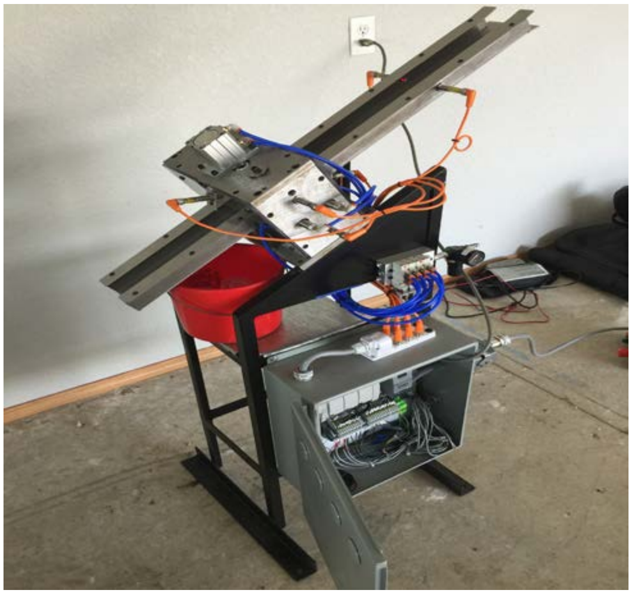
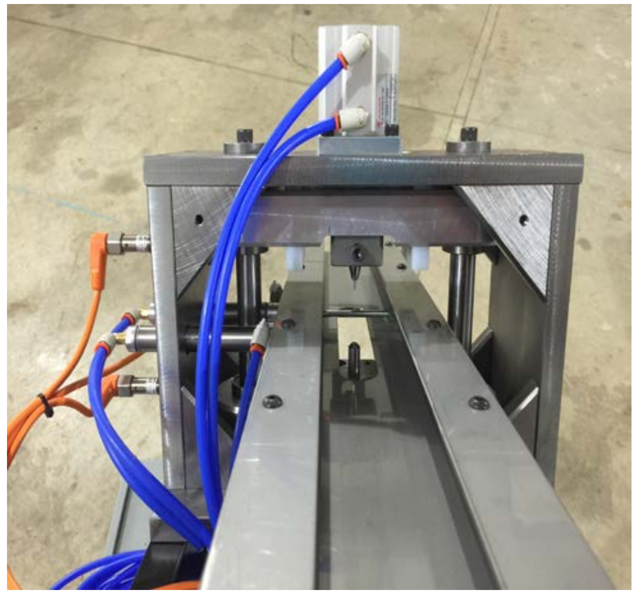
Flex Spout Punch Assembly





Final Project Report

4/27/15

Senior Design Team:

Mike Woodcock

Scott Vorndran

Carl Garringer

MET 494 Senior Design and Analysis
Department of Mechanical Engineering Technology
Indiana University-Purdue University Fort Wayne, Indiana

Preface

This document explains the procedures used to create a vent hole in the spouts produced by rieke Packaging Systems found in five gallon bucket and similar pail lids. The flex spout punch assembly will replace the automated drill equipment. The drill equipment currently used today has several areas that affect production of the vented spout body. These areas span from plastic debris control to the ability to meet the production needs of rieke Packaging Systems.

The flex spout punch assembly will be able to utilize the feed system of the current drill equipment or allow for a new work cell to be developed. The punch assembly incorporates an entirely new method for producing the vent holes in the spouts. The new system will reduce the amount of scrap produced as well as eliminate plastic debris from getting into the final product packaging.

Throughout the course of this project, the team learned many new concepts in addition to applying several relevant courses taught in the Mechanical Engineering Technology curriculum. The customer for this project, rieke Packaging Systems, voiced their needs, and the team created a new design based on their requirements. The team learned to expound on each other's talents, yet work cohesively together to efficiently complete this project.

The teamwork aspect of the project went very well with the workload being divided among the team members equally and fairly. Each team member brought a different set of talents to the team that ultimately culminated in a successful design and build for the customer.

The team would like to personally thank rieke Packaging Systems for this opportunity as well as for sponsoring this project. We would also like to thank Kris Heiman (rieke Packaging Systems) for his willingness to assist the team with much of the electrical and programming aspects of this project.

Table of Contents

Introduction

Abstract

Some pour spouts on five gallon buckets lids require vent holes so that product can vent through these holes during shipment and storage without causing a rupture in the containers. These vented spouts supplied by rieke Packaging Systems are created using a drill process. The drill process does not have the ability to meet the capacity needs of the plant. The process is prone to drill bit breakage, requiring additional setup and operator interaction to verify that broken drill bits do not enter final packaging. Tool life is minimized from drill bit breakage and the material composition of the spout. In order to maximize the tool life of the drill equipment, rieke Packaging Systems has exhausted attempts to improve drill bit quality and has resorted to slowing the speed of the drill, causing poor vent hole quality. Poor vent quality requires additional operator involvement. Operators have gone from a visual vent inspection to probe inspections, adding costs to the process. The drill process produces random exit points of the drill shaving debris. The random exit points make control and collection of the debris for recycling virtually impossible. In addition, the debris has a tendency of finding its way into the final packaging.

Mike Woodcock, an employee of rieke Packaging Systems, brought this idea for a senior design project to the team's attention. He coordinated a site visit where we were able to evaluate the impending project and determine the project's feasibility. After the team decided that this project was within the scope of our Senior Design syllabus, we immediately began formulating a solution to rieke's vent hole problem. Our solution was the flex spout punch assembly.

Purpose

With a clear understanding of the problems rieke Packaging Systems has with adding vents to the flex spouts, the team outlined the following performance specifications the new process needed to address:

- Low production rates
- Poor vent hole quality
- Too much operator interaction
- Shortened tool life
- Plastic debris control
- Tool changes & maintenance

The team determined a punch system would be the best solution for all the issues the current process does not address. In addition to the issues mentioned above, the new design needed to incorporate automated part detection and PLC control in order to accomplish all the goals of the project. This equipment also needed the ability to be incorporated to the current part feed system or function as a stand-alone work cell.

Design Overview

Design

The flex spout punch assembly foot print was determined by the existing drill equipment. This design allowed us to accomplish the footprint goals of direct replacement into the current feed system, or as a supplemental work station if so desired by our sponsors. The team determined a punch system would be the best solution for controlling plastic debris due to a single exit point. The punch system will extend tool life because it is a more robust system when compared to an unsupported drill bit and our knowledge of column buckling. The punch system design uses catalog available parts to minimize tool replacement cost, and facilitates tool replacement and maintenance.

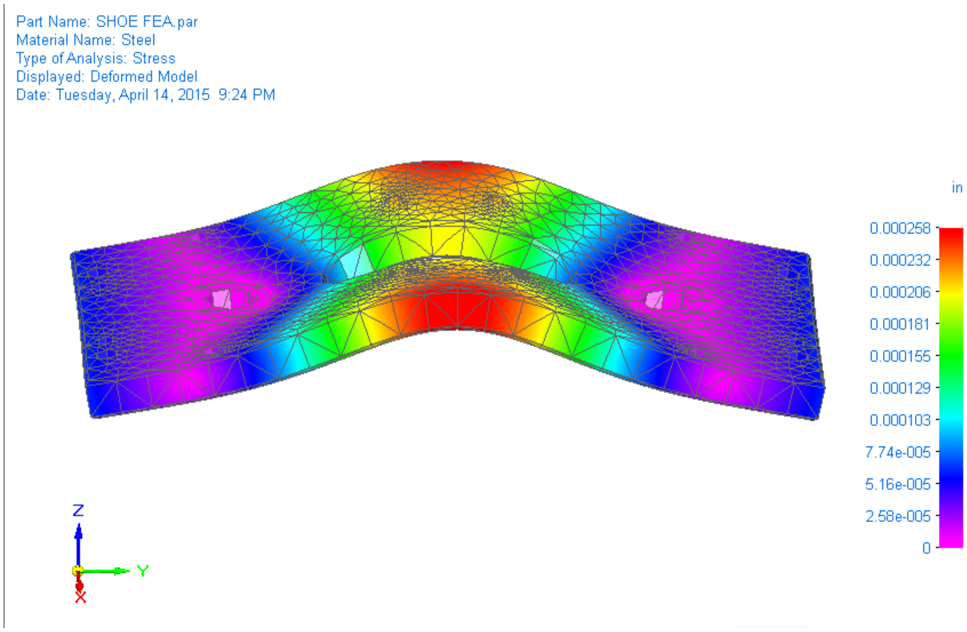
The biggest challenge was getting the die into the recessed portion of the spout. Generally speaking, punching operations are performed on flat materials. This meant the team needed a moveable die shoe and punch shoe. The die shoe needed to be able to handle the forces created by the punching action. In order to limit operator interaction with the system, it needed to be operator independent, which meant it would use photo eyes and limit switches controlled by a PLC.

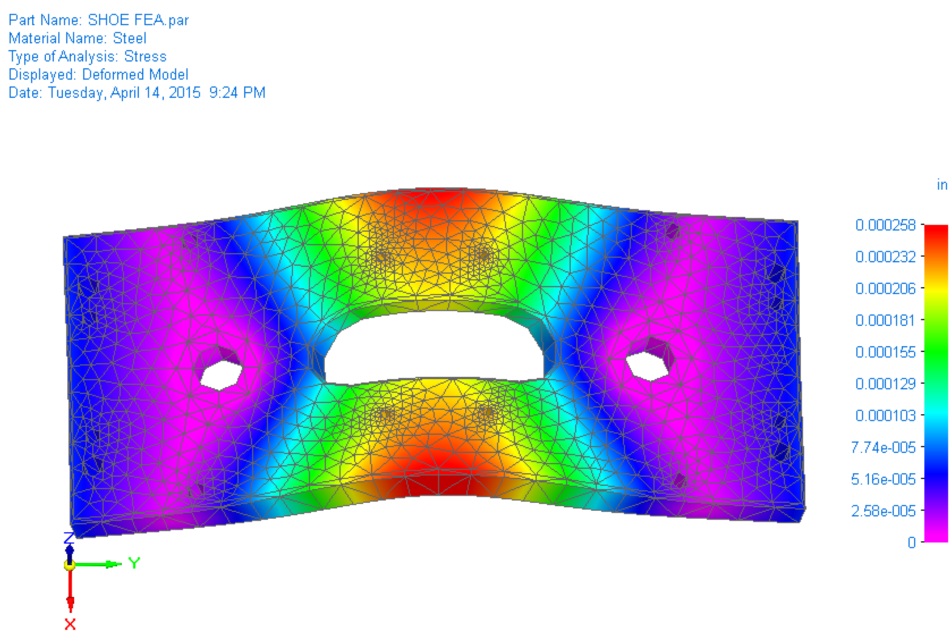
PLC Control

This punch assembly utilizes pneumatic cylinders to raise and lower die shoes that contain a die button and a punch. When a spout is located directly below the punch, it breaks the beam of a photo eye and a signal from the PLC extends the die button into the spout's lower cavity. A proximity switch senses when the button is in position and signals the PLC to extend the punch into the upper cavity of the spout, punching a vent hole in the spout. When the proximity sensor detects the punch in the fully extended position, both cylinders are retracted by the PLC to their home positions. The two locating cylinders extend and retract according to the signal received by the part present photo eyes, allowing the punched part to continue down the slide and a new part to take its place under the punch. This cycle continues until the photo eyes in the upper section of the slide fail to detect a part, if a load error occurs, or if a punch-die position proximity sensor cycle has not been completed at the punch station.

Finite Element Analysis

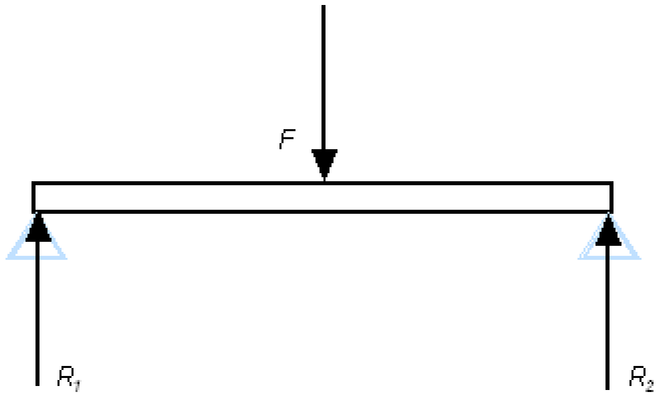
The finite element analysis shows 0.00026" deflection in the die shoe. This analysis confirmed the calculated deflection.





Calculations

Die Shoe Deflection:



$$\Delta_{max} = \frac{PL^3}{48EI}$$

$$Force\ of\ cylinder = \ Pressure\ x\ area = \frac{60\ lb}{in^2}\ x\ \frac{(\pi)(1.575\ in)^2}{4} = 117\ lb$$

$$I_x = \frac{bh^3}{12} = \frac{(2.5\ in)(.985\ in)^3}{12} = \ .199\ in^4$$

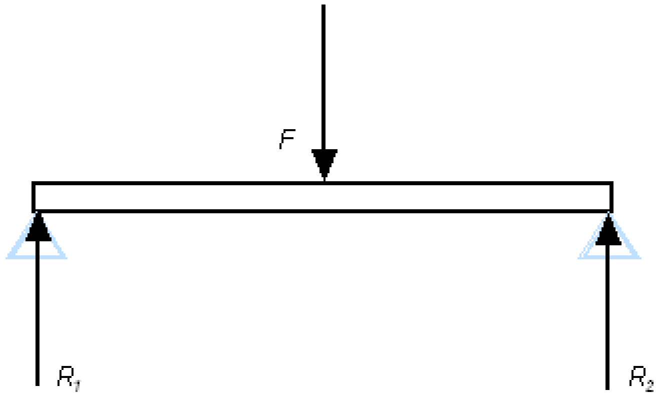
$$E_{6061\ aluminum} = \frac{10.0\ x\ 10^6\ lb}{in^2}$$

$$L = 3.07\ in$$

$$\Delta_{max} = \frac{(117\ lb)(3.07\ in)^3(in^2)}{48(10.0\ x\ 10^6\ lb)(.199\ in^4)} = \ .00004\ in$$

.00004” deflection will not affect our tooling design.

Top Plate Deflection:



$\Delta_{max} = \frac{PL^3}{48EI}$

$$Cylinder\ bore\ \emptyset = 40mm\ x\ \frac{1\ in}{25.4\ mm} = 1.575\ in$$

$$Regulated\ air\ pressure = \frac{60\ lb}{in^2}$$

$$Force\ of\ cylinder\ P = \ pressure\ x\ area = \frac{60\ lb}{in^2}\ x\ \frac{(\pi)(1.575\ in)^2}{4} = 117\ lb$$

$$I_x = \frac{bh^3}{12} = \frac{(3.5\ in)(.625\ in)^3}{12} = \ .071\ in^4$$

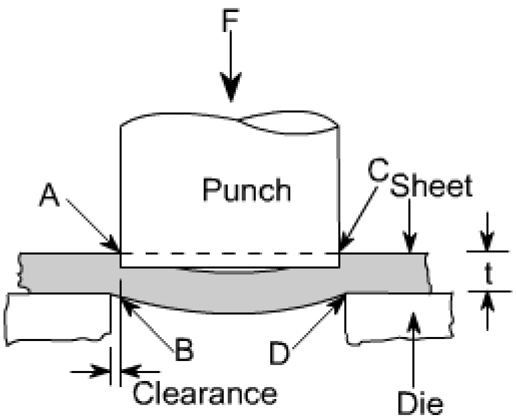
$$E_{steel} = \frac{30\ x\ 10^6\ lb}{in^2}$$

$$L = 6.5\ in$$

$$\Delta_{max} = \frac{(117\ lb)(6.5\ in)^3(in^2)}{48(30\ x\ 10^6\ lb)(.071\ in^4)} = \ .0003\ in$$

.0003” deflection will not affect our tooling design.

Punch Force Calculation:



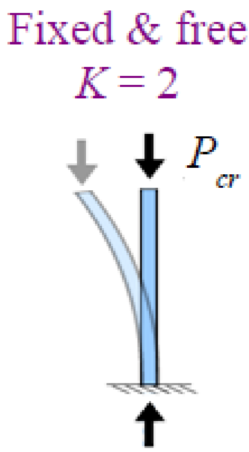
$Thickness\ T = .060\ in$

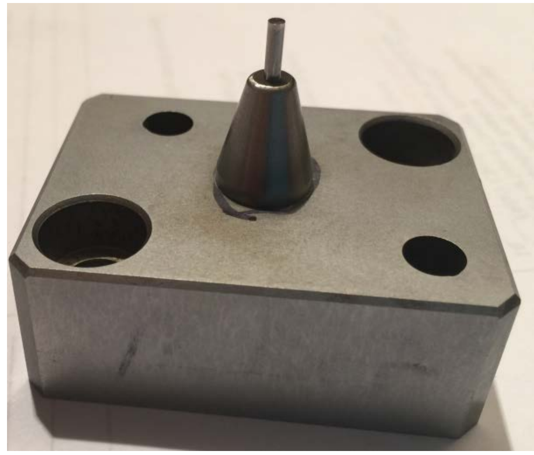
$Length\ of\ cut\ L = \pi d = (\pi)(.070\ in) = .22\ in$

$Shear\ strength\ of\ material\ S = \dfrac{4350\ lb}{in^2}$

$Punch\ force\ F = TLS = \dfrac{(.060\ in)(.22\ in)(4350\ lb)}{in^2} = 57.4\ lb$

Punch - Column Buckling Calculation





Excel Macro for Column Buckling

Column Analysis Program				Data from:		
				Use consistent U.S. Customary Units		
Ø.070" M-2 Punch				**Computed Values:**		
Data to Be Entered:						
Length and End Fixity:						
Column Length, L =	0.25	in				
End fixity, K =	2		→	Eq. Length, L_e= KL =	0.5	in
Material Properties:						
Yield Strength, S_y=	471000	psi				
Modulus of elasticity, E=	30000000	psi	→	Column constant, C_c=	35.5	
Cross Section Properties:						
[Note: Enter r or compute r = sqrt(I/A)						
[Always enter Area]						
[Enter zero for I or r if not used.]						
Area, A =	0.003848451	in^2				
Moment of inertia, I =	0	in^4				
Or						
Radius of gyration, r =	0.0175	in	→	Slender Ratio, KL/r =	28.6	
				Column is:	**short**	
Design Factor:				**Critical buckling load =**	**1,224**	**lb**
Design factor on load, N =	3		→	**Allowable load =**	**408**	**lb**

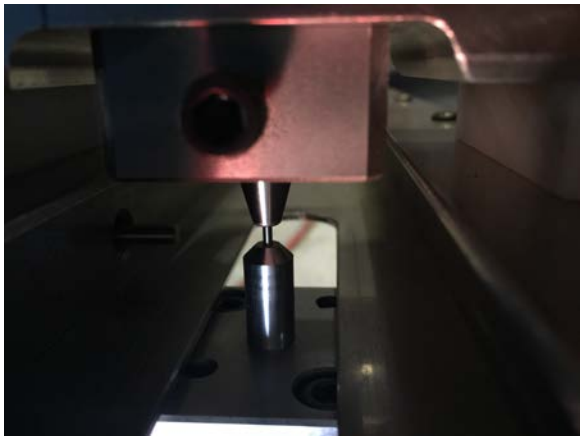
With a design factor of 3, our allowable load of 408 lbs. is greater than the punch force of 57.4 lbs. required to punch the hole in the material. Therefore, the punch will not buckle from the force.

Testing

Testing Results

The initial testing of the punch assembly verified that the punch and die were aligned correctly. With only .002” per side die clearance, alignment was critical. To accomplish this, we assembled the punch assembly components and manually moved the punch and die shoes to verify punch and die alignment. After determining there wasn’t any tool shear, we connected air to the tool and cycled the locating cylinders as well as the punch and die cylinders. The next test procedure punched a piece of paper to see how clean of a hole the tool was capable of producing. The final test checked the hole quality produced in the spouts. We cycled several parts looking for burrs around the holes, slug conditions, and we verified the slugs exited as planned.

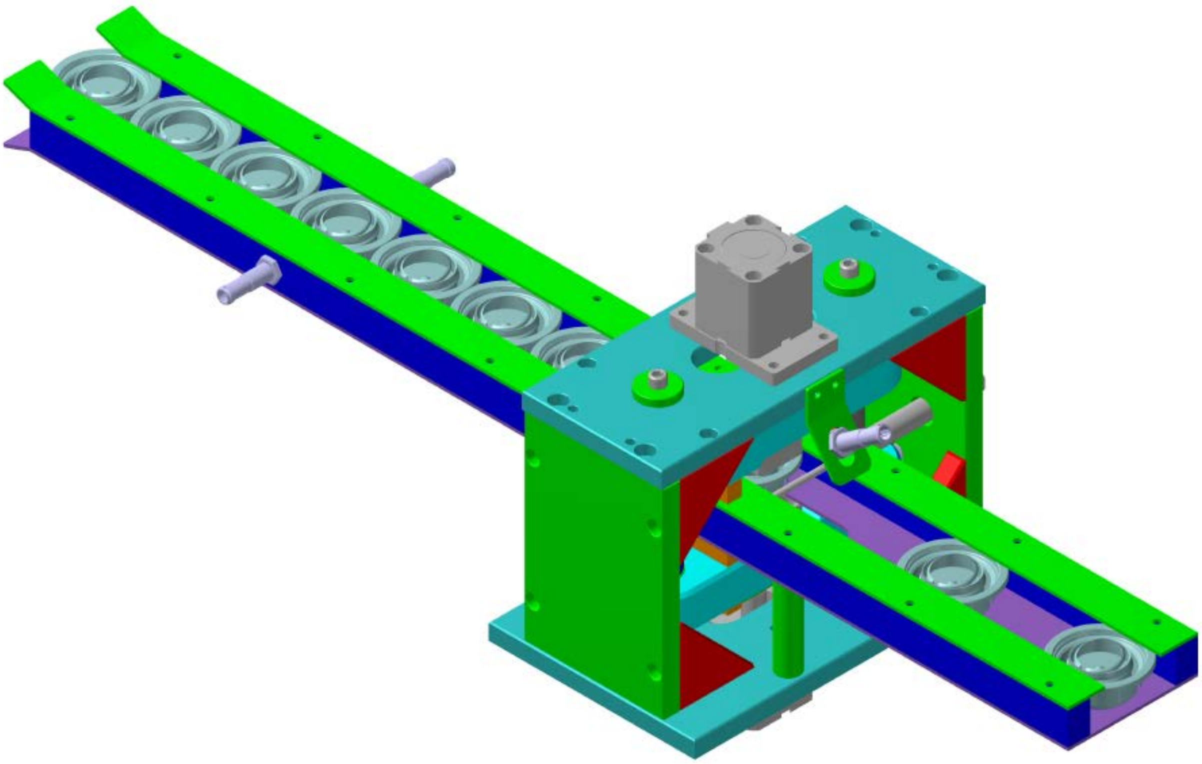
Per the trial testing, the new punch operation was capable of producing one part per second. This equates to 28,880 per shift.



