Scarf Cutting Machine

Final Report

4/25/2016

Indiana University-Purdue University Fort Wayne

College of Engineering, Technology, and Computer Science

Senior Design & Analysis - MET 494

Team 2

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Project Background

At Trelleborg Sealing Solutions, this project's sponsor, they manufacture hydraulic and pneumatic seals for the Oil & Gas, Automotive, Industrial, and Aerospace markets. These seals are machined from a cylindrical tube on a lathe, typically made from PTFE composite or other engineered plastics.

Trelleborg Sealing Solutions Fort Wayne (TSSFW) requires most of these machined components to have a secondary operation before they can be packaged to ship. Within this manufacturing site, the building is divided into small "cells". Each cell supervisor will schedule the jobs within their cell that uses equipment dedicated to their own cell.

The goal of this project is to build a machine that will decrease material travel distance, decrease labor cost, and minimize scheduling issues. This project will allow the CNC machine operator to produce a finished product before it leaves their machining cell (Cell 1) and enters the shipping cell.

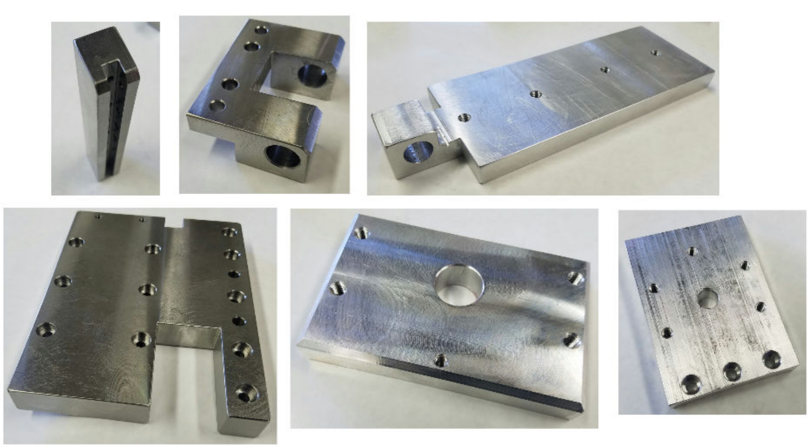
The scarf cutting machine will operate with an actuator that has an attached cutting tool. The machine will use an existing cutting tool that TSSFW already stocks in-house. The operator will use a low-force hand operated push button that will actuate the cylinder to cut a part. The cutting tool will pierce the seal creating an angled cut. This angled cut is known as a "scarf cut".

This project will yield a second-operation machine that is only to be used in Cell 1. Cell 2 currently has a similar second-operation machine, but scheduling conflicts arise when Cell 1 uses Cell 2's machine. This project will include designing and building a second-operation scarf cutting machine that will allow the operator to scarf cut seals and back-up-rings while they are simultaneously running a CNC lathe.

Introduction

Since the last report, we have received all of the components purchased from McMaster Carr, MSC Direct, Neff Engineering, and ToolCraft. All of the components were standard purchased components except for the designed components that we had ToolCraft manufacture.

We have completely assembled the machine. We are testing each component and feature to make sure everything is working properly before we run a capability test with our quality engineering group.



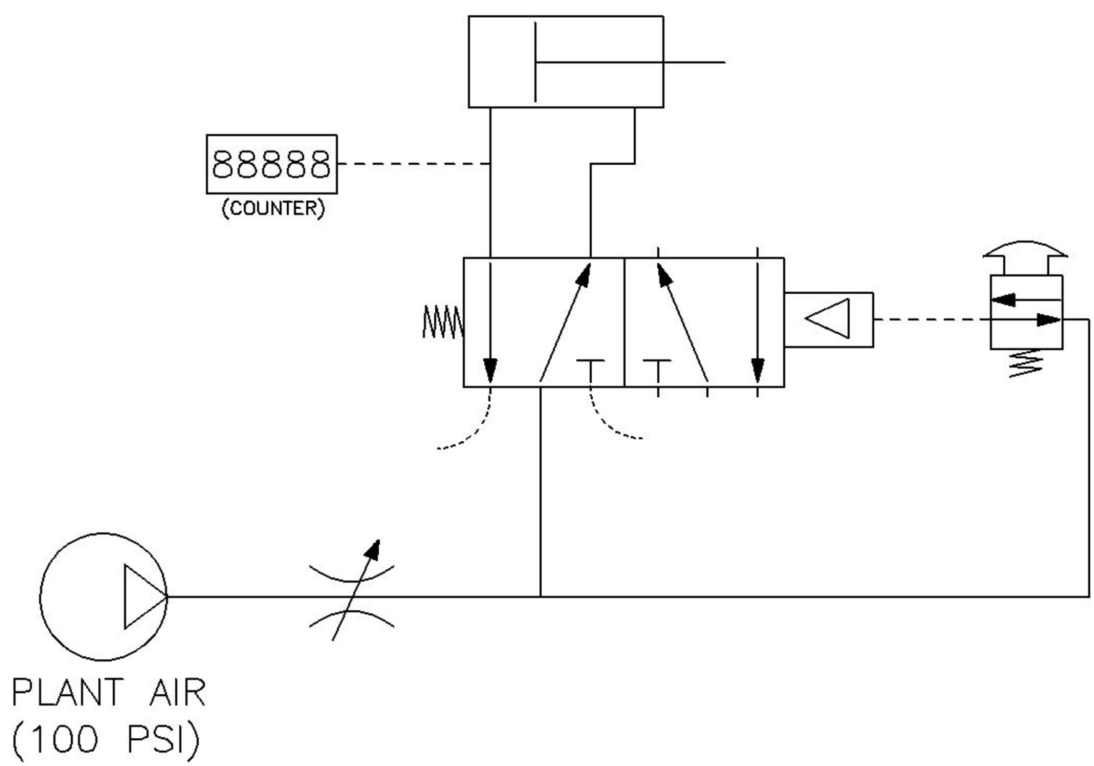
[Figure 1: Some of the machined components. All of these components were inspected by our group at ToolCraft to make sure all of the parts met the print specifications]

Design Information

After direction from the operators to set up the machine, our group tested a few different sized components to check the function of the machine itself. We are very happy with how the machine is working. See figure 7 for the new machine we have designed and assembled.

During the process of designing the machine, the few adjustments that were needed to be made to the design were:

- The operators requested the button to be placed in a different location. We designed the table top to have 2 different mounting locations (one on the side and one on the top). The operators like the button on the side, but they want it back a little further so they can rest their hand on the table top. This will decrease the operators fatigue at their wrist joint.
- We also created a new design for the safety guard. We have designed the table top to have a few extra mounting holes to give our safety guard design a little flexibility.
- Pneumatic mufflers needed to be added to decrease the noise from the valve's exhaust ports. After installing the mufflers, a sound meter was used to set the machines noise levels to verify it is not too loud; it must be under 90dBA. The goal of being under 90dBA was achieved as expected.
- We would like to add another valve or switch that would allow the cylinder to extend and stay extended. This will help the operator set up a new job safely.



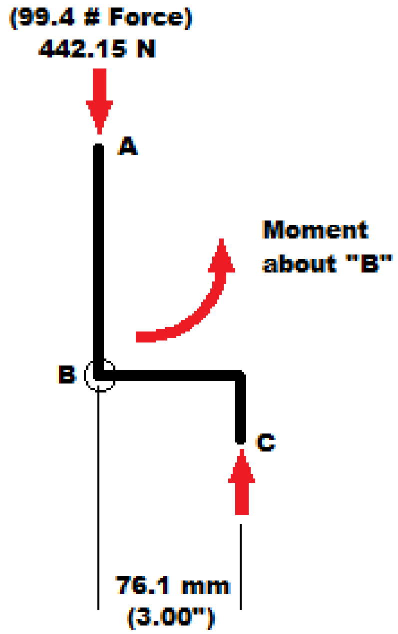
[Figure 2: Pneumatic Diagram. The push button controls the pilot operated directional control valve. When the button is pressed, the cylinder will extend. When the button is released, the cylinder will retract. Each time the cylinder is extending, the counter will increase by 1 unit. The plant air fluctuates between 90-110 PSI, so we will also need to add a regulator.]

Actuator Force

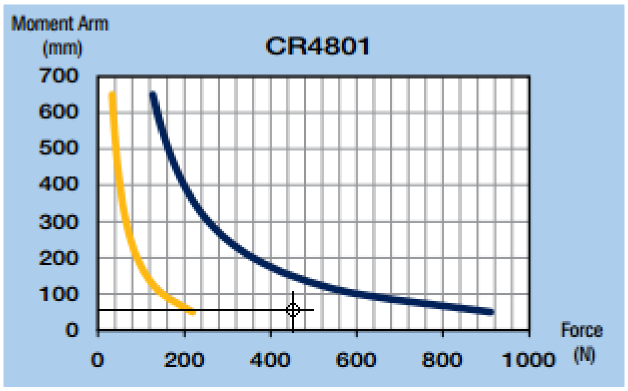
Operating Pressure: 100 psi
Piston diameter: 1-1/8”
$\boldsymbol{Max\ Force = P * A = 100\ psi * [\pi(1.125)^2/4] =\ 99.4\ \#\ Force}$

Selecting Linear Guide

Member A-B represents the center line of the linear slide, and point C represents the tool tip. When the cylinder is extended (with 99.4# force) the tool tip will see a reaction force of 99.4# @ location C. Parker Motion gives a maximum moment curve represented by the blue curve in figure 4; the yellow curve represents the moment in a different direction. The intersection of the black lines in figure 4 shows the moment about point B; we used 76.1 mm for the moment arm and 442.15 N for the force. This guide will work perfect because the moment we will experience is less than the maximum moment.



[Figure 3: Free body diagram of Parker CR 4801 linear guide]

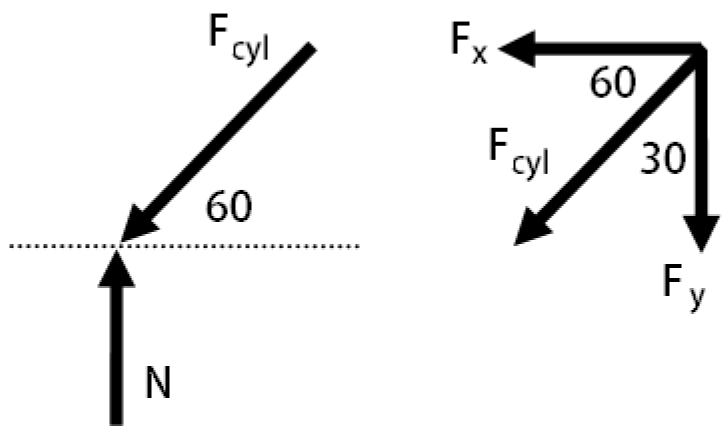


[Figure 4: Maximum moment curve for Parker CR 4801 linear guide]

The linear guide we selected is the Parker Motion part number CR4801.

Selecting Clamp for PTFE Pad

This is the clamp located under the PTFE pad; see figure 9, DET. 17. The maximum cutting angle will be 60 degrees from the table top surface. Figure 5 shows the free body diagram and component angles of the actuator force. We need a clamp that will have a higher clamping force than the vertical force from the actuator.



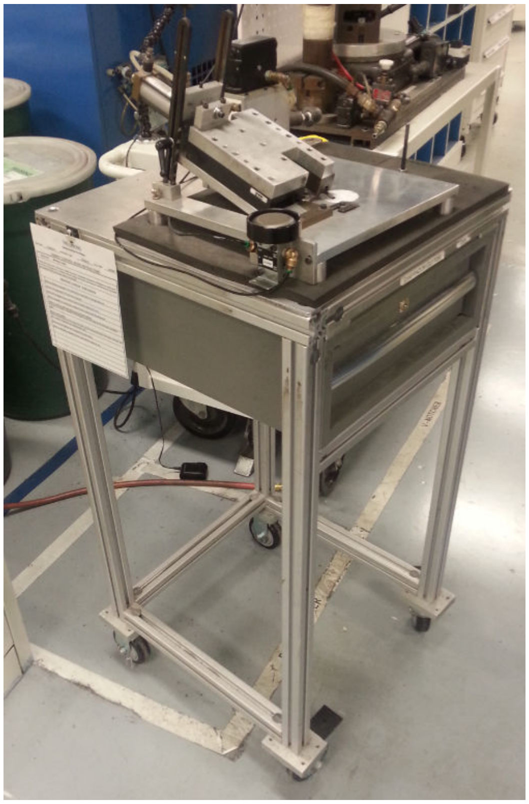
[Figure 5: Free Body Diagram of tool tip]

$$\Sigma F_{y-direction} = 0 = -[F_y] + N$$

$$0 = -[99.4\# * \cos(30)] + N$$

$$N = 86.09\#\ upward$$

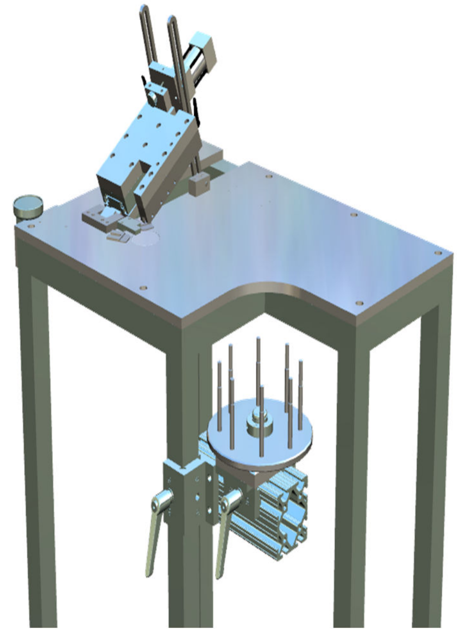
The clamp we select must have a clamping force greater than 87#, otherwise the clamp would fail. We selected a clamp from McMaster Carr; Part number 5128A46. This is a stainless steel hold-down clamp with a clamping force of 200#. This gives us a factor of safety greater than 2.



