Water Well Drilling Rig

Final Project Report

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List of Nomenclature

Aquifer: an underground water-bearing stratum of permeable rock, sand, or gravel

Bailer: a long, cylindrical container fitted with a valve at its lower end, used to remove water, sand, mud, drilling cuttings, or oil from a well in cable-tool drilling

Cholera: a water-borne disease, which can spread rampantly when clean water and proper sanitation are not available

Crown Block: The fixed set of sheaves located at the top of the derrick, over which the drilling line is threaded

Derrick: a framework erected over a well for boring, bailing, and lowering casing

Developing world: countries and regions where low per capita income levels and low levels of industrialization exist

Drill string: the assembled set of tools that go subsurface to create the bore for the well; typically comprised of a wire rope, rope socket, drill stem, drill bit and a jar

Dressing: new material welded onto the end of the drill bit where it has become worn

Drilling mud: primarily water, with a thickening agent, In most cases bentonite clay, used during the drilling process both to keep the borehole open and to cause drilled cuttings to float closer to the surface

Guy wire: A rope or cable used to steady a mast or pole.

Jar: a tool used in the drillstring for imparting an upward or downward jar or jolt to the drillpipe should it get stuck in the hole while drilling

Left/Right-Hand Lay Cable: wire rope laid in a helix shape and in a directional wrapping that causes the winding to tighten/loosen during percussive drilling

Pitman Arm: a metal lever which transmits force from the rotating flywheel to the walking beam

Rope socket: a device that connects the drill stem to the wire rope; allows the drill stem to rotate during operation

Sedimentary Rock: rocks created by the gradual compaction and hardening of soils and/or minerals slowly deposited over time and is one of the major groups of rock that makes up the crust of the Earth

Sheave: a wheel or roller with a groove along its edge for holding a belt, rope or cable

Stack valve: allows for selection of a particular type of valve for each hydraulic system

Walking Beam: a mechanism that oscillates at one end and pivots around the other to operate with the pitman arm for transmitting rotary motion from the flywheel to vertical fluctuating motion of the drill string, therefore producing the required motion for drilling

Wire rope: a rope made of small strands of twisted wire around a fiber core; used interchangeably with cable

Abstract

In this report, the improvements of a previously produced cable tool drilling rig are described. The purpose of the rig is to drill water wells for use in Africa in order to provide safe drinking water to many in need. An affordable, effective, and controllable rig is the design goal for this project. With the San Luis Obispo Rotary Club sponsoring the project the design team of WHole Engineering have made necessary design choices to manufacture the product. Actions performed include background research of existing drilling technologies, analysis of top concepts for the controlling mechanism, and selection for the final design. The drilling rig will be modified in many ways to increase control, safety, and provide adequate drilling capabilities. The final design will be operated by a hydraulic system, using chains and sprockets to transmit power to the necessary mechanisms, rather than the tension belts that were present when the design team was assigned to the project.

Chapter 1: Introduction

Sponsor background and Need

Lifewater International and the Rotary Club's main purpose are to bring clean water to those without access. There are approximately 1.1 billion people worldwide whom cannot access clean drinking water within their means. Unclean water can lead to the spread of disease such as cholera and also inhibit the production of food. Sub-Saharan Africa is one area of the world that is in desperate need for a solution to acquire clean drinking water. Beginning in fall 2008, Cal Poly mechanical engineering students have aided in this need by designing a portable water well drilling rig. A drill rig would make potable water that is stored in aquifers approximately 100 feet below the earth's surface obtainable. The Rotary Club would like a design that can be reproduced in Africa so entrepreneurs can manufacture the rig there to help their economy grow as well. Jobs would be created from manufacturing and operating the rig as well. It must be manageable to operate and repair in these developing nations as well. Current affordable rigs do not meet the requirement to get through the geology of Africa. Soil in these countries is composed of either crystalline Precambrian basement rock or consolidated sedimentary rock, which the common affordable rotary drilling rig cannot penetrate. A cable tool drill rig will meet the sponsor's need and is what they have requested. As of January 2010, the stakeholders in this project include the design team of WHole Engineering along with the Rotary Club, those that suffer from lack of potable water and possible businessmen in developing countries.

Problem Definition

WHole Engineering is required to improve the design of an existing cable tool rig for production and use in Sub-Saharan Africa. Major modification includes a controllable drive system powerful enough to drill with a 600 pound bit. A second, stronger drill string must be added for effective drilling. This product must be proven safe and efficient at drilling to the water table using a small gas engine. A bit sized for creating a four inch diameter hole to a depth of 100 ft is required. Overall weight is desired not to exceed the towing capacity of small trucks.

Objective/Specification Development

The primary objective is to improve the cable tool drilling rig designed by Cal Poly students that was completed in June 2009. This current device does not meet the customer's specifications set forth in October 2008. The members of WHole Engineering intend to complete the drilling rig so that it meets the customer specifications set in the Table 1 below. This table was produced from sponsor requirements and from our House of Quality design matrix, which can be seen in Appendix A.

Table 1 Design specifications

Spec #	Parameter Description	Requirement or Target (units)	Tolerance	Risk	Compliance
1	Drilling Depth	100 feet	Min	H	A, T
2	Bore Diameter	4 inches	Min	L	S, T
3	Drill Bit Weight	600 lb	Min	H	A, I
4	Safety	0 exposed gears/pulleys	Max	H	I, T
5	Operators	2 Trained Operators	Target	L	A,T
6	Drilling components	3 bits	Min	M	A
7	Robust Design	20 Wells	Min	M	A, S
8	Transportability	3000 lbs	Max	M	I
9	Horizontal Sway	6 inches	Max	M	A, T
10	Operation Speed	50 – 60 rpm	Target	L	A, T

Risk is characterized by high (H), medium (M), and low (L).
Compliance shall be confirmed using analysis (A), inspection (I), similarity (S), and/or test (T).

Discussion of Specifications

Specification 1

The drilling rig shall be capable of drilling to a depth of at least 100 ft. The rationalization being those 100 feet would be the depth at which the water table would be reached. The customer has experience with the water table being located at a maximum depth of 75 to 100 feet in the region that the drilling rig shall be used. Currently the rig does not operate properly, so this is a high risk.

Specification 2

The bore diameter designed for shall be 4 inches. This specification comes from the customer requirement to generate a well large enough for a hand pump to be installed into the well. A hole smaller than 4 inches would not be adequate for the end user so it must be at least 4 inches. Most bits used for drilling wells are a minimum of 4 inches, so there is low risk of meeting this goal.

Specification 3
The weight of the drill bit shall be a minimum of 600 pounds. A smaller weight would not be capable of cutting through the ground material that has been described by the customer. The team shall produce a drilling rig capable of operating this size bit, and also acquire a bit for use. The current rig originally was designed to lift a 200 pound bit, so this is a high risk.

Specification 4
The machine shall have no exposed gears, belts, or pulleys. This comes from the customer requirement to have a safe machine that will not injure operators. Due to the nature of the project with heavy machinery in motion, there is a high risk of meeting this goal.

Specification 5
The drilling rig shall be capable of being operated by two trained operators minimum required for operation. Rational for this specification is for safety and ease of operation. Even though this measurement is a minimum the operation complexity should only dictate more than two skilled laborers. Many operators are available, and training is available for the users of this rig, so there is a low risk of meeting this goal.

Specification 6
The drill shall be delivered with a minimum of three drilling attachments. The justification for this specification comes from the need to be able to drill through multiple types of geological material. There must also be a bailer capable of removing material from the bore. A moderate risk is present for meeting this goal due to availability.

Specification 7
The design shall be robust and capable of producing at least twenty wells before requiring major components replaced. This specification does not include routine maintenance and implies that proper user care was taken. Drill bit life is not included in this quantity. There is a moderate risk of this goal being met since endurance testing has not been done.

Specification 8
The combined towing weight shall not be greater than 3000 pounds. This specification comes from the average towing capacity of small size trucks. A moderate risk is present for this specification since part of redesigning this rig is to add weights and components.

Specification 9
The rig shall not sway more than 6 inches in the horizontal direction while in operation. A larger sway would lead to instability and be a safety concern. This specification will be verified through testing and analysis. A moderate risk is present to meet this goal since it has not been proven to handle the loads we will be placing on this rig.

Specification 10

The flywheel of the drilling rig shall operate between 50 and 60 rpm. This is the optimum drilling speed for cable tool drilling rigs. A slower speed will not produce the adequate drilling force and a faster speed will be a safety issue. This specification will be verified through testing. The risk is low for meeting this specification due to the current rig meeting this specification.

Project Management

Due to the complicated nature of the machine each team member will be assigned various aspects of the project. The drilling rig has been broken up into design subsystems that each team member will be responsible for. A list of each group member and his responsibilities is provided below:

Thad Jablonski

- Primary Sponsor Contact
- Financial Planning
- Ordering Parts
- Bearing/Bushing analysis
- Brake comparison and design

Coel Schumacher

- Fabrication analysis
- Stress Testing
- Clutch research and design
- Tooling research and production
- Control placement and interface

Alex Wargnier

- Project progress
- CAD drawings
- Testing Planning and documentation
- Transmission analysis
- Shaft calculations
- Motor sizing and interface

Schedule

Our project must move along according to a predetermined schedule to ensure project completion. Milestone occurrences for this project include:

Receive drilling rig	January 23, 2010	√
Initial test run of rig	January 23, 2010	√
Analysis of design improvement concepts		
• Motor sizing	February 23, 2010	√
• Hydraulic system design	February 25, 2010	√
• Chains and sprockets	March 9, 2010	√
• Brake system for main spool	March 11, 2010	√
Remove Old Components	April 2, 2010	√
Order Components		
• Steel for spool, derrick extension, and more	March 30, 2010	√
• Hydraulic motors/pumps	March 30, 2010	√
• Sprockets	April 30, 2010	√
• Chains	May 12, 2010	√
• Hydraulic hoses and fittings	May 12, 2010	√
• Final parts ordered	May 25, 2010	√
Manufacture		
• Mount the walking beam	March 30, 2010	√
• Extend the derrick	April 27, 2010	√
• Majority of frame modifications complete	April 30, 2010	√
• Fabricate/Mount Spools	May 4, 2010	√
• Mount motors and pumps	May 8, 2010	√
• Install sprockets	May 12, 2010	√
• Install Chains	May 25, 2010	√
• Mount hydraulic hoses, control valves, and reservoir	May 25, 2010	√
• Manufacture pitman arm	May 28, 2010	√
• Complete Top Sheave mount	May 30, 2010	√
• Initial run of hydraulic system	June 3, 2010	√
• Complete ML Brake Fabrication	June 8, 2010	√
• Complete manufacturing	June 11, 2010	√
Test new system		
• Dry run of assembled system	October 7, 2010	√
• Initial drilling test	October 12, 2010	√
• Observe any areas for improvement	October 12, 2010	√
• Continue drilling to test performance	November 6, 2010	√
• Test a new area for versatility	November 6, 2010	√

Chapter 2: Background

Existing Drilling Products

Manual Drilling – Manual drilling methods include boring and driving. In boring a spiral or hand auger is spun in order to dig into the earth. Shaft extensions are attached as needed to reach the necessary depths. Driving involves using a pointed tool attached to pipe with a weight on the end that acts as a hammer. The tool is pounded into the ground until it can no longer go any further or the water table is reached. Boring and driving are limited to the strength of their operator and cannot get through the metamorphic rock that exists throughout much of Africa. (Gibson, 1971)

Rotary drilling – In rotary drilling a downward force is applied to a bit that rotates or rolls in order to produce a crushing or chipping action on the material. A pit is filled with water to create mud, which then is pumped down the hole via the drill pipe and serves as the drilling fluid. The mud caries the cuttings up to the top of the well while drilling is underway. Although rotary drill work well in soft soils, they are extremely slow in rock formations and require a large amount of water to drill, which may not be available in some remote areas. The schematic to the right (Figure 1) shows the workings of Lifewater's LS-100, a small, portable, rotary drill. (Lifewater, 2010)

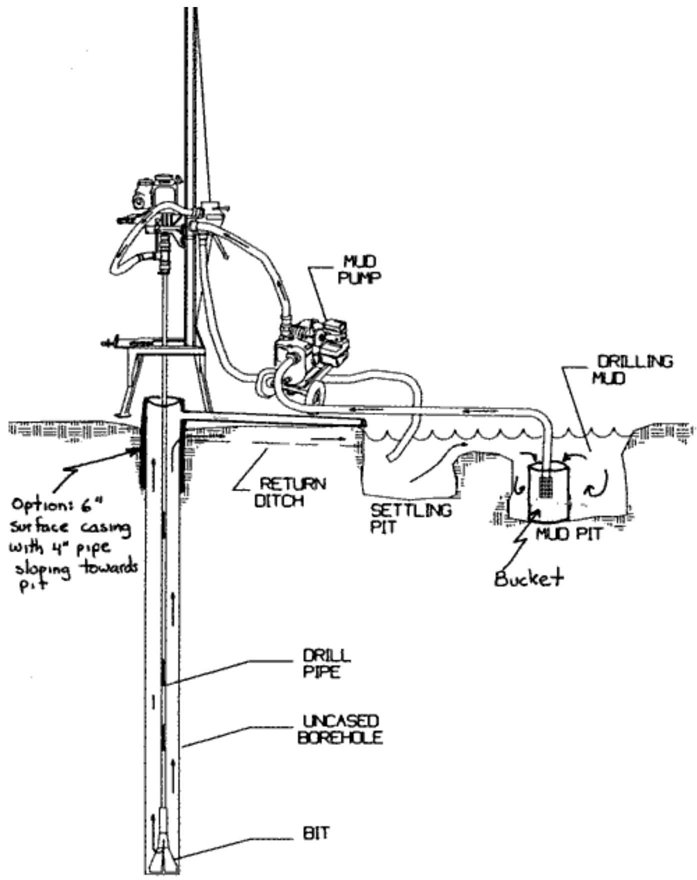

Figure 1: Schematic of Lifewater LS-100 (http://www.lifewater.ca/Section_3.htm)

Jetting – This process involves forcing high pressure water through the end of a bit in order to wash away cutting. It is part of the rotary drilling method and can also be used as an addition to cable tool drilling. (Michael, 2008)

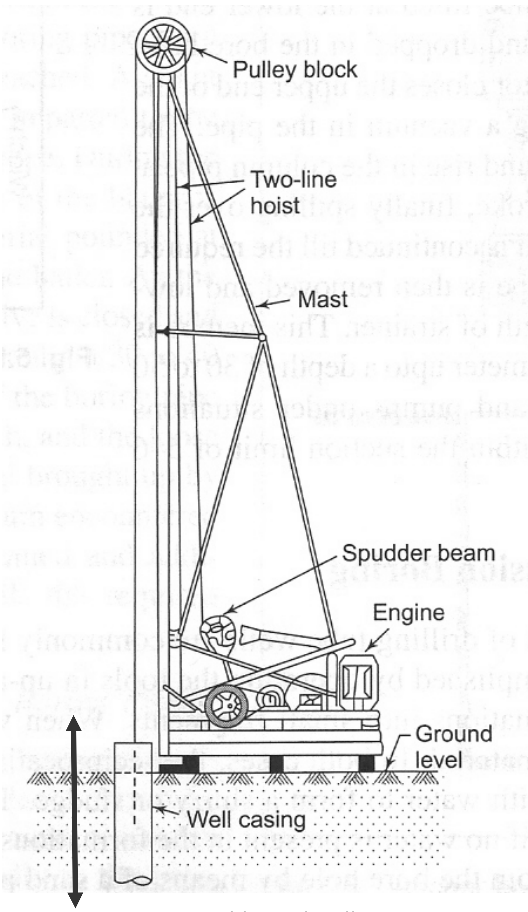

Figure 2: Cable Tool Drilling Rig
(Michael, 2008)

Cable tool drilling – This method of drilling involves picking up and dropping a large weight attached to a drill bit. The engine produces circular motion which is converted to vertical oscillations via a pitman arm attached to the walking beam (spudder beam). The walking beam is attached to the drill cable which moves the drill string up and down. It is this pounding action that enables cable tool drill rigs to drill through all types of ground conditions including rock. Well casing is used for the entire depth of the hole to ensure collapse does not occur. Figure 2 provides the basic layout of a typical cable tool drill rig. The Bucyrus-Erie 22W is one of the most common types of cable tool drill rigs in operation today. These machines weigh 9,750 pounds and are capable of drilling to depths greater than 1000 feet. The masts of these machines are 40' tall and are either truck or trailer mounted. The 22W is the smallest drill rig that was produced by Bucyrus-Erie. (Pees, 2010)

The previous team decided on a cable tool drilling rig mounted on a trailer due the requirements by the sponsor, and due to cost and transportability. Tim Cleath, project sponsor and hydro-geologist, informed the team that the majority of the geology the rig will face will be Precambrian metaphoric rock and consolidated sedimentary rock. Cable tooling is the only portable drilling method that will be able to efficiently and effectively drill through this geology. Larger, more expensive machines would be able to drill, but the goal of this project is produce a relatively inexpensive, portable machine.

A simplified drawing of components of a cable tool rig is provided in Figure 3 on the next page.

Current State of the Art

The most common current technique used to drill water wells uses a rotary drill rig, or other types that are large and expensive. These machines are not affordable for Africans, and not effective at punching through basement rock that exists in the geology of Africa. Cable tool rigs have not been produced in significant quantity in the last 30 years.

Basic components and operation

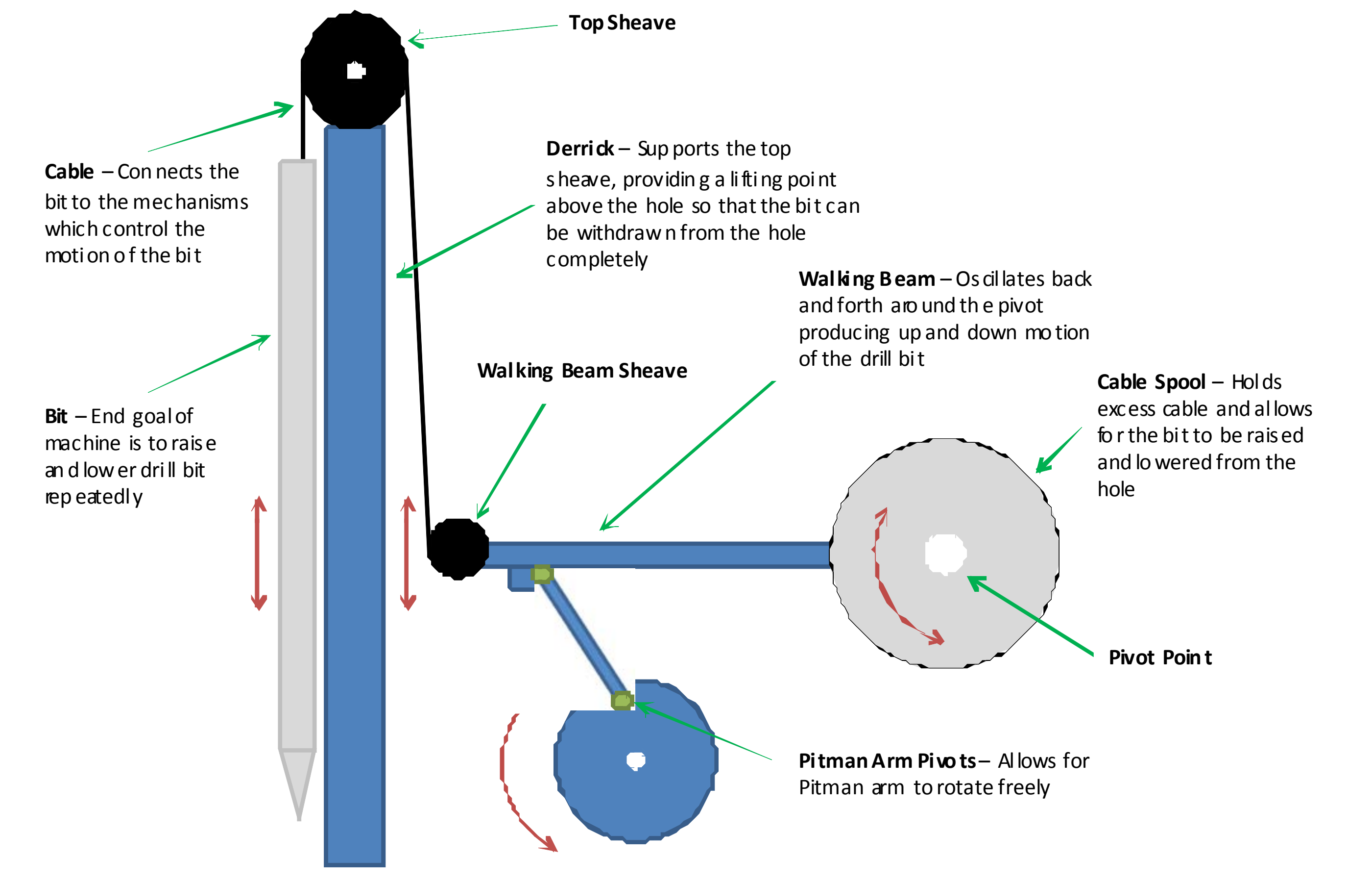

Figure 3 Simplified Cable Tool Rig Components

Previously Designed Cal Poly Rig

The Whole Engineering team has to fully understand how the current rig functions and its limitations before any redesign can occur. The drilling rig is powered by a Honda 13 HP gasoline engine attached to a centrifugal clutch. At 800 rpm the clutch engages to transmit power to the main power shaft at the top of the rig seen in Figure 4. Power can be transmitted to either the main spool or the walking beam using the control levers located at the front of the rig seen in Figure 5. The levers apply pressure to the belts, which serve as the clutching mechanism. While the walking beam is running, the spool needs to be held in place using the disk brake seen in Figure 5.

There are several problems that have been identified with the machine. One problem is that the belt clutching system does not function properly. The belts engage at unwanted times and fail to engage when required to. This inhibits proper drilling and is a major safety concern. Additionally, the brake easily engaged and does not allow cable to be let out while drilling. The members of WHole engineering will be redesigning the power transmission system of the rig in order to solve the control issues as well as adding a fully functioning brake. There are many other changes that will be made to the rig, which will be documented as the design develops.

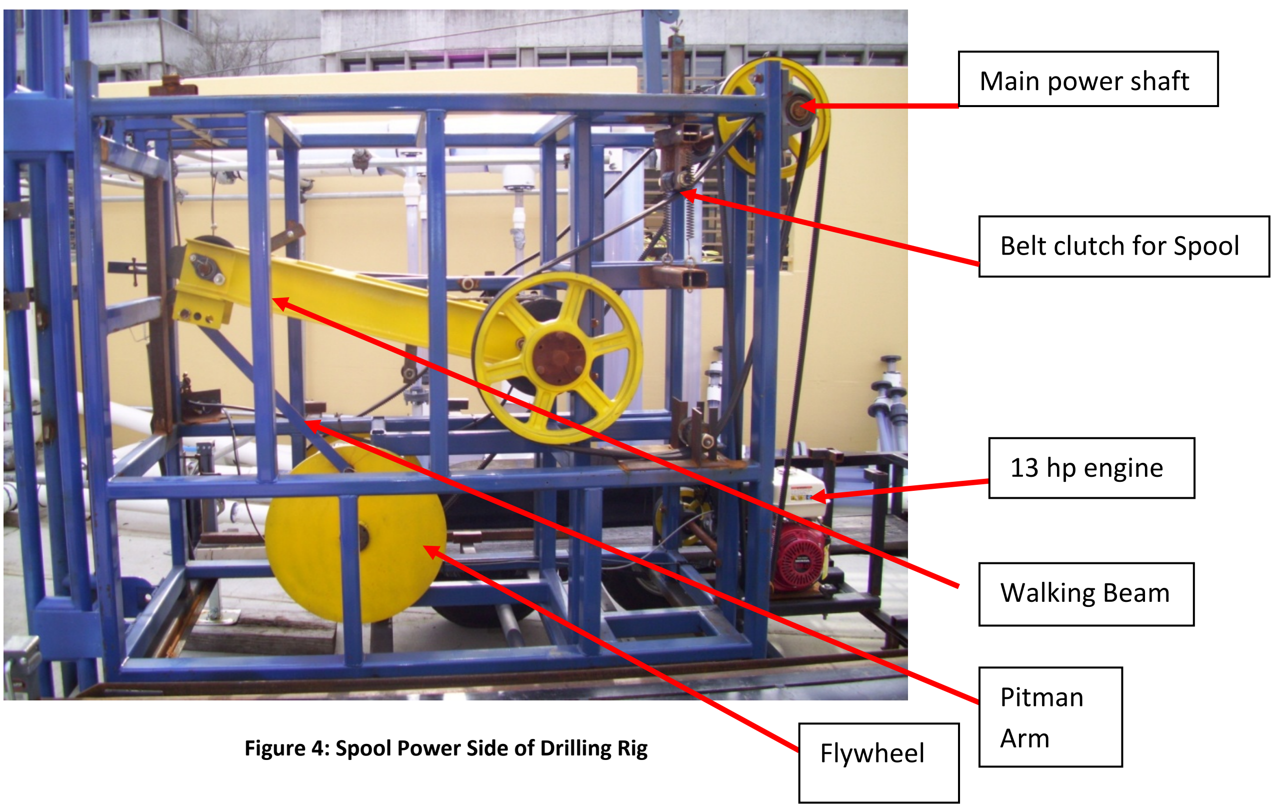

Figure 4: Spool Power Side of Drilling Rig

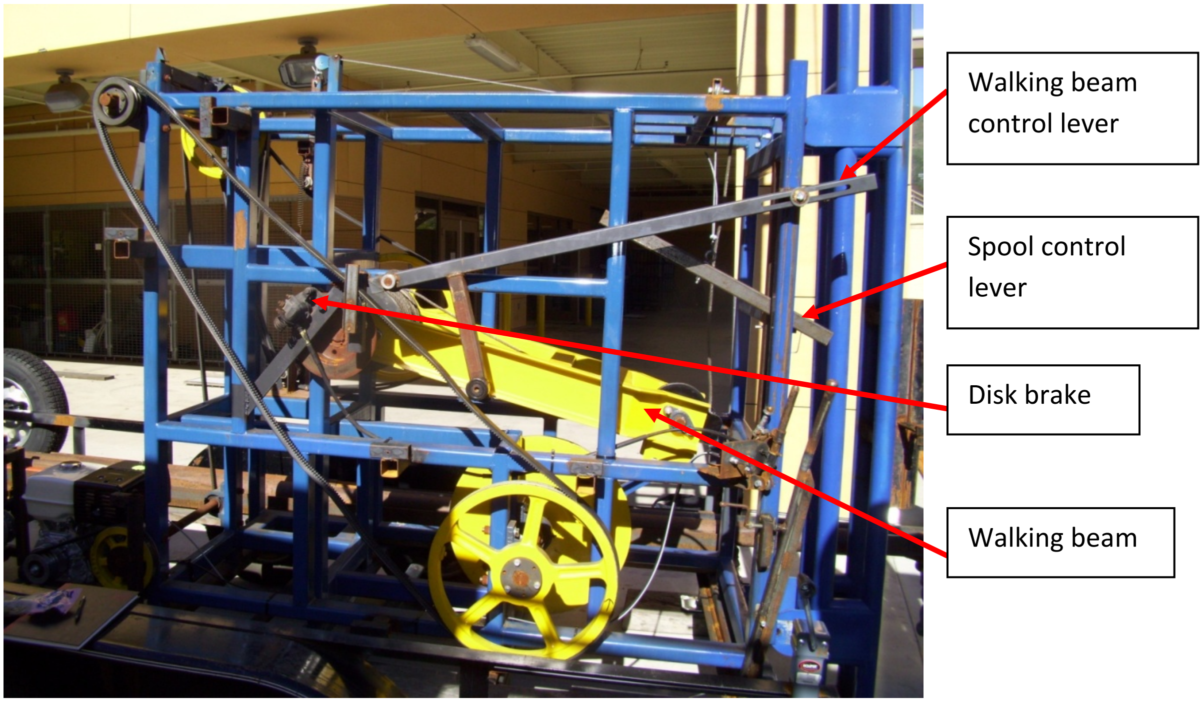

Figure 5: Walking Beam Power Side of Drilling Rig

List of Applicable Standards

There are no applicable standards for the construction of cable tool drilling rigs. Robustness must be tested with extensive use of the equipment.

Chapter 3: Design Development

Discussion of Conceptual Designs with Preliminary Analysis

The four main design areas consist of (1) power transmission, (2) power engagement, (3) walking beam control and the (4) main line brake. These are directly related to the three main power systems: the walking beam, main line and sand line. See Appendix B for concept drawings.

The first component that was discussed by the design team was the motor. It is unclear if the 13 Hp gasoline engine can produce adequate torque to move a 600 lb drill bit. In order to determine if the engine is powerful enough, force and acceleration of each component was modeled using a Cal Poly Mechanical Engineering program called Engineering Equation Solver (EES). The result was mixed because of the circular motion of the pitman arm. There seemed to be adequate power through most of the cycle, but there was a certain angle where downward force disappeared. The EES calculation and results are given in Appendix E. The calculation was not enough on its own to verify adequate torque so more research was conducted. The team found information on an existing drill rig owned by Seeds of Hope in San Luis Obispo that is currently being used in Africa. Their rig currently runs on with an 11 Hp gasoline engine and is used with a 675 lb drill bit. The Seeds of Hope drilling rig provided the evidence necessary for the WHole Engineering team to move forward in the design with the current 13Hp engine.

Power Transmission

Ideas for power transmission utilize chains, belts or gears. Gears were considered because they would provide the necessary speed reductions in a relatively small space. They are difficult to mount, but are able to transmit large horsepower. Chains are easier to mount than gears, but take up more space. They are able to handle large enough loads for this application as well. Chains are the easiest of the three to mount and provide a possible clutching system. They do not offer as much control as gears or chains and must be very large in order to handle the working loads. Belts are the least expensive of the three, followed by chains and then gears.

Power Engagement

Power engagement equipment requires switching power on and off for three functions. To do this for the walking beam, main line and sand line a method of engaging and disengaging power is necessary. Belts easily lend themselves to this through adjustable tensioning so that they slip to disengage and are tensioned to engage. However, this leads to increased belt wear and poor control of engagement. The next solution is to use automotive style clutches. Automotive clutches use a flywheel, clutch disk and pressure plate to engage and disengage by clamping the clutch disk between the flywheel and pressure plate. Clutches have better life, power capabilities and control, but the linkages to run them are complicated would be rather complicated. The third solution is to use a hydraulic system. Hydraulic systems have the benefit of engaging very controllable, having a long life and a lot of power. They also provide the majority of the gear reduction required which cuts down on using chains and belts.

Walking Beam

The oscillation of the drill string unit is controlled by the walking beam. The goal is to lift the bit two feet and let it fall unrestricted. The walking beam needs good control to produce this oscillation. The traditional way is to connect it to a rotating disk via a pitman arm. This produces an oscillation where the walking beam experiences accelerations described by a sign wave. This is not completely desirable due to the limitation that the walking beam must oscillate 60 times per minute to work effectively. Another method that helps solve this problem is a cam. By using a cam the ramp up and down of the walking beam can be custom tailored. However, there are some limitations. Certain speeds will work better than others. A third Idea is to take advantage of a hydraulic system that would control the walking beam using a hydraulic ram. This would allow great control but may be expensive and hard to design properly. The fourth Idea again uses the rotary motion first introduced with one variation. A rotating flywheel will have a second wheel mounted to it that rotates on bearings and is allowed to turn freely in one direction and is driven by the flywheel in the other. This motion would allow the walking beam to be driven at any speed but once the bit falls, it will do so with little restriction.

Main Line Brake

The fourth main design area is the main line brake. The brake must be strong enough to resist the impact force of the bit (transferred by the cable) when it reaches the bottom of the stroke and also have good control to allow the main spool cable to feed out and continue drilling deeper during normal operation. Main line cable is connected to the drill string assembly on one end and is wrapped around the main line spool. This spool needs to be held solid when desired, yet also allow the wire rope to release when needed. This is most readily accomplished with an adjustable brake. There are four types of brakes considered here: automotive drum or disk brakes, an automotive clutch used as a brake, and lastly a band brake. Drum, disk and clutch brakes are readily available and could be sourced from old cars. Disk brakes work by squeezing a disk with two brake pads. Drum brakes are similar except the pads are inside of the drum and are forced outward to engage the drum. A clutch works as described in the power engagement section, but engages a brake pad instead of a powered disk. A band brake operates with an external pad band that engages the outside of a cylinder when the band is clamped. The requirements for the brake consist of good holding power and good control over release. Ease of procurement and positive control are the main concerns.

Concept Selection

The selection of concepts is driven by function and ease of application. Due to this project going to Africa, it is important to keep in mind the capabilities of the people and availability of parts and machine tools. Our decision matrices are listed in Appendix A. Concept drawings are in Appendix B-3

Hydraulic systems can be purchased for use in Africa. However, the machining necessary to implement some of the concepts may be rare. To reduce the possibility of failure in construction the more simplistic designs will be generally favored. Power transmission systems such as chains are more forgiving concerning alignment and will be utilized.

Description of top concept

A hydraulic system for controlling the mechanism presents the most potential. It offers better control and easier installation, while the only drawback is availability. Hydraulic systems can be found or delivered to developing nations, and therefore we are choosing to install it on our rig. Three identical motors will be used to simplify the parts that must be purchased, and present the option that only one spare is needed to backup each of the three systems and swapping parts will be simple and possible.

Chains will be used because they are common and easily understood. Precision mounting will also be reduced to make construction easier. Three chain sets will be used in conjunction with sprocket sets. One set of each will be required for the walking beam, main line, and the sand line.

The walking beam will be controlled with a rotary flywheel with the possibility of the one way bearing addition. The best part about this design is that if it fails in testing or results in not offering any benefit it can be welded solid and used as a traditional rotary set up. If it does work it will be a nice addition to the control and efficiency, and it is a concept that we have not seen used on any other rig.

The main line brake will utilize a disk brake similar to the one currently on the rig. Analysis has been done to evaluate the brake's holding power and a larger brake will be required. See calculations in Appendix E.

Construction plans

The first step is to remove the components on the rig that will not be retained. All of the pulleys and belts will be removed as well as the tension clutches. Aside from minor adjustments, some components will be left alone such as the derrick, frame, and walking beam. Other components will be relocated such as the flywheel, main line, and sand line. Shafts and pillow block bearings will be moved as well for better design and utilization.

Once the hydraulic system is properly sized, the pump can be mounted to the gasoline motor. The hydraulic motors will then be mounted in place followed by chain and sprocket sets to transfer power to their respective systems. To accomplish this, the machining of adapters is necessary to mount chain rings to the system shafts. Control valves and a hydraulic reservoir will be mounted with hydraulic lines

connecting the components as required. The walking beam flywheel will have to be machined and installed as well. The brake system for the main line will also have to be machined and mounted. The next step will be to take care of small machining and installation of guards followed by other small machining and installation tasks.

Proof of concept analysis or testing

During the design phase of this project we had the major components already on hand. Since the largest portion of the project involved refining and bulking the design, along with installing hydraulic controls, we did not perform initial testing. Once we have the rig operable, tests and analysis will be carried out. A major test will be to find the impact loading on the rig from the drill stem while it does not contact the ground.

Chapter 4: Description of Final Design

Figures 6 and 7 below provide the planned layout for the components of the drill rig. Only the motors are shown for the hydraulic system. The controls, hydraulic tank, and gasoline engine, will be located on the side of the trailer. The motors will be bolted to plate steel welded to the frame.

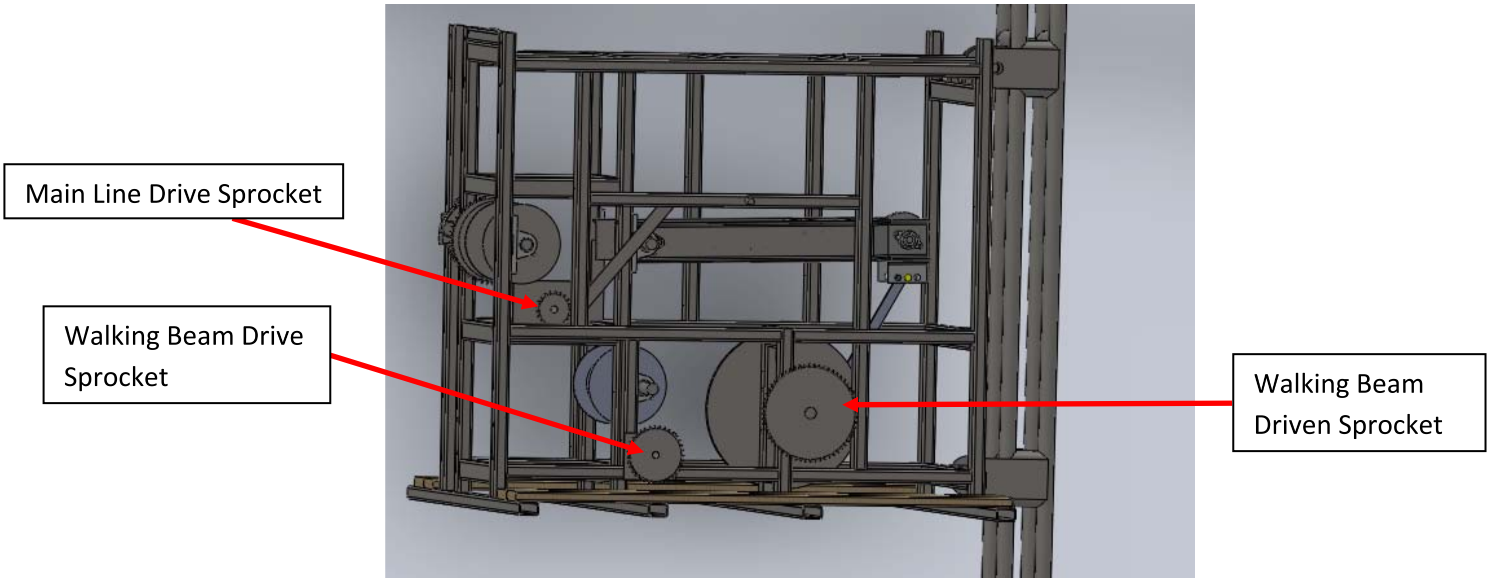

Figure 6: Preliminary SolidWorks Model (right view)

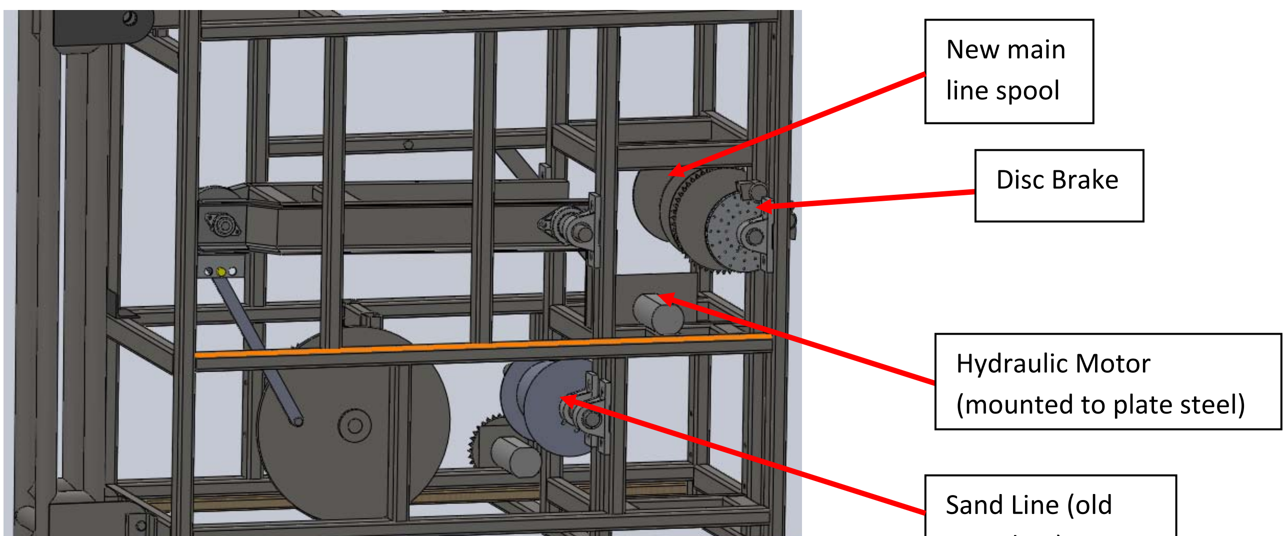

Figure 7: Preliminary SolidWorks Model (left view)

Main Line and Sand Line

The main line spool has been removed from the walking beam and will be replaced with a larger unit to allow for a larger wire rope. A new main line will be constructed from 6 inch outer diameter pipe. It will need to be large enough to accommodate at least 200 feet of 5/8 inch left hand lay cable. It will also have a separator which allows the majority of the cable to be spooled onto one portion with a separate portion allotted for just a few wraps of the outbound cable. A drawing of this feature is shown in Figure 8. This allows for maximum pulling force when desired by decreasing the effective spool diameter as well as protecting the cable from becoming bound up and tangled. The main line must be moved from the initial location on the walking beam shaft because of an inadequacy of space.