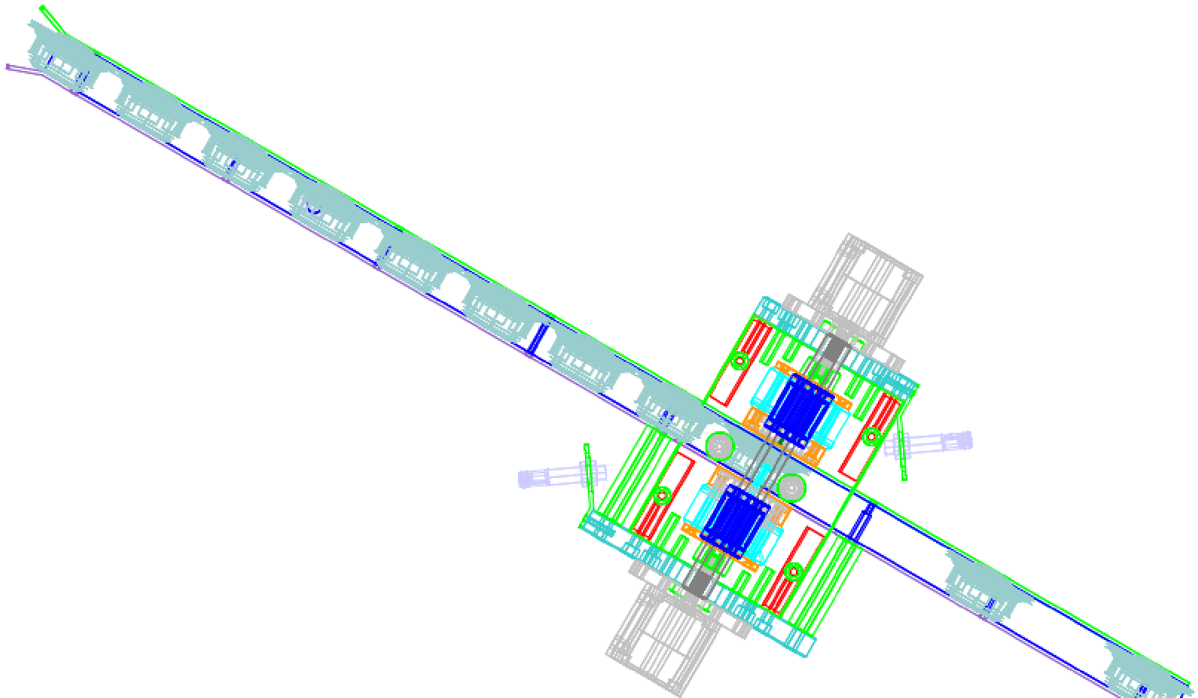
Models

Model Sketches

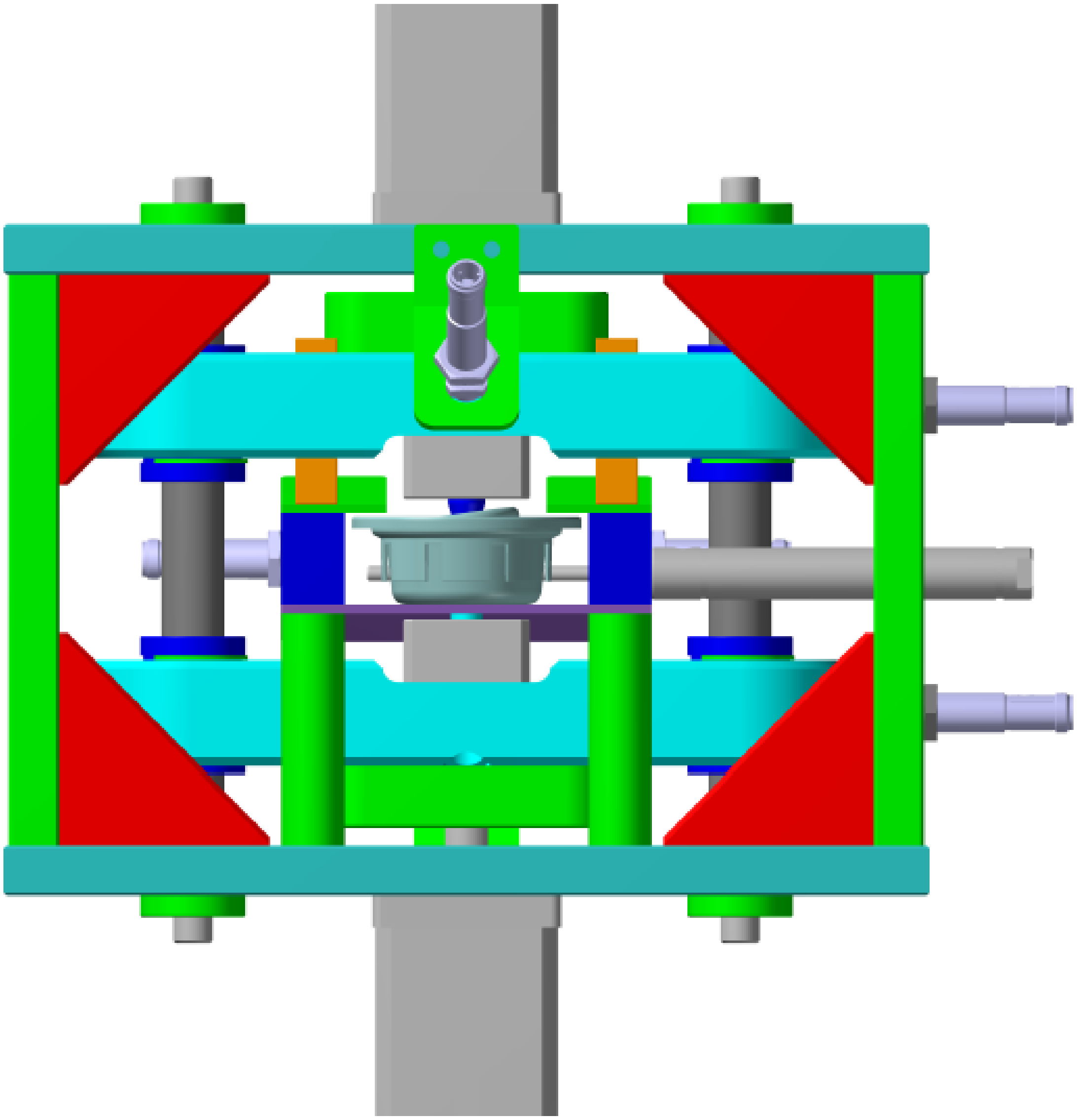
<u>Isometric view</u>



Front View (In machine position)