[Figure 6: Existing Machine; benchmarked design]

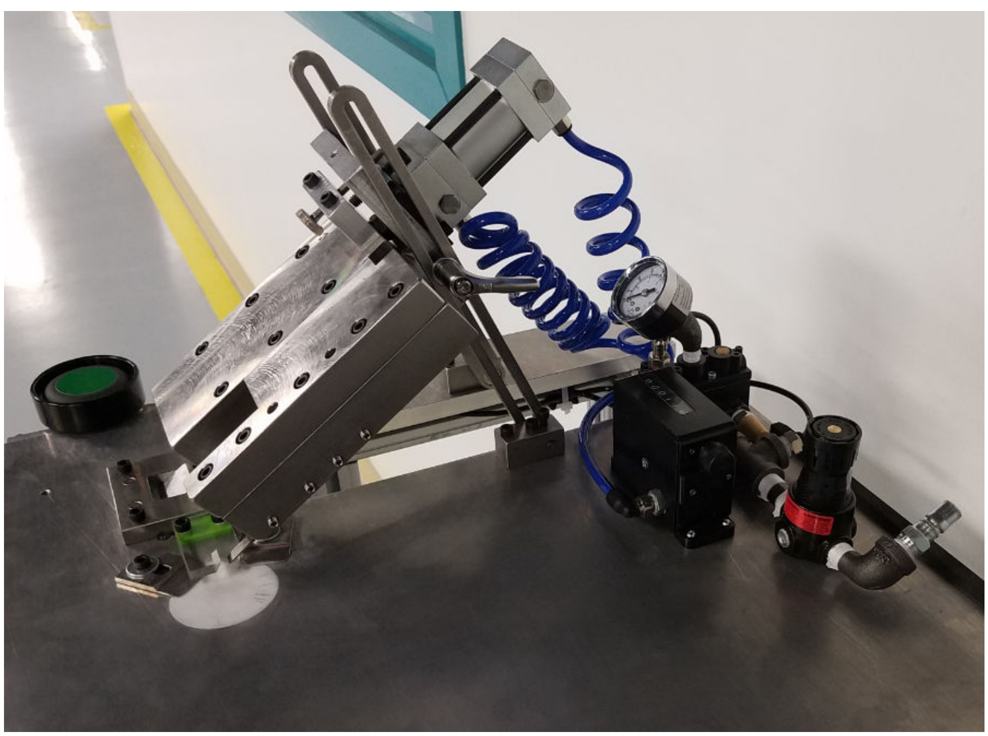
Figure 6 shows the machine that we used to benchmarked the design. We have changed or added the following things:

- Widened the table top. This will give the operator a little more room to work with.
- Added a manual indexing table. This table on the side will allow the operator to slide the cut seal off the right side of the table top (see figures 7 & 8), directly on to a cardboard mandrel. This will decrease the time it takes the shipping department to package this order.
- Added a digital angle gage. This will allow the operator to set up the angle of the cut very quickly.
- New designed PTFE pad. This is the white pad that is under the cutting tool, mounted inside the table top plate. The old design had the PTFE pad pressed into the top; when the pad needs to be changed or rotated, the locators (figure 9, DET. 8) and tool need to be removed in order to take out the pad. We designed a new pad that is pressed in from the bottom, and held by the clamp on the bottom side (figure 9, DET. 17). This will allow the operator to change/rotate this pad without having to set up the machine again.
- Added foam railing to ensure that no parts would be slid off of the cart-top during rapid movements of the operator.
- Additional storage bins for easy access as opposed to the drawer that in order for the operator to open, would need to move from working position to access.



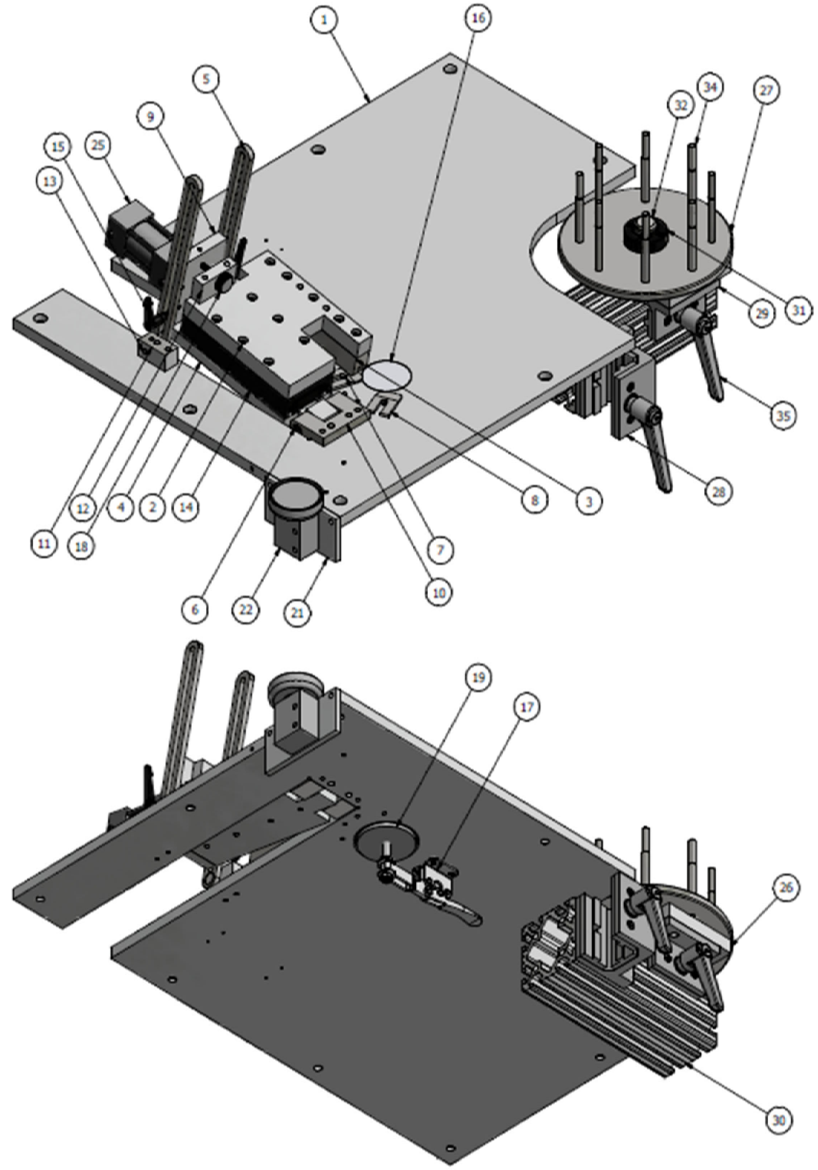
[Figure 7: Newly Assembled Machine]

[Figure 8: New designed Machine]



[Figure 9: New designed machine, close up]

Print Drawings



PARTS LIST				
ITEM	QTY	PART NUMBER	DESCRIPTION	MATERIAL
1	1	501-596-04	Table Top	Aluminum
2	1	501-596-05	Tool Mount	Aluminum
3	1	501-596-06	Tool Holder	Stainless Steel
4	1	501-596-08	Guide Mount	Aluminum
5	2	501-596-10	Adjustment Rail	Stainless Steel
6	1	73079634	Dowel Pin; MSC	Purchased
7	1	501-596-12	Seal Locator; 1	Stainless Steel
8	1	501-596-13	Seal Locator; 2	Stainless Steel
9	1	501-596-18	Cylinder Mount	Aluminum
10	1	501-596-20	Large Hinge	Stainless Steel
11	2	501-596-21	Small Hinge	Stainless Steel
12	1	501-596-22	Cylinder Hard-stop	Aluminum
13	2	501-596-25	Small Pin	Stainless Steel
14	1	03370301	Linear Guide; MSC	Purchased
15	2	5580K110	Adjustment Handle; Mcmaster	Purchased
16	1	501-596-55	Cutting Pad (made in house)	PTFE
17	1	5128A460	Toggle Clamp	Purchased
18	1	93015A210	Thumb Screw; Mcmaster	Purchased
19	1	501-596-27	Clamp Plate	Aluminum
20	1	Machine Frame	Not Shown (made in house)	Purchased
21	1	501-596-26	Push Button Adapter	Aluminum
22	1	80187909	Push Button; MSC	Purchased
23	1	6453K320	Cylinder Flange; Mcmaster (not shown)	Purchased
24	1	3353A67	Angle Finder; Mcmaster (not shown)	Purchased
25	1	AR-1-1/8x1-P-D	AV-NFPA Series, Air Cylinder	Purchased
26	1	501-596-63	Rotary Adapter Plate	Aluminum
27	1	501-596-64	Rotary Table Plate	Stainless Steel
28	1	60585K330	Small Linear Guide; Mcmaster	Purchased
29	1	60585K760	Large Linear Guide; Mcmaster	Purchased
30	1	47065T811	Aluminum Extrusion; 3x3 x 8	Purchased
31	1	5631T160	Shaft Collar; Mcmaster	Purchased
32	1	97352A974	1.00" Dowel Pin; Mcmaster	Purchased
33	1	8686A192	Spring Plunger; Mcmaster (not shown)	Purchased
34	8	501-596-65	Mandrel Pin	Stainless Steel
35	2	60585K320	Hand Brake; Mcmaster	Purchased

NOTES

1. FASTENERS AND SOME PURCHASED COMPONENTS ARE NOT INCLUDED ON THIS BOM

TRELLEBORG SEALING SOLUTIONS
2531 BREMER DRIVE,
FORT WAYNE, IN 46803
260-749-9631

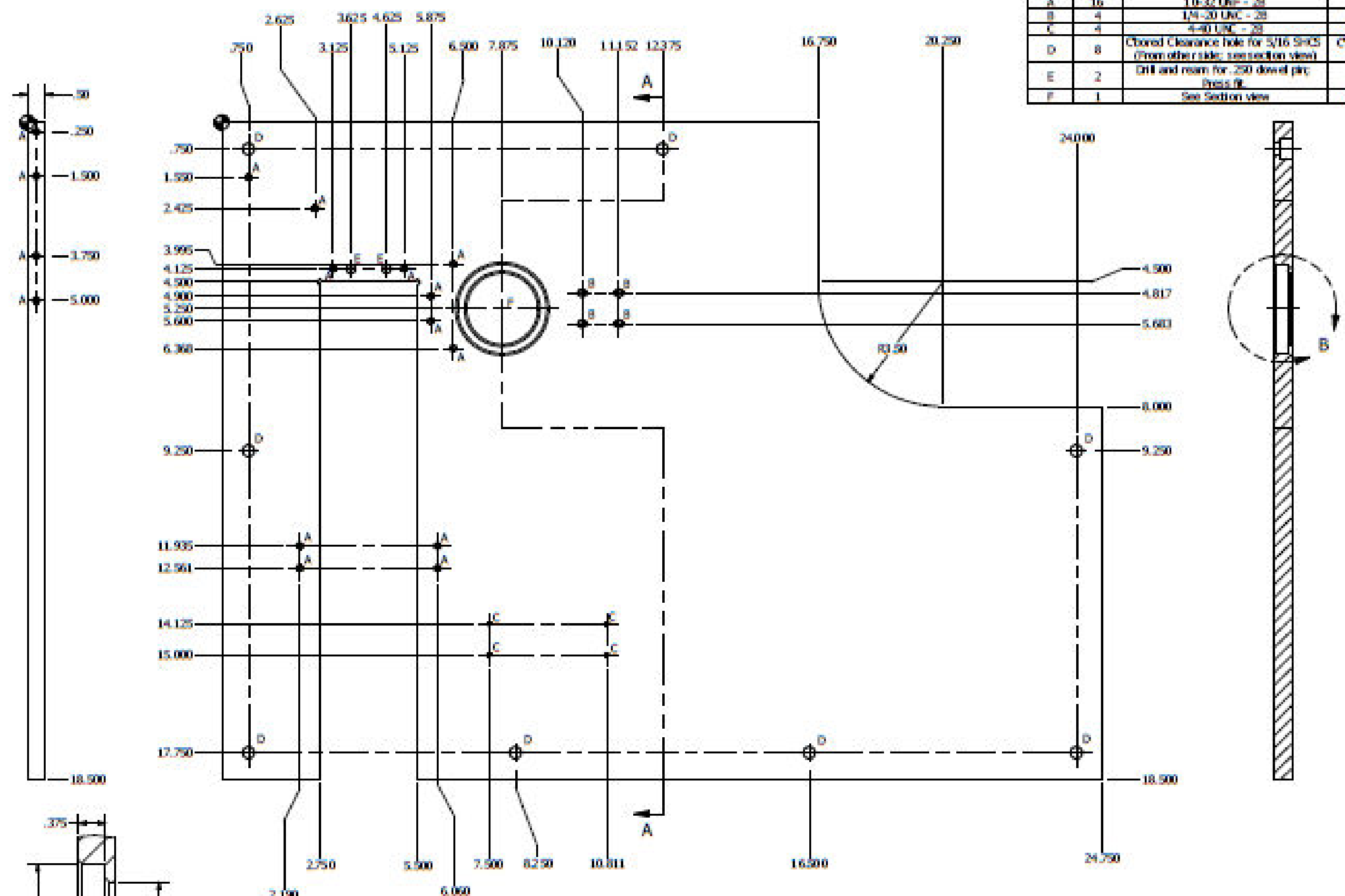
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