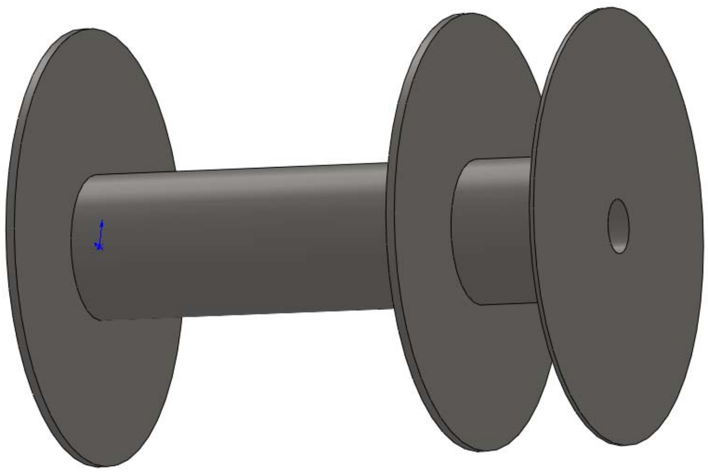

Figure 8: New Main Line Spool

A new sand line spool will also be fabricated using the same material as the main line spool. However, the sand line will have more conventional spool construction with only one section for wrapping the cable.

Power Transmission

Power will be transmitted to the three main components (main line, sand line, and walking beam) by a hydraulic system. Each component will have an independent hydraulic motor. The hydraulic motors will eliminate the need for clutches and provide exceptional control.

The existing 13hp gasoline motor, even though it may be used near capacity, has been proven sufficient to power the system and a suitable Hydraulic pump was sized to mate with it. The Hydraulic pump will take fluid from the reservoir and supply it to a custom stack valve. A stack valve allows for selection of a particular type of valve for each system. These valves can then be bolted together into one convenient valve unit and will serve to distribute fluid to each system's hydraulic motor. The hydraulic motors are three of the same type to facilitate repair and replacement.

Both the main line and sand line cable spools will be driven intermittently. The main consumer of power will be the walking beam motor which will run the majority of the time while drilling and therefore was

used to calculate the maximum power requirements of the system. Hydraulic fluid will be returned from the motors to the reservoir in a loop during operation. All of the motors will be set up to run in forward and reverse so that the main and sand line can spool in and out, and while the walking beam only needs to run in one direction, it will have the ability to rotate in both to add flexibility in the event that the bit becomes stuck. Components for the expected hydraulic system are listed in Table 2. Appendix B contains labeled drawings and layouts of the hydraulic system, and three driven systems.

Table 2. Hydraulic Drive Installation Costs

Vendor	Part Number	Description	Unit Price($)	Quantity	Price($)
Grainger	6W549	Inlet Section	74.40	1	74.40
Grainger	6W560	Bolt Kit	10.16	1	10.16
Northern	201617	Outlet End Plate	39.99	1	39.99
Northern	201614	Valve SVW1DD1	104.99	1	104.99
Northern	201612	Valve SVW1BA1	79.99	2	159.98
Northern	201615	Valve SVW1BB1	89.99	1	89.99
Northern	2040	Flow Control Valve	84.99	1	84.99
Northern	10600	Hyd. Pump	184.99	1	184.99
Northern	1039	Hyd. Motor	239.99	3	719.97
Northern	4052	Hyd. Oil Tank	99.99	1	99.99
Northern		Hyd. Hoses	15.00	12	180.00
Northern		Motor-Pump Bracket	60.00	1	60.00
Northern		Motor-Pump Coupling	38.00	1	38.00
Northern		Filter	30.00	1	30.00
Northern		Pressure Gauge	15.00	1	15.00
Northern		Couplings and Adapters	2.50	15	37.50
				Total	1929.95

The total with 25% added for unexpected costs was introduced to the sponsor as the estimated bulk cost for the hydraulic system and was well received.

Shafts, Bearings, Pillow Blocks

The drill rig has existing shafts and pillow blocks that will be retained and analysis has been done to verify they are correctly sized. These consist of the main line shaft and walking beam shaft. The new sand line will have a recycled 1 ½ inch shaft and pillow blocks from the previous rig and has been determined sufficient. Work will also be done to reduce bending moments on shafts particularly in the shaft supporting the walking beam sheave.

The pins (shafts) supporting the derrick will be increases in size and relocated, while the pillow blocks previously used will be removed and replaced with a simple steel on steel hinge. The reason for this is

that expensive bearings are unnecessary for a component that rarely moves. Wear from vibration will also be reduced due to using a larger pin and dispersing the force over a larger area.
The pillow blocks from the derrick mount will be recycled for use on the pitman arm. Currently it does not have bearings and by adding them we will reduce wear and friction for robust design.
If necessary, additional Pillow blocks and bearings will be purchased from Central Coast Bearings and Shafts will be purchased from B & B Steel or McMaster Carr.

Chains and Sprockets

The initial intent was to use readily available motorcycle chains in order to transmit power from the hydraulic motors to the machine's shafts. Unfortunately, these chains are not rated to the working load required to operate this machine. Therefore ANSI 60 H series chains will be used to transmit power. These chains have a working load of 2000 lbs, which is larger than the force they can see from the motor torque.

Sprockets were chosen based on necessary chain requirements and gear ratios. The main line will have a 21 tooth to a 54 tooth sprocket and will be required to winch much larger weight so it is a larger gear reduction than the sand line. A 21 tooth to a 30 tooth sprocket will be installed for the sand line and will be required to raise and lower the bailer a longer distance more frequently than the main line. Higher line speeds of the sand line will help reduce overall drilling time. The walking beam will use a 35 tooth to a 60 tooth sprocket to produce a flywheel rotation speed of 60 rpm with the motor spinning at 102 rpm. Smaller sprockets decrease cost, but increase the working load seen by the chain. The walking beam is using the largest driving sprocket because it has the potential to see the largest amount of shock. There are an odd number of teeth on the driving sprocket in order to prevent uneven wear on the chain. (Shigley) Sprocket sizes were also constrained by readily available sizes. Detailed chain and sprocket calculations are provided in Appendix E. Table 3 below provides chain and sprockets that have been selected and the price from McMaster Carr.

Table 3 Chain and Sprocket Costs

Description	Part Number	Unit Cost ($)	Quantity	Total ($)
60 teeth, 1 3/4" bore	6236K587	84.74	1	84.74
35 teeth, 1" bore	6236K541	58.84	1	58.84
21 teeth, 1" bore	6280K301	42.43	2	84.86
30 teeth, 1 1/2" bore	6236K534	55.86	1	55.86
54 teeth, 1 3/4" bore	2741T122	80.9	1	80.90
20' of ANSI 60H chain	7265K522	158.00	1	158.00
			Total	523.20

Derrick Extension

The Derrick will be extended in order to accommodate a long enough drill stem and bit. The drill string must be able to be pulled at least seven feet above the hole in order to allow for the installation of casing. With a 16 foot drill stem a twenty foot derrick would not have been sufficient. The extension will be hinged in order for the rig to continue to be towed by a vehicle. Figure 9 shows the derrick in the collapsed position. Figure 10 shows a close up of the hinging mechanism that will be constructed.

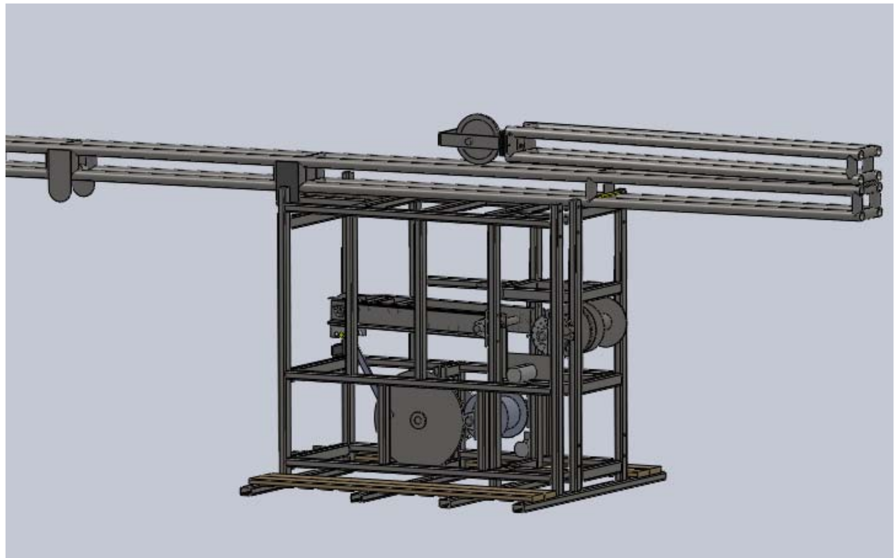

Figure 9: Modified Derrick Extension in Collapsed Position

This hinge will be constructed from steel rings that will be welded onto the derrick frame. Half of the rings will be on each the derrick extension and half will be on the top of the original derrick for even load distribution. A 6 inch long shaft will be put through the rings of both pieces in order to create a conventional hinge mechanism.

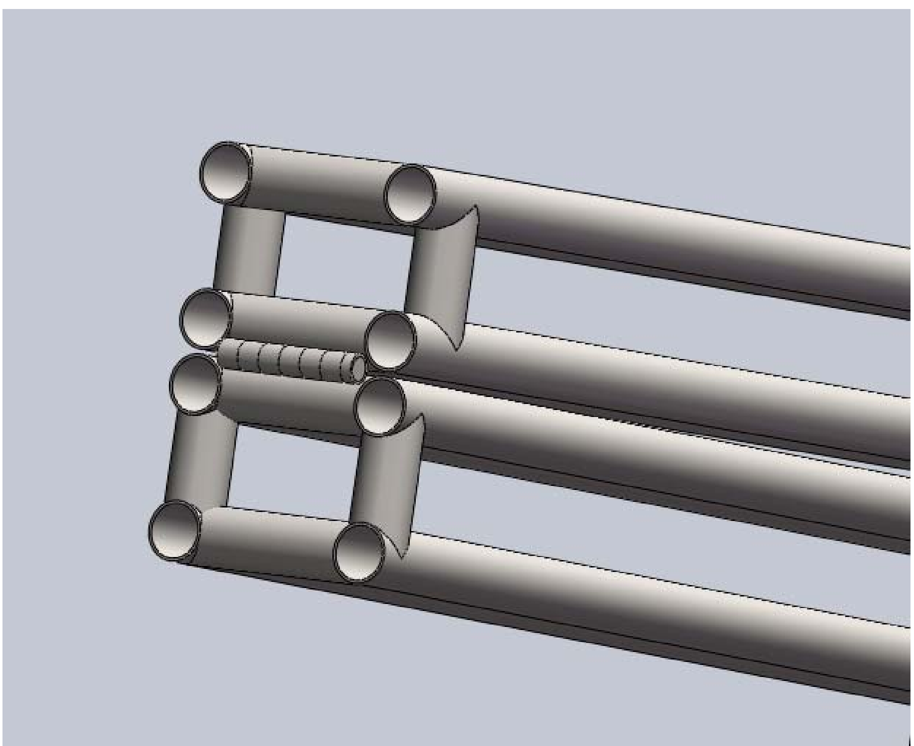

Figure 10: Derrick Extension Hinge

Safety considerations

This project has been under scrutiny for safety concerns from both the past project and the current design. Potential hazards and preventative measures are outlined in table 4 below. For safety in Africa the colors chosen for the drill rig are neutral to prevent any conflicts arising upon delivery to the developing continent. Expanded steel mesh has been installed as a guard on each side of the rig near the moving chains to avoid accidental harm from occurring. The majority of the moving parts are located in the interior of the box frame to maintain a safe distance for anyone near the machine.

Table 4 Safety Risk Analysis and Prevention

Item/Area	**Risk**	**Prevention**
Wire rope	Pinch fingers	Training and inspection of proper cable operation
Engine	Noise	Ear Plugs
Engine	Exhaust inhalation	Open air ventilation
Pitman arm and Flywheel	Pinched limbs	Location and training
Rotating parts	Loose items caught	Loose clothing or hair properly secured
Cable spools	Fingers and hands caught	Guards and training
Chains and sprockets	Fingers and loose items caught	Guards and training
Drill bit	Crushing limbs	Training, warnings, using guides and casing
Derrick	Crush surrounding people/property	Use grounded guy wires and training

Chapter 5: Product Realization

Manufacturing Processes and Components

Fabrication of the current drill rig required a great deal of time to deconstruct the previous design. Cutting off many components with a cutting wheel and then using a grinder to remove any excess metal was the process. Grinding down the weld to a smooth surface has made the frame surface ready for painting and for new beams to be attached. Consideration was taken to avoid grinding or cutting into the frame to prevent weakening the steel.

Walking Beam Counter Weight

Figure 11 Walking beam counter weight

The walking beam has an attachment for an adjustable amount of weights to be placed on top of it to even out the load on the engine. If the precise amount of counter weight is added to the walking beam, the motor will see an equal load in the up and down stroke of the drill bit. This will allow for smooth drilling operation. An extra bar of steel was added to the walking beam with a shaft welded in place to allow for a stack of weights to be added as necessary. Weight lifting weights were chosen because they are easy to add and remove, and are able to provide the large amount of counter weight required. The will be held in place on the walking beam using clamping device in order to ensure they do not move during drilling.

Pitman arm and Flywheel

The Pitman arm was manufactured from square steel bar stock with end plates welded on. The end plated were constructed from ¼" plate steel and cut to shape using a plasma cutter. ½" holes were drilled into the plate to allow for a pillow block to easily be mounted for each end. A larger bore of 1 ½" was drilled for the attachment shaft to the pitman arm. Once the shaft was put in place, it was welded securely in place. The walking beam had two 7" long pieces of 2"x3" steel bars welded to it for mounts. A 1 ½" diameter hole was drilled into each of these pieces and a shaft was run through them along with the pillow block.

Figure 12 Pitman arm and flywheel

Derrick Extension

Figure 14 Derrick extension welded onto the derrick

In order to allow for a the use of a 16 foot drill bit, the derrick had to be extended. The addition of the derrick extension to the end of the derrick already in place was done with a hinge. A hinge was needed to limit the length of the derrick extending forward onto the towing vehicle during transport. The hinge was constructed from steel tubing welded intermetantly to the upper and lower portions of the derrick. A pin was then placed running through each of the pieces of tubing. Extensive reinforcement metal plates were welded on to the hinges for added strength. FigThe same steel used in the derrick was used in the derrick extension, ordered from B&B Steel of Santa Maria, CA. Figure 14 displays how the extension folds over and on top of the original derrick. Once unfolded, there are bolt holes in place to ensure a solid connection during drilling operations. The Derrick is held secure using three ¾" bolts. Figure 15 shows a close up

Figure 13 Close up of derrick hinge and mounts

Figure 15 Derrick extension with derrick mounted on the frame

of the hinge constructed from the steel tubing. It also shows the brackets that are used to secure the derrick open when drilling is in operation. The two pieces of the derrick rest up against each other during drilling to prevent movent between them.

Hydraulic System

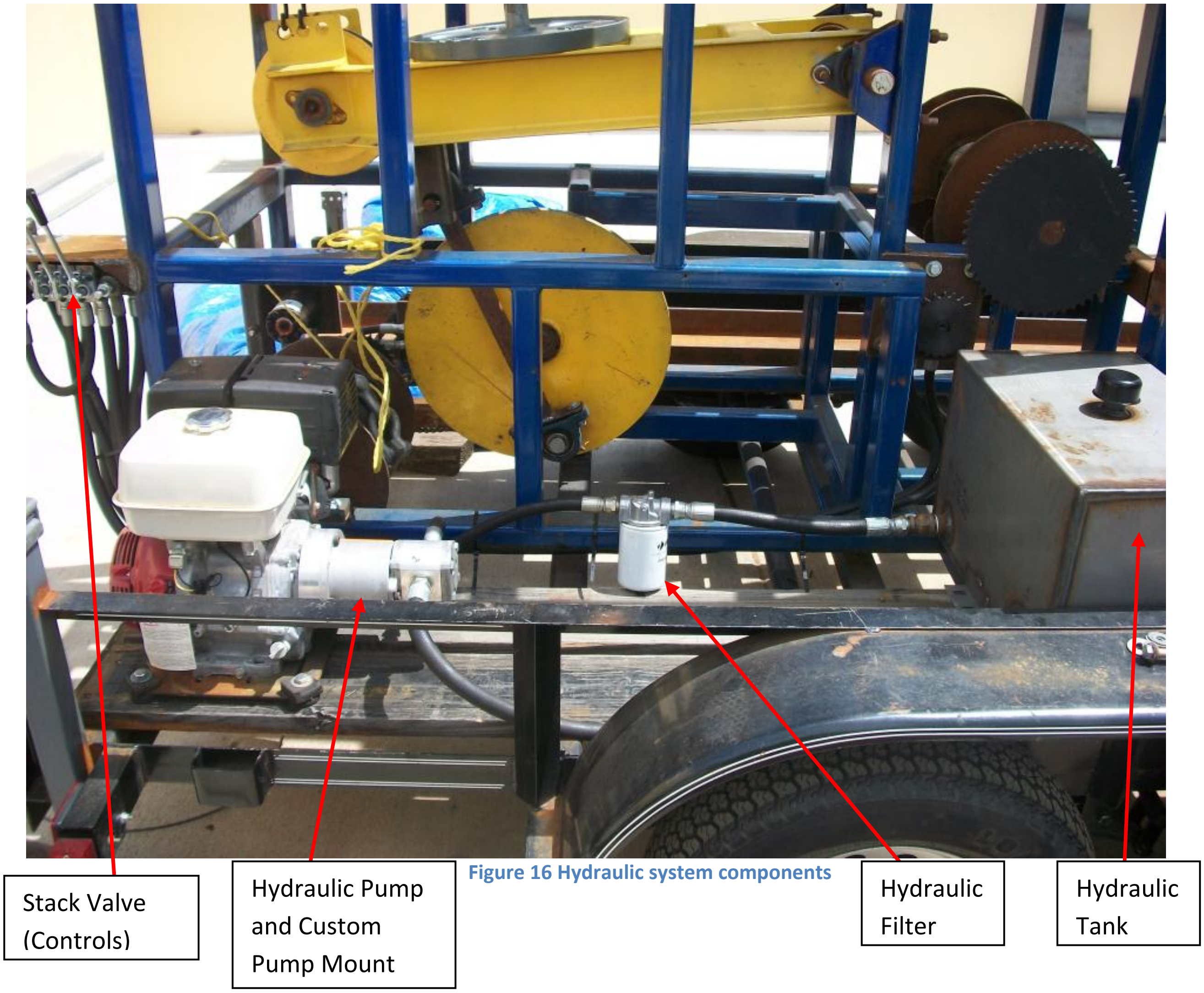

Figure 16 Hydraulic system components

Figure 16 above shows the location of the major hydraulic components for the machine (excluding motors). The location of these components was laid out prior to running the hoses to them. Everything was placed in its final position so that hose lengths could be properly determined. The hoses and fittings were installed by DIESELRO of San Luis Obispo. The tank is able to hold up to 19 gallons of hydraulic fluid, but will generally operate with between 10 -15 gallons. The hydraulic filter was also installed by DIESELRO and will prevent contamination from flowing from the hydraulic tank to through the system, which would decrease power output. There was no available pump adaptor for this particular motor so a custom mount had to be created.

Figure 20 shows the construction of the custom mount for the pump. SolidWorks models were created in order to use CNC machines to create the part. The piece was cut from 8" solid aluminum. Figure 19 shows a close up of the custom hydraulic stack valve. Also shown on this picture is the speed controller (running from the center valve), which will allow the operator to control the frequency of the walking beam motion. The stack valve was mounted to the frame with plate steel welded to the frame and strengthened with triangular brackets on each side.

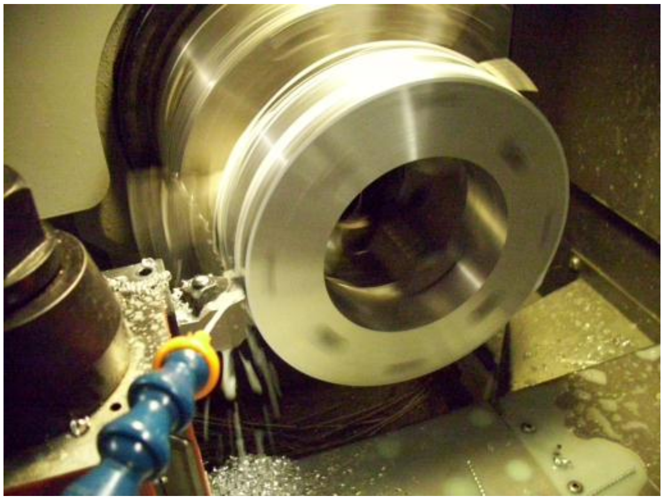

Figure 20 Custom CNC facing the motor mount on a lathe

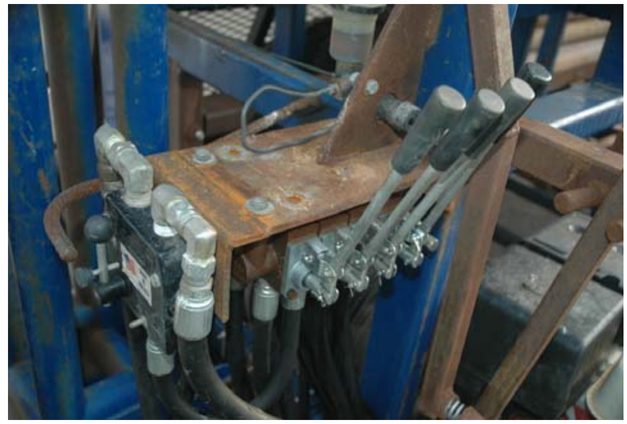

Figure 19 Stack valve with hydraulic speed control

Figure 18 Adapter for gas and hydraulic moter mounted

Figure 17 Hydraulic pump motor mounted

Motor Mounts

The hydraulic motors are front mounted with 4 bolts and could not be mounted to 3"x2" steel bars. Custom motor mounts were required in order to mount the motors to the frame. These mounts were constructed from 3/8" thick plate steel. For ease of manufacturing, one design was used for all three mounts. The mounts were drawn up in SolidWorks and then built using the CNC mill. The mounting holes are slotted to allow for small adjustments to change chain tension. The adjustability varies between vertical and horizontal from the mounts depending on location, but the overall purpose is served.

Figure 21 Motor mount in final location

Crown Block

Mounting of the crown block appeared to be done the safest in the midst of the derrick's structure. Grade 8 bolts were used along with sheet metal to construct the apparatus. Rubber dampening pads were installed as a force damper. Two sheaves were found to thread the two cable lines through.

Figure 22 Crown Block mounted inside the derrick extension

Cable Spools

Figure 23 Plasma cutting of the spool sides

The team fabricated cable spools from ¼" plate steel. In order to cut the spool outer diameter to 14", precision plasma cutting was used. The main line spool required three 14" OD pieces of steel to construct the separated portion of the spool. The separated portion will allow for decreased slip in the line and preserve the cable during drilling operations. The middle of the three large circular pieces had to have two large rounded notches so that cable is easily able to be fed from one section of the spool to the other. The plasma cutter was able to trace a carefully drawn circle of the desired diameter in order to create a perfect circle for the spools. Figure 22 shows the plasma cutter cutting the plate steel to shape. The inner portion of the spools was constructed from 6" OD steel pipe. The steel pipe had holes drilled and tapped in it so that the cable can be securely fastened to the spool using plate steel and bolts. The size of each spool was calculated to determine the required length for all of the cable to fit on the spool and to prevent runoff during operation. Figure 24 shows the main line cable spool mounted to the frame. The main line cable installed is 6X21 fiber core left lay wire rope. It weighs 0.66 lb/ft, with 200ft it weighs 132 lb overall, and is bright, which means it is not galvanized. Doug Enloe instructed us that left lay wire rope is the industry standard, so that is what we order. It tightens upon ground impact. A proper rope socket allows the cable to freely spin upon ground impact, and one was obtained by the sponsor.

Figure 25 Main line mounted to frame with 5/8" left lay wire rope spooled on

Figure 24 Sand line mounted on frame near the motor

Figure 26 Guard of expanded steel placed over the main spool chain

Chains and Sprockets

60 series sprockets were ordered and put on place on the ends of the hydraulic motor shafts and the spools and flywheel for transmitting power. The sprockets came finished from McMaster-Carr with pre cut keyways and set screws. The chain was 60-H series, riveted chain for added strength and came in 10 foot lengths. The chain is to be cut to fit for each location and held together via a master link. The adjustability in the motor mounts will ensure that the chain will be tight and thus prevent slippage.

Figure 27 Walking beam and sand line chains and sprockets prior to guard mounting

Main line Brake

Figure 29 Main line brake mounted on the frame

The main line brake is mounted on an angled piece of rectangular tubing. Two calipers were used from for greater breaking force to minimize slip of the main line spool when undesired. Controlling the brake presented a challenge and a combination of a lever for coarse adjustments and a compression spring for fine tuning was used. Locating the controls near the motor and the cable was essential to minimize the operators required and also provide ergonomic controls. The brake fluid level is easily monitored next to the controls

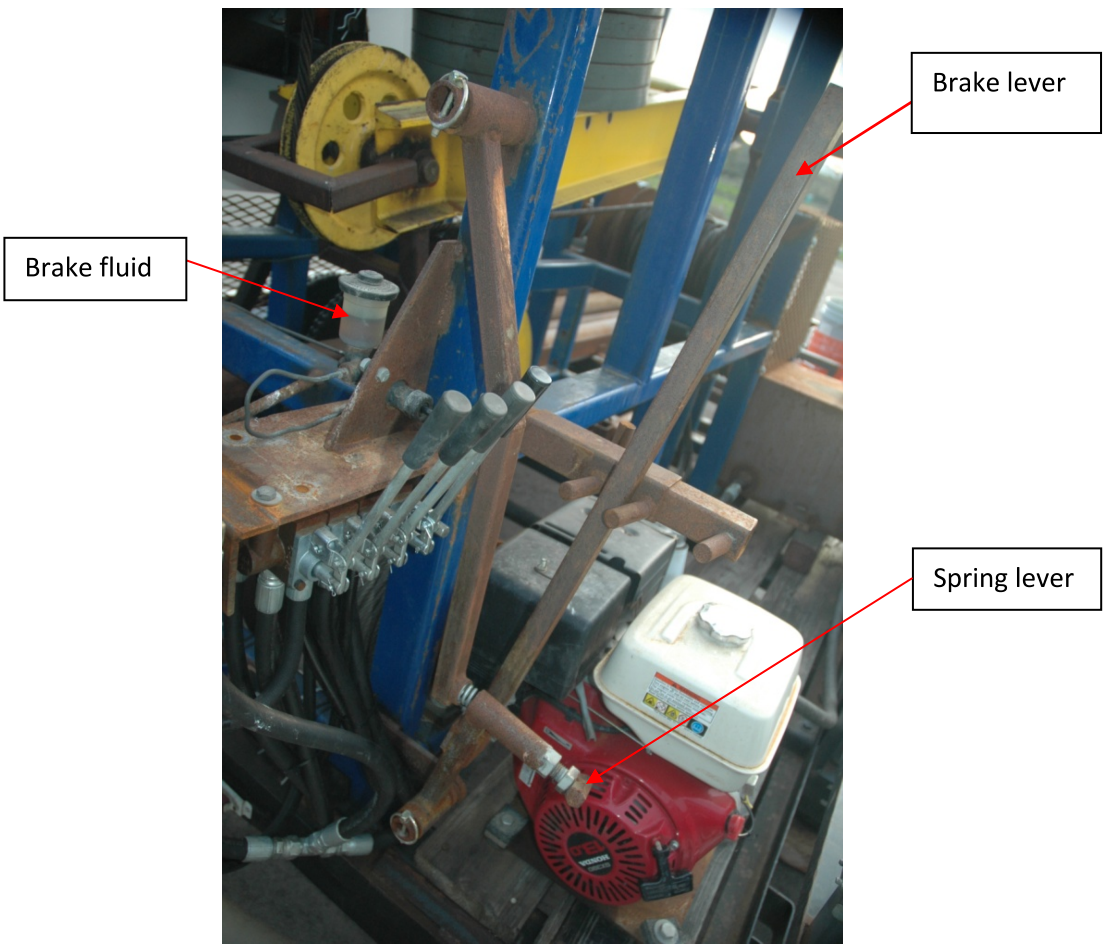

Figure 28 Brake controls

Hydraulic Ram

A hydraulic ram was installed to ease the lifting the derrick. Since the hydraulic system was already installed, with extra hoses, and valve, the ram was added by sponsor Bob Hather. It has a 2 inch shaft with 20 inches of throw, and is overall 24 inches long. A cross beam was added to distribute the lifting force on the derrick to minimize the moment felt at one point.

Figure 31 Cross beam installed with the hydraulic ram

Figure 30 Red hydraulic ram installed in the frame

Modifications in the Manufacturing Process

A few modifications were made to our design, along with the order of item production also changed as necessary to avoid rework. The following were modifications necessary for an effective product:

- The control systems on the rig were placed on the right side of the rig to allow an operator to run the rig with their right hand, and feel the cable with their left hand.
- The gas motor was relocated to the end of the right side of the rig near the controls for closer and easier operation.
- The location of the sand line was placed at the very end of the rig to allow space for the flywheel to operate and to minimize interaction with other components. Because of this change, the sand line cable goes directly up to the top sheave, and down to the bailer.
- The hydraulic motors were positioned in optimal locations to allow for solid support and the mounts have adjustable slots for adjustability when the chains are installed.
- With the relocation of controls, the tool rack was cut and moved to the left side of the rig for better ergonomics. It was not welded down since it did not seem necessary.
- Due to strength considerations the crown block was not placed on the very end of the derrick, and was instead placed inside the derrick extension.

Chapter 6: Design Verification

Specifications

The WHole Engineering design team will have to provide proof that the drilling rig passes the specified requirements in table 3. Test descriptions appear after the table with a list of necessary equipment. The last column in table 3 is for specification verification after testing.

Table 5 Specifications to be verified

Test No.	Specification Parameter	Test Description	Requirement	Value Reached after testing
1	Drilling Depth	Drill to target depth	>100 ft	Not fully tested
2	Hole Diameter	Measure diameter of drilled hole	>4 inch	5 in
3	Drill String Weight	Weigh Drill String	>600 lb	625 lb
4	Operators	Operate with 2 people	2 people	2 people
5	Transportability	Weigh trailer	<3000 lb	Estimated >3000 lb
6	Horizontal Sway	Measure sway of drilling rig	<6 inches	>6 in
7	Operation Speed	Measure flywheel rotational speed	50-60 rpm	60 rpm

Test 1

In order to verify the drilling rig is capable of reaching the water table, it will be tested to a depth of 100 ft. This test will require at least 20 five foot section of 4in. inner diameter steel tubing (casing) as well as enough fuel and water for the operation. The test will require several drilling bits and the bailer in order to successfully reach the target depth.

Test 2

The bore diameter will be measured using a caliper. Compliance will also be verified during test 1. If the drill bit can fit within the inner diameter of the casing and the casing can be successfully driven into the hole.

Test 3

The drill string will be weighed using a vehicle scale. An engine hoist will be required if the scale is located indoors and the rig cannot be used. If the drill bit weighs less than 600 lbs, a replacement will be needed.

Test 4

This test will be performed during test 1. If it takes more than 2 people for any of the operations during drilling the test is a failure and proper modifications will have to be made to the drilling rig.

Test 5

The completed drilling rig will be weighed on a vehicle scale to ensure it is less than 3000 lbs. Drill bits and additional drilling equipment will be removed from the trailer as well as water from the tank. If failure occurs weight will be removed from non-critical locations in the machine.

Test 6

The horizontal sway of the drilling rig will be measure through the use of observation of various points on the machine. A horizontal sway of more than 6 inches will require additional supports or reinforcements to be added to parts of the machine.

Test 7

The rotational speed of the flywheel will be measured by counting the number of oscillations of the bit in one minute. If the speed is outside of the 50-60 rpm range proper gear reductions will be added or removed from the drilling rig.

Test Results

The drilling rig was tested on Bob Hather's property. Due to the lack of necessary casing and the extensive time required to drill a full well the rig was only tested to a depth of 25ft. There were no complications and the types of soil encountered included clay, sandstone, and serpentine. The drill rig was able to successfully drill through all the soil types, with some water added, and a summary of the drilling speeds are shown in table below:

Table 6 Drilling rates through different types of geology tested

Soil Type	Drill Time (hours)	Drill Depth (ft)	Drilling Speed (ft/hr)
Clay	1	12	12
Sandstone	3/4	5	6.7
Serpentine	2	4	2

Testing proved a rock could be easily crushed with the force of the buttoned bit in the Figure below.

Figure 32 Drill testing on a rock

Figure 33 Bore hole after a few minutes of drilling with water

Impact Testing:

The crown block was an area of safety concern due to the immense forces that could be seen and potential danger if failure were to occur. In order to determine if the machine would be able to handle the loads the team had to determine the actual forces the crown block welds experienced. An accelerometer ICP from PCB Piezotronics, model Number 353B15 was attached to the drill stem during drilling to calculate the loads that the top would see. This accelerometer can be seen in Figure 34. A Dactron LDS program was used on a borrowed Cal Poly computer for the testing, which the apparatus can be seen in Figure 35.

Figure 34 Accelerometer mounted on the drill stem

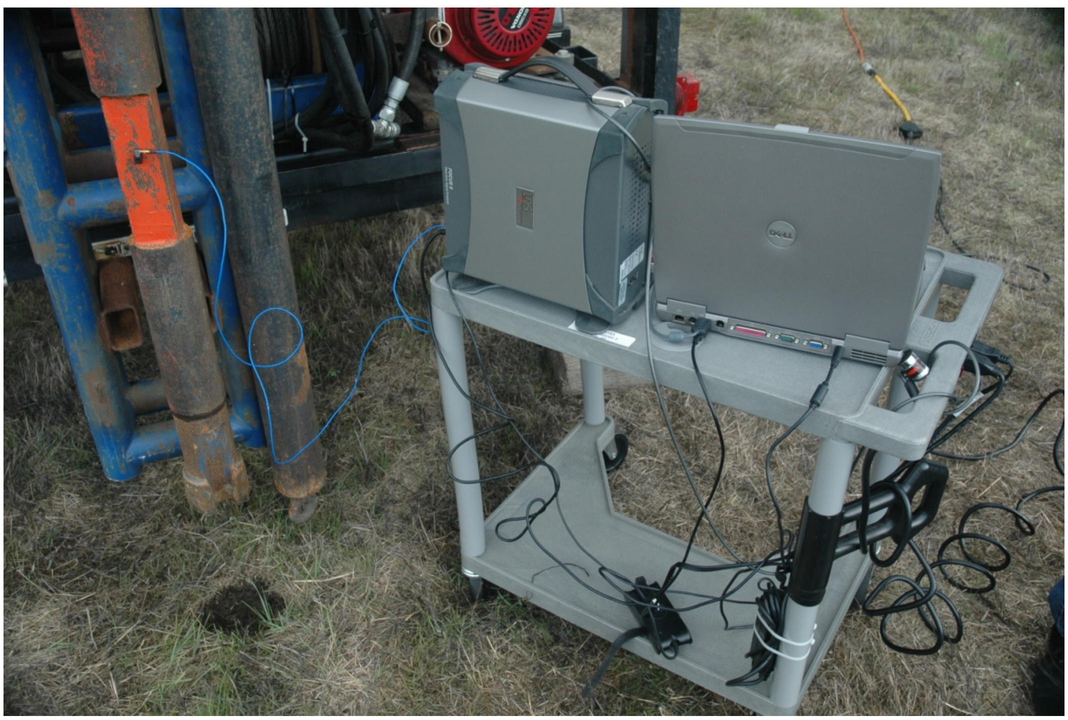

Figure 35Testing apperatus set up on Bob Hather's property

Results from the accelerometer tests were consistent through four tests and the test readout shown in Figure 36 is from one of the four runs.

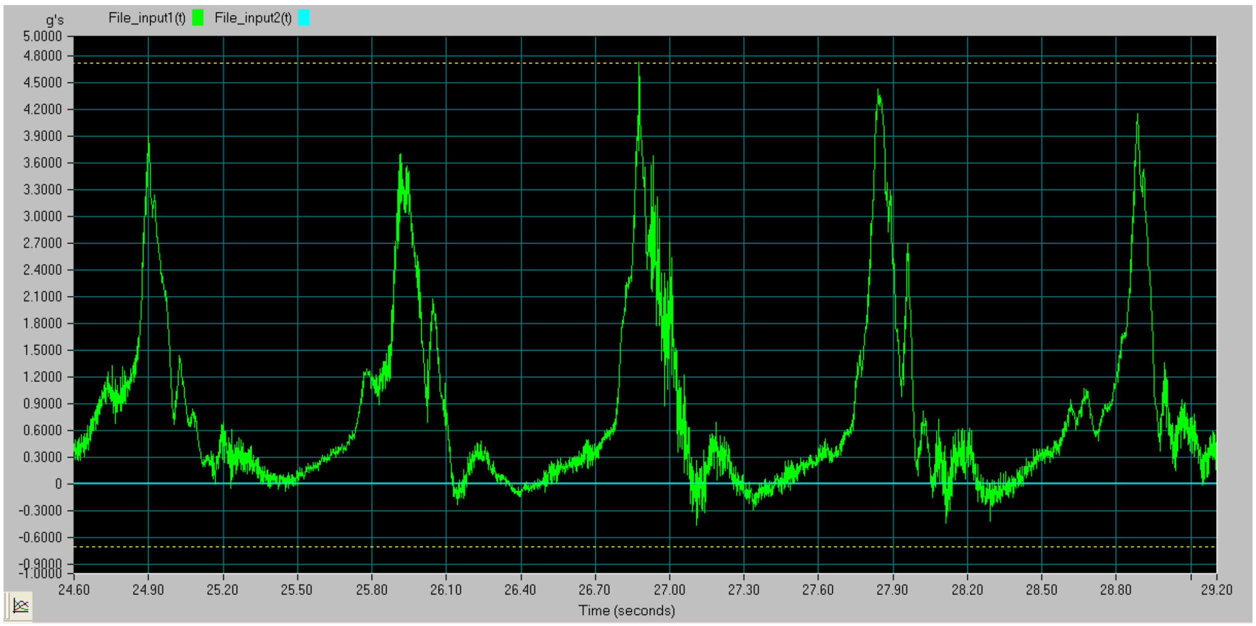

Figure 36 g forces acting on the crown block while the drill string does not contact the ground

The graph shows the worst impact force that the drill bit would experience to be 4.7 g's. This translates to the crown block seeing a force 2820 lbs. or 1410 lbs. per weld. This was far less than the team initially expected and the rig will be able to handle these loads.

