a family in a village of Madagascar. This project will hopefully provide a good contribution in technology to a water scarcity crisis of the world that desperately needs attention. The group has worked hard to help provide a solution to this issue and is on a good pace having a very successful semester.

11 Future Plans for Prototype

This section includes future work for next semester regarding each system of the overall design as well as anticipated additional research. The need for an instruction manual and performance booklet will also be discussed.

11.1 Basic Construction of System

The earlier months of the spring (January and February) will be dedicated to the construction of the prototype in order to have a working model and since this isn't a prime time period for solar radiation in Florida. This will allow the group to conduct the best possible test results of the system. The prototype will include the solar sausage, open trough, condenser, and side supports.

11.2 Storage system

Possibilities of implementing a small storage system holding a couple gallons of water will be researched in the future. This could include a sand and rock filter system and be placed above the solar sausage as well for preheating with the bottom painted black for maximum absorption. Another storage system will be placed on the side of the system collecting the clean, potable water. A cheap, promising option for this includes a plastic bladder that could hold the water without it becoming contaminated. These both would be deconstructable to maintain the portable aspect of the design.

11.3 Pressure Regulation System

The plan for the pressure regulation system is to have two foot pumps regulating the pressure of the two chambers inside of the Solar Sausage and a precise pressure gauge to maintain the pressure difference between the two. This is an inexpensive system that uses no electricity and fits the criteria of the constraints.

11.4 Sun Tracking System

The planned sun tracking system will most likely be manually controlled, by turning of the Solar Sausage so that the sausage follows the sun during the peak hours. The Solar Sausage will be held to the side supports by a bearing that should allow the sausage to turn. Mobility of the trough and condenser will be considered if deemed necessary. This may be some mechanical measurement or alignment, following exact turning instructions from a performance booklet given with the entire system's packaging.

11.5 Instructions and Performance Booklet

Although this is a simple system, the packaging will include an instruction manual along with a performance booklet specific to the area of the system's deployment. The instruction manual will describe the assembly and disassembly process, a parts list, and simple maintenance procedures to allow the consumer to have the best understanding of the system. The performance booklet will include sun positions based on the time of day and day of the year for optimum solar concentration. This will allow for maximum performance of the entire system. The performance booklet will also be optimized and developed from the testing of the prototype in the spring.

12 References

[1] "Safe Drinking Water Is Essential: Why Is Safe Water Essential?" Safe Drinking Water Is Essential. National Academy of Science, 1 Jan. 2008. Web. 21 Sept. 2014. <http://www.drinking-water.org/html/en/Overview/Why-is-Safe-Water-Essential.html>.

[2] Group Seven, Ian . Personal interview. 8 Sept. 2014. FAMU-FSU College Of Engineering Building A Atrium.

Solar Insolation

Before atmospheric affects: $S = 1347 \frac{W}{m^2}$

After atmospheric affects at the equator: $S = 1000 \frac{W}{m^2}$

The values changes with latitude (θ): $S_\theta = \left(1000 \frac{W}{m^2}\right) cos\theta$

Local Solar Insulation for Tallahassee:

Latitude: $\theta = 30°$

$S_\theta = 1000cos(30°) \frac{W}{m^2} = 866 \frac{W}{m^2}$

$S_\theta = \left(866 \frac{W}{m^2}\right)\left(\frac{0.3171 \frac{Btu}{h*ft^2}}{1\frac{W}{m^2}}\right) = 274.6 \frac{Btu}{h*ft^2}$

$S_\theta = 274.6 \frac{Btu}{h*ft^2}$

Reflective Surface Area

Solar Sausage dimensions:

Length: L = 10ft

Diameter: D = 3ft

- Unobstructed Reflective Surface Area:

$A_{surface} = LD = (3ft)(10ft) = 30ft^2$

$A_{surface} = 30ft^2$

- Obstructed Area:

The condenser obstructs the solar sausage bottom dimension:

Width: $w = \frac{5}{12} ft$

The maximum surface obstructed by the condenser is:

$A_{obstructed} = (10ft)\left(\frac{5}{12} ft\right) = 4ft^2$

$A_{obstructed} = 4ft^2$

- Total Reflective Surface Area:

$A_{reflective} = A_{surface} - A_{obstructed} = 30ft - 4.17ft = 25.83ft^2$

$A_{reflective} = 25.83ft^2$

Heat Delivered to Trough

The Solar Sausage has 3 points of loss

- $\sim$ 16% loss when entering the project, $\eta_{entering}$

- ~ 10% reflective membrane, $\eta_{\text{reflective}}$
- ~ 12% loss when exiting the membrane, η_{exiting}

Therefor the heat delivered to the trough:

$$\dot{Q} = (S_\theta)(A_{reflective})(1 - \eta_{entering})(1 - \eta_{reflective})(1 - \eta_{exiting})$$

$$\dot{Q} = \left(274.6 \frac{Btu}{h * ft^2}\right)(25.83ft^2)(1 - 0.16)(1 - 0.1)(1 - 0.12) = 4943.48 \frac{Btu}{h}$$

$$\dot{Q} = 4943.48 \frac{Btu}{h}$$

<u>Maximum Evaporation Rate</u> [2]

We assume that water source provides saline water at temperature:

$$T_{source} = 77°\text{F} = 25°\text{C}$$

The maximum temperature the body of water will be allowed to achieve is:

$$T_{max} = 221°\text{F} = 105°\text{C}$$

The enthalpy of evaporation at 221°F:

$$h_{fg@105°\text{C}} = 2243.1 \frac{kJ}{kg}$$

$$h_{fg@221°\text{F}} = \left(2243.1 \frac{kJ}{kg}\right)\left(\frac{0.430\frac{Btu}{lbm}}{1\frac{kJ}{kg}}\right) = 964.533 \frac{Btu}{lbm}$$

$$h_{fg@221°\text{F}} = 964.533 \frac{Btu}{lbm}$$

The maximum evaporation rate can be calculated using the heat input to the trough and the enthalpy:

$$\dot{Q} = \dot{m}_{evap} h_{fg@221°\text{F}}$$

$$4943.48 \frac{Btu}{h} = \dot{m}_{evap}(964.533 \frac{Btu}{lbm})$$

$$\dot{m}_{evap} = \frac{4943.48\frac{Btu}{h}}{964.533\frac{Btu}{lbm}} = 5.125 \frac{lbm}{h}$$

$$\dot{m}_{evap} = 5.125 \frac{lbm}{h}$$

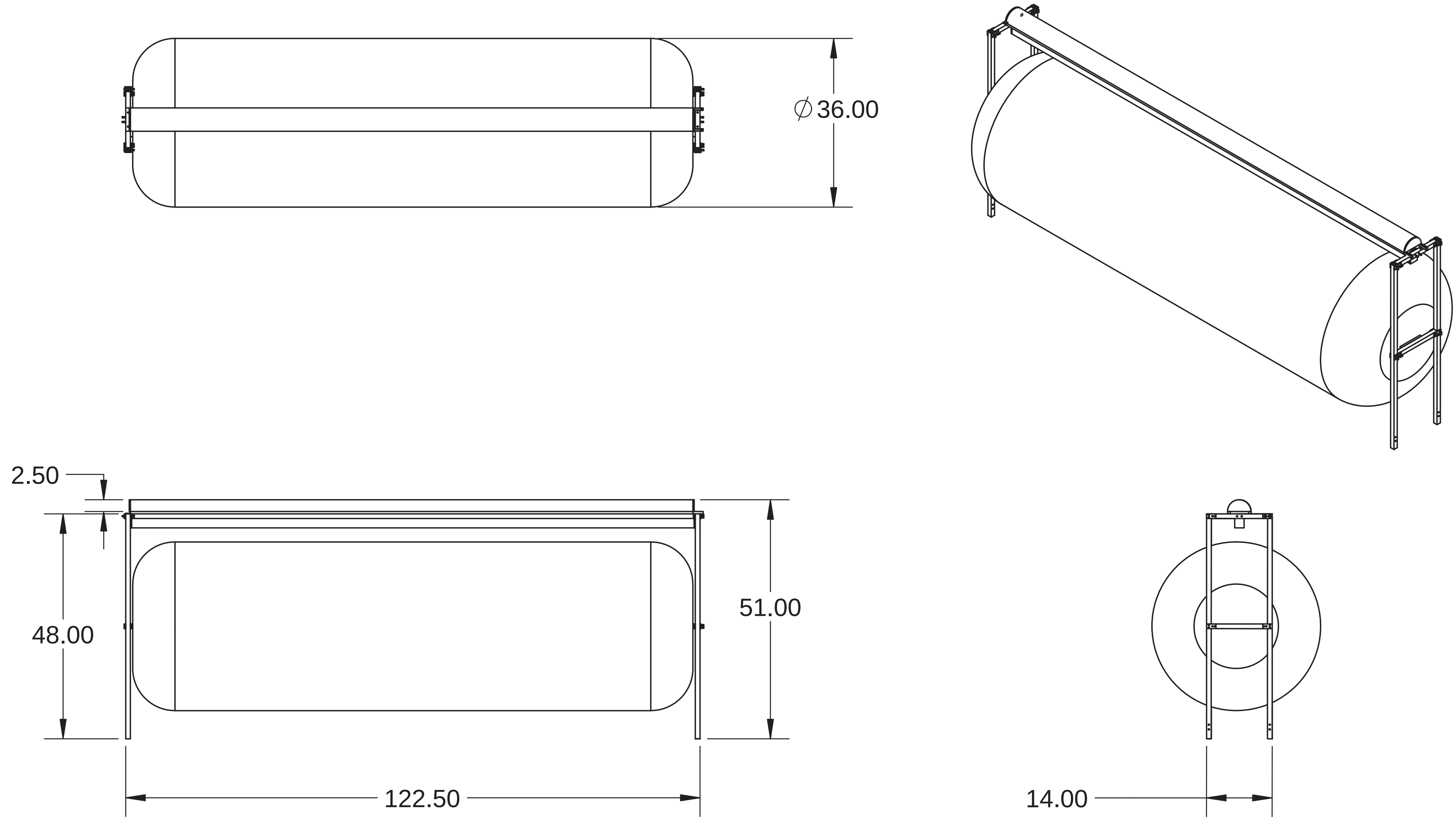
References

[1] Sinha, Sayontan. "Solar Insolation." *Solar Insolation*. Web. 21 Oct. 2014.

[2] Engel, Yunus A. *Fundamentals of Thermal-fluid Sciences*. 4th ed. Singapore: McGrawHill, 2012. Print.