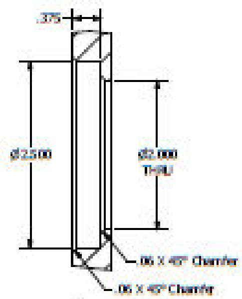
.XX	.XXX	.XXXX	ANGLES
± .010	± .005	± .001	± 1/2°

TITLE	Scarf Cutting Machine
MATERIAL	
SHRINK RATE	
QUANTITY	
PART NUMBER	501-596-00 Assembly
REV	
DRAWN BY	D.J.M.
DATE	2/1/2016
SIZE	C
SCALE	
FILE NAME	501-596-00 Assembly.idw
SHEET	1 OF 1

Hole Specifications

Hole	Qty.	Description	Depth
A	16	10-32 UNF - 2B	THRU
B	4	1/4-20 UNC - 2B	0.375"
C	4	4-40 UNC - 2B	THRU
D	8	C'bored Clearance hole for 5/16 SHCS (From other side; see section view)	C'BORE & THRU
E	2	Drill and ream for .250 dowel pin; Press fit.	THRU
F	1	See Section view	C'BORE

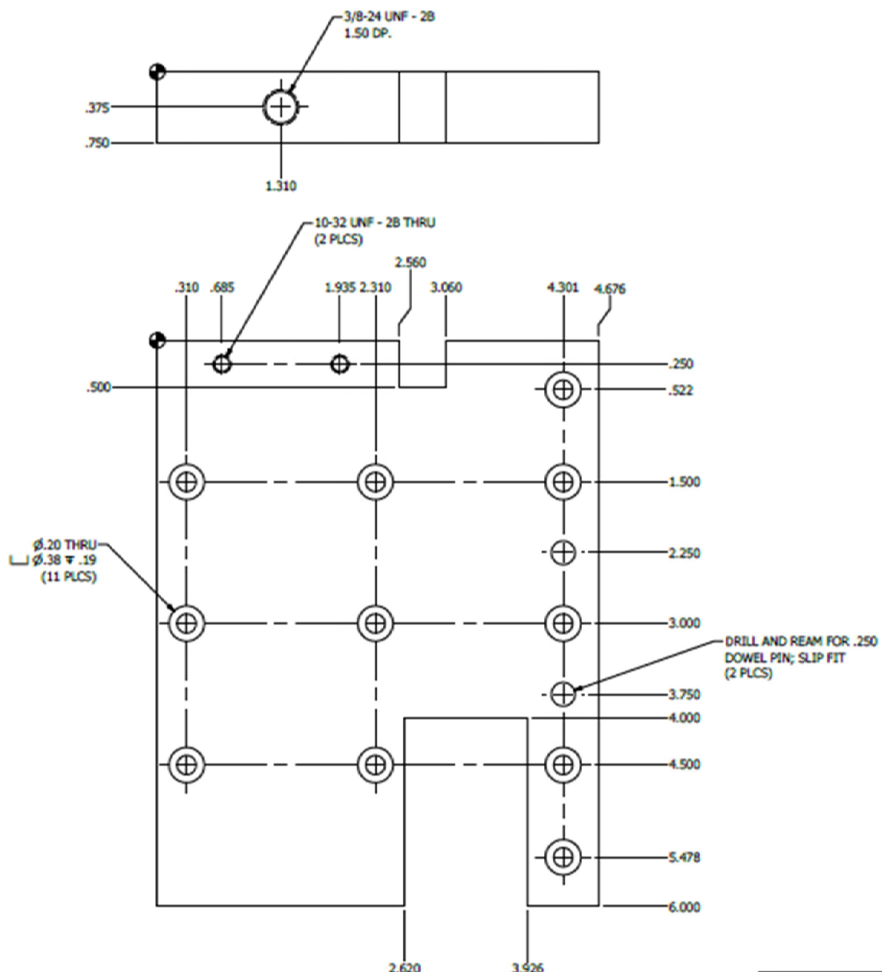


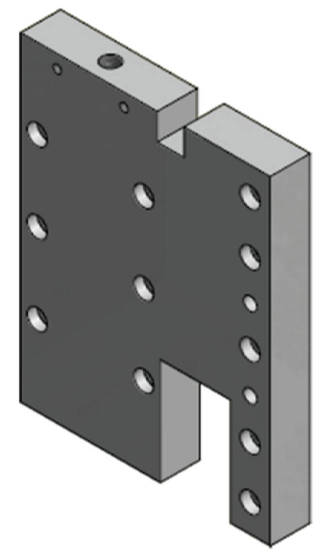


**** IMPORTANT NOTES****

1. HOLES MARKED "B" ARE NOT THRU HOLES
2. HOLES MARKED "D" ARE C'BORED HOLES FROM THE OPPOSITE SIDE
3. BREAK ALL SHARP CORNERS AND EDGES

TRELLEBORG SEALING SOLUTIONS	
TITLE	Table Top
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	±.010, ±.005, ±.001, ±1/2°
MATERIAL	Alum.
DRAWN BY	D.J.M.
DATE	2/16/2016
QUANTITY	1
PART NUMBER	501-596-04
REV	A
SIZE	C
FILE NAME	501-596-04.idw
SHEET	1 OF 1





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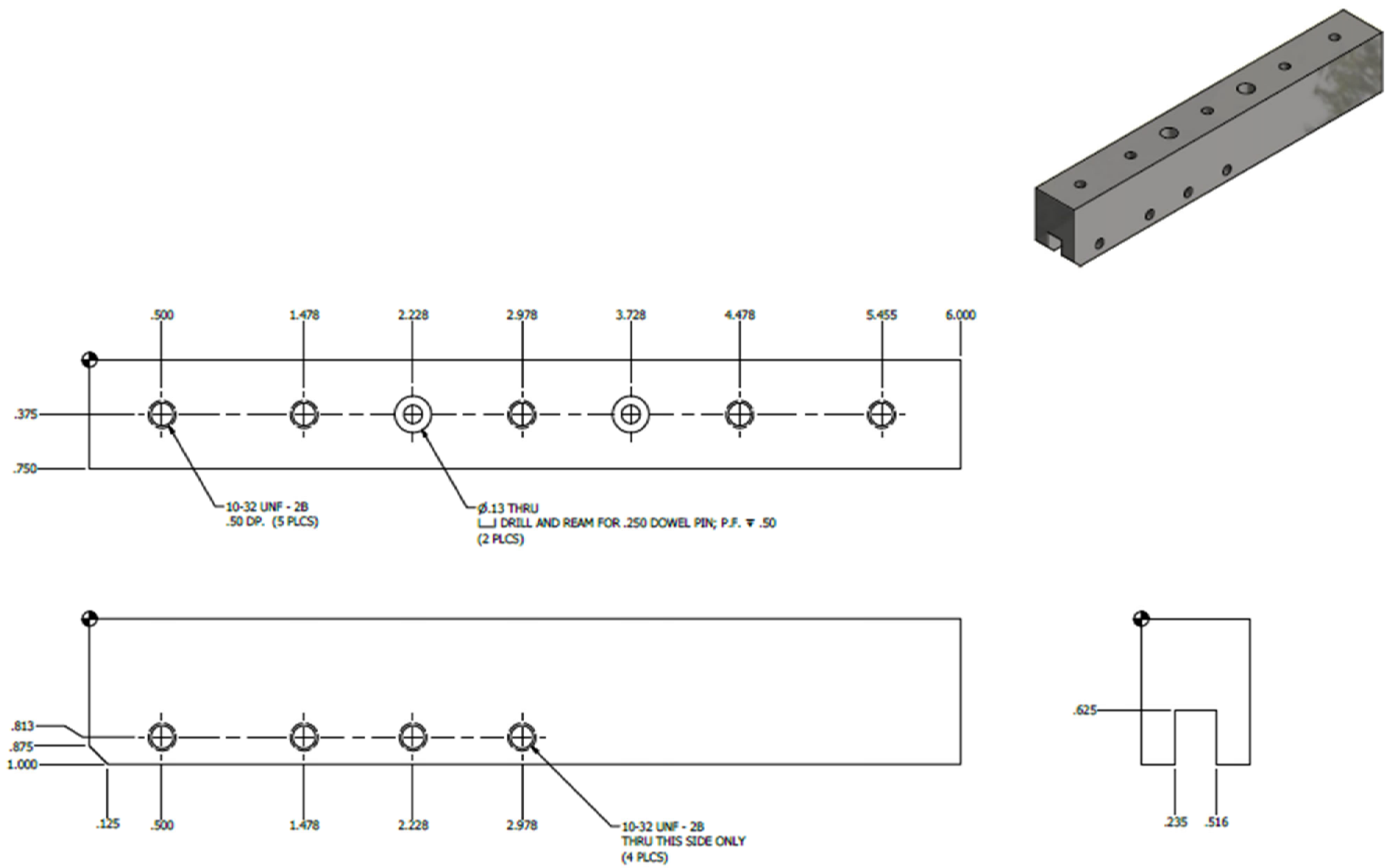
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES				TITLE Tool Mount
.XX ± .010	.XXX ± .005	.XXXX ± .001	ANGLES ± 1/2°	
MATERIAL	Stainless Stl.	QUANTITY		PART NUMBER 501-596-05 / REV A
SHRINK RATE				
DRAWN BY	D.J.M.	1	SIZE C / SCALE	FILE NAME 501-596-05.idw / SHEET 1 OF 1
DATE	2/17/2016			

NOTES
1. BREAK ALL SHARP CORNERS AND EDGES



NOTES
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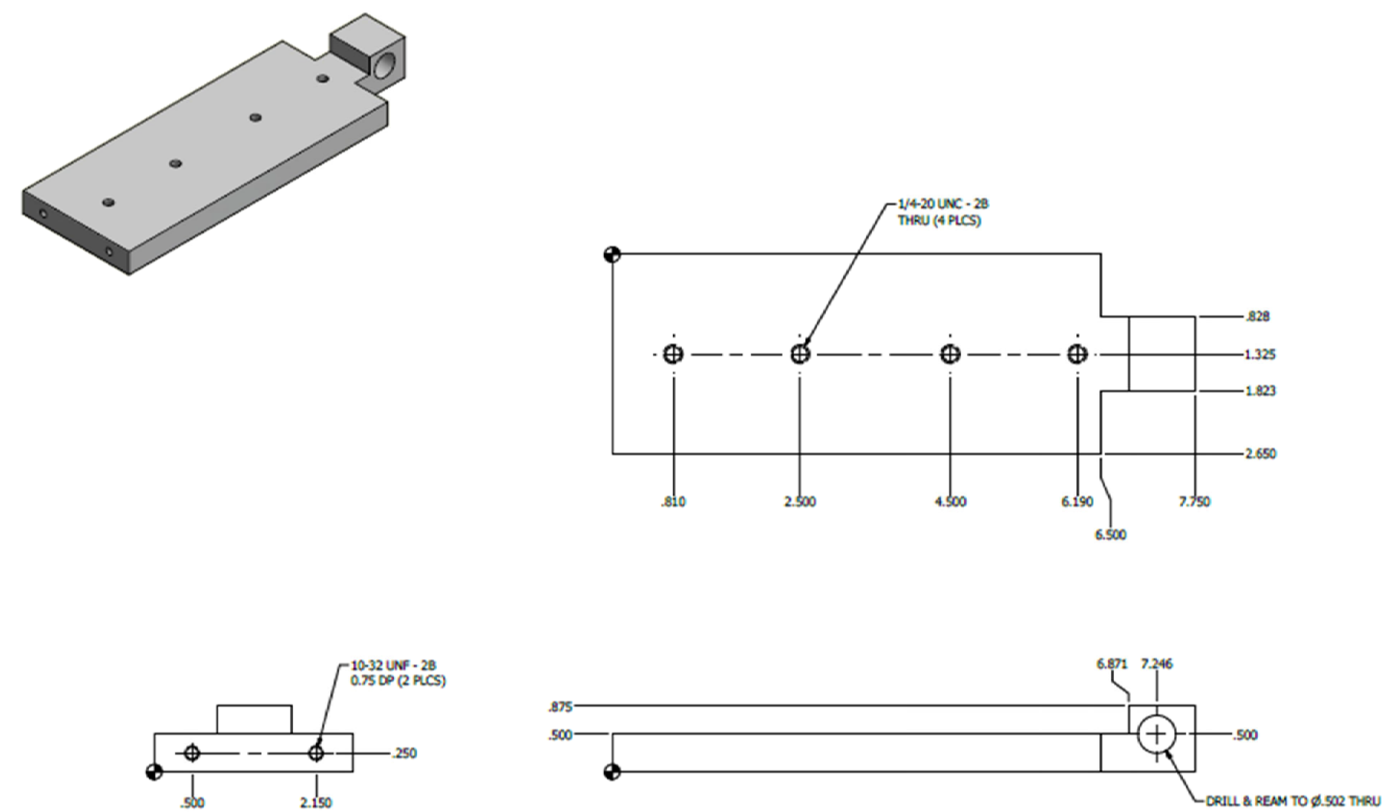
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES .XX ± .010 .XXX ± .005 .XXXX ± .001 ANGLES ± 1/2°		TITLE Tool Holder		
MATERIAL Stainless Stl.	QUANTITY 1	PART NUMBER 501-596-06		REV A
SHRINK RATE				
DRAWN BY D.J.M.		SIZE C	SCALE	FILE NAME 501-596-06.idw
DATE 2/17/2016				SHEET 1 OF 1