An impact test was also performed with the drill bit contacting the ground. This test allowed the team to calculate the drilling force that the machine was producing and also see the impact the top mount would see when the walking beam would suddenly pull the bit back up while the wire rope went back into tension during the lifting portion of the stroke. Results of the drilling impact on the ground test are shown in Figure 37

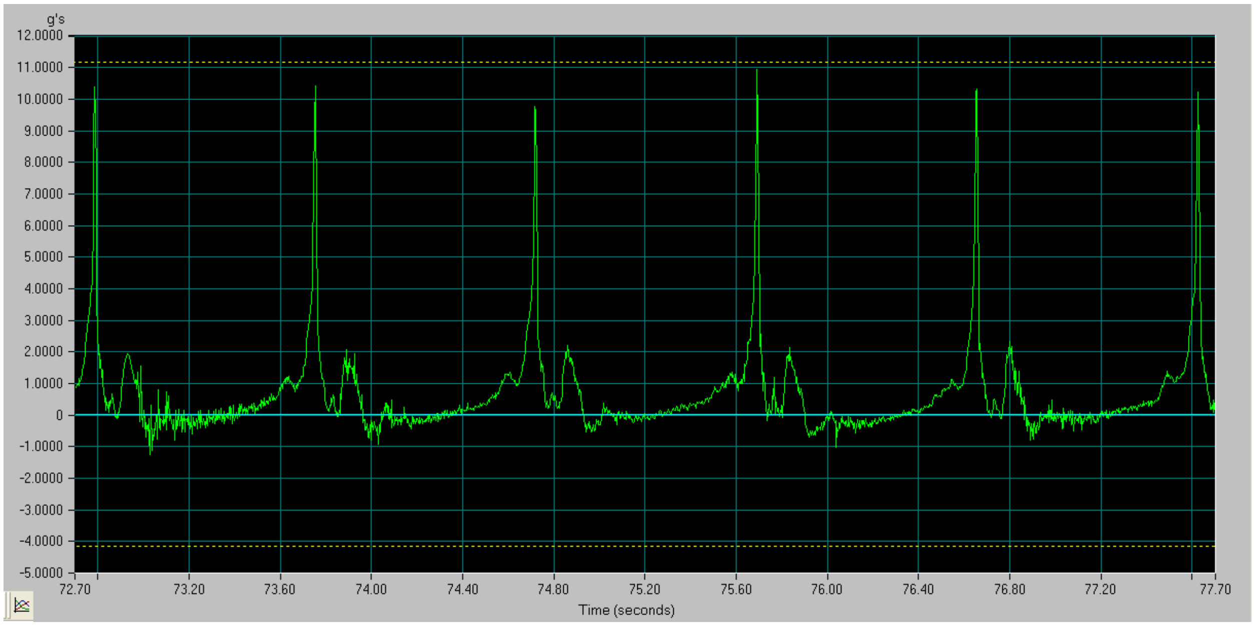

Figure 37 Ground impact testing g forces

The peak impact acceleration shown on the graph is 11 g's. This acceleration translates to an impact force of 6600 lbs. on the ground. There is also a smaller jump in acceleration on the graph. This hump is due to the walking beam picking the drill bit back up. The maximum acceleration for picking the bit back up was determined to be 2g's. This acceleration translates to an impact force of 1200 lbs. on the crown block or 600 lbs. on each of the welded pieces that attach the crown block to the derrick. Based on this force, these welds will not fatigue due to the repeated impact on them.

While testing, the Figure below shows the angular momentum in the flywheel and herringbone gear help maintain a steady rotation for proper operation.

Figure 38 Still shot of the flywheel and herringbone gear spinning

Chapter 7: Conclusions and Recommendations

This project greatly enhanced our collegiate experience and fully challenged the team to learn by doing. Challenges included understanding the sponsor's need for going in one specific direction to account for all improvements, the time consumed in manual labor removing parts, then reapplying them, working out each new design and ensuring that it all will work together. Additionally challenging was to understand the drilling process and terminology.

We were fortunate to work with great people striving to improve lives and help sustain life in developing countries. This goal has kept the team inspired to construct a functional and robust drilling rig. Professional advice was readily available from an operator's standpoint, but not on the design engineer's point of view.

We conclude that the drilling rig constructed is functional and should be able to drill at least ten wells before a few components will need significant attention, with an overall life of 100wells.

Additional testing is necessary to determine failure points before additional rigs can be constructed. Lifewater of San Luis Obispo, along with the help of several cable tool drillers, will be testing the machine to failure in order to make the necessary changes. There are also changes that can be made in the frame structure and derrick. Since the WHole Engineering Team did not complete the rig from scratch and major changes were made, there are improvements that can be made to simplify the design. The trailer should be custom designed to place the tires further back where the center of mass is to ensure that the suspension can support the impact of drilling. Also, the derrick currently is constructed of steel tubing that requires tube notching and difficult welds. We recommend using rectangular steel similar to the frame in order to make a derrick that can be bolted together. These changes will help make the rig a more effective, cost efficient machine to drill wells for those in need.

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Appendix A Decision Matrices, QFD

Table 7 Walking beam decision matrix

Walking beam control					
Criteria	weight	Traditional rotary	Rotary with one way feature	Cam	Hydraulic Ram
Control	8	6	9	8	9
Cost	7	9	7	7	5
Safety	9	7	8	7	8
Power	7	7	7	7	8
Weight	5	8	8	8	6
Size	5	7	7	7	6
Complication	6	8	5	6	6
Robust	7	7	6	6	8
Efficiency	5	7	9	8	8
Total		66	66	64	64
Weighted total		430	434	418	427

Table 8 Power Transmission decision matrix

Power Transmission				
Criteria	weight	Chains	Belts	Gears
Control	8	8	7	8
Cost	7	7	7	4
Safety	9	6	5	6
Power	7	7	6	7
Weight	5	7	7	7
Size	5	6	6	7
Complication	6	8	7	4
Robust	7	8	7	8
Efficiency	5	7	6	8
Total		64	58	59
Weighted total		420	378	385

Table 9 Power engagement decision matrix

Power engagement				
Criteria	weight	Belts as clutch	Automotive Clutches	Hydraulic
Control	8	4	7	8
Cost	7	8	7	6
Safety	9	4	7	9
Power	7	6	8	8
Weight	5	8	7	6
Size	5	8	7	6
Complication	6	8	5	6
Robust	7	6	8	9
Efficiency	5	7	8	6
Total		59	64	64
Weighted total		371	420	432

Table 10 Main line brake decision matrix

Main line brake					
Criteria	weight	Band brake	Drum Bake	Disk brake	Clutch as brake
Control	8	8	6	7	7
Cost	7	8	8	8	7
Safety	9	8	7	7	7
Power	7	8	6	6	6
Weight	5	6	7	7	6
Size	5	6	7	7	6
Complication	6	7	7	7	6
Robust	7	8	7	7	6
Obtain ability	9	6	8	9	6
Efficiency	5	8	7	7	7
Total		73	70	72	64
Weighted total		500	477	494	437

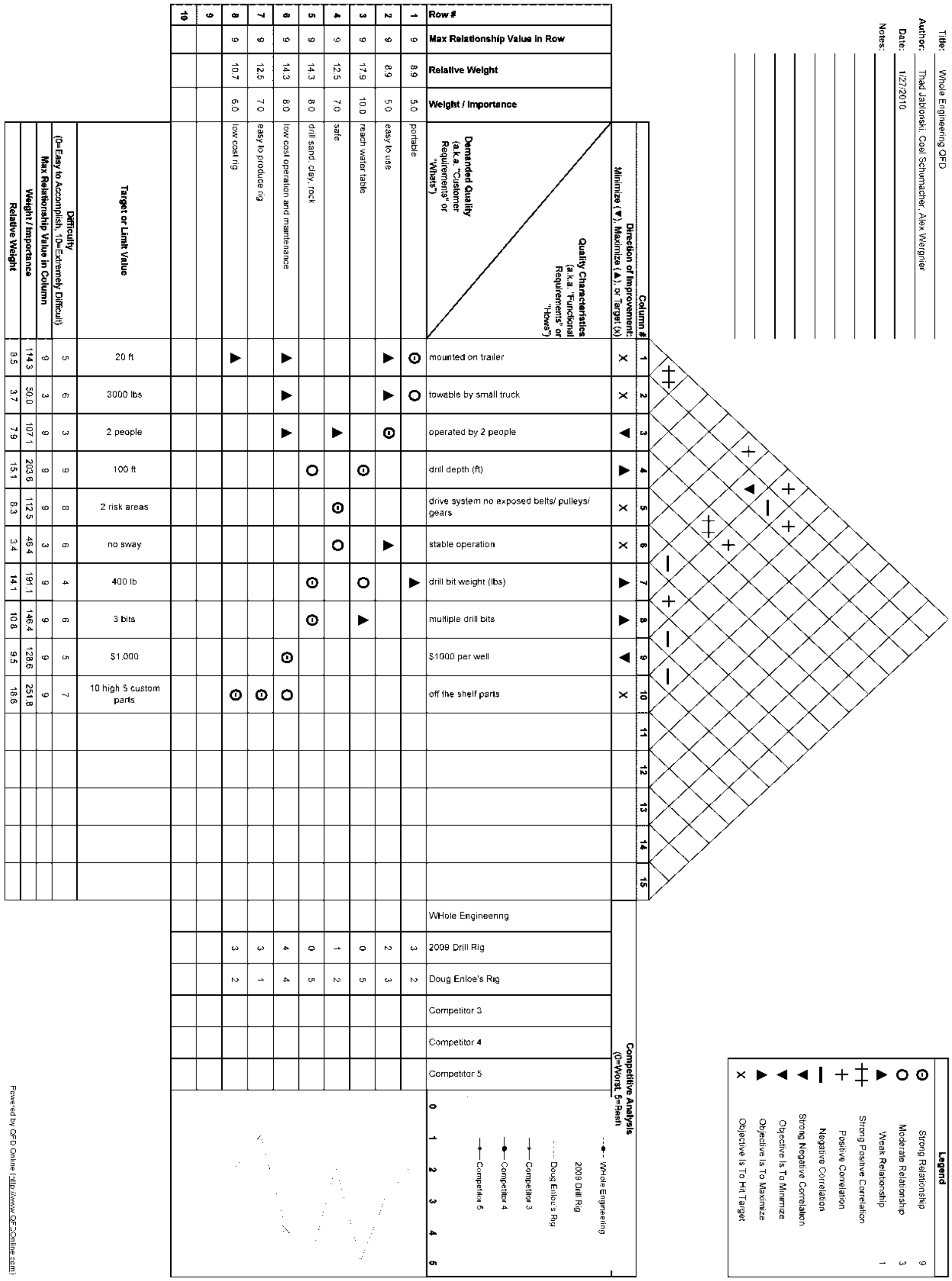
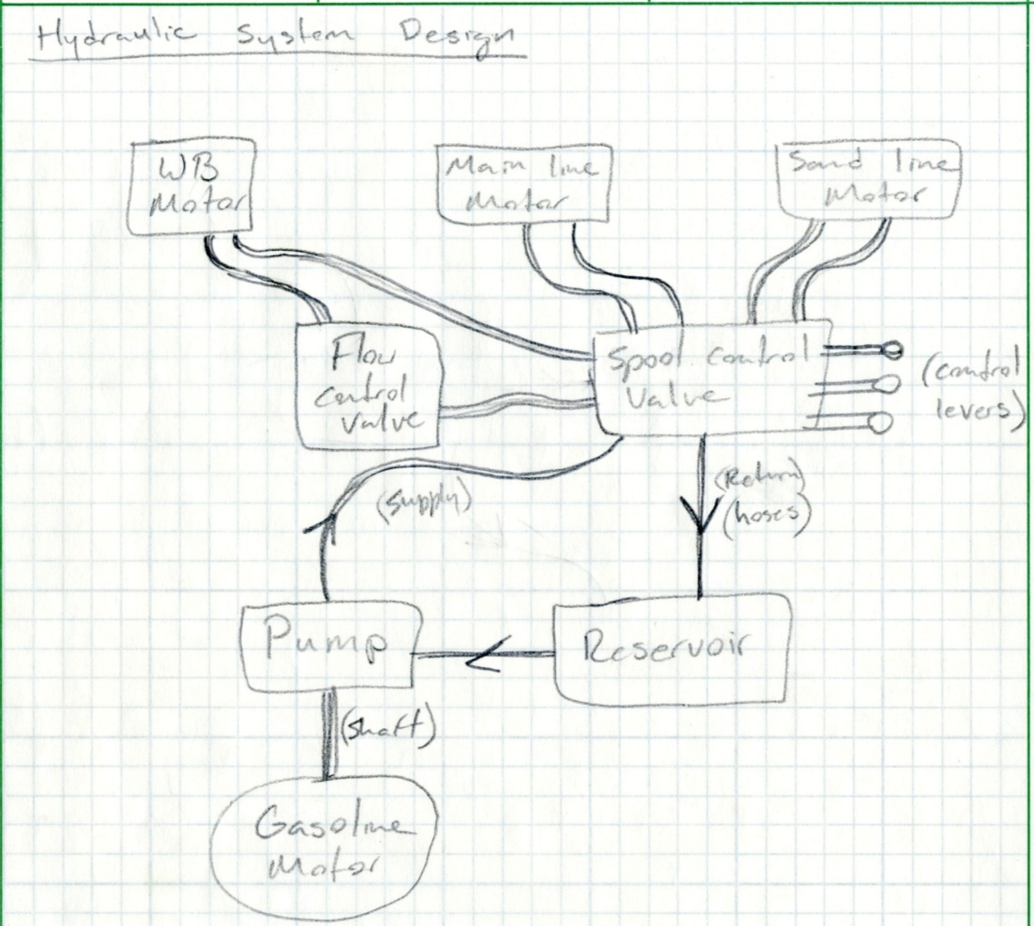


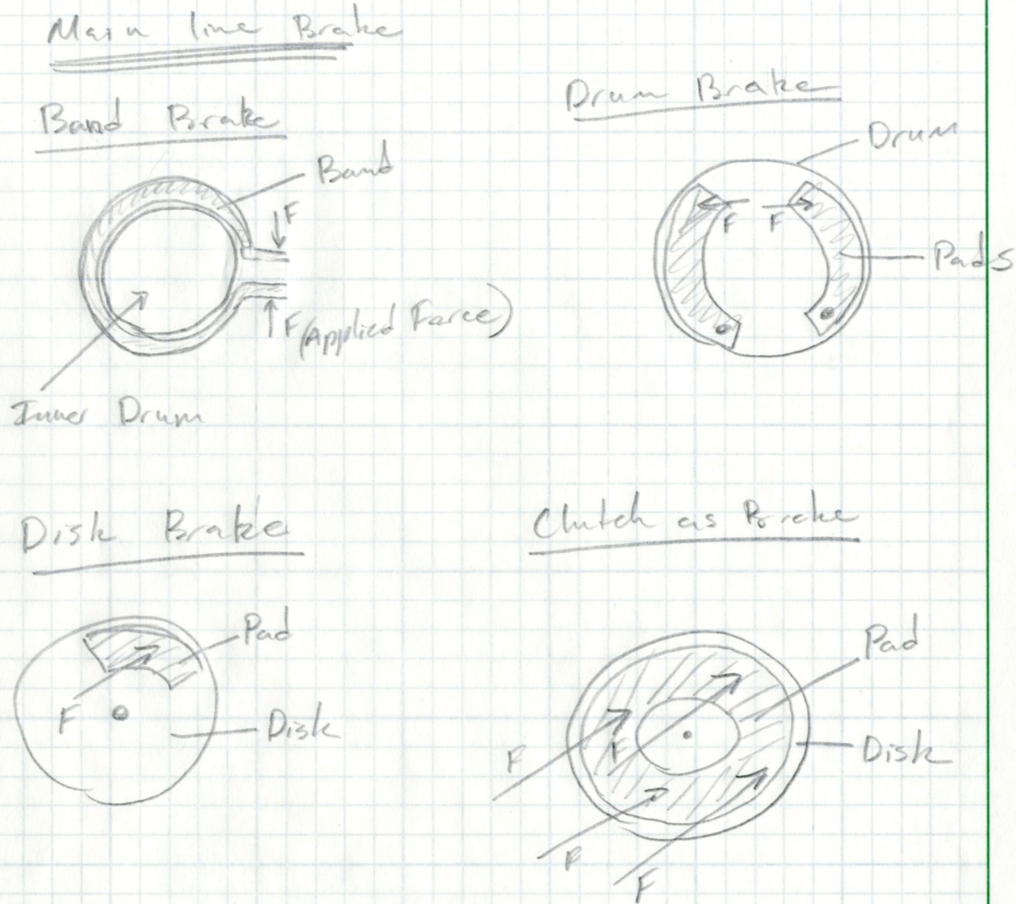
Figure 39 QFD

Appendix B Drawing packets

Hydraulic system sketch



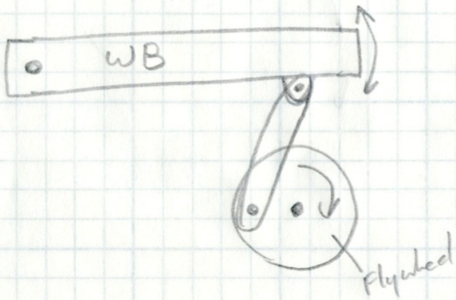
Brake sketches



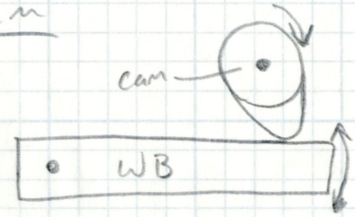
	Walking Beam Control	Sketch

Walking Beam Control – the walking beam oscillates to make the bit go up and down.

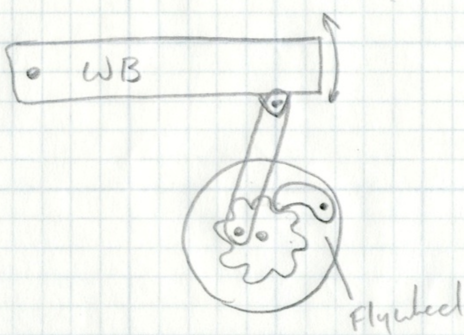
Rotery



Cam

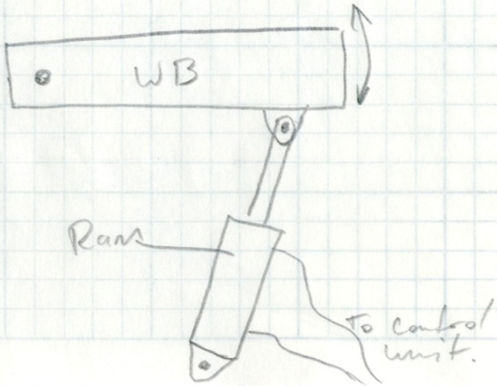


Rotary w/ one way

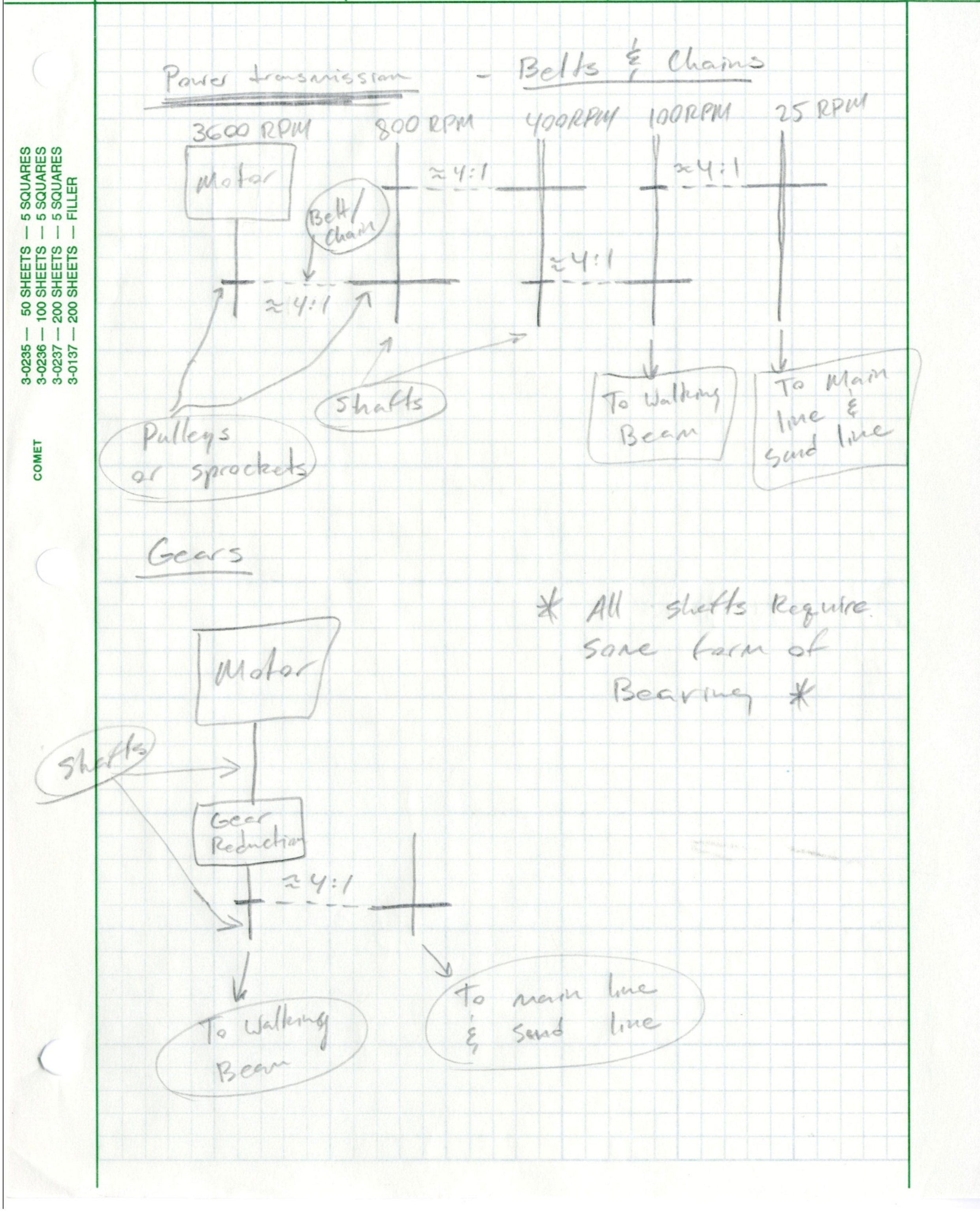


This allows the WB to move/fall freely (w/Bit) when the flywheel is going slower than optimum (Due to desire for increased control).

Hydraulic



	Chains & Sprockets	Sketch



Power Engagement	Sketch

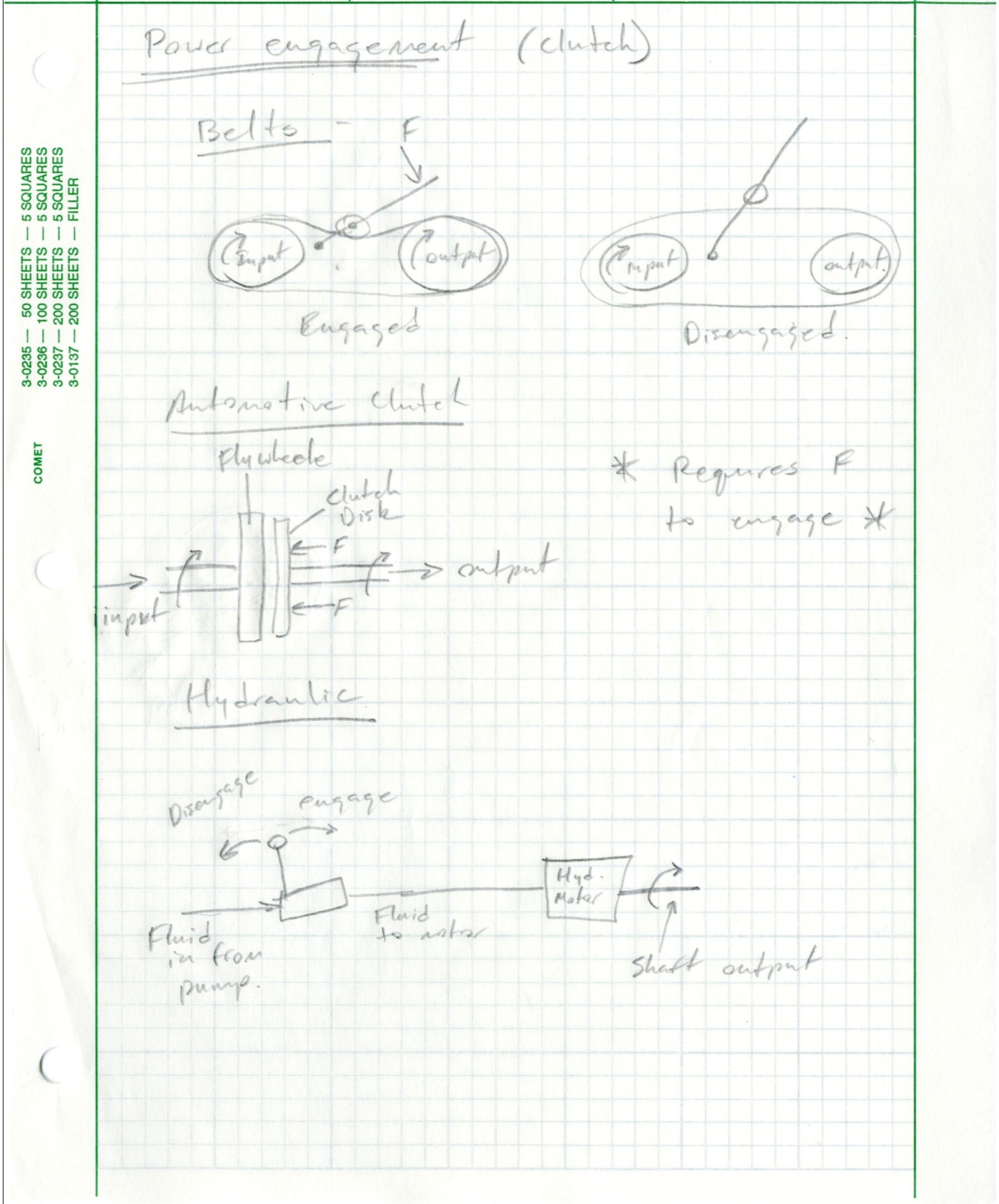


Table 11 Parts ordered details

Vendor	Part Number	Description	Unit Price($)	Quantity	Price($)
Grainger	6W549	Inlet Section	74.40	1	74.40
Grainger	6W560	Bolt Kit	10.16	1	10.16
Northern	201617	Outlet End Plate	39.99	1	39.99
Northern	201614	Valve SVW1DD1	104.99	1	104.99
Northern	201612	Valve SVW1BA1	79.99	2	159.98
Northern	201615	Valve SVW1BB1	89.99	1	89.99
Northern	2040	Flow Control Valve	84.99	1	84.99
Northern	10600	Hyd. Pump	184.99	1	184.99
Northern	1039	Hyd. Motor	239.99	3	719.97
Northern	4052	Hyd. Oil Tank	99.99	1	99.99
Northern		Hyd. Hoses	30.00	12	360.00
Northern		Motor-Pump Bracket	60.00	1	60.00
Northern		Motor-Pump Coupling	38.00	1	38.00
Northern		Filter	30.00	1	30.00
Northern		Pressure Gauge	15.00	1	15.00
Northern		Couplings and Adapters	10.00	15	37.50
	6236K587	60 teeth 1 3/4" bore	84.74	1	84.74
	6236k541	35 teeth 1" bore	58.84	1	58.84
	6280k301	21 teeth 1" bore	42.43	2	84.86
	6236k534	30 teeth 1 1/2" bore	55.86	1	55.86
	2741t122	54 teeth 1 3/4" bore	80.90	1	80.90
	7265k522	20' Ansi 60H chain	158.00	1	158.00
		5/8" Left lay cable 200ft	500.00	1	500.00
B&B		2"x3"x3/16" Steel Tubing 20ft	78.00	17	1326.00
B&B		1/4" plate steel 4'x4'	105.00	1	105.00
B&B		6" sch. 40 steel water pipe 4ft	50.00	1	50.00
		Clutch master cylinder	30.00	1	30.00
		Brake rotor	45.00	1	45.00
		Brake caliper	80.00	2	160.00
		Brake lines	50.00	1	50.00
		Pillow blocks	25.00	12	300.00
Northern		Engine	400.00	1	400.00
B&B		1 3/4" steel shaft 15ft	150.00	1	150.00
		Pulleys	150.00	3	450.00

Appendix C List of Donors and Vendors

Donors

Doug Enloe
PO Box 1698
Nipomo, CA 93444
(805) 343-1698
Donations: Professional advice,
Rope Socket and other parts offered
Approx value: $200#

Rod Thompson
12264 Topa Lane
Santa Paula, CA 93060
(805) 660-2453
Donations: drill bit, sheaves, bailer
Approx value: $900

Stephen Michl of Michl Tool Works
445 So. Ojai St
Santa Paula, CA 93060
(805) 525-6638
Donations: bearings shafts flywheel
Approx value: $900

Paul Hofmeister of Hofmeister Const
1114 Ayers Ave
Ojai, CA 93023
(805) 640-8318
Donations: Drill string
Approx value $1,200

Ray Newmyer
PO Box 5, 11481 2nd Ave
Hooper, CO 81146
Donations: Professional advice
Approx value: $400#

Vendors

McMaster-Carr
(609)223-4200

Grainger
(800)323-0620

Northern Tool
(800) 221-0516

OnlineMetals.com
(800) 704-2157

Landmann Wire Rope Products Inc.
(800) 344-6751

Central Coast Bearing
860 Capitolio Way Ste A
San Luis Obsipo, CA 93401
(805) 546-9082

Precision Machine
3055 McMillan Avenue
San Luis Obispo, CA 93401
(805) 544-5694

B&B Steel
1233 Furukawa Way
Santa Maria, CA 93458
(805) 349-9991

Home Depot
1551 Froom Ranch Way
San Luis Obispo, CA 93405
(805) 596-0857

Kelly Supply Company Direct
(800) 918-8939

Heacock Trailers and Truck Accessories
417 Traffic Way
Arroyo Grande, CA 93420
(805) 489-8442

Preferred Pump And Equipment
1740 Carlotti Dr
Santa Maria, CA 93454
(805) 922-8510

Royal Supply
7050 E. 54th Place
Commerce City, CO 80022
(303) 286-1704

Appendix D Vendor supplied Component Specifications and Data Sheets

D-1 Component price and specifications sheets

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PRINCE Inlet Section

Hydraulics > Valves > Hydraulic Manual Stack Valve Systems

Stack Valve Inlet Section, 12 GPM, 500-1500 PSI

Grainger Item #	6W549
Price (ea.)	**$74.40**
Brand	PRINCE
Mfr. Model #	SV124
Ship Qty.	1
Sell Qty. (Will-Call)	1
Ship Weight (lbs.)	4.1
Usually Ships**	1-3 Days
Catalog Page No.	3515
Country of Origin (Country of Origin is subject to change.)	USA

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Qty.

Add Grainger TripleGuard® repair & replacement coverage for $16.95 each.

[Add to Order] [Add to Personal List]

Price shown may not reflect your price. Sign in or register.

Tech Specs | Additional Information | Compliance & Restrictions | MSDS | Required Accessories | Optional Accessories | Alternate Products | Repair Parts

Item	Hydraulic Inlet Section
Type	Stack Valve
Thread Porting	#100 RB(7/8-14) Straight
Flow Rate (GPM)	12
Design	Smooth, Efficient Differential Poppet
Function	Offer Top and End Porting and are Machined for Cartridge Type Relief Valve
Adjustable PSI Range	500 to 1500
Preset Setting (PSI)	1000
For Use With	Stack Valve

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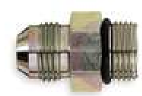
The "Usually Ships" reflects when an item is generally expected to ship from Grainger based on its stocking location. Real-time availability

Accessories

Optional

>More...



Hose Adapter, SAE to JIC, Straight
Grainger Item #: 2F339
Price (ea.): $3.93
Brand: EATON AEROQUIP

Qty.

[Add to Order]

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PRINCE Bolt Kit, For 4 Section

Hydraulics > Valves > Hydraulic Manual Stack Valve Bolt Kits

Stack Hydraulic Valve Bolt Kit, Number of Work Stations 4, 12 GPM

Grainger Item #	6W560
Price (ea.)	**$10.16**
Brand	PRINCE
Mfr. Model #	660401004
Ship Qty.	1
Sell Qty. (Will-Call)	1
Ship Weight (lbs.)	0.75
Usually Ships**	Today
Catalog Page No.	3515
Country of Origin (Country of Origin is subject to change.)	USA

Enlarge Image

Qty.

Add to Order   Add to Personal List

Price shown may not reflect your price. Sign in or register.

Tech Specs | Additional Information | Compliance & Restrictions | MSDS | Required Accessories | Optional Accessories | Alternate Products | Repair Parts

Item	Bolt Kit
Number of Work Sections	4
For Use With	12 GPM Stack Directional Control Valves

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To order this item online visit: www.northerntool.com and enter Item# 201617 | Print this page | Back to product page

NORTHERN® TOOL + EQUIPMENT

Prince Standard Outlet End Plate, Model# SVE21

Prince

In Stock

Ship Wt. 5.0 lbs.

Item# 201617

Only $39.99

Share this Product:

Overview

Sectional body hydraulic directional control valves for mobile and industrial hydraulic systems. Power beyond plug capability. Use with double-acting cylinders. U.S.A.

Product shown is representational; actual unit is outlet end plate body only.

Features + Benefits

- Inlet or outlet section not included
- Does not include through-bolt kit
- Standard Outlet End Plate, top and side ports
- Adjustable pressure range from 1500–3000 PSI
- Precision ground spools
- 1–10 sections per valve bank
- Load checks on each section
- Hard chrome-plated spools
- Compact construction
- Reversible handle
- Parallel circuit construction
- Foot mounting
- Max. 12 GPM and 180°F
- 3/4-16 ORB, #8 SAE working port, 7/8-14 ORB, #10 SAE inlet and outlet ports

NORTHERN TOOL + EQUIPMENT

Prince Control Valve — 4-Way/4-Position, Model# SVW1DD1

In Stock

Ship Wt. 5.0 lbs.

Item# 201614

Only $104.99

Share this Product:

Overview

Sectional body hydraulic directional control valves for mobile and industrial hydraulic systems. For use with double-acting cylinders. Power beyond plug capability. U.S.A.

Product shown is representational; actual unit is single-valve body only.

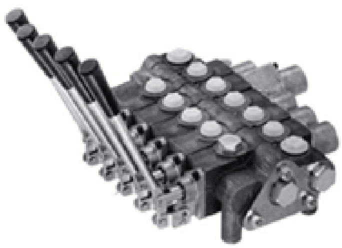
Features + Benefits

- Single-valve body only
- Inlet or outlet section not included
- Does not include through-bolt kit
- Float section can be placed anywhere within the stack assembly
- Not more than one float section per assembly
- Precision ground spools
- 1-10 sections per valve bank
- Load checks on each section
- Hard chrome-plated spools
- Compact construction
- Reversible handle
- Parallel circuit construction
- Foot mounting

Key Specs

- Max. Flow (GPM): 12
- Working Port (in.): 3/4-16 ORB, 8
- Max. PSI: 3,000
- Directional Control: 4 way, 4 position
- Adjustable Release Pressure PSI: 1,500 - 3,000

Prince Control Valve — 4-Way/3-Position Cylinder Spool, Model# SVW1BA1



In Stock

Ship Wt. 5.0 lbs.

Item# 201612

Only $79.99

Overall Rating 4 / 5

1 of **1** would recommend this product to a friend.

See all reviews below

Share this Product:

Overview

Sectional body hydraulic directional control valves for mobile and industrial hydraulic systems. For use with double-acting cylinders. U.S.A.

Product shown is representational; actual unit is single-valve body only.

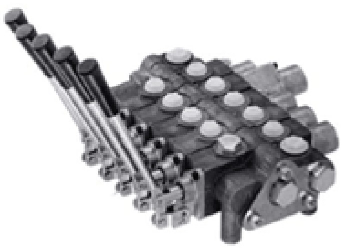
Features + Benefits

- Single-valve body only
- Inlet or outlet section not included
- Does not include through-bolt kit
- Precision ground spools
- 1-10 sections per valve bank
- Load checks on each section
- Hard chrome-plated spools
- Compact construction
- Reversible handle
- Parallel circuit construction
- Foot mounting

Key Specs

- Max. Flow (GPM): 12
- Inlet Port (in.): 7/8-14 ORB
- Outlet Port (in.): 7/8-14 ORB
- Working Port (in.): 3/4-16 ORB
- Max. PSI: 3,000
- Directional Control: 4 way, 3 position
- Adjustable Release Pressure PSI: 1,500 - 3,000

Prince Control Valve — 4-Way/3-Position, Detent, Model# SVW1BB1



In Stock

Ship Wt. 5.0 lbs.

Item# 201615

Only $89.99

Overall Rating 5 / 5

1 of **1** would recommend this product to a friend.

See all reviews below

Share this Product:

Overview

Sectional body hydraulic directional control valves for mobile and industrial hydraulic systems. For use with double-acting cylinders. U.S.A.

Product shown is representational; actual unit is single-valve body only.

Features + Benefits

- Single-valve body only
- Inlet or outlet section not included
- Does not include through-bolt kit
- 4-Way/3-Position Detent
- Precision ground spools
- 1-10 sections per valve bank
- Load checks on each section
- Hard chrome-plated spools
- Compact construction
- Reversible handle
- Parallel circuit construction
- Foot mounting
- 3/4-16 ORB, 7/8-14 ORB

Key Specs

- Inlet Port (in.): 10 SAE
- Working Port (in.): 8 SAE
- Max. PSI: 3,000
- Max. Flow (GPM): 12
- Adjustable Release Pressure PSI: 1,500 - 3,000

NORTHERN®
TOOL + EQUIPMENT

Prince Adjustable Flow Control Valve — 1/2in. Port Size, Model# PFC51-1/2

Prince

In Stock

Ship Wt. 8.0 lbs.

Item# 2040

Only $84.99

Share this Product:

Overview

The Prince Adjustable Flow Control Valve controls the speed of hydraulic motors. This type of valve will start and stop a hydraulic motor or cylinder and vary the speed over a wide range. Once the speed is set it will remain constant regardless of load variation. Any remaining flow is bypassed to the excess flow port to return to tank or to power another hydraulic function. U.S.A.

Features + Benefits

- Rated up to 3000 PSI
- Rated flow 0-16 GPM

Key Specs

- Port Size (in.): 1/2
- Max. Flow (GPM): 16
- Max. PSI: 3,000

What's Included

- (1) Control valve

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NORTHERN® TOOL + EQUIPMENT

Haldex High Performance Gear Pump .976 Cu. In., Model# WP09A1B160L03BA102N

In Stock

Ship Wt. 6.0 lbs.