Table of Drawings

Bill of Materials		
Part	Part Name	Quantity
1	Solar Sausage	1
2	Stand Leg	4
3	Cross Bar	4
4	Connector Plate	16
5	Trough Wall	2
6	Trough Channel	1
7	Condenser Hood	1
8	Condenser Channel	2
9	Condenser Wall	2
10	Cross Bar Connector	1
11	Spike Leg	4
12	Spike Baseplate	4
13	Spike Spike	4



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL ± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

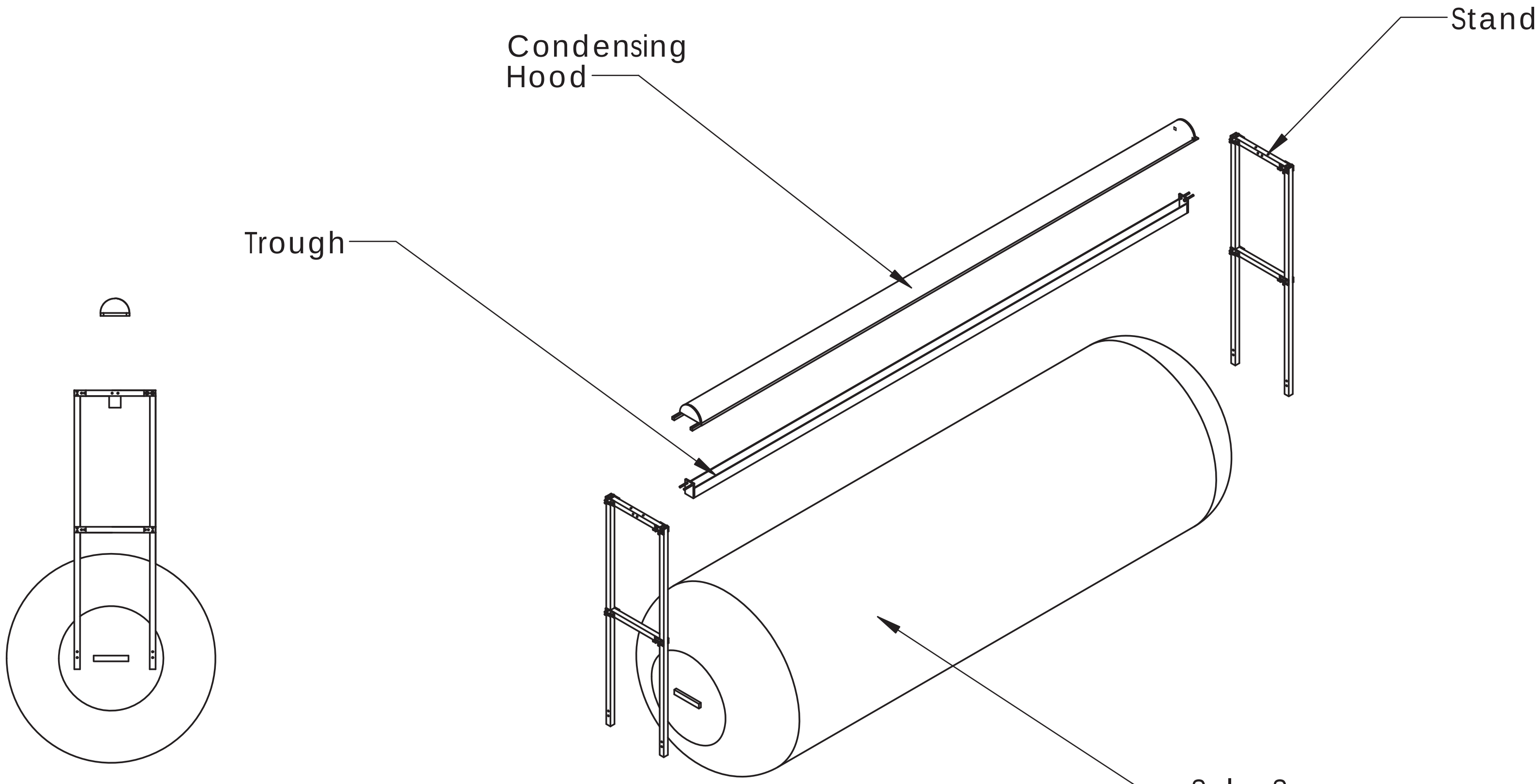
Team 7

TITLE:

Master Assembly

SIZE	DWG. NO.	REV
A		
	WEIGHT:	SHEET 1 OF 2

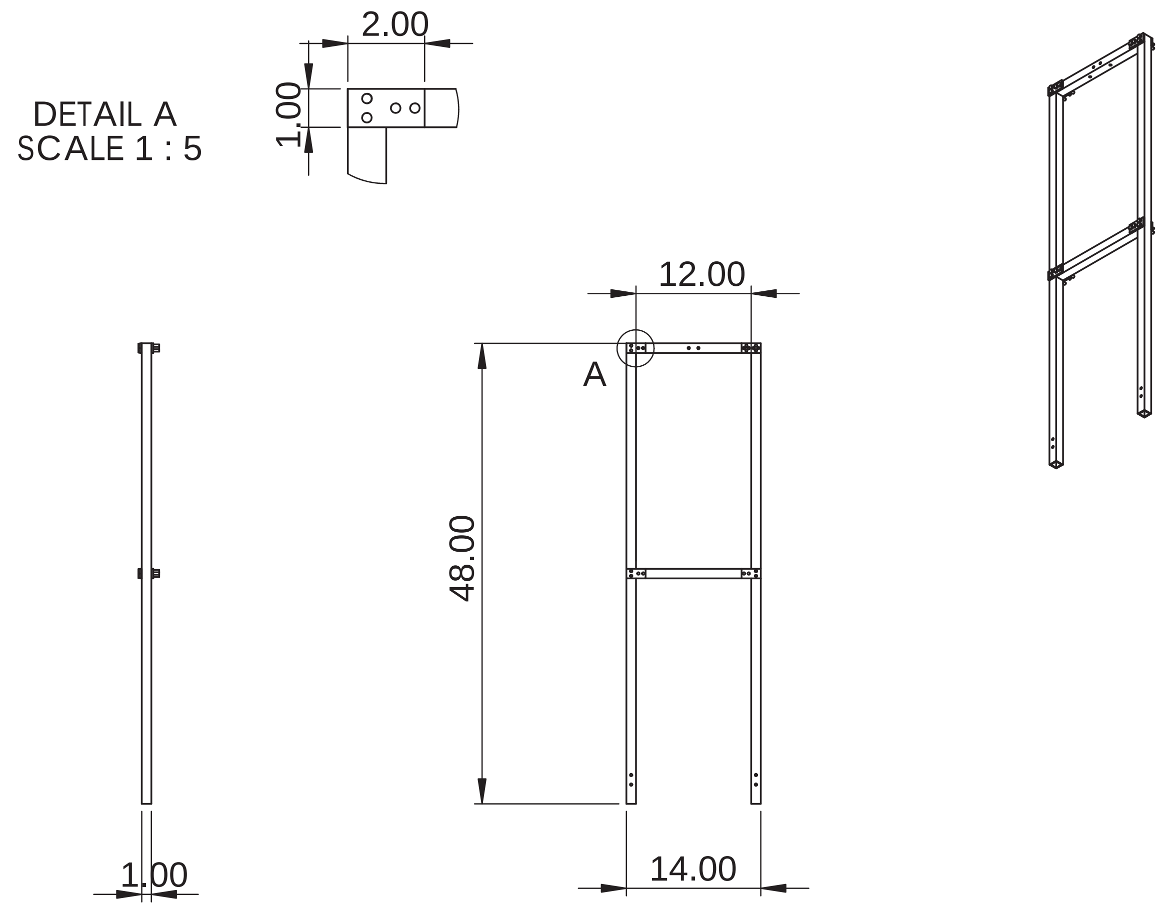
B2



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL ± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

Team 7		
TITLE: Master Assembly		
SIZE A	DWG. NO.	REV
	WEIGHT:	SHEET 2 OF 2

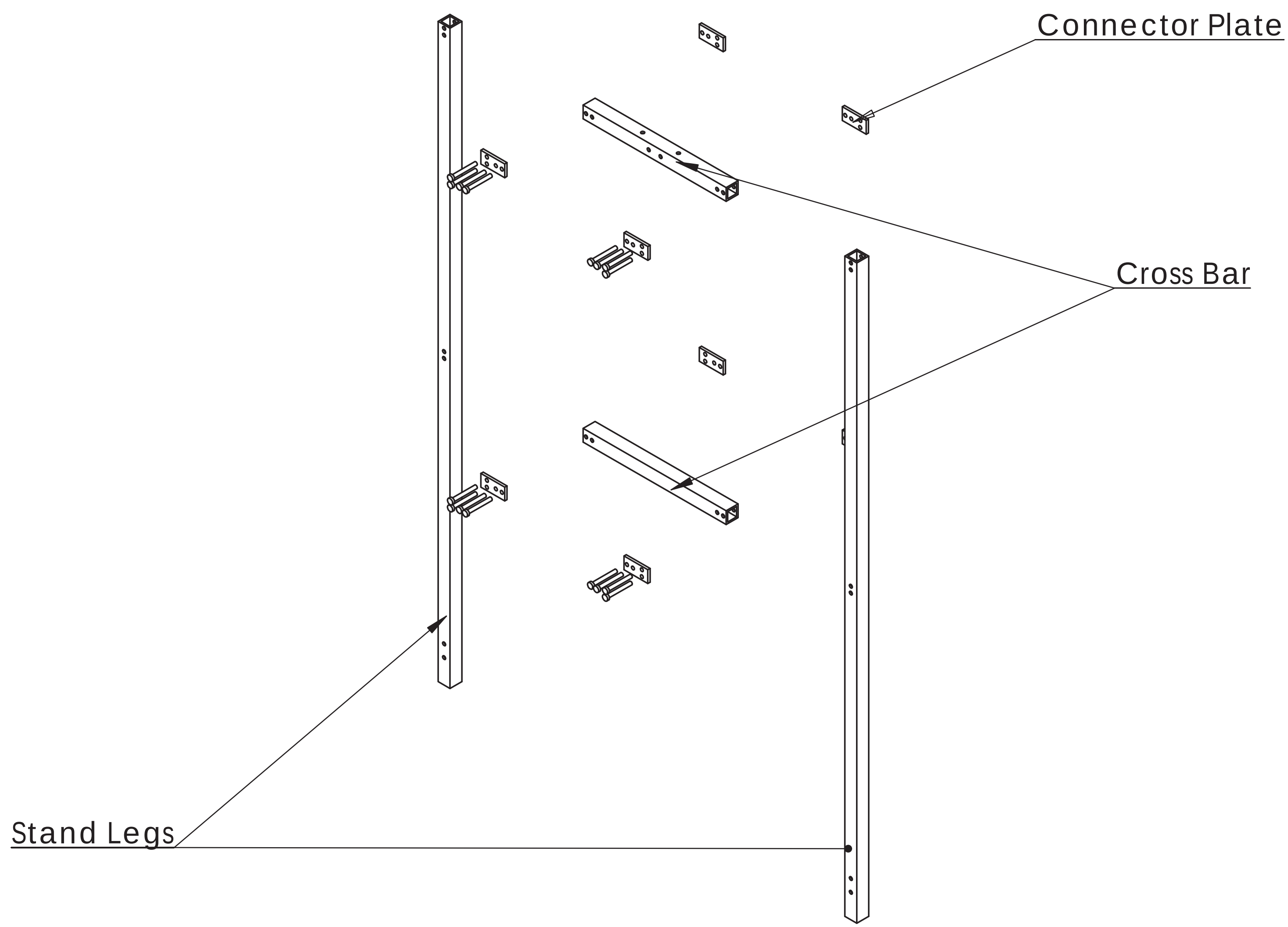
B3



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Aluminum	COMMENTS:		
FINISH Smooth			
DO NOT SCALE DRAWING			

