DESIGN AND FABRICATION OF A VERTICAL PUMP MULTIPHASE FLOW LOOP

A Thesis

by

KLAYTON EDWARD KIRKLAND

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Approved by:

Chair of Committee,	Gerald Morrison
Committee Members,	Yassin A. Hassan
	Dan McAdams
Head of Department,	Jerald A. Caton

December 2012

Major Subject: Mechanical Engineering

ABSTRACT

A new centrifugal pump has been devised to handle two-phase flow. However, it requires full scale testing to allow further development. Testing is required to verify performance and to gain information needed to apply this design in the field. Further, testing will allow mathematical models to be validated which will allow increased understanding of the pump's behavior. To perform this testing, a new facility was designed and constructed.

This facility consists of a closed flow loop. The pump is supplied by separate air and water inlet flows that mix just before entering the pump. These flows can be controlled to give a desired gas volume fraction and overall flow rate. The pump outlet flows into a tank which separates the fluids allowing them to re-circulate. Operating inlet pressures of up to three hundred PSIG will be used with a flow rate of twelve hundred gallons per minute. A two-hundred fifty horsepower electric motor is used to power the pump.

The loop is equipped with instrumentation to measure temperature, pressure, flow rate, pump speed, pump shaft horsepower, shaft torque, and shaft axial load. The pump itself has a clear inlet section and a clear section allowing visualization of the second stage volute interior as well as numerous pressure taps along the second stage volute. This instrumentation is sufficient to completely characterize the pump.

Design and construction details are provided as well as a history of the initial operating experiences and data collected. A discussion of lessons learned is given in the conclusions. Future projects intended to use this facility are also given. Finally, detailed design drawings are supplied as well as operating instructions and checklists.

DEDICATION

This thesis is dedicated to Katelyn Anne Kirkland and Connor James Kirkland.

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. Morrison for his unwavering support. I also wish to thank Shell for sponsoring the project which made this thesis possible.

For encouragement and advice, I wish to thank Glenn Wiltcher, and Todd Grage. At the Turbomachinery Lab, there are many people to thank including Ray Mathews, and my colleagues Sahand Pirouzpanah, Emanual Marsis, Ramy Moaness, Nicolas Carvajal, and Joseph Marchetti. All of you have contributed enormously to this thesis.

Finally, thanks to Karen Vierow for her unwavering support and love.

NOMENCLATURE

GVF	Gas Volume Fraction
MVP	Multi-Vane Pump
PH	Pipe Hanger*
PHA	Pipe Hanger Assembly*
PS	Pump Stand*
PSA	Pump Stand Assembly*
PSIG	Gauge Pounds per Square Inch
PSID	Differential Pound per Square Inch
SPOOL	Pipe Spool*
TS	Tank Stand*
TSA	Tank Stand Assembly*
VFD	Variable Frequency Drive

*These items appear as drawing number prefixes (see Appendix B)

TABLE OF CONTENTS

Page

LIST OF FIGURES

FIGURE Page

LIST OF TABLES

1 INTRODUCTION

1.1 Background

Centrifugal pumps have been in use for well over a century and are some of the most common pieces of industrial equipment in existence. It is easy to see why, they are reliable and efficient. They possess relatively few moving parts and can handle high flow rates. Finally, the vertical turbine layout lends itself to downhole applications. They do possess one drawback in that they cannot easily tolerate two phase flow. A new, proprietary pump design has been developed to address this issue. This has been named the Multi-Vane Pump, (MVP).

The MVP is a development of the Electric Submersible Pump (ESP), which is a vertical centrifugal pump with a self-contained, close coupled electric motor. The entire unit can be immersed in the working fluid as the motor is hermetically sealed, with power provided by electrical cabling. Immersing the inlet helps ensure that the pump has sufficient Net Positive Suction Head Available (NPSHA) to prevent pump cavitation. In centrifugal pumps, cavitation occurs when the pump fluid vaporizes due to the local pressure falling below the vapor pressure for the fluid. This typically occurs in the eye (center) of the impeller as the pressure is lowest at this point. When the pressure increases above the vapor pressure, the vaporized fluid bubble collapses rapidly, often with enough force to damage the pump. To prevent this, the inlet pressure must be maintained safely above the vapor pressure. This margin is calculated by the pump manufacturer and is called the Net Positive Suction Head Required (NPSHR). To prevent cavitation, the NPSHA (determined by the inlet conditions and intake design) must be greater than the NPSHR (determined by the pump design). [1]

This requirement is a limitation of all centrifugal pumps, but is neatly addressed by the ESP configuration. The close coupling of the electric motor means that the shaft very short, reducing the cost and the alignment and dynamic problems associated with a long power shaft.

Applications for ESPs are numerous, including sewage treatment, fire water, and general industrial purposes. They are very useful for wells, due to their vertical configuration and immersive capabilities. Many impellers can be stacked within an ESP to provide pressure generating capability while still fitting within a well bore. Furthermore, immersing the inlet in the pumped fluid helps ensure that enough NPSHA is available to prevent cavitation. For these reasons, ESPs are often found in oilfield applications. Oil wells often do not possess enough pressure to produce oil without some work input. In other words, oil must be pumped to the surface. In the past, surface mounted pump jacks have been used. These have been replaced in many cases by ESP units.

Oil wells, however, produce more than oil. Wells often will have a mixture of fluids, including gases. The pump must in that case be capable of handling two-phase flow. Note that this is a different phenomenon than the cavitation mentioned earlier. Cavitation is the vaporizing and rapid condensing of a fluid within the pump. The two phase flow mentioned here is of two or more different species, with gas already present at the pump inlet. This is a challenge for centrifugal pumps as the gas tends to accumulate on the low pressure side of the impeller vanes, impeding the flow. For fluids with an appreciable Gas Volume Fraction (GVF), a gas separator can be fitted to the pump ahead of the inlet. Gas is separated by inducing a vortex in the inlet fluid, which forces the denser liquid to the perimeter of the separator. The gas is left near the center, where it can be routed to bypass the pump. [2] This is an inefficient process, and the MVP intends to improve on this by handling a large GVF within the pump itself due to its unique impeller design as shown in figure 1.1. The vanes are split to prevent gas accumulating at the low pressure side of the vanes, which is what normally occurs in centrifugal pumps in two-phase service. Large balance holes can also be used to break up the gas buildup. [3]

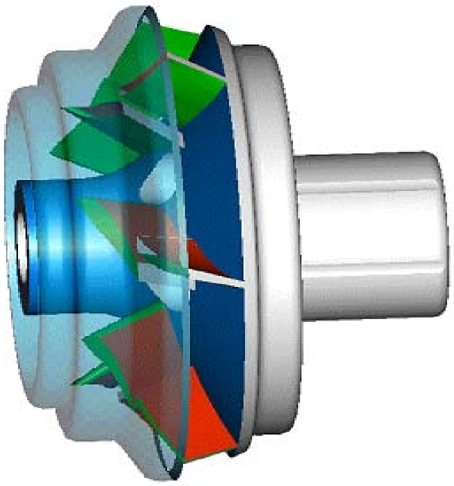


Figure 1.1 MVP impeller [3]

To apply any pump effectively in the field, its operating characteristics must be known. The pump must be appropriately sized for the expected conditions. In this particular case, the MVP impellers are somewhat less efficient than standard impellers. So, an MVP pump will use a number of MVP type impellers for the first few stages and then progress to more conventional impellers for the remaining stages. As the pressure rises from stage to stage, the GVF declines due to compression of the entrained gas, eventually allowing normal impellers to be used. It is critical to know how the MVP impellers behave so that the proper number can be determined for an application prior to pump installation. This is a particularly important point as the cost of an installed ESP can approach one million dollars.

1.2 Problem Statement

The performance of MVP pump stages needed to be evaluated under varying operating conditions. These included controlled parameters such as Gas Volume Fraction, inlet pressure, speed, and flow rate. Other parameters, such as power consumption, differential pressure, internal pressure, and thrust load are also measured. MVP performance had not been extensively characterized previous to this work. Operating characteristics were thus not known to the level of detail desired.

1.3 Test Program

A test program using an actual MVP pump was conducted. The MVP impeller configuration is sufficiently different from normal designs that it was not prudent to extrapolate data from existing designs.

Concurrently with the construction of the test loop, a Computational Fluid Dynamics (CFD) model was developed and validated. This CFD model can be used to predict behavior under conditions beyond those tested as well as give insight for possible design improvements. Note that development of this model, while part of the overall MVP research project, is outside the scope of this thesis. It is, in fact, the subject of a dissertation currently being developed.

This thesis describes the designing and constructing a test loop for a 250 hp, three stage MVP that can record the inlet and outlet conditions under various flow rates and pressures. Additionally, the pressure distribution within the pump can also be determined. This was accomplished by adding a number of pressure taps (about 30) into the casing on the second stage of the pump. These were placed to record the pressure of the fluid as it progresses through the stage. A window installed on the side of the pump opposite the pressure taps allows flow visualization. A large hole was milled into the pump and a CNC milled clear acrylic plug inserted. An o-ring seals the plug and it is held in place against the pump pressure by a clamp assembly. This window looks directly into the second stage volute allowing a detailed view of the internal two-phase flow characteristics.

The pump tested is a three stage MVP driven by a two hundred fifty horsepower electric motor. It will be able to handle up to 350 PSIG of inlet pressure at 1000 GPM of water flow and a GVF of up to 60%. The motor will use a variable frequency drive to allow it to run from 1800 to 3600 rpm as desired.

2 LITERATURE REVIEW AND REQUIREMENTS

2.1 Previous Work

Test facilities are not new for pumps, of course, even in two phase flow. However, none have the unique capabilities of this one. A full scale pump will be evaluated at high pressures and flow rates, with many parameters analyzed both external to the pump and internal. A typical full scale pump test examines the inlet and outlet conditions only. This facility will have the capability to measure and observe flows within the pump.

Gruselle, Steimes, and Hendrick, for example, tested a two phase pump system, but, only at a pressure of less than one quarter bar.[4] Gamboa, and Prado built an ESP test loop, with an acrylic casing to allow flow visualization. Pump differential pressures were no higher than 1.2 PSID, whereas the proposed loop is expected to reach 150 PSID or more. [5]

Manufacturers often test their pumps by use of a deep well. Immersing the test pump in the well allows for realistic operating conditions. Baker Hughes Centrilift, for example can test an entire ESP system at elevated temperatures to 240º C and 400 psig. But, this does not allow very many parameters to be measured, nor does it allow access to the pump interior for flow visualization. [6]

2.2 Description of MVP Pump

The pump used is a three stage vertical turbine pump manufactured by Baker Hughes Centrilift. Their designation is MVP G470. The stages are stacked together and held in place by a set of four threaded tie rods. Included with the pump was a coupling.

Each stage has a multi-vane impeller similar to that shown in figure 1.1. The basic assembly is shown below in figure 2.1, with the pump intake on the bottom and the outflow near the top. The coupling is shown at the very top.

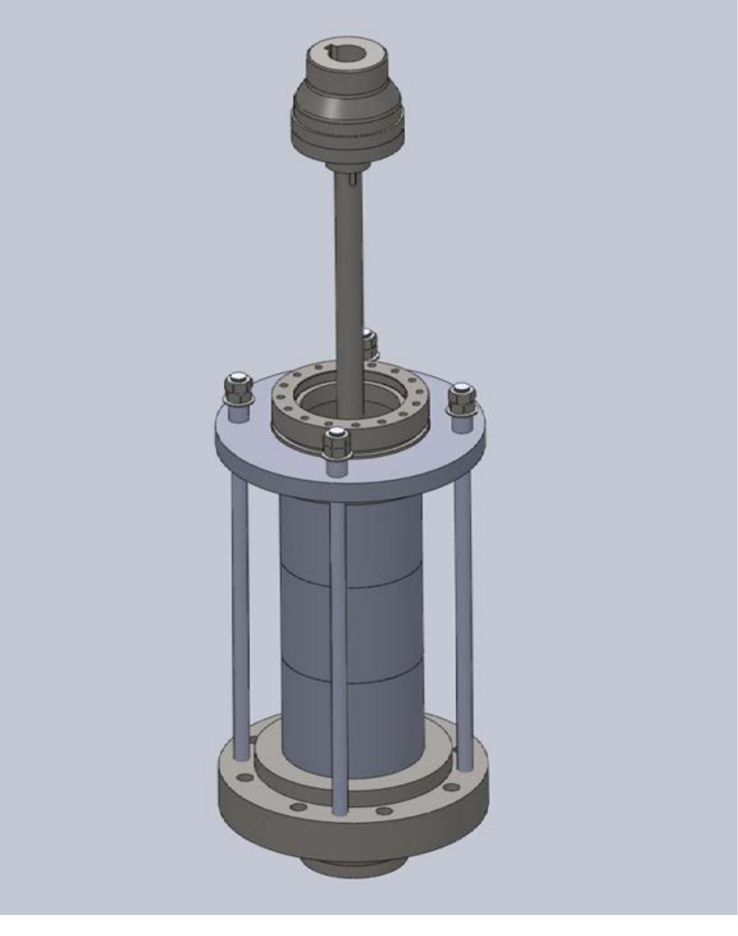


Figure 2.1 Basic pump assembly

Figure 2.2 Pump with pressure taps

To make the pump suitable for measurement, the manufacturer milled a slot in the second stage volute and drilled holes on the opposite side for pressure taps. An acrylic plug was made to fit into the slot forming a window into the second stage. Figure 2.2 above shows the pressure taps in the completed pump. Below (figures 2.3 and 2.4) is a view of the second stage volute with the window slot milled into it and a view of the assembled pump with the window slot.

Figure 2.3 Second stage volute with window slot

Figure 2.4 Window slot on assembled pump

The acrylic plug is held in place with an assembly of square tubes and tie rods in order to hold it in place under the high pump operating pressure. The plug is sealed by an o-ring which fits into a groove machined in the plug itself.

The completed pump as installed is shown in figure 2.5. The inlet and outlet assemblies and the coupling will be described in section three.

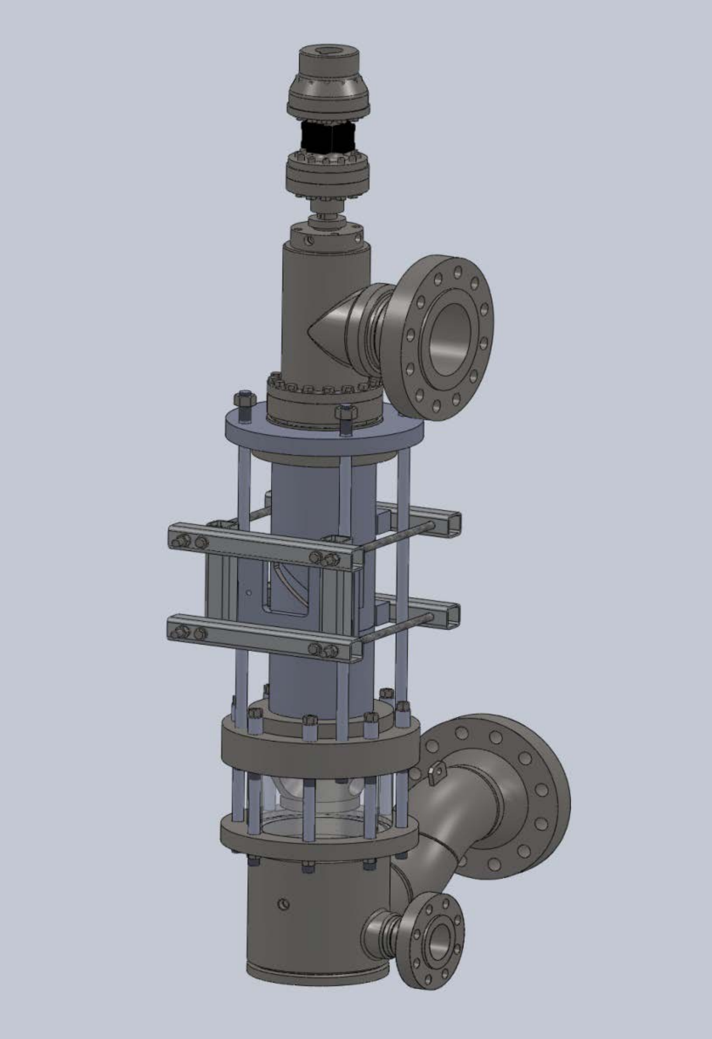


Figure 2.5 Complete pump assembly

2.3 Test Loop Requirements

The test rig configuration must allow a series of tests to be run on the pump varying the pump speed, inlet pressure, flow rate and GVF as desired. This will provide adequate data for pump verification and CFD validation. Table 2.1 shows the test matrix to be used:

Table 2.1 Test Matrix

Speed (rpm)	Inlet Pressure (PSI)	Inlet flow (BPD)	Inlet GVF (%)
3600	100	35000	0+
3300	200	30000	5% increments
3000	300	25000	To max possible
2700	400	20000	
2400		15000	
1800		10000	

BPD = Barrels per day, 1 BPD = .02916 GPM

For each speed, the pump was tested at all inlet pressure and flow combinations, starting at 0% GVF and moving upward until the maximum GVF is obtained.

Data collected from each run included:

Water inlet flow rate, temperature and pressure
Air inlet flow rate, temperature and pressure
Pump inlet temperature and pressure
Pump outlet temperature and pressure
Differential pressure between pump inlet and outlet
Pressures within the pump volute
Pump speed
Shaft torque and axial loading

In addition, future work will include resistive tomography measurement of the pump inlet flow and second stage volute GFV distributions. The current design allows visual inspection of the pump inlet as well as air and water inlet pipes via sight glasses. However, no data was taken from these sources.

3 DESCRIPTION OF FACILITY

3.1 Overall Configuration

A closed loop arrangement was used due to the desire to have high inlet pressures. A non-loop configuration would require a huge reservoir of high pressure air and water, and would also produce enormous amounts of discharge.

The working fluids are air and water. In actual service, oil is the predominant liquid. But, its use would complicate the test facility design. The facility uses a heat exchanger to cool the test fluid (actually a surplus air conditioning unit). Oil cannot be used in this unit, so an additional heat exchanger would be required to keep the process fluid separate from the coolant if oil was used as the process fluid. Further, oil may be difficult to separate from the air due to excessive foaming, making a flow loop difficult to achieve. There is also the cost of such a large volume of oil and the issue of disposal. Future work may include viscosity enhancing additives to achieve more oil like behavior without the aforementioned difficulties.

In schematic form, the facility appears as figure 3.1:

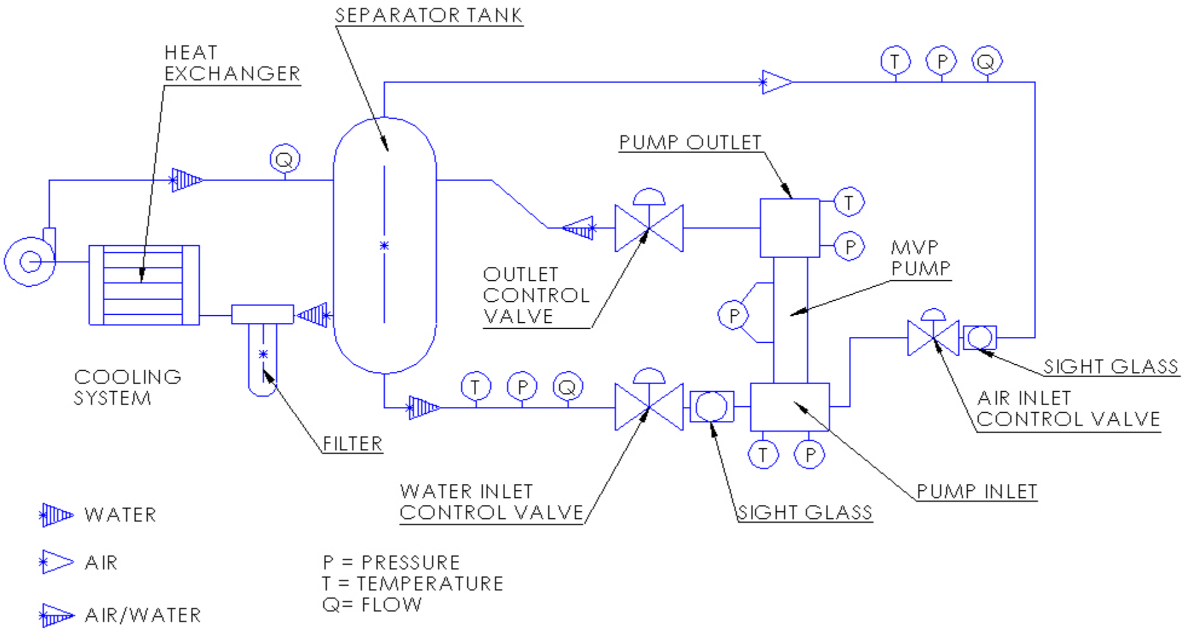


Figure 3.1 Two phase flow pump test loop piping and instrumentation diagram, (P&ID)

The pump is supplied with two separate inlets, one for air and one for water as well as a single outlet. Pneumatically controlled valves are placed at the inlets for the air and water supply and at the pump outlet. These will allow the control of the inlet pressure, flow rate, and gas volume fraction. The inlet valves are controlled automatically via Labview to maintain a specified inlet pressure and liquid flow rate. The water inlet valve will control the liquid flow rate via a Proportional/ Integral (PI) controller. The air inlet valve will control the inlet pressure also via a PI controller. Manually controlling (again via Labview) the outlet valve will change the GVF of the inlet fluid. Opening the outlet valve will cause a drop in the inlet pressure, causing the air control valve to open, increasing the GVF. Views of the pump flow loop are included in Figures 3.2 to 3.4.

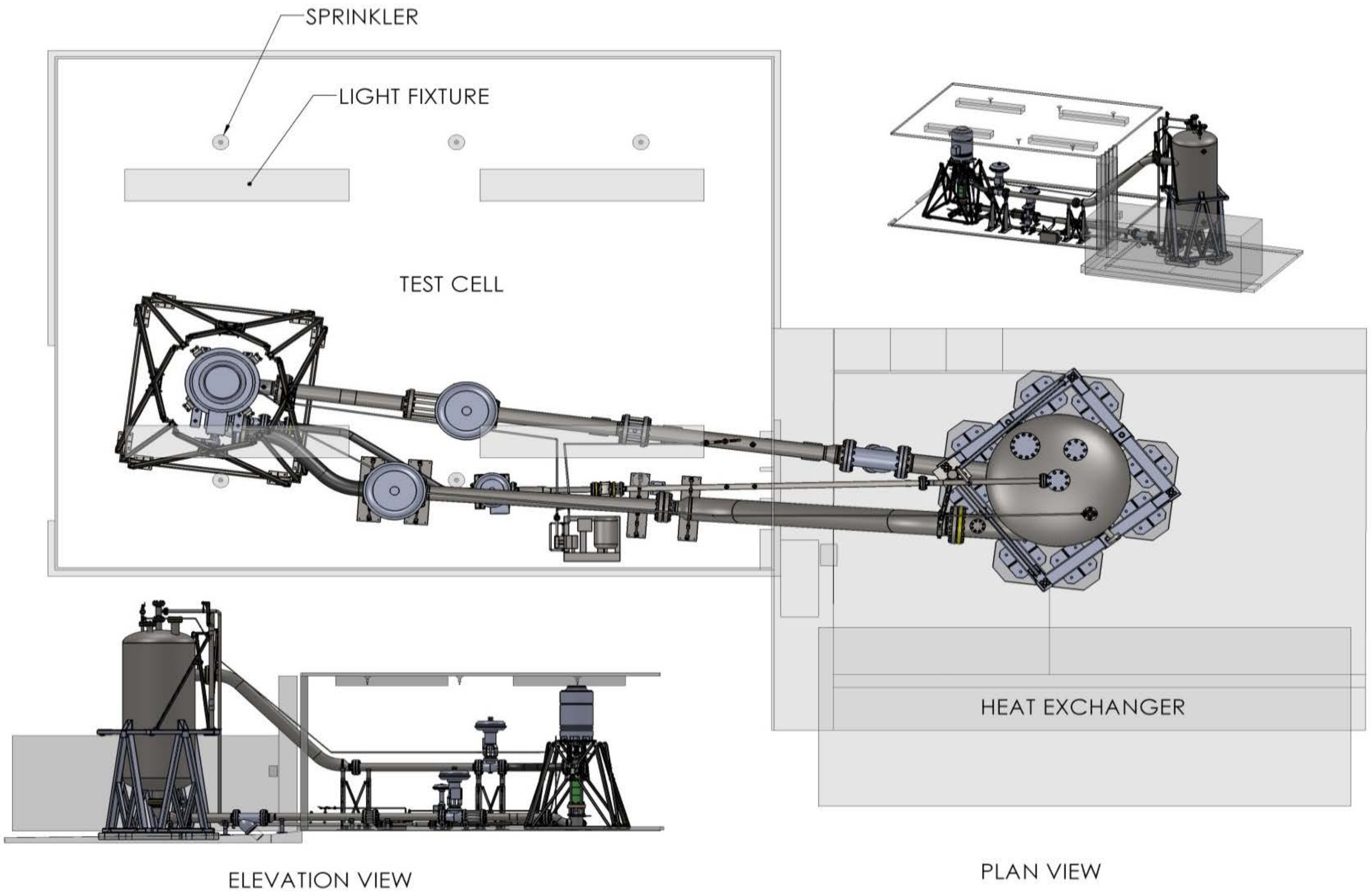


Figure 3.2 Plan and elevation views

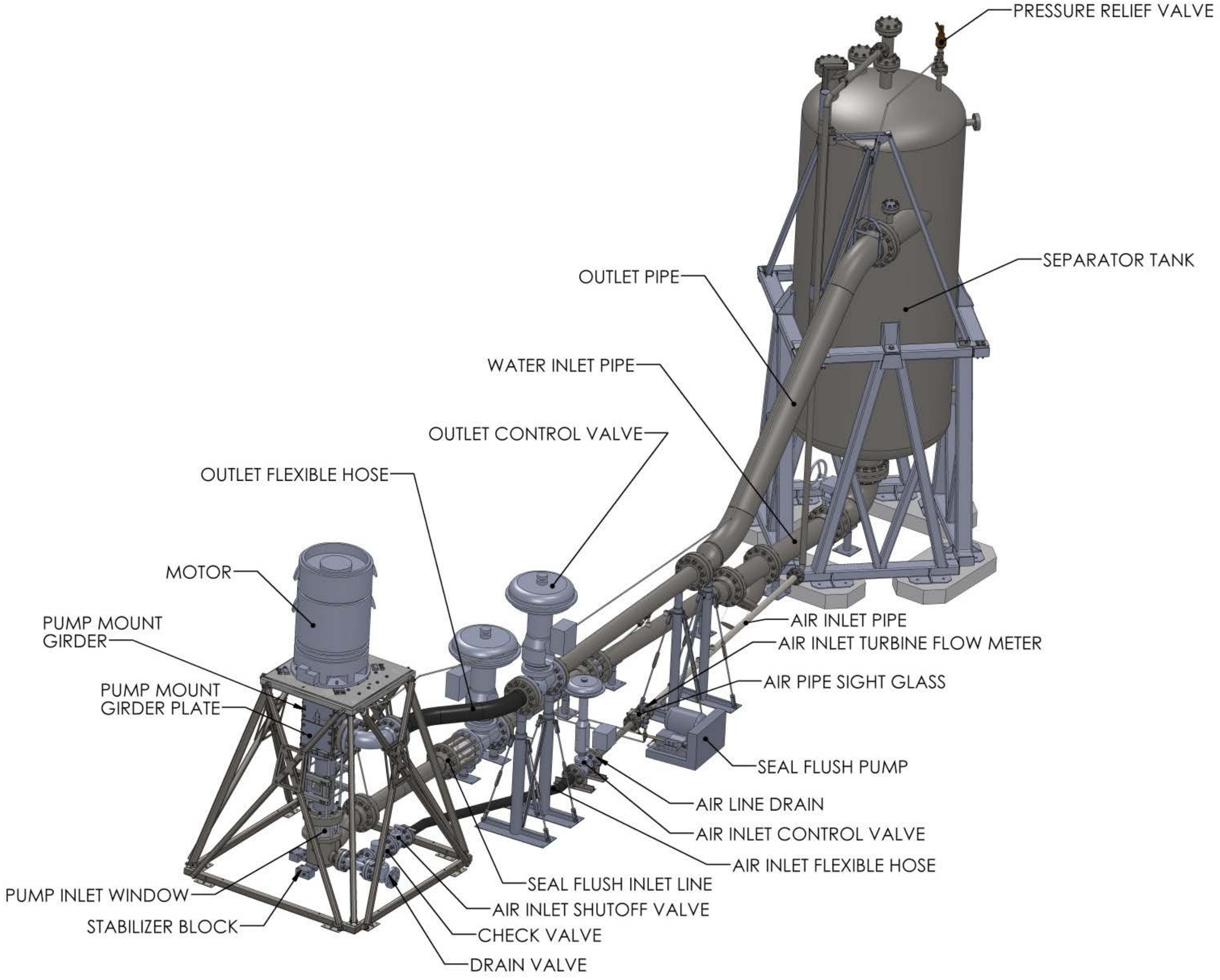


Figure 3.3 Facility north view

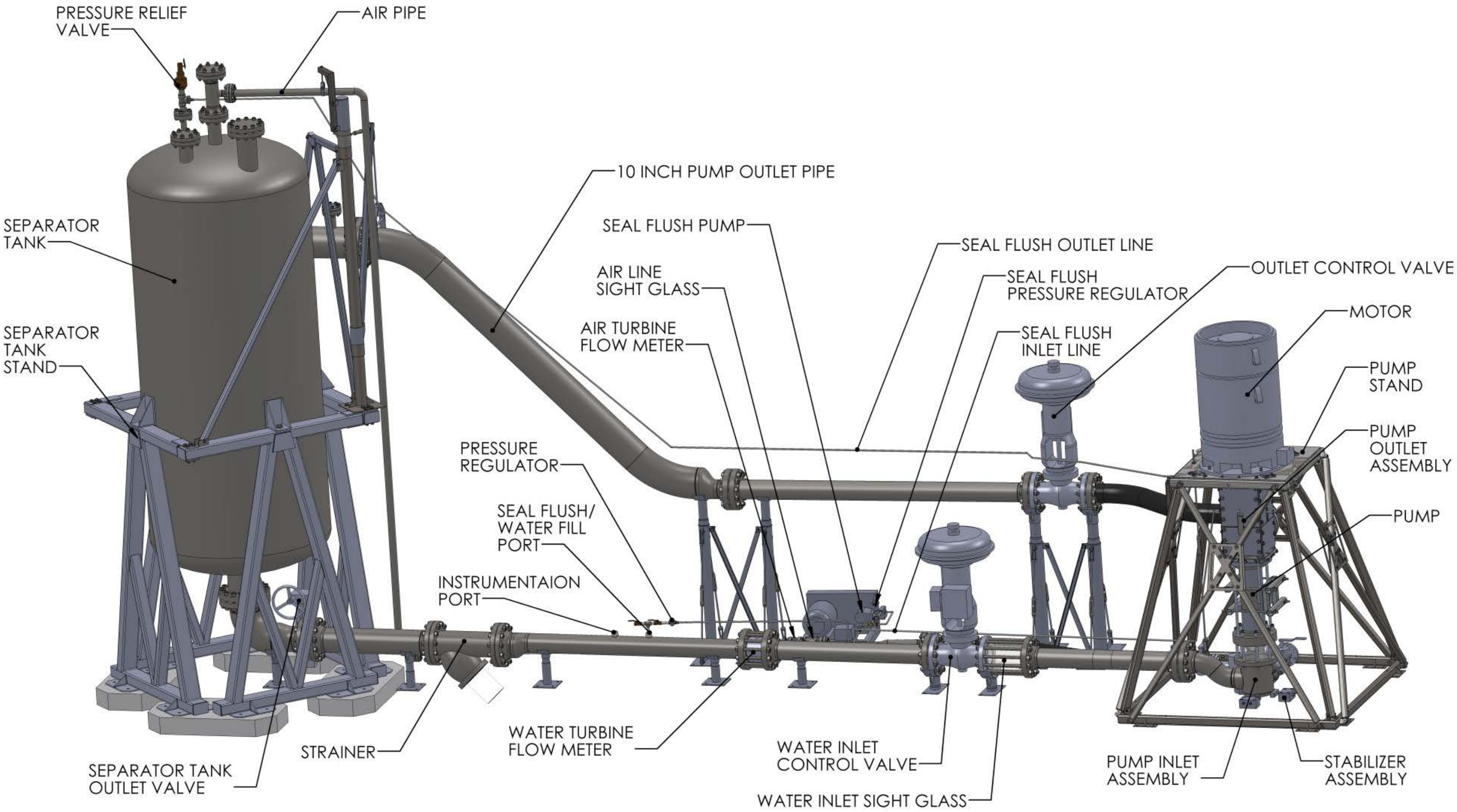


Figure 3.4 Facility south view

The pump itself is mounted on a derrick type stand with the motor on top. This will allow ready access to the pump and can easily be adapted to accept other pumps of similar design. The pump will be driven by a standard industrial vertical electric motor. Using a sealed ESP motor is not required as the motor behavior is not being investigated.

Water is added to the system via the fill port located on the water inlet pipe. A differential pressure gauge measuring the pressure difference between top and bottom of the separator allows the water column height to be monitored when the pump is not running. A fitting in the air inlet pipe allows a commercial portable air compressor to be attached in order to pressurize the system.

3.2 Piping

The main piping runs are six inch schedule 40 for water and water/air mixtures, and three inch schedule 40 for air. Flanges are ANSI class 600. These sizes were chosen to allow for the required flow rates and pressures with the ability to extend the facility’s capability to handle one-thousand PSIG inlet pressures. The pipe material is stainless steel in order to minimize corrosion. All piping was fabricated and tested per industry standards.

Some piping is of different sizing to match existing equipment. In particular, the separator tank has a pair of ten inch class 300 nozzles for the inlet and outlet.

Beginning at the separator tank outlet, the first pipe is a fabricated elbow/reducer. The reducer is concentric rather than the preferred eccentric design. The original configuration called for a forged flanged elbow and separate eccentric reducer. This proved impossible to procure, and fabricated elbows take more space than standard forged elbows. As the tank and its stand were already installed, the reducer was changed to a concentric design to compensate. Following the elbow is a butterfly valve. This allows the downstream piping to be drained without draining the entire tank. An eight inch strainer is next, with a section of eight inch pipe to clear the tank stand.

After the strainer, the next pipe has a reducer to bring the pipe to six inches, this reducer is eccentric but, is installed inverted from normal to help make up the shortfall caused by the fabricated elbow. This piece also has a pair of welded threadolets for instrumentation, and also for the seal flush and water supply line. The water turbine flow meter is next, followed by a straight six-inch pipe to the water inlet control valve. The connection from the control valve to the pump inlet is a six- inch triple ply flexible metal hose, as is the connection from the pump outlet to the outlet control valve. From the outlet control valve, a straight run six-inch pipe connects to the final outlet pipe. This has a reducer to change the pipe size to ten inches to match the tank, and a pair of elbows to allow the pipe to reach the tangential separator tank inlet.

3.3 Pipe Supports

The prime concern for the pipe support designs was to ensure that the pipe flanges would be stressed only by the fluid pressure, and would not support any weight of either the pipes themselves or any fluid. Whenever possible, commercial components were used for piping supports. The lower pipes i.e. the water inlet and air inlet pipes are supported by saddle/base assemblies without the need for any custom fabrication. The control valves, however, required some additional work so that they would remain upright. This work is in the form of a plate, welded to the end of each saddle support and drilled to match each valve’s flange bolt holes. In this manner, the flange bolts hold the valve upright. For the smaller three inch air control valve, a pair of plates and L-beams was fabricated to support it. These details are shown in figure 3.5.

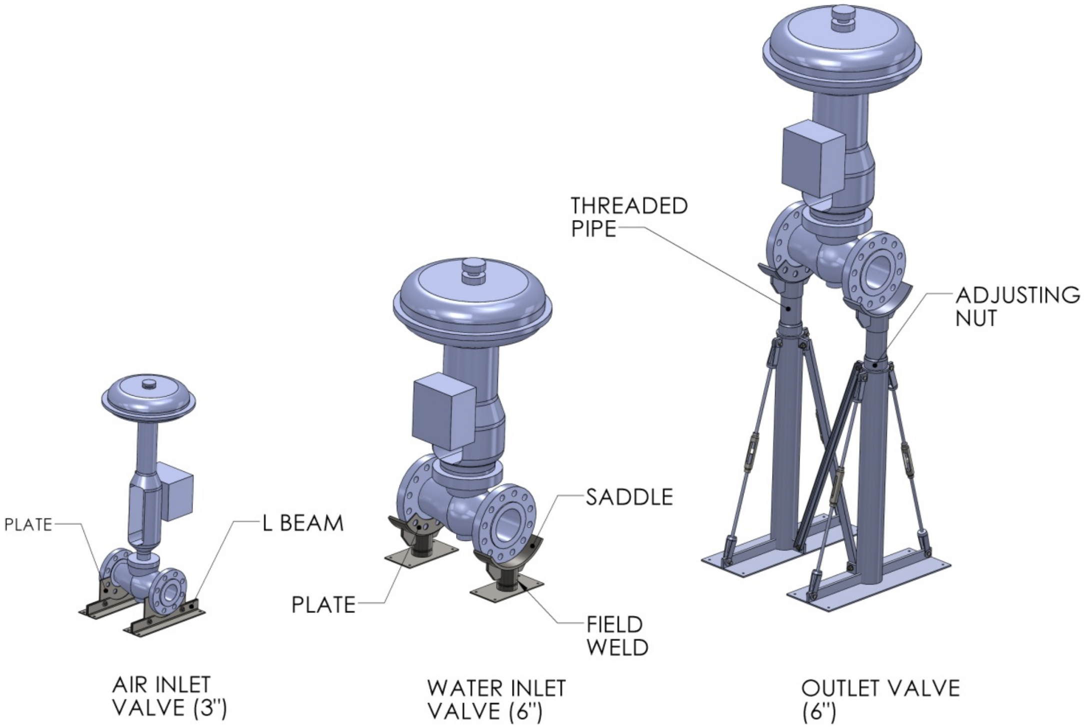


Figure 3.5 Valve support stands

The outlet valve and piping required a higher elevation than was possible with commercial buyout components. Two separate stands were designed, one for the outlet control valve and one for the end of the straight run outlet valve. Each consisted of a pair of vertical tubes welded to base plates. The tubes are supported by a set of turnbuckles and rods and a set of channel irons. A threaded nut and sleeve assembly fits into the top of each tube and in turn supports a saddle, allowing adjustment for height.

The supports near the separator tank proved particularly challenging to implement (figure 3.6). After much thought, a column was devised which would be mounted on the arms of the separator support stand. This would reduce the footprint of the support assembly and reduce the amount of raw materials needed. The arms of the support stand are cantilevered and are thus not the most efficient structural design. However, analysis indicates that additional support is not needed.

The column is in the form of a 3.500” nominal diameter pipe with a welded base which is bolted to the separator support stand. Braces support the column, and are bolted to tabs which were field welded in place. The column has short sections of 4.000” pipe welded in place which support rotating sections of pipe which serve as mounting points for the supports themselves. The ten inch pipe support is in the form of a crane using a gaff with a turnbuckle from which is suspended a clevis hanger. This allows two degrees of freedom to position the hanger. In addition, the crane assembly provided a mounting point for a chain hoist to lift the ten inch pipe into position.

The top of the column likewise has a mount for the small two inch clevis hanger supporting the air pipe.

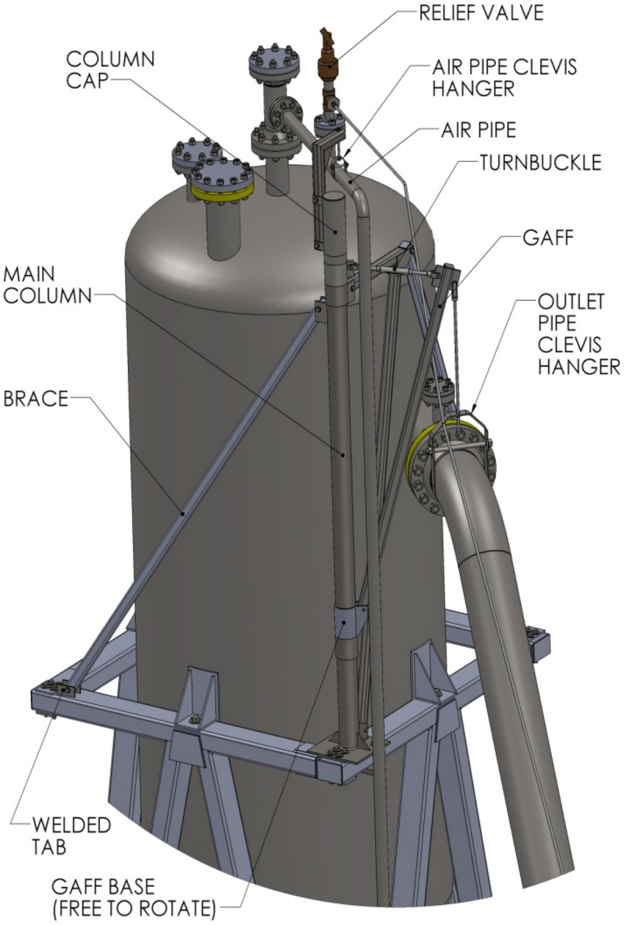


Figure 3.6 Separator mounted supports

3.4 Cooling Loop

A cooling loop was added to the system to keep the water temperature to a reasonable level. This is critical due to the use of Plexiglas components to allow for flow visualization. Plexiglas loses strength rapidly with elevated temperatures. Uncooled, the process temperature rises rapidly allowing for only short data acquisition runs.

The cooling loop is constructed mainly of existing components. Primarily, the heat exchanger has been salvaged from the Turbomachinery Laboratory air conditioner unit, which was replaced by a newer unit early in the project. A skid mounted pump/motor assembly also came from a prior project.

The cooling system draws water from near the bottom of the separator tank, draws it through a filter assembly and then through the heat exchanger. After leaving the heat exchanger, the water is pumped back to the separator tank near the top, passing through a turbine flow meter on its way.

3.5 Separator Tank and Stand

The separator tank is a refinery surplus item. It was chosen because of its low cost and immediate availability. It is made of 304 stainless steel and is rated for 450 psig working pressure. Capacity is 1760 gallons. The inlet is tangential and the interior is equipped with a disk shaped sparger to aid in liquid/gas separation. Four mounting tabs exist, equally spaced around the tank.

The stand was designed to support the tank from the existing tabs. Each tab has its own a framed support the bottom of which has two foot plates that are grouted and bolted to the underlying surface. The top of each frame is a long, square tube allowing it to be bolted to the adjoining frames. An FEA(figure 3.7) analysis was performed on the stand to ensure it met strength requirements.

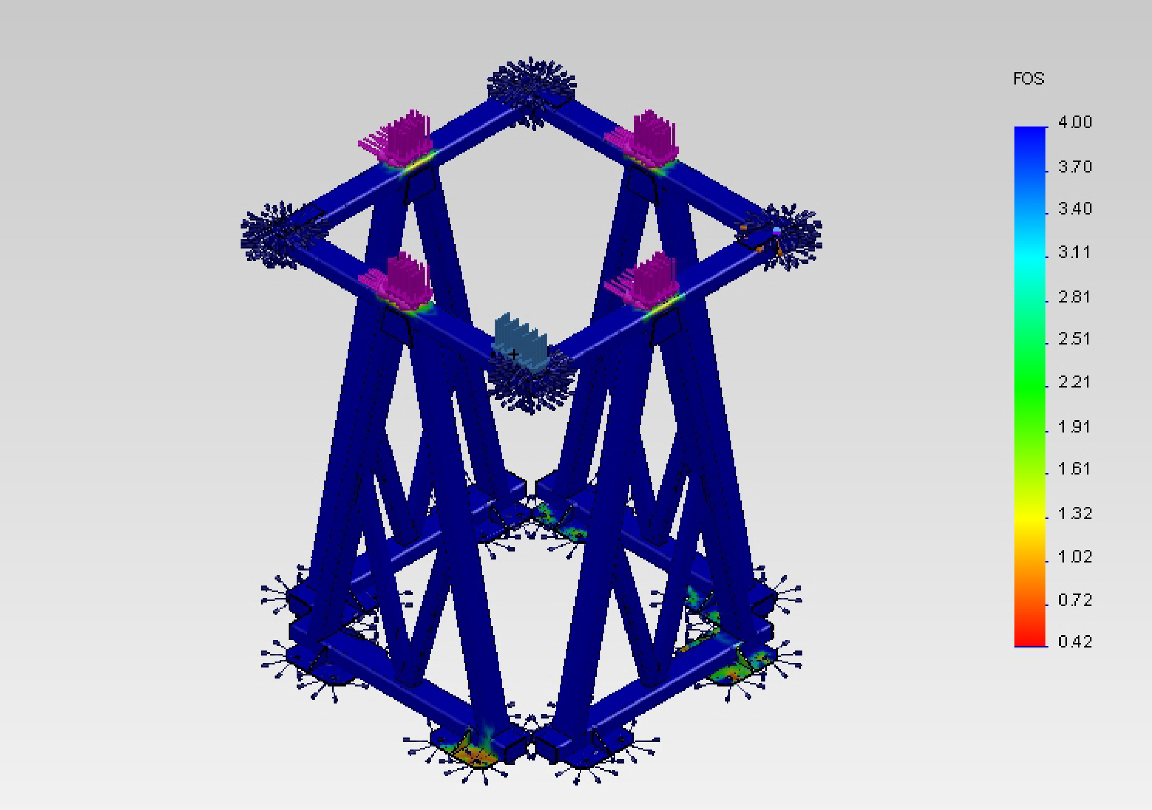


Figure 3.7 Separator support stand

Here the stand is shown loaded with the full weight of the tank filled with water and a one thousand pound force side load. Note that results within one diameter of a hole edge can show unrealistically high stress levels due to limitations of the FEA software (Solidworks simulation)

3.6 Pump Stand

The pump is mounted in a derrick (figure 3.8) with the motor on top. This design allows ready access to the pump and can easily be adapted to accept other pumps of similar design. A key design feature is the ability to be disassembled as the stand is too large to fit through the doors in the test cell when assembled. Therefore, the stand is designed to bolt together. The cross members are also threaded to allow some minor adjustment.

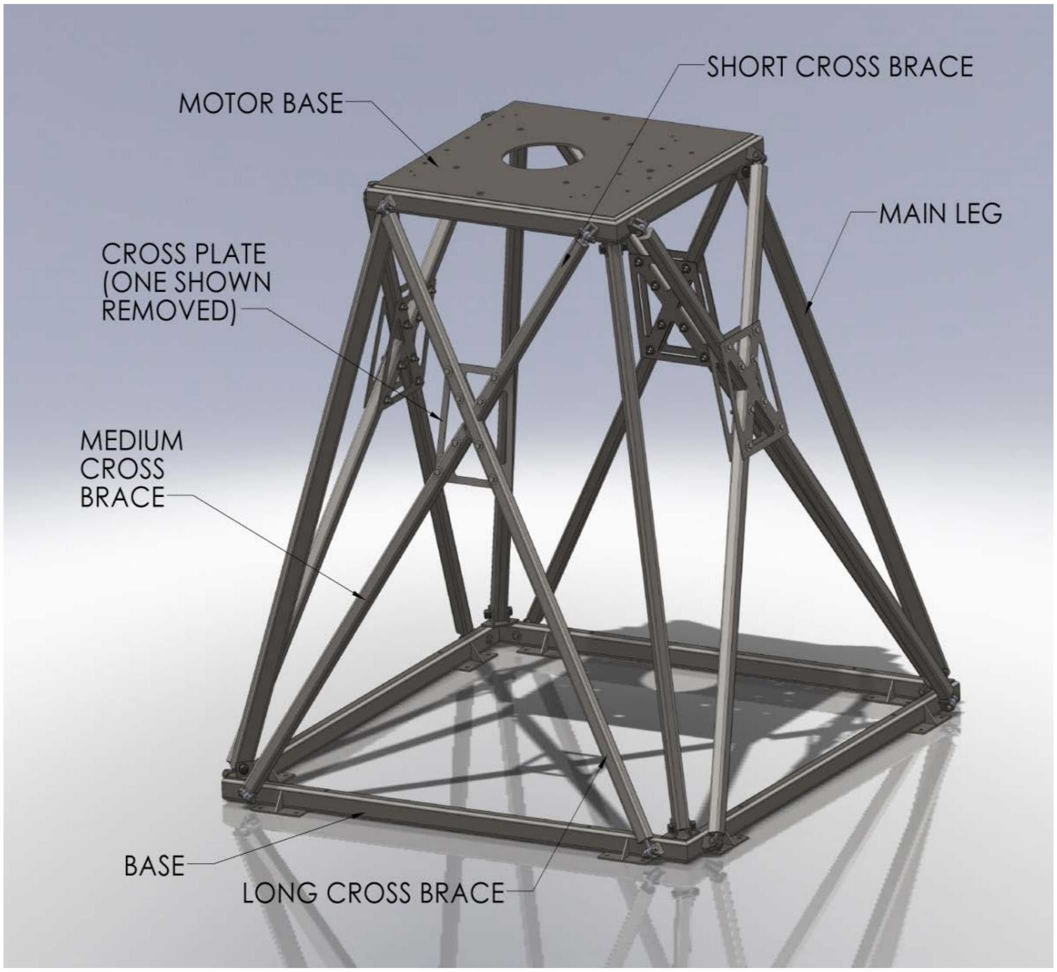


Figure 3.8 Pump stand

The motor base is a welded piece of one half inch steel plate and steel tubing while the base is welded steel tubing. The other components are all bolted together as

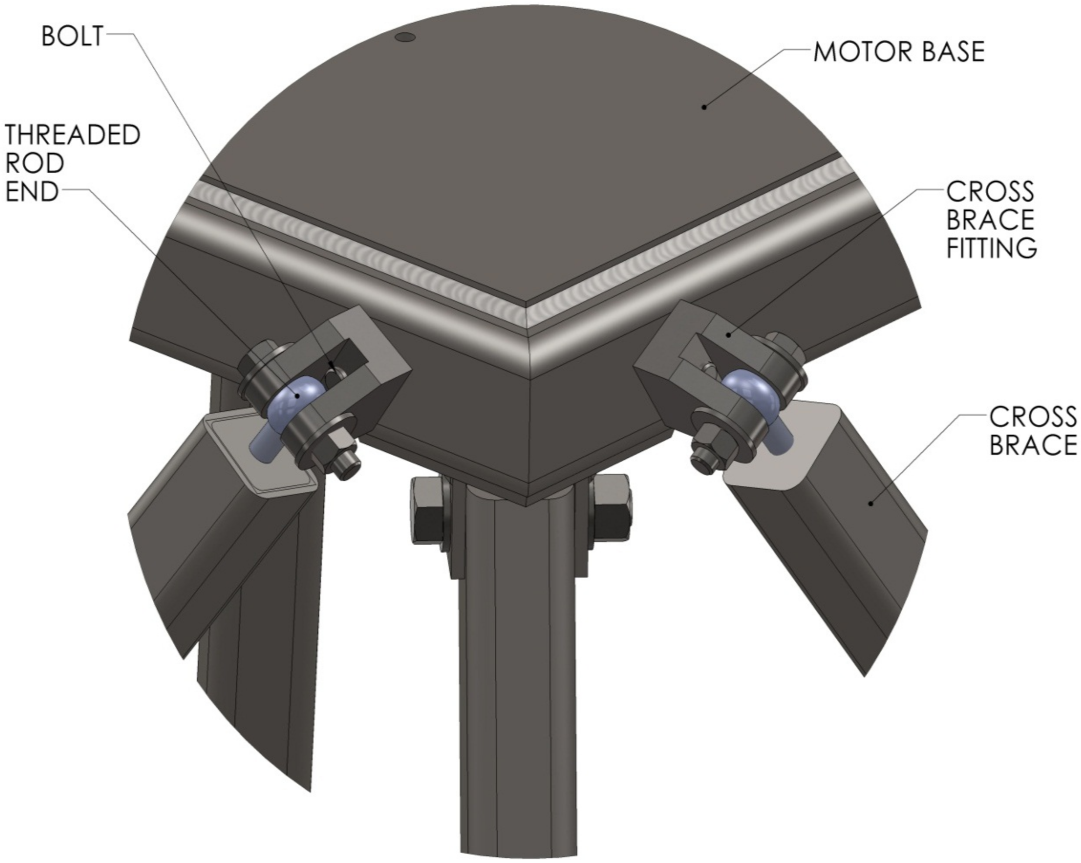


Figure 3.9 Detail of cross brace fittings

shown. The cross braces on any one side can be removed if needed whether or not the motor or pump is in place. This is needed for removing or installing the pump itself. A detail of the cross brace threads is shown above (figure 3.9).

In order to mount the pump, a girder assembly (figure 3.10) is bolted to the bottom of the motor stand after the pump is maneuvered into position. The pump is attached to the girder assembly via the holes in the mounting blocks at the bottom of the girder assembly. The bottom of each girder has a block welded into it with a threaded hole in it. This allows the mounting blocks to be bolted to the girders. Inserting shims between the girder and mounting blocks allows the angular alignment of the pump to be adjusted. Plates are bolted to the girders to provide additional stiffness and to serve as coupling guards.

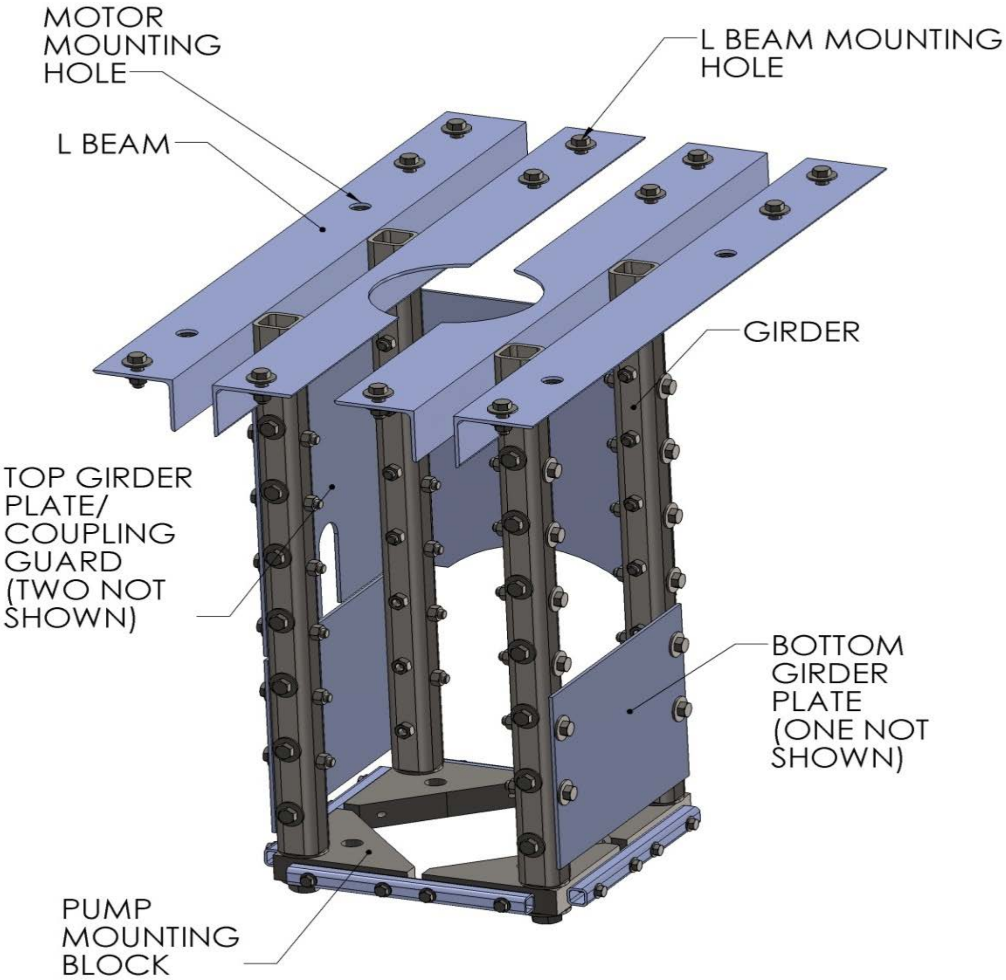


Figure 3.10 Pump mount

Figure 3.11 shows the pump when mounted. The motor base of the pump stand and some of the plates are not shown so that the mounting arrangement can be seen.

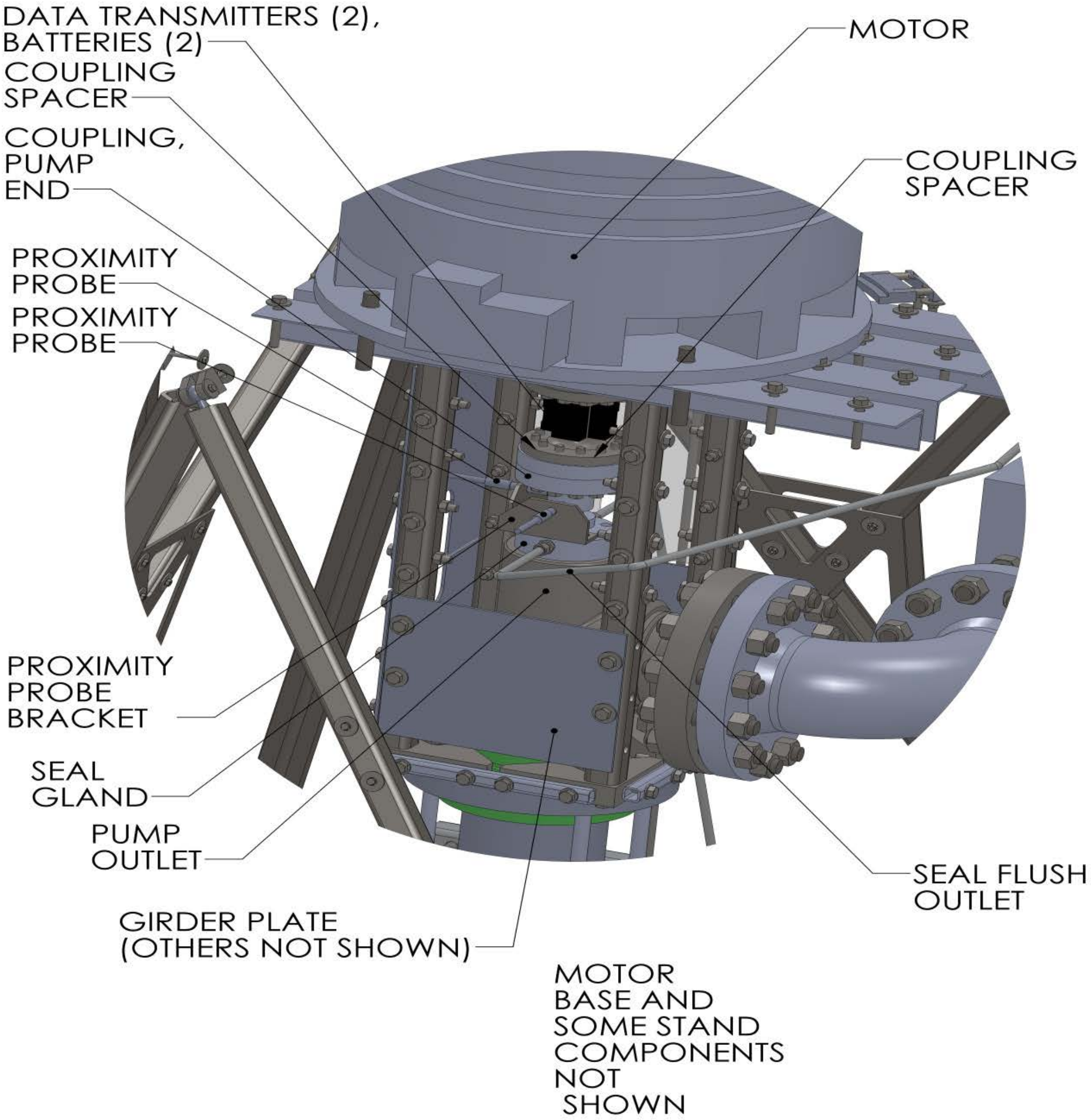


Figure 3.11 Pump head

The top part of the MVP pump is seen in green at the bottom of the picture. Proximity probes to monitor the shaft position were added after the pump began operating as will be described under initial operating experiences.

3.7 Pump Inlet

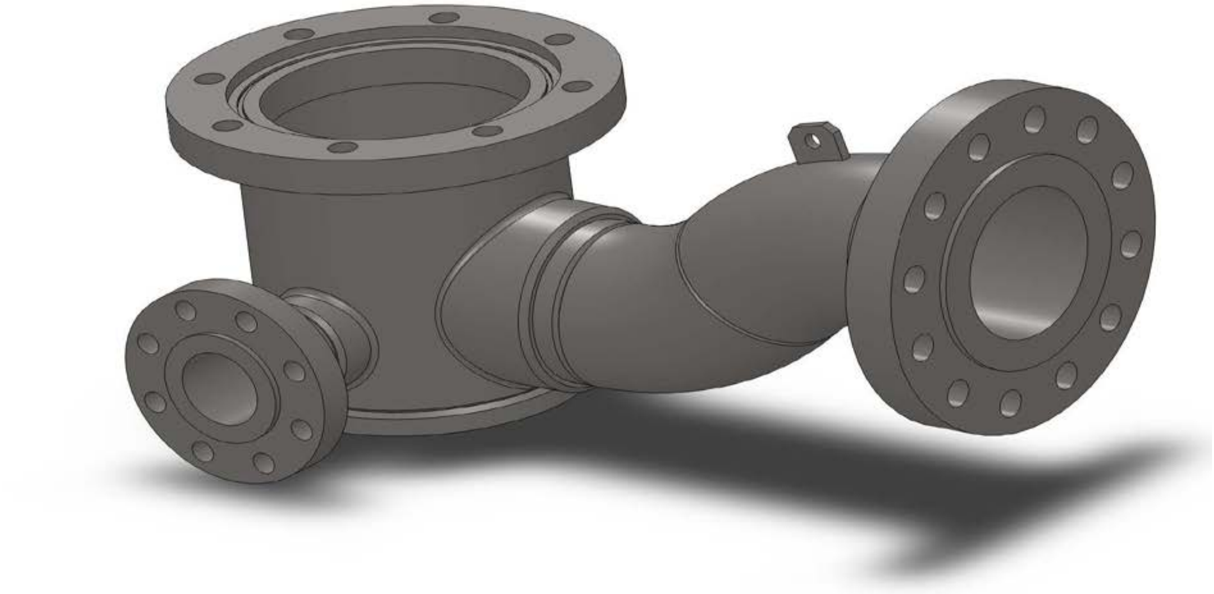


Figure 3.12 Inlet assembly

The pump inlet (figure 3.12) was fabricated by a vendor from commercial elbows and flanges along with several custom machined parts. The double elbow design provides clearance for the six inch flange while keeping the overall height of the assembly as low as possible. The air inlet flange simply fits on the side of the inlet with plenty of room.

