Hydraulic and Electric Animation Project

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Disclaimer Page

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Table 1. Nomenclature

Abbreviation or Symbol	**Definition**
Blue frame	Rose Float chassis
A-Frame	3 Ton Capacity Manual Overhead Hoist
Tournament of Roses (ToR)	Organization responsible for the Rose Parade
Inspectors	ToR personnel checking safety of floats
Animation	Moving Mechanisms that “animate” the float

Executive Summary

Each New Years' Day, the Cal Poly Rose Float presents a flower-covered float to the world at the Tournament of Roses parade. This floral display, paired with moving mechanical animations, shows off Cal Poly to the world. This project strove to keep Cal Poly on the cutting edge of technology both in parade floats, and in engineering, by creating a completely electric-powered animation system.

To accomplish this, a group of students set out to make the fully electric animation system that can power both the hydraulic and electric mechanisms on the Float. This was accomplished through months of planning and development leading up to manufacturing, assembling, and testing the system. The students used deep cycle lead acid batteries to power an electric motor. This motor turns a hydraulic pump that pumps fluid throughout the animated mechanism actuators.

Aside from being cutting edge, this new animation system is both quieter and a lower-profile on the float. This allows for the design of the float to be lower, more unique, and beautiful. It also creates less noise pollution during animation testing and makes communication easier during this time.

Introduction

Every year, the Tournament of Roses Parade is held in Pasadena, California. Seen by millions of people world wide, it features marching bands, equestrian units, and floral covered floats. Every year, California State Polytechnic University, Pomona and California Polytechnic State University, San Luis Obispo enter a float together in the Tournament of Roses Parade.

Figure 1. Cal Poly's Entry to the 2018 Tournament of Roses Parade Titled "Dreams Take Flight"

The design of each float can be anything from 40 foot tall giraffes, to space ships, and often, elements are "animated," meaning they move during the parade. For example, as seen in Figure 1, Cal Poly's entry to the 2018 Tournament of Roses Parade featured three large airplanes. These large airplanes were animated with pitch and roll movements, spinning propellers, and moving ailerons using hydraulic cylinders, electric motors, and pneumatics. These animations were powered by the Cal Poly Rose Float Animation System.

Currently, the animation system uses a propane-powered Chevy 350 V8 engine. The engine is coupled to a hydraulic pump, AC generator, and alternator. These supply the necessary hydraulic and electric power required to run animations. The project goal is to provide the same hydraulic and electric supply while removing the engine and propane system. The new system should additionally have a range of benefits compared to the old system.

A clean energy source is one of the driving forces for the project, but there are many other factors about the current system which can be improved. These factors include the amount of wasted heat produced, the high noise level, the unreliability of the system, and the CO produced as a combustion byproduct. The new system aims to resolve these factors in order to provide a modern and sustainable solution for the Cal Poly Rose Float.

These issues led to the development of a project team tasked with designing, building, and testing an animation system to replace the current engine. This system must run off a cleaner energy source than both gasoline and propane, as well as reduce the impact of the issues mentioned before. Finally, this project needs to be tested in order to be considered 'Parade Ready' for use in future parades.

The project team consists of four senior project students with an interdisciplinary focus. The team members have backgrounds in either Mechanical Engineering or Electrical Engineering, and all have worked with the system in the past. With an interdisciplinary focus, the team divided tasks suited to each others abilities and interests. Sourcing components and assessing compatibility was completed before manufacturing and assembly began. Constructed at the Rose Float lab, the system and the process to complete it is detailed below. Looking to the future, being the system is complete, it is intended to be operational for the 2020 Parade.

Background

The governing body of the Pasadena Rose Parade, the Tournament of Roses, has set safety and engineering guidelines for Float builders. These guidelines are set in the Float Builder's Manual[1]. The current animation system meets all the requirements set by the Tournament of Roses, and the new system is expected to meet these standards as well. If the new design is outside the scope of the current manual, the team will work closely with the Inspectors to ensure that the system is safe and reliable for Tournament's standards.

Current System

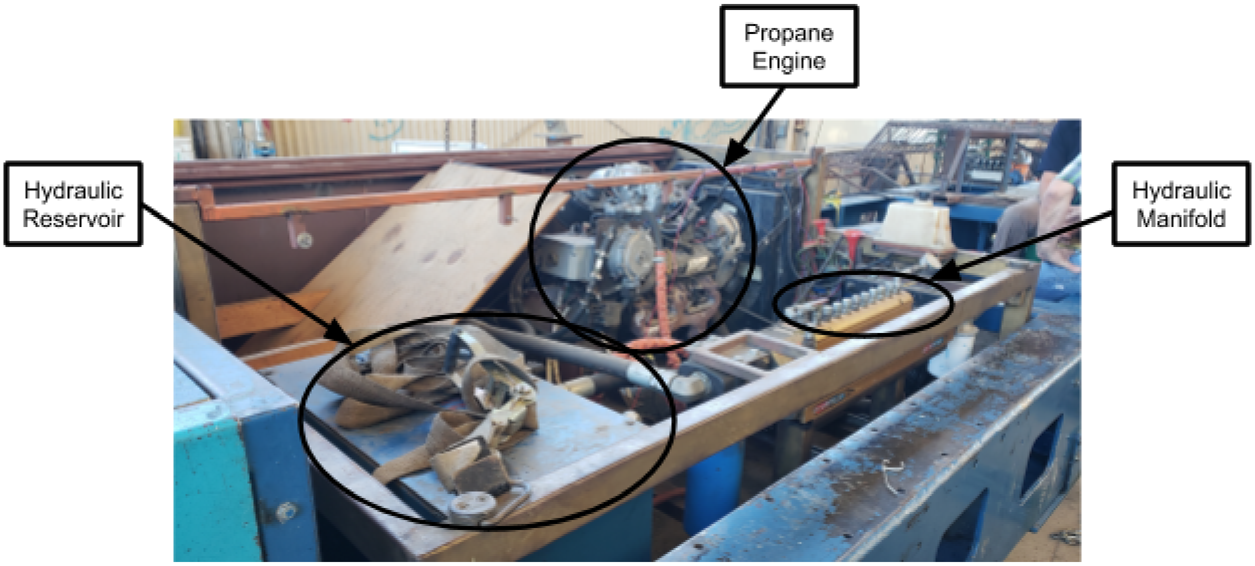

Figure 2. The Current Rose Float Animation System

Currently, the Rose Float animation system meets the standards set by the Tournament of Roses, so a new system with similar operational design would also meet these standards. On the mechanical and hydraulics end, the engine powers a large hydraulic pump that sends oil to a hydraulic rail, with ports used for oil distribution seen in Figure 2. There are two rails, one for pressure and one for return. There, moving mechanisms are connected to the hydraulic system via long hoses which get routed throughout the float. On the electrical side, there is a bank of 12V batteries charged by an alternator on the animation engine (Figure 3). This supplies power to a DC distribution box with 16 switched power channels. From these ports, the electric animations can be powered such as motors, lights, and actuators. Additionally, there is a belt driven AC generator attached to the current engine. This supplies power to laptops, air compressors, and some of the programming related animation system controls.

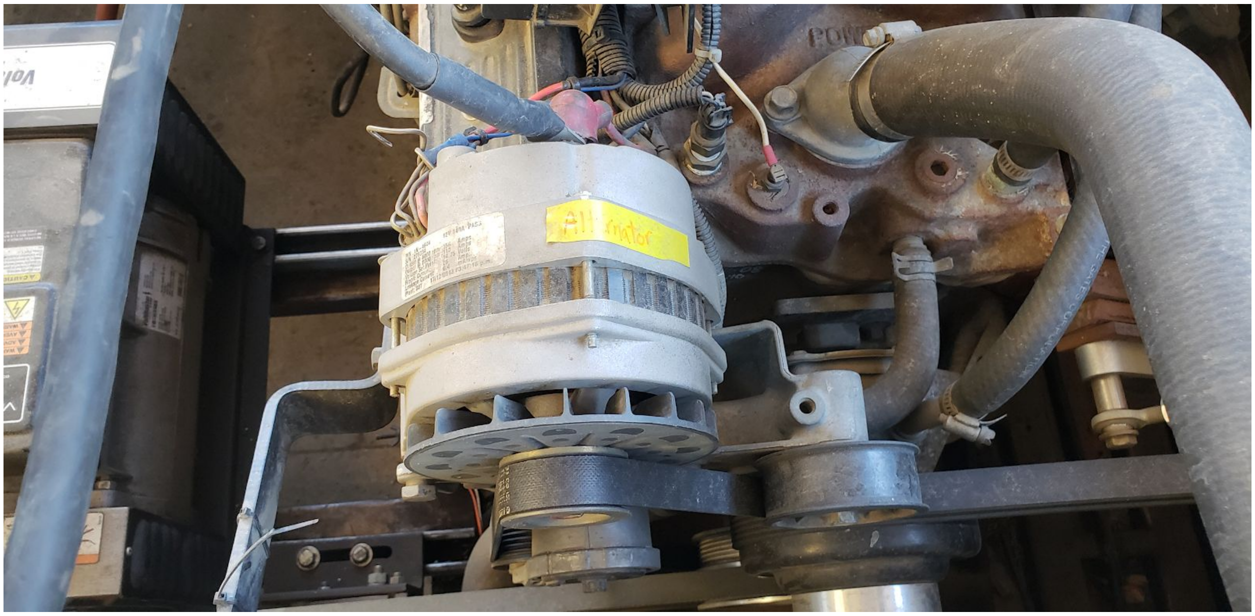

Figure 3. One of the two alternators on the animation engine

Industry Research

Most of the other floats in the parade use small Honda generators to power hydraulic subsystems. Each generator has enough energy output to power 2 hydraulic mechanisms. Most floats animate around 4 elements on their floats, which lends well to the small generator and hydraulic system idea.

Many different industries use hydraulics, electric power systems, and batteries. For example, hydraulics are widely used in aircrafts. The Airbus uses a 5000 psi system in their A380 airplane. They use a combination of AC motors and engines to drive their pumps. They use eight Vickers PV3-300-31 engine-driven hydraulic pumps and four AC motor pumps. The engine driven pumps have a displacement of 2.86 cuin/rev, are pressure compensated, and have variable displacement[7]. The motor pumps are powered by a 115 VAC, 21.3 kW AC motor.

On the power electronics side, Tesla Motors uses a 346 V Lithium Ion battery. Their high voltage DC current is converted to a 240 V three-phase AC current using a three phase inverter, which powers the three-phase AC induction motors that are directly coupled to the wheels. Their system uses a Variable Frequency Drive (VFD) in order to control the speed of the motors and maintain optimal output power.

Looking at the automobile and other transportation industries gives many more sources from which to pull ideas. From the simple engine, just as the current system, to new and emerging technologies, this industry is a great resource. Many of these companies have already analyzed their systems for reliability, safety, and many other factors important to power supplying systems. From different engine types, like the smart car and the F-150, to completely different systems, represented by Tesla's electric propulsion to jet engines on fighter jets, this industry is rich in ideas. The challenge comes from taking these transportation concepts and applying them to a Rose Float animation system.

Industry Standards

To further research the mechanical aspects of this project, the team and project sponsor are communicating with other float builders to take a trip to their facilities and see how they designed their systems. Looking at this will help to define an "industry standard" on Rose Float animation systems. Furthermore, it will allow the start of conversations with professional float builders to talk about safety, ideas, and potential concerns they would have. Being able to see other floats and communicate with other builders will greatly strengthen this project.

Furthermore, in the Tournament of Roses parade float industry, there are three major inspections that occur to make sure the floats are built safely. These inspections check for driving safety, operator safety, hydraulics safety, and animations. Specifically, animation control, testing, and expected movements are looked into by inspectors. The inspectors conducting these inspections regulate the industry to ensure its consistency and reliability.

Other power systems that are comparable to the current animation system were analyzed as industry standards. Many tractors and construction equipment use hydraulic systems to power their mechanics. These systems are the most similar to the animation engine; however, other power generating systems such as those in cars and power plants serve as examples as well.

On the hydraulic-mechanical side, this project will follow common industry standards. The National Fluid Power Association (NFPA) as well as the International Organization for Standardization (ISO) have many rules, guidelines, and recommendations regarding fluid power systems. When designing the hydraulics system for this project, those standards will be followed so it can be as safe and efficient as possible.

Most of the standards set by the ISO and NFPA are focused on safety. An example of an ISO standard[11] is

> *5.2.2.4. Loss of pressure or pressure drop shall not expose persons to a hazard and should not damage the machinery.*

This connects to the project through the hydraulic components purchased. All components should be up to the ISO or NFPA standards and should be confirmed before purchase. Furthermore, if any hard-plumbing is to be used, it will also need to follow those standards. If this is the case, those standards will be researched and followed.

Functional Requirements and Engineering Specifications

The system must be able to perform all of the tasks the current system can in order to be a complete replacement. By the conclusion of the project, a finished, tested, and compatible hydraulic and electric system will be 'Parade Ready' to use in upcoming parades. This includes maintaining the full functionality of the current system, as well as enabling the system to adapt with the program's needs. The goal of this project is to meet all of the current abilities of the system by analyzing it and to design an adaptable system that can meet the program's requirements for years to come. Using knowledge of the program from talking with program alumni and advisors, the team created a list of customer requirements. The engineering requirements followed from these customer requirements. The Quality Function Deployment (QFD), which can be found in Appendix E, was used to analyze the customer's requirements and to relate them to measurable engineering specifications.

Many of the engineering specifications were requirements carried over from the old system. The new system will produce hydraulic pressure at 1200 psi and a variable flow rate of 10 gpm. Additionally, the hydraulic ports and electric connections must be compatible with the current float subsystems. A critical requirement of the new system is the ability to run animations for at least 2.5 hours. The dimensions of the new system are strictly limited by the float's frame and need to have the same or a smaller footprint than the current solution. As a project for the Cal Poly Rose Float program, the cost of the project and the longevity is an important factor. Safety and reliability of the system is naturally a critical component. For the safety of the float operators and the crowds, the system must perform as expected and safely shut down. Although the project will see less use than some industrial applications, with tens of millions of viewers watching the parade, having a reliable animation system is a must. The preliminary specifications for the new system can be seen in Table 2 below.

Table 2: Initial Engineering Specifications

Spec. #	Parameter Description	Requirements or Target	Tolerance	Risk	Compliance
1	System Pressure	1200 psi	±10 psi	H	T, S
2	Flow rate	10 gpm	MIN	M	A, T, S
3	Reservoir Volume	30 gallon	± 5 gallon	M	I
4	Hydraulic Ports	6 #	MIN	L	I
5	DC System Voltage	12 V	± 0.5 V	L	A, S
6	DC System Current Draw	50 A	MIN	M	A
7	Electric Ports	16	MIN	L	I
8	Cost	$ 1500	MAX	H	A
9	Operators Required	1	MAX	H	S
10	Energy Capacity	25 kWh	MIN	H	A
11	Noise Level	40 dB	MAX	L	T, I
13	Dimensions	7' 8" X 5' 7" X 1' 8"	± 4"	L	A, I
14	Weight	3500 lbs	MAX	L	T
15	Number of Parts	600 #	± 100 #	L	I
16	Safety Factor of Stress	4	± 0.5	M	A
17	System Run Time	2.5 hours	MIN	H	A, T
18	Hydraulics standards	ISO/NFPA	N/A	M	

There are several areas of concern that impact the design of the system. The first concern is the size of the animation cage. The physical size of the current animation system imposes a restriction on the Cal Poly Rose Float Design Team. Specifically, it prevents the Design Team from lowering the pod/decking to the height of the frame. While the frame itself restricts what dimensions Design can shape their pod, it is important that the animation system is contained within the frame of the float, ensuring that the new system does not limit the Design Team's creativity (Appendix C).

The second factor regarding the design of the new animation system is heat. Typically, the float frame is covered by twelve inches of spray insulation foam (Figure 4). The spray foam allows Design to shape the float to match their artistic vision, and gives them an easy surface to mount the flowers to. Fresh flowers are typically put into vials, and the vials are stabbed into the foam. One of the unintended consequences of using foam is it acts as a large insulator with two hot engines underneath. This system will replace one of these engines. Although this will decrease the risk of Carbon Monoxide poisoning, the heat generated from the new animation is still a concern so that the surrounding crew compartments do not get too hot for the operators. In Section 5.4.4 of the Float manual , the Tournament of Roses states that "no compartment shall ever be more than 120 ° F at any time during the Pre-Parade, Convoy, and Parade.[1]" Although the technical standard is set by the manual, the new system aims to be well below this for operator comfort.

Figure 4. Foamed Pod/Decking that is mounted above the Blue Frame

Design Development

Conceptual Designs

Given the above engineering requirements, the next step was to research potential solutions that meet all the given requirements. Ideas were generated by analyzing current systems used both in the Rose Float industry as well as other industries related to this field. Pugh matrices as well as conversations with past animation operators and the advisor led to the decision on the final design.

The first consideration was the topology of the components. Currently, the system has one engine driving one pump to generate all of the hydraulic power. From looking at other float builders, a less centralized topology would enable the team to move the smaller systems around the float to create different spaces year to year. After considering these two, the central power system gave the most benefits to the program. By limiting the height of the system to the height of the frame, the system will take up no more space than the frame itself. Also, having one centralized system requires less assembly and greater accessibility which will improve the reliability of the system.

Next, the central power system had to be discussed. The team chose to analyze the power systems used by other float builders, the simple, smaller engines used in smaller cars, the Tesla all electric vehicle, and the jet engine. These systems are compared to the current using Pugh matrices to determine the final direction of the project. These matrices can be found in Appendix G. These systems could all provide the necessary central power to the pump, which makes each a viable candidate. The decisions and their implications are discussed in the following section.

Concept Selection

After consideration in the Pugh matrices, the all electric system best met the requirements, both engineering and marketing. Although this came out on top, the advantages of the system used by other float builders are necessary to discuss. The adaptation of the new electric technology to the Rose Float industry requires close analysis of the established systems to ensure the new system maintains all of its advantages.

The reason the electric system eventually beat out the Honda generators is Cal Poly Rose Float is notoriously generous with the amount of animations installed on the float. Most Cal Poly floats use around 8 hydraulic mechanisms on top of the numerous DC electric and pneumatic mechanisms. With the average Honda generator outputting 2,000 Watts, the animation system would require 5 compared to the 2 required by other floats. This increase in power requirements is one of the reasons the electric system was chosen. The Honda generators are also no cleaner than the current system since they run off gasoline, and even this system would need to be adapted to fit the DC electric needs of the animation system.

To create hydraulic power from electric sources, multiple options were considered. To create the most efficient system, the motor should be directly coupled to the hydraulic pump. Tesla was the first inspiration for this design. Tesla uses a Li-Ion battery pack and converts that DC voltage to 3-phase AC. This is used to power their 3-phase motors, and a variable frequency drive is used to control the speed. Although this may lead to better speed and output power control, the cost and complexity of this system is far beyond what is necessary for this project. Thus, the team chose to adapt this system to best fulfil the needs in the Rose Float industry.

The two main adaptations from the Tesla design were the motor type and battery pack. Tesla uses a high voltage 3-Phase motor, which has unnecessary power and complexity for this application. Other motor types, such as single phase AC, brushed DC, and brushless DC, were compared in the Pugh matrices in Appendix G. The 3-phase AC motor was still chosen for its availability and higher power capabilities, but it will operate at a lower voltage for safety and feasibility concerns. The battery pack in the Tesla is made from Li-Ion batteries that reach hundreds of volts. Although Li-Ion batteries have great energy density, the system is not severely restricted by weight. The high voltages are used to limit the current draw from the system, but it causes significantly higher risk since the Rose Float system is far more exposed. For these reasons, as well as accessibility and cost, a lower voltage, lead acid battery pack was chosen.

When using the engineering specifications to decide the battery pack, creating two seperate packs made the most sense. One pack will provide power to the motor controller and motor and the second pack should power the 12V systems. This way, the inefficiencies from converting from a higher voltage to 12V are avoided.

These adaptations of the all electric systems best fit the Rose Float industry and improve upon the current system without adding drawbacks of complexity or risk. With this concept, the team moved forward with initial analysis of size, power requirements, and other necessary features the new system needs to fully replace the current system.

Preliminary Analysis

Analysis began by characterizing the current system to obtain the system specifications. These were then used to specify the components discussed in the following sections. Once the system was analyzed and the high level concept had been created, the calculations for size and quantity of the specific components followed. Below is the overview of those calculations.

The current system can be used to calculate the necessary power output of the new system. It is known that the current system is overpowered for Rose Float's usage, so the current component specifications could not be used to determine the required power. Instead, the float with the most animations in recent history, the 2018 Dreams Take Flight, was used as a baseline. Each mechanism on the float was included into a spreadsheet that calculated the maximum instantaneous power. This spreadsheet is shown in Appendix F. This value was then used as the baseline for specifying components. From these calculations, we determined that the hydraulic system needed an average of 12.72 gpm at 1200 psi or 8.9 hp.

Similar to the hydraulic system, the DC and AC systems were analyzed on a heavy usage year to determine the load for the new system. These calculations were later used to specify the number of batteries needed as well as the power required from the inverter for the 120 VAC supply.

From the mechanical calculations above, the minimum electrical power was calculated. The hydraulic system requires 8.9 hp or 6.6kW of instantaneous power. This specification is necessary for sizing the battery pack as well as the motor controller and motor. The AC and DC electrical power was calculated in a similar manner, yielding 2kW of power each. These instantaneous powers multiplied by the 2.5 hour duration gives the battery capacity requirement of 26 kWh.

The required Battery capacity of 26 kWh can be achieved with 28 Batteries in a set of 24 and 4:

$$12V \times 81Ah \times 24batts \ + \ 12V \times 81Ah \times 4batts \ = \ 27,216Wh$$

These two packs will provide power to all other systems on the float. The 81Ah batteries were found using a previous Rose Float supporter in Santa Maria. Using these batteries, at this voltage, allows the program to operate the system safely and reliably. Although most EV systems use significantly higher voltages from Li-Ion batteries, the low voltage lead acid pack is best suited for student use at Cal Poly.