Team 7		
TITLE: Stand		
SIZE A	DWG. NO. Assembly	REV
	WEIGHT:	SHEET 1 OF 5

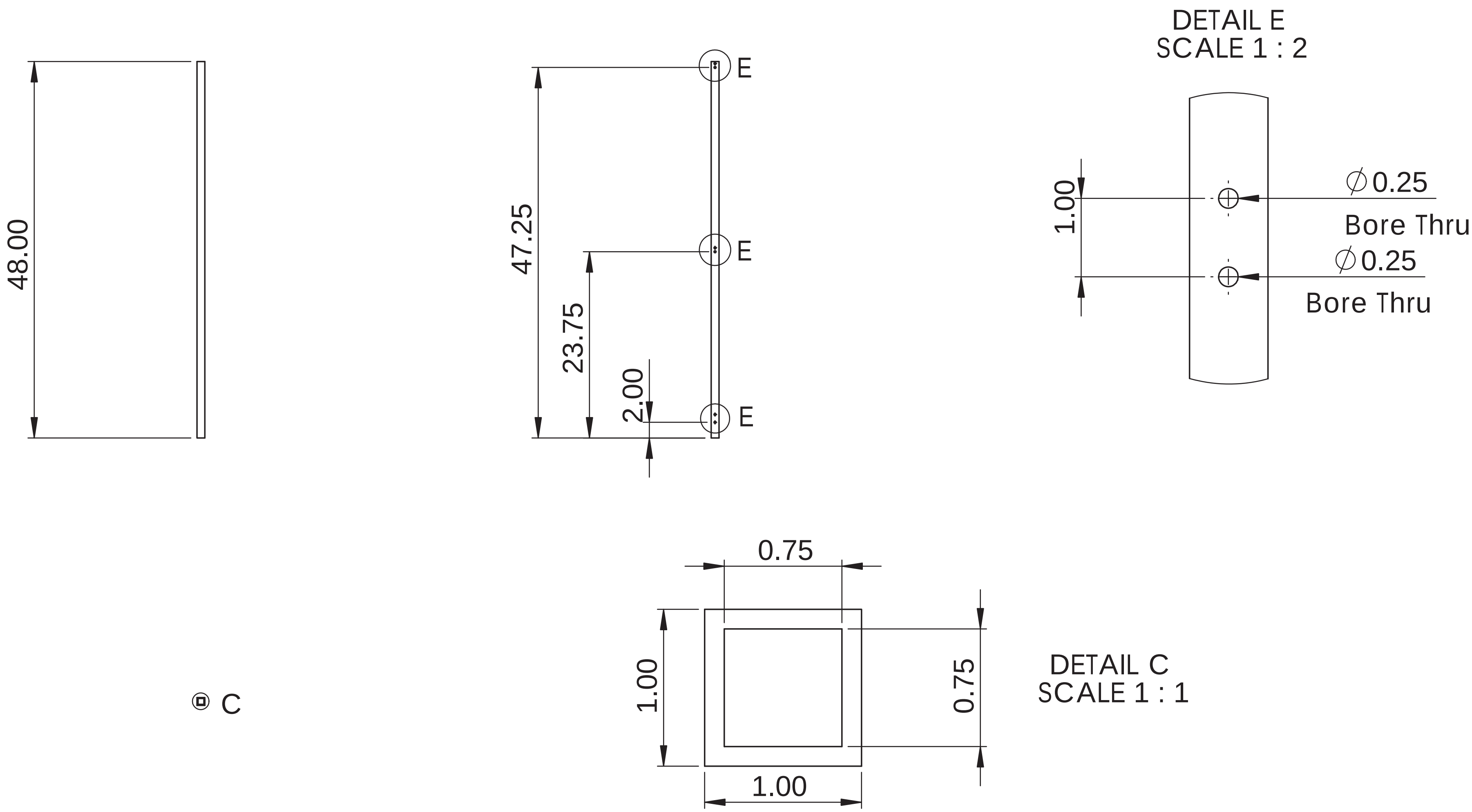
B4



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL ± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

Team 7		
TITLE: Stand		
SIZE A	DWG. NO. Assembly	REV
	WEIGHT:	SHEET 2 OF 5

B5



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Al6063	COMMENTS:		
FINISH Smooth			
DO NOT SCALE DRAWING			

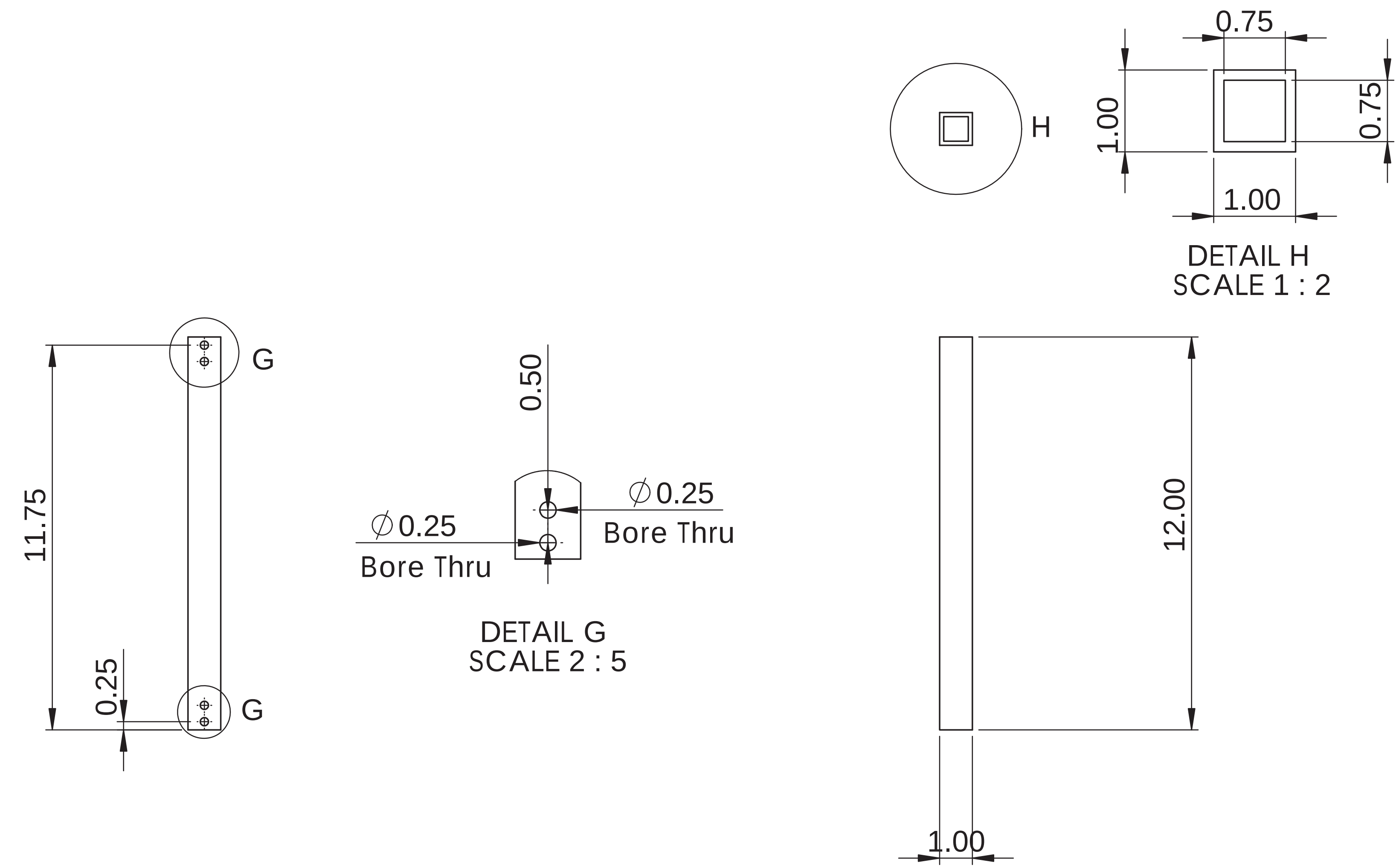
Team 7

TITLE:

Stand

SIZE	DWG. NO.	REV
A	Stand Leg	
	WEIGHT:	SHEET 3 OF 5

B6



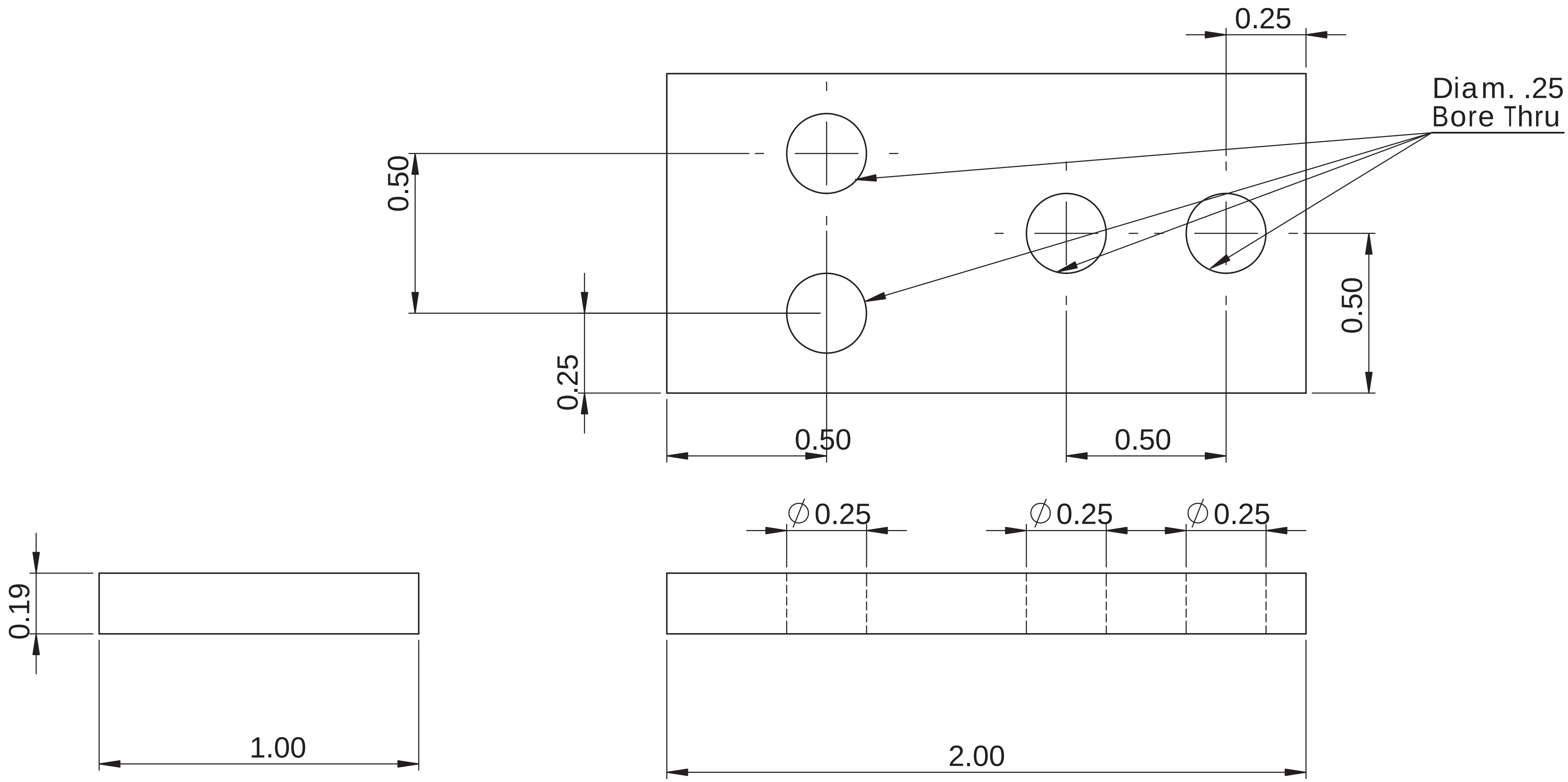
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL ± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Al6063	COMMENTS:		
FINISH Smooth			
DO NOT SCALE DRAWING			

Team 7

TITLE:

Stand

SIZE	DWG. NO.	REV
A	Cross Bar	
	WEIGHT:	SHEET 4 OF 5



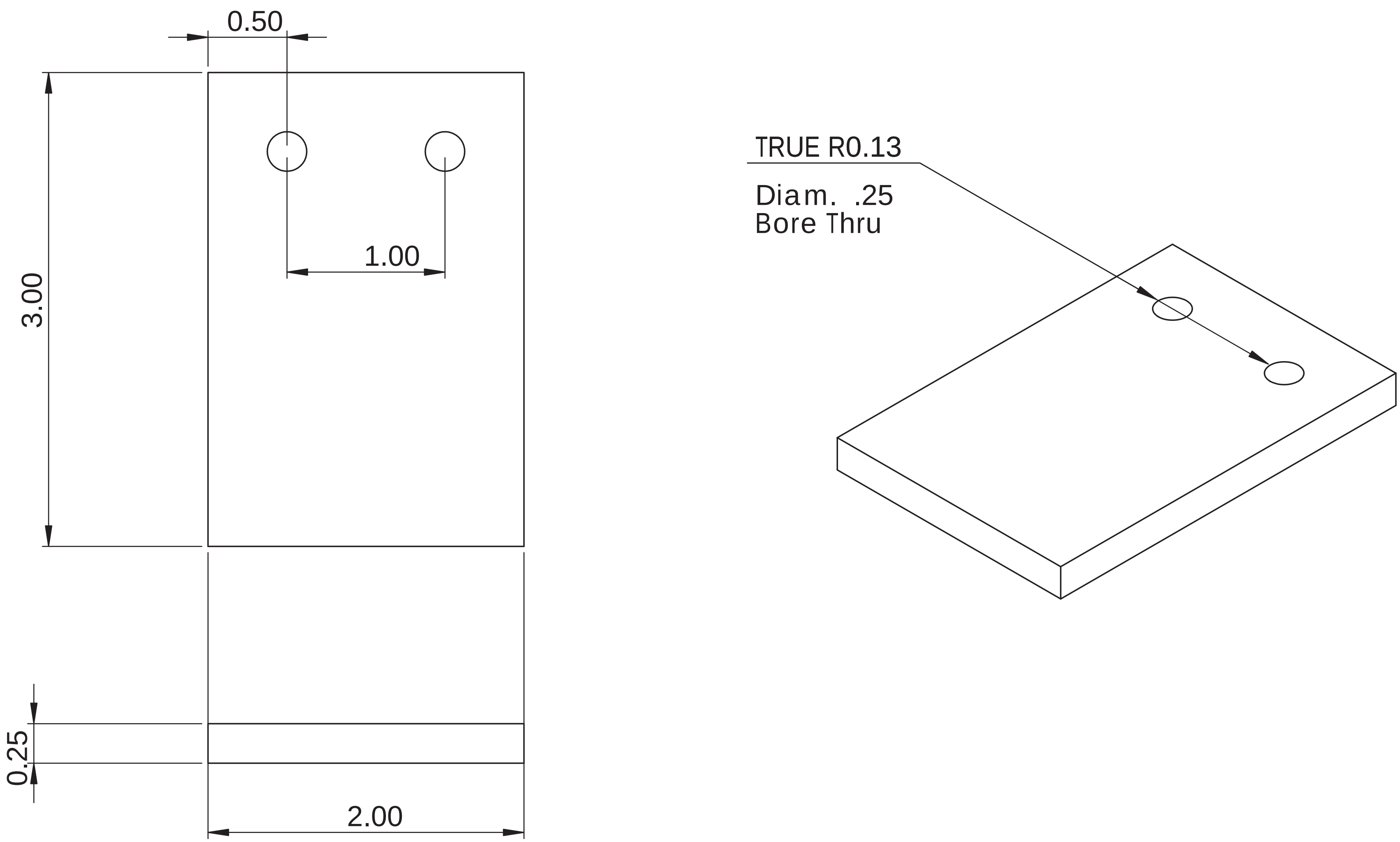
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Al6061-T651	COMMENTS: Connects the cross bar to the leg. There are two for each connection, and are bolted together		
FINISH Smooth			
DO NOT SCALE DRAWING			

Team 7

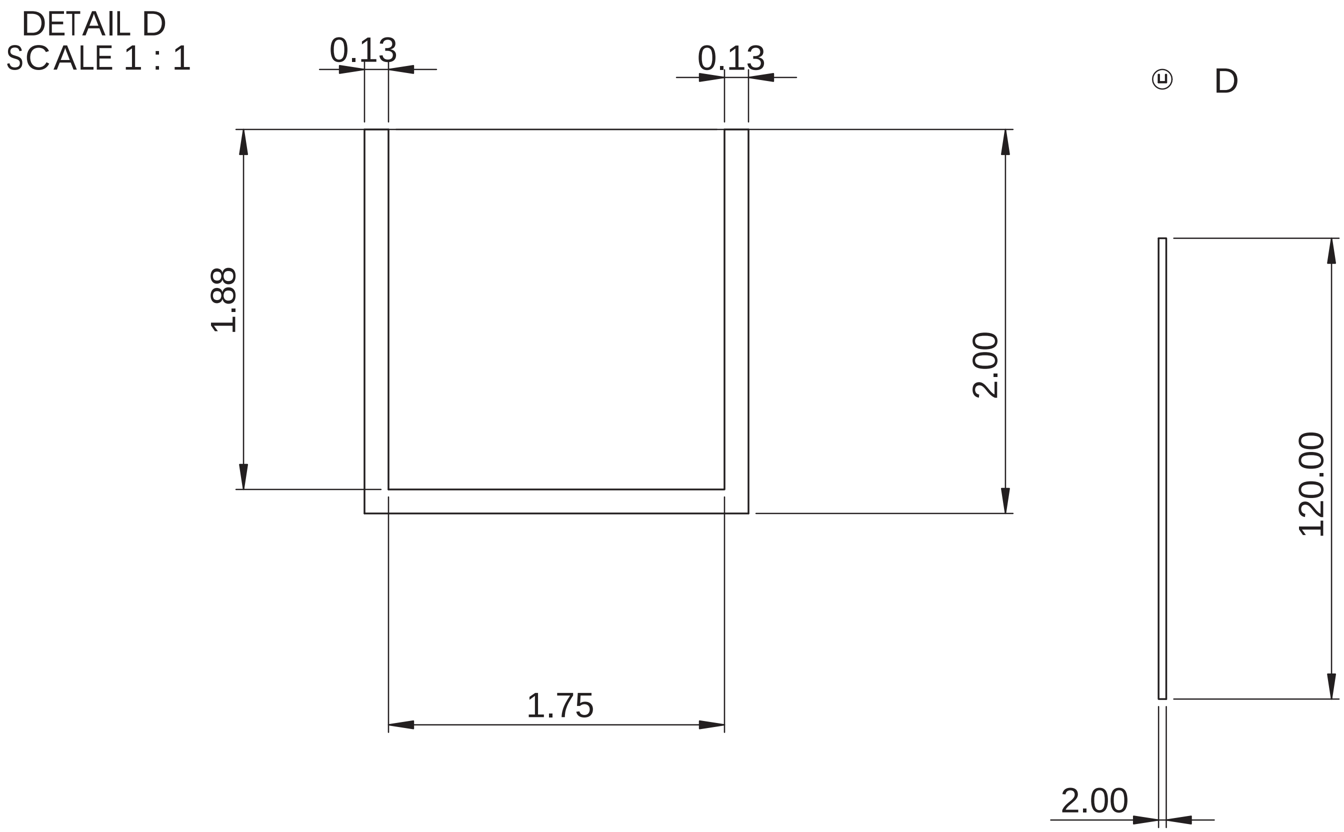
TITLE: Stand

SIZE	DWG. NO.	REV
A	Connector Plate	
	WEIGHT:	SHEET 5 OF 5

UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Team 7
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer		TITLE: Trough
	CHECKED	Joseph Hamel		
	ADVISOR APPR.	Dr. Shangchao Lin		
	FUNDING APPR.	Crystal Wells		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo		
MATERIAL Aluminum	COMMENTS:			SIZE A / DWG. NO. Assembly / REV
FINISH Smooth/Painted				
DO NOT SCALE DRAWING				WEIGHT: / SHEET 1 OF 3



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Team 7
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer		TITLE: Trough
	CHECKED	Joseph Hamel		
	ADVISOR APPR.	Dr. Shangchao Lin		
	FUNDING APPR.	Crystal Wells		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo		
MATERIAL Al3003-H14	COMMENTS:			SIZE A · DWG. NO. Trough Wall · REV
FINISH Smooth				
DO NOT SCALE DRAWING				WEIGHT: · SHEET 2 OF 3

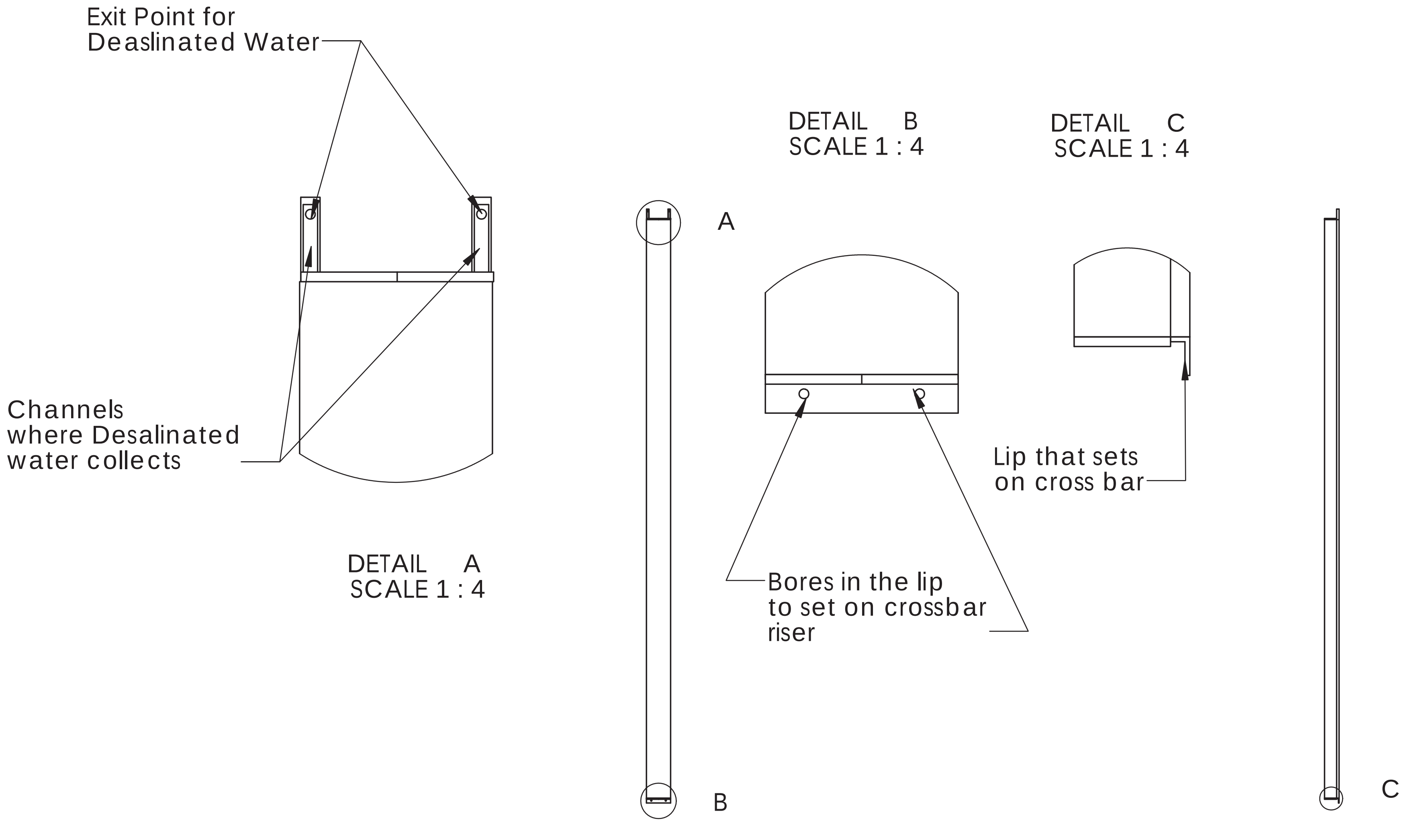


UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Al6063-T52	COMMENTS:		
FINISH Smooth/Painted			
DO NOT SCALE DRAWING			