Item# 10600

Only $199.99

Share this Product:

Overview

Compact, high-performance package is constructed of high-strength aluminum housing with cast iron end covers. Ideal for a wide variety of applications such as material handling, aerial lifts, turf care, agriculture and construction. Low-noise pumps have SAE A 2-bolt mounts and SAE O-ring side ports. W900 Series: 90% efficiency, 3/4in. keyed shaft. U.S.A.

Features + Benefits

- Displacement Cubic In.: .976
- Maximum Flow at 1800 RPM: 7.49 GPM
- Maximum Flow at 3600 RPM: 14.99 GPM
- Maximum RPM at 4000 PSI: 3000
- Outlet: 7/8in.-14
- Rotation: CCW

Key Specs

- Max. PSI: 4,000
- Shaft Diameter (in.): 3/4
- GPM: 7.49, 14.99
- Material: Aluminum and cast iron
- Rotations Per Minute: 500 - 4,000

NORTHERN® TOOL + EQUIPMENT

Dynamic Low Speed, High Torque Hydraulic Motor — 15.8 GPM, 1250 PSI

DYNAMIC

In Stock

Ship Wt. 17.0 lbs.

Item# 1039

Only $239.99

Overall Rating 5 / 5

1 of **1** would recommend this product to a friend.

See all reviews below

Share this Product:

Overview

For light- and medium-duty applications. Replacement for Charlynn H, White HS and Ross TRW MG series. Maximum inlet pressure is 2500 PSI and maximum back pressure is 1000 PSI. Fully reversible. 4-bolt mount. 1in. x 1 3/4in. shaft has 1/4in. keyway. 1/2in. NPTF ports. Orbiting Gerotor Principle. 1-year limited warranty.

Features + Benefits

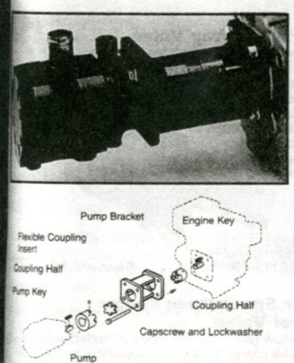
- 1-year limited warranty

Key Specs

- Mounting Type: 4 bolt
- Shaft Dimensions Diameter x L (in.): 1 x 1 3/4
- Port Size (in.): 1/2 NPTF
- Displacement (cu. in.): 23.6
- Max. RPM: 150
- Max. PSI: 1,250
- Max. Torque (in.-lbs.): 3,720
- Max. Flow (GPM): 15.8

Prince

HYDRAULICS



With Northern's mounting brackets, you can speed assembly time, ensure shaft alignment and improve compactness and appearance at a reasonable price.

Hydraulic Pump Mounting Brackets

4-Bolt brackets for J.S. Barnes 11, 13.6 and 16 GPM Pumps; Fit Item#s 1012, 1053 and 1056 pumps. Item#s 3030 and 3031 are Zytel fiberglass-reinforced nylon, all others are cast aluminum. U.S.A.

Item#	Bracket Length	Bolt Circle	Fits these Engines	Ship Wt.	Discount Price
3030-2601	4"	3⅝"	5 HP Briggs STD or IC/IP, 5 HP Robin Industrial, 5 & 6 HP Tecumseh® and 5.5 HP Honda	1 lb.	$26.99
3031-2601	5"	3⅝"	7, 8 and 10 HP Tecumseh®	1 lb.	$26.99
3032-2601	5⅝"	6½"	7 & 8 HP Briggs STD or IC/IP, 12, 14, 16, & 18 HP Tecumseh®, 6½, 7½, 8 & 11 HP Robin Industrial and 8, 10 & 11 HP Honda	4 lbs.	$49.99
3033-2601	4⅞"	6½"	10, 11, 16 & 18 HP Briggs STD or IC/IP and 6 & 8 HP Kohler	5 lbs.	$49.99
3034-2601	5¾"	7¾"	16 & 18 HP Briggs STD or IC and 10, 12, 14 & 16 HP Kohler	5 lbs.	$49.99

2-Bolt Brackets

For J.S. Barnes 22 and 28 GPM pumps; fit Item#s 1057 and 1058 pumps. U.S.A.

Item#	Bracket Length	Bolt Circle	Fit these Engines	Ship Wt.	Discount Price
3042-2601	6"	6½"	10, 11, 16 & 18 HP Briggs STD or IC/IP, 12, 16 & 18 HP Tecumseh® and 8, 10 & 11 HP Honda	5 lbs.	$49.99
3044-2601	7"	7¾"	16 & 18 HP Briggs STD or IC and 17, 19, 20, 21 & 23 HP Kohler	5 lbs.	$54.99

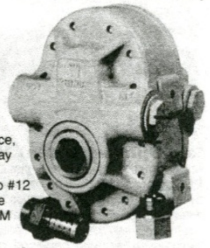
Bolt Kits for Brackets

Use these to mount pump, engine and bracket. Bolts and lock washers included. To select the correct kit, match your bracket, engine and pump type. Ship Wt. 1 lb./ea.

- **For Bracket 3030. Pump 1012, 1053, 10102, 10103. Engine 5-6 HP Tecumseh®, Briggs, Honda, Robin Industrial**
  Item# 3210-2601 — **Discount Price $2.99**
- **For Bracket 3031. Pump 1012, 1053, 1056, 10102, 10103 Engine 7-8-10 HP Tecumseh®.**
  Item# 3212-2601 — **Discount Price $2.99**
- **For Bracket 3032. Pump 1012, 1053, 1056, 10102, 10103 Engine: 7-8-10 HP Briggs, Tecumseh®, Kohler, Honda, 8–11 HP Wisconsin/Robin.**
  Item# 3215-2601 — **Discount Price $2.99**

Prince PTO Tractor Pump

PTO Pumps!

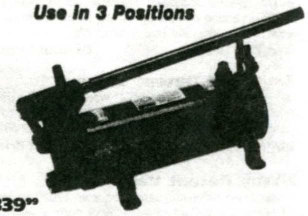


Gear-type, heavy-duty pump is designed for PTO drive operation on tractors of all sizes. No additional gearing is required. These pumps feature self-adjusting wear plates that seal off leakage and offset any wear or expansion that may occur during the life of the pump. High tensile aluminum housing, minimum gear clearance, cast iron endplates. Internal splined shafts go all the way through and are supported on both sides by roller bearings. All models have a #16 SAE inlet port and two #12 SAE outlet ports. Include #12 SAE to 3/4" NPTF female adapter. Reservoir must be at least as large as the GPM of the pump. U.S.A.

Item#	GPM	RPM	Dia./Spline	Ship Wt.	Discount Price
1051-2601	11.4	540	1⅜" / 6-spline	37 lbs.	$379.99
1052-2601	23	1000	1⅜" / 21-spline	36 lbs.	$379.99
1050-2601	21	540	1⅜" / 6-spline	41 lbs.	$389.99
10521-2601	40	1000	1⅜" / 21-spline	41 lbs.	$409.99

Tri-Power Hand Pump

Use in 3 Positions

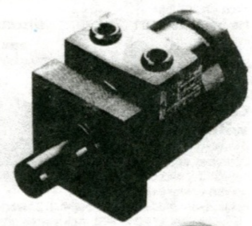


Powers a hydraulic press, dump, plow, snowblade, platform, frame straightener and other low-flow equipment. 3 positions: 1) 1.25 cu. in. per stroke @1500 PSI, 2) .95 cu. in per stroke @ 200 PSI, 3) .60 cu. in. per stroke @ 3000 PSI. 1-gallon reservoir. Inlet check valve, release valve. Pressure port 3/8" NPT. Applied handle force 60–65 lbs. Use on up to 200 cu. inch, single- or double-acting cylinder. 16½"L. U.S.A. Ship Wt. 33 lbs.

Item# 1098-2601

Discount Price $339.99

Rule of Thumb for Hydraulic Motor Applications



For longer motor life and better performance, we recommend that the operating pressure be kept below 1000 PSI by selecting the next larger size motor.

- **1 HP electric motor equals 1½ HP hydraulic motor**
- **1 HP gasoline engine equals 2/3 HP hydraulic motor**
- **1 HP hydraulic motor equals 1⅔ HP gasoline engine**
- **1 HP hydraulic motor equals 2/3 HP electric motor**

HP = Torque x RPM / 63,025

Heavy-Duty Hydraulic Motors for High Torque, Low Speed!

- **Max. inlet pressure 2500 PSI; 1/2" NPTF ports**
- **Max. back pressure 1000 PSI; 1" x 1¾" shaft has 1/4" keyway**
- **For light- and medium-duty applications; fully reversible**
- **Replacement for Charlynn 'H', White 'HS' and Ross TRW 'MG' series**
- **4-bolt mount; orbiting Gerotor Principle**

Item#	Max. Displacement (cu. in.)	Max. GPM	Max. RPM	Max. PSI	Max Torque. (in. lbs.)	Ship Wt.	Discount Price
1001-2601	3.0	12	1000	2200	787	8 lbs.	$179.99
1003-2601	6.07	14	750	2000	1437	13 lbs.	$189.99
1004-2601	12.15	14	400	1800	2305	15 lbs.	$199.99
1007-2601	17.9	14	250	1600	2890	16 lbs.	$229.99
1008-2601	24.4	14	160	1300	3392	16 lbs.	$239.99

NORTHERN Order Anytime 1-800-556-7885 · NorthernTool.com

Hydraulic Hose in Precut Lengths

Boxed hydraulic hose. You can cut it to lengths you need and ...ch reusable couplings (sold separately).

...dium-Pressure Hydraulic Hose

SAE 100R1, type AT. Rated @ 2000–2750 PSI, 1 wire hose.

Item#	Size (L x Dia.)	PSI	Ship Wt.	Discount Price
5004025-2601	25' x 1/4"	2750	6 lbs.	$29.99
5004050-2601	50' x 1/4"	2750	11 lbs.	$48.99
5004100-2601	100' x 1/4"	2750	18 lbs.	$88.99
5006025-2601	25' x 3/8"	2250	6 lbs.	$31.99
5006050-2601	50' x 3/8"	2250	12 lbs.	$52.99
5006100-2601	100' x 3/8"	2250	27 lbs.	$99.99
5008025-2601	25' x 1/2"	2000	10 lbs.	$35.99
5008050-2601	50' x 1/2"	2000	19 lbs.	$62.99
5008100-2601	100' x 1/2"	2000	33 lbs.	$111.99

High-Pressure Hydraulic Hose

R2 hose. Rated @ 2000–5000 PSI, 2 wire hose.

Item#	Size (L x Dia.)	PSI	Ship Wt.	Discount Price
5004125-2601	25' x 1/4"	5000	6 lbs.	$30.99
5004150-2601	50' x 1/4"	5000	12 lbs.	$51.99
5004200-2601	100' x 1/4"	5000	24 lbs.	$102.99
5108025-2601	25' x 1/2"	3500	13 lbs.	$39.99
5108050-2601	50' x 1/2"	3500	25 lbs.	$69.99
5108100-2601	100' x 1/2"	3500	50 lbs.	$119.99
5112025-2601	25' x 3/4"	2250	18 lbs.	$58.99
5112050-2601	50' x 3/4"	2250	33 lbs.	$104.99
5112100-2601	100' x 3/4"	2250	65 lbs.	$182.99
5116025-2601	25' x 1"	2000	24 lbs.	$84.99
5116050-2601	50' x 1"	2000	44 lbs.	$146.99
5116100-2601	100' x 1"	2000	88 lbs.	$268.99

Polycarbonate Housed Fluid L...el Gauge with ...rmometer

... level gauge features polycarbonate housing. Will never rust. Easily mounts on side wall of reservoirs up to 1/2" wall thickness. Includes thermometer. Mounts with hollow 1/2"-13 bolts on 5" centers. 1.5"W x 2.2"D x 6.5"H. Ship Wt. 1 lb.

Item# 406011-2601 **Discount Price $13.99**

Flow Meter

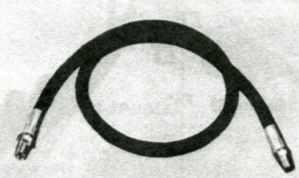
Handles up to 30 GPM at 5000 PSI. 4% FDS accuracy. Large 2½" direct read dial. Can be mounted horizontal or vertical. 3/4" in and out ports. Comes with 1/4" port to mount pressure gauge. Use on pressure or return line. Measures in GPM. Ship Wt. 4 lbs.

Item# 2048-2601 **Discount Price $249.99**

Flow Meter with Thermometer

Handles up to 32 GPM at 6000 PSI. Includes 180°F thermometer. Otherwise similar to #2048. Ship Wt. 5 lbs.

Item# 20480-2601 **Discount Price $289.99**



1/4" SAE 100R1 Type AT Hydraulic High-Pressure Hose

1-wire solid male coupling, 1/4" pipe thread. Working pressure up to 4000 PSI.

Item#	Length	Ship Wt.	Discount Price
50012-2601	12"	1 lb.	$4.69
50036-2601	36"	1 lb.	$5.99
50042-2601	42"	1 lb.	$6.99
50048-2601	48"	1 lb.	$7.69

3/8" 2-Wire Hose

Working pressure of 4500 PSI. 3/8" pipe thread.

Item#	Length	Ship Wt.	Discount Price
50250-2601	18"	2 lbs.	$5.99
50251-2601	24"	2 lbs.	$6.69
50252-2601	36"	2 lbs.	$8.49
50253-2601	48"	3 lbs.	$9.89
50254-2601	96"	3 lbs.	$15.99
50255-2601	120"	4 lbs.	$17.99

1/2" 2-Wire Hose

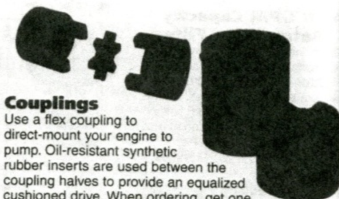
2-wire solid male couplings, 1/2" pipe thread. Working pressure up to 4000 PSI.

Item#	Length	Ship Wt.	Discount Price
50112-2601	12"	1 lb.	$6.49
50114-2601	14"	1 lb.	$6.69
50116-2601	16"	1 lb.	$6.79
50118-2601	18"	2 lbs.	$6.99
50121-2601	21"	2 lbs.	$7.49
50124-2601	24"	2 lbs.	$7.99
50130-2601	30"	2 lbs.	$8.59
50136-2601	36"	2 lbs.	$9.49
50148-2601	48"	3 lbs.	$10.99
50160-2601	60"	3 lbs.	$11.99
50172-2601	72"	3 lbs.	$13.99
50196-2601	96"	4 lbs.	$16.99
51120-2601	120"	4 lbs.	$19.99
51144-2601	144"	5 lbs.	$22.99

3/4" 2-Wire Hose

Working pressure of 2500 PSI, 3/4" pipe thread.

Item#	Length	Ship Wt.	Discount Price
50212-2601	12"	2 lbs.	$8.79
50218-2601	18"	2 lbs.	$9.99
50224-2601	24"	2 lbs.	$11.89
50230-2601	30"	3 lbs.	$12.49
50236-2601	36"	3 lbs.	$13.69
50248-2601	48"	4 lbs.	$16.99
50260-2601	60"	4 lbs.	$19.99



Couplings

Use a flex coupling to direct-mount your engine to pump. Oil-resistant synthetic rubber inserts are used between the coupling halves to provide an equalized cushioned drive. When ordering, get one side to fit the motor and the other side to fit the pump shaft dia. Order two halves plus insert for complete coupling. When mounting, do not pound on the end of your pump shaft.

Standard Half

LO 90 and LO 95 series, up to 11.16 HP at 3600 RPM. Maximum torque is 194 in.-lbs. Ship Wt. 1 lb./ea.

Item#	Size	Discount Price
3001-2601	7/16"	$9.99
3002-2601	1/2"	$9.99
3003-2601	9/16"	$9.99
3004-2601	5/8"	$9.99
3005-2601	3/4"	$9.99
3006-2601	7/8"	$9.99
3007-2601	1"	$9.99
3008-2601	1⅛"	$9.99

Insert for Standard Half

Ship Wt. 1 lb.

Item# 3009-2601 **Discount Price $7.99**

Heavy-Duty Half

Fits model LO 99 & L 100 series up to 23 HP at 3600 RPM. Made for 2 bolt brackets. Ship Wt. 2 lbs./ea.

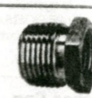
Item#	Size	Discount Price
3011-2601	1/2"	$12.99
3013-2601	5/8"	$12.99
3014-2601	3/4"	$12.99
3015-2601	7/8"	$12.99
3017-2601	1"	$12.99
3019-2601	1⅛"	$12.99
3021-2601	1¼"	$16.99

Insert for Heavy-Duty Half

Ship Wt. 1 lb.

Item# 3022-2601 **Discount Price $9.99**

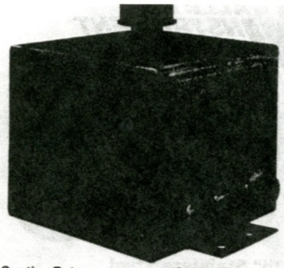
Reducer Bushing



Item#	M NPTF	F NPTF	Discount Price
51CSC064-2601	3/8"	1/4"	$.99
51CSC084-2601	1/2"	1/4"	$.99
51CSC124-2601	3/4"	1/4"	$1.99
51CSC086-2601	1/2"	3/8"	$.99
51CSC126-2601	3/4"	3/8"	$1.99
51CSC128-2601	3/4"	1/2"	$1.99
51CSC1612-2601	1"	3/4"	$1.99
51CSC2012-2601	1¼"	3/4"	$4.99
51CSC2016-2601	1¼"	1"	$4.99

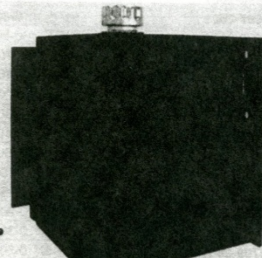
Call for Our Complete Line of Hydraulic Fittings!

HYDRAULICS



Hydraulic Oil Steel Tanks

Item#	Gallons	Dimensions	Suction Port	Return Port	Mount	Ship Wt.	Discount Price
4049-2601	2.8	9"L x 8"H	1½"	3/4"	4 bolt	14 lbs.	$49.99
4050-2601	4.8	15"L x 9"W x 8"H	1½"	3/4"	4 bolt	22 lbs.	$59.99
4051-2601	7	16"L x 10"W x 10½"H	2"	1"	2 bolt	27 lbs.	$69.99
4052-2601	10	17¾"L x 11"W x 12"H	2"	1"	2 bolt	29 lbs.	$79.99
4053-2601	12	18¼"L x 11¼"W x 14"H	2"	1"	2 bolt	40 lbs.	$84.99
40519-2601	19.5	22¼"L x 14¼"W x 14¾"H	2"	1"	4 bolt	48 lbs.	$99.99



15-Gallon Side Mount Hydraulic Reservoir

13-gauge HRPO steel with welded mounting angles. 1/4 turn chrome filler breather with basket strainer. Oil level gauge with temperature indicator. Interior baffle between suction and discharge. 2" NPT suction ports and magnetic drain plug. 11-gallon usable capacity. Powder-coat finish. U.S.A.
Ship Wt. 57 lbs.

Item# 4054-2601

Discount Price $129.99

25-Gallon Side Mount Hydraulic Reservoir

Usable capacity of 18 gallons. Otherwise similar to Item# 4054. U.S.A.
Ship Wt. 73 lbs.

Item# 40541-2601

Discount Price $139.99

Our Newest Additions!

Hose Barb Fittings

NPT Male threads. Zinc plated. U.S.A. Ship Wt. 1 lb./ea.

Item#	NPT Thread	Hose I.D.	Barb End Length	Discount Price
109019-2601	3/4"	3/4"	1.35"	$3.99
109001-2601	1"	1"	1.35"	$4.99
109002-2601	1¼"	1¼"	1.65"	$4.99

Hydraulic Suction Hoses

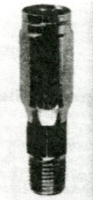
100R4. Internally reinforced suction/return line hose. U.S.A.

Item#	I.D. X Length	Ship Wt.	Discount Price
109003-2601	1" x 72"	4 lbs.	$29.99
109004-2601	1¼" x 72"	7 lbs.	$36.99
109005-2601	1" x 180"	12 lbs.	$59.99
109006-2601	1¼" x 180"	19 lbs.	$79.99

Reusable Hose Coupling

Male pipe NPTF.

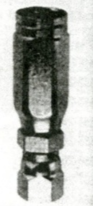
Item#	Size	Wire	Price
50RCM4-2601	1/4"	1	$6.99
50RCM6-2601	3/8"	1	$7.49
50RCM81-2601	1/2"	1	$8.99
50RCM82-2601	1/2"	2	$9.99
50RCM12-2601	3/4"	2	$12.99



Female Thread (37 JIC Swivel)

Reusable fitting for female SAE 37. Female thread on both ends.
Ship Wt. 1 lb./ea.

Item#	Size	Wire	Price
50RCF4-2601	1/4"	1	$6.99
50RCF6-2601	3/8"	1	$7.99
50RCF8-2601	1/2"	2	$13.99
50RCF12-2601	3/4"	2	$18.29



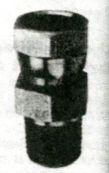
Hydraulic Break-Away Couplers

Use one size larger than hose to prevent restriction. Not for use on the suction line of our 2-stage pumps. Ship Wt. 1 lb./ea.

Item#	Size	Ship Wt.	Price
50C4W-2601	1/4"	2 lbs.	$9.99
50C6W-2601	3/8"	2 lbs.	$12.49
50C8W-2601	1/2"	2 lbs.	$13.49
50C12W-2601	3/4"	2 lbs.	$34.99
51C16W-2601	1"	3 lbs.	$49.99

Straight Swivel Adapter

Item#	F NPSM	M NPTF	Price
51ASC004-2601	1/4"	1/4"	$1.29
51ASC046-2601	1/4"	3/8"	$1.99
51ASC006-2601	3/8"	3/8"	$1.69
51ASC068-2601	3/8"	1/2"	$2.29
51ASC008-2601	1/2"	1/2"	$1.99
51ASC812-2601	1/2"	3/4"	$2.99
51ASC012-2601	3/4"	3/4"	$2.99



90 Degree Elbow

Item#	M JIC37	M NPTF	Price
51ERC004-2601	1/4"	1/4"	$1.49
51ERC006-2601	3/8"	3/8"	$1.99
51ERC068-2601	3/8"	1/2"	$2.69
51ERC008-2601	1/2"	1/2"	$2.69
51ERC812-2601	1/2"	3/4"	$3.99
51ERC012-2601	3/4"	3/4"	$4.49

Reducer Bushing

Item#	M NPTF	F NPTF	Price
51CSC064-2601	3/8"	1/4"	$.99
51CSC084-2601	1/2"	1/4"	$.99
51CSC124-2601	3/4"	1/4"	$1.19
51CSC086-2601	1/2"	3/8"	$.99
51CSC126-2601	3/4"	3/8"	$1.19
51CSC128-2601	3/4"	1/2"	$1.49
51CSC1612-2601	1"	3/4"	$1.99
51CSC2012-2601	1¼"	3/4"	$4.49
51CSC2016-2601	1¼"	1"	$4.69

CALL Us for Our Full Line of Hydraulic Fittings

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NORTHERN® TOOL + EQUIPMENT

Hydraulic Pump Mounting Bracket

In Stock

Ship Wt. 5.0 lbs.

Item# 3042

Only $59.99

Overall Rating **4.6** / 5

5 of **5** would recommend this product to a friend.

See all reviews below

Share this Product:

Overview

With Northerns mounting brackets, you can speed assembly time, ensure shaft alignment and improve compactness and appearance at a reasonable price. 2-bolt brackets for J.S. Barnes 22 and 28 GPM pumps. Fit our items 1057 and 1058 pumps.

Features + Benefits

- Fits: 10, 11, 16 and 18 HP Briggs STD or IC/IP
- Fits: 12, 16 and 18 HP Tecumseh
- Fits: 8, 10 and 11 HP Honda

Key Specs

- Bracket Length (in.): 6
- Bolt Circle (in.): 6 1/2
- Mounting Type: 2 bolt

NORTHERN®
TOOL + EQUIPMENT

NorthStar Steel Hydraulic Oil Tank — 10 Gallon

In Stock

Ship Wt. 35.0 lbs.

Item# 4052

Only $99.99

Overall Rating **4.8 / 5**

4 of **4** would recommend this product to a friend.

See all reviews below

Share this Product:

Overview

Features sturdy 12-gauge steel welded construction. Welded-on mounting brackets. Includes clip-on style breather cap. Suction strainer Item# 4010 fits oil tank Item# 4052 (strainer not included).

Features + Benefits

- Replacement parts available from Northern or a Northern retail store

Key Specs

- Capacity (gal.): 10
- Suction Port (in.): 2
- Return Port (in.): 1
- Mount Type: 2 bolt
- Material Type: Steel
- Dimensions L x W x H (in.): 17 3/4 x 11 x 12

Hyd. Motor Specs

BMP/BMPH 250		231 Cm^3/Rev 14.1 in^3/Rev					Max Cont	Max Int.
Pressure Mpa (psi)		3 (440)	6 (880)	7 (1030)	8 (1175)	10 (1470)	11 (1620)	14 (2060)
	LPM (GPM)	Torque Mn (in.Lbs) Speed Specification						
FLOW	8 (2.10)	93 (823)	195 (1726)	226 (2000)	259 (2292)	325 (2876)	357 (3159)	
		31 rpm	29 rpm	29 rpm	27 rpm	25 rpm	24 rpm	
	15 (3.95)	92 (814)	192 (1699)	226 (2000)	260 (2301)	325 (2876)	360 (3186)	456 (4036)
		60 rpm	58 rpm	57 rpm	57 rpm	55 rpm	55 rpm	
	20 (5.25)	90 (797)	191 (1690)	225 (1991)	258 (2283)	322 (2850)	356 (3151)	455 (4027)
		79 rpm	78 rpm	77 rpm	76 rpm	75 rpm	75 rpm	65 rpm
	30 (7.90)	86 (761)	188 (1664)	221 (1956)	255 (2257)	319 (2823)	354 (3153)	452 (4000)
		119 rpm	118 rpm	117 rpm	116 rpm	114 rpm	114 rpm	103 rpm
	35 (9.20)	82 (726)	184 (1628)	217 (1920)	251 (2221)	317 (2805)	350 (3098)	448 (3965)
		138 rpm	137 rpm	135 rpm	133 rpm	133 rpm	124 rpm	
	45 (11.9)	79 (699)	179 (1584)	214 (1894)	246 (2177)	312 (2761)	345 (3053)	442 (3912)
		179 rpm	178 rpm	177 rpm	176 rpm	173 rpm	173 rpm	163 rpm
	50 (13.2)	74 (655)	174 (1540)	209 (1850)	243 (2151)	306 (2708)	339 (3000)	438 (3876)
		198 rpm	197 rpm	197 rpm	195 rpm	194 rpm	193 rpm	185 rpm
Max Cont.	60 (15.85)	71 (628)	171 (1513)	206 (1823)	239 (2115)	303 (2682)	336 (2974)	433 (3832)
		237 rpm	236 rpm	236 rpm	234 rpm	232 rpm	232 rpm	224 rpm
Max Int.	75 (19.75)	53 (469)	153 (1353)	189 (1673)	221 (1956)	280 (2478)	312 (2761)	
		297 rpm	295 rpm	295 rpm	293 rpm	292 rpm	291 rpm	

BMP/BMPH 315		311.7 Cm^3/Rev 19 in^3/Rev				Max Cont	Max Int.
Pressure Mpa (psi)		3 (440)	6 (880)	7 (1030)	8 (1175)	10 (1470)	12.5 (1840)
	LPM (GPM)	Torque Mn (in.Lbs) Speed Specification					
FLOW	8 (2.10)	116 (1027)	243 (2151)	282 (2496)	313 (2770)	388 (3434)	
		25 rpm	24 rpm	22 rpm	16 rpm	13 rpm	
	15 (3.95)	115 (1018)	243 (2151)	284 (2513)	324 (2867)	406 (3593)	503 (4452)
		47 rpm	46 rpm	45 rpm	43 rpm	41 rpm	20 rpm
	20 (5.25)	114 (1009)	242 (2142)	282 (2496)	323 (2859)	405 (3584)	505 (4469)
		63 rpm	62 rpm	61 rpm	58 rpm	56 rpm	44 rpm
	30 (7.90)	109 (956)	237 (2097)	277 (2451)	319 (2823)	401 (3549)	501 (4433)
		94 rpm	93 rpm	92 rpm	90 rpm	88 rpm	77 rpm
	35 (9.20)	105 (929)	232 (2053)	273 (2416)	314 (2779)	397 (3513)	497 (4398)
		110 rpm	109 rpm	108 rpm	106 rpm	103 rpm	93 rpm
	45 (11.9)	99 (876)	226 (2000)	268 (2372)	309 (2735)	391 (3460)	491 (4345)
		141 rpm	141 rpm	139 rpm	137 rpm	135 rpm	124 rpm
	50 (13.2)	92 (814)	218 (1929)	262 (2319)	304 (3960)	384 (3398)	486 (4301)
		157 rpm	157 rpm	155 rpm	154 rpm	151 rpm	141 rpm
Max Cont.	60 (15.85)	89 (788)	215 (1903)	258 (2283)	299 (2646)	379 (3554)	479 (4239)
		189 rpm	188 rpm	187 rpm	185 rpm	182 rpm	171 rpm
Max Int.	75 (19.75)	69 (611)	194 (1717)	237 (2097)	278 (2460)	355 (3141)	
		236 rpm	235 rpm	234 rpm	232 rpm	229 rpm	

Northern Cross Over 1039 BMPH-400

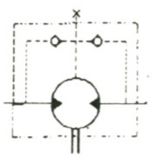
BMP/BMPH 400		386.2 Cm^3/Rev 23.58 in^3/Rev				Max Cont	Max Int.
Pressure Mpa (psi)		3 (440)	6 (880)	7 (1030)	8 (1175)	8.5 (1251)	12.5 (1840)
	LPM (GPM)	Torque Mn (in.Lbs) Speed Specification					
FLOW	8 (2.10)	147 (140)	304 (2690)	354 (3133)			
		20 rpm	19 rpm	16 rpm			
	15 (3.95)	147 (1301)	308 (2726)	359 (3177)	408 (3611)	435 (3850)	532 (4708)
		37 rpm	36 rpm	35 rpm	33 rpm	32 rpm	25 rpm
	20 (5.25)	144 (1274)	305 (2699)	358 (3168)	406 (3602)	435 (34850)	533 (4717)
		50 rpm	49 rpm	47 rpm	45 rpm	43 rpm	38 rpm
	30 (7.90)	139 (1230)	302 (2664)	352 (3115)	402 (3558)	430 (3806)	530 (4691)
		74 rpm	73 rpm	72 rpm	70 rpm	68 rpm	62 rpm
	35 (9.20)	133 (1177)	294 (2602)	345 (3053)	396 (3505)	423 (3744)	525 (4646)
		86 rpm	86 rpm	85 rpm	82 rpm	80 rpm	75 rpm
	45 (11.9)	125 (1106)	287 (2540)	339 (3000)	389 (3443)	416 (3682)	517 (4575)
		111 rpm	111 rpm	109 rpm	106 rpm	105 rpm	100 rpm
	50 (13.2)	117 (1035)	278 (2460)	330 (2920)	282 (3381)	409 (3620)	509 (4505)
		124 rpm	124 rpm	122 rpm	120 rpm	119 rpm	113 rpm
Max Cont.	60 (15.85)	112 (991)	274 (2425)	326 (2177)	377 (3337)	404 (3575)	505 (4469)
		149 rpm	149 rpm	147 rpm	145 rpm	144 rpm	137 rpm
Max Int.	75 (19.75)	88 (779)	246 (2177)	298 (2637)	351 (3106)	376 (3328)	
		185 rpm	185 rpm	185 rpm	182 rpm	181 rpm	

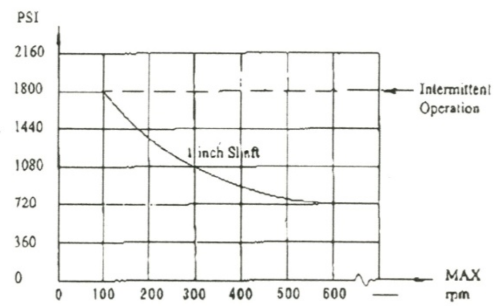
8

DYNAMIC
FLUID COMPONENTS, INC.

MODEL BMPH/BMP TECHNICAL DATA

SHAFT SEAL RATED PRESSURE

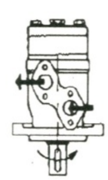




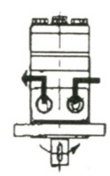
CASE DRAIN

In applications without a motor drain line, the pressure exerted on the shaft seal is marginally in excess of the return line pressure. When the drain line is used the pressure exerted on the shaft seal is equal to the return line pressure.

SHAFT ROTATION DIRECTION



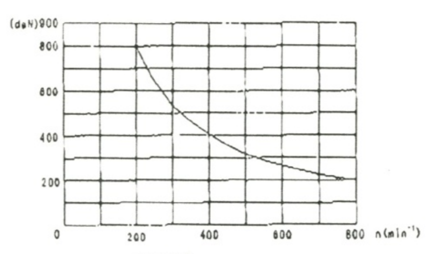
BMP



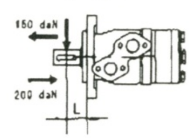
BMPH

RADIAL FORCES

Status of the shaft's radial force



$$F_r = \frac{800}{n} \cdot \frac{2500}{95+L} \text{ daN}$$



F_r =Radial Force (daN)
L =Distance (mm)
n =Speed (rpm)

Rhomb-flange L=30mm
Square-flange L=24mm

9

W900

Hydraulic Gear Pump

Featuring Integrated Valve Packages

Pressure
(P1) 276 BAR (4000 PSI)
(P2) 300 BAR (4400 PSI)

Speed
4000 RPM
Min. 500 RPM at 4000 PSI (276 BAR) Continuous

Efficiency
Overall > 90%
Volumetric 98%
Mechanical 92%

Noise
13 Tooth Design
Superior trapping configuration
Optimum gear profile

Flexibility
SAE, ISO & DIN shafts
Mounting flanges, Port styles, Integrated valves, Multiple pumps

Quality
ISO 9001 Registered

The W 900 is one family in the W Series of high performance gear pumps. It is a through bore bushing type design constructed of high strength aluminum housings. The W Series is suitable for a wide range of equipment applications from material handling, agricultural, construction and paving to aerial lifts, winch and turf care.

The hydraulic performance, flexibility, high efficiency, low and high speed operation, low noise performance and the variety of options have established the W Series as the standard by which other pump performance is measured. *This catalog illustrates the options* available for the W 900 family as well as performance and dimensional information. An easy to follow ordering guide is also included.

Haldex continuous improvement efforts have produced the WQ900 pump which is ideally suited to low noise applications. Contact your local Haldex representative for information about how the WQ900 can meet your specific needs.