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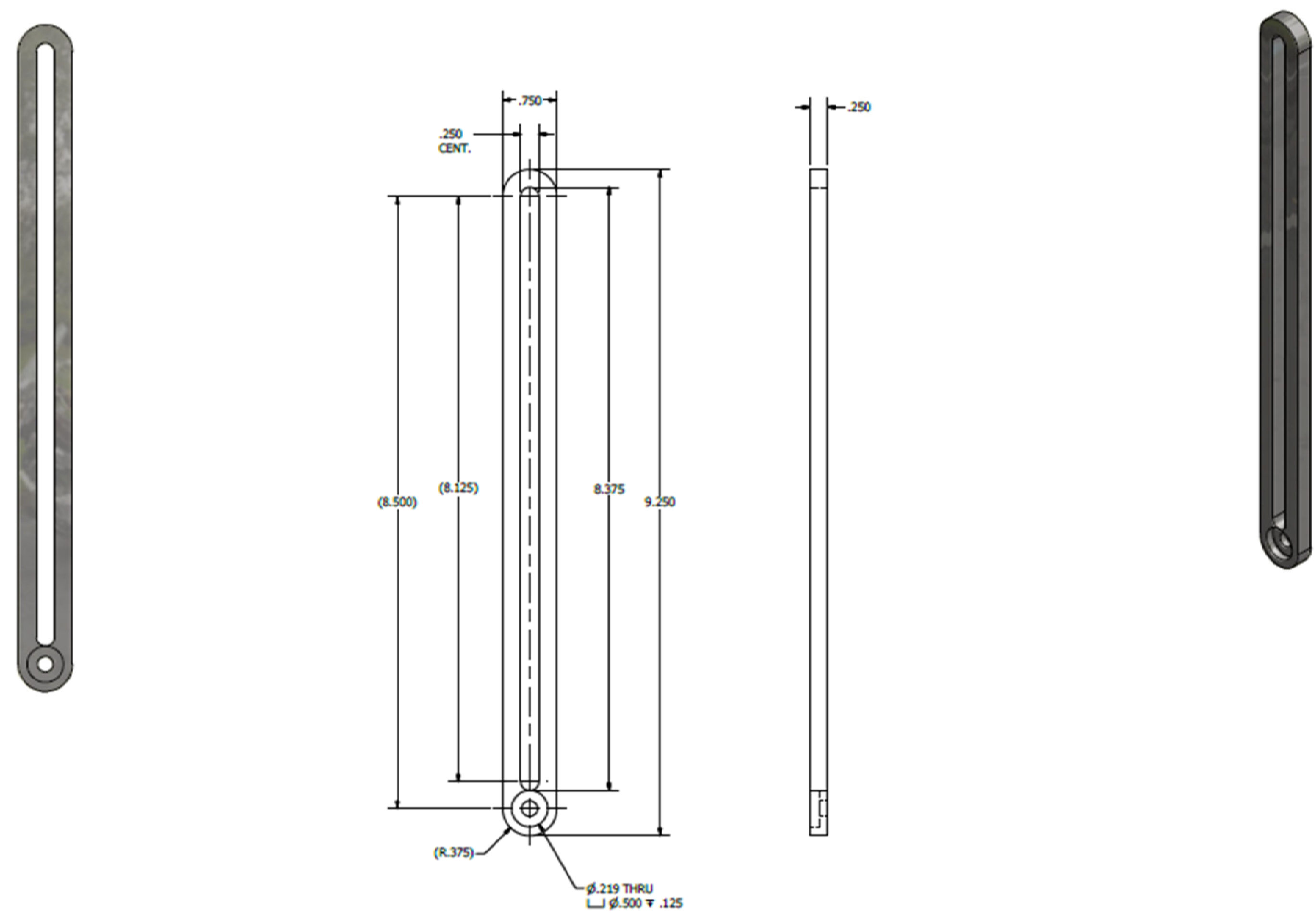
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

.XX	.XXX	.XXXX	ANGLES
± .010	± .005	± .001	± 1/2°

TITLE	Guide Mount
PART NUMBER	501-596-08
REV	A
MATERIAL	Alum.
SHRINK RATE	
QUANTITY	1
DRAWN BY	D.J.M.
DATE	2/17/2016
SIZE	C
SCALE	
FILE NAME	501-596-08.idw
SHEET	1 OF 1



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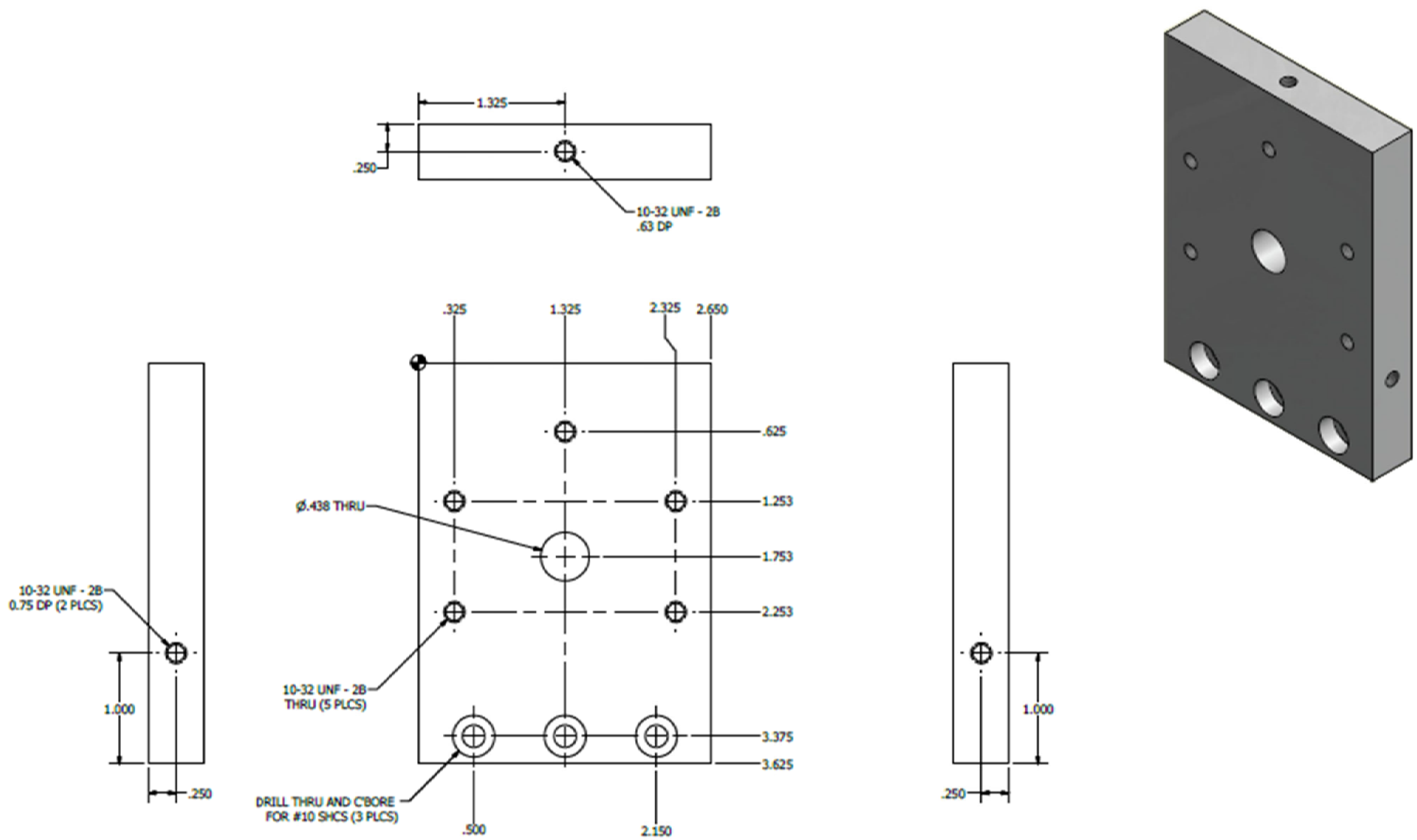
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES			TITLE Adjustment Rail		
.XX ± .010	.XXX ± .005	.XXXX ± .001	ANGLES ± 1/2°		
MATERIAL	Stainless Stl.	QUANTITY	PART NUMBER 501-596-10		REV A
SHRINK RATE					
DRAWN BY	D.J.M.	2	SIZE C	SCALE	FILE NAME 501-596-10.idw
DATE	2/18/2016				SHEET 1 OF 1

NOTES

1. BREAK ALL SHARP CORNERS AND EDGES



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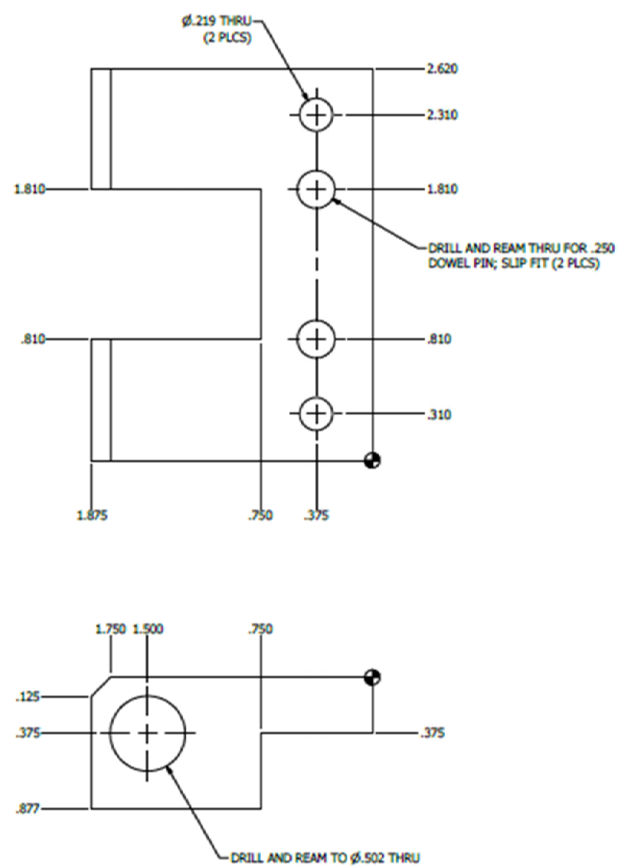
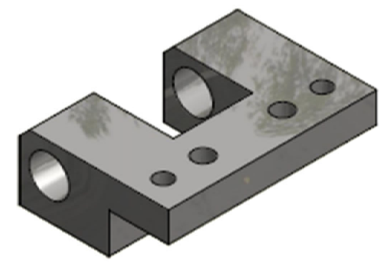
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

.XX	.XXX	.XXXX	ANGLES
± .010	± .005	± .001	± 1/2°

TITLE	Cylinder Mount
MATERIAL	Alum.
SHRINK RATE	
QUANTITY	1
DRAWN BY	D.J.M.
DATE	2/18/2016
PART NUMBER	501-596-18
REV	A
SIZE	C
SCALE	
FILE NAME	501-596-18.idw
SHEET	1 OF 1