The original concept called for a perforated tube to be inserted into the inlet via the air inlet flange. The idea was to evenly distribute the air and mix it with the water prior to entering the pump. This proved to be unnecessary and more difficult to model with CFD. So, it was not implemented.

Between the inlet and the pump is a tubular polycarbonate window allowing visualization of the flow into the pump (figure 3.13).

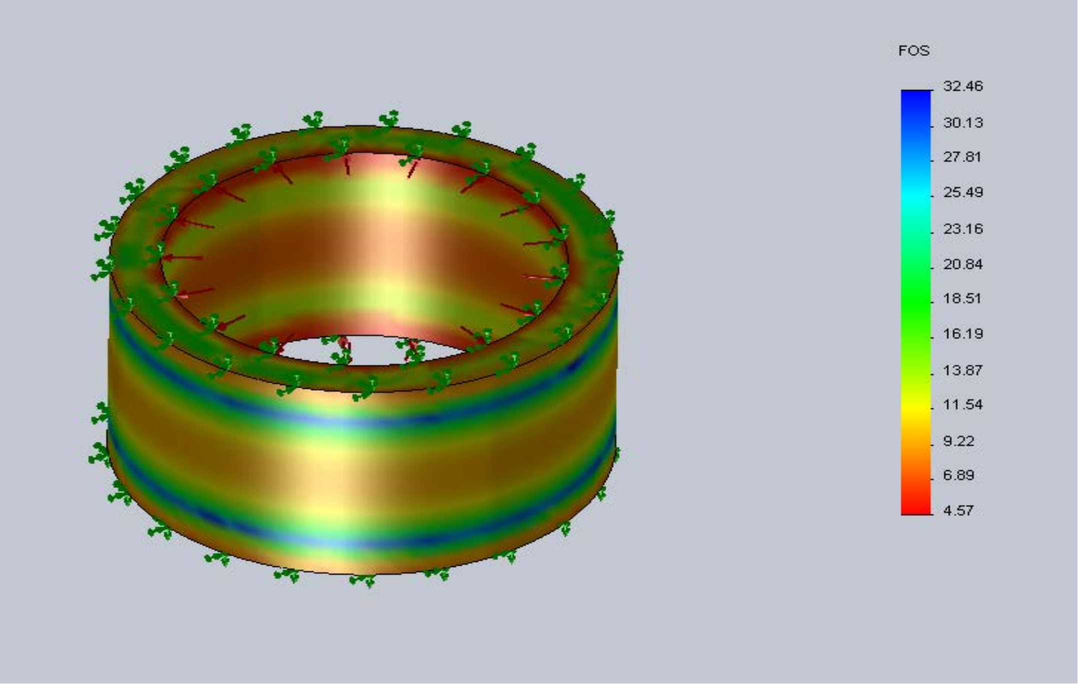


Figure 3.13 Inlet window at 1000 PSIG and ambient temperature

This was expected to be a weak point in the design as the rest of the pressure boundaries are made of steel. However, the window's ability to withstand the loop operating pressure is clearly adequate.

3.8 Pump Outlet

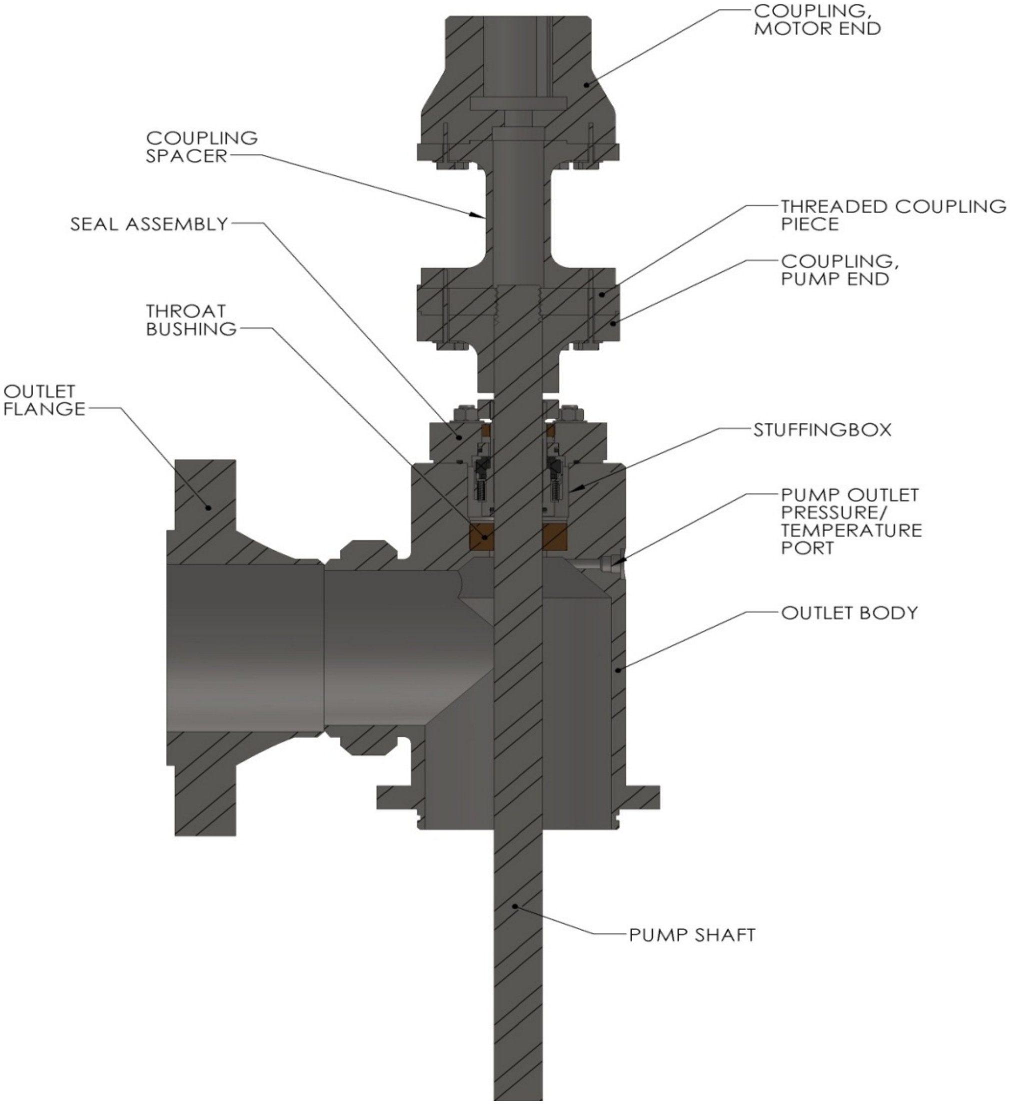


Figure 3.14 Pump outlet, seal, and coupling cross section

The pump outlet is an assembly that consists of a machined body to which is welded the outlet flange via a commercially available weldment. The body is bolted to the top of the pump and is sealed to the pump by means of an O-ring. The body also has a stuffing box machined into the top for a mechanical seal, a bore for a throat bushing, and a port for instrumentation. Figure 3.14 shows the outlet assembly.

3.9 Seal Assembly

The seal is a Flowserve QB-2000 cartridge commercially available single inside mounted end face design (figure 3.15). The basic seal is composed of a ring shaped stationary face against which runs a rotating face. The rotating face is spring loaded to ensure contact with the stationary face. In addition, hydraulic forces act to force the faces together when the stuffing box is pressurized. In fact, this particular seal has a shoulder on the sleeve underneath the rotating face to reduce the hydraulic pressure. In industry terms, it is *balanced.*

All of the basic seal components are contained in a cartridge assembly with a sleeve and gland so that the seal may be easily installed and removed from the pump. The cartridge also includes a gland bushing (sometimes called a disaster bushing). The bushing serves to protect the seal components from damage if the shaft should become misaligned as the sleeve will rub against the bushing before contacting the brittle stationary face. It also reduces the amount of leakage should the seal fail. A drain port has also been drilled into the gland (not shown on the figure). It is located at the same location axially as the flush ports and rotated ninety degrees as seen from the top. The drain has a thru hole situated between the stationary face and the flange bushing so that any leakage from the seal will be directed out through the drain port rather than be an uncontained flow past the bushing. In this assembly, the drain port is plumbed to a short piece of tubing terminating in easy view of the operator. This allows any leakage to be detected before becoming a serious problem.

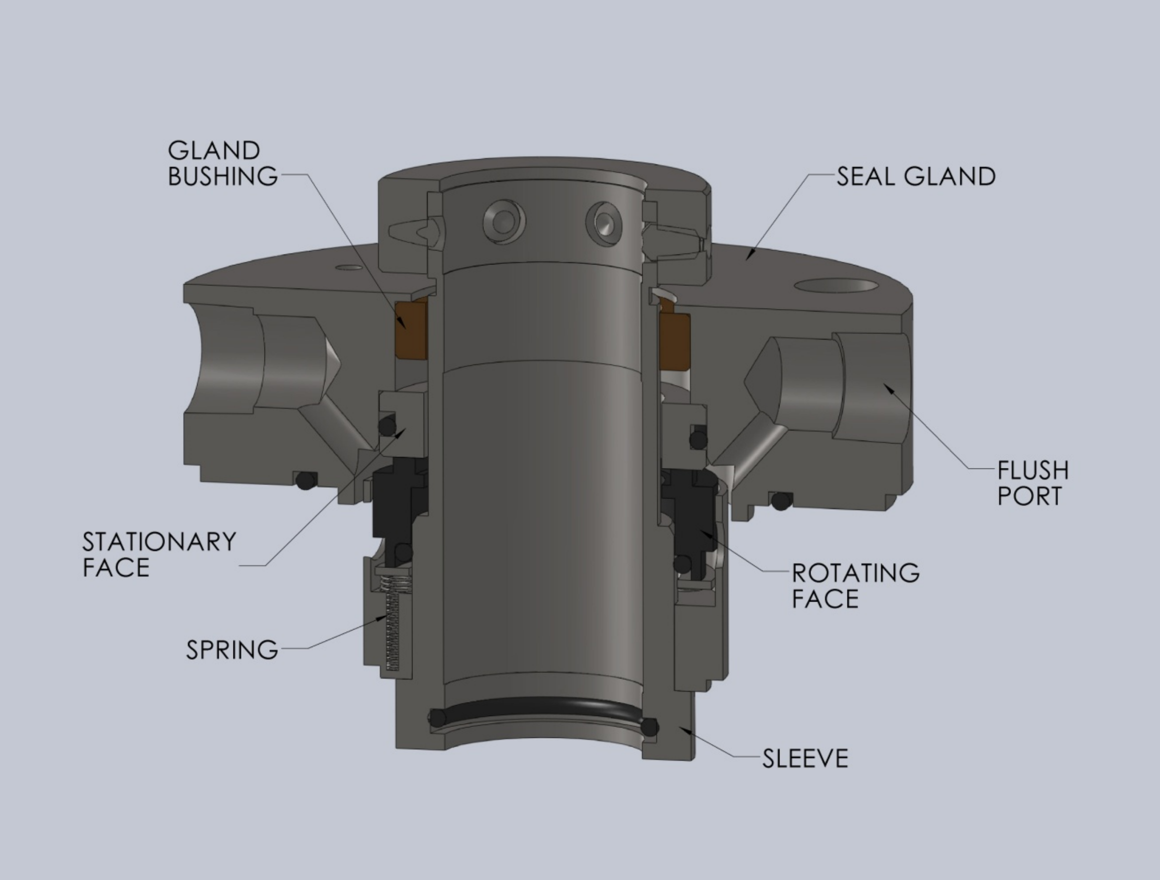


Figure 3.15 Seal assembly

This seal configuration is common in industry [7] for is simplicity and reliability. However, for best functioning it requires the proper environment. Typically, this is done by providing a seal flush. A number of configurations have been standardized by the American Petroleum Institute. [8] The most common is the API Plan 11, a small amount of fluid is drawn from the pump discharge and routed into the seal chamber. The flush cools the fluid and keeps it from vaporizing across the seal faces. In vertical pumps a Plan 13 is common; a flush line runs from the seal chamber back to the pump inlet rather than the discharge. This will tend to draw any vapor bubbles out of the seal chamber as the chamber is typically at the pump discharge pressure. In both cases, the pressure gradient between the chamber and the discharge or inlet provides the motive force for the flush. Combining the two gives a plan 14, a modified version of which has been employed here.

The flush is of particular concern for this project due to the multiphase nature of the flow. Mechanical seals for liquid service can suffer damage if operated in a vapor environment. In order to ensure a healthy seal environment, a modified plan 14 is used. One flush line comes from the water inlet and is run through a pump and regulator (a normal plan 14 flush has no pump or regulator) to provide flow into the seal chamber while another line runs from the chamber to the top of the separator tank.to allow any vapor to escape as in a plan 13. A close clearance bushing is press fit into the bottom of the stuffing box to limit the amount of flush flowing into the process fluid. This ensures a cool, pure liquid environment around the seal.

3.10 Coupling

The coupling assembly, save for the spacer, was provided by Baker Hughes Centrilift. As supplied, the coupling consisted of three main components. The lowest piece slides onto the pump shaft and is keyed to transmit torque. The next piece is threaded to match the pump shaft. Turning this part changes the shaft axial position and thus sets the impeller spacing for the pump. A spacer bolts to the threaded, and pump pieces. Removing it creates a coupling gap through which the seal can be installed or removed without disturbing the pump itself. Figures 3.16, 3.17 and 3.18 show the spacer.

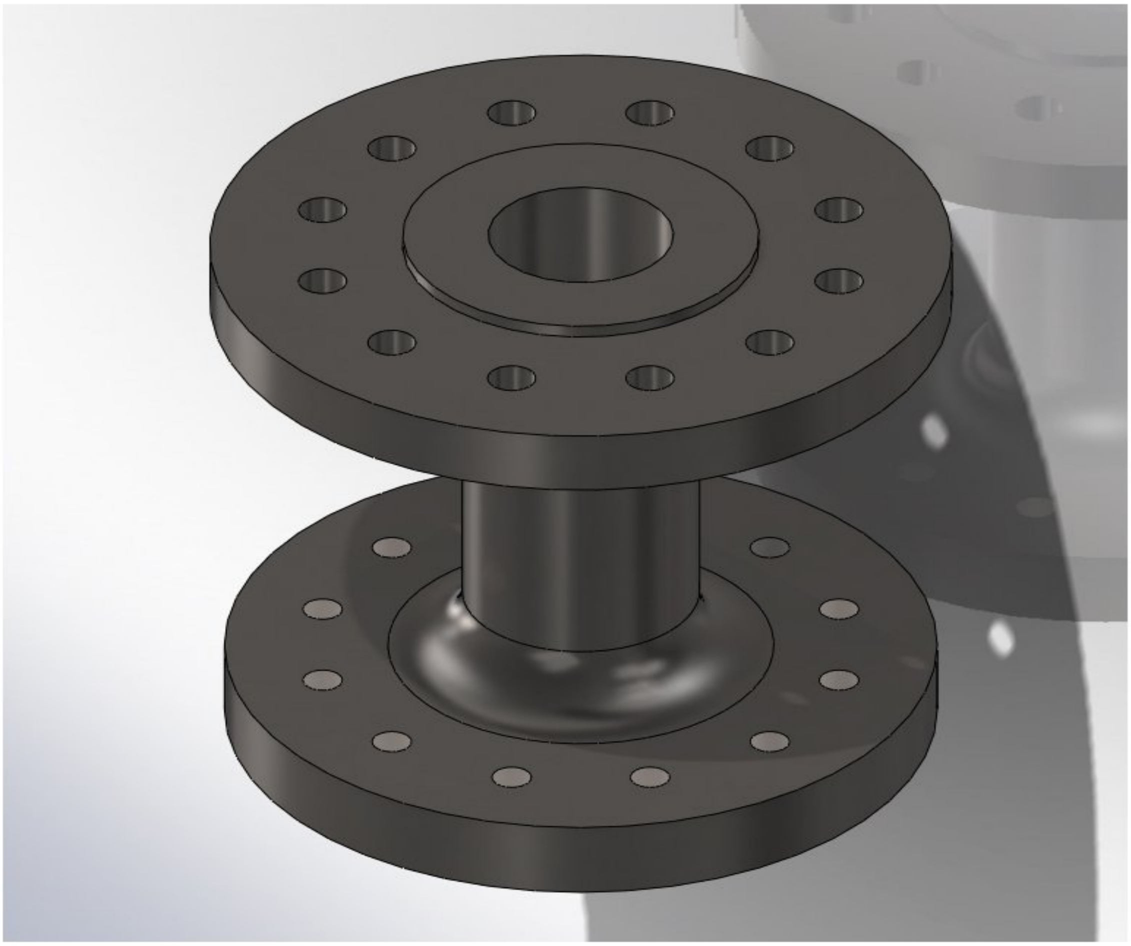


Figure 3.16 Coupling spacer

The spacer also serves as the point for torque and axial load measurements. Strain gauges configured for axial and for torque measurements are mounted on the tube of the. A pair of Binsfeld transmitters are mounted with the strain gauges to allow real time reading of the axial load and torque. The spacer has been designed to provide adequate strain response for the expected loadings. Further, a separate test fixture has been made so that the entire spacer, strain gauge and transmitter assembly can be calibrated and tested off of the pump assembly.

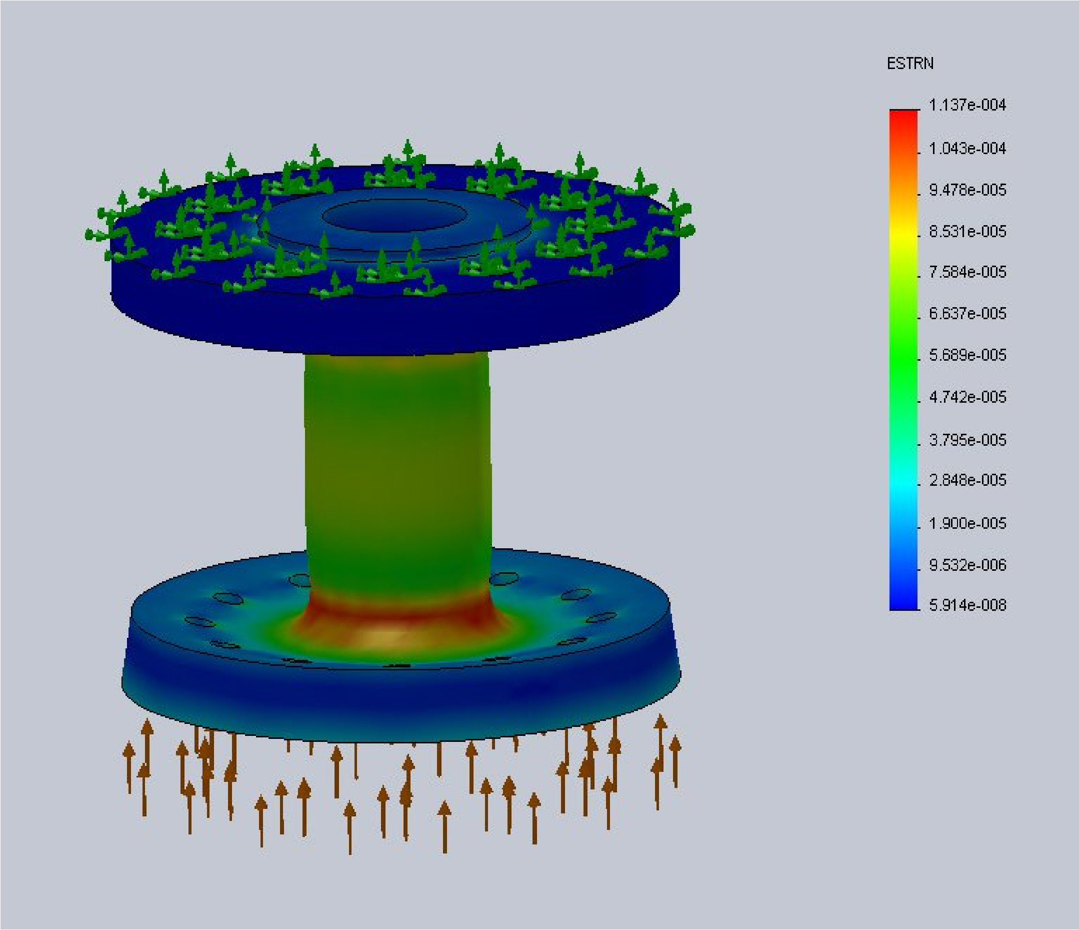


Figure 3.17 Coupling spacer strain under 3000lb axial load

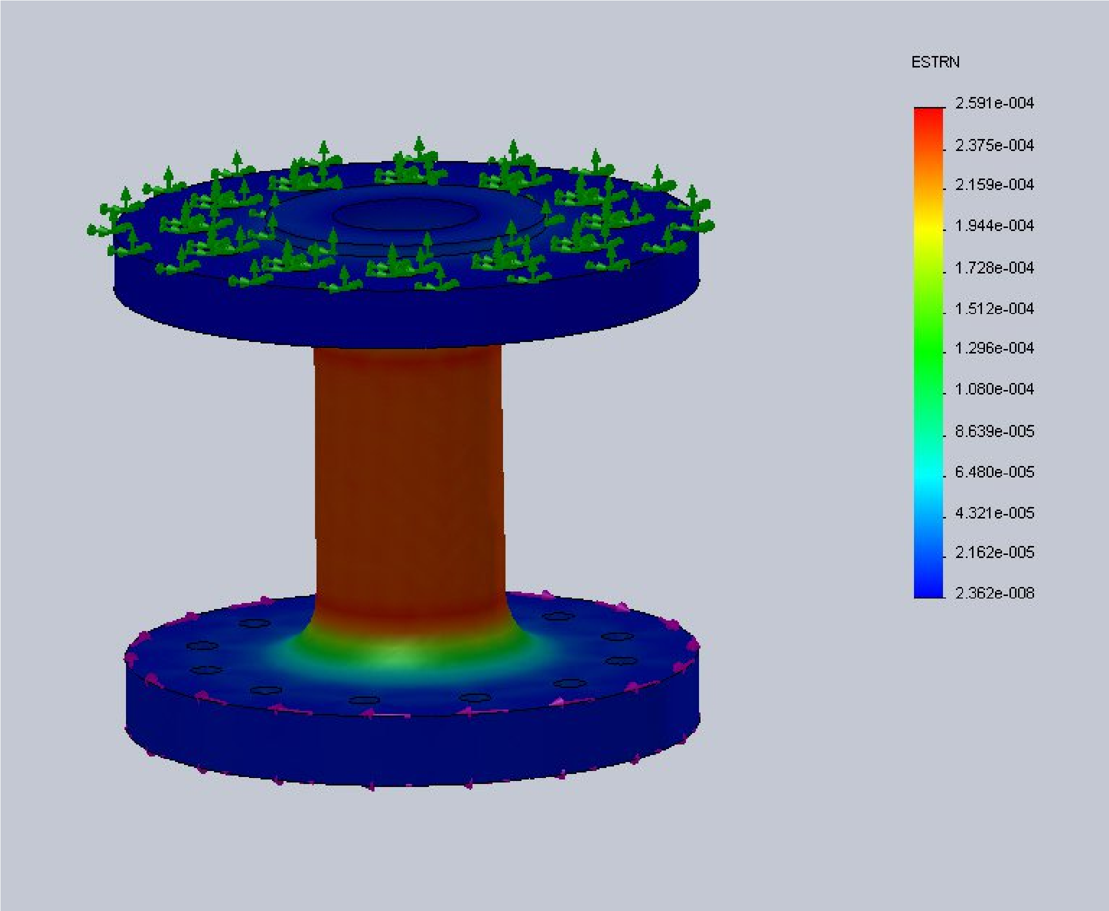


Figure 3.18 Coupling spacer strain under 4380lb-ft torque

The coupling was sized to provide an even, measurable strain in response to the expected torque and axial loading.

3.11 Operating Instructions

Checklists for before operation and after operation are given in the appendix. In this section, those checklists are annotated in *italics.* Refer to figures 3.3 and 3.4 for locations of components

Before operation checklist:

Piping and flanged connections – check for integrity

Flange bolting should be tight for every nut and stud.

Tubing – check for integrity:

Water supply to inlet pipe
Inlet pipe to seal flush pump
Seal flush pump to seal
Seal flush outlet to top of separator tank
Instrumentation tubing

Tubing is especially prone to damage.

Variable frequency drive – covered

The variable frequency drive is mounted on the north wall of the test cell adjacent to the pump stand. It is fitted with a sheet steel cover to protect it from spraying water. The cover must be in place with its top cover and access panel closed.

Instrumentation wiring – check for integrity

Wires must be fully plugged in to function.

Labview valve control program – running

This is run from the computer at the southwest corner of the control room. When it is running, the instrumentation can be checked.

Water inlet control valve – open (via Labview)

Outlet control valve – open (via Labview)

Pump Outlet/seal area– clear of debris, loose items etc.

Look into the area around the seal. Tools and loose items can congregate there.

Coupling strain gauge transmitters – connected to batteries.

The battery wires are connected to the transmitters with a miniature screw.

Coupling guards – installed and bolts tightened

IMPORTANT – do NOT run the pump without the coupling guard in place except at very low speeds (90 RPM or less).

Water drain – closed

This valve drains the water out of the system. It must be closed in order to pressurize the system.

Air inlet shut off valve – closed

If this valve is open, water could enter the air inlet pipe, possibly damaging the flowmeter.

Instrument air supply – open

This is located on the wall near the control valves and supplies air to operate the control valve actuators.

Air supply line sight glass – check for water

There should be no water in the air line. If water is present, see below.

Air drain – open to drain any water, then closed

Use this to drain any water out of the air inlet line as needed.

Separator tank outlet valve – open

This valve must be open to run the pump. It can be closed to drain water out of the pump without draining the tank.

Water supply valve – open (if needed to fill separator tank)

See below.

Separator tank water level - 10 to 12 feet.

Water level is indicated on the Labview control panel.

Pressure relief valve – closed

Located on top of the tank. It must be manually closed as the return spring is not strong enough to close it.

Tank air pressure – set (at least 120 psig)

Attach the portable air compressor to the air inlet connection with the high pressure yellow hose. Run the compressor until the desired pressure is reached. Disconnect the air compressor when done. Disconnect the hose at the inlet pipe before disconnecting the hose from the compressor.

Proximity probe power supply – on

The power supply is a box mounted above the window next to the door into the control room.

Shaft alignment – within .005" each axis

Shaft alignment is displayed on the Labview control panel.

Seal flush pump – on

The switch is located on the pump itself.

Manual transfer switch - In up position for the MVP pump.

Located on the side of the electrical panel next to the VFD.

Safety switch of Variable frequency drive –on

VFD handheld controller – Switch to LOCAL

The handheld controller is located in the control room.

The test loop is now ready to run.

VFD handheld controller- Press the RUN bottom

After Operation Checklist:

Air inlet shut off valve – closed (while pump is running)

This will prevent water from entering the air line.

VFD – Press the STOP bottom

Variable frequency drive's safety switch – power off

Seal flush pump – off

Air inlet line sight glass – check for water

There should be no water. If water is present, drain it as noted below.

Air drain – open to drain any water, then closed

Proximity probe power supply – off

Instrument air supply – off

Secondary loop's pump- off

This is the heat exchanger pump.

Secondary loop's heat exchanger fans- off

The switch for this is located on the heat exchanger on the side furtherest from the test cell.

Secondary loop's inlet and outlet valves-off

The loop may be kept pressurized in this condition if it is anticipated that it will be run again shortly, i.e. within a week.
If the system will not be run for an extended time, or if it is necessary to work on any pressure containing component, the system should be depressurized and drained.

To depressurize:

Instrument air supply – on
This must be on to open the control valve.
Outlet control valve – open (via Labview)
Pressure relief valve – open
Simply pull on the chain to the valve to open. Note, the exiting air will make a loud noise for several minutes.
Pressure – monitor until pressure is at atmospheric
This can be done via Labview or one of the mechanical pressure gauges.

To drain:

Separator tank outlet valve – open to drain entire water supply, closed to drain only the pump and piping.
Usually, the tank will not have to be drained, so this valve will remain closed.
Water inlet control valve – open (via Labview)
Water drain – connected to hose leading to storm drain.
The water drain has a quick connect fitting for this purpose.
Water drain – open
When system is drained:
Water drain – closed
Instrument air supply – off (control valves will close)
Separator tank outlet valve – closed
If previously opened.
Pressure relief valve - closed

4 CONSTRUCTION AND COMMISSIONING

4.1 Separator Tank and Stand

The separator tank was the first major item to be installed. The tank itself was delivered in the summer of 2010. Due to its previous use and long period of outdoor storage, some preparation work needed to be done. Surface scale, old paint, and corrosion, was removed by grinding. Also, one of the support tabs was corroded beyond use and was replaced. These tabs are made of carbon steel as opposed to the stainless steel employed in the rest of the vessel. When first inspected for use in this facility, the tank had been lying on its side in an unpaved yard positioned so the corroded tab was in the dirt. This no doubt was the cause of the excess corrosion. To replace the tab, a wooden jig was made to locate the tab relative to the other tabs. Then, the tab was removed with a cutting wheel and the jig used to fit the replacement piece in place. The other tabs also showed some corrosion, but, not enough to require replacement. Other than that, the tank was found to be in very good condition despite its age and relative neglect.

While the tank was being readied, the stand was being fabricated by an outside contractor. Also, the site was prepared by clearing the area of existing equipment and preparing forms for grouting. The site was marked as to the location and orientation of the tank. Wooden forms were then placed in the proper location and sealed with caulking. A great deal of effort was spent to ensure a watertight seal between the forms and the concrete site pad. This was shown to be unnecessary due to the grout’s extremely high viscosity.

When the stand was finally delivered, it was cleaned and painted at the Turbomachinery Laboratory and assembled inside the main bay using the large overhead crane located there. The completed assembly frame was moved to location via forklift and placed over the forms. The frame was supported by shims to keep the weight off of the forms and to facilitate leveling. With the frame in place, the forms were filled with grout and eventually, one inch diameter anchor bolts were installed.

With this done, the tank was ready for installation. An outside rigging contractor brought a crane to emplace the tank. This was done on January 12th, 2011. All openings were then sealed with plastic covered plywood disks to protect against the weather.

This was the only outside help required for the erection of the facility. All other installations were done entirely with Turbomachinery Laboratory resources.

4.2 Piping and Control Valves

In general, piping was installed by moving it into place and bolting the flanges in place. Only when the pipe was in place were the flange bolts loosened or removed to allow the flange gasket to be installed. Doing the initial installation without the gaskets prevents them from being crushed due to uneven loading. In all cases, the final flange bolting was done per industry standards. That is, the bolts are torqued in intermediate steps to the final value. Each time the bolts are tightened, it was done in an alternating pattern to ensure even tightening of the flanges.

The largest and most difficult section of pipe was installed first. This was the ten inch diameter angled pipe that leads directly to the separator tank tangential inlet (drawing: Spool-7). This is the heaviest pipe section. It also needed to be lifted a considerable distance. Moreover, with other pipes in place, it would be difficult to reach, which is why it was chosen to be the first piece installed.

The first step was to emplace the tank mounted supports for the pipe. To do this, a temporary crane was fabricated by bolting a timber across the top of the tank. This timber was braced with a number of cargo straps to support the required loads. This was used to raise the main support column into place. Figures 4.1 through 4.4 show this process.

Once in place, the braces were fitted into place and their tabs welded. The braces and main support column were then taken down, painted and reinstalled.

With the support in place, a chain hoist was attached and used to lift the top end of the pipe spool into place. The lower end was lifted with a portable jib crane. With both ends in place, the upper end flange was bolted to the tank and the lower end's support was erected in place, leaving the pipe fully supported.

Figure 4.1 Main support column being raised

Figure 4.2 Rear of tank showing the temporary crane arrangement

Figure 4.3 Temporary crane assembly mounted to top of separator tank

Figure 4.4 Ready to lift spool seven

The adjoining pipe section (Spool-6) was then lifted into place with the same jib crane and bolted into place.

The next part was the outlet control valve. With a weight of eight hundred pounds, this presented another challenge. Two portable cranes were used. One lifted each end of the valve. During lifting, the valve was supported on each end by a sling which went under the body of the valve and was attached to one of the cranes. When the slings were tensioned prior to lifting, cables were wrapped between the slings and the stem of the valve to provide stability. Both cranes were then used to lift the valve into place.

Directly below the tank is attached a large elbow leading to the water inlet piping. This was installed by maneuvering the elbow underneath the tank. This required lifting the two hundred pound fitting about three feet to clear the tank support struts and pulling it underneath the tank. The lifting was provided by an engine hoist and the pulling by a block and tackle rigged between the elbow and the flange at the bottom of the tank. Once there, the elbow was lifted into place by using threaded rods as jacking screws.

The inlet water pipes and valve were emplaced using the portable cranes with wooden blocks to provide temporary support. When all of the piping was in place, the permanent supports were fitted into place and welded.

The inlet air pipes were light enough to be fit into place by hand with no special lifting equipment. The air inlet control valve weighs three hundred pounds. However, it did not need to be lifted any distance. It was simply lifted upright on its support and pushed into place.

At this point, it was envisioned to pressure test the tank and piping assembly. However, this proved to be impossible due to the fact that the control valves were not designed to hold pressure. They will leak up to five percent of their maximum flow rate even when fully closed. Pressure testing would have to await the completion of the full pressure loop.

In the meantime, all of the pipe supports were secured to the floor via wedge anchors. The actual location of the components were measured and compared to the design specifications. The inlet water pipe and outlet pipe were seen to diverge at an angle of about five degrees. Plans called for these pipes to be parallel, and it appears the discrepancy was caused by the separator tank mounting tabs not being positioned in the correct location. This required a slight redesign of the flexible outlet hose, resulting in its having an s-curve shape.

4.3 Motor and Stand

One of the most difficult tasks contemplated in this project was the installation of the electric motor. This was due to its position on top of the pump stand and lack of clearance between the top of the motor and the ceiling of the test cell. Only twelve inches were available, and to get this much requires removing the light fixtures. Clearly, raising the three-thousand pound motor some eight feet in the air under these constraints was going to be quite a challenge.

The solution involved the use of a forklift. One was available which was capable of fitting inside the test cell control room. From this point, the forks could reach into the test cell through the main doors, although the forklift itself could not fit. Therefore, the motor was bolted to its base outside the test cell and carried via forklift inside the cell. At this point, the motor/base could be raised high enough to attach the remaining pump stand components. The stand was now assembled just inside the test cell. But it was positioned adjacent to the doorway, not where it was needed. The forklift could only reach just inside the cell. The assembled stand would have to be moved. This was accomplished by raising the entire structure onto rollers. Temporary crossbeams were attached to the frame base with bolts that were turned to lift the structure. Each crossbeam had a roller positioned under it, so that as the bolts were tightened, the frame was lifted off of the floor to rest solely on the rollers. At this point, the entire assembly was easily moved into position.

The variable frequency drive (VFD) for the motor was attached to the test cell wall. Wiring for the motor and VFD was done by a certified electrician.

4.4 Pump Installation

Removing the cross members on one side of the pump stand opened up enough space to roll the pump into position in the vertical orientation. So, the pump was placed on a dolly vertically with the outlet assembly bolted into place. Also in place, were the mounting blocks and bars that provide the transition from the pump to the pump mounting. Elevated boards were laid across the base of the pump stand to allow the dolly to be rolled over the structural members that formed the base. With the pump rolled under the stand, the mounting girders were bolted onto the bottom of the motor base. Bolt could then be inserted through the pump mounting blocks and into the mounting girders allowing the pump to be lifted into position by tightening the bolts.

The pump inlet was then bolted to the bottom of the pump. The remaining piping components were then installed.

Aligning the motor and pump was the next task. This was done per the procedure outlined in the appendix. It is important to note that the alignment was between the motor shaft and the pump case. It was not done between the motor shaft and pump shaft since the rigid coupling provides for this. Initially, no provision was made for monitoring the alignment during operation.

After that, the seal and seal support system was added. This involved sliding the seal assembly onto the pump shaft and bolting the flange into place. Then the coupling was installed. The uppermost part of the coupling was bolted to the motor shaft. The lowermost part was slid onto the pump shaft and the disk threaded onto the end of the pump shaft far enough to allow the spool piece to be inserted. The spool was then inserted and bolted to the uppermost piece. The disk was then rotated until the gap between it and the bottom of the spool was one sixteenth of an inch and the motor shaft rotated until the bolt holes were aligned. The spool, disk and lower part were then bolted together, which raised the pump shaft by one sixteenth of an inch, setting the impeller clearance.

The tubing for the seal flush was installed using compression fittings. All pressure and temperature sensors were fitted and wired into the controlling computer.

4.5 Initial Operating Experiences

Initial operation was done with water only. The entire system was filled with water until the pressure was equal to the water main pressure, 100 psig. All joints and fittings were checked for leaks. The motor was then run at 1800 rpm briefly while monitoring the pump for any unusual vibrations or other problems. None were detected. Water was drained until the separator tank was half full and the system pressurized with the air compressor.

The pump was then run at a series of increasing speeds to give a baseline pump performance curve. After several hours of operation, the seal began to leak. The pump was stopped and the system depressurized and drained. A visual inspection revealed that the seal sleeve had rubbed against the bushing, indicating an out of alignment condition. Upon further disassembly and inspection, the seal faces were seen to have broken. The seal was returned to the vendor for repair. Investigation of the pump showed that the misalignment was caused by the pressure in the inlet line pushing against the bottom of the pump. To combat this, stabilizer blocks were added to the bottom of the inlet assembly. These were bolted to the floor and had adjusting screws to hold the pump inlet in position.

In addition to this, proximity sensors were added to the shaft at the seal. This allowed continuous monitoring of the alignment while the pump was running. It also allowed the alignment to be adjusted after the pump was pressurized. With these changes in place, the system was run with no more alignment problems.

After running with pure water, air was added to the inlet stream. Very low air flow rates, however, did not supply sufficient pressure to open the check valve that was in the air inlet line. Pressure would build up until the valve opened and let a bubble of air into the pump. This lowered the pressure enough to close the check valve. Pressure would build up and the process repeat, resulting in a surging of inlet gas volume fraction rather than a steady state condition. To prevent this, the check valve was removed and a manual valve substituted. This valve was opened by hand after the system was running and enough air pressure existed to keep water from back flowing into the air supply pipes. These pipes were also modified by adding a sight glass to verify that no water was in the line and a drain to remove any water that accumulated.

Operations were continued long enough to obtain a complete set of data for the 100 psig and 200 psig inlet pressure conditions, and were continuing onto higher pressures when the motor suffered a critical failure. This failure was apparently caused by an aftermarket shaft sleeve that was installed inside the motor at some point prior to its acquisition by the Turbomachinery Lab.

Removal and reinstallation of the motor was a difficult task due to its three thousand pound weight and the limited clearance between the motor and the ceiling. A pair of overhead gantry cranes was erected inside the test cell, one on each side of the motor. Each gantry had a chain hoist that was connected to the pump via a frame assembly.

Due to the limited space, the chain hoist hooks could not be used. Instead, the hooks were removed from the chain and the chain passed through the frame and a toggle bolted to the chain. The resulting system allowed the absolute maximum amount of space for lifting the pump. This is shown in figures 4.5 and 4.6.

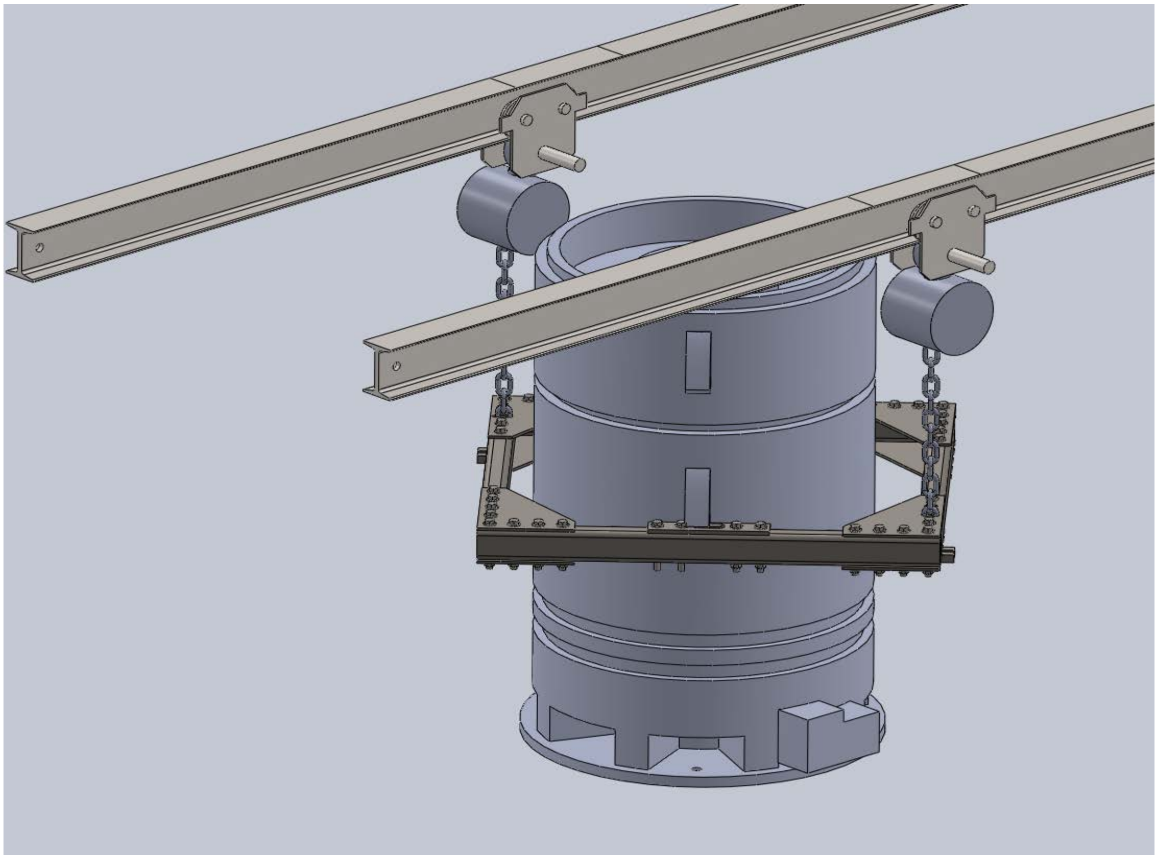


Figure 4.5 Lifting frame

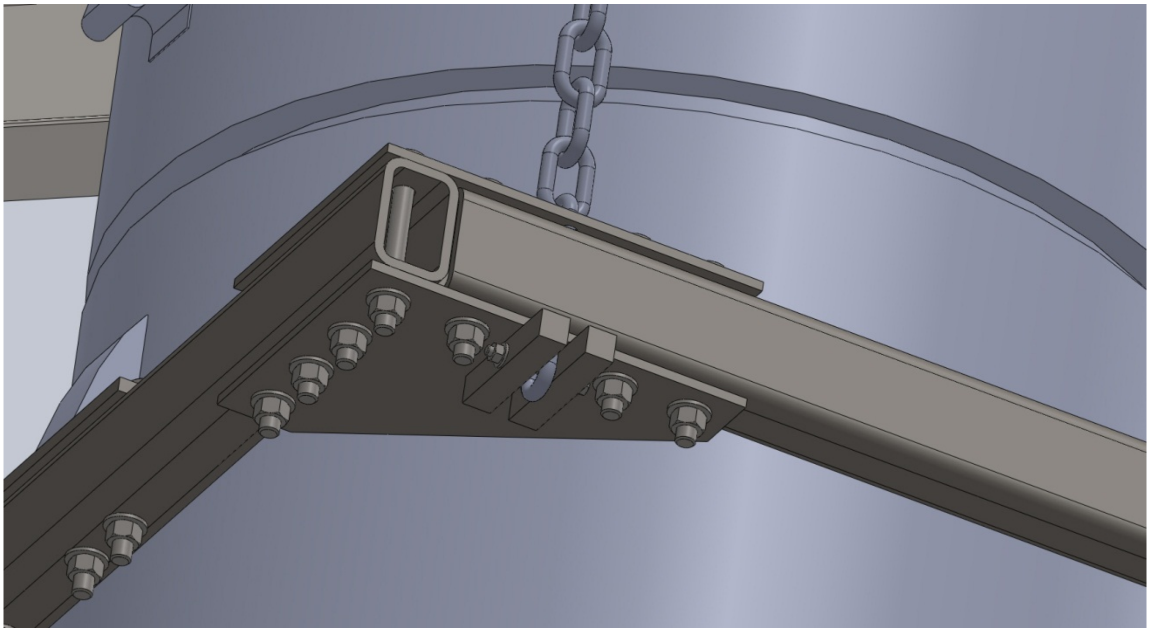


Figure 4.6 Lifting frame toggle

4.6 Initial Data Collection

My colleague Sahand Pirouzpanah is in charge of pump testing and instrumentation. Complete details of the flow loop instrumentation and testing procedures will be available in his dissertation. This is expected to be completed in December of 2012. All of the graphs in this section (figures 4.7 through 4.10) are courtesy of Mr. Pirouzpanah.

The pump manufacturer supplied reference data for the differential pressure and flow rate for pure water. Initial test loop data was plotted against the manufacturer supplied data as shown:

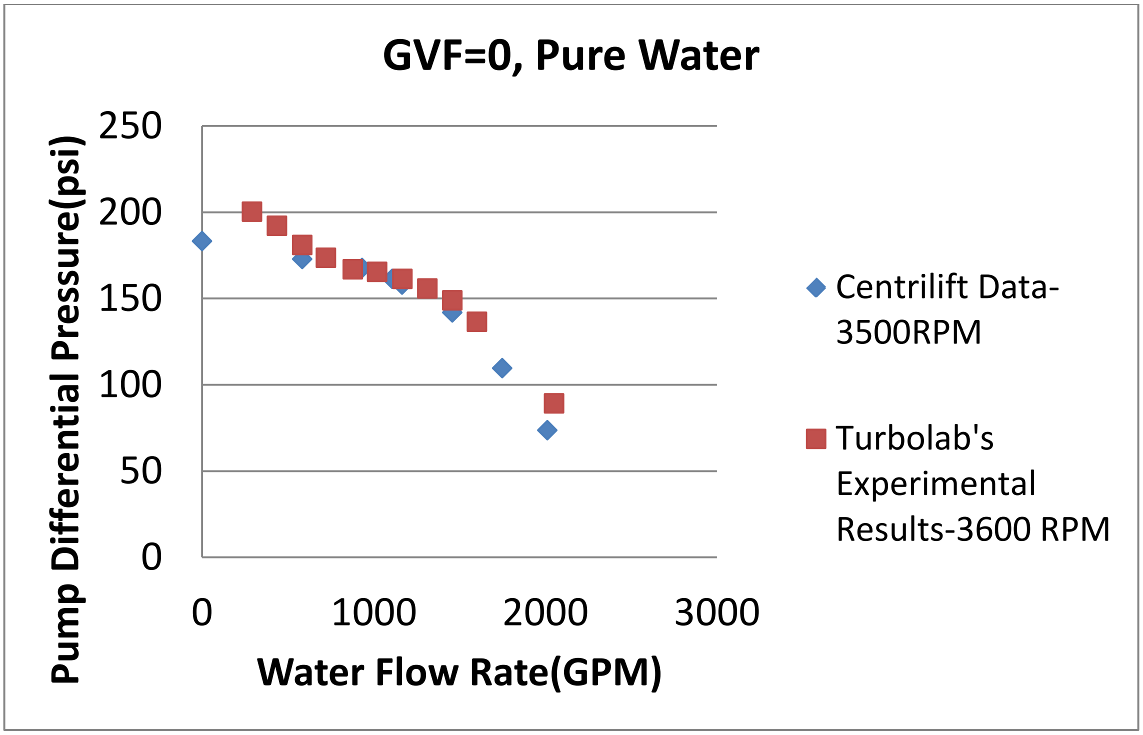


Figure 4.7 Comparison of Experimental data to pump supplier data

The data are in close agreement with the experimental data being slightly higher. This can be attributed to the slightly higher pump speed. Some data for the one hundred PSIG inlet pressure for varying GVF are shown below. Data collection for higher pressures is continuing at the present time.

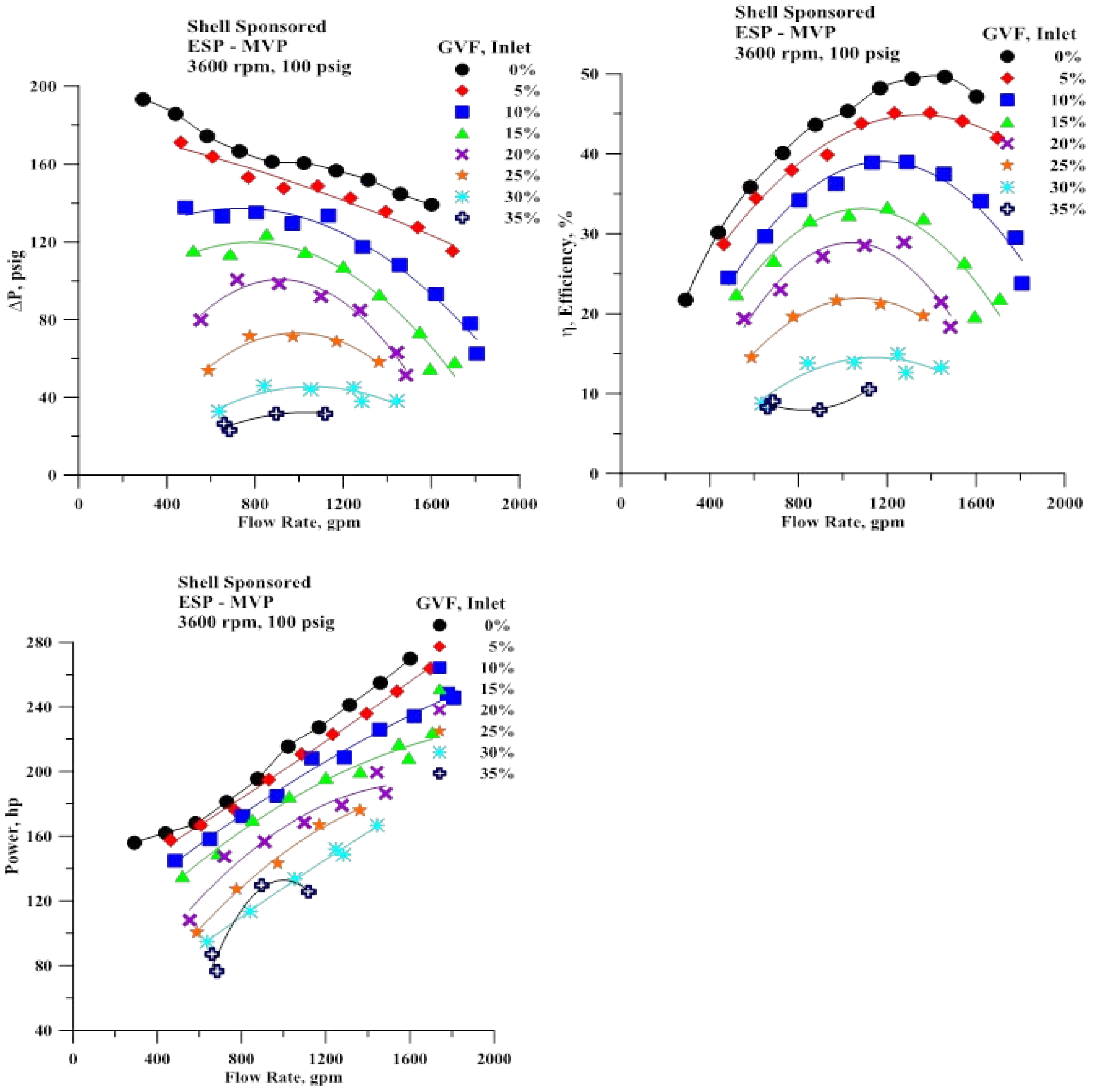


Figure 4.8 Data for 100 Psig inlet pressure at 3600 rpm

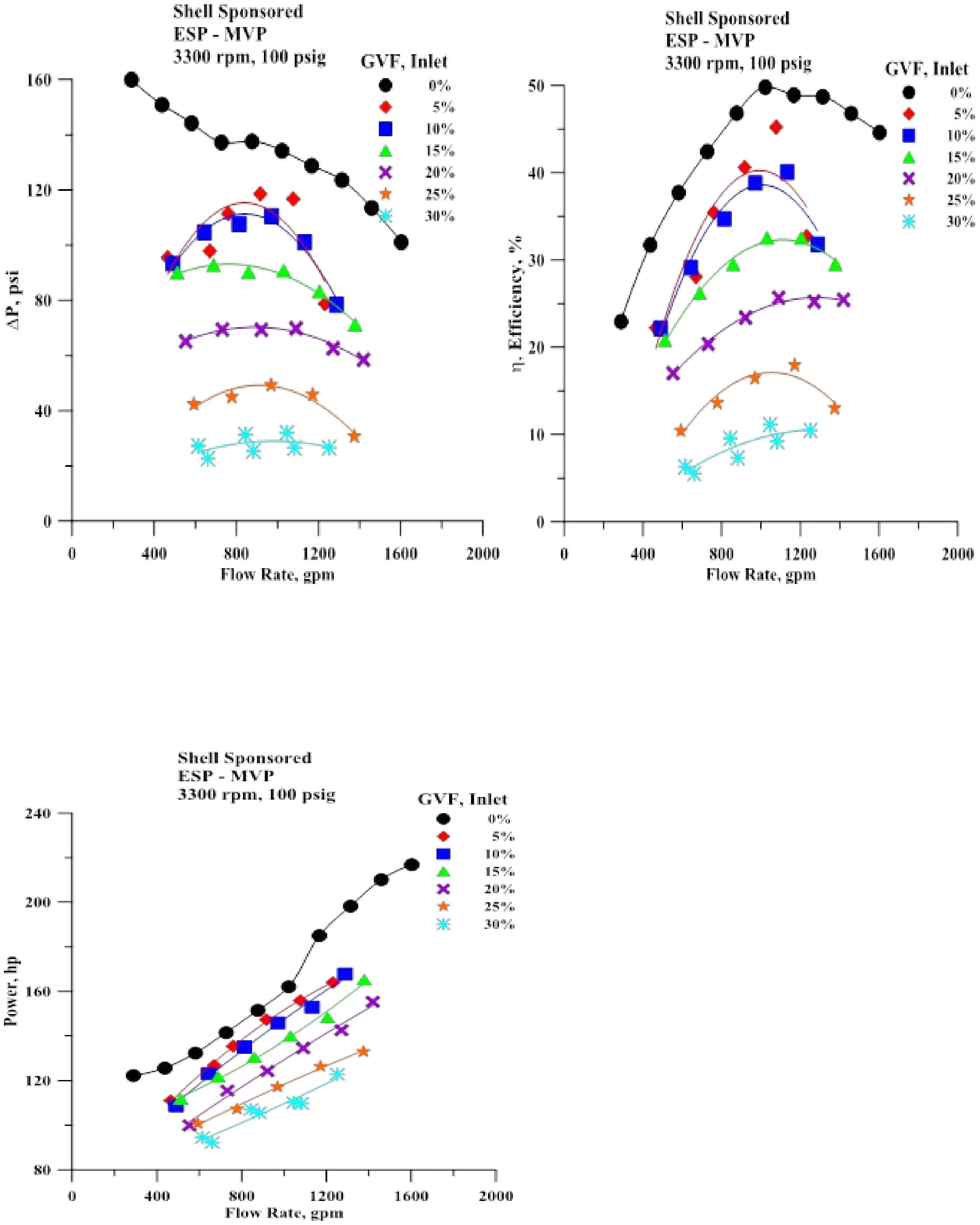


Figure 4.9 Data for 100 psig inlet pressure at 3300 rpm

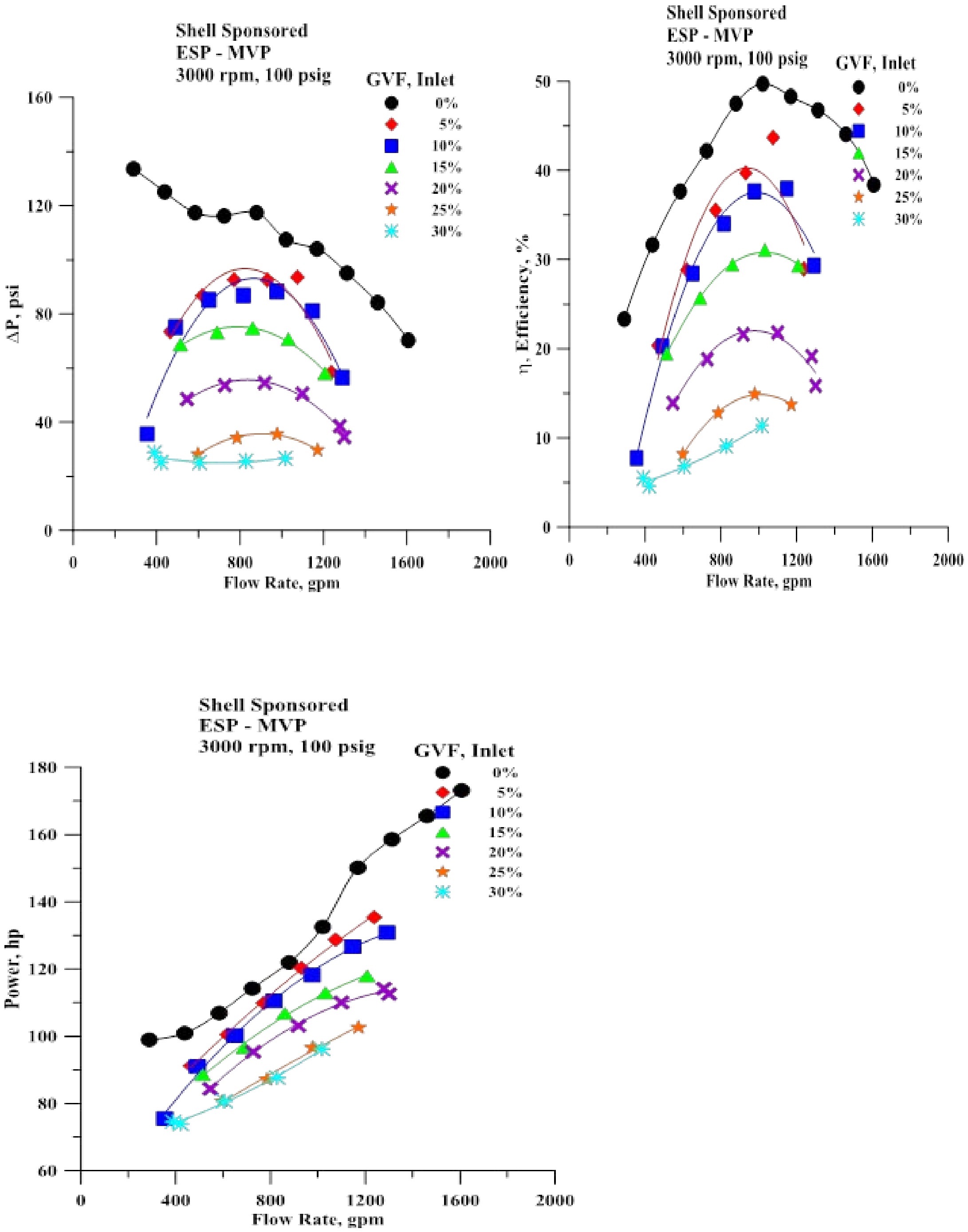


Figure 4.10 Data for 100 psig inlet pressure at 3000 rpm

In general, the curves look similar to that which would be expected for normal, pure liquid pumps. The pressure generated decreases with increasing flow rate, while power consumption grows larger. Efficiency peaks at around 1400 GPM at 3600 rpm. This is higher than the 3300 and 3000 rpm case, where efficiency reaches its maximum at 1000 GPM.

Increasing the GVF lowers efficiency, power output, and differential pressure. This would be expected as energy is being expended in compression of the gas rather than increasing the head of the liquid.

Changing from a pure liquid flow to multiphase flow does have a startling effect on the differential pressure. For liquid, the differential pressure decreases almost in a linear fashion with flow rate. When gas is added, however, the differential pressure peaks at just over 800 GPM. This effect grows more pronounced at slower speeds and at lower GVF.

5 SUMMARY AND CONCLUSIONS

5.1 Summary

A two-phased flow pump test loop has been constructed to test a three stage vertical pump. The loop is capable of handling flows of up to twelve hundred gallons per minute at three hundred PSIG inlet pressure.

The loop was run initially with only water. Pure water (i.e. 0%bGVF) data is very close to manufacturer supplied information.

Operating data was then taken for one hundred PSIG inlet pressure at speeds from 3000 to 3600 rpm. In each case the gas volume flow rates were varied from zero to the maximum possible. In these cases, the maximum attainable GVF was 30% to 35%.

Data for higher inlet pressures are presently being collected.

5.2 Conclusions

Throughout construction, many difficulties were encountered and solved. Many of these can serve as valuable lessons learned when engaged in future projects.

The most significant problem has been maintaining the alignment between the pump and motor. This alignment must be closely monitored for this type of installation. For future projects, a stiffer motor base and pump mount should be considered as well as a means to secure the inlet of the pump to prevent movement due to pipe stresses. An alternate design concept would be to provide a gimbaled mount for the motor and pump so that they move together. Such a design would be more difficult to achieve than the current one. But, it may be worthwhile to consider for future projects.

A lesser problem has been sealing around the second stage pump window plug. Initially, a flat gasket was used. But, this proved inadequate. An o-ring gives a much better seal as long as a proper o-ring groove can be used.

Sight glasses were not part of the original design. One was added to each inlet pipe to observe the flow. In the case of the water pipe, it allows operators to verify that the separator is functioning properly and supplying only water through the water inlet. The air inlet line sight glass is used to verify that there is no back flow of water from the pump. This could cause a problem if water gets to the air flow meter. Water will damage the flow meter.

In specifying flanged connections, it should be noted that ‘slip on’ flanges are actually welded into place while ‘lap joint’ flanges are free to rotate for installation reasons.

Another industry standard is the fact that control valves do not seal entirely when closed but will leak about five percent of the maximum flow rate. They can be made to seal completely if this is specified when the valve is ordered.