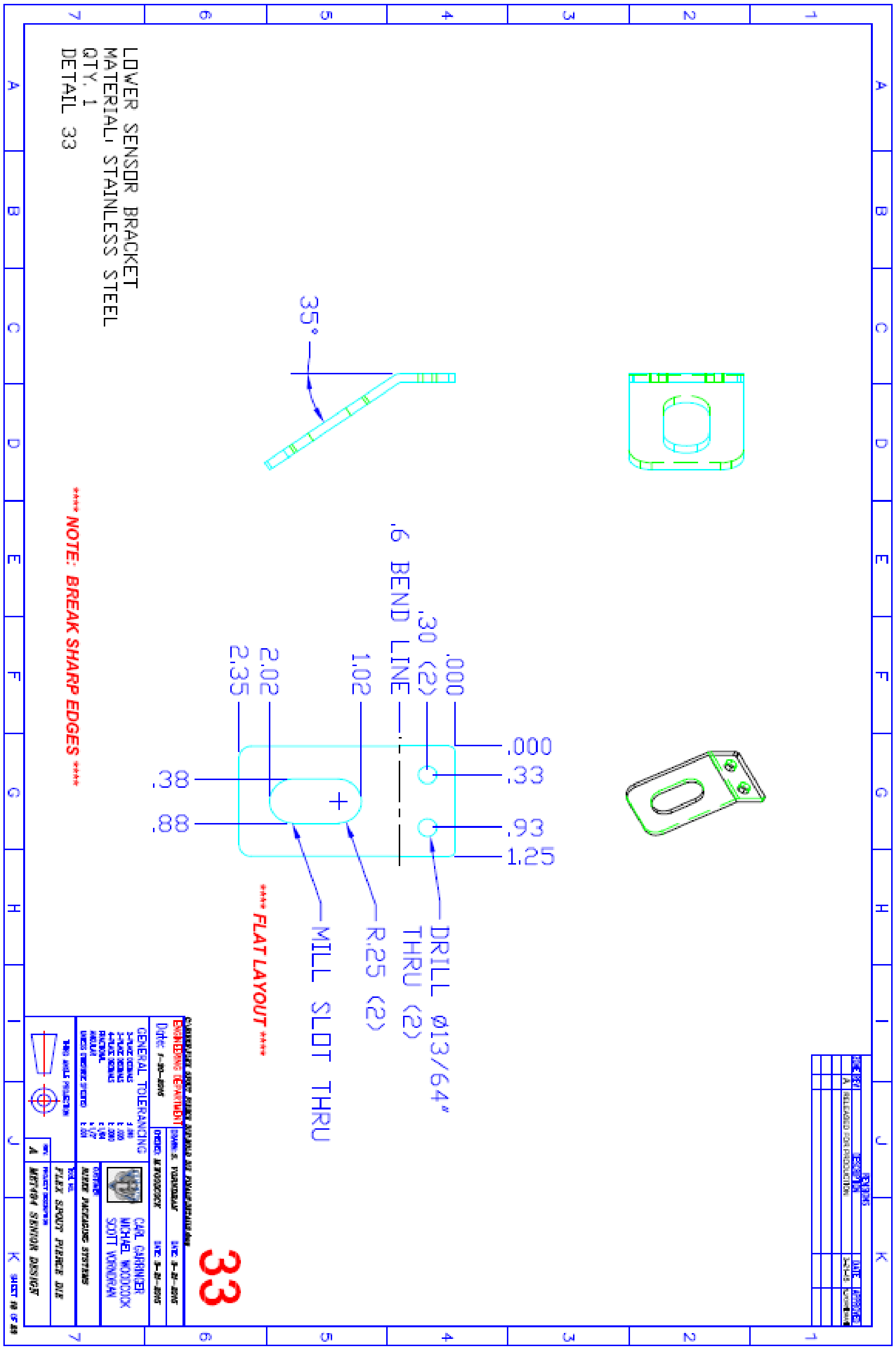


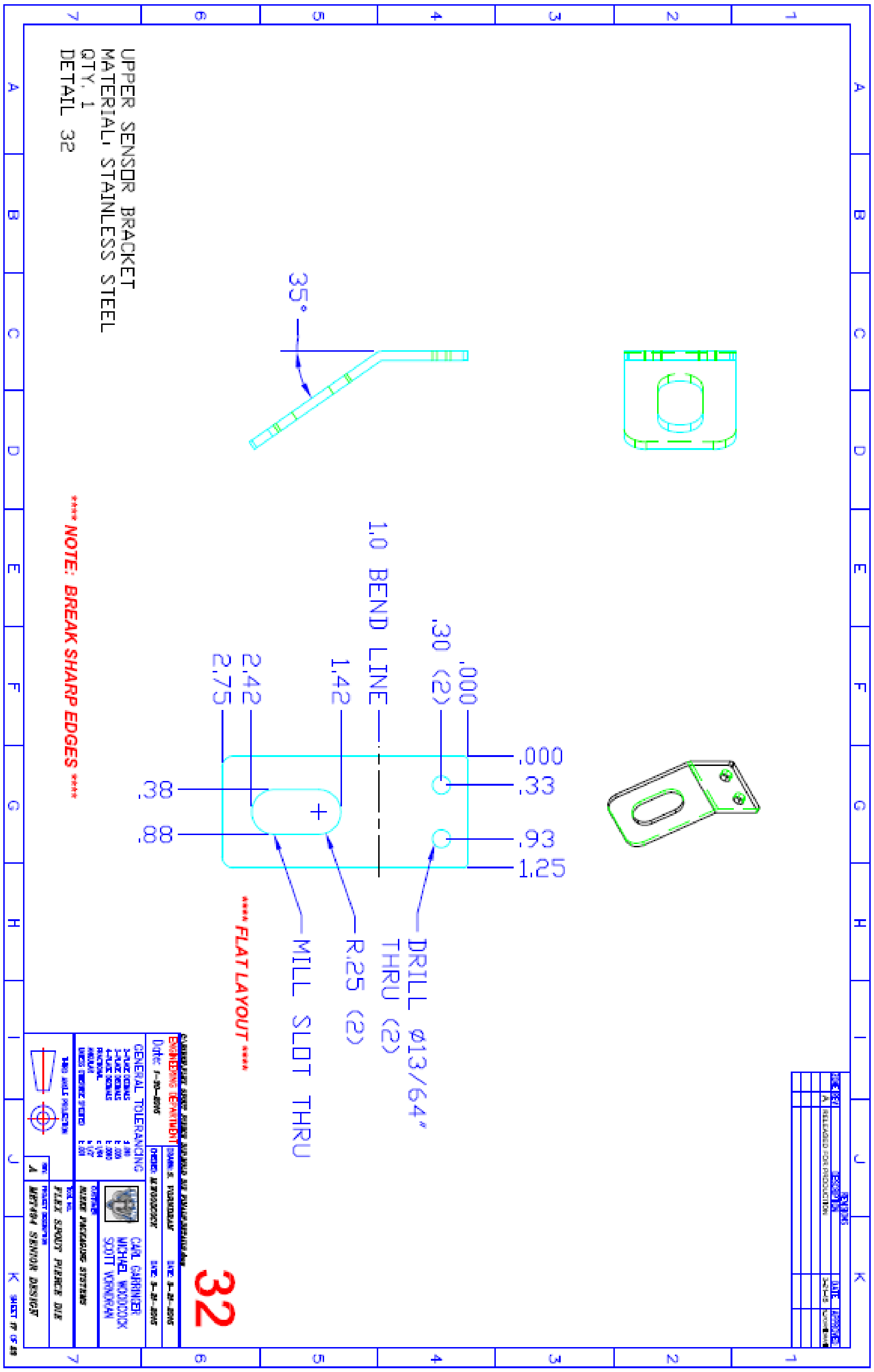
Side View

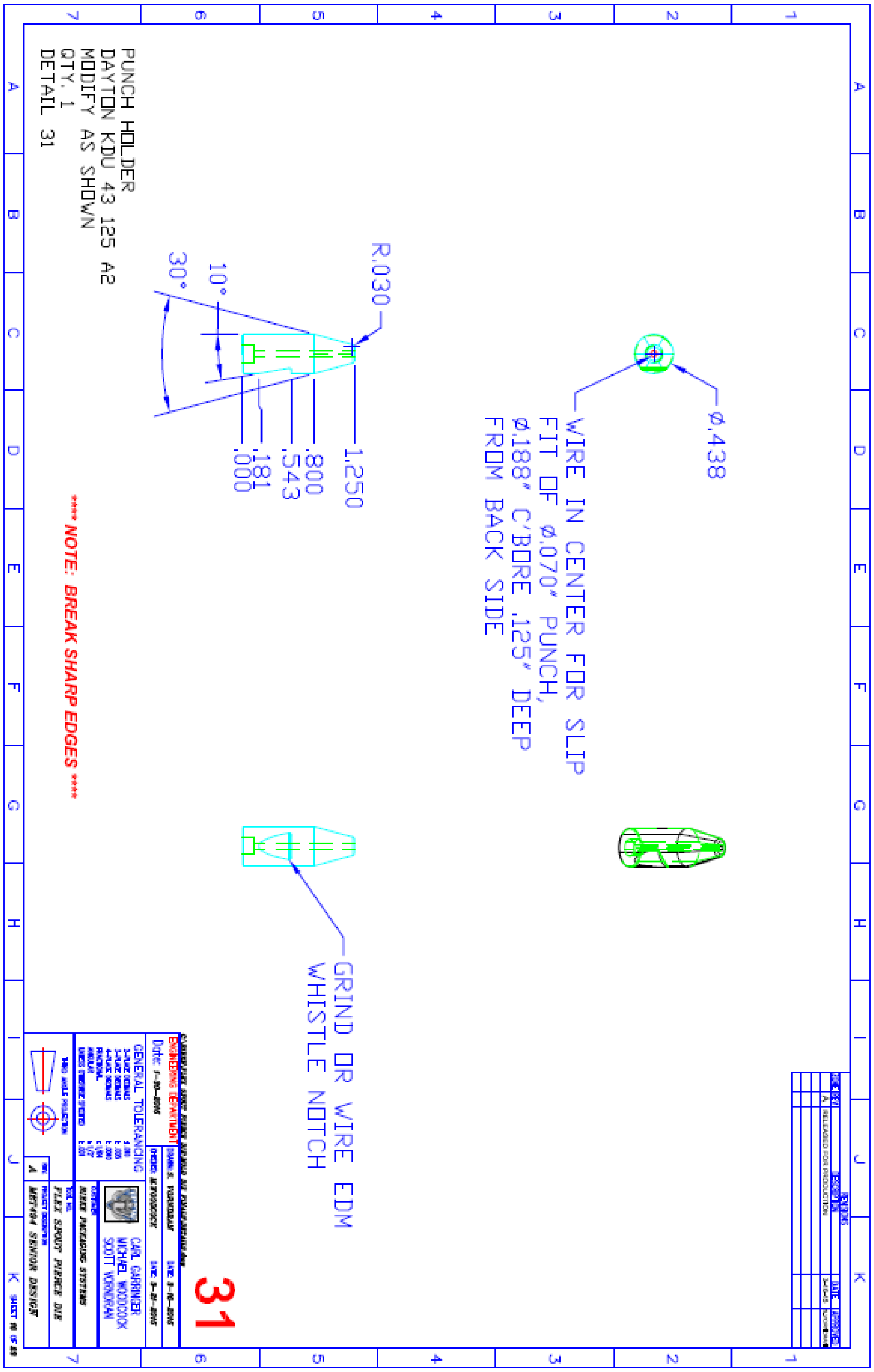


Drawings

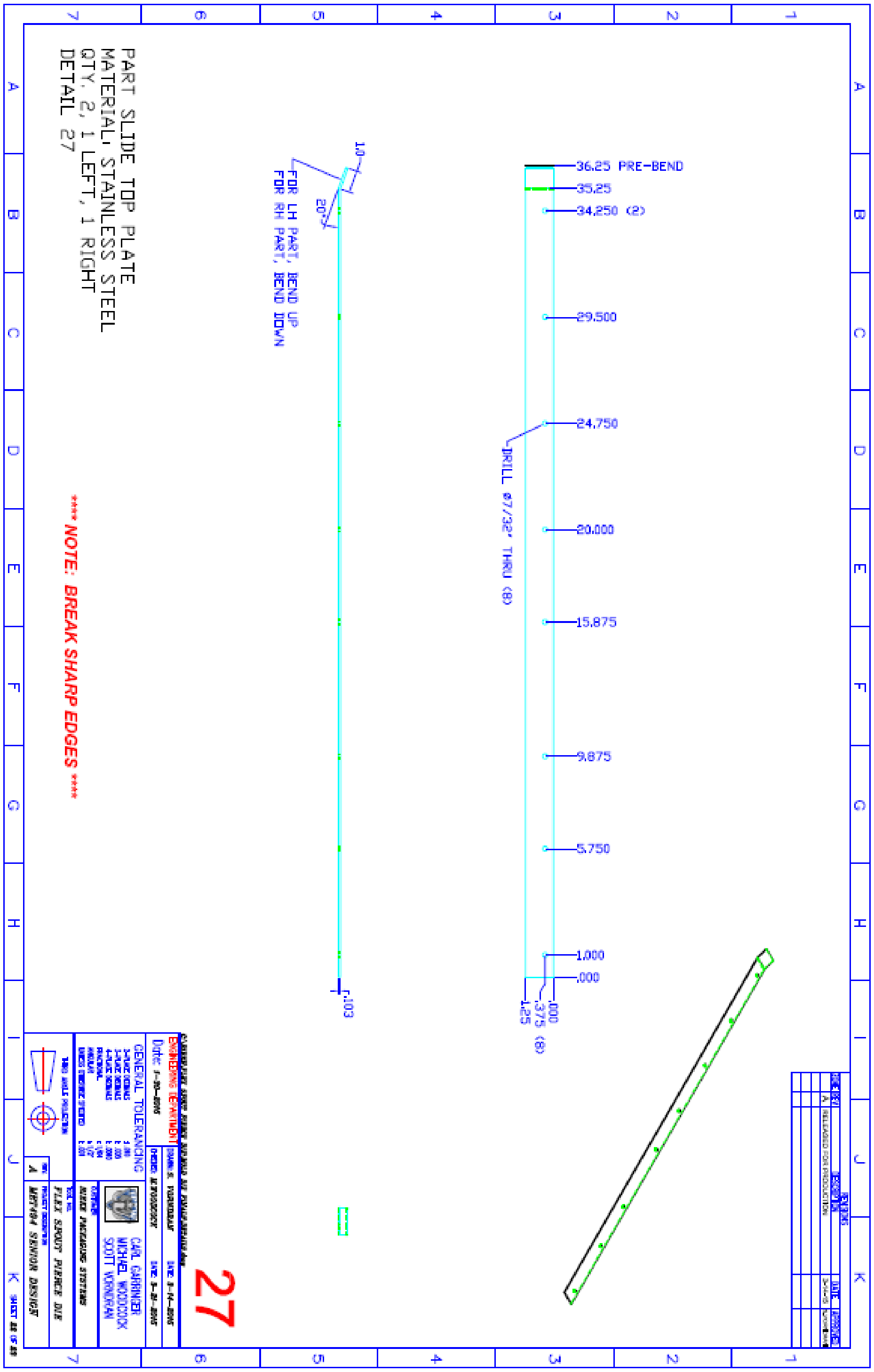
Component Drawings

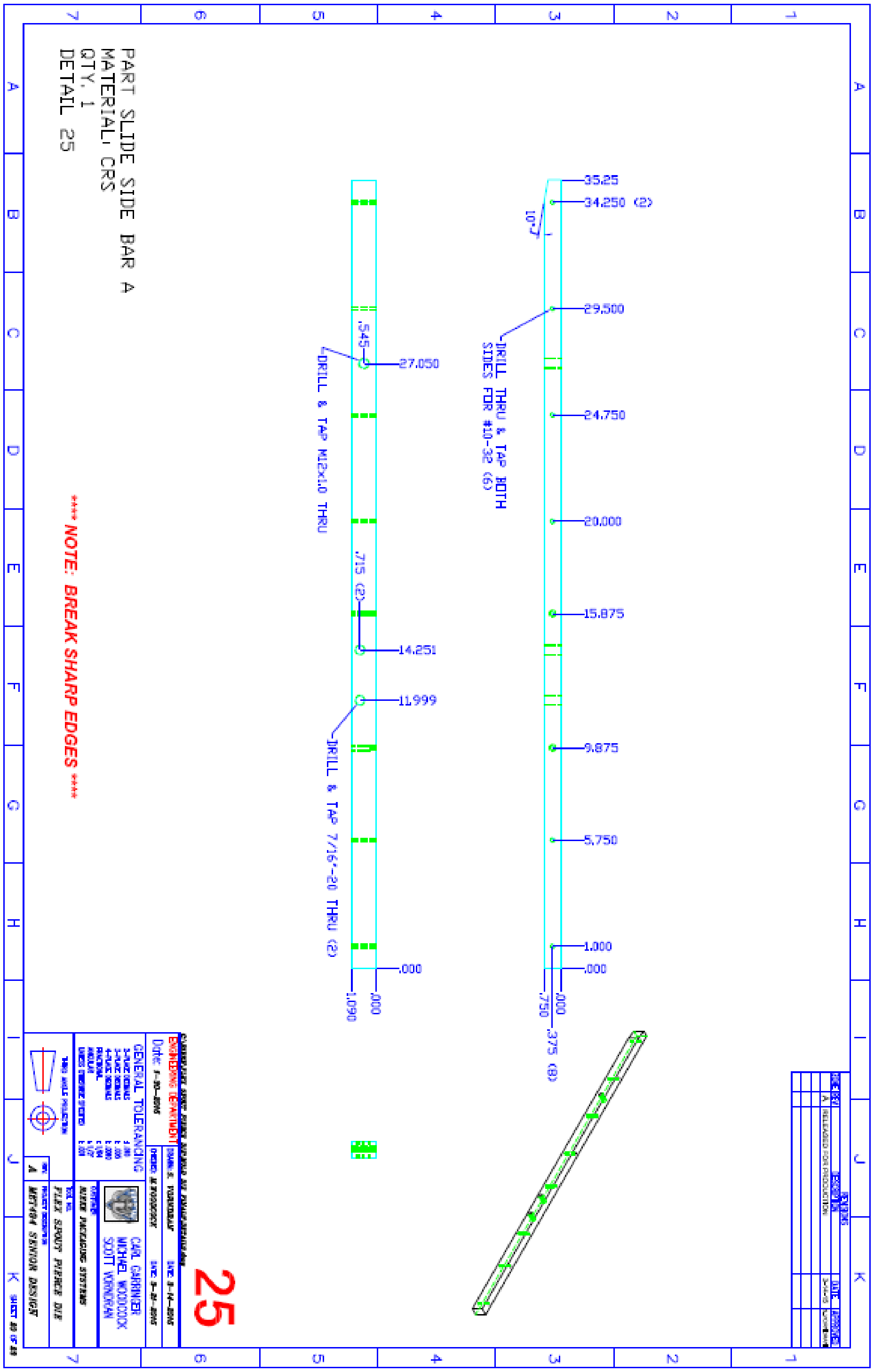


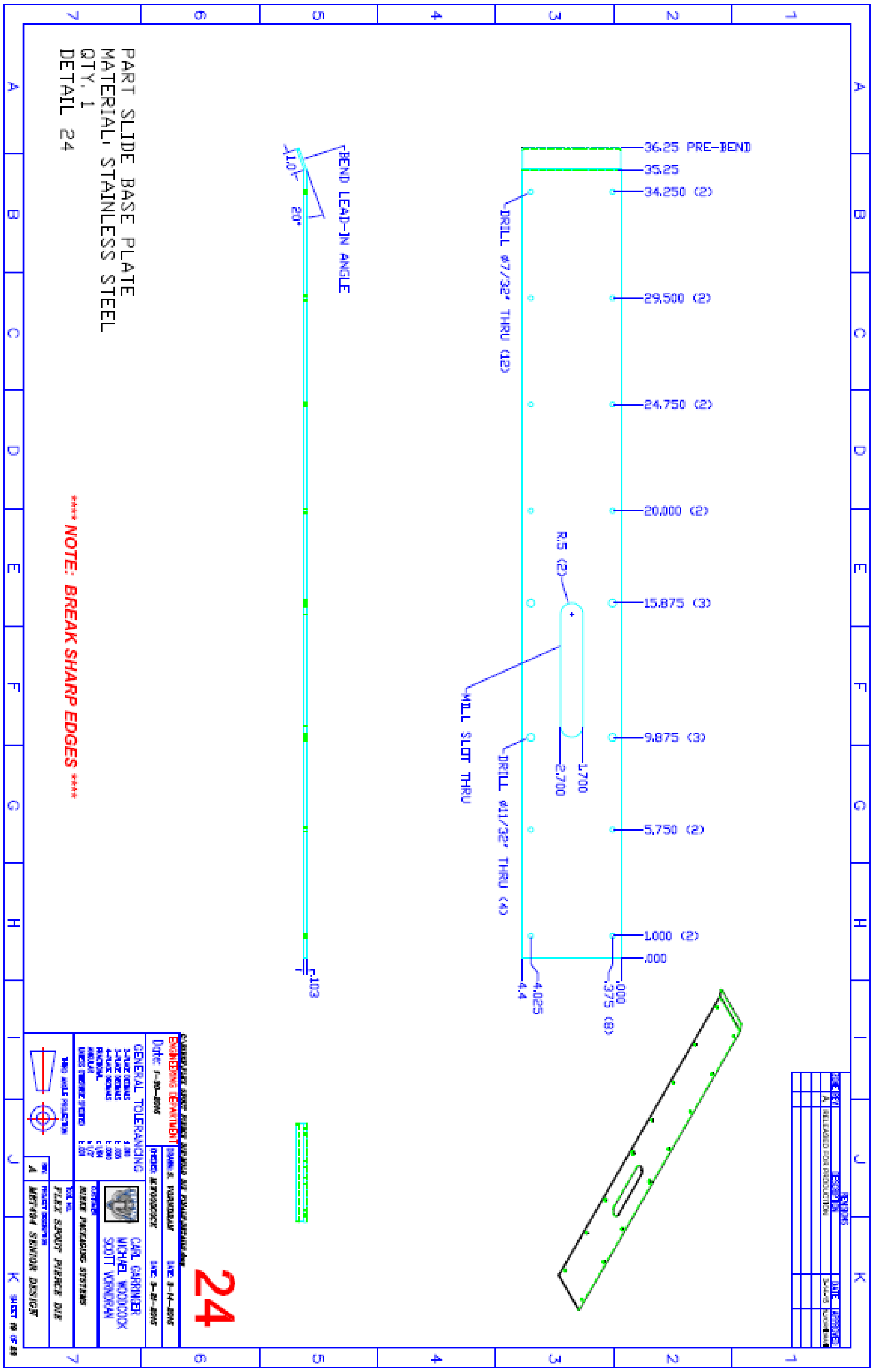

UPPER SENSOR BRACKET
MATERIAL STAINLESS STEEL
QTY. 1
DETAIL 32
35°
1.0 BEND LINE
.000
.30 (2)
1.42
2.42
2.75
.000
.33
.93
1.25
.38
.88
DRILL Ø13/64"
THRU (2)
R.25 (2)
MILL SLOT THRU
**** FLAT LAYOUT ****
**** NOTE: BREAK SHARP EDGES ****
GENERAL TOLERANCING
32



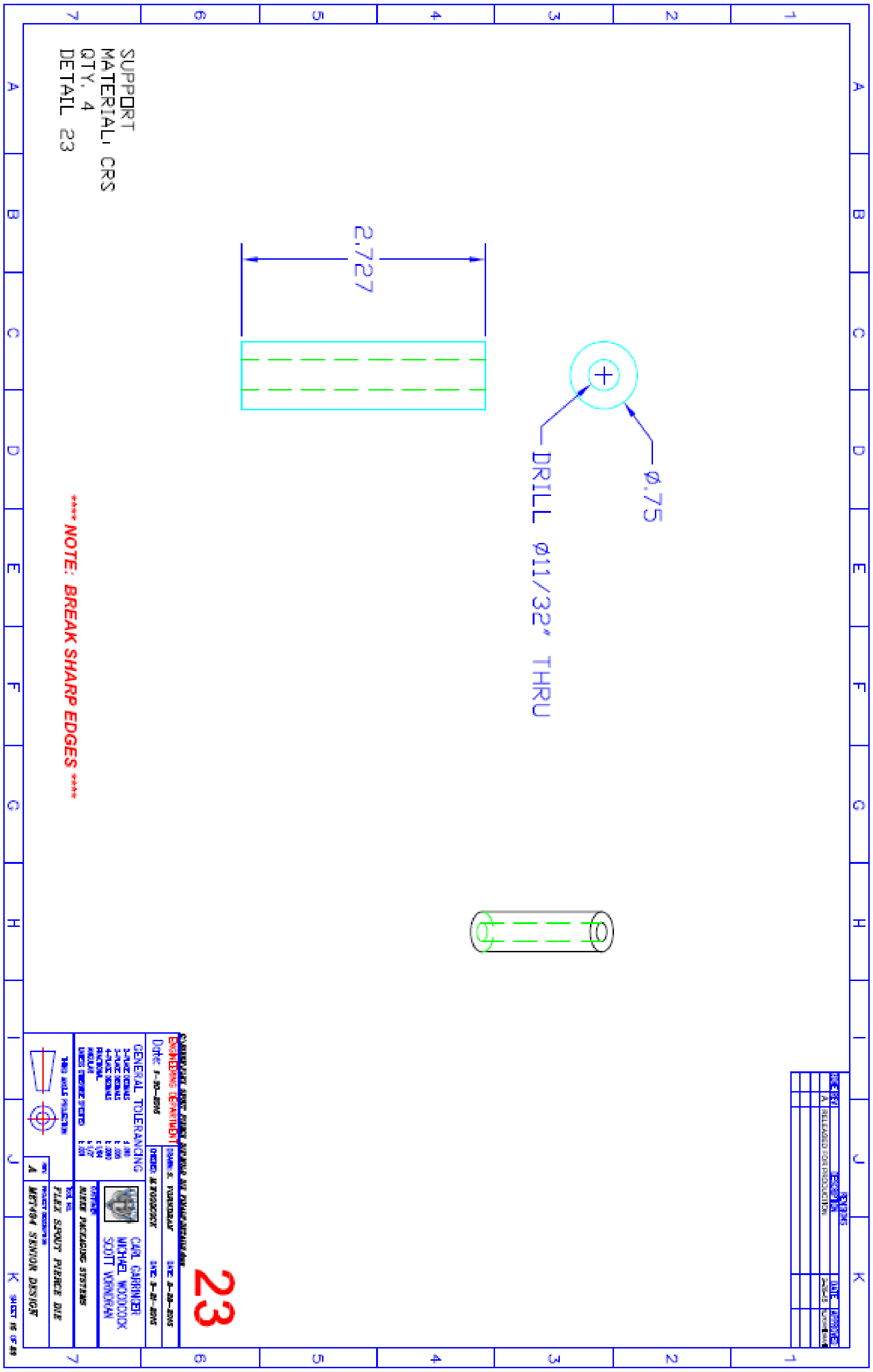
PUNCH HOLDER
DAYTON KDU 43 125 A2
MODIFY AS SHOWN
QTY. 1
DETAIL 31
R.030
10°
30°
1.250
.800
.543
.181
.000
Ø.438
WIRE IN CENTER FOR SLIP
FIT OF Ø.070" PUNCH,
Ø.188" C'BORE .125" DEEP
FROM BACK SIDE
GRIND OR WIRE EDM
WHISTLE NOTCH
**** NOTE: BREAK SHARP EDGES ****
31
ENGINEERING DEPARTMENT
GENERAL TOLERANCING
CARL GARRINGER
MICHAEL WOODCOCK
SCOTT VORNDRAN
FLEX SPOUT PIERCE DIE
MET494 SENIOR DESIGN
RELEASED FOR PRODUCTION


PART SLIDE TOP PLATE
MATERIAL: STAINLESS STEEL
QTY. 2, 1 LEFT, 1 RIGHT
DETAIL 27
**** NOTE: BREAK SHARP EDGES ****
FOR LH PART, BEND UP
FOR RH PART, BEND DOWN
1.0
20°
.103
36.25 PRE-BEND
35.25
34.250 (2)
29.500
24.750
20.000
15.875
9.875
5.750
1.000
.000
.000
.375 (8)
1.25
DRILL Ø7/32" THRU (8)
GENERAL TOLERANCING
CARL GARRINGER
MICHAEL WOODCOCK
SCOTT VOORHEAN
FLEX SPOUT PIERCE DIE
27

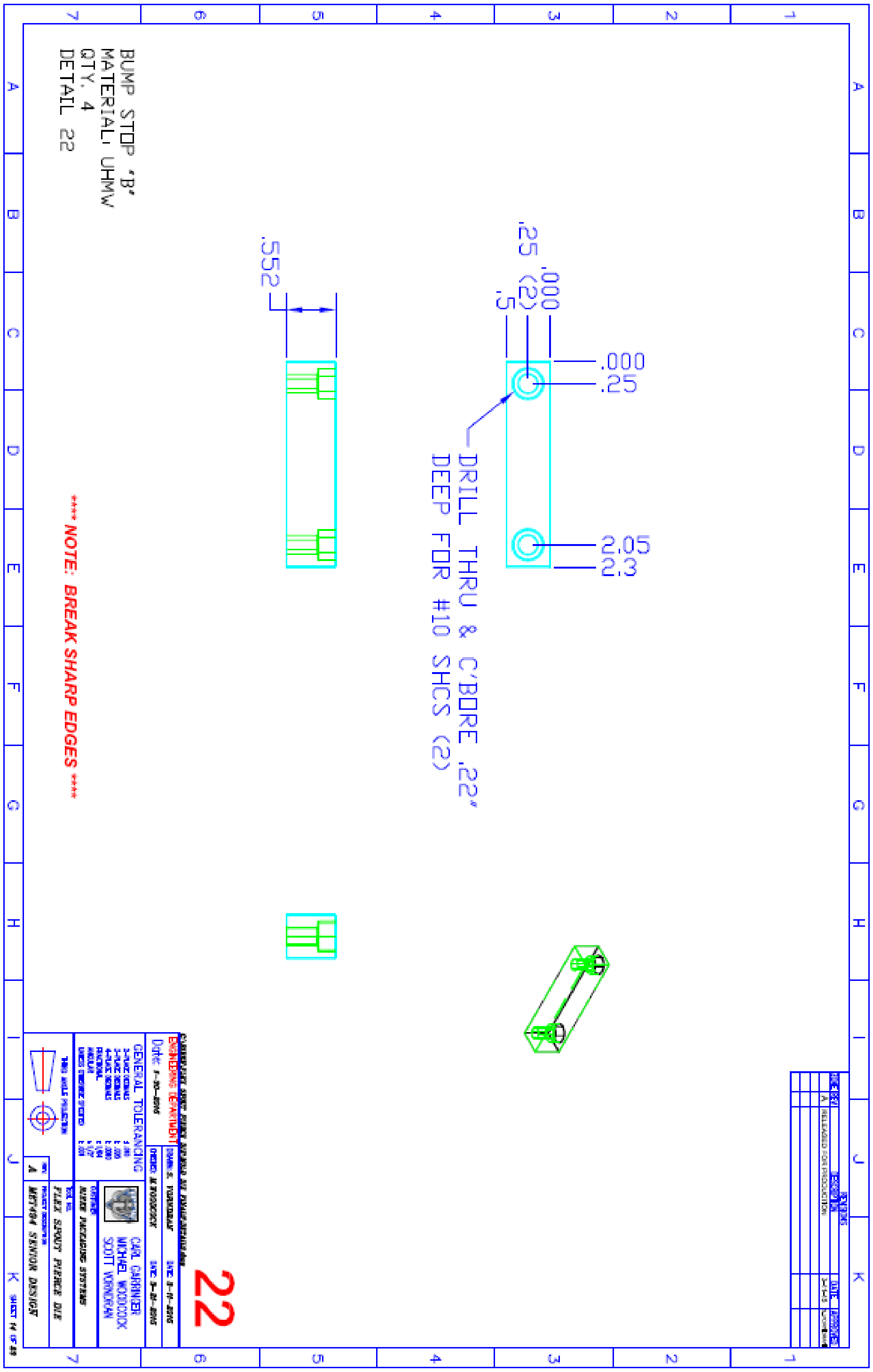

PART SLIDE SIDE BAR A
MATERIAL CRS
QTY. 1
DETAIL 25
**** NOTE: BREAK SHARP EDGES ****
DRILL THRU & TAP BOTH SIDES FOR #10-32 (6)
DRILL & TAP M12x1.0 THRU
DRILL & TAP 7/16"-20 THRU (2)
35.25
34.250 (2)
29.500
24.750
20.000
15.875
9.875
5.750
1.000
.000
.750
.375 (8)
10°
.545
27.050
.715 (2)
14.251
11.999
1.090
GENERAL TOLERANCING
ENGINEERING DEPARTMENT
CARL GARDNER
MICHAEL WOODCOCK
SCOTT VOORMAN
FLEX SPOUT PIERCE DIE
MET494 SENIOR DESIGN
25



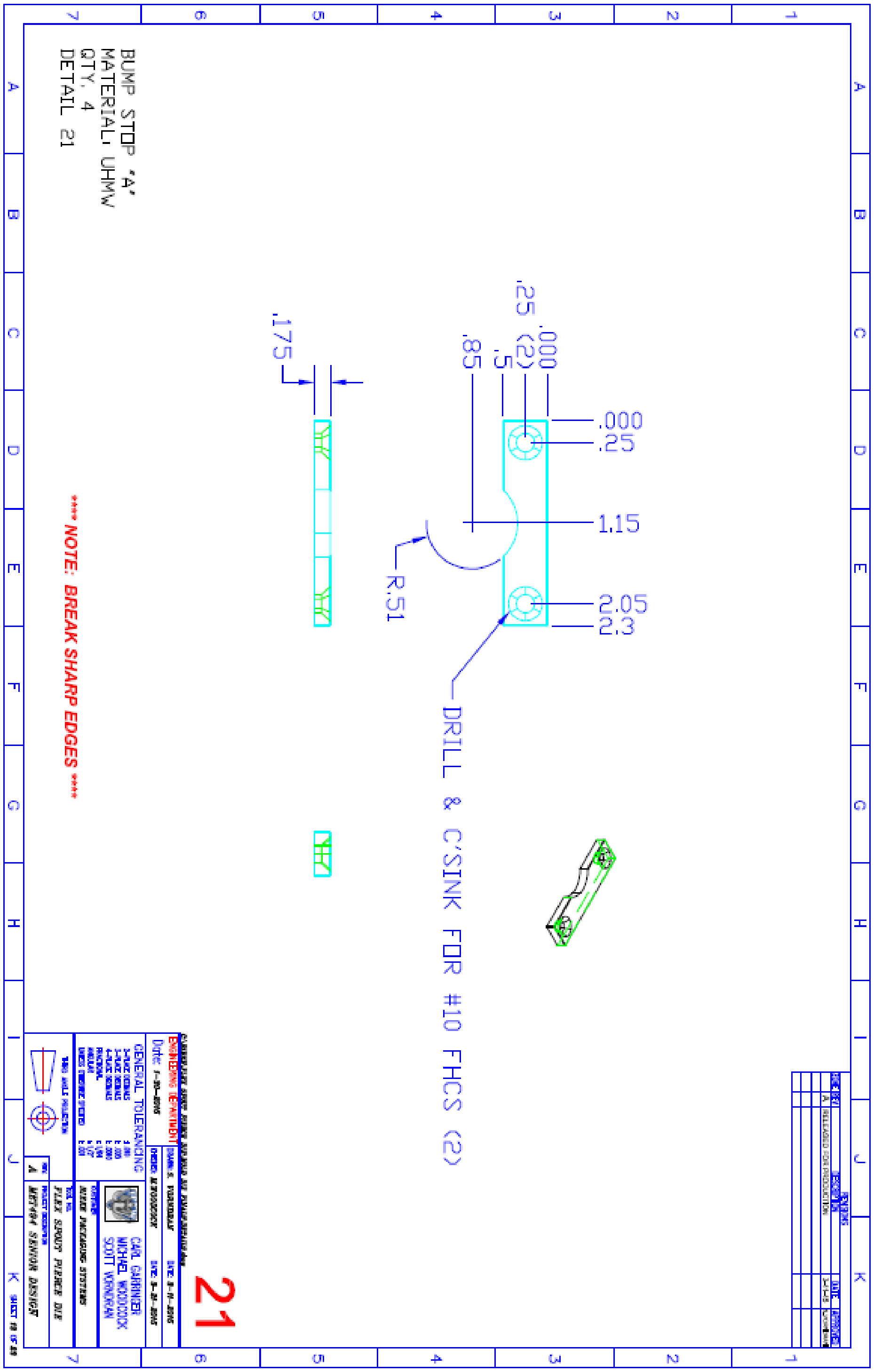
PART SLIDE BASE PLATE
MATERIAL STAINLESS STEEL
QTY. 1
DETAIL 24
*** NOTE: BREAK SHARP EDGES ***
BEND LEAD-IN ANGLE
20°
.103
36.25 PRE-BEND
35.25
34.250 (2)
29.500 (2)
24.750 (2)
20.000 (2)
15.875 (3)
9.875 (3)
5.750 (2)
1.000 (2)
.000
DRILL ⌀7/32" THRU (12)
DRILL ⌀11/32" THRU (4)
MILL SLOT THRU
R.5 (2)
1.700
2.700
4.025
4.4
.000
.375 (8)
24
GENERAL TOLERANCING
CARL GARRINGER
MICHAEL WOODCOCK
SCOTT VORNDRAN
FLEX SPOUT PIERCE DIE
MET404 SENIOR DESIGN
RELEASED FOR PRODUCTION