Due to this lower voltage, each string of batteries is drawing a higher current to deliver the same amount of power. Deep cycle lead acid batteries are rated for continuous discharge, but going above about 30 A leads to inefficiencies and power losses. In order to compensate for these losses, the battery pack was expanded to include 32 batteries in the 48V pack and 8 in the 12V pack. This will both decrease the amount of current drawn from each string, but also increase the capacity in the event the batteries run into inefficiencies.

These calculations allowed the team to move forward and begin specifying the required components. At this time, the team also began applying for funding from different sources so that the parts could be ordered and manufacturing could begin. These values also dictate the final design of the system.

Critical Design Review

Once concept selection was complete, the critical design was revised and reviewed. This is the stage where the entire system was decided and review had begun. Since the Critical Design, multiple changes have occurred and the choices will be explained. Below is the system design submitted for the Critical Design Review.

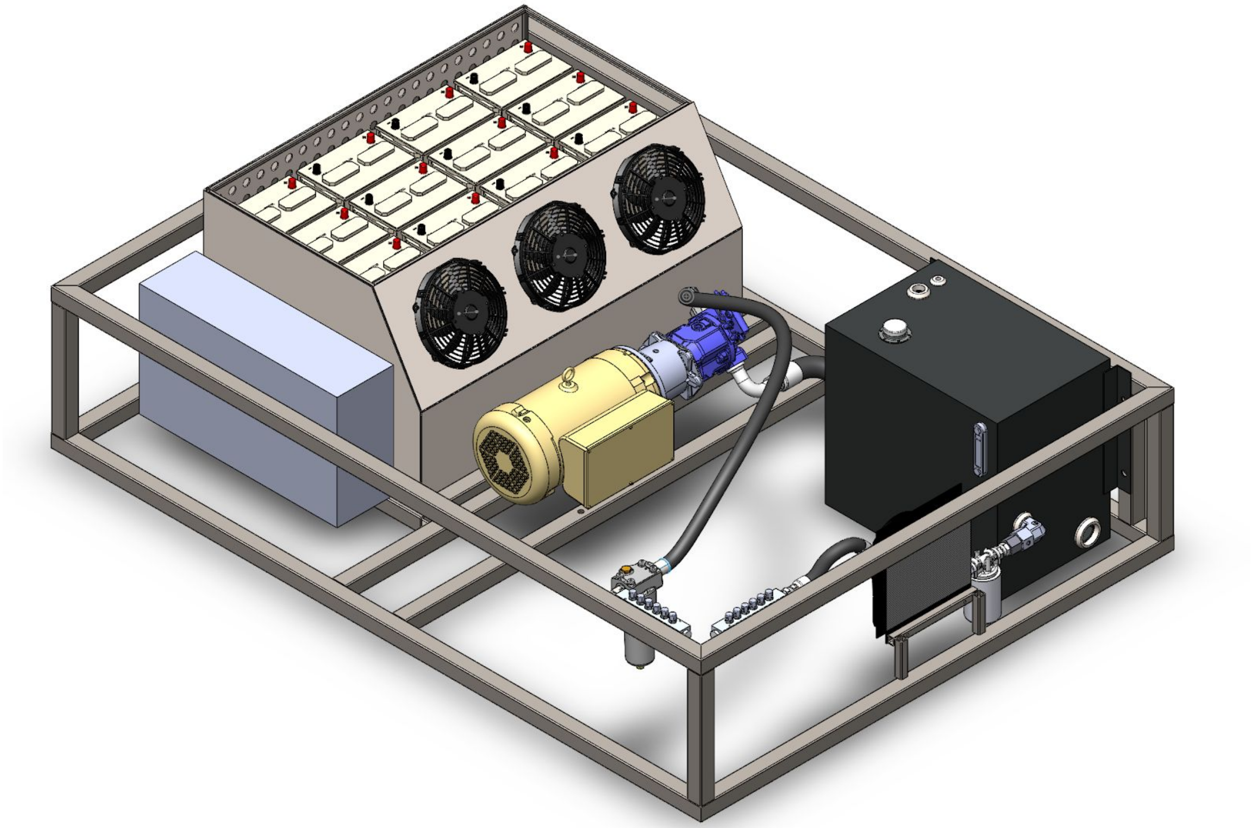

Figure 5. Critical Design CAD of Animation System

The main topology for the system remained the same from the initial concept generation through the final product. The main difference between the Critical Design and the Final Design is the motor and how it is driven. The Critical Design uses a single phase 240 VAC motor to drive the pump. This Baldor motor was relatively large for a single phase motor due to the power requirements. This motor was planned to be driven by a 48 VDC to 240 VAC power inverter originally intended for the solar industry. This inverter could supply enough power to the motor for steady state operation and allowed for a lower 48 VDC battery pack. Since the inverter was designed to tie into the grid, it would automatically drive the motor at the desired 1800 rpm. In steady state, these components would be able to power the system.

Issues occurred with this system when analyzing startup. Single phase AC motors have high current draws when starting compared to 3-phase motors. Although the inverter was rated for a 300% inrush current capability, it was not enough to supply the motor with its needed inrush current. Research was done into soft-starters and other solutions to this problem, but the best solution was to pivot and find a new motor-driver pair. This led the team to a 3-phase motor that had significantly lower inrush current and a motor controller made specifically for that motor.

Seen in Figure 5 below the system looks similar to the final product seen in Figure 6. The battery box is the same format but increased in capacity to 40 batteries. This was due to feedback from industry experts who wanted more expandability in battery capacity. The fans were also mounted vertically to minimize ingress from debris. The junction box and controls box function remained the same between designs with a few minor modifications. The hydraulics components are the same for the final design but the location changed. The hydraulic manifolds were moved to a more optimal location for hose management. The most significant change between the critical design and final result is the inverter and motor unit. Moving from 48V at the batteries, it was planned to go into a 240VAC inverter. From there it would be input into a 15hp single phase 240VAC motor. This would be coupled to the pump. Upon further research and discussion with the inverter manufacturer, it was determined this would not be feasible. Even for capacitor motors, the inrush current would exceed the inverter's rating. Through all the research and reaching out to industry experts, a solution to this problem was found. This necessitated moving to a different option. Researching about electric car conversions, the current low voltage three phase motor and motor controller was found. The final system will be detailed below.

Final Design

Overview

Once the Conceptual Design Review was submitted and reviewed by the Rose Float sponsor, some changes were made on the project. These changes paved the way for the final design. The final design of the animation system has been broken up into four major subsystems: the frame subsystem, the motor-pump subsystem, the hydraulics subsystem, and the electrical subsystem. A CAD of the entire animation system can be seen below in Figure 6.

A 48V battery pack will supply DC power to a Curtis Instruments SE1236 motor controller. There will also be a smaller 12V battery bank that powers the 12V DC mechanisms through a DC distribution box. This battery bank will additionally provide power for a 120VAC inverter. The motor controller will attach to a motor directly coupled to the hydraulic pump that will provide power to the entire hydraulic system. The hydraulic system itself will very closely mimic the current system relating to filters, cooling, and power distribution. These subsystems are further discussed below.

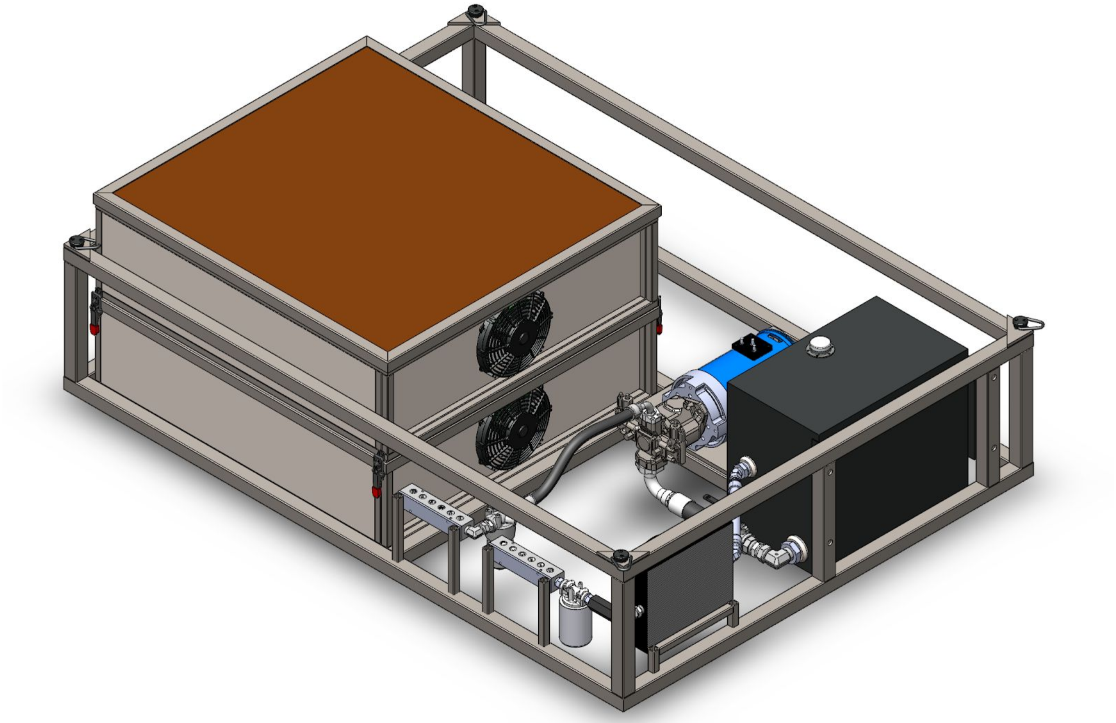

Figure 6. CAD of Animation System

Frame Subsystem

The frame subsystem is a cage that was built for this application, and it has two major benefits. The first benefit is that it will protect the animation system. Because the Rose Float lab is a heavy manufacturing environment, it is critical to have large support pieces around the system that can keep other large components away from the fragile and expensive components. The second major benefit is that having a frame around the system greatly assists in installing and mounting the system. In total, this system weights around 3000 lbs, which enables the system to be lifted in by the A-Frame as a single unit. This value is based off the maximum load capacity of the Rose Float A-Frame.

Furthermore, this cage, seen in Figure 7, allows for the animation system to be modular and mounted easily into multiple compartments in the Rose Float chassis. This enables the team to use both the current and new animation systems this coming year, and later, move the new system into the place of the old system.

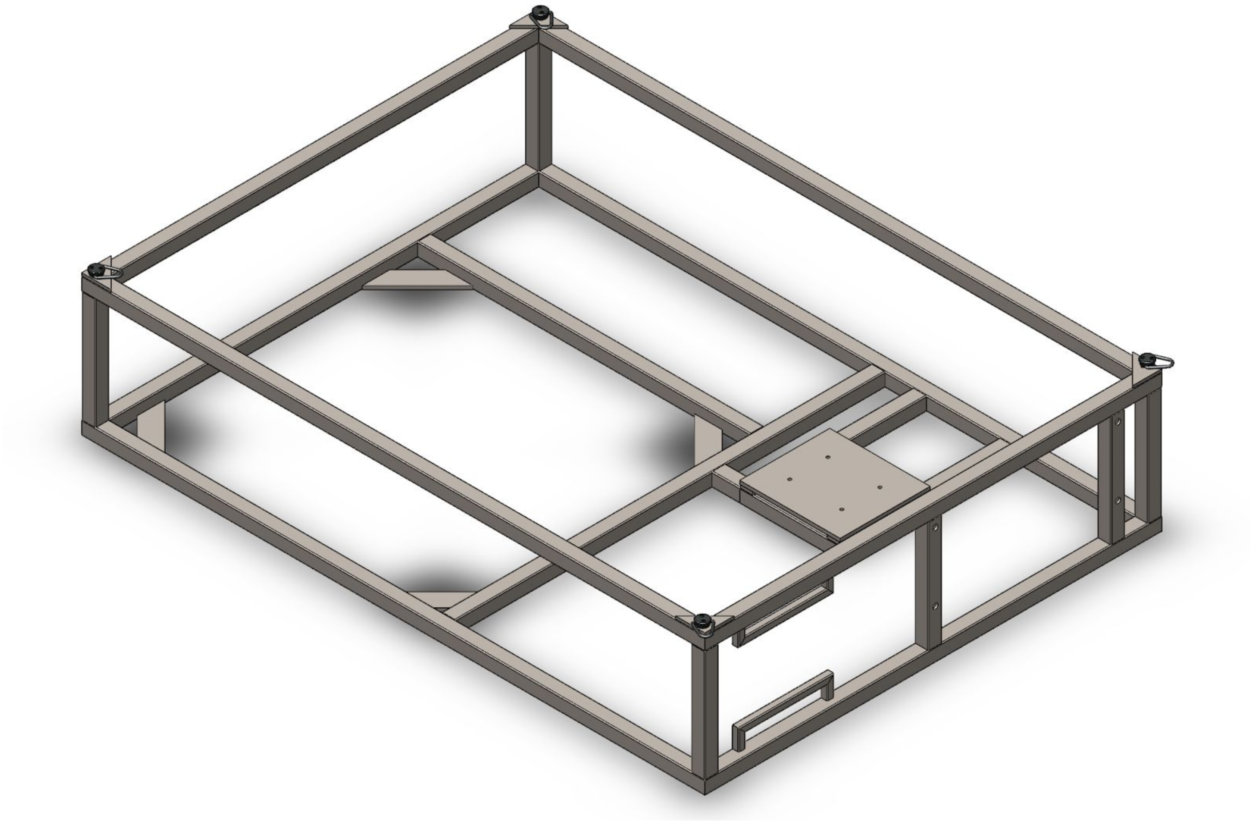

Figure 7. The frame subsystem will be placed into the Rose Float chassis (Appendix C)

Figure 8. Motor Mount Installation on Lower Half System Frame

Another important component of the Frame Subsystem is the trapezoidal-shaped ½-in. steel plate supports for the battery enclosure. These are critical because the batteries and their enclosure weigh about 2000 lbs. To ensure these supports are sufficient for the battery enclosure, a Finite Element Analysis (FEA) was done on Solidworks. To do the analysis, a pressure load of 20.833 psi was put on each support. This was used to represent each support taking one-quarter of the battery and enclosure weight as there are four supports under the enclosure. The stress in the support was found to be 4.724 ksi, which leads to a factor of safety of 7.7 on yield. The results of the FEA can be seen below in Figure 9, and a more complete analysis can be seen in Appendix J.

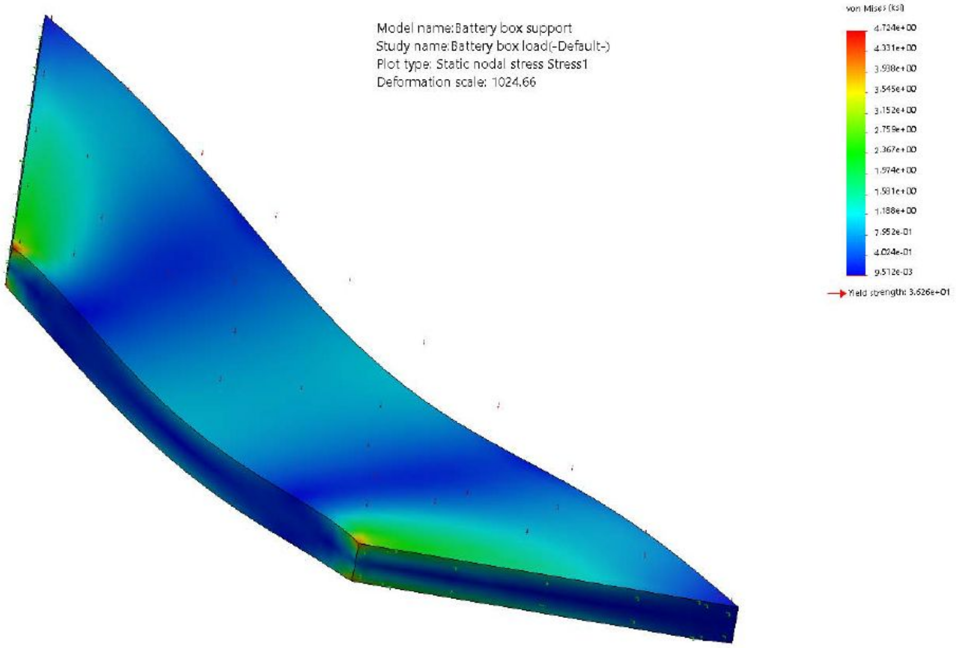

Figure 9. Finite element analysis results on the battery enclosure supports

Motor-Pump Subsystem

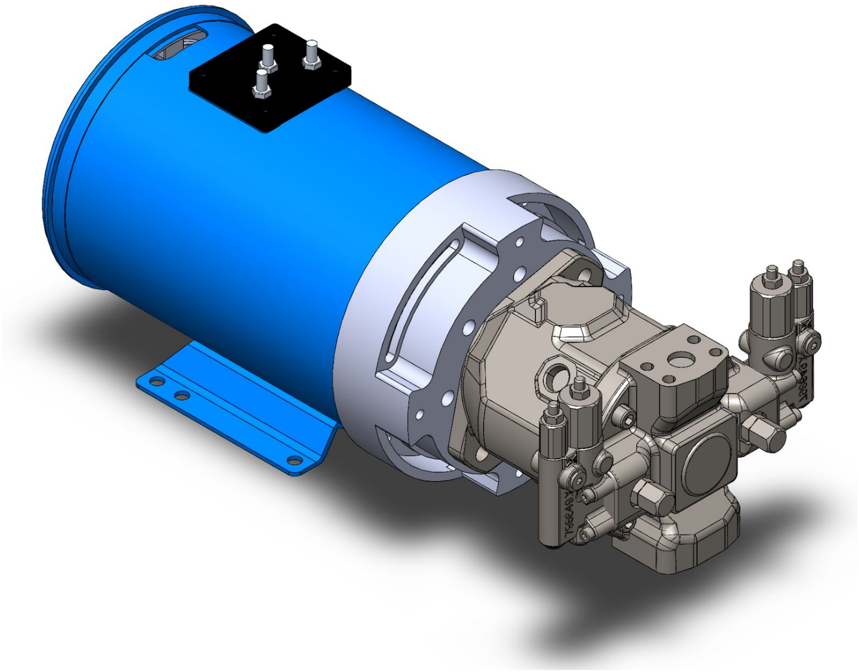

Figure 10: Motor-Pump Subsystem

The motor-pump subsystem consists of an AC induction motor directly coupled to a Rexroth A10VO Axial Piston Pump. It converts AC power from the motor controller into hydraulic power.

The motor, HPEVS AC50-31.73.8 is a three phase, AC, induction motor. It can run at 48, 72, 96 108, or 144 volts, but a proper controller must be used. This system runs the motor at 48 volts and 1800 rpm. At 1800 rpm, the motor is rated for a 27 lbf-ft. When the load is 27 lbf-ft, it will pull about 250 amps. A graph of the motor's continuous performance can be seen below.

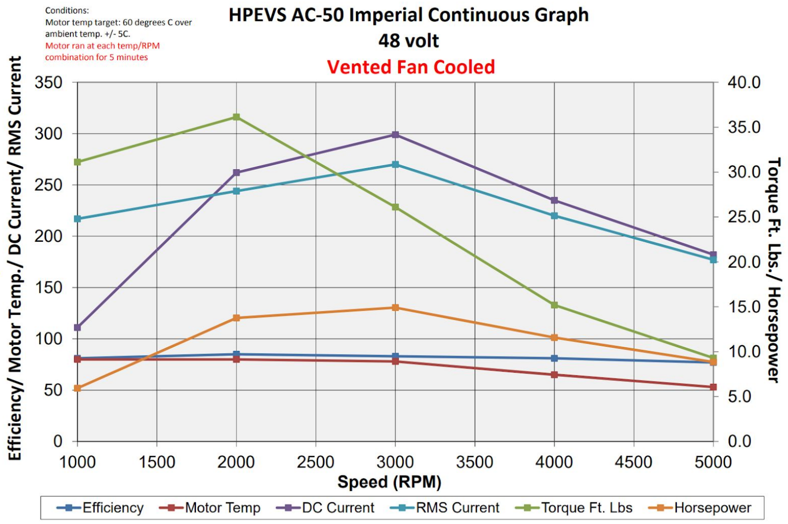

Figure 11. HPEVS AC-50 Continuous Graph

The motor has a vent and is fan cooled to provide adequate cooling. Additionally, the motor has a built in encoder and temperature sensor, which will be wired to the Motor Controller. The encoder allows for constant speed operation and the temperature sensor provides protection against motor burnout.

The primary criteria for selection of the pump was energy efficiency. Although the system is intended to run at 1200 psi and 10 gpm for the duration of the parade, in actuality, the pressure demands and flow demands fluctuate greatly depending on the load. The pump is a part of the A10VO series made by Bosch-Rexroth, which is the same series pump that is in the current Animation system. It is a pressure compensated axial piston pump, which means that the internal swash plate changes angles to reduce flow if the pump senses pressure above the set pressure. This massively increases efficiency as fixed displacement pumps require all unused flow to be dumped into tank through a pressure relief valve. According to the calculations, the system requires less power than the current pump is capable of providing, so the new pump has a smaller displacement than the current pump. The current pump has a displacement of 6.1 cuin/rev. We considered two new pumps displacement, 1.71 cuin/rev and 1.1 cu in/rev. However, because the 1.1 cu in/rev pump was not available with a 2 week lead time with a splined shaft; we elected to go with the 1.71 cuin/rev By using the data in Figure 11, we converted the torque and rpm values into flow rate and pump pressure while assuming that pump was operating at max displacement.

