

Manufacturing Systems Demonstration

PRON: R302C208R3

Focus: HOPE Center for Advanced Technology



Contract No: W56HZV-05-C0721

Start: 20 September 2010

Completion: 20 January 2012

WD-FH-0004 Task 3.2

Manufacture and Preparation of Test Specimens for Johnson-Cook Material Characterization

Report Date: 10 January 2012

(Text and format edited Jan 2013)

Contract Officer Tech. Representative: M. M. McDonnell (586) 282-7999
U.S. Army TARDEC, Warren, MI

Project Engineer: R. E. Miller (313) 494-4716
FH – CAT, Detroit, MI

Disclaimer: *The views and conclusion contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Government.*

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE 10 JAN 2013	2. REPORT TYPE Technical Report	3. DATES COVERED 20-09-2010 to 20-01-2012			
4. TITLE AND SUBTITLE Manufacture and Preparation of Test Specimens for Johnson-Cook Material Characterization		5a. CONTRACT NUMBER W56HZV-05-C0721			
		5b. GRANT NUMBER			
		5c. PROGRAM ELEMENT NUMBER			
6. AUTHOR(S) R Miller		5d. PROJECT NUMBER			
		5e. TASK NUMBER			
		5f. WORK UNIT NUMBER			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Focus: HOPE Center for Advanced Technology,1355 Oakman Boulevard,Detroit,Mi,48238		8. PERFORMING ORGANIZATION REPORT NUMBER WD-FH-0004 Task 3.2			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army TARDEC, 6501 East Eleven Mile Rd, Warren, Mi, 48397-5000		10. SPONSOR/MONITOR'S ACRONYM(S) TARDEC			
		11. SPONSOR/MONITOR'S REPORT NUMBER(S) #23657			
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT As a revision to Contract #W56HZV-05-0721 (WD-FH-0004), this task was added to the current project for the purpose of performing material characterizations and developing Johnson-Cook (J-C) strength and damage constants of friction stir welded (FSW) ballistic joints. These material constants will be used by the government for ballistic blast and other types of modeling and simulation, and will be included in the Elastic Plastic Impact Code (EPIC) library. This report describes the welding and machining processes used to manufacture the material test specimens used for the J-C material characterization tests and provides the results of metallurgical analysis for the FSW joint of each selected armor material.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Public Release	18. NUMBER OF PAGES 98	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

TABLE OF CONTENTS

1.0 INTRODUCTION..... 2

2.0 WELD COUPON MANUFACTURING..... 3

 2.1 Material 3

 2.2 Coupon Production 3

3.0 WELD JOINT METALLURGICAL ANALYSIS 7

 3.1 Sample Preparation 7

 3.2 Microstructural Analysis 7

 3.3 Microhardness..... 10

 3.4 Electron Backscatter Diffraction 12

 3.5 Tensile Strength 15

 3.5 J-C Test Specimen Location 17

4.0 FINAL SPECIMEN MACHINING 18

Appendix A – FSW Process Parameter Development Tables

Appendix B – Test Specimen Prints

Appendix C – FH-CAT Machining Process Details

1.0 INTRODUCTION

As a revision to Contract #W56HZV-05-0721 (WD-FH-0004), this task was added to the current project for the purpose of performing material characterizations and developing Johnson-Cook (J-C) strength and damage constants of friction stir welded (FSW) ballistic joints. These material constants will be used by the government for ballistic, blast and other types of modeling and simulation, and will be included in the Elastic Plastic Impact Code (EPIC) library. This report describes the welding and machining processes used to manufacture the material test specimens used for the J-C material characterization tests and provides the results of metallurgical analysis for the FSW joint of each selected armor material.

At the onset of this project, U.S. Army TARDEC personnel identified six armor materials (See Table 1-1) which were either currently in use or under consideration for future use for ballistic structures and had not undergone FSW joint material strength characterization. Due to budgetary limitations, only three of these materials were selected for J-C analysis: 6061, 5083, and 2139 aluminum alloys. TARDEC wanted high-hardness steel armor to be one of the chosen materials however preliminary FSW tool trials using a tungsten-rhenium tool to weld ½-inch thick plate of this material indicated that excessive tool wear would prohibit its inclusion in this study. Development of FSW weld joints of high-hardness steel armor are continuing at FH-CAT with the goal of including this material in a future J-C material characterization study.

TABLE 1-1: Ballistic Armor Materials

Selected for J-C Analysis	Material
Selected for J-C Analysis	1. 6061-T6511 aluminum alloy, Class 1, MIL-DTL-32262
Selected for J-C Analysis	2. Steel - high-hardness, MIL-DTL-46100E
Selected for J-C Analysis	3. 5083-H131 aluminum alloy, Class 1, MIL-DTL-46027K
Selected for J-C Analysis	4. 2139-T8 aluminum alloy, Class 1, MIL-DTL-32341
Selected for J-C Analysis	5. 2195-T64 aluminum alloy, Class 2, MIL-DTL-32341
Selected for J-C Analysis	6. Steel – homogeneous, Class 1 or 2, MIL-DTL-12560J

2.0 WELD COUPON MANUFACTURING

2.1 Material

The 6061 aluminum armor used for this project was manufactured by Kaiser Aluminum (Fairfield, IL) and was delivered as 1-in. x 2-in. x 12-ft. bars (Lot #Z00222015). The full-length bars were then cut into 8-in. lengths¹ using a band saw with cooling fluid.

The 2139 aluminum armor used for this project was manufactured by Alcan Rolled Products (Ravenswood, WV). Due to the limited availability of this experimental armor, it was delivered as three large plates: one 1-in. x 24-in. x 47.5-in. (Lot #820081) and two 1-in. x 48-in. x 48 in. (Lot # 820091). The plates were cut into 2-in. wide bars using a water-jet machine and these bars were then cut into 8-in. lengths using a band saw with cooling fluid. One side of each bar was milled to remove the surface finish left by the water-jet cutting process.

The 5083 aluminum armor used for this project was also manufactured by Alcan and originally delivered to Sunshine Metals (Glenpool, OK) as a 1 1/8-in. x 20-in. x 170-in. plate (Lot #125831). At Sunshine, the plate was then milled to 1.0-in. thick and then sawed into the 12-in. x 156-in. plate that was subsequently delivered to FH-CAT². The plate was then cut into 2-in. x 8-in. segments using a band saw with cooling fluid. One side of each bar was milled to remove the saw marks.

2.2 Coupon Production

The weld coupons (Figure 2-1) were all manufactured on the same FH-CAT FSW machine, a Transformation Technologies, Inc. (Elkhart, IN) Model GG1 (Figure 2-2), in single batches for each material. For all three materials, an FSW tool made of H13 tool steel with a scrolled pin and shoulder (See Figure 2-3) was used however the different heat requirements of the materials required that different tool shoulder diameters be used; 50.8-mm for 6061 and 40-mm for 5083 and 2139. The 6061 coupons were

¹At the beginning of this expedited project an FSW coupon fixture and machine program that was currently in use at FH-CAT at that time was used for coupon manufacturing.

² This 12-in. wide plate was originally ordered as material for ballistic target weldments.

completed on July 11, 2011, the 5083 coupons on August 2, 2011, and the 2139 coupons on November 9, 2011.



Figure 2-1: 6061 FSW Coupon



Figure 2-2: Friction Stir Weld Machine



Figure 2-3: FSW Tool (40-mm dia. shown)

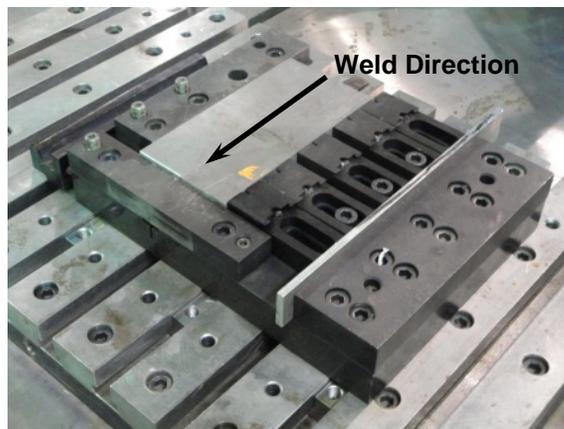
Other than the material-specific welding parameters shown in Table 2-1, the manufacturing of each coupon followed the following process:

1. Clean two material bars with ethyl alcohol and a disposable towel.
2. Blow debris from the fixture using a compressed air nozzle.
3. Place the bars into the fixture (See Figure 2-4), with the square/milled sides at the joint, and tighten the fixture clamps with a hex head torque wrench (25 ft-lbs).
4. Inspect the material installation to confirm proper positioning and fit.
5. Using machine manual mode, lower the spindle so that the FSW tool tip is near the top of the material bars. The exact point of where the tip contacts the material is then found using the manual mode micro adjustment knob.
Recalibrate the Z-axis positioning to account for fixture height variations caused by heat variations.
6. Initiate the CNC welding program via the machine's operator interface panel.
7. Visually monitor the entire welding cycle.
8. Upon completion of the automated welding cycle, the welded coupon remains in the fixture for 1-2 minutes to allow cooling.
9. Visually inspect the quality of the weld.
10. After the in-fixture cooling period, release the clamps and transfer the coupon to the machine's bed plate to allow it to cool to room temperature.
11. During this cooling step, mark the coupon with a sequential number using a paint pen.
12. Allow the empty fixture to cool before installing the next set of material bars.
(The cooling period was 10 minutes minimum for the 6061 and 5083 materials. Due to high spindle torque during welding of 2139 coupons, the fixture and machine were cooled for a minimum of 30 minutes.)

On several occasions for all material batches, the time span between individual coupon welding was several hours to several days because of personnel and shop work schedules.

