Automated Bearing Press

Final Design Report

Micro-Vu

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Our group was presented with a challenge to design an automated machine to replace Micro-Vu's current manual pressing operation. We moved, planned, and scheduled our tasks for the three quarters we will be working on this project by using a Gantt chart. In designing the machine, we generated concepts and used analysis and prototyping to select the most promising ones. Our final design uses a pneumatic press to press the parts, and it includes magazines to hold the parts before pressing, pneumatic actuators to move the parts to and from the pressing location, and a lever to separate the defective parts from the parts within tolerance after they have been pressed. The electrical, pneumatic, and mechanical components of the machine are described, and part drawings and specifications are provided.

CHAPTER 1: INTRODUCTION

1.1 Introduction

This Micro-Vu sponsored senior project will be to design, build, and test a fully automated bearing press operation for a specific assembly provided by Micro-Vu. This project was proposed by John Wilson at Micro-Vu, and is currently supervised by Austin George. It will be utilized by workers who currently perform this task manually. Our goal is to design a reliable, safe, and automated machine to replace the current manual process, and reduce the effective cost of producing the part by decreasing the required labor and time.

1.2 Problem Definition

Currently at Micro-Vu, bearings are being pressed manually into pulleys, and with many manual operations, the results are susceptible to human error. We want to minimize this error and increase efficiency by limiting the human interaction to only loading and unloading the batches of the parts and bearings. For a company that specializes in precision, manufacturing, and innovation, automating this process would be beneficial in multiple ways. It would reduce the variance in assembly process, increase traceability and design feedback through data acquisition, and reduce the amount of repetitive tasks workers have to do. As a company that is constantly growing, eliminating the human labor required for repetitive processes would allow more attention to be directed elsewhere.

1.3 Specification Development

To ensure we would design a machine that would meet the requirements of Micro-Vu, a table of engineering requirements was created. This table includes all the requirements for the machine, and provides current and target values for each requirement.

Engineering Reqt #	Function	Metric	Unit of Measure	Current	Target	Directional
1	Automation of total operation	Human Interaction	%	100%	Minimize	↓
2	Machine Size	Footprint Dimension	ft^2	TBD	3'x3'	↓
3	Press Capability	Force Output	lbf	2000	3000	↑
4	Batch Size	Number of parts able to be loaded	Count	1	150	↑
5	Reliability	% of parts failed	%	0	1	↓
6	Measurement of data	Data measured	Yes/No	No	Yes	x
7	Easy to maintain	Frequency of service required	months	TBD	3	↑
8	No possibility of shrapnel	Guard in place	Yes/No	No	Yes	x

9	Eliminate pinch points	Presence of exposed points	Yes/No	Yes	No	x
10	Peak Power used	Maximum power used	kW	TBD	1	↓
11	Safe in emergency	Presence of E-Stop	Yes/No	Yes	Yes	x
12	Minimize batch loading time	Loading Time	seconds	TBD	60	↓
13	Maximize Mobility	Weight	lbf	TBD	Minimize	↓
14	Machine Durability	Component Lifetime	years	TBD	2	↑
15	Machine Lifetime	Machine Lifetime	years	TBD	15	↑
16	Speed of pressing process	Time per part	seconds	30	10	↓

Table 1. Table of Project Requirements

To get an idea of how closely the customer requirements related to the quantifiable engineering specifications, a quality function deployment was used (see Appendix A). We were also able to compare alternative pressing methods to our sponsor's requirement, and find where each was deficient. By assigning the requirements values of relative importance, we were able to get a general idea of what specifications would be the most critical to a successful design, and what areas competing products were deficient in. The biggest problems with the alternatives were that they were either manual processes, were automated but had very small batch sizes (reference 2), or were automated for large batch sizes (reference 1) but were on a much bigger scale and extremely expensive. Because a large part of Micro-Vu's requirements included limiting the size to a table-top unit and having automated batch sizes in excess of one hundred units, none of the alternative pressing methods we found were able to satisfy the project requirements. Despite not being able to implement exactly the same system as used elsewhere, these larger machines were used to show different methods of holding, moving, locating, and pressing the parts.

Based on the quality function deployment we created, we believe that the most critical requirements to be met for a successful design are the reliability of the pressing operation, data acquisition to identify any parts where the press was unsuccessful, and a large batch size capacity. These requirements directly impact the automation of the machine, and allow for longer periods of runtime with minimal human intervention. To ensure Micro-Vu can rely on the machine, it is also important to ensure its parts have a decent lifetime and can easily be replaced when they wear out.

CHAPTER 2: BACKGROUND

2.1 Existing Methods

In researching the existing solutions for automated pressing operations, we found that their specifications and applications did not meet the requirements Micro-Vu wanted. Many operations required too much human interaction, some were limited to batch sizes that were much less than the 100 batch size requirement (reference 2) while others were designed for batch sizes that were too large (reference 1). Because a large part of Micro-Vu's requirements included limited the size to a table-top units and having automated batch sizes in excess of one hundred units, none of the alternative pressing methods were able to satisfy the project requirements.

2.2 Technical Information

The force required to press the bearings in Micro-Vu's current process is at most one ton. The average force and stroke length obtained from their manual press will give us specific requirements to what the automated machine will have to achieve. Using this data, we were able to select an appropriate press.

2.3 Safety Considerations

Mechanical presses create many potentially dangerous situations, including pressing an unwanted object (such as an operator's hand) and possibly creating dangerous shrapnel if a part fails. An automatic press can also be difficult to stop if safety is not considered. Standard safety features for automatic presses include emergency stop switches, point-of-operation covers, and feed guards. In addition, all electrical systems must adhere to electrical regulations to prevent shocks and fires. The design for our automatic press takes these essential safety features into consideration. The Occupational Safety & Health Administration (OSHA) has the full list of requirements for mechanical power presses that our design includes. This list can be found in Appendix G.

In addition to the standards set by OSHA, a design hazard identification checklist was completed for our machine. In this document, hazards are identified and described. After meeting with mechanical and electrical technicians, corrective actions and their corresponding target completion dates will be specified. This document can be found in Appendix G.

CHAPTER 3: DESIGN DEVELOPMENT

3.1 Conceptual Designs

After completing our understanding of the problem and defining the requirements for the project we came up with several different ideas of how to design the machine. This ideation showed a trend where there were four main functions of the machine that we needed to design: the organizing and feeding of the pulleys and bearings, the positioning method, the pressing operation, and the removal of the assembled parts from the pressing area. We separated our ideas into each of these four areas, and compared them using Pugh decision matrices. After comparing the ideas, we noticed that precision of the positioning system would be the most difficult task to overcome and the most difficult to estimate without data from prototype testing. Therefore our current top concepts differ in the positioning process, but are similar in the feeding and removal method. The Pugh decision matrices that document how we arrived at our decisions can be found in Appendix A.

The final design of the automated bearing press includes different subsystems and part selections that we want to arrive at based on unbiased decisions supported by published data and testing results. The following sections summarize our preliminary design decisions of the press type, press model, and subsystem methods based on results from Pugh matrices.

3.1.1 Loading

"Funneling system":
This idea used the concept of using a funnel to organize the pulley parts before using a ramp to feed them to a specific position for the pressing operation. The funnel would be used to both hold the disordered pulley parts before they are pressed and to separate and orient the parts as they exit the funnel. Because the bearings are organized in a tube by the manufacturer, this funnel would only be used for the pulleys. To prevent the pulleys from getting stuck and stop feeding down the ramp, a vibrating device could be attached to the funnel. This design was attractive because it features the minimum human interaction with the machine; the operator just needs to dump the pulleys in the funnel, place the bearings in the correct position, and start the machine.

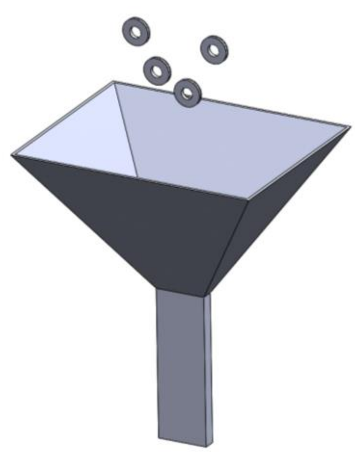


Figure 1. Funneling feeder system

"Parts magazine" into rotary table:
The parts magazine idea uses similar concepts as the funneling system, but differs in its organizing and loading of the parts into the table. Instead of using a funnel, the parts magazine idea requires that the pulleys be organized into a tube, similar to how the bearings are supplied. The bearings are fed from another magazine on the top of the table. These magazines can then be attached to the machine where the parts will be positioned and pressed. To meet our batch size requirement, the length of the magazines would be long enough to house 150 pulleys and 150 bearings. Multiple magazines could be used for a part if the length of a single magazine created issues in the system. The use of magazines reduces the risk of parts getting stuck, however it does require more human interaction to load the pulleys into the magazine.

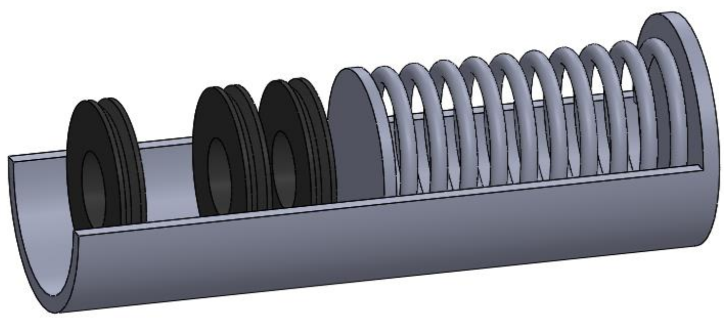


Figure 2. Magazine loading system

"Feeder bowl" into rotary table:
The feeder bowl is a concept that is used in many current manufacturing processes. The disorganized parts are loaded into a bowl that has a ramp spiraling up the sides. The bowl is then vibrated, and the angle of the bottom of the bowl forces the parts up the ramp. Several levers and covers are placed over the ramp, as the parts travel up the ramp any parts stacked on each other or in the wrong orientation are knocked off the ramp and back to the bottom of the bowl. The end product is a steady stream of oriented parts out of the bowl. These parts would slide down a ramp to the rotary table. The bearings would be loaded from a tube above the table. The feeder bowl solution has a minimum of human interaction, and is very reliable, but is also excessive, very expensive, and hard to manufacture due to the curves and contours of the bowl.

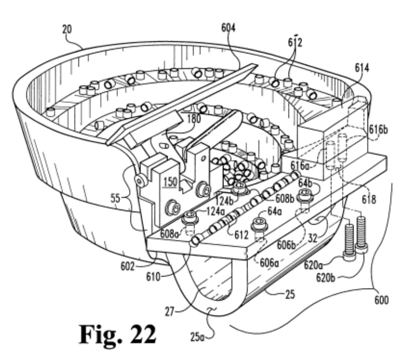


Figure 3. Vibratory bowl feeder system.

3.1.2 Positioning

Whether the funnel, the magazine, or the feeder bowl will be used, the parts must be positioned for the pressing process. This can be done with a rotary system, such as the “hole cutout” and the “guide rods” concepts, or it can be done via the linear “V-block” concept.

“V-block Actuators”
This positioning method utilizes the precision of V-blocks commonly used in machining fixture applications. On one side of the press, one of the magazines described in the previous section will be feeding pulleys down onto our work surface. With only one pulley at a time protruding from the bottom of the magazine, an actuated arm with a V-block attached to the end will push the pulley out horizontally to another V-block located under the press. This fixed V-block will ensure that the pulley will be correctly positioned in the same location every time. Following this, the bearing is positioned by a block with guide arms on top of the pulley. The block holding the bearing remains in place during the beginning of the pressing operation to ensure that the bearing is correctly positioned, it then retracts after the bearing has been pressed a small amount. The rest of the pressing operation is completed after the guide rods are not in the way of the press.

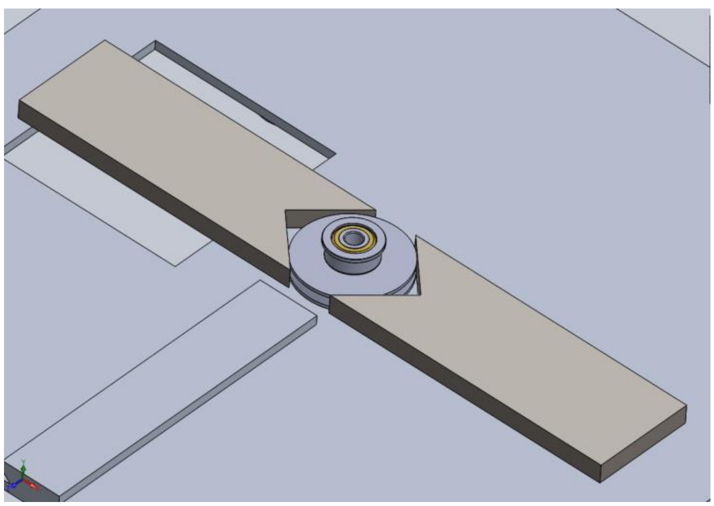


Figure 4. 3D model of V-block actuator concept

“Hole cutout” in rotary table
Parts will be fed into circular cutouts in the rotary table by the magazines. The rotary table will orient the parts such that the bearing will be concentric to and on top of the pulley. The rotary table will then rotate the parts over a surface so that they do not fall out of the cutouts. It will then rotate some given angle and the parts will be positioned under the press for the pressing operation.

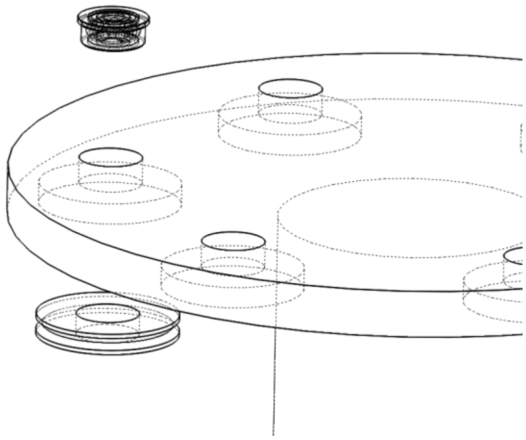


Figure 5. Hole cutouts in rotating fixture

“Guide rods” on rotary table

Parts will be fed onto guide rods with the same outer diameter as the inner diameter of the bearings. The bearing will rest on the pulley as the rotary table rotates the parts into position for pressing. A guide, such as the “constraining arms” described below, will then accurately position the pulley and bearing so that they are concentric relative to one another.

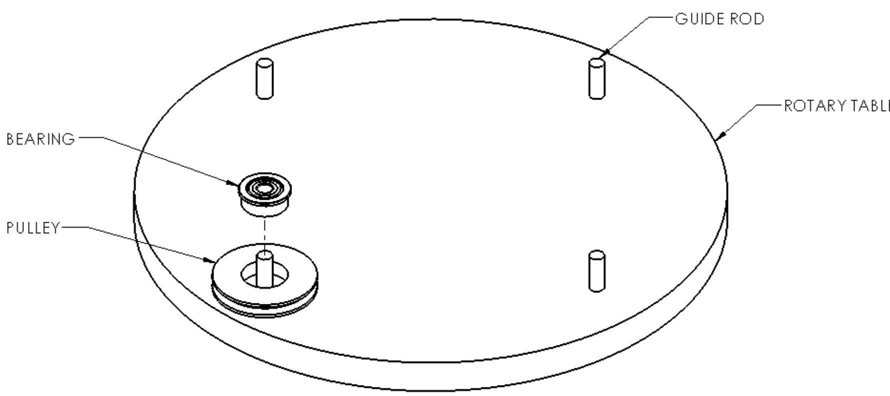


Figure 6. Guide rods on rotation table.

3.1.3 Pressing

After feeding and positioning the parts, they will then be pressed. Regardless of whether a linear or rotary system is used for this machine, the “constraining arms” concept can be implemented.

“Constraining Arms”

If the “Guide Rods” method is chosen, a more precise alignment of the two pieces would be required before pressing. A pair of electromechanically actuated constraining arms would be located under the press which would hold the pulley in the correct position. Because the bearings are located by the guide rods, only the pulley needs to be positioned by the constraining arms.

If the "V-block" method is chosen, the pulley would be positioned by the V-block and the bearing would have to be positioned relative to the pulley via the constraining arms. As the bearing is pressed into the pulley, the constraining arms would release the bearing so that the bearing's flange does not interfere with the arms.

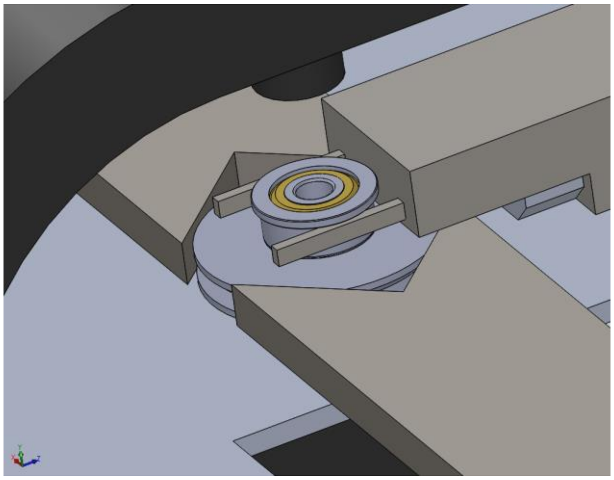


Figure 7. Constraining arms securing bearing and pulley to be pressed.

3.1.4 Assembly Removal

"Base table cutout" under V-block arms.
If the V-block actuating arms method is chosen, a simple and reliable way to remove the pressed parts is a cutout in the table next to the press. This would be on the side opposite of the magazine for the pulleys. After the pressing operation, the V-blocks would push the finished part over the cutout, then return to their positions to prepare the next part for pressing.

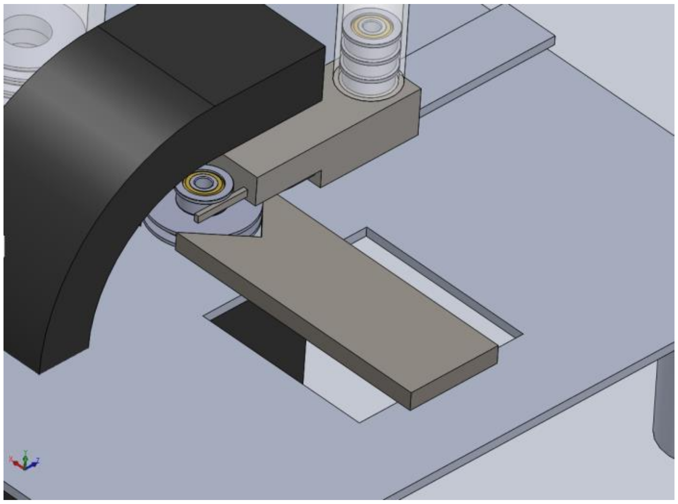


Figure 8. Base table cutout for actuating arms.

“Rotary table cutout” under rotating slots.
At the final station of the rotating table, a slot in the base surface will allow the assembled piece to fall down onto a ramp where they will be directed towards either a “reject” or “conforming” bin. This will be controlled by a lever on the ramp that will be activated when the load cell in the press detects a value high enough that signifies a defect in the part or operation.

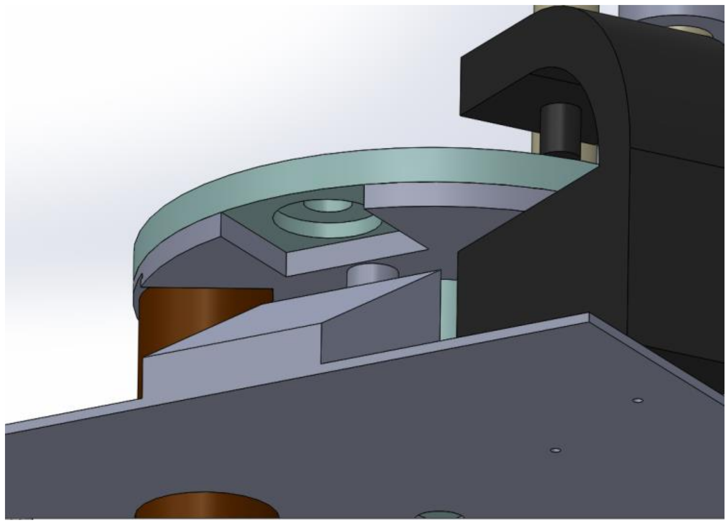


Figure 9. Rotary table cutout allowing assembled parts to drop out from bottom.

Justification for the scoring in each of the categories was based off our research for similar processes or prototyping results. Quantitative data such as cost, size, and estimated speed were compared directly to determine the relative scoring between the concepts. Estimations for criteria without published data such as safety, reliability, and manufacturing effort were determined through qualitative assessment by team members. The weightings for each category were based off of the engineering specifications table proposed to Micro-Vu. The Pugh matrices with these values can be seen in Appendix A.

3.2 Press Selection

In addition to selecting concepts of the process we designed our machine to perform, we also considered all different types of presses that would be suitable for our application. A decision process for this is outlined below as well, displaying the data support our decision of the selected model.

A decision matrix was completed to determine the advantages and disadvantages of a C-frame versus an H-frame pneumatic press for our application. Because the geometry of a C-frame allows more options for rotational positioning and is generally smaller in size, only C-frame models of pneumatic presses were included in our matrix to determine the specific model we planned to order.

Press Models						
Criteria	Baseline	Weight	H-Frame		C-Frame	
			Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation
Size/Weight	0	20	0	0	1	20
Safety	0	20	0	0	0	0
Ease of Implementation	0	30	-1	-30	1	30
Lifetime Reliability	0	15	3	45	0	0
Mobility	0	15	-1	-15	1	15
		100	**Sum**	0	**Sum**	65

Table 2. H-frame and C-frame press model comparison

Based on the magnitude of force associated with the pressing operation, we decided that a pneumatic press would be most appropriate. The current arbor press being used at Micro-Vu is rated at 1 ton and through calculations, the maximum force required for the pressing of the bearing into the pulley was determined to be 2800 lbf or 1.4 tons (see Appendix E for calculations). The presses shown in Table 3 all meet the 1 ton minimum force requirement.

Press	Cost	Rated Force (lb)	% of Rated Force at Maximum Conditions
McMaster-Carr	$1,949.35	3020	92.7%
Toggle Aire 1030	$5000+	6000	46.7%
Model 28A	$2185+	2800	100%

Table 3. Comparison of pneumatic press models

3.3 Concept Selection

In the ideation process, many ideas were presented for each of the four functions. After realizing that there were several possibilities for each step of the process, each of the methods were organized into different subsystems. The top concepts for the organizing and feeding, the positioning, the pressing, and the removal functions of the machine will be discussed in this section. Various concepts for each function will then be combined for a preliminary design concept for the entire system.

3.3.1 Selected Concepts

In starting the detailed design of the machine, we decided that a linear system with V-blocks better fit our requirements than the rotary system. Testing and further analysis of this method (discussed later in the report) justified our decision.

“V-block Positioning Actuators”
This concept uses the “Parts magazine” for the loading method, the “V-block Actuators” for the positioning, and a ramp located in the front of the machine to as the exit for the pressed assemblies. This machine concept is favorable for a couple different reasons. The first and most important reason is that

the positioning precision of the parts before they are pressed is dependent on the mechatronics and the V-blocks, both of which can be controlled or bought for our desired tolerance. This design also requires less complicated and custom parts that would have to be machined for our specific design. However, this concept uses multiple moving parts which greatly increases the complexity of the electronic portion of the machine. Although the cost of this concept might be greater than that of the "Rotary Table" design, further testing shows that it is more precise and offers more flexibility. In addition, the positioning of the magazines allows the parts to be fed by gravity and allows for some clearance between the v-block and the magazine, greatly reducing the chance of the machine jamming. We decided the linear actuator design was superior due to its increased precision and reduced chances of jamming.

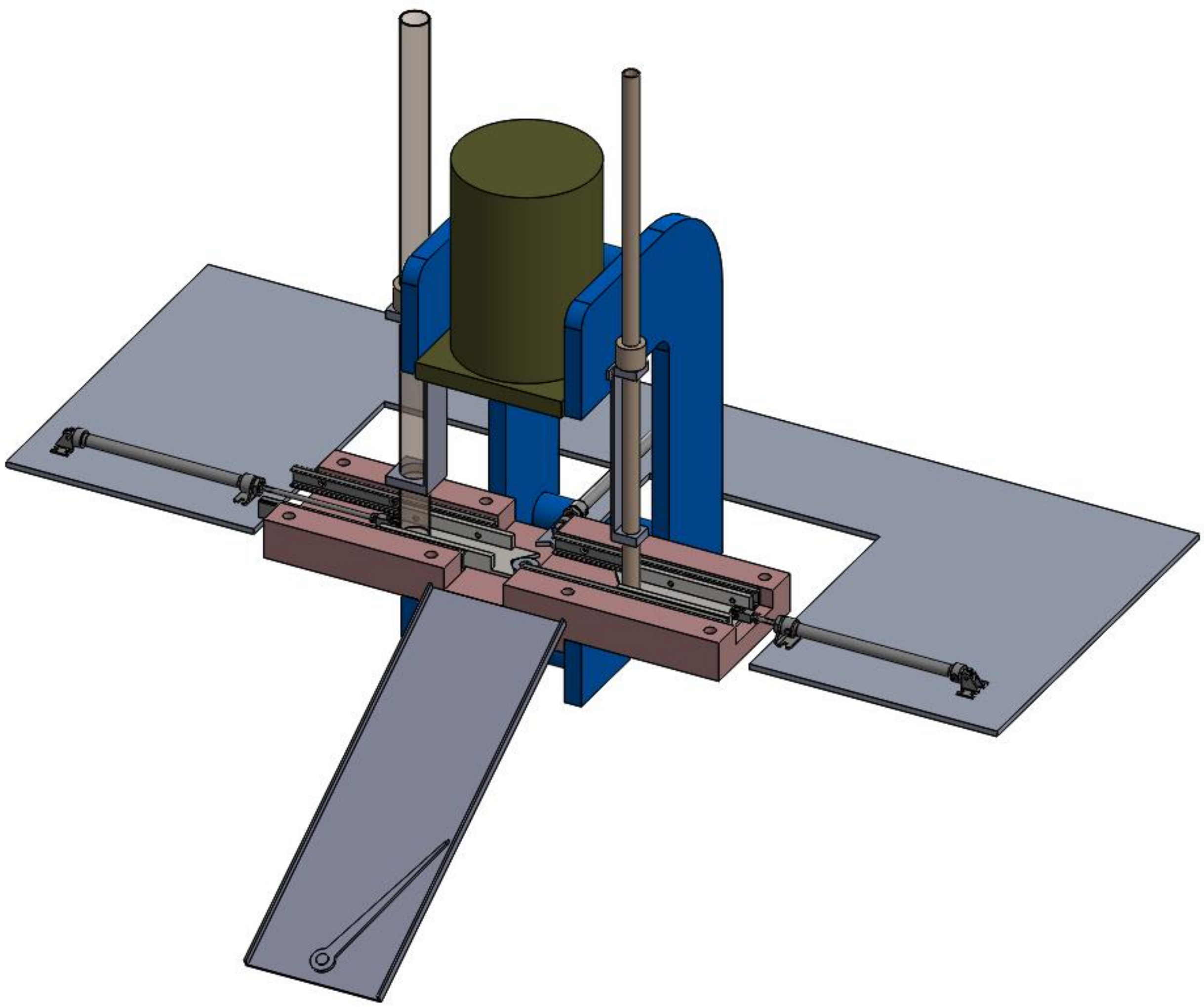


Figure 10. Solid model assembly of "V-block Actuator" Concept

3.4 Preliminary Analysis

To justify various decisions we would be making, and to get an idea of what parts to be including in the machine, we performed preliminary analyses. Additionally, we created prototypes for physical proof of concepts.