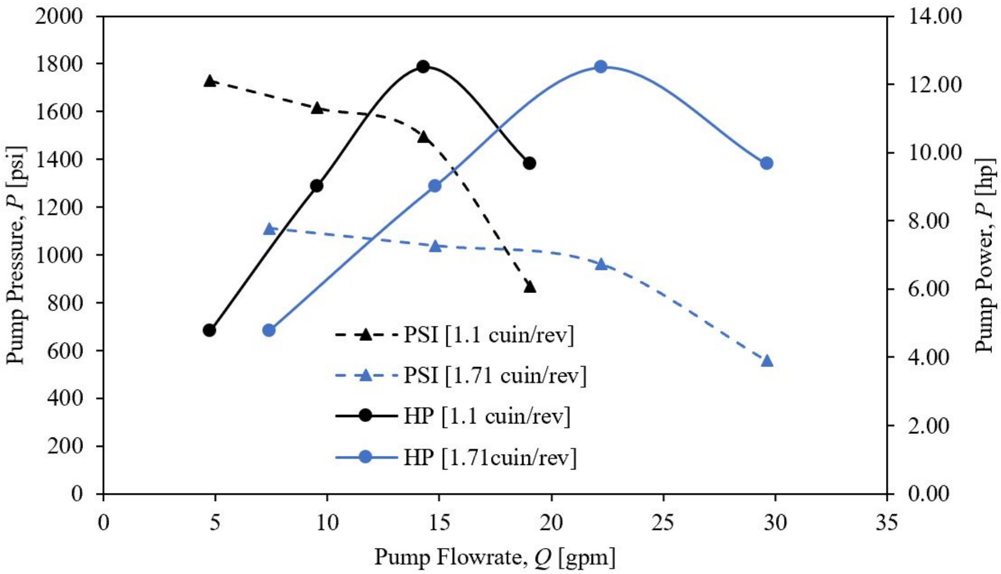

Figure 12. Pump Power Output

The new pump will create a flow rate of 13.3 gpm at 1800 rpm. The pump also has a 2 bolt SAE B (45 deg offset) mounting face, which can be directly mounted to the AC50 motor.

As discussed above, the pump has a DRG control system. This allows for external control of the system by connecting a solenoid operated Proportional Pressure Relief Valve to the x port of the pump. Currently, there is an ordinary pressure relief valve connected to the x port. However, in the future, a HydraForce TS08-27 should be installed. With an already installed RC circuit, the TS08-27 will allow for ramp up of pressure. This will reduce pressure shock on pump start up, increasing the lifespan of hydraulics components, and decreasing starting current.

Electrical Subsystem

The electrical subsystem is responsible for storing power and distributing it to the motor. Additionally, controlling the entire project is covered in this section. The battery assembly is composed of a set of series and parallel combined 12V deep cycle batteries. The 48V battery bank provides power to the motor controller and thus motor. The 12V bank powers 12V mechanisms, the 120VAC inverter, and the controls systems. The primary boxes include the battery box, junction box, and controls box.

Battery Assembly

The batteries chosen are 12V Interstate SRM-24 deep cycle batteries. They were chosen for their high capacity to cost ratio, reliability, and resilience in harsh conditions. Each battery is rated for 12V and 81 Ah resulting in 972 Wh. The motor set of batteries will be configured with 4 in series and up to 8 in parallel. This results in a 48 VDC supply with 32 kWh capacity. The second set of batteries will be 8 in parallel to provide about 8 kWh of 12V power. This will supply enough 12V power for low voltage subsystems.

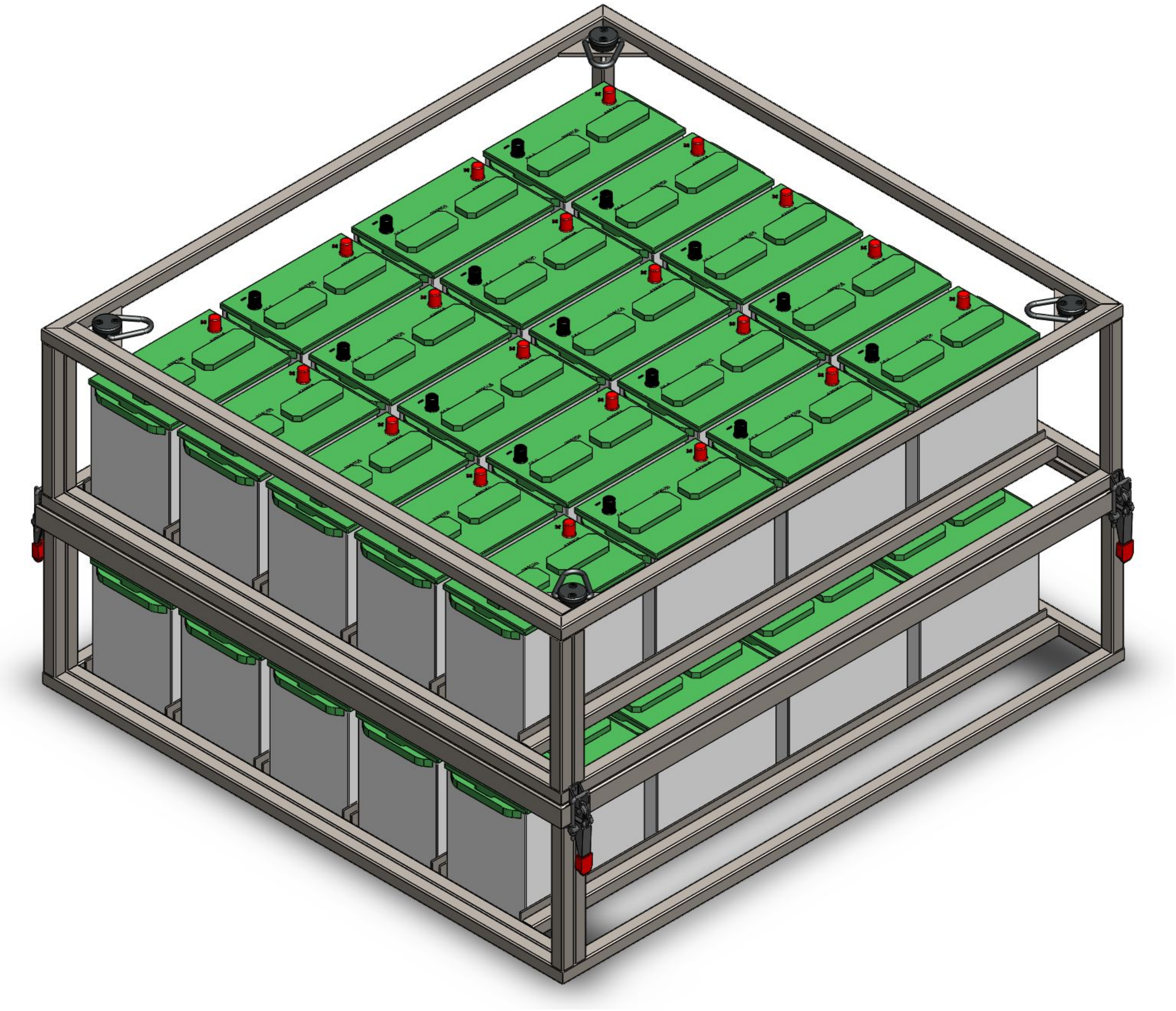

Figure 13. Battery Enclosure without Cover and Side Panels

As seen in Figure 14, the battery enclosure will protect the batteries from debris and the outside environment. 12V fans mounted on the front will provide ample airflow to prevent H2 gas buildup during charging and discharging. Each string of 48V will be fused at 50A to protect the batteries. The 12V bank will be fused to protect these batteries as well. To connect the battery box, Camlock connectors will be used.

For easy access for maintenance and repairs, the two levels of the battery box can be separated. In order to lift the batteries out of the frame, four latches connect them, supporting the weight of the bottom half when lifting.

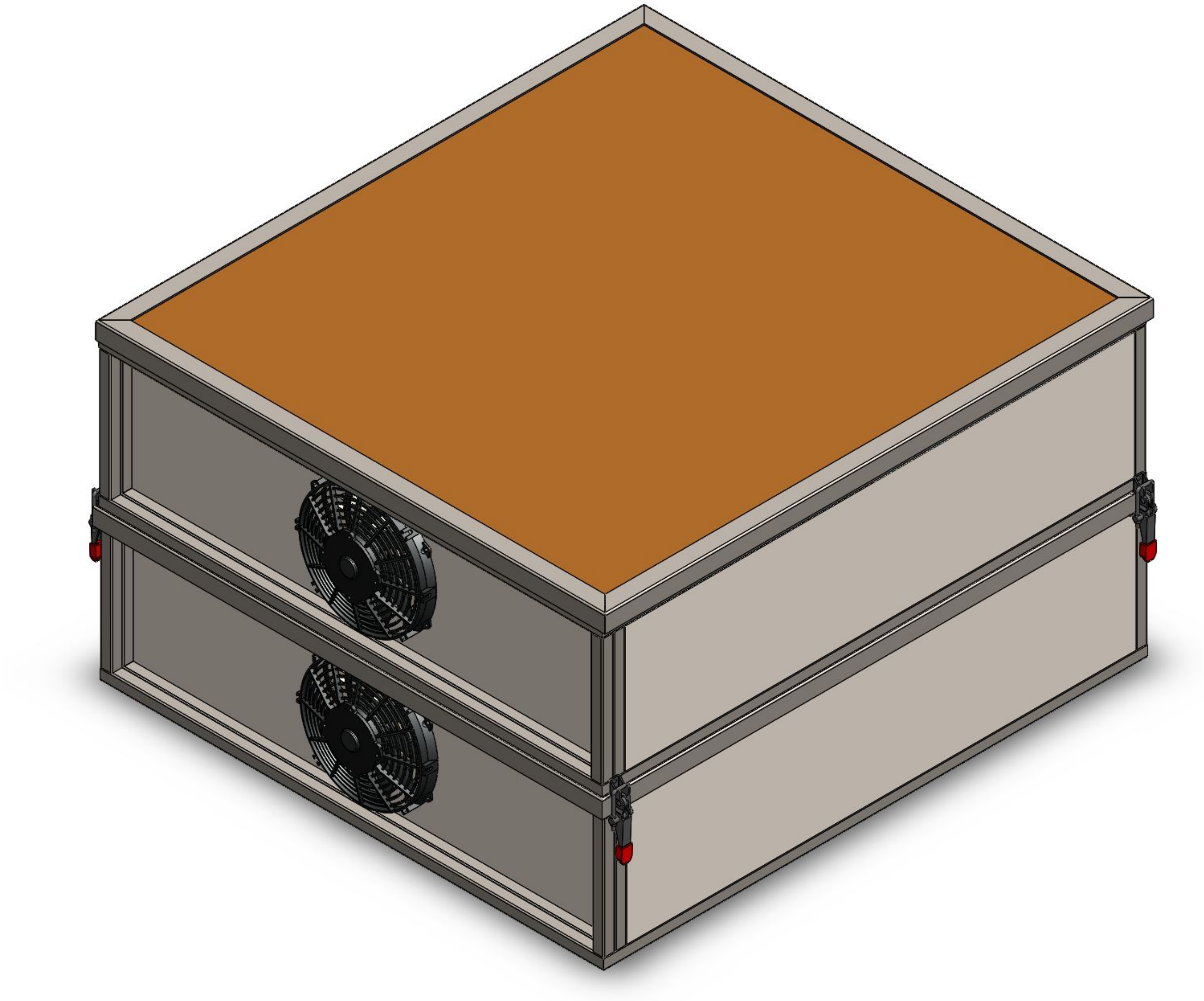

Figure 14. Battery Enclosure

Junction Box

The junction box is the primary distributor of power and signals. It takes in 48V, 12V, and ground cables from the battery box. On the rear, the 48V and 12V chargers in addition to the 1 kW inverter are connected. There is a 15 pin Dsub connector for the controls box and a 12V and ground Camlock for additional 12V mechanisms. Two XLR connections are to power fans: the electronics fan and the battery fans. There is an additional cannon cable to connect to other units in the frame such as the motor controller. Seen in Figure 15 below, internally there are buses for 12V and ground, a 48V contactor, terminal blocks for both the controls and cannon cable, a 12V relay, and a relay box. The relay box has 5 relays and is controlled from the controls box. Importantly, there is a low voltage cutoff for the 12V system. The 48V cutoff is built into the motor controller. The 12V cutoff will turn the main 12V battery relay off preventing damage to the batteries.

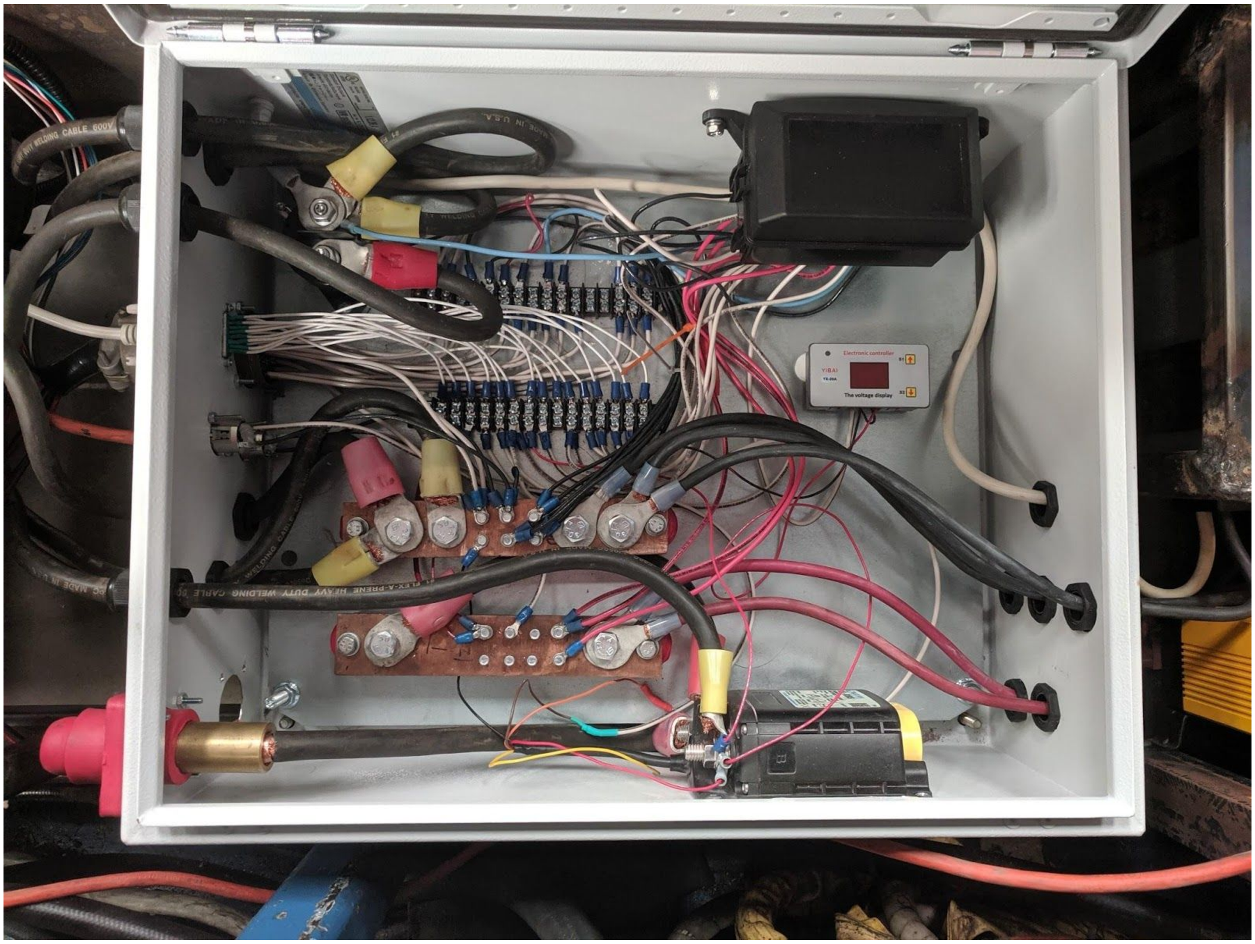

Figure 15. Internal Picture of Junction Box

Seen in Figure 16 below, next to the junction box are the two battery chargers and inverter. Each charger can be set to provide the correct charging voltage and has three stage charging: bulk, absorption, and float. They were specified to provide the fastest charging from a 120VAC source. Due to the large battery capacity, the packs will take up to 8 hours to fully charge. The inverter required for additional loads could be up to 3kW. Currently a 1kw is installed due to practical limitations.

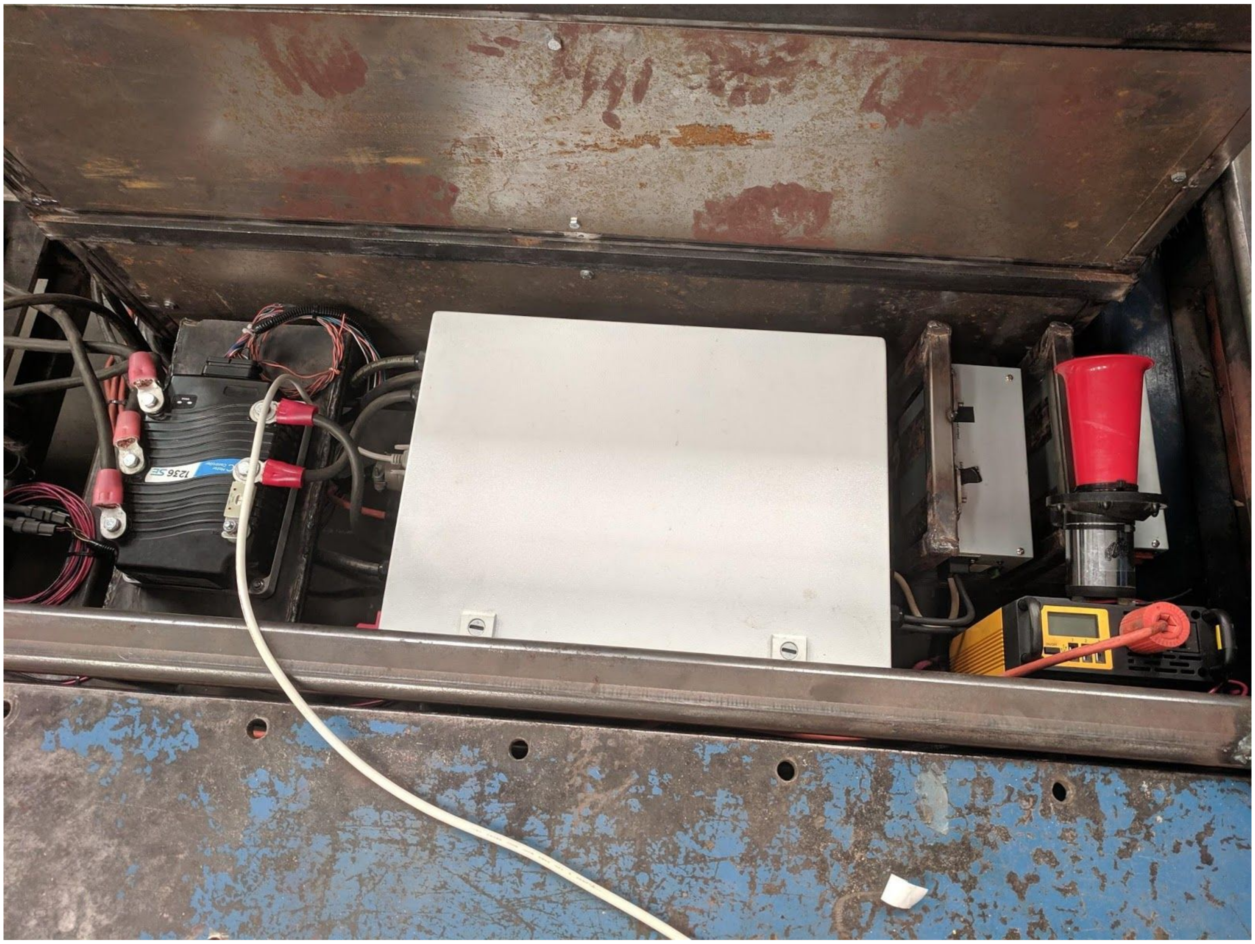

Figure 16. External Picture around Junction Box

Controls Box

An operator will use the controls box to control all aspects of the system. It was modeled similarly to the current controls box. It was constructed in a hard cover case to protect against water, paint, and decoration material which is common in the rose float program. Seen in Figure 17 below, there are 8 buttons, 4 momentary and 4 latching. There is also a display for the motor controller and a 12V voltage gauge. The button functions are for menu toggle, horn, 12V power on, 12V power off, motor controller on, motor on, battery fans, and high-low oil pressure bypass. These enable the operator to safely control the necessary functions to start and stop the system.