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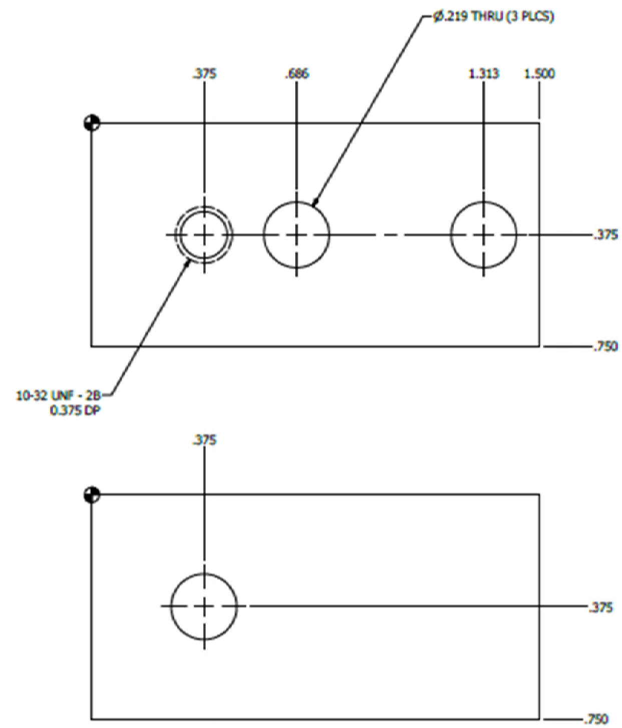
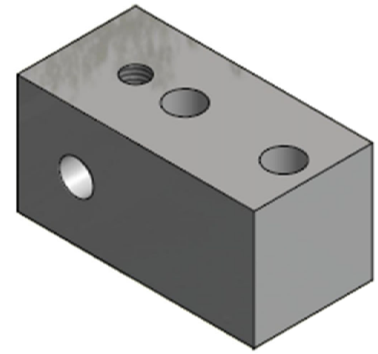
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES				TITLE Large Hinge		
.XX ± .010	.XXX ± .005	.XXXX ± .001	ANGLES ± 1/2°			
MATERIAL	Stainless Stl.	QUANTITY		PART NUMBER 501-596-20		REV A
SHRINK RATE						
DRAWN BY	D.J.M.	1		SIZE C	SCALE	FILE NAME 501-596-20.idw
DATE	2/18/2016					SHEET 1 OF 1





NOTES
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2531 BREMER DRIVE,
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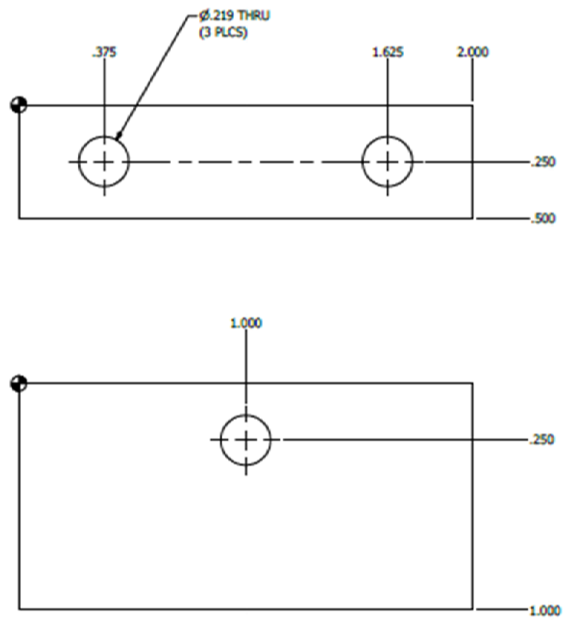
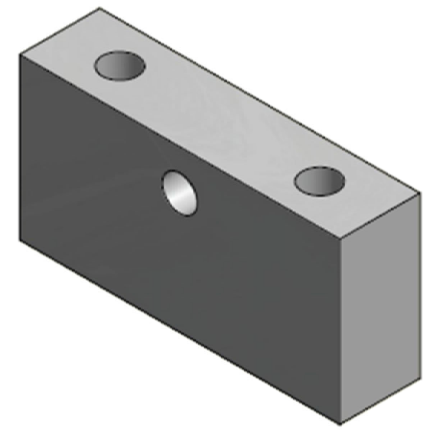
260-749-9631

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES				TITLE: Small Hinge
.XX ± .010	.XXX ± .005	.XXXX ± .001	ANGLES ± 1/2°	
MATERIAL	Stainless Stl.	QUANTITY		PART NUMBER: 501-596-21 — REV: A
SHRINK RATE				
DRAWN BY	D.J.M.	2		SIZE: C — SCALE: — FILE NAME: 501-596-21.idw — SHEET 1 OF 1
DATE	2/18/2016			





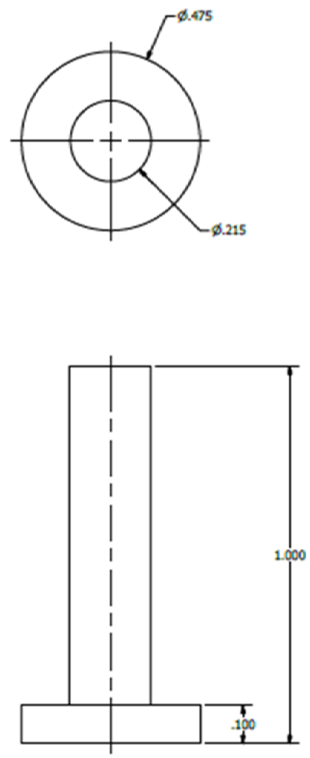
NOTES
1. BREAK ALL SHARP CORNERS AND EDGES

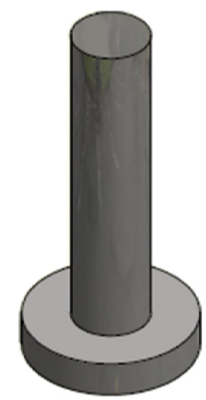
TRELLEBORG SEALING SOLUTIONS
2531 BREMER DRIVE,
FORT WAYNE, IN 46803
260-749-9631

UNLESS OTHERWIZE SPECIFIED DIMENSIONS ARE IN INCHES

.XX	.XXX	.XXXX	ANGLES
± .010	± .005	± .001	± 1/2°

TITLE	Cylinder Hard-stop
MATERIAL	Alum.
SHRINK RATE	
QUANTITY	1
DRAWN BY	D.J.M.
DATE	2/18/2016
PART NUMBER	501-596-22
REV	A
SIZE	C
SCALE	
FILE NAME	501-596-22.idw
SHEET	1 OF 1





NOTES
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TRELLEBORG SEALING SOLUTIONS
2531 BREMER DRIVE,
FORT WAYNE, IN 46803
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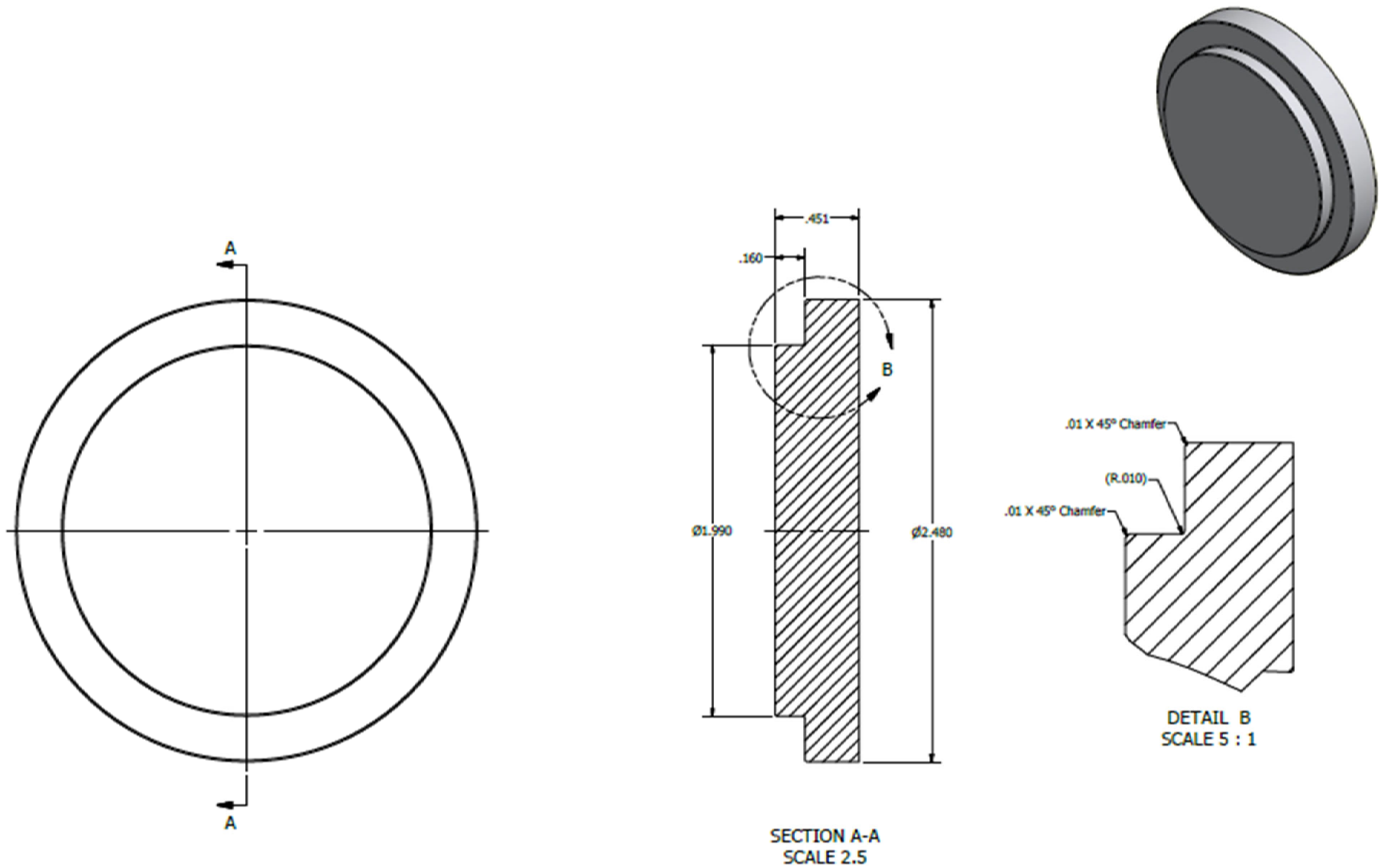
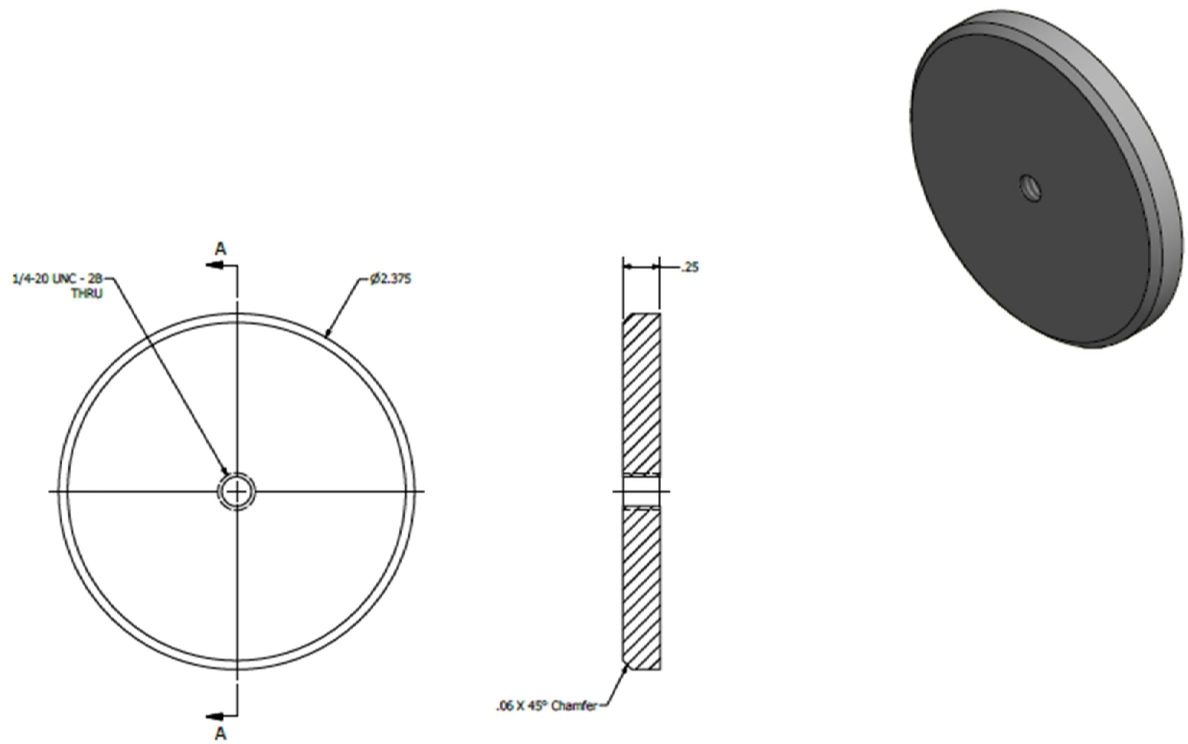
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES				TITLE Small Pin	
.XX ±.010	.XXX ±.005	.XXXX ±.001	ANGLES ±1/2°		
MATERIAL	Stainless Stl.	QUANTITY		PART NUMBER 501-596-25	REV A
SHRINK RATE					
DRAWN BY	D.J.M.	2	SIZE C	SCALE	FILE NAME 501-596-25.idw
DATE	2/18/2016				SHEET 1 OF 1