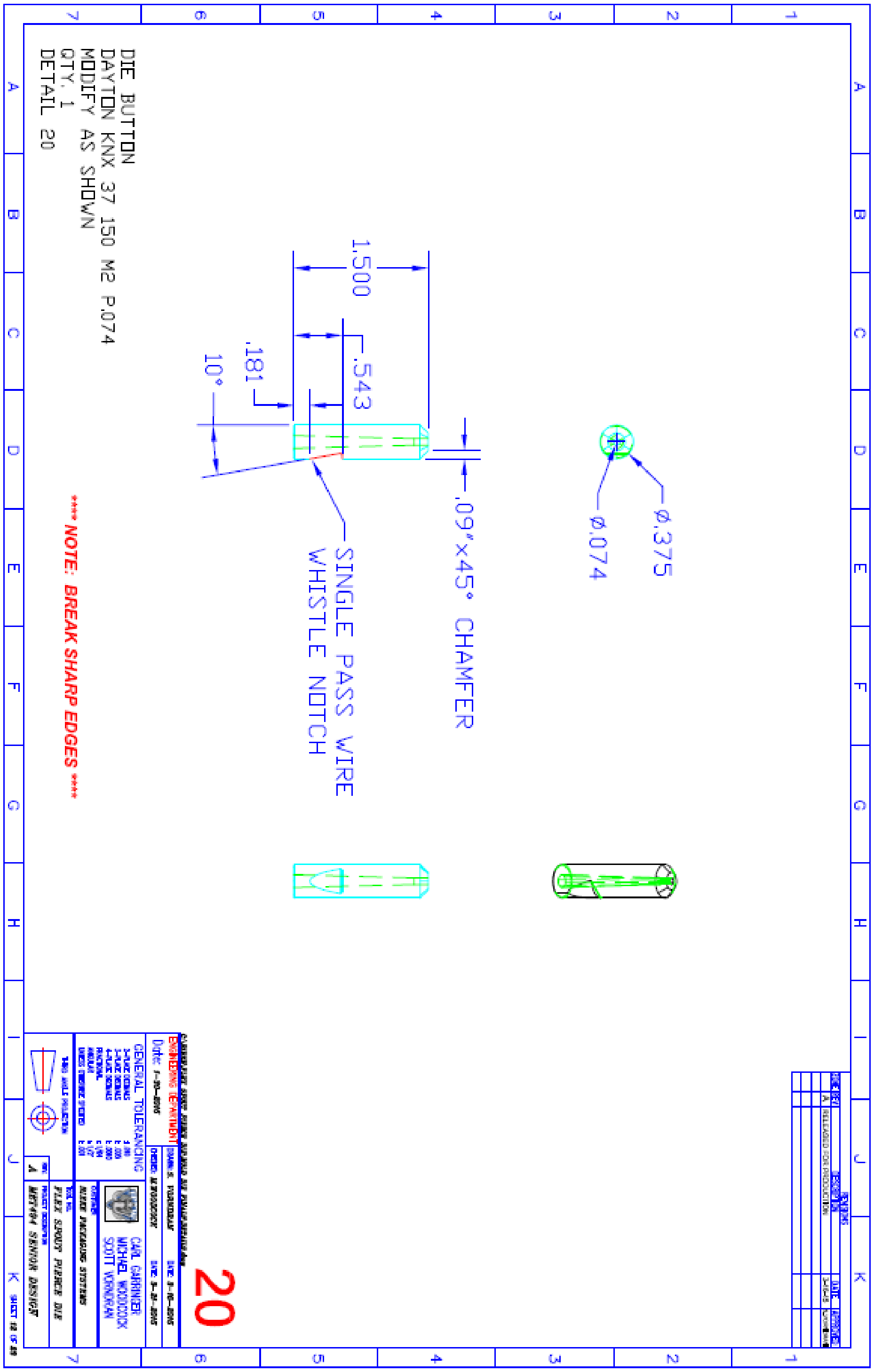


SUPPORT
MATERIAL, CRS
QTY. 4
DETAIL 23
2.727
Ø.75
DRILL Ø11/32" THRU
**** NOTE: BREAK SHARP EDGES ****
23

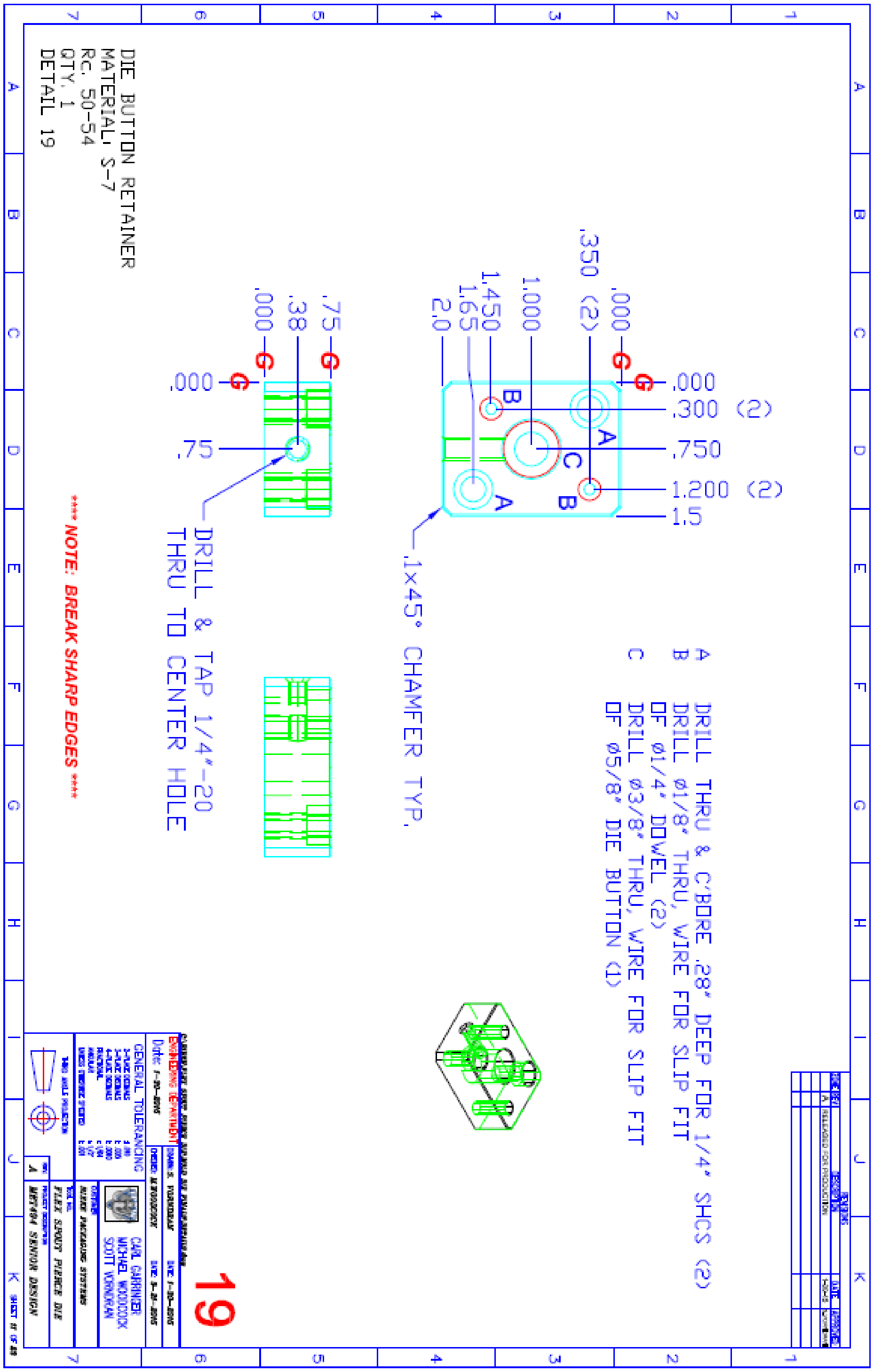


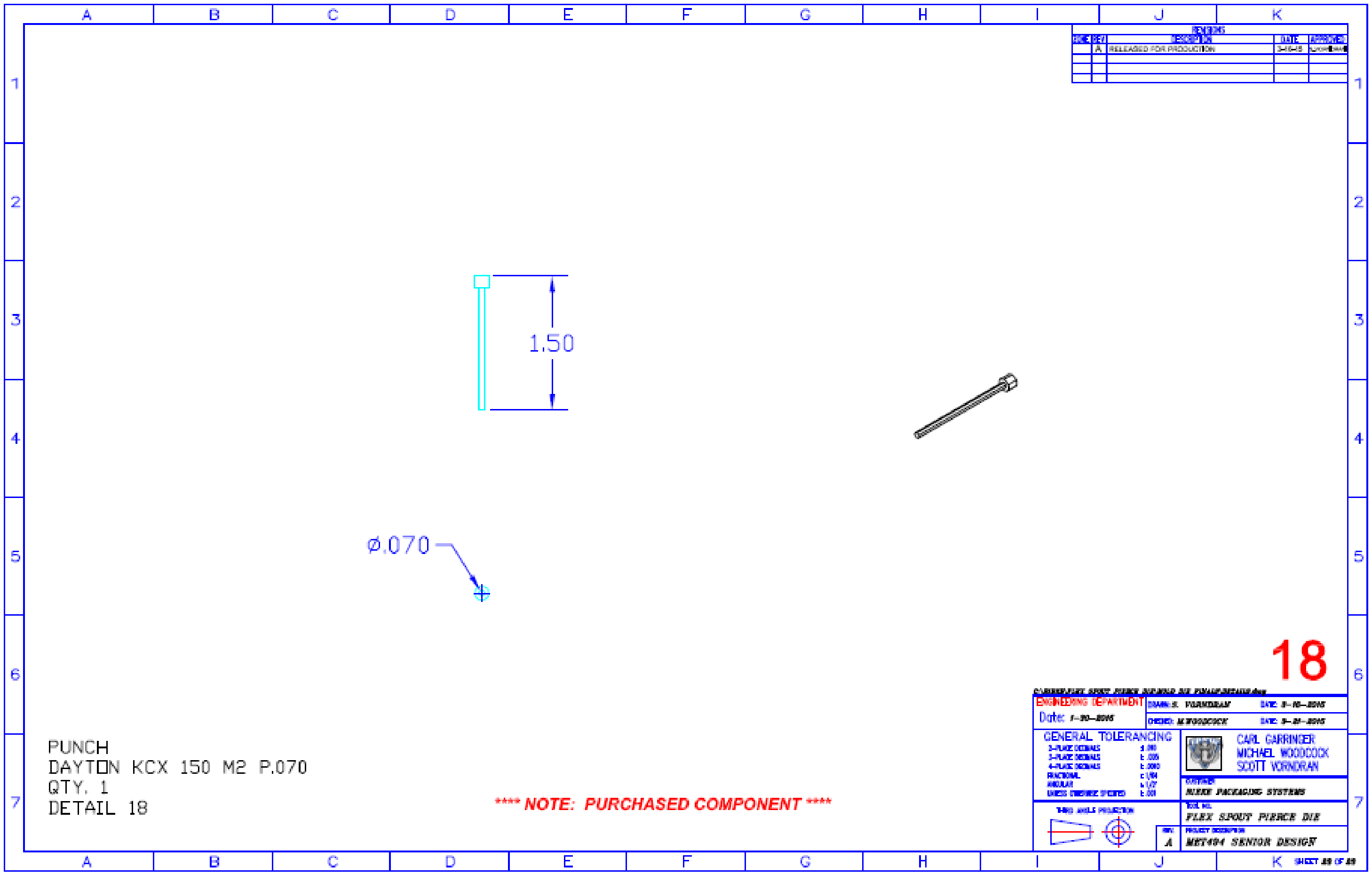
BUMP STOP 'B'
MATERIAL: UHMW
QTY. 4
DETAIL 22
.25 (2)
.000
.5
.000
.25
2.05
2.3
.552
DRILL THRU & C'BORE .22" DEEP FOR #10 SHCS (2)
*** NOTE: BREAK SHARP EDGES ***
ENGINEERING DEPARTMENT
GENERAL TOLERANCING
CARL GARRINER
MICHAEL WOODCOCK
SCOTT VORNDRAN
FLEX SPOUT PIERCE DIE
MET494 SENIOR DESIGN
22


BUMP STOP 'A'
MATERIAL UHMW
QTY. 4
DETAIL 21
.000
.25 (2)
.5
.85
.175
.000
.25
1.15
2.05
2.3
R.51
DRILL & C'SINK FOR #10 FHCS (2)
**** NOTE: BREAK SHARP EDGES ****
ENGINEERING DEPARTMENT
GENERAL TOLERANCING
CARL GARRINGER
MICHAEL WOODCOCK
SCOTT VORNDRAN
BOXER PACKAGING SYSTEMS
FLEX SPOUT PIERCE DIE
MET494 SENIOR DESIGN
21

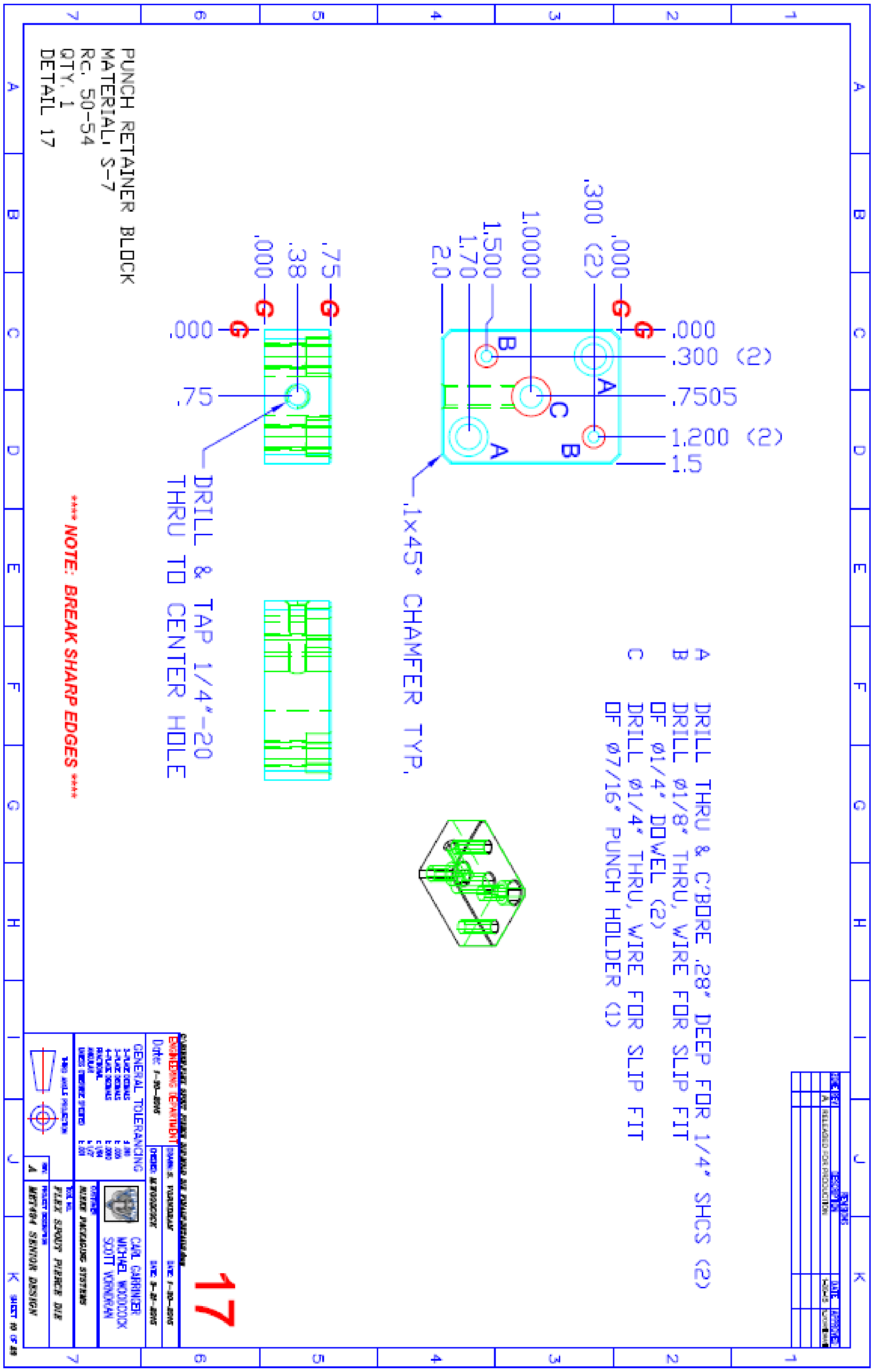


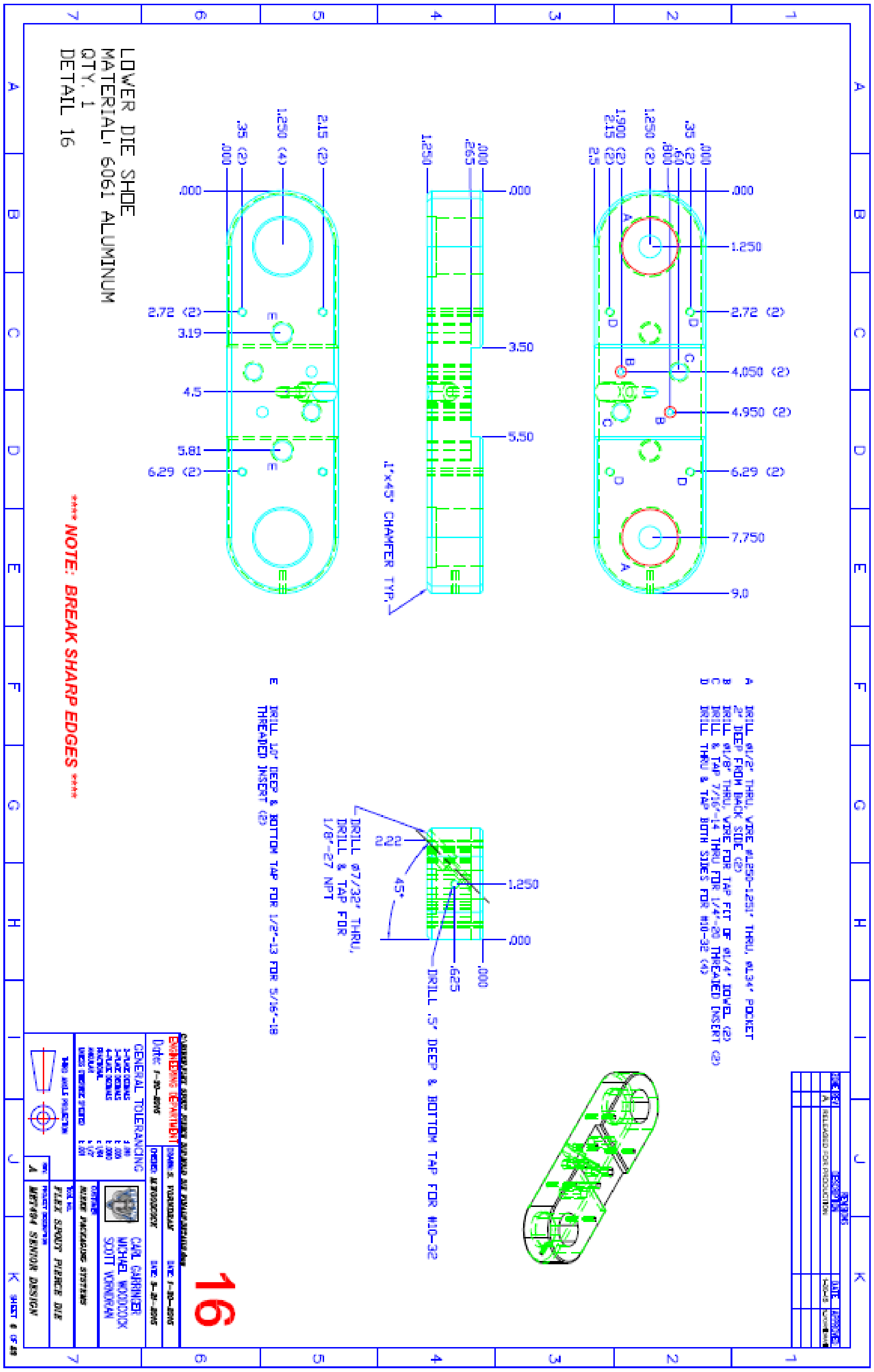
DIE BUTTON
DAYTON KNX 37 150 M2 P.074
MODIFY AS SHOWN
QTY. 1
DETAIL 20
1.500
.543
.181
10°
Ø.375
Ø.074
.09"x45° CHAMFER
SINGLE PASS WIRE WHISTLE NOTCH
**** NOTE: BREAK SHARP EDGES ****
20
ENGINEERING DEPARTMENT
GENERAL TOLERANCING
CARL GARRINER
MICHAEL WOODCOCK
SCOTT VORNDRAN
FLEX SPOUT PIERCE DIE
MET494 SENIOR DESIGN