Figure 17. Controls Box

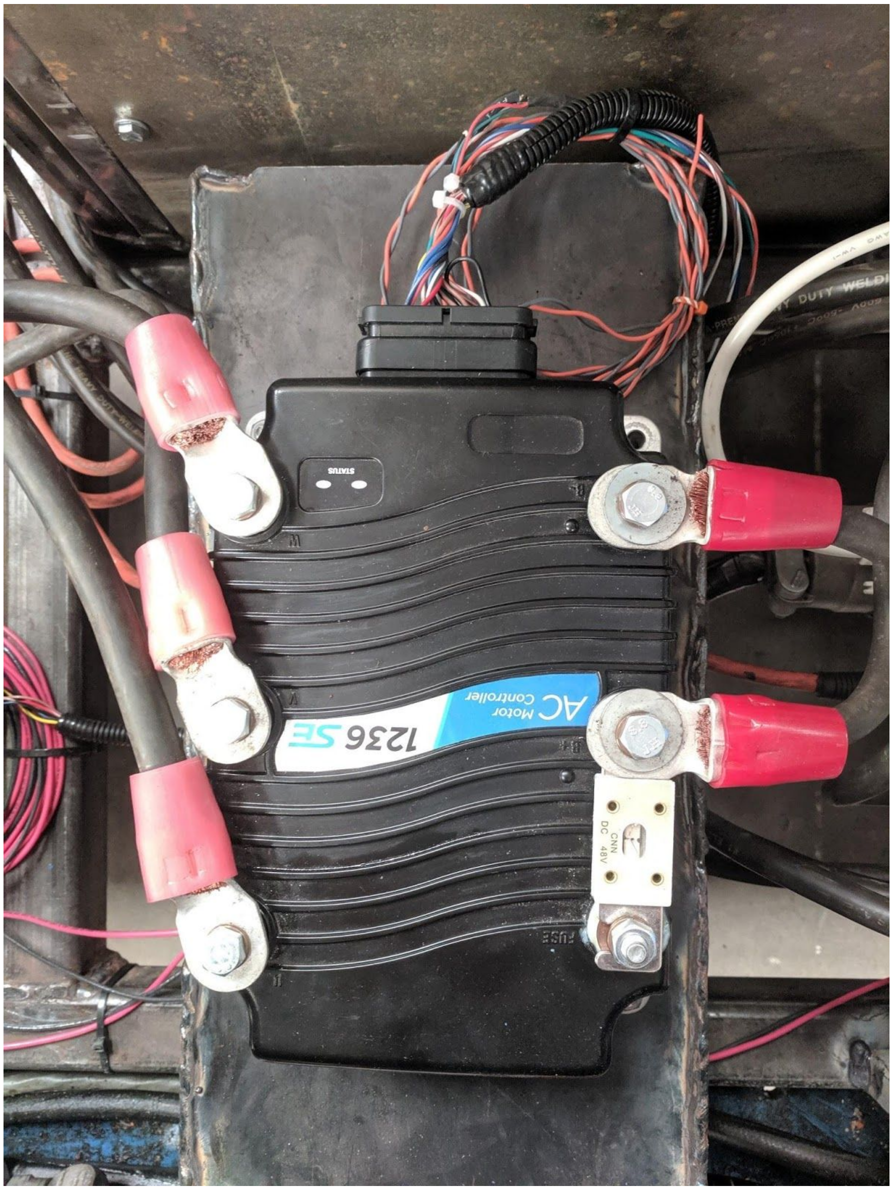

Figure 18. Motor Controller

The motor controller comes in a package with the motor. It is a Curtis 1236SE-5621 AC induction motor controller. Under a S2 duty cycle, it has a max current of 600 A_{rms} at 2 minutes and 260 A_{rms} at 60 minutes.

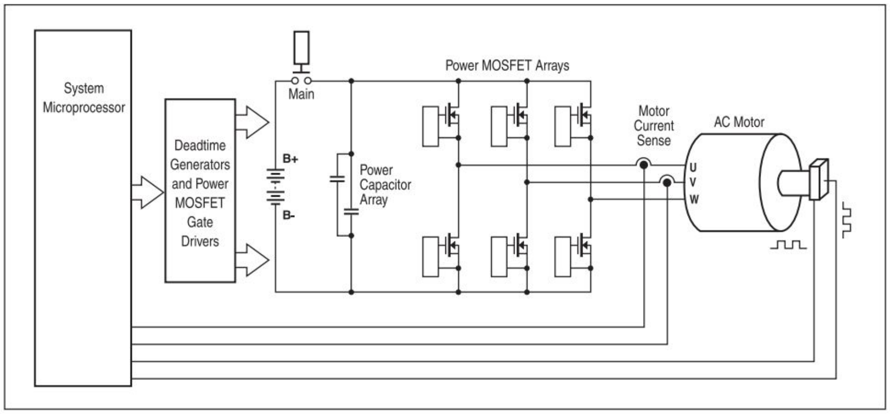

Figure 19. 1236SE Power Section Topology

The motor controller's primary purpose is to convert 48 VDC from the batteries into 48 VAC for the motor using three high frequency MOSFET half-bridge power stages, which are controlled by three pwm signals. With the quadrature type encoder on the AC50 motor, the controller maintains a constant motor speed. In addition, the motor controller monitors the temperature of the AC motor, current, and battery voltage.

Hydraulics Subsystem

The hydraulics subsystem consists of the parts that carry hydraulic fluid to and from the high and low pressure manifolds. Although the operating conditions are 1200 psi and 13.3 gpm, it can be run at up to 1500 psi and 14.5 gpm.

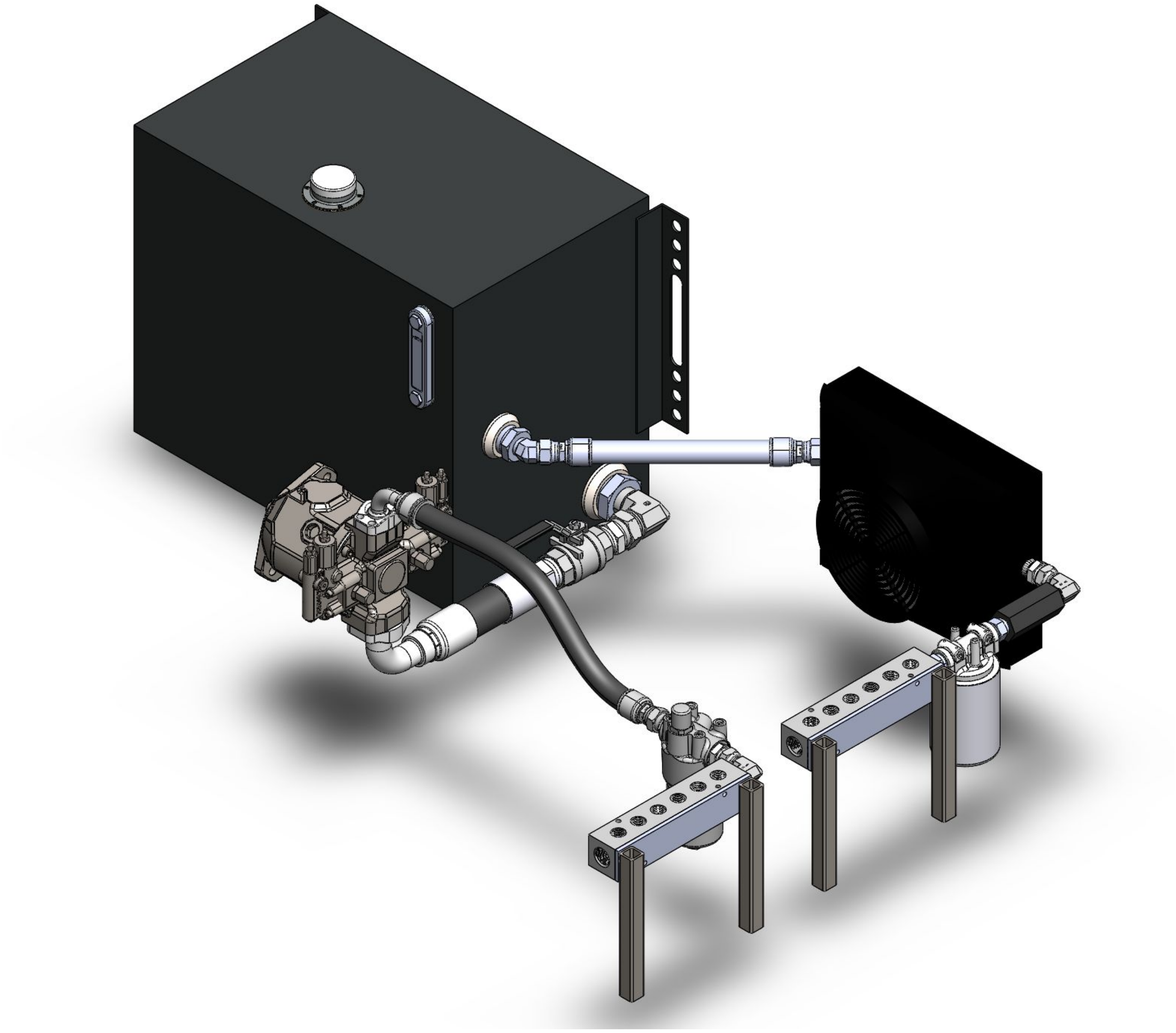

Figure 20. CAD model of the Hydraulics Subsystem

There are two filters in the hydraulic system, one high pressure and one low pressure. These filter out the foreign materials that enter the hoses as new actuators are hooked up into the system. The high pressure filter will be between the manifold and the pump, and the low pressure filter will be between the manifold and oil cooler.

The high pressure filter is 2109N1 from McMaster-Carr, and can remove particles down to three microns. It is rated to 4,000 psi,14.5 gpm, and 210 F. It has a pressure gauge, which indicates when the filter has to be changed. The low pressure filter is a Parker 12AT10CN15BBH filter. It is capable of operating to 20 gpm, 225 F, and 150 psi.

The tank capacity is 30 gal. It was specified so it could hold 2-3 times the flow rate, which is the industry standard in hydraulic tank specification. This tank also has a low profile over the frame. Three modification had to be made for this tank. Two holes were cut for the addition of two hydraulic ports for Case Drain and Pressure Controller port. Additionally, one 8 in diameter hole was cut to add a Cleanout Cover for future maintenance.

Most of the hydraulic hoses are currently owned by the Rose Float program, so those will be used throughout the system. However, there are three hoses that were purchased: the hose going from the tank to the pump, the hose going from the pump to the high-pressure manifold, and the hose from the oil cooler to the tank. These hoses needed to be purchased because of their unique fittings and specific sizes.

The hydraulic oil cooler is the D10 - 12 by AKG thermal systems. Hydraulic system can vary in efficiency from anything from 80 percent to 40 percent. Because this hydraulic system consist of solenoid proportional control valves, long rubber hosing, and hydraulic cylinders, it is assumed that the system has 40 percent efficiency. The system is sized to input 10.5 hp, which means that the radiator should be capable of rejecting 6.5 hp of heat. The max operating temperature of THF 1000 hydraulic fluid is 190 F. Thus, the max fluid inlet temperature is assumed to be 190 F and the max ambient temperature is assumed to be 100 F, which results in a 90 F ETD, or Entering Temperature Difference. Charts for specing the oil cooler are based on 100 F ETD, so it was adjusted using the equation:

$$Adjusted\ Heat\ Load = Actual\ Heat\ Load \times \frac{100}{Desired\ ETD}$$

The adjusted heat load calculates to be 7.2 hp. According to the D Series performance charts, the D10 model reject 10 HP at 13.3 gpm.

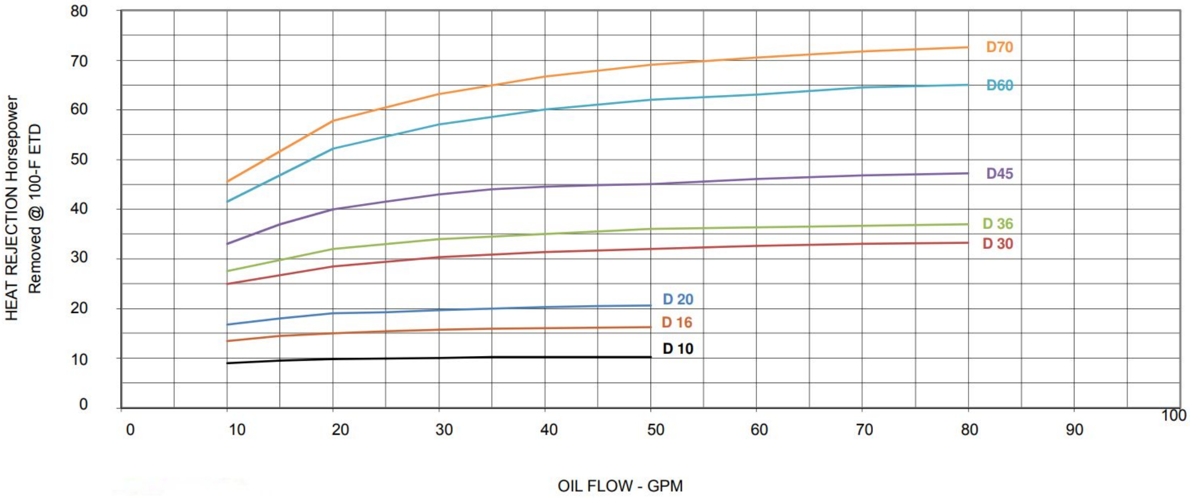

Figure 21. AKG Thermal System Standard Model Performance Data

There are two aluminum hydraulic manifolds. They are both rated to 3000 psi and threaded with ¾” NPT. One manifold distributes high pressure fluid from the pump to the remote pressure compensated solenoid manifolds. The other collects returning hydraulic fluid from remote pressure compensated solenoid manifolds, channels it through a filter and a heat exchanger and back to the reservoir.

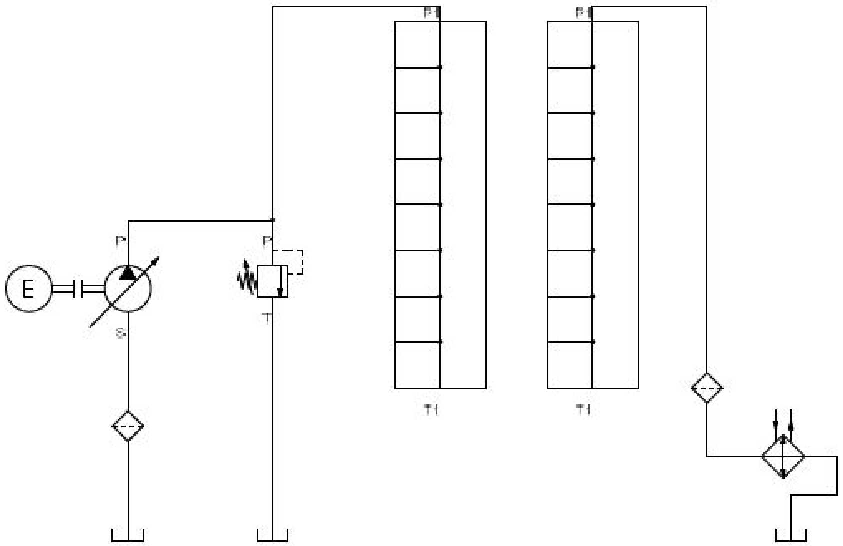

Figure 22.. Hydraulic schematic of the entire hydraulics system

Final Design Assembly

Fully assembled, the entire animation system is similar to the CAD in Figure 22 below. This is the culmination of months of hard work including extensive design, fabrication, and assembly.

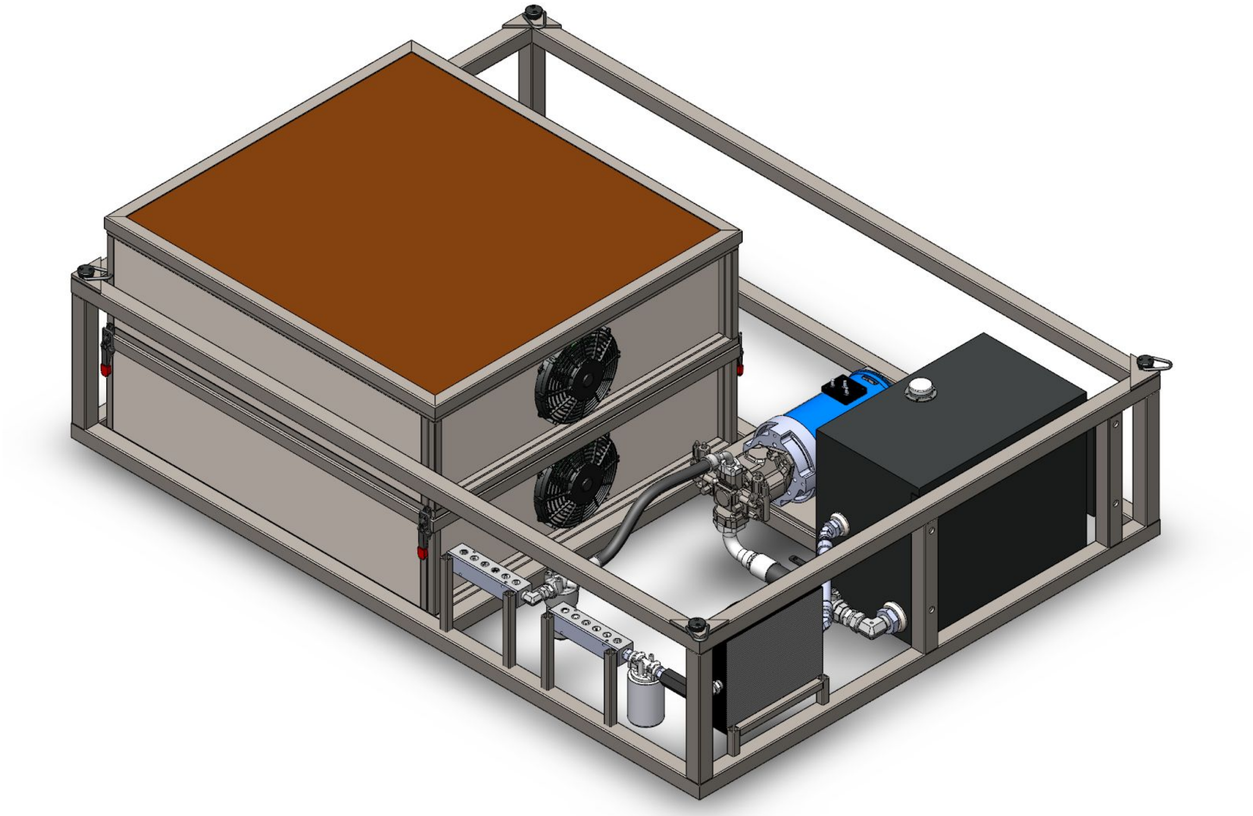

Figure 23. CAD model of the entire animation system assembled together

This system was then placed in the Float for showcase to drive an example mechanism that was used in the Open House Parade. The completed system can be seen in Figure 23.

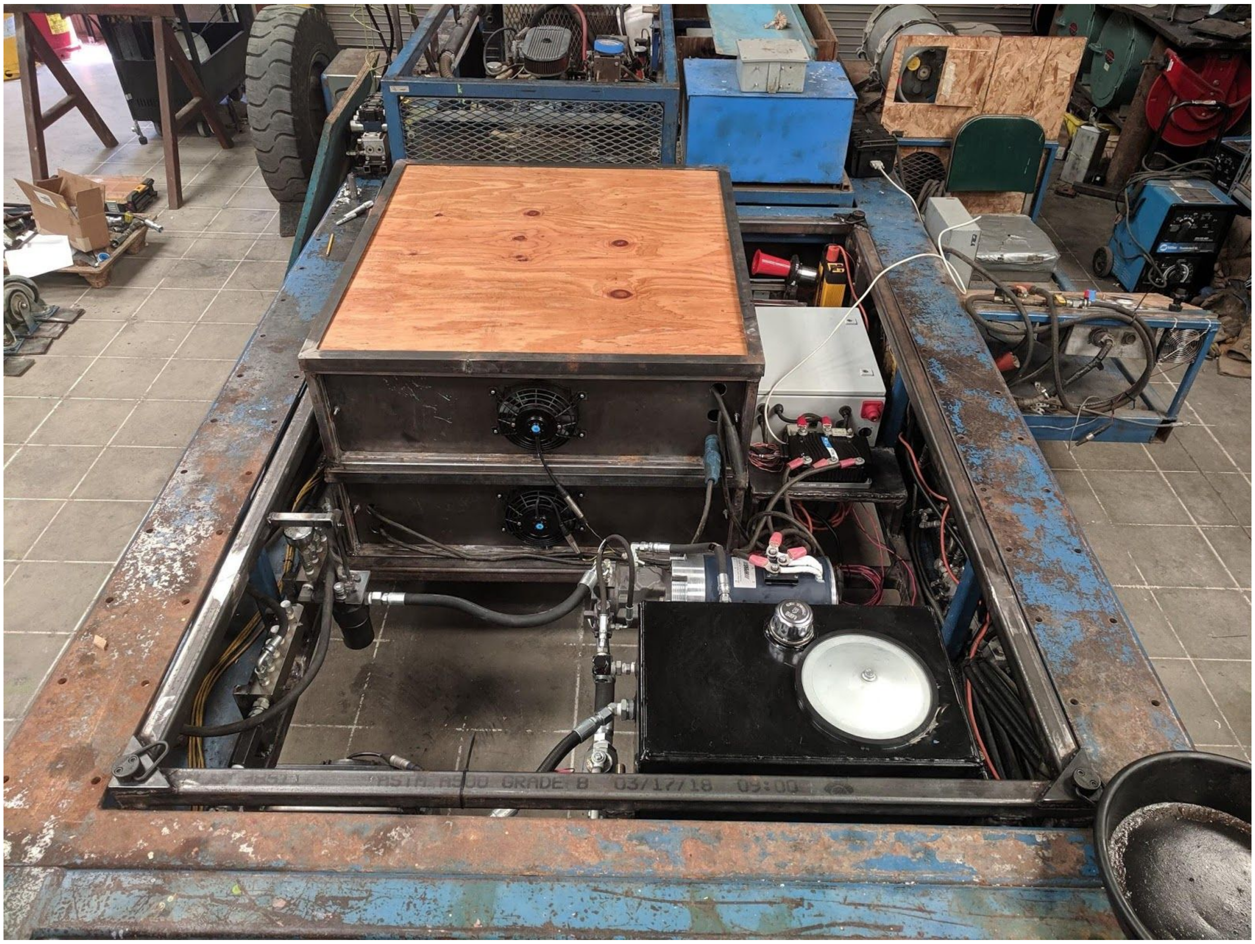

Figure 24. Full System Picture

This project finished with a working hydraulic system capable of operating one mechanism for about three hours. The system will include a few improvements and expansions prior to the next Rose Parade which are discussed below.

Safety

Potential safety concerns were identified using the Hazard Identification Checklist in Appendix I. One potential hazard is the presence of rotating machinery in the system. A motor-pump drive system will be spinning at 1800 rpm and fans will be spinning to cool the hydraulic and electric systems. However, a rotary machine is not a high risk in the system because there are no exposed rotating components and the operator will be physically isolated from the rotating components. The motor and pump are the only components likely to undergo high accelerations and moving masses. However, because they are designed for these applications, there is a low risk associated with this hazard. Additionally, the battery enclosure will have metal panels to mitigate body parts coming in contact with hazardous surfaces.