Table 2-1: FSW Coupon Process Parameters

	<i>Tool Shoulder Dia. (mm)</i>	<i>Rotation (RPM)</i>	<i>Traverse Speed (mm/min)</i>	<i>Axial Force (kN)</i>	<i>Tilt Angle (deg.)</i>	<i>Tool Coolant</i>
6061	50.8	450	150	45	2	no
5083	40.0	300	25	33	3	yes
2139	40.0	250	40	43	3	yes

**Figure 2-4: Coupon Weld Fixture**

As preparation for X-ray inspection of the welds, each coupon was machined to remove the inherent FSW flaws. Both ends of the coupons were removed using a laboratory precision wet saw to remove the weld starts and exit holes and to set the final coupon lengths of 4.5-in. The top surface of each coupon was then milled to remove weld flash.

Each material batch of coupons was then X-ray inspected at Magna Chek Inc. (Madison Heights, MI). None of the coupons exhibited any internal flaws.

3.0 WELD JOINT METALLURGICAL ANALYSIS

3.1 Sample Preparation

After the material-specific FSW process parameters were optimized (See Appendix A for development process parameters.), a set of coupons was segmented using a laboratory wet saw to provide transverse weld joint samples for hardness evaluation, micrographs, scanning electron microscopy (SEM), electron backscatter diffraction (EBSD), and tensile strength analysis. As required, samples were mounted, polished, and/or chemical etched (Keller's reagent). The transverse tensile test specimens (ASTM E8 – flat, sub-size) were machined and tested at FH-CAT (See Figure 3-1).

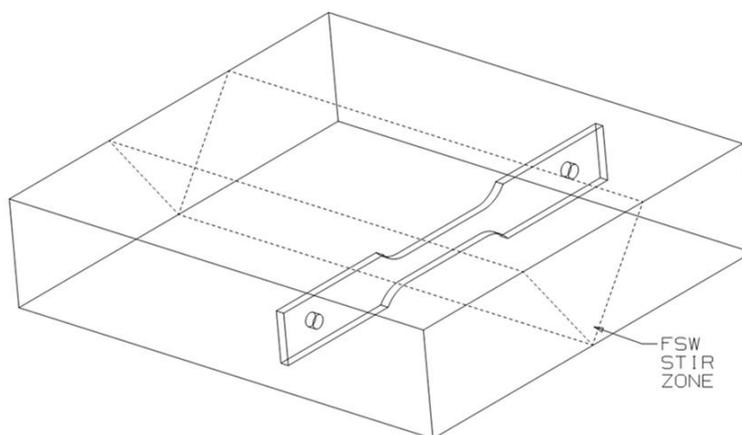


Figure 3-1: FH-CAT Tensile Test Specimen Location

3.2 Microstructural Analysis

Microstructural analysis was conducted using a Nikon Eclipse LV150 optical microscope and a Zeiss EVO MA10 SEM. Images were obtained from the optical microscope using a calibrated digital camera, and Scentis software. Optical microscope images were captured at 500x magnification and SEM images were captured at 500x and 1000x magnifications. Figures 3-2, 3-3 and 3-4 show the microscopic results for Al 6061, Al 5083, and Al 2139 respectively.

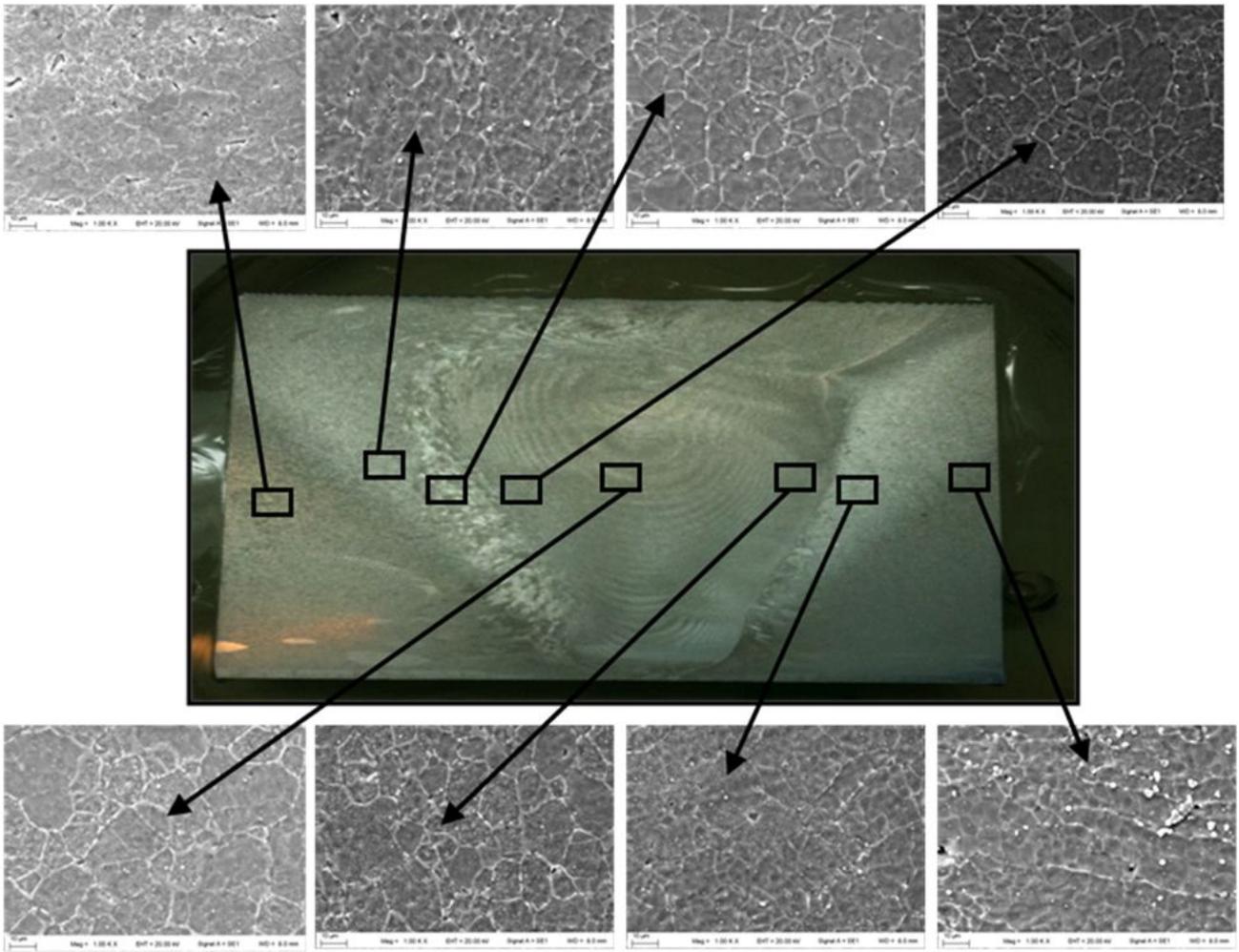


Figure 3-2: Microscopic Views of 6061 FSW Joint

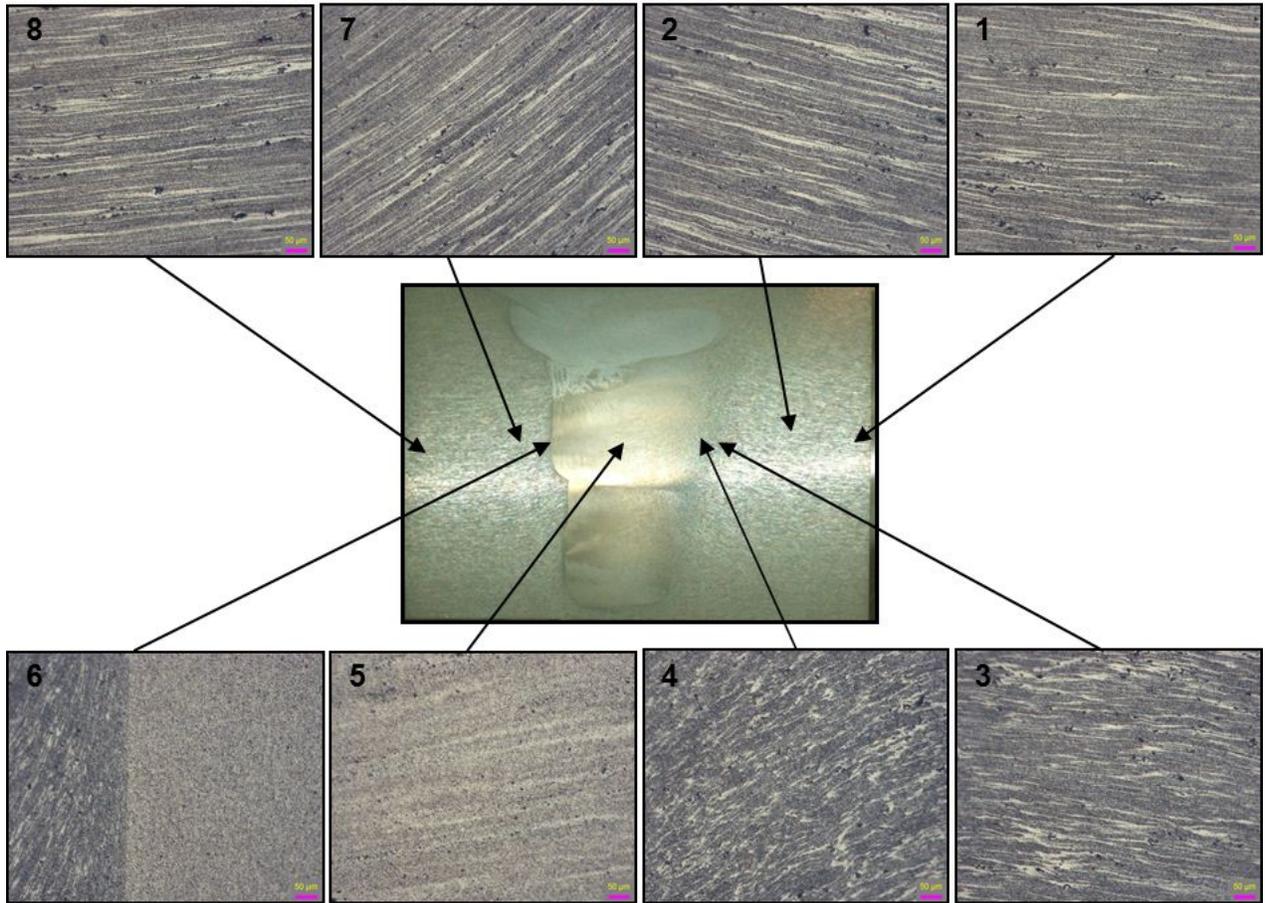


Figure 3-3: Microscopic Views of 5083 FSW Joint.