3.4.1 Press Fit Force Calculation

To estimate the force that would be required of the press we calculated the maximum force that could be required to make the press fit. We found that maximum force to be 2800 lbs, although Micro-Vu currently uses a 2000 lb manual press for this application. We based our press choice on being able to press at least one ton.

3.4.2 Proof of Concept and Testing

To ensure that other parts of our design would work we created prototypes and conducted testing. We used a hydraulic press to test how sensitive the parts were to being non-parallel when pressed. We found that no matter how large the angle was, as long as the bearing part was on top of the hole in the pulley part the parts would self-align, and be pressed correctly (see Figure 11). This allows us to merely push the bearing parts on top of the pulley without worrying about the angle, instead of having to make sure that the bearing part was horizontal. In addition we measured the actual force needed to press the parts together using a force gauge attached to the press. The average force necessary was about 400 lbs, with a maximum of 800 lbs, although that maximum could have resulted from pressing while the bearing was already seated, as it was a significant outlier from all the other pressing forces necessary. Using this data we are confident that our selected press will be able to press even barely-in-tolerance parts.

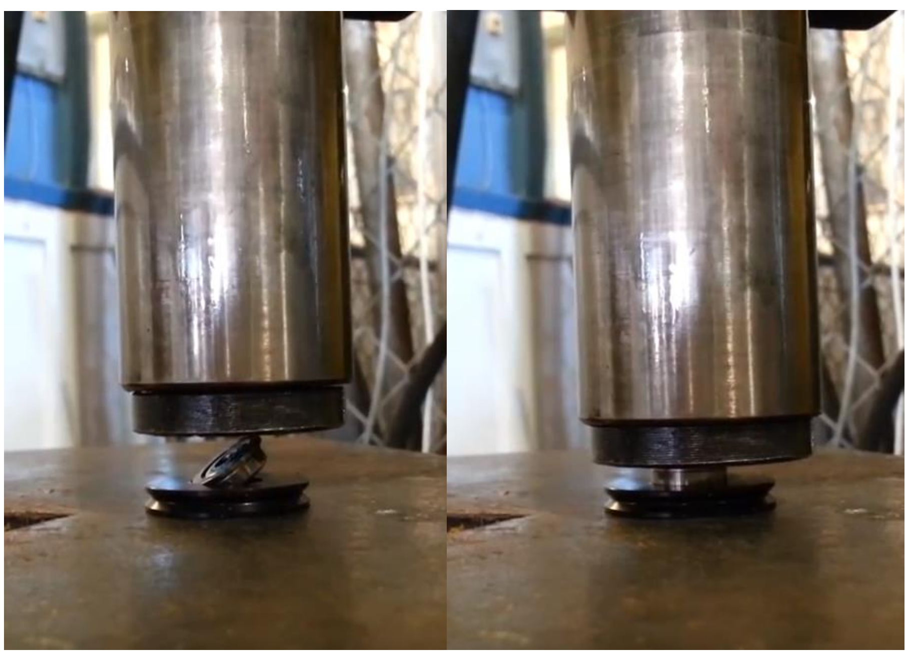


Figure 11. Self-righting behaviour of bearing

To test our magazine and pusher design we created a prototype magazine and v-shaped pusher using a 3-D printer. Using this as well as some of the pulley parts we received from Micro-Vu we tested the design by repeatedly pushing parts out of the magazine. The prototype worked perfectly, with the parts being pushed out easily and repeatedly. After concluding this testing we are confident that our pusher design will work in the machine. The pusher and magazine can be seen in Figure 12.

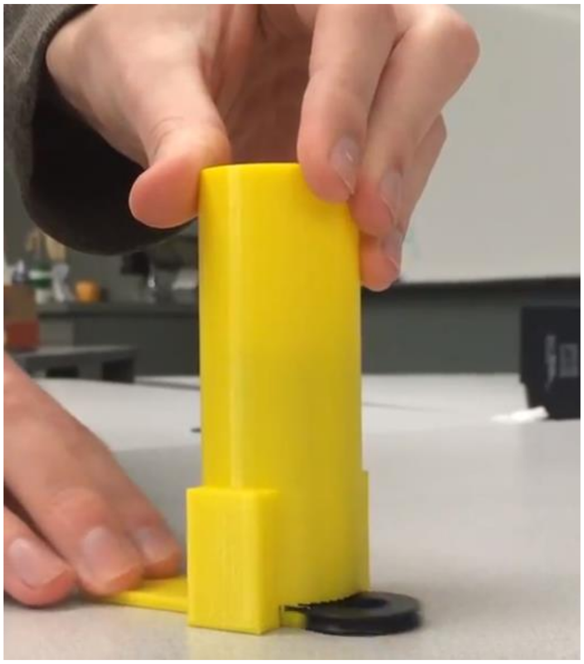


Figure 12. Pusher and magazine prototype

CHAPTER 4: DESCRIPTION OF THE FINAL DESIGN

Our final design uses linear actuators to position the parts for pressing. The machine has four main functions: organizing and storing the parts with cylindrical “magazines”, moving the parts to the press with linear actuators, pressing the parts, and moving the parts away from the press with another linear actuator. A layout of the machine with each component labeled can be seen scaled down below. A larger paper size and image can be referenced in Appendix B.

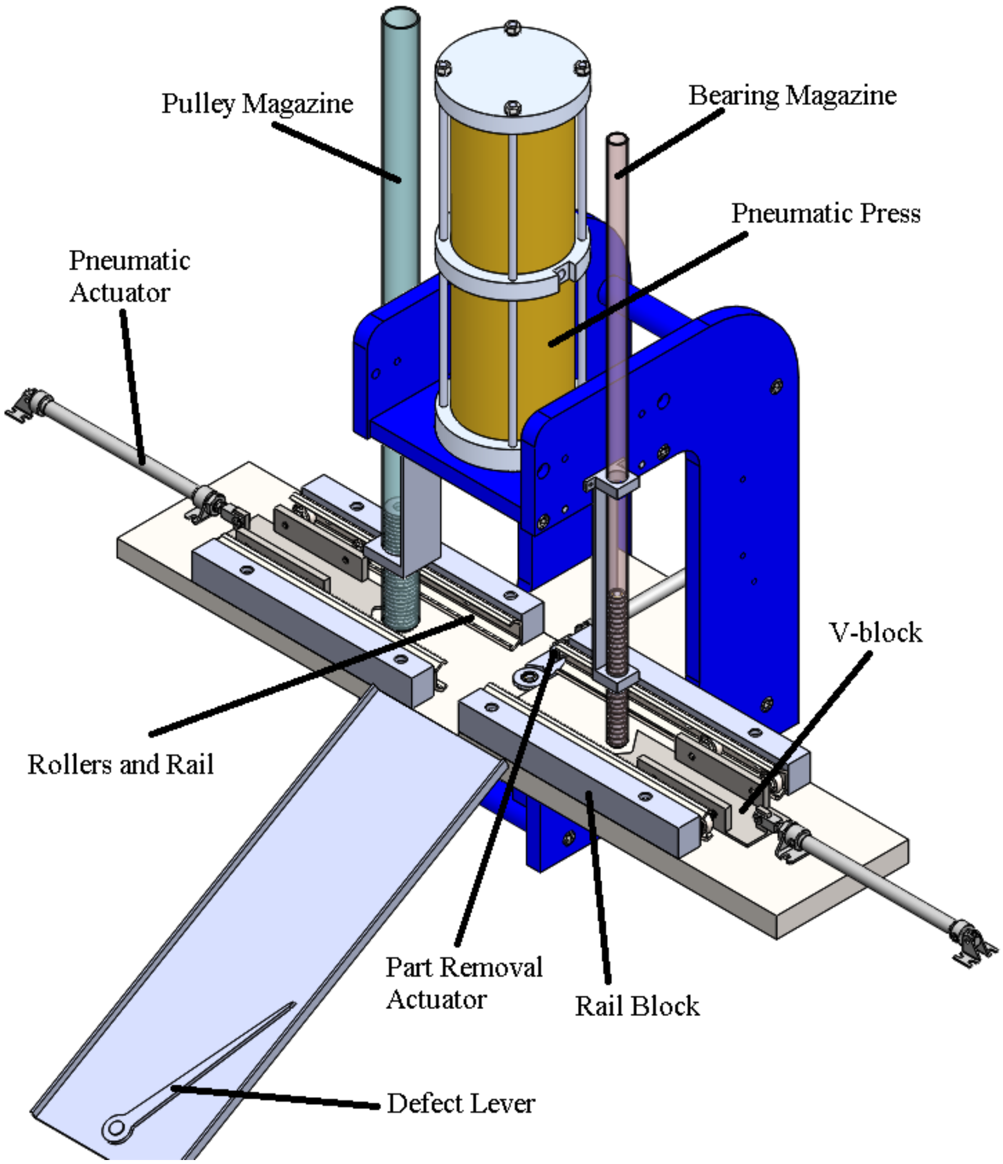


Figure 13. Full mechanical machine layout.

4.1 Detailed Design Description

4.1.1 Parts Magazine

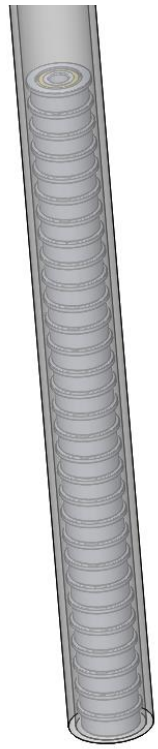


Figure 14. Bottom half of bearing magazine with loaded bearings

The first step in the operation of the machine is the loading of the magazines. This is the only part that is completed non-autonomously, as a worker will need to manually place the parts in the tube. When all the parts are loaded the bottom of the magazine is covered, and it is placed in the brackets that are attached to the press frame. See Appendix B for drawings of the magazines and brackets. The cover on the bottom is removed, and the first part drops into place.

4.1.2 Moving Parts from their Magazines to the Pressing Location

The supporting brackets are positioned so that the magazine rests with the bottom just above the base plate. In this position the part on the very bottom is free to move sideways, but the parts above it is constrained by the magazine. When the bottom part is pushed away from the magazine the part above it is supported by the pusher, it only falls down and becomes free to move when the pusher has completely retracted. This setup ensures that only one part is being moved at a time, and the next part will be free when the machine has finished with the part before it.

The pusher that moves the parts away from the magazines is a v-shaped part that is controlled by a double-acting pneumatic actuator. The v shape allows the pusher to restrict the sideways movement of the part while still being able to retract without pulling the part with it. The actuator is attached to the pusher with a ball and socket joint.

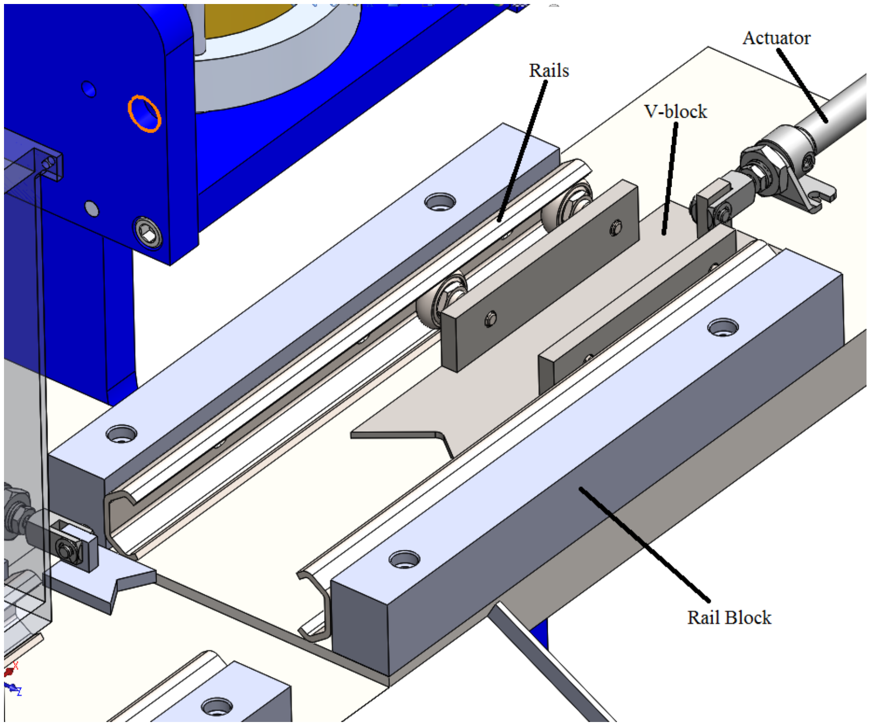


Figure 15. Pneumatically actuated v-block with linear bearing system

The v-shaped part the pushes the parts does not slide against the base plate. Instead it is supported by roller pins in side rails. This eliminates the wear of the pusher sliding against the plate, and allows for smoother movement as the parts move to the press. The rails themselves are attached to blocks which screw into the base plate. See Appendix B for drawings of the v-blocks.

4.1.3 Pressing Operation

The v-shaped pushers move the blocks away from the magazines to the location where the parts are pressed together. The pulley part is pushed first, and the pusher for the pulley remains to ensure the part is directly under the press. The bearing is then moved to the pressing location, and because the height of the base plate under the bearing is slightly higher than the base plate under the pulley the bearing slides on top of the pulley. The pusher for the bearing then retracts, and the parts are pressed together. For this application we selected a Joraco Direct-air 400T pneumatic press, with a maximum force of 2300 lbs at 100 psi. In addition we will also order a force monitoring package to detect parts that are out of tolerance. During the pressing operation the press measures the force required and the stroke length to detect defective parts.

4.1.4 Removal of Assembled Part

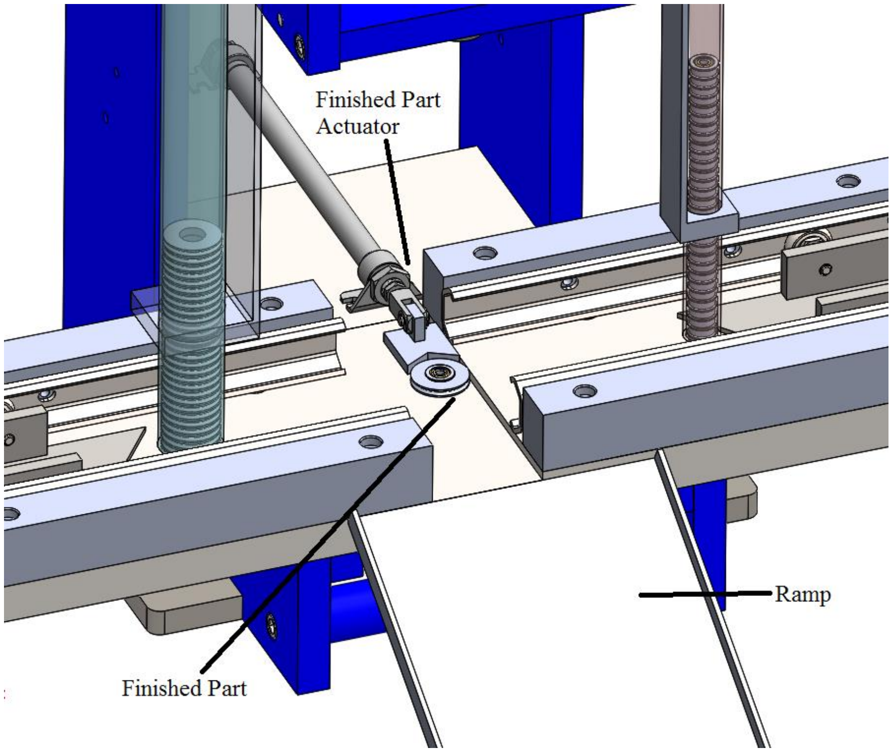


Figure 16. Removal of assembled part

After the parts are pressed together the third actuator pushes the assembly sideways, off the base plate and onto a ramp. On the ramp a lever directs the part to one side or the other; one side leads to the bin for finished parts and the other side leads to the bin for defective parts. After the third actuator has retracted the machine is ready to process the next part.

4.1.5 Controlling the Machine

The machine is controlled by a programmable logic controller (PLC), which controls the solenoids that move the actuators, the press, and the servo that controls the position of the lever on the ramp. The PLC takes input from sensors that measure the actuators position to tell when to move the next part, and uses the force and stroke length data the press gathers to determine whether or not the lever on the ramp should move the part to the defective bin. To increase safety and avoid the machine jamming the PLC also receives input from proximity sensors under the magazines, that detect whether there is a part to be pressed, and will only move the actuators if there is a part. The machine is controlled with a touch-screen that interfaces with the PLC, this screen will allow an operator to stop and start the machine, as well as displaying error messages and the number of defective parts found. A safety switch will also be present in the door of the safety cover, which will prevent the machine from being operated while the door is open.

The pneumatic components use shop air provided at 100 psi which is separated into each line at a manifold. The actuators are controlled by 4 way solenoids, with needle valves to control the speed, and the press is fed air directly.

4.2 Analyses

4.2.1 Bolster Plate Analysis

Due to the low loads in most of the machine the only part under high stress is the bolster plate that the parts are pressed on top of. The maximum stress for the plate was calculated to be 4900 psi, well below the yield strength of steel (36 ksi). To confirm that the maximum stress in bolster plate was low enough to not raise concerns, a finite element model of the plate was created. From the finite element analysis, we were able to determine the stresses at areas with stress concentrations. A maximum stress in the 4000 psi range was predicted. We also used the finite element analysis to estimate the deflection of the plate, and found that the ends of the plate would deflect 0.002 degrees, not enough to cause any parts of the machine to lose alignment or become stuck. Refer to Appendix E for analyses.

4.2.2 Cost Analysis

When we selected parts for our machine we also compared the prices, and chose parts based on reliability and cost. By far the most expensive component of our machine is the press. The Joraco Direct-Aire 400T press costs $4250, and the force monitoring system that will detect whether a part is defective costs $7500. The budget for all other parts of the project is $3000, and we estimate we will use at least 75% of this budget to build the machine. The expenses for the rest of the system mostly comes from off the shelf parts such as the solenoids and actuators, as well as electrical components like the PLC and sensors. The raw materials that we will machine are relatively inexpensive, totaling $500. A full list of off the shelf parts and their costs can be seen in Table 4 below. If necessary, the remainder of this budget will be used to cover miscellaneous expenses such shipping, handling, tax, and other unpredicted costs.

Part Name	Quantity	Procurement Type	Cost	Notes
AIM Joraco DA-400T	1	OTS	$11,750.00	With FM-PKG add-on
Bolster Plate	1	MTS	$200.00	Machined by Micro-Vu
Round Body Air Cylinder	3	OTS	$40.00	6" stroke, 7/16" bore, 10-32 UNF Female inlet
Siemens s7 1200 PLC	1	OTS	$210.00	
Actuator Plate	1	MTS	$150.00	
Ball Joint Rod End	3	OTS	$10.00	(59915K481)
Foot Bracket	3	OTS	$4.00	(4952K126)
Pivot Bracket	3	OTS	$4.00	(6498K71)
Guide Rail	4	OTS	$35.00	(60135K52)
Track Roller	8	OTS	$37.00	(60135K51)
V-Block 1	2	MTS	$10.00	Machined from steel
V-Block 2	1	MTS	$10.00	Machined from steel
Bearing Magazine	1	MTS	$10.00	

Pulley Magazine	1	MTS	$10.00	
Bearing Magazine Mounting Tab	1	MTS	$10.00	Machined from aluminum
Pulley Magazine Mounting Tab	1	MTS	$10.00	Machined from aluminum
Part Ramp	1	MTS	$10.00	
Part Lever	1	MTS	$10.00	
Stepper Motor	1	OTS	$20.00	
Manifold	1	OTS	$19.00	(5469K123)
50" 80/20 Extrusion	4	OTS	$28.00	40-4040
1/4 Tube ID Barbed Straight Connector (10-32 UNF)	1	OTS	$12.00	Male thread matches female threads of air cylinder. Pack of 12
Hose for Push-on Fitting	1	OTS	$20.00	(5633K21)
needle valves*	5	OTS	$50.00	*to be determined
solenoid valves*	1	OTS	$300.00	*to be determined
fasteners*	1	OTS	$50.00	*to be determined
sensors*	1	OTS	$200.00	*to be determined
safety guards*	1	MTS	$100.00	*to be determined

Table 4. Bill of materials

4.3 Material and component selection

The key concern when selecting the material for different parts in our machine was limiting the wear of moving parts. Parts such as the v-blocks and the bolster plate may wear and become out of tolerance. Therefore the base plate, rail support blocks, and the v-shaped pusher blocks are steel. Other components that do not need to be as precise and are not subject to as much wear can be fabricated with cost and manufacturability in mind. For example, the frame is constructed from 80/20 aluminum struts, and the magazines are plastic. All off the shelf parts are the material listed in their specification sheet in Appendix D.

4.4 Flowcharts and schematics

This machine consists of many inputs and outputs (i.e. air and signals). To minimize confusion and error, pneumatic diagrams, logic diagrams, and input/output diagrams were created.

4.4.1 Pneumatic Diagram

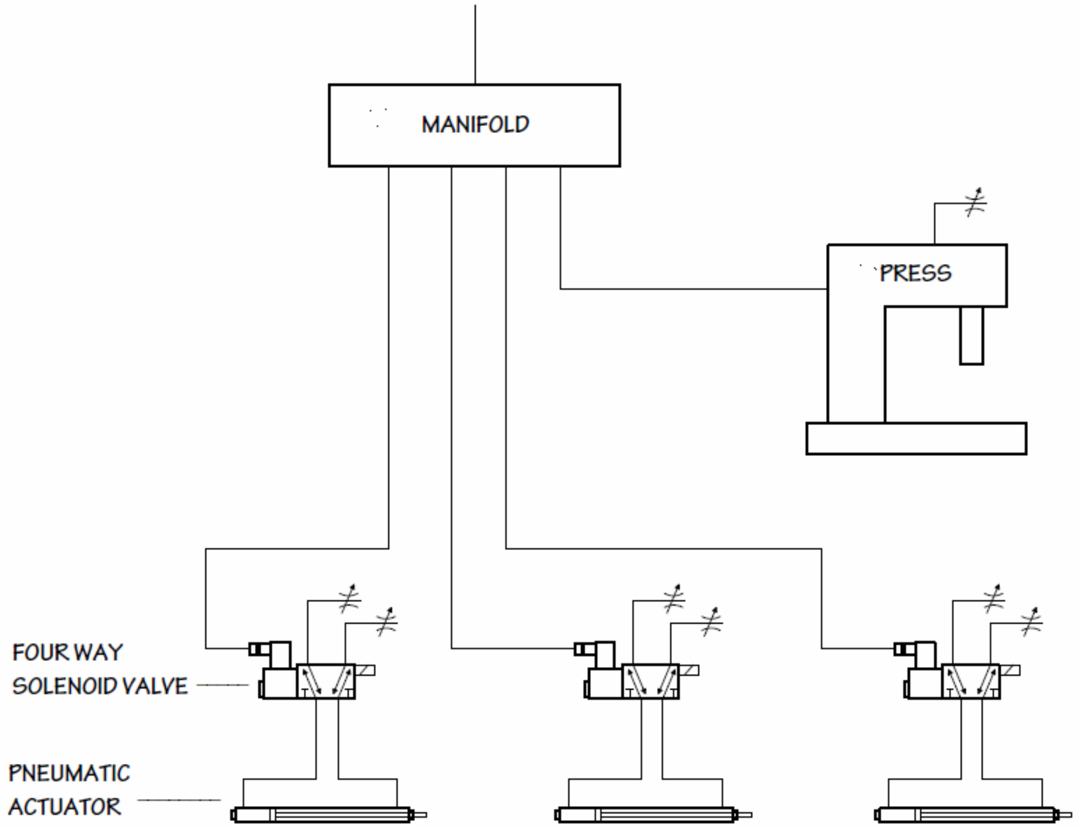


Figure 17. Pneumatic diagram

Figure 17 shows the pneumatic components of the machine. Shop air is supplied to the manifold, where it is split into 4 different hoses and sent to the press and each of the solenoids controlling the actuators. The solenoids then control the flow of air in the actuators, determining which direction the actuator moves in.