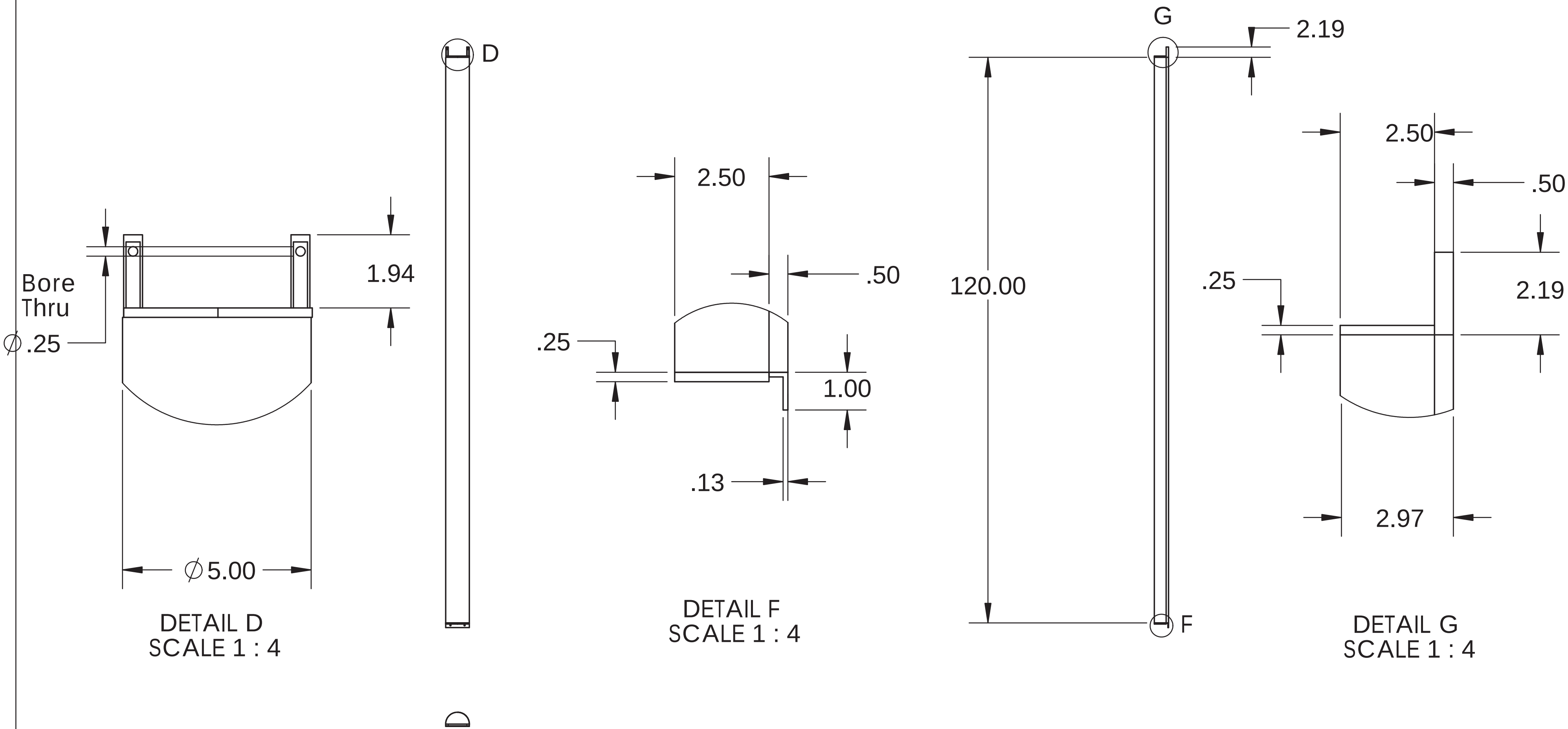
Team 7

TITLE: Trough

SIZE	DWG. NO.	REV
A	Trough Channel	
	WEIGHT:	SHEET 3 OF 3



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Team 7
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer		TITLE:
	CHECKED	Joseph Hamel		Condensor
	ADVISOR APPR.	Dr. Shangchao Lin		
	FUNDING APPR.	Crystal Wells		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo		
MATERIAL Aluminum	COMMENTS:			SIZE A — DWG. NO. Assembly — REV
FINISH Smooth/Painted				
DO NOT SCALE DRAWING				WEIGHT: — SHEET 1 OF 6



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Aluminum	COMMENTS:		
FINISH Smooth/Painted			
DO NOT SCALE DRAWING			

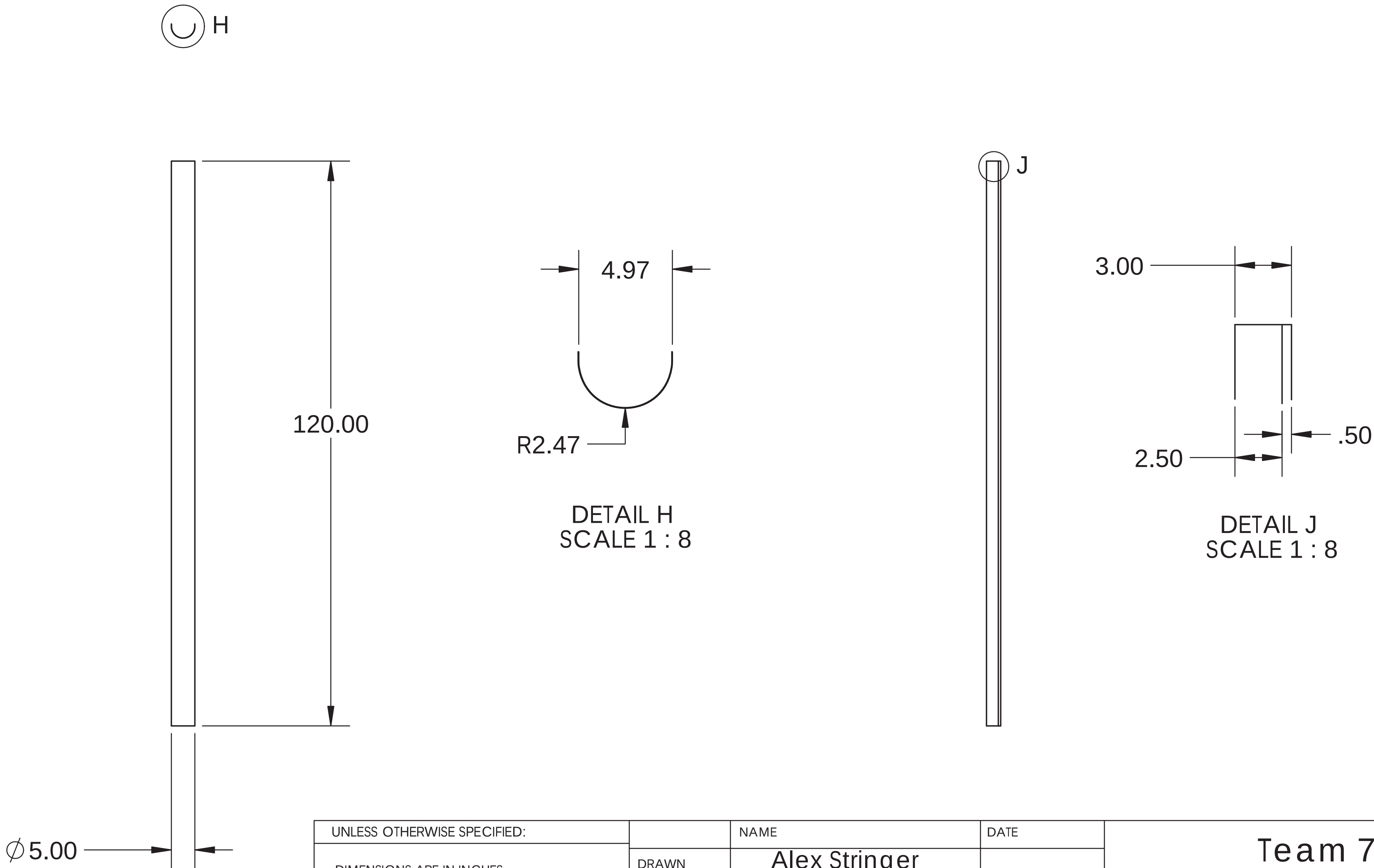
Team 7

TITLE:

Condenser

SIZE	DWG. NO.	REV
A	Assembly	
	WEIGHT:	SHEET 2 OF 6

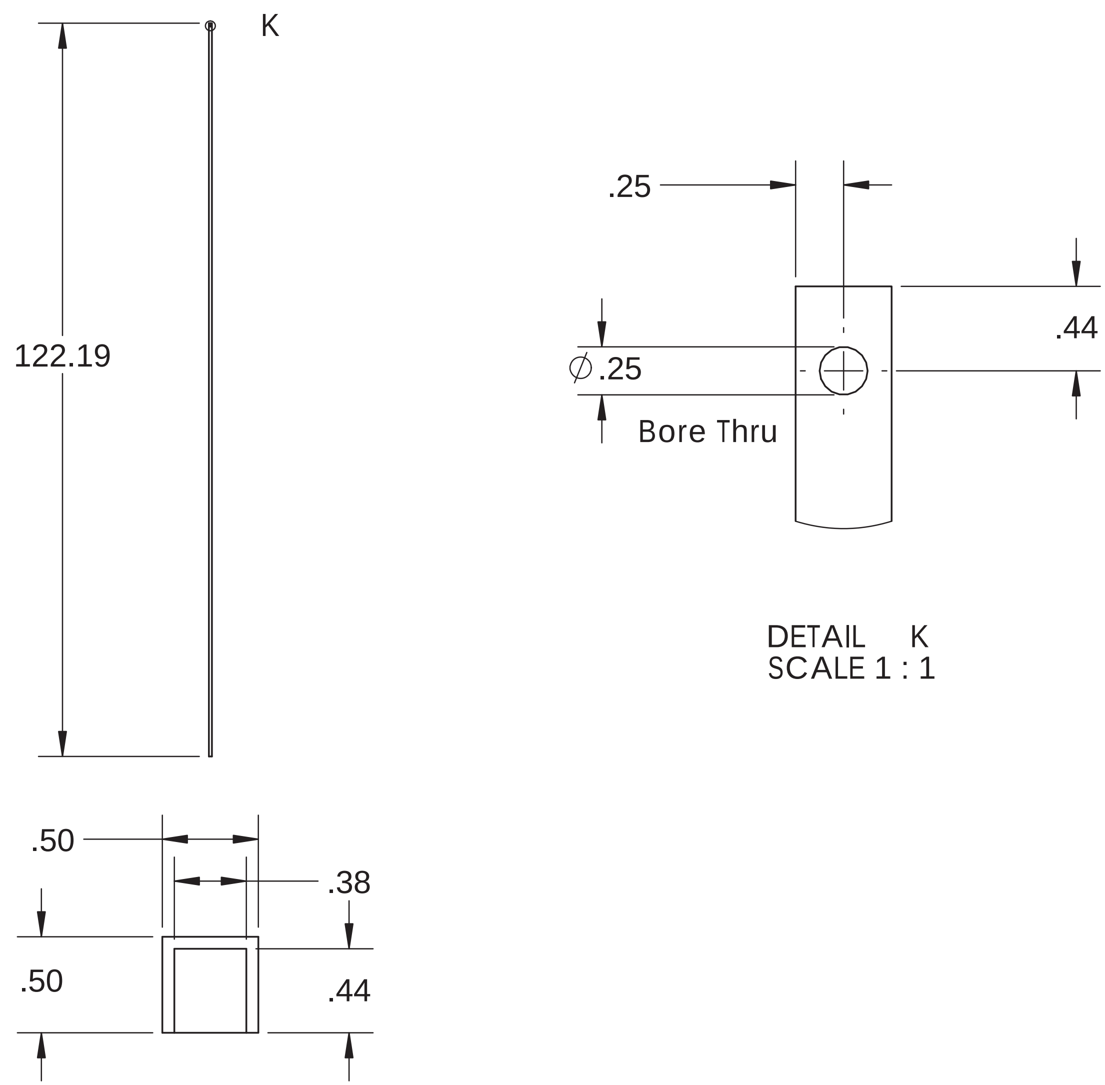
B13



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL ± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Al6061-T6	COMMENTS:		
FINISH Smooth/Painted			
DO NOT SCALE DRAWING			