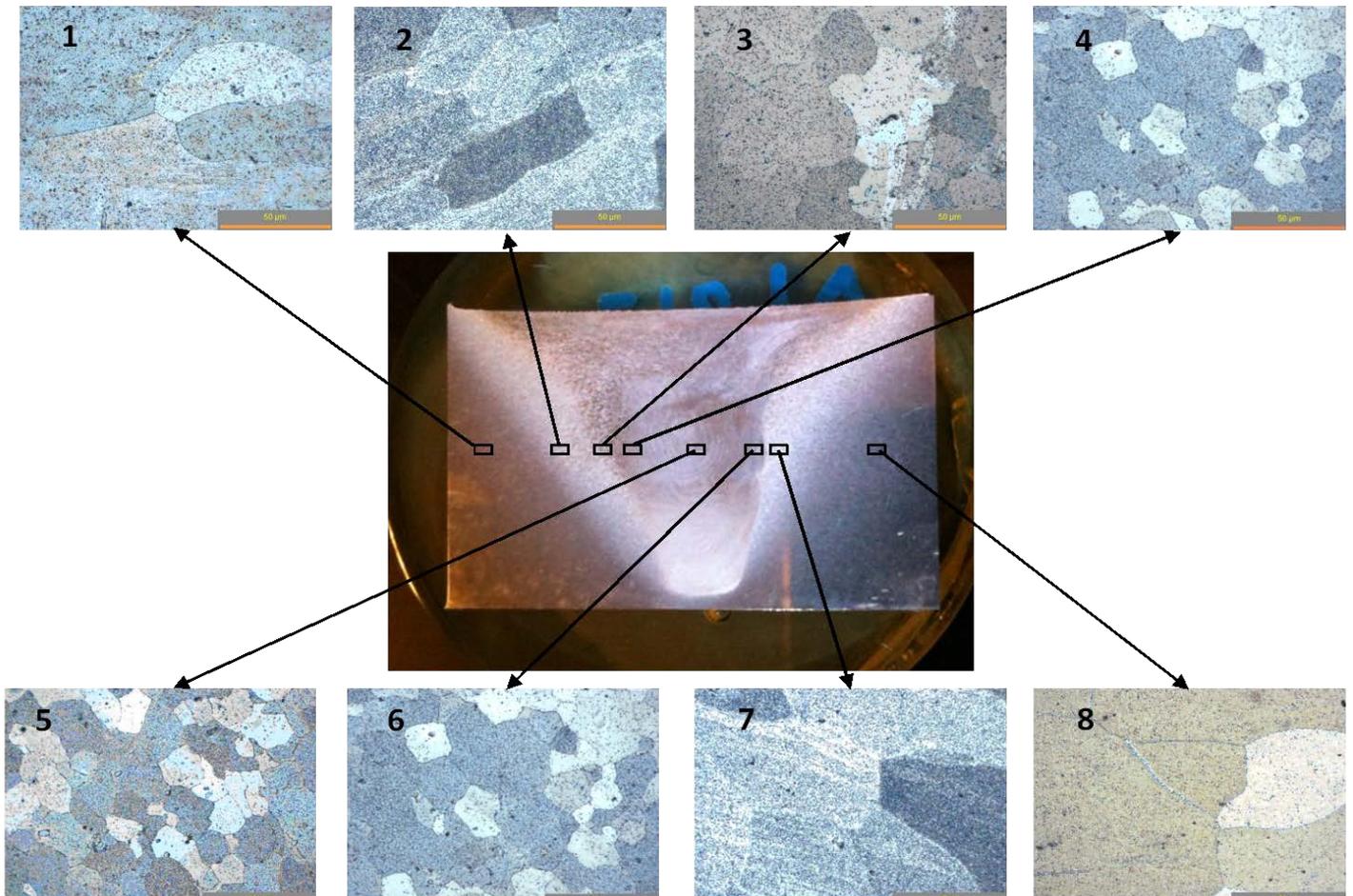


Figure 3-4: Microscopic Views of 2139 FSW Joint.

3.3 Microhardness

Microhardness charts were created using a Leco LM100AT hardness tester. Figure 3-5 compares the microhardness charts for the 6061, 5083, and 2139 FSW weld joints.

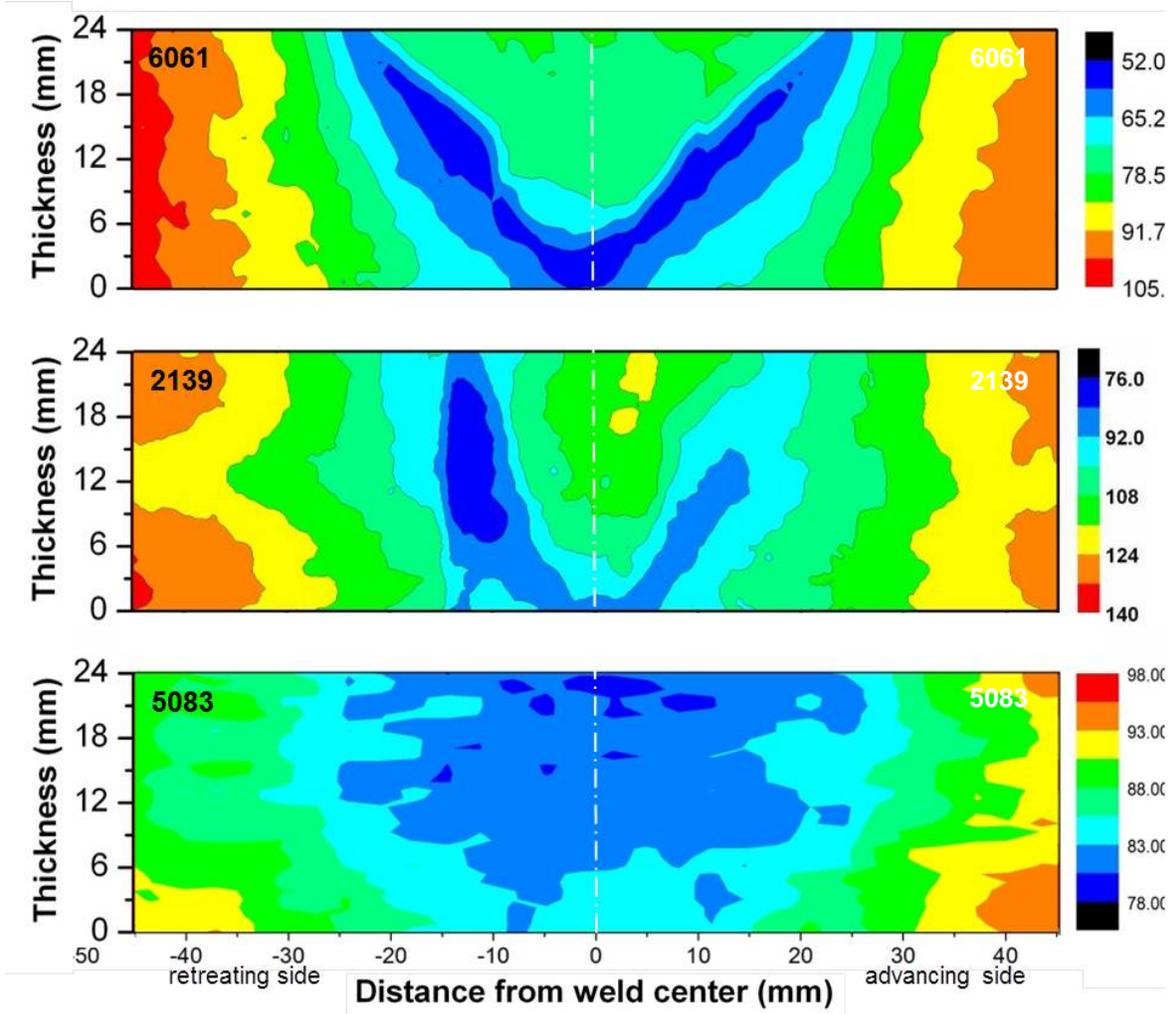


Figure 3-5 : FSW Joint Micro-Hardness (HV)

3.4 Electron Backscatter Diffraction

Further definition of the metallurgic grain structure across the weld joint was conducted using EBSD. Prepared FSW joint samples were analyzed with a Hikari/EDAX backscatter detection system mounted to a Zeiss EVO MA10 SEM. Figures 3-6, 3-7, and 3-8 show the EBSD results.