4.4.2 Programming Logic Diagram

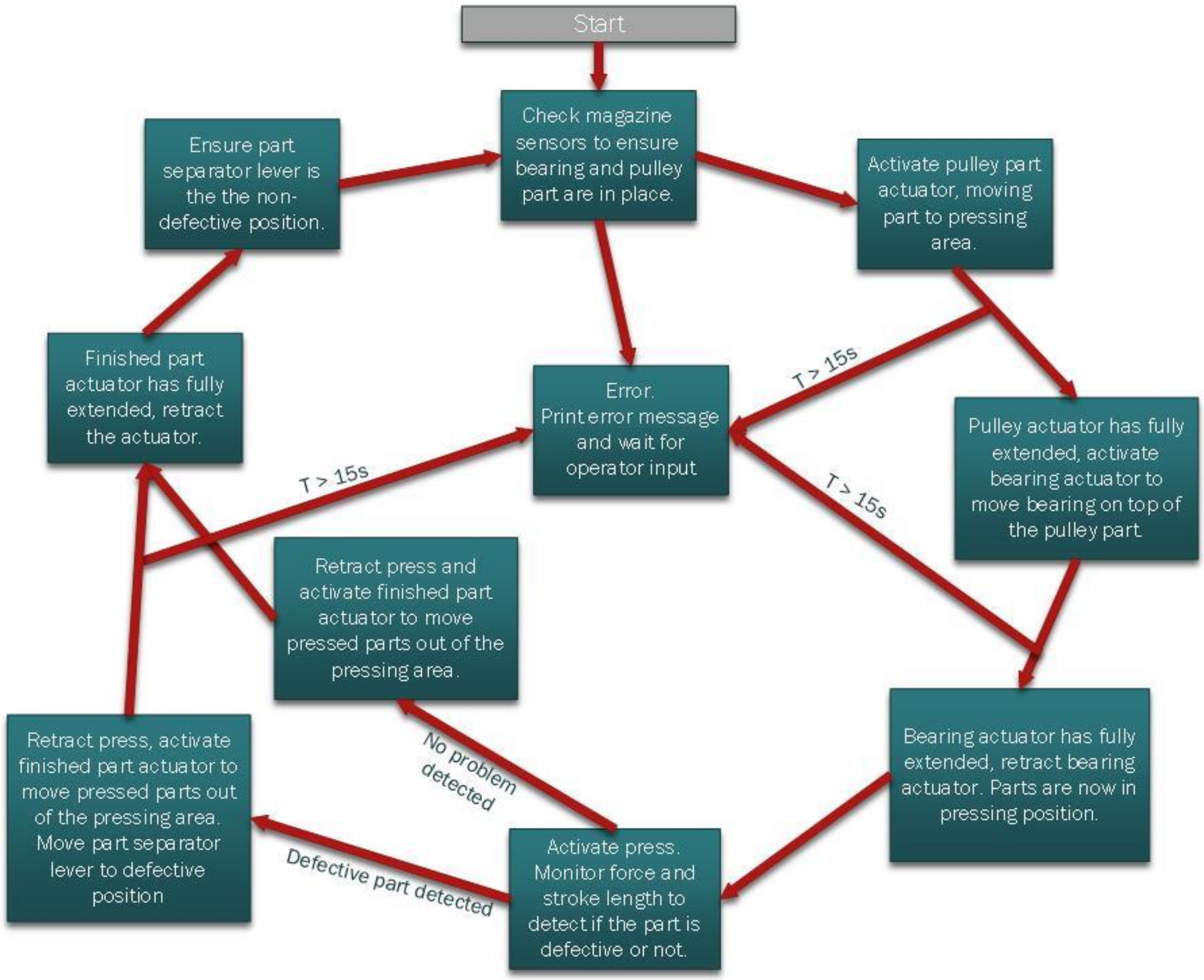


Figure 18. Logic flowchart for the programmable logic controller

Figure 18 shows the logic that the PLC will follow to ensure that the machine will run without breaking. The PLC uses inputs received from sensors, the press, and the touchscreen interface to determine what action to take. The PLC also monitors how long the actuators take to extend, and if they take too long it will assume a jam has occurred and print an error to the touchpad. Using these logical steps and sensor inputs the PLC is able to control the machine step by step.

4.4.3 Input and Output Diagram

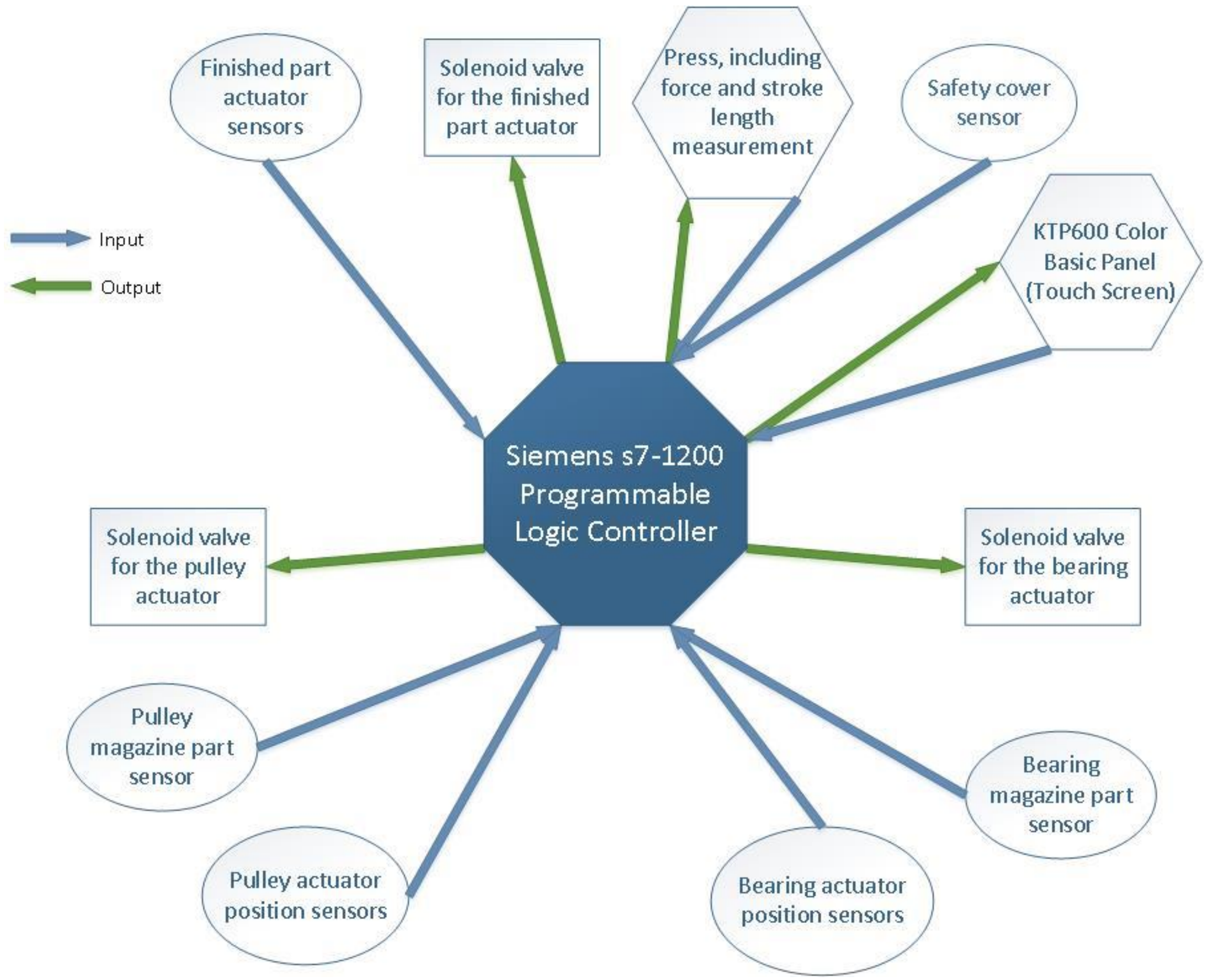


Figure 19. Input/Output diagram for the programmable logic controller

Figure 19 shows the inputs and outputs that the PLC will use to determine which action to perform next. The case switch is a safety switch that will cause the PLC to prevent operation if the door is open. The PLC will use the force and stroke length data from the press to determine if a pressed assembly is defective or not.

4.5 Safety Considerations

Because we have a press and many moving parts, pinch points and shrapnel are a concern. A list of possible hazards for pressing equipment was found on OSHA's website which allowed us to determine what kind of safety designs we wanted to implement. Both the possibility of flying debris and pinch points will be eliminated with a plastic safety shield that will surround the machine. A design similar to what we will build is shown in Figure 20. It will be fool-proofed with a switch in the door that prevents the machine from operating while the door is open. Another potential hazard is electrical shocks or fires, which will be prevented with wiring that is up to code and inspected. The machine will also display an error message if it encounters something that impedes its operation, allowing an operator to identify and fix the problem easily.

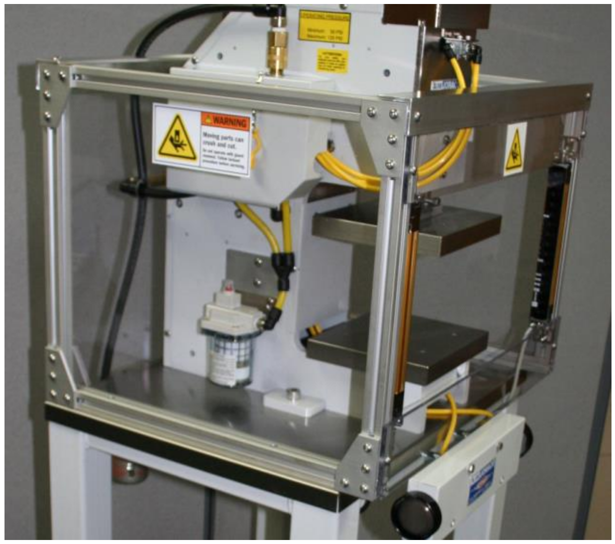


Figure 20. Example of machine safety guard

4.6 Maintenance and Repair Considerations

When designing our machine we took into consideration that the machine's lifetime should be around fifteen years. Many of the parts, such as the rails and rollers for the v-blocks, are designed to reduce wear to promote a longer lifespan. To increase this resistance to corrosion, the material selected for the v-blocks, bolster plate, and rail blocks is carbon steel. The rails for the rollers are stainless steel and ordered from McMaster Carr. When the machine is in use, inspections should be conducted every 3 months to ensure that all the parts remain within tolerance, and any rust or corrosion should be attended to. In order to prevent the onset of rust on the critical parts, oil and/or lubricant should be applied during these inspection times. To expedite repairs, we designed our machine to use as many off the shelf parts as possible, as well as common fasteners to ease the replacement of parts. In addition, we designed with reliability as more critical than minimizing costs. For example, it might be possible to use a photoresistors as a makeshift proximity sensor, but it would be unreliable and difficult to replace, so we used off the shelf sensor models instead.

CHAPTER 5: PRODUCT REALIZATION

5.1 Manufacturing Process

As we approached the manufacturing phase, we initially planned to split the manufacturing between Cal Poly and Micro-Vu. Due to high volume of manufacturing already taking place at Micro-Vu, our parts had to be manufactured at Cal Poly. Parts manufactured at Cal Poly included the parts magazines, v-blocks, rail blocks, bolster plate, safety guards, and the frame. A list of the components we manufactured can be seen in the following table.

Component	Material	Equipment
Parts magazines	Aluminum	Vertical band saw
V-blocks	Steel	Haas VF3 CNC Mill
Rail blocks	Steel	Haas VF3 CNC Mill
Bolster plate	Steel	Haas VF3 CNC Mill
Frame	80/20 Aluminum	Horizontal band saw
Safety guards	Acrylic	Table saw

Table 5. Components manufactured at Cal Poly.

5.1.1 Bolster Plate

Prior to processing the steel for the bolster plate, an NC code was developed through HSMWorks. Toolpaths were created, feeds and speeds were calculated, and the code was simulated. After ensuring that there were no errors in the program, the NC code was posted. The next step in manufacturing the bolster plate was cutting an extrusion of steel to a length slightly longer than the part's dimension. The part was then processed in the Haas VF-3 CNC mill where facing and drilling operations were performed. The holes on the bolster plate were manually tapped. Lastly, the part was inspected and compared to drawing dimensions and tolerances.

An issue we encountered during the facing operation of this part was with warping. Due to the length of the plate and high temperature the material experienced, the ends deflected downwards and the finishing operation did not remove as much material on both ends. This resulted in an inconsistent surface finish, but the function of the part was not affected as the fixture points on the machine are in the middle of the plate.

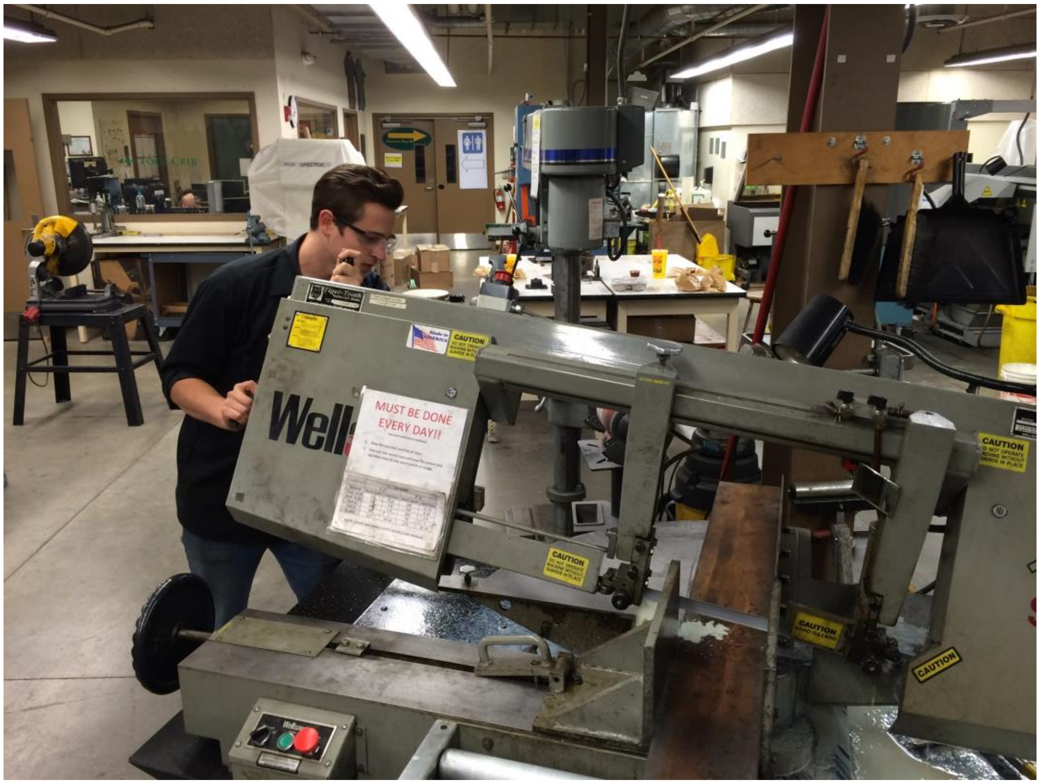


Figure 21. Cutting steel extrusion to length.

Figure 22. Bolster plate milling setup.

Figure 23. Tapered face mill used to face bolster plate.

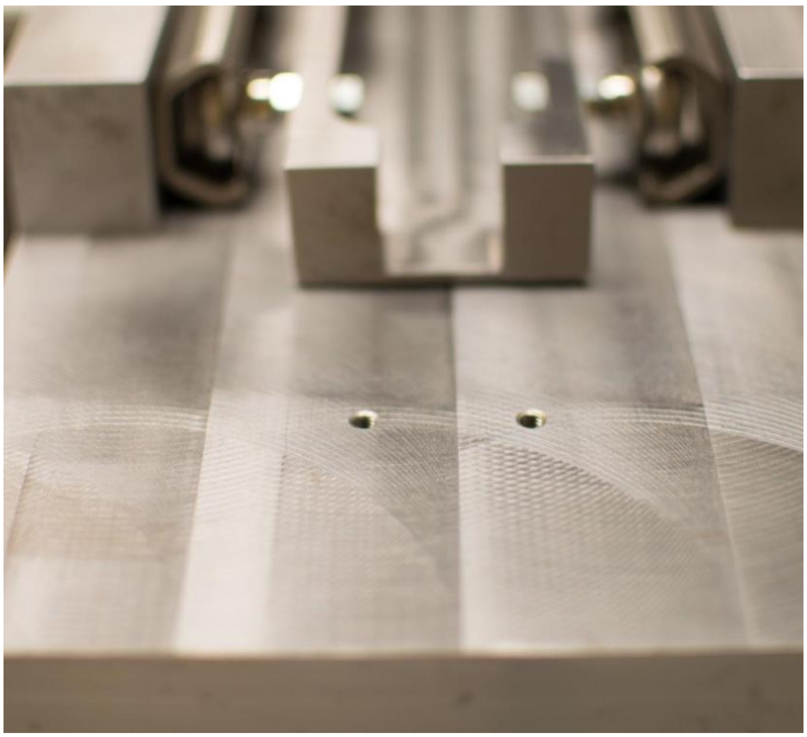


Figure 24. Variation in surface finish due to warping during facing operation.

5.1.2 Rail Blocks

The rail blocks were manufactured in a similar way as the bolster plate. An NC code was created, simulated, and used to process an extrusion of steel. After machining the rail blocks, they were inspected and compared with drawing dimensions and tolerances. No problems were encountered while manufacturing the rail blocks.

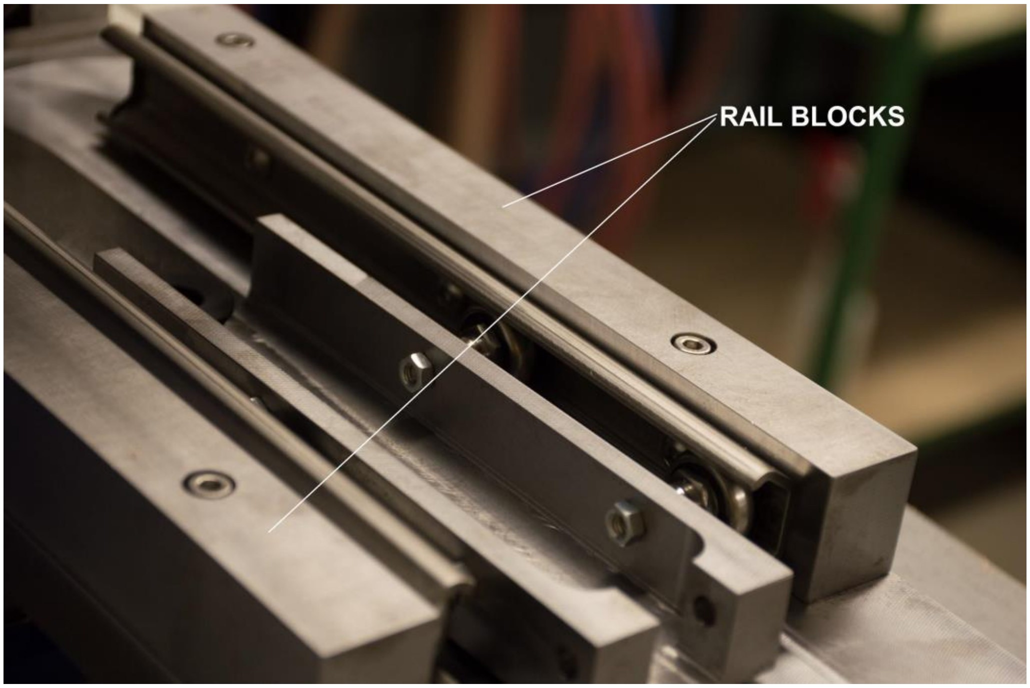


Figure 25. Rail blocks attached to bolster plate.

5.1.3 V-blocks

The manufacturing process for the v-blocks were similar to the manufacturing process for the rail blocks and the bolster plate. An NC code was created, simulated, and used to process an extrusion of steel. After machining the v-blocks, they were inspected and compared with drawing dimensions and tolerances. No problems were encountered while manufacturing the rail blocks.

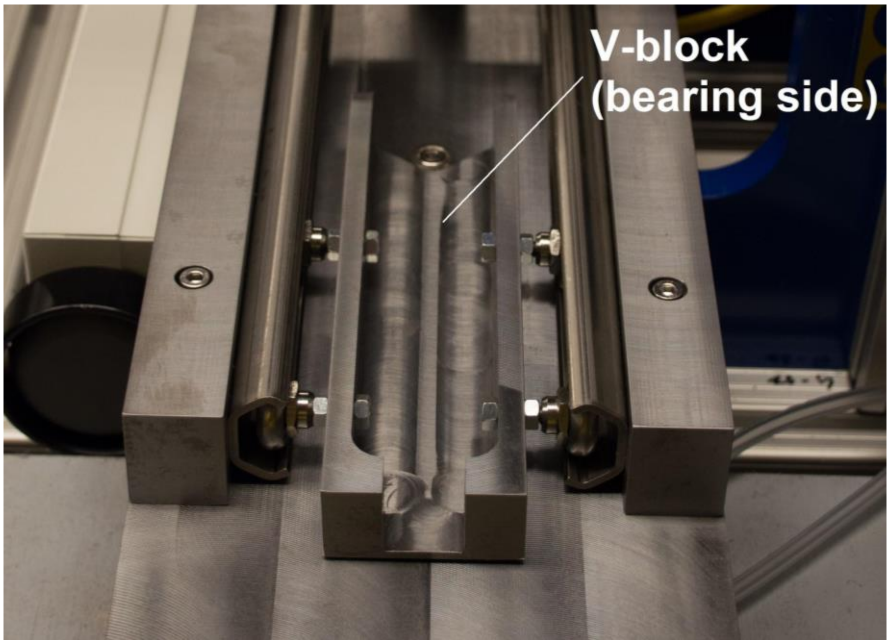


Figure 26. V-block on the bearing side of the machine.

5.1.4 Part Magazines

The part magazines were cut on a vertical band saw with a custom fixture. This fixture was used to keep the tube oriented correctly while cutting down the middle axis of the tube. There were no problems while cutting these parts however the brackets for these magazines still have to be fastened onto the frame of the press in the correct location.

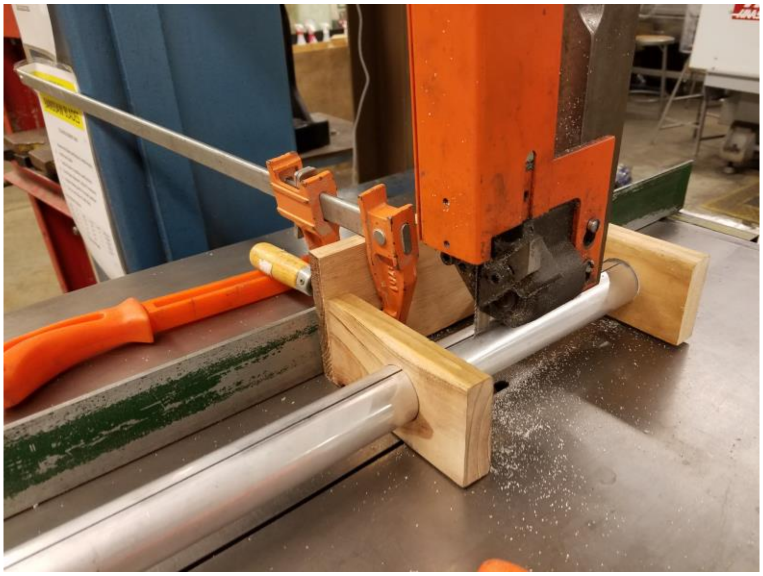


Figure 27. Aluminum tubing being cut on the vertical band saw with a custom wood fixture used to maintain proper orientation.

5.1.5 Frame

The frame of the machine was assembled using 80/20 components allowing for it to be configurable. Should the machine need to be moved or transported, the frame can easily be detached or disassembled. Additionally, if any modifications need to be made to the machine, the frame can easily accommodate these changes with the addition of hardware that can be purchased off the shelf.

Figure 28. Assembled frame with 80/20 components.

5.1.6 Safety Guards

The safety guards for the machine were cut to size using a table saw. A 48” x 96” sheet of acrylic was cut into four pieces. Holes were drilled into the sides of the panels to allow them to be bolted on to 80/20 components.

5.2 Differences in Designed vs. Manufactured

During the manufacturing of the components, the design of the v-blocks were changed. They remain the same functionally, but the new design offers greater manufacturability without compromising performance. The updated drawings for the v-blocks are included in Appendix B.

5.3 Recommendations

After constructing the prototype of the bearing press, we noticed that there were various areas of the machine that could be improved. Areas of improvement include the v-blocks and the linear bearing system.

5.3.1 V-blocks

When assembling these v-blocks with the rollers for our sliding track system, we observed that it would have been better to have four tapped holes in the sides of the v-blocks rather than clearance holes. This was for a few reasons. The first was that the lengths of the threaded extrusions on the rollers were not all the same length or precisely cut. This led to only a few threads of engagement on the nuts. Another reason to change the clearance holes was because of the amount of movement that these holes allowed. Even though the clearance is minimal, it allows the v-blocks to "sag" and slightly rub against the plate when moved. Tapped holes would hold these blocks up and above the plate as designed. A final reason is that the nuts holding the rollers to the v-block would interfere with the pulley magazine. Tapping the holes would eliminate the need for these nuts and resolve the problem of interfering with the pulley magazine. Figure 29 shows the inward protrusion of the nuts holding the rollers leading to interference.