NOTES
1. MAKE FROM PTFE, TSS FW PROTOXPRESS

TRELLEBORG SEALING SOLUTIONS
2531 BREMER DRIVE,
FORT WAYNE, IN 46803
260-749-9631

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES				TITLE Stopping Pad
.XX ±.010	.XXX ±.005	.XXXX ± .001	ANGLES ± 1/2°	
MATERIAL	PTFE	QUANTITY		PART NUMBER 501-596-55 / REV A
SHRINK RATE				
DRAWN BY	D.J.M.			SIZE C / SCALE / FILE NAME 501-596-55.idw / SHEET 1 OF 1
DATE	3/17/2016			



SECTION A-A
SCALE 2

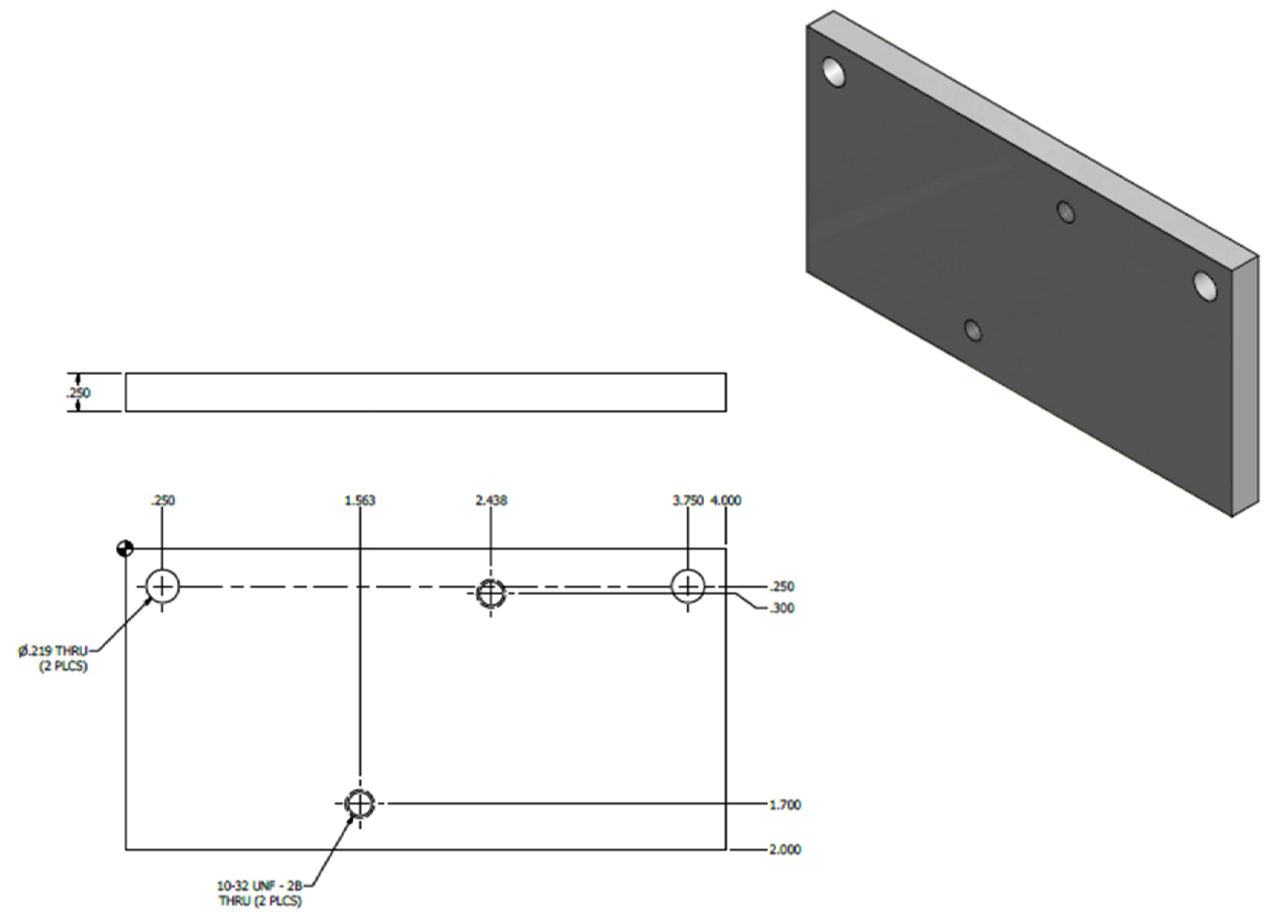
NOTES
1. BREAK ALL SHARP CORNERS AND EDGES

TRELLEBORG SEALING SOLUTIONS
2531 BREMER DRIVE,
FORT WAYNE, IN 46803
260-749-9631

UNLESS OTHERWIZE SPECIFIED DIMENSIONS ARE IN INCHES

.XX	.XXX	.XXXX	ANGLES
± .010	± .005	± .001	± 1/2°

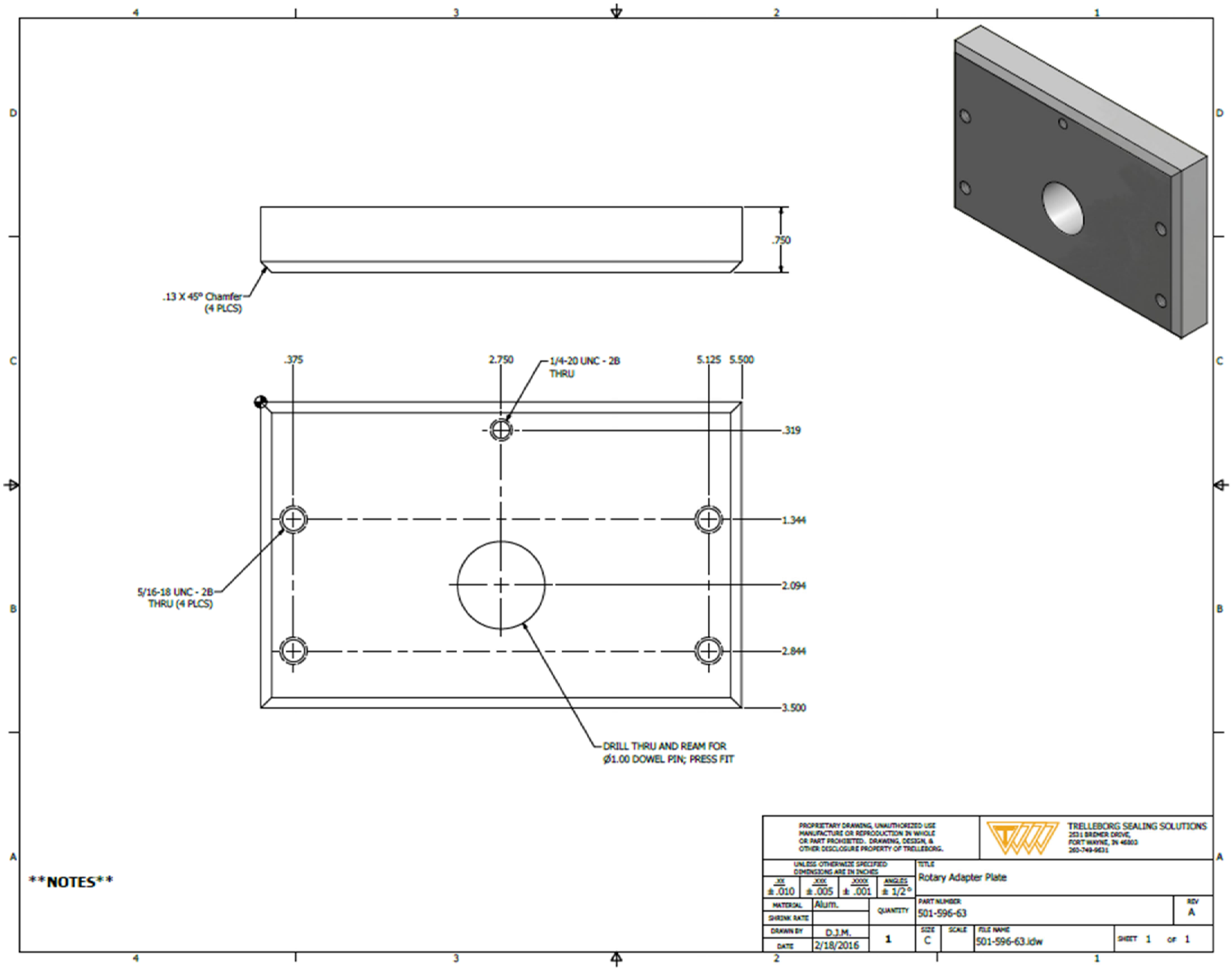
TITLE	Clamp Plate
MATERIAL	Alum.
SHRINK RATE	
QUANTITY	1
PART NUMBER	501-596-27
REV	A
DRAWN BY	D.J.M.
DATE	2/18/2016
SIZE	C
SCALE	
FILE NAME	501-596-27.idw
SHEET	1 OF 1

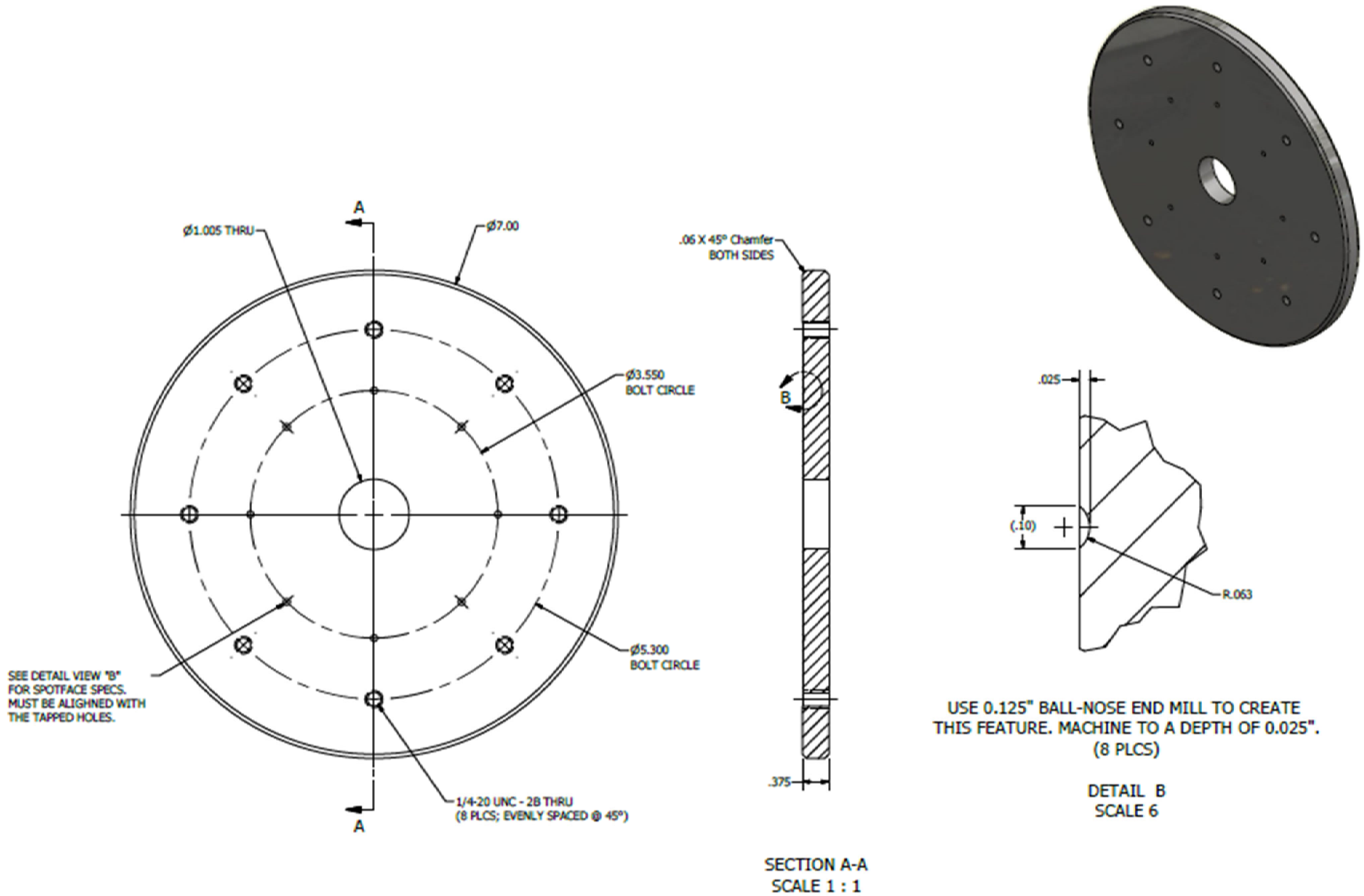


NOTES
1. BREAK ALL SHARP CORNERS AND EDGES

TRELLEBORG SEALING SOLUTIONS
2531 BREMER DRIVE,
FORT WAYNE, IN 46803
260-749-9631

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES				TITLE Push Button Adapter	
.XX ±.010	.XXX ±.005	.XXXX ±.001	ANGLES ± 1/2°		
MATERIAL	Alum.	QUANTITY		PART NUMBER 501-596-26	REV A
SHRINK RATE					
DRAWN BY	D.J.M.	1	SIZE C	SCALE	FILE NAME 501-596-26.idw
DATE	2/18/2016				SHEET 1 OF 1