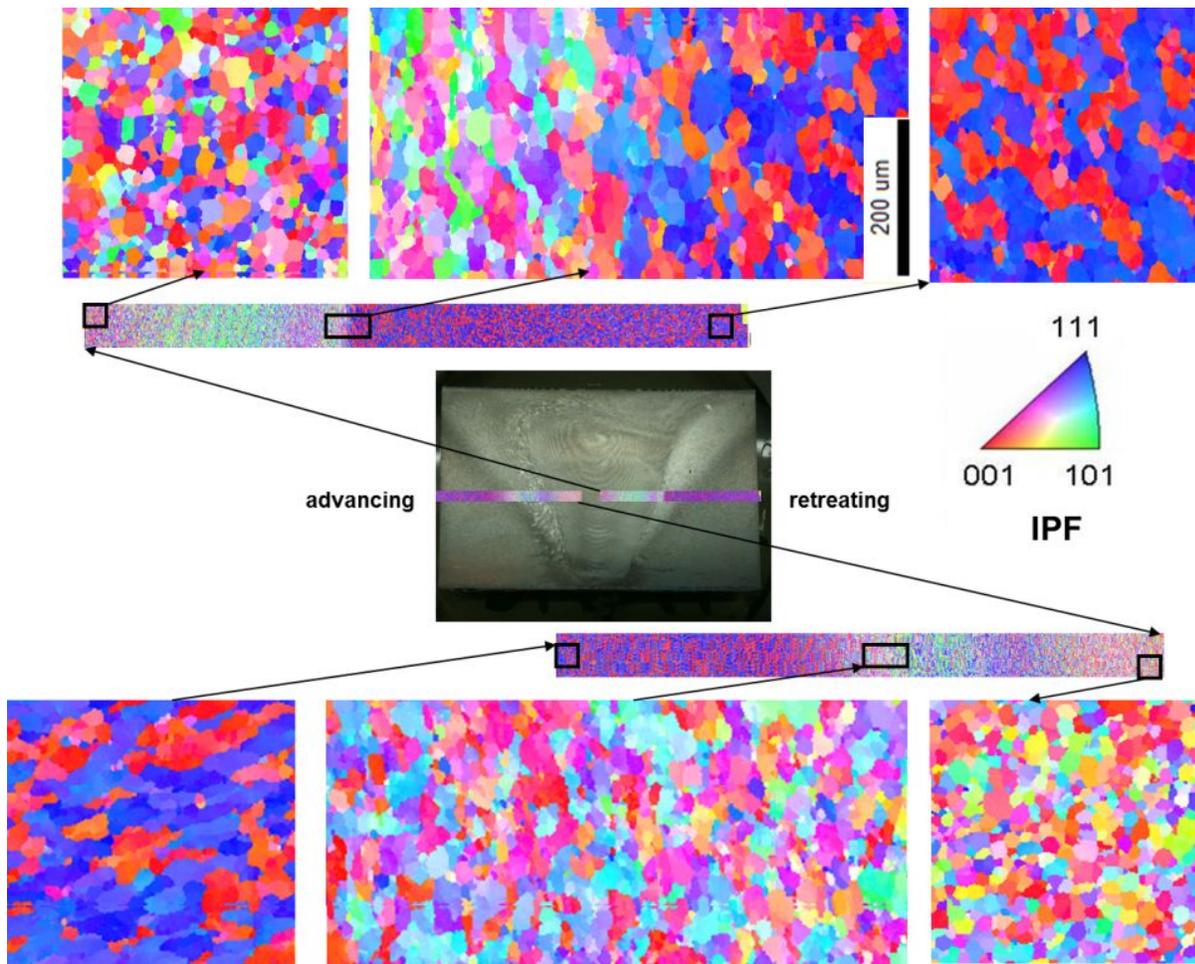


Figure 3-6: EBSD of 6061 FSW Joint

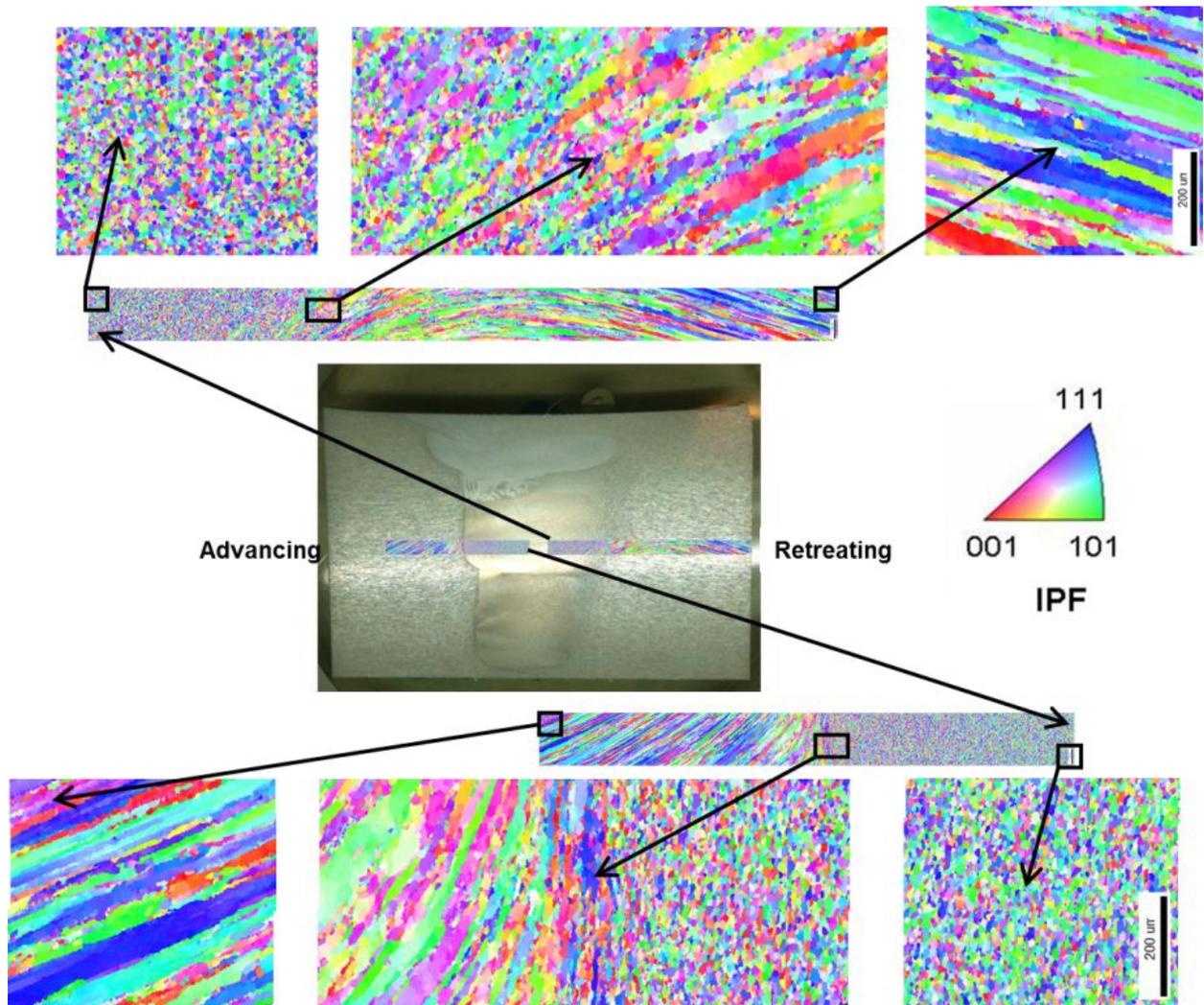


Figure 3-7: EBSD of 5083 FSW Joint

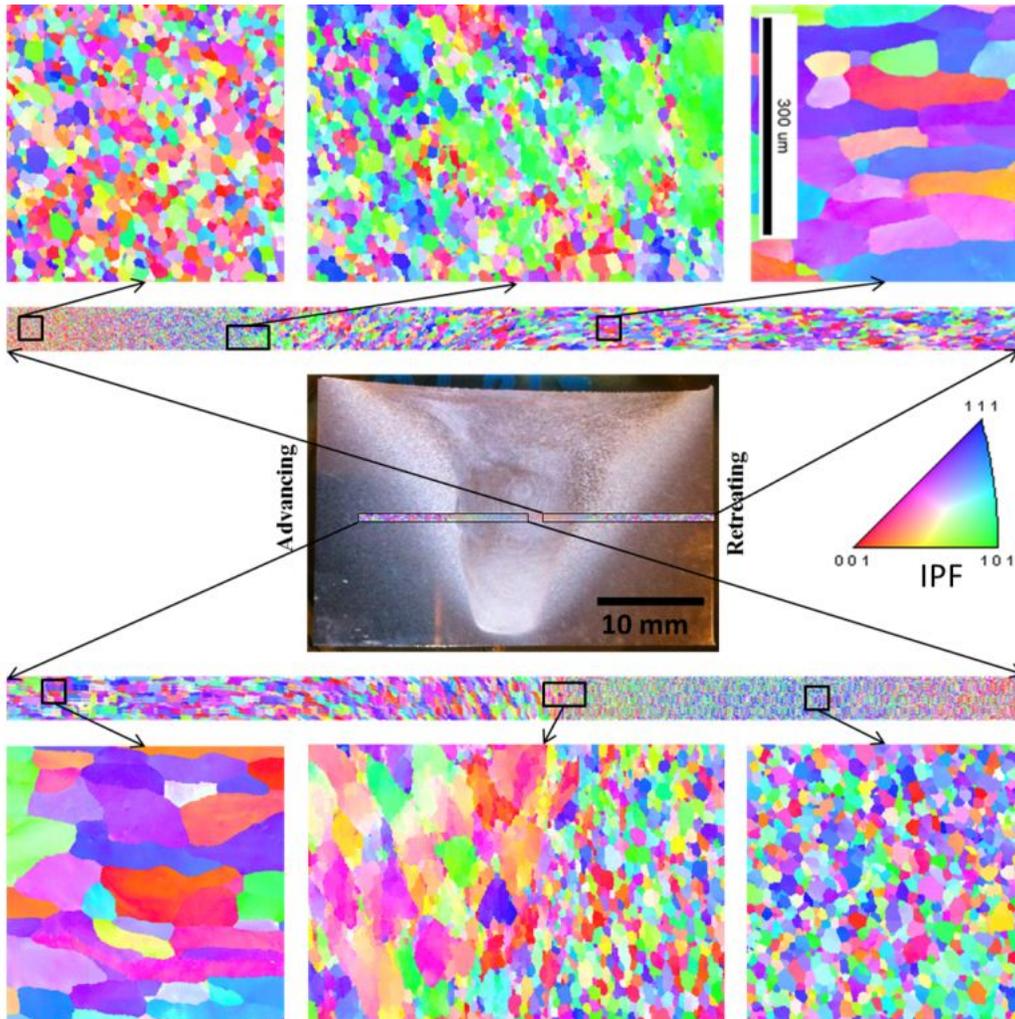


Figure 3-8: EBSD of 2139 FSW Joint

3.5 Tensile Strength

Tensile tests were conducted using an Instron Model 5982 universal testing machine with a strain rate of 1 mm/min. The force was measured using a 100 kN load cell, and elongation was measured using a 1-in. length extensometer. Table 3-1 compares the strength test results for all three FSW materials with their respective base materials. Figures 3-9, 3-10, and 3-11 show the stress vs. strain relationships of the FSW joints.