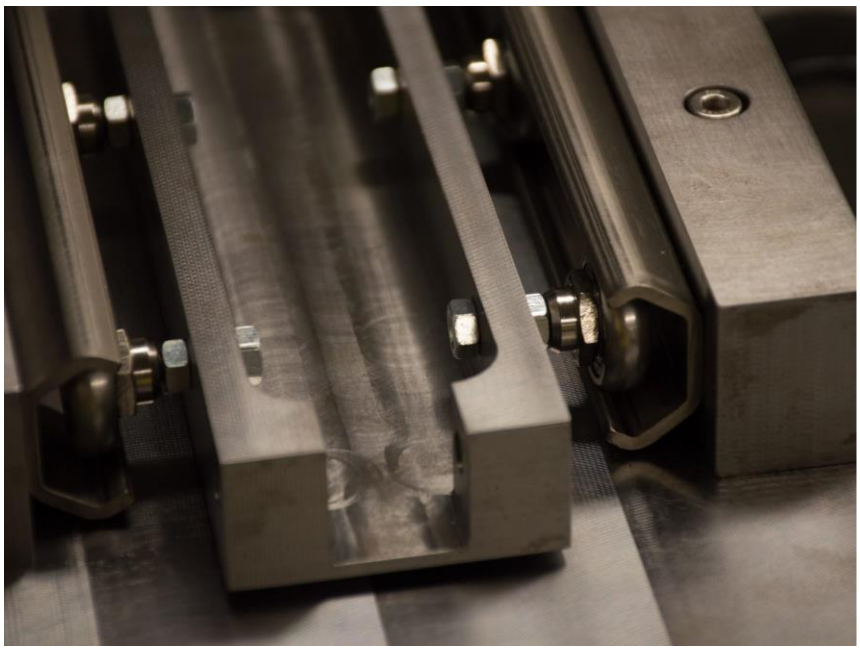


Figure 29. Nuts protruding into slot of pulley v-block.

5.3.2 Linear Bearing System

The current linear bearing system consists of guide rails and rollers. These were found to have a high amount of play and were not very precise. Additionally, in the event where the roller rotates out of plane with the guide rail, the system would bind and the v-block would become very difficult to move. Investing in a more precise and reliable linear bearing system would improve the feeding of the machine and reduce the amount of wear in the components. Figure 30 shows the sensitivity of the current linear bearing system. The roller on the left side is in contact with the guide rails whereas the roller on the right side is not.

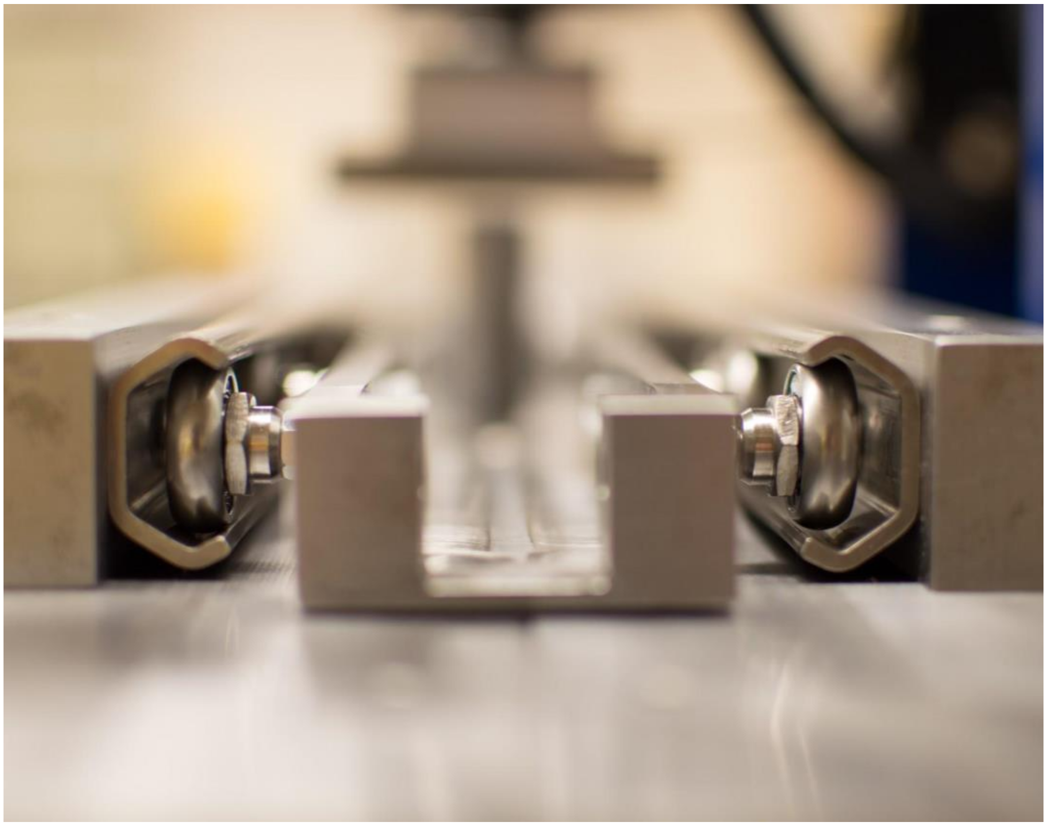


Figure 30. Linear bearing system with left roller touching only.

5.4 Cost Analysis

Given a budget of $3000 for the project not including the cost of the pneumatic press, we were able to keep the project spending within budget by doing the manufacturing ourselves at Cal Poly. Table 6 below shows the cost for the different parts of the machine.

Component	Cost
Joraco Press	$10,000.00
Aluminum tubing	$33.84
DIN rail	$5.07
Fastening hardware	$65.95
Al Manifold	$33.25
Air regulator	$40.10
Position control motor+driver	$160.86
Air hoses	$95.16
Hose couplings+fittings	$92.12
Air cylinders + brackets	$238.24
Guide rails	$136.64
Rollers	$293.20
E-stop	$32.76
Ball ends	$12.44
Sensors	$177.22
Power cords	$22.93
Exhaust valve	$138.16
Solenoid valves	$245.67
Acrylic sheet	$109.00
80/20 fastening hardware	$512.40
80/20 extrusions*	$400.00
Steel stock	$289.40
PLC enclosure	$51.45

*donated

Table 6. Actual component costs.

CHAPTER 6: DESIGN VERIFICATION

Because the mechatronics portion of this project was not completed, a full test of every system working together from start to finish was not was not able to be completed. Mechanically, the positioning v-blocks move as designed and work well in placing the pulleys and bearings in the correct position. An alternative linear bearing system is recommended as described in the section 5.3.2.

CHAPTER 7: CONCLUSIONS, RECOMMENDATIONS, AND CONTINUATION

Based on our calculations and testing we believe that our design will meet the specifications designated by Micro-Vu. The magazine design allows the machine to handle large batch sizes, and the actuators move the parts automatically to perform the pressing operation without and human interaction. While safety is a concern, the largest risks of shrapnel and pinch points are prevented with a safety shield, while electrical fires and other similar hazards can be prevented by thoroughly inspecting the wiring during installation and during periodic maintenance. The machine's lifetime is increased by limiting wear and using parts that are easy to replace, and the PLC can diagnose and display any errors it encounters during operation.

The electronics and programming are the main portions that have yet to be completed. Currently the press is set up as received, with the manufacturer's PLC recording the force output and allowing a minimum and maximum setting for the allowed force output. We ordered the press with this feature in order to detect the parts that were over or under the force values that we measured during testing. In order to automate this machine, several things have to be done. The first is to bypass the two-handed tie down actuator that prevents anyone from activating the press without pressing two separate buttons at the same time. These buttons are connected to a solenoid valve that detects this actuation. Running a uninterrupted air line from the two ports on the solenoid valve rather than having the tie-down actuator present should take care of this problem. Interfacing the Siemens PLC with the PLC currently on the press is the major task that still needs to be completed. The Siemens PLC is meant to control the timing of the solenoid valves connected to the actuators, receive the signal from the proximity sensors, and control the motor that will be attached to the part ramp. A final step would be to include the E-stop in an accessible location in case of an emergency.

Appendix A. Quality Function Deployment and Decision Matrices

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality (a.k.a. "Customer Requirements" or "Whats") / Quality Characteristics (a.k.a. "Functional Requirements" or "Hows")	Footprint	Reliability	Lifetime	Force Output	Loading Time	Weight	Component Life	Batch Size	Service Frequency	Power Drawn	Speed (time per part)	12	13	14	15	Our C	Arbor	Semi-	Roller
				Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Competitive (0=Worst,			
				Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)	▼	▲	▲	x	▼	▼	▲	▲	▲	▼	▼								
1	9	25.0	25.0	Automation	▲	Θ	▲		Θ	▲	▲	Θ	▲	▲	Θ						1	2	4
2	3	25.0	25.0	Safety				O	▲		O	O	O	▲	▲						3	2	3
3	9	15.0	15.0	Reliability		Θ	Θ	O			Θ	▲			▲						4	4	3
4	9	5.0	5.0	Size	Θ			▲		O		O	▲	O							5	4	2
5	3	10.0	10.0	Data Acquisition		O		O						▲							1	2	1
6	9	10.0	10.0	Serviceable	O		Θ						Θ								5	3	5
7	3	10.0	10.0	Cost	▲	▲	O	▲			O		O	▲	O						5	3	4
8																							
9																							
10																							
				Target or Limit Value	3'x3'	99%	15 Years		1 minute	150 lbs	2 Years	150 Units	3 months	5 kW	10 seconds								
				Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)	3	8	7		3	2	5	7	5	2	6								
				Max Relationship Value in Column	9	9	9	3	9	3	9	9	9	3	9								
				Weight / Importance	110.0	400.0	280.0	165.0	250.0	40.0	265.0	330.0	225.0	85.0	295.0								

Loading System										
Criteria	Baseline	Weight	Funnel+Vibration		Spring Magazine		Bowl Feeder		Conveyer System	
			Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation
Speed	0	10	1	10	2	20	2	20	2	20
Safety	0	10	2	20	2	20	2	20	-1	-10
Size	0	5	-1	-5	0	0	-2	-10	-1	-5
Quantity Capability	0	25	2	50	1	25	2	50	2	50
Cost	0	15	1	15	1	15	-3	-45	-2	-30
Manufacturing Effort	0	5	-1	-5	-1	-5	0	0	-1	-5
Weight	0	5	0	0	0	0	-2	-10	-1	-5
Reliability	0	25	-1	-25	1	25	2	50	0	0
		100	Sum	60	Sum	100	Sum	75	Sum	15

Table 2-A. Pugh matrix values for selection of a loading system.

Positioning System										
Criteria	Baseline	Weight	Rotating Slotted Fixture		Rotating Rods		Conveyer Belt		Direct Drop from Tracks	
			Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation
Speed	0	5	2	10	2	10	2	10	2	10
Safety	0	10	2	20	2	20	1	10	0	0
Size	0	5	1	5	1	5	1	5	2	10
Precision	0	30	2	60	2	60	1	30	-1	-30
Cost	0	10	-1	-10	-1	-10	-3	-30	2	20
Manufacturing Effort	0	10	-1	-10	-2	-20	-3	-30	2	20
Weight	0	5	0	0	0	0	0	0	2	10
Reliability	0	25	0	0	-1	-25	-1	-25	-2	-50
		100	Sum	75	Sum	40	Sum	-30	Sum	-10

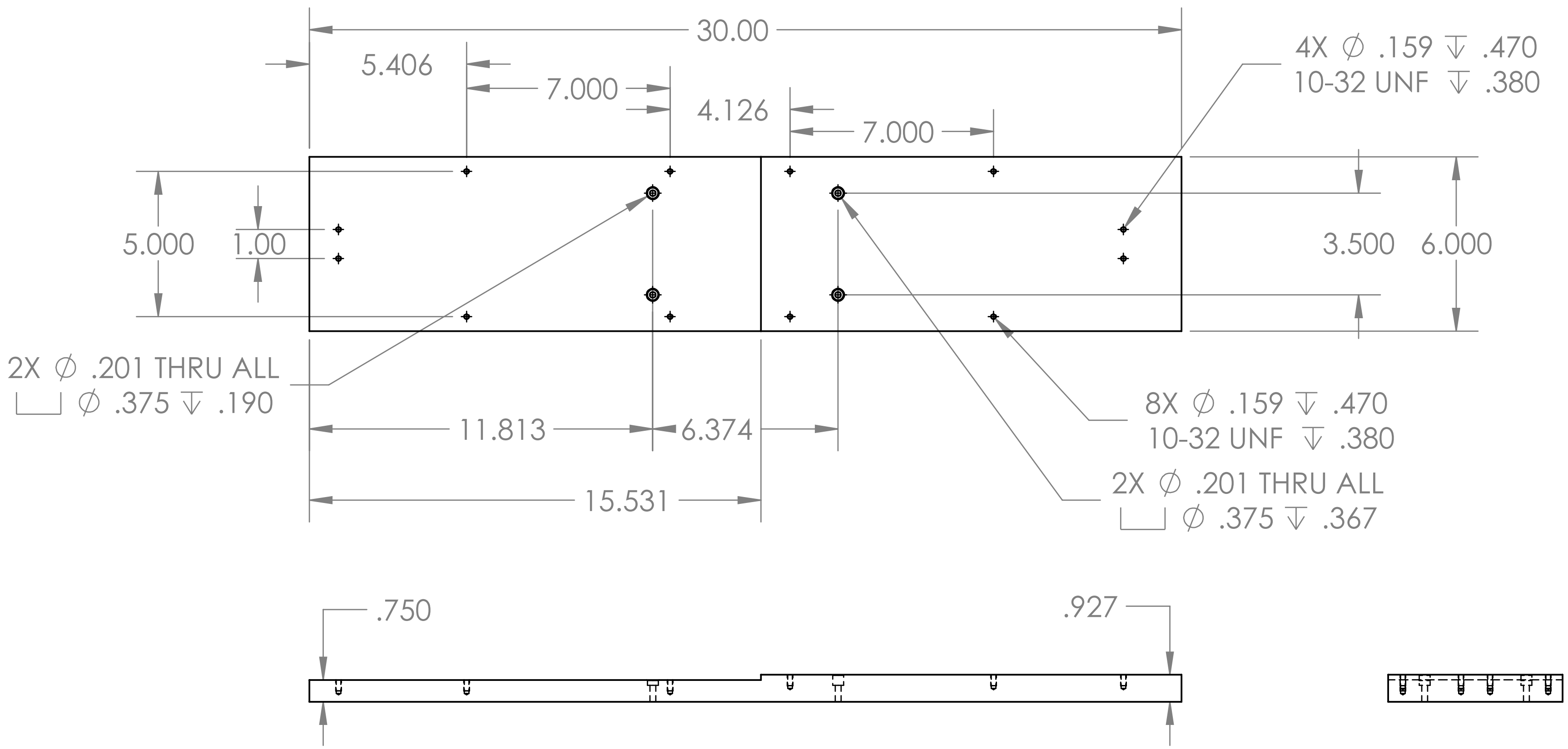
Table 3-A. Pugh matrix values for selection of a positioning system.

Pressing Method										
Criteria	Baseline	Weight	Bearing Over Pulley Slot		Bearing Constrained by Rod		Bearing Attached to Press Head		Parts Independently Positioned	
			Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation
Safety	0	10	2	20	2	20	1	10	0	0
Precision	0	35	2	70	2	70	2	70	3	105
Cost	0	15	-1	-15	-1	-15	1	15	2	30
Manufacturing Effort	0	15	-1	-15	-2	-30	-1	-15	-1	-15
Reliability	0	25	0	0	0	0	-2	-50	-2	-50
		100	Sum	60	Sum	45	Sum	30	Sum	70

Table 4-A. Pugh matrix values for selection of a pressing method.

Removal of Assemblies										
Criteria	Baseline	Weight	Fall Through Slot in Table		Blown out by Air		Spring Activated Actuator		Robotic Arm	
			Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation	Evaluation	Weighted Evaluation
Speed	0	10	1	10	2	20	1	10	2	20
Safety	0	15	3	45	-1	-15	-1	-15	0	0
Cost	0	20	2	40	-1	-20	2	40	-3	-120
Manufacturing Effort	0	15	2	30	-1	-15	0	0	-1	-30
Reliability	0	40	1	40	1	40	1	40	3	120
		100	Sum	165	Sum	10	Sum	75	Sum	-10

Table 5-A. Pugh matrix values for selection of a removal method.



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APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
TWO PLACE DECIMAL ±.015
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: STEEL

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ENG APPR.		
MFG APPR.		
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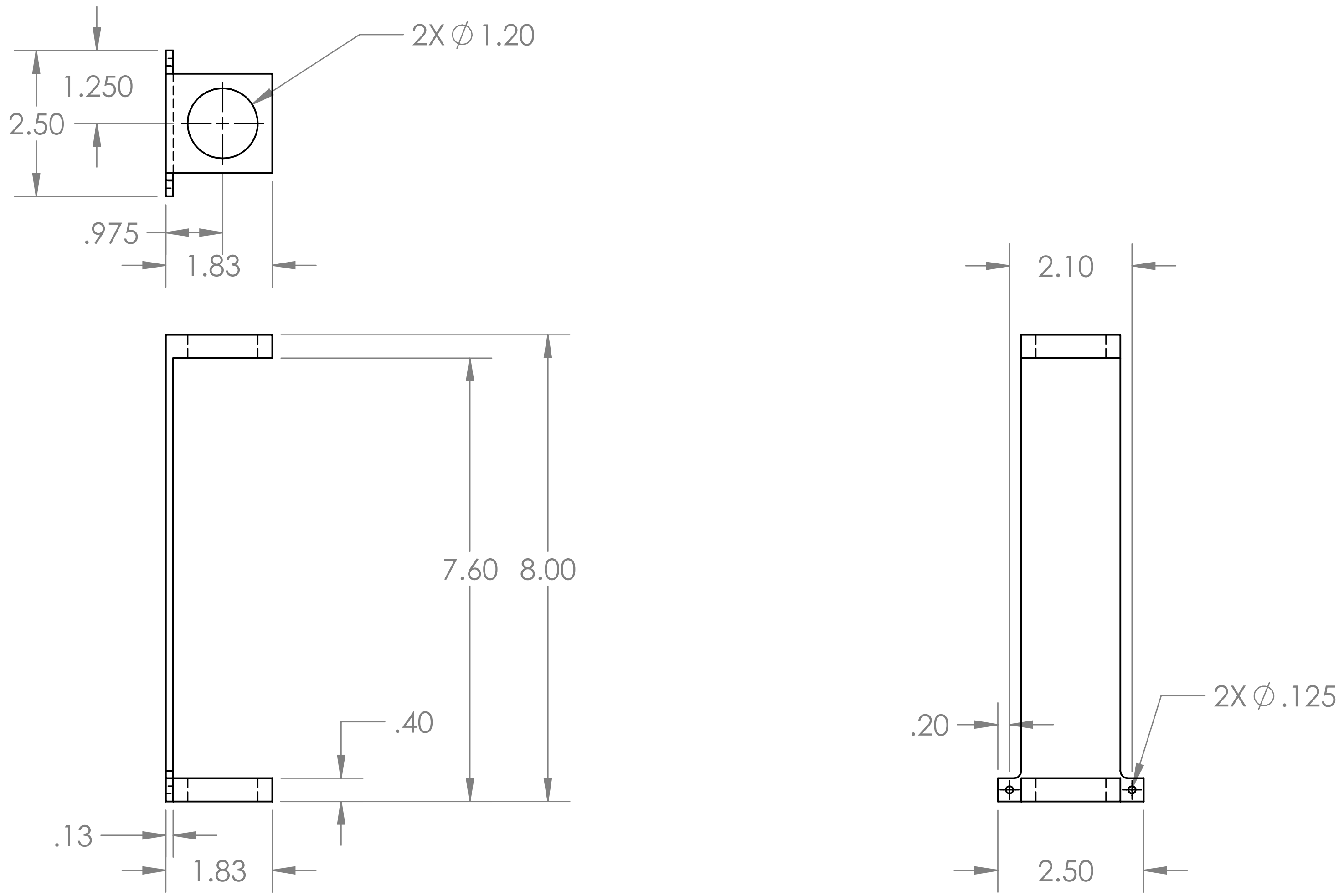

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THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: 6061 ALUMINUM

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MAGAZINE BRACKET

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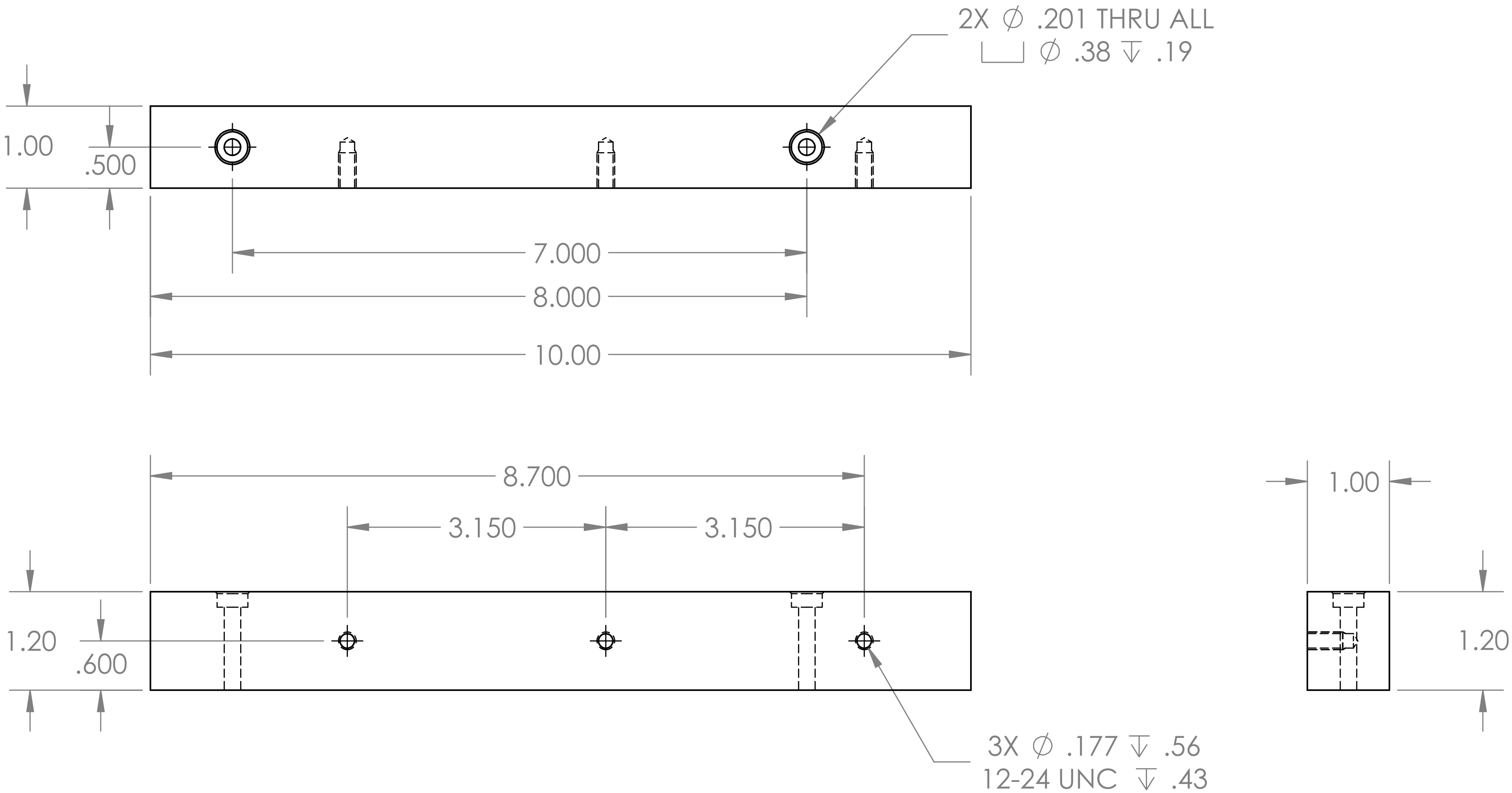

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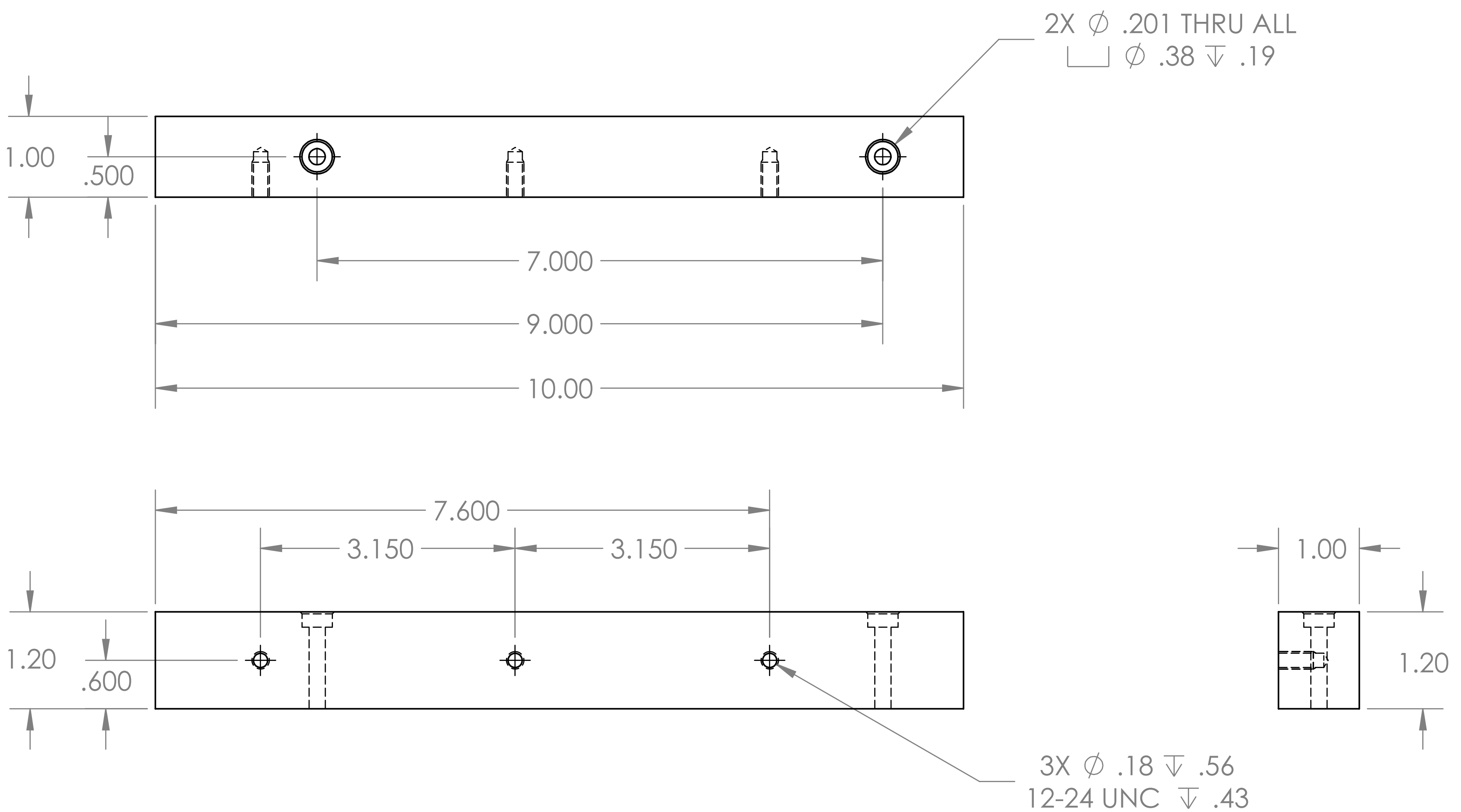
			MFG APPR.			
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
		MATERIAL: STEEL	COMMENTS:			SIZE A / DWG. NO. 1003 / REV A
NEXT ASSY	USED ON	FINISH				
APPLICATION		DO NOT SCALE DRAWING				SCALE: 1:2 / WEIGHT: / SHEET 1 OF 1