Performance Information

Model Code		060	080	100	110	140	160	190	230	270	280
Displacement	cm³/rev	6	8	10	11	14	16	19	23	27	28
	in³/rev	.366	.488	.610	.671	.854	.976	1.159	1.403	1.647	1.709
Inlet Pressure	BAR (PSI)	min. 0.2 BAR below atmospheric (6 IN.HG)max. 2.0 BAR (29 PSI)									
Max. Continous Pressure (P1)	BAR / PSI	276 BAR 4000 PSI							221 / 3200	185 / 2700	180 / 2600
Max. Intermittent Pressure (P2)	BAR / PSI	300 BAR 4400 PSI							241 / 3500	203 / 2950	197 / 2850
Min. Rotational Speed At (P1)		500									
Max. Rotational Speed At (P1)		4000		3600		3300	3000		2800	2400	2300
Input Power	KW	3.01	4.02	5.02	5.52	7.03	8.03	9.54	9.24	9.15	9.14
@ P1 @ 1000 RPM	HP	4.0	5.4	6.7	7.4	9.4	10.8	12.8	12.4	12.3	12.3

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2

HALDEX-W900 SERIES PUMPS-US-2009-10

W900 DISTRIBUTOR STOCK PUMPS

W900 SERIES PUMPS WITH SAE "A" 2-BOLT MOUNT, 3/4" DIA. SAE "A" STRAIGHT SHAFT, AND SAE STRAIGHT THREAD SIDE PORTS

DISPLACEMENT			SAE SIDE PORTS	MODEL	CATALOG		
IN.³	CC	ROTATION	IN	OUT		NUMBER	X-REF
.366	6	CW	7/8-14	3/4-16	1303191	WP09A1B060R03BA101N	
.366	6	CCW	7/8-14	3/4-16	1303192	WP09A1B060L03BA101N	
.488	8	CW	1-1/16-12	7/8-14	1303193	WP09A1B080R03BA102N	
.488	8	CCW	1-1/16-12	7/8-14	1303194	WP09A1B080L03BA102N	
.610	10	CW	1-1/16-12	7/8-14	1303195	WP09A1B100R03BA102N	
.610	10	CCW	1-1/16-12	7/8-14	1303196	WP09A1B100L03BA102N	
.671	11	CW	1-1/16-12	7/8-14	1303197	WP09A1B110R03BA102N	
.671	11	CCW	1-1/16-12	7/8-14	1303198	WP09A1B110L03BA102N	
.854	14	CW	1-1/16-12	7/8-14	1303199	WP09A1B140R03BA102N	
.854	14	CCW	1-1/16-12	7/8-14	1303200	WP09A1B140L03BA102N	
.976	16	CW	1-1/16-12	7/8-14	1303201	WP09A1B160R03BA102N	
.976	16	CCW	1-1/16-12	7/8-14	1303202	WP09A1B160L03BA102N	
1.159	19	CW	1-5/16-12	1-1/16-12	1303203	WP09A1B190R03BA103N	
1.159	19	CCW	1-5/16-12	1-1/16-12	1303204	WP09A1B190L03BA103N	
1.403	23	CW	1-5/16-12	1-1/16-12	1303205	WP09A1B230R03BA103N	
1.403	23	CCW	1-5/16-12	1-1/16-12	1303206	WP09A1B230L03BA103N	
1.647	27	CW	1-5/16-12	1-1/16-12	1303207	WP09A1B270R03BA103N	
1.647	27	CCW	1-5/16-12	1-1/16-12	1303208	WP09A1B270L03BA103N	

W900 SERIES PUMPS WITH SAE "A" 2-BOLT MOUNT, 9 TOOTH SAE "A" SPLINE SHAFT, AND SAE STRAIGHT THREAD SIDE PORTS

DISPLACEMENT			SAE SIDE PORTS	MODEL	CATALOG	
IN.³	CC	ROTATION	IN	OUT	NUMBER	X-REF
.366	6	CW	7/8-14	3/4-16	1303209	WP09A1B060R03FA101N
.366	6	CCW	7/8-14	3/4-16	1303210	WP09A1B060L03FA101N
.488	8	CW	1-1/16-12	7/8-14	1303211	WP09A1B080R03FA102N
.488	8	CCW	1-1/16-12	7/8-14	1303212	WP09A1B080L03FA102N
.610	10	CW	1-1/16-12	7/8-14	1303213	WP09A1B100R03FA102N
.610	10	CCW	1-1/16-12	7/8-14	1303214	WP09A1B100L03FA102N
.671	11	CW	1-1/16-12	7/8-14	1303215	WP09A1B110R03FA102N
.671	11	CCW	1-1/16-12	7/8-14	1303216	WP09A1B110L03FA102N
.854	14	CW	1-1/16-12	7/8-14	1303217	WP09A1B140R03FA102N
.854	14	CCW	1-1/16-12	7/8-14	1303218	WP09A1B140L03FA102N
.976	16	CW	1-1/16-12	7/8-14	1303219	WP09A1B160R03FA102N
.976	16	CCW	1-1/16-12	7/8-14	1303220	WP09A1B160L03FA102N
1.159	19	CW	1-5/16-12	1-1/16-12	1303221	WP09A1B190R03FA103N
1.159	19	CCW	1-5/16-12	1-1/16-12	1303222	WP09A1B190L03FA103N
1.403	23	CW	1-5/16-12	1-1/16-12	1303223	WP09A1B230R03FA103N
1.403	23	CCW	1-5/16-12	1-1/16-12	1303224	WP09A1B230L03FA103N
1.647	27	CW	1-5/16-12	1-1/16-12	1303225	WP09A1B270R03FA103N
1.647	27	CCW	1-5/16-12	1-1/16-12	1303226	WP09A1B270L03FA103N

W900 SERIES PUMPS WITH SAE "A" 2-BOLT MOUNT, 11 TOOTH SAE "A" SPLINE SHAFT, AND SAE STRAIGHT THREAD SIDE PORTS

DISPLACEMENT			SAE SIDE PORTS	MODEL	CATALOG	
IN.³	CC	ROTATION	IN	OUT	NUMBER	X-REF
.976	16	CW	1-1/16-12	7/8-14	1303227	WP09A1B160R03GA103N
.976	16	CCW	1-1/16-12	7/8-14	1303228	WP09A1B160L03GA102N
1.159	19	CW	1-5/16-12	1-1/16-12	1303229	WP09A1B190R03GA103N
1.159	19	CCW	1-5/16-12	1-1/16-12	1303230	WP09A1B190L03GA103N
1.403	23	CW	1-5/16-12	1-1/16-12	1303231	WP09A1B230R03GA103N
1.403	23	CCW	1-5/16-12	1-1/16-12	1303232	WP09A1B230L03GA103N
1.647	27	CW	1-5/16-12	1-1/16-12	1303233	WP09A1B270R03GA103N
1.647	27	CCW	1-5/16-12	1-1/16-12	1303234	WP09A1B270L03GA103N
1.709	28	CW	1-5/16-12	1-1/16-12	1303235	WP09A1B280R03GA103N
1.709	28	CCW	1-5/16-12	1-1/16-12	1303236	WP09A1B280L03GA103N

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PRODUCT RANGE

HE Powerpacks
12/24/48 VDC 0.3 – 4.5 kW and
0.75 – 3 kW AC modular power packs

HE Box Powerpacks
12/24/48 VDC modular powerpacks
in weatherproof boxes

Pressure Switches
5 - 350 bar, connecting/disconnecting

W100 Hydraulic pumps
0.5 - 2.0 cc 227 bar

W300 Hydraulic pumps
0.8 – 5.7 cc 230 bar

W600 Hydraulic pumps / motors
3 – 12 cc 276 bar

W900 Hydraulic pumps / motors
5 – 31 cc/section 276 bar

Calma The new quiet pumps
6.2 - 23.7 cc/section 250 bar

WQ900 The quiet pumps
5 - 23 cc/section 230 bar

WP900X Hydraulic pumps
16 - 31 cc/section 276 bar

W1500 Hydraulic pumps / motors
19 - 50 cc/section 276 bar

F12 FERRA Heavy duty pumps
16 - 41 cc/section 276 bar

F15 FERRA Heavy duty pumps
19 - 50 cc/section 276 bar

F20/F30 (LS) Hydraulic pumps / motors
23 – 161 cc/section 276 bar

GPA Internal Gear pumps
1.7 – 63 cc/section 100 bar

GC Hydraulic pumps / motors
1.06 – 11.65 cc/section 276 bar

D Hydraulic pumps
3.8 – 22.9 cc/section 207 bar

II-Stage Hydraulic pumps
4.2 – 22.8 cc/section 276 bar

Rotary Flow Dividers
3.8 – 13.3 cc/section 300 bar

Transmission pumps

HALDEX-W900 SERIES PUMPS-US-2009-10

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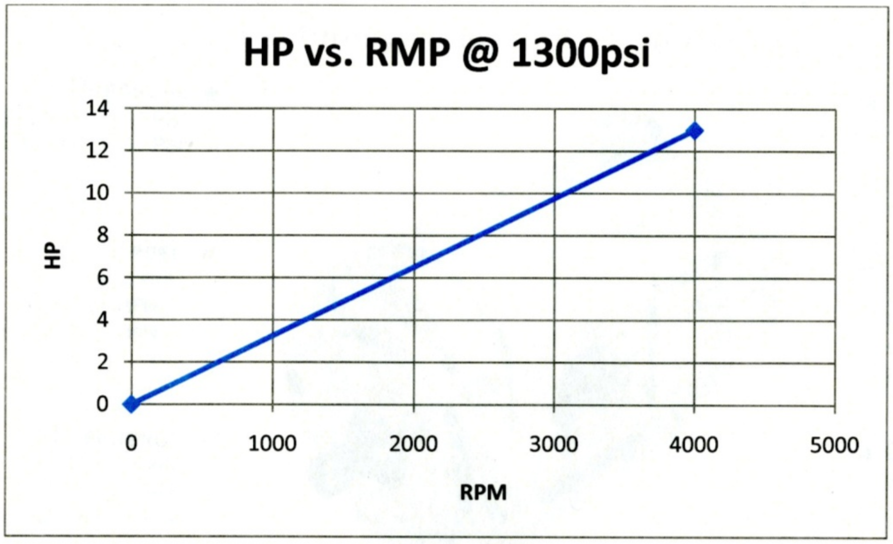
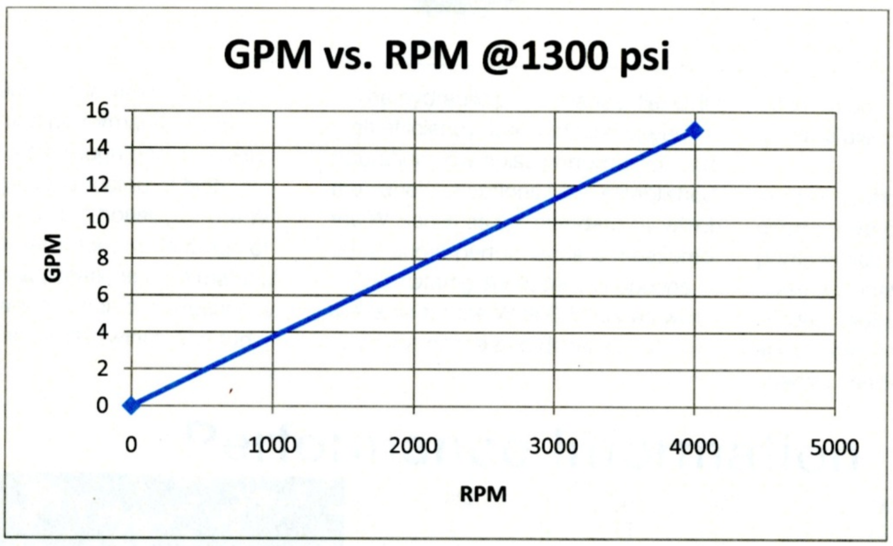
W900 pump .976 in^3/rev





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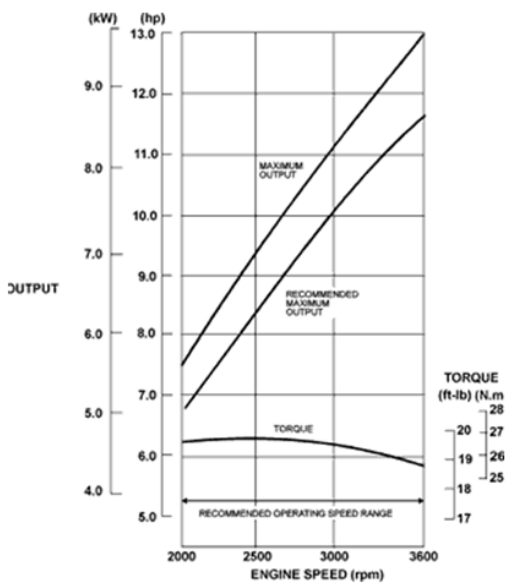
HONDA ENGINES

Honda GX390K1 Performance Curve



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Appendix E Support analysis

Impact Force

$$F = W + W\left[1 + \left(\frac{2hk}{W}\right)\right]^{1/2}$$ (shigleys)

$$K_{cable} = \frac{AE}{L}$$

$A = cd^2 = .46(.5)^2 = .115\ in^2$ (oil drilling book)

$E = 12 \times 10^6$ psi

$$K = \frac{\left(\frac{.115}{12}\right)(12 \times 10^6)(12^2)}{75} = 220{,}800\ lbf/ft$$

$h = 2\ ft$

$W = 600\ lb$

K_{Rig} => rig flexes under loading.
approximated as $X = .25\ in$ under 1000 lb

$F = Kx \Rightarrow 1000 = k\left(\frac{.25}{12}\right)$ $K_{rig} = 48{,}000\ lbf/ft$

$$K_{total} = \left(\frac{1}{220{,}800} + \frac{1}{48{,}000}\right)^{-1} = 39{,}428.6$$

$$F = 600 + 600\left[1 + \frac{2(2)(39{,}428.6)}{600}\right]^{1/2}$$

$$F = 10{,}346\ lbf$$

Line Speed Gear Reductions (for main and sand lines)

- Sand Line will have 4" spool that is 12" when full

want 100 ft in under 2 minutes

$$\frac{100\ ft}{120\ s} = 0.833\ ft/s$$

with empty spool $\phi = 4"$

$$0.833\ ft/s \times \frac{1}{2"} \times \frac{12"}{1\ ft} = 5.0\ rad/s = 47.7\ rpm$$

w/ full spool

$$0.833\ ft/s \times \frac{1}{6"} \times \frac{12"}{1\ ft} \times \frac{1\ rot}{2\pi} \times \frac{60\ s}{1\ min} = 15.9\ rpm$$

Take average of 30 rpm

motor will operate between 80-100 rpm

* will need 1:3 gear ratio for both main line and sand line

$Torque_{motor} = 3744\ in \cdot lb_f$

After reduction $T = 11232\ in \cdot lb_f$

at $4"\phi$ $F = \frac{11232\ in \cdot lb_f}{2\ in} = 5616\ lb_f$

at $12"\phi$ $F = \frac{11232\ in \cdot lb_f}{6\ in} = 1872\ lb_f$

enough to lift 600 lb bit

Chain Sizing

- main line and sand line need 1:3 gear ratio

60 series chain has working load of 1980 lb

50 series has working load of 1400 lb

14 to 42 teeth

3.74" to 10.46"

$$F = \frac{3744 \text{ in}\cdot\text{lbf}}{\frac{3.74''}{2}} = 2002 \text{ lb}_f$$

18 to 54 teeth

4.7" to 13.33"

$$F = \frac{3744 \text{ in}\cdot\text{lbf}}{\frac{4.7''}{2}} = 1593 \text{ lb}_f$$

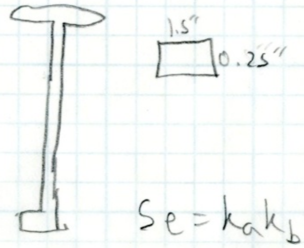
will use 18 to 54 teeth

For Walking Beam use 16 to 24 teeth

$$F = \frac{3744 \text{ in}\cdot\text{lbf}}{\frac{4.22''}{2}} = 1774.4 \text{ lb}_f$$

60 series chain is required

Pitman Arm Strength (fatigue)



material unknown steel

use $S_{ut} = 43$ kpsi

$S_e' = 0.5\,S_{ut} = 21.5$ kpsi

$S_e = k_a k_b k_c k_d k_e k_f S_e'$

$k_a = 1.43\,S_{ut}^{-0.085}$

$k_a = 1.43(43)^{-0.085} = 0.973$

$k_b = 1$

$k_c = 0.85$

$k_d = 1$

$k_e = 1-(0.08)(3.091) = 0.753$ (99.9% reliability)

$k_f = 1$

$S_e = 13.4$ kpsi

$\sigma_m = 0 \quad \sigma_a = \dfrac{6000\,lb_f}{(0.25)(1.5)\,in^2} = 16$ kpsi

$n_f = \dfrac{1}{\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{ut}}} = \dfrac{1}{\frac{16}{13.4} + 0} = 0.8375$

need to increase to at least 1.5" x 0.5"

3-0235 — 50 SHEETS — 5 SQUARES
3-0236 — 100 SHEETS — 5 SQUARES
3-0237 — 200 SHEETS — 5 SQUARES
3-0137 — 200 SHEETS — FILLER
COMET

Hydraulic system Calculations

Given: 13 Hp Gasoline Motor

Hydralic Pump

$$\text{Pump GPM} = \frac{1028\,(\text{Gas HP})}{\text{Psi}} = \frac{1028(13)}{1250} = 10.69\ \text{GPM}$$

=> Northern Pump 10599-2601 ($169.99)
Displacement .976 in^3
Flow rate @ 3600 RPM 14.99 GPM

Hydraulic Motor

=> Northern Pump Item # 1039
Max RPM = 150   15.8 GPM   1250 Psi
Max torque = 3720 in-lbs

Will this torque work?

18in diameter spool (outside coil)
4:1 gear reduction.

$$\frac{3720(4)}{9} = 1653\ \text{lbs}$$ => This should be good for lifting 800 lb bit.

line speed

$$\text{Spool RPM} = \frac{150}{4} = 37.5$$

$$\text{line speed} = 37.5(18\cdot\pi) = 2120\ \frac{in}{min} \Rightarrow 176\ ft/min$$

5sec to lift bit 15 ft.

File:H:\ME 428\Torque calculation.EES 2/25/2010 8:32:45 AM Page 1

EES Ver. 8.400: #552: For use by Mech. Engin. Students and Faculty at Cal Poly

$$M_{bit} \cdot g \cdot L_{beam} - T_{beam} - M_{beam} \cdot g \cdot \frac{L_{beam}}{2} = -M_{bit} \cdot L_{beam} \cdot a_1 - M_{beam} \cdot L_{beam} \cdot \frac{a_2}{2} + I_{beam} \cdot \alpha + I_{flywheel} \cdot \alpha$$

$$a_1 = \alpha \cdot L_{beam}$$

$$a_2 = \alpha \cdot \frac{L_{beam}}{2}$$

$$I_{beam} = \frac{M_{beam}}{12} \cdot L_{beam}^2$$

$$I_{flywheel} = M_{flywheel} \cdot R_{flywheel}^2$$

$$T_{motor} = 200$$

$$W_{bit} = 800$$

$$W_{beam} = 100$$

$$W_{flywheel} = 60$$

$$M_{bit} = \frac{W_{bit}}{g}$$

$$M_{beam} = \frac{W_{beam}}{g}$$

$$M_{flywheel} = \frac{W_{flywheel}}{g}$$

$$g = 32.2$$

$$R_{flywheel} = 1$$

$$L_{beam} = 3$$

$$T_{beam} = L_{arm} \cdot F_{arm}$$

$$F_{arm} = T_{flywheel} \cdot \frac{\sin[\theta]}{R_{flywheel}}$$

$$T_{motor} = \frac{T_{flywheel}}{Ratio}$$

$$Ratio = 6$$

$$L_{arm} = 3$$

$$\alpha = 0$$

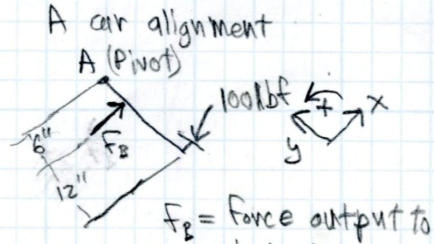
SOLUTION

Unit Settings: [kJ]/[C]/[kPa]/[kg]/[degrees]

α = 0 [rad/s^2]
a_1 = 0 [ft/s^2]
a_2 = 0 [ft/s^2]
F_{arm} = 750 [lbf]
g = 32.2 [ft/s^2]
I_{beam} = 2.329 [ft*lbf*s^2]
$I_{flywheel}$ = 1.863 [ft*lbf*s^2]
L_{arm} = 3 [ft]
L_{beam} = 3 [ft]
M_{beam} = 3.106 [(lbf/ft)*s^2]
M_{bit} = 24.84 [(lbf/ft)*s^2]
$M_{flywheel}$ = 1.863 [(lbf/ft)*s^2]
Ratio = 6 [-]
$R_{flywheel}$ = 1 [ft]
θ = 38.68 [deg]
T_{beam} = 2250 [ft*lbf]
$T_{flywheel}$ = 1200 [ft*lbf]
T_{motor} = 200 [ft*lbf]
W_{beam} = 100 [lbf]
W_{bit} = 800 [lbf]
$W_{flywheel}$ = 60 [lbf]

No unit problems were detected.

Brake force from hydraulic sytem. A car alignment



F_B = Force output to hydraulic system

$\circlearrowleft + \; \Sigma M_A = -18^{in}(100^{lbf}) + F_B(6^{in}) = 0$

$F_B = 300^{lbf}$

Applied over a 5/8" bore $A_B = \pi r^2 = \pi\left(\frac{5}{16}\right)^2 = 0.3068$

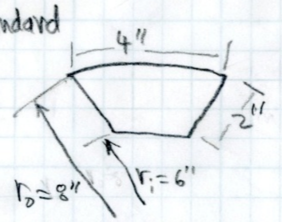
$\Rightarrow P_B = 977.8 \frac{lbf}{in^2}$

Same pressure applied to 3" dia slave cylinder. $A_s = \pi(1.5)^2 = 7.0686$

$F_S = \left(977.8 \frac{lbf}{in^2}\right)(7.0686 in)^2$

$F_s = 48{,}850 \, lbf$

Brake Pad standard



Continued on next

Force to stop impact load of 10,000 lb @ 18 in dia spool ⇒ 9 in lever arm

size disk brakes 2-3 ft dia

Torque Produced = (10,000 lb)(9 in)

$T_{spool} = 90{,}000 \text{ in lb}$

Disk brake

Assume

uniform wear $T = \frac{\Delta\theta}{2} f\, P_a r_i (r_o^2 - r_i^2)$

Assumptions

Worn in brake pad

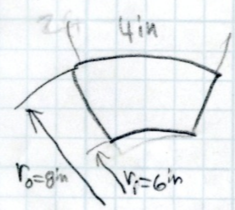
$f = 0.3$

$\Delta\theta = 28.65°$ initially

$r_i = 6 \text{ in}$ $r_o = 8 \text{ in}$

$P_a = \dfrac{(90{,}000 \text{ lb})2}{\left(\frac{28.65° \cdot 2\pi \text{ rad}}{360°}\right)(0.3)(6 \text{ in})\left[(8 \text{ in})^2 - (6 \text{ in})^2\right]}$

$P_a = 7{,}421 \frac{lb}{in^2}$



$F = \left(\frac{28.65 \cdot 2\pi \text{ rad}}{360 \text{ deg}}\right)(7{,}421 \frac{lb}{in^2})(6 \text{ in})(8 \text{ in} - (6 \text{ in}))$

$F = 42{,}857 \text{ lb}$ required on brake pad

Circumference $= 2\pi r$

$C = 50 \text{ in}$

4 in over 50 in

is 7.95%

convert to $\Delta\theta$

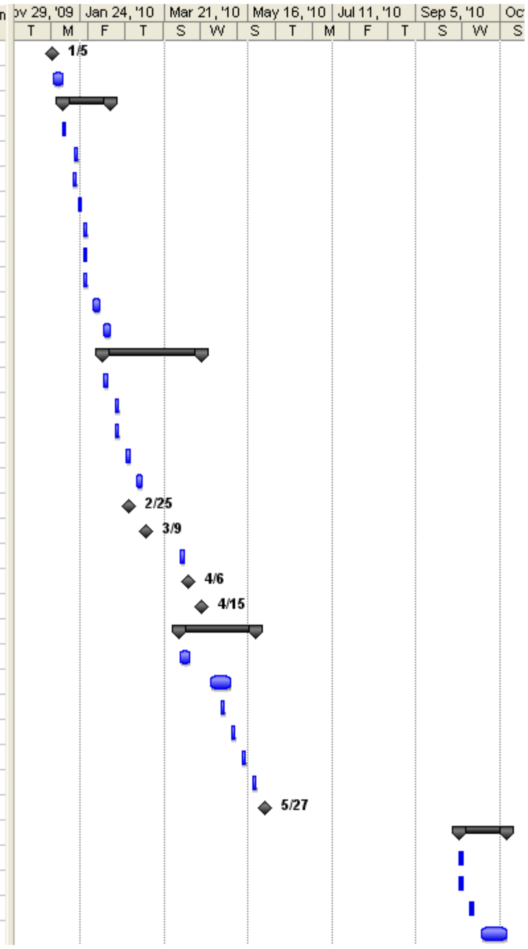
$\frac{7.95\%}{}\Big|\frac{180°}{50\%} = 28.65°$

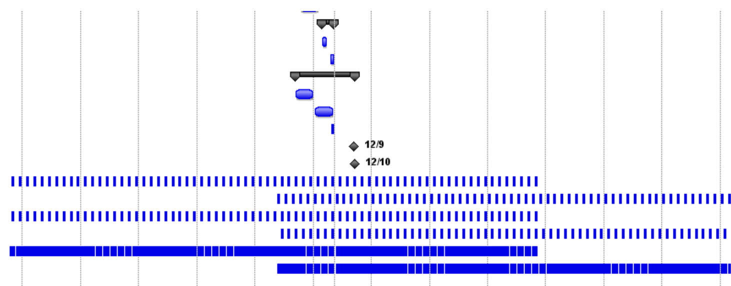
From previous page $F_s = 48{,}850 \text{ lbf}$

⇒ The disk brake w/ 3 in cylinder and sized above works

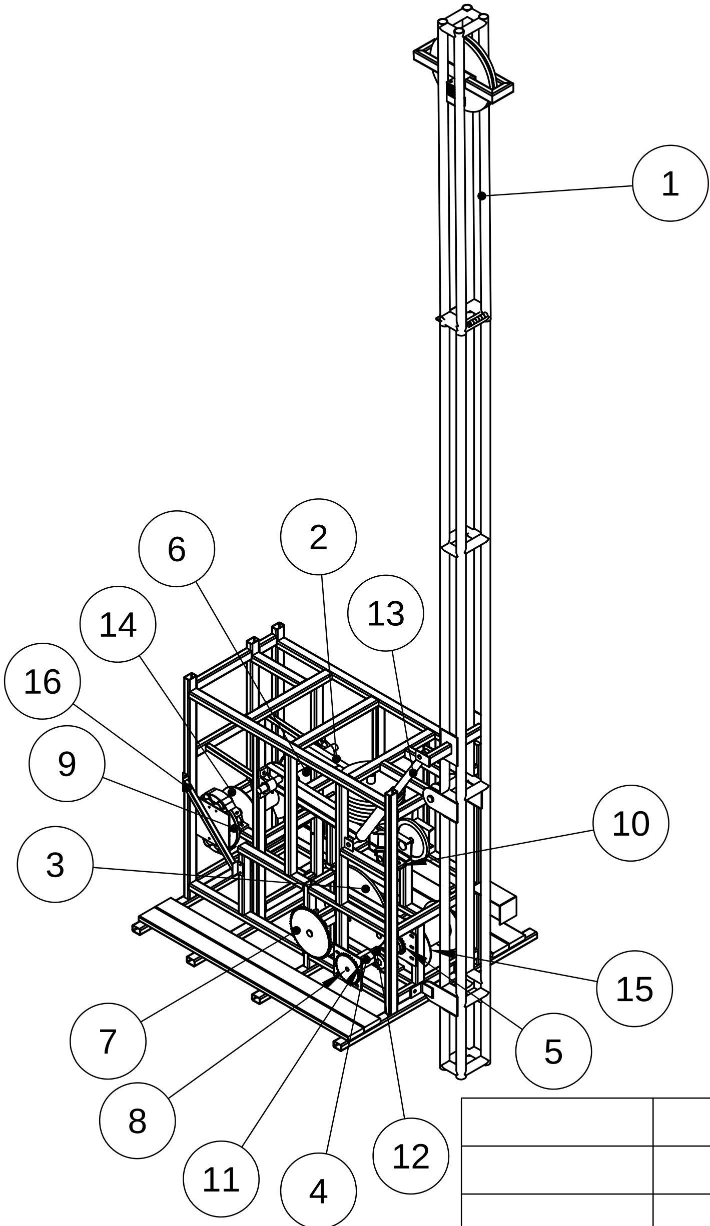
Appendix F Gantt chart

	Task Name	Duration	Start	Finish	Predecessors	Resource Nam
1	Project start date	0 days	Tue 1/5/10	Tue 1/5/10		
2	Sponsor presentations &student selection	1 wk	Tue 1/5/10	Mon 1/11/10		
3	**Project introduction & research**	**25 days**	**Tue 1/12/10**	**Fri 2/12/10**		
4	Introduction letter to sponsor	2 hrs	Tue 1/12/10	Tue 1/12/10		
5	Obtain past senior project report	3 days	Tue 1/19/10	Thu 1/21/10		
6	Research current similar designs	3 days	Mon 1/18/10	Wed 1/20/10		
7	See demo of older rig	3 hrs	Sat 1/23/10	Sat 1/23/10		
8	Read through past group's report	3 days	Mon 1/25/10	Wed 1/27/10		
9	Initial specification & requirements (QFD)	1 day	Tue 1/26/10	Tue 1/26/10		
10	Project Proposal writing	3 days	Mon 1/25/10	Wed 1/27/10		
11	Other background research	5 days	Mon 2/1/10	Fri 2/5/10		
12	Research design improvements	5 days	Mon 2/8/10	Fri 2/12/10		
13	**Project design**	**48 days**	**Mon 2/8/10**	**Thu 4/15/10**		
14	Ideation & brainstorming	3 days	Mon 2/8/10	Wed 2/10/10		
15	Power source sizing	2 days	Tue 2/16/10	Wed 2/17/10		
16	Component modification ideas	2 days	Tue 2/16/10	Wed 2/17/10		
17	CAD Modeling	3 days	Tue 2/23/10	Thu 2/25/10		
18	Part selection	4 days	Tue 3/2/10	Fri 3/5/10		
19	Concept Design Report Due	0 days	Thu 2/25/10	Thu 2/25/10		
20	Interim Design Report Due	0 days	Tue 3/9/10	Tue 3/9/10		
21	Order Parts	3 days	Wed 3/31/10	Fri 4/2/10		
22	Critical Design Review	0 days	Tue 4/6/10	Tue 4/6/10		
23	Final Design Report Due	0 days	Thu 4/15/10	Thu 4/15/10		
24	**Fabrication**	**37 days**	**Wed 3/31/10**	**Thu 5/20/10**		
25	Tear out unneccesary parts	5 days	Wed 3/31/10	Tue 4/6/10		
26	Mount Major Components	10 days	Tue 4/20/10	Mon 5/3/10		
27	Machine adapters and small components	3 days	Tue 4/27/10	Thu 4/29/10		
28	Mount Chains and sprockets to main cor	3 days	Tue 5/4/10	Thu 5/6/10		
29	Mount controls	3 days	Tue 5/11/10	Thu 5/13/10		
30	Hydraulic line installation	3 days	Tue 5/18/10	Thu 5/20/10		
31	Manufacturing and Test Review	0 days	Thu 5/27/10	Thu 5/27/10		
32	**Project Testing**	**24 days**	**Mon 10/4/10**	**Thu 11/4/10**		
33	Strength and safety testing	2 days	Mon 10/4/10	Tue 10/5/10		
34	Inspection functional rig	2 days	Mon 10/4/10	Tue 10/5/10		
35	Verify design requirements	2 days	Mon 10/11/10	Tue 10/12/10		
36	Test run drilling a well	14 days	Mon 10/18/10	Thu 11/4/10		
37	**Final Fabrication**	**10 days**	**Mon 11/8/10**	**Fri 11/19/10**		
38	Final iteration on design	5 days	Mon 11/8/10	Fri 11/12/10		
39	Final modifications & testing	4 days	Tue 11/16/10	Fri 11/19/10		
40	**Project Finalization**	**41 days**	**Thu 10/14/10**	**Fri 12/10/10**		
41	Product manual writing	12 days	Thu 10/14/10	Fri 10/29/10		
42	Final Project Report writing	14 days	Mon 11/1/10	Thu 11/18/10		
43	Hardware Demo	1 day	Thu 11/18/10	Thu 11/18/10		
44	Design Expo	0 days	Thu 12/9/10	Thu 12/9/10		
45	Final Project Report Due	0 days	Fri 12/10/10	Fri 12/10/10		
46	**Meeting with Advisor Weekly**	**1.13 days**	**Thu 1/14/10**	**Thu 6/2/11**		
120	**Meeting with Advisor weekly**	**0.13 days**	**Mon 9/27/10**	**Mon 12/5/11**		
184	**Meeting with Sponsor Weekly**	**1.13 days**	**Thu 1/14/10**	**Thu 6/2/11**		
258	**Meeting with Sponsor Weekly**	**5.13 days**	**Thu 9/30/10**	**Thu 12/1/11**		
321	**Log entry Daily**	**3.06 days**	**Tue 1/12/10**	**Thu 6/2/11**		
829	**Log entry daily**	**0.13 days**	**Mon 9/27/10**	**Mon 12/5/11**		





Appendix G Part Drawings



ITEM	DESCRIPTION	PART #	QTY.
1	Frame and Derrick	R002	1
2	Walking Beam	W001	1
3	Flywheel	R105	1
4	Hydraulic Motor	N/A	3
5	Sprocket 60b21	N/A	2
6	Sprocket 60b54	N/A	1
7	Sprocket 60b60	N/A	1
8	Sprocket 60b35	N/A	1
9	Brake Rotor	N/A	1
10	Pitman Arm	R106	1
11	Motor mount	M101	3
12	Sprocket 60b30	N/A	1
13	Hydraulic Ram	N/A	1
14	Main Line Spool	S001-1	1
15	San Line Spool	S001-2	1
16	Brake Assembly	R104	1

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APPLICATION	

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DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±5 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

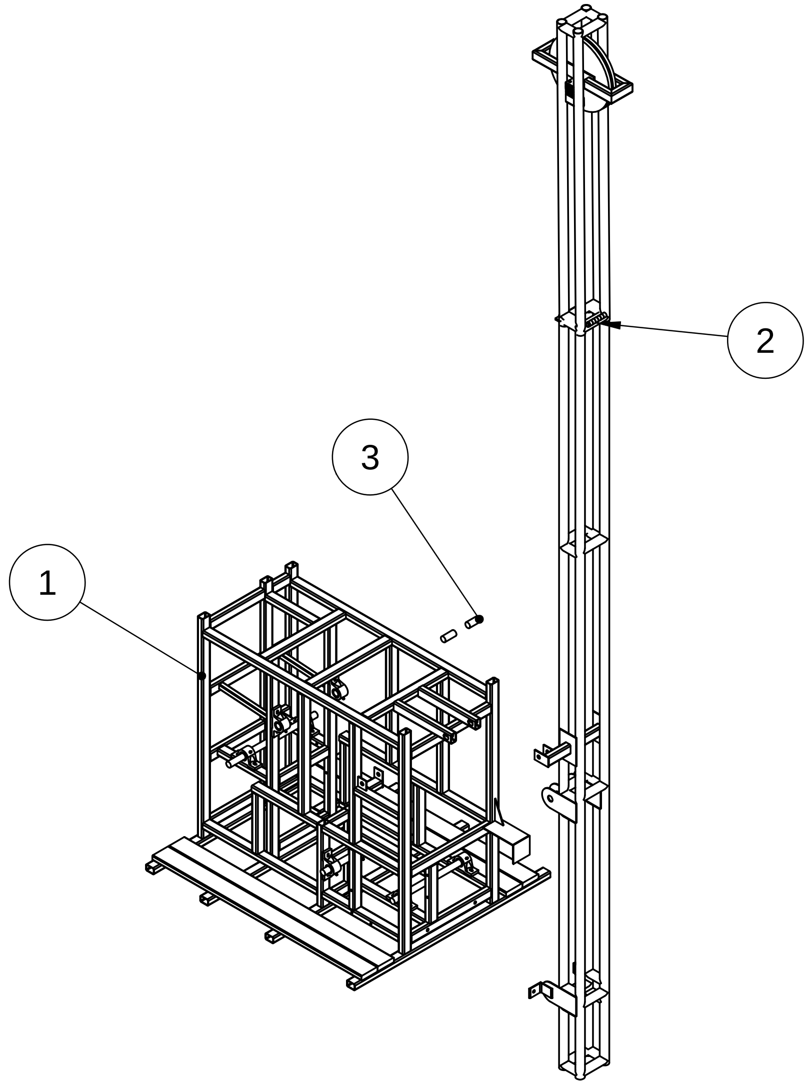
TITLE:

Rig Final Assembly

SIZE	DWG. NO.	REV
A	R001	

SCALE: 1:60 | SHEET 1 OF 1

5 4 3 2 1



ITEM	DESCRIPTION	PART #	QTY.
1	Frame With Shafts	R003	1
2	Derrick Assembly	D001	1
3	1.75"X4" Derrick Pins	N/A	2

R001	R001	
NEXT ASSY	USED ON	
APPLICATION		

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TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

Frame and Derrick

SIZE	DWG. NO.	REV
A	R002	

SCALE: 1:50 | SHEET 1 OF 1

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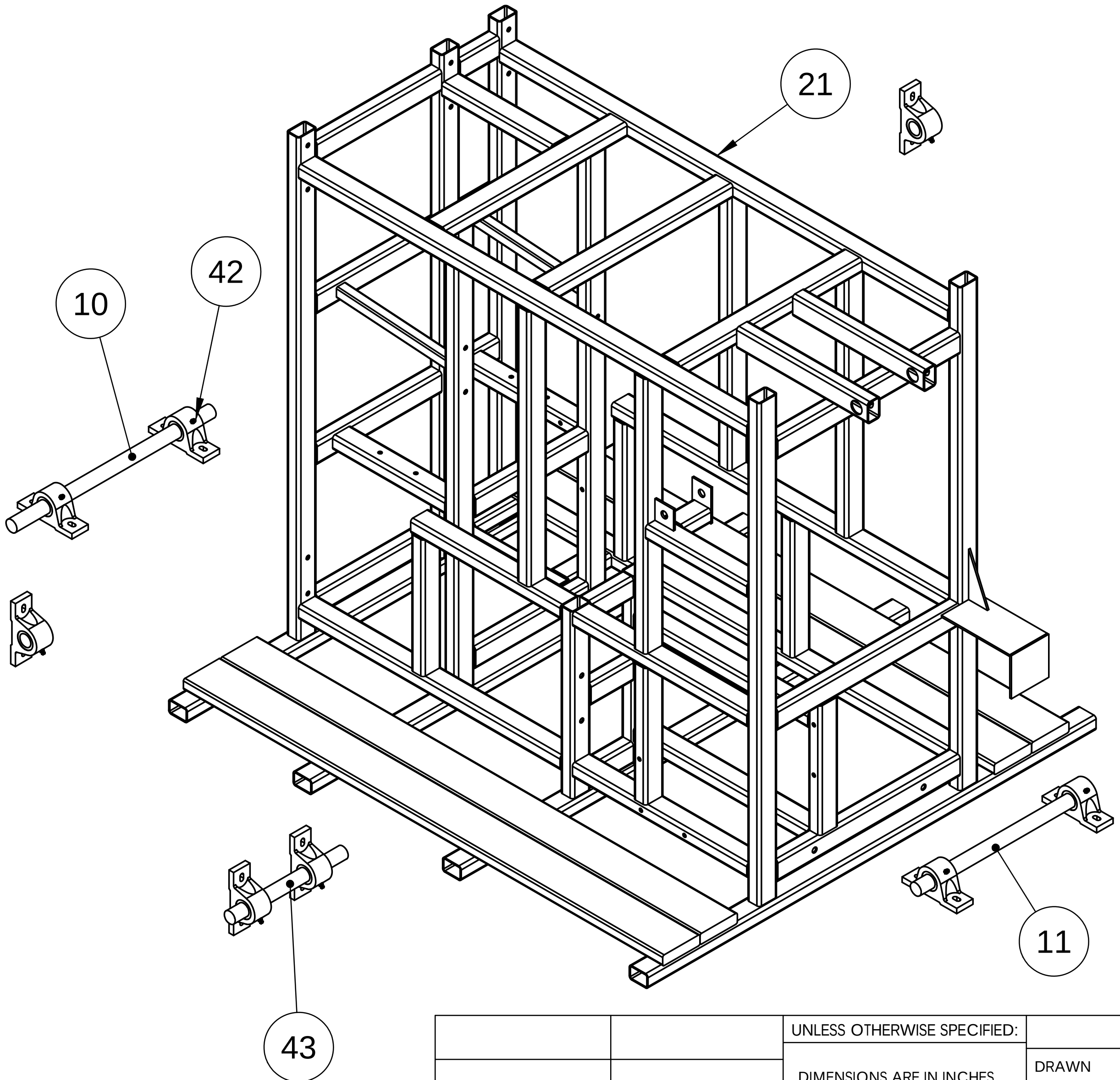
5 4 3 2 1



ITEM	DESCRIPTION	PART #	QTY.
10	1.75"X32" Shaft	N/A	1
11	1.75"X2.75" Shaft	N/A	1
21	Frame Components	R004	7
42	1.75" Pillow Block	N/A	8
43	1.75"X11" Shaft	N/A	1
50	Center WB Mount		1

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NEXT ASSY	USED ON
R003	R001

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ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/28/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

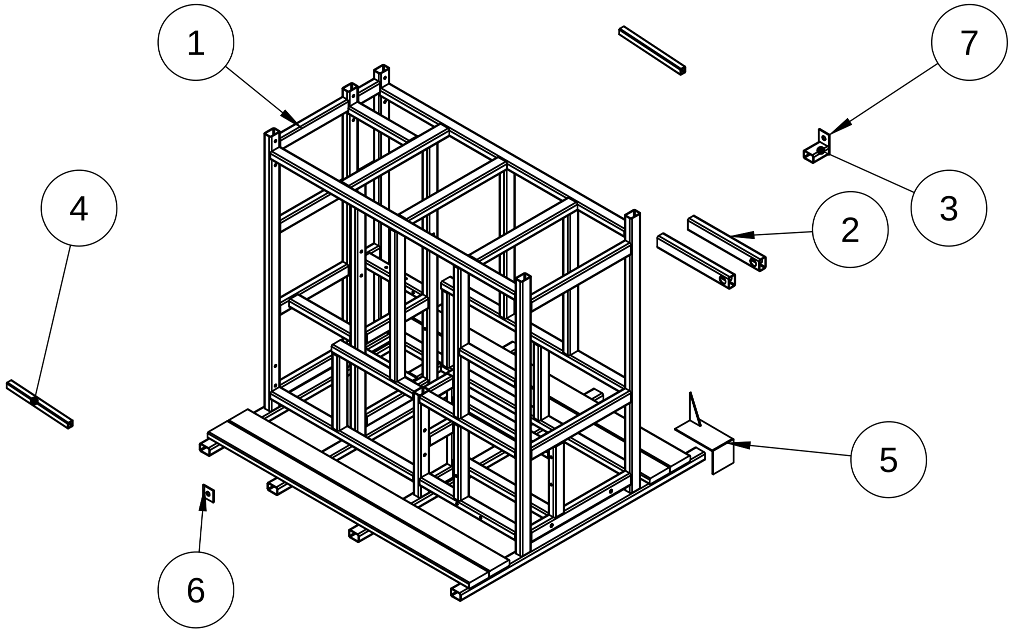
TITLE:

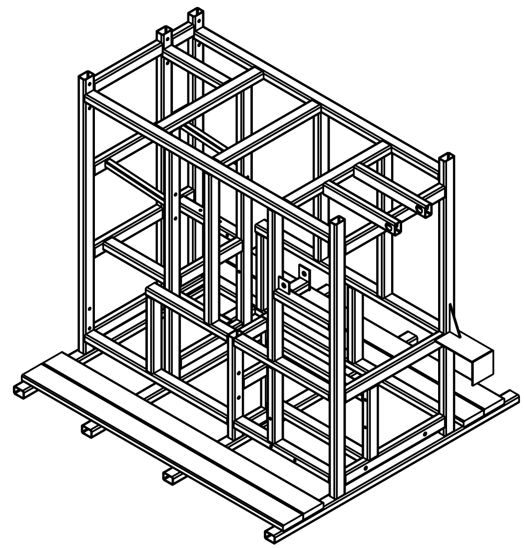
Frame With Shafts

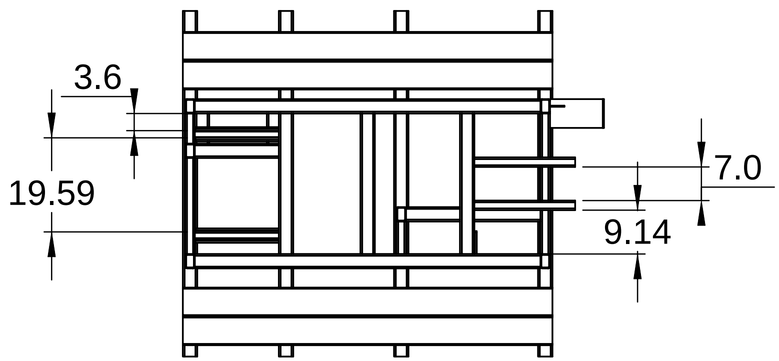
SIZE: A
DWG. NO. R003
REV

SCALE: 1:20
SHEET 1 OF 1

5 4 3 2 1







Top View

ITEM	DESCRIPTION	PART #	QTY.
1	Frame Sections	R005	1
2	Derrick Mount	R101	2
3	TR 3x2x0.1875 (4.5")	N/A	1
4	Cross Member	R102	2
5	Control Mount	R103	1
6	Ram Mount 1	D103-1	1
7	Ram Mount 2	D103-2	1

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NEXT ASSY	USED ON
R003	R001

APPLICATION

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TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/28/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

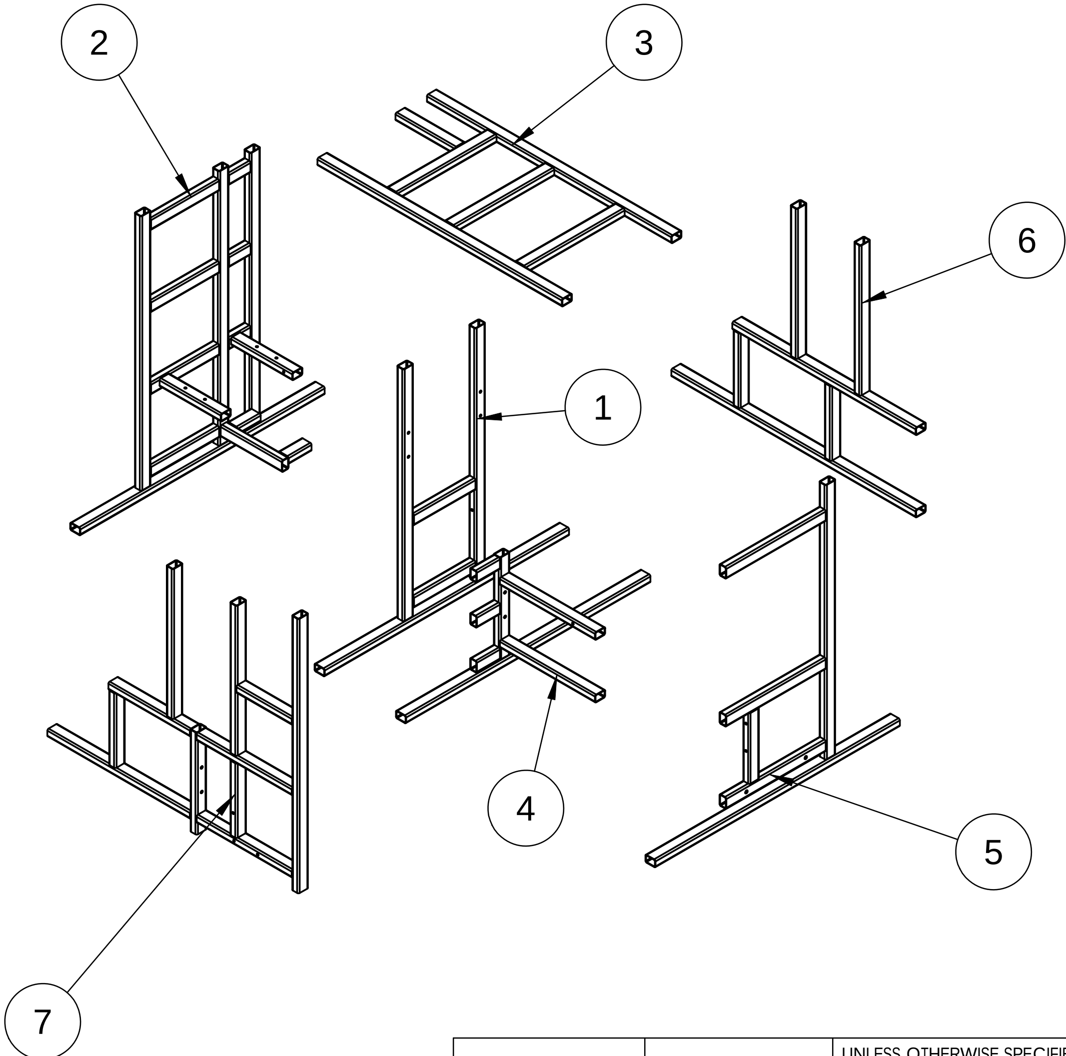
TITLE:

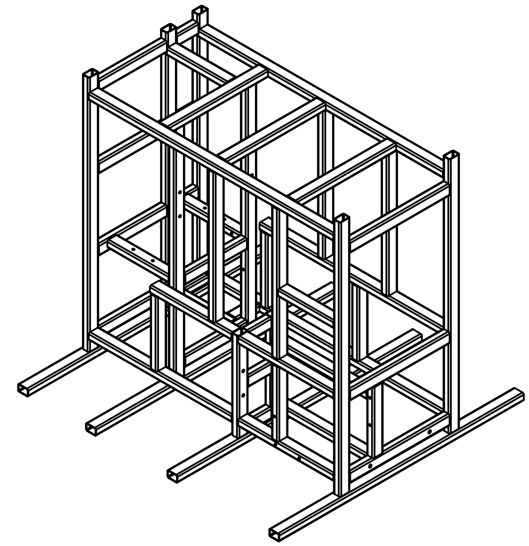
Frame With Controls

SIZE	DWG. NO.	REV
A	R004	

SCALE: 1:40 | SHEET 1 OF 1

5 4 3 2 1





ITEM	DESCRIPTION	PART #	QTY.
1	Center WB Mount	F001	1
2	Rear	F002	1
3	Top	F003	1
4	Center Flywheel Mount	F004	1
5	Front	F005	1
6	Right Side	F006	1
7	Left Side	F007	1

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NEXT ASSY	USED ON
R004	R001

APPLICATION

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TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/28/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

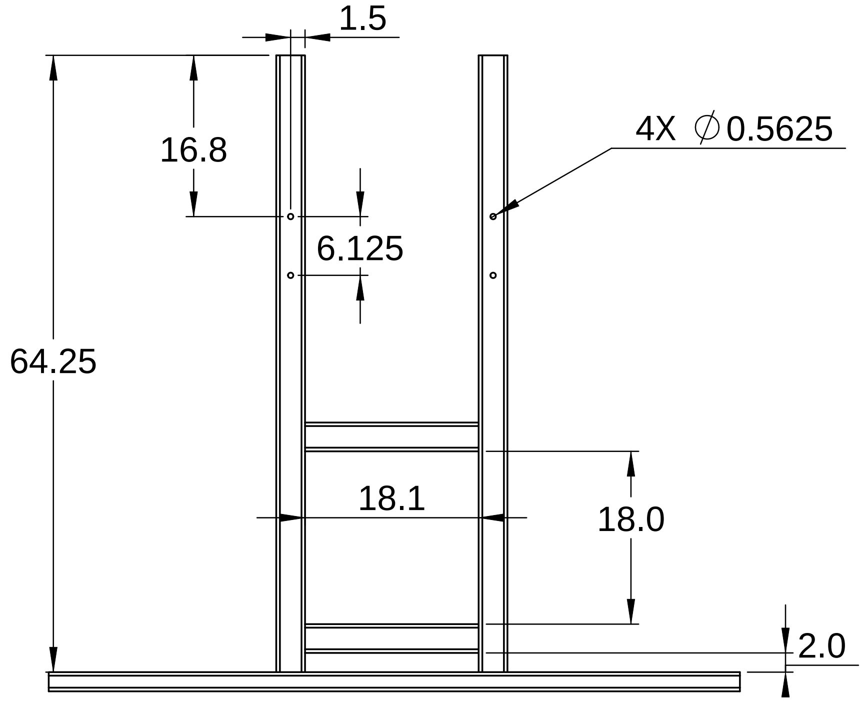
TITLE:

Frame Sections

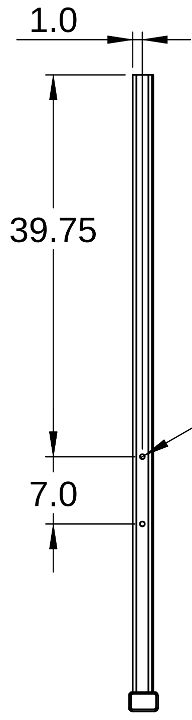
SIZE: A | DWG. NO. R005 | REV

SCALE: 1:40 | SHEET 1 OF 1

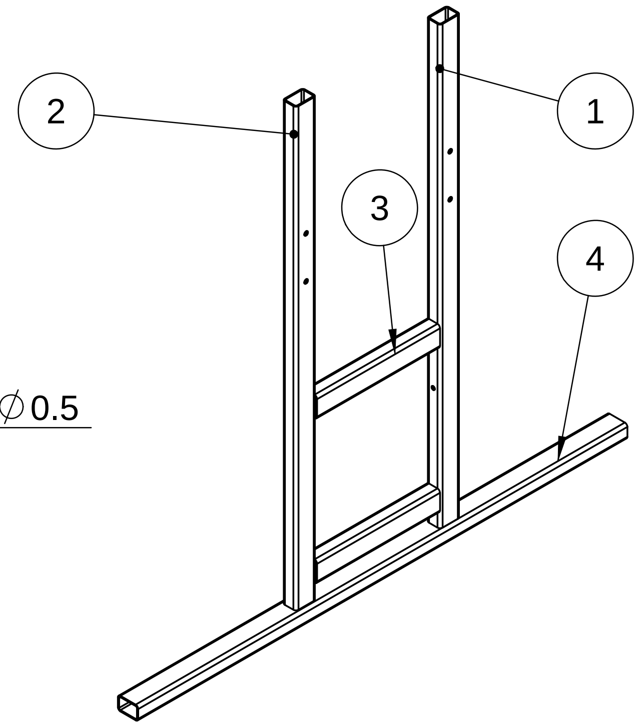
5 4 3 2 1

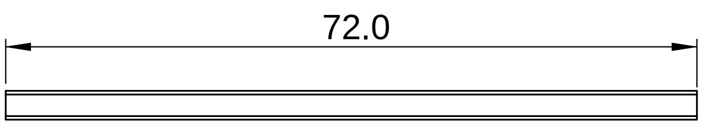


FRONT



RIGHT





BOTTOM

ITEM	DESCRIPTION	PART #	QTY.
1	TR 3x2x0.1875 (64.25")	N/A	1
2	TR 3x2x0.1875 (64.25")	N/A	1
3	TR 3x2x0.1875 (18.1")	N/A	2
4	TR 3x2x0.1875 (72")	N/A	1

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NEXT ASSY	USED ON
R005	R001

APPLICATION

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TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/29/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

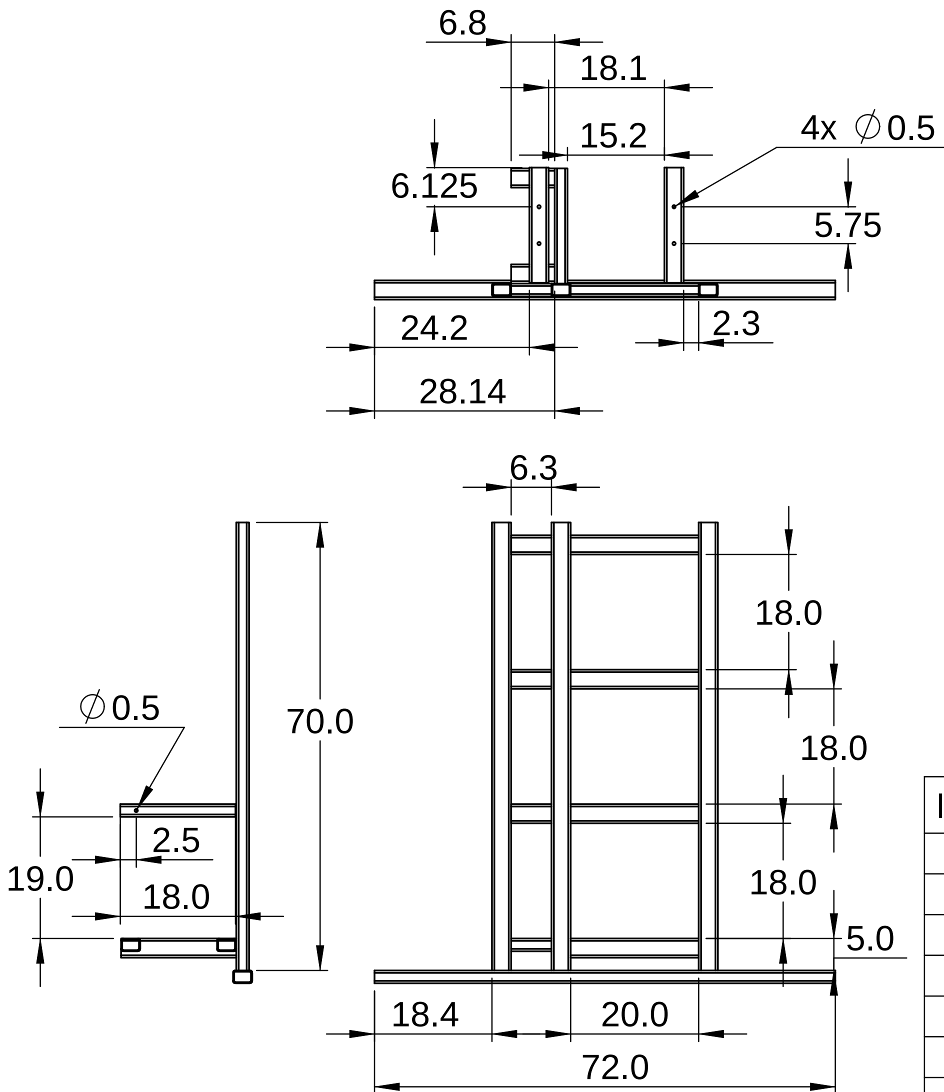
TITLE:

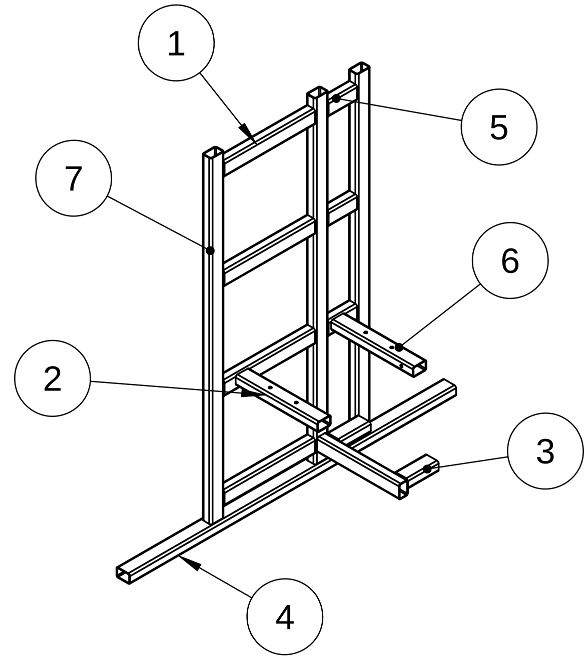
Center WB Mount

SIZE: A | DWG. NO. F001 | REV

SCALE: 1:20 | SHEET 1 OF 1

5 4 3 2 1





ITEM	DESCRIPTION	PART #	QTY.
1	TR3x2x0.1875 (20")	N/A	4
2	TR3x2x0.1875 (18" Spool Only)	N/A	1
3	TR3x2x0.1875 (6.8")	N/A	2
4	TR3x2x0.1875 (72")	N/A	1
5	TR3x2x0.1875 (6.3")	N/A	3
6	TR3x2x0.1875 (18" Spool and Motor)	N/A	1
7	TR3x2x0.1875 (70")	N/A	3

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NEXT ASSY	USED ON
R005	R001
APPLICATION	

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DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL Steel

FINISH Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/29/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

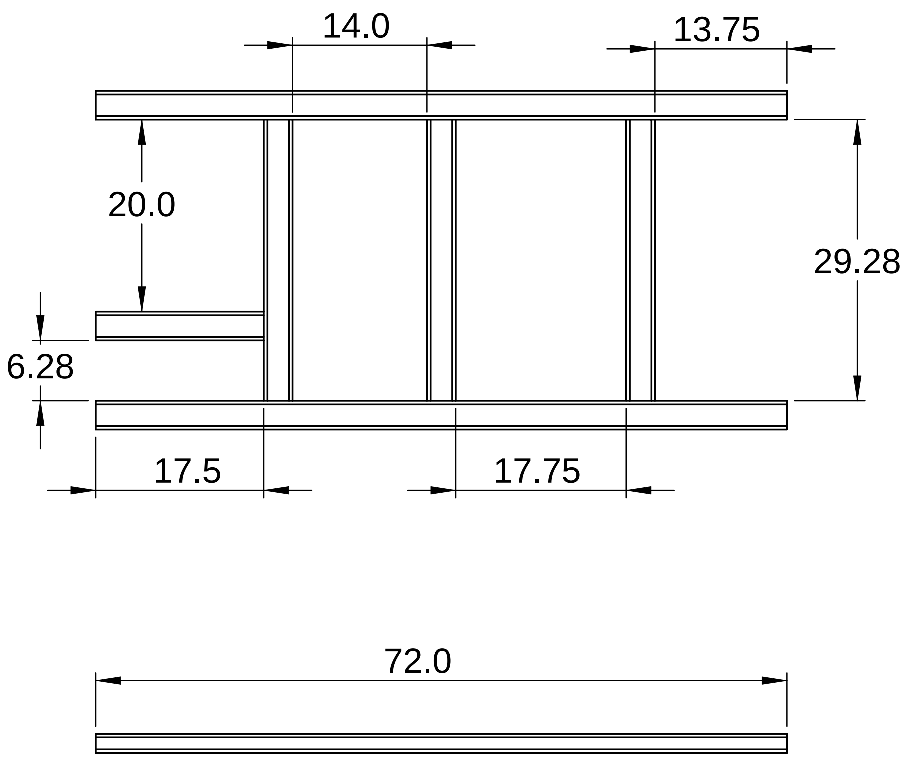
TITLE:

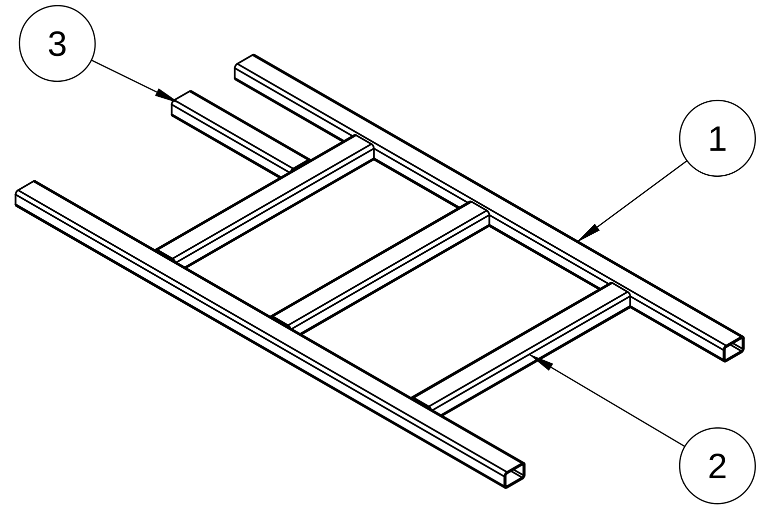
Rear

SIZE A | DWG. NO. F002 | REV

SCALE: 1:30 | SHEET 1 OF 1

5 4 3 2 1





ITEM	DESCRIPTION	PART #	QTY.
1	TR3x2x0.1875 (72")	N/A	2
2	TR3x2x0.1875 (29.28")	N/A	3
3	TR3x2x0.1875 (17.5")	N/A	1

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R005	R001
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/29/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

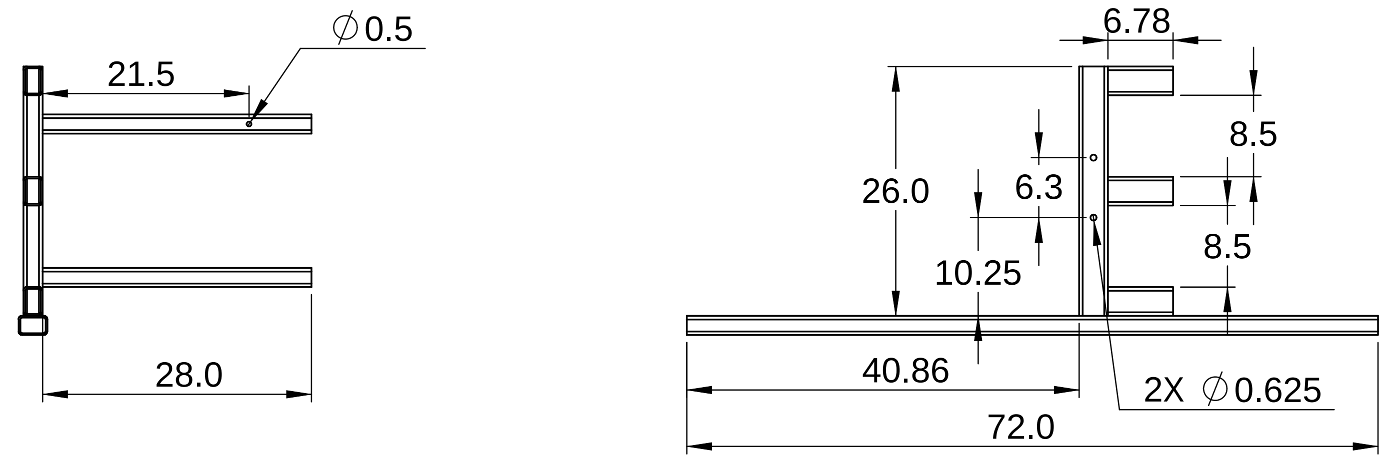
TITLE:

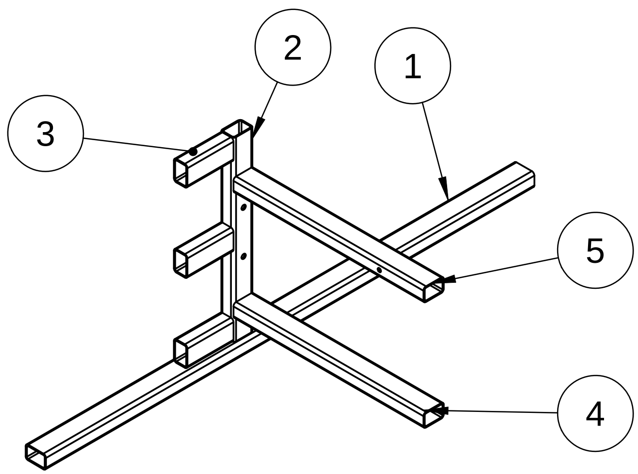
Top

SIZE: A | DWG. NO. F003 | REV

SCALE: 1:20 | SHEET 1 OF 1

5 4 3 2 1





ITEM	DESCRIPTION	PART #	QTY.
1	TR3x2x0.1875 (72")	N/A	1
2	TR3x2x0.1875 (26")	N/A	1
3	TR3x2x0.1875 (6.78")	N/A	3
4	TR3x2x0.1875 (28")	N/A	1
5	TR3x2x0.1875 (28" Motor)	N/A	1

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NEXT ASSY	USED ON
R005	R001

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL Steel

FINISH Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/29/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

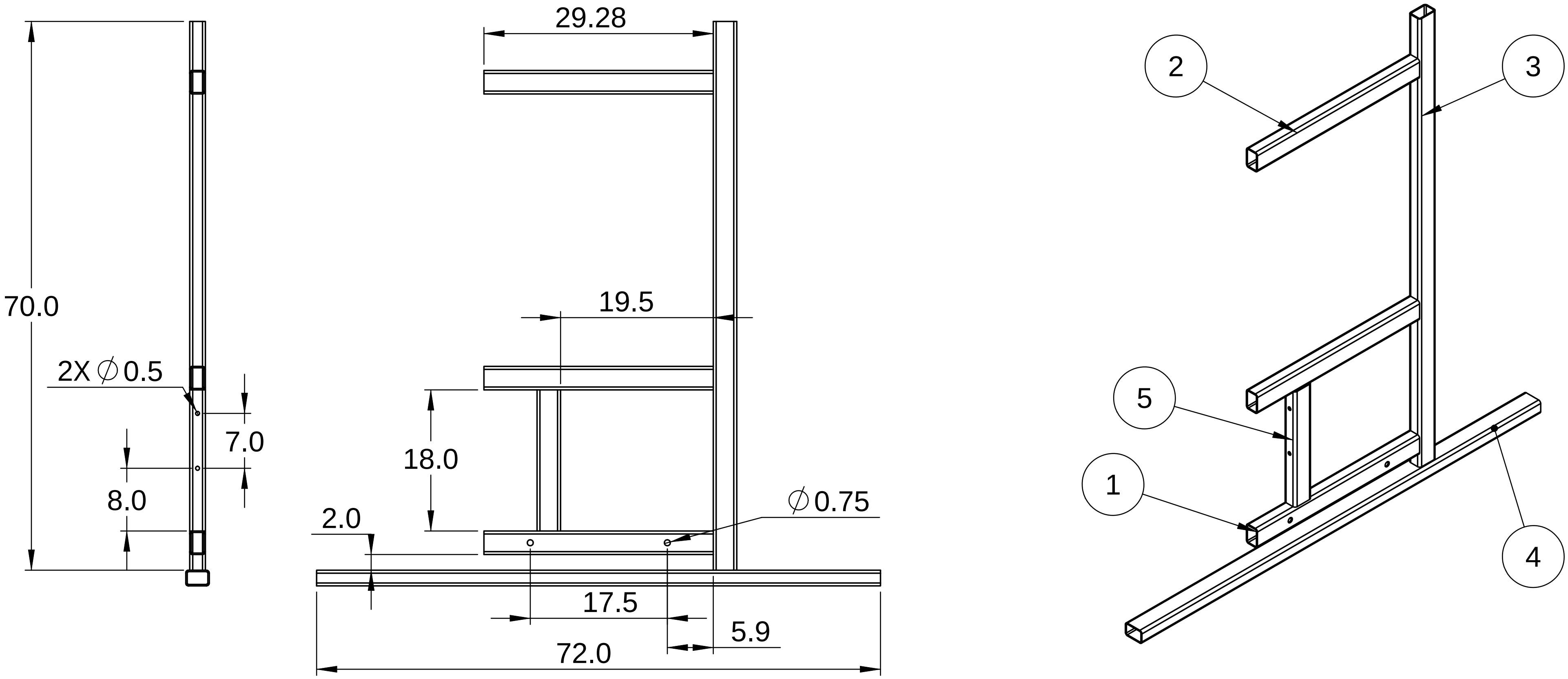
TITLE:

Center Flywheel Mount

SIZE A | DWG. NO. F004 | REV

SCALE: 1:20 | SHEET 1 OF 1

5 4 3 2 1



ITEM	DESCRIPTION	PART #	QTY.
1	TR3x2x0.1875 (29.28" Holes)	N/A	1
2	TR3x2x0.1875 (29.28")	N/A	2
3	TR3x2x0.1875 (70")	N/A	1
4	TR3x2x0.1875 (72")	N/A	1
5	TR3x2x0.1875 (18" Holes)	N/A	1

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NEXT ASSY	USED ON
R005	R001

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/29/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

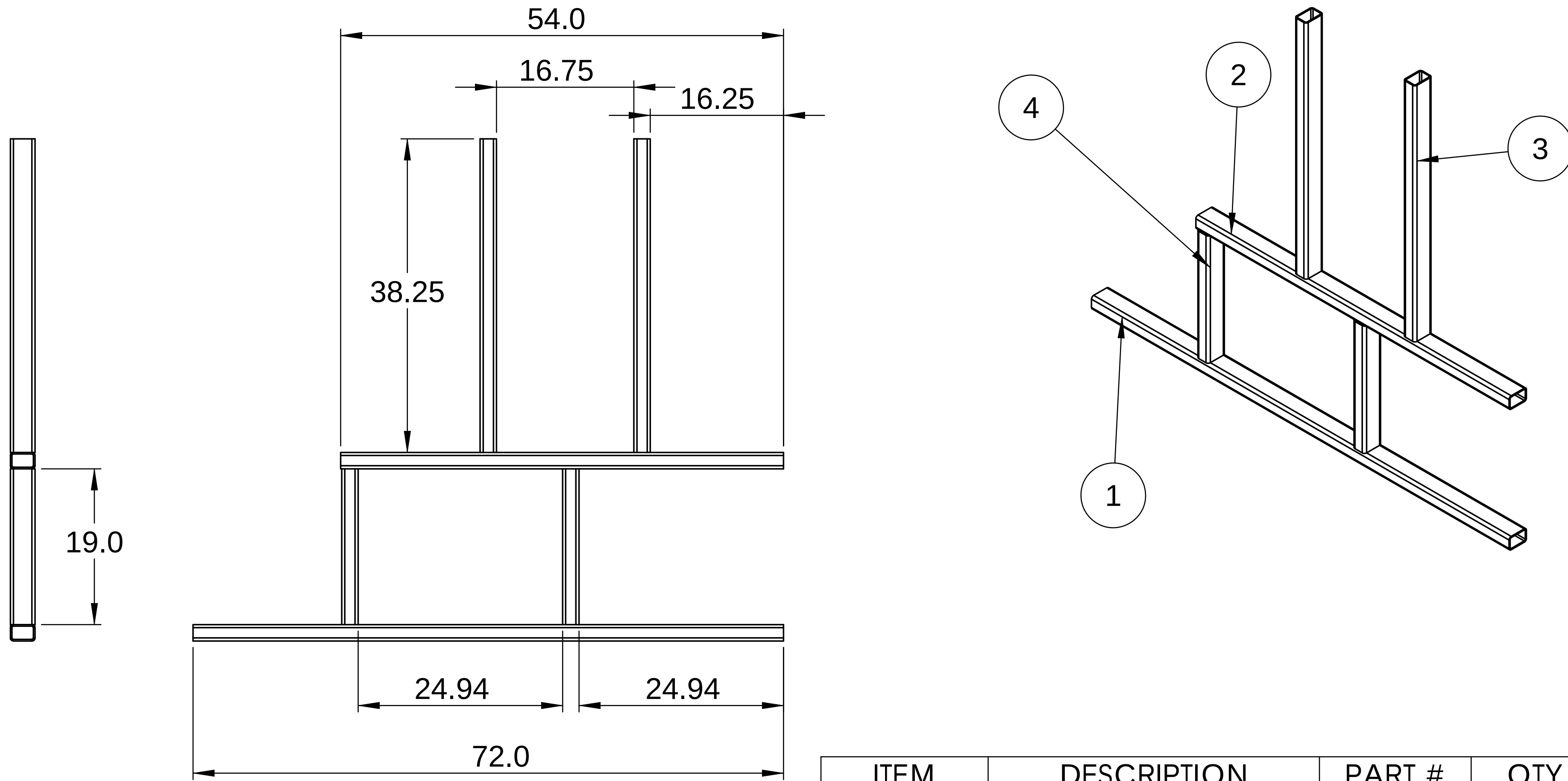
TITLE:

Front

SIZE **A** DWG. NO. F005 REV

SCALE: 1:20 SHEET 1 OF 1

5 4 3 2 1



ITEM	DESCRIPTION	PART #	QTY.
1	TR3x2x0.1875	N/A	1
2	TR3x2x0.1875	N/A	1
3	TR3x2x0.1875	N/A	2
4	TR3x2x0.1875	N/A	2

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NEXT ASSY	USED ON
R005	R001

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/29/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

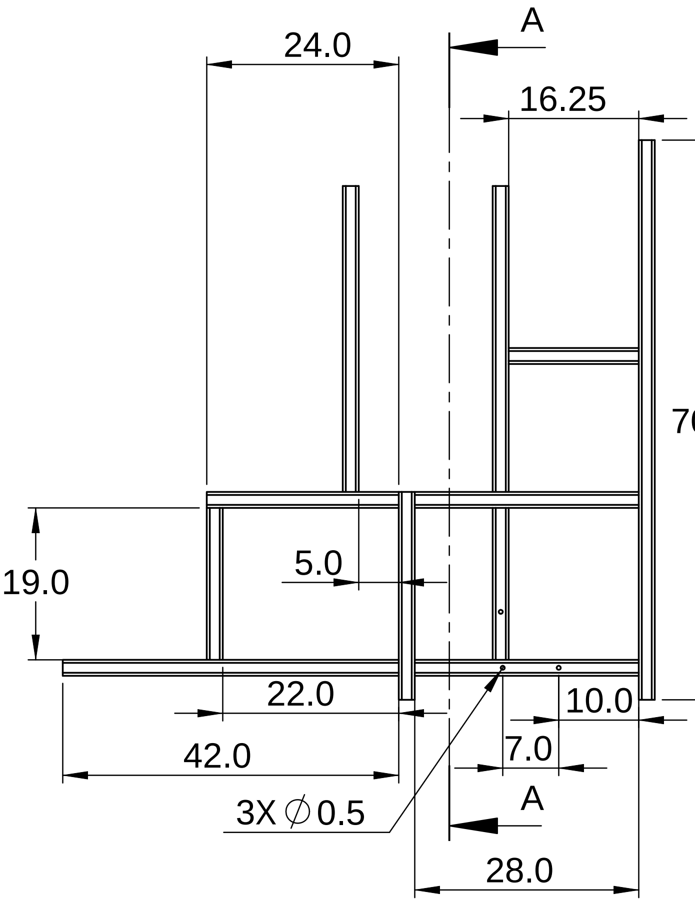
TITLE:

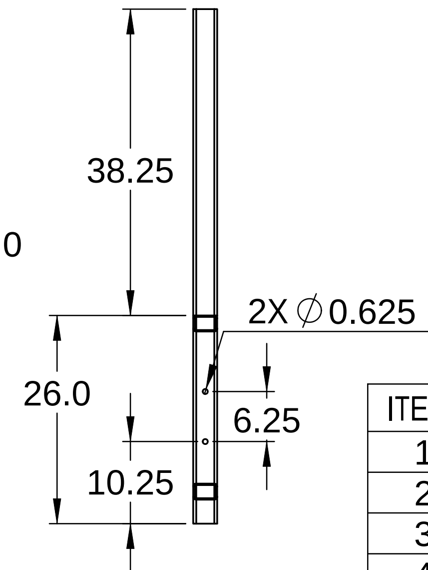
Right Side

SIZE: A
DWG. NO. F006
REV

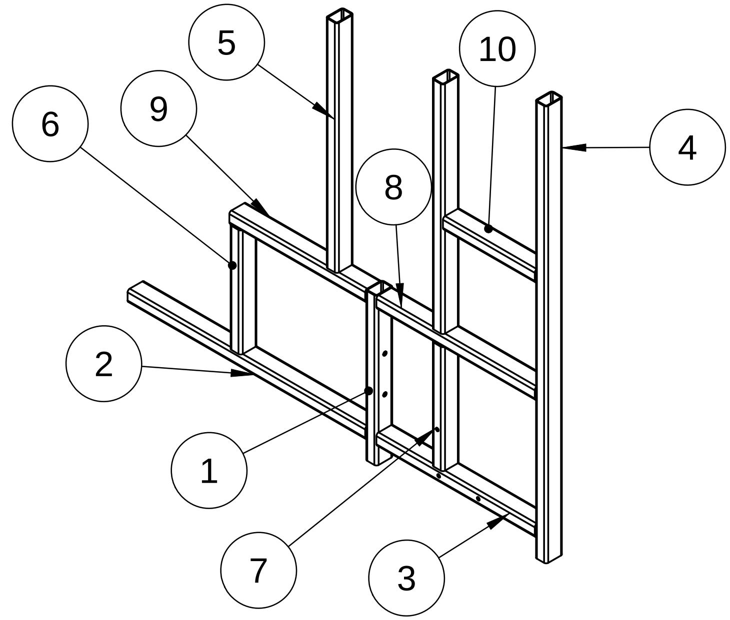
SCALE: 1:20
SHEET 1 OF 1

5 4 3 2 1





SECTION A-A



ITEM	DESCRIPTION	PART #	QTY.
1	TR3x2x0.1875 (26" Holes)	N/A	1
2	TR3x2x0.1875 (42")	N/A	1
3	TR3x2x0.1875 (28")	N/A	1
4	TR3x2x0.1875 (70")	N/A	1
5	TR3x2x0.1875 (38.25")	N/A	2
6	TR3x2x0.1875 (19")	N/A	1
7	TR3x2x0.1875 (19" Hole)	N/A	1
8	TR3x2x0.1875 (28")	N/A	1
9	TR3x2x0.1875 (24")	N/A	1
10	TR3x2x0.1875 (16.25")	N/A	1

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NEXT ASSY	USED ON
R005	R001

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/29/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