5.3 Future Work

Electrical Resistive Tomography (ERT) will be used to analyze the flow. ERT uses a series of electrodes on the perimeter of a pressure vessel that make contact with the process fluid. An electric current between pairs of electrodes and the voltage difference between the remaining pairs is measured. This is repeated for each pair of electrodes and produces a map of the electrical conductivity of the fluid. Since conductivity will vary from different species or phases, a map of the flow conditions can be made. In this case, a map of the air and water phases of the inlet or interior pump flow can be seen.

A set of sixteen electrodes has been mounted onto the pump inlet window to allow ERT measurements to be made at the inlet. A new insert to fit into the second stage volute has also been made. This insert has its own electrodes on the interior surface which will allow data collection of the second stage volute flow. ERT testing is expected to begin soon.

In addition to ERT testing on this pump, a different pump of similar configuration is likely to be tested in the near future. This is an ASM series 1025P ARC model by the same manufacturer. This pump is slightly longer than the existing pump so that the inlet configuration will have to be modified.

Another project which will use some of this loop is a polycarbonate pump. A pump will be made with a casing of polycarbonate. This will allow unprecedented visual access to the operating pump. An additional set of valves and tee fittings will be added to the loop to allow the new pump to use the existing separator tank, control valves and piping.

Finally, an erosion pump project has been initiated which will measure the effects of entrained sand on pump internal components. Although this does not use the same facilities, the design of the pump stand is identical to that for this project with minor changes due to different pump and motor dimensions.

REFERENCES

[1] Heald, C. C. editor, 1988, “Cameron Hydraulic Data,” Ingersoll-Rand Company pg. 1-42.

[2] Baker Hughes Centrilift, 2009, Claremore, OK , “Centrilift Submersible Pump Handbook Ninth Edition,” pg.47.

[3] Burliegh, Lawrence, 2009, “Pushing the Limit: Taking ESP Systems to 250º C,” Baker Hughes Centrilift, Claremore, OK pg. 3.

[4] Gruselle, F, Steimes, J., and Hendrick, P., 2010, “Study of a Two-Phase Flow Pump and Separator System,” Proceedings of ASME Turbo Expo 2010: Power for Land, Sea, and Air (GT2010) pg. 5.

[5] Gamboa, J. , and Prado, M., 2010, “Visualization Study of Performance Breakdown in Two-Phase Performance of an Electric Submersible Pump,” 26th International Pump Users Symposium Proceedings pg. 4.

[6] Burliegh, Lawrence, 2009, “Pushing the Limit: Taking ESP Systems to 250º C,” Baker Hughes Centrilift, Claremore, Oklahoma pp. 1-3.

[7] Hydraulic Institute, 2006, “Mechanical Seals for Pumps: Application Guidelines,” Hydraulic Institute pg.39.

[8] Hydraulic Institute, 2006, “Mechanical Seals for Pumps: Application Guidelines,” Hydraulic Institute pp. 139-220.

APPENDIX A

PROCEDURES

A-1 Alignment procedure

The pump is equipped with two proximity probes that allow the alignment to be monitored even when the pump is running. They check the axial alignment of the pump shaft to the seal housing. They do not directly measure angular alignment.

The proximity probes must be calibrated before use. Once calibrated, they do not need to be recalibrated unless they are disturbed. Calibration involves aligning the pump using ‘traditional’ means. i.e. dial indicators. This is a lengthy process. So, do not disturb the proximity probes unless absolutely necessary!

A-1.1 Calibration (do this only if the proximity probes have been disturbed)

To align the pump using dial indicators, first depressurize the system. Failure to do this could cause injury and damage to the equipment. Then remove the coupling guard nearest to the control room door. Then remove the coupling spacer and bottom components of the coupling. It is not necessary to remove the coupling piece that is attached to the motor shaft. Now remove the seal by disconnecting the tubing fittings and replacing the setting plates into the seal sleeve grooves. (Refer to the seal assembly drawing) Loosen the drive collar set screws and the flange nuts. The seal should slide up the shaft and can be removed through the coupling gap.

The dial indicator holder can now be attached to the motor shaft and the dial indicator set to read the top surface of the pump outlet. This will indicate the angular alignment of the pump. Set the dial on the indicator to zero and carefully rotate the motor shaft through one revolution by turning the motor coupling. Avoid using the dial indicator holder to turn the motor. Ensure that the dial indicator probe travels freely over the pump outlet surface. Ideally, the indicator should read zero for the entire shaft revolution. If it does not, the alignment can be adjusted using shims at the pump mount. To determine the needed shims, set the dial indicator to zero when it is positioned near one of the four mounting girders. Rotate the motor shaft and record the dial readings at each girder. Compare each reading to the one that is opposite. The shim thickness is nearly equal to the difference between the two values and is placed under the girder where the dial indicator value is higher. Example: the girders are on the northeast (NE), southeast (SE), southwest (SW) and northwest (NW) of the pump. Rotate the dial indicator until it is on the northwest and set it to zero. Rotating clockwise, we get the following values: NW: 0, NE, +.010”, SE +.015”, SW -.020”. Southeast is directly opposite northwest and it is a higher value (+.015 as opposed to 0) so a .015” thick shim should be tried at that point (since +.015 – 0 = +.015). Similarly, a .030” shim should be tried under the northeast since +.010 – (-.020) = .030.

To add a shim, loosen all of the 7/8” main attach bolts sequentially enough to allow the shim to be slipped into position. Then tighten all of the bolts and check the alignment. It may require several iterations to get the alignment close to zero. The dial readings should be no more than .002” when the pump is properly aligned. Once the pump is aligned angularly, the axial alignment should be set.

Remove the dial indicator and its holder and slide the seal back into place. Bolt the flange into place without the proximity probes or probe mounts. Reinstall the coupling and set the impeller height. Tighten the seal drive collar set screws and remove the setting plates. Do not throw the setting plates away! Put them in the box the seal came in. Do not install the tubing or tubing fittings into the gland yet.

Mount the dial indicator holder on the coupling and set the dial indicator to read the outside diameter of the seal gland near the top of the seal. Rotate the shaft through one revolution and ensure that the indicator probe slides freely over the gland surface. Rotate the shaft until the indicator is even with one girder, set the reading to zero and rotate the shaft through one revolution, recording the readings at each corner. The axial shaft position is controlled by moving the motor using the positioning blocks located on top of the motor base. Each is equipped with two small threaded bolts which can be turned to move the motor away from that block. The motor should be moved a distance of one half the difference between two opposite sides in the direction of the higher number. That is away from the lower number. To move the motor, loosen all four main motor mount studs holding the motor onto the base plate. Then loosen *all* of the positioning blocks bolts to allow the motor to move. Move the dial indicator until it is even with the block the motor is to move away from. Set the dial to read the negative value of the distance that the motor is to be moved and slowly and evenl y tighten the two positioning block bolts until the dial indicator reads zero. Repeat for the other direction if needed. Then tighten the main motor mount studs. Recheck the alignment. Repeat the process as necessary until no more than .002” runout is indicated.

Remove the dial indicator and its assembly. Attach the proximity probe mounts and the probes onto the seal gland. Adjust the probes until the tips are about .050” from the coupling. Connect the probes to the converter box mounted near the door. Turn on the box and refer to the Labview valve control program. Set the alignment readings in Labview to read zero. The pump is now aligned and calibrated.

A-1.2 Alignment

After the proximity probes have been calibrated, the pump can be aligned without dismantling the coupling or seal. Simply loosen the main pump mounting bolts and move the motor as needed referring to the Labview readouts to check the alignment. Note that the readings may shift some when the mounting studs are retightened. The stabilizer blocks at the bottom of the pump inlet assembly can be used to tweak the alignment after the studs have been tightened. Also, with some experience, it is possible to anticipate how the alignment will shift when the studs are tightened and to compensate accordingly.

A-2 Before operation checklist

Piping and flanged connections – check for integrity

Tubing – check for integrity:

- Water supply to inlet pipe
- Inlet pipe to seal flush pump
- Seal flush pump to seal
- Seal flush outlet to top of separator tank
- Instrumentation tubing

Variable frequency drive - covered

Instrumentation wiring – check for integrity

Labview valve control program – running

Water inlet control valve – open (via Labview)

Outlet control valve – open (via Labview)

Pump Outlet/seal area– clear of debris, loose items etc.

Coupling strain gauge transmitters – connected to batteries.

Coupling guards – installed and bolts tightened

Water drain – closed

Air inlet shut off valve - closed

Instrument air supply - open

Air supply line sight glass – check for water

Air drain – open to drain any water, then closed

Separator tank outlet valve – open

Water supply valve – open (if needed to fill separator tank)

Separator tank water level - 10 to 12 feet.

Pressure relief valve - closed

Tank air pressure – set (at least 120 psig)

Proximity probe power supply - on

Shaft alignment – within .005” each axis

Seal flush pump - on

Manual transfer switch - In up position for the MVP pump.

Safety switch of Variable frequency drive –on

VFD handheld controller – Switch to LOCAL

The test loop is now ready to run.

VFD handheld controller- Press the RUN bottom

To fill water tank, ensure pressure in tank is below 100 psig. The shop water supply is about 100 psig, so if the tank pressure is higher, no water will flow into the test loop. Then open the Separator tank outlet valve and the water supply fill valve. Monitor the water level. Do not allow it to climb higher than 14 feet. Turn the water supply fill valve off to read the water level gauge. It will not read properly with the water supply flowing. When the proper level is reached, close the supply valve.

Tank pressure – check, should be at least 120 psig to operate. Higher values will be needed depending on the test being run. Pressure can be decreased by cracking open the air drain valve. Pressure is increased by use of the air compressor. To use the air compressor, open the drain on the air compressor to drain any moisture. Close the drain. Plug in the compressor and attach compressor to the air supply line via the high pressure yellow air hose. Turn on the air compressor and monitor the tank pressure until the desired pressure is achieved. Note, the water tank level gauge will read erroneously when the air compressor is running. When the tank is at the right pressure, turn the air compressor off and disconnect the high pressure air hose starting with the end attached to the air line, then the end attached to the compressor.

To adjust the speed before and during the operation the RPM of the VFD drive can be set by going to U1-01 in the handheld controller.

A-2.1 Running Secondary loop (Heat Exchanger)

Inlet valve (bottom valve) and outlet valve (top valve) before running the secondary loop pump-Open

Safety switch behind the secondary-loop’s VFD drive (outside the test-cell) - Switch on.

Safety switch next to the secondary-loop’s pump and VFD drive –Switch on.

Frequency of the secondary-loop’s VFD drive- Set to 60Hz.

VFD drive- Switch to LOCAL then press the RUN bottom to turn on

Fans of the heat exchanger – Turn on

Secondary-loop’s water flow rate - Check (via LabView)

A-3 After operation checklist

Air inlet shut off valve – closed (while pump is running)

VFD – Press the STOP bottom

Variable frequency drive’s safety switch – power off

Seal flush pump – off

Air inlet line sight glass – check for water

Air drain – open to drain any water, then closed

Proximity probe power supply – off

Instrument air supply – off

Secondary loop’s pump- off

Secondary loop’s heat exchanger fans- off

Secondary loop’s Inlet and outlet valves-off

The loop may be kept pressurized in this condition if it is anticipated that it will be run again shortly, i.e. within a week.

If the system will not be run for an extended time, or if it is necessary to work on any pressure containing component, the system should be depressurized and drained.

A-3.1 To depressurize:

Instrument air supply - on

Outlet control valve – open (via Labview)

Pressure relief valve – open

Pressure – monitor until pressure is at atmospheric

A-3.2 To drain:

Separator tank outlet valve – open to drain entire water supply, closed to drain only the pump and piping.

Water inlet control valve – open (via Labview)

Water drain – connected to hose leading to storm drain

Water drain – open

When system is drained:

Water drain – closed

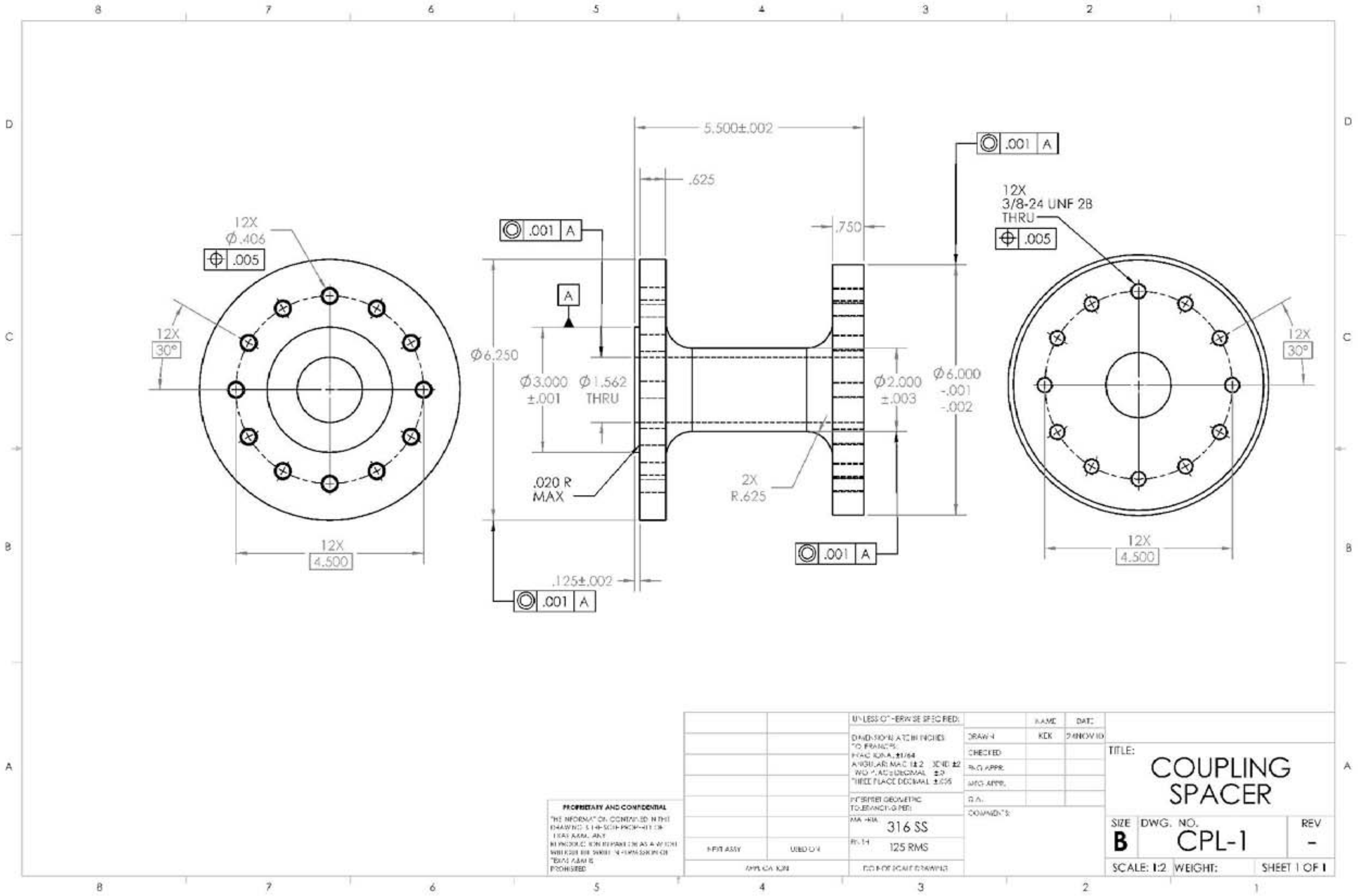
Instrument air supply – off (control valves will close)

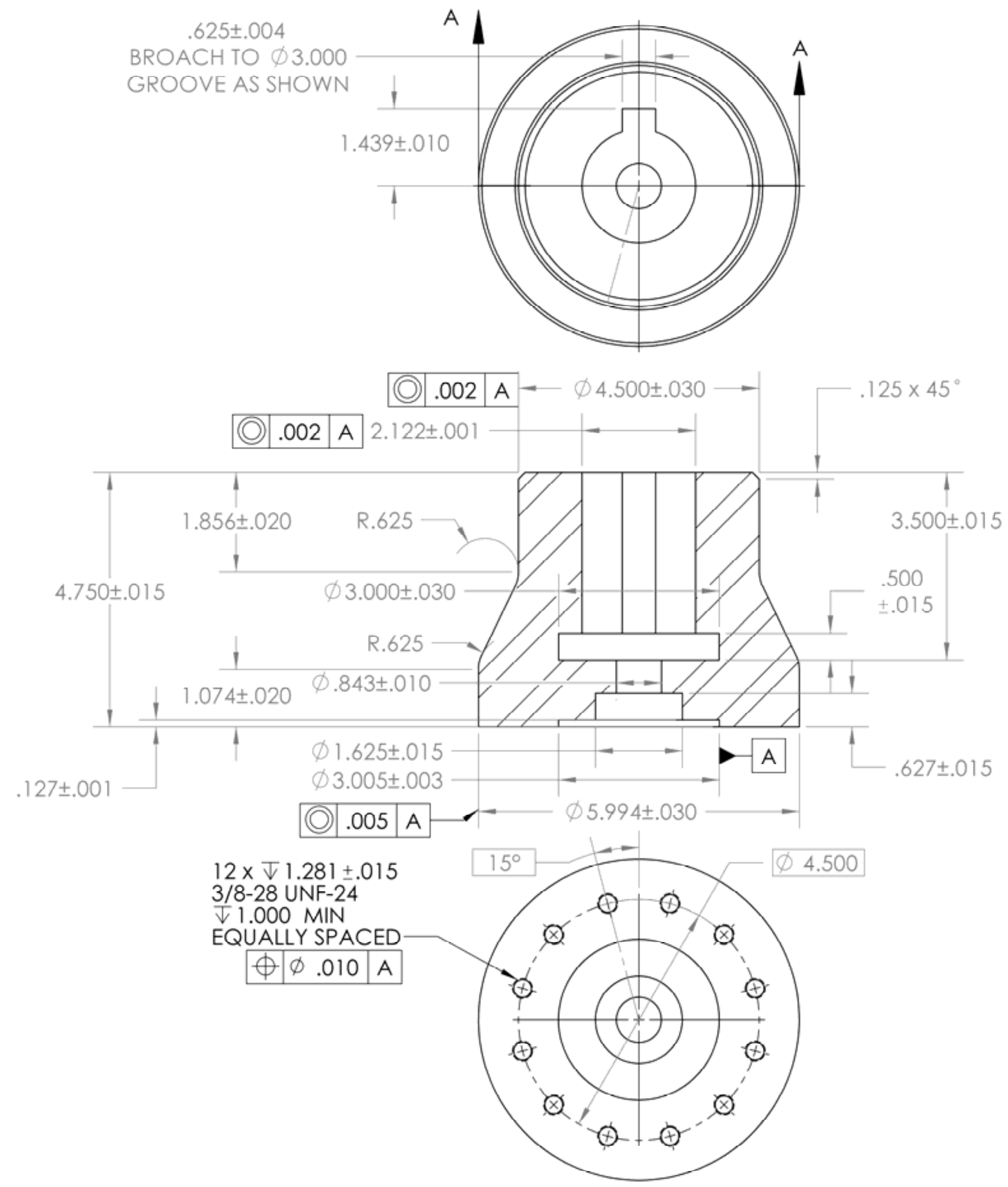
Separator tank outlet valve – closed

Pressure relief valve - closed

APPENDIX B

DRAWINGS


12X
Ø.406
⊕ .005
12X
30°
12X
4.500
5.500±.002
.625
◎ .001 A
A
Ø6.250
Ø3.000
±.001
Ø1.562
THRU
.020 R
MAX
.125±.002
◎ .001 A
.750
2X
R.625
Ø2.000
±.003
◎ .001 A
Ø6.000
-.001
-.002
◎ .001 A
12X
3/8-24 UNF 2B
THRU
⊕ .005
12X
30°
12X
4.500
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±.2 BEND ±2
TWO PLACE DECIMAL ±.?
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL 316 SS
FINISH 125 RMS
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
24NOV10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
COUPLING SPACER
SIZE
B
DWG. NO.
CPL-1
REV
-
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1



PROPRIETARY AND CONFIDENTIAL

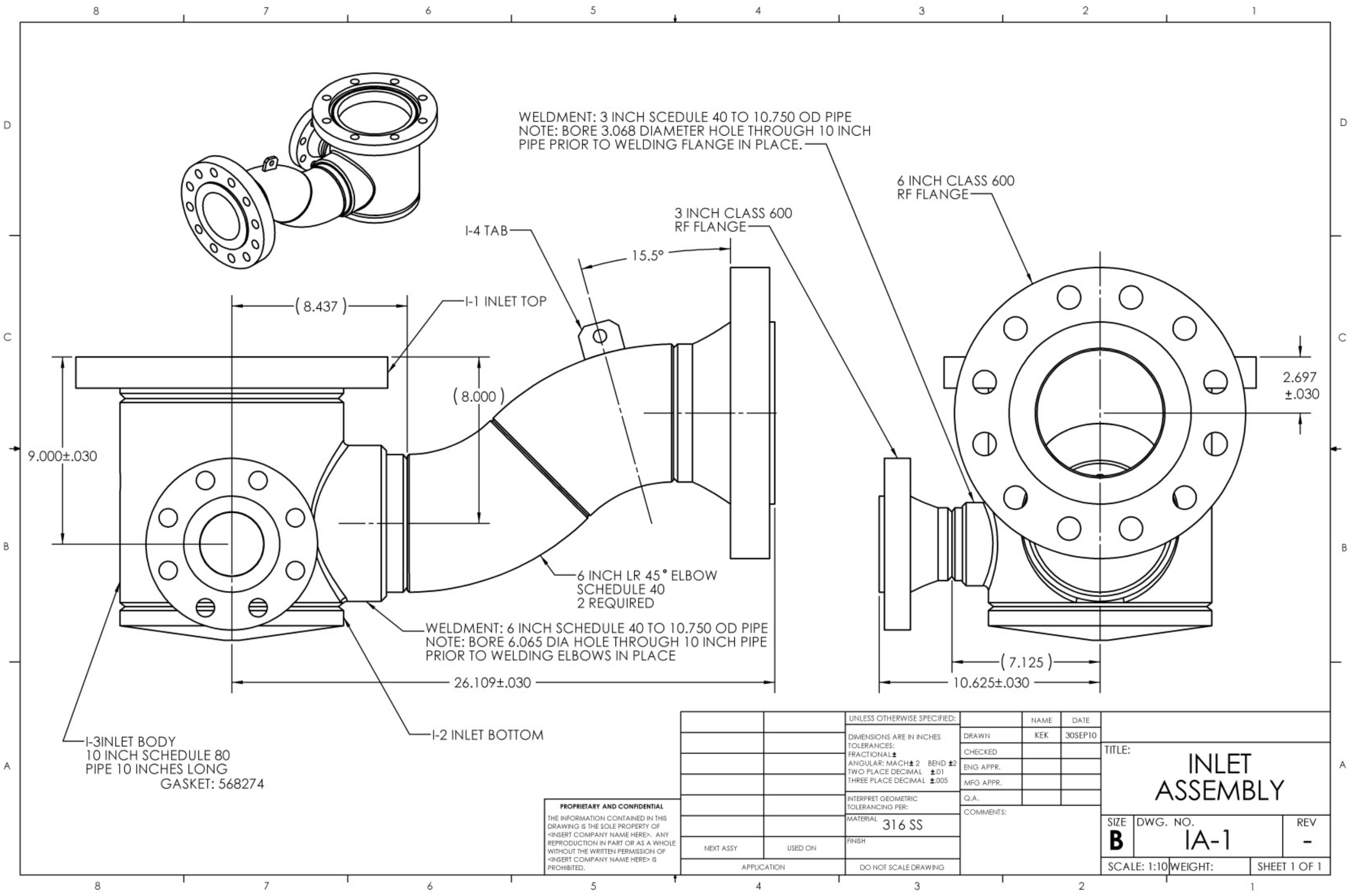
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

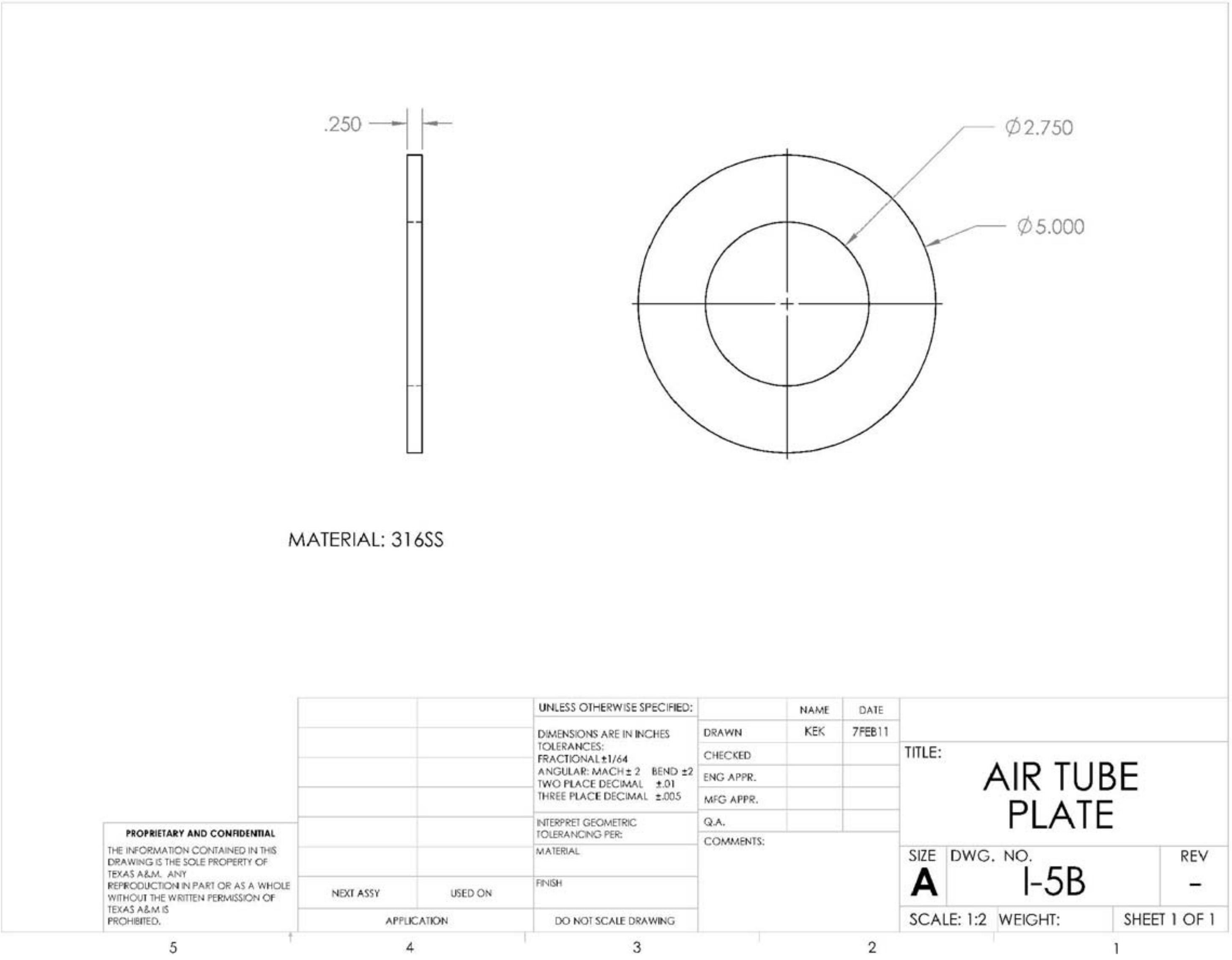
			NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/64 ANGULAR: MACH ±2 BEND ±2 TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005	DRAWN KEK	29APR11
			CHECKED	
			ENG APPR.	
			MFG APPR.	
		MATERIAL	Q.A.	
NEXT ASSY	USED ON	FINISH	COMMENTS:	
APPLICATION		DO NOT SCALE DRAWING		

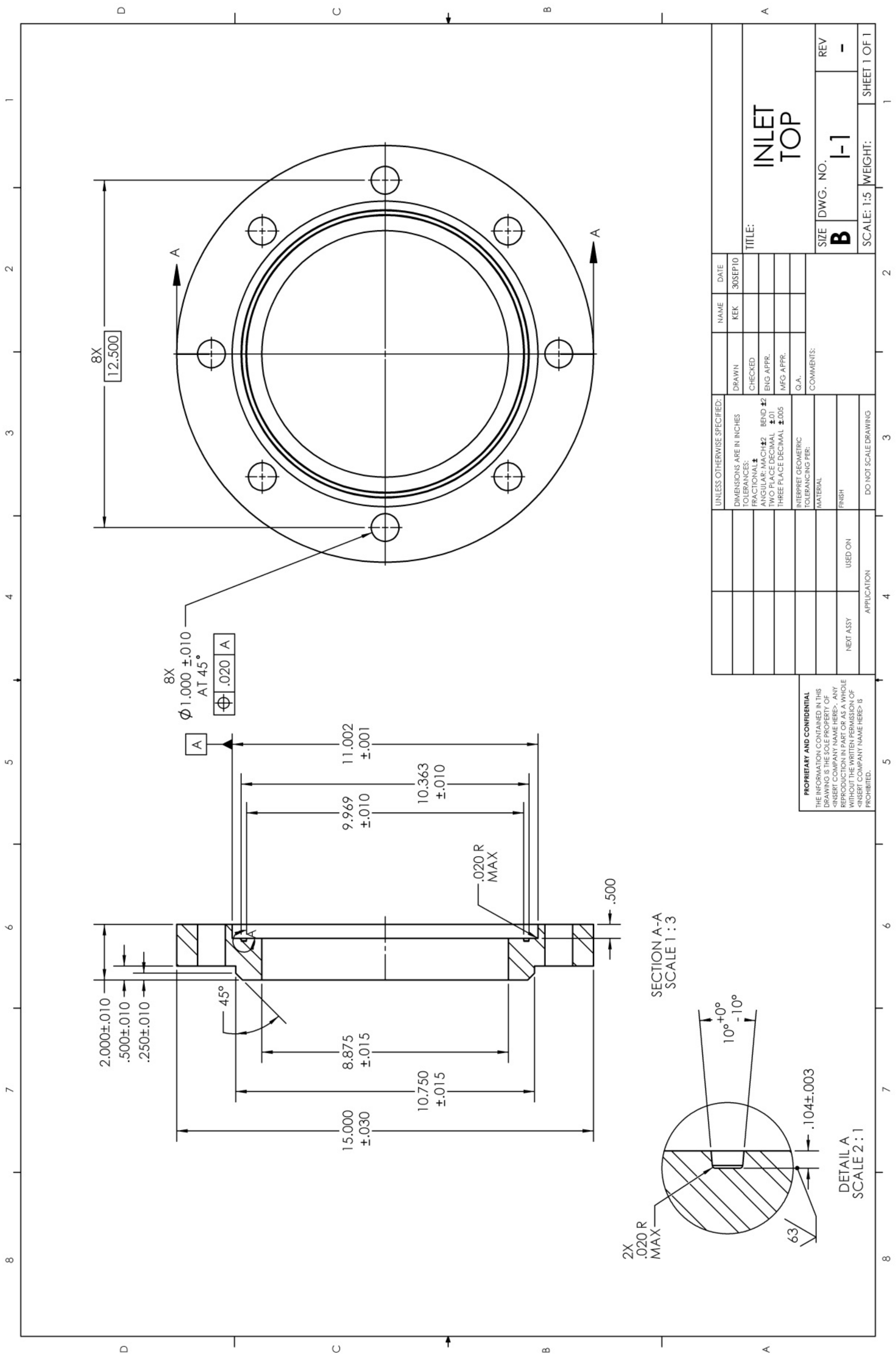
COUPLING, MOTOR END

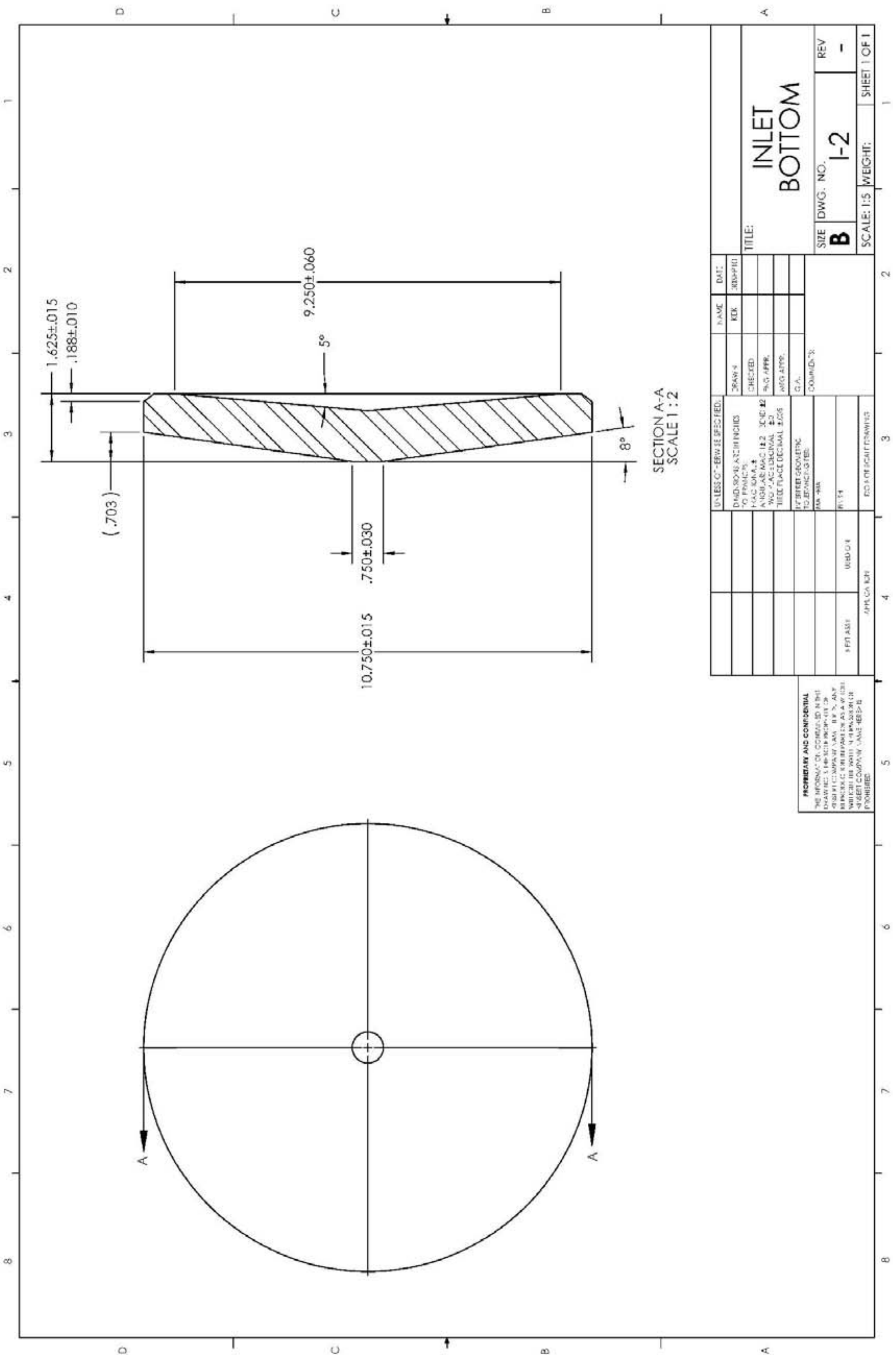
SIZE A DWG. NO. CPL-2 REV. A

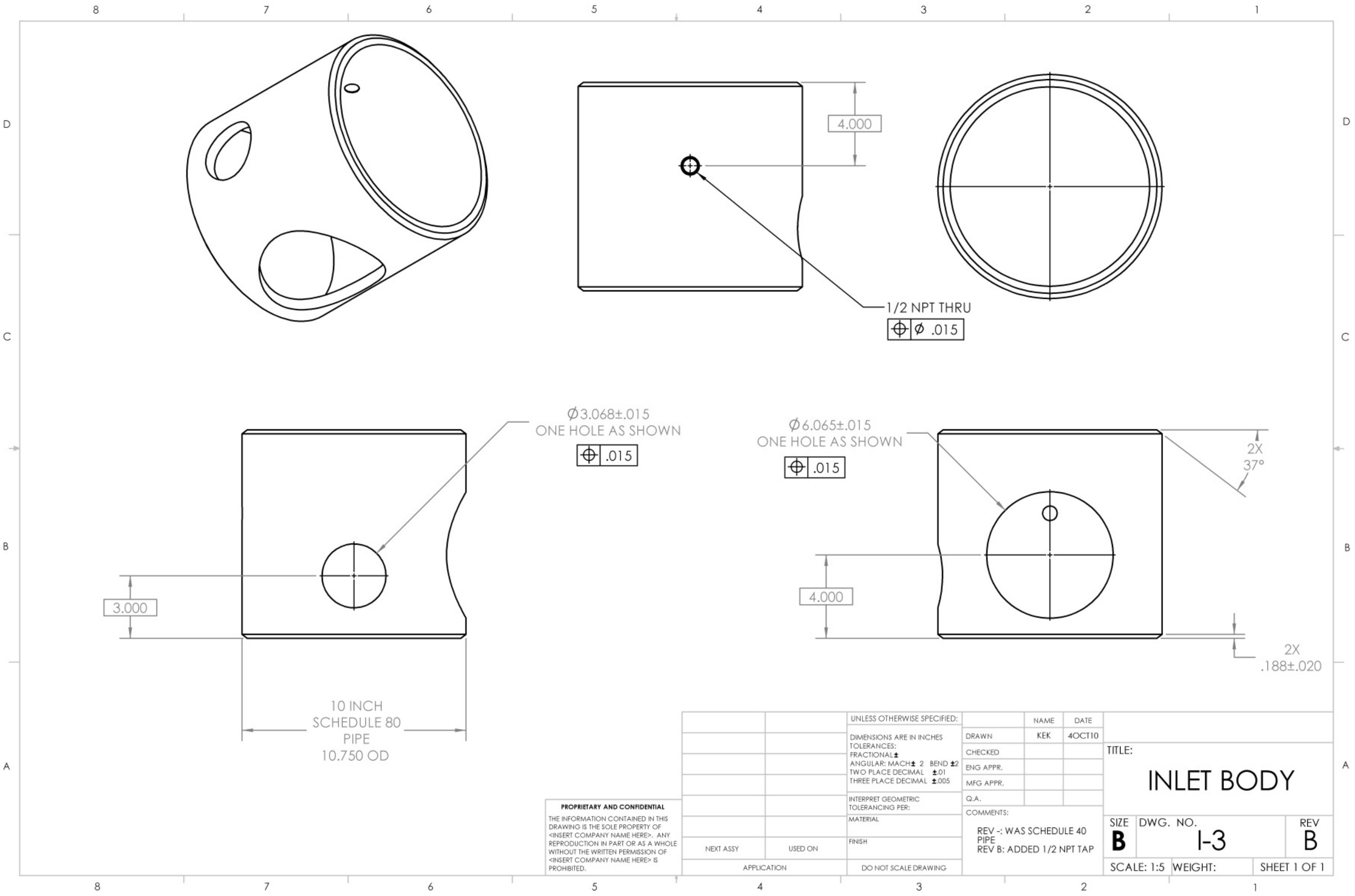
SCALE:1:4 WEIGHT: SHEET 1 OF 1


WELDMENT: 3 INCH SCEDULE 40 TO 10.750 OD PIPE
NOTE: BORE 3.068 DIAMETER HOLE THROUGH 10 INCH PIPE PRIOR TO WELDING FLANGE IN PLACE.
6 INCH CLASS 600 RF FLANGE
3 INCH CLASS 600 RF FLANGE
I-4 TAB
15.5°
(8.437)
I-1 INLET TOP
(8.000)
9.000±.030
2.697 ±.030
6 INCH LR 45° ELBOW SCHEDULE 40 2 REQUIRED
WELDMENT: 6 INCH SCHEDULE 40 TO 10.750 OD PIPE
NOTE: BORE 6.065 DIA HOLE THROUGH 10 INCH PIPE PRIOR TO WELDING ELBOWS IN PLACE
26.109±.030
(7.125)
10.625±.030
I-3INLET BODY
10 INCH SCHEDULE 80
PIPE 10 INCHES LONG
GASKET: 568274
I-2 INLET BOTTOM
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL 316 SS
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
30SEP10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
INLET ASSEMBLY
SIZE B
DWG. NO. IA-1
REV -
SCALE: 1:10
WEIGHT:
SHEET 1 OF 1
8
7
6
5
4
3
2
1
D
C
B
A


.250
Ø2.750
Ø5.000
MATERIAL: 316SS
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
7FEB11
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
AIR TUBE PLATE
SIZE
A
DWG. NO.
I-5B
REV
-
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1


8X
12.500
A
A
8X
Ø1.000 ±.010
AT 45°
⌖ .020 A
A
11.002
±.001
10.363
±.010
9.969
±.010
.020 R
MAX
.500
A
2.000±.010
.500±.010
.250±.010
45°
8.875
±.015
10.750
±.015
15.000
±.030
SECTION A-A
SCALE 1 : 3
10° +0° -10°
.104±.003
2X
.020 R
MAX
63
DETAIL A
SCALE 2 : 1
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
NAME
DATE
DRAWN
KEK
30SEP10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
INLET
TOP
SIZE
B
DWG. NO.
I-1
REV
-
SCALE: 1:5
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
D
C
B
A
1
2
3
4
5
6
7
8


1.625±.015
.188±.010
9.250±.060
5°
(.703)
8°
.750±.030
10.750±.015
SECTION A-A
SCALE 1 : 2
A
A
INLET
BOTTOM
TITLE:
SIZE
B
DWG. NO.
I-2
REV
-
SCALE: 1:5
WEIGHT:
SHEET 1 OF 1
DRAWN
CHECKED
KEK
NAME
DATE
PROPRIETARY AND CONFIDENTIAL



PROPRIETARY AND CONFIDENTIAL

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

NEXT ASSY
USED ON
APPLICATION

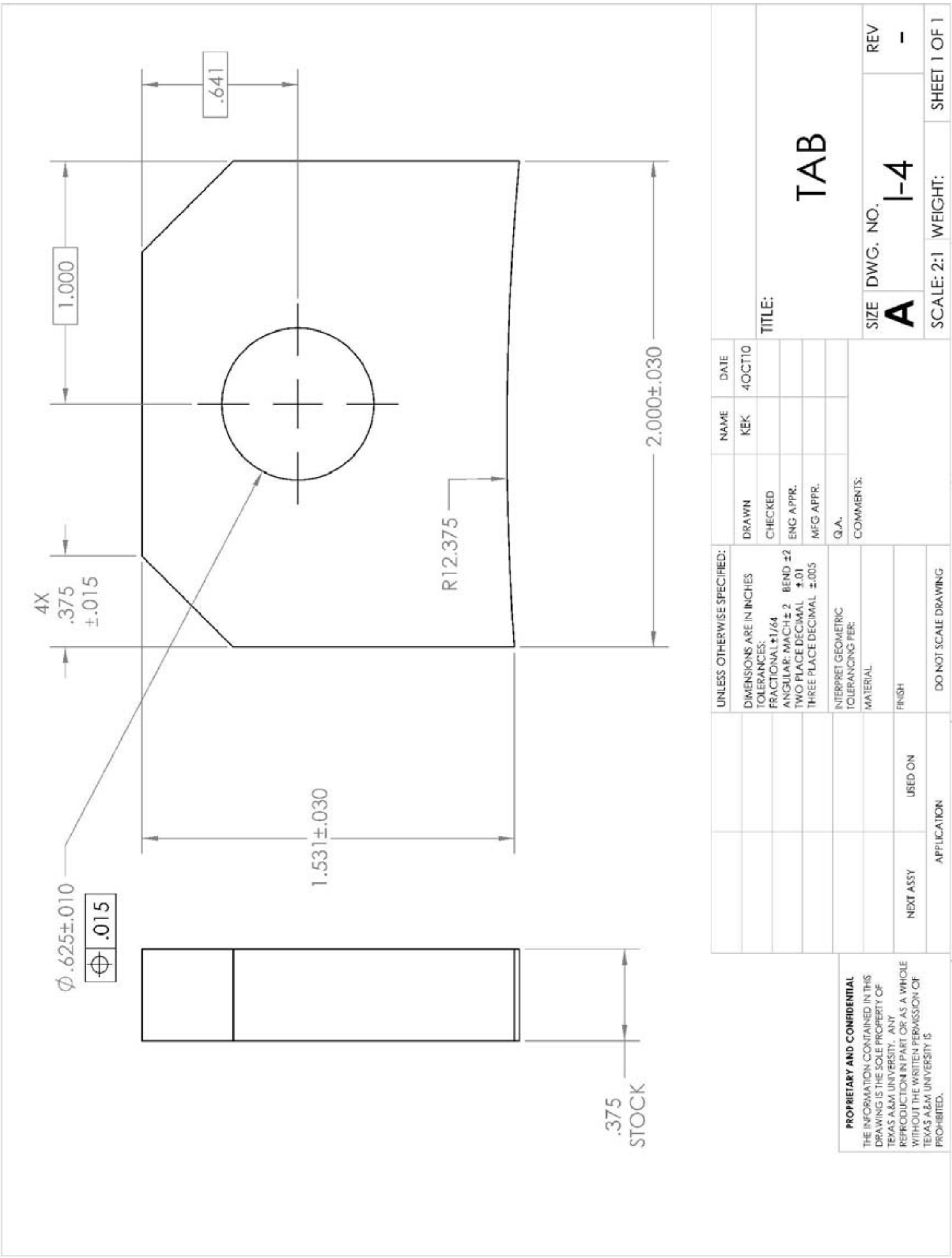
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

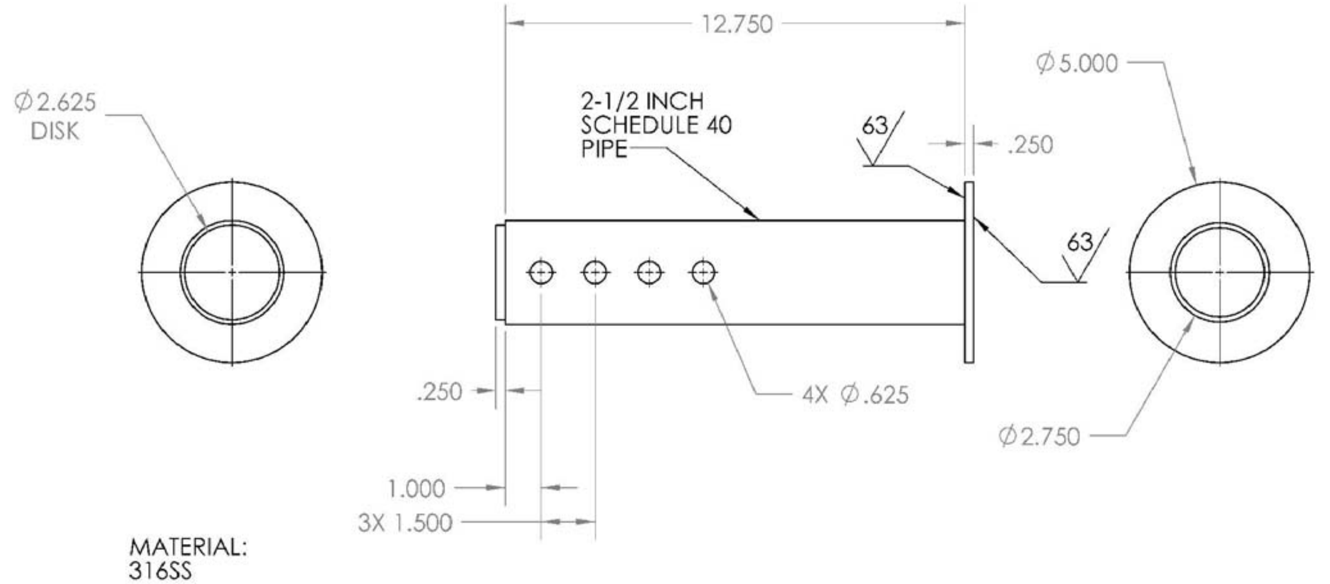
	NAME	DATE
DRAWN	KEK	4OCT10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:
REV -: WAS SCHEDULE 40 PIPE
REV B: ADDED 1/2 NPT TAP

TITLE:
INLET BODY

SIZE B
DWG. NO. I-3
REV B
SCALE: 1:5
WEIGHT:
SHEET 1 OF 1


1.000
.641
4X
.375
±.015
R12.375
2.000±.030
1.531±.030
∅.625±.010
⊕ .015
.375
STOCK
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
NAME
DATE
DRAWN
KEK
4OCT10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
TAB
SIZE
A
DWG. NO.
I-4
REV
-
SCALE: 2:1
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.
5
4
3
2
1



MATERIAL:
316SS

PROPRIETARY AND CONFIDENTIAL

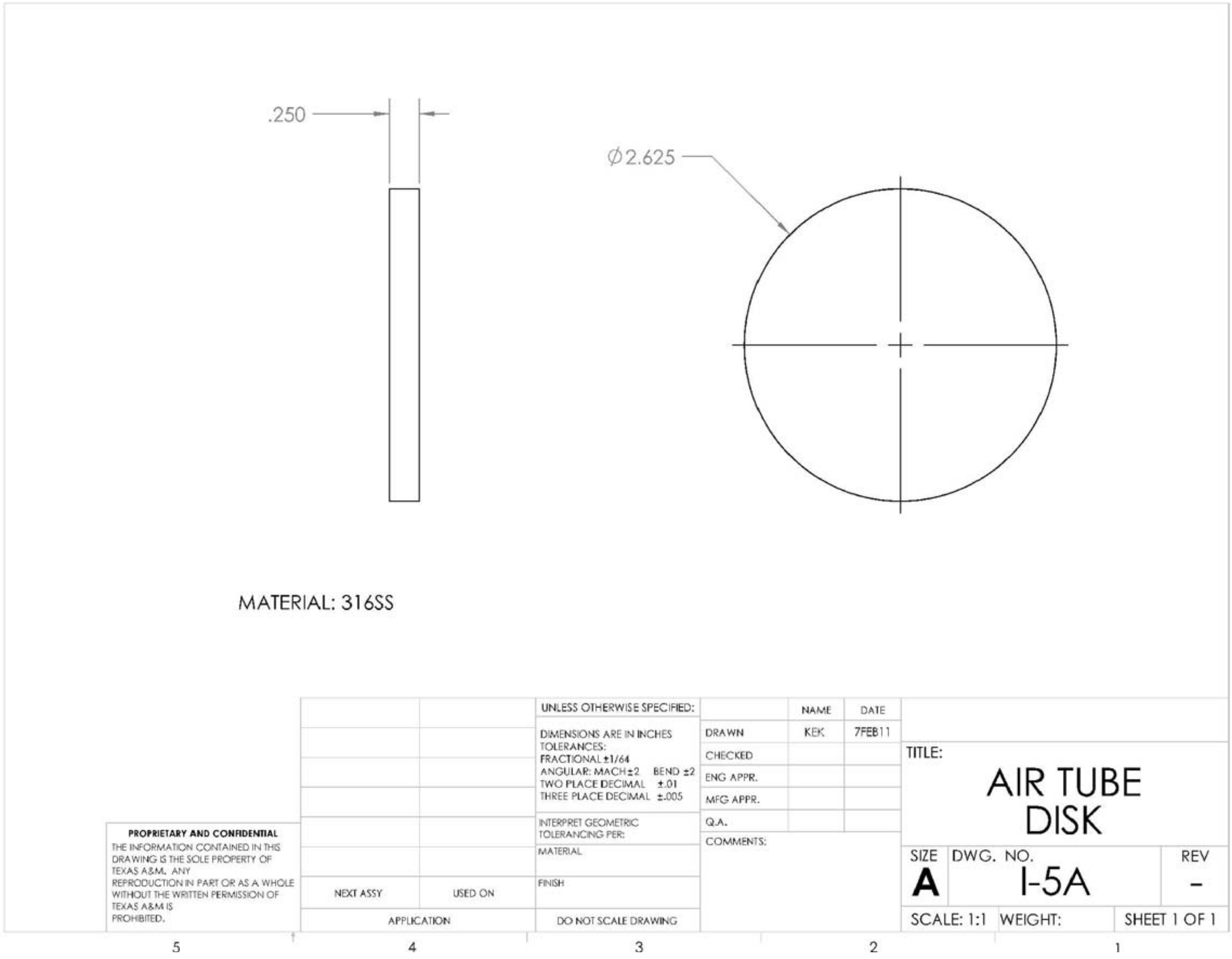
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

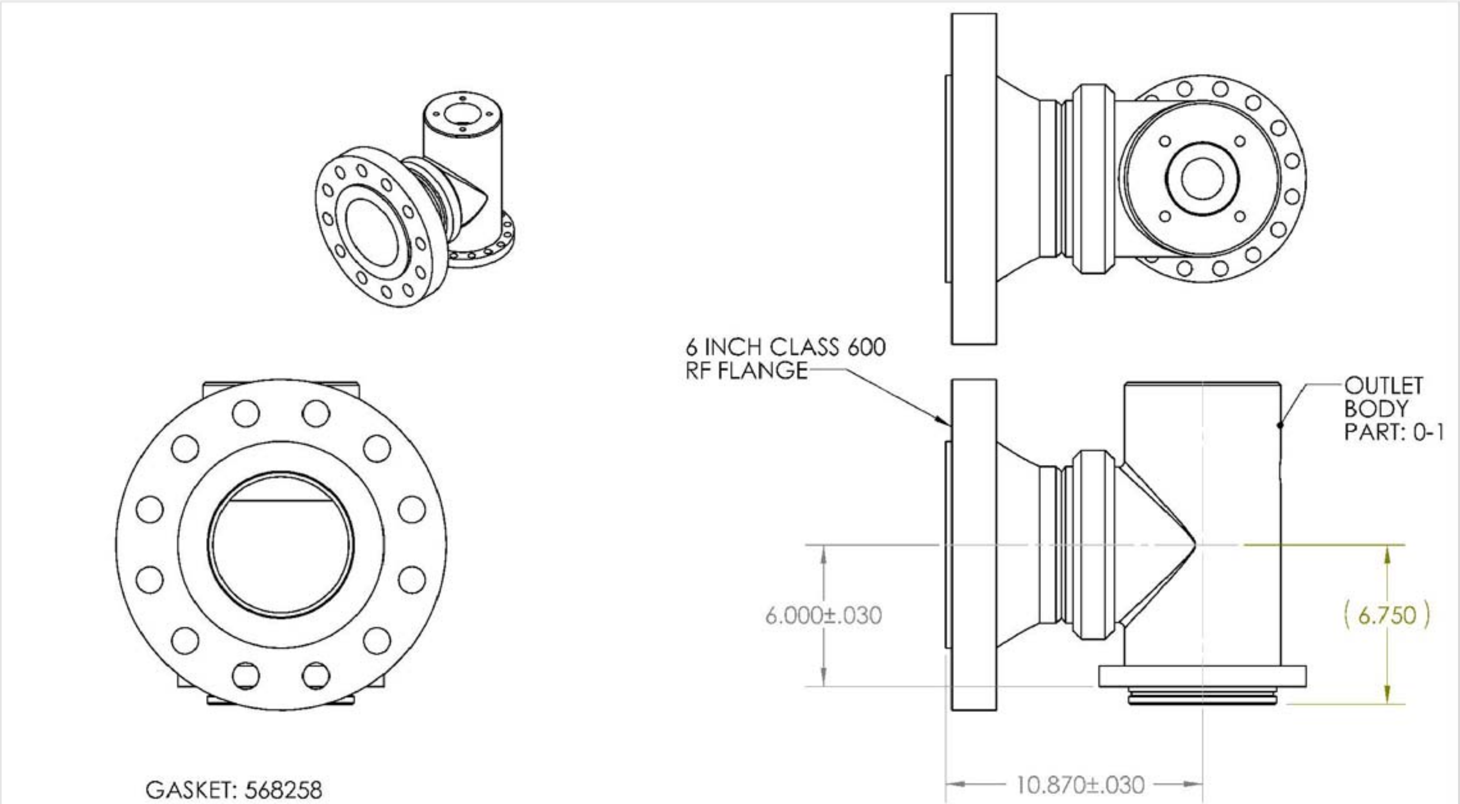
		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/64 ANGULAR: MACH ± 2 BEND ±2 TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005	DRAWN	KEK	7FEB11
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:

AIR TUBE

SIZE	DWG. NO.	REV
A	I-5	-
SCALE: 1:4	WEIGHT:	SHEET 1 OF 1


.250
Ø2.625
MATERIAL: 316SS
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
7FEB11
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
AIR TUBE DISK
SIZE
A
DWG. NO.
I-5A
REV
-
SCALE: 1:1
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	10OCT10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:
REV A: UPDATED
O-RING PN

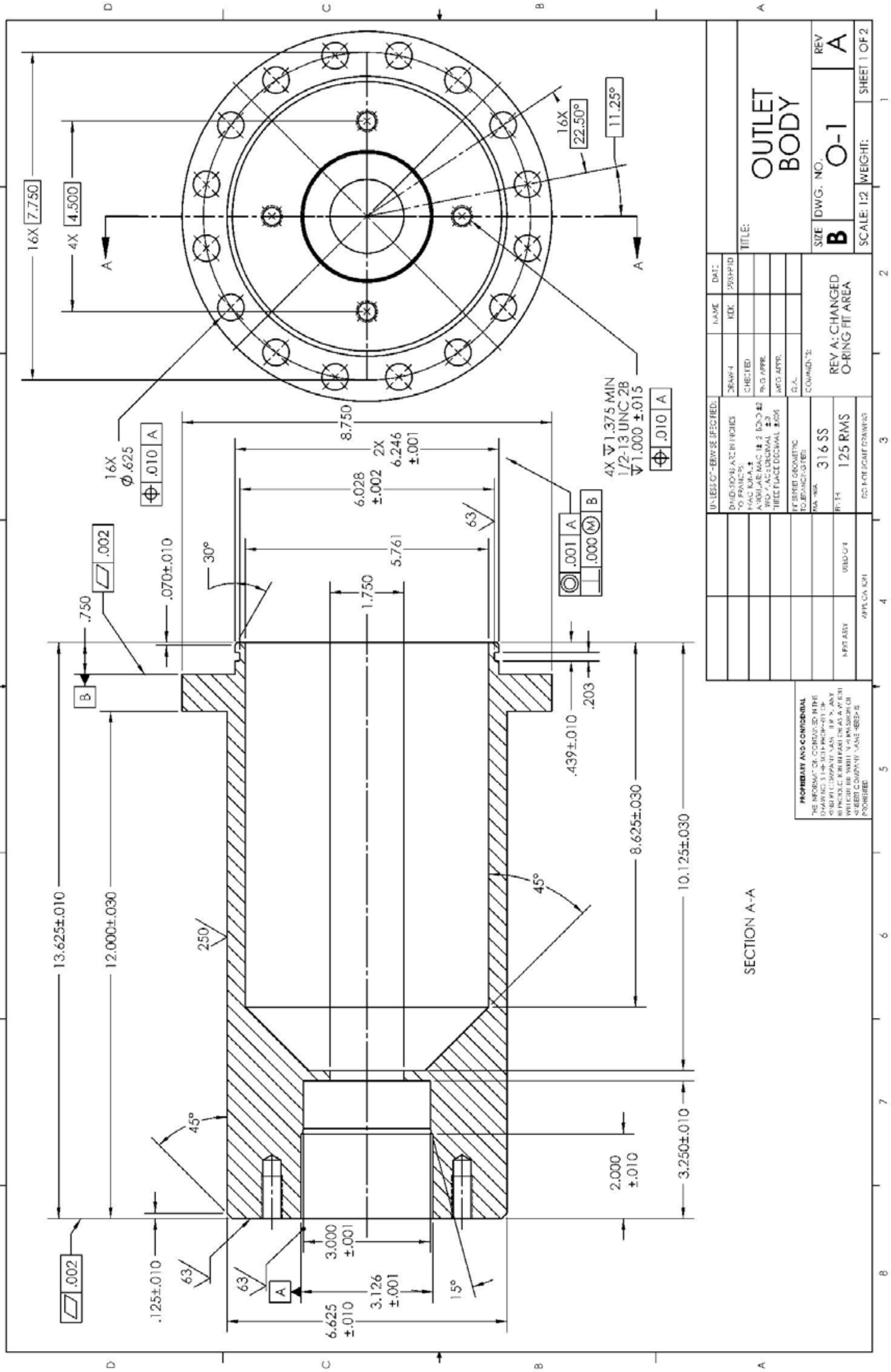
TITLE:

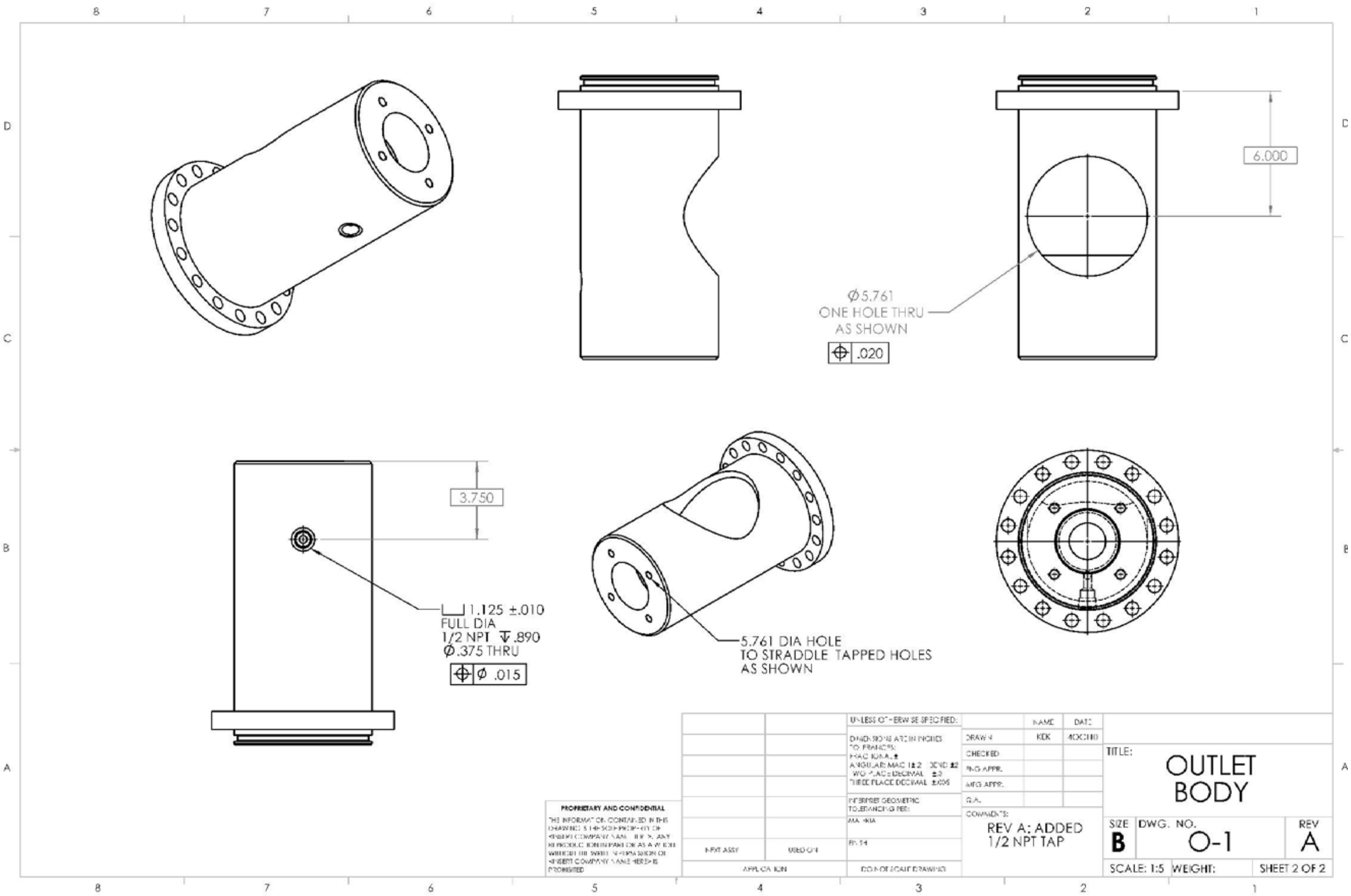
OUTLET ASSEMBLY

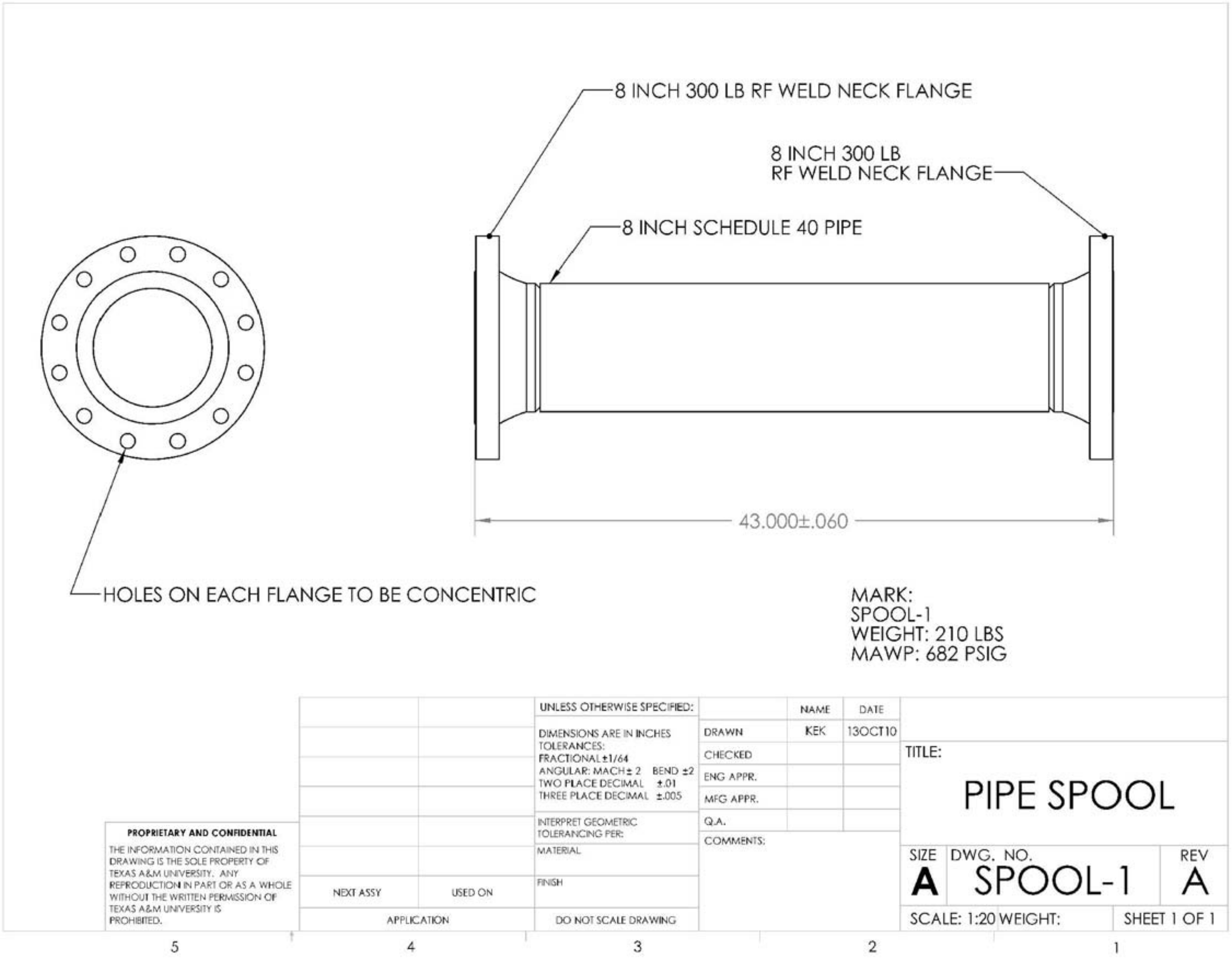
SIZE	DWG. NO.	REV
A	OA-1	A

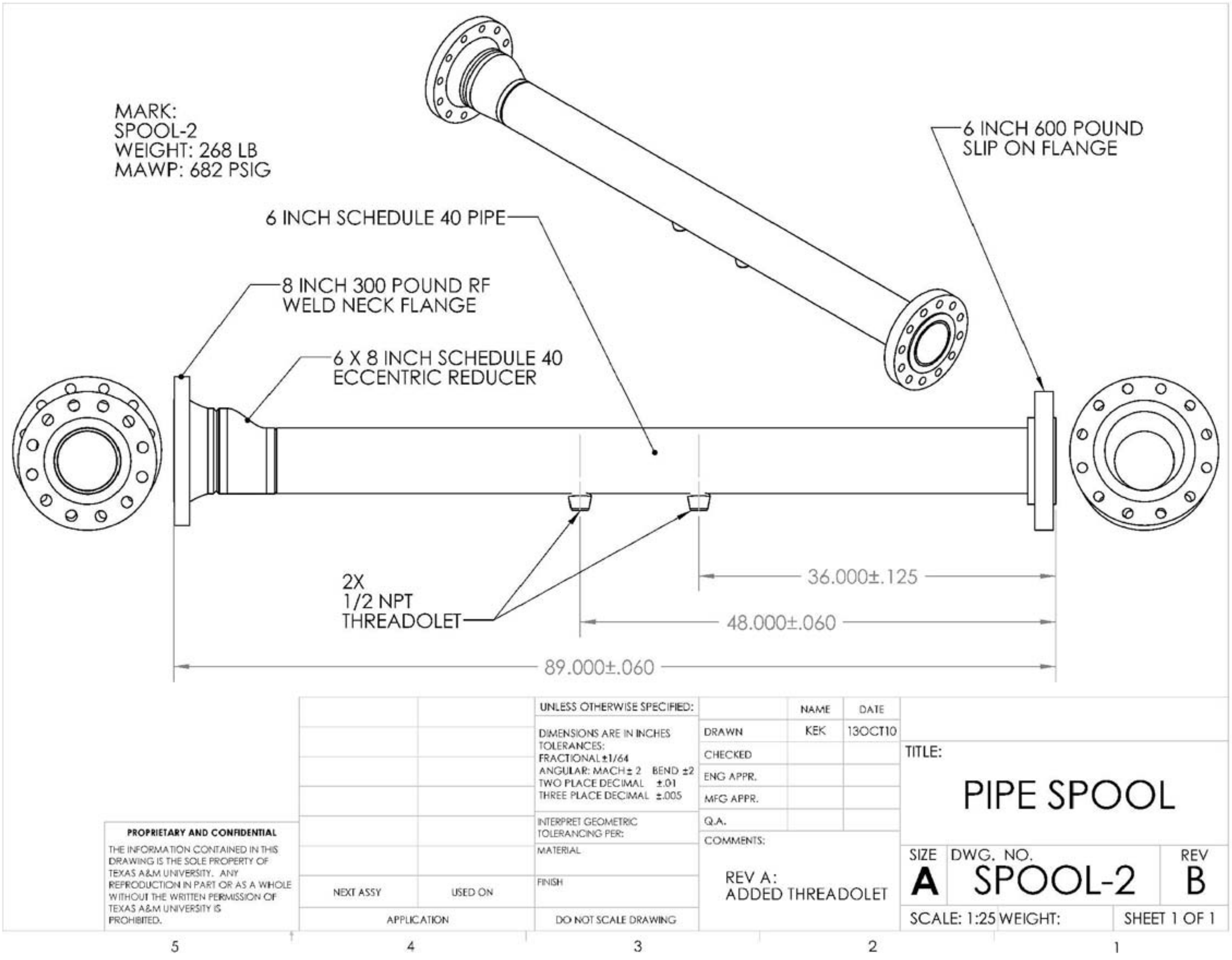
SCALE: 1:6 WEIGHT: SHEET 1 OF 1

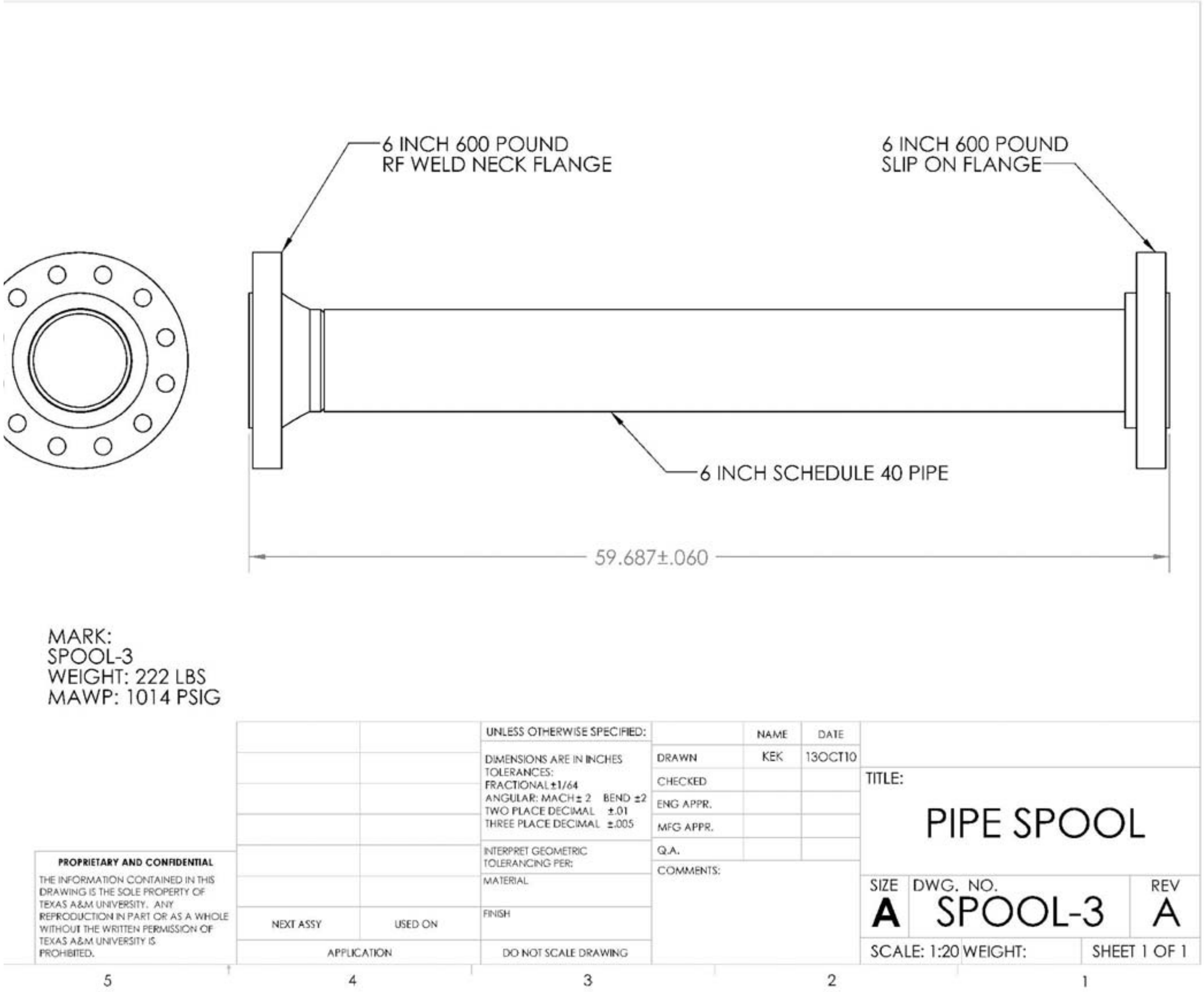
5 4 3 2 1

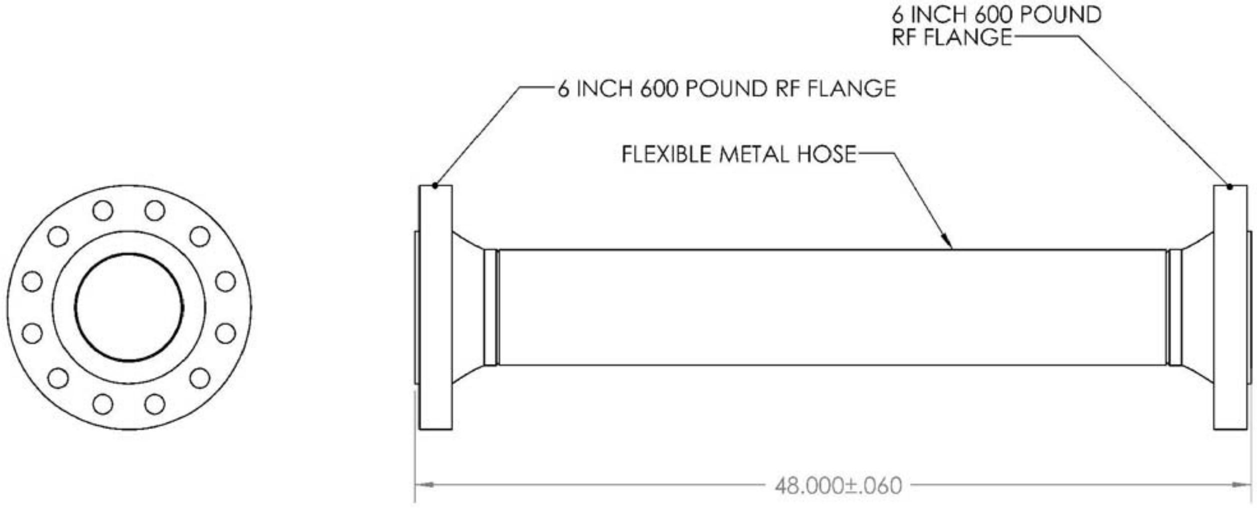

OUTLET BODY
TITLE:
SIZE B
DWG. NO. O-1
REV A
SCALE: 1:2
WEIGHT:
SHEET 1 OF 2
DRAWN KDK
COMMENTS:
REV A: CHANGED O-RING FIT AREA
UNLESS OTHERWISE SPECIFIED:
MATERIAL 316 SS
FINISH 125 RMS
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL
SECTION A-A
16X 7.750
4X 4.500
16X 22.50°
11.25°
16X ⌀.625
⌖ .010 A
4X ↧1.375 MIN
1/2-13 UNC 2B
↧1.000 ±.015
⌖ .010 A
8.750
2X 6.246 ±.001
6.028 ±.002
5.761
1.750
63
◎ .001 A
⊥ .000 Ⓜ B
.750
▱ .002
.070±.010
30°
B
.439±.010
.203
8.625±.030
10.125±.030
45°
13.625±.010
12.000±.030
250
45°
3.250±.010
2.000 ±.010
▱ .002
.125±.010
63
63
A
3.000 ±.001
3.126 ±.001
15°
6.625 ±.010
A
A
1
2
3
4
5
6
7
8
A
B
C
D


6.000
Ø5.761
ONE HOLE THRU
AS SHOWN
⊕ .020
3.750
⌴ 1.125 ±.010
FULL DIA
1/2 NPT ↧.890
Ø.375 THRU
⊕ Ø .015
5.761 DIA HOLE
TO STRADDLE TAPPED HOLES
AS SHOWN
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.3
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KDK
4OCT10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
REV A: ADDED
1/2 NPT TAP
TITLE:
OUTLET
BODY
SIZE
B
DWG. NO.
O-1
REV
A
SCALE: 1:5
WEIGHT:
SHEET 2 OF 2
1
2
3
4
5
6
7
8
A
B
C
D


8 INCH 300 LB RF WELD NECK FLANGE
8 INCH 300 LB
RF WELD NECK FLANGE
8 INCH SCHEDULE 40 PIPE
43.000±.060
HOLES ON EACH FLANGE TO BE CONCENTRIC
MARK:
SPOOL-1
WEIGHT: 210 LBS
MAWP: 682 PSIG
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
13OCT10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
PIPE SPOOL
SIZE
A
DWG. NO.
SPOOL-1
REV
A
SCALE: 1:20
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.
5
4
3
2
1


MARK:
SPOOL-2
WEIGHT: 268 LB
MAWP: 682 PSIG
6 INCH SCHEDULE 40 PIPE
8 INCH 300 POUND RF WELD NECK FLANGE
6 X 8 INCH SCHEDULE 40 ECCENTRIC REDUCER
6 INCH 600 POUND SLIP ON FLANGE
2X 1/2 NPT THREADOLET
36.000±.125
48.000±.060
89.000±.060
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
NAME
DATE
DRAWN
KEK
13OCT10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
REV A:
ADDED THREADOLET
TITLE:
PIPE SPOOL
SIZE
A
DWG. NO.
SPOOL-2
REV
B
SCALE: 1:25
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.
5
4
3
2
1


6 INCH 600 POUND
RF WELD NECK FLANGE
6 INCH 600 POUND
SLIP ON FLANGE
6 INCH SCHEDULE 40 PIPE
59.687±.060
MARK:
SPOOL-3
WEIGHT: 222 LBS
MAWP: 1014 PSIG
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
13OCT10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
PIPE SPOOL
SIZE
A
DWG. NO.
SPOOL-3
REV
A
SCALE: 1:20
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.

NEXT ASSY	USED ON		
APPLICATION			

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	13OCT10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

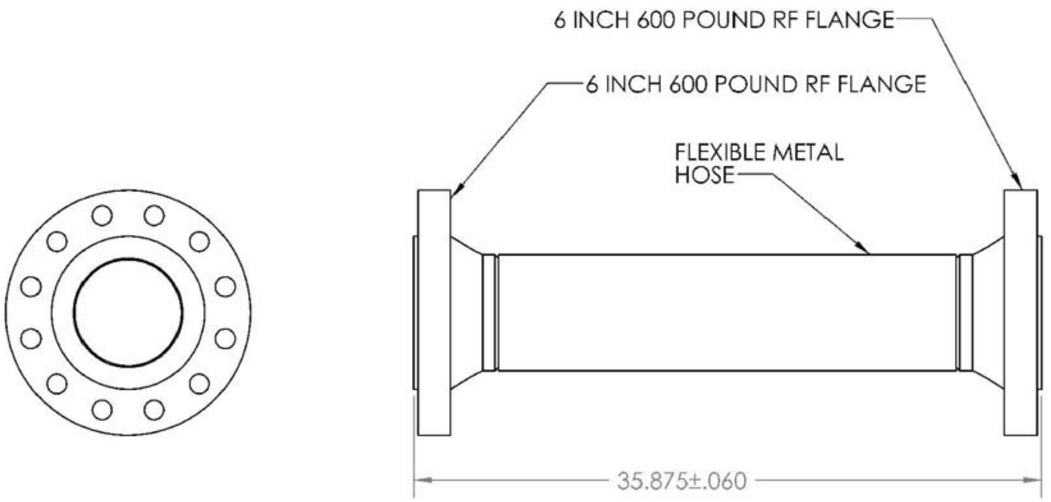
TITLE:

PIPE SPOOL

SIZE	DWG. NO.	REV
A	SPOOL-4	A

SCALE: 1:20 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



	NAME	DATE
DRAWN	KEK	13OCT10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC
TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

NEXT ASSY USED ON

APPLICATION

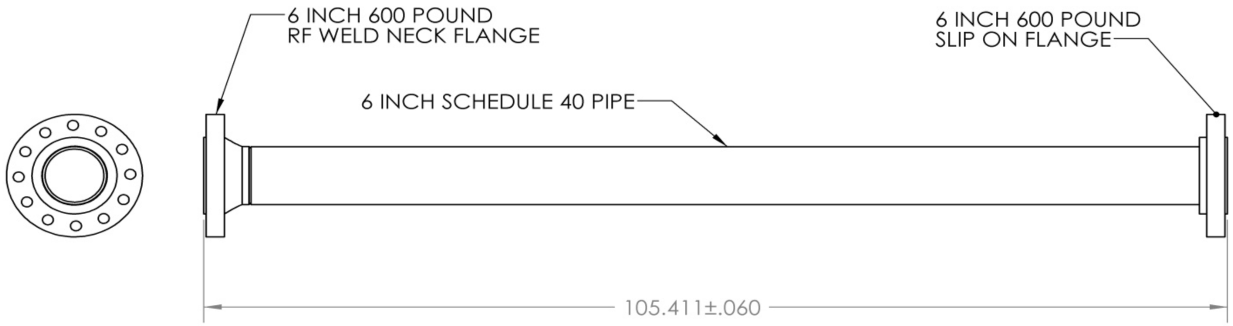
TITLE:

PIPE SPOOL

SIZE A
DWG. NO. SPOOL-5
REV A

SCALE: 1:10 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



MARK:
SPOOL-6
WEIGHT: 301 LBS
MAWP: 1014 PSIG

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.

NEXT ASSY
USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	13OCT10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

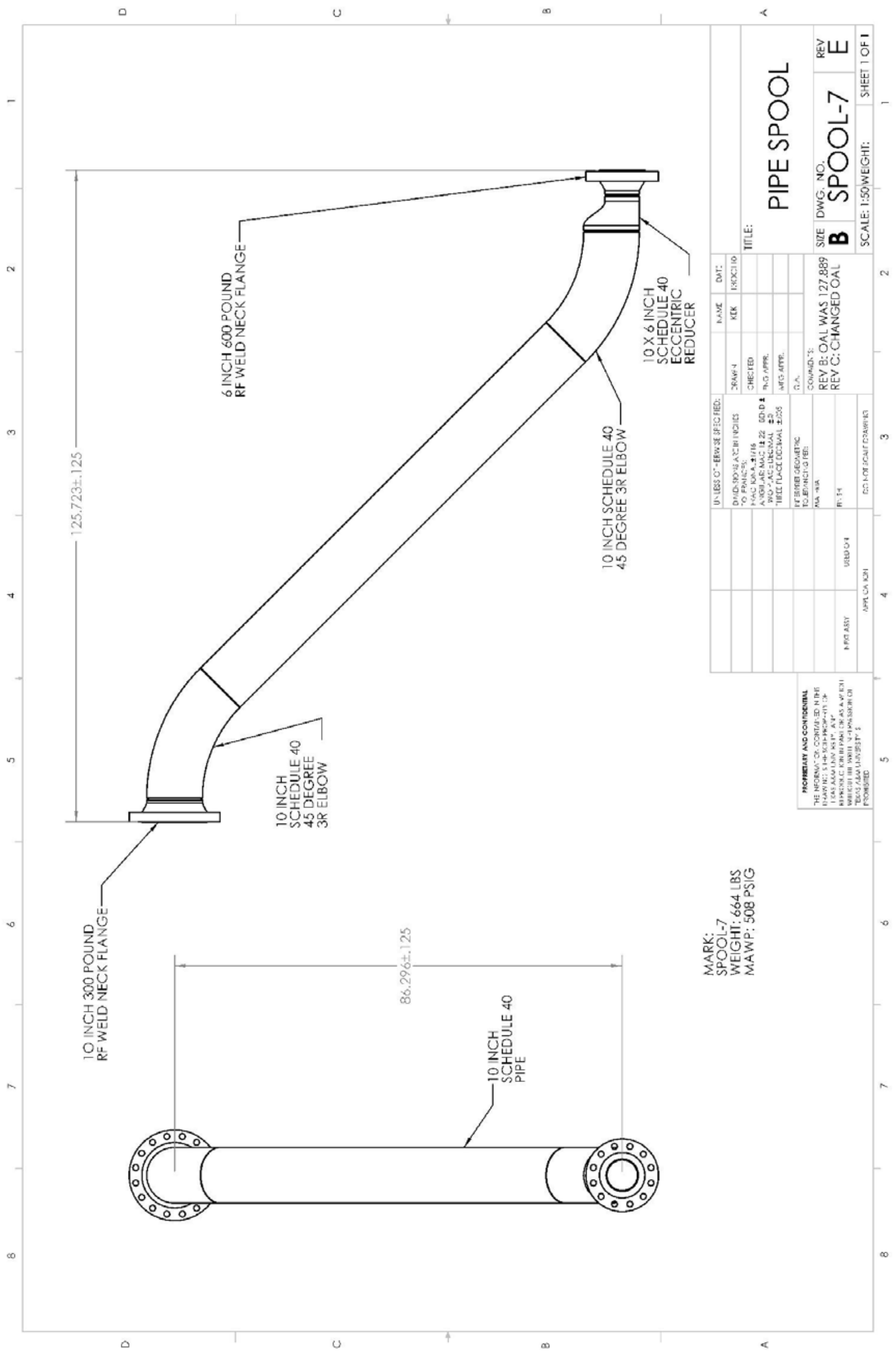
COMMENTS:
REV -: WAS 103.484 OAL
REV A: CHANGED OAL
REV B: CHANGED OAL
REV C: CHANGED OAL

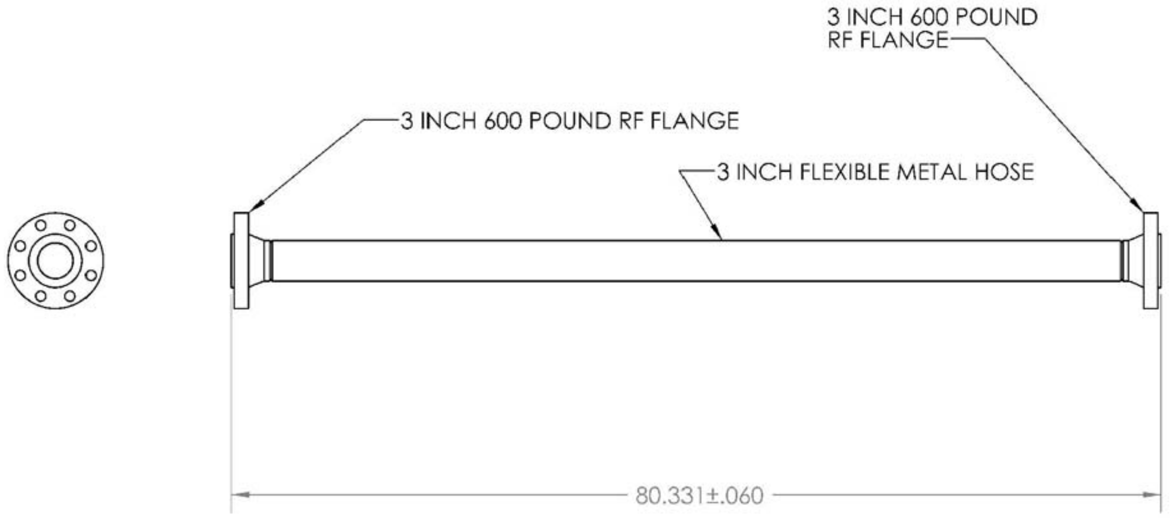
TITLE:

PIPE SPOOL

SIZE A
DWG. NO. SPOOL-6
REV E
SCALE: 1:33.3
WEIGHT:
SHEET 1 OF 1

5 4 3 2 1


6 INCH 600 POUND RF WELD NECK FLANGE
125.723±.125
10 X 6 INCH SCHEDULE 40 ECCENTRIC REDUCER
10 INCH SCHEDULE 40 45 DEGREE 3R ELBOW
10 INCH SCHEDULE 40 45 DEGREE 3R ELBOW
10 INCH 300 POUND RF WELD NECK FLANGE
86.296±.125
10 INCH SCHEDULE 40 PIPE
MARK: SPOOL-7
WEIGHT: 664 LBS
MAWP: 508 PSIG
PROPRIETARY AND CONFIDENTIAL
UNLESS OTHERWISE SPECIFIED:
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
KEK
REV B: OAL WAS 127.889
REV C: CHANGED OAL
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
TITLE:
PIPE SPOOL
SIZE
B
DWG. NO.
SPOOL-7
REV
E
SCALE: 1:50
WEIGHT:
SHEET 1 OF 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.

NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	13OCT10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

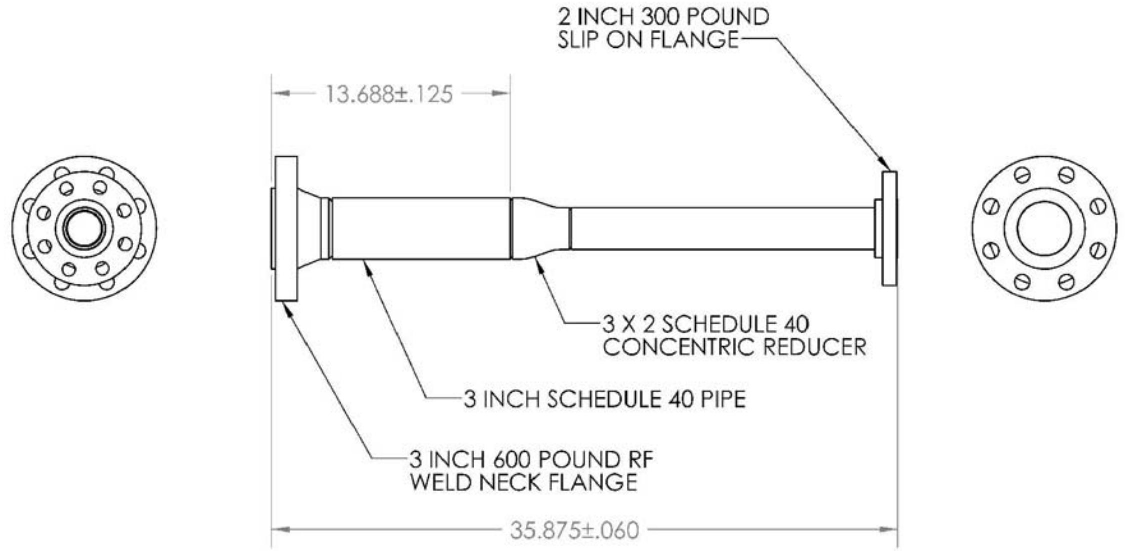
TITLE:

PIPE SPOOL

SIZE A | DWG. NO. SPOOL-8 | REV A

SCALE: 1:20 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



MARK:
WEIGHT: 38 LBS
MAWP: 507 PSIG

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	13OCT10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

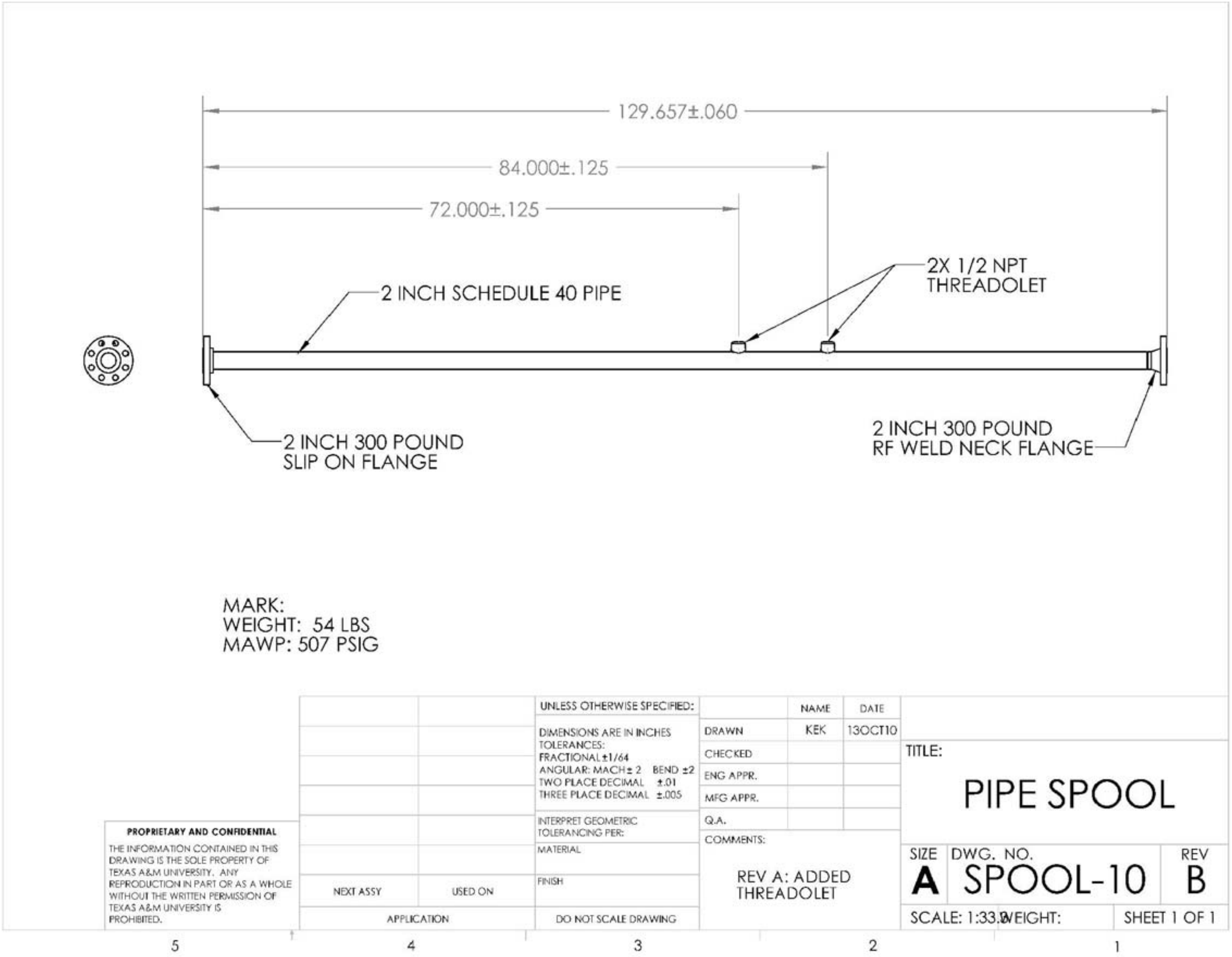
TITLE:

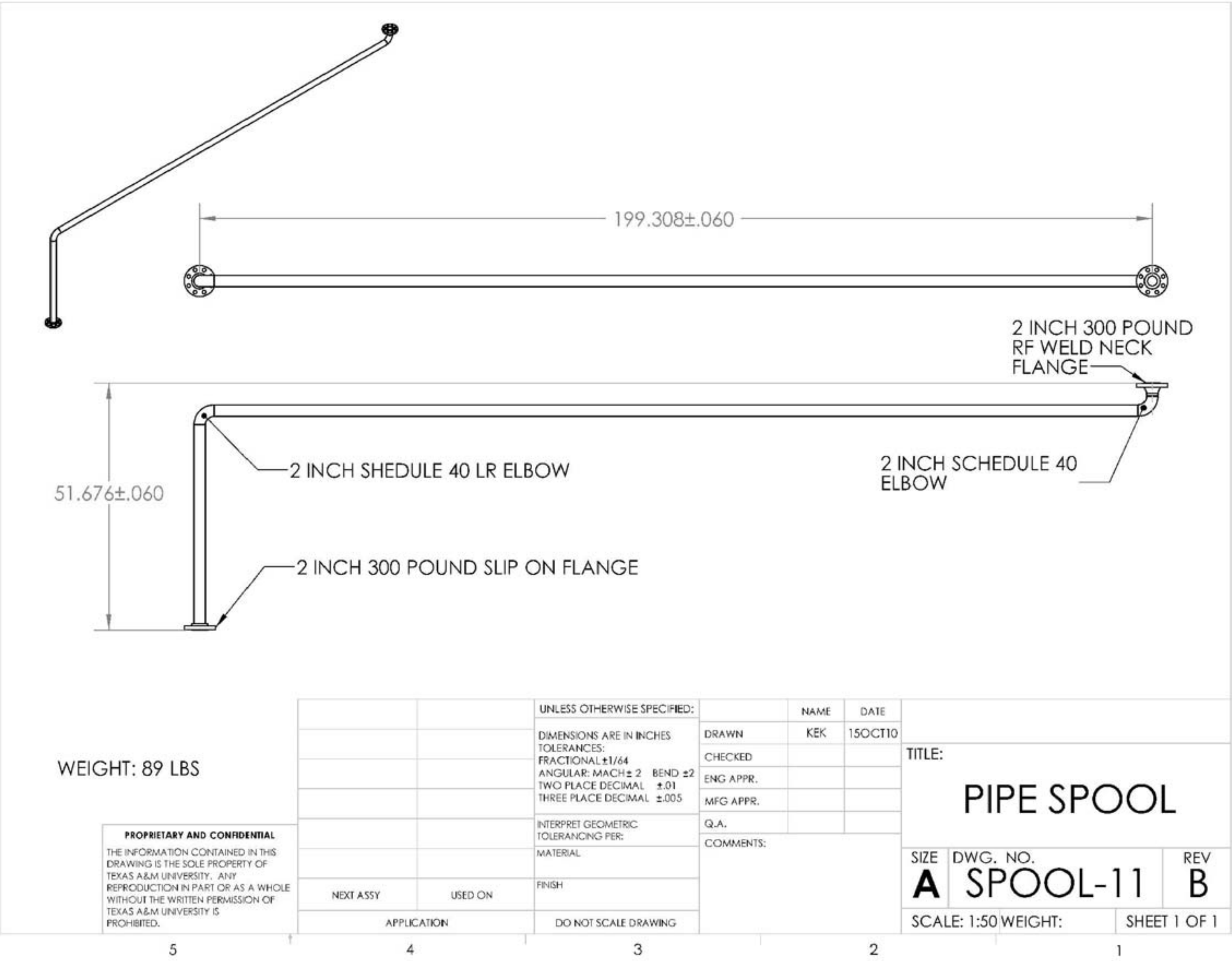
PIPE SPOOL

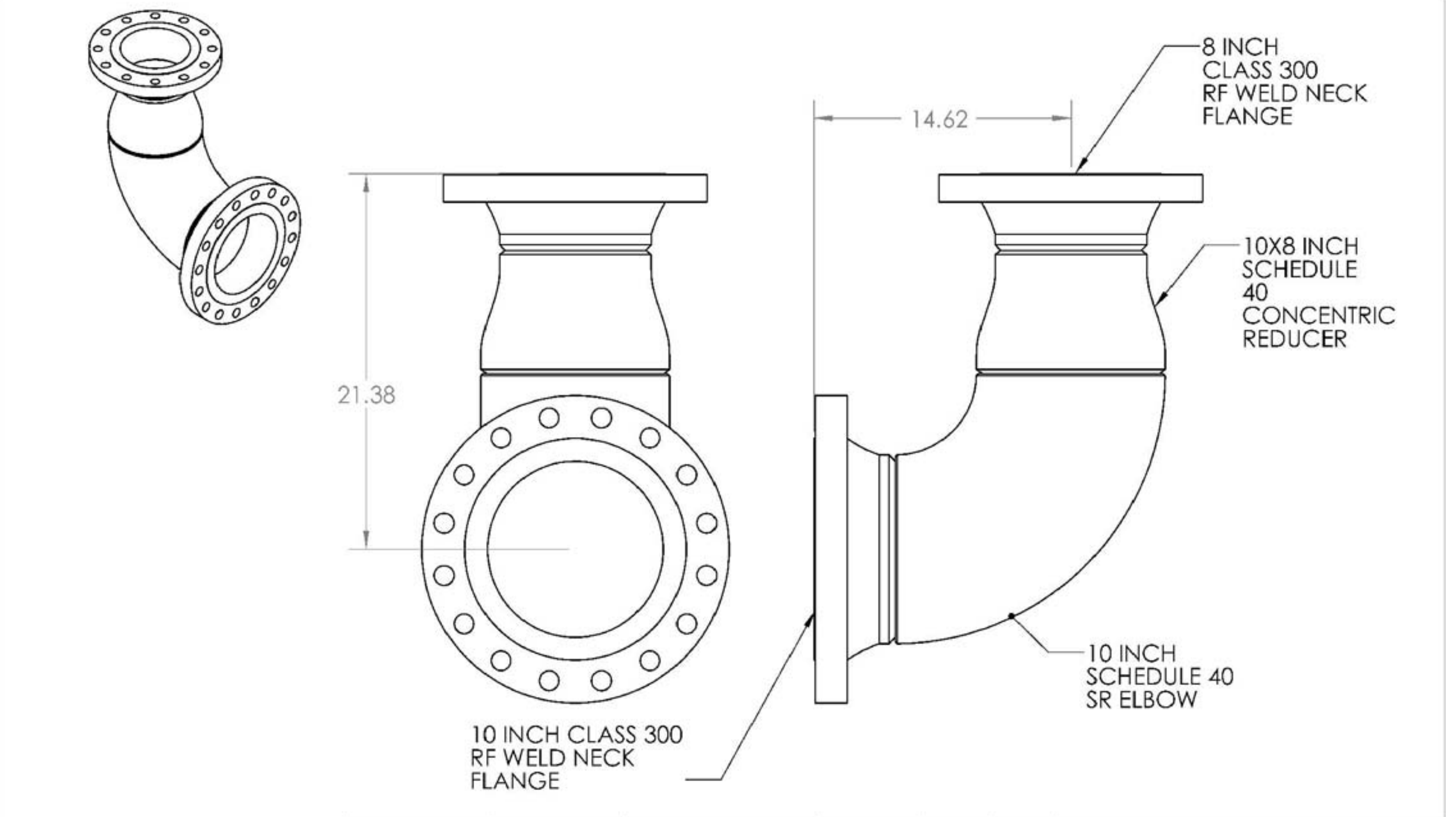
SIZE	DWG. NO.	REV
A	SPOOL-9	-

SCALE: 1:10 WEIGHT: SHEET 1 OF 1

5 4 3 2 1


129.657±.060
84.000±.125
72.000±.125
2X 1/2 NPT THREADOLET
2 INCH SCHEDULE 40 PIPE
2 INCH 300 POUND SLIP ON FLANGE
2 INCH 300 POUND RF WELD NECK FLANGE
MARK:
WEIGHT: 54 LBS
MAWP: 507 PSIG
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
13OCT10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
REV A: ADDED THREADOLET
TITLE:
PIPE SPOOL
SIZE
A
DWG. NO.
SPOOL-10
REV
B
SCALE: 1:33.3
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1


199.308±.060
2 INCH 300 POUND
RF WELD NECK
FLANGE
2 INCH SHEDULE 40 LR ELBOW
2 INCH SCHEDULE 40
ELBOW
51.676±.060
2 INCH 300 POUND SLIP ON FLANGE
WEIGHT: 89 LBS
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
15OCT10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
PIPE SPOOL
SIZE
A
DWG. NO.
SPOOL-11
REV
B
SCALE: 1:50
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	6DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

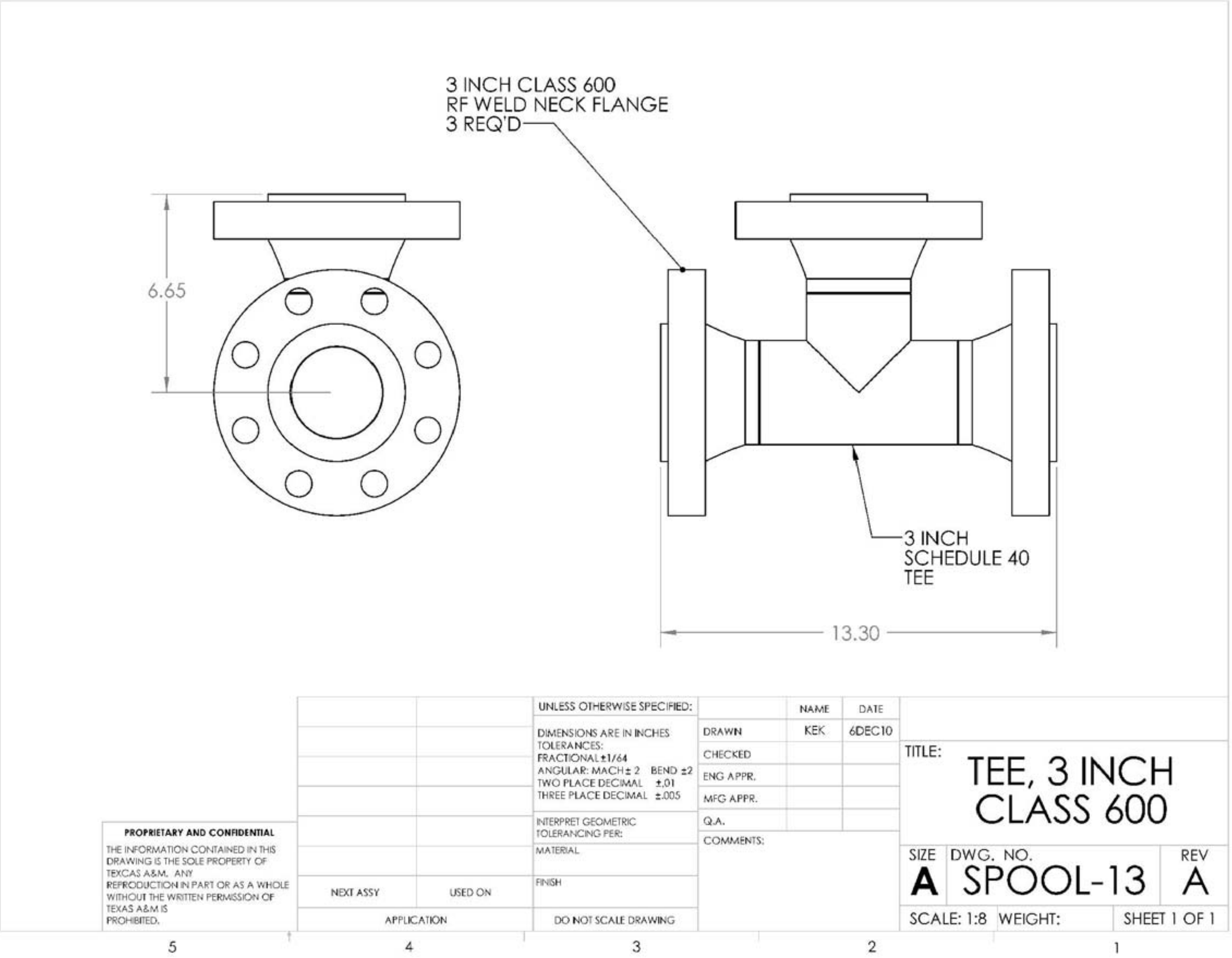
TITLE:

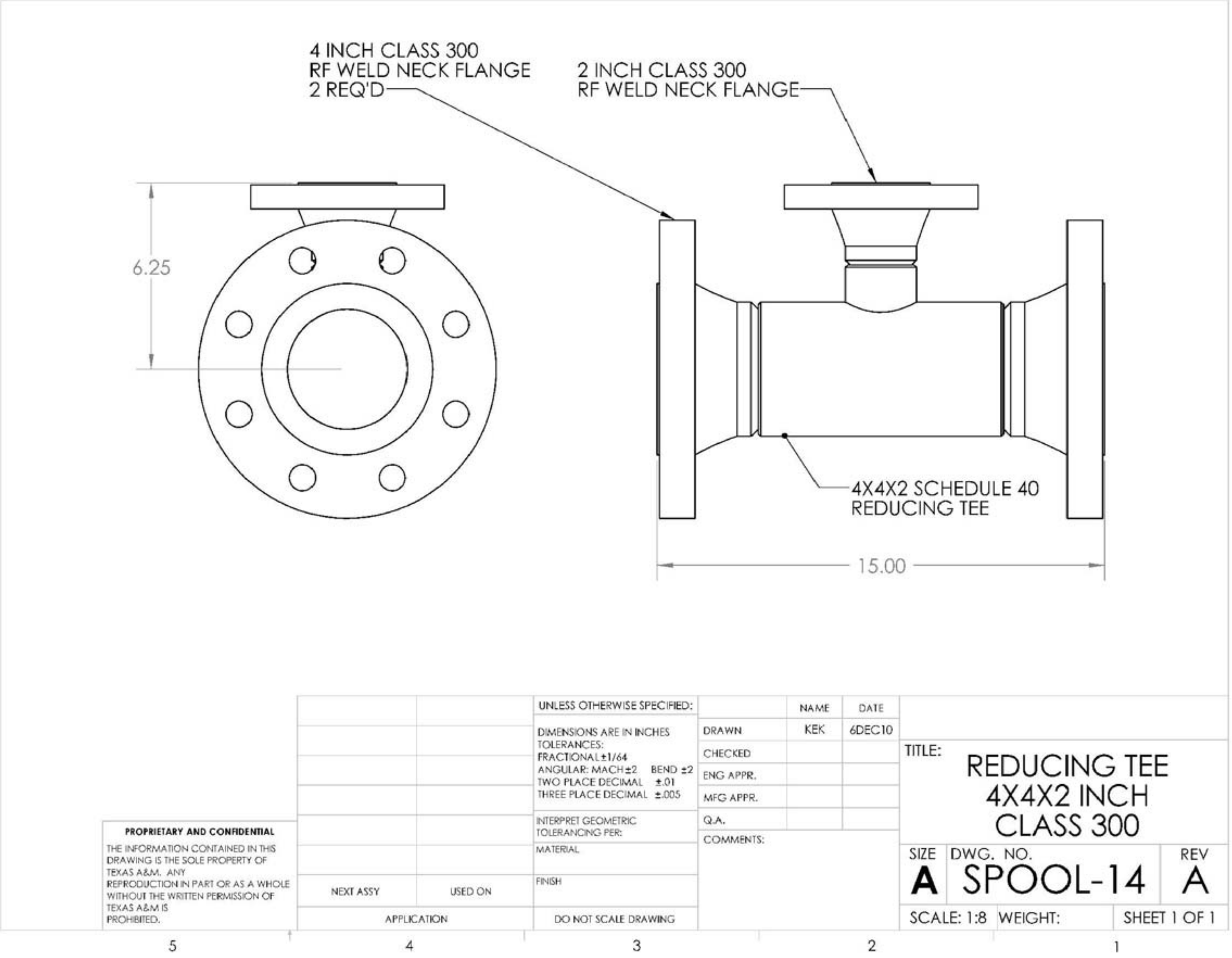
REDUCING ELBOW
10X8 300LB

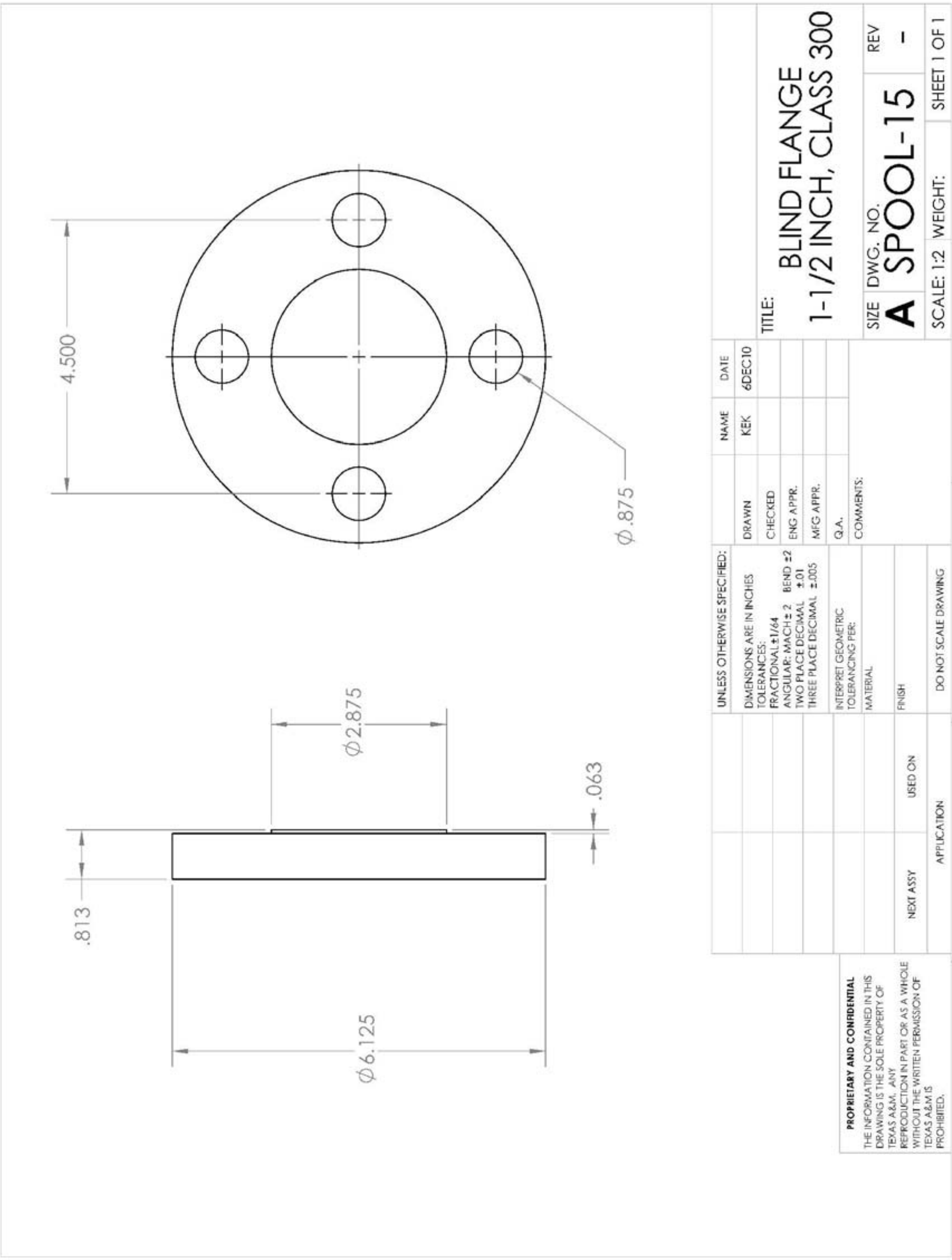
SIZE A | DWG. NO. SPOOL-12 | REV A

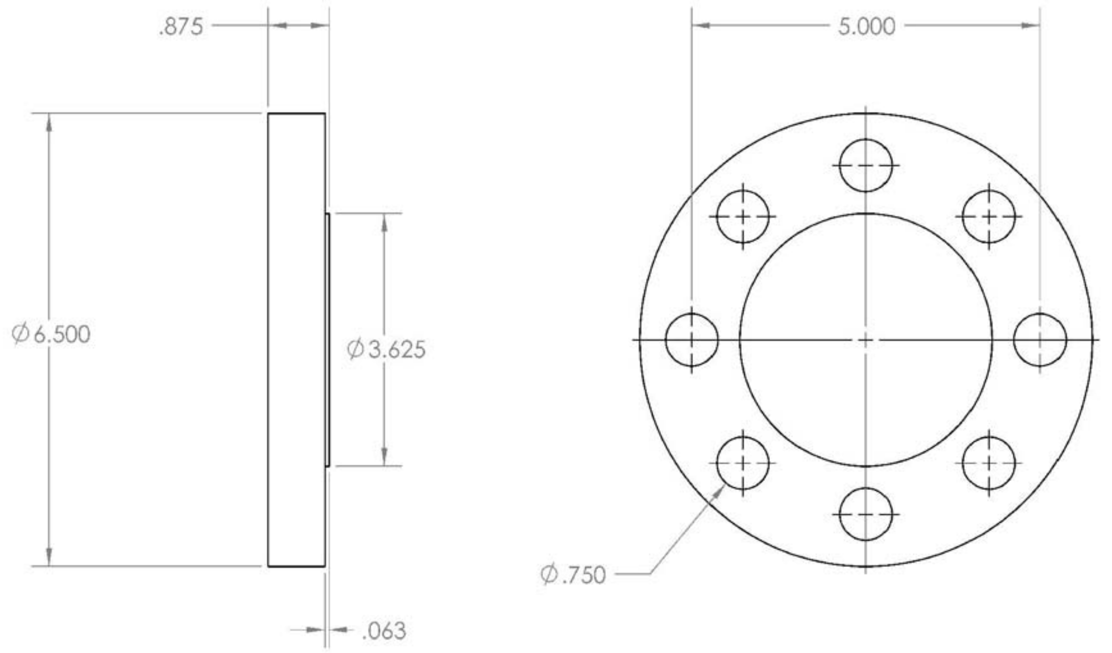
SCALE: 1:12 WEIGHT: | SHEET 1 OF 1

5 4 3 2 1


3 INCH CLASS 600
RF WELD NECK FLANGE
3 REQ'D
6.65
3 INCH
SCHEDULE 40
TEE
13.30
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXCAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
6DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
TEE, 3 INCH
CLASS 600
SIZE
A
DWG. NO.
SPOOL-13
REV
A
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1


4 INCH CLASS 300
RF WELD NECK FLANGE
2 REQ'D
2 INCH CLASS 300
RF WELD NECK FLANGE
6.25
4X4X2 SCHEDULE 40
REDUCING TEE
15.00
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
6DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
REDUCING TEE
4X4X2 INCH
CLASS 300
SIZE
A
DWG. NO.
SPOOL-14
REV
A
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1


4.500
⌀.875
.813
⌀2.875
.063
⌀6.125
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
6DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
BLIND FLANGE
1-1/2 INCH, CLASS 300
SIZE
A
DWG. NO.
SPOOL-15
REV
-
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
1
2
3
4
5



PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

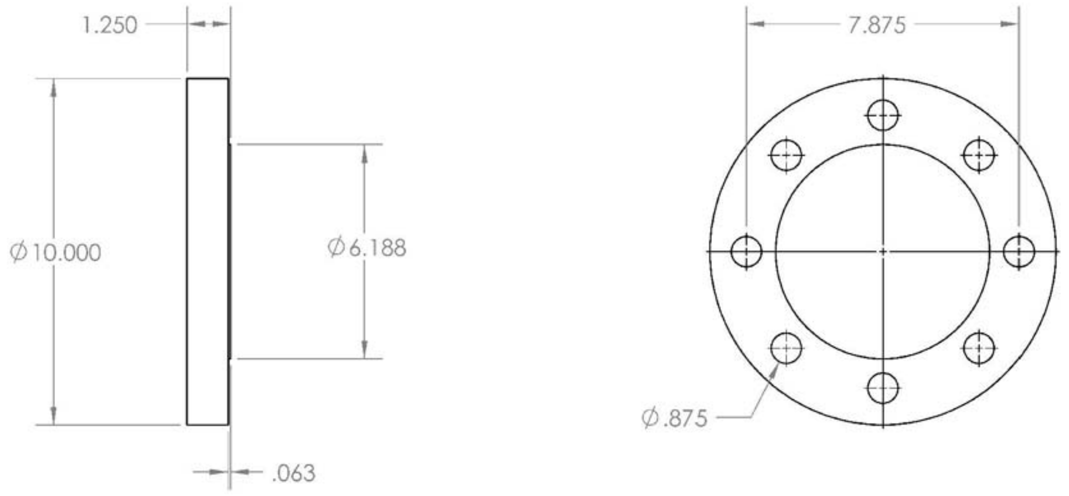
	NAME	DATE
DRAWN	KEK	6DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:
BLIND FLANGE
2 INCH, CLASS 300

SIZE A | DWG. NO. SPOOL-16 | REV -
SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1



2 REQUIRED

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	6DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

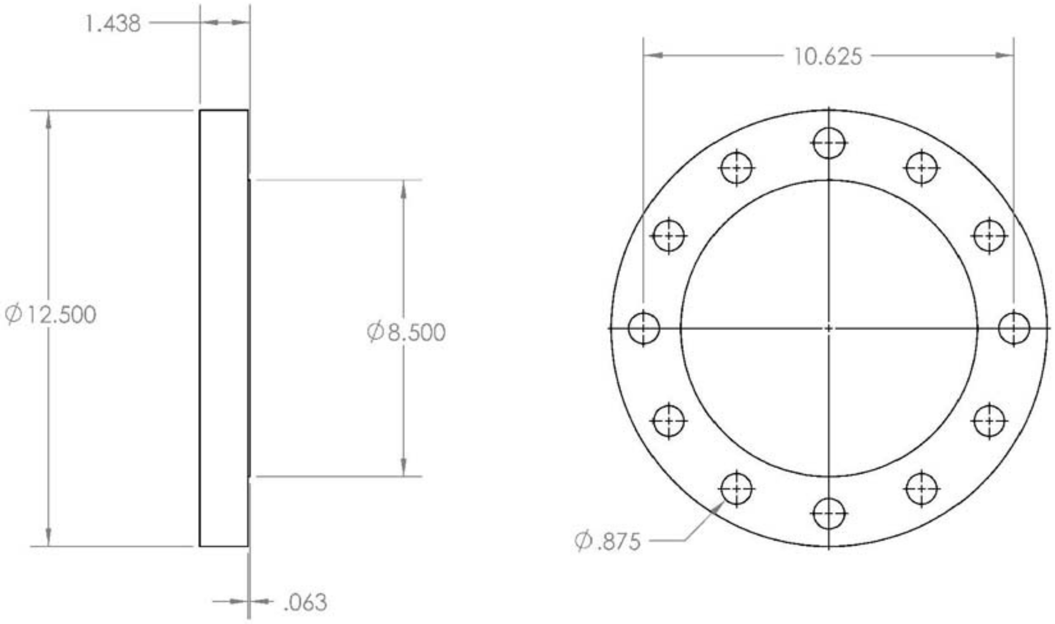
COMMENTS:

TITLE:
BLIND FLANGE
4 INCH, CLASS 300

SIZE	DWG. NO.	REV
A	SPOOL-17	-

SCALE: 1:4 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

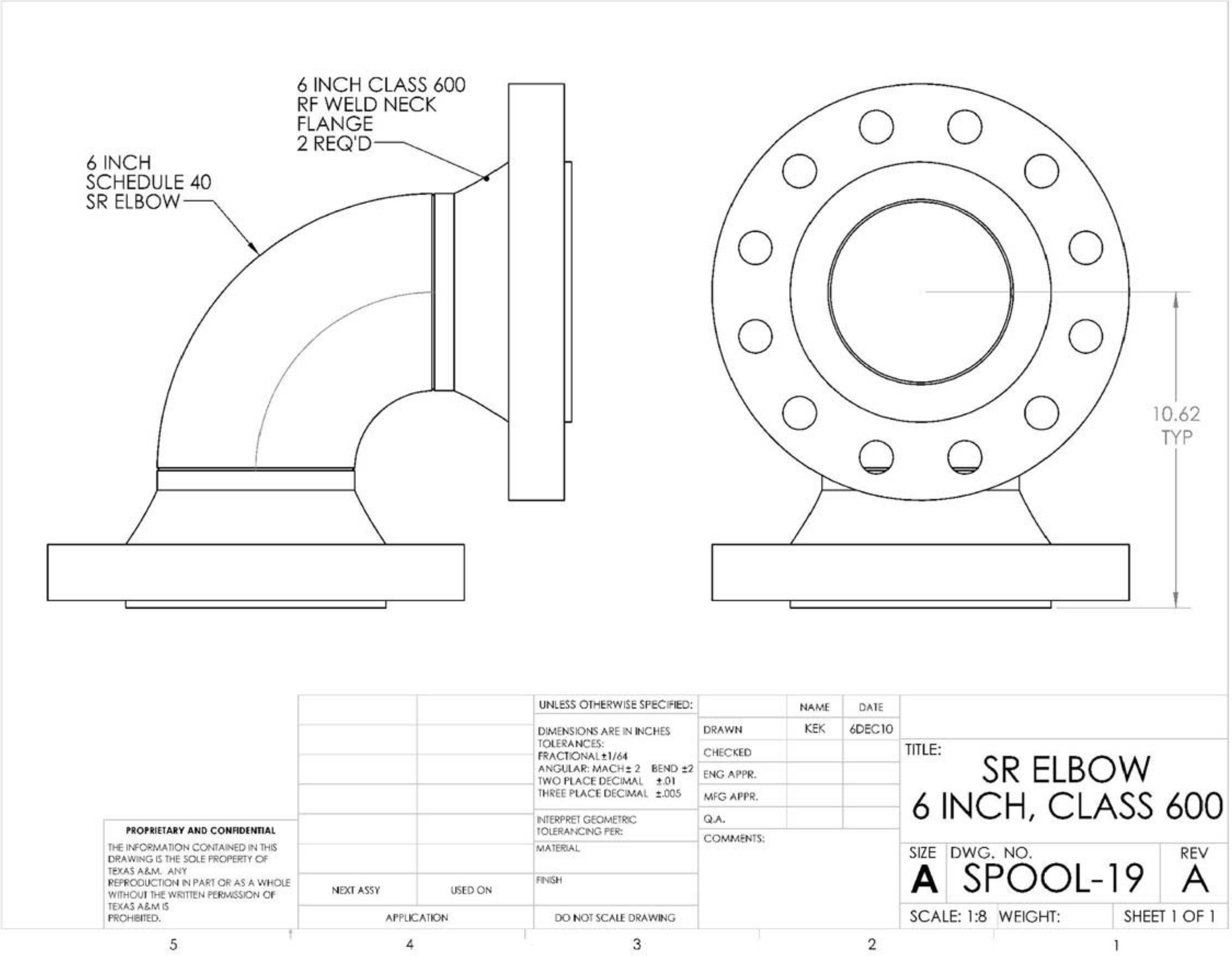
	NAME	DATE
DRAWN	KEK	6DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

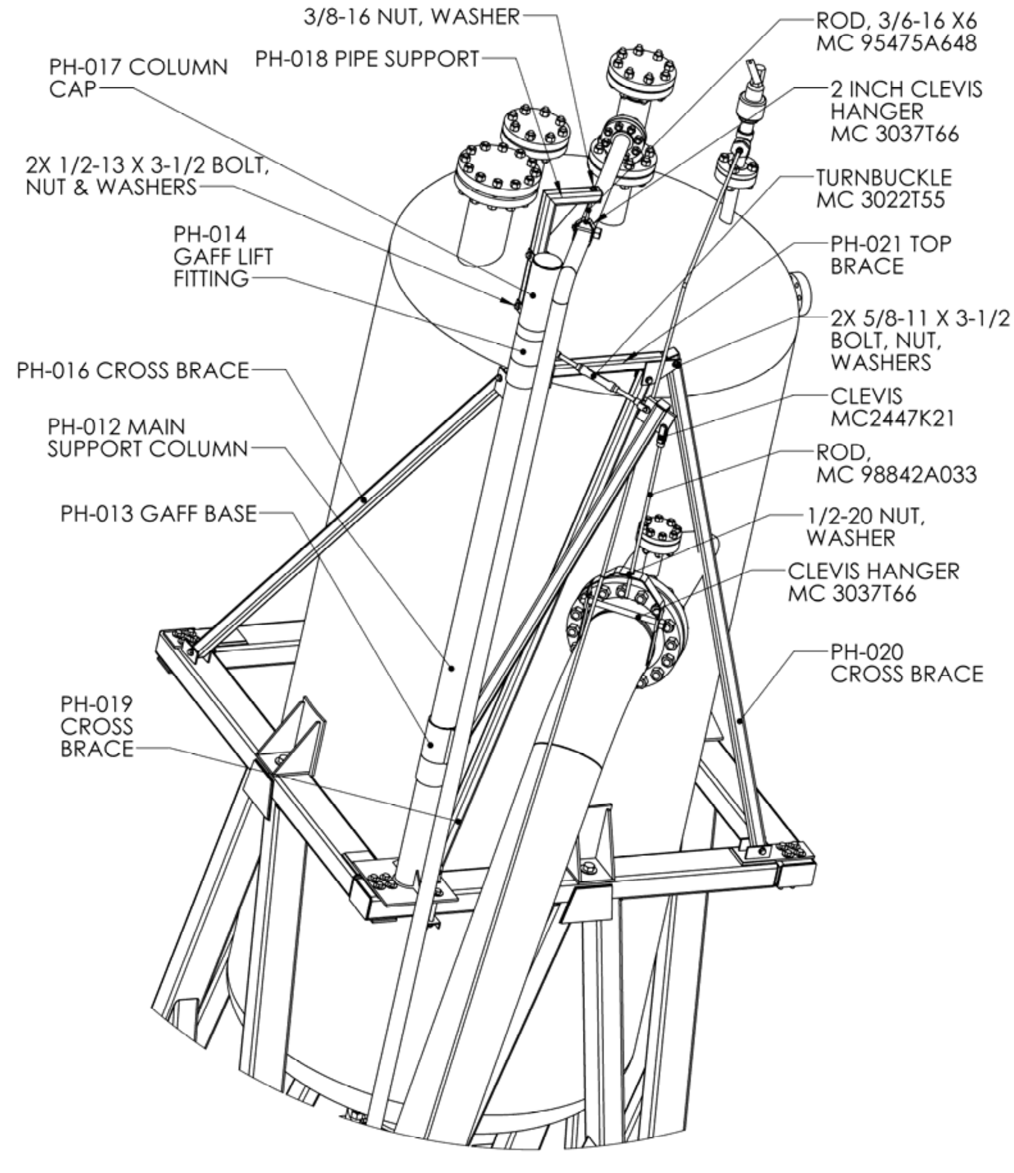
TITLE:
BLIND FLANGE
6 INCH, CLASS 300

SIZE	DWG. NO.	REV
A	SPOOL-18	-

SCALE: 1:4 WEIGHT: SHEET 1 OF 1

5 4 3 2 1


6 INCH CLASS 600
RF WELD NECK
FLANGE
2 REQ'D
6 INCH
SCHEDULE 40
SR ELBOW
10.62
TYP
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC
TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
NAME
DATE
DRAWN
KEK
6DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
SR ELBOW
6 INCH, CLASS 600
SIZE
A
DWG. NO.
SPOOL-19
REV
A
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
5
4
3
2
1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

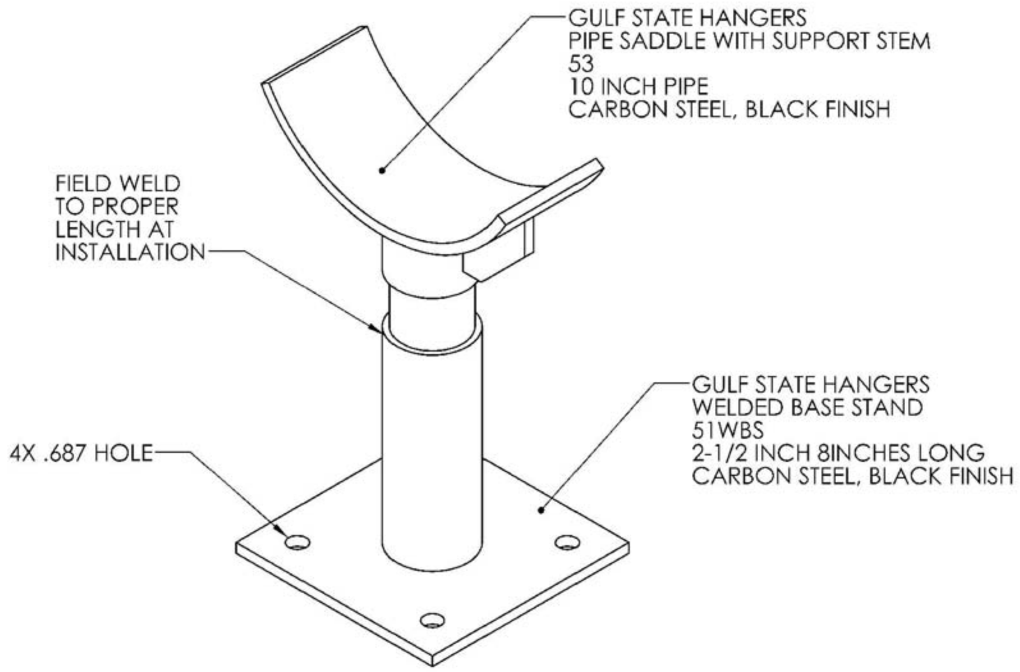
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	2FEB11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

PIPE SUPPORT ASSEMBLY

SIZE A
DWG. NO. PHA-100
REV. A
SCALE:1:192
WEIGHT:
SHEET 1 OF 2



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TE3XAS A&M>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC
TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	26JAN11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

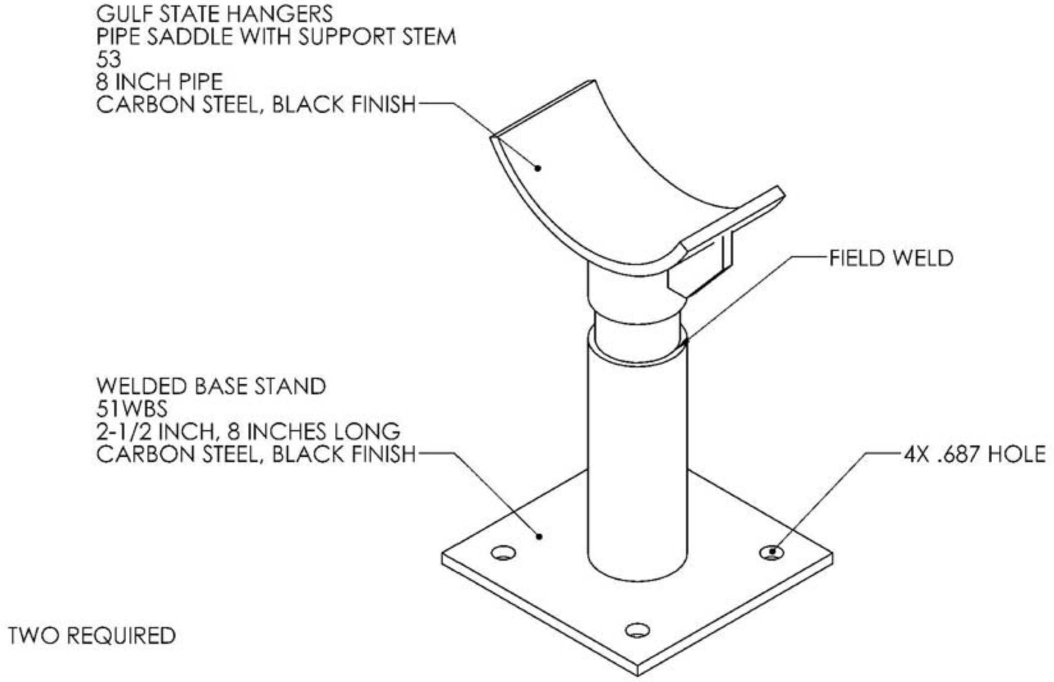
TITLE:

PIPE SUPPORT
SPOOL 12

SIZE A DWG. NO. PHA-001 REV -

SCALE: 1:8 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



PROPRIETARY AND CONFIDENTIAL

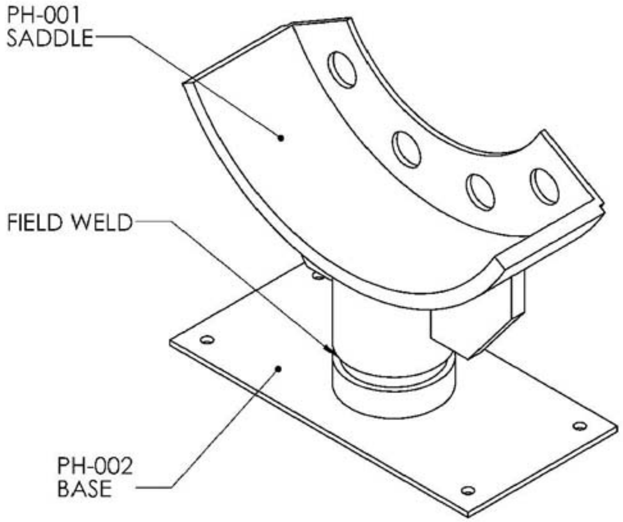
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/64 ANGULAR: MACH ±2 BEND ±2 TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005	DRAWN	KEK	26JAN11	
	CHECKED			TITLE:
	ENG APPR.			PIPE SUPPORT SPOOL-1
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL	COMMENTS:			SIZE A DWG. NO. PHA-002 REV -
FINISH				
DO NOT SCALE DRAWING				SCALE: 1:8 WEIGHT: SHEET 1 OF 1

NEXT ASSY	USED ON
APPLICATION	

5 4 3 2 1

TWO REQUIRED



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	26JAN11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

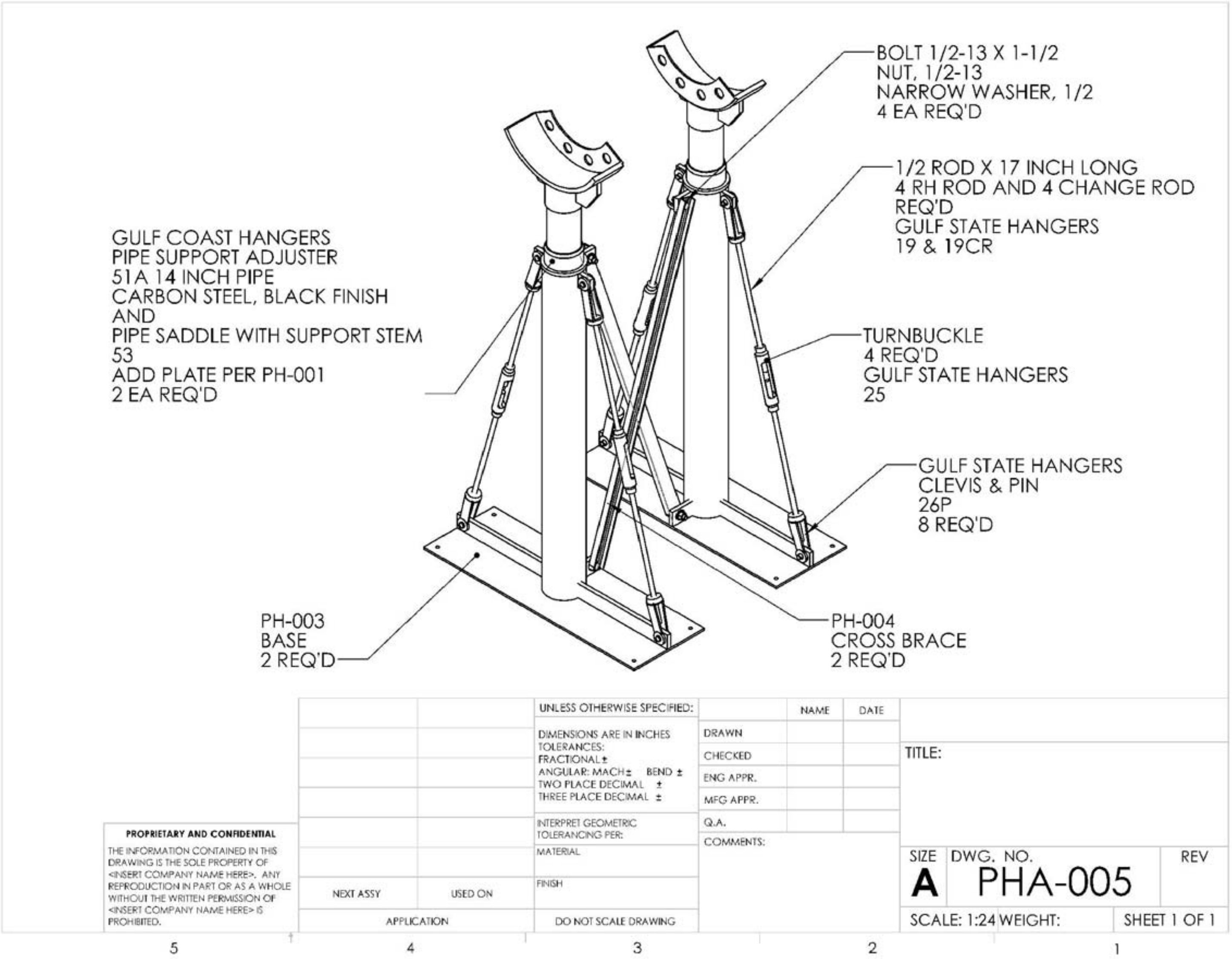
COMMENTS:

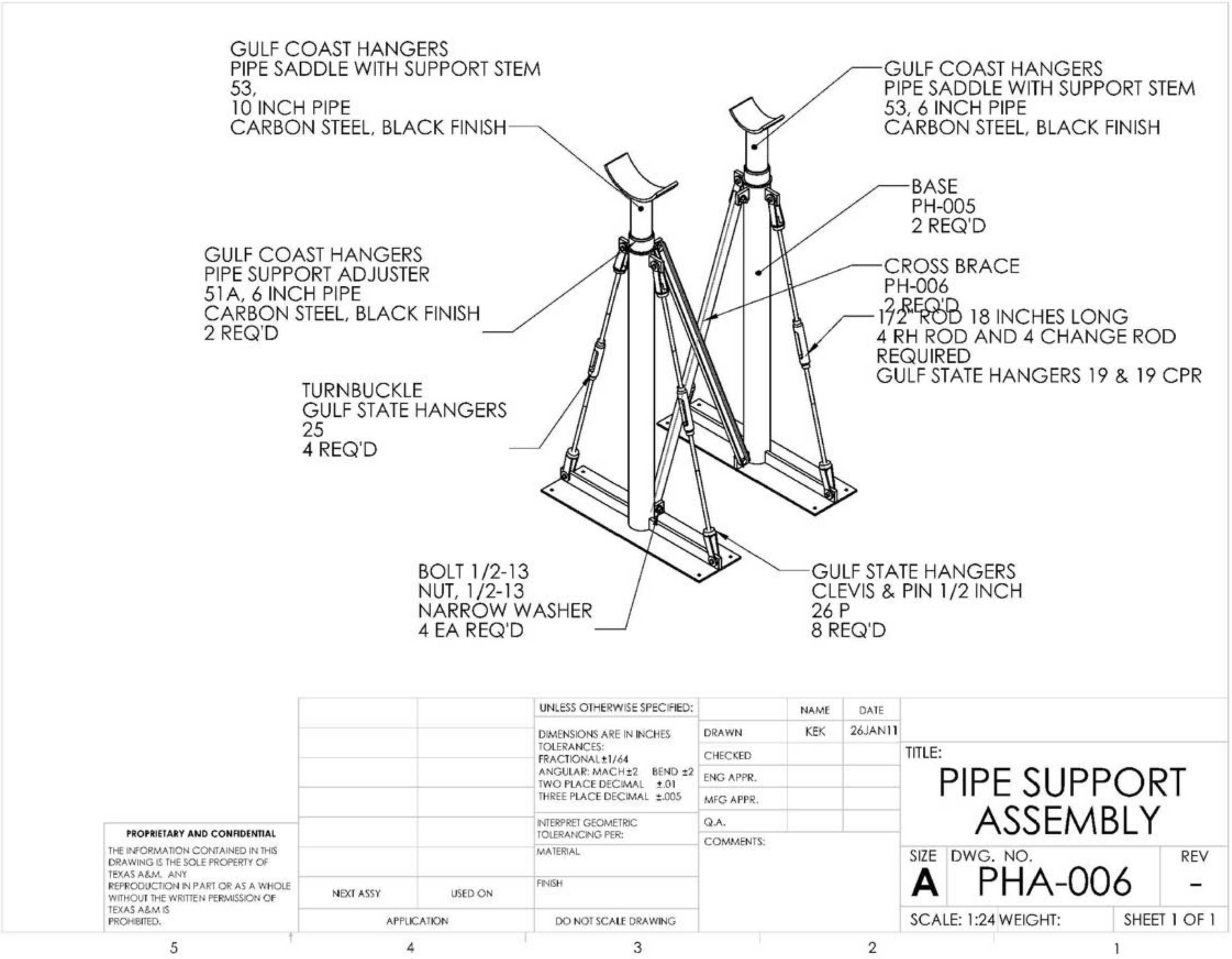
TITLE:
VALVE SUPPORT ASSEMBLY 6" IN

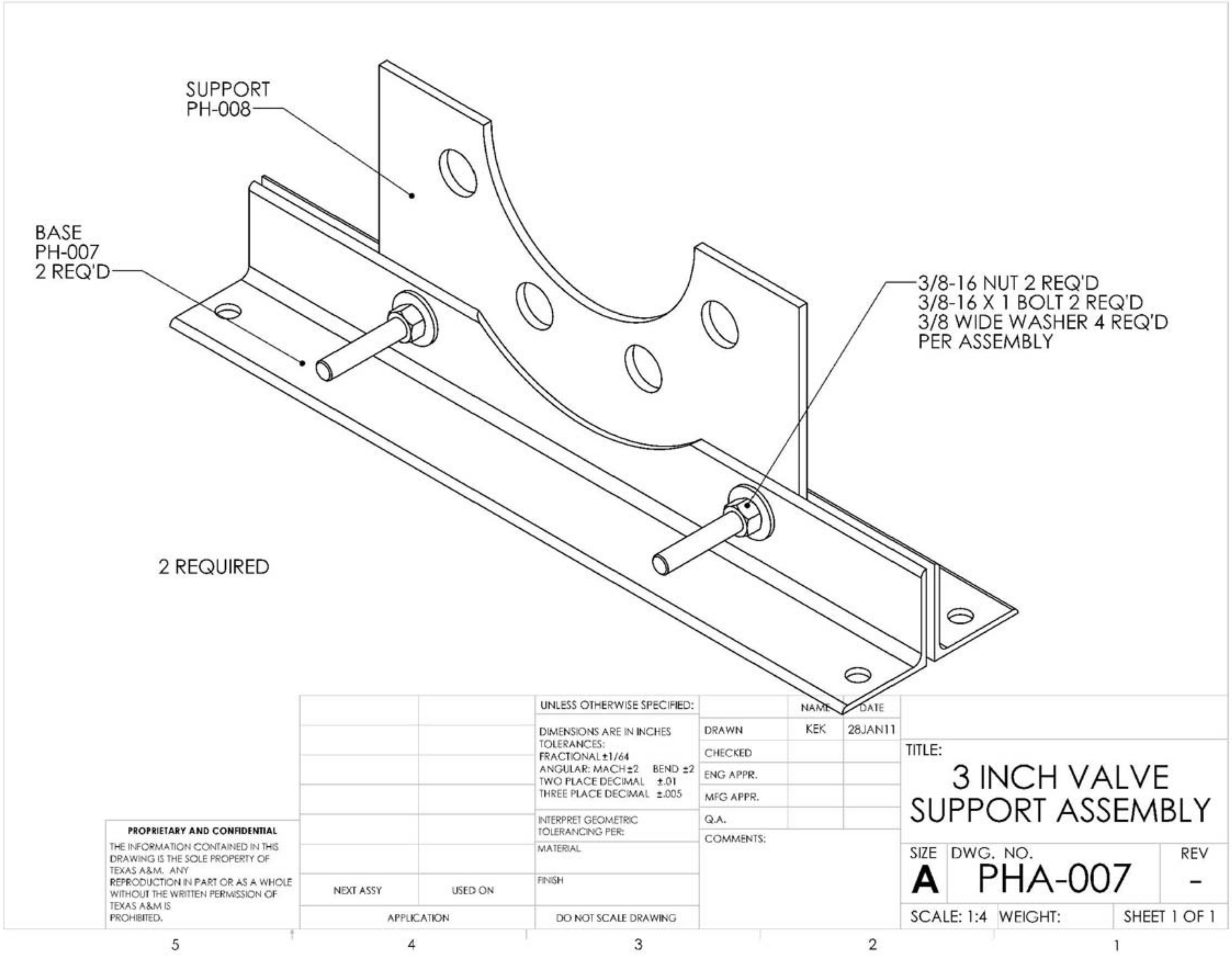
SIZE	DWG. NO.	REV
A	PHA-004	-

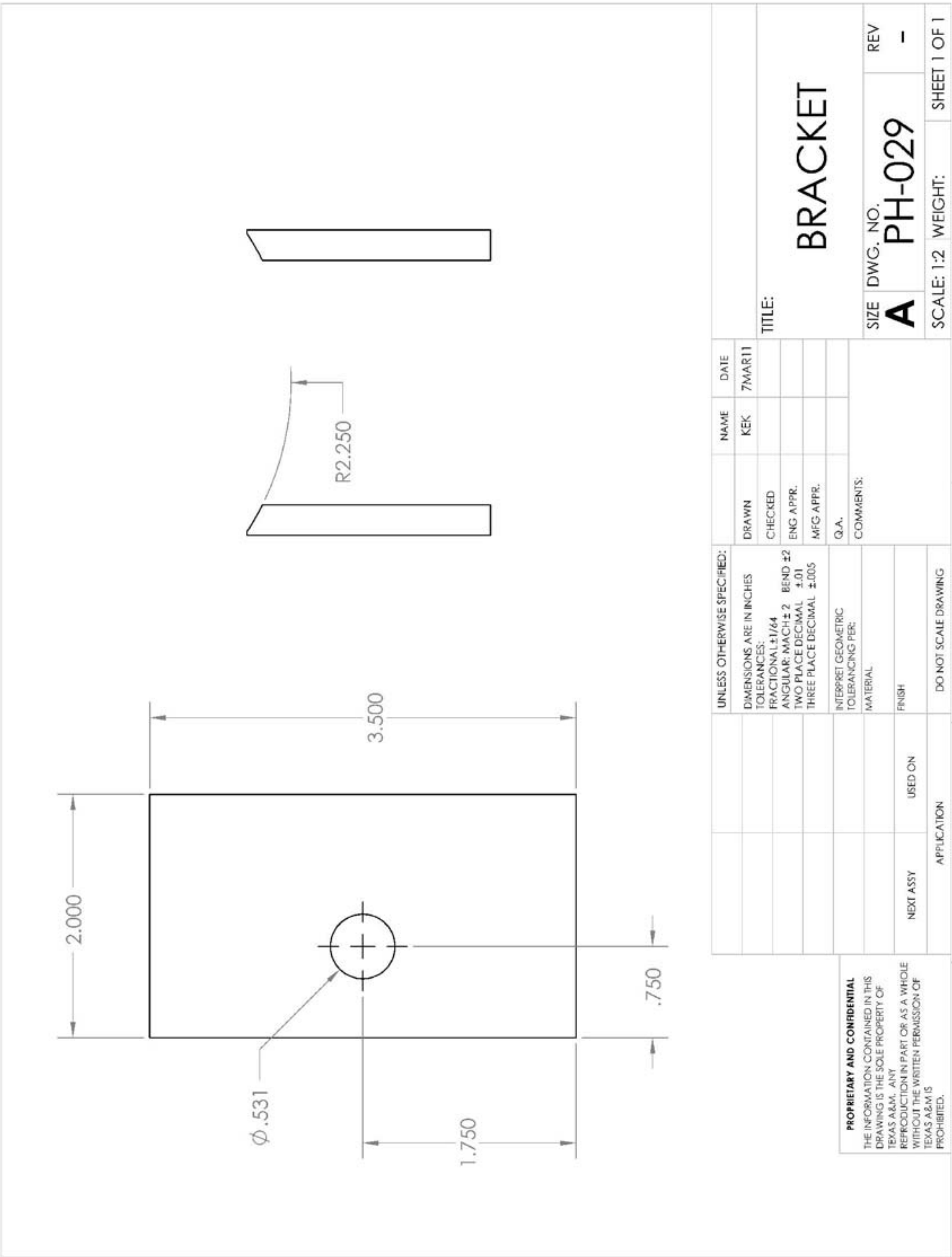
SCALE: 1:4 WEIGHT: SHEET 1 OF 1

5 4 3 2 1


BOLT 1/2-13 X 1-1/2
NUT, 1/2-13
NARROW WASHER, 1/2
4 EA REQ'D
1/2 ROD X 17 INCH LONG
4 RH ROD AND 4 CHANGE ROD
REQ'D
GULF STATE HANGERS
19 & 19CR
GULF COAST HANGERS
PIPE SUPPORT ADJUSTER
51A 14 INCH PIPE
CARBON STEEL, BLACK FINISH
AND
PIPE SADDLE WITH SUPPORT STEM
53
ADD PLATE PER PH-001
2 EA REQ'D
TURNBUCKLE
4 REQ'D
GULF STATE HANGERS
25
GULF STATE HANGERS
CLEVIS & PIN
26P
8 REQ'D
PH-003
BASE
2 REQ'D
PH-004
CROSS BRACE
2 REQ'D
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
SIZE
A
DWG. NO.
PHA-005
REV
SCALE: 1:24
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1


GULF COAST HANGERS
PIPE SADDLE WITH SUPPORT STEM
53,
10 INCH PIPE
CARBON STEEL, BLACK FINISH
GULF COAST HANGERS
PIPE SADDLE WITH SUPPORT STEM
53, 6 INCH PIPE
CARBON STEEL, BLACK FINISH
BASE
PH-005
2 REQ'D
GULF COAST HANGERS
PIPE SUPPORT ADJUSTER
51A, 6 INCH PIPE
CARBON STEEL, BLACK FINISH
2 REQ'D
CROSS BRACE
PH-006
2 REQ'D
1/2" ROD 18 INCHES LONG
4 RH ROD AND 4 CHANGE ROD
REQUIRED
GULF STATE HANGERS 19 & 19 CPR
TURNBUCKLE
GULF STATE HANGERS
25
4 REQ'D
BOLT 1/2-13
NUT, 1/2-13
NARROW WASHER
4 EA REQ'D
GULF STATE HANGERS
CLEVIS & PIN 1/2 INCH
26 P
8 REQ'D
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
26JAN11
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
TITLE:
PIPE SUPPORT ASSEMBLY
SIZE
A
DWG. NO.
PHA-006
REV
-
SCALE: 1:24
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1


SUPPORT
PH-008
BASE
PH-007
2 REQ'D
3/8-16 NUT 2 REQ'D
3/8-16 X 1 BOLT 2 REQ'D
3/8 WIDE WASHER 4 REQ'D
PER ASSEMBLY
2 REQUIRED
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
28JAN11
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
3 INCH VALVE SUPPORT ASSEMBLY
SIZE
A
DWG. NO.
PHA-007
REV
-
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

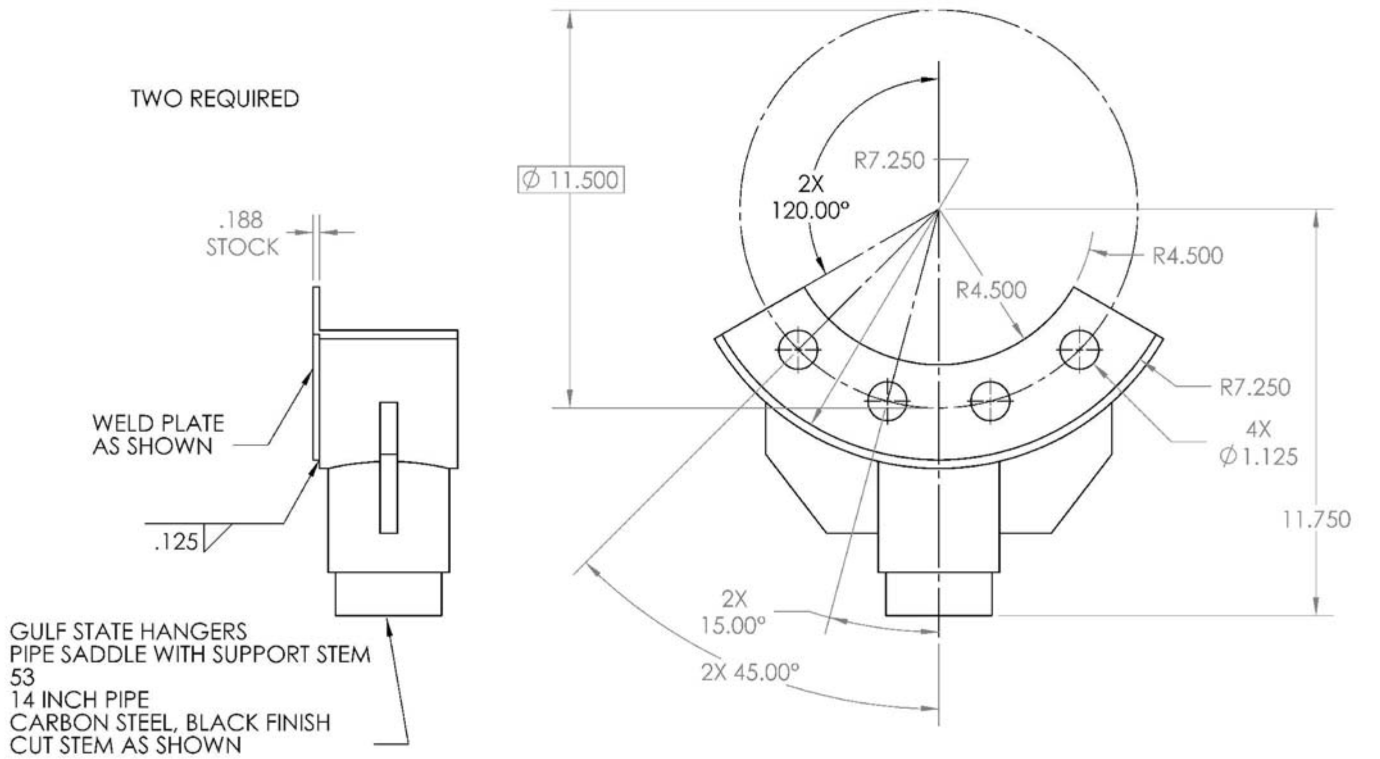
	NAME	DATE
DRAWN	KEK	7MAR11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:
BRACKET

SIZE A
DWG. NO. PH-029
REV –
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1

NEXT ASSY
USED ON
APPLICATION

PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	26JAN11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

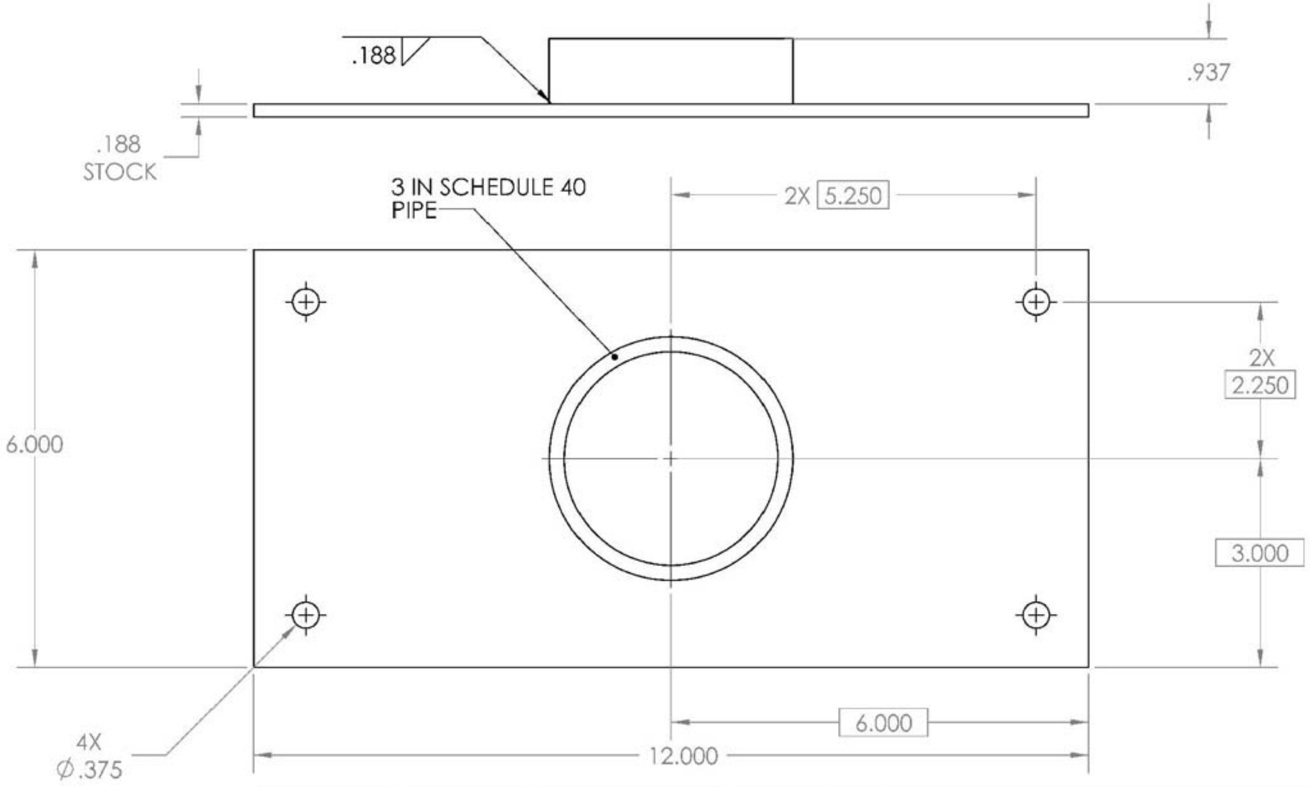
COMMENTS:

TITLE:
PIPE SADDLE
INLET 6" VALVE

SIZE	DWG. NO.	REV
A	PH-001	-

SCALE: 1:4 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

NEXT ASSY
USED ON
APPLICATION

	NAME	DATE
DRAWN	KEK	26JAN11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

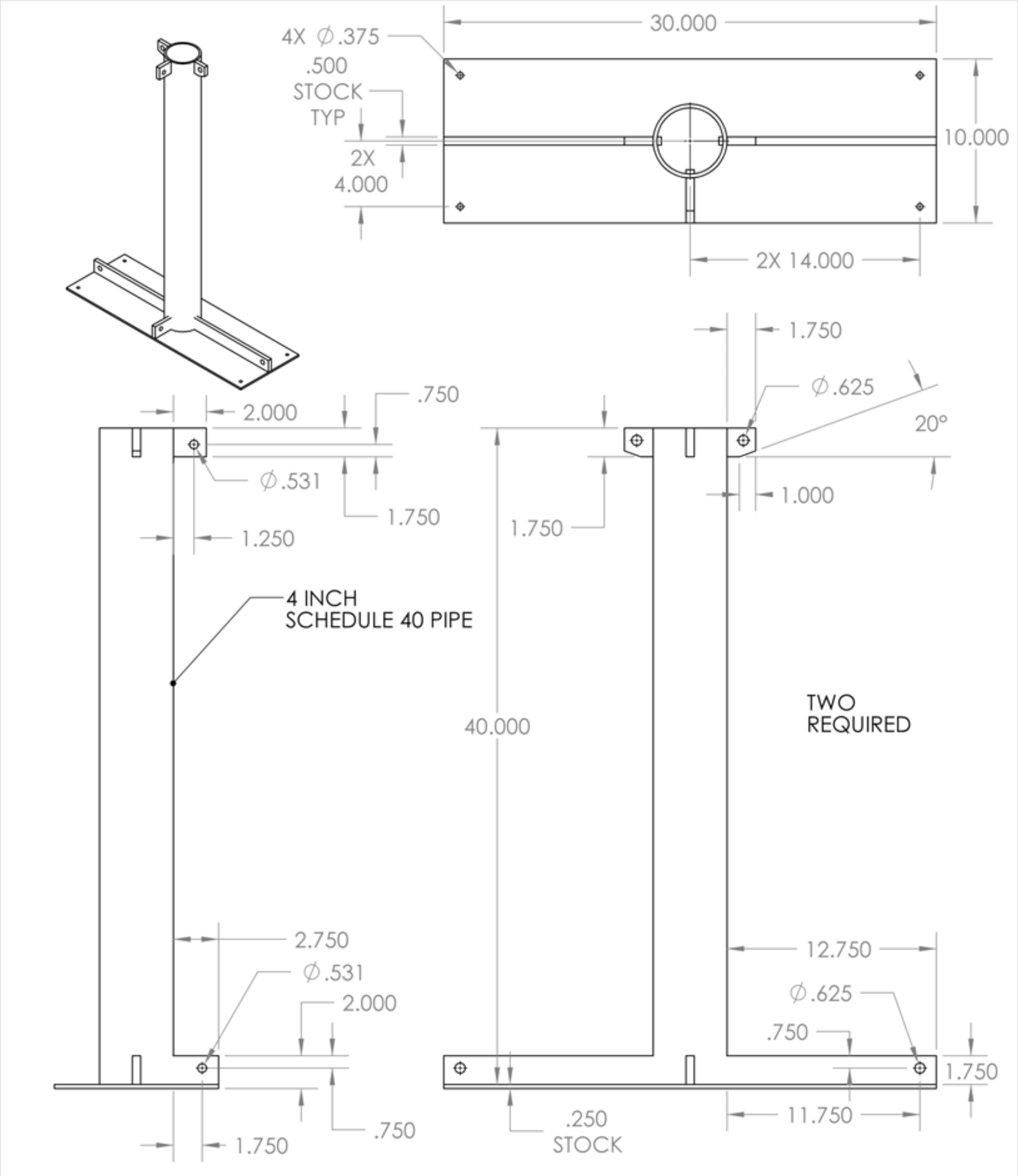
COMMENTS:

TITLE:
BASE
INLET 6" VALVE

SIZE A
DWG. NO. PH-002
REV -
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1

PROPRIETARY AND CONFIDENTIAL

5 4 3 2 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

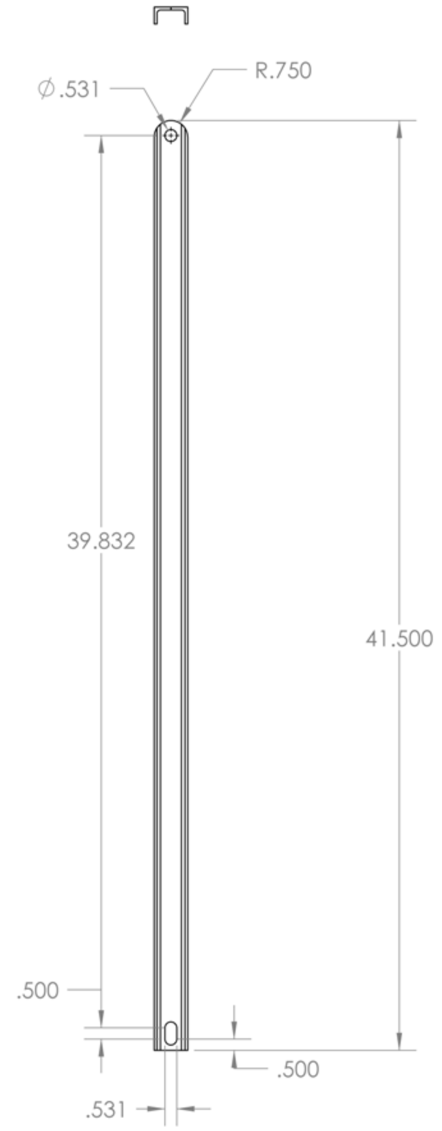
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	26JAN11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

BASE,
OUTLET VALVE

SIZE A
DWG. NO. PH-003
REV. -
SCALE:1:12
WEIGHT:
SHEET 1 OF 1



1.500 X .750 X .125
CHANNEL IRON
A36

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXCAS A&M IS PROHIBITED.

NEXT ASSY	USED ON	
APPLICATION		

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

DO NOT SCALE DRAWING

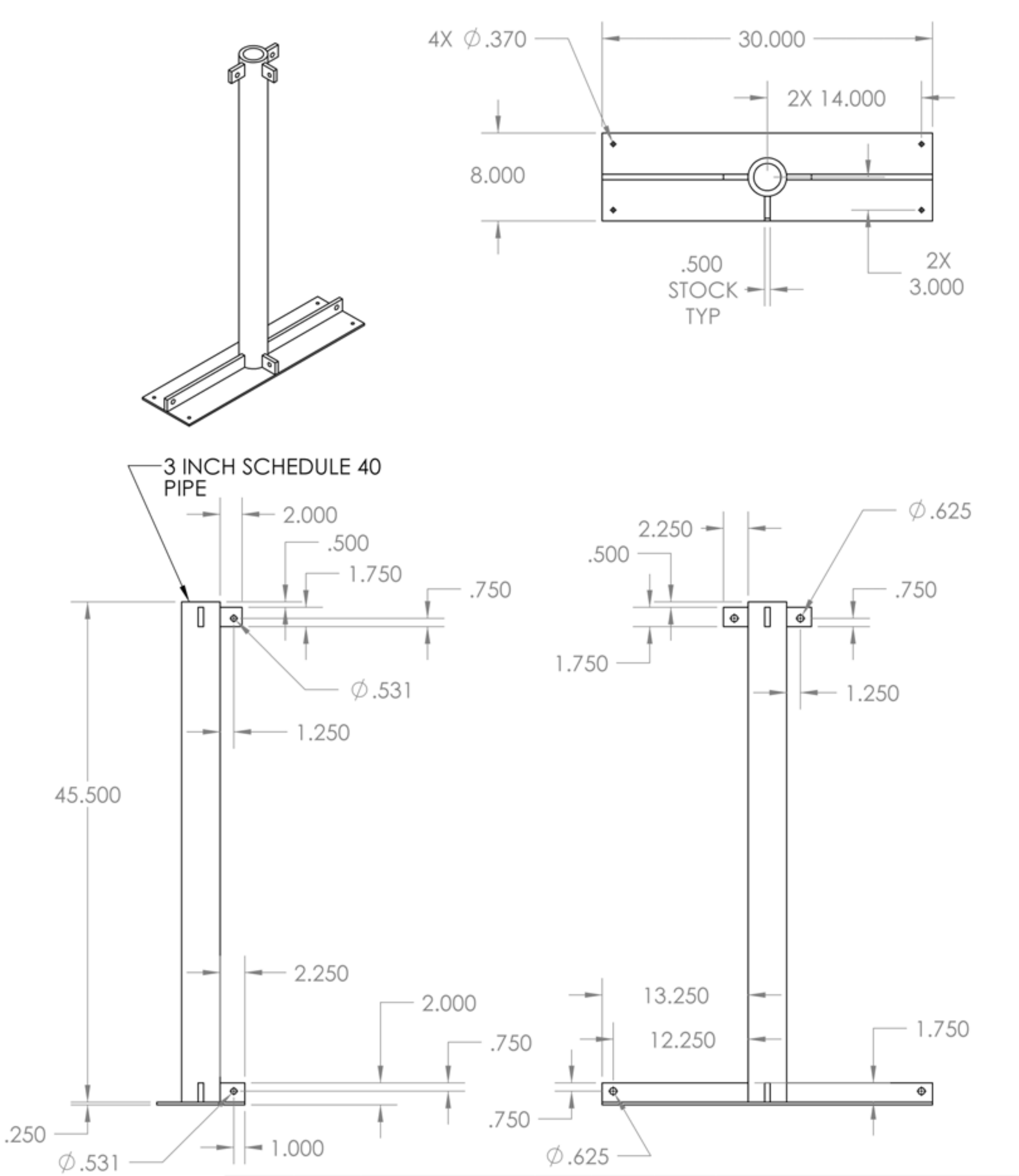
	NAME	DATE
DRAWN	KEK	26JAN11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

CROSS BRACE,
OUTLET VALVE

SIZE	DWG. NO.	REV.
A	PH-004	-

SCALE:1:12 WEIGHT: SHEET 1 OF 1



DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

	NAME	DATE
DRAWN	KEK	26JAN11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

MATERIAL

FINISH

NEXT ASSY | USED ON

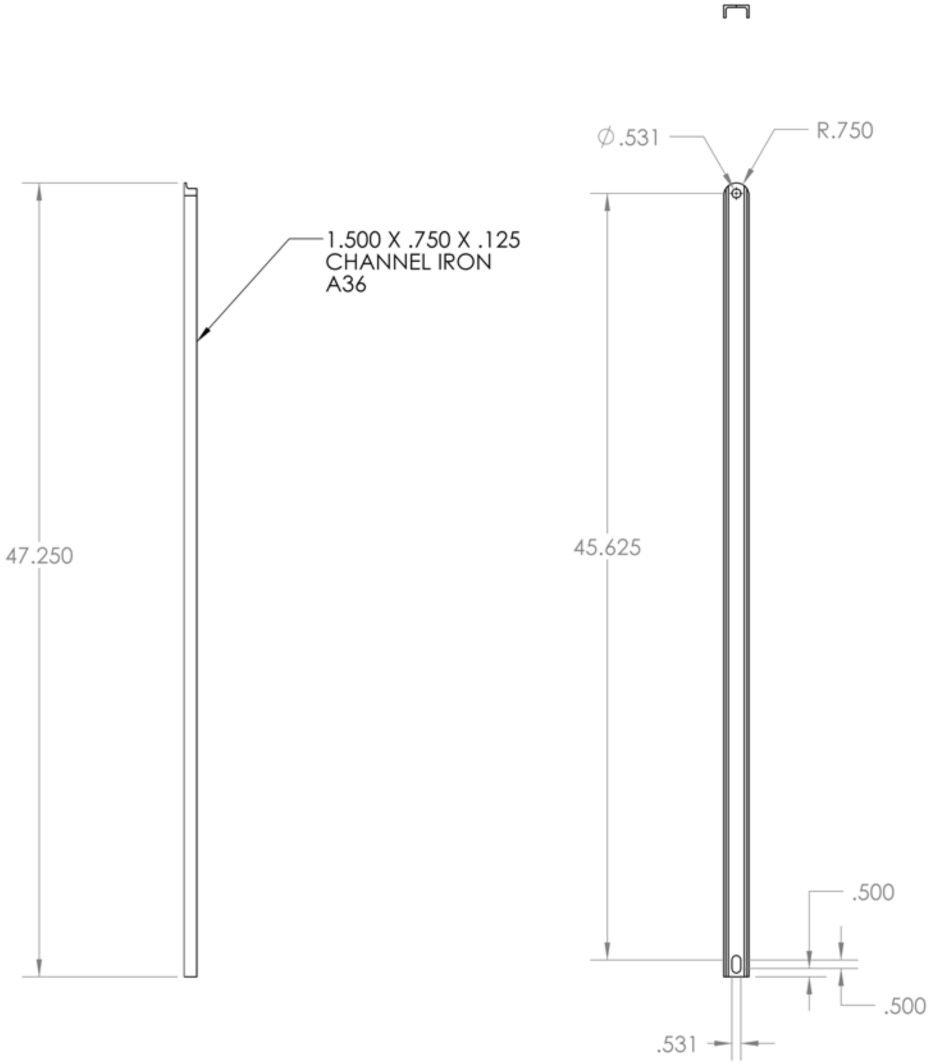
APPLICATION

DO NOT SCALE DRAWING

PROPRIETARY AND CONFIDENTIAL

BASE,
SPOOLS 6&7

SIZE A
DWG. NO. PH-005
REV. -
SCALE:1:12
WEIGHT:
SHEET 1 OF 1



	NAME	DATE
DRAWN	KEK	26JAN11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

NEXT ASSY	USED ON
APPLICATION	

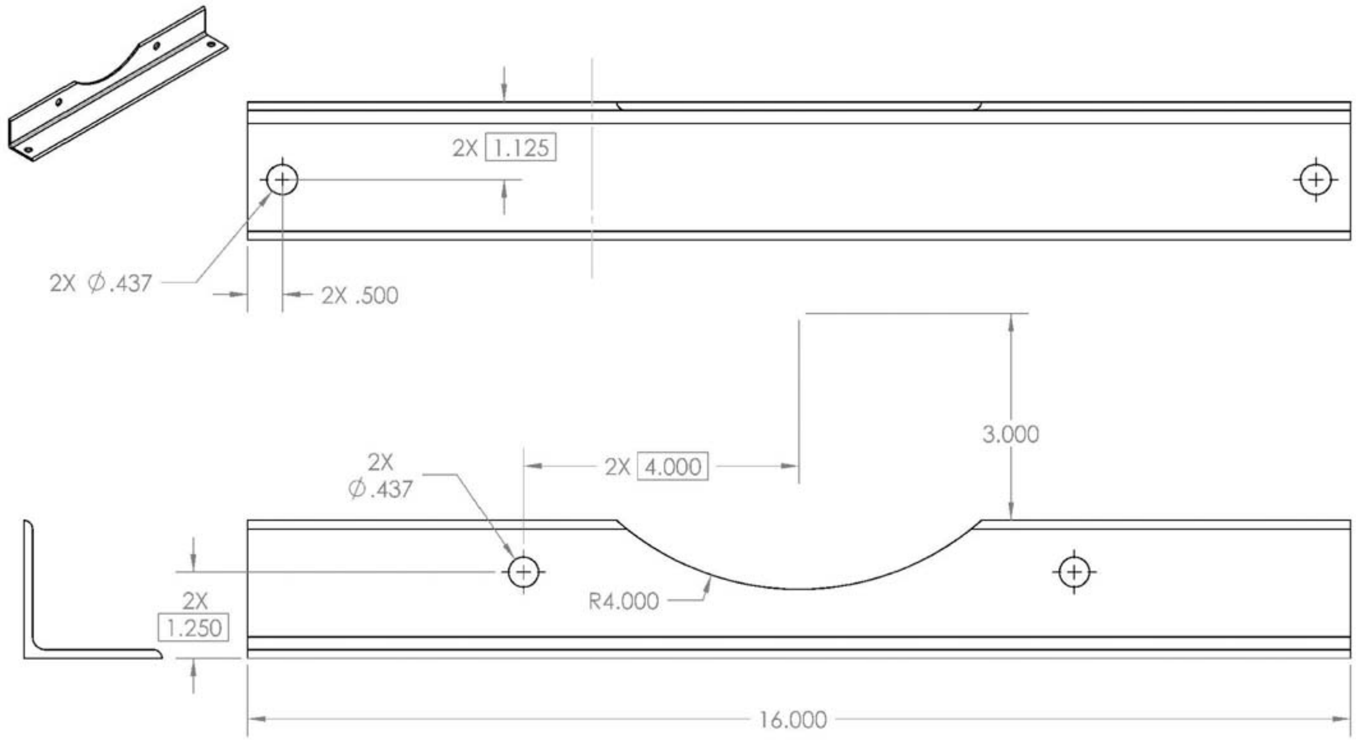
DO NOT SCALE DRAWING

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

CROSS BRACE, SPOOLS 6&7

SIZE A
DWG. NO. PH-006
REV. -
SCALE:1:12
WEIGHT:
SHEET 1 OF 1



2 X 2 X 1/8 ANGLE
IRON
2 REQ'D

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL
A36

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	28JAN11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

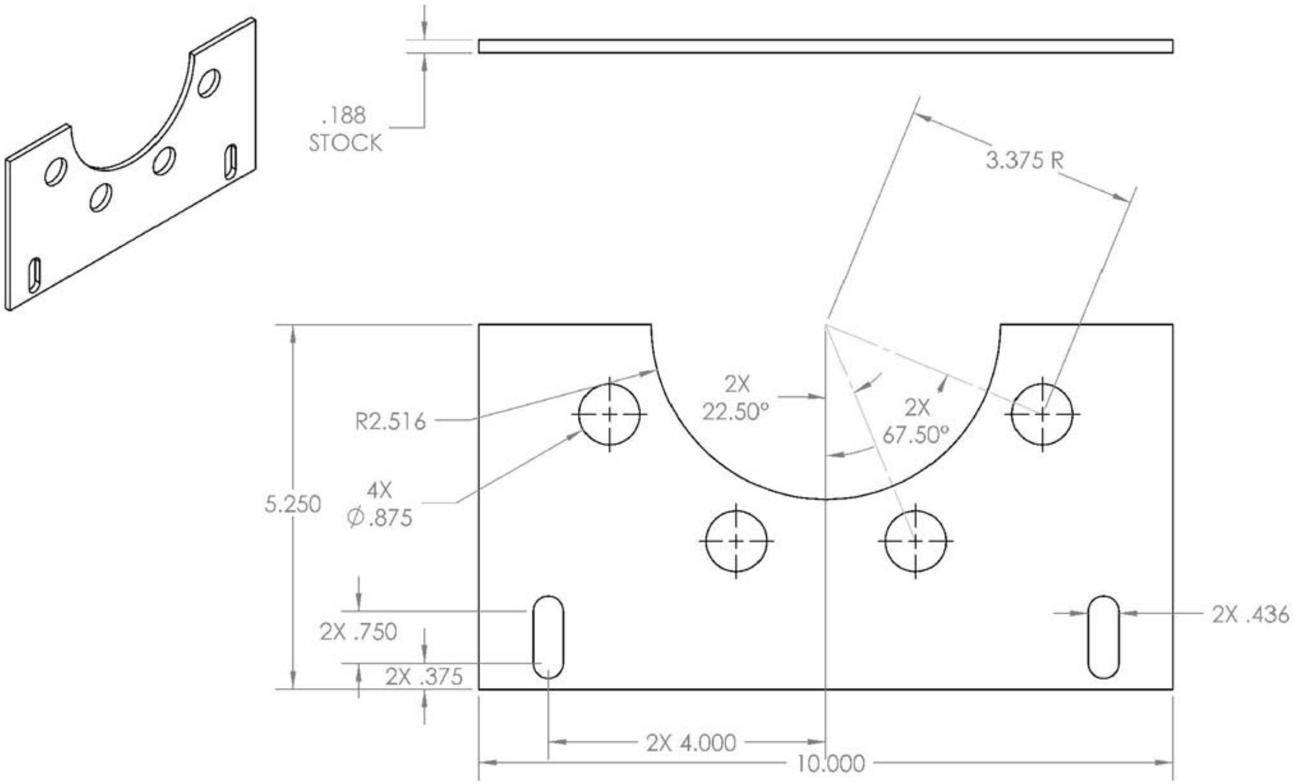
TITLE:

BASE,
3 INCH VALVE

SIZE A
DWG. NO. PH-007
REV A

SCALE: 1:2 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

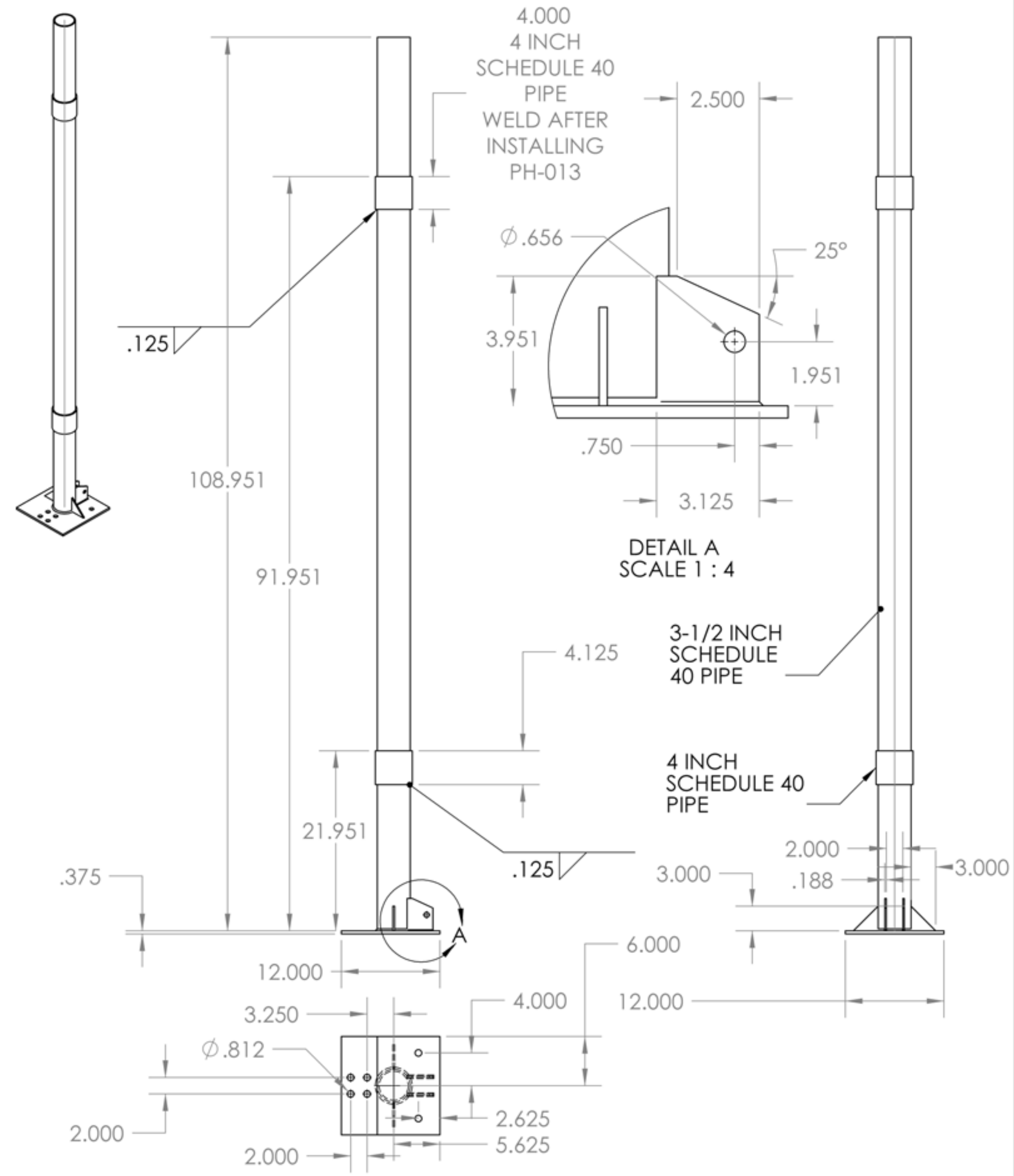
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
A36
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	28JAN11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:
VALVE SUPPORT,
3 INCH