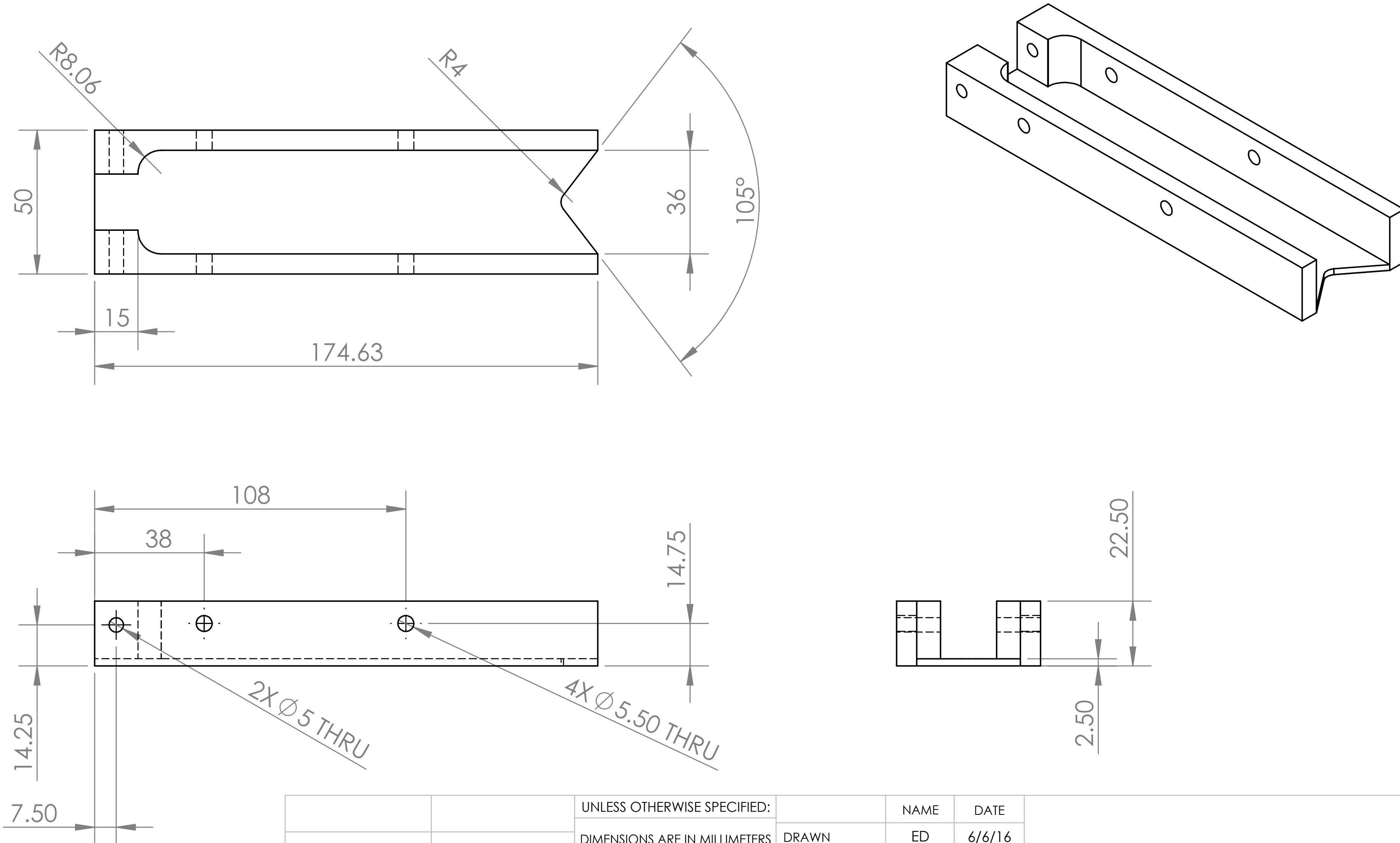
PROPRIETARY AND CONFIDENTIAL



UNLESS OTHERWISE SPECIFIED:		NAME	DATE		
DIMENSIONS ARE IN INCHES TOLERANCES: TWO PLACE DECIMAL ±.015 THREE PLACE DECIMAL ±.005	DRAWN	DB	2/10/16		
	CHECKED			TITLE:	
	ENG APPR.			RAIL BLOCK FRONT	
	MFG APPR.				
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.				
MATERIAL: STEEL	COMMENTS:			SIZE A	DWG. NO. 1004	REV A
FINISH					
DO NOT SCALE DRAWING				SCALE: 1:2	WEIGHT:	SHEET 1 OF 1

NEXT ASSY	USED ON
APPLICATION	

PROPRIETARY AND CONFIDENTIAL



PROPRIETARY AND CONFIDENTIAL

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN MILLIMETERS
TOLERANCES:
TWO PLACE DECIMAL ±.3
THREE PLACE DECIMAL ±.1

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: STEEL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	ED	6/6/16
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

RADIUS SHOWN IN TOP VIEW IS RADIUS OF END MILL

TITLE:

v-block

SIZE	DWG. NO.	REV
A	1002	A

SCALE: 1:2 WEIGHT: SHEET 1 OF 1

Appendix C. List of Vendors

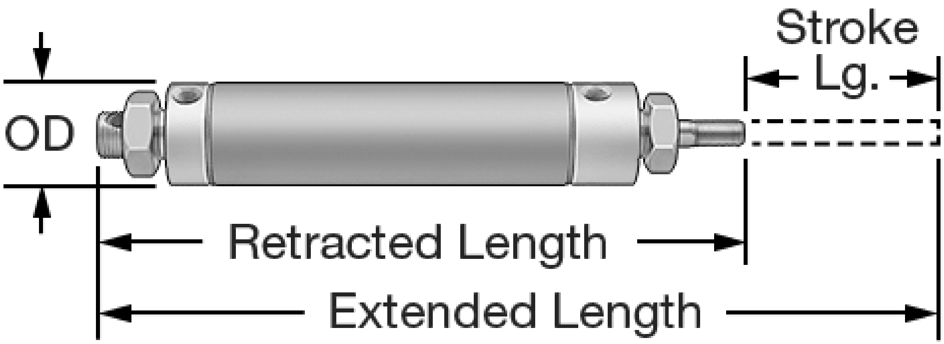
Vendor	Phone	Email	Address	Components
Joraco	(401) 232-1710	info@joraco.com	347 Farnum Pike, Smithfield, RI 02917 USA	Pneumatic press
McMaster Carr	(562) 692-5911	la.sales@mcmaster.com	9630 Norwalk Blvd., Santa Fe Springs, CA 90670-2932	Air cylinder, Ball joint rod end, Foot bracket, Pivot bracket, Guide rail, Track roller, Bearing magazine, Pulley magazine, Stepper motor, Manifold, Air hose, Fasteners
Pneumadyne	(763) 559-0177	N/A	14425 23rd Avenue North Plymouth, MN 55447-4706	1/4" ID straight connector
80/20 Inc.	(884) 802-0932	info@8020inc.com	1701 County Rd 400 E, Columbia City, IN 46725	80/20 Extrusion

McMASTER-CARR® OVER 555,000 PRODUCTS
(562) 692-5911
(562) 695-2323 (fax)
la.sales@mcmaster.com
Text 75930

Round Body Air Cylinder

Double-Acting, Universal Mount, 7/16" Bore Size, 6" Stroke

In stock
$39.20 Each
6498K608

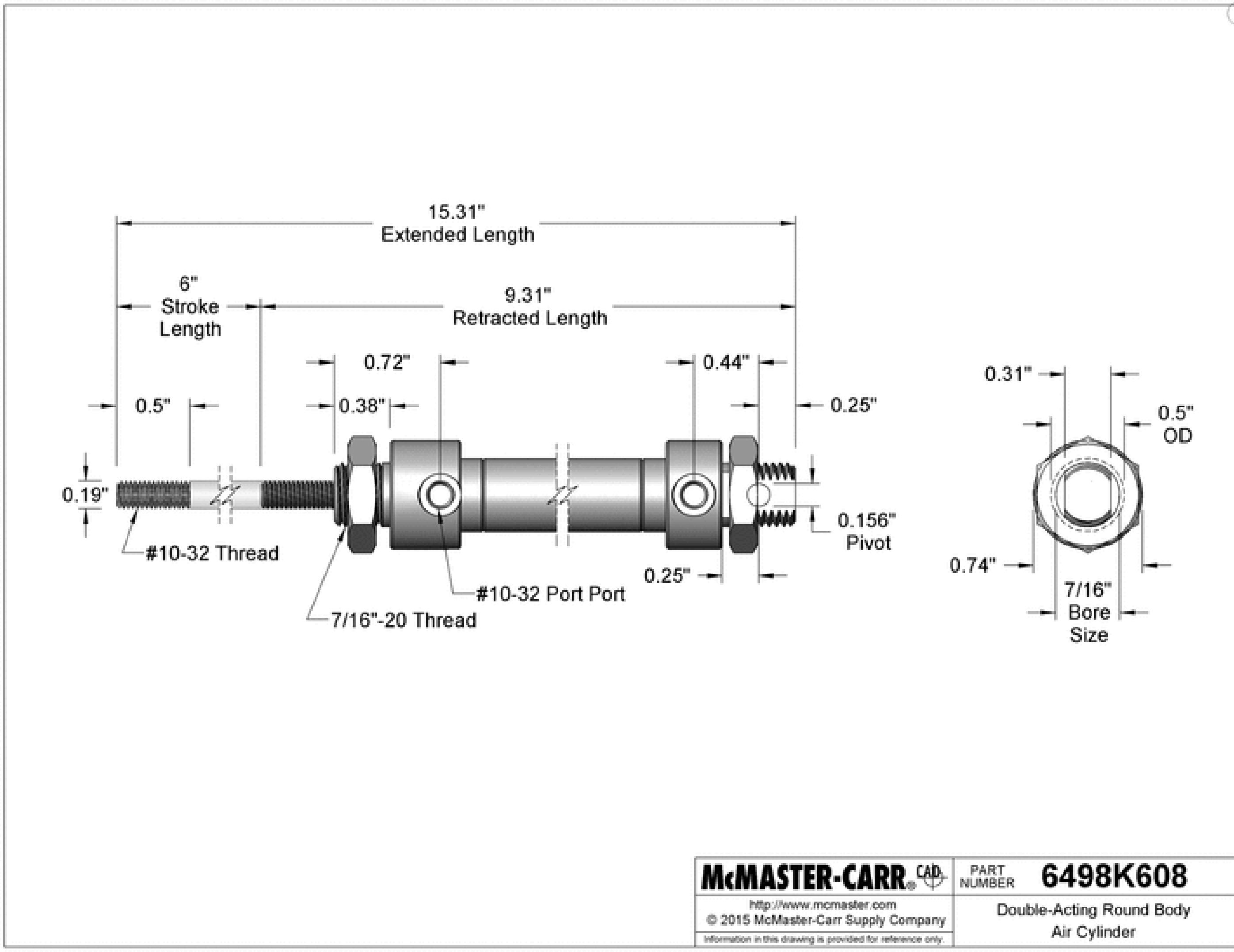


Motion	Linear
Air Actuator Type	Air Cylinder
Linear Air Cylinder Type	Round Body
Mount Type	Universal
Mounting Orientation	Any
Bore Size	7/16"
OD	1/2"
Length	
Stroke	6"
Retracted	9.31"
Extended	15.31"
Force @ 50 psi	8 lbs.
Force @ 100 psi	15 lbs.
Force @ 150 psi	22.5 lbs.
Force @ 200 psi	30 lbs.
Sensor Ready	Not Sensor Ready
Air Cushion Type	No Cushion
Actuation Style	Double Acting
Actuation Mechanism	Air Extend, Air Retract
Repairable	Nonrepairable
Body Material	304 Stainless Steel
End Cap	

Material	Aluminum
End Cap Construction	Double Rolled
Included Component	Mounting Nuts, Pivot Bushing, Pivot Pin, Retaining Rings
Number of Mounting Nuts Included	2
Mounting Nut Material	Zinc-Plated Carbon Steel
Rod	
Material	303 Stainless Steel
Diameter	0.19"
End Type	Threaded
Thread Size	10-32
Air Inlet	
Thread Size	10-32
Thread Type	UNF
Gender	Female
Nose Mount Thread Size	7/16"-20
Pivot Mount Thread Size	7/16"-20
Pivot Pin Diameter	0.16"
Bearing Type	Sleeve
Bearing Material	Sintered Bronze
Maximum Pressure	250 psi
Maximum Number of Cycles	15,840,000
Duty Cycle	Continuous
Temperature Range	-20°F to 200°F

Create linear motion with the most popular of our air cylinders.

Universal-mount cylinders have threads on both ends to mount in a fixed position or you can use the hole on the back end to pivot mount.



The information in this 3-D model is provided for reference only.

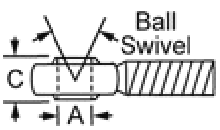
McMASTER-CARR® OVER 555,000 PRODUCTS

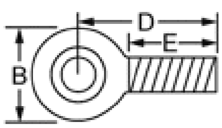
(562) 692-5911
(562) 695-2323 (fax)
la.sales@mcmaster.com
Text 75930

PTFE-Lined Stainless Steel Ball Joint Rod End

10-32 RH Female Shank, 3/16" Ball ID, 1/2" Thread Length

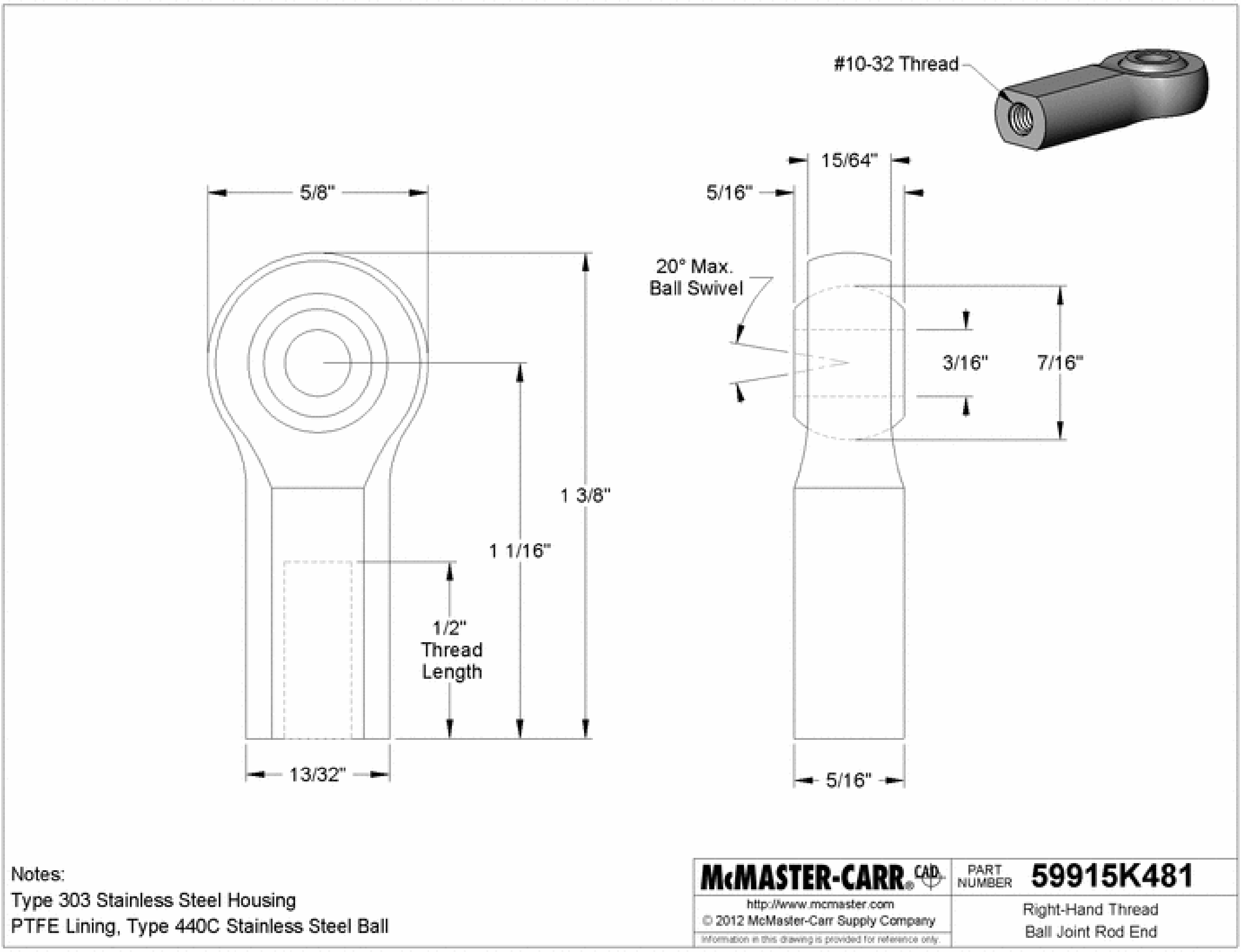
In stock
$9.86 Each
59915K481





Shank Thread Direction	Right-Hand Threads
Shank Type	Female-Threaded
Shank Thread Size	10-32
Ball ID (A)	3/16"
Maximum Ball Swivel	20°
Overall Width (B)	5/8"
Overall Thickness (C)	5/16"
(D)	1 1/16"
Thread Length (E)	1/2"
Static Radial Load Capacity	930 lbs.

A Type 303 stainless steel housing and Type 440C stainless steel ball provide excellent corrosion resistance while a PTFE liner allows smooth ball rotation and reduces the need for lubrication.



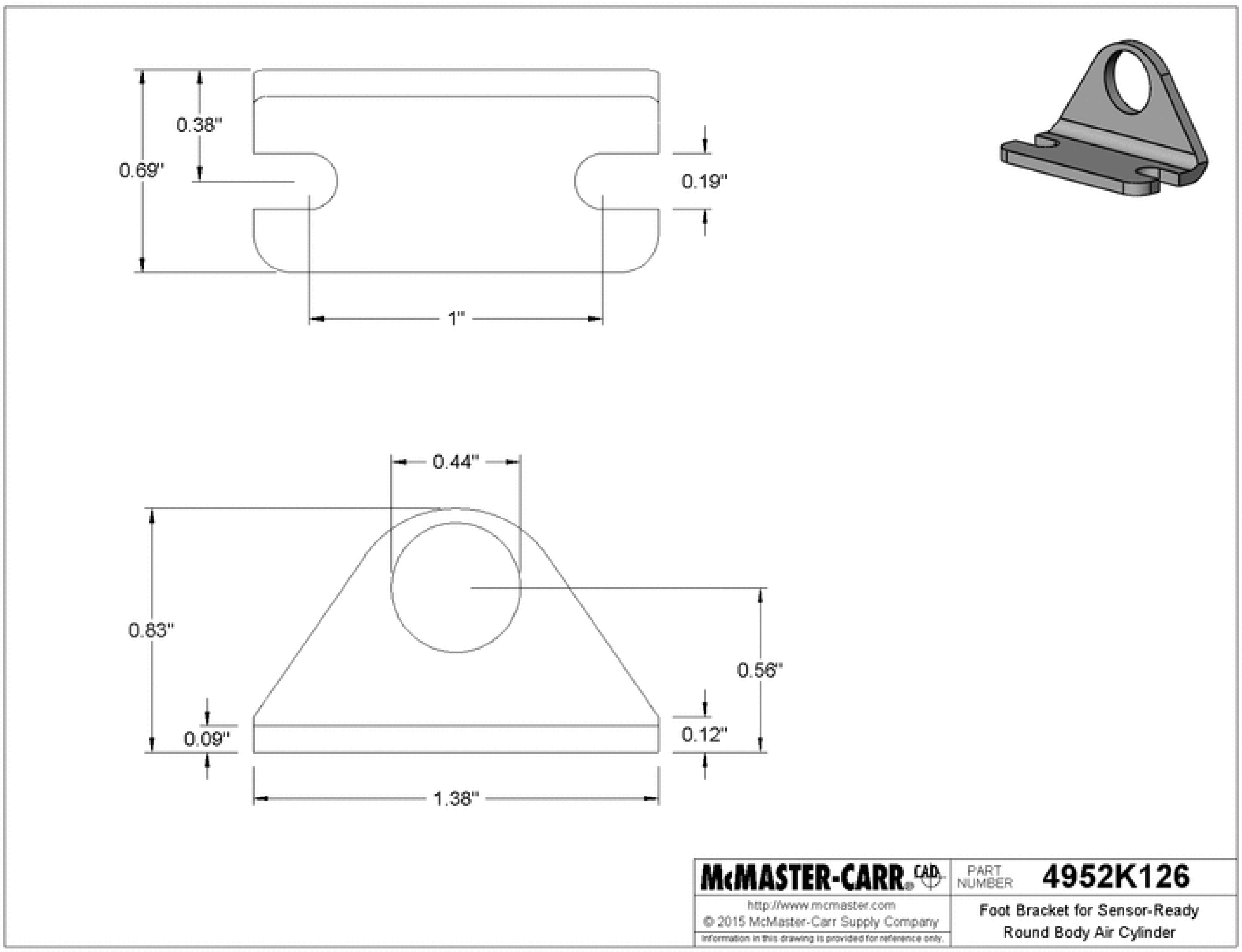
The information in this 3-D model is provided for reference only.

(562) 692-5911
(562) 695-2323 (fax)
la.sales@mcmaster.com
Text 75930

Foot Bracket for 7/16", 9/16", and 5/8" Bore Sensor-Ready Round Body Air Cylinder

In stock
$3.64 Each
4952K126

For Bore Size	7/16", 9/16", 5/8"
Material	Zinc-Plated Steel



The information in this 3-D model is provided for reference only.