Table 3-1 : Tensile Test Results

	<i>Yield Strength (MPa)</i>	<i>Ultimate Yield (MPa)</i>	<i>% Elongation</i>
6061 FSW	194	270	7.06%
6061 Base	507	576	12%
% Change	-61.7%	-53.1%	-41.2%
5083 FSW	229	394	18.4%
5083 Base	333	442	19%
% Change	-31.2%	-10.9%	-3.2%
2139 FSW	235	405	14.9%
2139 Base	475	500	13.1%
% Change	-50.5%	-19.0%	13.7%

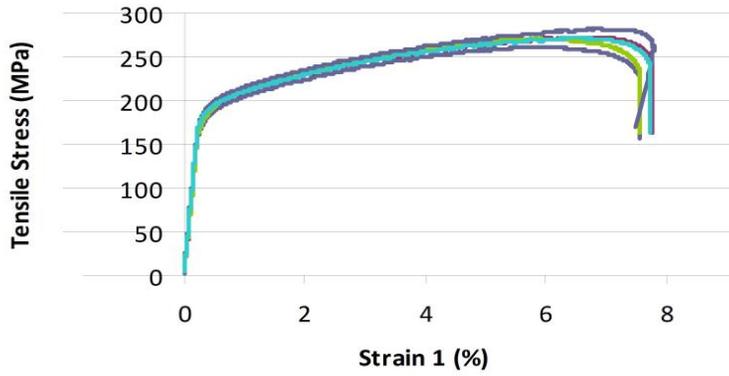


Figure 3-9: 6061 FSW Stress vs. Strain

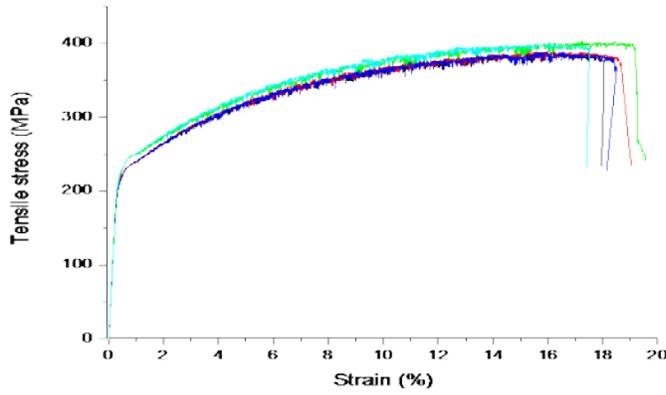


Figure 3-10: 5083 FSW Stress vs. Strain

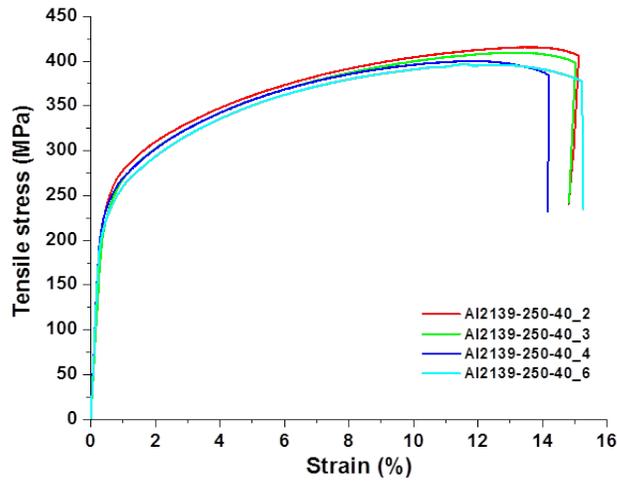


Figure 3-11: 2139 FSW Stress vs. Strain

3.5 J-C Test Specimen Location

SWRI selected the centerline positions of the final specimens using the coupon transverse micro-hardness chart (See Figure 3-12) and macro-etch sample for each material. While the weakest part of an FSW joint is typically the thermo-mechanically affected zone (TMAZ) where the softest material is found, commonality with a previous FSW joint characterization study³ was the driving factor for the positions selected for this project. For only the 2139 FSW zone material, the horizontal centerline of the specimen location was slightly lower (1.3-mm) than all other locations to avoid a small area of relatively harder material in the upper, advancing side of the FSW zone.

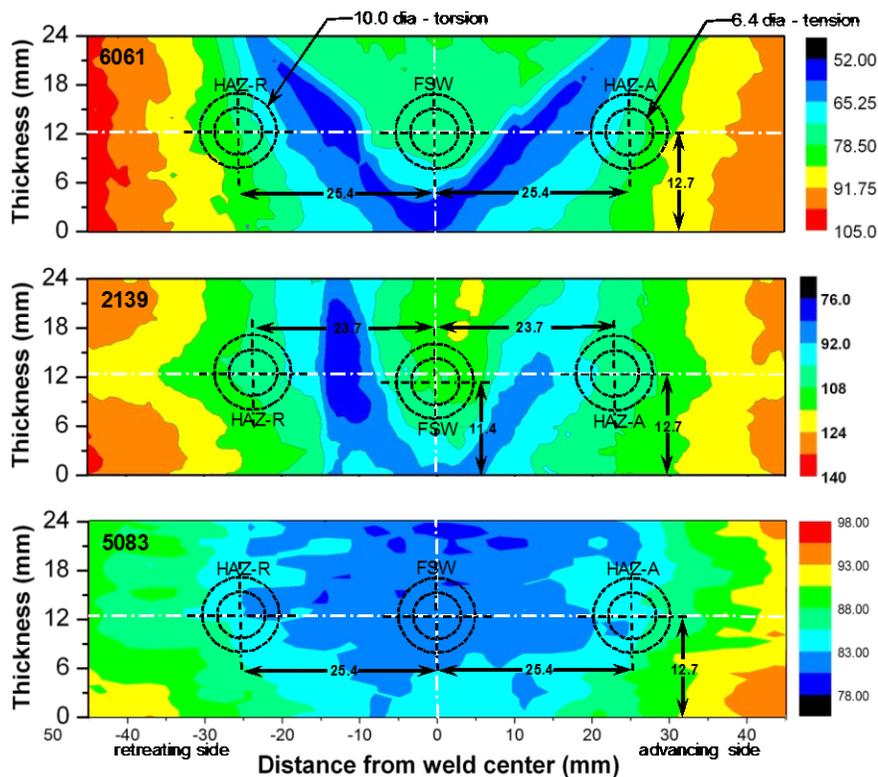


Figure 3-12: Specimen Locations

³ TARDEC Report 18.12544/026, *Mechanical Characterization of Friction Stir Welded Aluminum 5059-H131 (Weld and Heat Affected Zone) for Determination of Johnson-Cook Constitutive Constants*, Sep 2010, Southwest Research Institute, San Antonio, TX

4.0 FINAL SPECIMEN MACHINING

After returning from X-ray inspection, three specimen bars were longitudinally extracted from each FSW coupon; FSW zone, HAZ advancing side, and HAZ retreating side (See Figure 4-1).

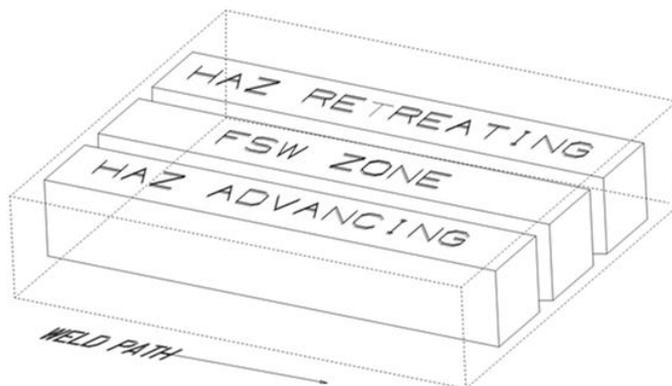


Figure 4-1: Specimen Bar Coupon Locations

To duplicate previous J-C strength and damage studies of armor material conducted at SWRI, several different specimen configurations were required from each of the coupon specimen positions (See Table 4-1). See Appendix B for the specimen design prints and Appendix C for FH-CAT machining process descriptions.

For all of the specimen bars of the 6061 and 5083 material sets, one end was machined using a Cincinnati 630XT CNC machining center to a diameter of 0.75-in. (0.80-in. for B and E Notch Tension specimen bars) to aid subsequent processes. One end of $\frac{3}{4}$ -13 UNC-2A threads for the B and E Notch Tension specimen bars were also machined at this operation. Throughout the FH-CAT manufacturing process, material coupons, specimen bars, and specimens were segregated into separate bins, bags, and/or laser marked between process steps. Each specimen was individually bagged for shipping to SWRI.