SIZE	DWG. NO.	REV
A	PH-008	-
SCALE: 1:2	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1



DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

	NAME	DATE
DRAWN	KEK	31JAN11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

MATERIAL

FINISH

NEXT ASSY | USED ON

APPLICATION

DO NOT SCALE DRAWING

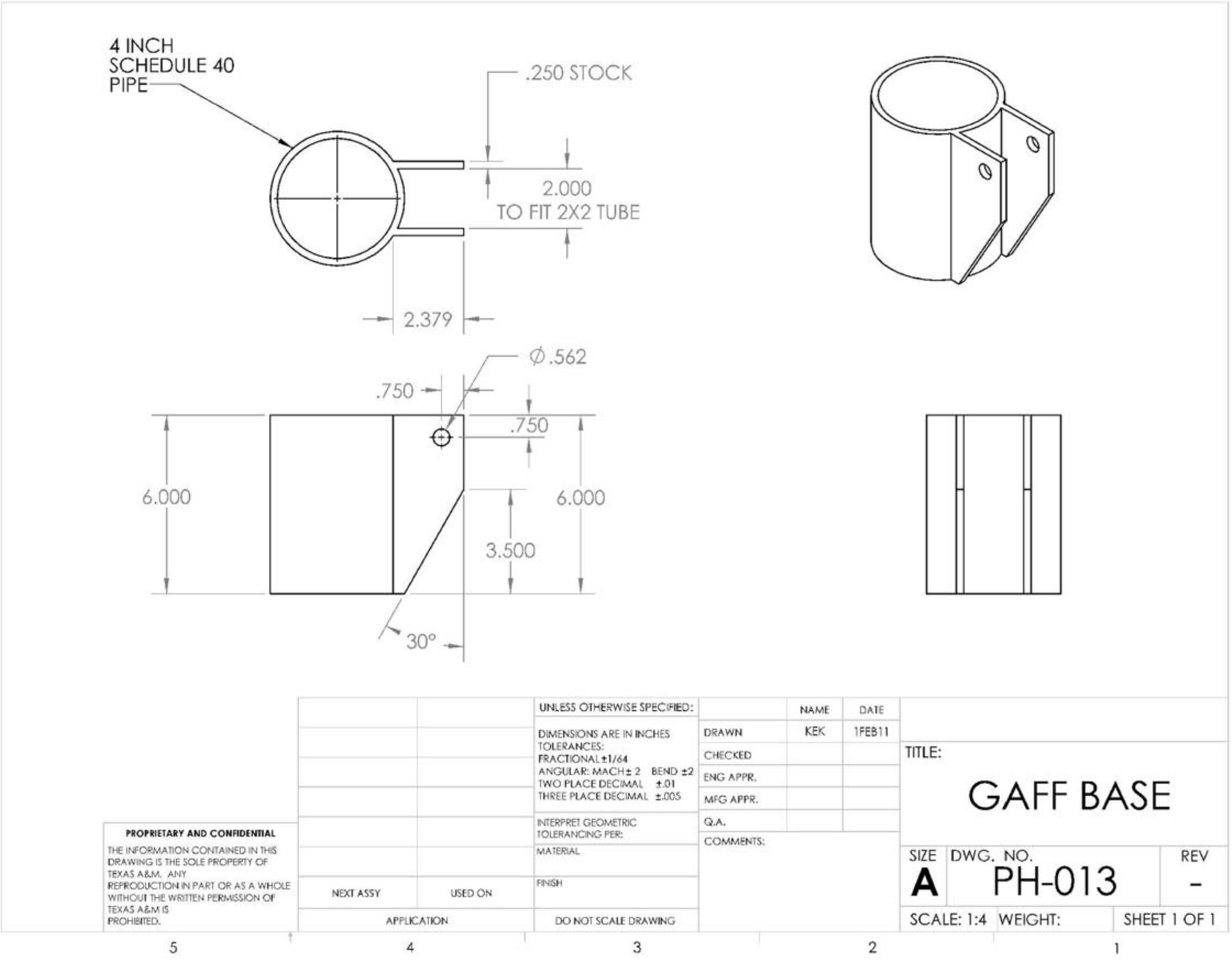
PROPRIETARY AND CONFIDENTIAL

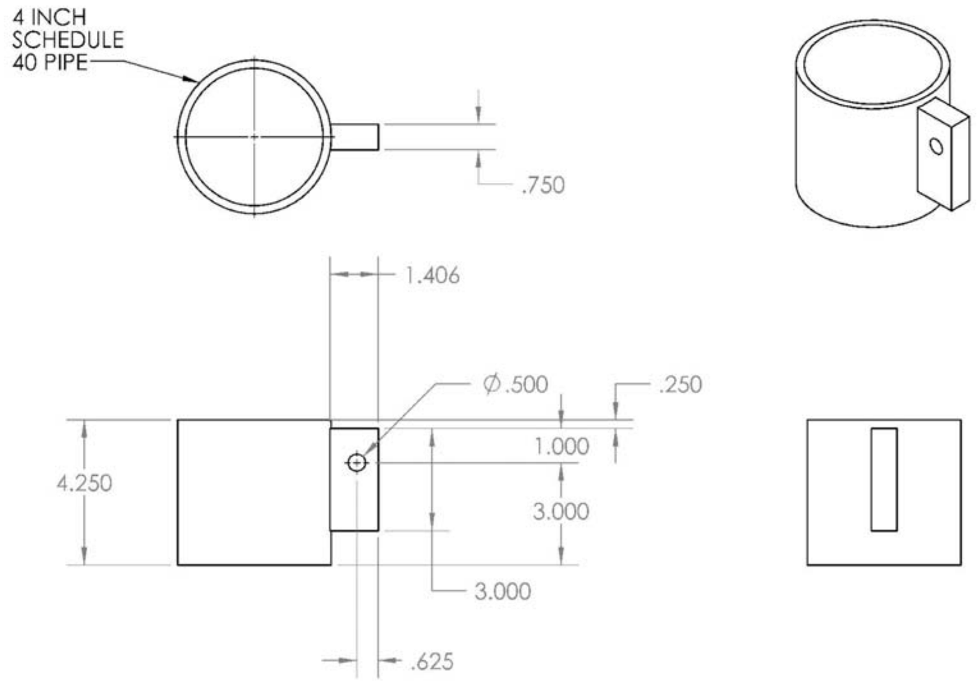
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

MAIN SUPPORT
COLUMN

SIZE A | DWG. NO. PH-012 | REV. A

SCALE:1:24 | WEIGHT: | SHEET 1 OF 1


4 INCH
SCHEDULE 40
PIPE
.250 STOCK
2.000
TO FIT 2X2 TUBE
2.379
Ø.562
.750
.750
6.000
6.000
3.500
30°
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC
TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
NAME
DATE
DRAWN
KEK
1FEB11
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
GAFF BASE
SIZE
A
DWG. NO.
PH-013
REV
-
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
5
4
3
2
1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL±1/64 ANGULAR: MACH±2 BEND ±2 TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005	DRAWN	KEK	1FEB11
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

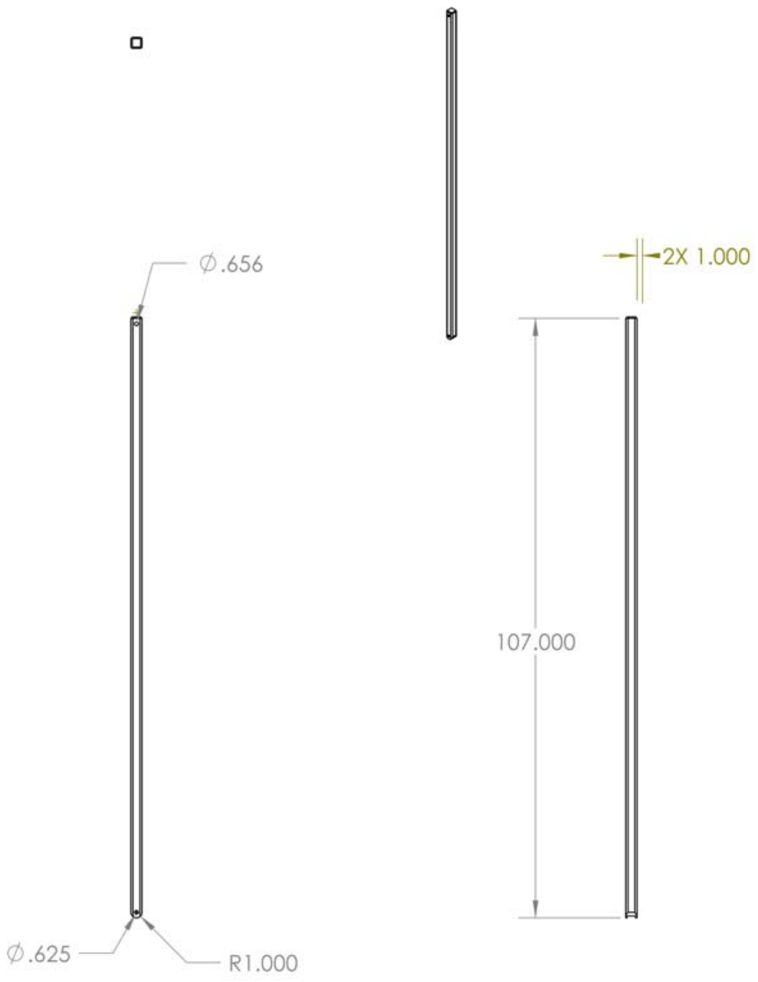
TITLE:
GAFF LIFT
FITTING

SIZE A
DWG. NO. PH-014
REV A
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

5 4 3 2 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

DO NOT SCALE DRAWING

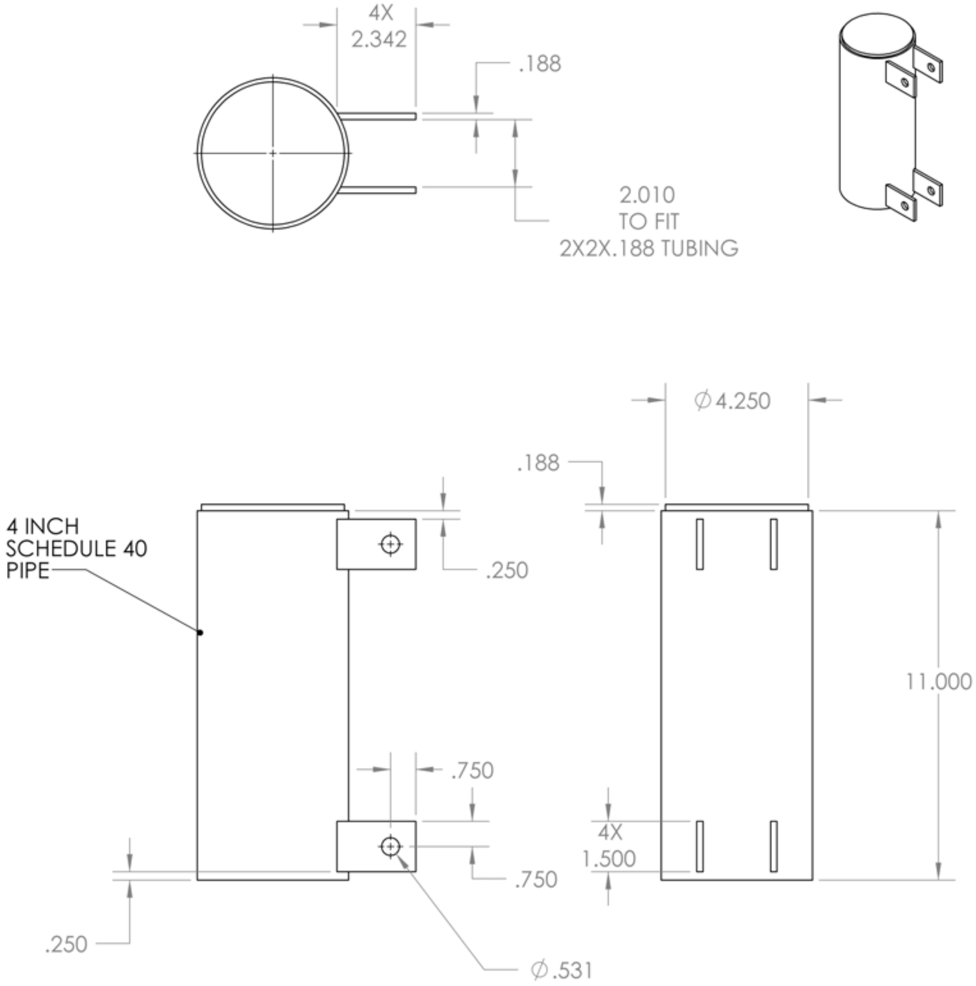
	NAME	DATE
DRAWN	KEK	1FEB11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

CROSS BRACE

SIZE	DWG. NO.	REV.
A	PH-016	-

SCALE:1:24 WEIGHT: SHEET 1 OF 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

DO NOT SCALE DRAWING

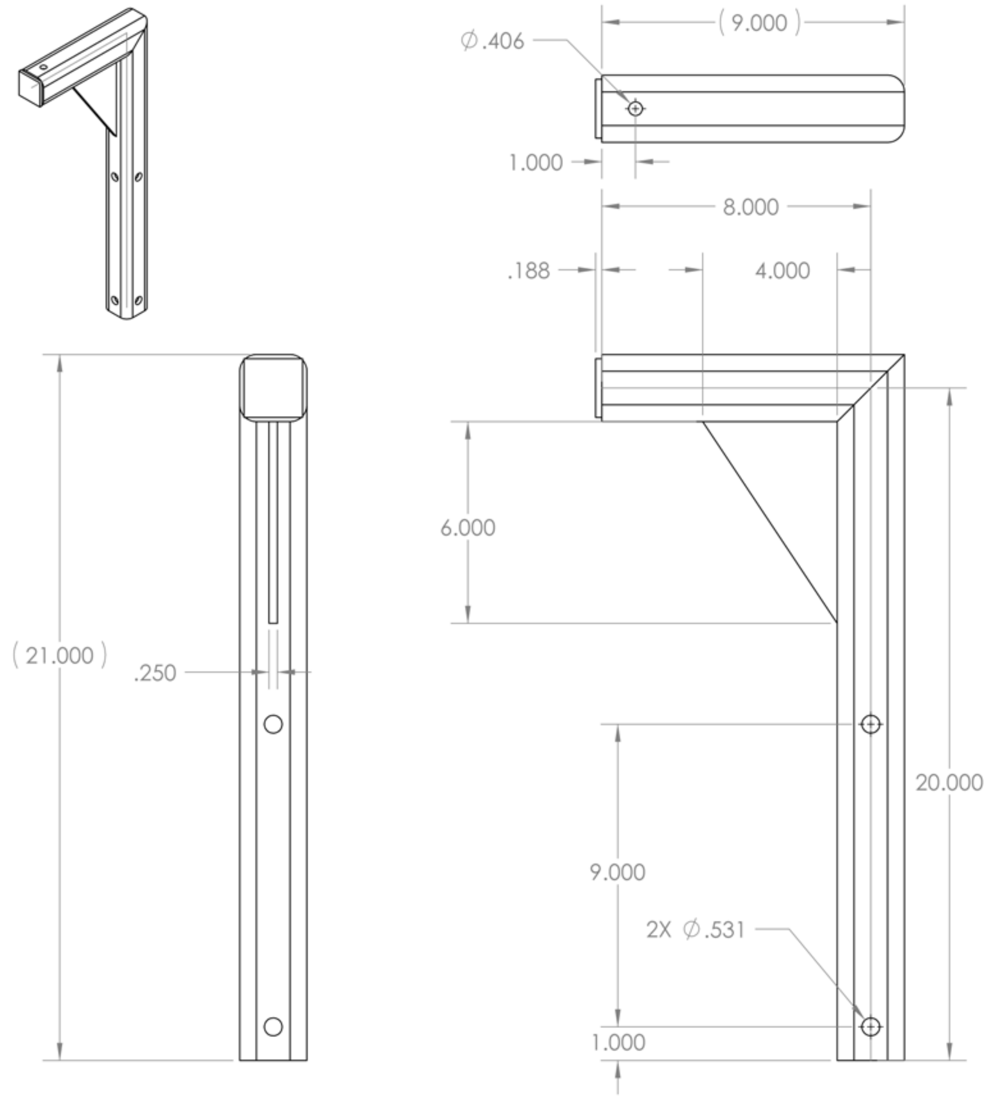
	NAME	DATE
DRAWN	KEK	1FEB11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

COLUMN CAP

SIZE A | DWG. NO. PH-017 | REV. -

SCALE:1:4 | WEIGHT: | SHEET 1 OF 1



PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON
APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL
A36

FINISH

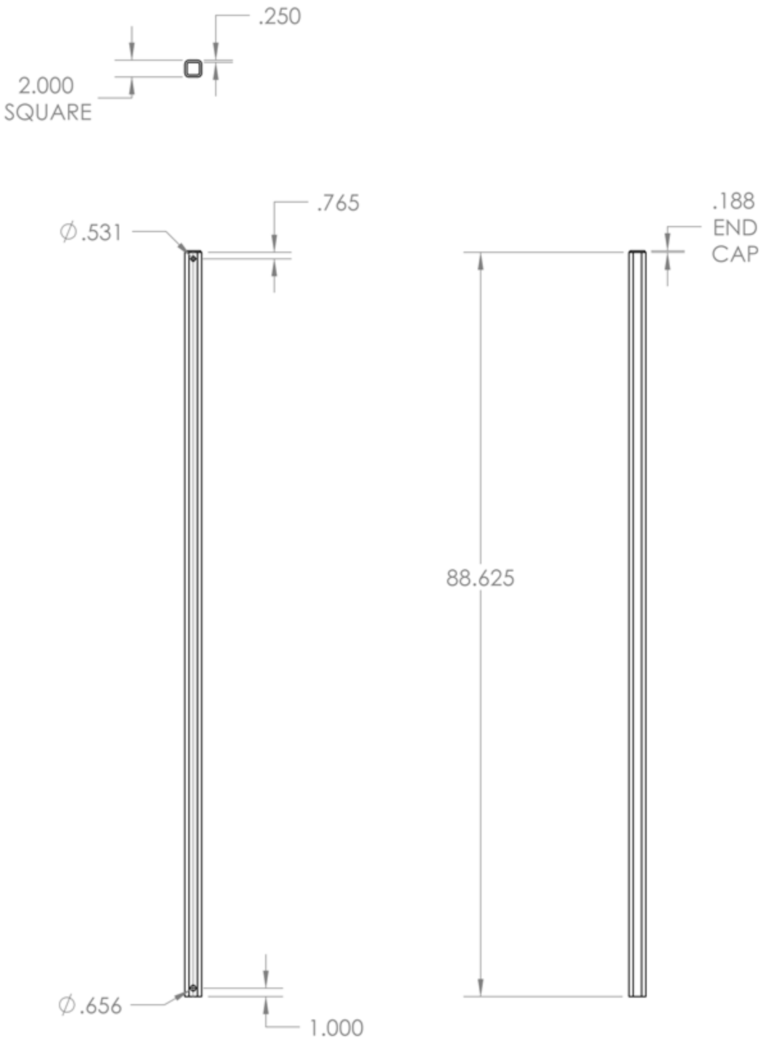
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	1FEB11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

PIPE SUPPORT,
SPOOL 11

SIZE A | DWG. NO. PH-018 | REV. -
SCALE:1:4 | WEIGHT: | SHEET 1 OF 1



NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

DO NOT SCALE DRAWING

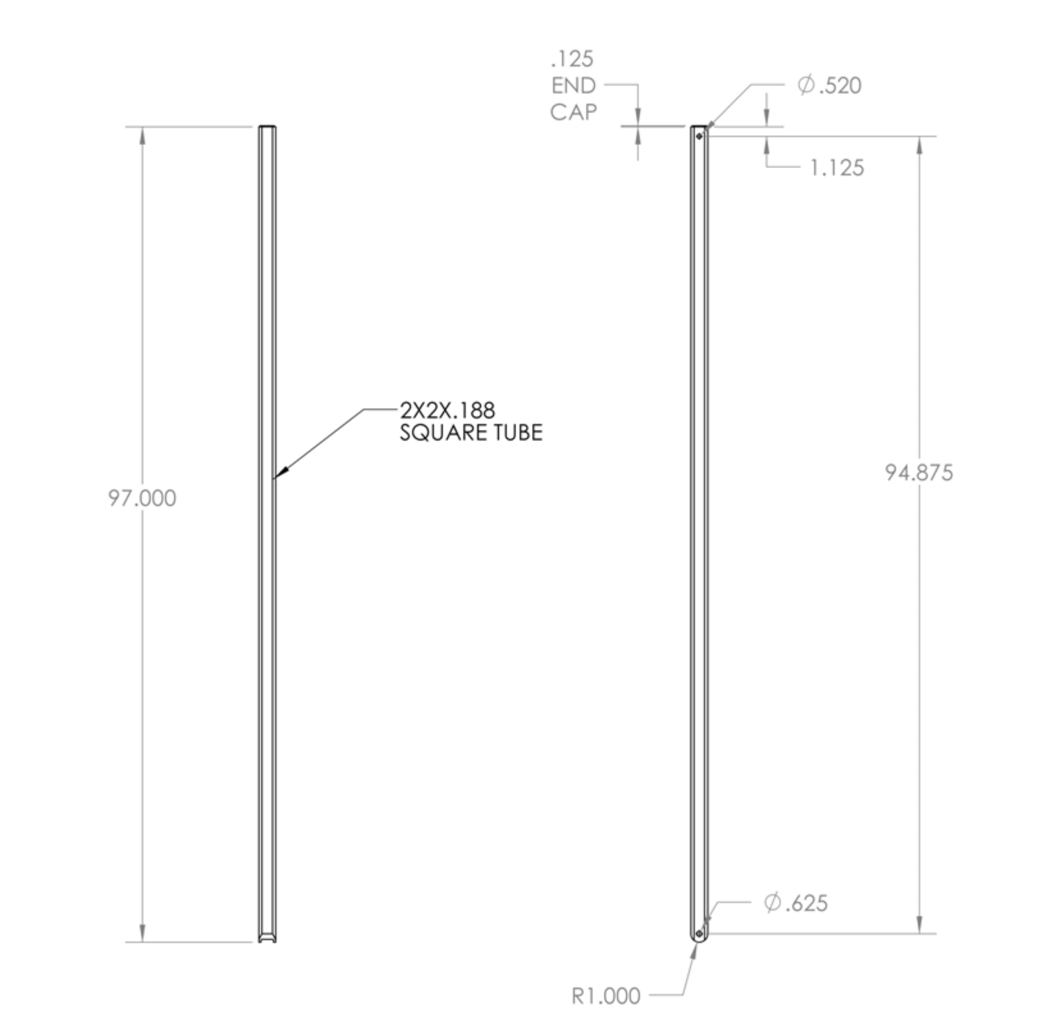
	NAME	DATE
DRAWN	KEK	1FEB11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

CROSS BRACE

SIZE	DWG. NO.	REV.
A	PH-019	-

SCALE:1:16 WEIGHT: SHEET 1 OF 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

DO NOT SCALE DRAWING

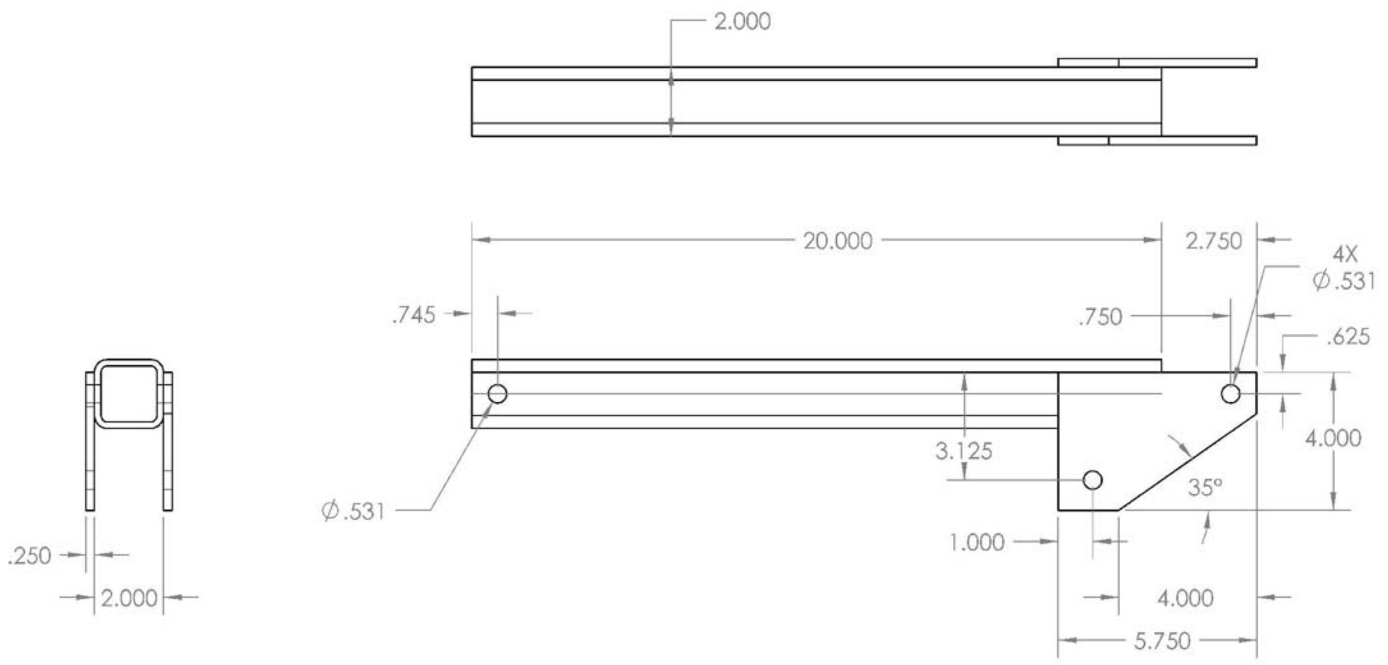
	NAME	DATE
DRAWN	KEK	1FEB11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

CROSS BRACE

SIZE **A** DWG. NO. PH-020 REV. -

SCALE:1:24 WEIGHT: SHEET 1 OF 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	1FEB11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

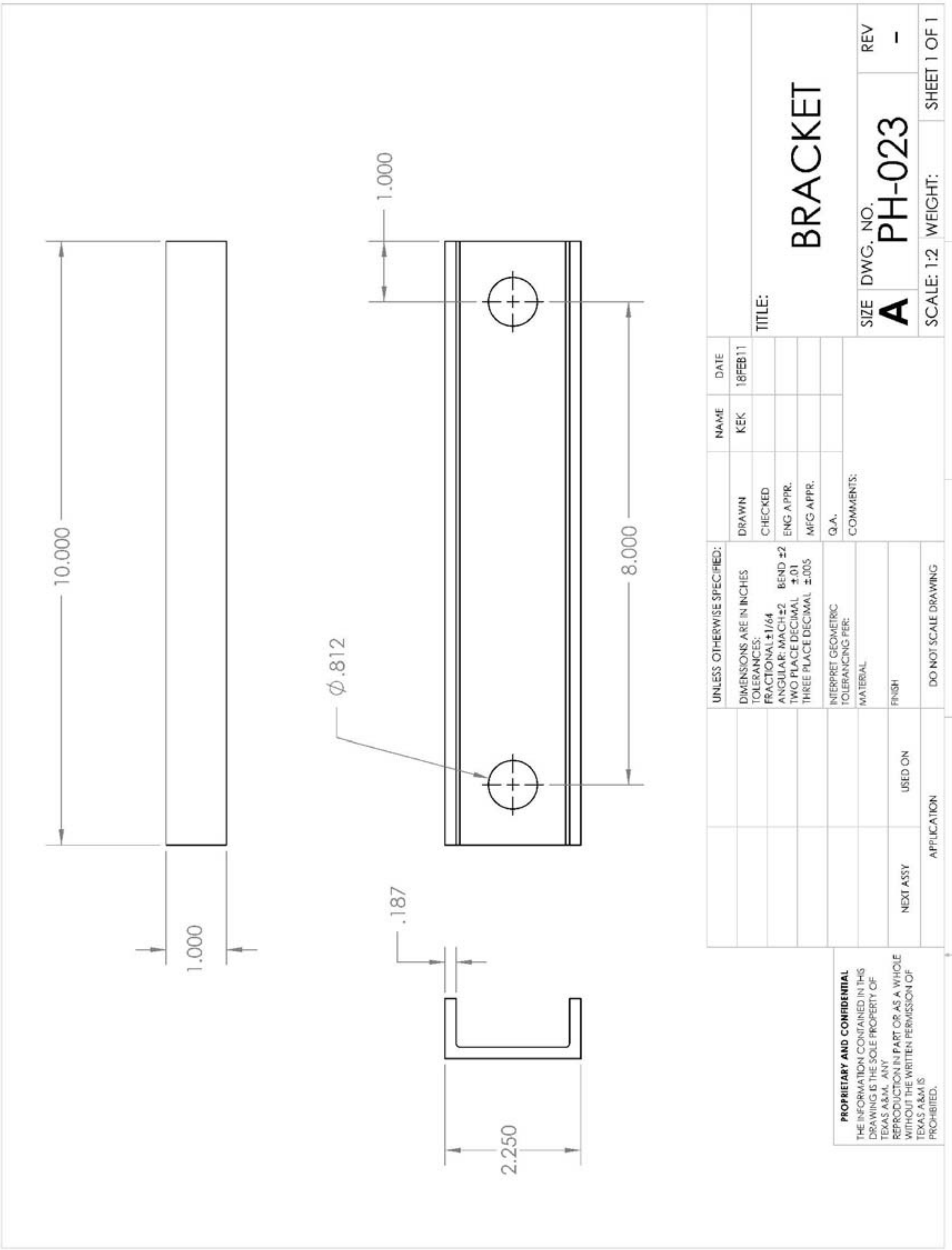
TITLE:

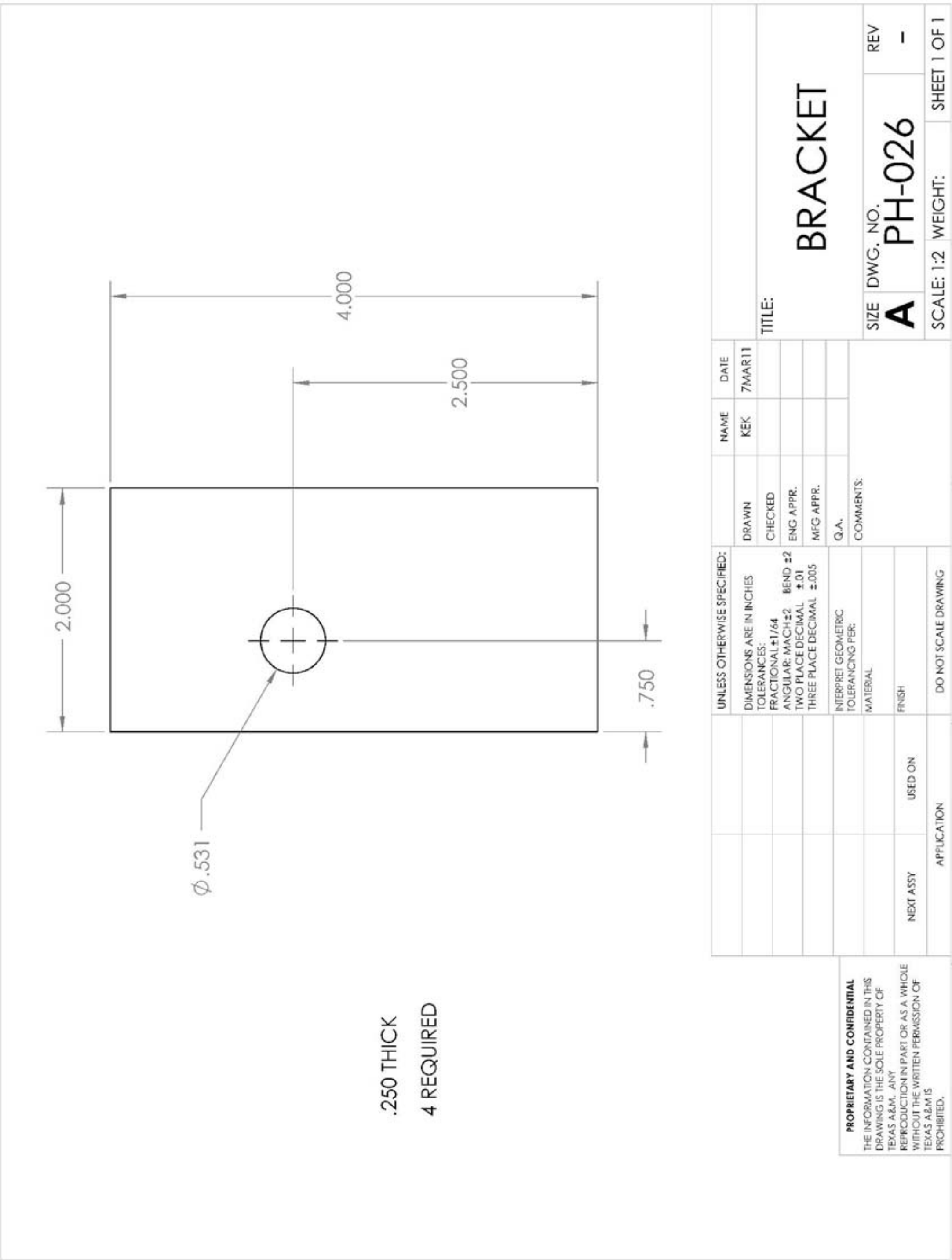
TOP BRACE

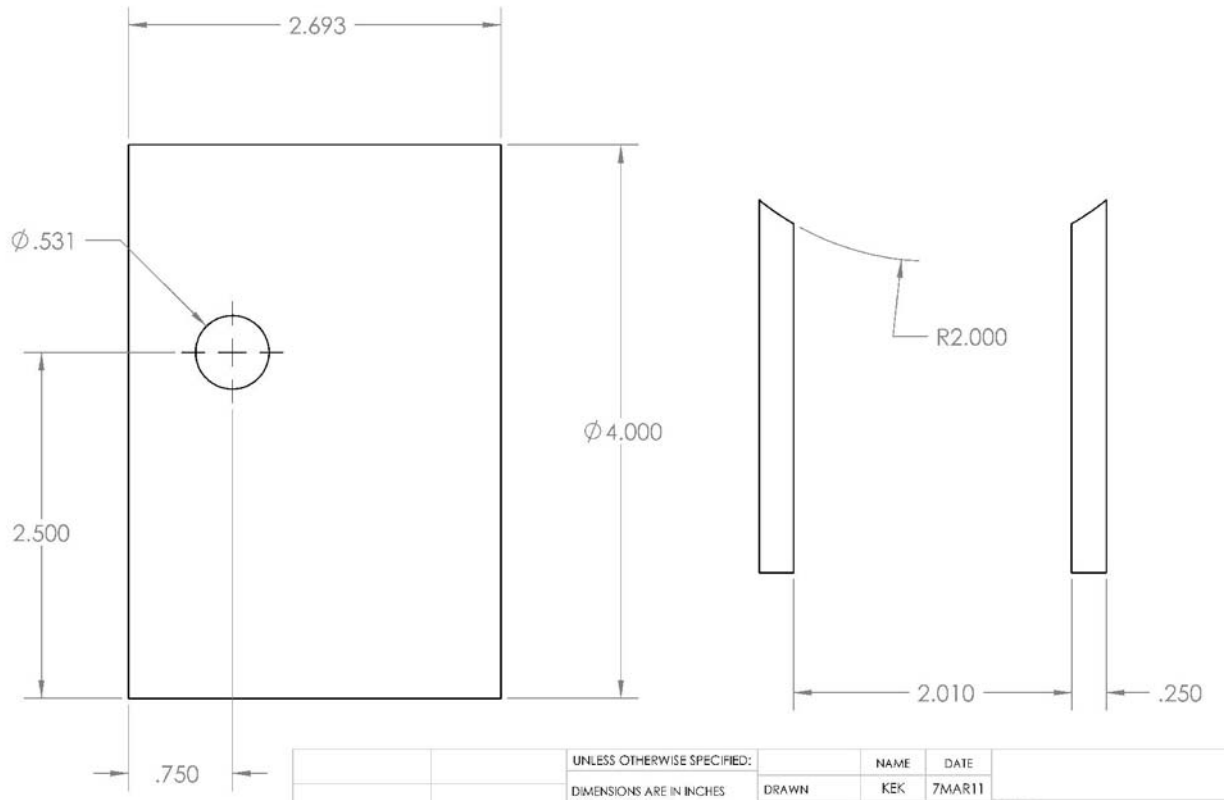
SIZE	DWG. NO.	REV
A	PH-021	A

SCALE: 1:8 WEIGHT: SHEET 1 OF 1

5 4 3 2 1


10.000
1.000
1.000
Ø.812
8.000
.187
2.250
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
18FEB11
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
BRACKET
SIZE
A
DWG. NO.
PH-023
REV
-
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
5
4
3
2
1


4.000
2.500
2.000
.750
⌀.531
.250 THICK
4 REQUIRED
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
NAME
DATE
DRAWN
KEK
7MAR11
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
BRACKET
SIZE
A
DWG. NO.
PH-026
REV
-
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
1
2
3
4
5



PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY
USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

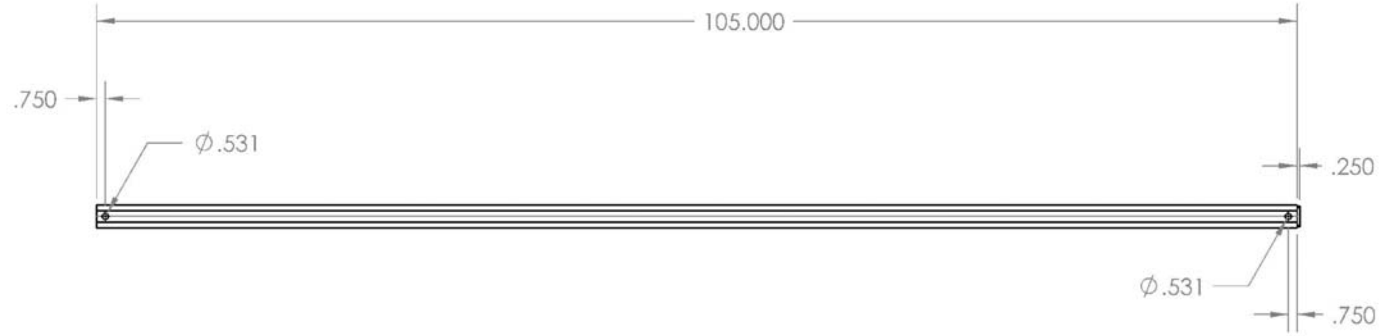
	NAME	DATE
DRAWN	KEK	7MAR11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:
BRACKET

SIZE A
DWG. NO. PH-027
REV -
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1

5 4 3 2 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	7MAR11
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

CROSS BRACE

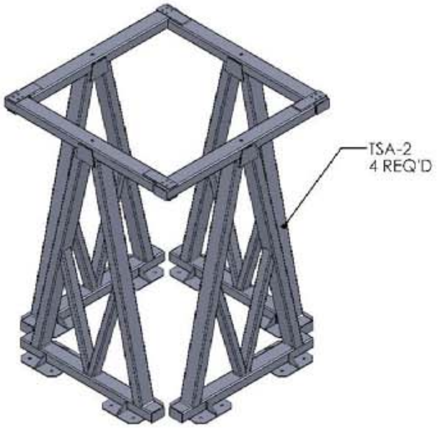
SIZE	DWG. NO.	REV
A	PH-028	-

SCALE: 1:24 WEIGHT: SHEET 1 OF 1

5 4 3 2 1

NOTES:

1. MATERIAL: ASTM-36
2. TSA-2 LEGS AND TO BE BOLTED TOGETHER AT ERECTION



PARTS LIST:

PART NUMBER	DESCRIPTION	QUANTITY/LEG	TOTAL QUANTITY
TS-001	BASE LEG	1	4
TS-002	MAIN LEG	2	8
TS-003	TOP LEG	1	4
TS-005	CROSS BRACE	2	8
TS-006	TOP GUSSET	2	8
TS-007	FOOT	2	8
TS-008	FOOT GUSSET	4	16
TS-009	LINKAGE PLATE	2	8
TS-010	END CAP	4	16

CUT LIST:

TUBE SIZE	TUBE LENGTH	SUB-COMPONENT OF:	QUANTITY/LEG	TOTAL QUANTITY
6 X 4 X .250	60	TS-001	1	4
6 X 4 X .250	92	TS-002	2	8
6 X 4 X .250	68	TS-003	1	4
4 X 3 X .250	44.615	TS-005	2	8

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

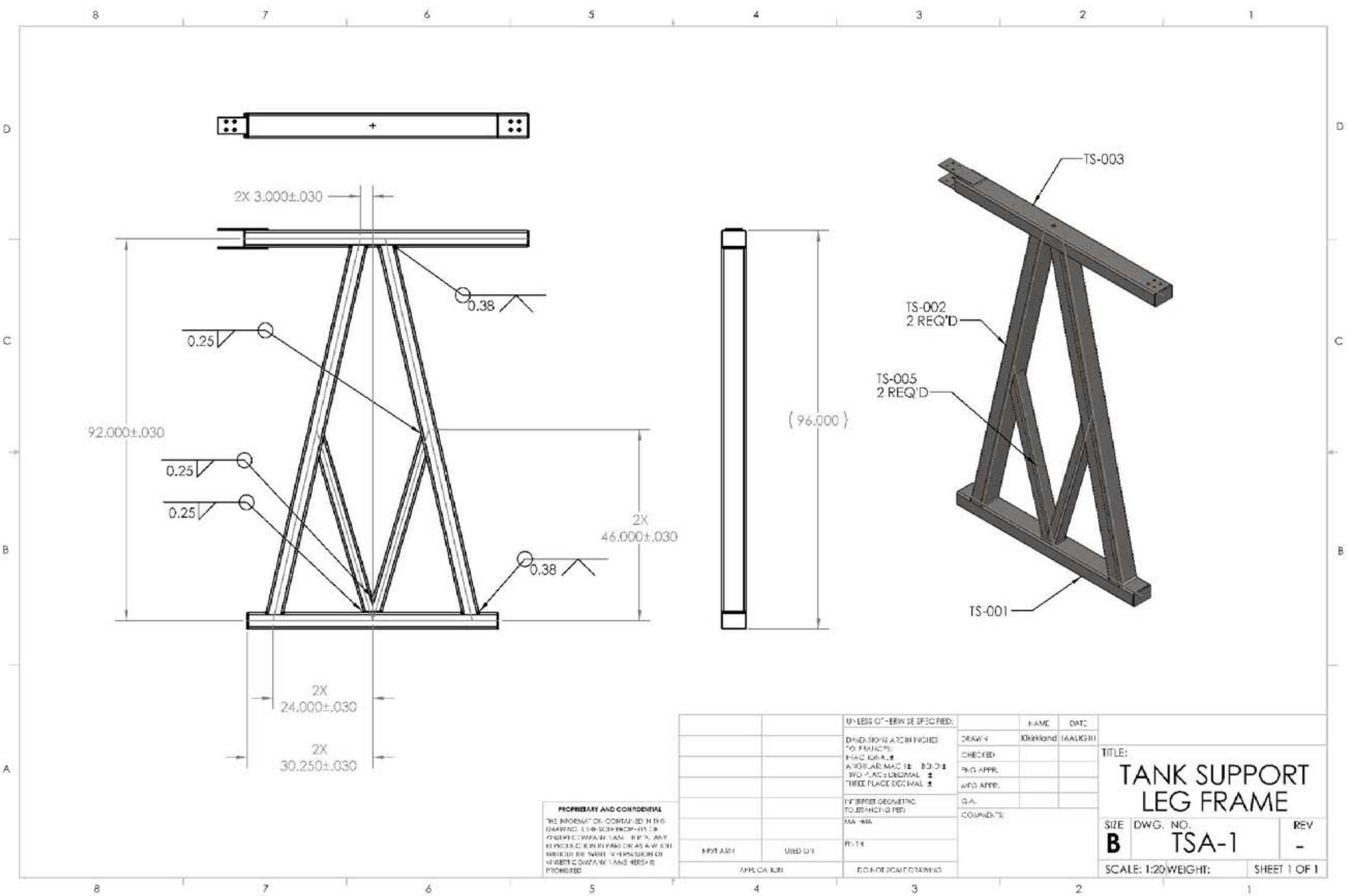
NEXT ASSY	USED ON	UNLESS OTHERWISE SPECIFIED:		NAME	DATE
APPLICATION		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/64 ANGULAR: MACH ±2 BEND ±2 TWO PLACE DECIMAL ±.3 THREE PLACE DECIMAL ±.005	DRAWN	Kkirkland	19AUG10
		INTERPRET GEOMETRIC TOLERANCING PER:	CHECKED		
		MATERIAL	ENG APPR.		
		FINISH	MFG APPR.		
		DO NOT SCALE DRAWING	Q.A.		
			COMMENTS:		

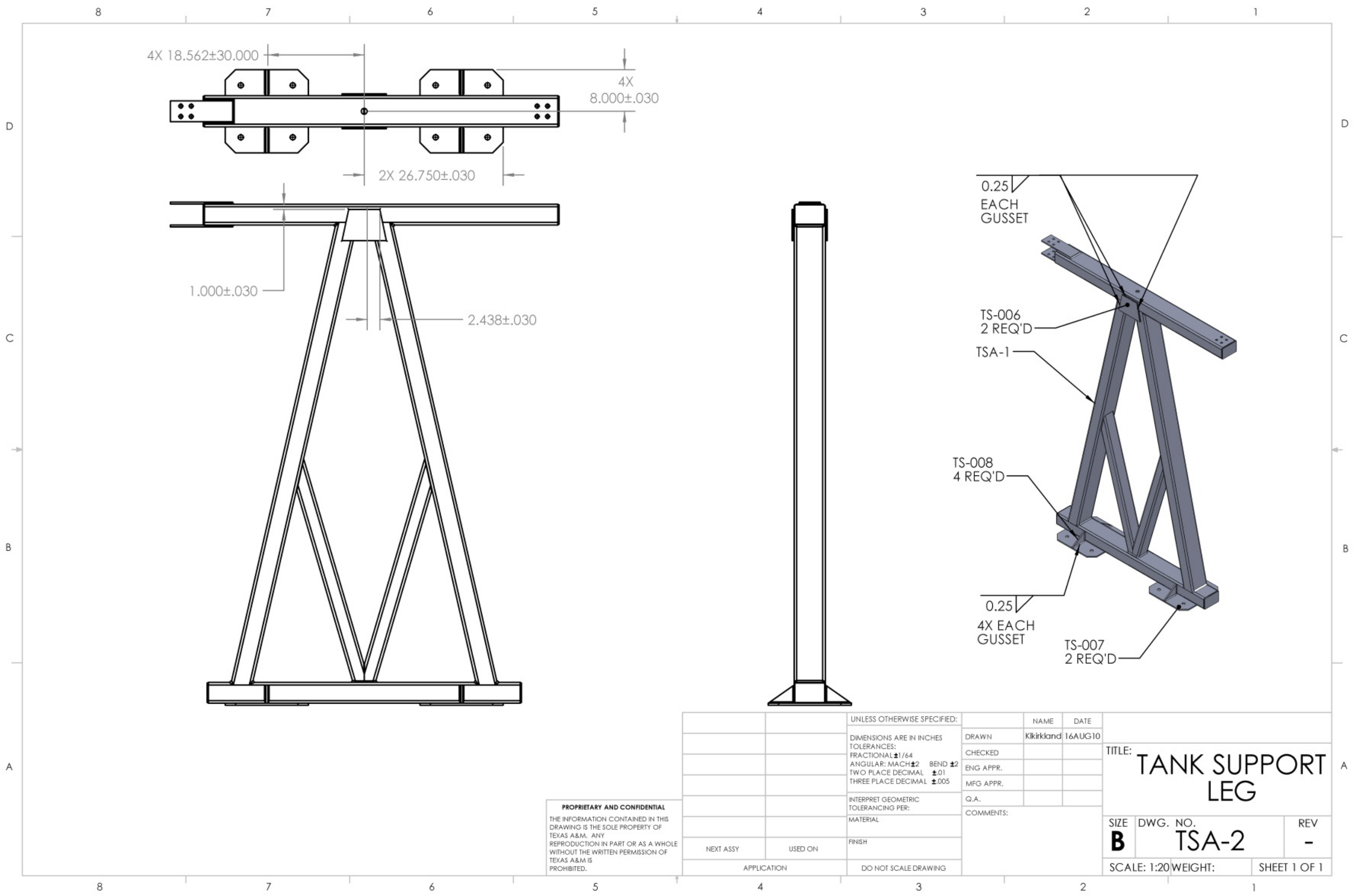
TITLE:

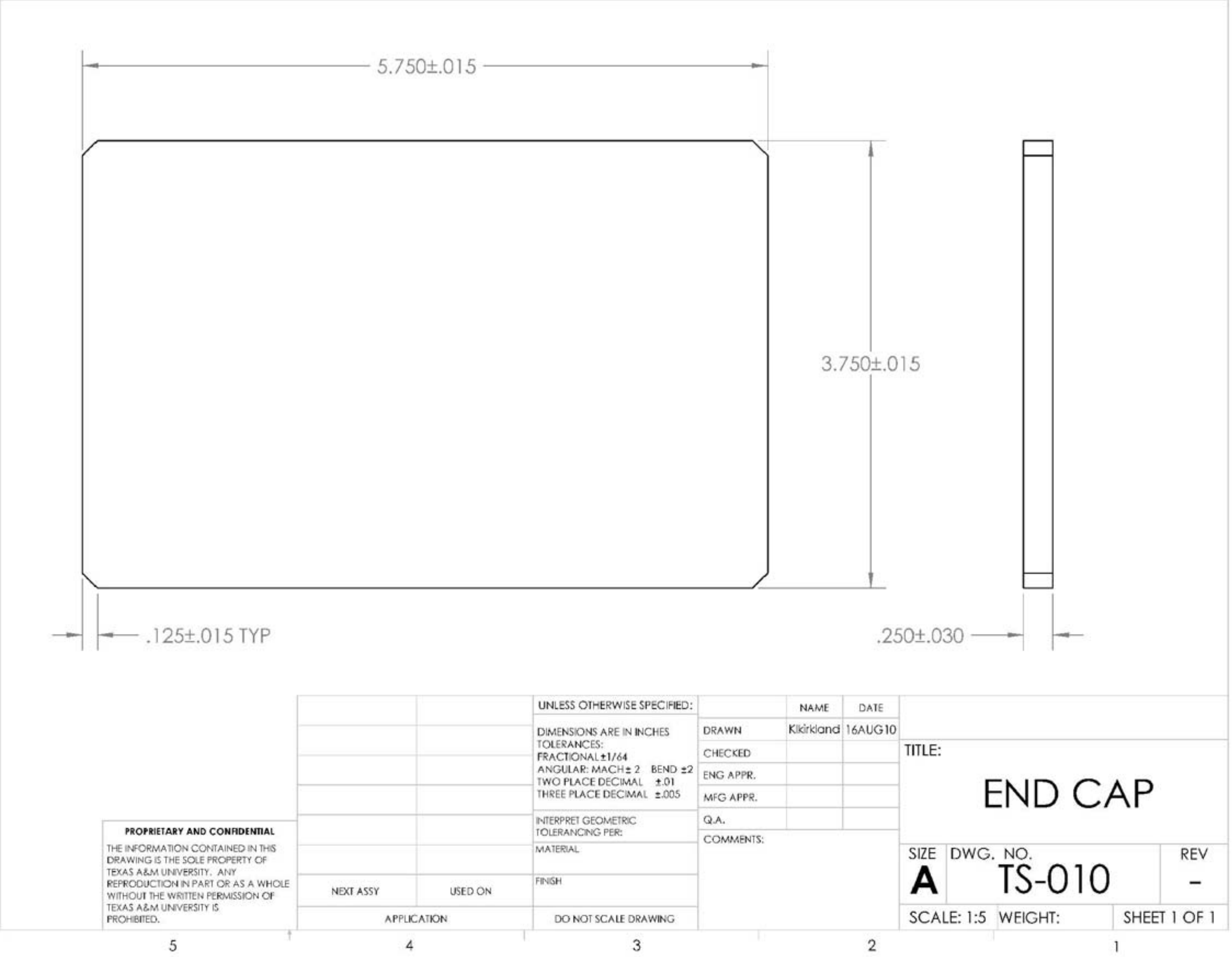
TANK SUPPORT ASSEMBLY

SIZE	DWG. NO.	REV
B	TSA-3	-

SCALE: 1:33 WEIGHT: SHEET 1 OF 1


2X 3.000±.030
92.000±.030
0.38
0.25
0.25
0.25
0.38
2X
46.000±.030
2X
24.000±.030
2X
30.250±.030
(96.000)
TS-003
TS-002
2 REQ'D
TS-005
2 REQ'D
TS-001
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
10kirkland
16AUG10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
TANK SUPPORT
LEG FRAME
SIZE
B
DWG. NO.
TSA-1
REV
-
SCALE: 1:20
WEIGHT:
SHEET 1 OF 1


4X 18.562±30.000
4X
8.000±.030
2X 26.750±.030
1.000±.030
2.438±.030
0.25
EACH
GUSSET
TS-006
2 REQ'D
TSA-1
TS-008
4 REQ'D
0.25
4X EACH
GUSSET
TS-007
2 REQ'D
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
Klkirkland
16AUG10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
TANK SUPPORT LEG
SIZE
B
DWG. NO.
TSA-2
REV
-
SCALE: 1:20
WEIGHT:
SHEET 1 OF 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.