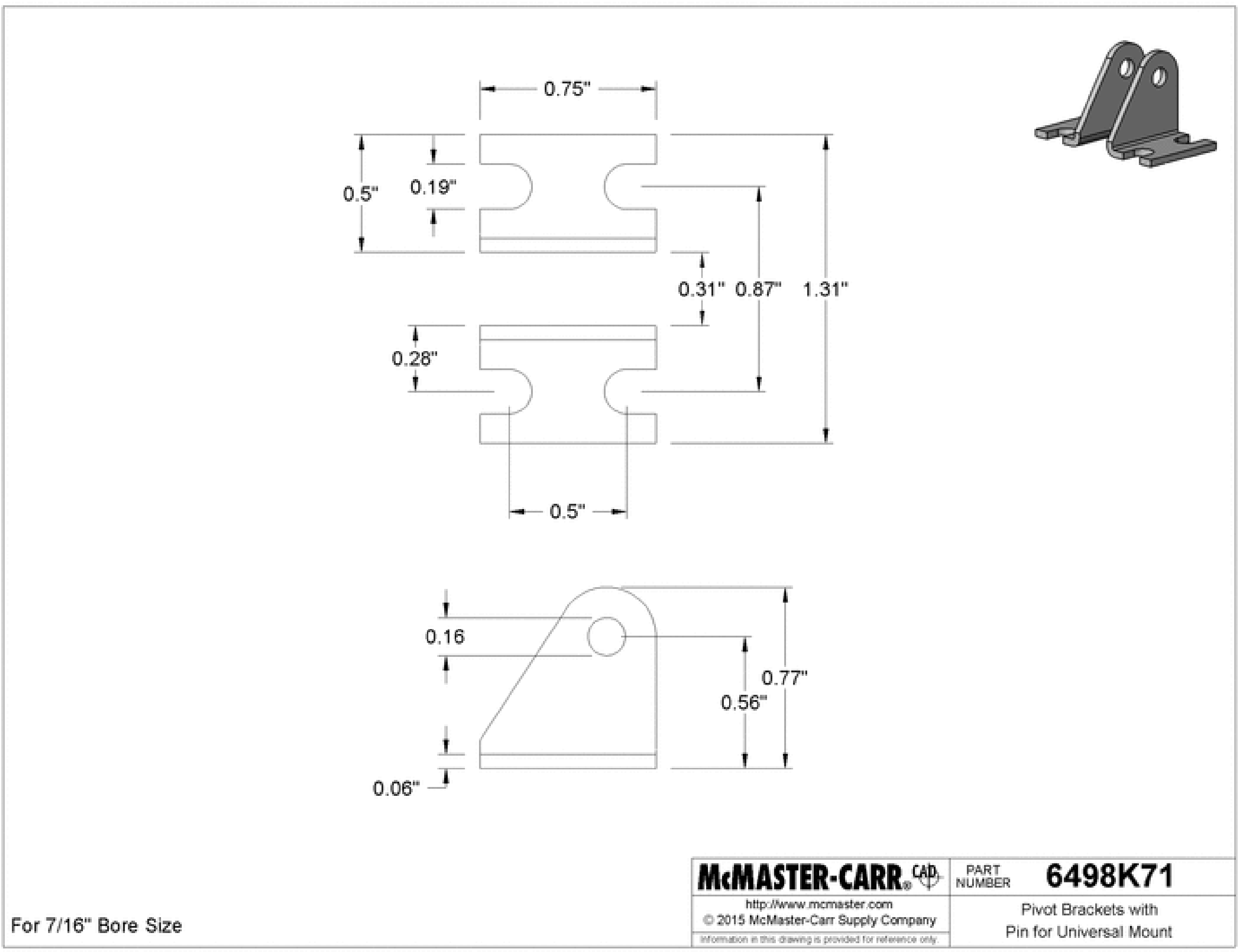
McMASTER-CARR® OVER 555,000 PRODUCTS

(562) 692-5911
(562) 695-2323 (fax)
la.sales@mcmaster.com
Text 75930

Pivot Bracket for 7/16" Bore Size Round Body Air Cylinder

In stock
$3.74 Each
6498K71

For Bore Size	7/16"
Material	Zinc-Plated Steel



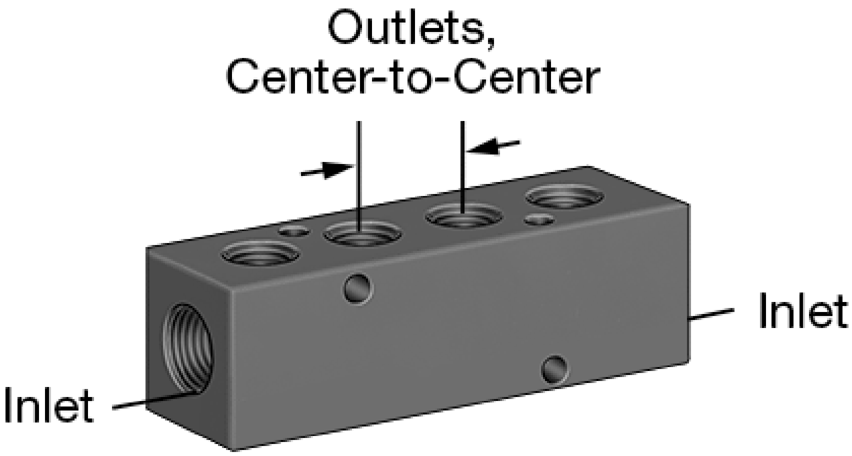
The information in this 3-D model is provided for reference only.

McMASTER-CARR® OVER 555,000 PRODUCTS
(562) 692-5911
(562) 695-2323 (fax)
la.sales@mcmaster.com
Text 75930

Black Anodized Aluminum Manifold

4 Outlets on One Side, 3/8 Pipe Size Inlet

In stock
$18.36 Each
5469K123

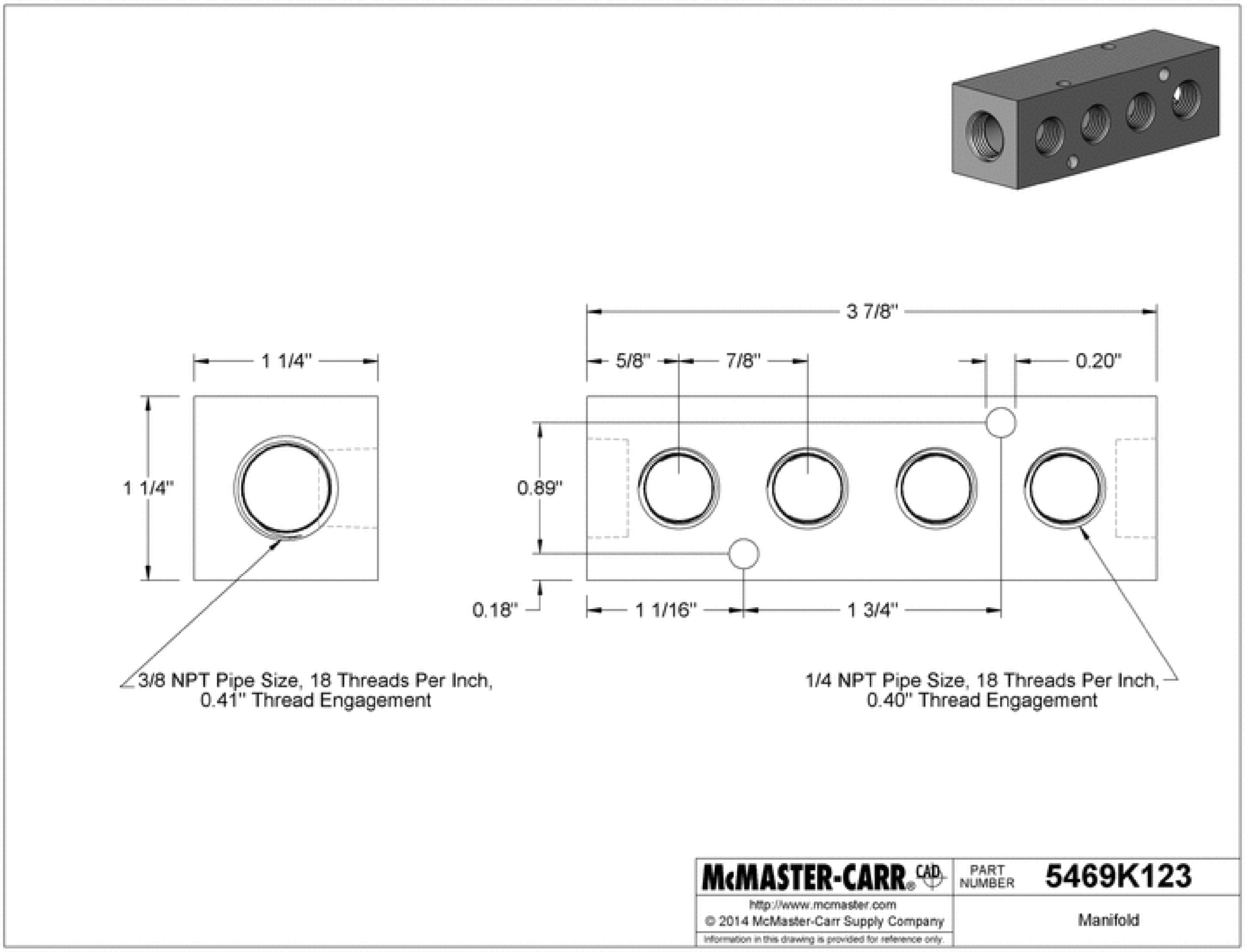


Number of Outlets	4
Pipe Size	
Inlet	3/8
Outlet	1/4
Thread Type	
Inlet	NPT
Outlet	NPT
Overall Size	
Length	3 7/8"
Width	1 1/4"
Height	1 1/4"
Outlets, Center-to-Center	7/8"
Maximum Pressure	
Air	1,000 psi @ 72° F
Water	1,000 psi @ 72° F
Nonshock Hydraulics	3,000 psi @ 72° F
Temperature Range	-10° to 200° F
For Use With	Water, Air, Hydraulic Oil
Color	Black
Material	Black Anodized Aluminum
RoHS	Compliant

Distribute air or fluid to multiple locations from a single supply source. Also known as headers, these have an inlet on both ends and four mounting holes so you can mount from the top or side.

Plugs (sold separately) close off any unused outlets or inlets. They are not rated for temperature.

Threaded Connections: NPT threads.



The information in this 3-D model is provided for reference only.

McMASTER-CARR. OVER 555,000 PRODUCTS
(562) 692-5911
(562) 695-2323 (fax)
la.sales@mcmaster.com
Text 75930

Hose for Push-on Fitting

Buna-N/PVC Blend, Black, 1/4" ID x 1/2" OD

$2.04 per ft. of 100
5633K21

Hose	
ID	1/4"
OD	1/2"
Bend Radius	2 1/2"
Length	5 ft., 10 ft., 20 ft., 25 ft., 30 ft., 50 ft., 100 ft., Other
Temperature Range	-20° to 150° F
Fittings	Use push-on style
Additional Specifications	Standard Buna-N/PVC Blend Maximum Pressure @ 72° F: Standard: 200 psi; Choose-a-Color: 250 psi; High-Pressure: 300 psi

Because of the unique braid-reinforced design, push-on hose doesn’t require clamps or ferrules to stay put. In fact, the more you pull on the fitting, the tighter the hose will grip. Not rated for vacuum.

Use with air and water. Both the tube and cover are Buna-N blended with PVC, reinforced with a textile braid. Hose meets ASTM D2240, D412, and D792. Color is black. **To Order:** Please specify hose length of 5-, 10-, 20-, 25-, 50-, or any length you choose up to 100 feet.

Phone 763-559-0177 Fax 763-559-0547

PNEUMADYNE

Specification Sheet

Pneumatic Fittings

Performance Data

Temperature Range	Operating Pressure	Media
-20° to 160° F -28° to 71° C	Vacuum to 125 psi	Fluids compatible w/ seals

When design makes data critical- contact factory for confirmation. All published information is based on usual manufacturing standards and product applications and is for general reference purposes. Supplied information is in no way a representation of a warranty for product.

Flow Rate- *Typical*

Standard Double Barb

Barb Size	Tube ID (PUR)	C_V	Flow Rate (scfm) 50 psi	125 psi
062	1/16	0.06	1.8	4.0
110	5/64 or 2.4mm	0.20	5.2	12.0
140	1/8	0.20	5.2	12.0
170 O-ring	.170	0.28	7.3	16.5
170 Tapered	.170	0.40	10.5	23.5

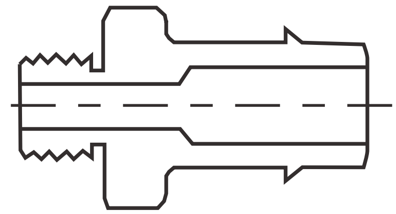
Pneu-Edge® (single-barb design)

Barb Size	Tube ID (PUR)	C_V	Flow Rate (scfm) 50 psi	125 psi
10	1/16	0.08	2.4	5.5
20	5/64	0.09	2.8	6.8
25	3/32	0.18	5.0	12.0
30	1/8	0.24	6.0	14.5
35	5/32	0.31	7.8	19.0
40	.170	0.48	11.5	27.0
50	3/16	0.60	14.0	33.0
60	1/4	1.07	22.0	52.0
70	5/16	1.62	35.0	82.0
80	3/8	3.40	59.0	140.0

Flow Rate- *Atypical*

Pneu-Edge® fittings ease installation by offering larger barbs on miniature threads. This configuration lowers the rate of flow. Please refer to the listing below for atypical dimensions and data.

Barb ID does not necessarily determine flow rate



Part Number	Tube ID (PUR)	Cv	Flow Rate (scfm) psi 50	125
EB35	5/32	.28	7.3	16.5
EB40	.170	.28	7.3	16.5
EB50	3/16	.28	7.3	16.5
EB60	1/4	.28	7.3	16.5
EB40-250	.170	.28	7.3	16.5
EB40-4-28	.170	.48	11.5	27.0
EB50-4-28	3/16	.48	11.5	27.0
EB60-4-28	1/4	.48	11.5	27.0
EB10-M3	1/16	.06	1.8	4.0
EB20-M3	.078	.06	1.8	4.0
EB25-M3	3/32	.06	1.8	4.0
EB30-M3	1/8	.06	1.8	4.0
EB40-M3	.170	.06	1.8	4.0
EB40-M5	.170	.28	7.3	16.5
ELB35	5/32	.28	7.3	16.5
ELB40	.170	.28	7.3	16.5
ELB50-4-28	3/16	.48	11.5	27.0
ELB10-M3	1/16	.06	1.8	4.0
ELB20-M3	.078	.06	1.8	4.0
ELB25-M3	3/32	.06	1.8	4.0
ELB30-M3	1/8	.06	1.8	4.0

Part Number	Tube ID (PUR)	Cv	Flow Rate (scfm) psi 50	125
ELB40-M3	.170	.06	1.8	4.0
ELB40-M5	.170	.28	7.3	16.5
ELB50-M6	3/16	.48	11.5	27.0
EA-LB40	.170	.40	10.5	23.5
EA-LB50	3/16	.40	10.5	23.5
EA-LB40-SL0T	.170	.40	10.5	23.5
EA-LB50-SL0T	3/16	.40	10.5	23.5
ETB35	5/32	.28	7.3	16.5
ETB40	.170	.28	7.3	16.5
ET50-4-28	3/16	.48	11.5	27.0
ET10-M3	1/16	.06	1.8	4.0
ET20-M3	.078	.06	1.8	4.0
ET25-M3	3/32	.06	1.8	4.0
ET30-M3	1/8	.06	1.8	4.0
ET40-M3	.170	.06	1.8	4.0
ET40-M5	.170	.28	7.3	16.5
ET50-M6	3/16	.48	11.5	27.0
EA-T40	.170	.40	10.5	23.5
EA-T50	3/16	.40	10.5	23.5
EA-T40-SL0T	.170	.40	10.5	23.5
EA-T50-SL0T	3/16	.40	10.5	23.5

Additional Recommendation: Pneu-Edge fittings ensure permanent polyurethane tubing installation without the need for clamps. However, we recommend the use of clamps in applications over 80 psi which also involve heat or vibration.

- All Flow Rates are approximate

Materials

Pneu-Edge
Brass with Electroless Nickel Plating Buna-N Seals
303 Stainless Steel

O-ring Seal Fittings
Brass with Electroless Nickel plating, Stainless Steel 303 passivated, Buna-N Seals

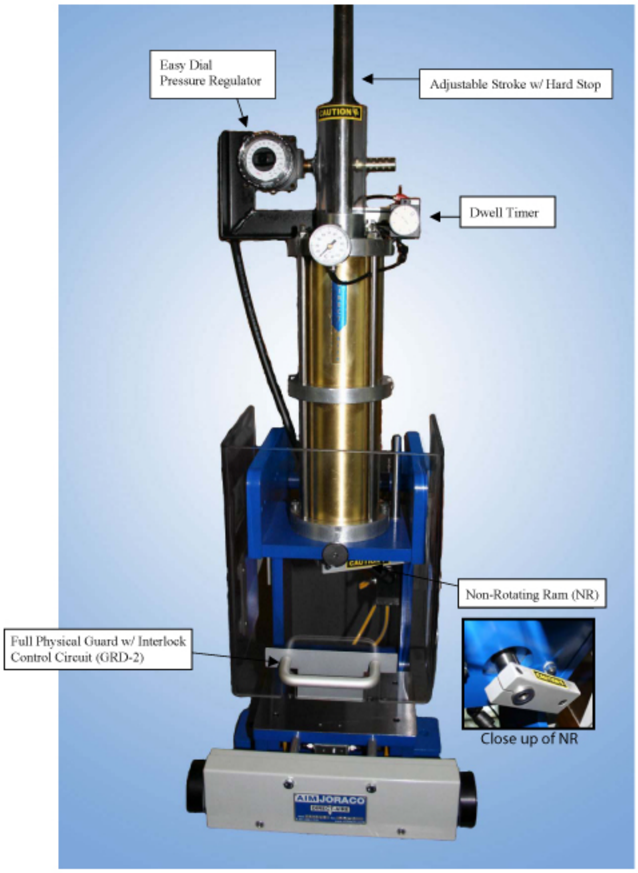
Tapered Thread Fittings
Brass

Barb-to-Barb Fittings
Brass with Electroless Nickel Plating

Push-to-Connect Fittings
Brass with Electroless Nickel Plating, Acetal Resin, Stainless Steel, NBR or 316L Stainless Steel, 301 Stainless Steel, FPM/FKM

Push-to-Connect Straight Connector
Brass with Electroless Nickel Plating, Acetal, Buna-N Seals

DIRECT-AIRE PNEUMATIC PRESS SERIES



DIRECT-AIRE Model 400T w/ Two-Hand Anti Tie-Down Controller (SS-PB-18)
Multiple Optional Accessories Included in Photo Above.

- **ECONOMICAL**
- **COMPACT**
- **TROUBLE FREE**
- **ACCURATE**
- **ADAPTABLE**

Model 300 Series	**650 lbs @ 100PSI**
Model 400 Series	**1200 lbs @ 100PSI**
Model 400T Series	**2300 lbs @ 100PSI**
Model 800 Series	**5000 lbs @ 100PSI**

SPECIFICATIONS

- **Stroke 4.5"**
- **Open Height 8"**
- **Throat Depth 4.25"**
- **Heavy Duty design with 6"x8" platen**
- **Throughspace 6"**
  (for flexible working area)

Call TODAY for a Quote!
1-888-889-4287
or email ***sales@joraco.com***

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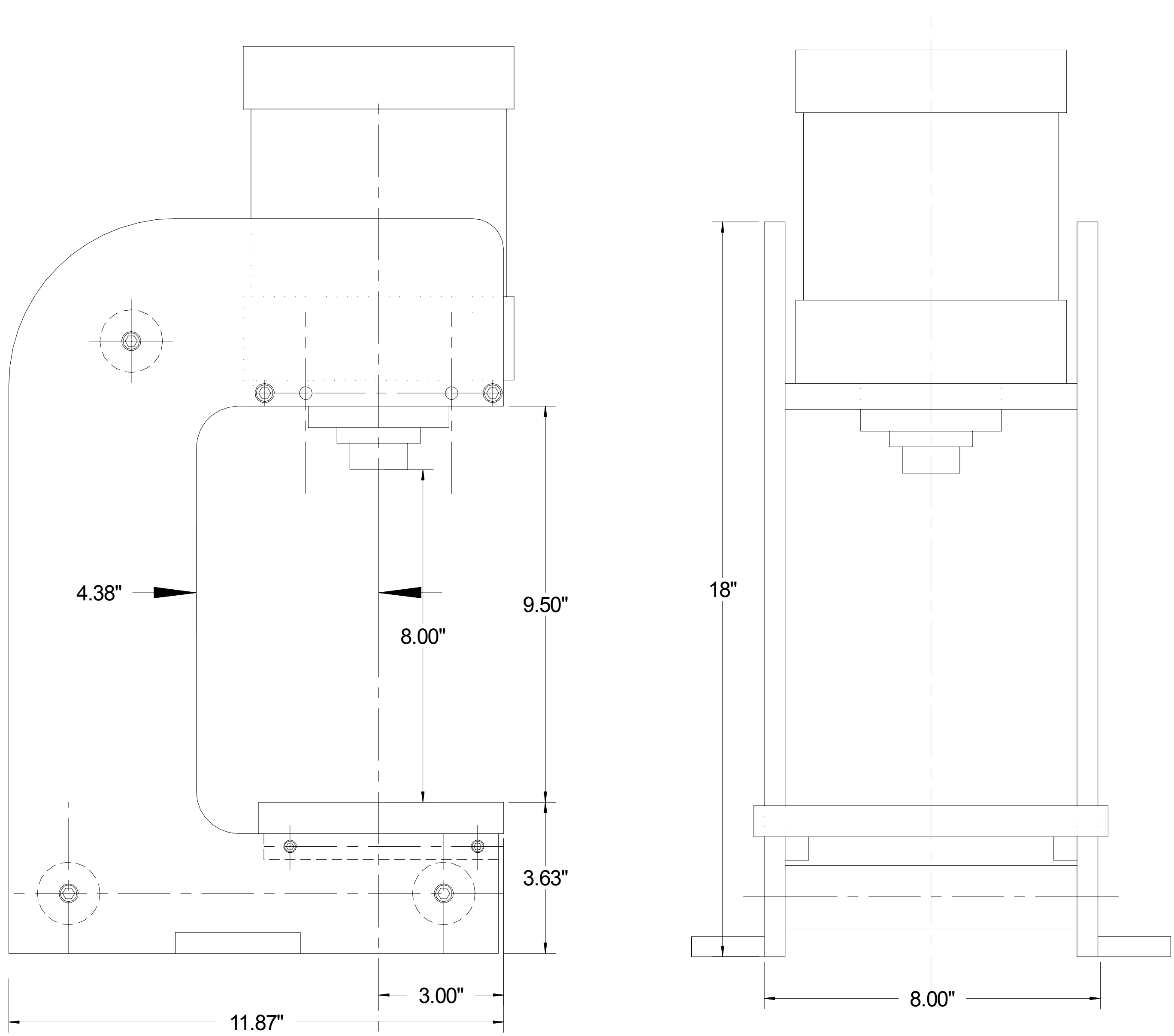
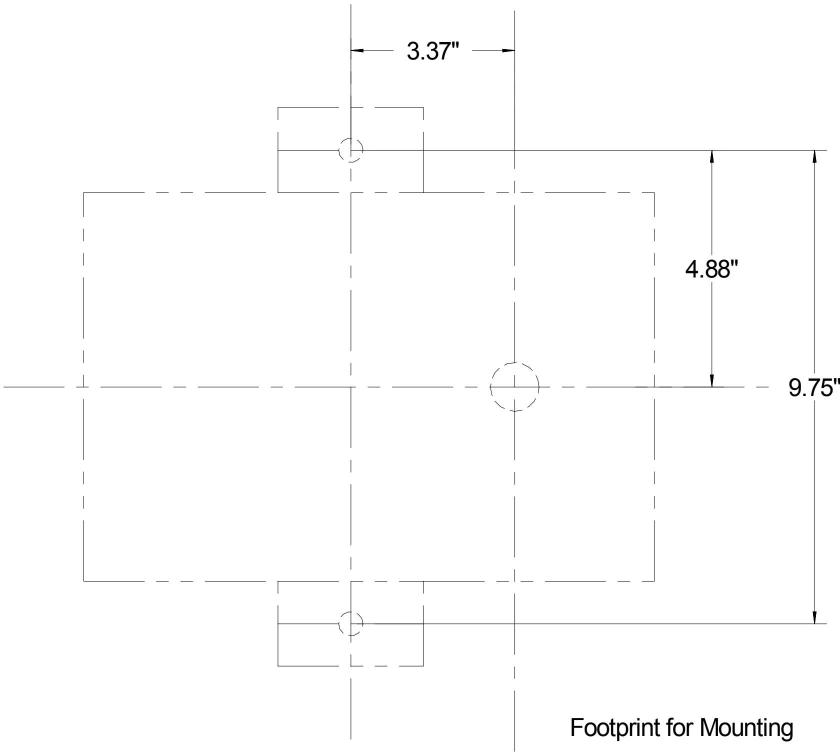




Footprint for Mounting

Direct-Aire

Straight Cylinder Press
Model 300 Series
Model 400 series

Section I: Installation

1. Carefully remove the press from the crate, taking note of separately packed items such as the "Quick Exhaust Unit"(Optional), FRL Unit (Optional) and "Synchro-Sig" Actuator(Optional).

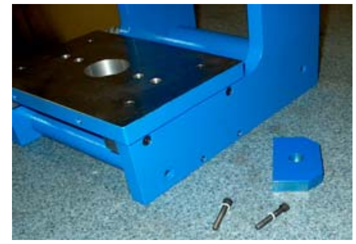


Photo 1.1

2. Attach Mounting Pads.
   (See photos 1.1, 1.2 and 1.3)

   A. Insert bolts from underside of press with lock washer.
   B. Screw bolts into mounting pad and tighten securely. Repeat with alternate side.

view from back
Photo 1.2

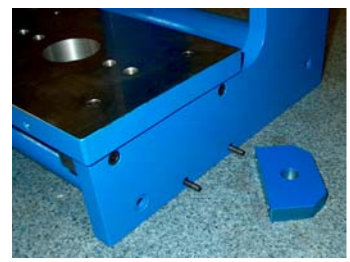


Photo 1.3

3. Attach "Synchro-Sig" Actuator.
   (See photos 1.4 and 1.5)

   A. Locate the 1/4" yellow tubing found under the press platen. Connect the tubing to the appropriate fittings on the actuator. See markings on the tubing. DO NOT OVERTIGHTEN.
   Normally, 1/2 turn past finger tight is sufficient for an airtight connection.
   B. Using the 1/4-20 hex head bolts supplied, mount the "Synchro-Sig" to the press as shown.

Photo 1.4

NOTE: **To insure operator safety some applications may require that you locate the "Synchro-Sig" actuator further away from your tooling.**

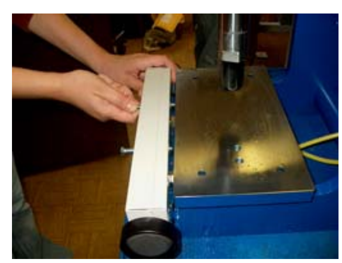


Photo 1.5

SOME SECTIONS OF THIS MANUAL MAY NOT APPLY TO YOUR PRESS UNIT. Pictures are for reference only.

4. Mount the press to your stand or workbench
   (See photo 1.6)
   - A. Select a bench of suitable size, strength and stability.
   - B. Bolt the press to the bench using the holes located in the press frame below the platen area. Never operate the press unless it is securely mounted on a bench or stand.

Photo 1.6

CAUTION: WHENEVER CONNECTING YOUR AIR SUPPLY TO THE PRESS BE CERTAIN TO FOLLOW SAFE OPERATING PROCEDURES AND KEEP ALL PARTS OF YOUR BODY AWAY FROM THE MOVING PARTS OF THE PRESS!