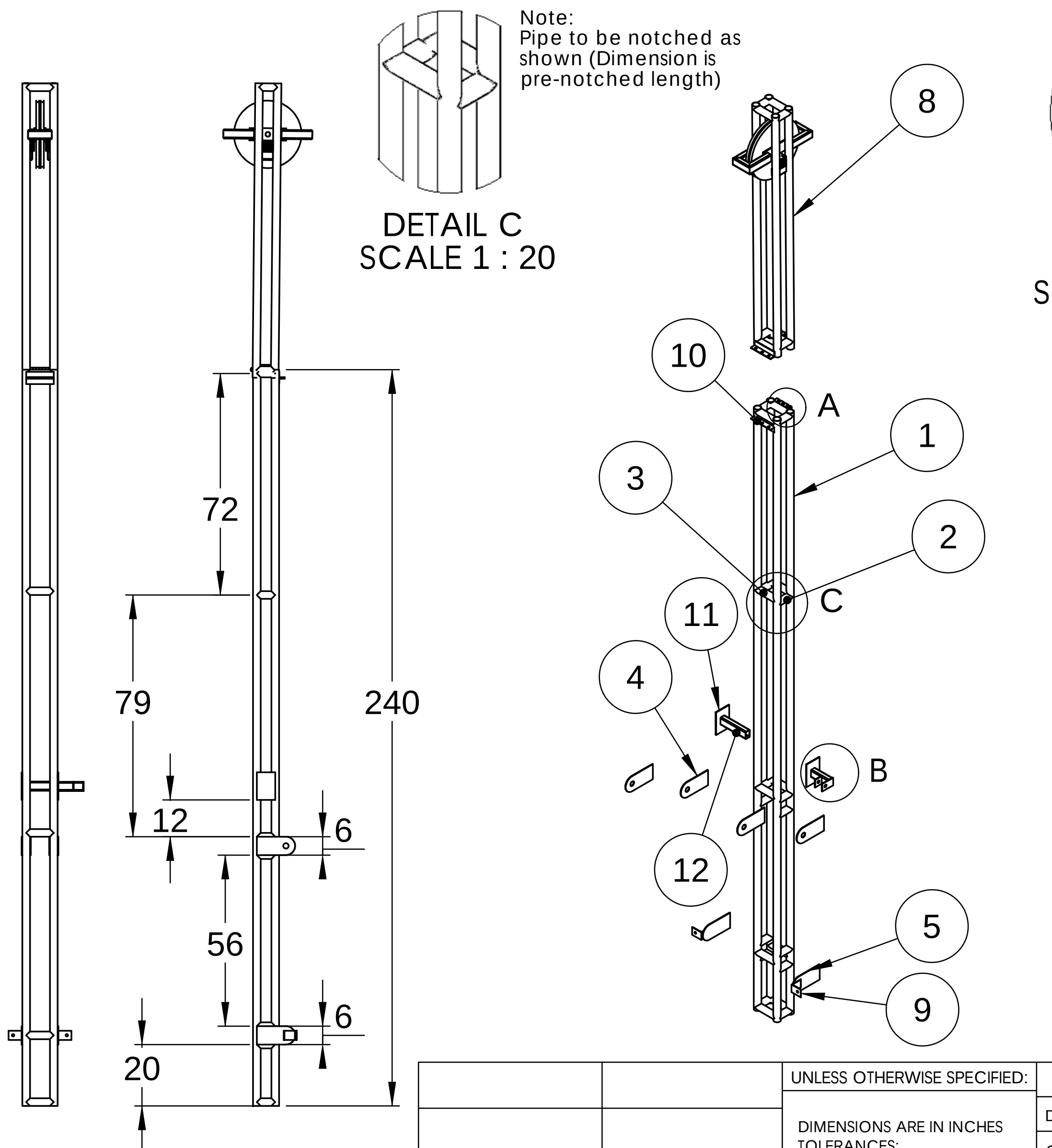
TITLE:

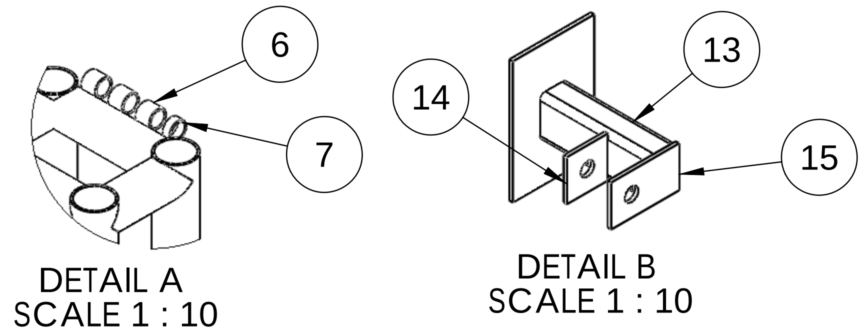
Left Side

SIZE: A | DWG. NO. F007 | REV

SCALE: 1:24 | SHEET 1 OF 1

5 4 3 2 1





ITEM	DESCRIPTION	Part #	QTY.
1	2.5"X2.25" Tube (20')	N/A	4
2	2.5"X2.25" TUBE (6")	N/A	14
3	2.5"X2.25" TUBE (9")	N/A	10
4	Gusset (Holes)	D101-1	4
5	Gusset	D101-2	2
6	Derrick Hinge Ring 1	D102-1	3
7	Derrick Hinge Ring 2	D102-2	1
8	Derrick Extension	D002	1
9	L3x3x0.25x3 (5/8" Hole)	N/A	2
10	Derrick L bracket	D104	1
11	Ram Mount Plate (9"X6"x0.25")	N/A	2
12	TR 3x2x0.1875 (11.5")	N/A	1
13	TR 3x2x0.1875 (8")	N/A	1
14	Ram Mount 1	D103-1	1
15	Ram Mount 2	D103-2	1

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±5 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH
Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

Derrick

SIZE A | DWG. NO. D001 | REV

SCALE: 1:60 | SHEET 1 OF 1

R002	R001
NEXT ASSY	USED ON
APPLICATION	

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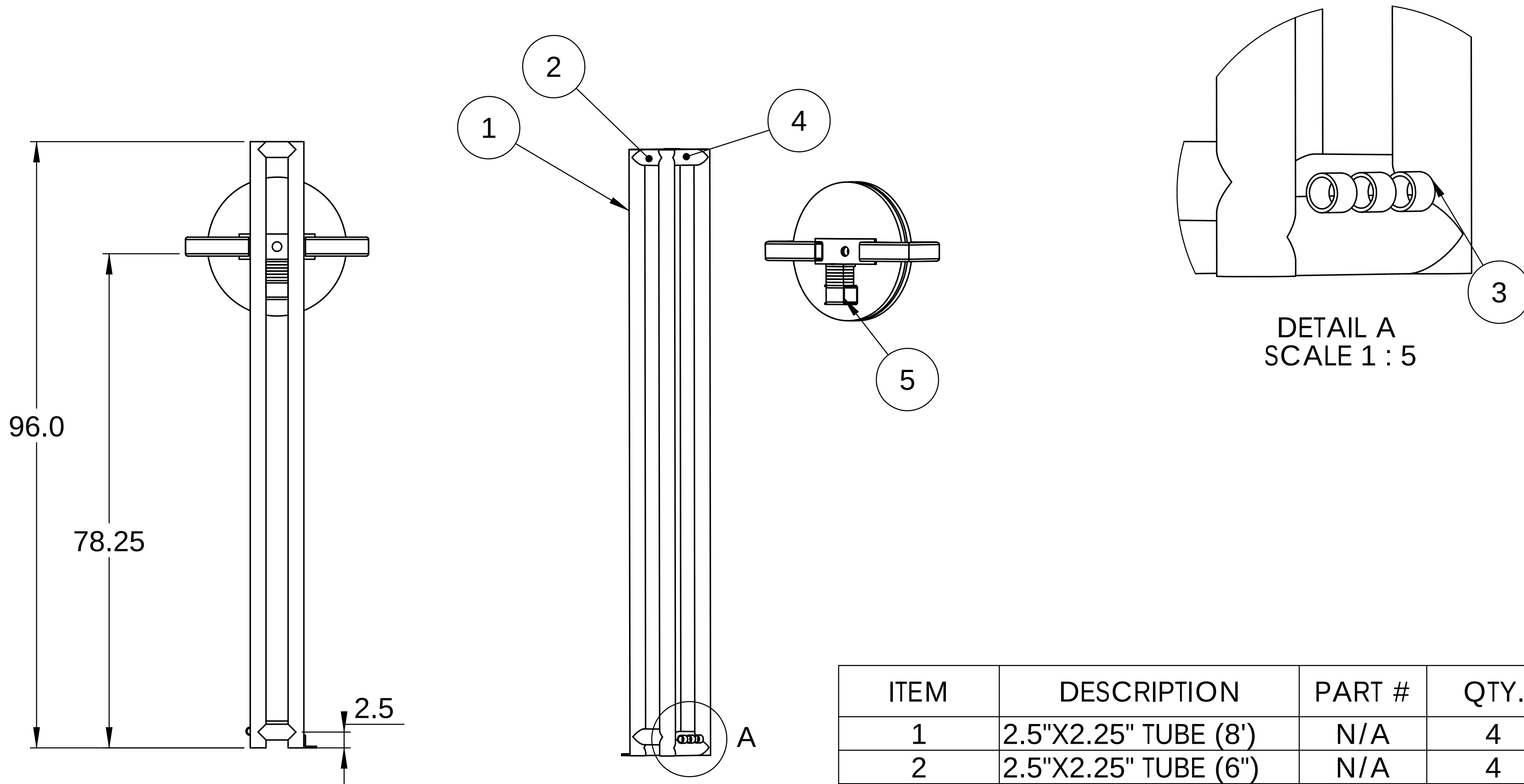
4 3 2 1



ITEM	DESCRIPTION	PART #	QTY.
1	2.5"X2.25" TUBE (8')	N/A	4
2	2.5"X2.25" TUBE (6")	N/A	4
3	Derrick Hinge Ring 1	D102-1	3
4	2.5"X2.25" TUBE (9")	N/A	4
5	Derrick Top Mount	D003	2

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NEXT ASSY	USED ON
D001	R001

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±5 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

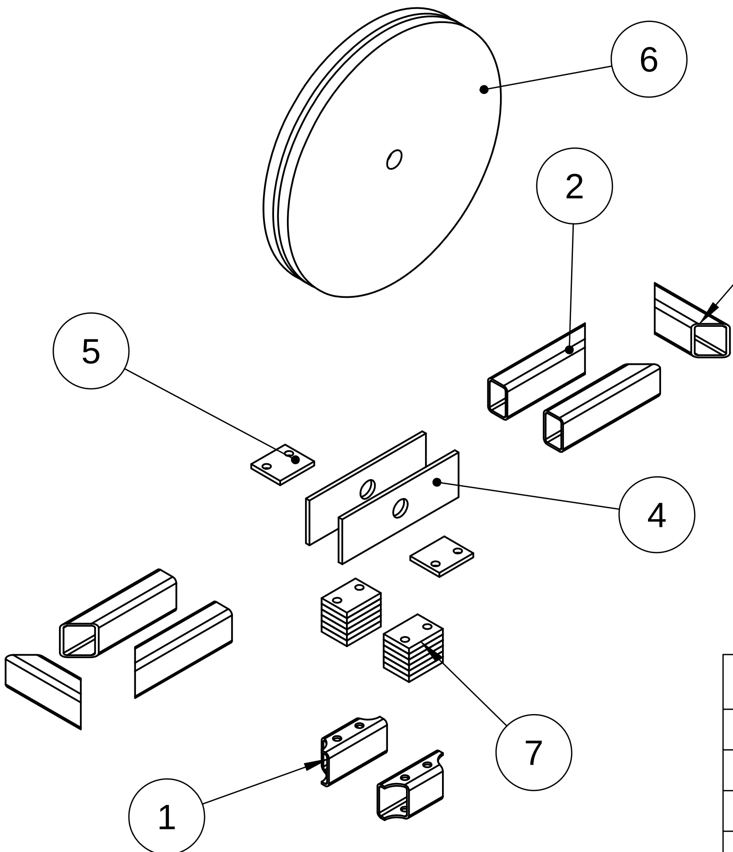
TITLE:

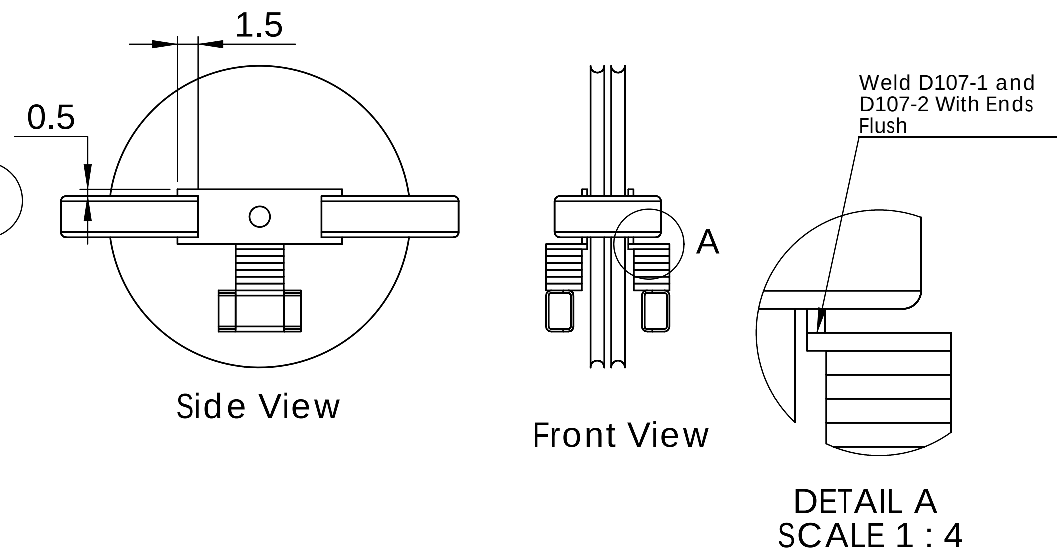
Derrick Extension

SIZE	DWG. NO.	REV
A	D002	

SCALE: 1:25 SHEET 1 OF 1

5 4 3 2 1





ITEM	DESCRIPTION	PART #	QTY.
1	TR 3x2x0.1875 (6" Top)	D105	2
2	TR 3x2x0.1875 (10", 45 deg)	D106-1	4
3	TR 3x2x0.1875 (7.75", 2X 45 Deg)	D106-2	2
4	Top Sheave Mount Plate Steel	D107-1	2
5	Top Sheave Mount Bolted Plate Steel	D107-2	2
6	Top Sheave	N/A	2
7	Rubber Top Mount	N/A	12

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D002	R001
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±5 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL Steel

FINISH Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

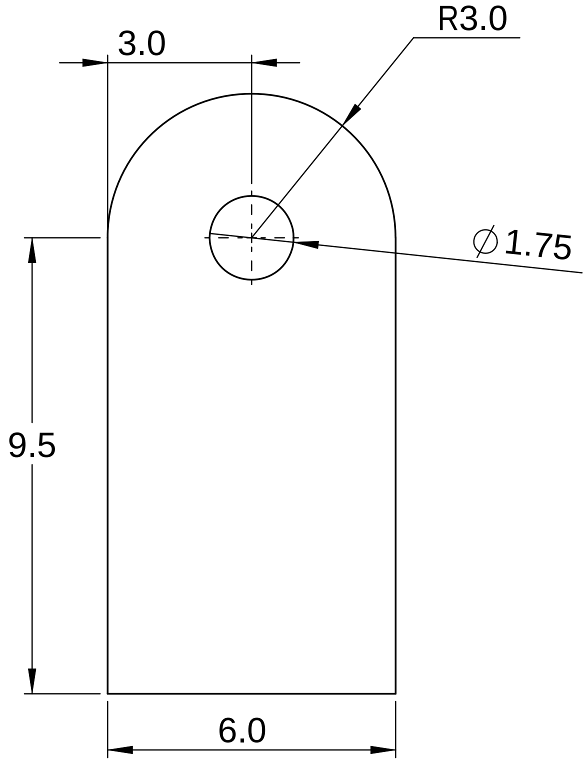
Derrick Top Mount

SIZE **A** DWG. NO. D003 REV

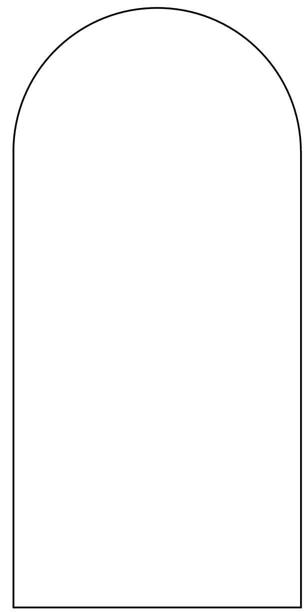
SCALE: 1:14 SHEET 1 OF 1

5 4 3 2 1

Note:
Use 1/4" Minimum
thickness Plate Steel



D101-1



D101-2

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: ±5 Deg ONE PLACE DECIMAL: ±.05 TWO PLACE DECIMAL: ±.05	DRAWN	A. Wargnier	11/23/10
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
D001	D001	MATERIAL Plate Steel	COMMENTS:		
NEXT ASSY	USED ON	FINISH Paint			
APPLICATION		DO NOT SCALE DRAWING			

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TITLE:

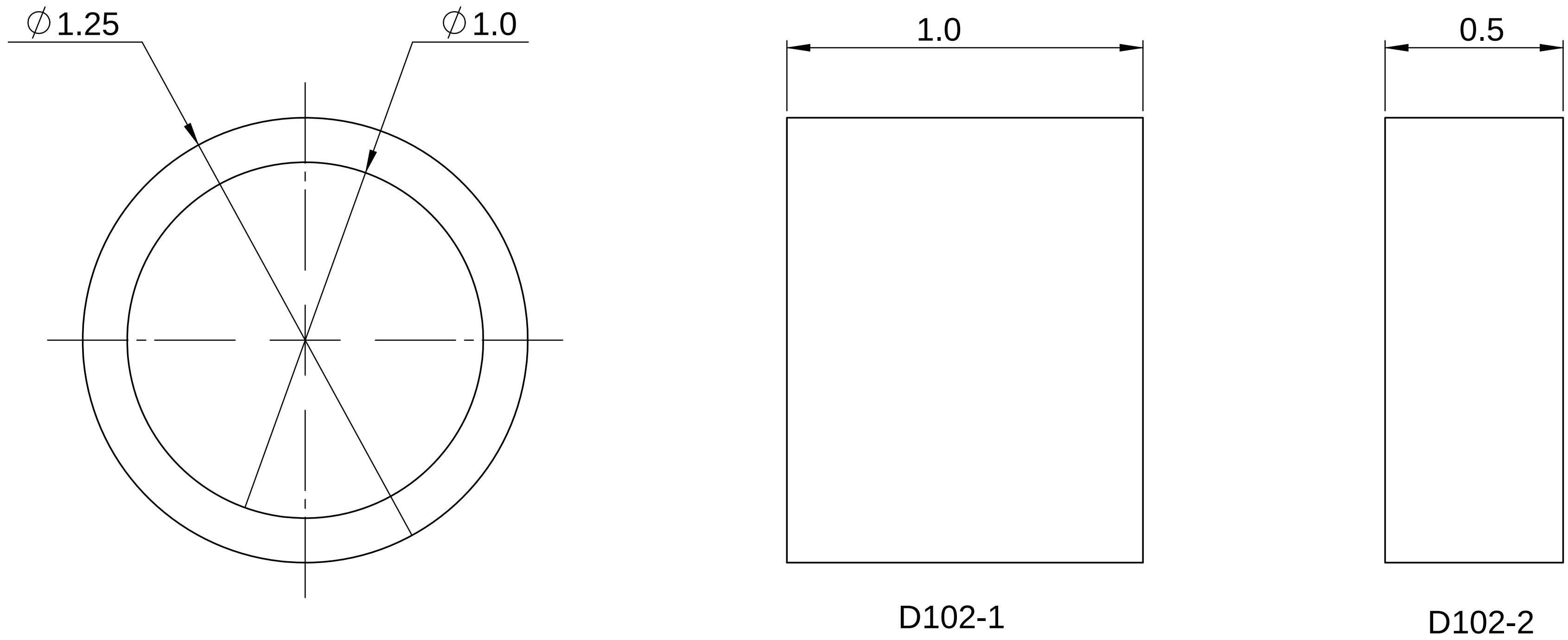
Gusset

SIZE	DWG. NO.	REV
A	D101	

SCALE: 1:4 | SHEET 1 OF 1

5 4 3 2 1

Note:
Use 1" pin to create hinge



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NEXT ASSY	USED ON
D002	
D001	R001

APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±5 Deg
ONE PLACE DECIMAL: ±.05
TWO PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

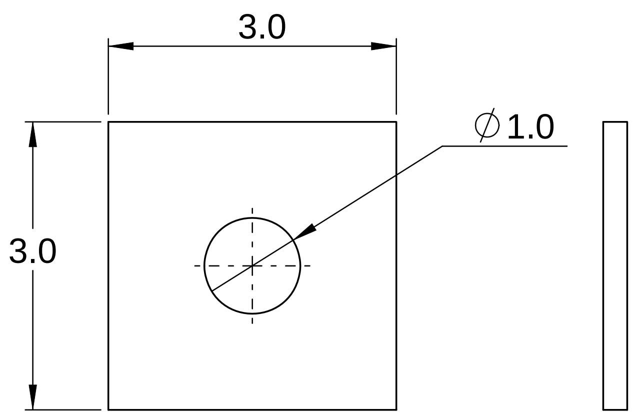
TITLE:
Derrick Hing Ring

SIZE: A | DWG. NO.: D102 | REV:

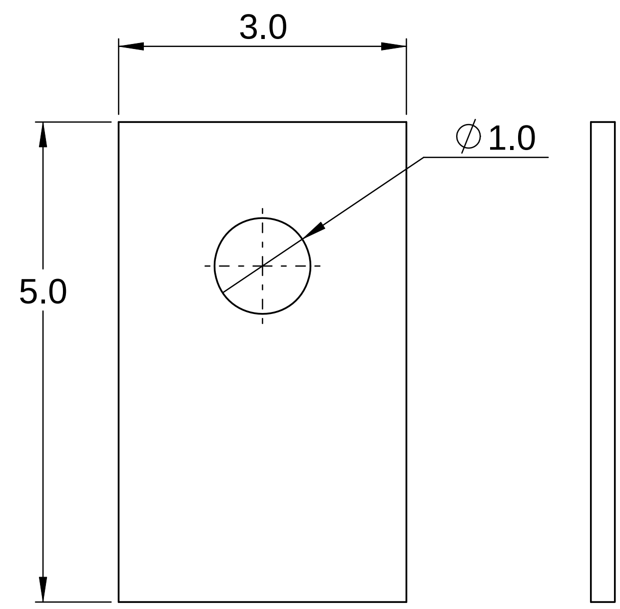
SCALE: 1:100 | SHEET 1 OF 1

5 4 3 2 1

Note:
Use 1/4" minimum
thickness plate steel



D103-1



D103-2

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: ±5 Deg ONE PLACE DECIMAL: ±.05	DRAWN	A. Wargnier	11/23/10	
			CHECKED			TITLE:
			ENG APPR.			Ram Mount
			MFG APPR.			
R003		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
D001	R001	MATERIAL Steel	COMMENTS:			SIZE A / DWG. NO. D103 / REV
NEXT ASSY	USED ON	FINISH Paint				
APPLICATION		DO NOT SCALE DRAWING				SCALE: 1:2 / SHEET 1 OF 1

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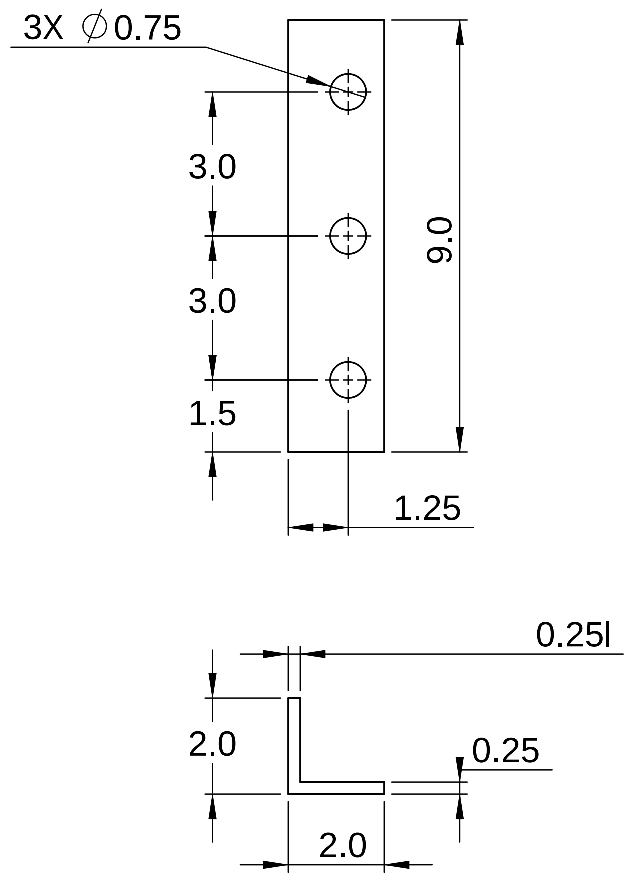
5 4 3 2 1

Note:
1. 1/4" minimum thickness steel
2. Bolt using 3/4" Bolt, Washer, Lock Washer and Nut



D002		
D001	R001	
NEXT ASSY	USED ON	
APPLICATION		

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±5 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL Steel

FINISH Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

Derrick L Bracket

SIZE A | DWG. NO. D104 | REV

SCALE: 1:4 | SHEET 1 OF 1

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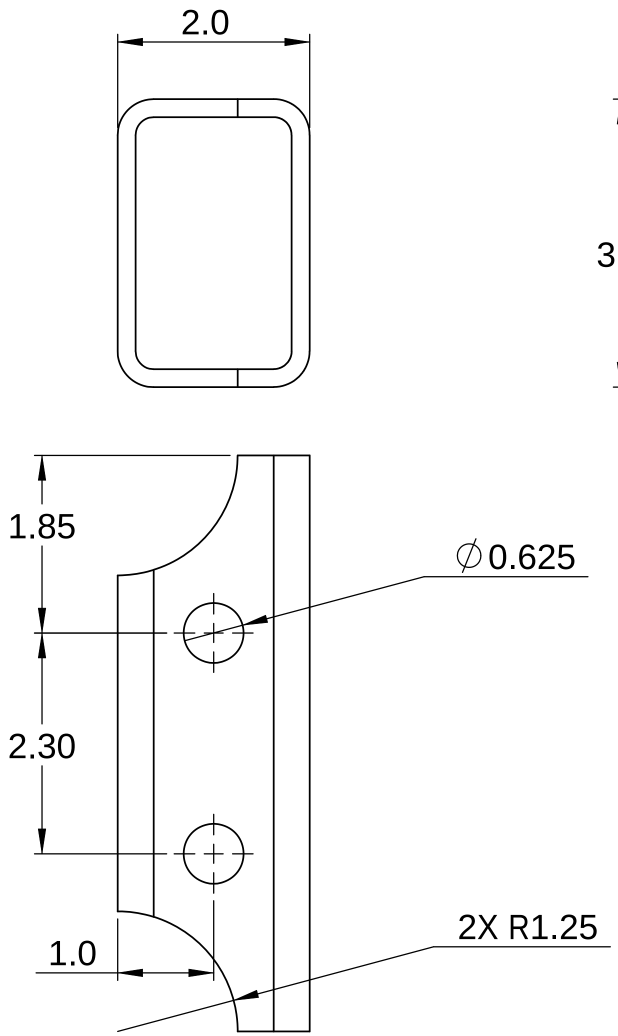
4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: ±5 Deg ONE PLACE DECIMAL: ±.05	DRAWN	A. Wargnier	11/23/10
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
D003	R001	MATERIAL Steel	COMMENTS:		
NEXT ASSY	USED ON	FINISH Paint			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:

Derrick Top Mount Notched

SIZE	DWG. NO.	REV
A	D105	
SCALE: 1:2		SHEET 1 OF 1

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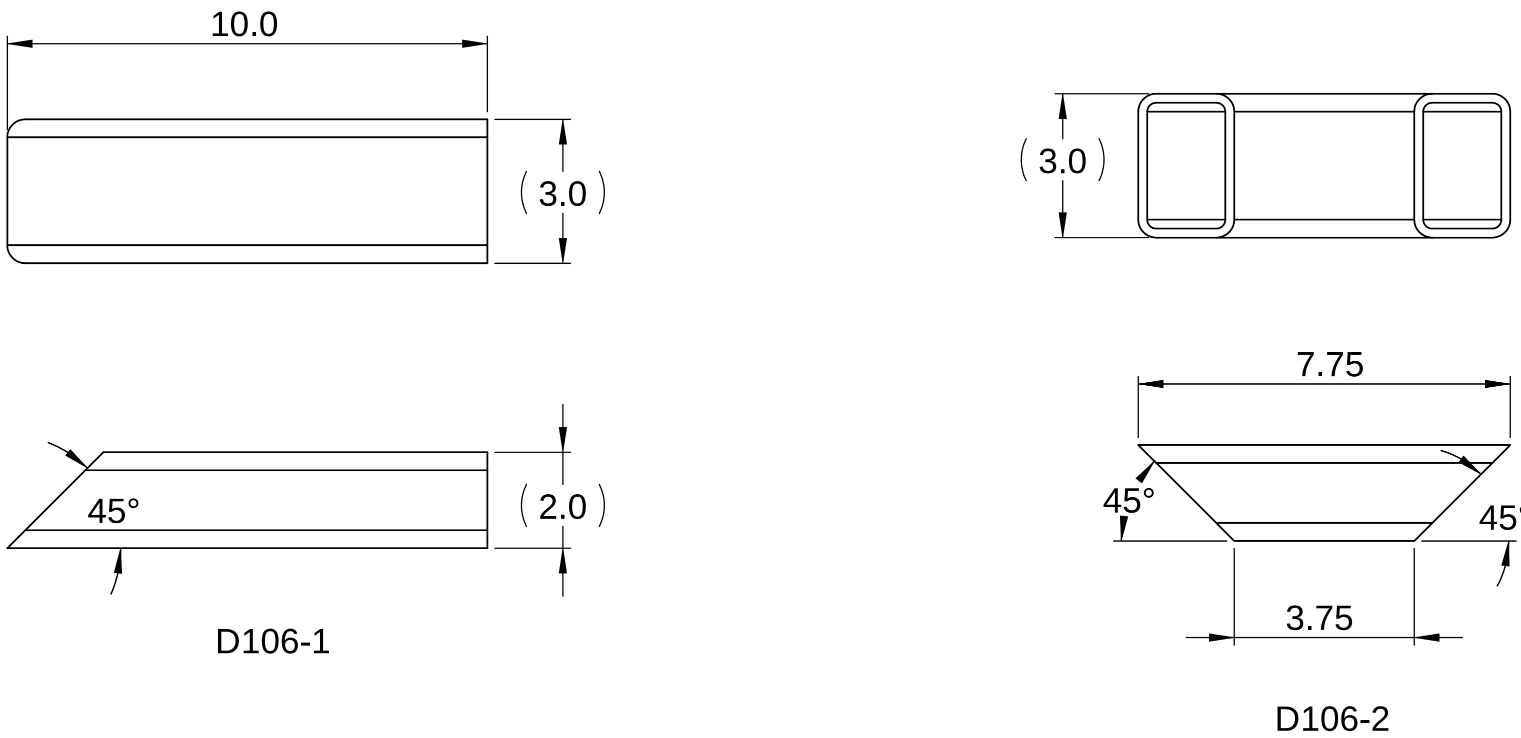
4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: ±1 Deg ONE PLACE DECIMAL: ±.05	DRAWN	A. Wargnier	11/23/10
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
D003	R001	MATERIAL Steel	COMMENTS:		
NEXT ASSY	USED ON	FINISH Paint			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:

45 Deg. Member

SIZE	DWG. NO.	REV
A	D106	
SCALE: 1:4		SHEET 1 OF 1

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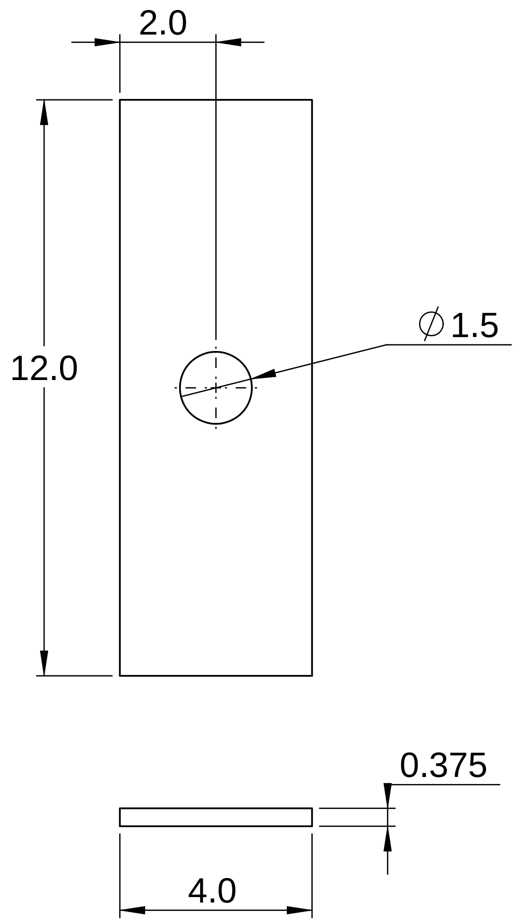
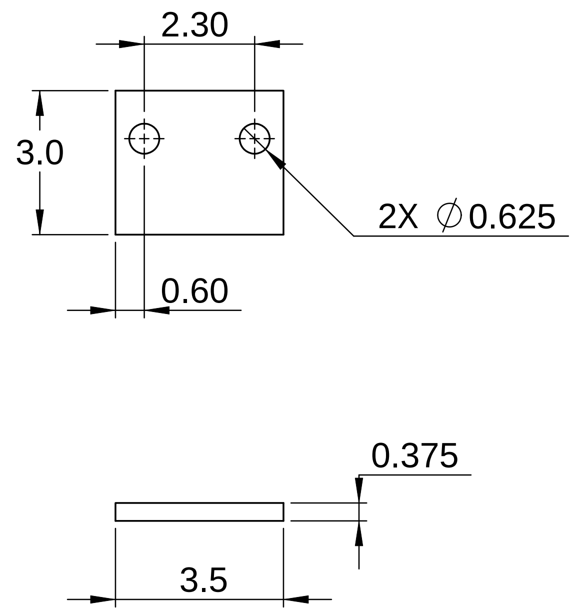
5 4 3 2 1

Note:
Use mininimum 3/8"
thick plate steel



D107-1



D107-2

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NEXT ASSY	USED ON
D003	R001

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

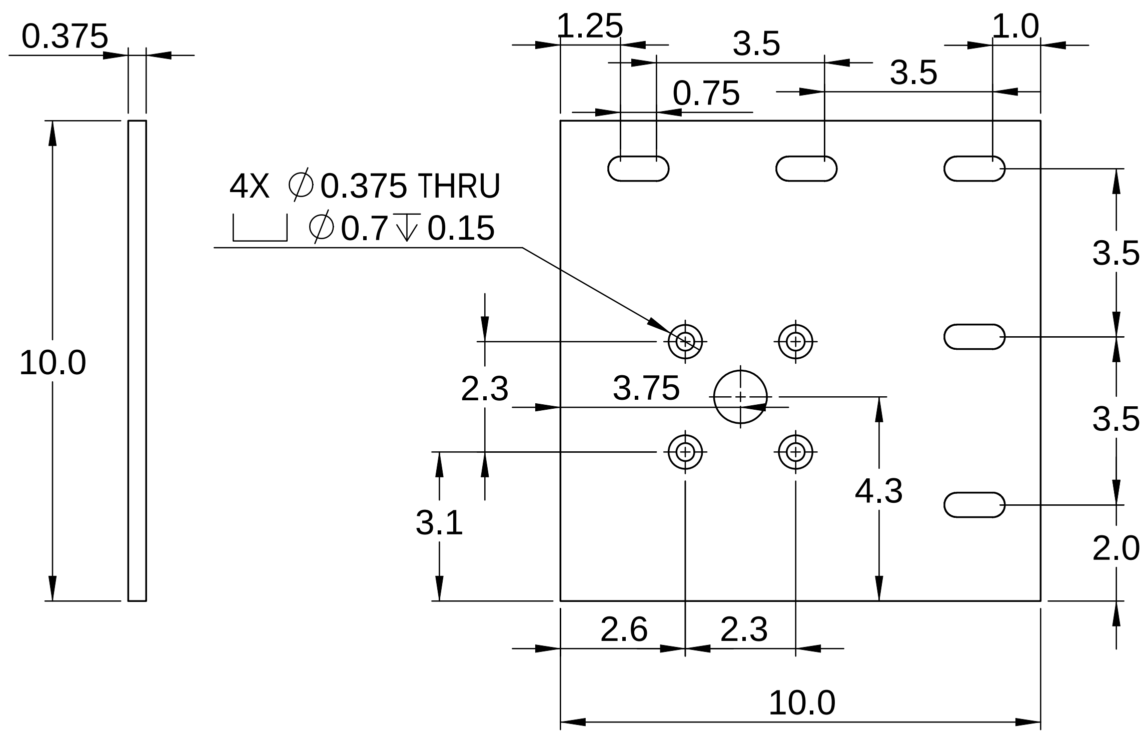
Top Sheave Mount

SIZE: A | DWG. NO.: D107 | REV

SCALE: 1:4 | SHEET 1 OF 1

5 4 3 2 1

Note:
Use 3/8" minimum thickness
plate steel



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

R001	R001
NEXT ASSY	USED ON

APPLICATION

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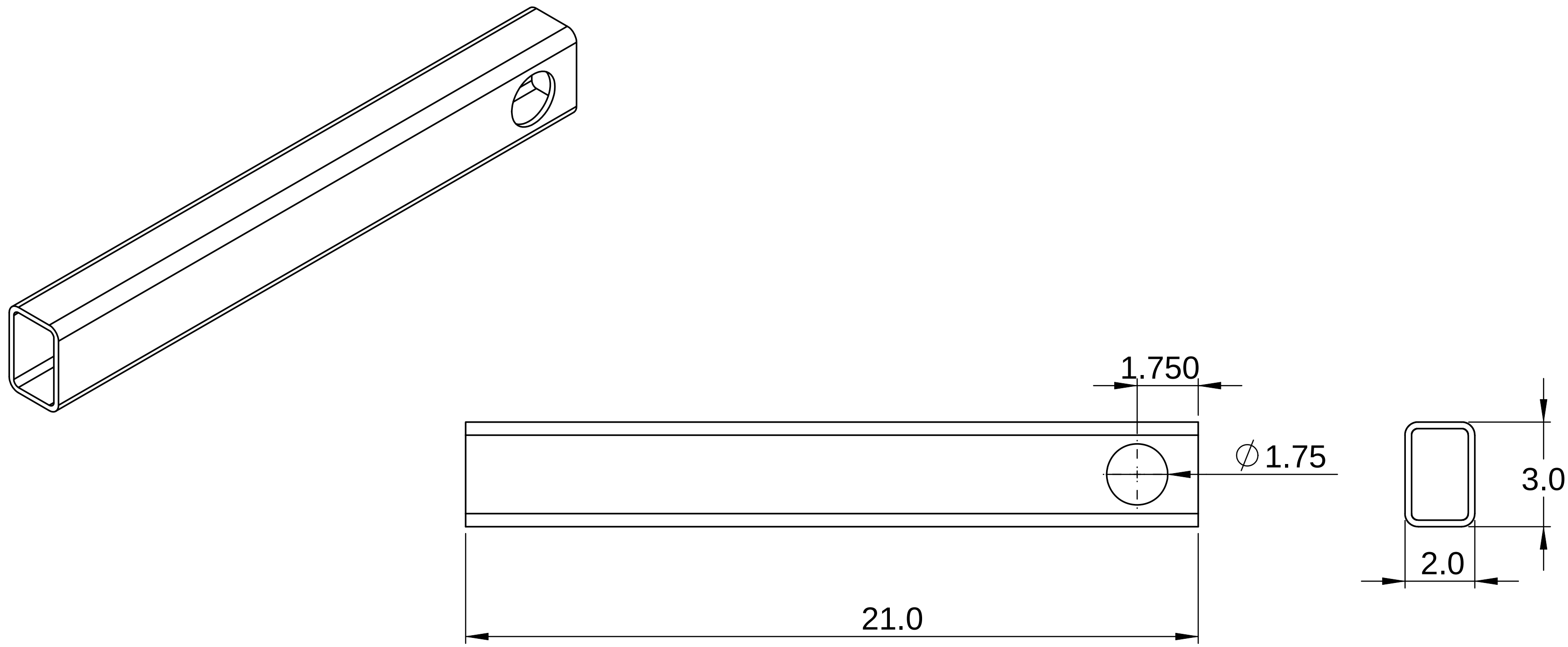
TITLE:

Motor Mount

SIZE: **A**
DWG. NO. M101
REV

SCALE: 1:4
SHEET 1 OF 1

5 4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: ±1 Deg ONE PLACE DECIMAL: ±.05	DRAWN	A. Wargnier	11/28/10
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
R004	R001	MATERIAL Steel	COMMENTS:		
NEXT ASSY	USED ON	FINISH Paint			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:

Derrick Mount

SIZE	DWG. NO.	REV
A	R101	
SCALE: 1:5		SHEET 1 OF 1

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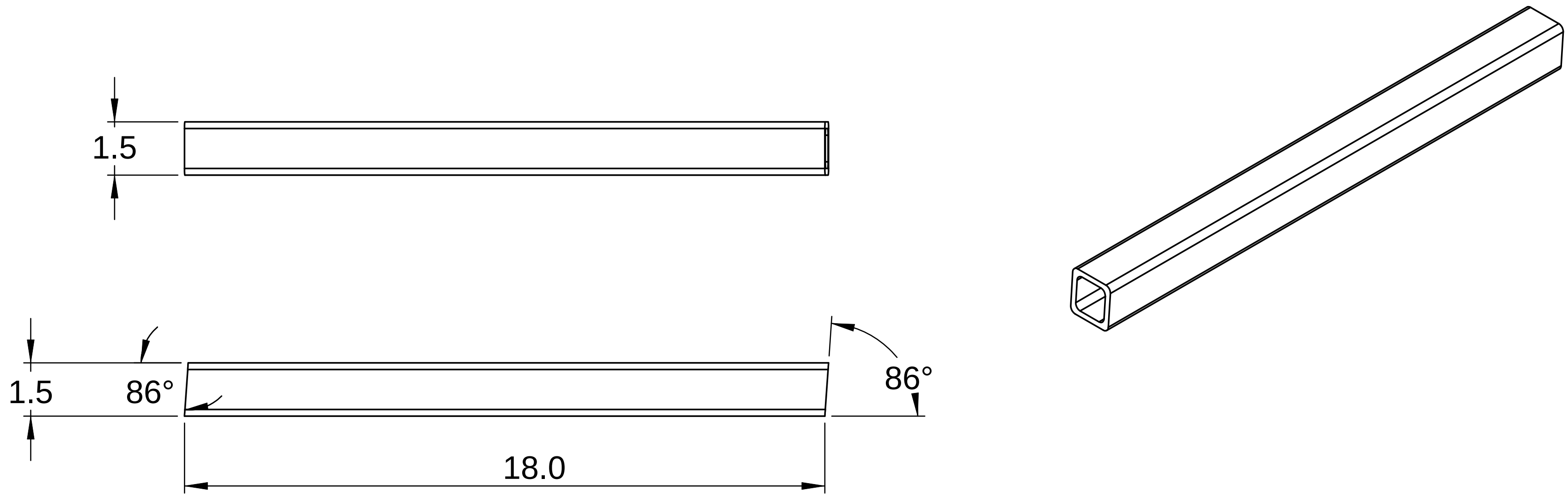
5 4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: ±1 Deg ONE PLACE DECIMAL: ±.05	DRAWN	A. Wargnier	11/28/10
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
R004	R001	MATERIAL Steel	COMMENTS:		
NEXT ASSY	USED ON	FINISH Paint			
APPLICATION		DO NOT SCALE DRAWING			

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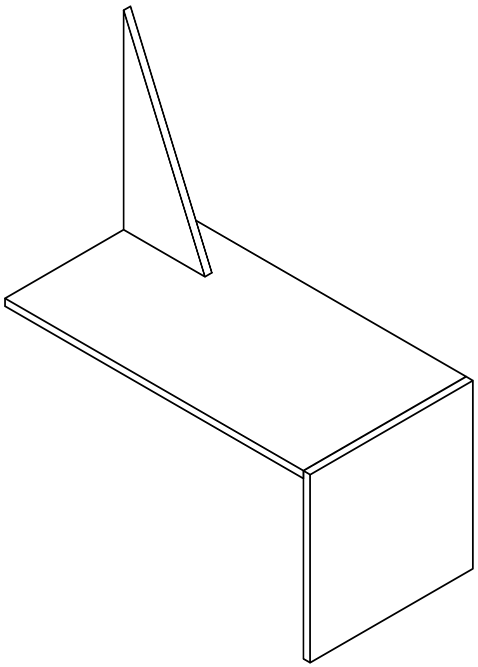
TITLE:

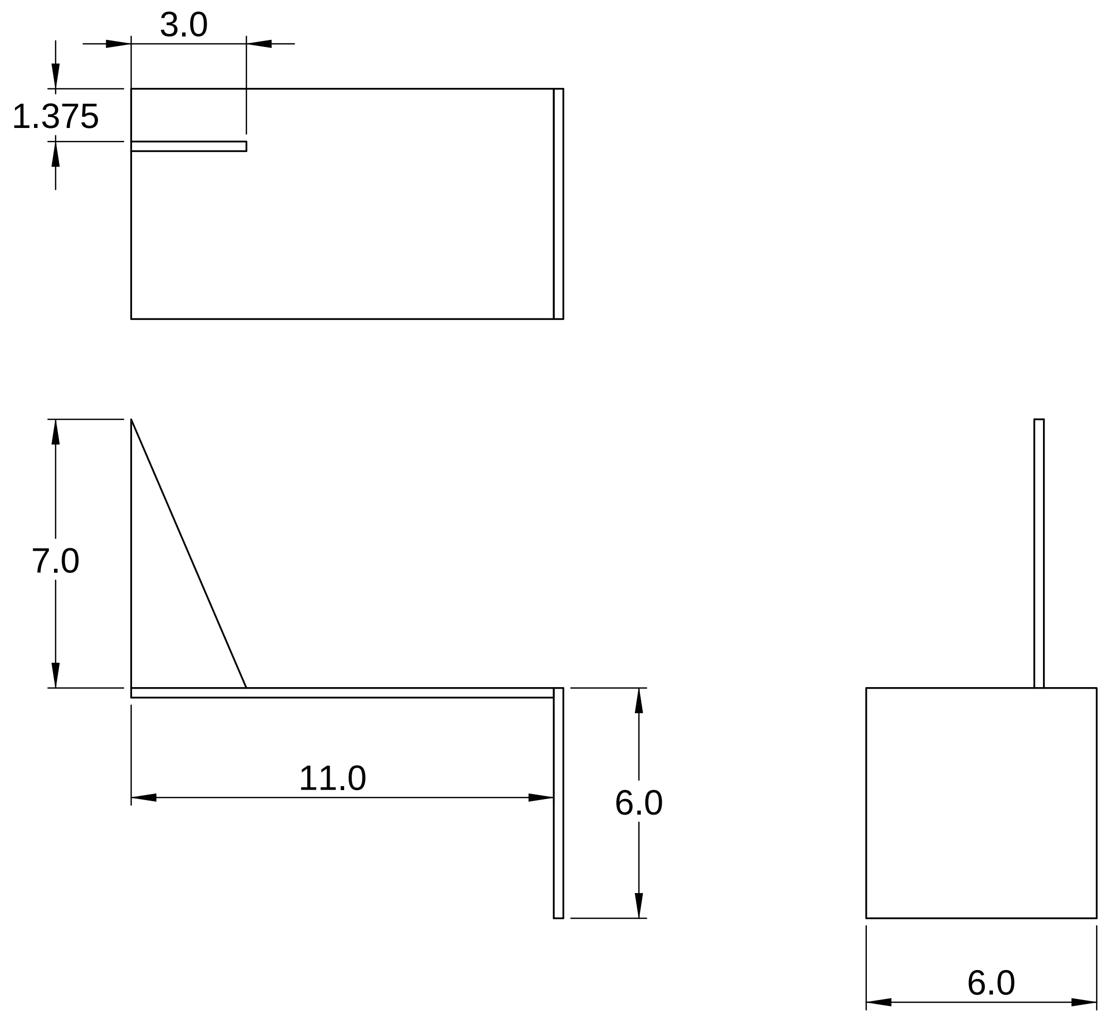
Cross Member

SIZE	DWG. NO.	REV
A	R102	
SCALE: 1:50		SHEET 1 OF 1

5 4 3 2 1

Note:
Construct from 1/4" minimum thickness plate steel





		UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: ±1 Deg ONE PLACE DECIMAL: ±.05
		INTERPRET GEOMETRIC TOLERANCING PER:
R004	R001	MATERIAL Steel
NEXT ASSY	USED ON	FINISH Paint
APPLICATION		DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/28/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

Control Mount

SIZE	DWG. NO.	REV
A	R103	
SCALE: 1:5		SHEET 1 OF 1

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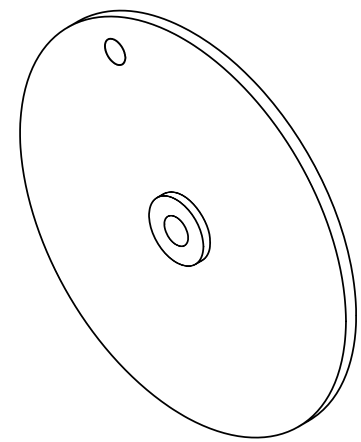
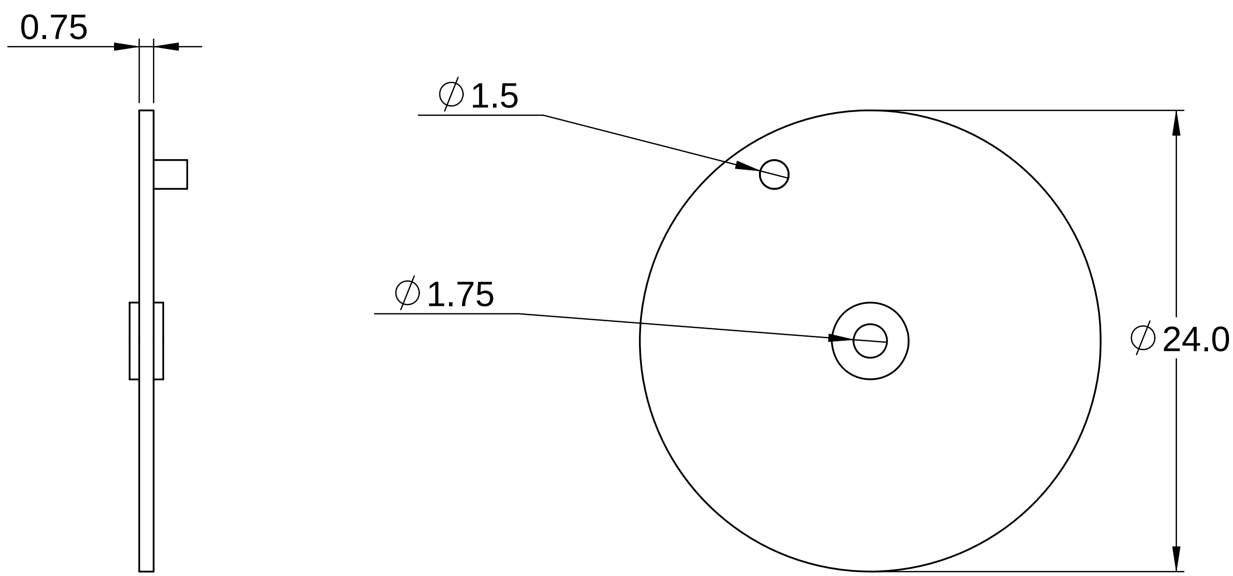
5 4 3 2 1

Note:
1. Weld 1.5"X2.5" shaft into flywheel to attach to pitman arm.
2. Thicker flywheel may be used for increased angular momentum.





		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: ±1 Deg ONE PLACE DECIMAL: ±.05	DRAWN	A. Wargnier	11/29/10
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
R001	R001	MATERIAL Steel	COMMENTS:		
NEXT ASSY	USED ON	FINISH Paint			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:

Flywheel

SIZE A | DWG. NO. R105 | REV

SCALE: 1:10 | SHEET 1 OF 1

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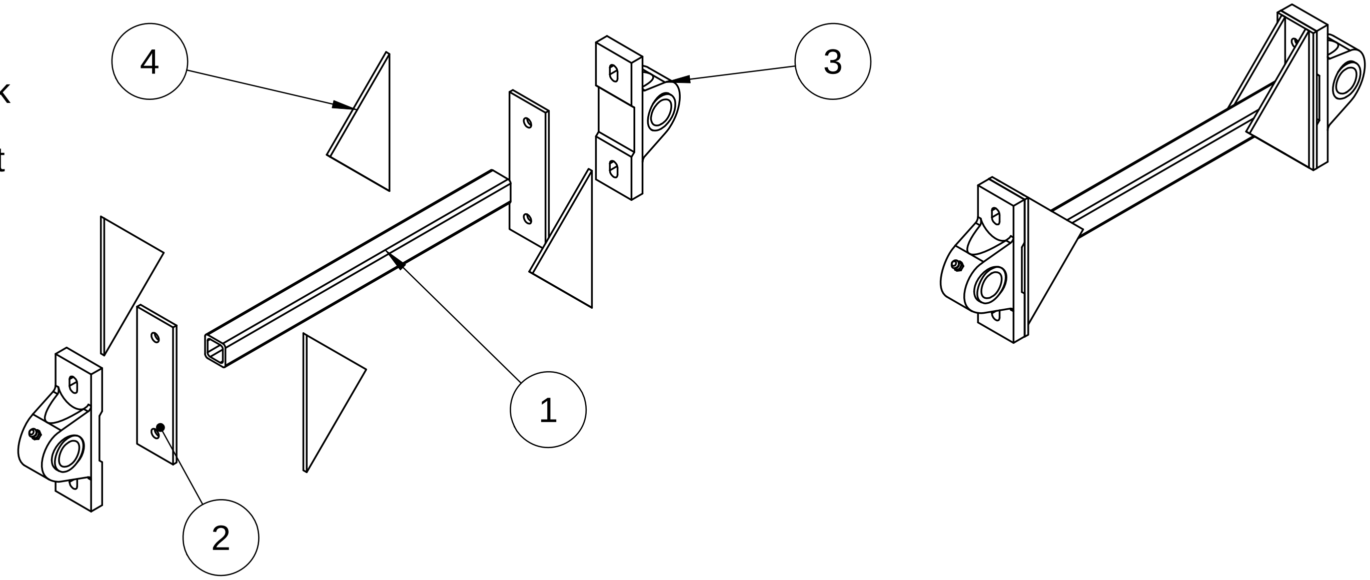
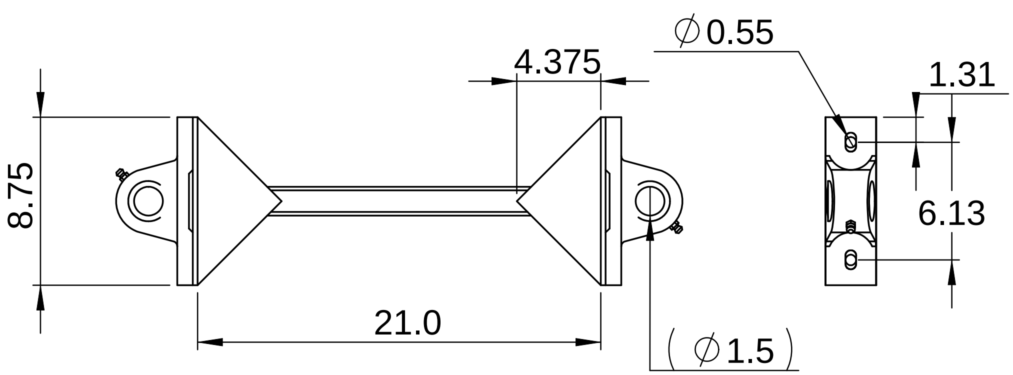
5 4 3 2 1

Note:
1. Pitman arm mount to be same shape as pillow block base.
2. Use 1/2" bolts to connect pillow block to mount.





ITEM	DESCRIPTION	PART #	QTY.
1	TS 1.5x1.5 (21")	N/A	1
2	Pitman Arm Mount	N/A	2
3	1.5" Pillow Block	N/A	2
4	Pitman Arm Support	N/A	4

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NEXT ASSY	USED ON
R001	R001

APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/29/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

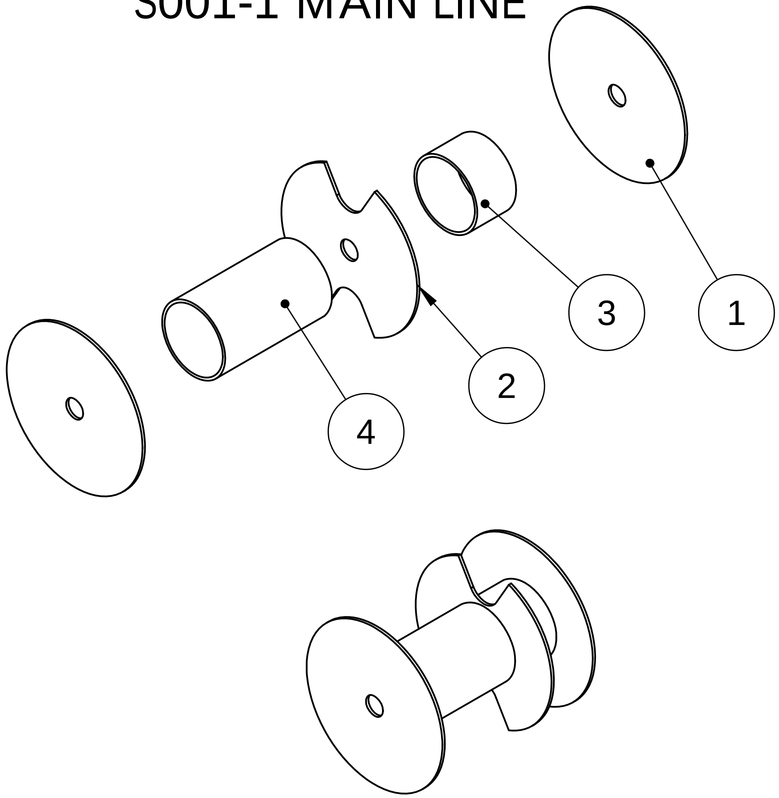
Pitman Arm

SIZE: A
DWG. NO. R106
REV

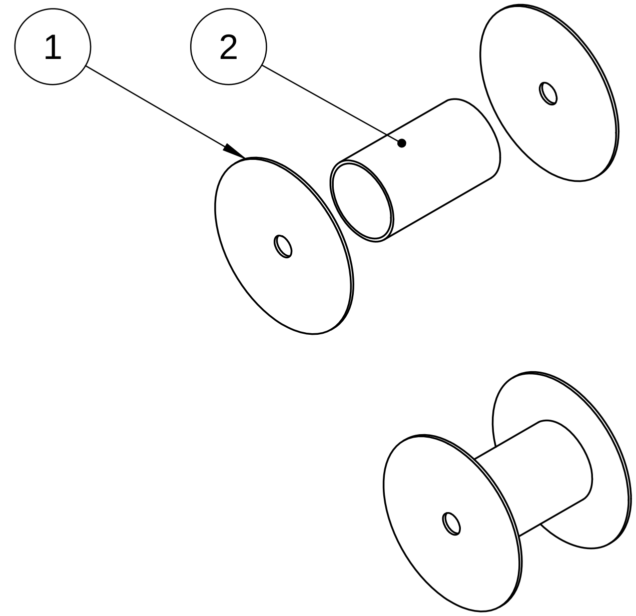
SCALE: 1:10
SHEET 1 OF 1

5 4 3 2 1

S001-1 MAIN LINE



S001-2 SAND LINE



ITEM	DESCRIPTION	PART #	QTY.
1	Spool Side	S101-1	2
2	Spool Side (Cut)	S101-2	1
3	Spool Tube (4")	S102-2	1
4	Spool Tube (11")	S102-1	1

ITEM	DESCRIPTION	PART #	QTY.
1	Spool Side	S101-1	2
2	Spool Center (11")	S102-1	1

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±5 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL Steel

FINISH Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

NEXT ASSY	USED ON
R001	R001

APPLICATION

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TITLE:

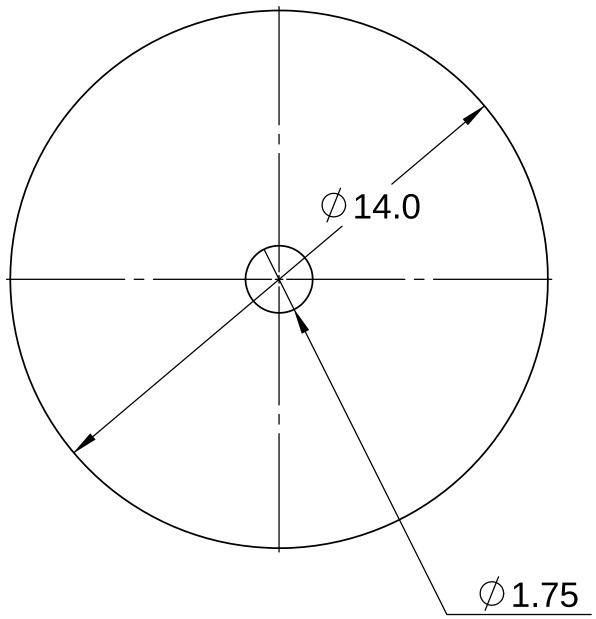
Spools

SIZE A | DWG. NO. S001 | REV

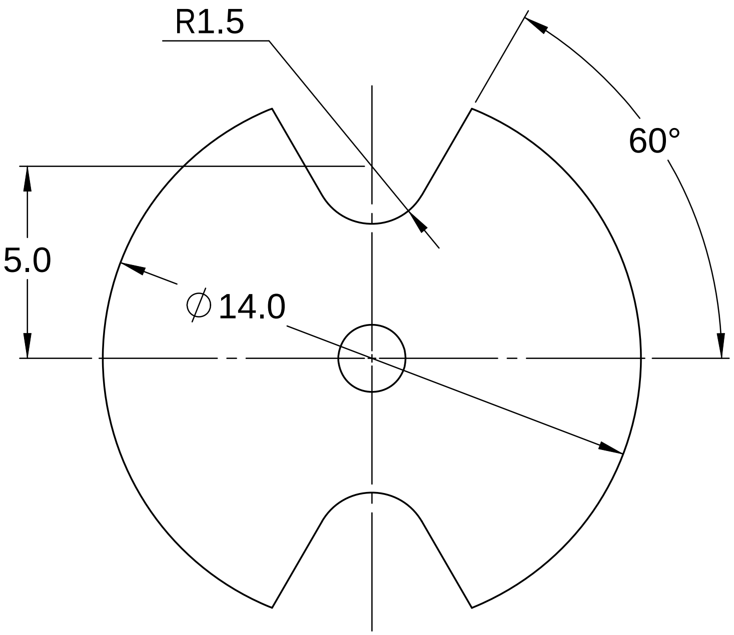
SCALE: 1:14 | SHEET 1 OF 1

4 3 2 1

Note:
Made from 1/4" plate steel



S101-1



S101-2

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S001	R001
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

Spool Side

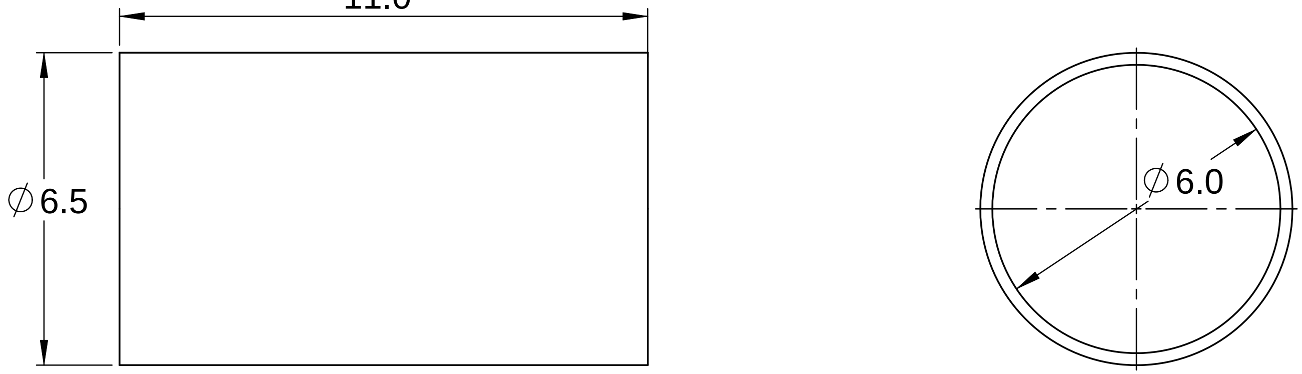
SIZE	DWG. NO.	REV
A	S101	

SCALE: 1:100 | SHEET 1 OF 1

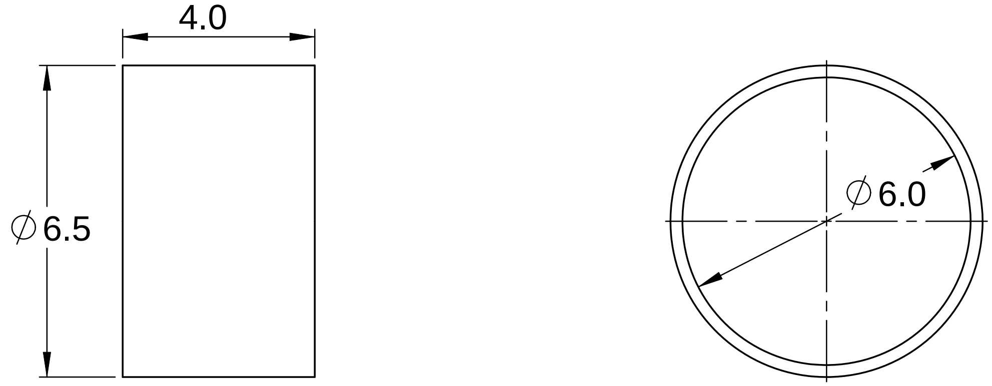
5 4 3 2 1

Note:
Made from 6.5"X6.25"
Steel Pipe

S102-1



S102-2



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: ±1 Deg ONE PLACE DECIMAL: ±.05	DRAWN	A. Wargnier	11/23/10
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
S001	R001	MATERIAL Steel	COMMENTS:		
NEXT ASSY	USED ON	FINISH Paint			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:

Spool Center

SIZE	DWG. NO.	REV
A	S102	

SCALE: 1:4 | SHEET 1 OF 1

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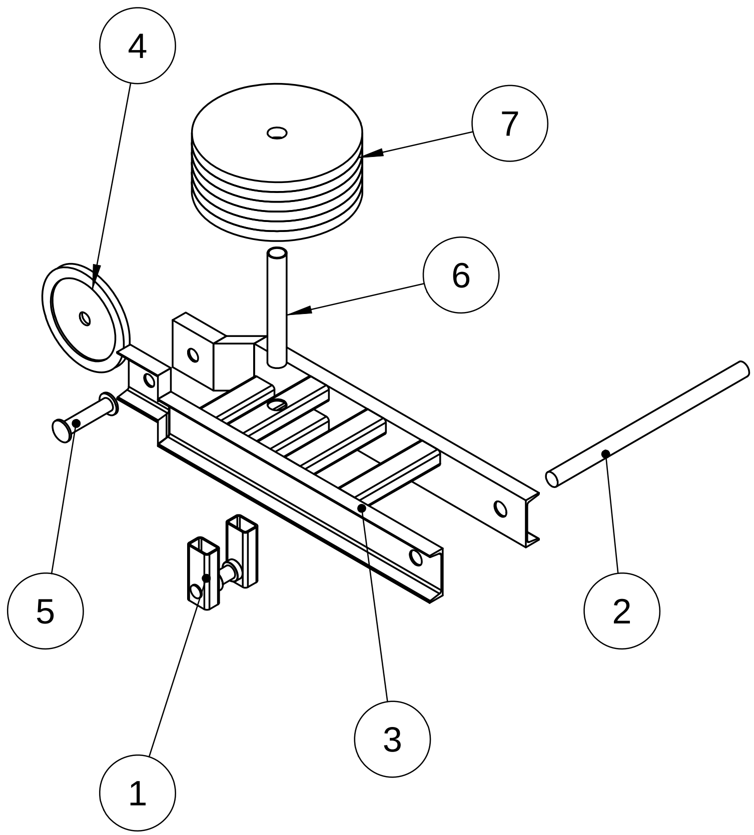
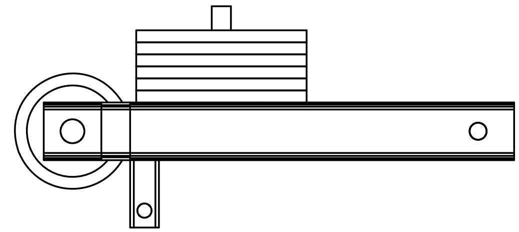
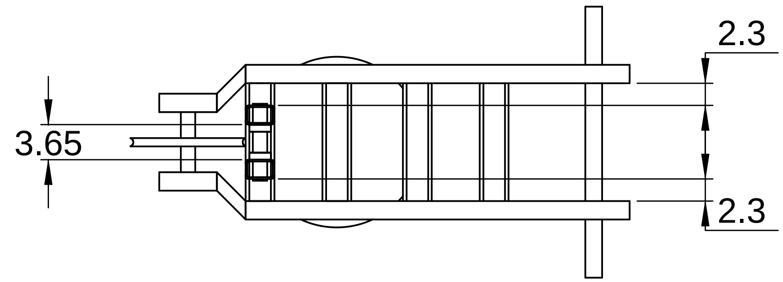
5 4 3 2 1

Note:
Shaft collar used to secure weight plate stack







ITEM	DESCRIPTION	PART #	QTY.
1	Pitman Arm Attachment	W003	1
2	WB Shaft (1.75"X28")	N/A	1
3	Walking Beam Frame	W002	1
4	12" DIa Pulley	N/A	1
5	Pulley Shaft (1.5"X6.75")	N/A	1
6	Weight shaft (2"X1.5"X14")	N/A	1
7	Weight plate	N/A	6

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NEXT ASSY	USED ON
S001	R001

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: Steel

FINISH: Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/23/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

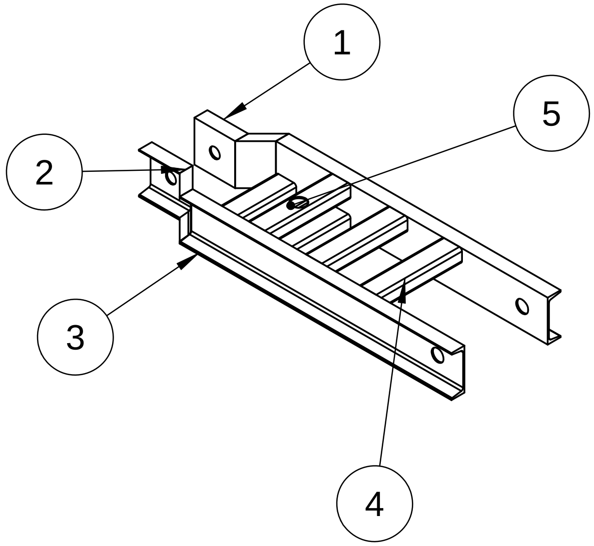
TITLE:

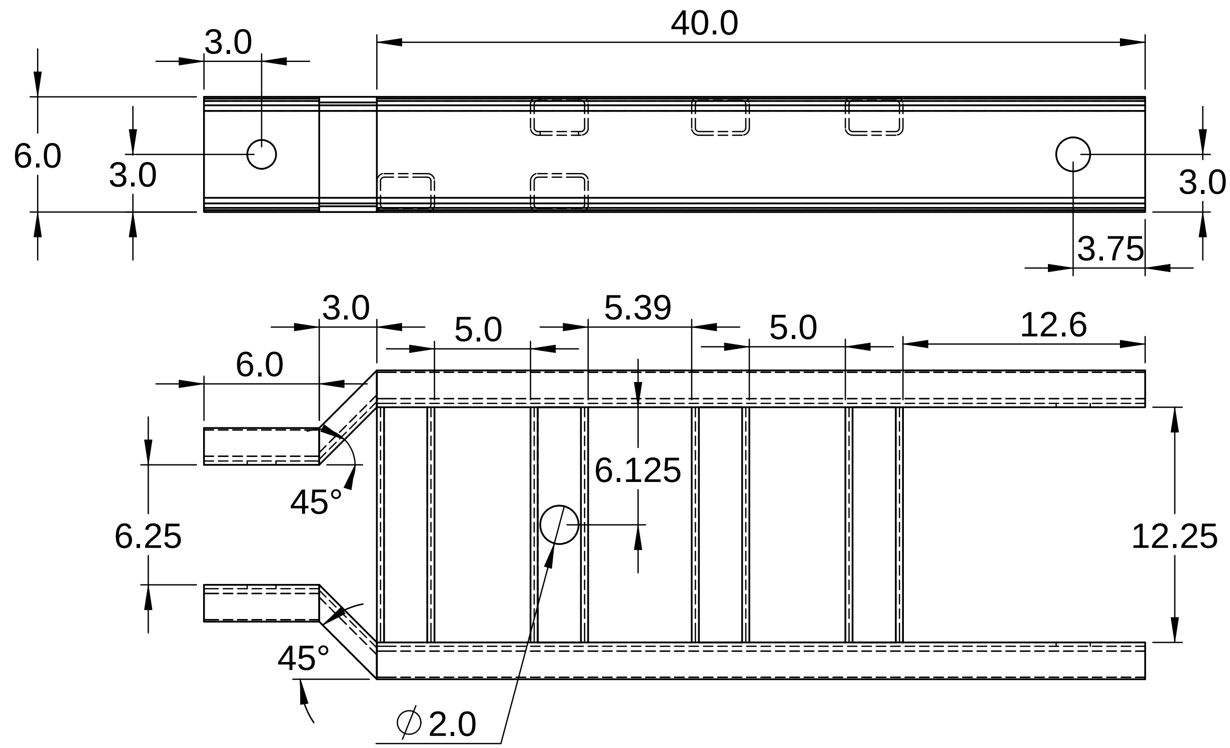
Walking Beam

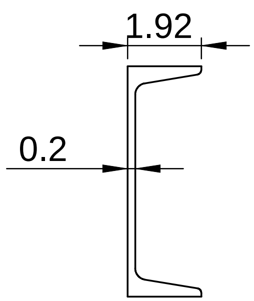
SIZE: A | DWG. NO. W001 | REV

SCALE: 1:20 | SHEET 1 OF 1

5 4 3 2 1







C6X8.2 Members

ITEM	DESCRIPTION	PART #	QTY.
1	C6x8.2x6	N/A	2
2	C6x8.2 (Angled)	N/A	2
3	C6x8.2x40	N/A	2
4	TR3x2x0.1875 (12.25")	N/A	4
5	TR3x2x0.1875 (2" Hole)	N/A	1

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W001	R001
NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL Steel

FINISH Paint

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	A. Wargnier	11/27/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

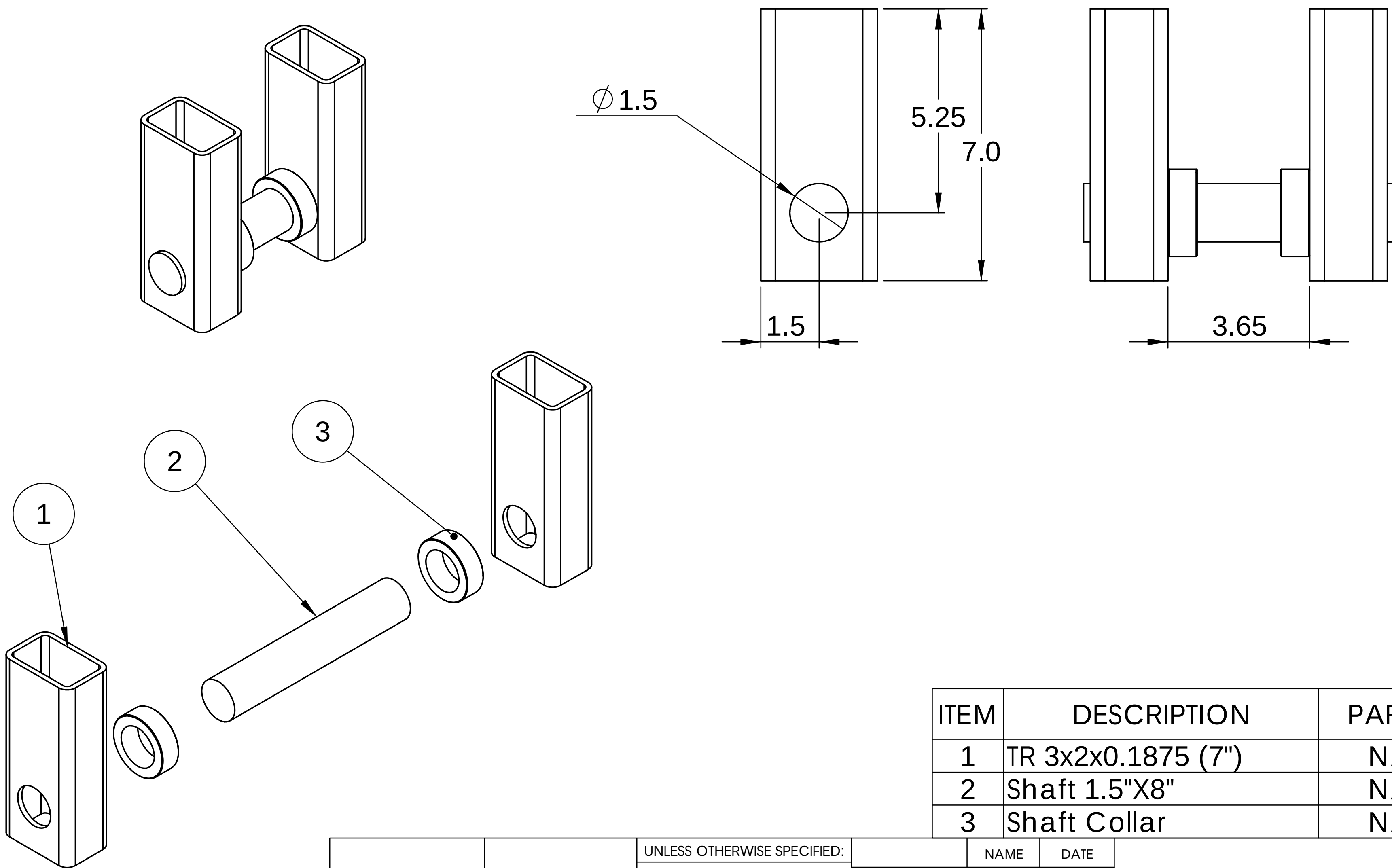
TITLE:

Walking Beam Frame

SIZE A | DWG. NO. W002 | REV

SCALE: 1:10 | SHEET 1 OF 1

5 4 3 2 1



ITEM	DESCRIPTION	PART #	QTY.
1	TR 3x2x0.1875 (7")	N/A	2
2	Shaft 1.5"X8"	N/A	1
3	Shaft Collar	N/A	2

	NAME	DATE
DRAWN	A. Wargnier	11/27/10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16
ANGULAR: ±1 Deg
ONE PLACE DECIMAL: ±.05

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL Steel

FINISH Paint

DO NOT SCALE DRAWING

NEXT ASSY	USED ON
W001	R001

APPLICATION

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TITLE:

Pitman Arm Attachment

SIZE	DWG. NO.	REV
A	W003	

SCALE: 1:4 SHEET 1 OF 1

5 4 3 2 1