High pressure will be present in the hydraulic systems. There is a high risk associated with this because exposure to 1200 psi hydraulic oil can be deadly in the case of hydraulic injection. This hazard will be mitigated by shielding all hydraulic components and using properly rated lines and fittings to prevent pinhole leaks. Hydraulic fluid used in this system will also get very hot. Although there will be an oil cooler in the system, this will not completely prevent the oil from reaching skin-burning levels before being cooled. To prevent injury, there will be physical barriers between people and the hydraulic components, the same as those to prevent hydraulic injection. Additionally, the oil temperature and pressure gauges can help determine when it is safe to approach the system.

Stored energy can be inherently dangerous. Using lead acid batteries reduces the chances of thermal runaway compared to lithium cells. The chosen batteries are known for their durability and resilience to non-ideal conditions such as high discharge, temperature, and vibrations. Through buying all new identical batteries, there is limited concern due to stacking in parallel and series. One concern the Tournament of Roses specifies is to construct an enclosure to minimize shorting and fire harzards. Through building the battery enclosure out of box and sheet metal, the system will protect against leakage and accidental ingress. Finally to prevent the concern of battery acid coming in contact with students, the enclosure walls and roof will direct any splashing or spillage downward.

There will be two distinct voltage levels on the float. The first is a 12 VDC low voltage system to power controls, DC mechanisms, and fans. The primary concern is the temperature of high current carrying wires. To prevent the melting of insulation, the wires will be sized to 1/0 AWG, that has the correct current carrying ability. The 48 VDC high voltage system will be created with 8 sets of 4 batteries in series. This is a high enough voltage to be a real concern for arcing and personnel safety. Ensuring every component has the proper insulation, distance of separation, and minimizing the possibility of falling debris is critical. Through design, there will be no bare connectors carrying 48 VDC and only short cables connecting the battery box to the Junction Box. Shielding bare conductors inside the battery box, junction box, or motor controller will prevent accidental shorts. Metal shields will be installed over the motor controller to minimize the chance of accidental contact from personnel or debris. Additionally, every string of 48V will be fused at 50A to protect the batteries. The 12V systems will be fused at 150A per set of 4 batteries. The motor controller is fused at 400A to protect the internal circuitry from overcurrent conditions. Importantly, the motor controller will shut off if the voltage reaches 40V to protect the battery health. A 12V low voltage disconnect was installed to protect the 12V batteries additionally.

Maintenance and Repair

Due to the nature of the Rose Float Program, the animation system must be dependable and long lasting. With an expected life of 10 years, every component was chosen with longevity in mind. There are a few aspects which may require maintenance. These components include replacing hydraulic filters, adding hydraulic oil, and eventually replacing batteries. Due to the relatively low usage of the system yearly, age will be the limiting factor of the batteries. It is possible that every 3-5 years the batteries need to be recycled and replaced. This is the primary ongoing expense related to the project. To make the batteries last as long as possible, the system will be protected from weather and debris when possible. Additionally, the battery chargers have a floating feature which will help lengthen the battery's life and health. This also prevents slow discharge while in storage. The electrical components sourced are widely available when possible and this should enable rapid repair if necessary. System wide, inspections should be done twice annually to check for leaks, debris, and solid electrical connections. This will help prevent malfunctions and promote longevity.

Upgradability and adjustability is an important benefit for the Rose Float Program. The system has been designed for future students to be able to change the batteries, battery quantity, controls, and or hydraulic system as necessary. Especially for the battery design, the enclosure could easily be rebuilt to account for different battery chemistries such as lithium. It is our hope, as lithium prices continue to decrease, future teams update the energy storage to lithium or other similarly advanced technology. The system is also modular regarding the needs of the animations. If there is more DC power required and less hydraulic power for a certain float, the batteries can be recombined to accommodate that. The design of the system is so that it can be put in the float in addition to the current animation system. This way, both systems can run in parallel to power mechanisms. To promote adjustability, a user manual will be designed to help document and explain each subsystem. Additionally, if trouble shooting is necessary, the manual will be an invaluable reference.

Cost Estimate

The expected cost of the system is detailed below in Table 3. While this table does not include cost for manufacturing, it does include cost for all the major components and assemblies.

Table 3. Estimated Cost of Core Components

	Name	Status	Funding Source	Total
Hydraulic Subassembly	Proportional Pressure Control, Pilot-Operated Relief	No		
	Hydraulic Tank	Received	CP Connect	$318.30
	Weld On Adapter 1/2	Received	Rose Float Alumni	3.23
	Weld On Adapter -6 NPT	Received	Rose Float Alumni	3.2
	Strainer	Purchased	CP Connect	27.13
	-32 M NPTF, -20 F NPTF	Received	Rose Float	$15.64
	-20 M NPT, -20 F NPSM, 90 deg	Received	Rose Float	$23.21
	-20 M NPT , -20 M NPT, Straight	Received	Rose Float	$12.16
	Ball Valve	Received	CP Connect	62
	[Suction Hose] SAE 4 Bolt Flange 1.25" Standard Pressure Series (Code 61) 90 deg to -20 F NPSM (Swivle)	Received	CP Connect	$66.31
	[Pressure Hose] SAE 4 Bolt Flange 0.75 " Standard Pressure Series (Code 61) 90 deg, -12 F NPSM Swivle,	Received	CP Connect	$67.71
	Pressure Relief Valve	Received	Rose Float	$43.65
	-12 M NPT, -12 UN/UNF (SAE) M, Straight	Received	Rose Float	$6.10
	High Pressure Filter	Received	CP Connect	$315.12
	-12 F NPSM, -12 NPT M, 90 deg	Received	Rose Float	$12.30
	Manifold	Received	CP Connect	$135.66
	-12 NPT Plug	Received	Rose Float	$3.34
	-08M NPT - 08M JIC 37 deg	Received	Rose Float	$17.64

	-08 JIC CAP	Received	Rose Float	$8.04
	-12 NPT M, -12 NPT M, Straight	Received	Rose Float	$4.64
	-12 NPSM F, -12 NPT M Straight	Received	Rose Float	$3.06
	Low Pressure Filter	Received	CP Connect	53.83
	-12 SAE M, -12 NPT M, Straight	Received	Rose Float	$3.05
	Heat Exchanger	Received	CP Connect	334.72
	-12 SAE M, -12 JIC M, 45 deg	Received	Rose Float	5.59
	[Tank Hose] -12 JIC F Swivle, -12 JIC F Swivle, 15 in horizonal	No	Rose Float	0
	-12 JIC M, - 12 NPT M, 45 deg	Received	Rose Float	$5.14
	-12 NPTF F, -20 NPTF M, Reducer	Received	Rose Float	5.11
				$1,555.88
Motor Pump Assembly	AC Motor	Received	Rose Float Alumni	$1,700.00
	Motor Controller	Received	Rose Float	$922.00
	Wiring Harness	Received	Rose Float	$115.00
	Display	Received	Rose Float	$79.00
	Contactor	Received	Rose Float	$100.00
	Pump	Received	CP Connect	$1,695.00
	-8 SAE M, -8 NPTF M, straight	No		$1.61
	-4 SAE M, -4 SAE M , straight	No		$1.30
	Oil-Resistant Vibration-Damping Pad	Received	Rose Float	$11.67
				$4,625.58
Control Subsystem	15 pin Dsub pack	Received	Rose Float Alumni	$8.95
	15 pin dsub cable	Received	Rose Float Alumni	$10.79
	9 pin Dsub pack	Received	Rose Float Alumni	$7.80
	Female Screw Lock	Received	Rose Float Alumni	$7.90
	9 pin Dsub cable 6ft	Received	Rose Float Alumni	$6.79

	Digital 12V gauge	Received	Rose Float Alumni	$5.49
	Anderson sb50	Received	Rose Float Alumni	$20.98
	controls dashboard	Received	Rose Float Alumni	$14.95
	Terminal Crimps	Received	Rose Float Alumni	$19.95
	Junction Box	Received	Rose Float Alumni	$150.00
	16 terminal block	Received	Rose Float Alumni	$15.46
	10 terminal block	Received	Rose Float Alumni	$6.99
	fuse n relay holder	Received	Rose Float Alumni	$11.95
	12v battery relay	Received	Rose Float Alumni	$164.49
	Bus Bar standoffs	Received	Rose Float Alumni	$14.69
	12V low voltage cutoff	Received	Rose Float Alumni	$10.99
	Cable Strain Relief	Received	Rose Float Alumni	$7.59
				$485.76
Batteries Subsystem	Interstate	Received	Rose Float Alumni	$260.00
	Interstate	Received	CP Connect	$160.00
	Interstate	No	Rose Float Alumni	$880.00
	Battery Fuses	Received	CP Connect	$57.52
	red camlock surface mount	Received	Rose Float	$29.39
	black camlock surface mount	Received	Rose Float	$76.50
	Blue Camlock surface mount	Received	Rose Float	$51.00
	blue camlock connectors	Received	Rose Float	$39.58

	48V charger	Received	Rose Float	$205.00
	12V charger	Received	Rose Float	$148.00
	Fans	Received	Rose Float	$50.00
				$1,758.99
Tools	Dremmel Stuff	Received	Rose Float Alumni	$12.98
				$12.98
Removed	Controls Box	Received	Rose Float Alumni	$22.00
	AC Motor Return	Received	CP Connect	$197.36
				$219.36
Frame Subassembly	Lifting Ring	Received	Rose Float Alumni	$168.32
	Bolt 1/2"-13	Received	Rose Float Alumni	$6.76
	Nut 7/16"-14	Received	Rose Float Alumni	$8.54
	Bolt 7/16"-14	Received	Rose Float Alumni	$10.47
				$202.09
			Total	8860.64

Product Realization

Frame

In order to make all of the purchased components work properly, there will need to be manufactured parts as well. The largest manufactured part is the Frame Subsystem. This was made out of ASTM 500 2” thick wall square tubing and made at the Rose Float lab. The pieces were cut on the Marvel 8-Mark-II vertical band saw, and welded together using SMAW (stick welding) and 7018 electrode. The bandsaw has the ability to tilt ±45°, which will allow to cut pieces at different angles.

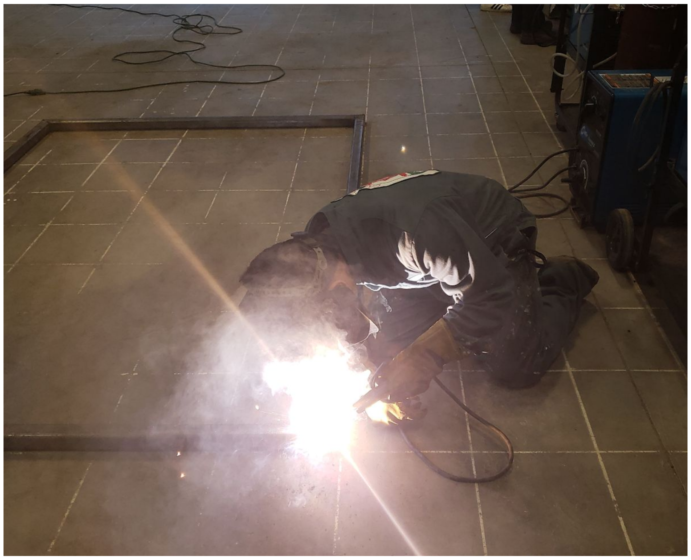

Figure 25. SMAW welding of Frame

The motor mount, battery box support pieces, and the hoist mount pieces were cut using the BRAE department’s CNC Plasma.

Figure 26: Motor Mount

There will also be pieces on the frame that will allow for major components such as the battery enclosure, pump-motor assembly, and oil tank. These pieces will have holes drilled to allow for the proper mounting of the individual components. All components will be bolted in with Grade 8 hardware, and lock washers will be used to help prevent nuts from vibrating off of the bolts.

Battery enclosure

The battery box enclosure was primarily made of 1 in square tubing and 1.5 in angle iron. All pieces were cut again by the Marvel bandsaw and welded using SMAW and 7011 electrode.

Upon the enclosure being manufactured, the batteries were assembled to create both battery sets. The two battery packs are wired to the Junction box through camlock cables that were assembled in house. Internal to the battery box, each string of batteries, in both the 48V and 12V systems are fused at 50A. Again, the cables connecting the batteries to the fuses and the fuses to the camlock connectors was manufactured by the team. In order to connect the batteries together, in both parallel and series, jumpers, seen in Figure 26, were made.

Figure 27. Jumper Cables

Hydraulics

In order to install the hydraulic system properly, the first step was to purchase the correct fittings so each of the components could connect properly without leaks. Many hydraulic components have SAE pipe female fittings, and most of the fittings used in the hydraulic actuators and hoses in the Rose Float use JIC fittings due to the lack of need to use teflon tape, making installation easier and faster. Figure 27 below shows how a male pipe to male JIC was used on the high and low pressure manifolds for ease of use of hose installation in the future.

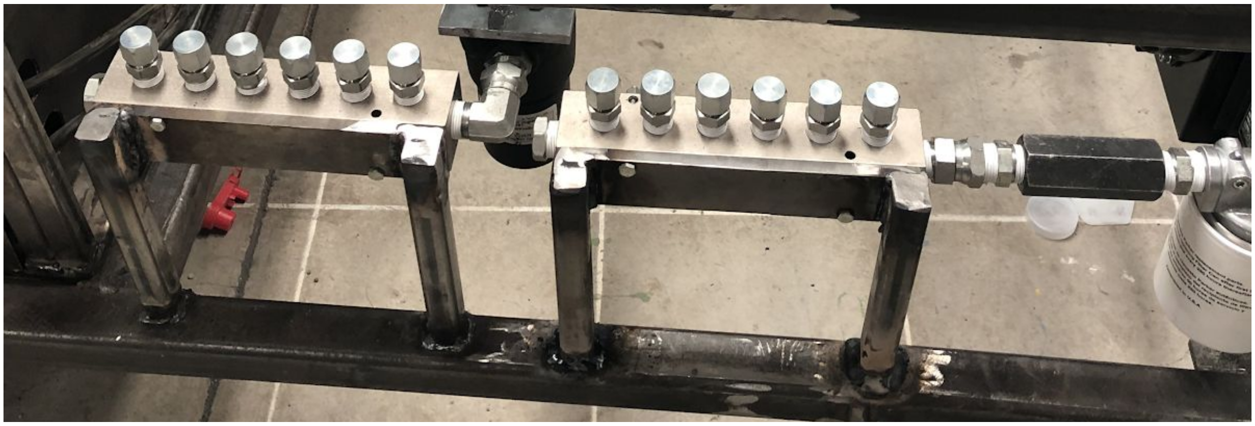

Figure 28. Hydraulic manifolds with male pipe to male JIC connections installed

The hydraulic tank underwent modifications in order to work best with the system. Two pipe connections were welded in so that a pressure sensing hose and pressure relief valve could be installed into the system. Also, a cleanout port hole was plasma cut into the top of the tank so that all of the chips created by drilling holes into the tank could be cleaned out, and so the tank could be cleaned out more fully in the future. The hydraulic tank can be seen below in Fig 28.

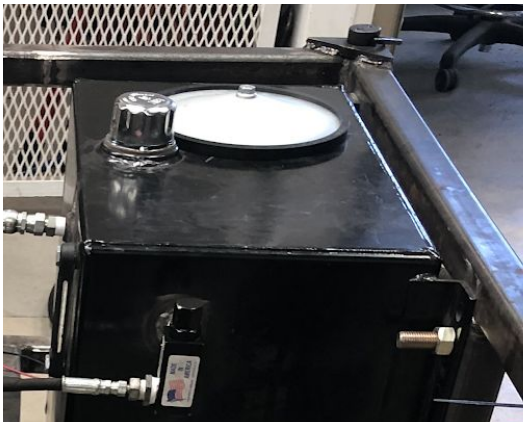

Figure 29. The hydraulic tank, showing the cleanout port and pressure relief valve.

Once the hydraulic components (which includes everything except the hoses) were in place, the lengths for the hoses were measured. Three hoses were purchased: two coming off the pump--including the suction and pressure hoses, and one hose to connect the end of the system to the tank.

Upon installation of the hoses, the next step was the pump. In order to not immediately cavitate the pump with the turning of the motor, both the tank and pump were filled with oil. Using a funnel, oil was filled into the pump. Oil was able to be poured directly into the tank through the cleanout port. Once the oil was filled in the system, the motor was able to turn the pump properly and without issue.

Controls box

Unique requirements of the controls assembly necessitate a custom box. The box will be a hard case shell providing impact and water resistance. Internally, a terminal block will help manage the in and outgoing signals. The gauges and buttons will be mounted to a thin sheet of aluminum which will act as the dashboard. When possible, the wires will be crimped and soldered to ensure a secure electrical connection. This can be assembled with Rose Float tools and equipment.

Junction box

In order to minimize and organize wires, a junction box was required. Built into a 20x16x8 inch metal box, connections from the battery enclosure, chargers, motor controller, and controls box were made. Internal components include a 48V contactor, relay box, terminal block for frame wiring, terminal block for controls wiring, low voltage cutoff, ground and 12V bus, and 12V relay. Before assembly began, every component was placed and the wiring lengths and ergonomics were checked. Most of the components were bolted onto the box subfloor or walls of the enclosure. As necessary, holes were drilled and cable strain reliefs were placed to allow cable pass throughs. Seen in Figure 15 above, wiring, crimping, and cable management is critically important. Once wires were initially placed, some lengths and locations were adjusted. Finally, the box was reviewed for correct wiring and potential shorts.

Design Verification

Once the hardware was received, testing of individual components could begin. When individual components were validated, assemblies were tested for compatibility. Finally, the entire system underwent testing to confirm the system worked safety and met the engineering requirements listed above. Through the summer, in conjunction with the Rose Float program, more testing will confirm it is reliable and safe to be placed in the 2020 Rose Parade.

Upon pickup of the deep cycle batteries, age and voltage was monitored. The batteries are new and charged. Ensuring we have new identical batteries is critical to a large series parallel battery bank. Both the 12V and 48V charger outputs were measured. Due to the three stage charging, a full battery charge was required to ensure every stage kept the voltage within the safe deep cycle battery voltage range. Being 5 bosch style automotive relays are used, ensuring they worked as expected was important. The 12V main relay and 48V contactor were tested to ensure they would work at the rated voltage. The 12V low voltage cutoff was tested thoroughly due to its importance. Additional electrical testing continued once assemblies were completed.

Once the motor and pump had arrived, they were assembled to ensure their fitment and bolt placement. The hydraulics were primarily tested once assembled and fluid and pressure could be applied.

Subassembly testing began with the frame. A visual inspection was performed on critical welds to ensure it could withstand the necessary loads. Electrical testing was performed on each box. For the control box, ensuring electrical isolation and connectivity was key. This was performed as the box was assembled. For the controls box, wire management, and electrical connections were most heavily monitored. The junction box required more management to ensure safe electrical connection and organization. Visual inspection and continuity checks confirmed our wiring. Visual inspections were performed for the inverter and chargers to check their affixment and wiring. The battery box welds were inspected, cabling was organized, and the battery fitment was confirmed. The hydraulics were filled with fluid once they were fully assembled. Tightening of fittings was required to eliminate leaks. Additionally, the pump pressure was adjusted to reach the 1200 psi requirement. Once leaks were fixed, the system was run to ensure no quarks would present themselves.

Final system testing was performed to confirm the project met the engineering requirements. Using the 12 available batteries split 8 for 48V and 4 for 12V, the system was tested. The motor-pump unit was able to provide the correct pressure as flow was varied. This was performed by connecting a hose from the high pressure rail to low pressure rail with a needle valve attached.

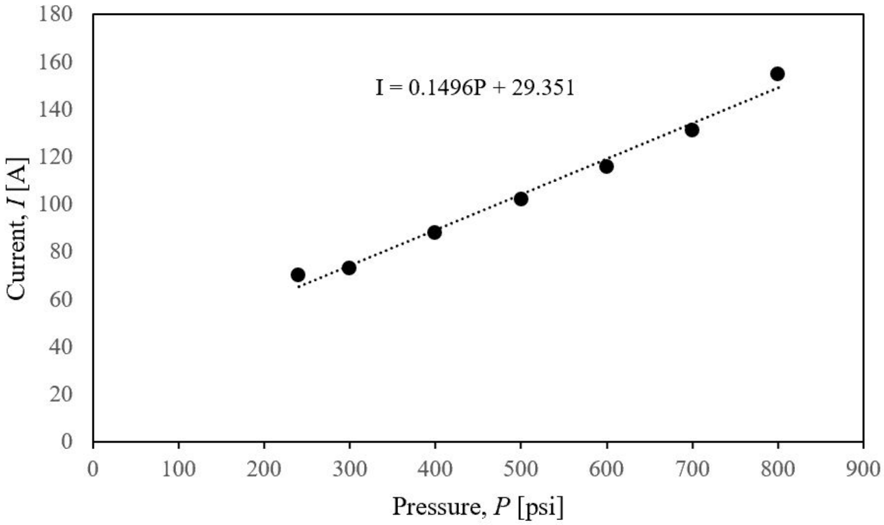

Figure 30. Measured Current Against Pressure

From our testing we determined that there is a linear relationship between pressure and current. With the needle valve completely open, the system experiences 240 psi. For every 100 psi increased, current increases about 15 amps. If this trend continues to 1200 psi, the motor should see about 208 amps.

Throughout the summer, tests will continue to be run on the system. A full list of the test conducted and planned is in the DVP&R in Appendix K. These tests include a full capacity battery test. Once all the batteries are procured, they will be run until they drop below the motor controller's low voltage cutoff. The power draw and total power dissipation will be recorded to ensure the bank can supply the system with enough power for the duration of the parade.

During this test, the battery temperature and H_2 levels in the battery box will be monitored. These values will also be monitored during the recharging of the pack to ensure the system is safe to both fully discharge and recharge.

During the discharge of the battery bank, the hydraulic will also be monitored for temperature dissipation and component wear. This will both ensure the batteries can provide the needed power and the hydraulic components can function safely for the duration of the parade.