Photo 1.7

5. Connect air supply.
   (See Photos 1.7, 1.8, and 1.9)
   - A. The air supply must be clean and conditioned. Preferably, a Filter, Regulator, Lubricator Unit, (Joraco Part No. FRL-300) should be located within 6 feet of the press. For optimum results all air lines, fittings, and hoses used to supply the press should be the equivalent of **1/4" NPT minimum.**
   - B. The minimum air pressure for operation is 50 PSI. The maximum is 125 PSI. The **optimum operating range is 80 to 100 PSI.** If your application consistently requires substantially more than 100 PSI it may indicate the need for a stronger press.
   - C. Connect the air supply to the press at the inlet port on Part No. G-300, 3-way, On-Off Valve.

Photo 1.8

NOTE: A three way Shut Off Valve like the one supplied must always be used to insure complete bleeding of the press circuits when air supply is off.

Photo 1.9

6. Turn on air supply.
   (See photos 1.10, 1.11)
   A. Remove the yellow lock out device found on the On-Off Valve. To turn the air on simply move the gold colored sleeve downward until it stops. Slide the sleeve upward to the stop to shut the supply off. With the supply on, check for air leaks and be sure all connections you have made are secure and air tight. If air leaks from inside the "Synchro-Sig" actuator the connections are incorrect. Correctly reconnect the tubing, taking note of the tubing labels.

NOTE: When the press is not in use or being serviced or maintained, always SHUT OFF the air supply and replace the lockout device. Secure with a padlock, etc. to prevent unauthorized use of the press.

Photo 1.10

Photo 1.11

CAUTION: BEFORE PROCEEDING, CLEAR THE PRESS TABLE AND WORK AREA OF ALL TOOLS, FOREIGN OBJECTS, AND BODY PARTS.

7. Test the installation.
   (See photo 1.12)
   A. Test the "Synchro-Sig" Two Hand Actuator by simultaneously depressing the buttons on the SS-PB or the levers on the Model SS-DM or by simultaneously placing a finger in each sensing "button" on the Model SS-OT. The press should cycle once, return to the top of the stroke, and await another signal from the actuator. If the levers or "buttons" are continuously held down the press should remain in the down position until one or both levers or buttons are released.

Photo 1.12

B. Test the "Set-Up" Valve(OPTIONAL).

The press maybe equipped with a "Set-Up" valve which allows tool setters or maintenance personnel to lock the ram in the down position to facilitate tool depth adjustment. Check the function of this valve. To actuate this valve, back out the red locking screw from the valve guard. Move the valve lever to the down position. The press ram will immediately descend to the bottom of the stroke and stay in that position. Once the ram depth has been set, (see Section II, Paragraph 2) return the valve lever to the up position. The ram will immediately return to the top of the stroke.

NOTE: **After using the "Set-Up" valve, always lock the valve in the up position using the red locking screw.**

CAUTION: **THIS VALVE IS NOT DESIGNED FOR USE IN PRODUCTION AND SHOULD ONLY BE USED BY AUTHORIZED AND QUALIFIED PERSONNEL.**

(See photo 1.17)

C. Ram Speed Adjustment (OPTIONAL).

The ram speed on the down stroke can be adjusted to suit your application. Locate the adjustable flo-control muffler,(see page 10, letter "H"). Unlock the adjusting screw and screw it in to slow the ram down, back it out to increase ram speed. NOTE: When operating the press with slow ram speed, special guarding and control considerations apply. **See the rear cover of this manual for CSR controls, etc.** Lock the adj. screw when speed has been set.

Photo 1.13


Photo 1.14


Photo 1.15

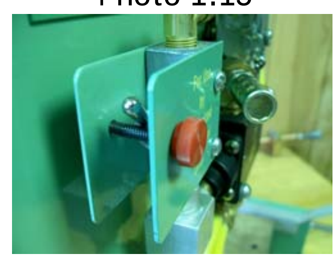


Photo 1.16

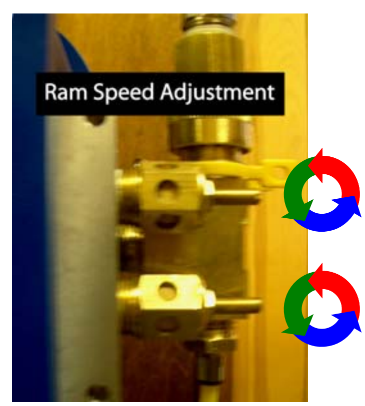


Photo 1.17

Section II: Set Up and Operation

Photo 2.1

Photo 2.2

(See photos 2.1, 2.2)

NOTE: **Prior to installing any tooling in the press, proper point of operation guarding, specifically designed for your tooling, must be built and mounted on or around your tooling.**

CAUTION: **NEVER OPERATE, SERVICE, OR ADJUST THIS MACHINE WITHOUT PROPER INSTRUCTION.**

NEVER SERVICE THIS MACHINE WITHOUT FIRST SHUTTING OFF AIR SUPPLY.

NEVER OPERATE THIS MACHINE WITH SAFETY GUARDS REMOVED.

1. Mount your tooling.
   (See photos 2.3, 2.4)
   A. Using the tapped holes in the press platen, mount the lower portion of your tooling to the press. The platen is machinable and can be drilled and tapped as necessary. The standard bore in the press ram is .8125" with a depth of 1.5". Precisely fit your shank to the bore of the ram and lock the shank in with the 5/16-18 hardened lock screw located on the face of the ram. The end of the ram should bear against the upper portion of your tooling. **If your tool incorporates guide pins, etc. be sure the tooling easily moves along the full length of travel with no binding or misalignment. Correct any problems found in the tool before placing tooling into production.**

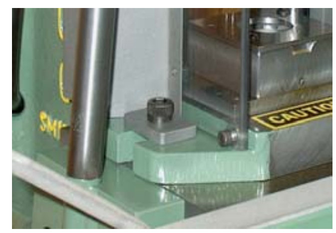


Photo 2.3

Photo 2.4

Section III: Maintenance

1. LUBRICATION.

A. Air Supply
(See Photo 3.1, 3.2)
1. Follow the instructions provided by the manufacturer of the Filter, Regulator, Lubricator Unit you are using. (See Section I, Paragraph 5A). Fill the reservoir with Joraco Air Tool Oil, Pt. No. JO-FRL. Adjust the drip rate to approx. one drop per 50 strokes of the press. **Only use oil specifically formulated for use in pneumatic equipment.**

Photo 3.1

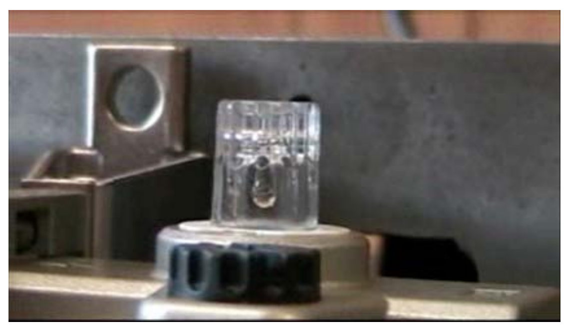


Photo 3.2

Factory Support . . .

Our 40 year reputation for providing quality *TOGGLE-AIRE & Direct-AIRE* presses that meet a wide range of special requirements and our 60 years of service and support experience are all available to you with one phone call. It's your biggest advantage in dealing directly with our factory. Make use of it. Please call with any and all questions you may have regarding your applications and our equipment.

Please contact our engineering department to discuss any questions you may have about control systems, modifications, and your applications. We are glad to supply our presses built to your specifications should you require other than our standard systems.

AIM JORACO™

Home of TOGGLE-AIRE Products™

DIRECT-AIRE™

WARRANTY

A I M (hereafter referred to as the manufacturer) warrants that all TOGGLE-AIRE & Direct-Aire products will be free from defects in material and workmanship for a period of 180 days from the date of shipment to the original purchaser. Any claim made against this LIMINTED WARRANTY must be made by contacting the customer service department of the manufacturer. At its option, A I M will repair or replace any product it deems defective under the terms of this warranty. If factory service is required, transportation costs to and from the factory are to be paid by the purchaser. This warranty does not apply to equipment that has been subject to abuse, misapplication, negligence, improper maintenance, alteration, or failure to follow manufacturer's instructions.

A I M's, SOLE OBLIGATION UNDER THIS WARRANTY IS STATED ABOVE. THIS WARRANTY IS IN LIEU OF ALL OTHERS, EXPRESSED OR IMPLIED, AND UNDER NO CIRCUMSTANCES WILL A I M BE LIABLE FOR ANY CONSEQUENTIAL DAMAGES RESULTING FROM THE USE OF TOGGLE-AIRE PRODUCTS.

THINK SAFETY . . . WORK SAFELY . . .

DIRECT-AIRE Series Press Force Chart

Model 300 Force Chart

PSI	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
LBS Force	65	97.5	130	162.5	195	227.5	260	292.5	325	357.5	390	422.5	455	487.5	520	552.5	585	617.5	650

Model 400 Force Chart

PSI	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
LBS Force	120	180	240	300	360	35	480	540	600	660	720	780	840	900	960	1020	1080	1140	1200

Model 400T Force Chart

PSI	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
LBS Force	230	345	460	575	690	805	920	1035	1150	1265	1380	1495	1610	1725	1840	1955	2070	2185	2300

Model 800 Force Chart

PSI	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
LBS Force	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000

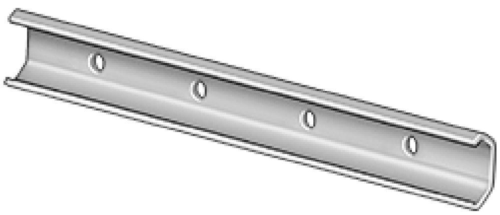
(Yellow-shaded cells, 10–50 PSI:) **EZ-Dial Force Regulator Option Necessary**

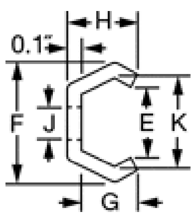
McMASTER-CARR. OVER 555,000 PRODUCTS

(562) 692-5911
(562) 695-2323 (fax)
la.sales@mcmaster.com
Text 75930

Rail for 89 lb. Dynamic Load Capacity, Stainless Steel Side-Mount Track Roller

In stock
$34.16 Each
60135K52





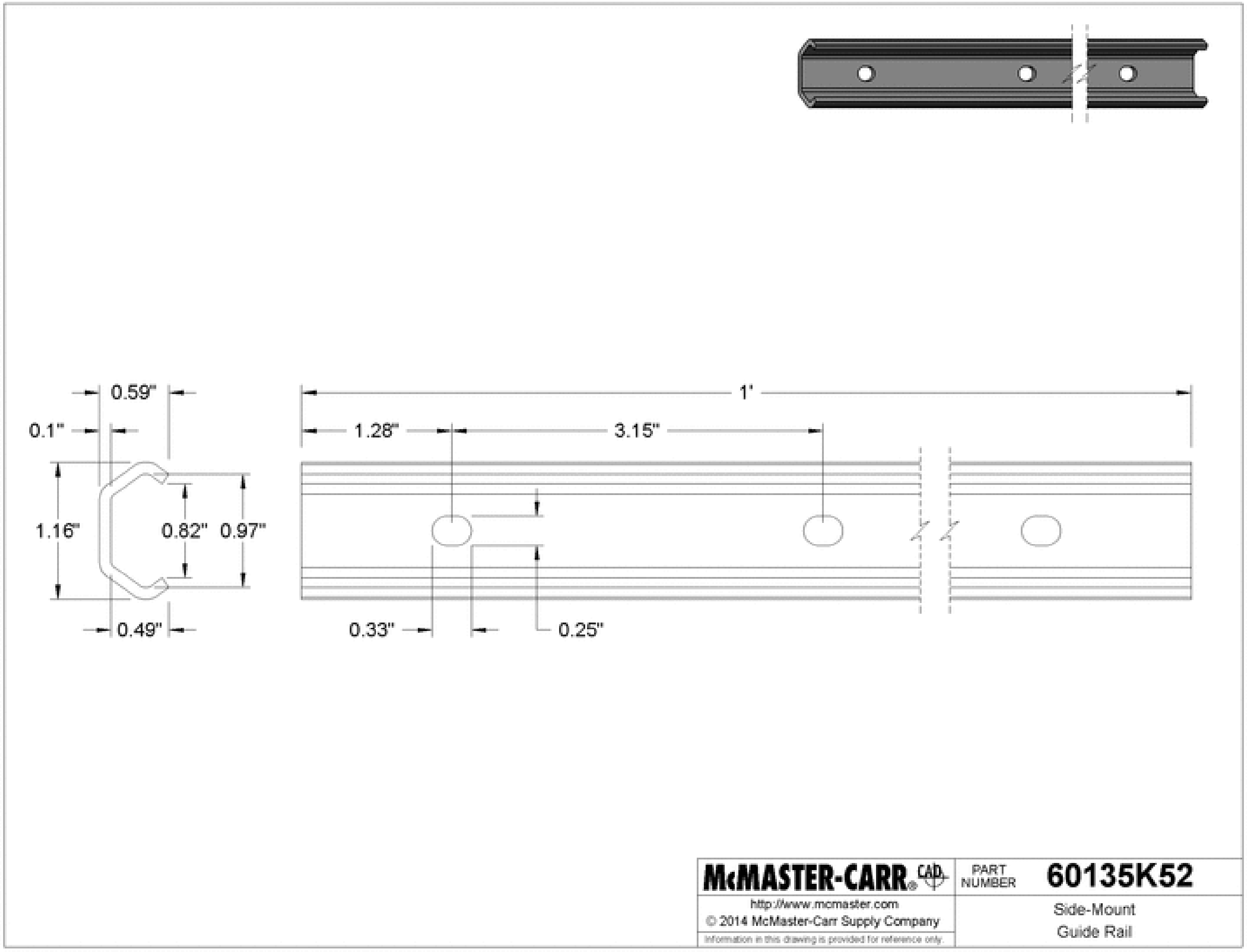
(E)	0.82"
(F)	1.16"
(G)	0.49"
(H)	0.59"
Mounting Holes Diameter (J)	0.25"
(K)	0.97"
Length	1 ft.
Additional Specifications	Stainless Steel Roller—Rail is Stainless Steel
RoHS	Not Compliant

Just like on your garage door, these stud-mount rollers ride on a rail. They can be loaded for a snug or loose fit in the rail.

Stainless Steel Roller and Rail—Offering excellent corrosion resistance, the roller is Type 440 stainless steel with double-sealed Type 440 stainless steel ball bearings. Roller has an M5 threaded stud. The rail is Type 316 stainless steel and can be cut to size. Maximum temperature is 212° F.

Note: Track rollers can only be used with guide rails listed on the same line in the table.

Length, Feet : 1



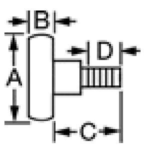
The information in this 3-D model is provided for reference only.

McMASTER-CARR. OVER 555,000 PRODUCTS
(562) 692-5911
(562) 695-2323 (fax)
la.sales@mcmaster.com
Text 75930

Side-Mount Track Roller

Stainless Steel, 89 lb. Dynamic Load Capacity

In stock
$36.65 Each
60135K51

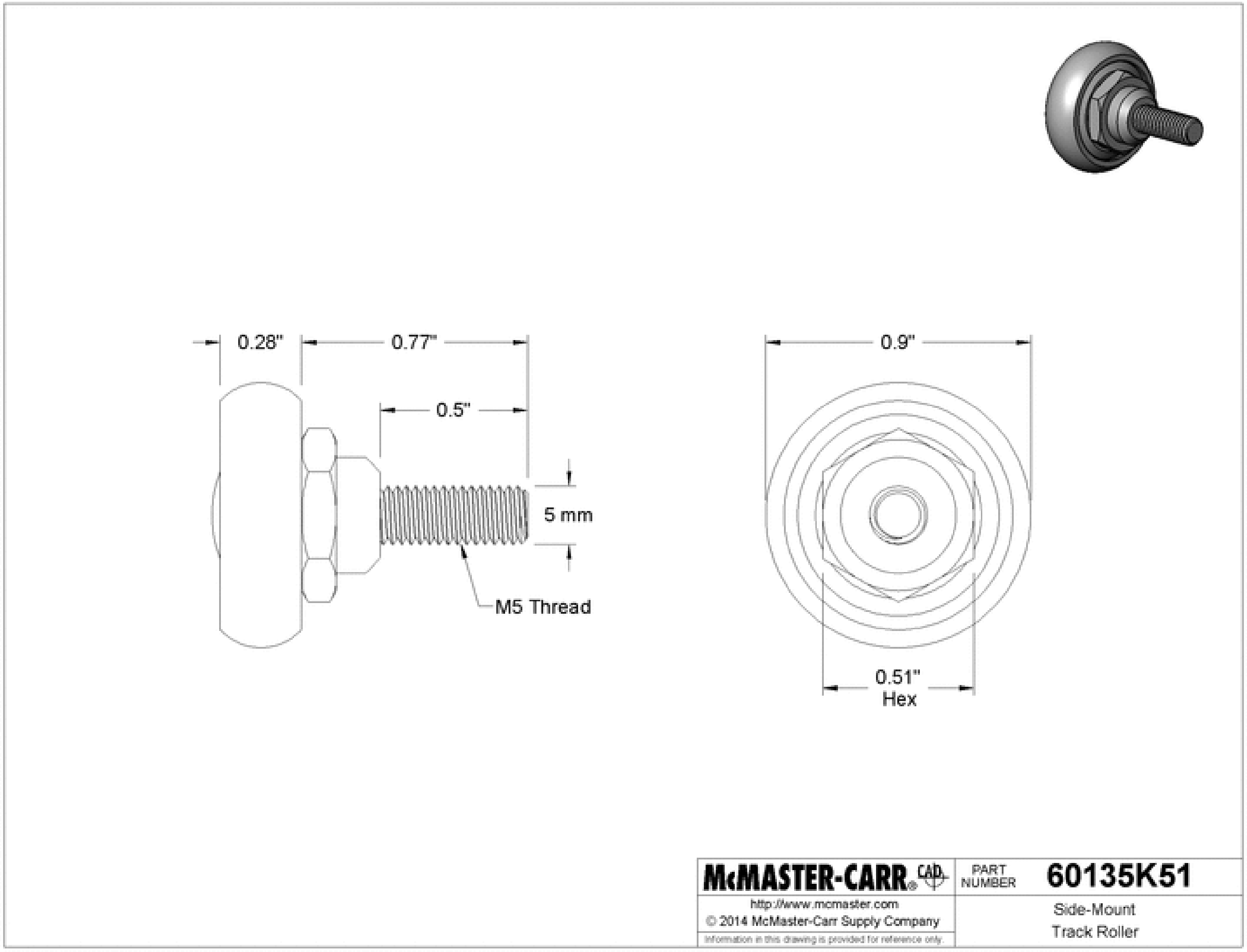


Dyn. Load Capacity	89 lbs.
(A)	0.9"
(B)	0.28"
(C)	0.77"
(D)	0.5"
Additional Specifications	Stainless Steel Roller—Rail is Stainless Steel
RoHS	Not Compliant
Related Product	Guide Rails

Just like on your garage door, these stud-mount rollers ride on a rail. They can be loaded for a snug or loose fit in the rail.

Stainless Steel Roller and Rail—Offering excellent corrosion resistance, the roller is Type 440 stainless steel with double-sealed Type 440 stainless steel ball bearings. Roller has an M5 threaded stud. The rail is Type 316 stainless steel and can be cut to size. Maximum temperature is 212° F.

Note: Track rollers can only be used with guide rails listed on the same line in the table.



The information in this 3-D model is provided for reference only.

McMASTER-CARR® OVER 555,000 PRODUCTS
(562) 692-5911
(562) 695-2323 (fax)
la.sales@mcmaster.com
Text 75930

Air Directional Control Valve
with 5 Ports, Single Solenoid, 1/8 NPT

In stock
$81.89 Each
6124K512

Style	E
Port Size	1/8 NPT
Maximum scfm @ 100 psi	43.1
Flow Coefficient	0.75
Operating Pressure Range	29-145 psi
Length	5 1/8"
Width	7/8"
Height	1 3/8"
Mounting Hole Diameter	0.18"
Voltage	24 DC
Additional Specifications	4-Way Valves for Double-Acting Cylinders—Single Solenoid 5 Ports, 2 Positions National Fluid Power Association (NFPA) Diagrams

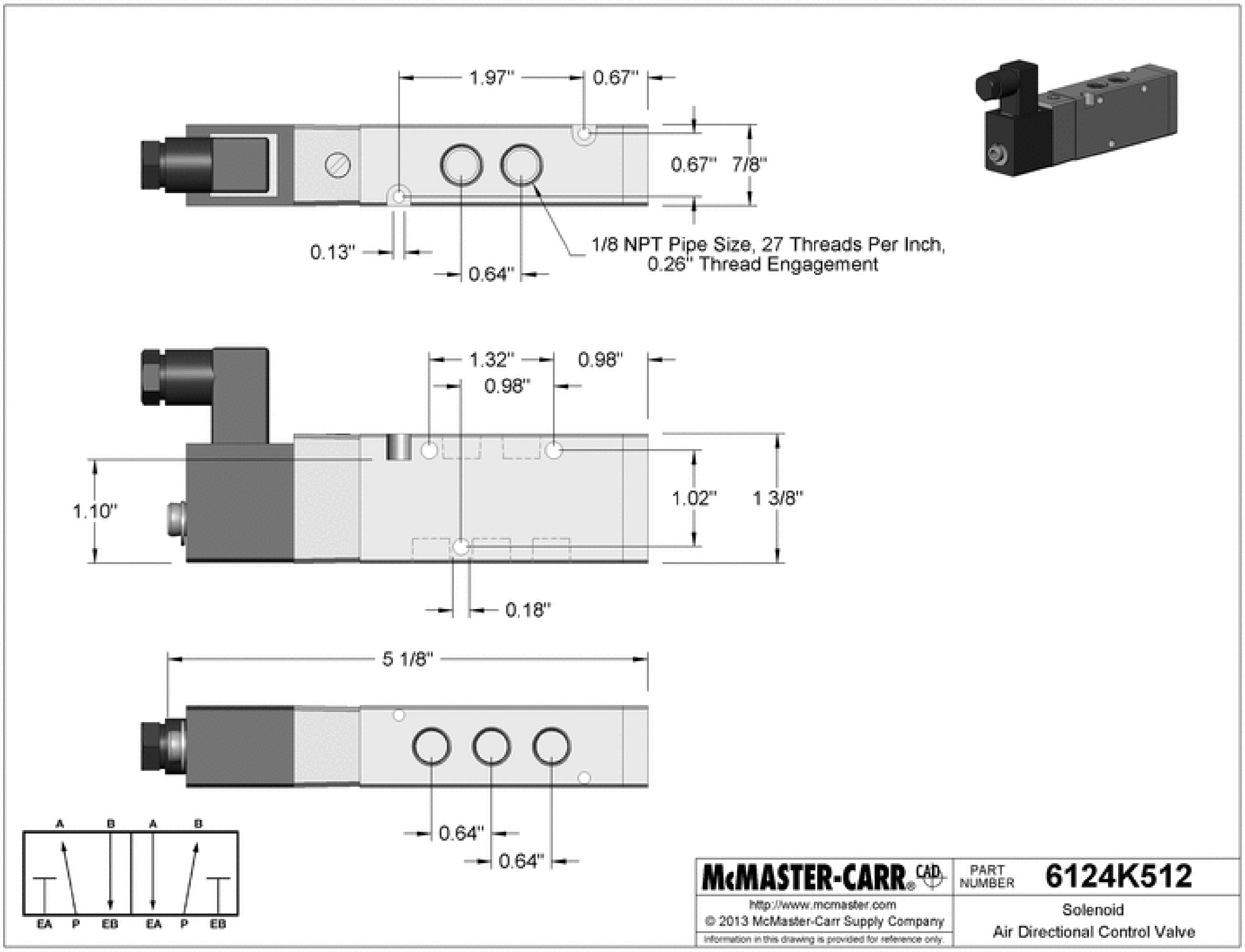
Add compressed air to the input and apply voltage to the electrical connection to operate these solenoid valves, which can be operated remotely as well as in automated processes. Connections are female.

Single-solenoid valves move into position when electrical current is supplied; a spring returns the valves to their original position once current is removed.

Style E-H—Made of aluminum, except 10-32 UNF valves are zinc. All have an 8 mm female DIN connector. Not vacuum rated.

1/8 and 1/4 NPT valves have a power draw of 2 watts for DC valves; 1.3 volt-amps for AC valves.

Voltage: 24 DC



The information in this 3-D model is provided for reference only.

MCMASTER-CARR. OVER 555,000 PRODUCTS
(562) 692-5911
(562) 695-2323 (fax)
la.sales@mcmaster.com
Text 75930

Air Regulator with Built-in Pressure Gauge

1/8 Pipe Size, 28 Maximum scfm @ 100 PSI

In stock
$34.37 Each
5447T2

Pipe Size	1/8 NPT
Maximum scfm @ 100 psi	28
Maximum psi	145
Maximum Temperature	140° F
Overall Size	
Height	4 1/2"
Width	2 5/8"
Regulating Range	7-125 psi
Additional Specifications	Regulators (D) With Built-In Pressure Gauge
Related Product	Mounting Brackets

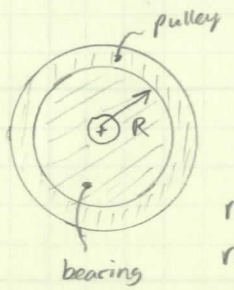
Adjust air pressure to the level you need. Regulators are relieving style, which exhaust excess downstream pressure when your system is blocked (except Style D are nonrelieving style). Inlet and outlet connections are female.

(C&D) With Built-In Pressure Gauge—Body is aluminum, except pipe size 1/8 NPT is zinc. Style D have a pressure gauge in the adjusting knob, which keeps the gauge in view when mounted in a panel or horizontally. Accuracy is ±2.5%.

Regulating Range, psi: 7-125

The information in this 3-D model is provided for reference only.