6061 and 5083 base material .250 Tension specimens were initially produced as a machining process trial and then provided to SWRI for inspection and approval. With their approval, “production” manufacturing of the FSW test specimens began.

Table 4-1: J-C Test Specimens

Material Location	Test Type	Specimen Type	SWRI Dwg. No.	Qty
FSW ZONE	Quasistatic Tension	Threaded cylind. tensile	18-01147-510-5A	8
	B-Notched Tension	Threaded cylind. tensile	18-01147-510-3	4
	E-Notched Tension	Threaded cylind. tensile	18-01147-510-4	4
	SHPB Tension	Threaded cylind. tensile	"SHPB Tensile"	8
	SHPB Compression	Cylinder L/D=2	18-01147-510-6	16
	Taylor Anvil	Cylinder L/D = 5	"T.A.I.T Specimen" 10-11-2005	10
	Torsion	Hollow, Hex head	"Torsion Specimen Subsize" 07-21-2005	8
HAZ ADVANCE	Quasistatic Tension	Threaded cylind. tensile	18-01147-510-5A	4
	Taylor Anvil	Cylinder L/D = 5	"T.A.I.T Specimen" 10-11-2005	10
HAZ RETREAT	Quasistatic Tension	Threaded cylind. tensile	18-01147-510-5A	4
	Taylor Anvil	Cylinder L/D = 5	"T.A.I.T Specimen" 10-11-2005	10
BASE	Quasistatic Tension	Threaded cylind. tensile	18-01147-510-5A	8

The Quasistatic Tension, SHPB Tension, SHPB Compression, and Taylor Anvil Impact Test specimens of the 6061 and 5083 materials were machined at FH-CAT. Due to machine resource limitations at FH-CAT, the machining of the 6061 and 5083 B-Notch Tension, E-Notch Tension, and Sub-size Torsion specimens and all of the 2139 specimens was done by the SWRI machine shop using FSW material blanks provided by FH-CAT.

The FH-CAT Quasistatic and SHPB Tension specimens were turned to final shape and threaded using a Mazak 100-III3 CNC machining center yielding one specimen per material blank. These specimens were then manually polished using a bench grinder with a 6-in. dia. sewn cotton buffing wheel. For the final operation, each tension

specimen was inserted into a ½-in. inside diameter plastic tube to protect the surface finish and then cut to final length using the Mazak 100. Figure 4-2 depicts the complete manufacturing process, material bars thru final machining, for the tension specimens.

The Taylor Anvil Impact Test (TAIT) specimen blanks were turned to 0.625-in. diameter using the Mazak 100 and subsequently turned to final diameter and rough length using a Hardinge Conquest T42 CNC lathe. This process yielded three specimens per material blank. The TAIT specimens were then milled to final length using a Cincinnati VMC500 CNC machining center.

The SHPB Compression specimens were turned to final diameter and rough length (four per blank) using the Hardinge CNC lathe and were then milled to final length using the Cincinnati VMC500.

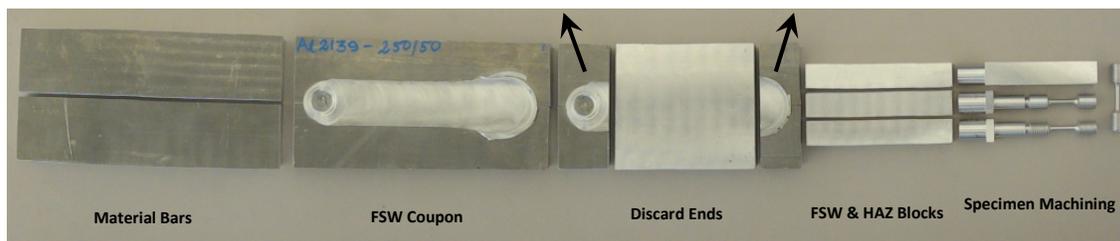


Figure 4-2: Specimen Manufacturing - Material Stock Thru Final Machining

UNCLASSIFIED

Appendix A

FSW Process Parameter Development

UNCLASSIFIED

DOE for FSP/FSW of 6061-T651 Al

DOE 014

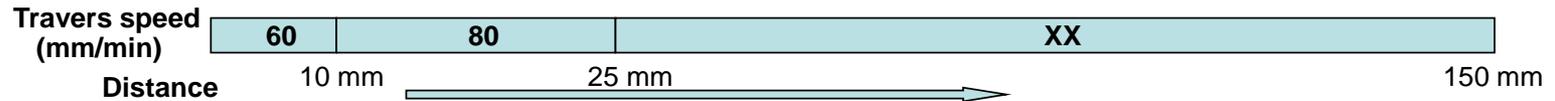
Operator:

Date: 04/13/11

Substrate Material: 6061-T651 Al, 1" thick plate, 8 " × 2 " in size

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	38	25		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	800	35	20	- 24	- 25



Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1(9)	300	100	35	34	2		
2(10)	300	120	35	36	2		
3(11)	300	140	35	38	2		
4(7)	400	120	35	25	2		
5(8)	400	150	35	28	2		

DOE for FSP/FSW of 6061-T651 Al

DOE 015

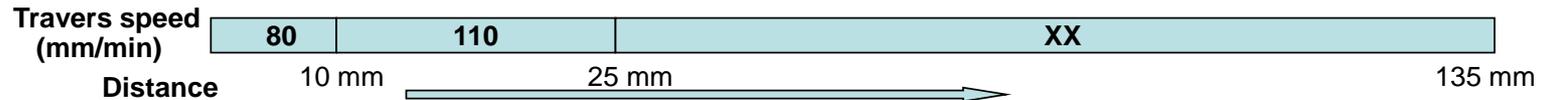
Operator:

Date: 04/28/11

Substrate Material: 6061-T651 Al, 1" thick plate, 10 " × 2 " in size

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	50.8	24		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	800	45	20	- 24.2	- 24.2



Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1(1)	450	140	45	48	2	No defect	
2(2)	450	160	45	50	2	No defect	
3	450	180	45		2		
4(3)	500	140	45	48	2	No defect	
5(4)	500	160	45	51	2	No defect	
6	500	180	45		2		
7	550	140	45		2		
8	550	160	45		2		
9	550	180	45		2		

DOE for FSW of Al 5083-H131

DOE 017

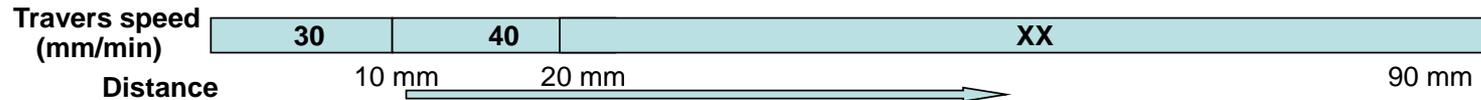
Operator:

Date: 06/08/11

Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.17		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.0	- 24.17



Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	300	36	60	32-34	2		
2	300	45	60	32-34	2		
3	300	54	60	35-37	2		
4	350	36	60	30-35	2		
5	350	45	60	31-33	2		
6	350	54	60	39-41	2		
7	400	36	60	33-35	2		
8	400	45	60	38-40	2		
9	400	54	60	40-42	2		

DOE for FSW of Al 5083-H131

DOE 019

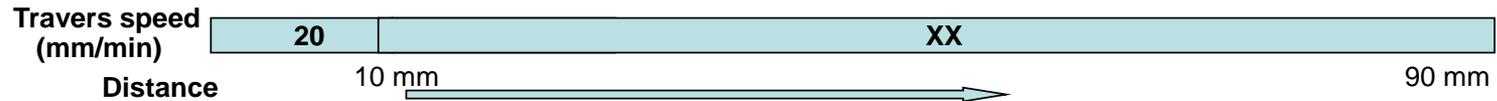
Operator:

Date: 06/22/11

Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.17		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.0	- 24.17



Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	300	20	60	28-31	2		
2	300	30	60	28-29	2		
3	300	40	60	28-29	2		
4	350	20	60	28-30	2		
5	350	30	60	28-29	2		
6	350	40	60	28-29	2		
7	400	20	60	27-33	2		
8	400	30	60	28-29	2		
9	400	40	60	30-31	2		

DOE for FSW of Al 5083-H131

DOE 020

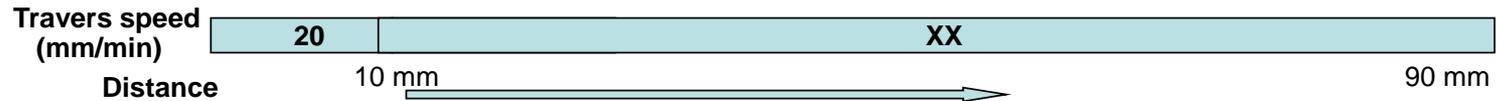
Operator:

Date: 06/23/11

Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.17		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.0	- 24.17



Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	300	20	60		3		
2	300	30	60		3		
3	300	40	60		3		
4	350	20	60		3		
5	350	30	60		3		
6	350	40	60		3		
7	400	20	60		3		
8	400	30	60		3		
9	400	40	60		3		

DOE for FSW of Al 5083-H131

DOE 021

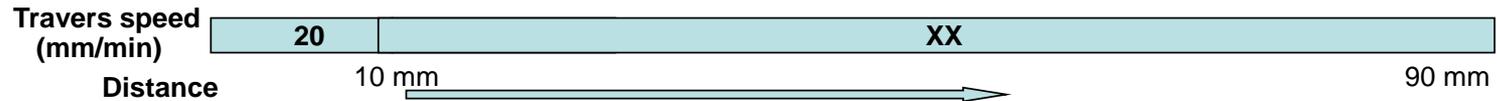
Operator:

Date: 06/24/11

Substrate Material: Al 5083-H131 , 1" thick plate, 6 " × 2 " in size

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.17		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.0	- 24.17



Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	250	20	60	33	3		No defect
2	250	25	60	33	3		No defect
3	250	30	60	33	3		No defect
4	300	20	60	34	3		No defect
5	300	25	60	33	3	Best Parameter	No defect
6	300	30	60	33	3		No defect
7	350	20	60	30	3		No defect
8	350	25	60	31	3		No defect
9	350	30	60	33	3		No defect

DOE for FSW of Al 2139-T8

DOE 022

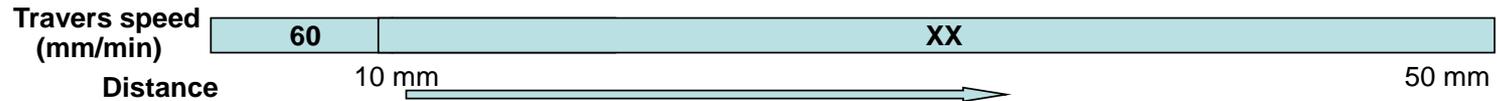
Operator:

Date: 09/26/11

Substrate Material: Al 2139-T8, 1" thick plate, 8 " × 2 " in size

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	50.8	24.05		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.05	- 24.05



Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	400	100	50	63	2		
2	400	70	60	69	2		
3	350	100	60	87	2		
4							
5							
6							
7							
8							
9							

DOE for FSW of Al 2139-T8

DOE 023

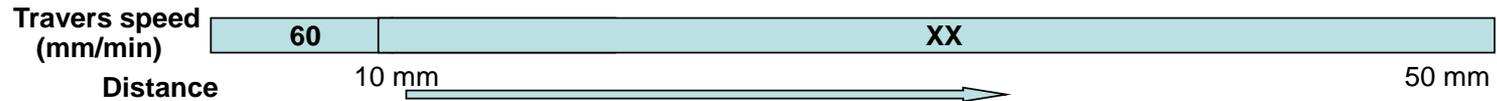
Operator:

Date: 09/26/11

Substrate Material: Al 2139-T8, 1" thick plate, 8 " × 2 " in size

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.17		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.17	- 24.17



Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	350	80	60	58	3	Wormhole	
2	300	60	60	57	3	Wormhole	
3	300	80	60	59	3	Wormhole	
4	250	60	60	50	3	Wormhole	
5	250	40	60	45	3	No defect	

DOE for FSW of Al 2139-T8

DOE 024

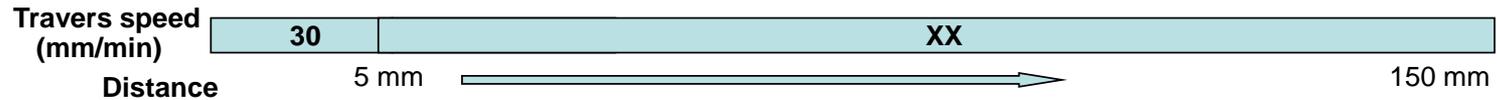
Operator:

Date: 09/28/11

Substrate Material: Al 2139-T8, 1" thick plate, 8 " × 2 " in size

Tool Material	Tool pin geometry	Shoulder diameter (mm)	Pin length (mm)	Pin diameter (mm)	Pitch width (mm)
H13 steel, Rc 54	Scrolled, conical	40	24.33		

Tool plunging	Rotation rate (rpm)	Force (KN)	Feed rate (mm/min)	W (mm)	Z (mm)
	600	60	20	- 24.35	- 24.35



Run Order (S.N.)	Rotation rate (rpm)	Traverse speed (mm/min)	Force (KN)	Actual Force (kN)	Tool tilt (degree)	Remarks on weld quality	
						Macroscopic	Microscopic
1	250	30	60	39-43	3		No defect
2	250	40	60	40-45	3	Best Parameters	No defect
3	250	50	60	42-48	3		No defect

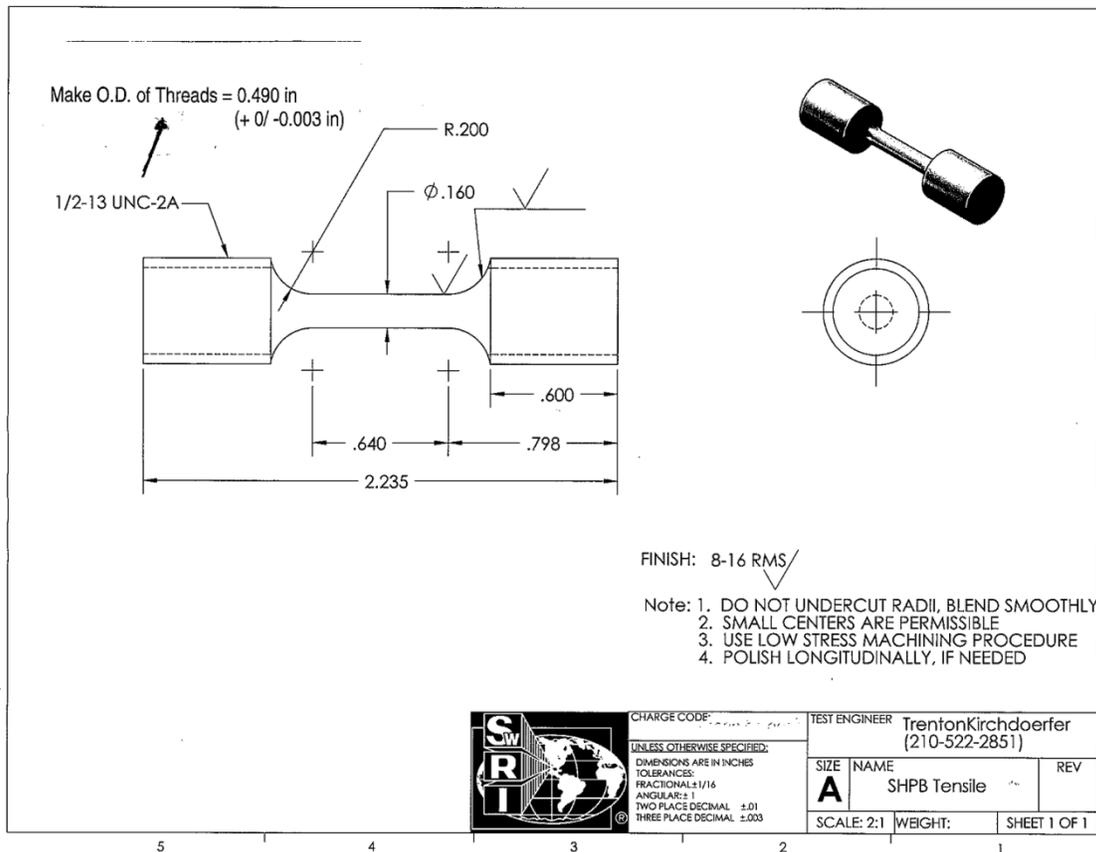
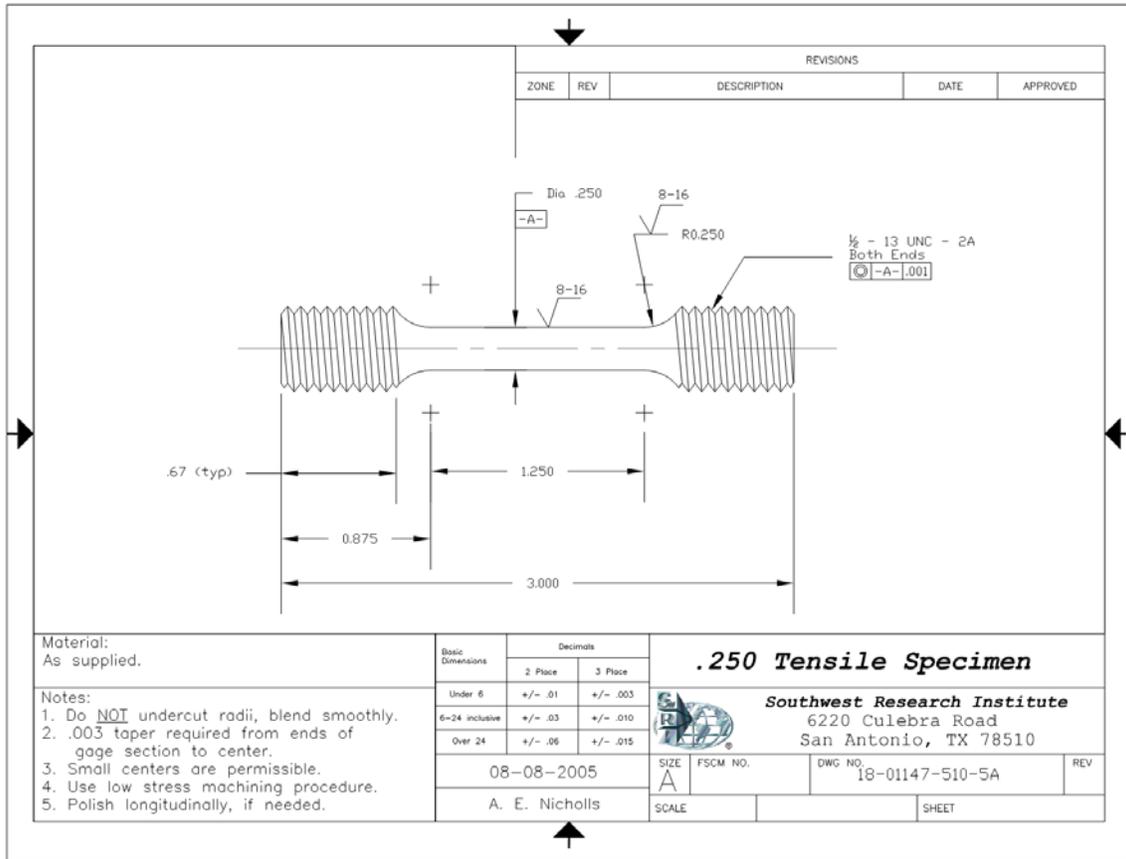
UNCLASSIFIED