NEXT ASSY
USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

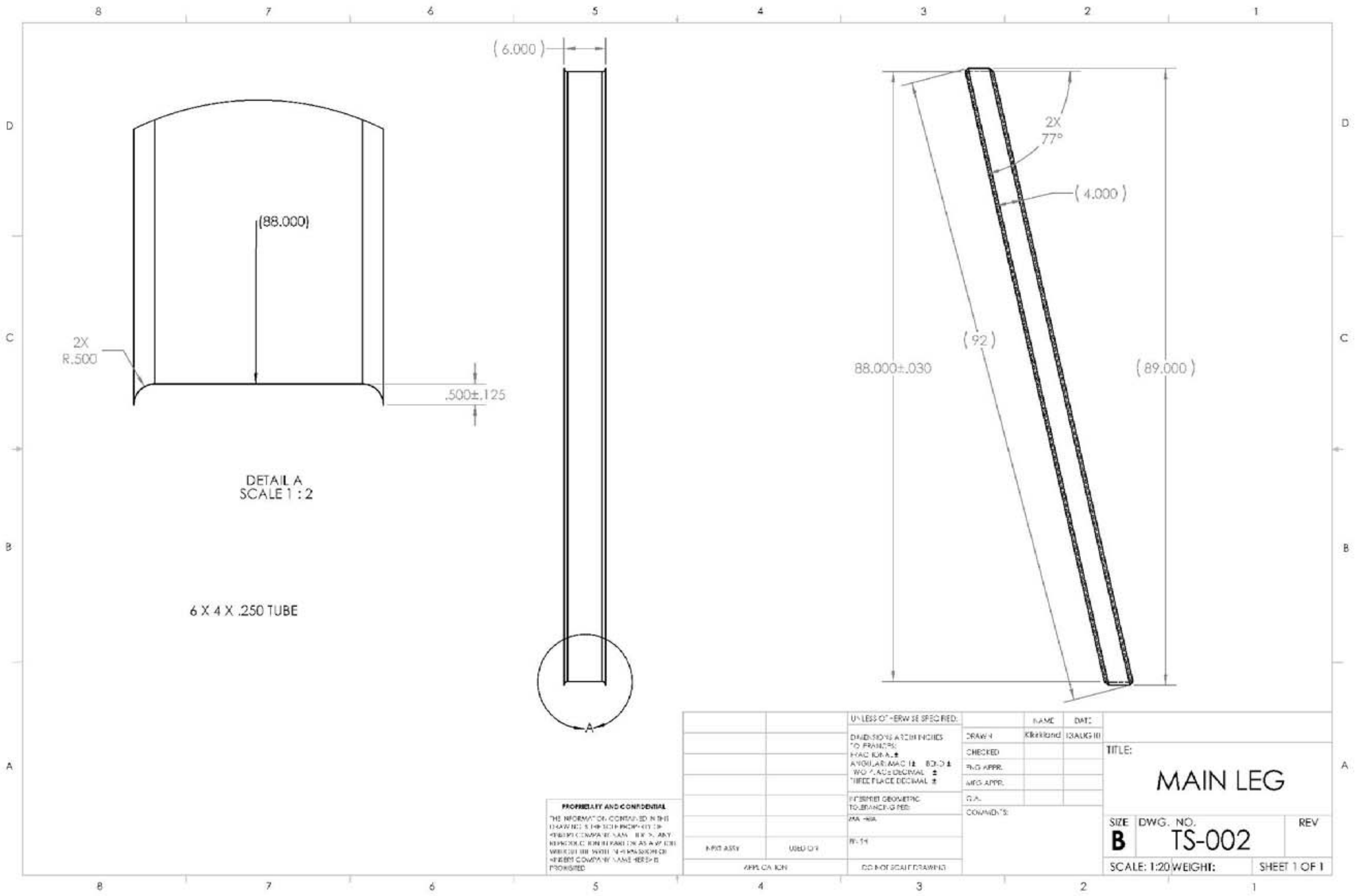
	NAME	DATE
DRAWN	Kikirkland	16AUG10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

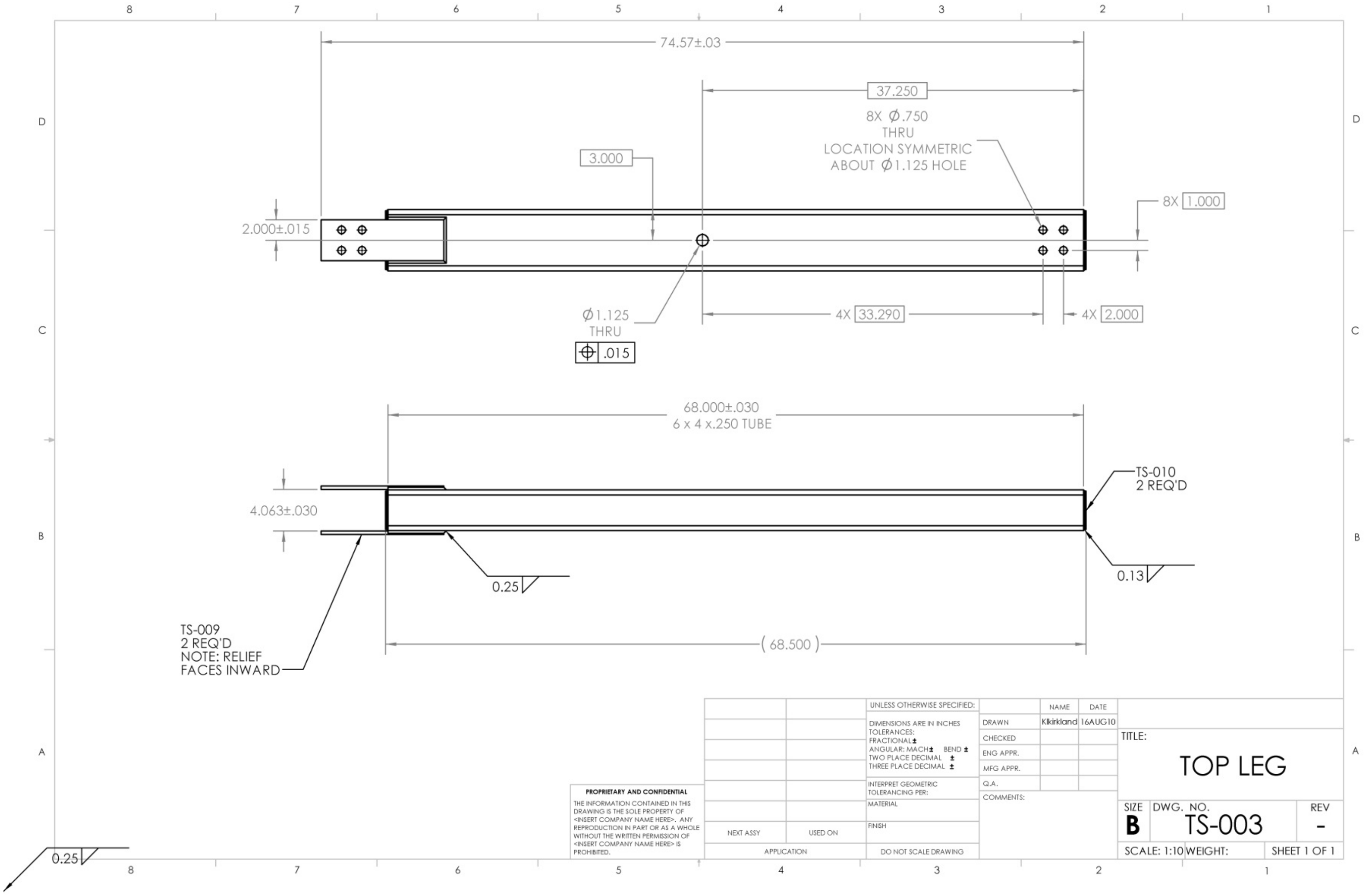
COMMENTS:

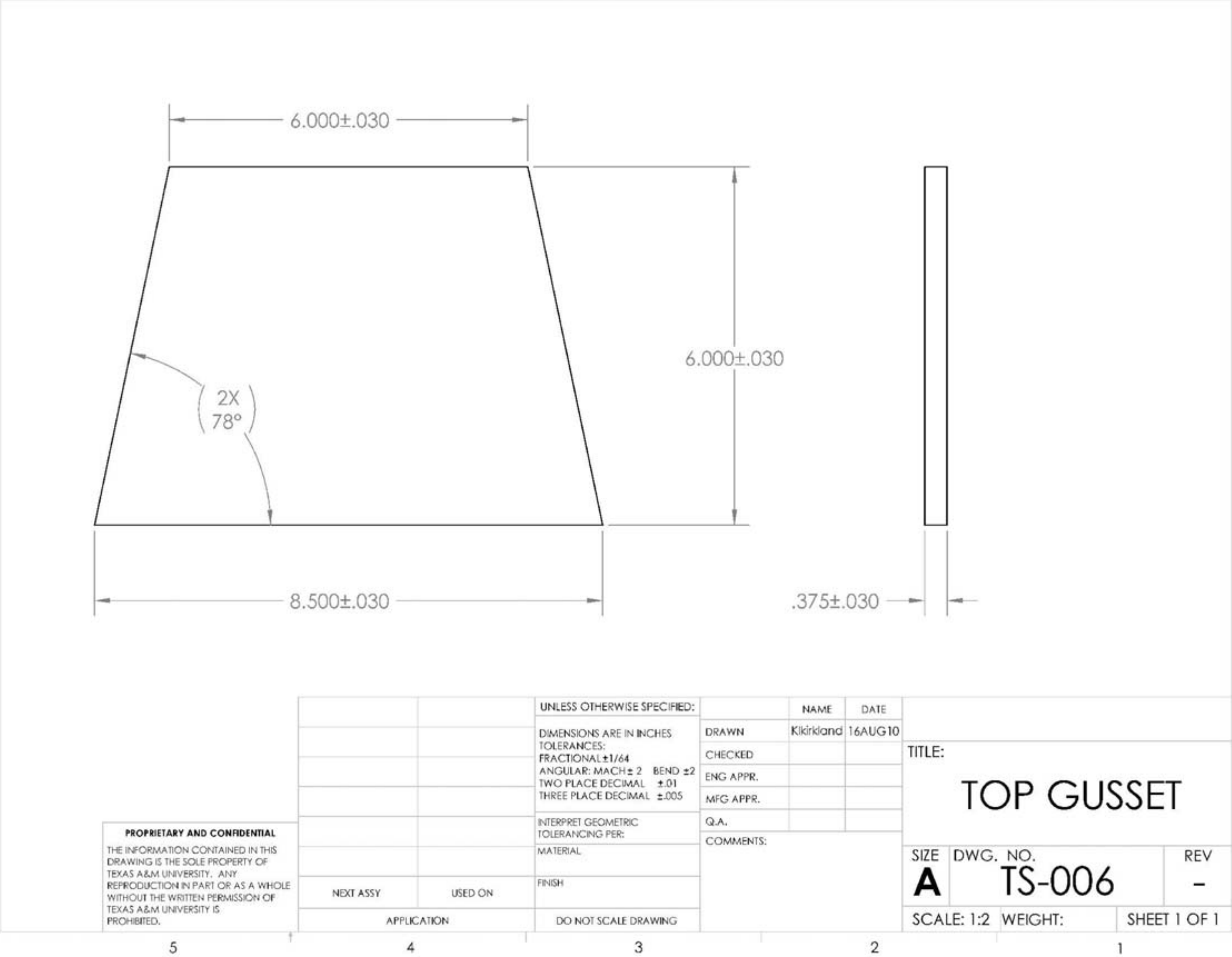
TITLE:

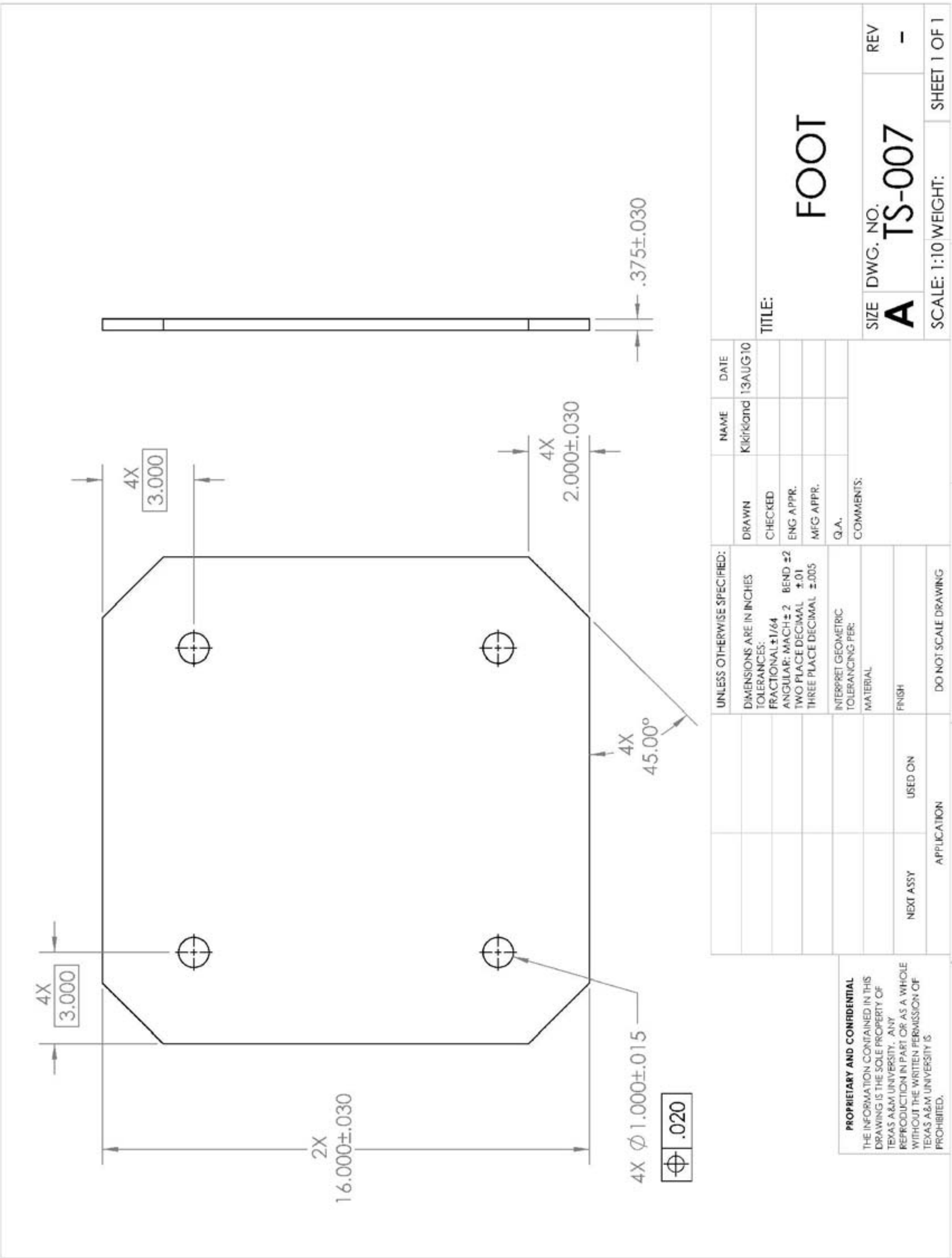
END CAP

SIZE A
DWG. NO. TS-010
REV -
SCALE: 1:5
WEIGHT:
SHEET 1 OF 1

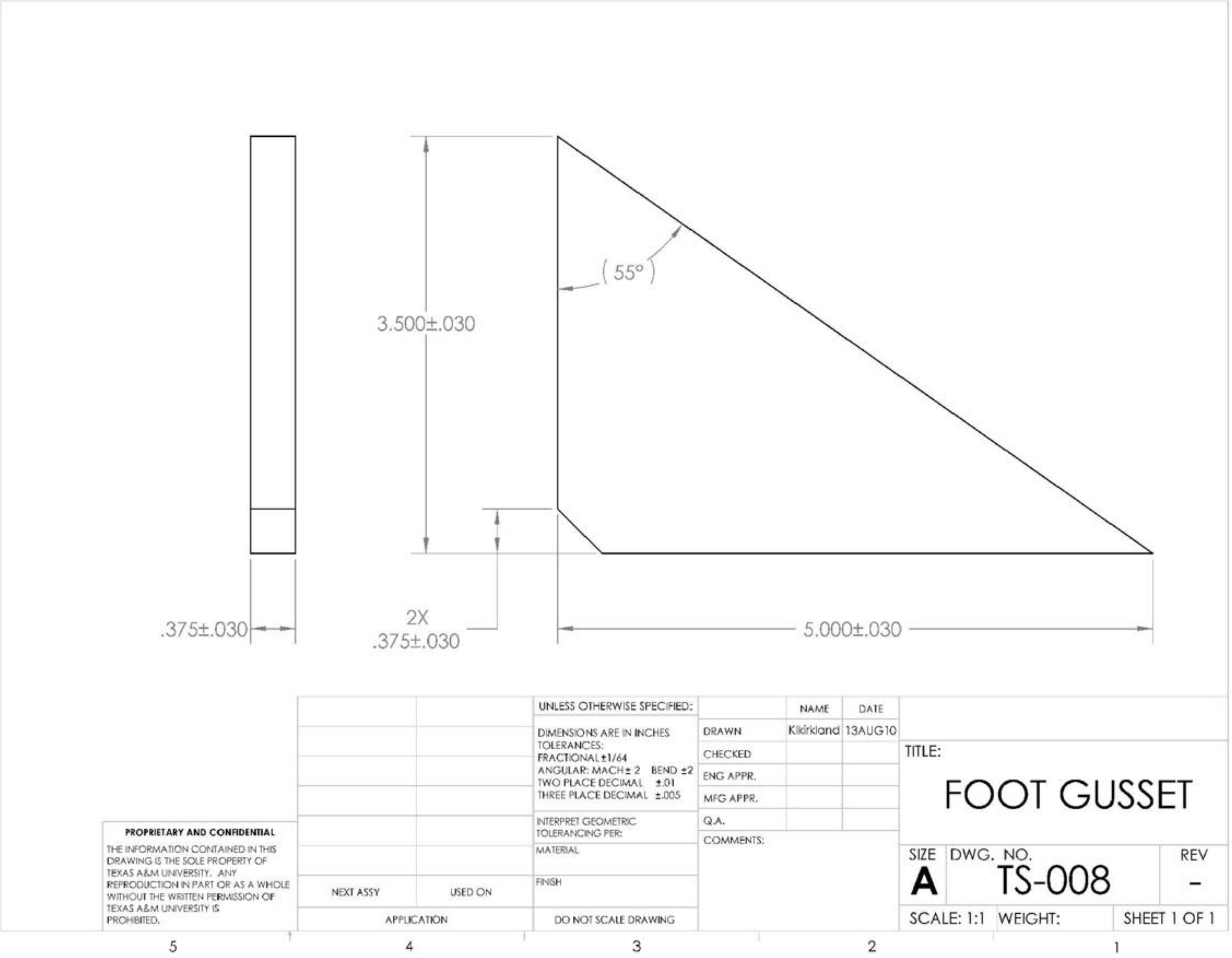

(6.000)
(88.000)
2X
R.500
.500±.125
DETAIL A
SCALE 1 : 2
6 X 4 X .250 TUBE
A
2X
77°
(4.000)
(92)
88.000±.030
(89.000)
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC
TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
NAME
DATE
DRAWN
Klinkland
13AUG10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
MAIN LEG
SIZE
B
DWG. NO.
TS-002
REV
SCALE: 1:20
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
8
7
6
5
4
3
2
1
D
C
B
A

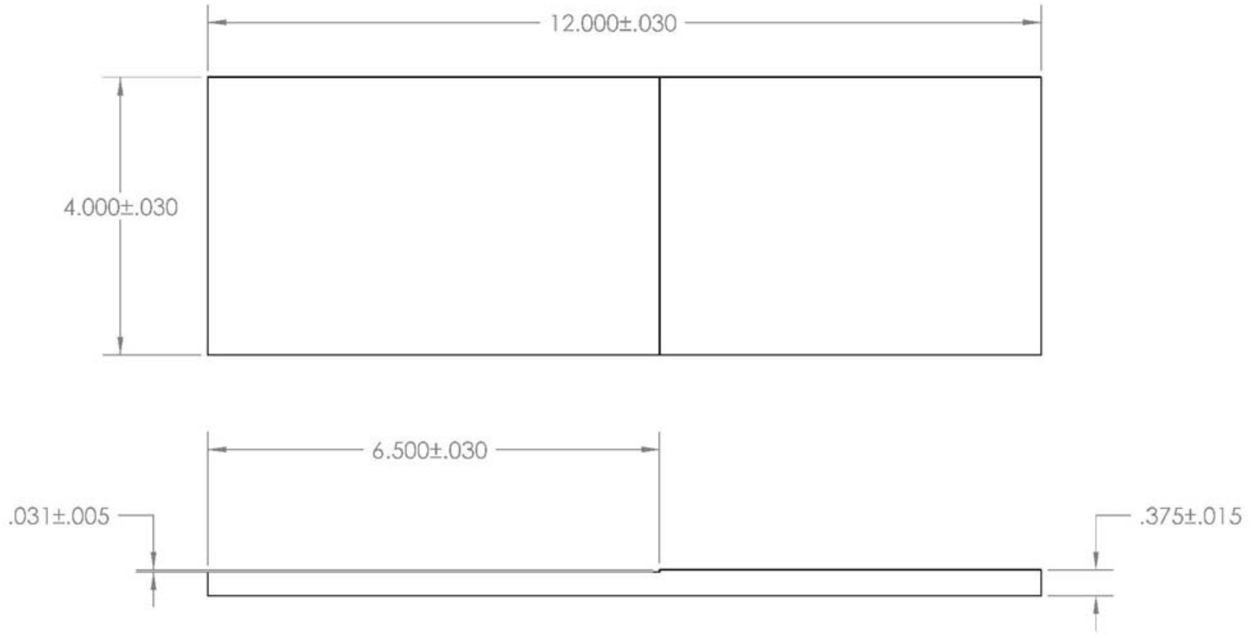

74.57±.03
37.250
8X Ø.750
THRU
LOCATION SYMMETRIC
ABOUT Ø1.125 HOLE
3.000
8X 1.000
2.000±.015
Ø1.125
THRU
⌖ .015
4X 33.290
4X 2.000
68.000±.030
6 x 4 x.250 TUBE
TS-010
2 REQ'D
4.063±.030
0.25
0.13
TS-009
2 REQ'D
NOTE: RELIEF
FACES INWARD
(68.500)
0.25
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±
ANGULAR: MACH± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
Klkirkland
16AUG10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
TOP LEG
SIZE
B
DWG. NO.
TS-003
REV
-
SCALE: 1:10
WEIGHT:
SHEET 1 OF 1
8
7
6
5
4
3
2
1
D
C
B
A

6.000±.030
6.000±.030
2X
78°
8.500±.030
.375±.030
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
Kikirkland
16AUG10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
TOP GUSSET
SIZE
A
DWG. NO.
TS-006
REV
-
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1



4X
3.000
4X
2.000±.030
.375±.030
4X
45.00°
2X
16.000±.030
4X Ø1.000±.015
⌖ .020
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
NAME
DATE
DRAWN
Kkirkland
13AUG10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
FOOT
SIZE
A
DWG. NO.
TS-007
REV
-
SCALE: 1:10
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.
1
2
3
4
5


(55°)
3.500±.030
.375±.030
2X
.375±.030
5.000±.030
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
NAME
DATE
DRAWN
KKirkland
13AUG10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
FOOT GUSSET
SIZE
A
DWG. NO.
TS-008
REV
-
SCALE: 1:1
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.
5
4
3
2
1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M UNIVERSITY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M UNIVERSITY IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	Kikirkland	13AUG10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

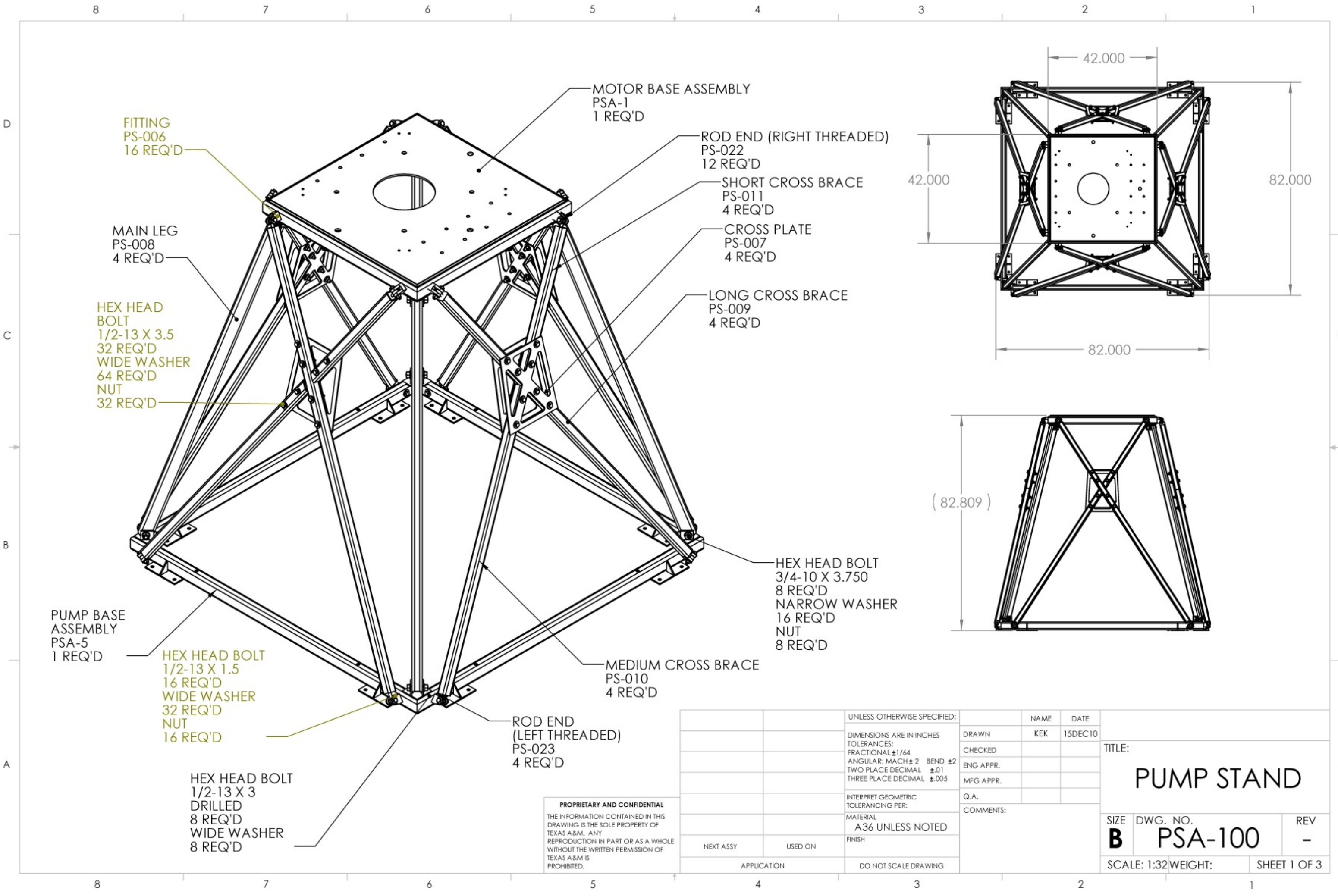
COMMENTS:

TITLE:

LINKAGE PLATE

SIZE A
DWG. NO. TS-009
REV -
SCALE: 1:5
WEIGHT:
SHEET 1 OF 1

5 4 3 2 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL
A36 UNLESS NOTED

FINISH

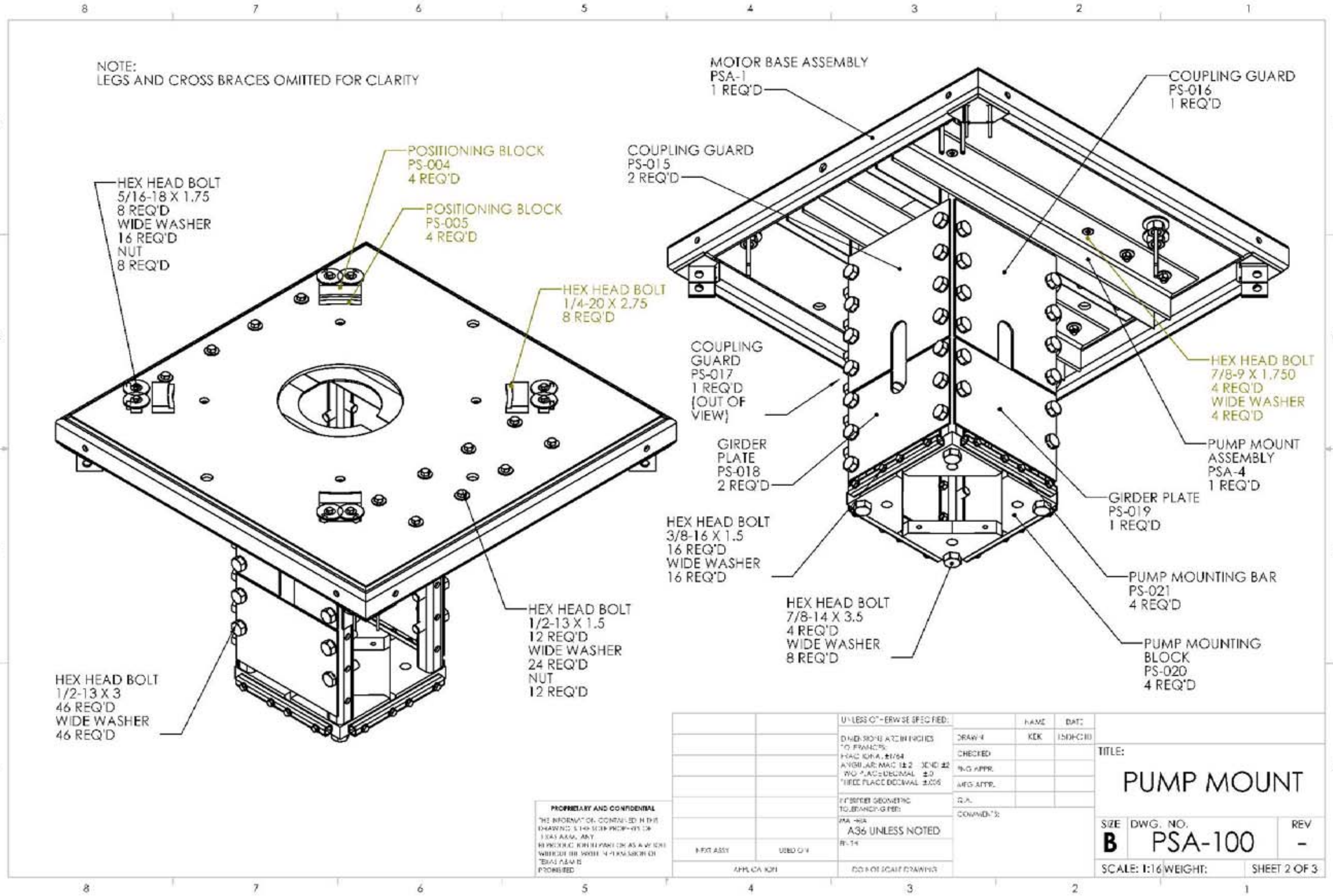
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	15DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:
PUMP STAND

SIZE B
DWG. NO. PSA-100
REV -
SCALE: 1:32
WEIGHT:
SHEET 1 OF 3


NOTE:
LEGS AND CROSS BRACES OMITTED FOR CLARITY
HEX HEAD BOLT 5/16-18 X 1.75 8 REQ'D WIDE WASHER 16 REQ'D NUT 8 REQ'D
POSITIONING BLOCK PS-004 4 REQ'D
POSITIONING BLOCK PS-005 4 REQ'D
HEX HEAD BOLT 1/4-20 X 2.75 8 REQ'D
HEX HEAD BOLT 1/2-13 X 1.5 12 REQ'D WIDE WASHER 24 REQ'D NUT 12 REQ'D
HEX HEAD BOLT 1/2-13 X 3 46 REQ'D WIDE WASHER 46 REQ'D
MOTOR BASE ASSEMBLY PSA-1 1 REQ'D
COUPLING GUARD PS-015 2 REQ'D
COUPLING GUARD PS-016 1 REQ'D
COUPLING GUARD PS-017 1 REQ'D (OUT OF VIEW)
GIRDER PLATE PS-018 2 REQ'D
HEX HEAD BOLT 3/8-16 X 1.5 16 REQ'D WIDE WASHER 16 REQ'D
HEX HEAD BOLT 7/8-14 X 3.5 4 REQ'D WIDE WASHER 8 REQ'D
HEX HEAD BOLT 7/8-9 X 1.750 4 REQ'D WIDE WASHER 4 REQ'D
PUMP MOUNT ASSEMBLY PSA-4 1 REQ'D
GIRDER PLATE PS-019 1 REQ'D
PUMP MOUNTING BAR PS-021 4 REQ'D
PUMP MOUNTING BLOCK PS-020 4 REQ'D
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.0
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
A36 UNLESS NOTED
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
15DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
PUMP MOUNT
SIZE
B
DWG. NO.
PSA-100
REV
-
SCALE: 1:16
WEIGHT:
SHEET 2 OF 3
8
7
6
5
4
3
2
1
D
C
B
A

ASSEMBLY	NAME	QUANTITY
PSA-1	MOTOR BASE ASSEMBLY	1
PSA-2	MOTOR BASE WELDMENT	1
PSA-3	BRACKET ASSEMBLY	8
PSA-4	PUMP MOUNT ASSEMBLY	1
PSA-5	PUMP BASE ASSEMBLY	1

PART	NAME	MATERIAL	QUANTITY
PS-001	MOTOR BASE	A36	1
PS-002	MOTOR BASE SUPPORT	A36	8
PS-003	BRACKET	A36	16
PS-004	POSITIONING BLOCK	316SS	4
PS-005	POSITIONING BLOCK	316SS	4
PS-006	FITTING	316SS	16
PS-007	CROSS PLATE	A36	8
PS-008	PUMP STAND MAIN LEG	A36	4
PS-009	LONG CROSS BRACE	A36	4
PS-010	MEDIUM CROSS BRACE	A36	4
PS-011	SHORT CROSS BRACE	A36	4
PS-012	FOOT	A36	8
PS-013	GUSSET	A36	16
PS-014	PUMP MOUNT GIRDER	A36	4
PS-015	COUPLING GUARD	A36	1
PS-016	COUPLING GUARD	A36	2
PS-017	COUPLING GUARD	A36	1
PS-018	GIRDER PLATE	A36	2
PS-019	GIRDER PLATE	A36	1
PS-020	PUMP MOUNTING BLOCK	316SS	4
PS-021	PUMP MOUNTING BAR	A36	4
PS-022	ROD END	316SS	12
PS-023	ROD END	316SS	4

TUBING CUT LIST

PART	TUBING SIZE	LENGTH	# OF PIECES
PSA-2	3X2X.250	42.000	4
PSA-5	3X2X.250	78.000	4
PS-008	3X2X.250	79.721	4
PS-009	2X2X.188	92.500	4
PS-010	2X2X.188	61.467	4
PS-011	2X2X.188	29.558	4
PS-014	2X2X.188	30.625	4
PS-021	1X1X.125	12.000	4

THIS ASSEMBLY PSA-100 CONSISTS OF TWO MAJOR COMPONENTS, THE PUMP STAND PROPER SHOWN ON SHEET 1 OF 3 AND THE PUMP MOUNT SHOWN ON SHEET 2 OF 3. THE STAND WILL BE ASSEMBLED ON LOCATION. THE PUMP MOUNT WILL BE BOLTED ONTO THE STAND AT INSTALLATION.

HARDWARE

PIECE	QUANTITY
HHCS 1/4-20 X 2.750	8
WIDE WASHER, 1/4	16
NUT, 1/4-20	8
HHCS 5/16-18 X 1.750	8
WIDE WASHER, 5/16	16
NUT, 5/16-18	8
HHCS 3/8-16 X 1.500	16
WIDE WASHER, 3/8	16
HHCS 1/2-13 X 1.500	28
HHCS 1/2-13 X 3.000	46
HHCS 1/2-13 X 3.000 DRILLED	8
HHCS 1/2-13 X 3.500	32
WIDE WASHER, 1/2	174
NUT, 1/2-13	60
HHCS 3/4-10 X 3.750	8
NARROW WASHER, 3/4	16
NUT, 3/4-10	8
HHCS 7/8-9 X 1.750	4
HHCS 7/8-14 X 3.500	4
WIDE WASHER, 7/8	16
NUT, 7/8-9	4

NOTE: HARDWARE WILL BE SUPPLIED BY CUSTOMER

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.2
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
AS NOTED
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	16DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

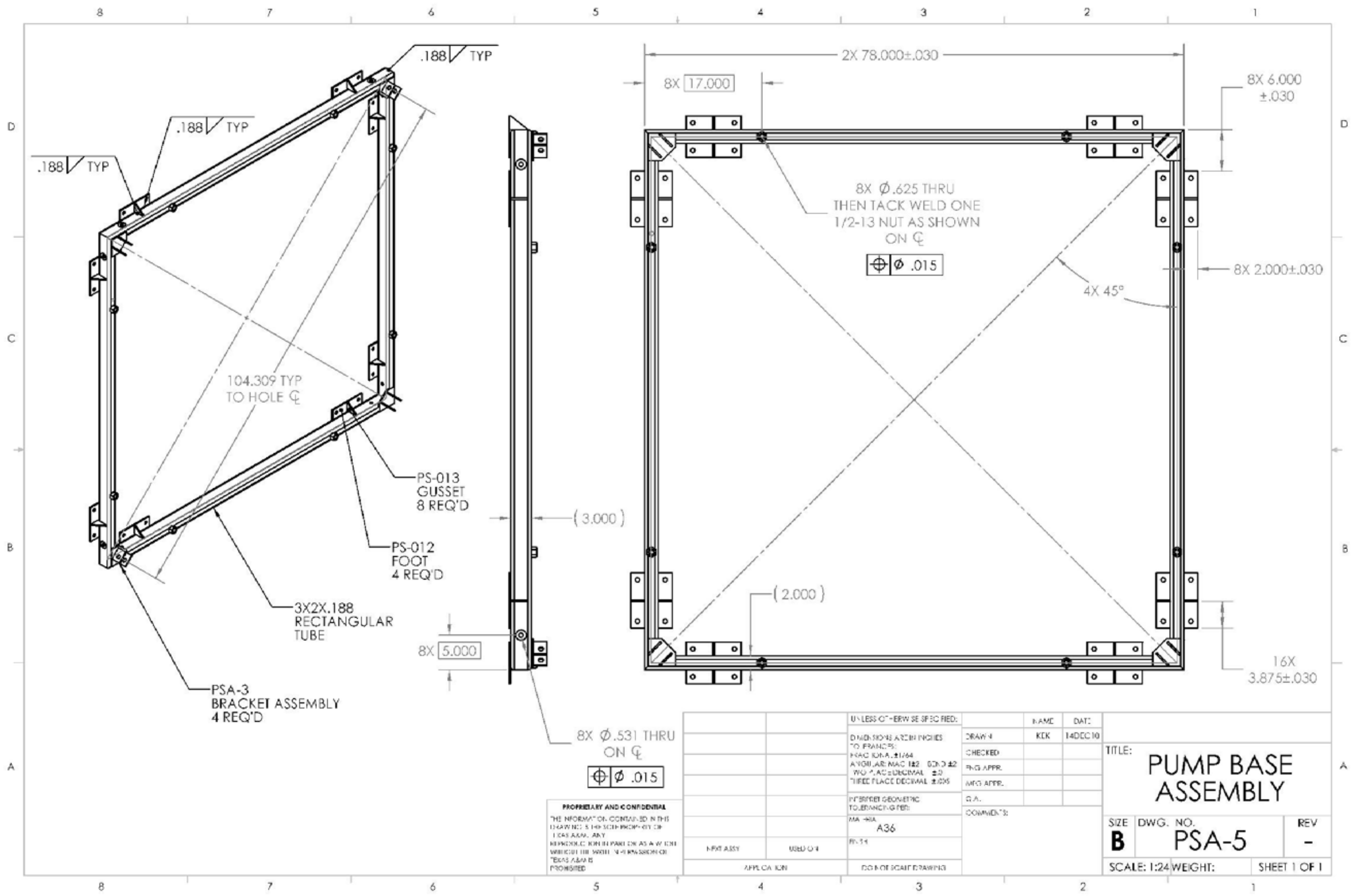
COMMENTS:

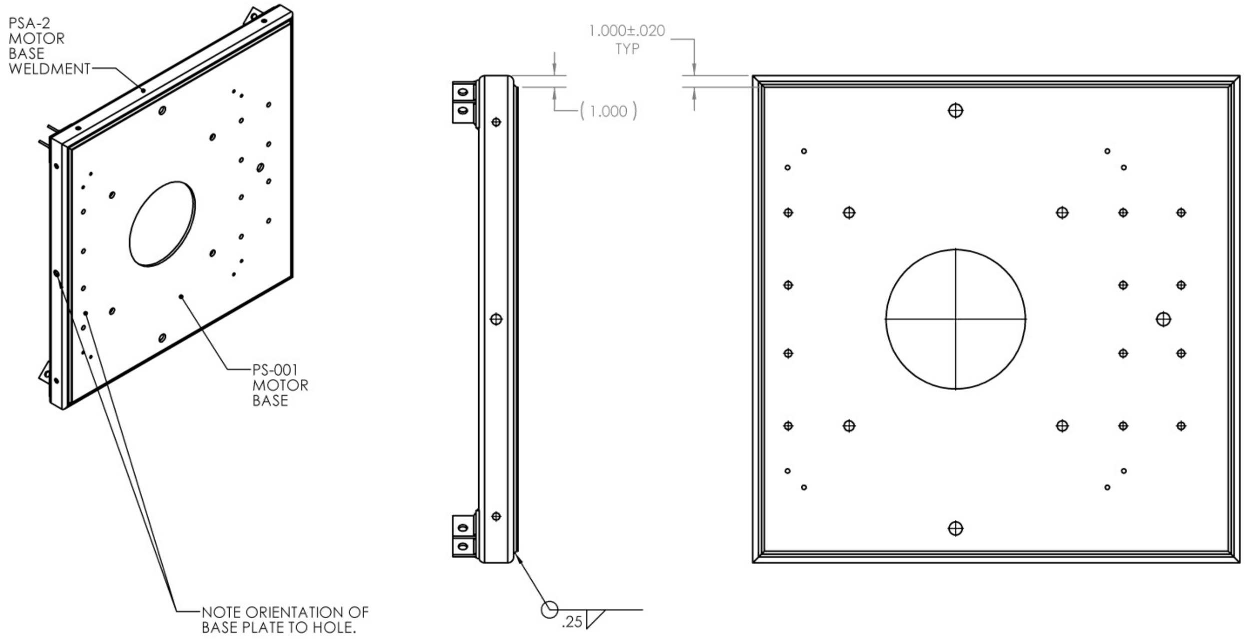
TITLE:

PUMP STAND

SIZE	DWG. NO.	REV
B	PSA-100	A

SCALE: 1:1 WEIGHT: SHEET 3 OF 3


.188 TYP
.188 TYP
.188 TYP
104.309 TYP
TO HOLE ℄
PS-013
GUSSET
8 REQ'D
PS-012
FOOT
4 REQ'D
3X2X.188
RECTANGULAR
TUBE
PSA-3
BRACKET ASSEMBLY
4 REQ'D
8X 5.000
(3.000)
8X Ø.531 THRU
ON ℄
⌖ Ø .015
2X 78.000±.030
8X 17.000
8X 6.000
±.030
8X Ø.625 THRU
THEN TACK WELD ONE
1/2-13 NUT AS SHOWN
ON ℄
⌖ Ø .015
8X 2.000±.030
4X 45°
(2.000)
16X
3.875±.030
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.0
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC
TOLERANCING PER:
MATERIAL
A36
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
14DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
PUMP BASE
ASSEMBLY
SIZE
B
DWG. NO.
PSA-5
REV
-
SCALE: 1:24
WEIGHT:
SHEET 1 OF 1
8
7
6
5
4
3
2
1
D
C
B
A



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

NEXT ASSY | USED ON

APPLICATION

DO NOT SCALE DRAWING

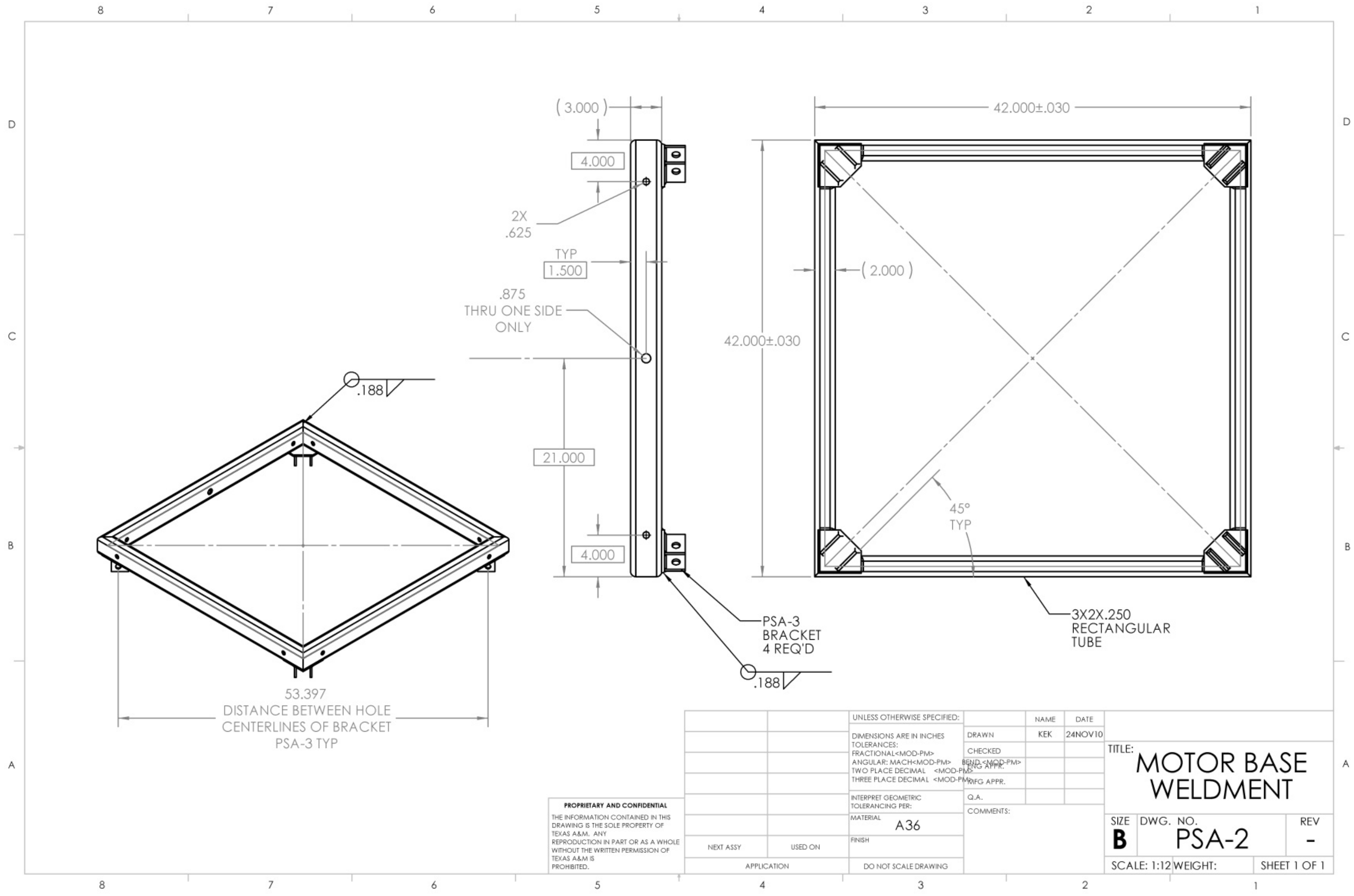
	NAME	DATE
DRAWN	KEK	29NOV10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:
MOTOR BASE
ASSEMBLY

SIZE B
DWG. NO. PSA-1
REV -

SCALE: 1:12 WEIGHT: SHEET 1 OF 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL<MOD-PM>
ANGULAR: MACH<MOD-PM> BEND <MOD-PM>
TWO PLACE DECIMAL <MOD-PM>
THREE PLACE DECIMAL <MOD-PM>

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL A36

FINISH

DO NOT SCALE DRAWING

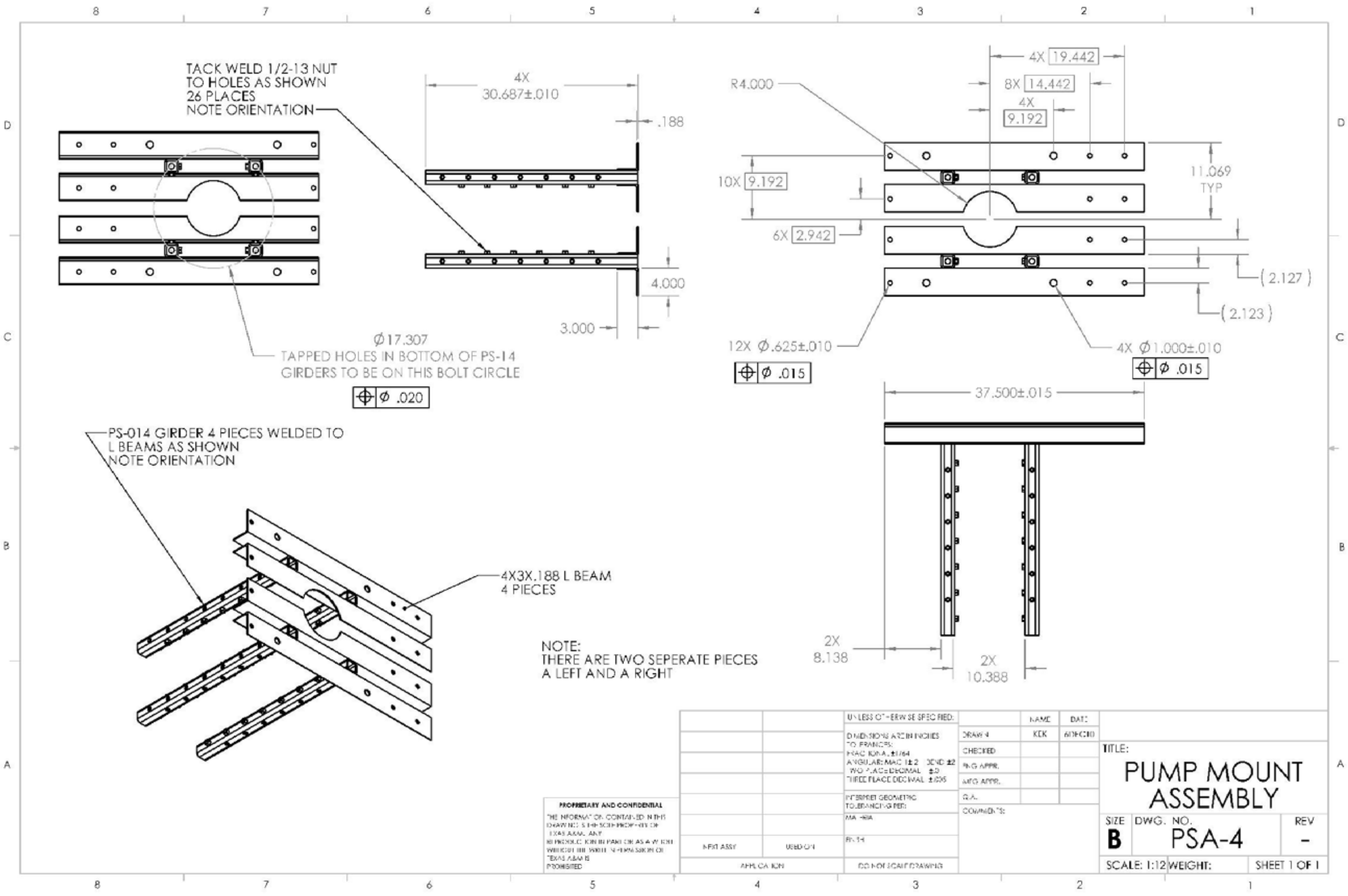
NEXT ASSY
USED ON
APPLICATION

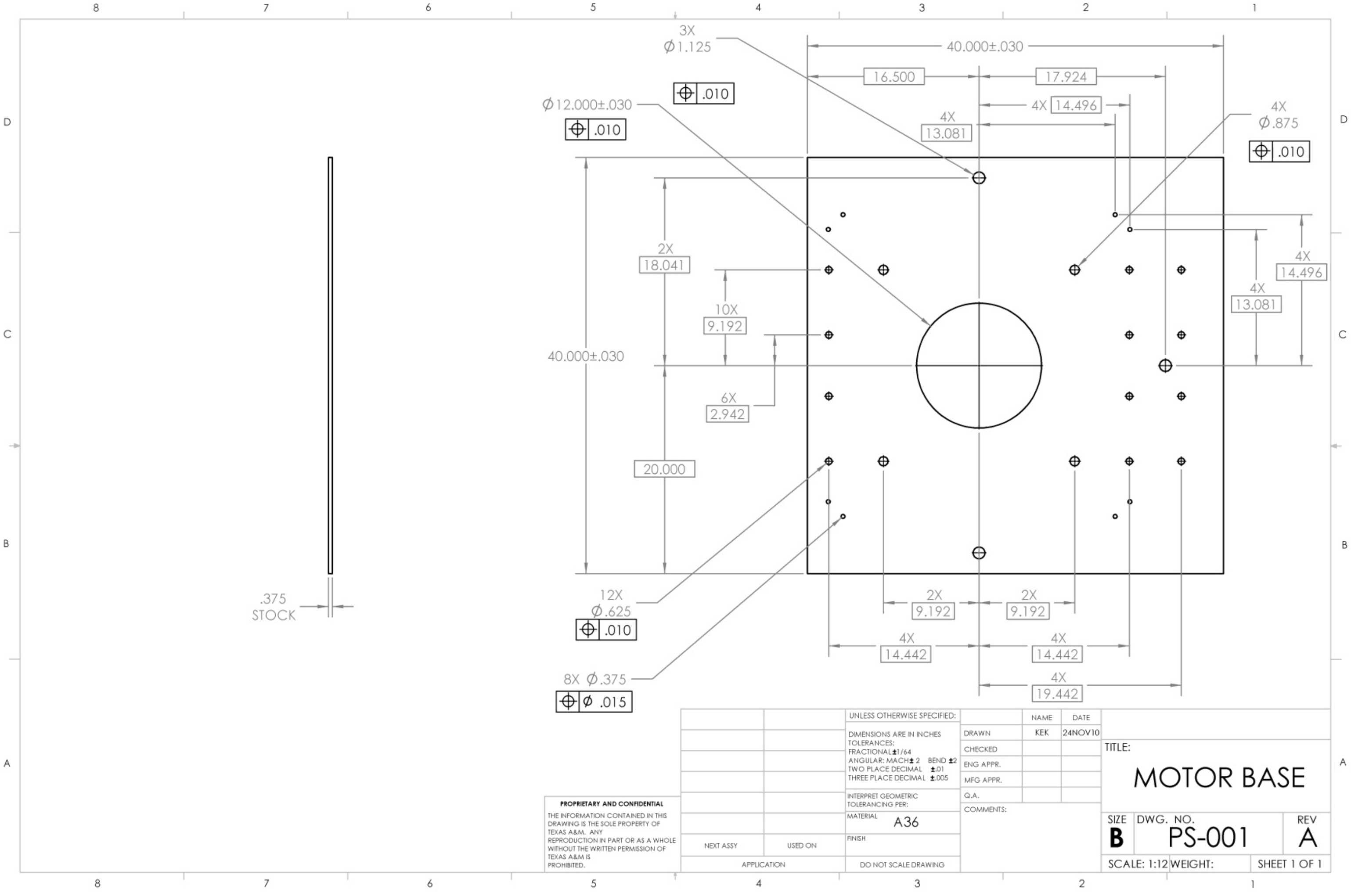
	NAME	DATE
DRAWN	KEK	24NOV10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

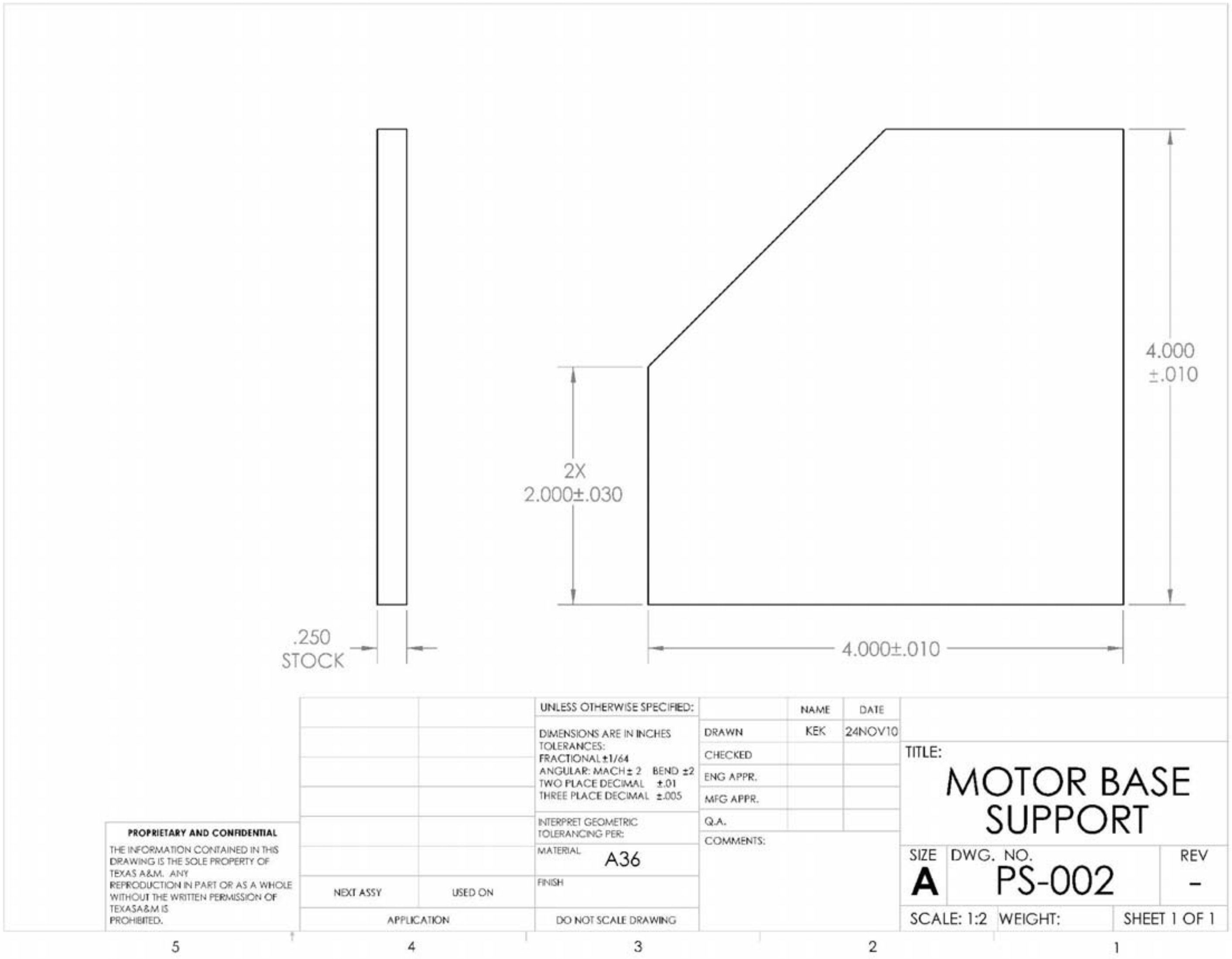
COMMENTS:

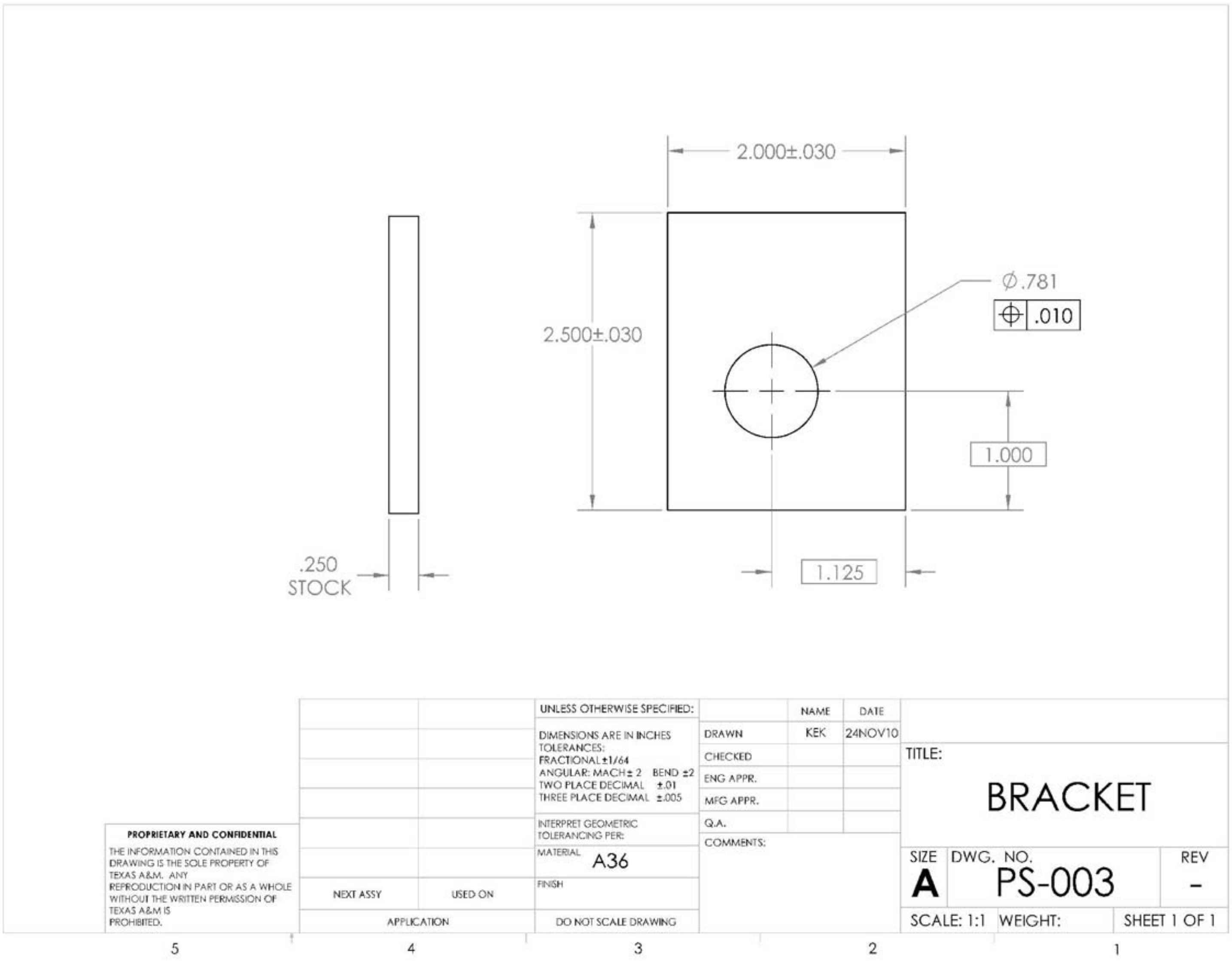
TITLE: MOTOR BASE WELDMENT

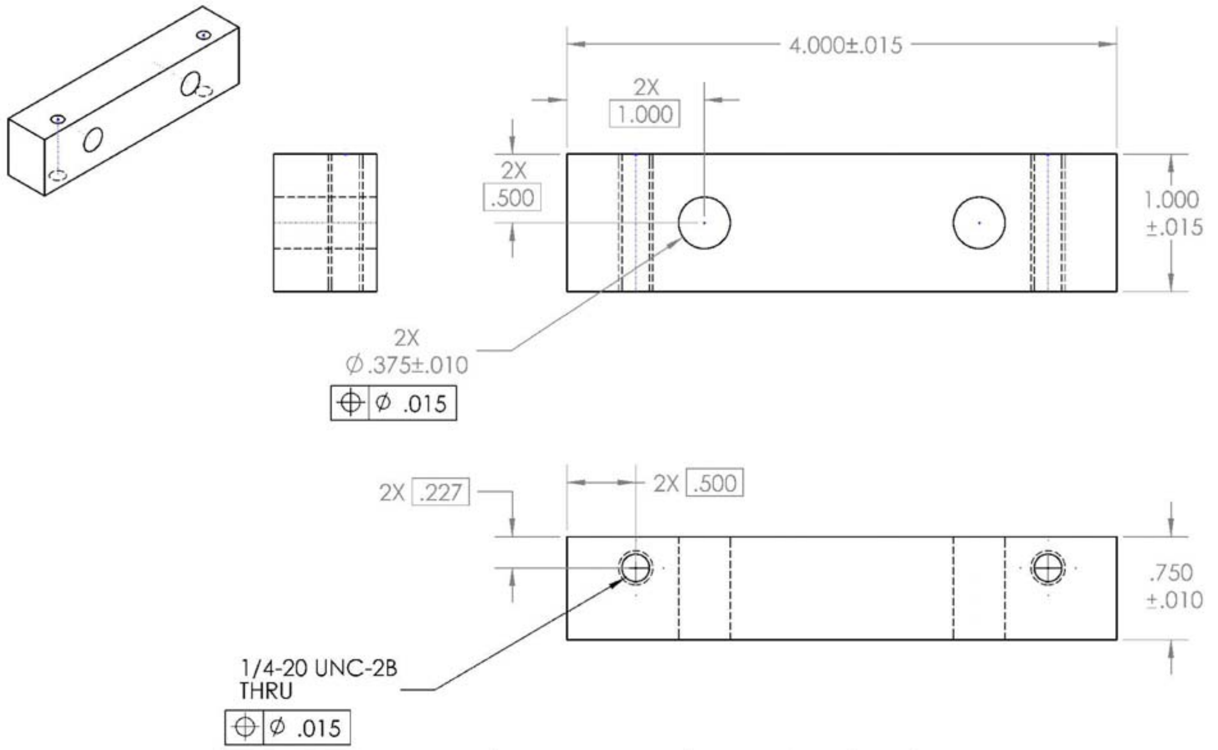
SIZE B
DWG. NO. PSA-2
REV -
SCALE: 1:12 WEIGHT: SHEET 1 OF 1


TACK WELD 1/2-13 NUT
TO HOLES AS SHOWN
26 PLACES
NOTE ORIENTATION
4X
30.687±.010
.188
4.000
3.000
Ø17.307
TAPPED HOLES IN BOTTOM OF PS-14
GIRDERS TO BE ON THIS BOLT CIRCLE
Ø .020
PS-014 GIRDER 4 PIECES WELDED TO
L BEAMS AS SHOWN
NOTE ORIENTATION
4X3X.188 L BEAM
4 PIECES
NOTE:
THERE ARE TWO SEPERATE PIECES
A LEFT AND A RIGHT
R4.000
4X 19.442
8X 14.442
4X 9.192
10X 9.192
6X 2.942
11.069
TYP
(2.127)
(2.123)
12X Ø.625±.010
Ø .015
4X Ø1.000±.010
Ø .015
37.500±.015
2X
8.138
2X
10.388
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.0
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC
TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
6DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
PUMP MOUNT
ASSEMBLY
SIZE
B
DWG. NO.
PSA-4
REV
-
SCALE: 1:12
WEIGHT:
SHEET 1 OF 1
8
7
6
5
4
3
2
1
D
C
B
A


3X
⌀1.125
⊕ .010
40.000±.030
16.500
17.924
4X 14.496
4X
13.081
⌀12.000±.030
⊕ .010
4X
⌀.875
⊕ .010
2X
18.041
10X
9.192
40.000±.030
6X
2.942
20.000
4X
14.496
4X
13.081
12X
⌀.625
⊕ .010
8X ⌀.375
⊕ ⌀ .015
2X
9.192
2X
9.192
4X
14.442
4X
14.442
4X
19.442
.375
STOCK
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL A36
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN KEK 24NOV10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
MOTOR BASE
SIZE B
DWG. NO. PS-001
REV A
SCALE: 1:12
WEIGHT:
SHEET 1 OF 1
8
7
6
5
4
3
2
1
D
C
B
A


4.000
±.010
2X
2.000±.030
4.000±.010
.250
STOCK
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC
TOLERANCING PER:
MATERIAL A36
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN KEK 24NOV10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NEXT ASSY
USED ON
APPLICATION
TITLE:
MOTOR BASE
SUPPORT
SIZE
A
DWG. NO.
PS-002
REV
-
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXASA&M IS PROHIBITED.
5
4
3
2
1


2.000±.030
2.500±.030
∅.781
⌖ .010
1.000
1.125
.250
STOCK
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC
TOLERANCING PER:
MATERIAL A36
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN KEK 24NOV10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
BRACKET
SIZE A
DWG. NO. PS-003
REV -
SCALE: 1:1
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
5
4
3
2
1



PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL 316 SS
FINISH 125 RMS
DO NOT SCALE DRAWING

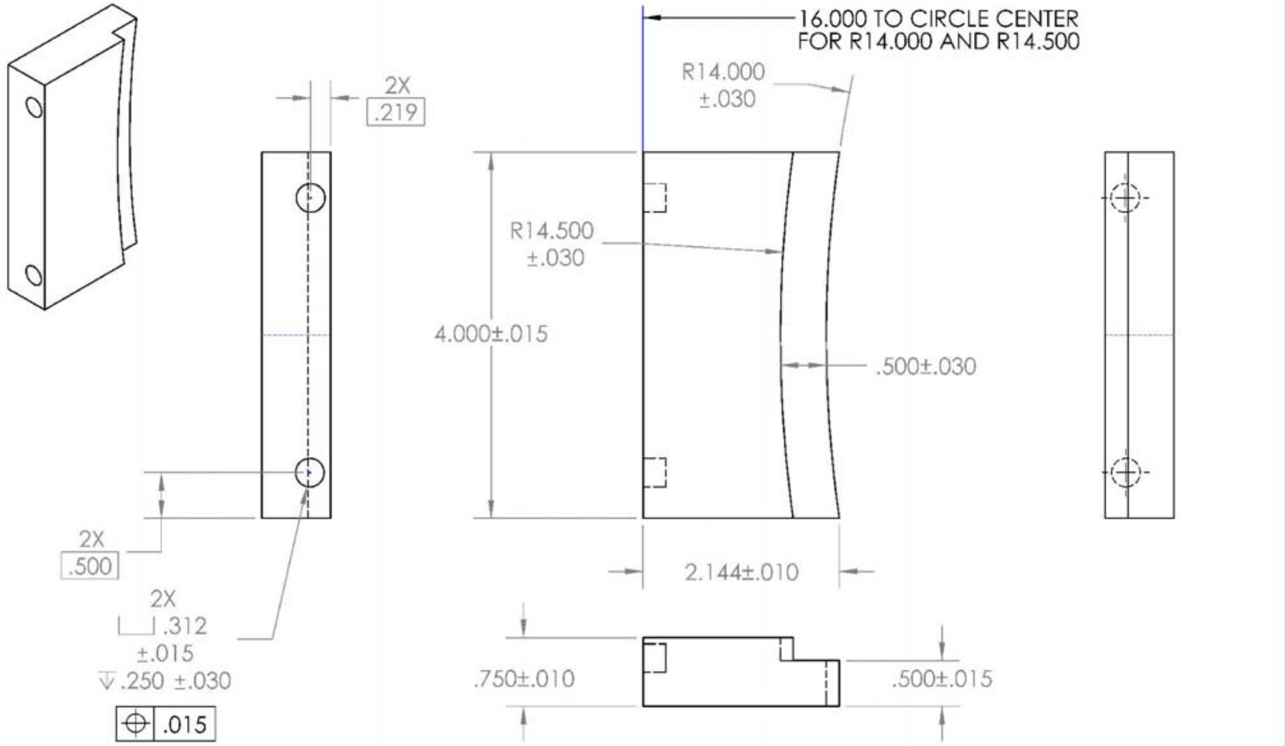
	NAME	DATE
DRAWN	KEK	29NOV10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE: POSITIONING BLOCK