Future Improvement

Although senior project is over, the intent is to use this project in the next Rose Float parade and well into the future. There are some additions or modifications which will make the system more refined and some quality of life improvements. Some of the students in collaboration with the Rose Float team will continue working over the summer to make sure this project is ready for the 2020 parade. These improvements include:

- GN 851.3 Horizontal Latch Type Toggle Clamps from JW WInco will be added to the battery box to allow for lifting of both halves of the battery box at once.
- Replacing the Pressure Relief Valve with a Hydraforce TS08-27 Proportional Pressure Controller
- Welding a compartment for the electrical equipment
- Adding cover to protect the hydraulics components from ingress
- Adding cover to motor to prevent shorting of leads and debris.
- Add ducting to the battery box
- Painting the system to protect against rusting

Given the time and funding to improve the project, there are also several improvements that we would like to make. Some of these would significantly improve the system and some would make the system more refined. These are tasks which future Rose Float teams can accomplish.

- Install the full capacity of 40 deep cycle batteries into the system
- Purchase and include a 3kW 120VAC inverter
- Add a battery management system for the lead acid batteries or buy and design a lithium ion battery pack.
- Evaluate the need for permanently plumbing accumulators into the animation system
- Upgrade the 2109N1 filter to a 2109N2 filter to increase flow capacity by 5 gpm.

Conclusion

From the initial need of a new and improved animation system, the team has developed a concept of an all electric power system. This system will supply power to the animations on the Cal Poly Rose Float starting in the year 2020. An all electric system not only fulfills the customer requirements, but it also enables the program to market a greener float. This marketing can expand the program participants as well as the program donors. Finally, this project begins the first step in converting the float from a propane powered float into an electric powered float. Cal Poly Rose Float has been the first float to use many new technologies that include the first use of hydraulics for animation in 1968, the first use of computer-controlled animation, and hopefully the first fully electric float in the parade in the coming future.

Acknowledgements

We would like to express special thanks and gratitude to our Rose Float Advisor Josh D'Aquisto for his guidance, support, and direction in completing this project. Additional thanks to our Senior Project Advisor Jim Widmann who pushed us to do our best work and kept us on track. Thank you to all the Rose Float alumni for funding and industry expertise. To Regina, Jeremy, Mara, Chris, and everyone else who helped in assembly, thank you.

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Appendix A

Table 4: Current System Data

Specifications	A10VO0100DFR/31 - PUC62K07
Speed (RPM)	1500/1800 RPM
Displacement	6.10 in^3/rev
Pressure (psi)	250 / 1050 pi
Flow Rate (gpm)	39.61/47.53 gpm
Horsepower (hp)	59.89 hp

Table 5: Pump Data

Specifications	A10VO0100DFR/31 - PUC62K07
Max speed (RPM)	2000 RPM
Displacement	6.10 in^3/rev
Max flow (GPM)	51/ GPM
Weight (Ibs)	99 Ibs
Max power (HP)	123 HP
Max Torque (Ib-ft)	117 Ib-ft
Nominal output pressure (psi)	4000 psi

Table 6: Engine Data

Specifications	350 Chevy engine
Horsepower	173 HP @ 3000 RPM
Torque	300 lb-ft @ 3000 RPM
Weight	434 Ibs

Appendix B

Initial Project Requirements

Customer Requirements:

- One minute overheight drop
- Capable of lowering overheight
- DC distribution box compatible with animation operator and easy power delivery
- Easy access to the charging system
- Simple motor startup and control in a simple box
- RPM, pump pressure, and temperature of the fluid feedback to the operator
- Easy to recharge the battery system
- Capable of recharging the battery system overnight
- Enough battery storage to last for four hours of parade animations
- Capable of supporting 10 hydraulic mechanisms, 20 electric mechanisms

Technical Requirements:

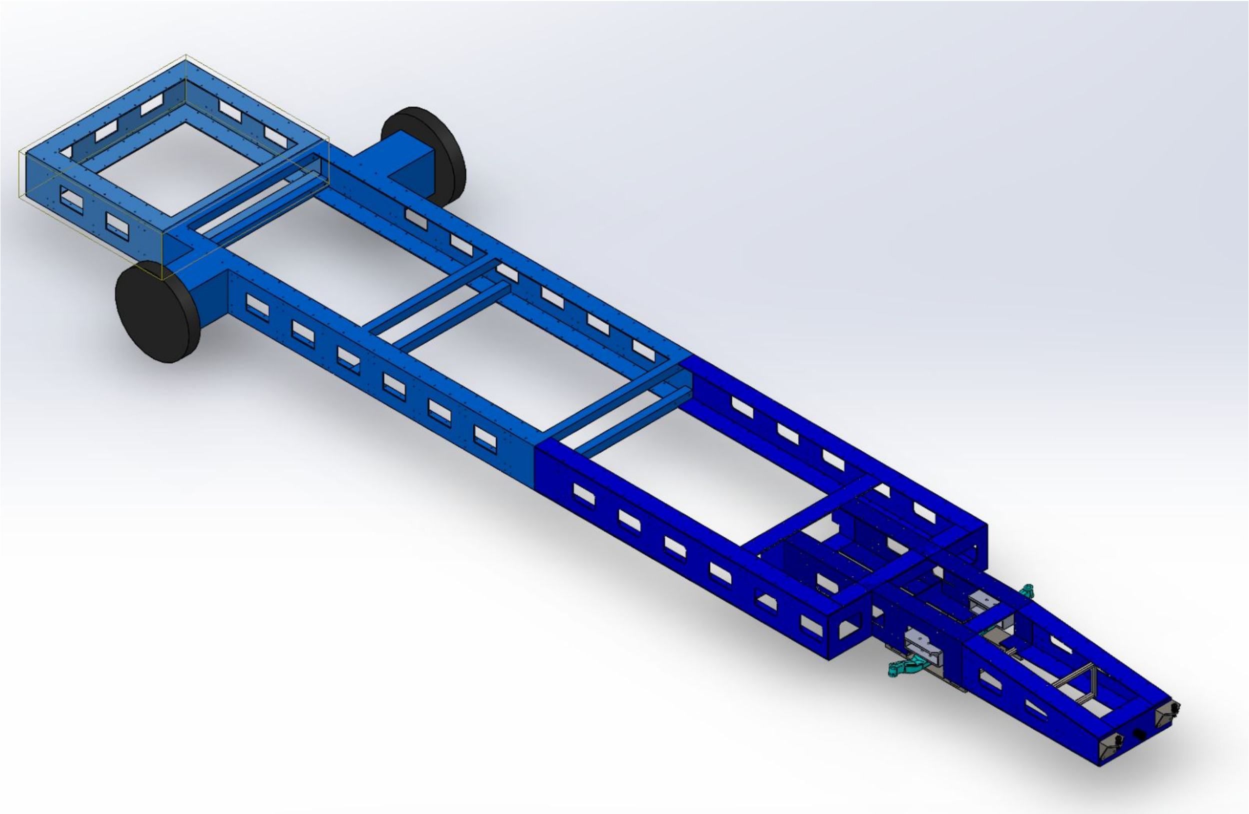
- Create approximately 1200 psi Hydraulic pressure
- Up to 25 GPM of flow
- System protected by pressure relief and accumulators
- Hydraulic Reservoir volume of 40 gallons
- Stable and safe battery management system under diverse conditions
- DC distribution box compatible with the current ecosystem
- Total system weights under 2000 lbs
- Total cost less than $5000
- Battery Storage of 2000 ahr
- Cable Rating: 200 amps

Assembly Requirements:

- Be able to fit in an enclosure smaller than 7 feet 8 inch, 5 feet 7 inch, 1 foot 8 inch
- Be fabricated with tools available to Rose Float Program
- Completion by Spring 2019

Appendix C

CAD Model of Cal Poly Rose Float Frame



Appendix D

The Heat Contract

Mission Statement

The mission of the HEAT is to design and construct an all electric animation system to fully replace the current animation engine used in Cal Poly Rose Float.

Section 1: Name

A. This organization shall be known as the HEAT.

Section 2: Membership

A. Members of the team include:
    a. Michael Cain
    b. Tyler Couvrette
    c. Sara Novell
    d. Dexter Yanagisawa
B. No member shall purport to represent the team unless so authorized by the team.
C. Each member shall be provided a copy of the team contract.

Section 3: Statement of Commitment

A. Members of the team commit to designing a system that satisfies all project requirements and present all deliverables.
B. Hourly commits are detailed as follows: During fall, hours are expected to be about ten hours a week. Winter and Spring will most likely require twenty hours a week. However, all times are subject to change depending on the fluctuating workload.

Section 4: Decision Making

A. Members of Heat will strive to make decisions by consensus. This will be accomplished by having as many meetings in person as possible, clearly explaining advantages and disadvantages of debated decisions, and committing to make decisions based on what will better fulfill project, technical, and customer requirements. If there is no consensus, members of Heat will defer to the people with expertise. (The group members with more experience, advisor, or alumni)

Section 5: Team Interactions

A. All affairs of the team shall be governed by professional behavior with respect given to all team members.
B. Meetings shall be determined using when is good and will adjust per quarter.
C. Unless otherwise noted, all meetings will be held at the Rose Float office.
D. Special meetings of the team may be called by the group text message group.
E. Attendance is mandatory unless prior notice is given and an approved excuse approved by the group. Excuses include school work, Doctor's appointments, family emergencies and any other excuses the group deems appropriate.
F. Meeting discussions will be conducted in a conversational format with special regard for a dialogue that is respectful and considerate of all members in attendance.
G. A meeting agenda, distributed a minimum of a few hours in advance, will guide meeting topics and timing.
H. The length of meetings shall be stated in advance.
I. All team members are expected to be punctual.
J. All meetings will be publicized to members using: phone calls, team websites, email, or texting.
K. Notices shall be distributed not less than 2 days before the meeting date.
L. Violation of team rules will be handled as follows:
    a. First violation of team rules will warrant a warning from other team mates and donuts will be purchased for the next team meeting
    b. If behavior continues, a meeting will be called and the accused team member will be given a chance to explain his or her position
    c. If no solution can be found, the issue will be brought to the Program Advisor or the Professor in charge.

Section 6: Conflict Resolution

A. After conversation does not converge to consensus, the decision will fall into the conflict resolution protocol.
B. Each person will be able to clearly explain their position as well as advantages/disadvantages of their position in sequence.
C. Oral vote will commence on issue at hand.
D. Matter will be decided if a four fifths majority is reached with all group members present.
E. If a four fifths majority is not reached, together, members will seek counsel from Program Advisor, alumni, or Professors and present arguments again to the team.

Section 7: Roles and Responsibilities

A. Sponsor Contact: Dexter Yanagisawa
    a. This team member will be the single point of contact for the sponsor in order to avoid any confusion regarding communication to/from the sponsor. The sponsor contact must communicate in a timely and professional manner with the sponsor.

Section 8: Amendments

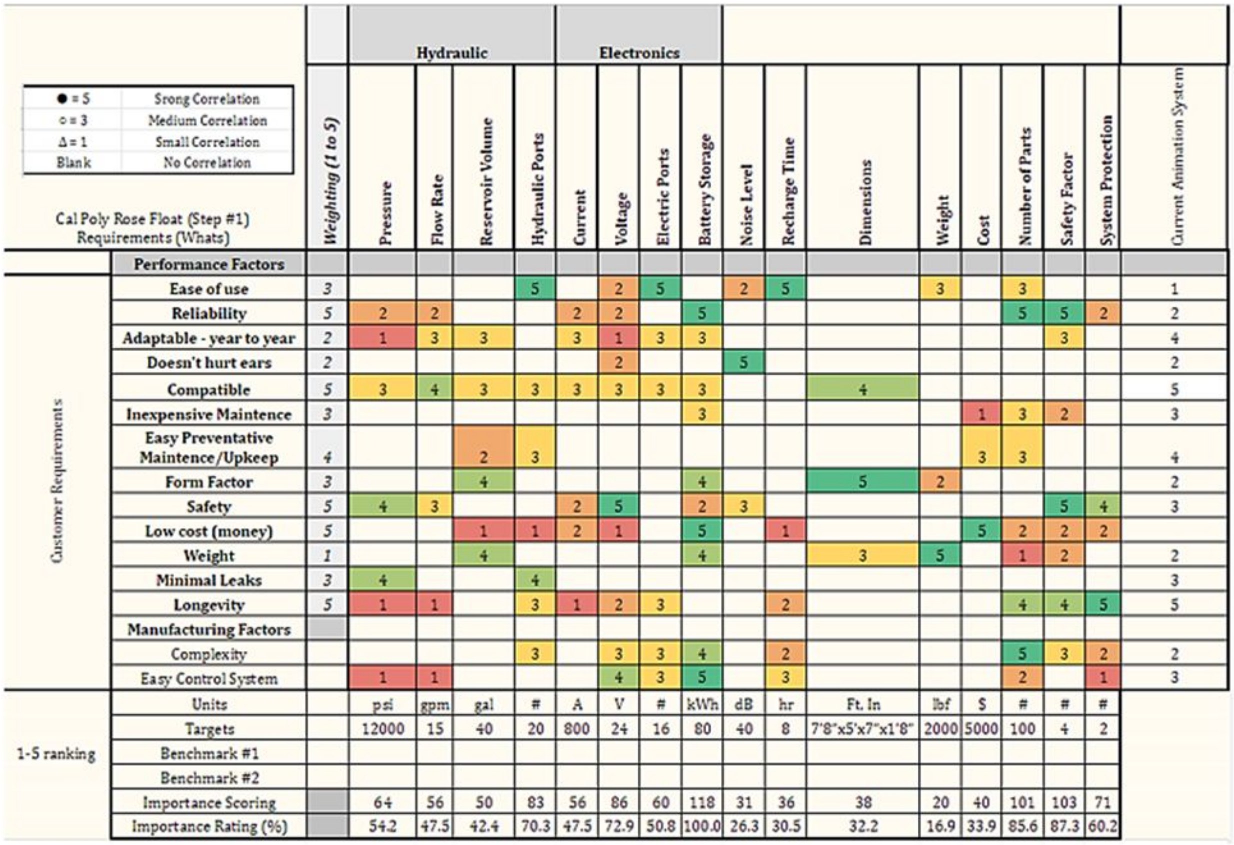
A. Amendments can be made using the following decision model.
B. Any member of heat can bring up any amendment.
C. Proposed amendment with a description of requested changes must be provided to all members and present on the agenda prior to the meeting.
D. Amendments require a four fifths majority with a members present to be implemented.

Section 9: Effective Date

A. This contract of the HEAT shall become effective on 4 October 2018.
B. Dates of amendment must be recorded in minutes of meetings at which amendments were approved, together with a revised set of bylaws.

Appendix E

Quality Function Deployment



● = 5	Srong Correlation
○ = 3	Medium Correlation
Δ = 1	Small Correlation
Blank	No Correlation

	Cal Poly Rose Float (Step #1) Requirements (Whats)		Hydraulic				Electronics												
		Weighting (1 to 5)	Pressure	Flow Rate	Reservoir Volume	Hydraulic Ports	Current	Voltage	Electric Ports	Battery Storage	Noise Level	Recharge Time	Dimensions	Weight	Cost	Number of Parts	Safety Factor	System Protection	Current Animation System
	Performance Factors																		
Customer Requirements	**Ease of use**	3				5		2	5		2	5		3		3			1
	Reliability	5	2	2			2	2		5						5	5	2	2
	Adaptable - year to year	2	1	3	3		3	1	3	3							3		4
	Doesn't hurt ears	2						2			5								2
	Compatible	5	3	4	3	3	3	3	3	3			4						5
	Inexpensive Maintence	3								3					1	3	2		3
	Easy Preventative Maintence/Upkeep	4			2	3									3	3			4
	Form Factor	3			4					4			5	2					2
	Safety	5	4	3			2	5		2	3						5	4	3
	Low cost (money)	5			1	1	2	1		5		1			5	2	2	2	
	Weight	1			4					4			3	5		1	2		2
	Minimal Leaks	3	4			4													3
	Longevity	5	1	1		3	1	2	3			2				4	4	5	5
	Manufacturing Factors																		
	Complexity					3		3	3	4		2				5	3	2	2
	Easy Control System		1	1				4	3	5		3				2		1	3
1-5 ranking	Units		psi	gpm	gal	#	A	V	#	kWh	dB	hr	Ft. In	lbf	$	#	#	#	
	Targets		12000	15	40	20	800	24	16	80	40	8	7'8"x5'x7"x1'8"	2000	5000	100	4	2	
	Benchmark #1																		
	Benchmark #2																		
	Importance Scoring		64	56	50	83	56	86	60	118	31	36	38	20	40	101	103	71	
	Importance Rating (%)		54.2	47.5	42.4	70.3	47.5	72.9	50.8	100.0	26.3	30.5	32.2	16.9	33.9	85.6	87.3	60.2	

Appendix F

Detailed Supporting Analysis

AC Loads	(W)	**DC Loads**	(W)
AMP	500	Crew Compartment Lights	24
Laptop	100	Crew Compartment Fans	96
Bubbles	100	20 Motors	720
2x air compressors	400	System Fans	480
cRio and M. Commander	100	Total	1320
2x Water Mech	600		
Total	1800		

	GPM	PSI	Current (A)	Voltage	HP	Watts	Time (Hrs)	kWh
Pump	13.32467532	1200	NA	NA	9.328827529	6956.506688	2.5	17391.26672
DC Load			110	12	1.770148853	1320	2.5	3300
AC Load				120	2.413839346	1800	2.5	4500
							Total Capacity:	25191.26672

Appendix G

Pugh Matrices

Pump	Datum				
	In-Line Piston Pump	**Gerotor Pump**	**Rotary Vane Pump**	**Gear Pump**	**Screw Pump**
Purchasability/How easy to come by	D	S	S	S	-
Capital Cost	D	-	-	+	-
O&M Costs	D	S	S	S	S
Functionality	D	-	S	-	-
Pressure	D	-	-	-	-
Efficiency	D	-	S	-	-
Max GPM	D	+	+	+	+
Size (dimensions)	D	S	S	S	S
Sum +	0	1	1	2	1
Sum -	0	-4	-2	-3	-5
Sum S	0	-3	-1	-1	-4

Power Unit	Datum						
	Propane V8 Engine	**Brushless DC Motor**	**Brushed DC Motor**	**AC Induction Motor**	**Synchronous Motor**	**Jet Turbine**	**4 Cylinder Engine**
Acquistions-ability	D	-	-	-	+	-	-
Capital Cost	D	+	+	+	+	-	+
O&M Costs	D	+	+	+	+	-	+
Functionality	D	-	+	-	-	-	-

Torque	D	-	-	-	-	+	-
HP	D	+	+	+	+	-	-
Max RPM	D	+	+	-	+	+	S
Size (dimensions)	D	+	+	+	+	-	+
Sum +	0	5	6	4	6	2	3
Sum -	0	-3	-2	-4	-2	-6	-4
Sum S	0	2	4	0	4	-4	-1

Configuration	Datum		
	One Engine One Pump	**One motor one pump**	**Many motors and pumps**
Acquistions-ability	D	S	+
Integratability	D	+	-
Modularity	D	S	+
Capital Cost	D	+	+
O&M Costs	D	+	S
Functionality	D	-	-
Size	D	+	+
Sum +	0	4	4
Sum -	0	-1	-2
Sum S	0	3	2

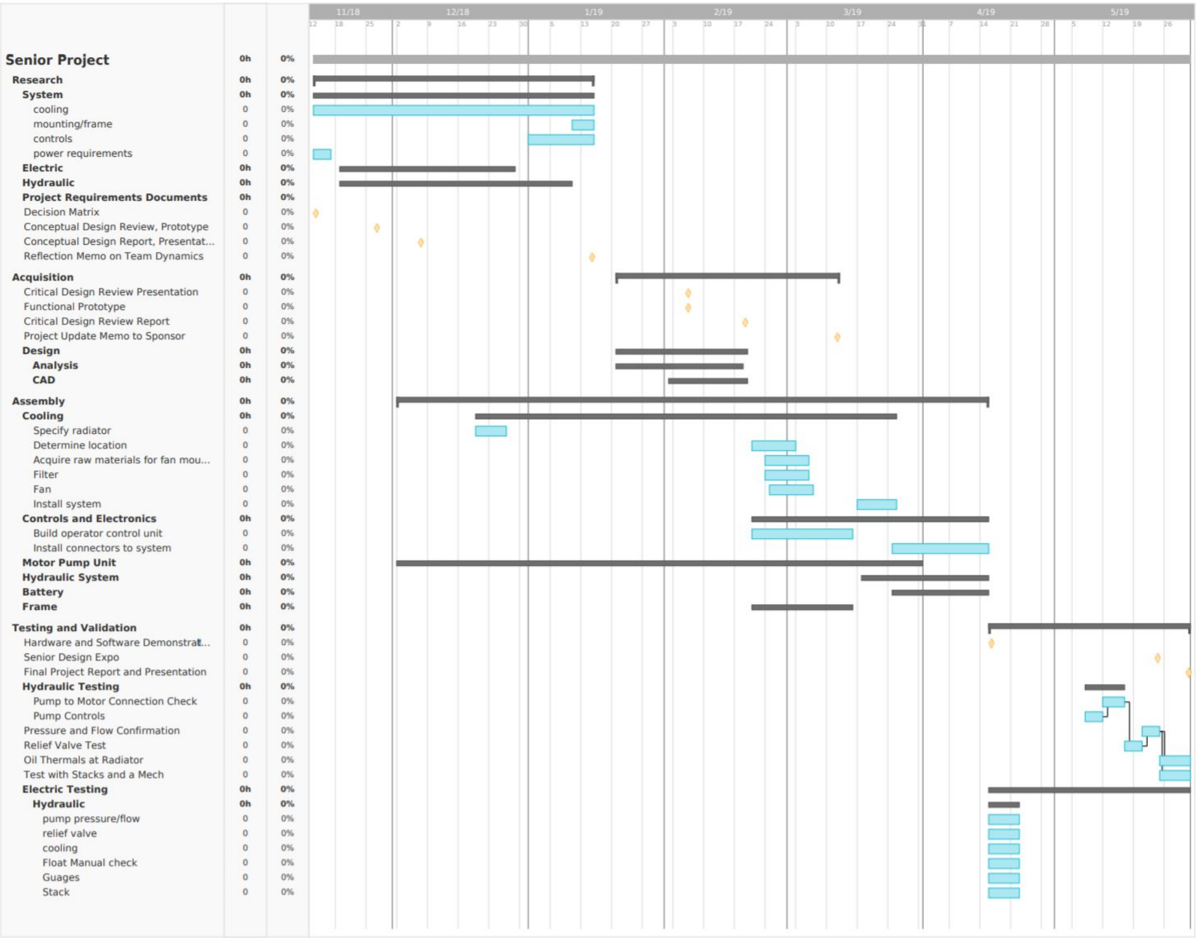
Energy Storage	Datum					
	Propane	**DIY from Cells**	**Tesla Vehicle Pack**	**Lead Acid Batteries**	**Lithium Pack**	**Capacitors**