A DRILL THRU & C'BORE .28" DEEP FOR 1/4" SHCS (2)
B DRILL ø1/8" THRU, WIRE FOR SLIP FIT
OF ø1/4" DOWEL (2)
C DRILL ø3/8" THRU, WIRE FOR SLIP FIT
OF ø5/8" DIE BUTTON (1)
.1x45° CHAMFER TYP.
DRILL & TAP 1/4"-20
THRU TO CENTER HOLE
DIE BUTTON RETAINER
MATERIAL: S-7
Rc. 50-54
QTY. 1
DETAIL 19
**** NOTE: BREAK SHARP EDGES ****
19
ENGINEERING DEPARTMENT
GENERAL TOLERANCING
CARL GARRINGER
MICHAEL WOODCOCK
SCOTT VORNDRAN
FLEX SPOUT PIERCE DIE
MET494 SENIOR DESIGN

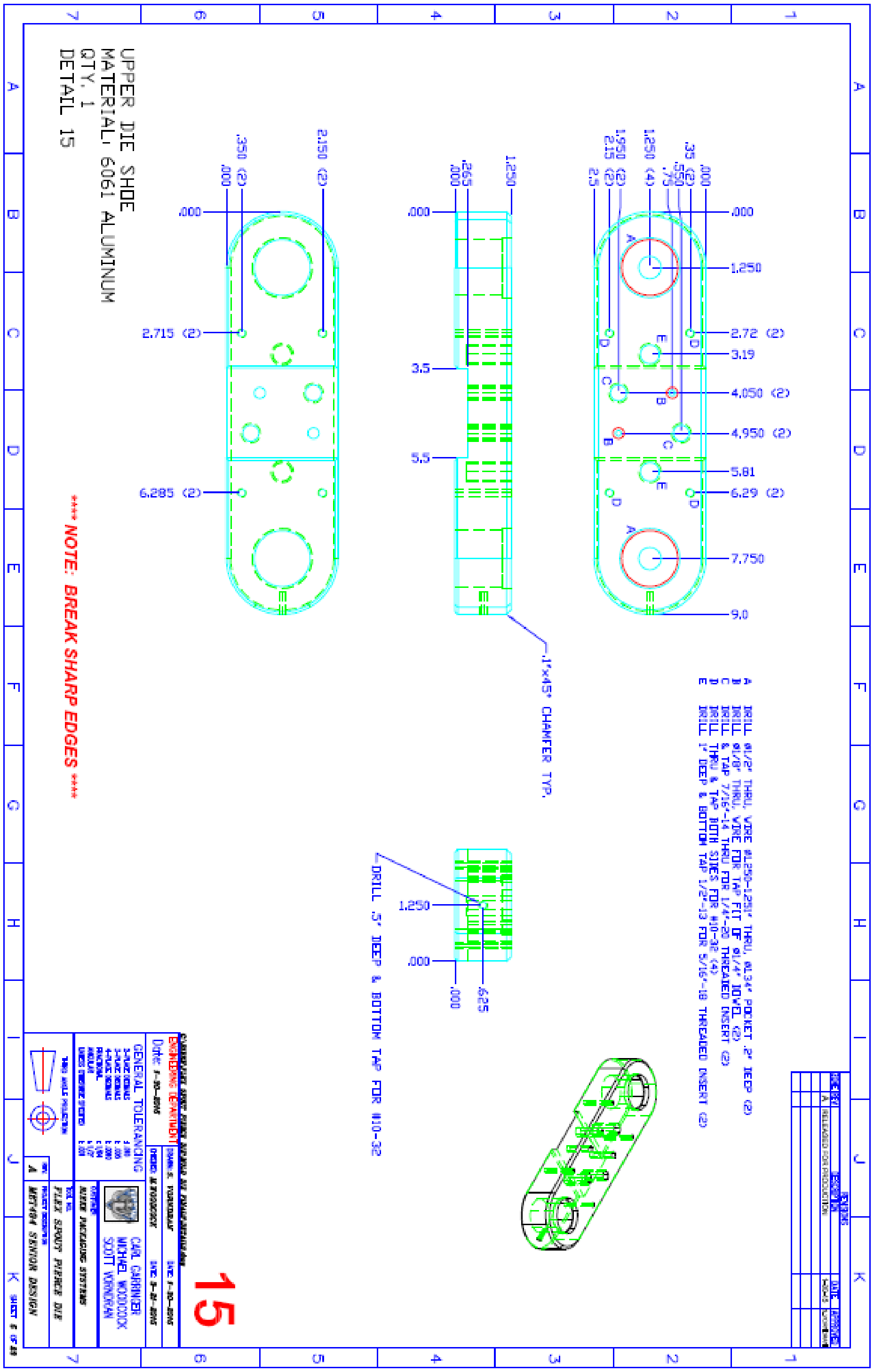


PUNCH
DAYTON KCX 150 M2 P.070
QTY. 1
DETAIL 18
1.50
ø.070
**** NOTE: PURCHASED COMPONENT ****
18
ENGINEERING DEPARTMENT
GENERAL TOLERANCING
CARL GARRINGER
MICHAEL WOODCOCK
SCOTT VORNDRAN
FLEX SPOUT PIERCE DIE
MET404 SENIOR DESIGN
RELEASED FOR PRODUCTION

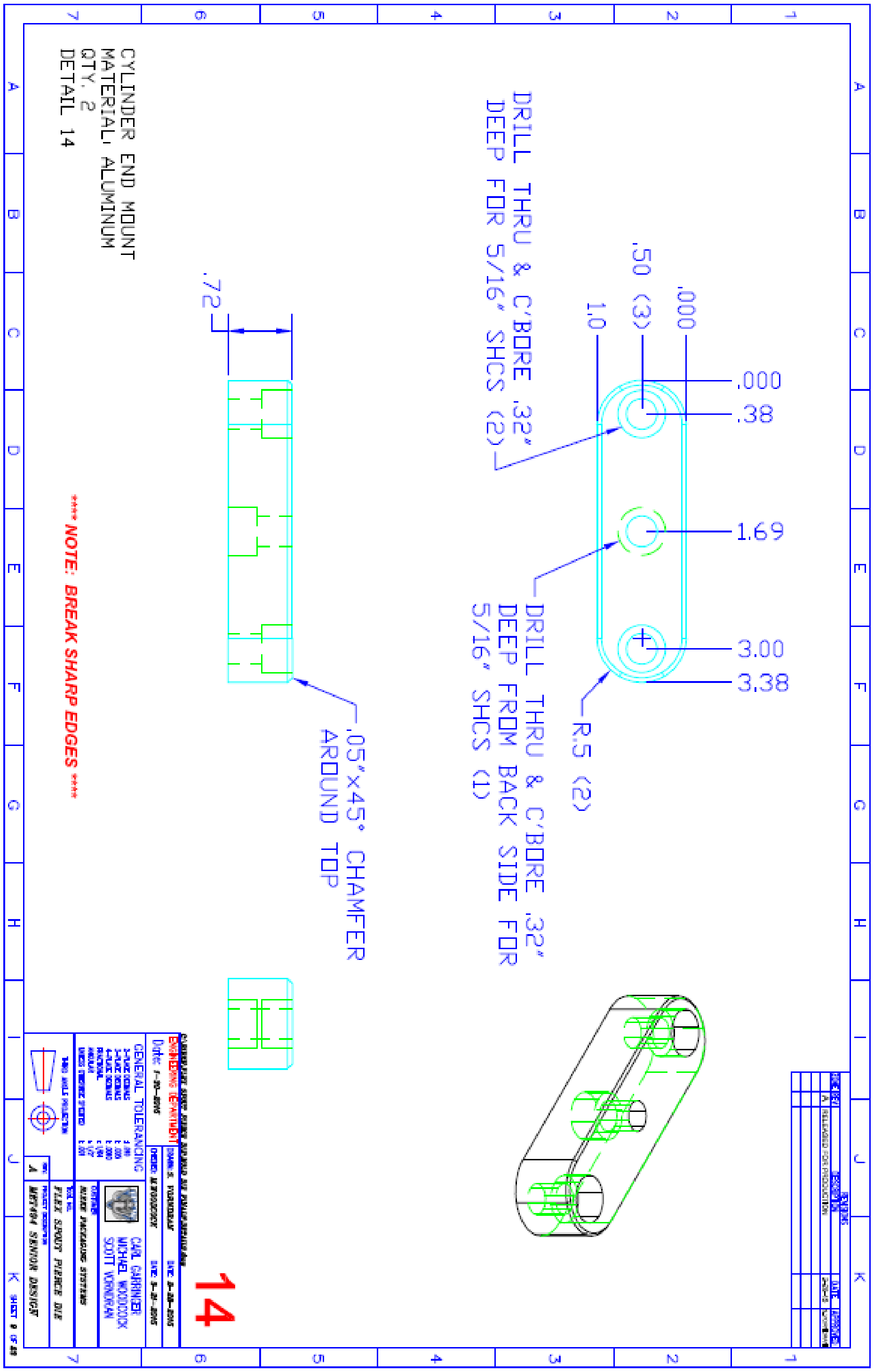

PUNCH RETAINER BLOCK
MATERIAL: S-7
Rc. 50-54
QTY. 1
DETAIL 17
A DRILL THRU & C'BORE .28" DEEP FOR 1/4" SHCS (2)
B DRILL Ø1/8" THRU, WIRE FOR SLIP FIT OF Ø1/4" DOWEL (2)
C DRILL Ø1/4" THRU, WIRE FOR SLIP FIT OF Ø7/16" PUNCH HOLDER (1)
.1x45° CHAMFER TYP.
DRILL & TAP 1/4"-20 THRU TO CENTER HOLE
*** NOTE: BREAK SHARP EDGES ***
.000
.300 (2)
.7505
1.200 (2)
1.5
1.0000
1.500
1.70
2.0
.75
.38
17
GENERAL TOLERANCING
ENGINEERING DEPARTMENT
CARL GARRINGER
MICHAEL WOODCOCK
SCOTT VORNDRAN
FLEX SPOUT PIERCE DIE

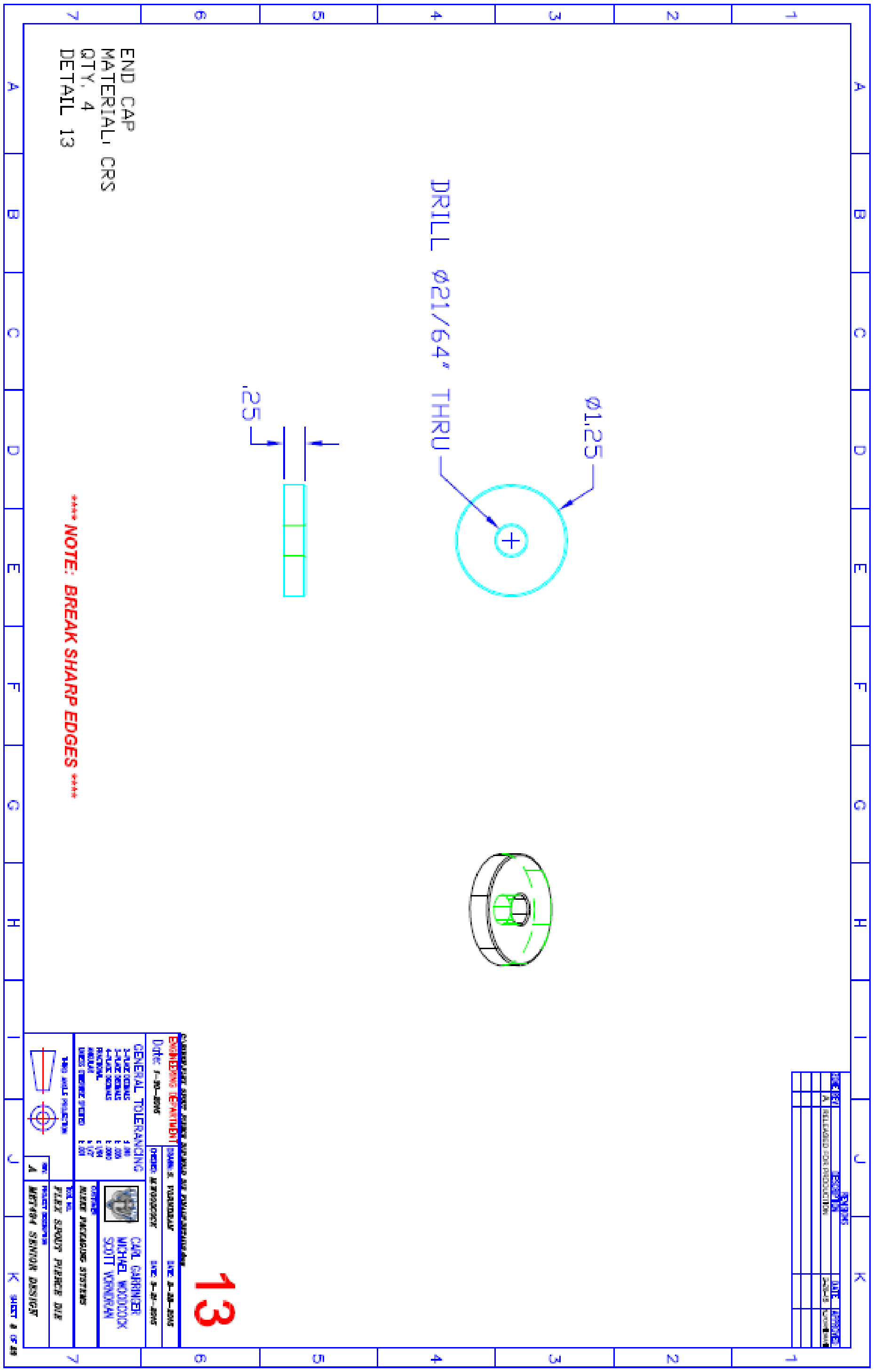


LOWER DIE SHOE
MATERIAL: 6061 ALUMINUM
QTY. 1
DETAIL 16
1"x45° CHAMFER TYP.
**** NOTE: BREAK SHARP EDGES ****
E DRILL 1.0" DEEP & BOTTOM TAP FOR 1/2"-13 FOR 5/16"-18 THREADED INSERT (2)
DRILL .5" DEEP & BOTTOM TAP FOR #10-32
DRILL ⌀7/32" THRU, DRILL & TAP FOR 1/8"-27 NPT
16

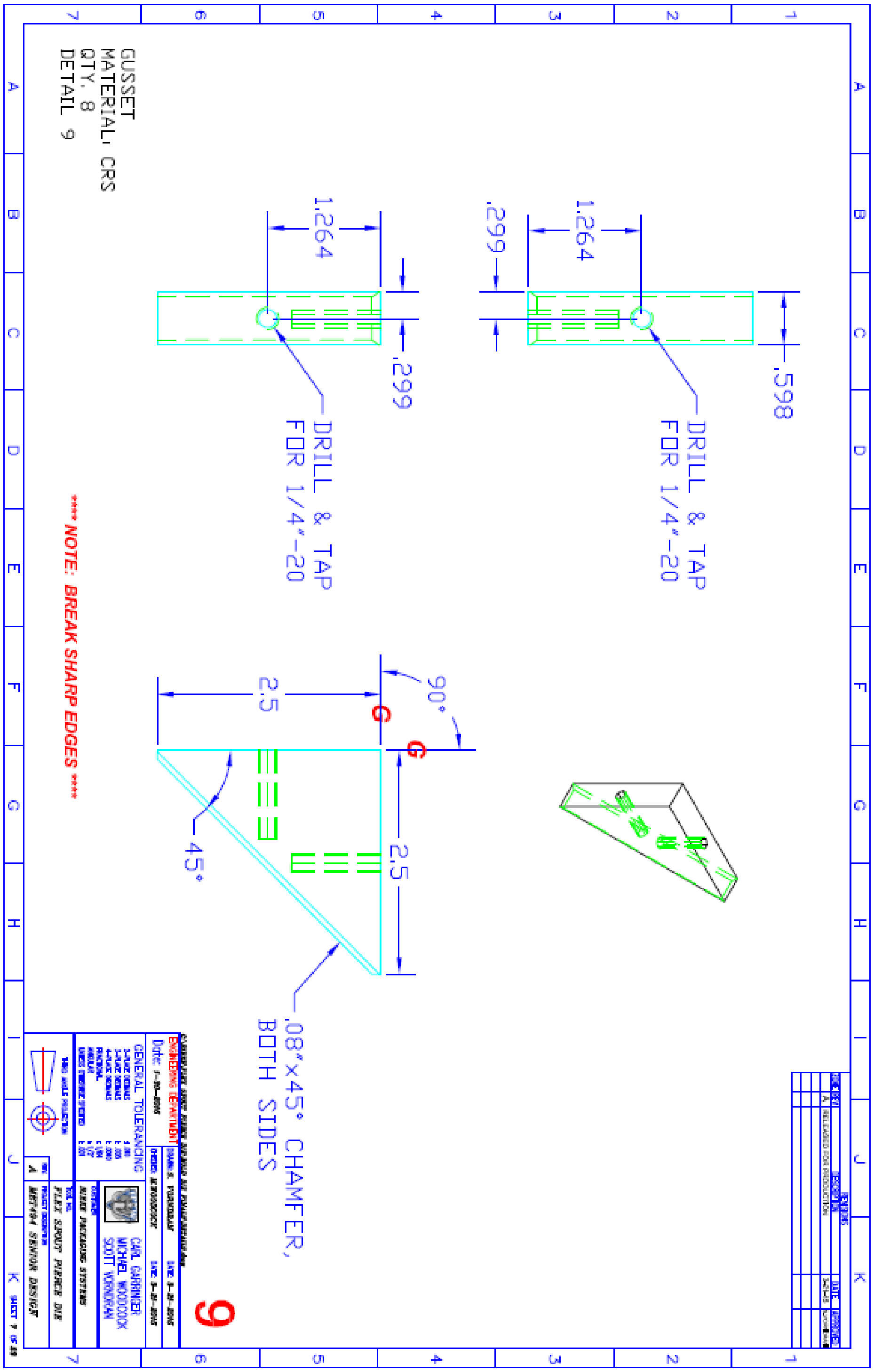


UPPER DIE SHOE
MATERIAL: 6061 ALUMINUM
QTY. 1
DETAIL 15
*** NOTE: BREAK SHARP EDGES ***
A DRILL ø1/2" THRU, WIRE ø1.250-1.251" THRU, ø1.34" POCKET .2" DEEP (2)
B DRILL ø1/8" THRU, WIRE FOR TAP FIT OF ø1/4" DOWEL (2)
C DRILL & TAP 7/16"-14 THRU FOR 1/4"-20 THREADED INSERT (2)
D DRILL THRU & TAP BOTH SIDES FOR #10-32 (4)
E DRILL 1" DEEP & BOTTOM TAP 1/2"-13 FOR 5/16"-18 THREADED INSERT (2)
.1"x45° CHAMFER TYP.
DRILL .5" DEEP & BOTTOM TAP FOR #10-32
FLEX SPOUT PIERCE DIE
ME 494 SENIOR DESIGN
15