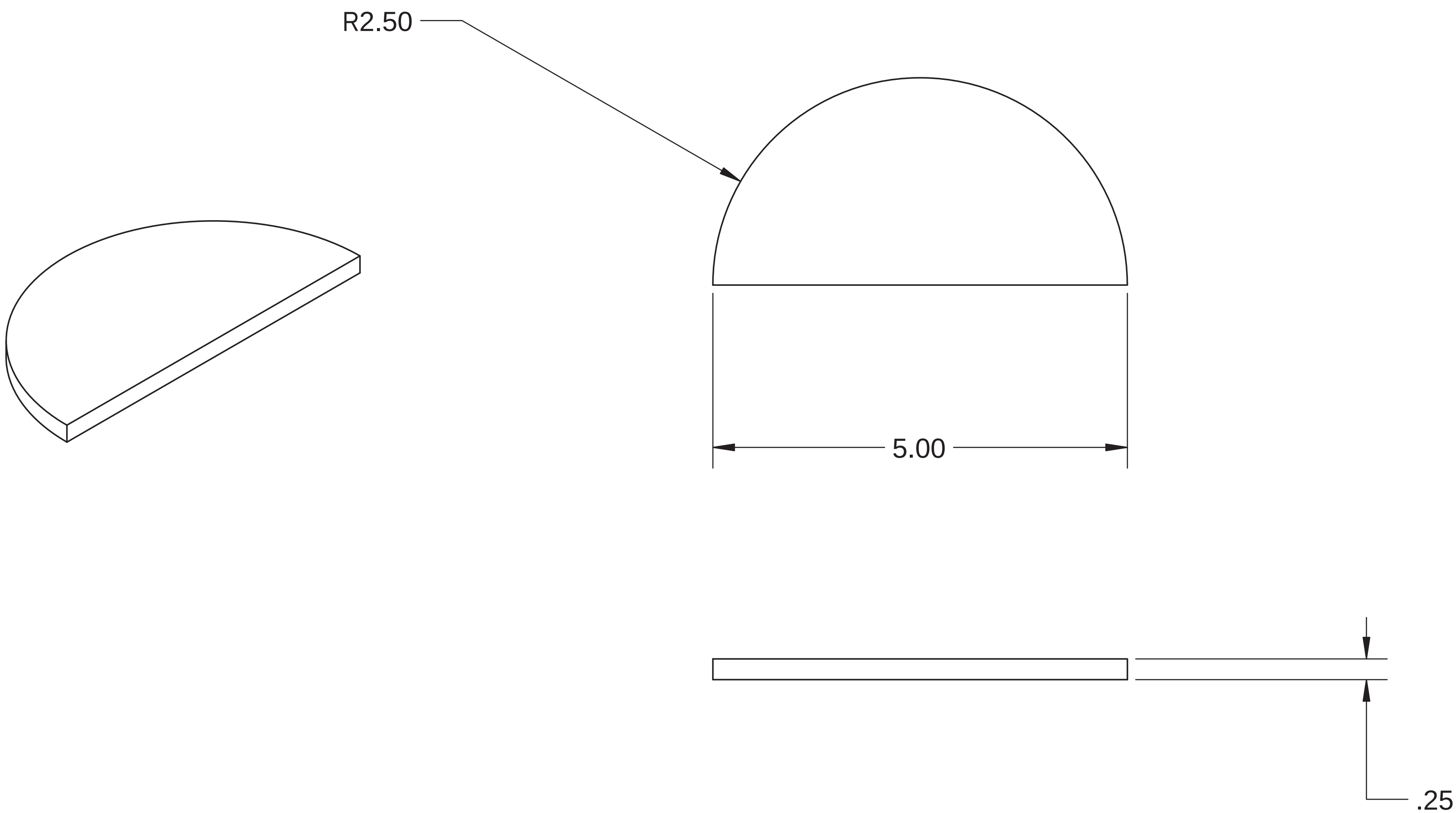
Team 7		
TITLE: Condensor		
SIZE A	DWG. NO. Condenser Hood	REV
	WEIGHT:	SHEET 3 OF 6

B14



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Al6063-T52	COMMENTS:		
FINISH Food Grade Safe Coating			
DO NOT SCALE DRAWING			

Team 7			
TITLE: Condensor			
SIZE A	DWG. NO. Condenser Channel		REV
	WEIGHT:	SHEET 4 OF 6	



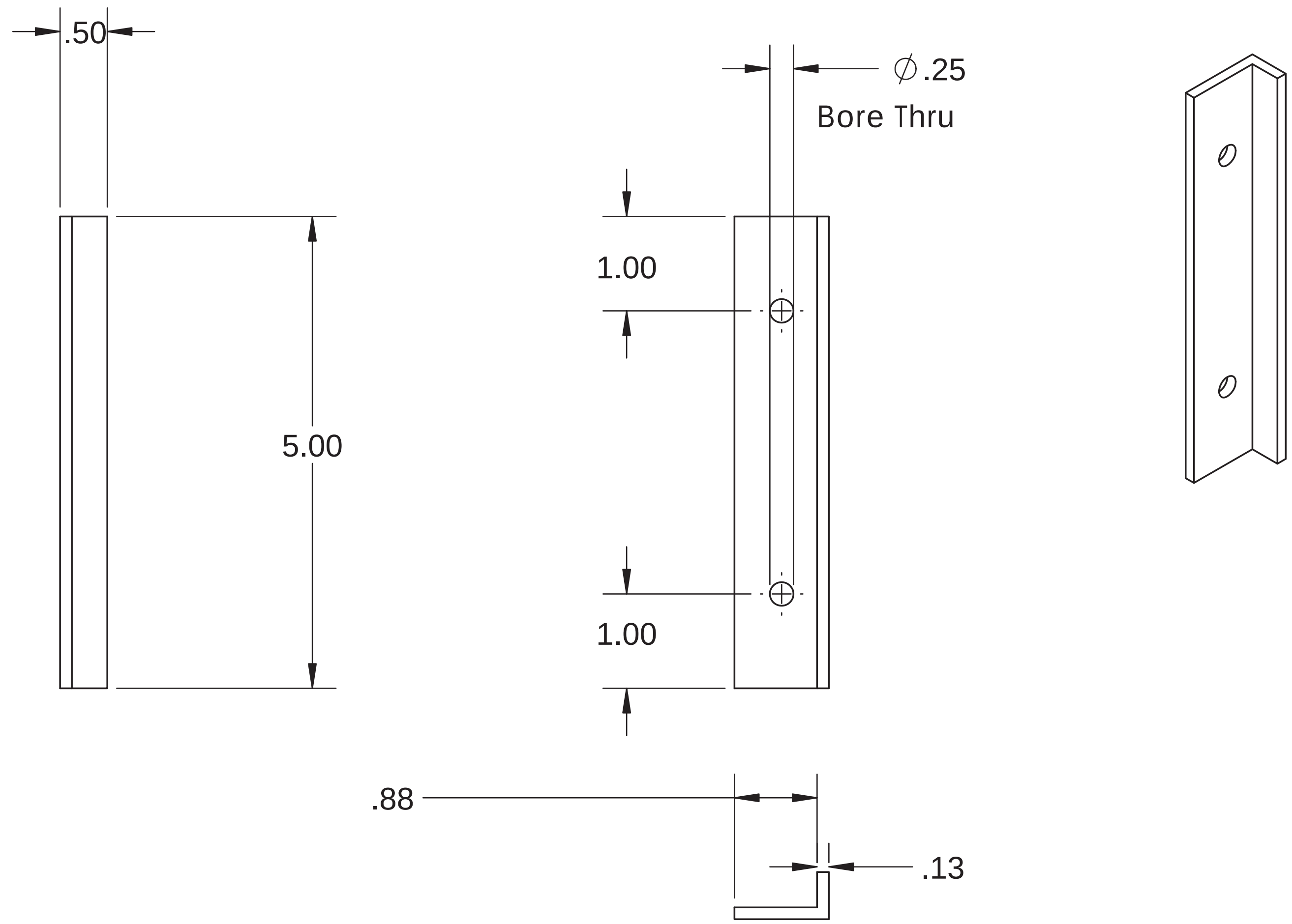
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Al3003-h14	COMMENTS:		
FINISH Smooth/Painted			
DO NOT SCALE DRAWING			

Team 7

TITLE:

Condenser

SIZE	DWG. NO.	REV
A	Condenser Wall	
	WEIGHT:	SHEET 5 OF 6



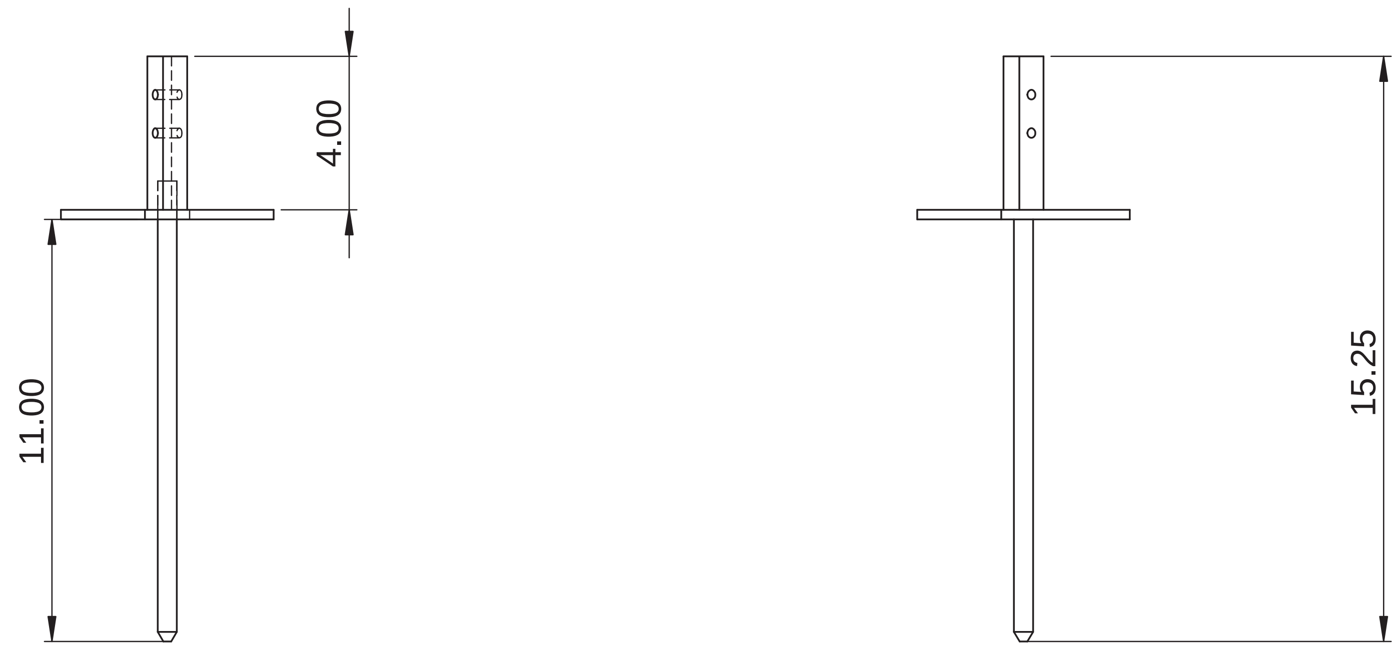
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Al6061-T52	COMMENTS:		
FINISH Smooth			
DO NOT SCALE DRAWING			

Team 7

TITLE:

Condenser

SIZE	DWG. NO.	REV
A	Cross Bar Connector	
	WEIGHT:	SHEET 6 OF 6



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Aluminum	COMMENTS:		
FINISH Smooth			
DO NOT SCALE DRAWING			

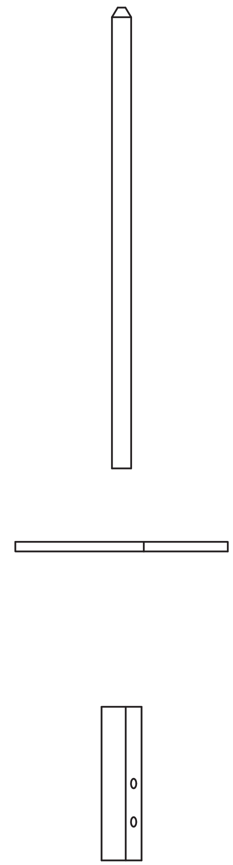
Team 7

TITLE:

Support Spike

SIZE	DWG. NO.	REV
A	Assembly	
	WEIGHT:	SHEET 1 OF 5

B18



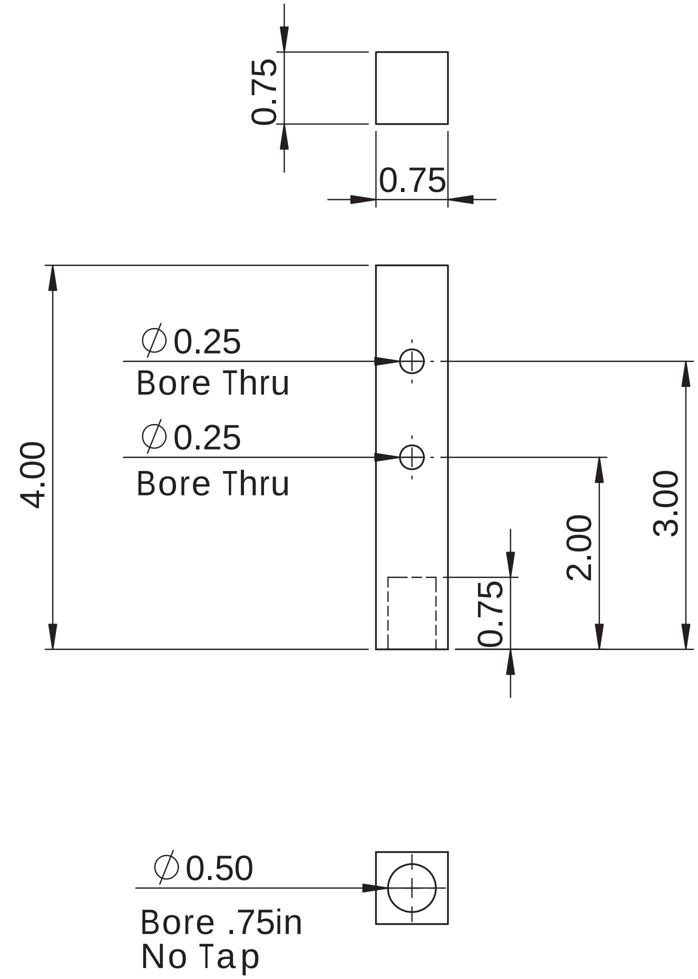
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

Team 7

TITLE:

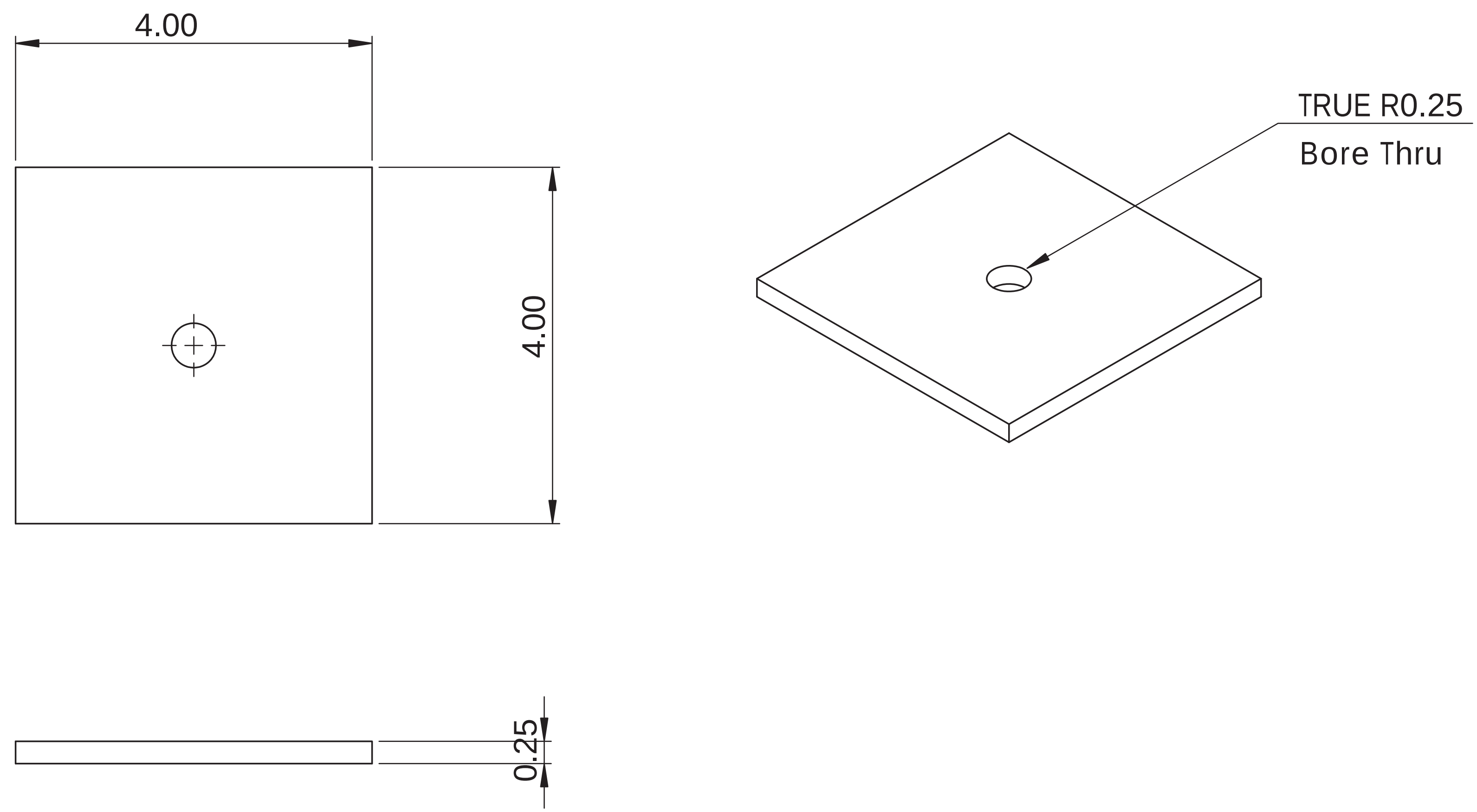
Support Spike

SIZE	DWG. NO.	REV
A		
	WEIGHT:	SHEET 2 OF 5

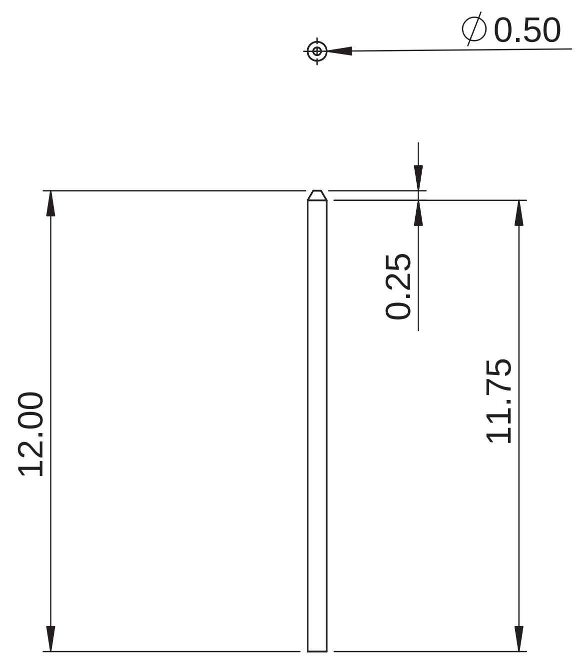


UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Al6061-T6511	COMMENTS:		
FINISH Smooth			
DO NOT SCALE DRAWING			

Team 7		
TITLE: Support Spike		
SIZE A	DWG. NO. Spike Leg	REV
	WEIGHT:	SHEET 3 OF 5



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Team 7
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer		TITLE:
	CHECKED	Joseph Hamel		Support Spike
	ADVISOR APPR.	Dr. Shangchao Lin		
	FUNDING APPR.	Crystal Wells		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo		
MATERIAL Al3003-H14	COMMENTS:			SIZE A · DWG. NO. Spike Baseplate · REV
FINISH Smooth				
DO NOT SCALE DRAWING				WEIGHT: · SHEET 4 OF 5



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL ± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Al6061-T6	COMMENTS:		
FINISH Smooth			
DO NOT SCALE DRAWING			

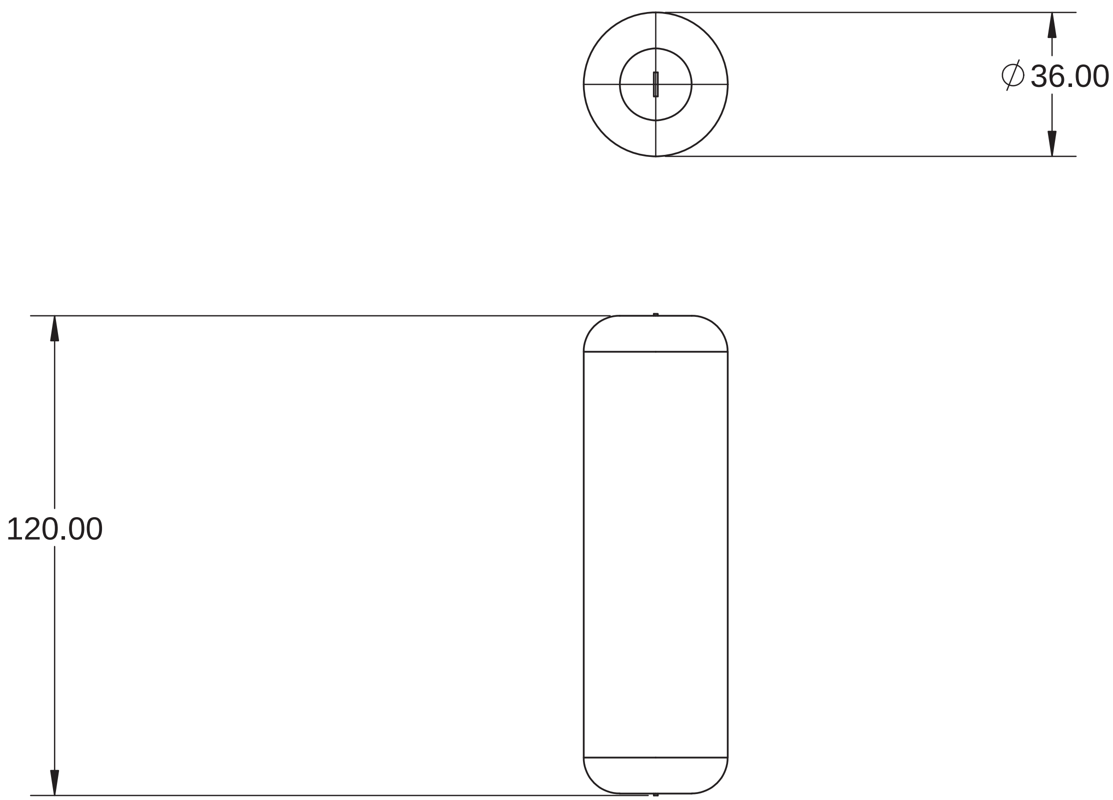
Team 7

TITLE:

Support Spike

SIZE	DWG. NO.	REV
A	Spike	
	WEIGHT:	SHEET 5 OF 5

B22



UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: .125 in. FRACTIONAL± 1/8 in. TWO PLACE DECIMAL ± .05 THREE PLACE DECIMAL ± .005	DRAWN	Alex Stringer	
	CHECKED	Joseph Hamel	
	ADVISOR APPR.	Dr. Shangchao Lin	
	FUNDING APPR.	Crystal Wells	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	Alex Filardo	
MATERIAL Mylar Polyester	COMMENTS:		
FINISH Transperent			
DO NOT SCALE DRAWING			