Acquistions-ability	D	-	-	+	-	-
Capital Cost	D	-	-	-	-	-
O&M Costs	D	+	+	+	+	+
Functionality	D	-	+	-	+	-
Safety	D	-	+	+	+	-
Energy Density	D	-	-	-	-	-
Longevity	D	-	S	-	S	+
Future Technology	D	+	+	+	+	+
Size (dimensions)	D	-	-	-	-	-
Sum +		2	4	4	4	3
Sum -		-7	-4	-5	-4	-6
Sum S		-5	0	-1	0	-3

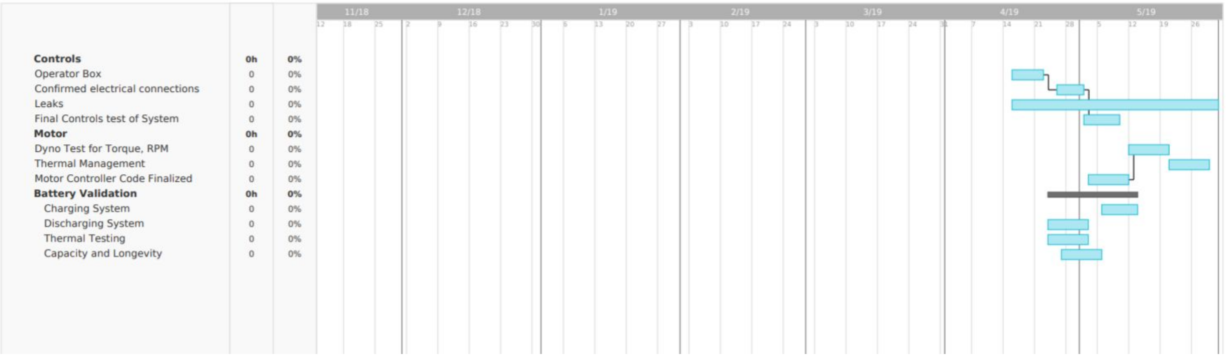
Cooling	Datum			
	Air cooled	**Water Cooled**	**Shell and tube**	**Tank/No cooler**
Feasibility	D	S	-	-
Capital Cost	D	-	-	+
O&M Costs	D	-	-	+
Functionality/Quality	D	+	S	-
Size (dimensions)	D	-	+	+
Sum +	0	1	1	3
Sum -	0	3	3	2
Sum S	0	-2	-2	1

Appendix H

Gantt chart of HEAT project



Senior Project	**0h**	**0%**
Research	**0h**	**0%**
System	**0h**	**0%**
cooling	0	0%
mounting/frame	0	0%
controls	0	0%
power requirements	0	0%
Electric	**0h**	**0%**
Hydraulic	**0h**	**0%**
Project Requirements Documents	**0h**	**0%**
Decision Matrix	0	0%
Conceptual Design Review, Prototype	0	0%
Conceptual Design Report, Presentat...	0	0%
Reflection Memo on Team Dynamics	0	0%
Acquisition	**0h**	**0%**
Critical Design Review Presentation	0	0%
Functional Prototype	0	0%
Critical Design Review Report	0	0%
Project Update Memo to Sponsor	0	0%
Design	**0h**	**0%**
Analysis	**0h**	**0%**
CAD	**0h**	**0%**
Assembly	**0h**	**0%**
Cooling	**0h**	**0%**
Specify radiator	0	0%
Determine location	0	0%
Acquire raw materials for fan mou...	0	0%
Filter	0	0%
Fan	0	0%
Install system	0	0%
Controls and Electronics	**0h**	**0%**
Build operator control unit	0	0%
Install connectors to system	0	0%
Motor Pump Unit	**0h**	**0%**
Hydraulic System	**0h**	**0%**
Battery	**0h**	**0%**
Frame	**0h**	**0%**
Testing and Validation	**0h**	**0%**
Hardware and Software Demonstrat...	0	0%
Senior Design Expo	0	0%
Final Project Report and Presentation	0	0%
Hydraulic Testing	**0h**	**0%**
Pump to Motor Connection Check	0	0%
Pump Controls	0	0%
Pressure and Flow Confirmation	0	0%
Relief Valve Test	0	0%
Oil Thermals at Radiator	0	0%
Test with Stacks and a Mech	0	0%
Electric Testing	**0h**	**0%**
Hydraulic	**0h**	**0%**
pump pressure/flow	0	0%
relief valve	0	0%
cooling	0	0%
Float Manual check	0	0%
Guages	0	0%
Stack	0	0%



Controls	**0h**	**0%**
Operator Box	0	0%
Confirmed electrical connections	0	0%
Leaks	0	0%
Final Controls test of System	0	0%
Motor	**0h**	**0%**
Dyno Test for Torque, RPM	0	0%
Thermal Management	0	0%
Motor Controller Code Finalized	0	0%
Battery Validation	**0h**	**0%**
Charging System	0	0%
Discharging System	0	0%
Thermal Testing	0	0%
Capacity and Longevity	0	0%

Appendix I

SENIOR PROJECT CONCEPTUAL DESIGN REVIEW HAZARD IDENTIFICATION CHECKLIST

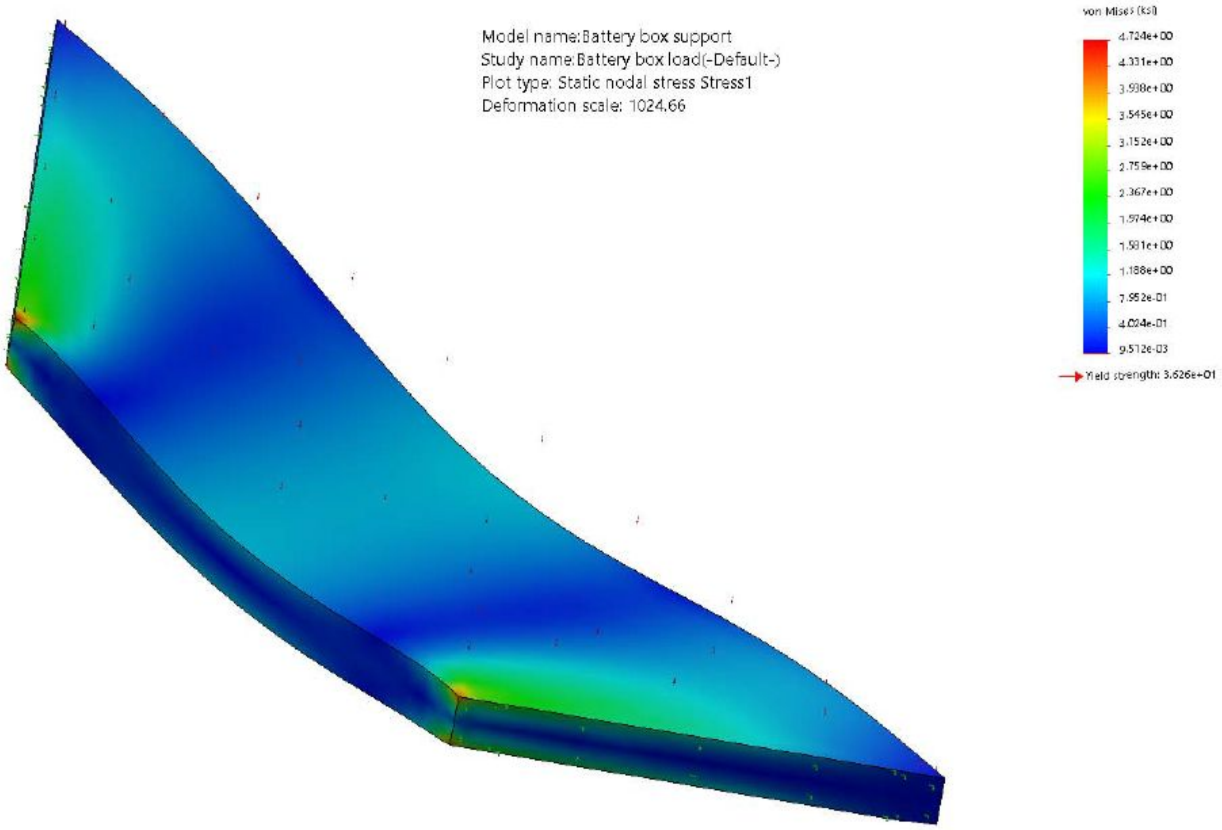
Yes	**No**	**Hazard Category**
☑	☐	Will any part of the design create hazardous revolving, reciprocating, running, shearing, punching, pressing, squeezing, drawing, cutting, rolling, mixing or similar action, including pinch points and sheer points? A 10HP motor will be spinning in the system. Additionally, fans for the radiators will be spinning. These hazards will be shielded physically or in locations not accessible to humans.
☑	☐	Can any part of the design undergo high accelerations/decelerations? The motor and connected pump will have internal components quickly accelerating or decelerating.
☑	☐	Will the system have any large moving masses or large forces? The motor and pump internals have large spinning masses. Large pressures will be exerted on the hydraulic system so hose and fitting pressure ratings will be closely monitored.
☐	☑	Will the system produce a projectile?
☐	☑	Would it be possible for the system to fall under gravity creating injury?
☐	☑	Will a user be exposed to overhanging weights as part of the design?
☐	☑	Will the system have any sharp edges?
☑	☐	Will all the electrical systems properly grounded? The battery system will be grounded to the frame to provide safety.
☑	☐	Will there be any large batteries or electrical voltage in the system above 40 V either AC or DC? 48V batteries will be present. The components will be rated for these voltages and proper insulating measures will be followed.
☑	☐	Will there be any stored energy in the system such as batteries, flywheels, hanging weights or pressurized fluids?

		A 25 kWh lithium battery pack will be used. Additional energy is stored in the hydraulic system.
☐	☑	Will there be any explosive or flammable liquids, gases, dust fuel part of the system?
☐	☑	Will the user of the design be required to exert any abnormal effort or physical posture during the use of the design?
☑	☐	Will there be any materials known to be hazardous to humans involved in either the design or the manufacturing of the design? Welding the frame together has hazardous components. Soldering electrical components uses lead. Manufacturing parts and assembling heavy components has their own hazards.
☐	☑	Can the system generate high levels of noise?
☐	☑	Will the device/system be exposed to extreme environmental conditions such as fog, humidity, cold, high temperatures ,etc...?
☑	☐	Will the system easier to use safely than unsafely? Through design of the operator controls, the system will only run if configured safely. Additionally, hazardous components like batteries will be enclosed to reduce accidental access.
☑	☐	Will there be any other potential hazards not listed above? If yes, please explain below? Hydraulic injection due to a leak in the hydraulic system.

Appendix J

FEA Results on the supports for battery enclosure

$$A_{individual} = 24\ in^2$$
$$P = F/A$$
$$F = 2000\ lb/4 = 500\ lb$$
$$P = 500\ lb/24\ in^2$$
$$P = 20.833\ psi$$



Model name:Battery box support
Study name:Battery box load(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 1024.66

$$\sigma_{max} = 4.724\ ksi$$
$$\sigma_{allowable,\,yield} = 36.26\ ksi$$
$$FOS\ on\ yield = 36.26/4.724 = 7.7$$

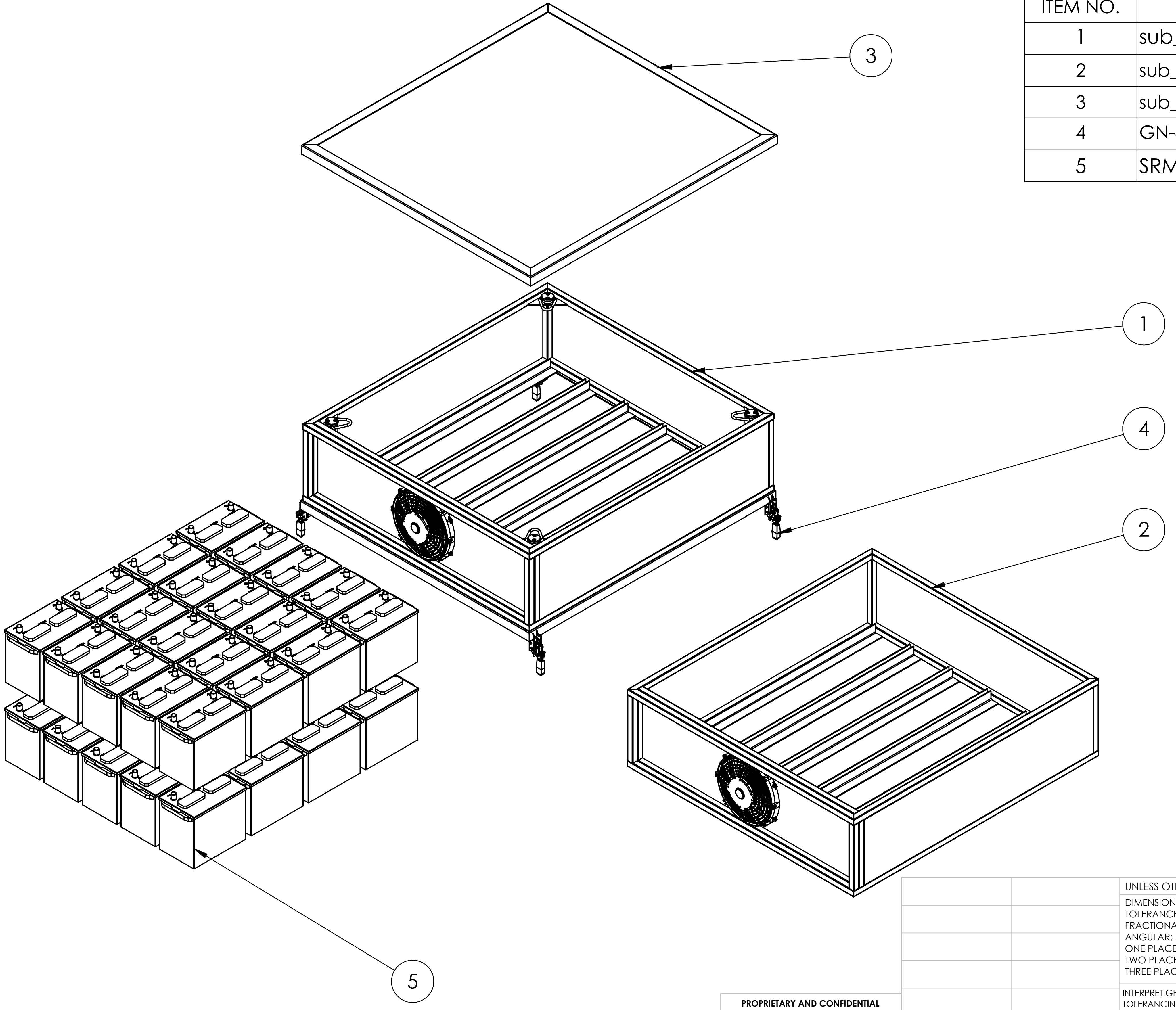
Appendix K

DVP&R													
Report Date			Sponsor									REPORTING ENGINEER:	
TEST PLAN										TEST REPORT			
						SAMPLES TESTED		TIMING		TEST RESULTS			
Item No	Specification or Clause Reference	Test Description	Acceptance Criteria	Test Responsibility	Test Stage	Quantity	Type	Start date	Finish date	Test Result	Quantity Pass	Quantity Fail	NOTES
1	Pressure Capacity	Pressure compensator set to 1200 psi. System run for 30 minutes. Hydraulics components monitored for failure and leaks.	1200 psi max	Dexter Yanagisawa	DV	30	Min	5/30/2019	5/30/2019	Pass	N/A	N/A	
2	Run Time	Batteries will be fully charged. System will be run at 1200 psi and 10 gpm until battery drains.	2.5 hours	Michael Cain	DV	3	Min	Summer	Summer				
3	Flow Rate Capacity	Flow meter will be placed onto pressure line coming out of the pump. Flowrate will be read of gauge.	10 gpm	Dexter Yanagisawa	DV	10	Min	Summer	Summer				
4	Operators Required	Simulating Parade conditions, can the system be used as intended minimal operators.	1 Operator	Tyler Couvrette	DV	1	Max	5/30/2019	5/30/2019	Pass	N/A	N/A	
5	Physical Size	System placed into blue frame.	67" by 92" by 20" Max	Dexter Yanagisawa	DV	1	Check	5/30/2019	5/30/2019	Pass	N/A	N/A	
6	Battery Charge Time	Can the battery pack start at empty and be filled to capacity in a reasonable duration	8 hours	Michael Cain	DV	2	Check	Summer	Summer				
7	Battery Voltage Range	During Charging and Discharging cycles, are the systems shut off at prescribed voltages to protect batteries	44-58V or 11-14.5V	Tyler Couvrette	DV	2	Min/Max	6/8/2019	6/8/2019	Pass	N/A	N/A	
8	Controls	Do the controls work as anticipated	Check		DV	1	Check	5/30/2019	5/30/2019	Pass	N/A	N/A	
9	Temperature of Hydraulic Fluid	Temperature of Fluid after full duration test run	190 degrees F max	Dexter Yanagisawa	DV	1	Max	Summer	Summer				
10	Temperature of Batteries	Battery temperature after max discharge and duration	80 degrees F	Michael Cain	DV	4	Max	Summer	Summer				
11	Leak Test	System will be charged to 1200 psi and isolated. Pressure will be monitored. If pressure falls, leaks are present.	600 psi drop	Dexter Yanagisawa	DV	1	Max	Summer	Summer				
12	Sound Test	Under expected load, monitor system for loud or unplesant noise	60 dB	Dexter Yanagisawa	DV	1	Max	Summer	Summer				
13	Wiring Test	Monitor Wiring for heat spots and	Check	Michael Cain	DV	1	Check	Summer	Summer				

Appendix L

This includes all of the Solidworks drawings done of the subsystems of the final design

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	sub_top	batteries, frame, top	1
2	sub_bottom	batteries, frame, bottom	1
3	sub_cover	batteries, cover	1
4	GN-851-3-320-T6	batteries, clamp	4
5	SRM-24	batteries, batteries	40



105	MAIN ASSY
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/4
ANGULAR: MACH ±2°
ONE PLACE DECIMAL ±.1
TWO PLACE DECIMAL ±.05
THREE PLACE DECIMAL ±.01
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL SEE NOTE 1
FINISH N/A
DO NOT SCALE DRAWING

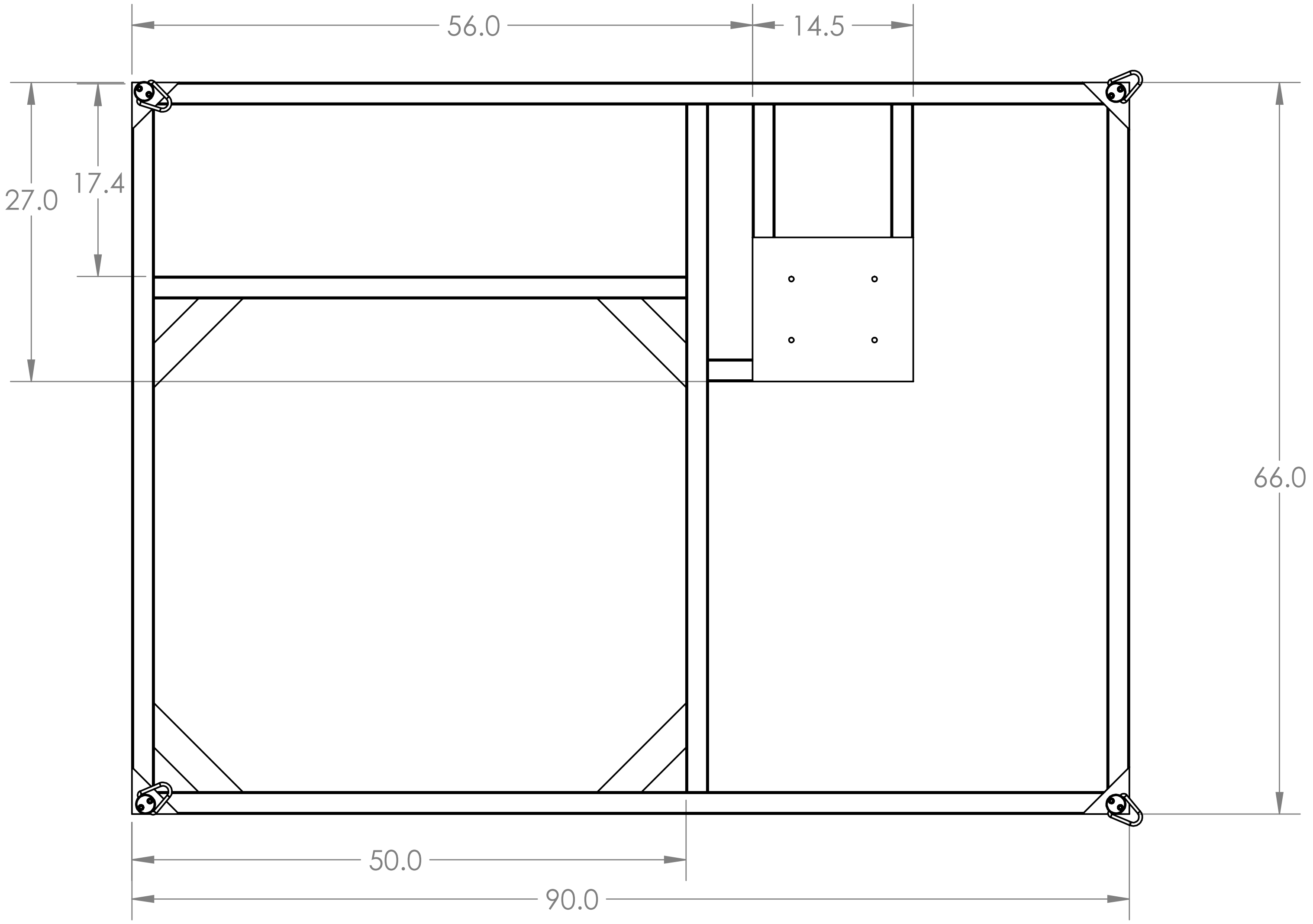
	NAME	DATE
DRAWN	DKY	6/7/2019
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