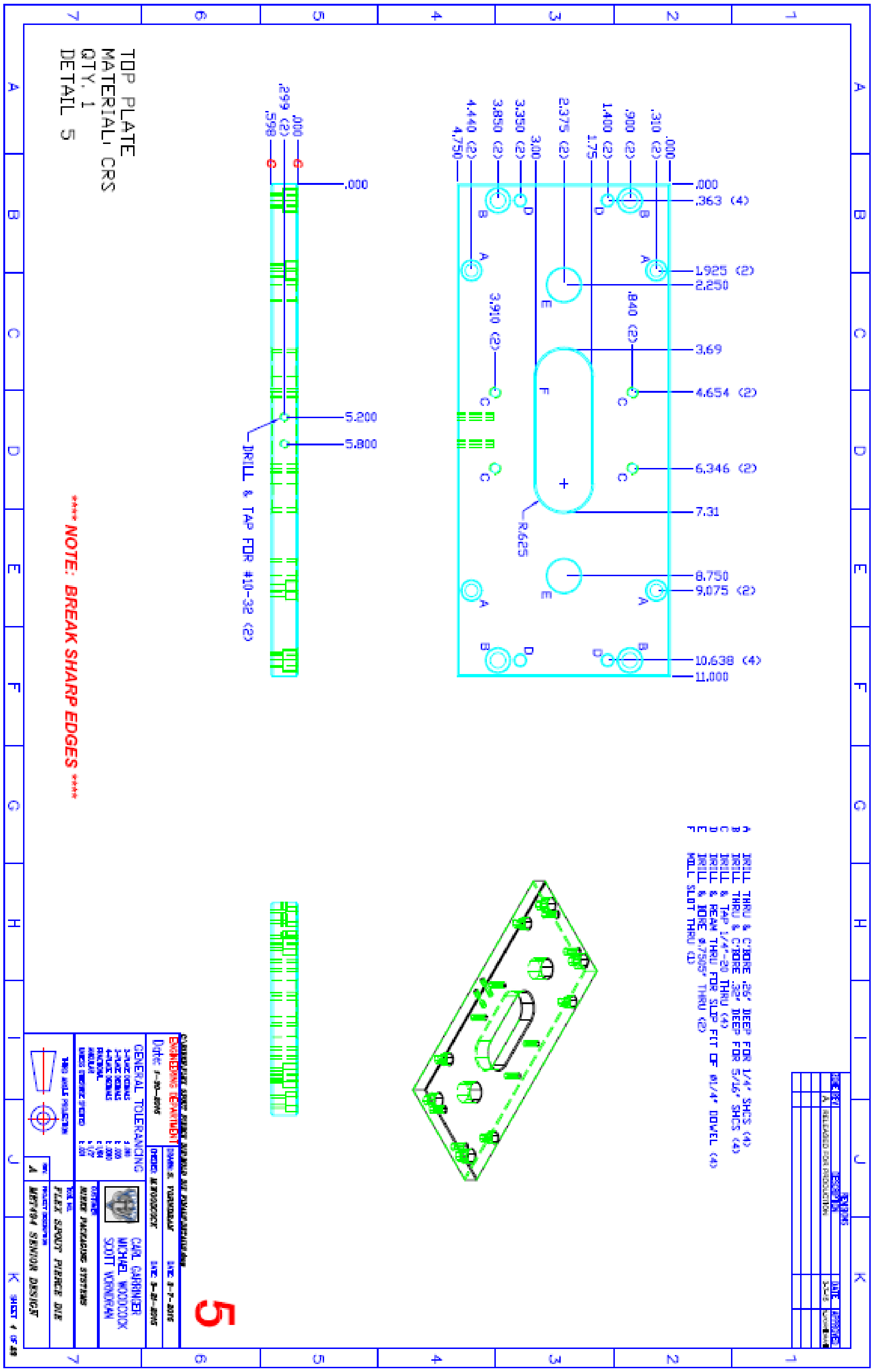

CYLINDER END MOUNT
MATERIAL ALUMINUM
QTY. 2
DETAIL 14
DRILL THRU & C'BORE .32" DEEP FOR 5/16" SHCS (2)
DRILL THRU & C'BORE .32" DEEP FROM BACK SIDE FOR 5/16" SHCS (1)
R.5 (2)
.05"x45° CHAMFER AROUND TOP
*** NOTE: BREAK SHARP EDGES ***
.000
.50 (3)
1.0
.000
.38
1.69
3.00
3.38
.72
GENERAL TOLERANCING
FLEX SPOUT PIERCE DIE
MET494 SENIOR DESIGN
CARL GARDNER
MICHAEL WOODCOCK
SCOTT VORNDRAN
14

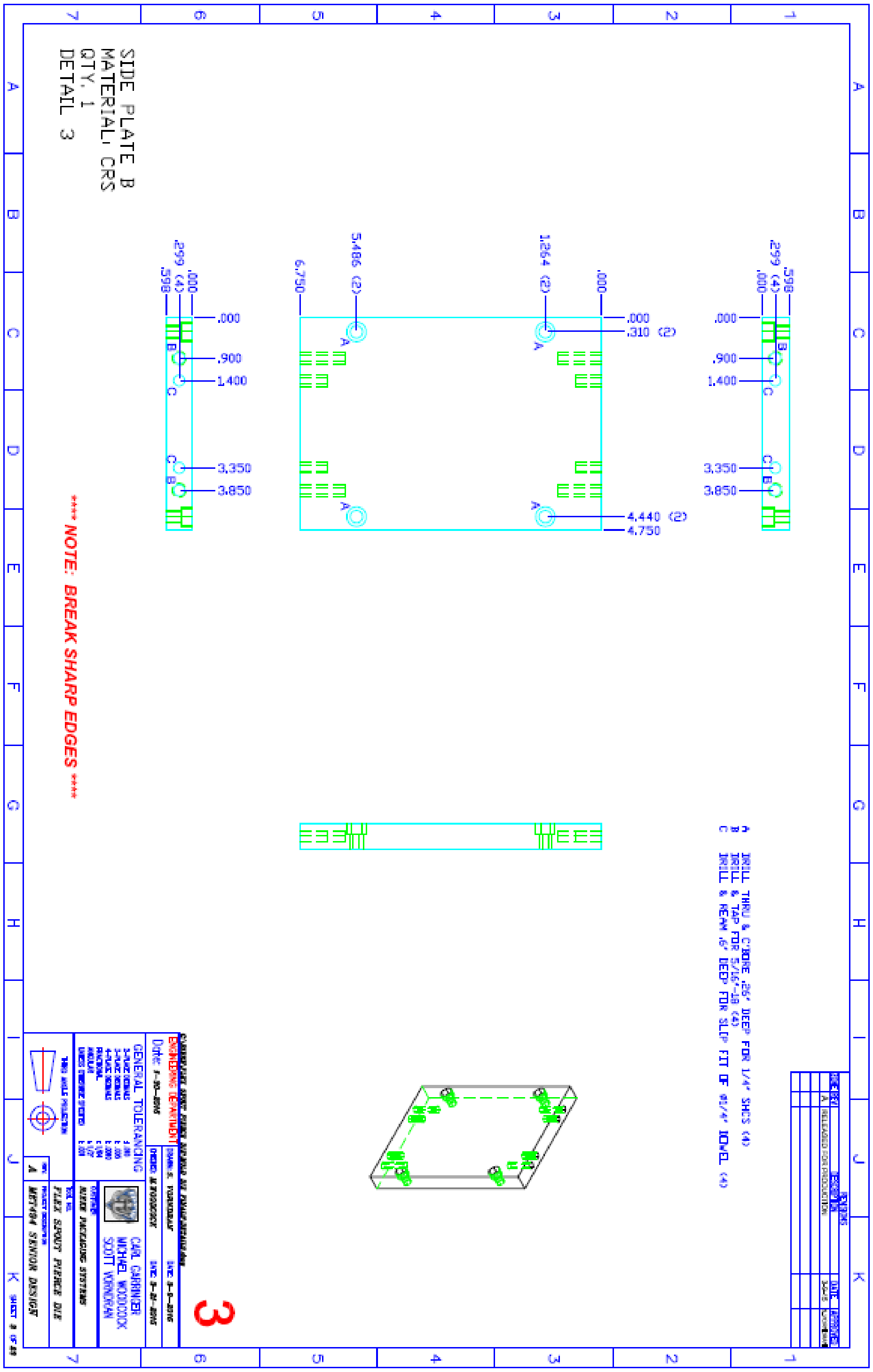


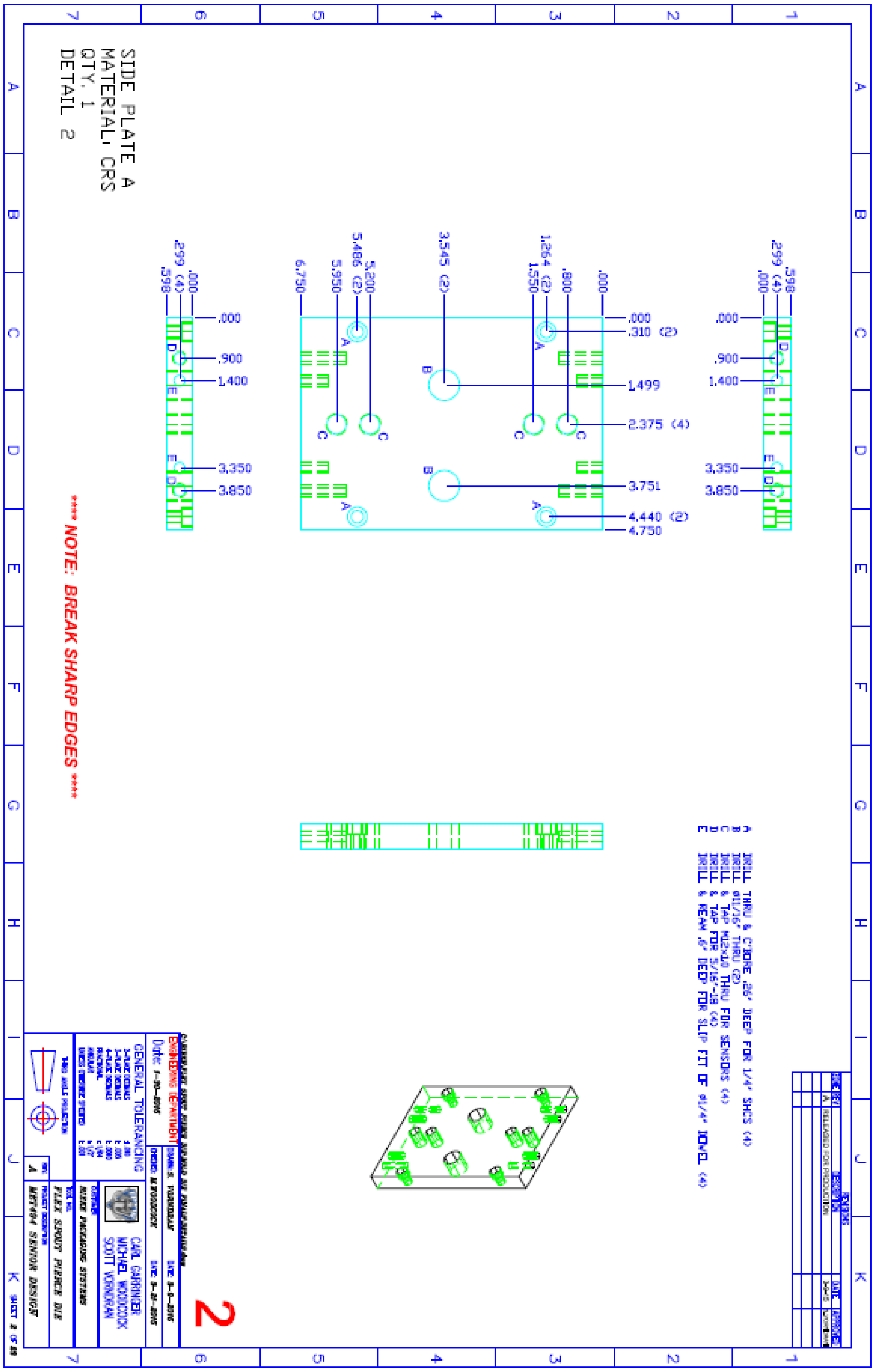
END CAP
MATERIAL: CRS
QTY. 4
DETAIL 13
DRILL Ø21/64" THRU
Ø1.25
.25
*** NOTE: BREAK SHARP EDGES ***
ENGINEERING DEPARTMENT
GENERAL TOLERANCING
CARL GARRINER
MICHAEL WOODCOCK
SCOTT VORNDRAN
FLEX SPOUT PIERCE DIE
MET494 SENIOR DESIGN
RELEASED FOR PRODUCTION
13



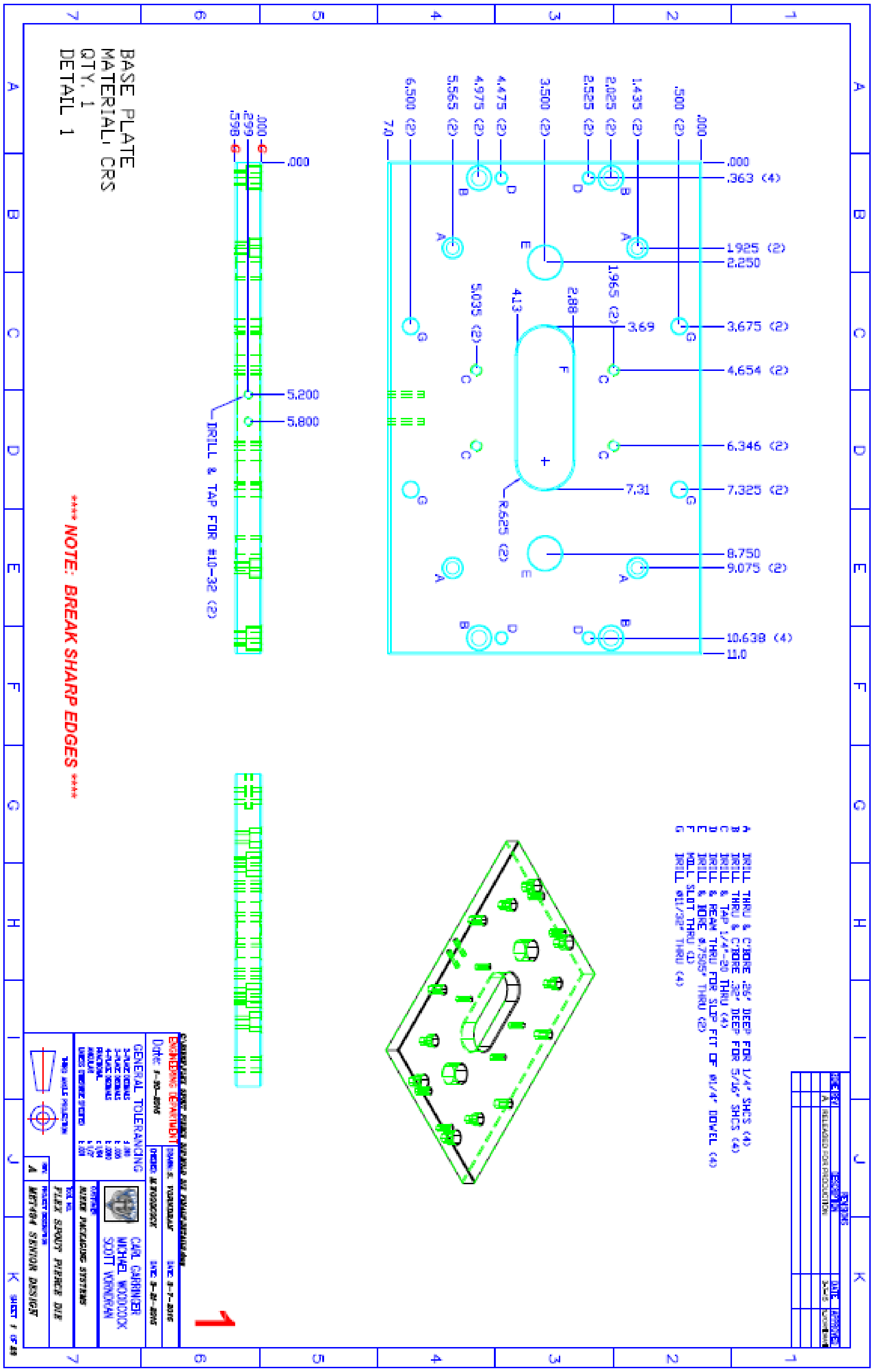
GUSSET
MATERIAL, CRS
QTY. 8
DETAIL 9
1.264
.299
1.264
.299
.598
DRILL & TAP FOR 1/4"-20
DRILL & TAP FOR 1/4"-20
90°
2.5
2.5
45°
.08"x45° CHAMFER, BOTH SIDES
*** NOTE: BREAK SHARP EDGES ***
GENERAL TOLERANCING
9


TOP PLATE
MATERIAL: CRS
QTY. 1
DETAIL 5
**** NOTE: BREAK SHARP EDGES ****
DRILL & TAP FOR #10-32 (2)
5

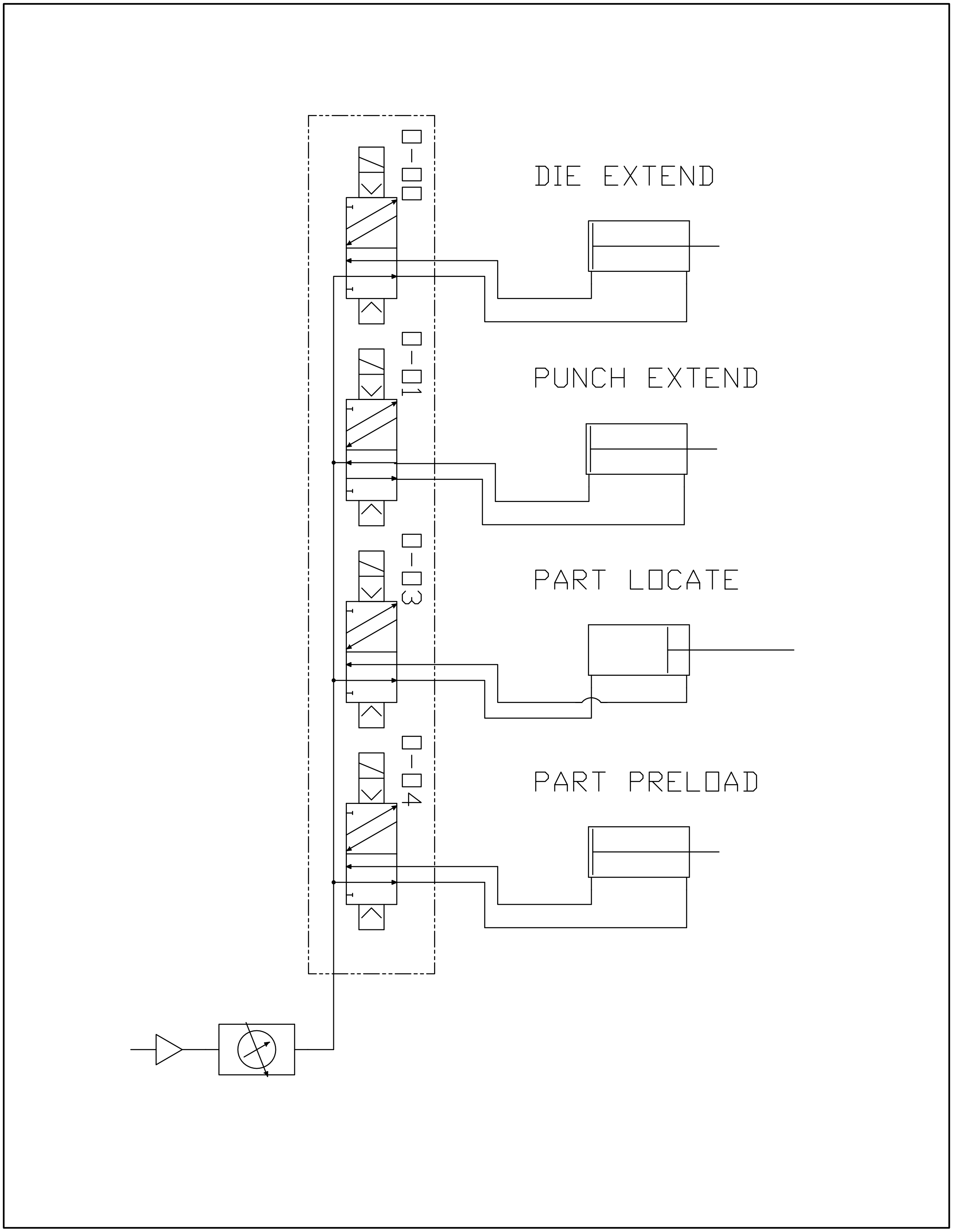

SIDE PLATE B
MATERIAL: CRS
QTY. 1
DETAIL 3
**** NOTE: BREAK SHARP EDGES ****
A DRILL THRU & C'BORE .25" DEEP FOR 1/4" SHCS (4)
B DRILL & TAP FOR 5/16-18 (4)
C DRILL & REAM .6" DEEP FOR SLIP FIT OF Ø1/4" DOWEL (4)
GENERAL TOLERANCING
FLEX SPOUT PIERCE DIE
MET494 SENIOR DESIGN
3



SIDE PLATE A
MATERIAL: CRS
QTY. 1
DETAIL 2
*** NOTE: BREAK SHARP EDGES ***
A DRILL THRU & C'BORE .26" DEEP FOR 1/4" SHCS (4)
B DRILL ø11/16" THRU (2)
C DRILL & TAP M12x1.0 THRU FOR SENSORS (4)
D DRILL & TAP FOR 5/16"-18 (4)
E DRILL & REAM .6" DEEP FOR SLIP FIT OF ø1/4" DOWEL (4)
.000
.310 (2)
1.499
2.375 (4)
3.751
4.440 (2)
4.750
.800
1.264 (2)
1.550
3.545 (2)
5.200
5.486 (2)
5.950
6.750
.900
1.400
3.350
3.850
.299 (4)
.598
GENERAL TOLERANCING
FLEX SPOUT PIERCE DIE
MET494 SENSOR DESIGN
CARL GARRINER
MICHAEL WOODCOCK
SCOTT VORNDRAN
2