SIZE A
DWG. NO. PS-004
REV -
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1

5 4 3 2 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: 316 SS

FINISH: 125 RMS

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	29NOV10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

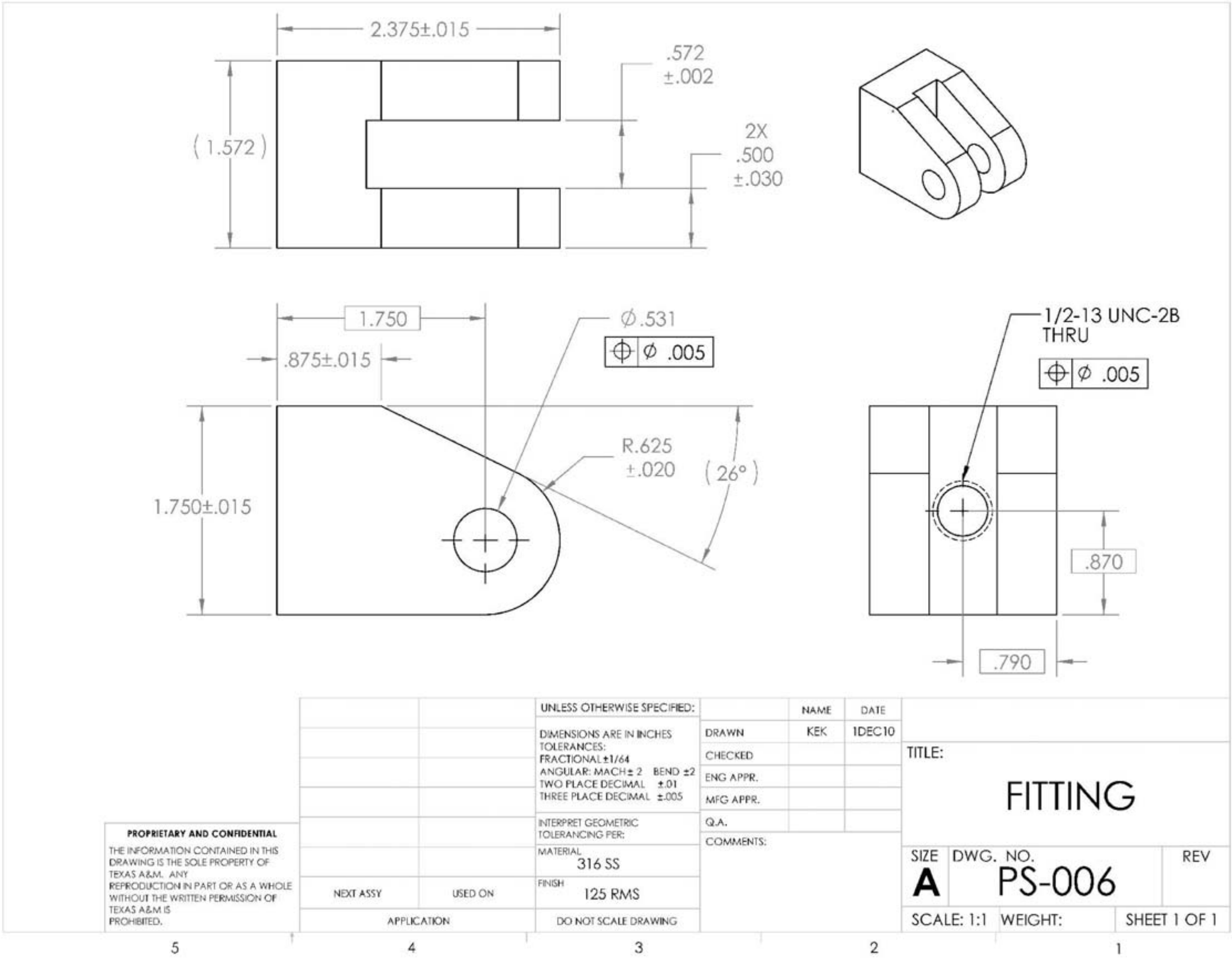
COMMENTS:

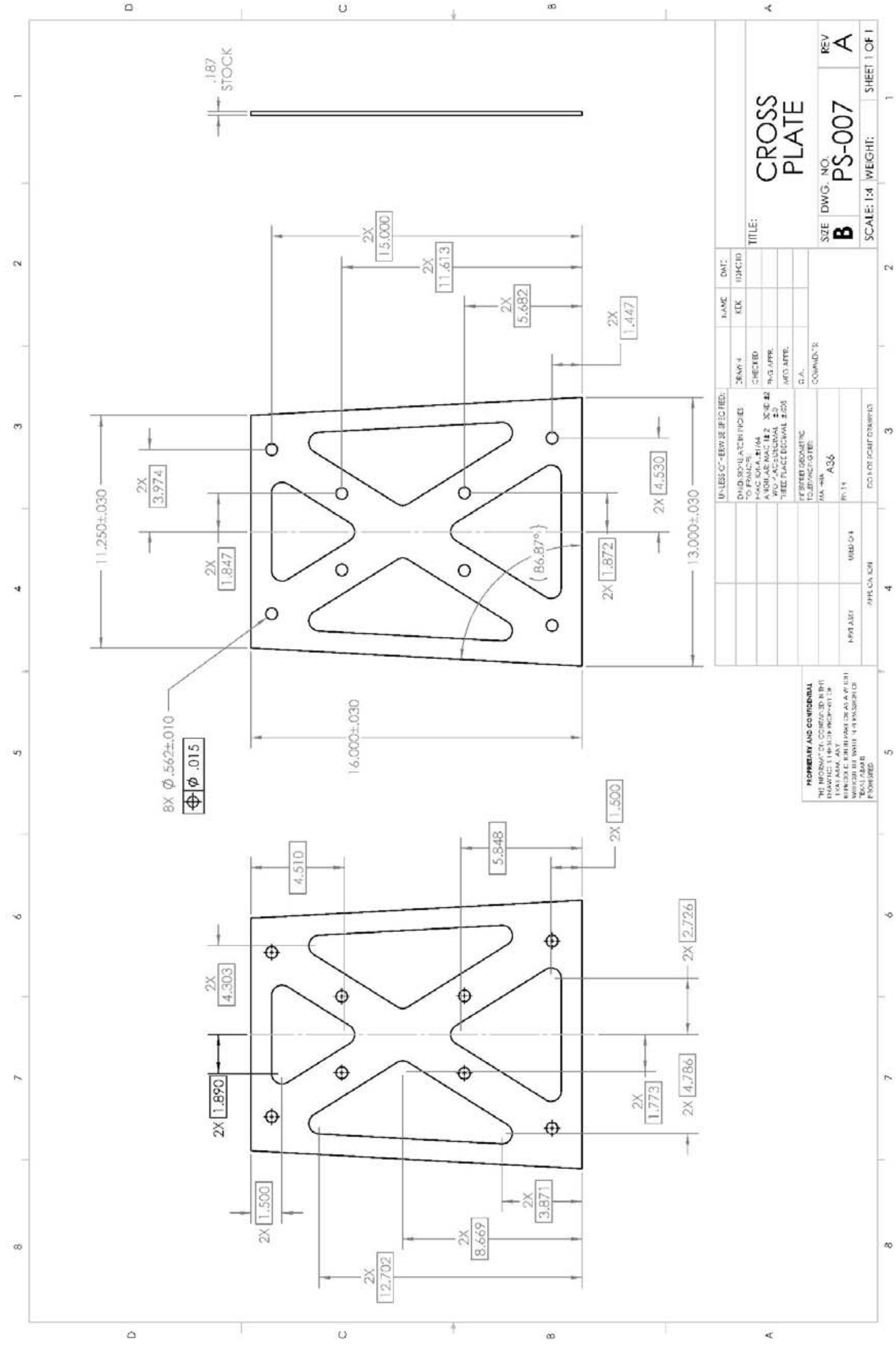
TITLE: POSITIONING BLOCK

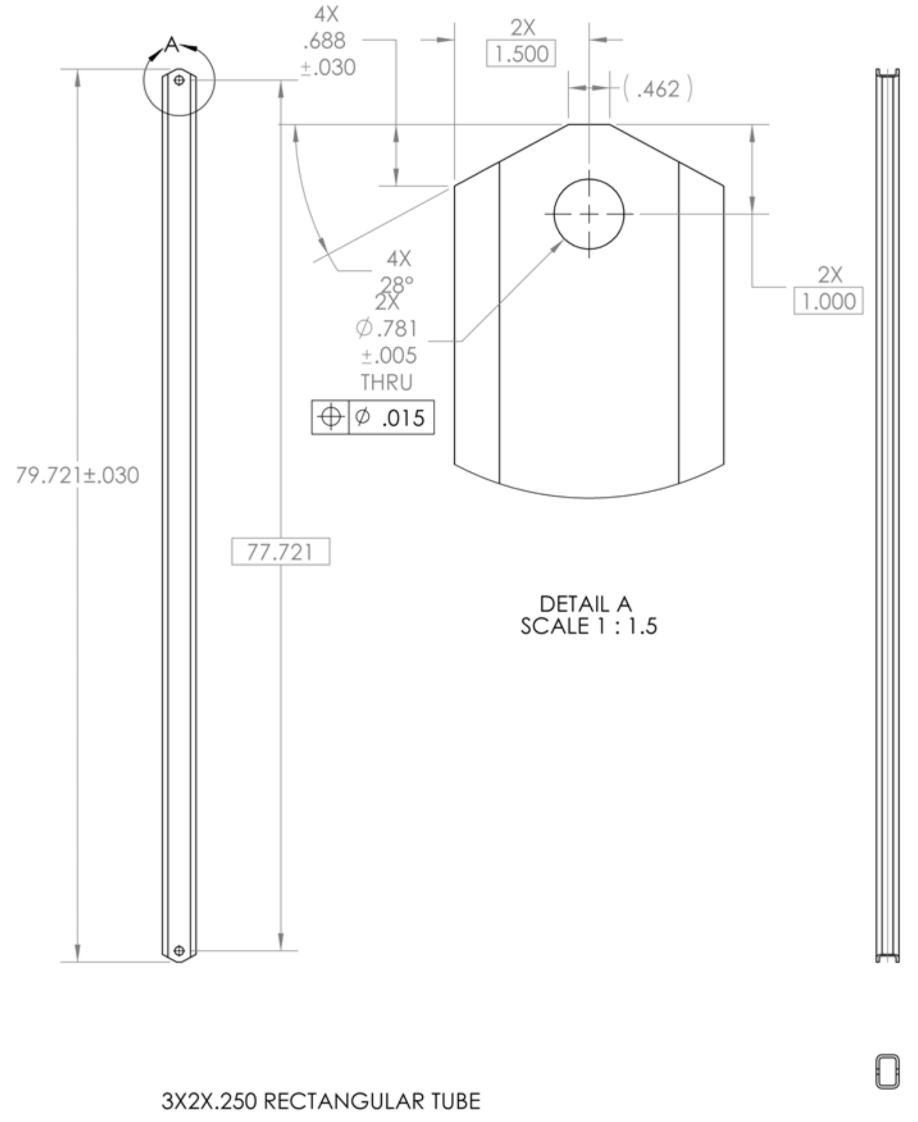
SIZE: A
DWG. NO. PS-005
REV: -

SCALE: 1:2 WEIGHT: SHEET 1 OF 1

5 4 3 2 1


2.375±.015
.572
±.002
2X
.500
±.030
(1.572)
1.750
.875±.015
Ø.531
⊕ Ø .005
R.625
±.020
(26°)
1.750±.015
1/2-13 UNC-2B
THRU
⊕ Ø .005
.870
.790
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
316 SS
FINISH
125 RMS
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
1DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
FITTING
SIZE
A
DWG. NO.
PS-006
REV
SCALE: 1:1
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
5
4
3
2
1


.187 STOCK
2X 15.000
2X 11.613
2X 5.682
2X 1.447
11.250±.030
2X 3.974
2X 1.847
(86.87°)
2X 1.872
2X 4.530
13.000±.030
16.000±.030
8X Ø .562±.010
Ø .015
4.510
5.848
2X 1.500
2X 4.303
2X 2.726
2X 1.890
2X 1.773
2X 4.786
2X 1.500
2X 3.871
2X 8.669
2X 12.702
UNLESS OTHERWISE SPECIFIED:
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
KEK
MATERIAL
A36
FINISH
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL
TITLE:
CROSS PLATE
SIZE
B
DWG. NO.
PS-007
REV
A
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL
A36

FINISH

DO NOT SCALE DRAWING

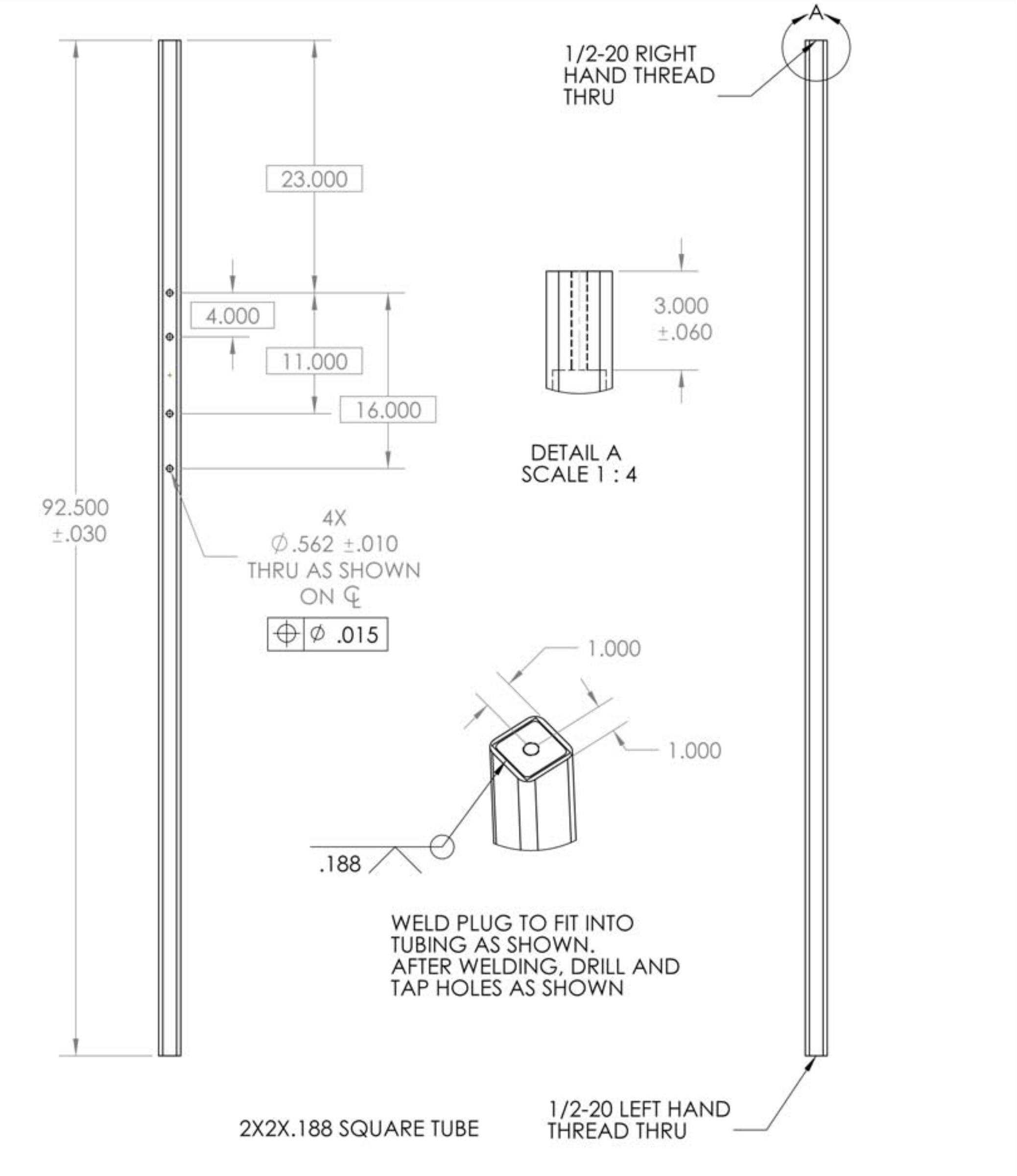
	NAME	DATE
DRAWN	KEK	2DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

PUMP STAND
MAIN LEG

SIZE A | DWG. NO. PS-008 | REV. A

SCALE:1:24 | WEIGHT: | SHEET 1 OF 1



1/2-20 RIGHT HAND THREAD THRU

WELD PLUG TO FIT INTO TUBING AS SHOWN.
AFTER WELDING, DRILL AND TAP HOLES AS SHOWN

2X2X.188 SQUARE TUBE

1/2-20 LEFT HAND THREAD THRU

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

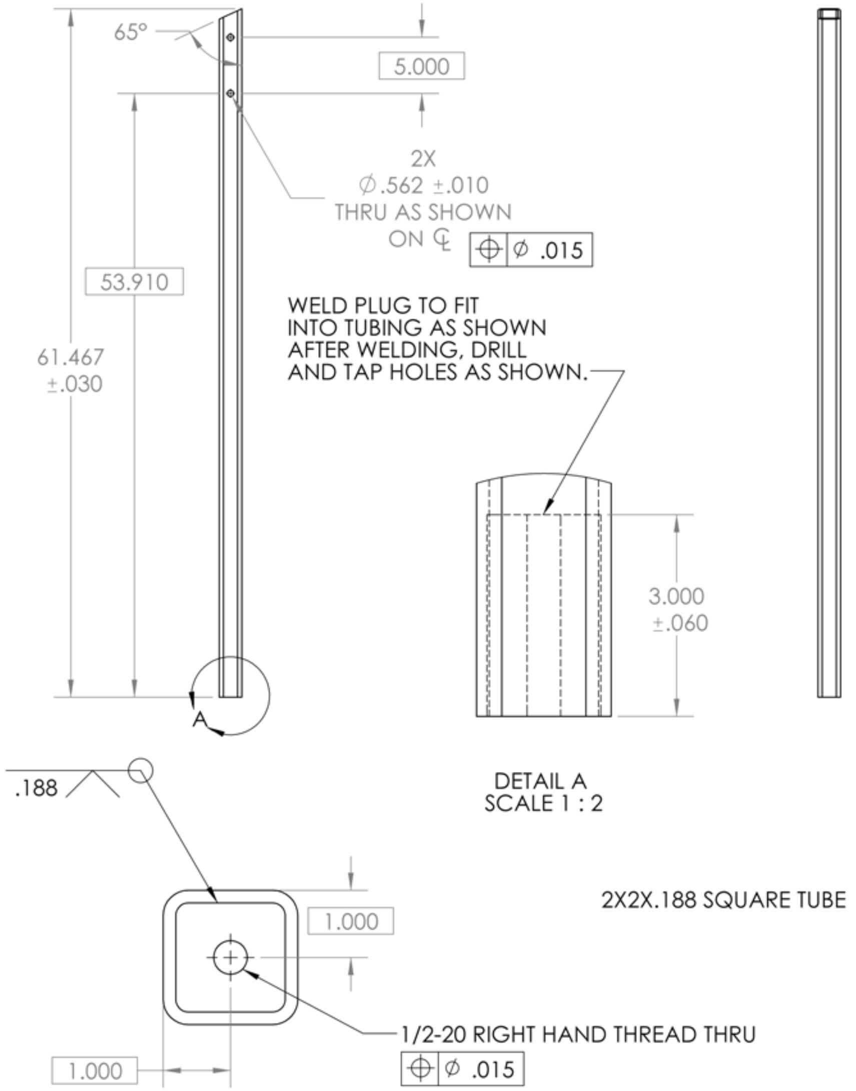
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	2DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

LONG CROSS BRACE

SIZE A
DWG. NO. PS-009
REV. A
SCALE:1:16
WEIGHT:
SHEET 1 OF 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ± 2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

MATERIAL
A36

FINISH

DO NOT SCALE DRAWING

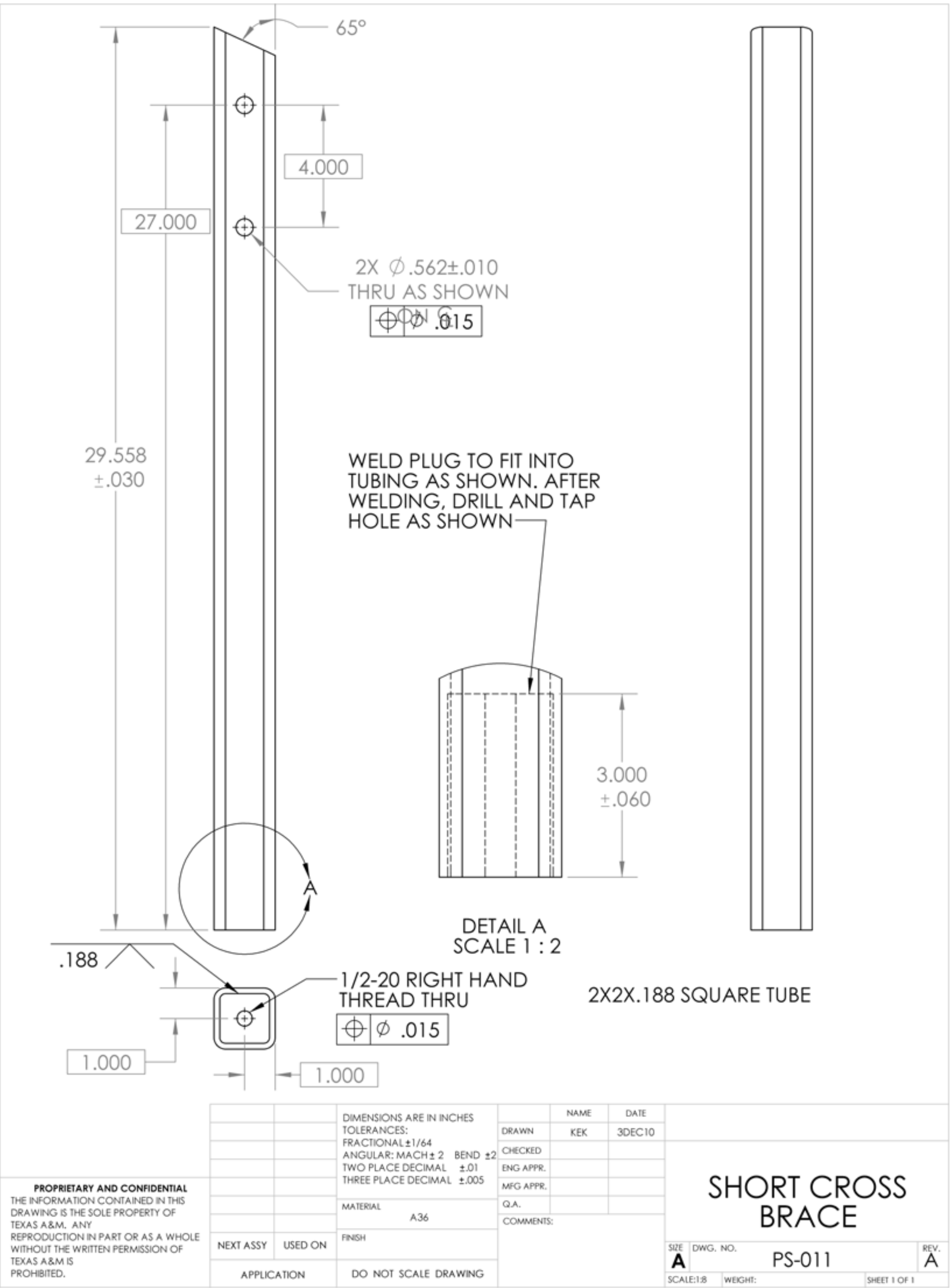
	NAME	DATE
DRAWN	KEK	3DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

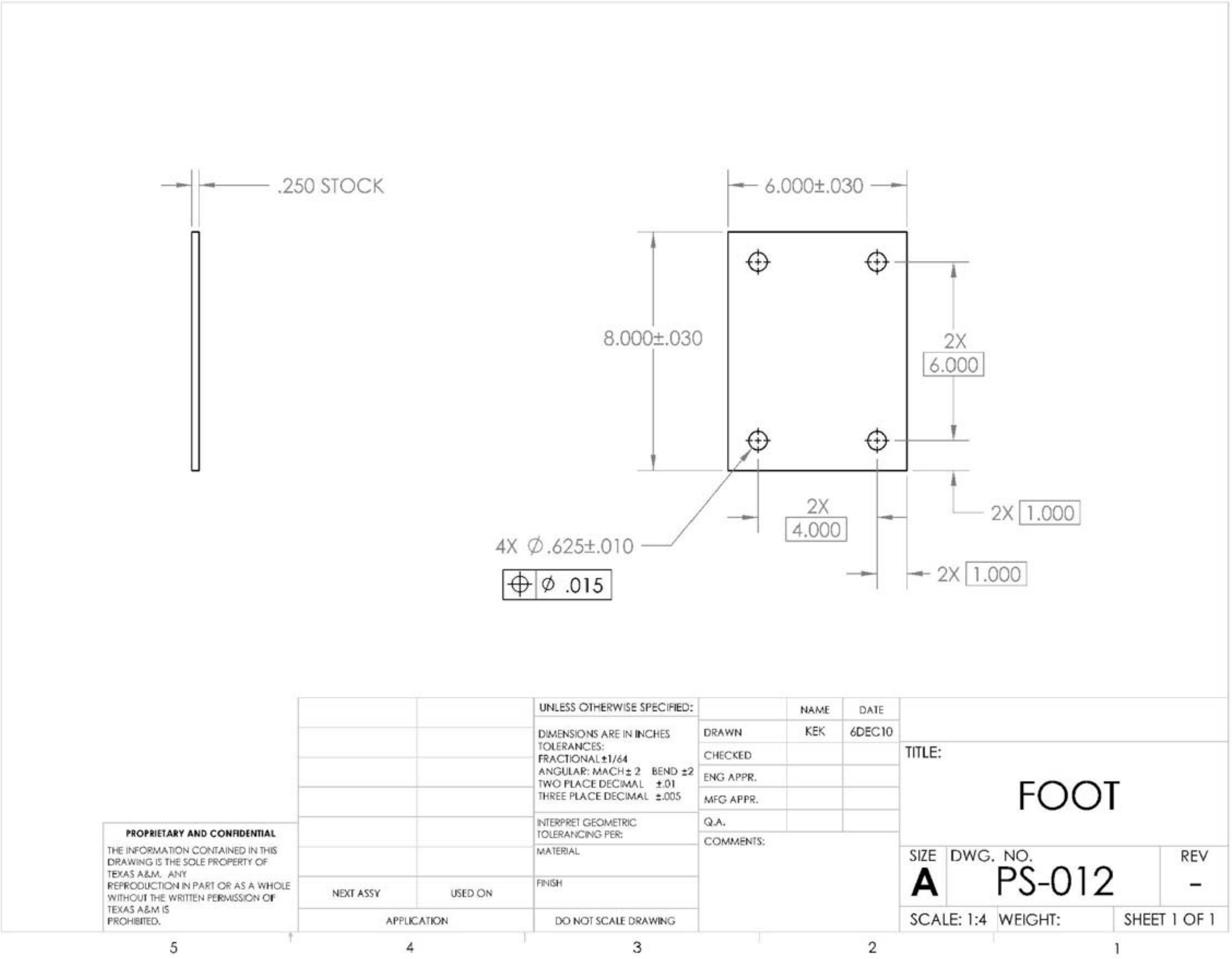
COMMENTS:

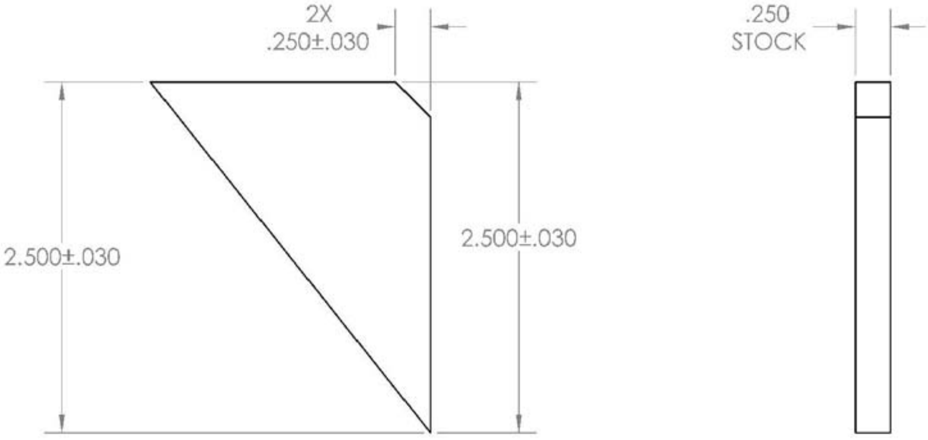
MEDIUM CROSS BRACE

SIZE A DWG. NO. PS-010 REV. A

SCALE:1:12 WEIGHT: SHEET 1 OF 1


65°
4.000
27.000
2X ∅.562±.010
THRU AS SHOWN
ON C
⌖ ∅ .015
29.558
±.030
WELD PLUG TO FIT INTO TUBING AS SHOWN. AFTER WELDING, DRILL AND TAP HOLE AS SHOWN
3.000
±.060
A
DETAIL A
SCALE 1 : 2
.188
1/2-20 RIGHT HAND THREAD THRU
⌖ ∅ .015
2X2X.188 SQUARE TUBE
1.000
1.000
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
MATERIAL
A36
FINISH
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
3DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
SHORT CROSS BRACE
SIZE
A
DWG. NO.
PS-011
REV.
A
SCALE:1:8
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.


.250 STOCK
6.000±.030
8.000±.030
2X
6.000
2X
4.000
2X 1.000
2X 1.000
4X Ø.625±.010
⌖ Ø .015
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
NAME
DATE
DRAWN
KEK
6DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
FOOT
SIZE
A
DWG. NO.
PS-012
REV
-
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1



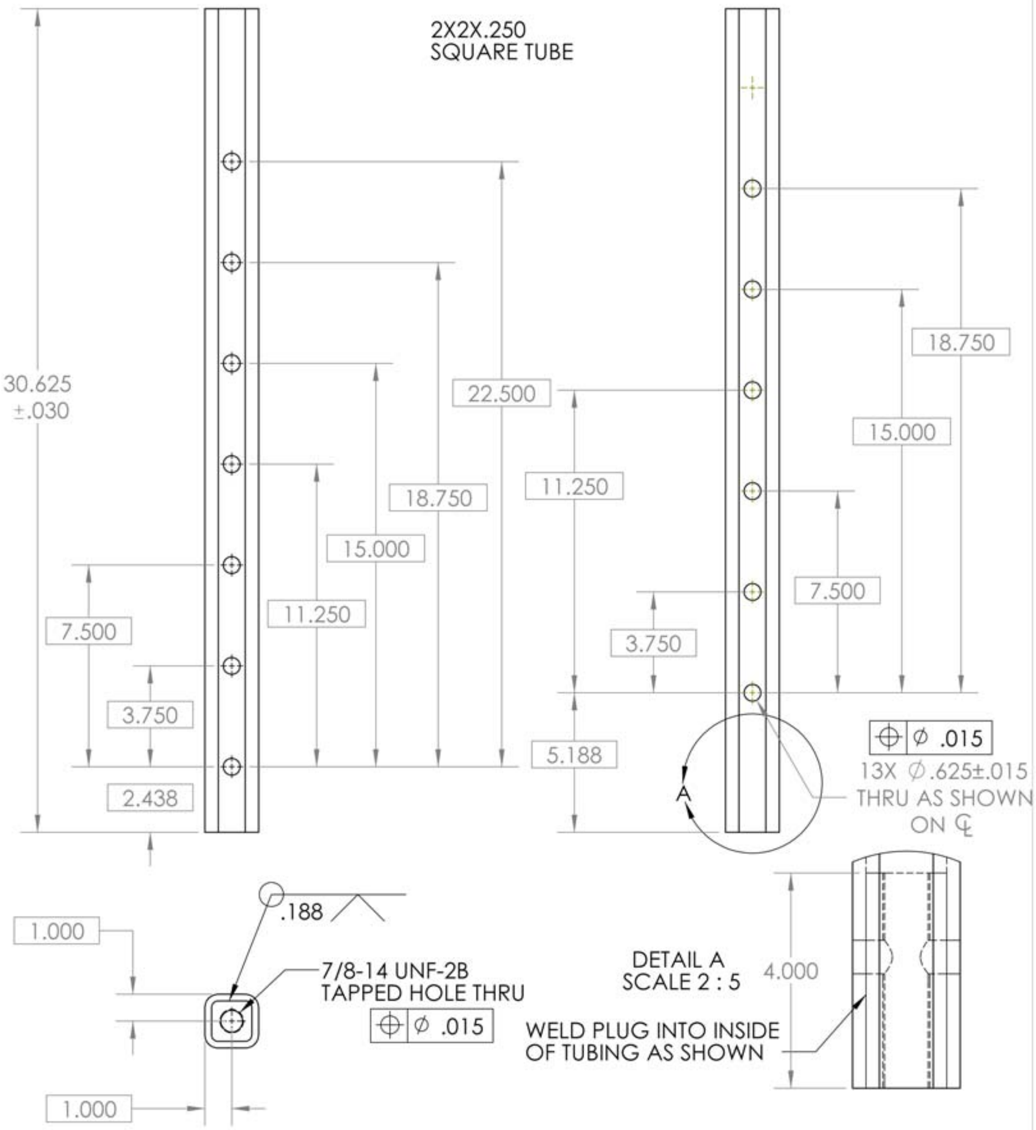
PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL±1/64 ANGULAR: MACH± 2 BEND ±2 TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005	DRAWN	KEK	6DEC10	
	CHECKED			TITLE:
	ENG APPR.			GUSSET
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL	COMMENTS:			SIZE A DWG. NO. PS-013 REV -
FINISH				
DO NOT SCALE DRAWING				SCALE: 1:1 WEIGHT: SHEET 1 OF 1

NEXT ASSY	USED ON
APPLICATION	

5 4 3 2 1



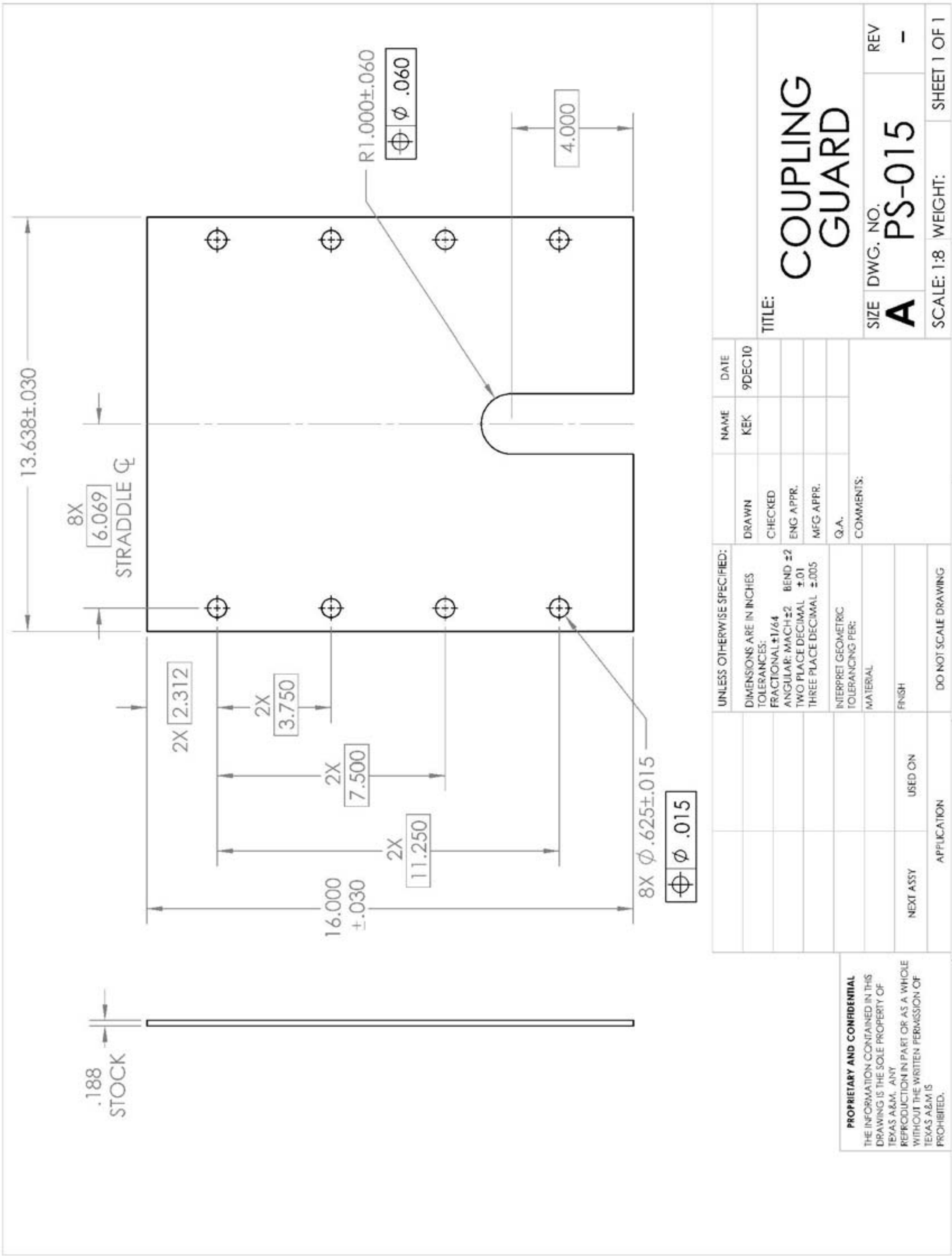
PROPRIETARY AND CONFIDENTIAL

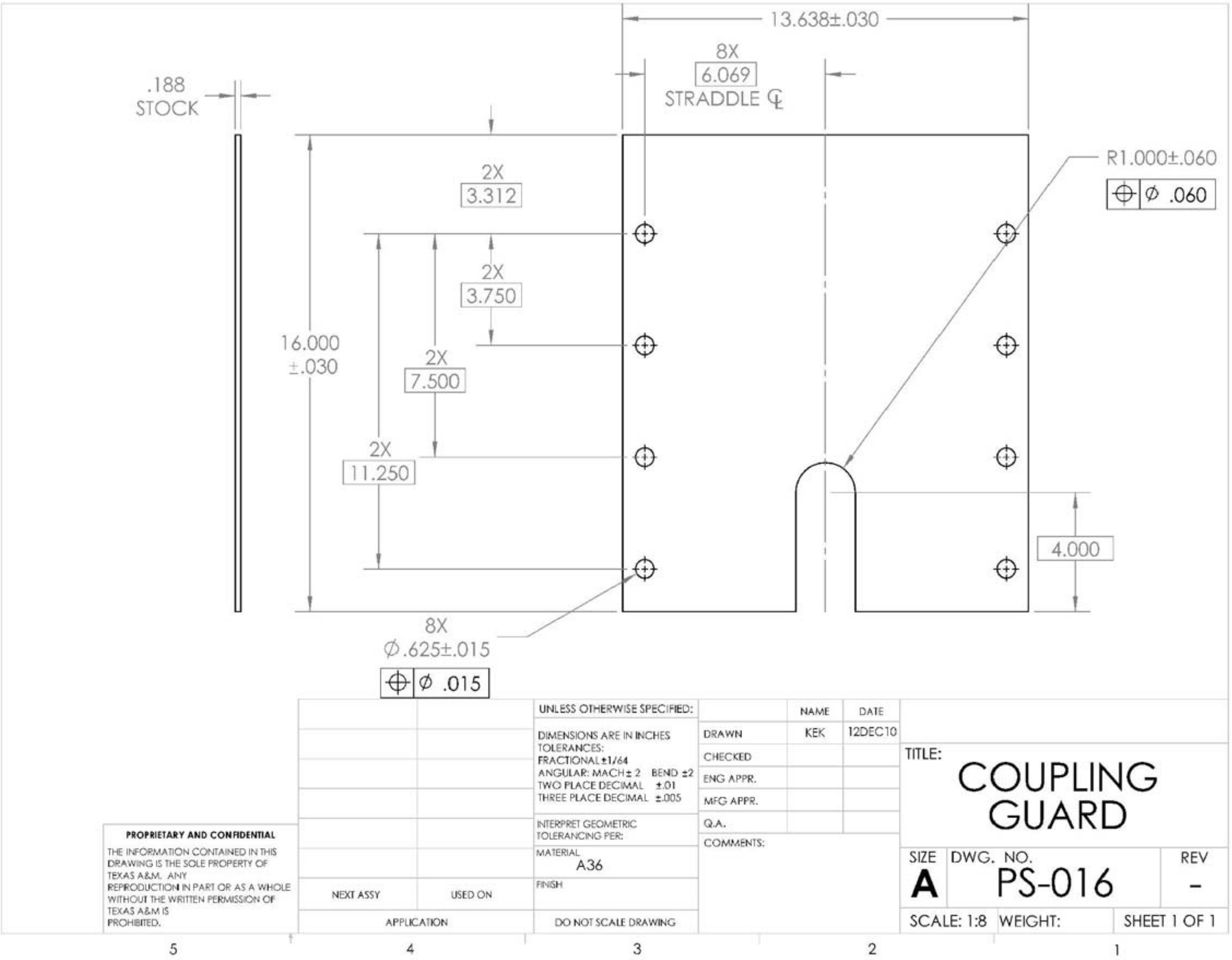
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

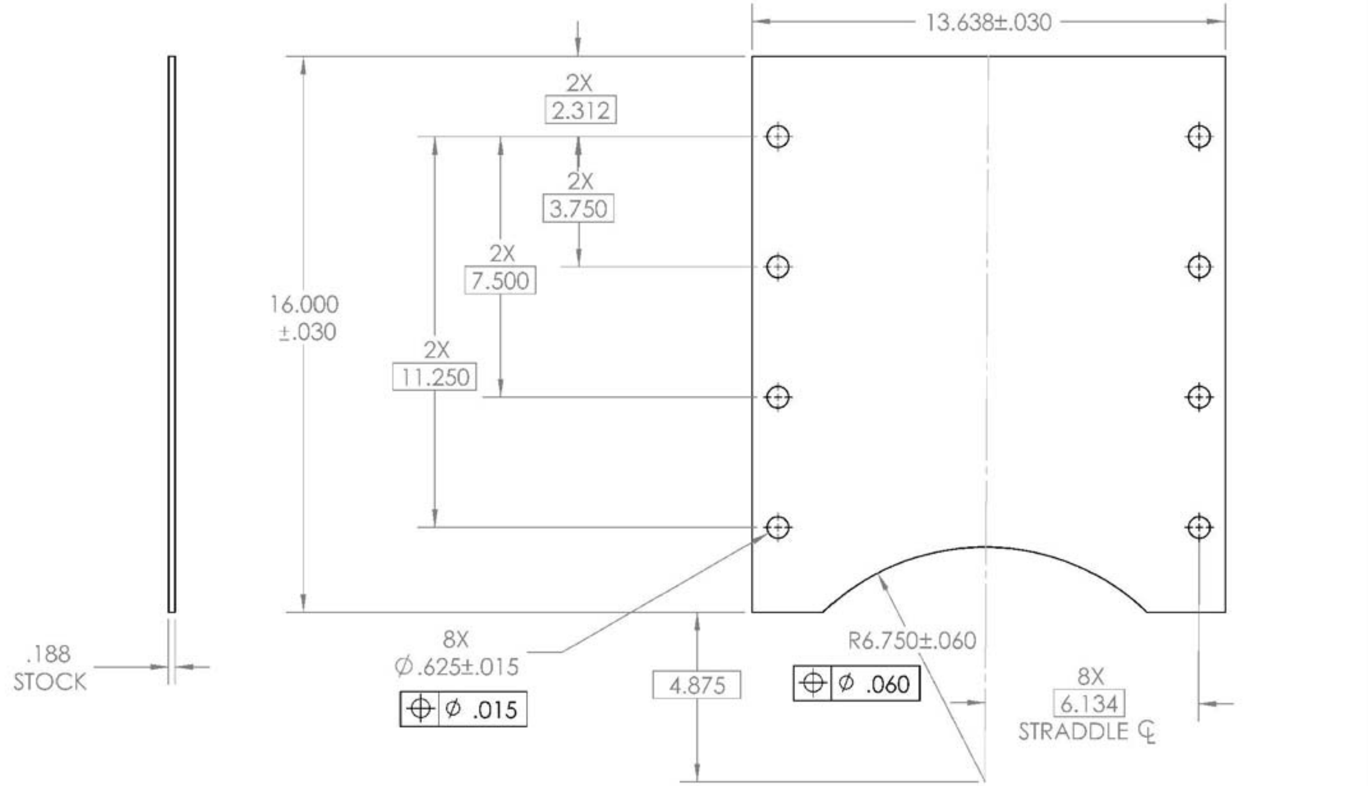
				NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/64 ANGULAR: MACH ±2 BEND ±2 TWO PLACE DECIMAL ±.01 THREE PLACE DECIMAL ±.005	DRAWN	KEK	7DEC10
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		MATERIAL A36	Q.A.		
NEXT ASSY	USED ON	FINISH	COMMENTS:		
APPLICATION		DO NOT SCALE DRAWING			

PUMP MOUNT GIRDER

SIZE A
DWG. NO. PS-014
REV. -
SCALE:1:8
WEIGHT:
SHEET 1 OF 1


13.638±.030
8X
6.069
STRADDLE ℄
R1.000±.060
⌖ ⌀ .060
4.000
2X 2.312
2X 3.750
2X 7.500
2X 11.250
16.000 ±.030
8X ⌀.625±.015
⌖ ⌀ .015
.188 STOCK
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
NAME
DATE
DRAWN
KEK
9DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
COUPLING GUARD
SIZE
A
DWG. NO.
PS-015
REV
-
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
1
2
3
4
5


13.638±.030
8X
6.069
STRADDLE ℄
.188
STOCK
2X
3.312
2X
3.750
16.000
±.030
2X
7.500
2X
11.250
R1.000±.060
⌖ Ø .060
4.000
8X
Ø.625±.015
⌖ Ø .015
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
A36
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
KEK
12DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
COUPLING GUARD
SIZE
A
DWG. NO.
PS-016
REV
-
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
5
4
3
2
1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	12DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

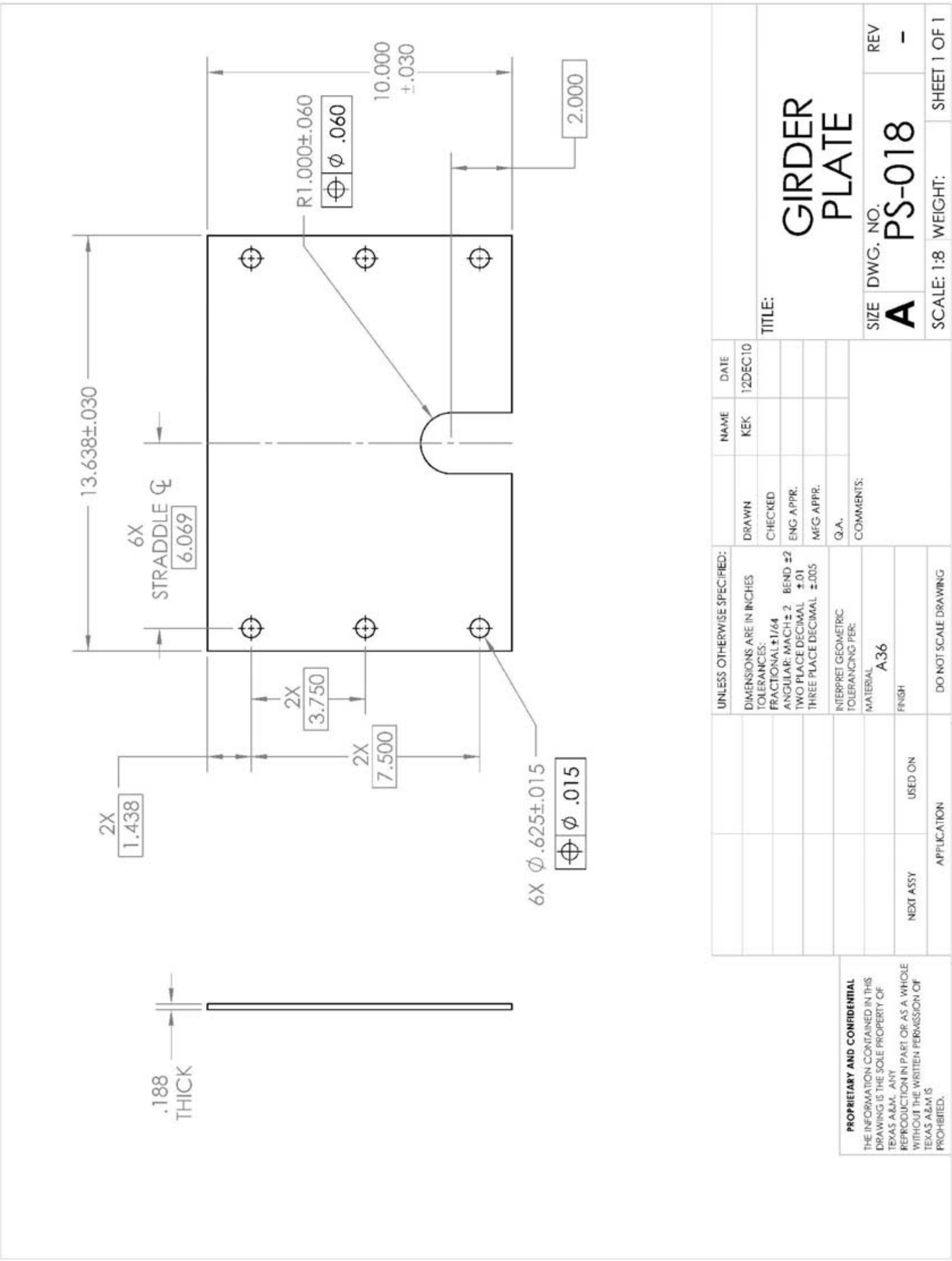
COMMENTS:

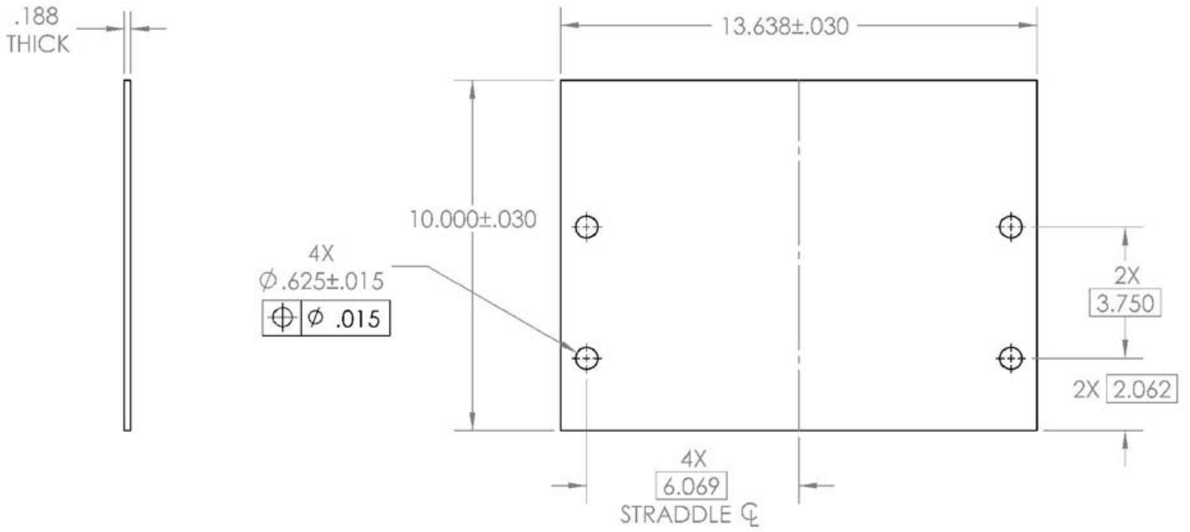
TITLE:

COUPLING
GUARD

SIZE	DWG. NO.	REV
A	PS-017	-
SCALE: 1:8	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1


13.638±.030
6X
STRADDLE ℄
6.069
10.000
±.030
R1.000±.060
⌖ Ø .060
2.000
2X
1.438
2X
3.750
2X
7.500
6X Ø.625±.015
⌖ Ø .015
.188
THICK
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC
TOLERANCING PER:
MATERIAL
A36
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
NAME
DATE
DRAWN
KEK
12DEC10
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
GIRDER
PLATE
SIZE
A
DWG. NO.
PS-018
REV
-
SCALE: 1:8
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.
5
4
3
2
1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH± 2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	12DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

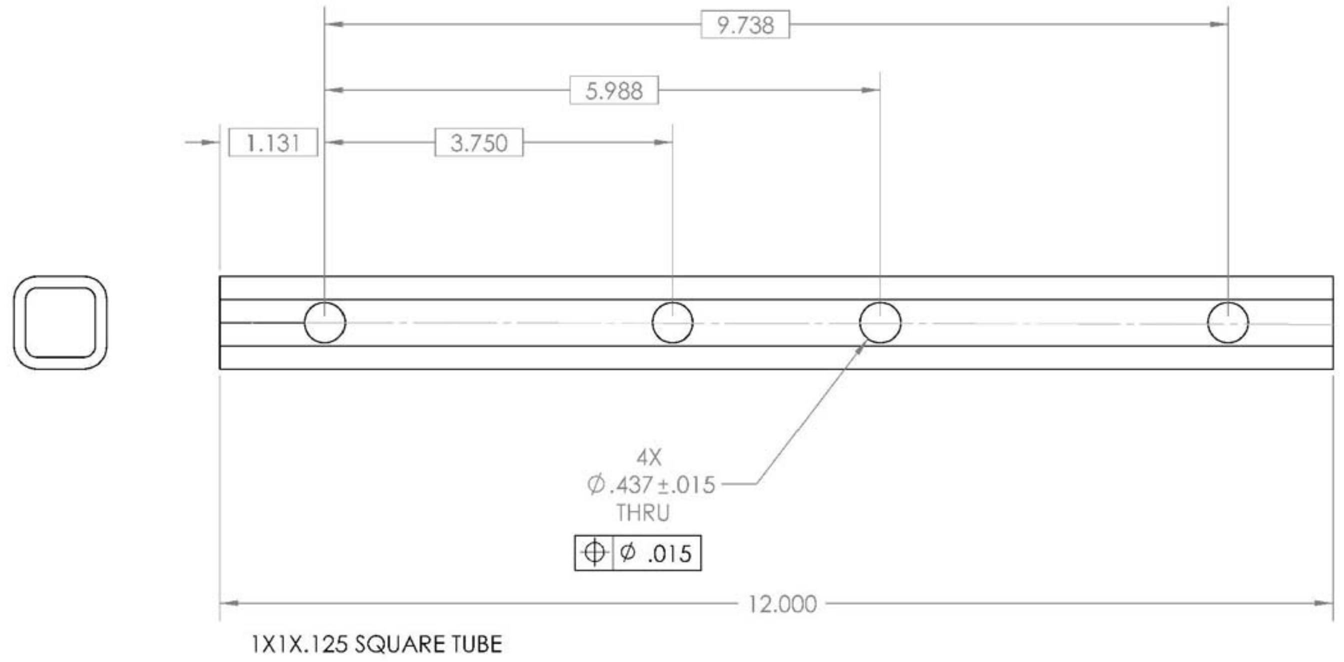
COMMENTS:

TITLE:

GIRDER PLATE

SIZE	DWG. NO.	REV
A	PS-019	-
SCALE: 1:8	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1



PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL A36
FINISH
DO NOT SCALE DRAWING

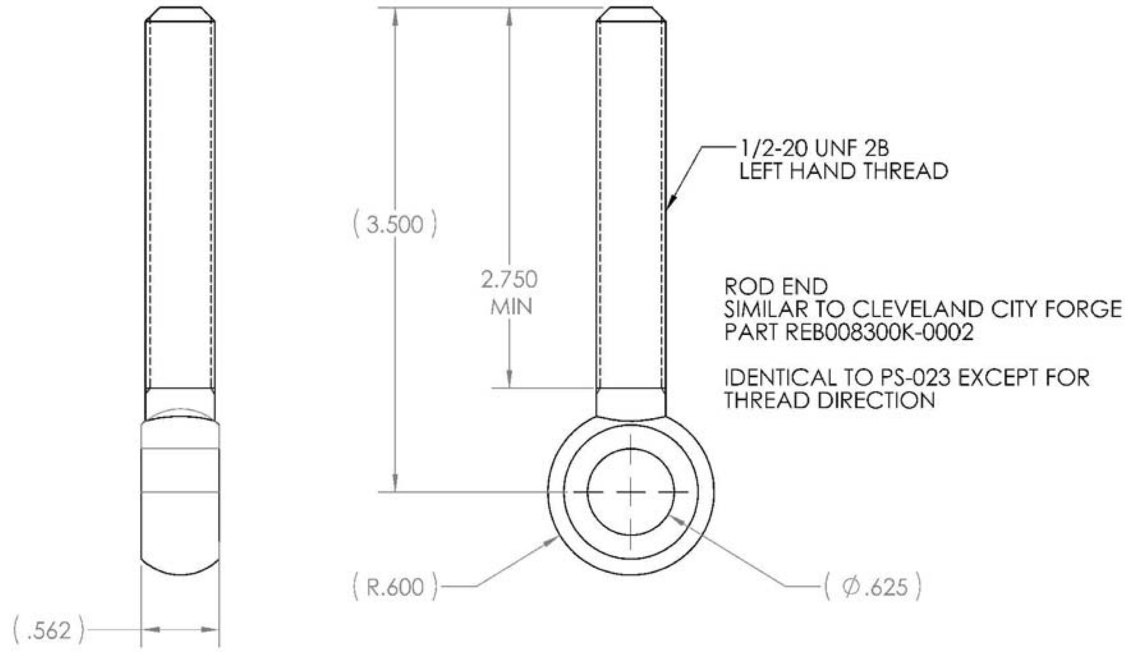
	NAME	DATE
DRAWN	KEK	12DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:
PUMP MOUNTING BAR

SIZE A
DWG. NO. PS-021
REV -
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1

5 4 3 2 1



ROD END
SIMILAR TO CLEVELAND CITY FORGE
PART REB008300K-0002

IDENTICAL TO PS-023 EXCEPT FOR
THREAD DIRECTION

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL
316SS

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	15DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

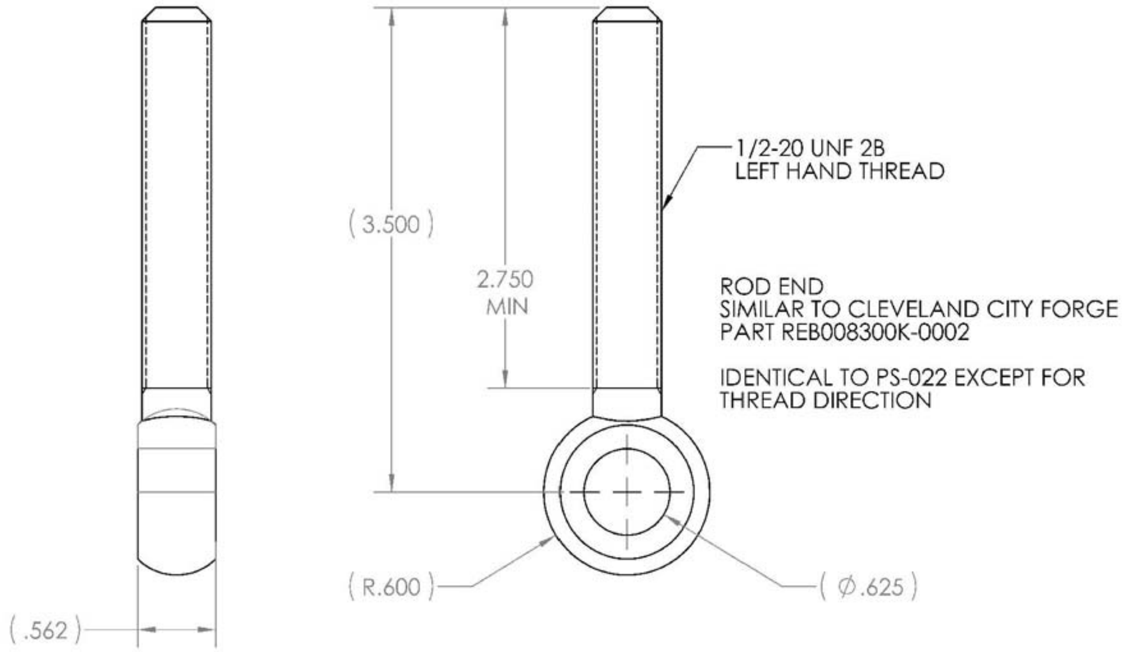
COMMENTS:

TITLE:
ROD END

SIZE	DWG. NO.	REV
A	PS-022	-

SCALE: 1:2 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



ROD END
SIMILAR TO CLEVELAND CITY FORGE
PART REB008300K-0002

IDENTICAL TO PS-022 EXCEPT FOR
THREAD DIRECTION

PROPRIETARY AND CONFIDENTIAL

THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF TEXAS A&M. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF TEXAS A&M IS PROHIBITED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64
ANGULAR: MACH ±2 BEND ±2
TWO PLACE DECIMAL ±.01
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
316SS
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	KEK	15DEC10
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:

ROD END

SIZE	DWG. NO.	REV
A	PS-023	-
SCALE: 1:2	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1