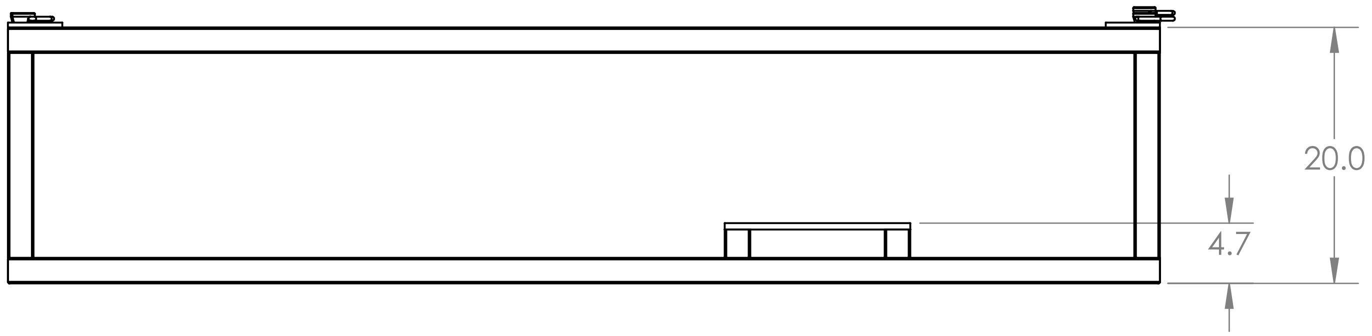
HEAT

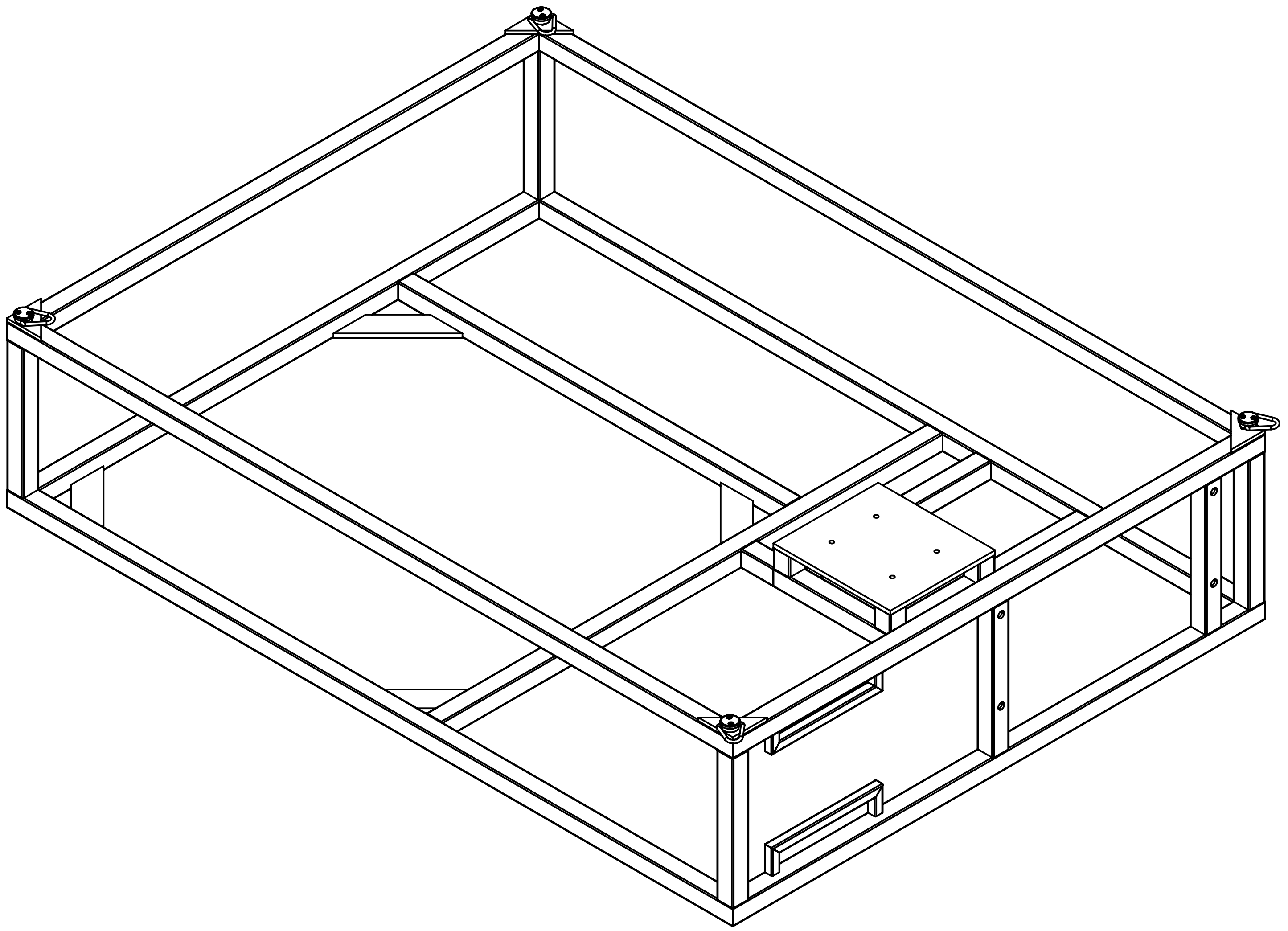
TITLE:

Batteries

SIZE **B**
DWG. NO. 016
REV 01
SCALE: 1:15
WEIGHT: N/A
SHEET 1 OF 1







PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF Cal Poly Rose Float. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF Cal Poly Rose Float IS PROHIBITED.

105	MAIN ASSY
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/4
ANGULAR: MACH ± 2°
ONE PLACE DECIMAL ± .1
TWO PLACE DECIMAL ± .05
THREE PLACE DECIMAL ± .01

INTERPRET GEOMETRIC
TOLERANCING PER:

MATERIAL
SEE NOTE 1

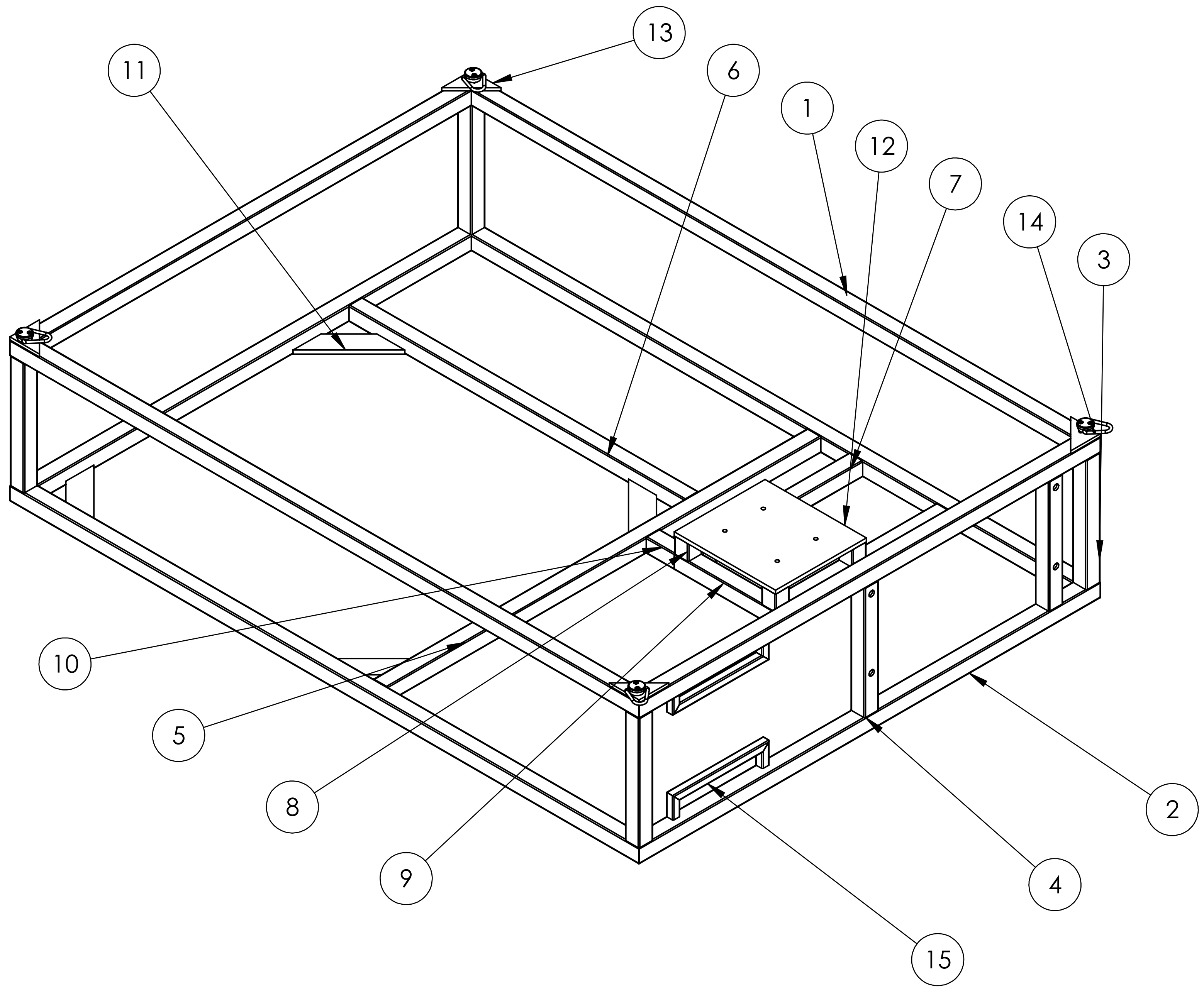
FINISH
N/A

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	DKY	6/7/2019
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

TITLE:
HEAT
Frame

SIZE B
DWG. NO. 016
REV 01
SCALE: 1:15
WEIGHT: N/A
SHEET 1 OF 2



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	2_x_2	frame, side, long	4
2	2_x_2	frame, side, short	4
3	2_x_2	frame, upright, corner	4
4	2_x_2	frame, mount, reservoir	2
5	2_x_2	frame, support, across	1
6	2_x_2	frame, support, battery box	1
7	2_x_2	frame, support, motor, long	2
8	2_x_2	frame, upright, motor	4
9	2_x_2	frame, support, motor, short	1
10	2_x_2	frame, support, connector	1
11	plate_support	frame, mount, battery box	4
12	motor_mount	frame, mount, motor	1
13	hoist_mount_frame	frame, mount, hoist	4
14	29505T21	frame, hoist	4
15	radiator_mount	frame, mount, radiator	2

105	MAIN ASSY
NEXT ASSY	USED ON
APPLICATION	

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TOLERANCES:
FRACTIONAL ±1/4
ANGULAR: MACH ±2°
ONE PLACE DECIMAL ±.1
TWO PLACE DECIMAL ±.05
THREE PLACE DECIMAL ±.01

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL
SEE NOTE 1

FINISH
N/A

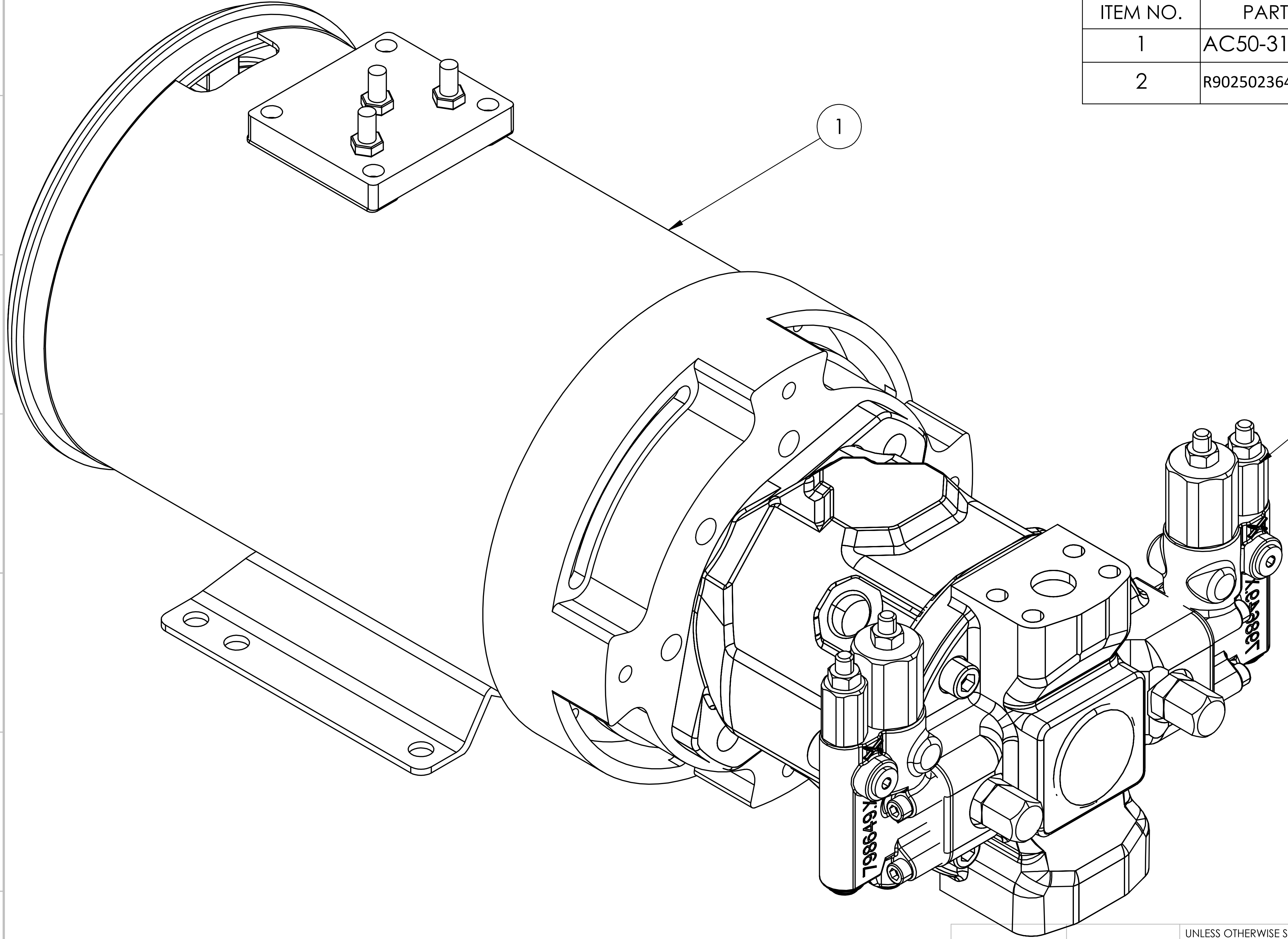
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	DKY	6/7/2019
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

TITLE:
HEAT
Frame

SIZE	DWG. NO.	REV
B	016	01
SCALE: 1:15	WEIGHT: N/A	SHEET 2 OF 2

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	AC50-31.73.8	power, motor	1
2	R902502364-001	power, pump	1



PROPRIETARY AND CONFIDENTIAL

105	MAIN ASSY
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/4
ANGULAR: MACH ±2°
ONE PLACE DECIMAL ±.1
TWO PLACE DECIMAL ±.05
THREE PLACE DECIMAL ±.01

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: SEE NOTE 1

FINISH: N/A

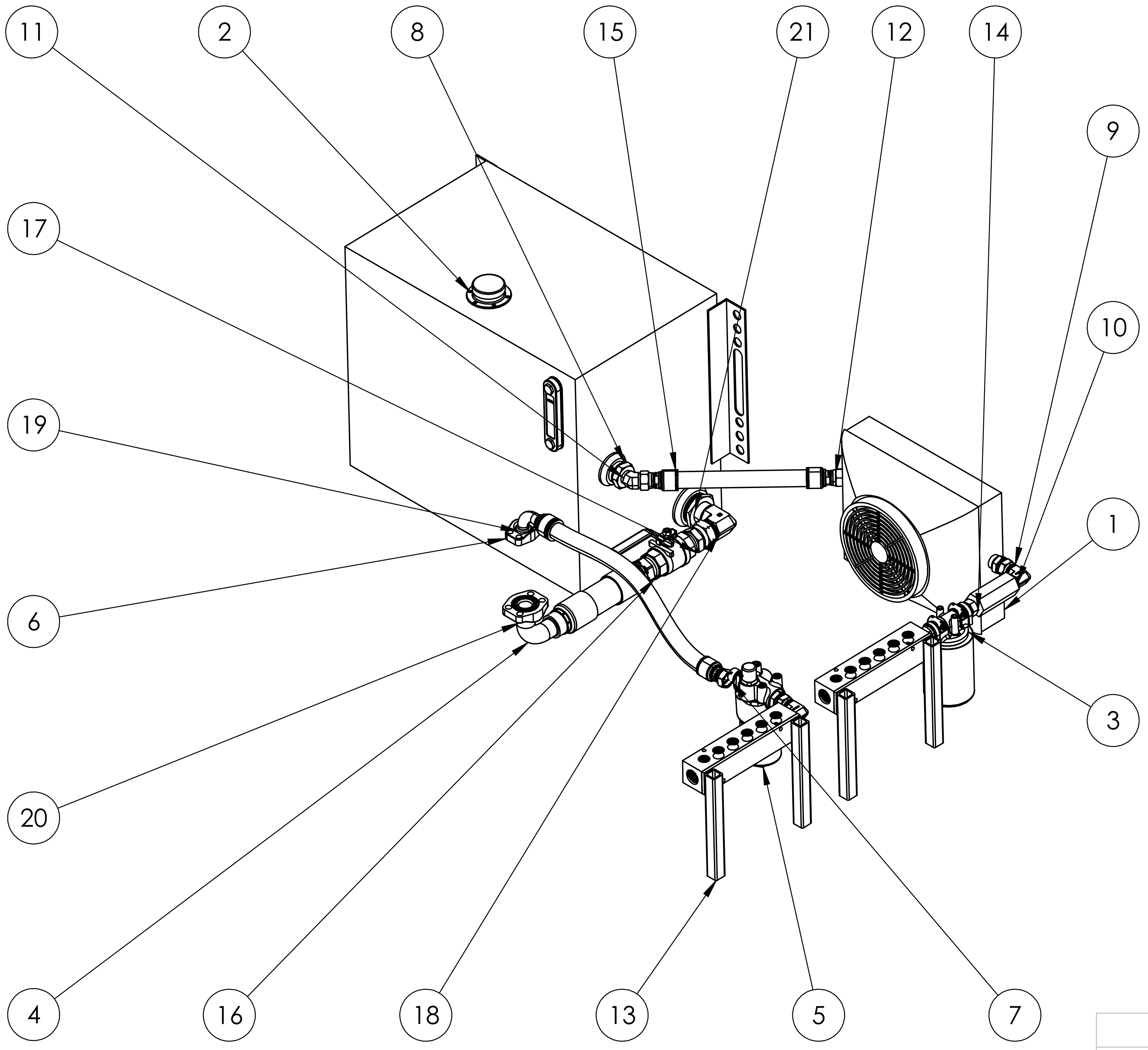
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	DKY	6/7/2019
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

TITLE:
HEAT
Power

SIZE	DWG. NO.	REV
B	016	01

SCALE: 1:2
WEIGHT: N/A
SHEET 1 OF 1



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	D10-12	hydraulic, radiator	1
2	A-3300	hydraulic, reservoir	1
3	12AT25CN25BBN	hydraulic, filter, low pressure	1
4	hose_suction	hydraulic, hose, suction	1
5	2109N11	hydraulic, filter, high pressure	1
6	Hidraulic Flange Connection-0,75''-Code 61	hydraulic, flange, -12	1
7	6401-12-12	hydraulic, fitting, straight, ORB-NPT	3
8	5406-20-12	hydraulic, fitting, reducer, NPT-NPT	1
9	1501-12-12	hydraulic, fitting, 90, NPT-NPT	2
10	CIT-06-5-2090	hydraulic, check valve	1
11	2503-12-12	hydraulic, fitting, 45, NPT-JIC	1
12	6802-12-12	hydraulic, fitting, 45, ORB-NPT	1
13	Sub_Manifold_Frame	hydraulic, mount, manifold	2
14	5404-12-12	hydraulic, fitting, straight, NPT-NPT	1
15	hose_lp	hydraulic, hose, low pressure	1
16	DB2-2-NPT	hydraulic, ball valve	1
17	5404-20-20	hydraulic, fitting, straight, NPT-NPT	1
18	1501-20-20	hydraulic, fitting, 90, NPT-NPT	1
19	hose_hp	hydraulic, hose, high pressure	1
20	Hidraulic Flange Connection-1,25''-Code 61	hydraulic, SAE flange, -20	1
21	4513K525	hydraulic, fitting, reducer, NPT-NPT	1

PROPRIETARY AND CONFIDENTIAL

105	MAIN ASSY
NEXT ASSY	USED ON
APPLICATION	

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FRACTIONAL±1/4
ANGULAR: MACH±2°
ONE PLACE DECIMAL ±.1
TWO PLACE DECIMAL ±.05
THREE PLACE DECIMAL ±.01

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL
SEE NOTE 1

FINISH
N/A

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	DKY	6/7/2019
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

HEAT

TITLE:

Hydraulics

SIZE **B**
DWG. NO. 016
REV 01

SCALE: 1:10
WEIGHT: N/A
SHEET 1 OF 1