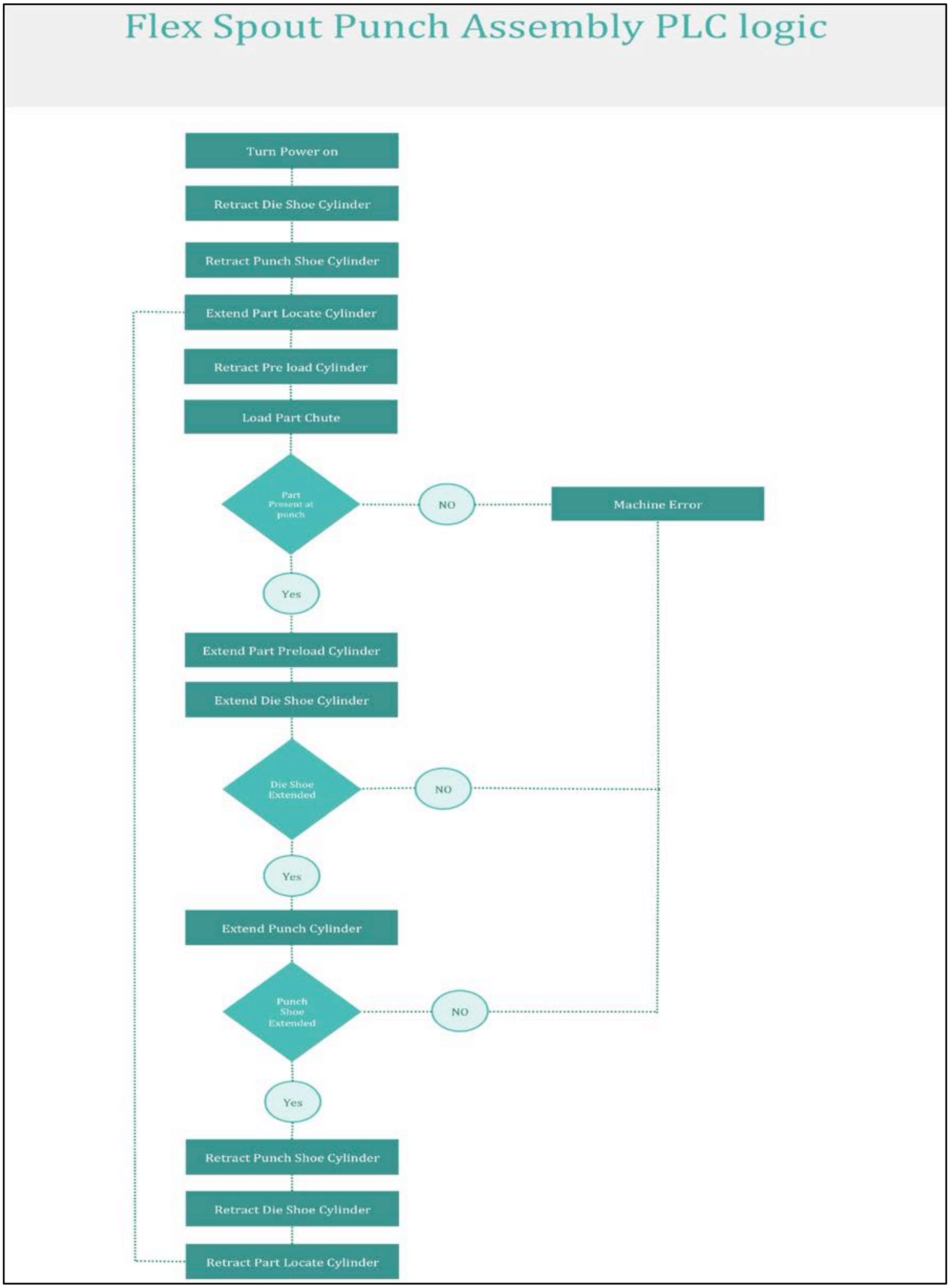

BASE PLATE
MATERIAL: CRS
QTY. 1
DETAIL 1
**** NOTE: BREAK SHARP EDGES ****
DRILL & TAP FOR #10-32 (2)

Pneumatic Schematic

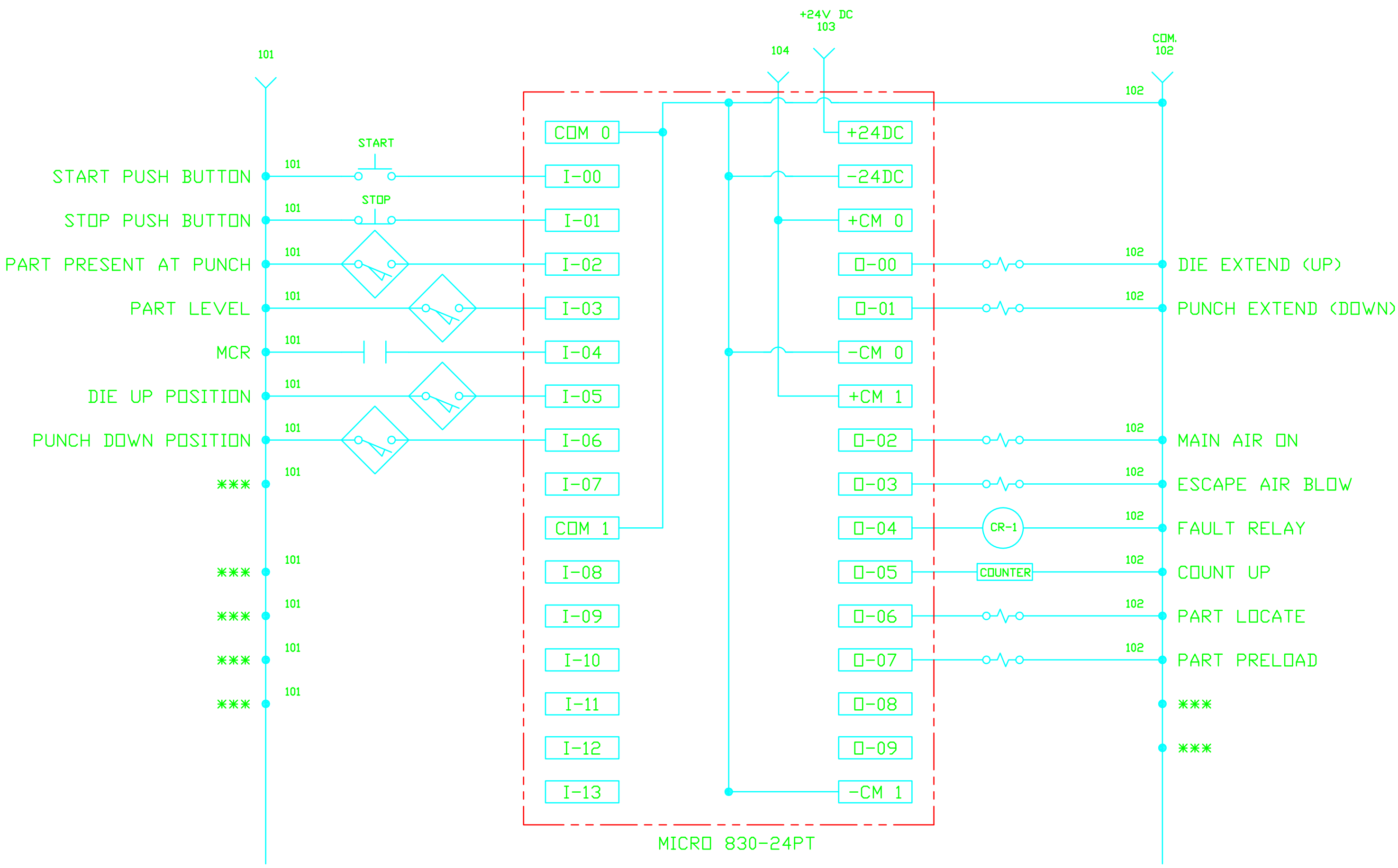


Electrical

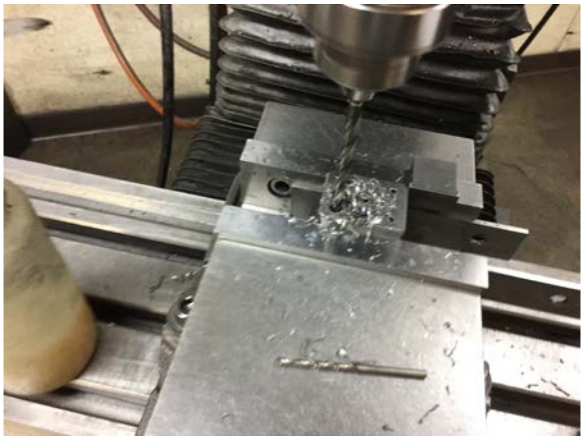
Flow Chart



I/O Schematic



Manufacturing Pictures



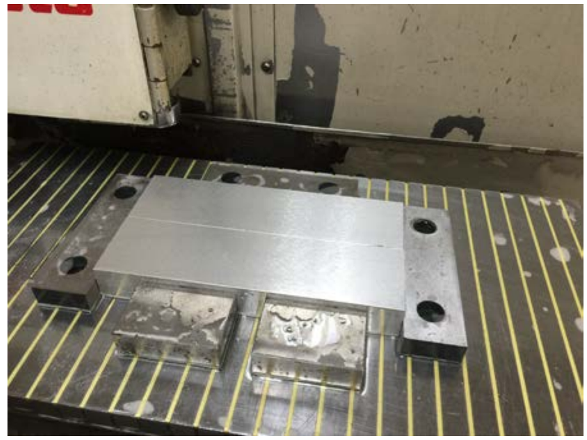
Drilling holes in punch holder

Punch & die holder ready for wire EDM

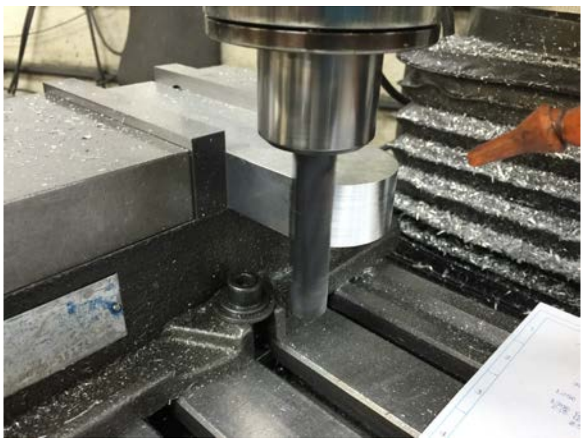
Checking retainer hardness on Rockwell tester

Finished retainers on die shoes

Sawing aluminum die shoe to rough length



Grinding aluminum shoes flat on surface grinder



Milling end radius on die shoes

Milling bearing counter-bore pocket

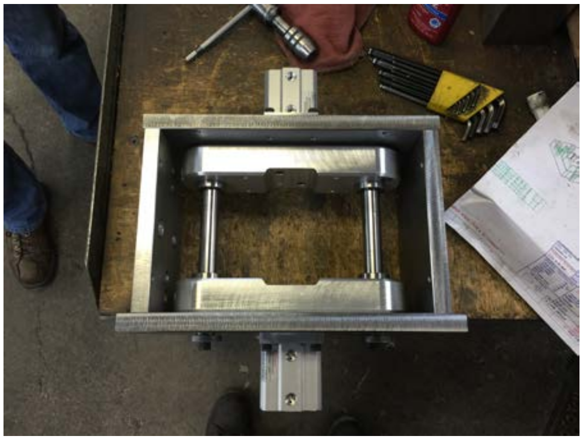
Rough machined die shoes

Die shoe with bearings installed

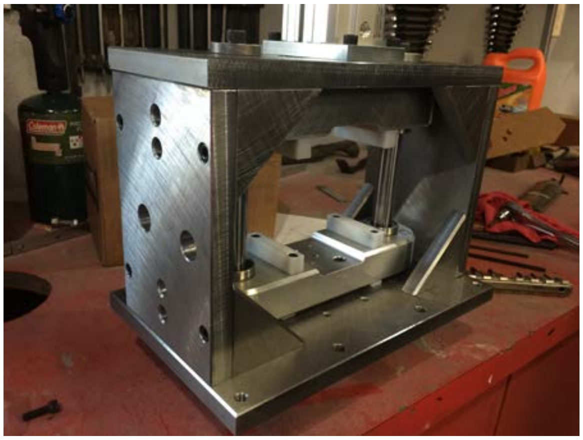
Blanchard grinding press plates flat

Finished upper and lower press plates

Upper press plate with air cylinder mounted



Press box with die shoes and cylinders installed



Press box with gussets installed for additional support

Grinding side rails to thickness

Feed system mock-up for visual inspection

Feed system completed and mounted

Looking down the feed system

PLC and electrical cabinet

Electrical cabinet mounted on frame

Carl marking frame leg to be cut to length

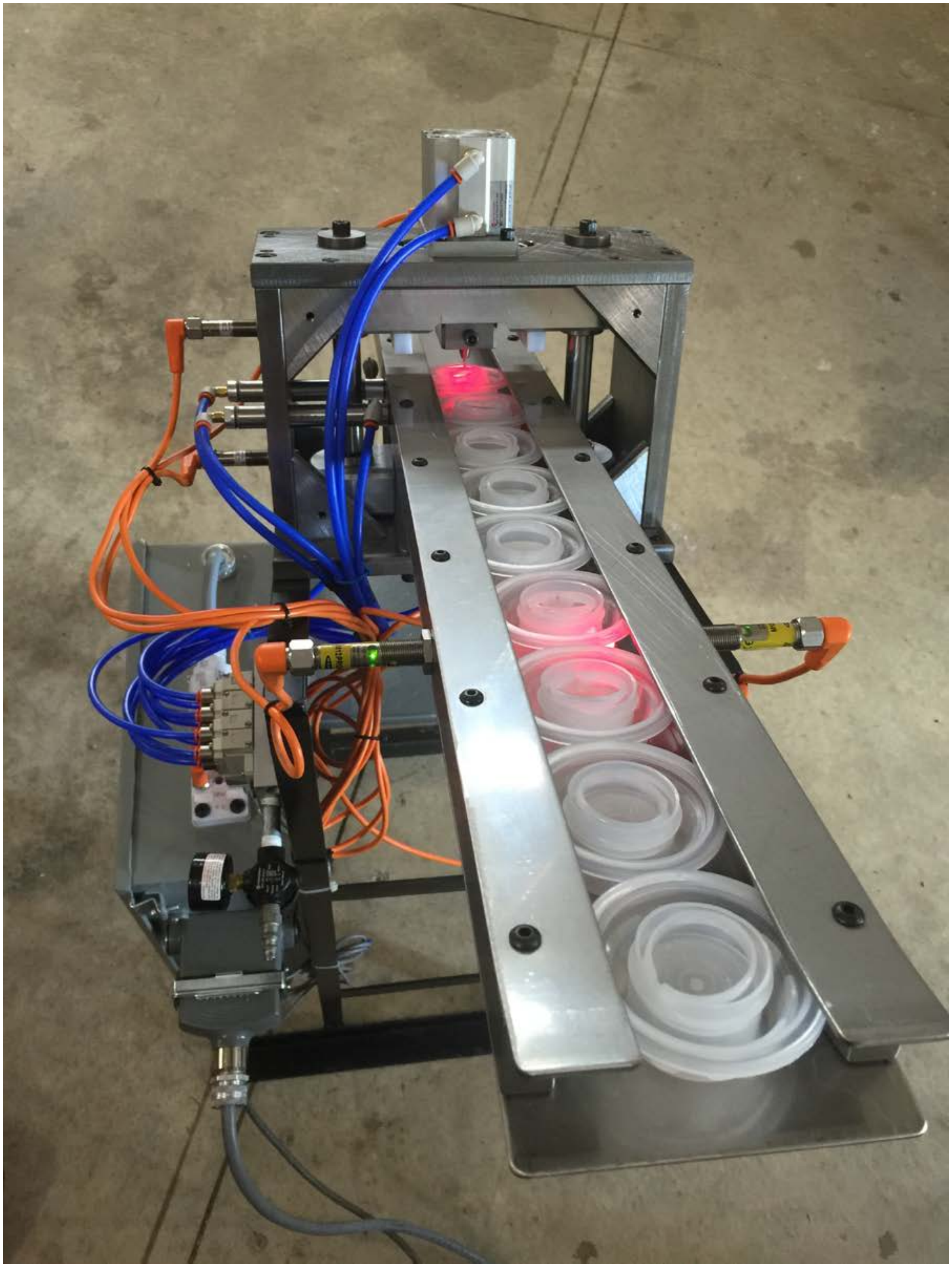
Carl cutting the frame leg to length

Grinding clearance angle on punch holder

Assembled punch retainer

Machine Pictures

Complete flex spout punch assembly machine



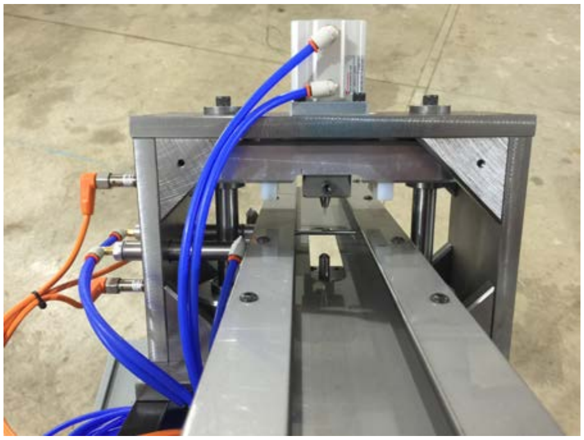
Machine loaded and ready to run.

Electrical control box

PLC and electrical cabinet

Sensor and air solenoid manifolds

Plastic slug drop slot



Punch assembly ready for parts

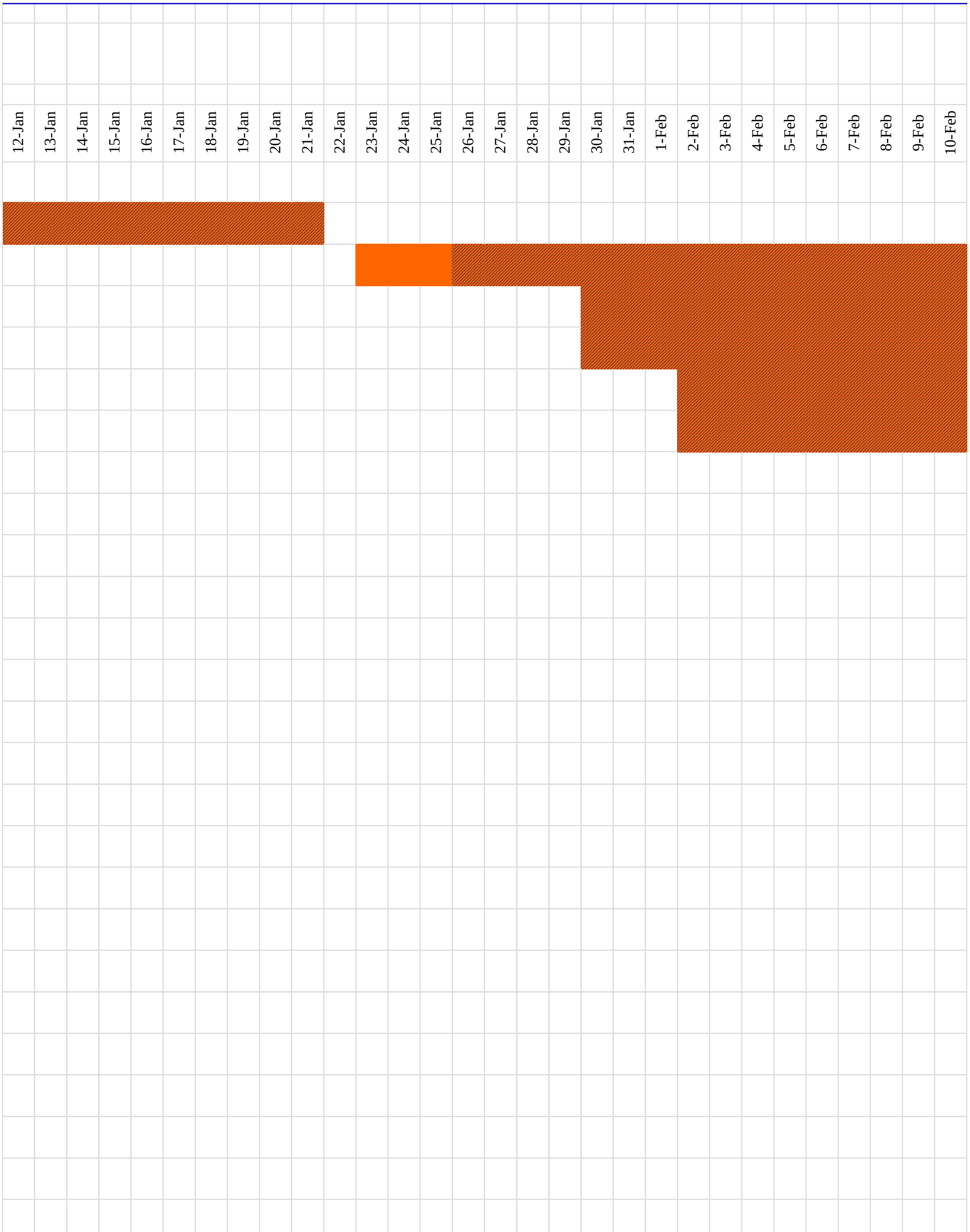
Punch assembly with guards in place

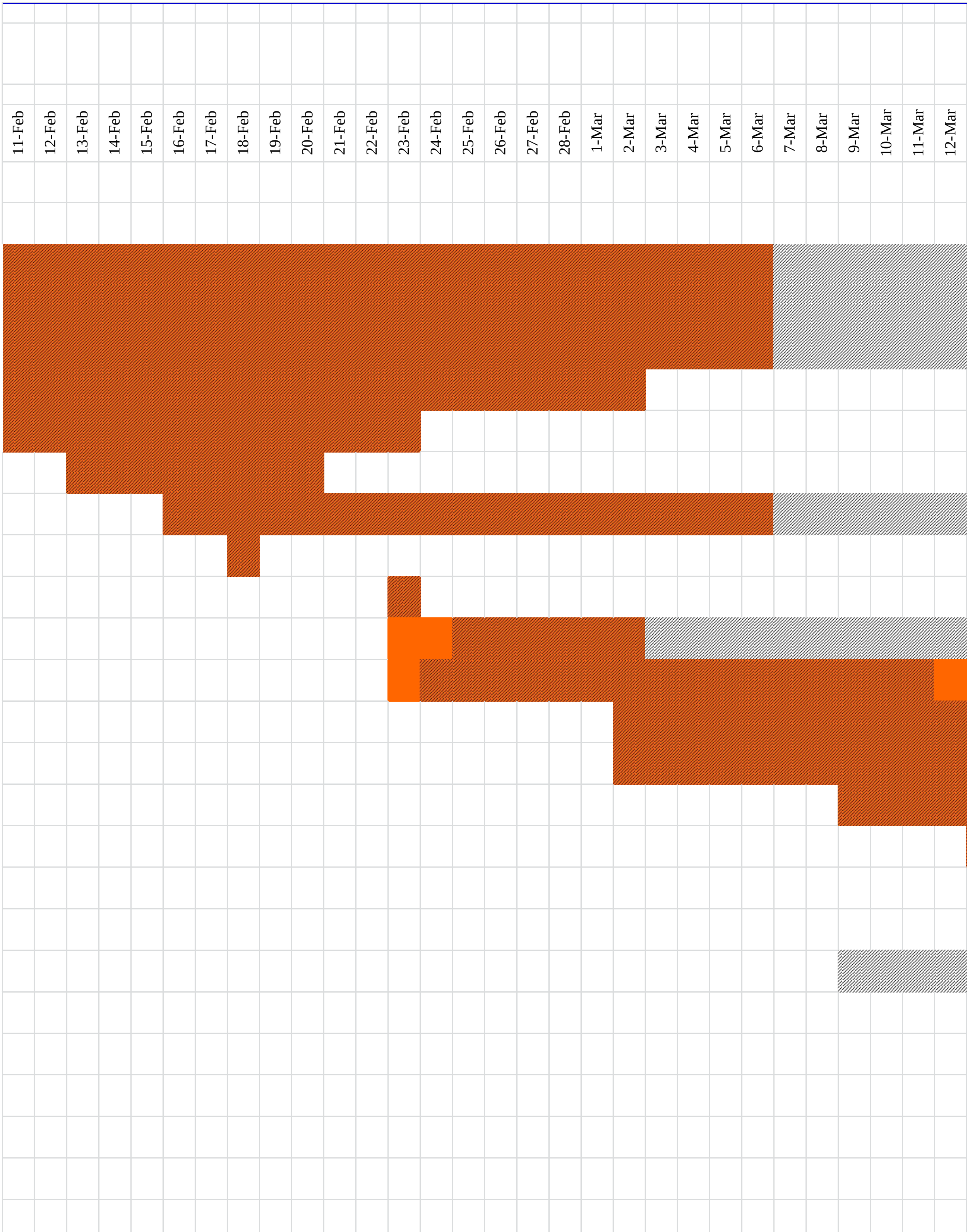
Team members left to right: Scott Vorndran, Carl Garringer, and Mike Woodcock