.13 X 45° Chamfer
(4 PLCS)
.750
.375
2.750
1/4-20 UNC - 2B
THRU
5.125
5.500
.319
1.344
2.094
2.844
3.500
5/16-18 UNC - 2B
THRU (4 PLCS)
DRILL THRU AND REAM FOR
Ø1.00 DOWEL PIN; PRESS FIT
NOTES
PROPRIETARY DRAWING, UNAUTHORIZED USE
MANUFACTURE OR REPRODUCTION IN WHOLE
OR PART PROHIBITED. DRAWING, DESIGN, &
OTHER DISCLOSURE PROPERTY OF TRELLEBORG.
TRELLEBORG SEALING SOLUTIONS
2531 BREMER DRIVE,
FORT WAYNE, IN 46803
260-749-9631
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
.XX ±.010
.XXX ±.005
.XXXX ± .001
ANGLES ± 1/2°
TITLE
Rotary Adapter Plate
MATERIAL Alum.
SHRINK RATE
QUANTITY 1
PART NUMBER
501-596-63
REV A
DRAWN BY D.J.M.
DATE 2/18/2016
SIZE C
SCALE
FILE NAME
501-596-63.idw
SHEET 1 OF 1



NOTES

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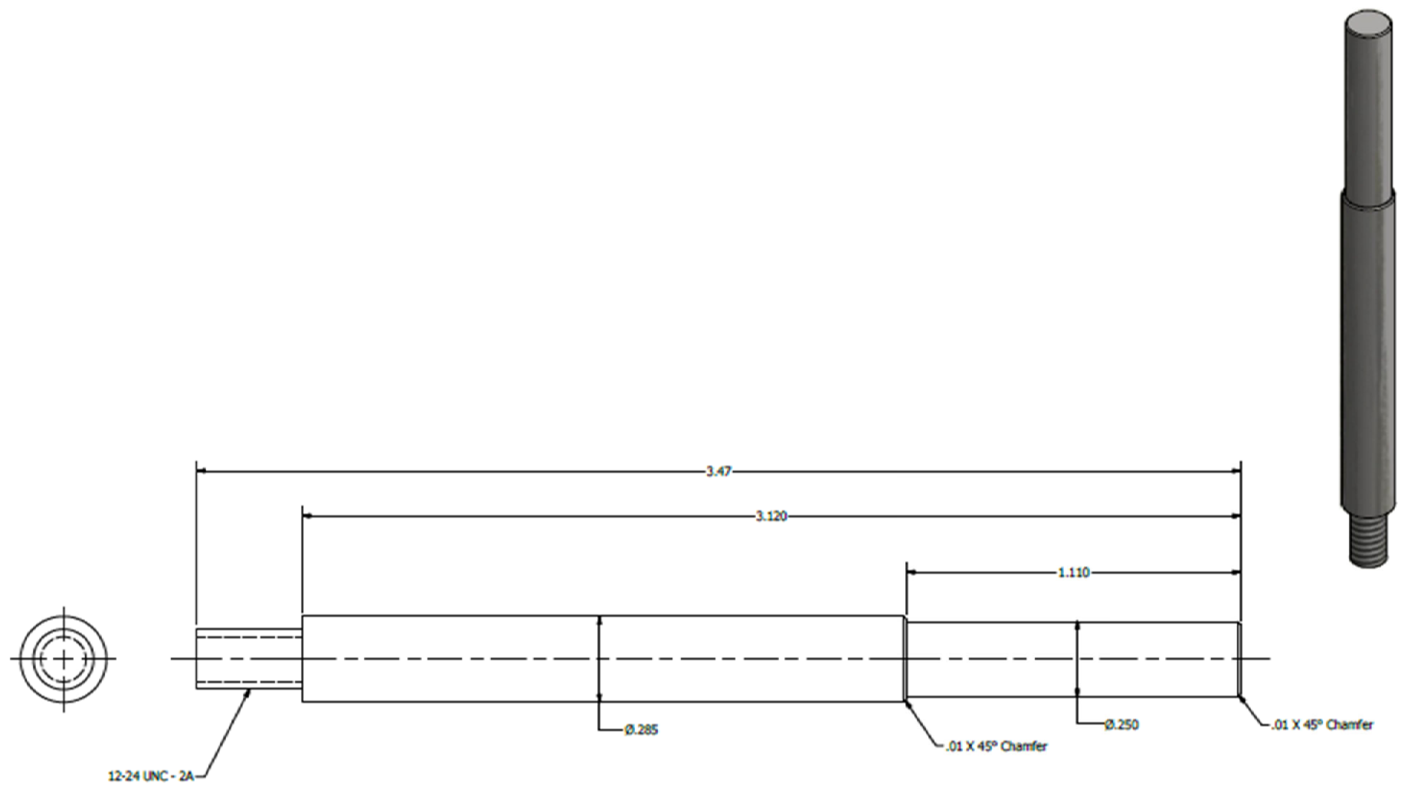
PROPRIETARY DRAWING, UNAUTHORIZED USE MANUFACTURE OR REPRODUCTION IN WHOLE OR PART PROHIBITED. DRAWING, DESIGN, & OTHER DISCLOSURE PROPERTY OF TRELLEBORG.

TRELLEBORG SEALING SOLUTIONS
2531 BREMER DRIVE,
FORT WAYNE, IN 46803
260-749-9631

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

.XX	.XXX	.XXXX	ANGLES
±.010	±.005	±.001	±1/2°

TITLE	Rotary Table Plate
MATERIAL	Stainless Stl.
SHRINK RATE	
QUANTITY	1
PART NUMBER	501-596-64
REV	A
DRAWN BY	D.J.M.
DATE	2/18/2016
SIZE	C
SCALE	
FILE NAME	501-596-64.idw
SHEET	1 OF 1



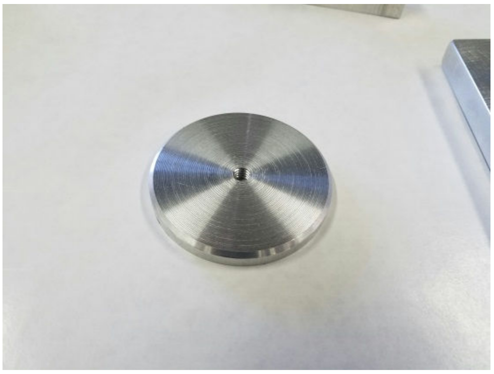
NOTES

1. BREAK ALL SHARP CORNERS AND EDGES

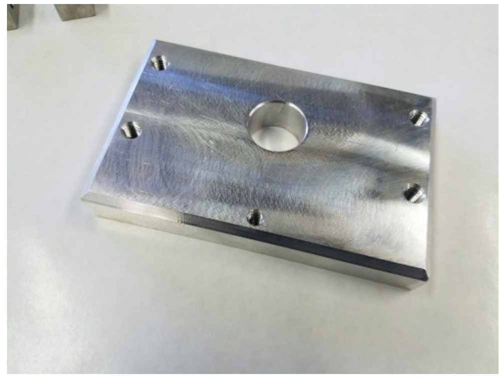
TRELLEBORG SEALING SOLUTIONS
2531 BREMER DRIVE,
FORT WAYNE, IN 46803
260-749-9631

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES				TITLE: Mandrel Pin
.XX ±.010	.XXX ±.005	.XXXX ±.001	ANGLES ±1/2°	
MATERIAL	Stainless Stl.	QUANTITY		PART NUMBER: 501-596-65 / REV: A
SHRINK RATE				
DRAWN BY	D.J.M.	8		SIZE: C / SCALE: / FILE NAME: 501-596-65.idw / SHEET 1 OF 1
DATE	2/18/2016			

Machined Components



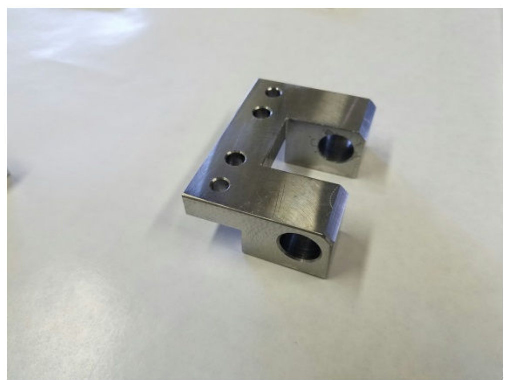
[*Clamp Plate: 501-596-27*]



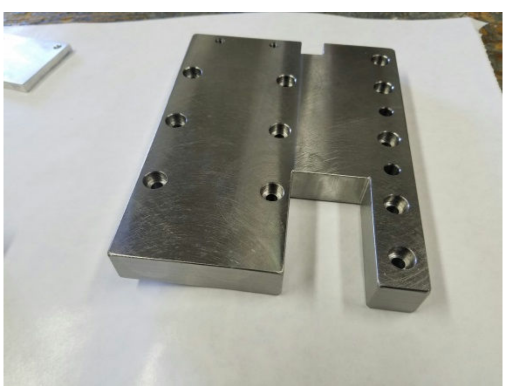
[*Rotary Adapter Plate: 501-596-63*]

[*Adjustment Rail: 501-596-10*]

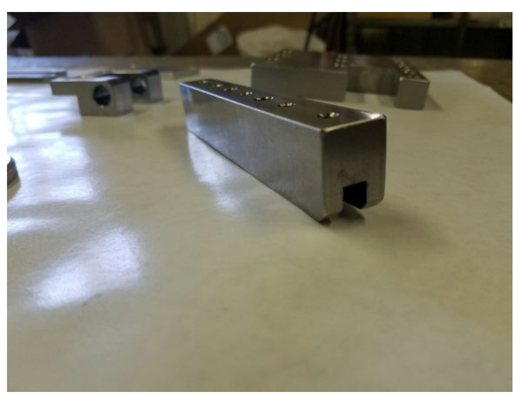
[*Small Hinge: 501-596-21*]



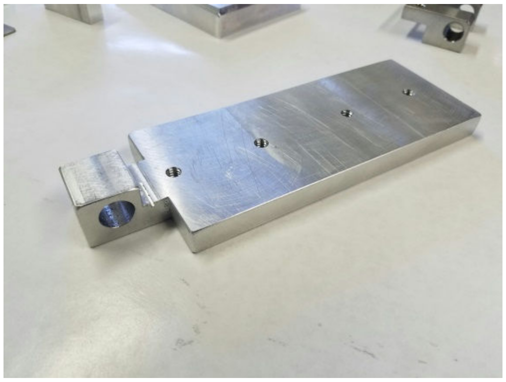
[*Large Hinge: 501-596-20*]



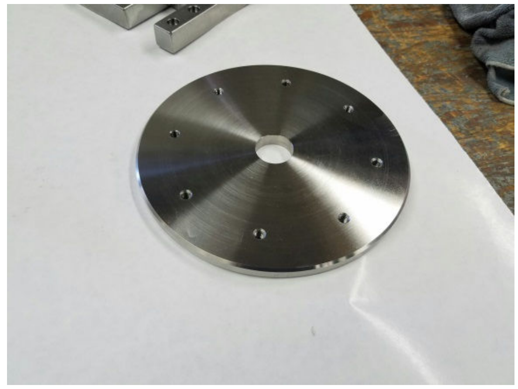
[*Tool Mount: 501-596-05*]



[*Tool Holder: 501-596-06*]



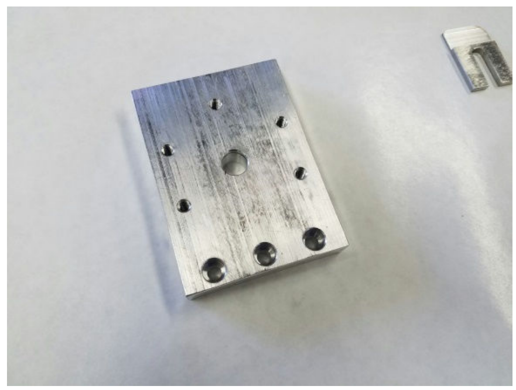
[*Guide Mount: 501-596-08*]



[*Rotary Table: 501-596-64*]

[*Mandrel Pin: 501-596-65*]

[*Small Pin: 501-596-25*]



[*Cylinder Mount: 501-596-18*]