I. GIVEN:



	PULLEY	BEARING
	6061 Al	Stainless Steel
	E= 68.9 GPa	200 GPa
	ν = 0.33	ν = 0.29

$r_o = 0.0135\,m$

$r_i = 0.00599\,m$

II ASSUME: R, deformed nominal radius = $\frac{11.98}{2}$ mm

$\mu_s = 0.61$ $\mu_k = 0.47$

III FIND: force required to press bearing into pulley housing

IV ANALYSIS:

$$p = \frac{\delta}{R\left[\frac{1}{E_o}\left(\frac{r_o^2 - R^2}{r_o^2 - R^2} + \nu_o\right) + \frac{1}{E_i}\left(\frac{R^2 + r_i^2}{R^2\ r_i^2} - \nu_i\right)\right]}$$ (EQN 3-56 in Shigley's)

δ, radial interference = (0.00005 m / 2)

$p = 1.34 \times 10^8\ N/m^2$

$F_N = pA = p(2\pi)\left(\frac{0.01198}{2}\,m\right)(0.004\,m)$ (normal force)

$F_N = 20{,}173\ N$

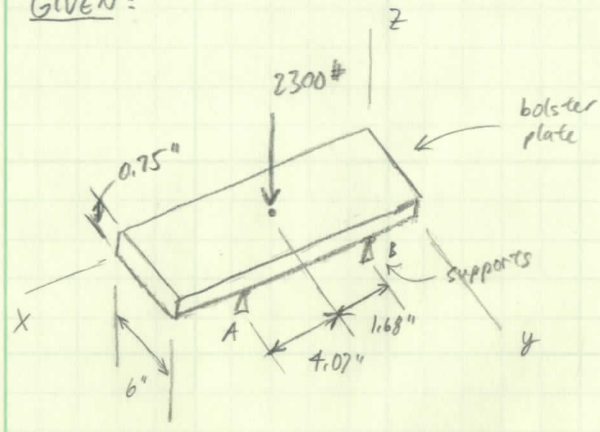
$F_{press} = \mu_s F_N = (0.61)(20{,}173\,N)$

$F_{press} = 12{,}300\ N$

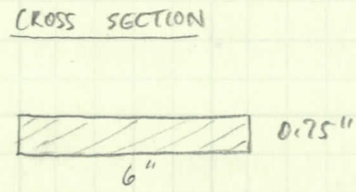
F_{press} = 2800 lb_f (1.4 tons) maximum force required

* NOTE: Micro-Vu uses 1 ton press

GIVEN:

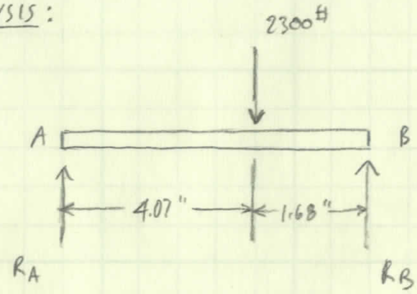


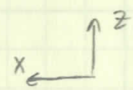
CROSS SECTION



$I_y = 0.211 \text{ in}^4$

ANALYSIS:



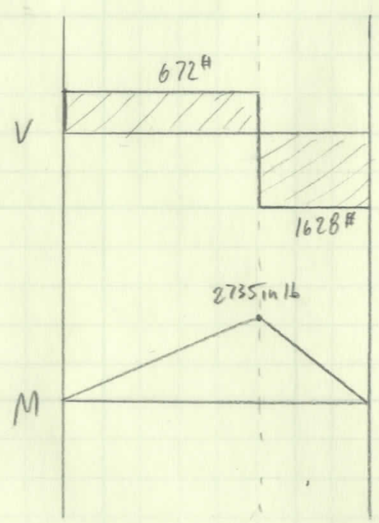


$R_A + R_B = 2300$

$4.07(2300) = 5.75\ R_B$

$R_B = 1628 \text{ lb}$, $R_A = 672 \text{ lb}$

Shear Moment Diagram



$$\sigma = \frac{My}{I}$$

$$= \frac{(2735 \text{ in lb})(0.75 \text{ in})\ \tfrac{1}{2}}{0.211 \text{ in}^4}$$

$$\boxed{\sigma = 4860 \text{ psi} = 4.86 \text{ ksi}}$$

COMMENTS:

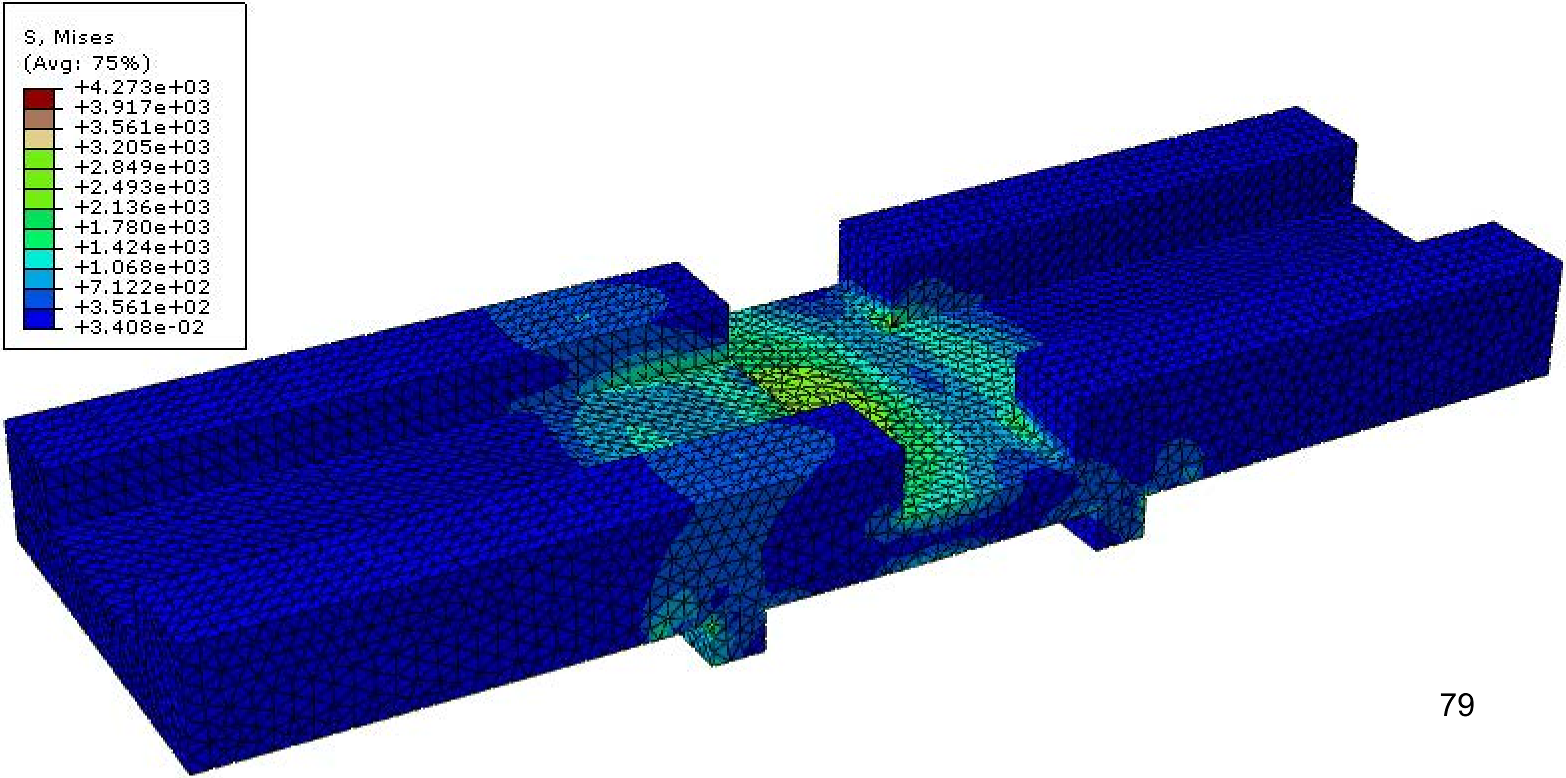
Actual load is more distributed, it is not a point load.

$\sigma_{y,steel} = 36 \text{ ksi}$ $\sigma_{max} = 4.86 \text{ ksi}$

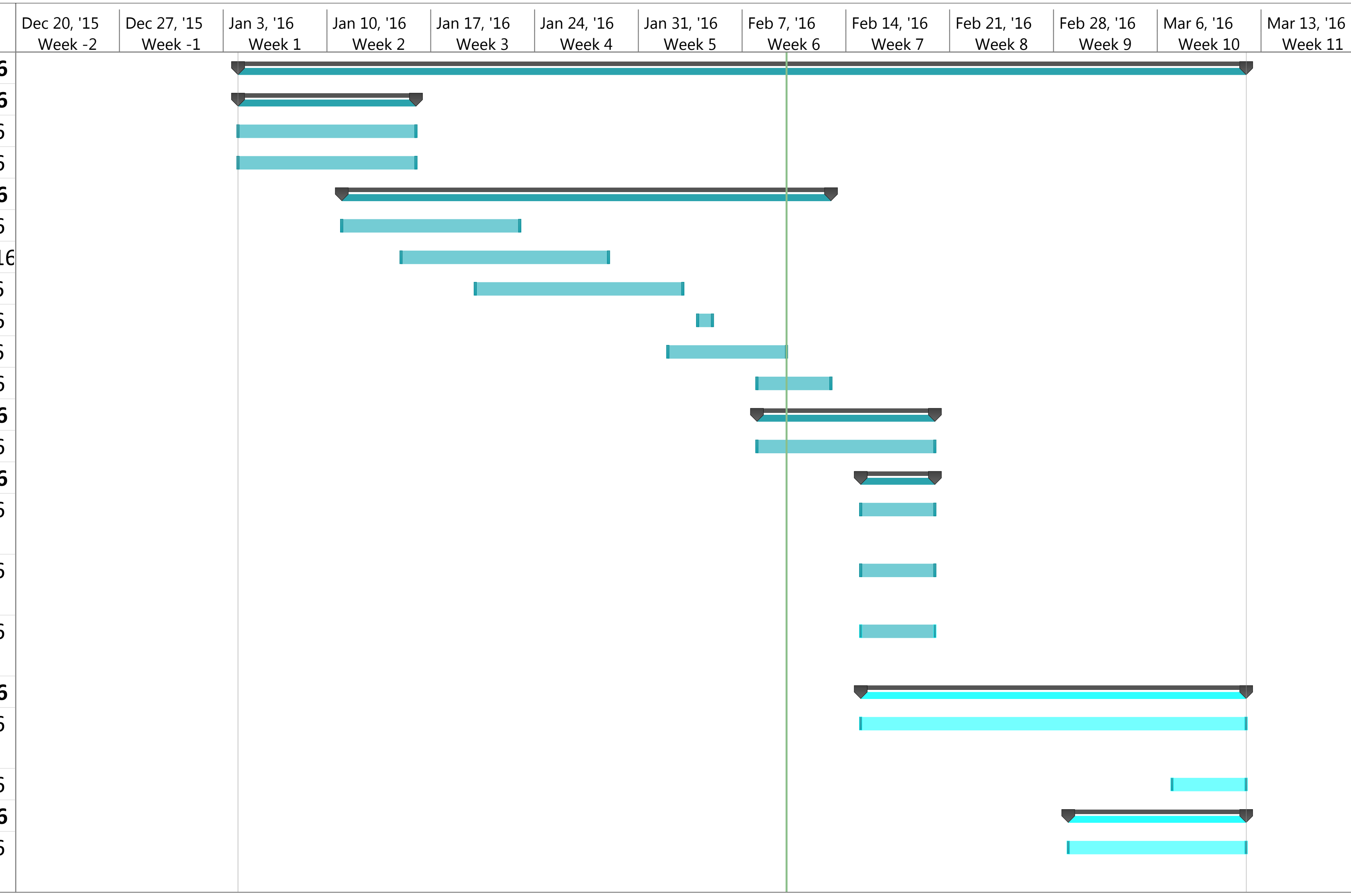
$n_y = 7.4$

Actual force will not be 2300 lb. 2300 lb is the maximum the press can achieve.

Bolster Plate Stress Analysis



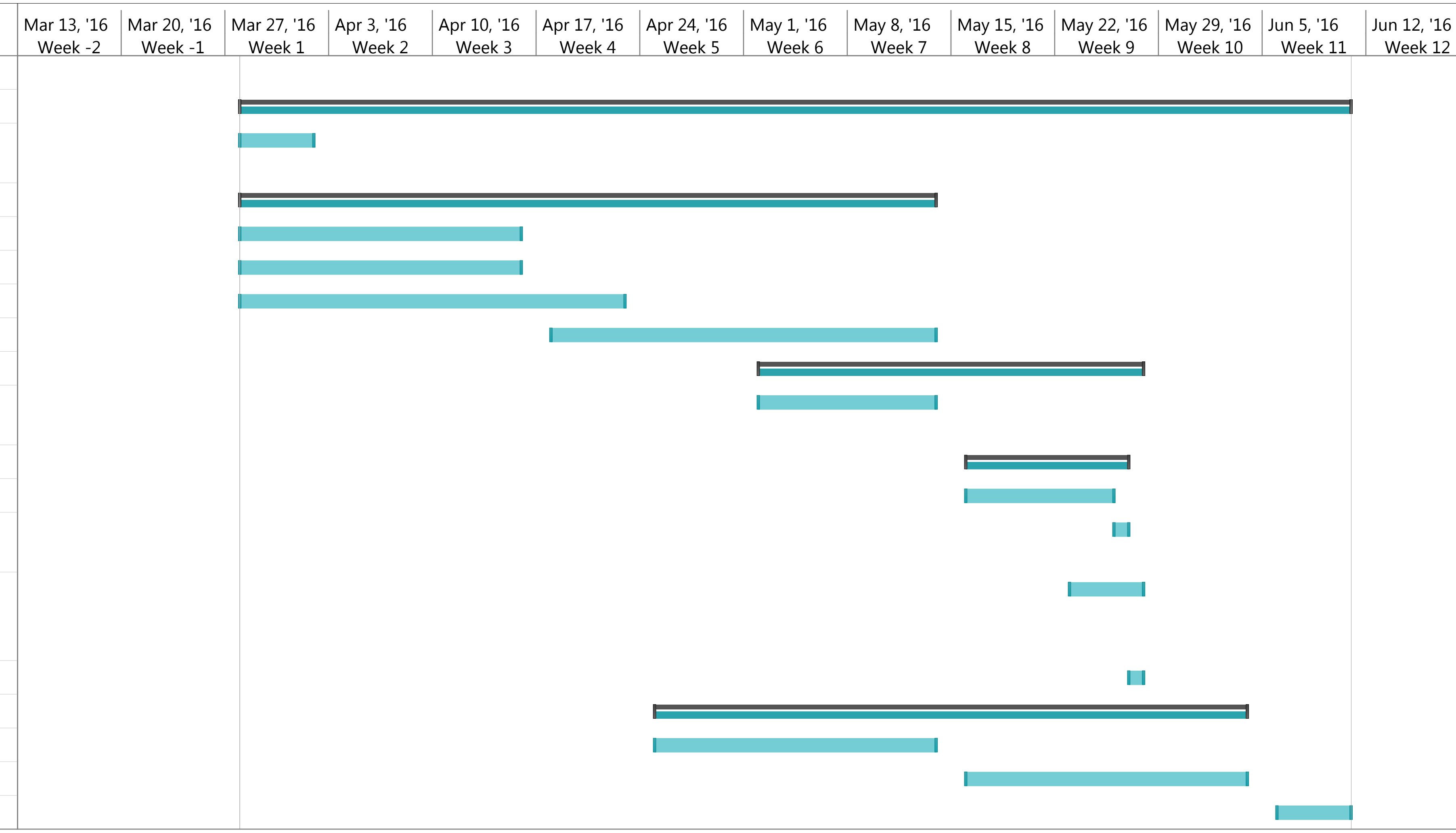
ID	Task Mode	WBS	Task Name	Duration	Start	Finish
1		**1**	**Winter Quarter**	**50 days**	**Mon 1/4/16**	**Fri 3/11/16**
2		**1.1**	**Design Analysis**	**10 days**	**Mon 1/4/16**	**Fri 1/15/16**
3		1.1.1	Safety analysis	10 days	Mon 1/4/16	Fri 1/15/16
4		1.1.2	Failure analysis	10 days	Mon 1/4/16	Fri 1/15/16
5		**1.2**	**Critical Design Review**	**25 days**	**Mon 1/11/1**	**Fri 2/12/16**
6		1.2.1	Create cost analysis	10 days	Mon 1/11/1	Fri 1/22/16
7		1.2.2	Create manufacturing plan	10 days	Fri 1/15/16	Thu 1/28/16
8		1.2.3	Create test plan	10 days	Wed 1/20/1	Tue 2/2/16
9		1.2.4	In-class presentation	1 day	Thu 2/4/16	Thu 2/4/16
10		1.2.5	Submit final design report	6 days	Tue 2/2/16	Tue 2/9/16
11		1.2.6	Present to sponsor	5 days	Mon 2/8/16	Fri 2/12/16
12		**1.3**	**Order Parts**	**10 days**	**Mon 2/8/16**	**Fri 2/19/16**
13		1.3.1	Obtain advisor approval	10 days	Mon 2/8/16	Fri 2/19/16
14		**1.4**	**Experimental Design**	**5 days**	**Mon 2/15/1**	**Fri 2/19/16**
15		1.4.1	Determine points of interest	5 days	Mon 2/15/16	Fri 2/19/16
16		1.4.2	Determine desired test results	5 days	Mon 2/15/16	Fri 2/19/16
17		1.4.3	Determine methods of testing	5 days	Mon 2/15/16	Fri 2/19/16
18		**1.5**	**Manufacturing**	**20 days**	**Mon 2/15/1**	**Fri 3/11/16**
19		1.5.1	Fabricate parts for prototyping	20 days	Mon 2/15/16	Fri 3/11/16
20		1.5.2	Prototype construction	5 days	Mon 3/7/16	Fri 3/11/16
21		**1.6**	**End of Quarter Report**	**10 days**	**Mon 2/29/1**	**Fri 3/11/16**
22		1.6.1	Manufacturing/testing plan presentation	10 days	Mon 2/29/16	Fri 3/11/16



Project: cdr gantt
Date: Wed 2/10/16

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

ID		Task Mode	WBS	Task Name	Duration	Start	Finish
1							
2			**2**	**Spring Quarter**	**55 days**	**Mon 3/28/16**	**Fri 6/10/16**
3			2.1	Write project update memo	1 wk	Mon 3/28/16	Fri 4/1/16
4			**2.2**	**Work on Prototype**	**35 days**	**Mon 3/28/16**	**Fri 5/13/16**
5			2.2.1	Order Parts	3 wks	Mon 3/28/16	Fri 4/15/16
6			2.2.2	Manufacturing	3 wks	Mon 3/28/16	Fri 4/15/16
7			2.2.3	Build Prototype	4 wks	Mon 3/28/16	Fri 4/22/16
8			2.2.4	Test Prototype	4 wks	Mon 4/18/16	Fri 5/13/16
9			**2.3**	**Prepare for expo**	**20 days**	**Mon 5/2/16**	**Fri 5/27/16**
10			2.3.1	Finish testing and review specifications	2 wks	Mon 5/2/16	Fri 5/13/16
11			**2.3.2**	**Expo Poster**	**9 days**	**Mon 5/16/16**	**Thu 5/26/16**
12			2.3.2.1	Design Poster	8 days	Mon 5/16/16	Wed 5/25/16
13			2.3.2.2	Print poster in 13-107	1 day	Thu 5/26/16	Thu 5/26/16
14			2.3.3	Review each team members role in expo	1 wk	Mon 5/23/16	Fri 5/27/16
15			2.3.4	Expo	1 day	Fri 5/27/16	Fri 5/27/16
16			**2.4**	**Write Final Report**	**30 days**	**Mon 4/25/16**	**Fri 6/3/16**
17			2.4.1	Draft Final report	3 wks	Mon 4/25/16	Fri 5/13/16
18			2.4.2	Finish Final report	3 wks	Mon 5/16/16	Fri 6/3/16
19			2.5	Clean up	1 wk	Mon 6/6/16	Fri 6/10/16



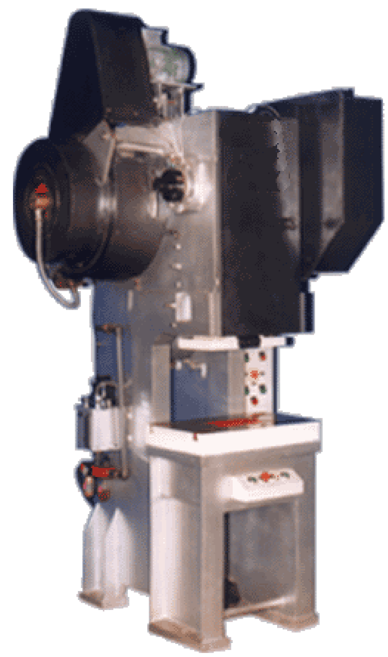
Project: springquarter
Date: Wed 2/10/16

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

Pneumatic Presses

A pneumatic press derives its primary mechanical action (such as shearing, punching, bending, forming, drawing, extruding, assembly, or other action) from a pressure source by means of compressed air. Such presses are used in mechanized binderies for a variety of purposes, and, although they cannot supply the extreme pressures available with the hydraulic press, they do offer the advantages of speed of operation and cleanliness.

A fully pneumatic power press differs from a mechanical or hydraulic press, which may use pneumatic systems to only activate a brake/clutch, slide counterbalance or other systems but that uses mechanical means or hydraulic fluid to power the ram.



Pneumatic press

Operator Involvement

The operator is responsible for feeding or placing the stock on the bottom die, seeing that it is properly positioned, activating the press cycle with a pressure control switch, and removing the completed part.

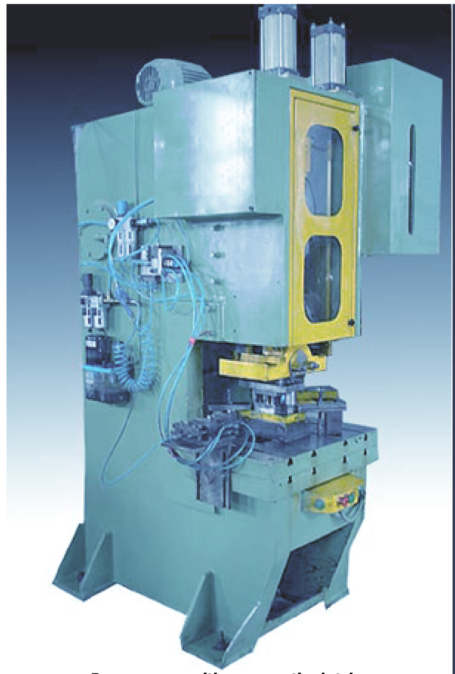
Point of Operation

Potential Hazards:

- As with other presses, the main hazard areas are located in or around the point of operation.
- Material can be sharp, slippery, or difficult to grasp.

Solutions:

- General machine guards (barrier guards, two-hand tripping devices, electronic safety devices, etc.) must be provided to protect the operator and other employees in the machine area from hazards created by point of operation, nip points etc. [29 CFR 1910.212(a)(1)]
- Guards must not create hazards themselves, and must be attached to the machine where possible. [29 CFR 1910.212(a)(2), (a)(3)(i)]
- Use special hand tools to keep hands away from point of operation. [29 CFR 1910.212(a)(3)(iii)]


Power press with pneumatic clutch

SENIOR PROJECT CRITICAL DESIGN HAZARD IDENTIFICATION CHECKLIST

Team: PRECISION PRESSING Advisor: DR. J MELLO

Y	N	
☒	☐	Do any parts of the design create hazardous revolving, reciprocating, running, shearing, punching, pressing, squeezing, drawing, cutting, rolling, mixing or similar action, including pinch points and sheer points adequately guarded?
☐	☒	Does any part of the design undergo high accelerations/decelerations that are exposed to the user?
☒	☐	Does the system have any large moving masses or large forces that can contact the user?
☐	☒	Does the system produce a projectile?
☒	☐	Can the system to fall under gravity creating injury?
☐	☒	Is the user exposed to overhanging weights as part of the design?
☐	☒	Does the system have any sharp edges exposed?
☐	☒	Are there any ungrounded electrical systems in the design?
☐	☒	Are there any large capacity batteries or is there electrical voltage in the system above 40 V either AC or DC?
☒	☐	Is there be any stored energy in the system such as batteries, flywheels, hanging weights or pressurized fluids when the system is either on or off?
☐	☒	Are there any explosive or flammable liquids, gases, dust, or fuel in the system?
☐	☒	Is the user of the design required to exert any abnormal effort and/or assume a an abnormal physical posture during the use of the design?
☐	☒	Are there any materials known to be hazardous to humans involved in either the design or the manufacturing of the design?
☒	☐	Will the system generate high levels of noise?
☐	☒	Will the product be subjected to extreme environmental conditions such as fog, humidity, cold, high temperatures ,etc. that could create an unsafe condition?
☐	☒	Is it easy to use the system unsafely?
☐	☒	Are there any other potential hazards not listed above? If yes, please explain on the back of this checklist.

For any "Y" responses, add a complete description on the reverse side. DO NOT fill in the corrective actions or dates until you meet with the mechanical and electrical technicians.

Description of Hazard	Corrective Actions to Be Taken	Planned Completion Date	Actual Completion Date
PNEUMATIC PRESS IS CAPABLE OF PRESSING WITH 2300 POUNDS OF FORCE			
MACHINE COULD TIP IF PUSHED. MACHINE IS NOT SECURED TO A BASE.			
PRESSURIZED SHOP AIR (~100 PSI) IS CONNECTED TO THE MACHINE			
NOISE CAN/WILL RESULT FROM EXPANSION OF COMPRESSED AIR			

Appendix H. References

[1] "Mid South Automation - Bearing Press and Inspection System." *YouTube*. YouTube, n.d. Web. 9 Oct. 2015.

[1] "P58 Adkjaf9." *YouTube*. YouTube. Web. 2 Dec. 2015.