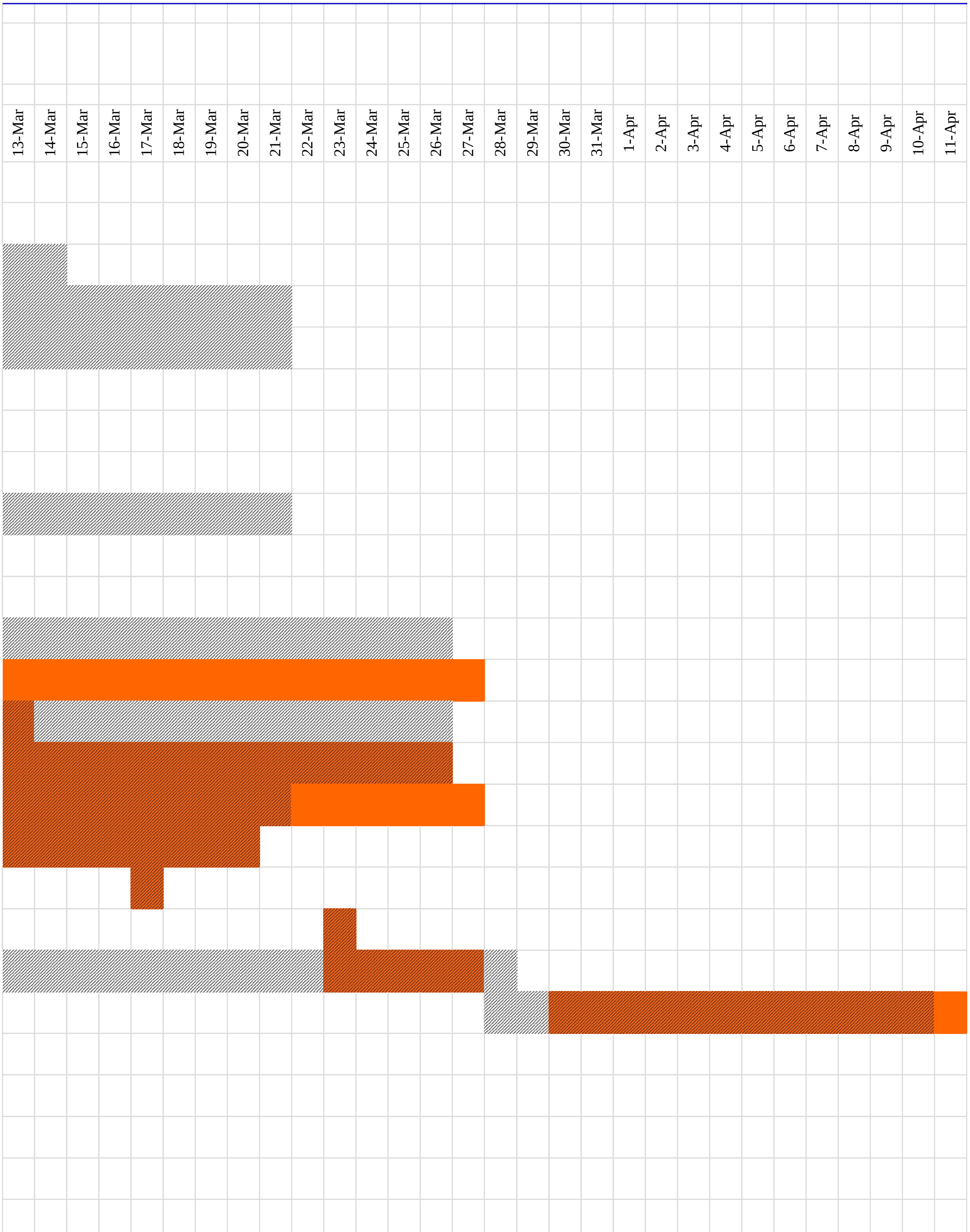
Project Management

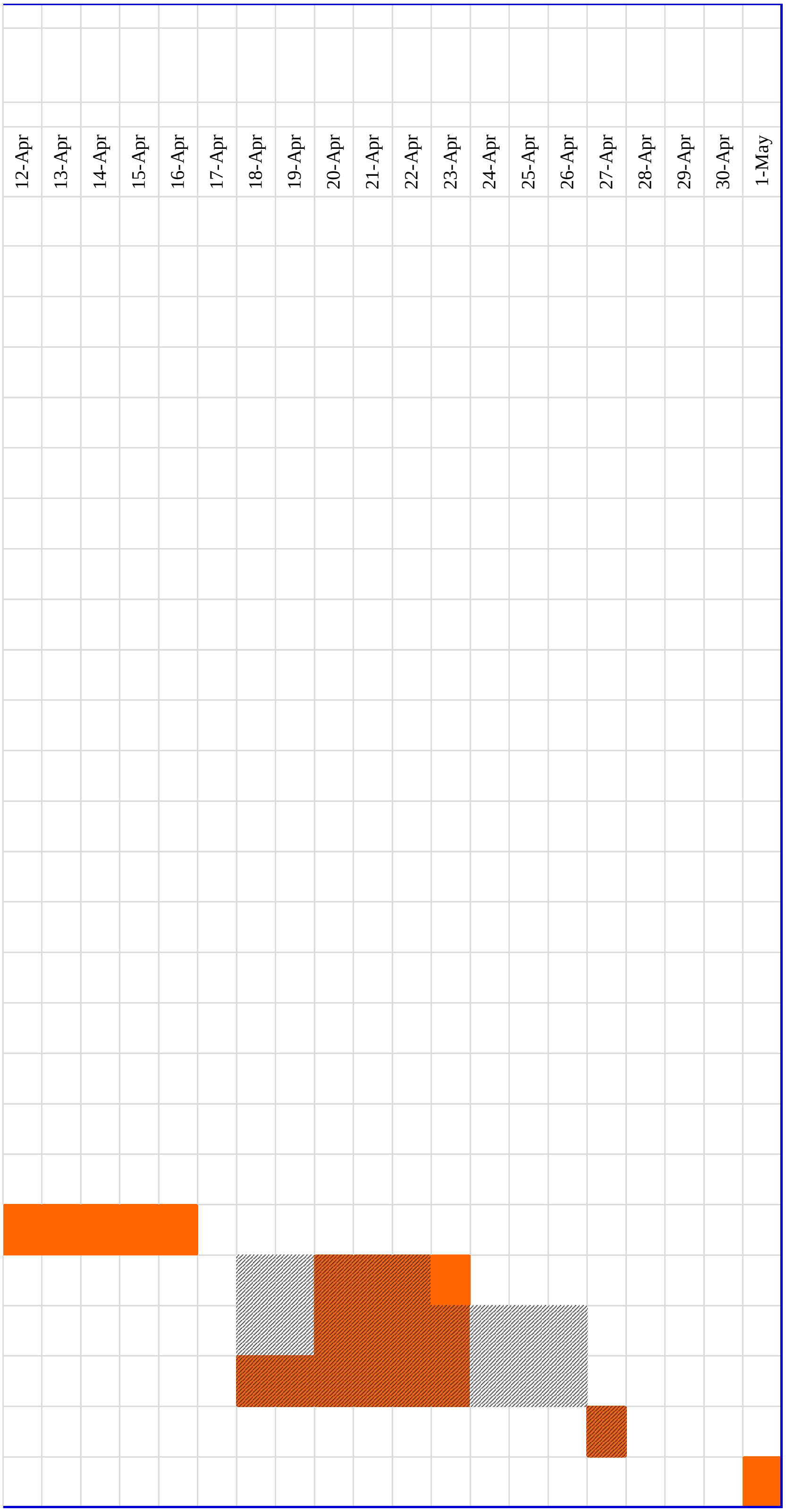
Gantt Chart

Flex Spout Punch Assembly					Actual Project Completion		Anticipated Duration (Days)		
Senior Design Spring 2015									
Mike, Scott, and Carl									Date:
Task	Person Responsible	Start Date	End Date	Actual Start Date	Actual End Date	Anticipated Duration (Days)	Actual Duration (Days)	% Complete	
Formal Proposal Due	Team	01/12/15	01/21/15	01/12/15	01/21/15	9	9	100%	
Model Components	Scott	01/23/15	03/06/15	01/23/15	03/14/15	42	50	100%	
Detail Drawings	Team	01/30/15	03/06/15	01/30/15	03/21/15	35	50	100%	
Component Production	Team	01/30/15	03/06/15	01/30/15	03/21/15	35	50	100%	
Material Ordering	Mike, Scott	02/02/15	03/02/15	02/02/15	03/17/15	28	43	100%	
Calculations	Scott	02/02/15	02/23/15	02/06/15	02/20/15	21	14	100%	
Progress Report #1 Rough Draft	Carl	02/13/15	02/20/15	02/13/15	02/20/15	7	7	100%	
Create Pneumatic Schematic	Mike	02/16/15	03/06/15	02/16/15	03/22/15	18	34	100%	
Update Gantt Chart	Mike	02/18/15	02/18/15	02/18/15	02/18/15	1	1	100%	
Progress Report #1 Due	Carl	02/23/15	02/23/15	02/23/15	02/23/15	1	1	100%	
PLC Logic Rough Draft	Carl	02/23/15	03/02/15	02/23/15	03/26/15	7	31	100%	
Build Electrical Cabinet	Mike, Carl	02/23/15	03/27/15	02/23/15	03/11/15	32	16	100%	
Plan for Testing	Mike	03/02/15	03/13/15	03/02/15	03/26/15	11	24	100%	
PLC Logic Complete	Mike, Carl	03/02/15	03/25/15	03/02/15	03/26/15	23	24	100%	
Update Drawings	Scott	03/09/15	03/27/15	03/09/15	03/21/15	18	12	100%	
Progress Report #2 Rough Draft	Carl	03/13/15	03/20/15	03/06/15	03/22/15	7	16	100%	
Update Gantt Chart	Mike	03/17/15	03/17/15	03/22/15	03/22/15	1	1	100%	
Progress Report #2	Carl	03/23/15	03/23/15	03/23/15	03/23/15	1	1	100%	
Assemble Components	Team	03/23/15	03/27/15	03/09/15	03/27/15	4	18	100%	
Test Components	Team	03/30/15	04/16/15	03/28/15	04/10/15	17	13	100%	
Oral Presentations and Rehearsals	Team	04/20/15	04/23/15	04/18/15	04/22/15	3	4	100%	
Final Report Rough Draft	Carl	04/22/15	04/26/15	04/18/15	04/26/15	4	8	100%	
Poster	Team	04/18/15	04/27/15	04/18/15	04/27/15	9	9	100%	
Final report Due	Team	04/27/15	04/27/15	04/27/15	04/27/15	1	1	100%	
Oral Presentations	Team	05/01/15	05/01/15	05/01/15	05/01/15	1	1	100%	


12-Jan
13-Jan
14-Jan
15-Jan
16-Jan
17-Jan
18-Jan
19-Jan
20-Jan
21-Jan
22-Jan
23-Jan
24-Jan
25-Jan
26-Jan
27-Jan
28-Jan
29-Jan
30-Jan
31-Jan
1-Feb
2-Feb
3-Feb
4-Feb
5-Feb
6-Feb
7-Feb
8-Feb
9-Feb
10-Feb


11-Feb
12-Feb
13-Feb
14-Feb
15-Feb
16-Feb
17-Feb
18-Feb
19-Feb
20-Feb
21-Feb
22-Feb
23-Feb
24-Feb
25-Feb
26-Feb
27-Feb
28-Feb
1-Mar
2-Mar
3-Mar
4-Mar
5-Mar
6-Mar
7-Mar
8-Mar
9-Mar
10-Mar
11-Mar
12-Mar


13-Mar
14-Mar
15-Mar
16-Mar
17-Mar
18-Mar
19-Mar
20-Mar
21-Mar
22-Mar
23-Mar
24-Mar
25-Mar
26-Mar
27-Mar
28-Mar
29-Mar
30-Mar
31-Mar
1-Apr
2-Apr
3-Apr
4-Apr
5-Apr
6-Apr
7-Apr
8-Apr
9-Apr
10-Apr
11-Apr


12-Apr
13-Apr
14-Apr
15-Apr
16-Apr
17-Apr
18-Apr
19-Apr
20-Apr
21-Apr
22-Apr
23-Apr
24-Apr
25-Apr
26-Apr
27-Apr
28-Apr
29-Apr
30-Apr
1-May

Material Costs

Description	Qty	Costs/ea	Itemized totals
Smart Relay (PLC)	1	$350.00	$350.00
Power supply (Donated)	1	$85.00	$85.00
Terminal Blocks (Dontated)	12	$2.40	$28.80
Proximity sensors (Donated)	2	$45.00	$90.00
Cables	4	$21.50	$86.00
Limit Switches (fiberoptic)	2	$83.00	$166.00
Fault Lights	1	$14.05	$14.05
Misc Wiring Supplies	1	$75.00	$75.00
Panel Closure	1	$79.00	$79.00
Push Button Closure	1	$39.00	$39.00
Punch Cylinder	1	$109.00	$109.00
Die Cylinder	1	$109.00	$109.00
Part Locate Cylinder	1	$23.75	$23.75
Part Preload Cylinder	1	$23.75	$23.75
DCV,Solenoid Controlled	4	$100.00	$400.00
Solenoid Manifold	1	$43.26	$43.26
Punch Die Set(combined costs)	5	$189.79	$189.79
Thompson Rod _3/4" dia. x 8"	2	$56.57	$113.14
Guide Bushings	4	$29.80	$119.20
Die shoe Aluminum (2-1/2"x1-1/4" x 8")	2	$27.98	$55.96
End caps Aluminum (3/4" x 3" x 8")	2	$12.48	$24.96
Retainer Blocks (4140 prehard)	2	$6.00	$12.00
Fab Materials _ Steel	1	$75.00	$75.00
4" x 12ga z 48"stainless steel plate	2	$0.00	$0.00
1/2" x 1/2" x 48" crs	1	$0.00	$0.00
Misc. Hardware Supplies	1	$50.00	$50.00
EZ Lock Inserts (1/4" - 20)	8	$0.88	$7.00
EZ Lock Inserts (5/16" -24)	8	$1.03	$8.20
Total Cost Analysis			$2,376.86

Cost Analysis

Description	Hours	Cost
Model & Design	80	$5200.00
Machining	60	$3900.00
PLC Schematic & Programming	40	$2600.00
Electrical Schematic & Wiring	30	$1950.00
Pneumatic Schematic	10	$650.00
Frame Design & Fabrication	10	$650.00
Assembly	10	$650.00
Testing	10	$650.00
Total Calculated Labor Cost	**250**	**$16,250.00**
Estimated Build Materials		$2582.13
Actual Build Materials		$2376.86

Our build came in 8% lower than our initial budget. By sponsoring our project, rieke saved an estimated $16,250 in labor costs.

The cost calculations were based on local tool shop rates of $65.00/hr.

rieke’s total material cost for this project was $2376.86.

Tooling Bill of Materials

Detail	Qty.	Description	Material	Size or Vendor Part #	Print Date	Status
1	1	Base plate	CRS	.598" x 7.0" x 11.0"	3/7/2015	Done
2	1	Side plate A	CRS	.598" x 4.75" x 6.750"	3/9/2015	Done
3	1	Side plate B	CRS	.598" x 4.75" x 6.750"	3/9/2015	Done
4	4	Proximity sensor	Allen Bradley	872C-D3NP12-D4	N/A	Done
5	1	Top plate	CRS	.598" x 4.75" x 11.0"	3/7/2015	Done
6	1	Punch cylinder	Norgren	DC/92040/M/1A	N/A	Done
7	1	Die cylinder	Norgren	DC/92040/M/1A	N/A	Done
8	2	Cylinder mount plate	Norgren	QC/90040/22	N/A	Done
9	8	Gusset	CRS	.598" x 2.5" x 2.5"	3/21/2015	Done
10	2	Guide pin	McMaster-Carr	6649K107	N/A	Done
11	4	Guide bushing	McMaster-Carr	60595K75	N/A	Done
12	8	Retaining clip	McMaster-Carr	9968K26	N/A	Done
13	4	End cap	CRS	Ø1.25" x .25"	2/28/2015	Done
14	2	Cylinder end mount	Aluminum	.72" x 1.0" x 3.38"	2/28/2015	Done
15	1	Upper die shoe	Aluminum	1.25" x 2.50" x 9.0"	1/30/2015	Done
16	1	Lower die shoe	Aluminum	1.25" x 2.50" x 9.0"	1/30/2015	Done
17	1	Punch retainer	S-7	.75" x 1.5" x 2.0"	1/30/2015	Done
18	1	Punch	Dayton	KCX 150 P=.070" M2	3/16/2015	Done
19	1	Die button retainer	S-7	.75" x 1.5" x 2.0"	1/30/2015	Done
20	1	Die button	Dayton	KNX 37 150 M2 P=.074"	3/16/2015	Done
21	4	Bump stop A	UHMW	.175" x .5" x 2.3"	3/11/2015	Done
22	4	Bump stop B	UHMW	.5" x .552" x 2.3"	3/11/2015	Done
23	4	Support	CRS	Ø.75" x 2.727"	2/28/2015	Done
24	1	Part slide base plate	Stainless Steel	.103" x 4.4" x 35.25"	3/14/2015	Done
25	1	Part slide side bar A	CRS	.75" x 1.09" x 35.25"	3/14/2015	Done
26	1	Part slide side bar B	CRS	.75" x 1.09" x 35.25"	3/14/2015	Done
27	2	Part slide top plate	Stainless Steel	.103" x 1.25" x 35.25"	3/14/2015	Done
28	2	Part stop cylinder	Norgren	RP056X2_5-DAN-UB-PL(1)-PR, MN-2	N/A	Done
29	4	Threaded insert - 1/4"-20	MSC	97435796	N/A	Done
30	4	Threaded insert - 5/16"-18	MSC	97435804	N/A	Done
31	1	Punch holder	Dayton	KDU 43 125 A2	3/16/2015	Done
32	1	Upper sensor bracket	Stainless Steel	.1" x 1.25" x 2.75"	3/21/2015	Done
33	1	Lower sensor bracket	Stainless Steel	.1" x 1.25" x 2.35"	3/21/2015	Done
34	2	Part present emitter	Banner	M12EQ8 77203	N/A	Done
35	2	Part present receiver	Banner	M12PRQ8 77199	N/A	Done

Conclusion

rieke Packaging Systems provided the team with the challenge of improving their current flex spout vent hole creation process. After the inefficiencies of the current process and the goals had been defined to us by our sponsors, the team visited the facility and evaluated the current process. The visit allowed the team to have a clear understanding of the problems the current process presented.

The team then outlined the performance specifications the new equipment would require to improve the process. The new equipment would have to increase production, control debris, improve vent hole quality, increase tool life, simplify maintenance, and limit operator interaction with automated part detection. The team concluded a punch system would address all the specifications identified.

The biggest challenges for the new punch system was to identify the forces required to punch a vent hole in the flex spouts, punch to die alignment, and positioning of the die in respect to the spout design. Finally, the punch system needed to be controlled with sensors and a PLC to be able to limit operator interaction. The MET program provided the team with the tools needed to perform the calculations for determining the required forces to punch the hole and for choosing the correct cylinder sizes to achieve the required forces. The MET program also provided us with the knowledge to design a punch and die system with 3-D modeling. The modeling allowed the team to verify the critical punch and die tool alignments and die positioning within the spout cavity. In addition, the program provided the team with the knowledge to set up an executable PLC flow chart and programing skills that allowed for limited outside assistance.

The flex spout punch assembly build was a success in terms of meeting the goals initially set by the team and the design requirements set forth by rieke. The punch creates a higher quality vent hole in the flex spout, is capable of a 250% increase in production, and eliminates the scrap that finds its way into the final packaging. An additional benefit of the new design is the cost saving realized by rieke from less compressed air usage. The team would like to thank rieke Packaging Systems for this opportunity to provide a solution to their problem, and help us fulfill the course goals of Senior Design and Analysis.

References

[1] "http://nptel.ac.in/courses/112107144/Metal%20Forming%20&%20Powder%20metallurgy/lecture5/lecture5.htm," [Online].

[2] R. Mott, Machine Elements in Mechanical Design, Upper Saddle River, New Jersey : Pearson Education, 2014.