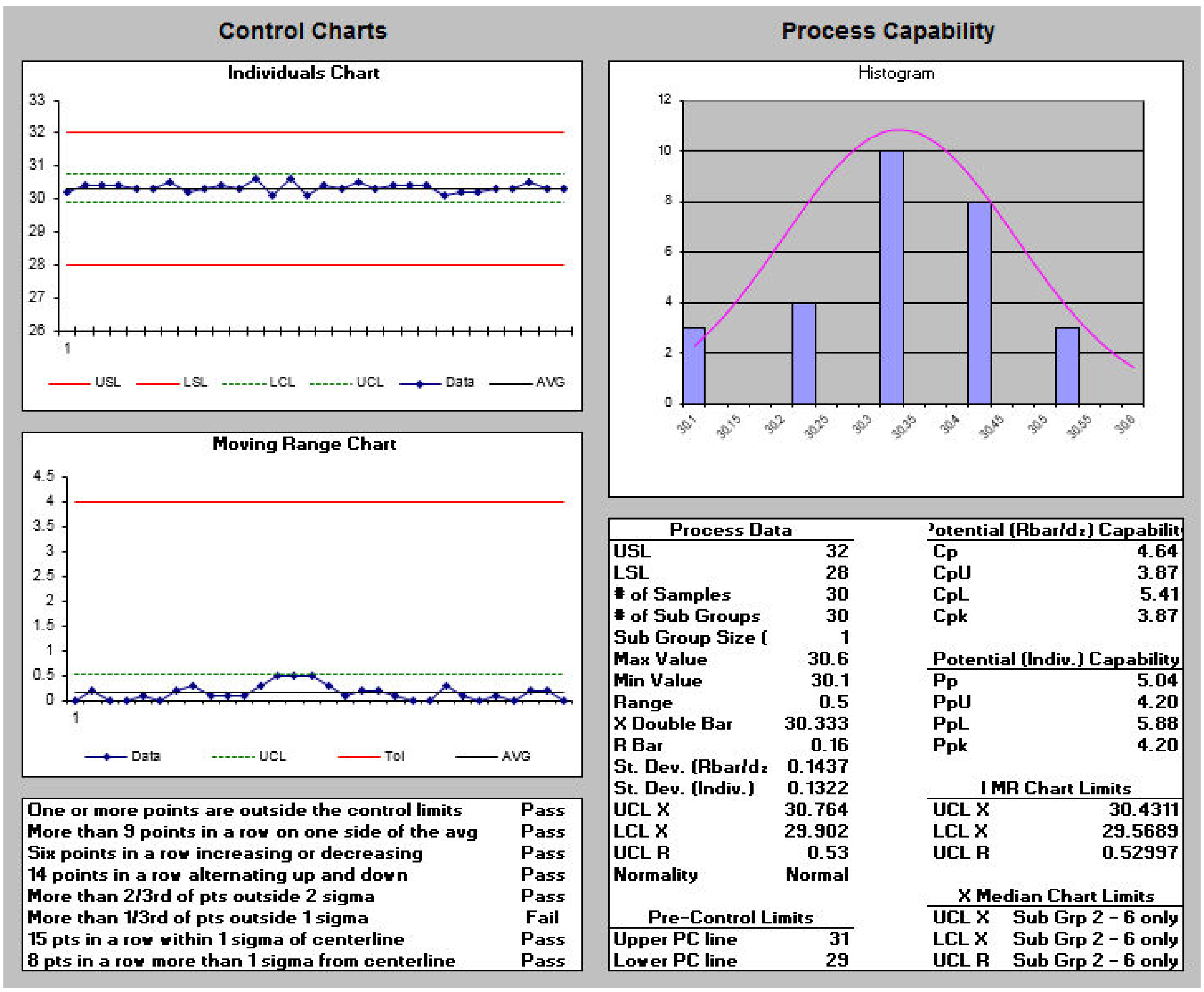
[*Seal Locator 1: 501-596-12*]

[*Seal Locator 2: 501-596-13*]

Testing Procedure

To validate this machine design, we have conducted the standard testing procure TSSFW has put in place for new equipment installation. Before any production parts can be ran on this machine, the operators must manufacture a set amount of parts from this machine (ranges from 10-100 pieces depending on the type of equipment) to run a capability test. For a second operation machine like this, a 30 pc sample size is adequate. We have inspected the cut angle of each part and used MiniTab to provide us with the results (Cp & Cpk).

Testing Results



[Figure 10: Capability Test]

We chose to have the operators set up the machine for a 30-degree angle cut and then cut 30 pieces. The test lab inspected the angle of each piece and provided us with this chart (figure 10). Trelleborg requires a minimum Cpk of 1.67 for a new machine to be released into production. Because the tolerance is quite large with angled cuts on back-up-rings, we achieved a Cpk of 3.87.

Safety Assessment

At TSSFW, the safety committee has a method of determining if a machine is safe to be released into production. There is not a scoring for something like this, it is either a pass or fail. Either the machine is safe for production, or it is not safe. There is no in between or value of safeness.

The safety committee determined that this machine was indeed safe for production use.

Purchased components

As previously stated, all of the components have been received. We made a decision to choose a different vender for all of the machined components. United Machine & Tool had a price that was a little cheaper than ToolCraft, but the lead time for the components would not have allowed us to complete this project on time. We chose to have ToolCraft machine these components for us; the lead time was less than 3 weeks vs. 8+ weeks from United Machine & Tool. We have spent a total of $5,378 on this machine. We are well under our budget of $8,741.

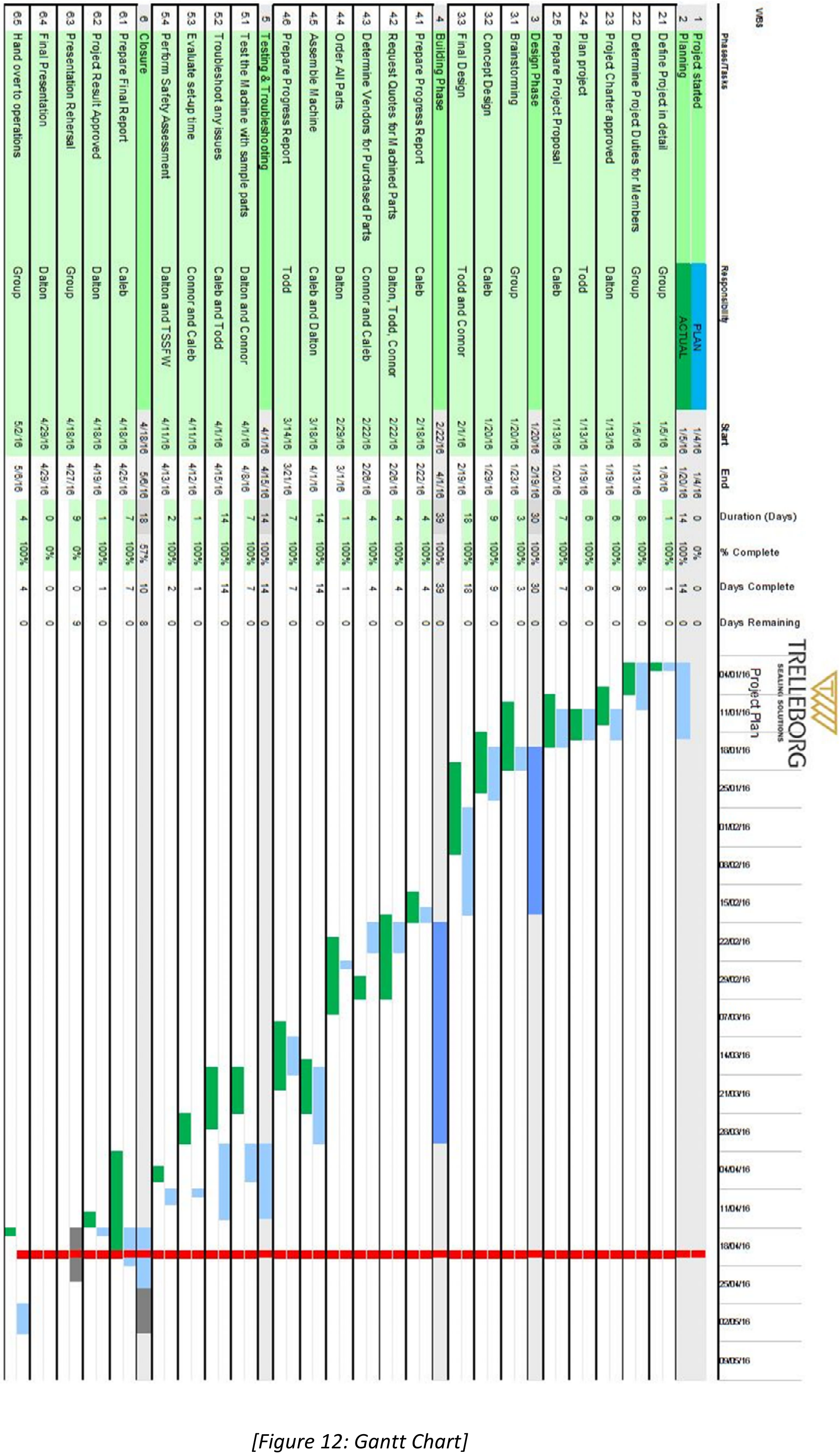
The table below shows a master list of all the components we have purchased. This will allow the project to easily be replicated if we need to make another one of these machines in the future. When this project started, each group member agreed that document control is one of the most important things with this project.

Cell 1 - Scarf Cutter						
Item	**Description**	**Mfr Part Number**	**Quantity**	**Cost/ea**	**Extended Cost**	**Supplier (P/N)**
1	All Machined Parts	*Quote# 17850*	1	$ 3,466.00	$ 3,466.00	Tool Craft
2	PHD Cylinder	AR-1-1_8x1-P-D	1	$ 138.75	$ 138.75	Neff Engineering
3	Mead Push-button	LTV-PBGF	1	$ 90.00	$ 90.00	MSC Direct (80187909)
4	ARO Valve	A212PS	1	$ 80.00	$ 80.00	MSC Direct (80121361)
5	ARO Counter	59095-1	1	$ 350.00	$ 350.00	MSC Direct (32142937)
6	Parker Linear Slide	CR4801	1	844.12	$ 844.12	MSC Direct (03370301)
7	Jergens Dowel Pin	31835	1	$ 6.59	$ 6.59	MSC Direct (73079634)
8	80/20 Cart	*Repurposed cart*	1	$ -	$ -	TSS FW
9	Cylinder Flange	6453K320	1	$ 22.94	$ 22.94	Mcmaster (6453K320)
10	Angle Finder	3353A67	1	$ 38.10	$ 38.10	Mcmaster (3353A67)
11	Toggle Clamp	5128A460	1	$ 24.84	$ 24.84	Mcmaster (5128A460)
12	Thumb Screw	93015A210	1	$ 7.61	$ 7.61	Mcmaster (93015A210)
13	Adjustment Handle	5580K110	2	$ 24.32	$ 48.64	Mcmaster (5580K110)
14	Dowel Pin .25 (10 pk)	97395A485	1	$ 11.99	$ 11.99	Mcmaster (97395A485)
15	10-32 Set Screw (25 pk)	92313A827	1	$ 3.76	$ 3.76	Mcmaster (92313A827)
16	10-32 x .75 SHCS (25 pk)	96006A693	1	$ 5.71	$ 5.71	Mcmaster (96006A693)
17	10-32 x .50 SHCS (25 pk)	96006A690	1	$ 9.36	$ 9.36	Mcmaster (96006A690)
18	10-32 x 1.00 SHCS (25 pk)	96006A696	1	$ 6.90	$ 6.90	Mcmaster (96006A696)
19	1" Dowel Pin	97352A974	1	$ 18.76	$ 18.76	Mcmaster (97352A974)
20	Linear Guide, small	60585K330	1	$ 55.35	$ 55.35	Mcmaster (60585K330)
21	Linear Guide, large	60585K760	1	$ 65.44	$ 65.44	Mcmaster (60585K760)
22	Aluminum Extrusion, 3x3x8	47065T811	1	$ 14.48	$ 14.48	Mcmaster (47065T431)
23	Spring Plunger	8686A192	1	$ 11.66	$ 11.66	Mcmaster (8686A192)
24	Hand Brake	60585K320	2	$ 15.50	$ 31.00	Mcmaster (60585K320)
25	Shaft Collar	5631T160	1	$ 25.48	$ 25.48	Mcmaster (5631T160)
				Total:	**$ 5,377.48**	

Ordered
Not Ordered
Received

[Figure 11: Master Purchase List]

Project Plan



[Figure 12: Gantt Chart]

Throughout the course of engineering the new scarf cutter for TSS, team two worked exceptionally well together. As you can see on the Gantt Chart above, the workload was divided into equal parts so all members were involved in each stage. All projected target dates were reached before or on time which verifies teamwork, communication, and preparation were all taken into great consideration.

Conclusion

The machine was easily introduced into the production enviornment and was able to make an immediate positive impact on productivity and efficiency. With the new machine, the set up time was much less than the previous machine that was in use. The implementation of this machine has made it possible to have a completed part built before it leaves the respective CNC machining cell. We also gathered feedback from the operators who unanimously agreed that the machine was much more comfortable to operate, immensely safer, and only took a fraction of the time to set-up in comparison to the previous machine. The set up time was decreased from ten minutes (benchmarked machine) to four minutes on the newly implemented machine. Not only did we accomplish all of our design improvement goals, but managed to do so while staying significantly under budget.

<u>What we have completed</u>

- Complete Machine Design
- Assembly of all components
- Official testing of machine
- Targeted areas for improvement
- Capability Test
- Evaluation of Set-Up Procedue
- Safety Assesment
- Release machine for production

References

The following references were used during the design phases for specifications of components that were used in the final assembly:

- McMaster-Carr at http://www.mcmaster.com
- MSC Industrial Supply Co. at http://www.mscdirect.com
- PHD Inc. at https://www.phdinc.com
- Parker Motion at http://www.parkermotion.com