Team 7

TITLE:

Solar Sausage

SIZE	DWG. NO.	REV
A		
	WEIGHT:	SHEET 1 OF 1

Team 7 : Purchasing

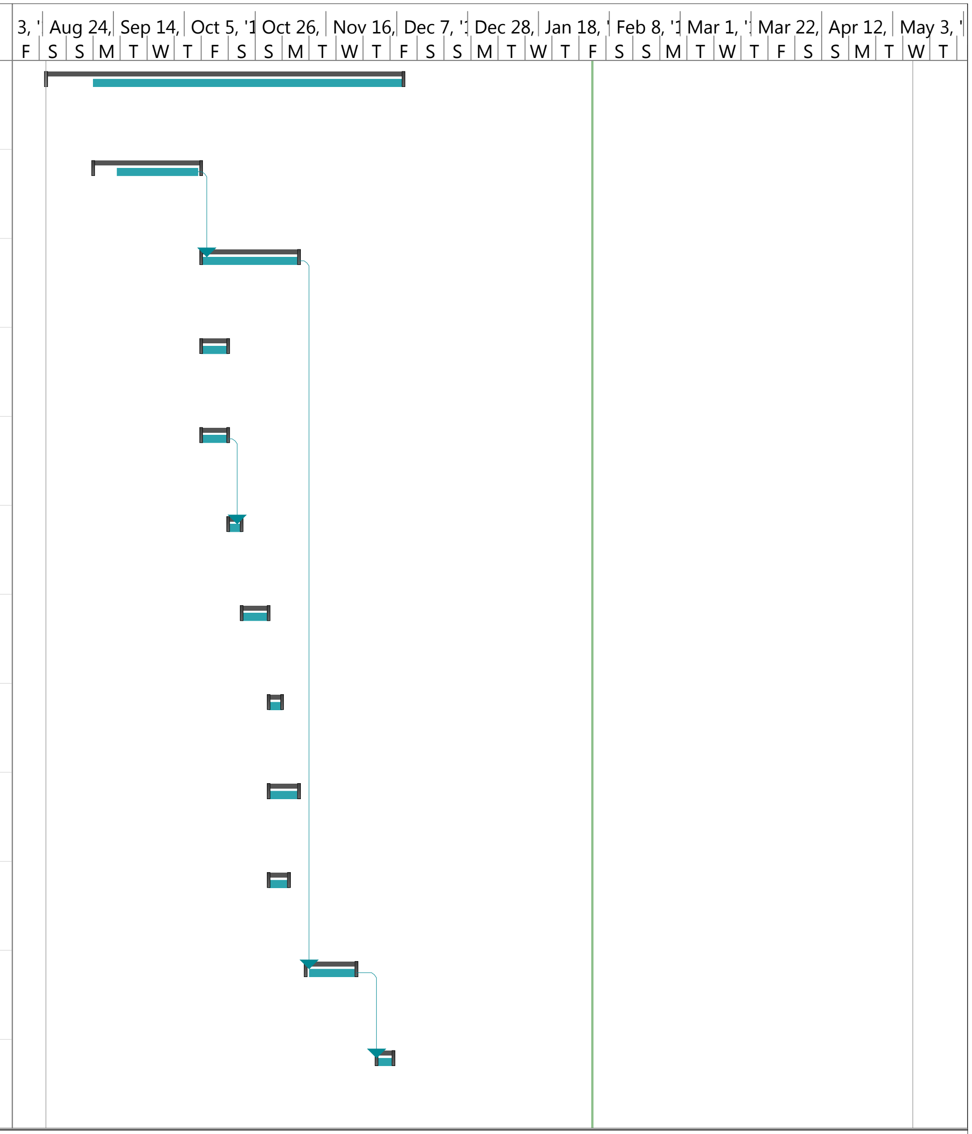
Purchase Order #1: Metals Supermarkets					
Item	**Description**	**SKU**	**Quantity**	**Unit Price**	**Total**
Alum. Square Tube (long)	Aluminum 6061 SQUARE TUBE 1.000 x 1.000 x 0.120 ; cut size : 48"	ATSQ6061/11120	4	13	51.99
Alum. Square Tube (short)	Aluminum 6061 SQUARE TUBE 1.000 x 1.000 x 0.120 ; cut size : 12"	ATSQ6061/11120	4	5.43	21.73
Alum. Plate	Aluminum 6061 Plate 0.190; cut size: 12"x6"	AP6061/190	1	20.09	20.09
Alum. Channel	Aluminum 6063 CHANNEL 2.000 x 2.000 x 0.125; Cut Size: 60"	AC6063/2218	2	26.86	53.72
Alum. Plate (large)	Aluminum 6061 Plate 0.250; cut size: 24"x24"	AP3003/250	1	81	81
Alum. Square Bar	Aluminum SQUARE BAR 0.750; cut size: 4"	ASQ6061/34	4	3.48	13.92

Purchase Order #2: Metals Supermarkets					
Item	**Description**	**SKU**	**Quantity**	**Unit Price**	**Total**
Alum. Round Bar	Aluminum 6061T6 ROUND BAR 0.500 ; cut size: 12"	AR6061/12	4	3.47	13.88
Alum. Angle	Aluminum 6063T5 ANGLE 1.000 x 0.500 x 0.125; cut size: 5"	AA6063/11218	1	7.68	7.68

Purchase Order #3: McMaster Carr					
Item	**Description**	**SKU**	**Quantity**	**Unit Price**	**Total**
3M Tape	3M VHB Foam Tape - Adhesive on Both Sides; 3/4" wide x 72 yards longx (	8127A72	1	190.6	190.6
Alum. U-Channel	High Corrosion-Resistant 6063 Aluminum U-Channel, 1/16" thick, 1/2" bas	9001K6	3	7.95	23.85
Steel Cap Screw	High-Strength Grade 8 Steel Cap Screw 1/4"-20x2", zinc-plated	91257A550	2	9.66	19.32
Hex Nut	Zinc Aluminum Coated Steel Hex Nut, Gr. 8, 1/4"-20, 7/16" wide, 7/32" hig	93827A211	1	6.74	6.74

GRAND TOTAL	**504.52**

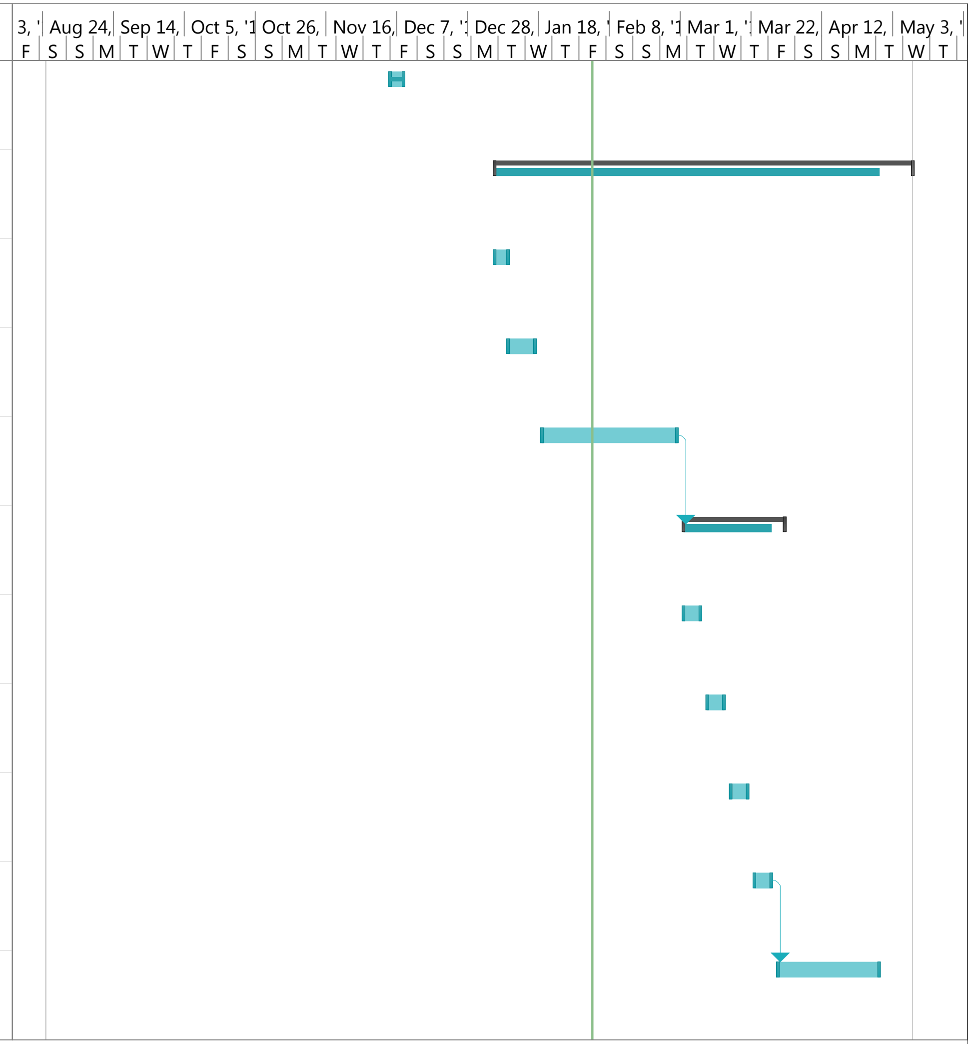
ID	Task Name	Duration	Start	Finish
1	**Senior Design Fall Semester**	**76 days**	**Mon 8/25/14**	**Mon 12/8/14**
2	**System Constraints**	**24 days**	**Mon 9/8/14**	**Thu 10/9/14**
5	**Concept Development**	**21 days**	**Fri 10/10/14**	**Fri 11/7/14**
6	**Heat Transfer Method**	**6 days**	**Fri 10/10/14**	**Fri 10/17/14**
12	**System Capacity Selection**	**6 days**	**Fri 10/10/14**	**Fri 10/17/14**
17	**Phase Change Energy Analysis**	**3 days**	**Sat 10/18/14**	**Tue 10/21/14**
21	**Solar Sausage Analysis**	**6 days**	**Wed 10/22/14**	**Wed 10/29/14**
24	**Pipe Flow Analysis**	**3 days**	**Thu 10/30/14**	**Sun 11/2/14**
27	**Condensor Analysis**	**7 days**	**Thu 10/30/14**	**Fri 11/7/14**
31	**Water Storage**	**4 days**	**Thu 10/30/14**	**Tue 11/4/14**
35	**Design Finalization**	**11 days**	**Mon 11/10/14**	**Mon 11/24/14**
39	**Material Research and Selection**	**5 days**	**Mon 12/1/14**	**Fri 12/5/14**



Project: Senior Design Updated
Date: Tue 2/3/15

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

ID	Task Name	Duration	Start	Finish
44	Holiday Preperation	2 days	Fri 12/5/14	Mon 12/8/14
45	**Spring Semester**	**90 days**	**Mon 1/5/15**	**Fri 5/8/15**
46	Storage Tank Design	4 days	Mon 1/5/15	Thu 1/8/15
47	Solar Tracking System design	6 days	Fri 1/9/15	Fri 1/16/15
48	Machining	30 days	Mon 1/19/15	Fri 2/27/15
49	**Trouble Shooting and Testing**	**22 days**	**Mon 3/2/15**	**Tue 3/31/15**
50	Pressure Regulation	5 days	Mon 3/2/15	Fri 3/6/15
51	Heat Delivery	5 days	Mon 3/9/15	Fri 3/13/15
52	Condensor Testing	5 days	Mon 3/16/15	Fri 3/20/15
53	Whole System Testing	5 days	Mon 3/23/15	Fri 3/27/15
54	Operations Manual Development	22 days	Mon 3/30/15	Tue 4/28/15



Project: Senior Design Updated
Date: Tue 2/3/15

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	