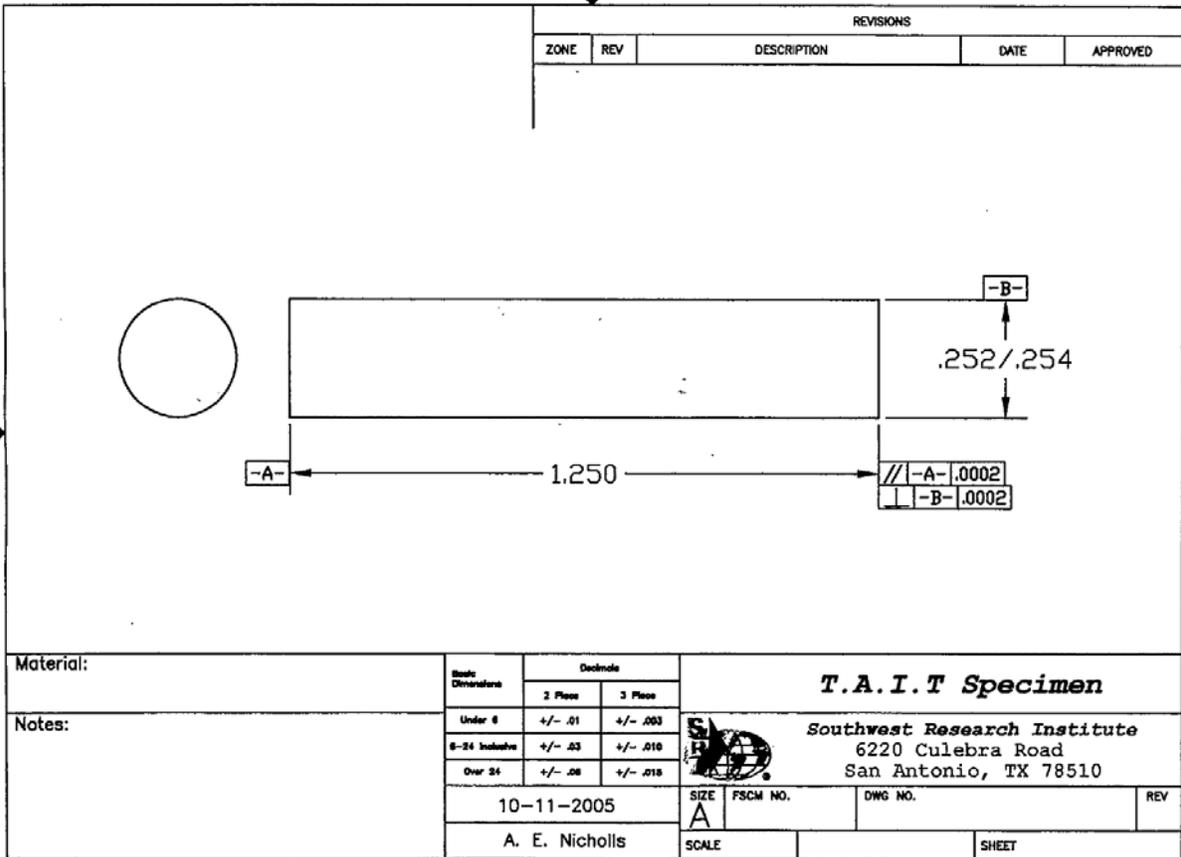
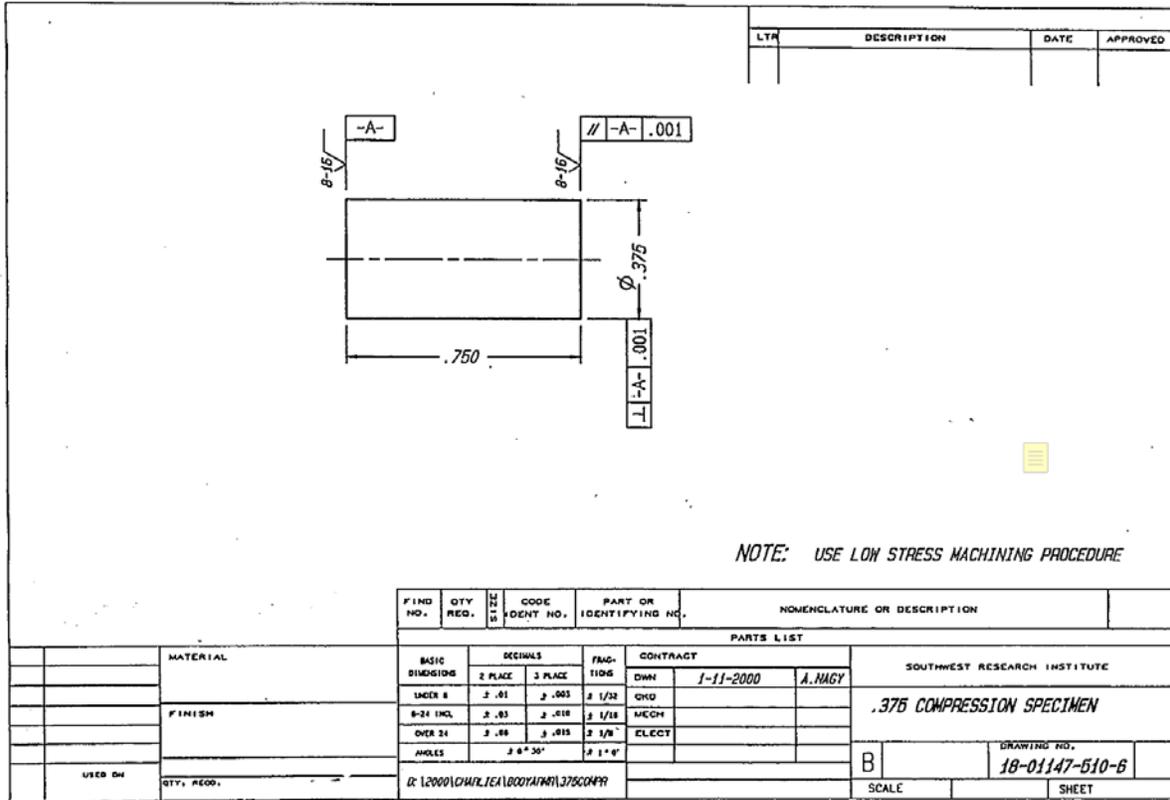
Appendix B

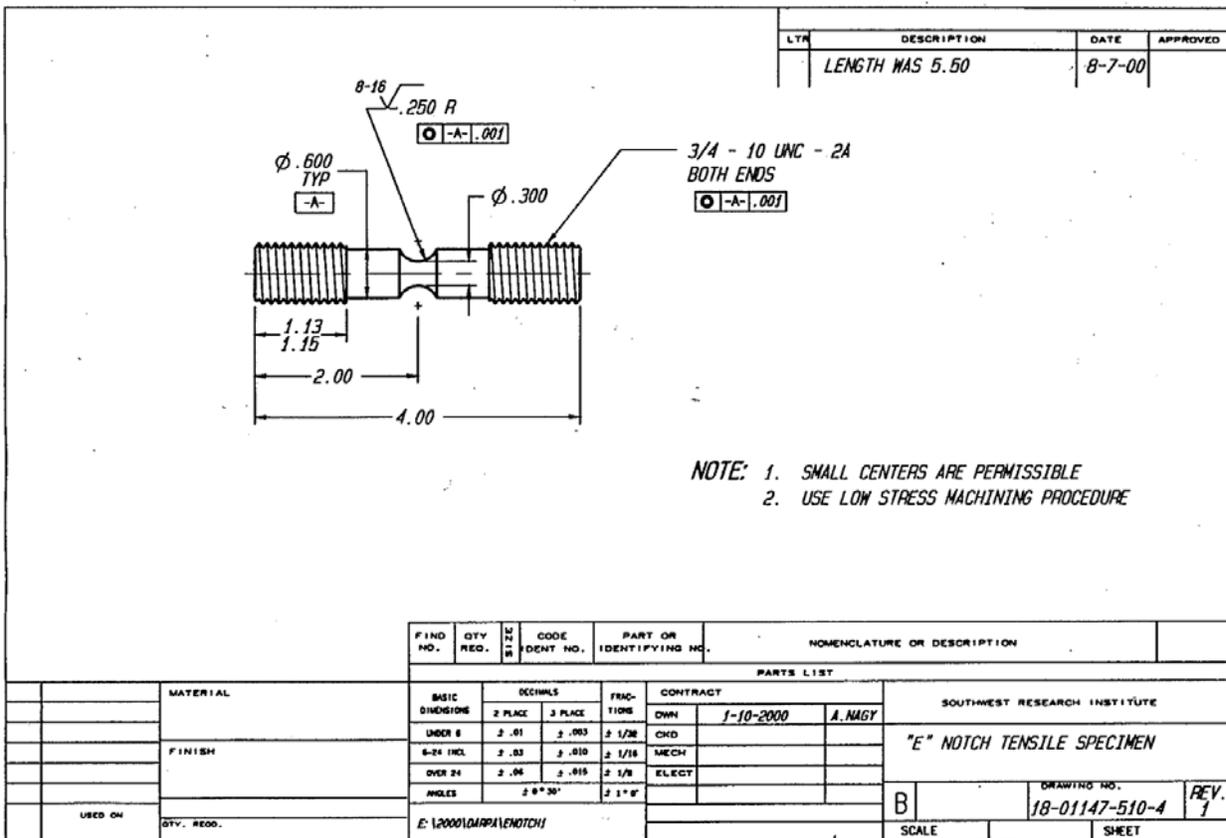
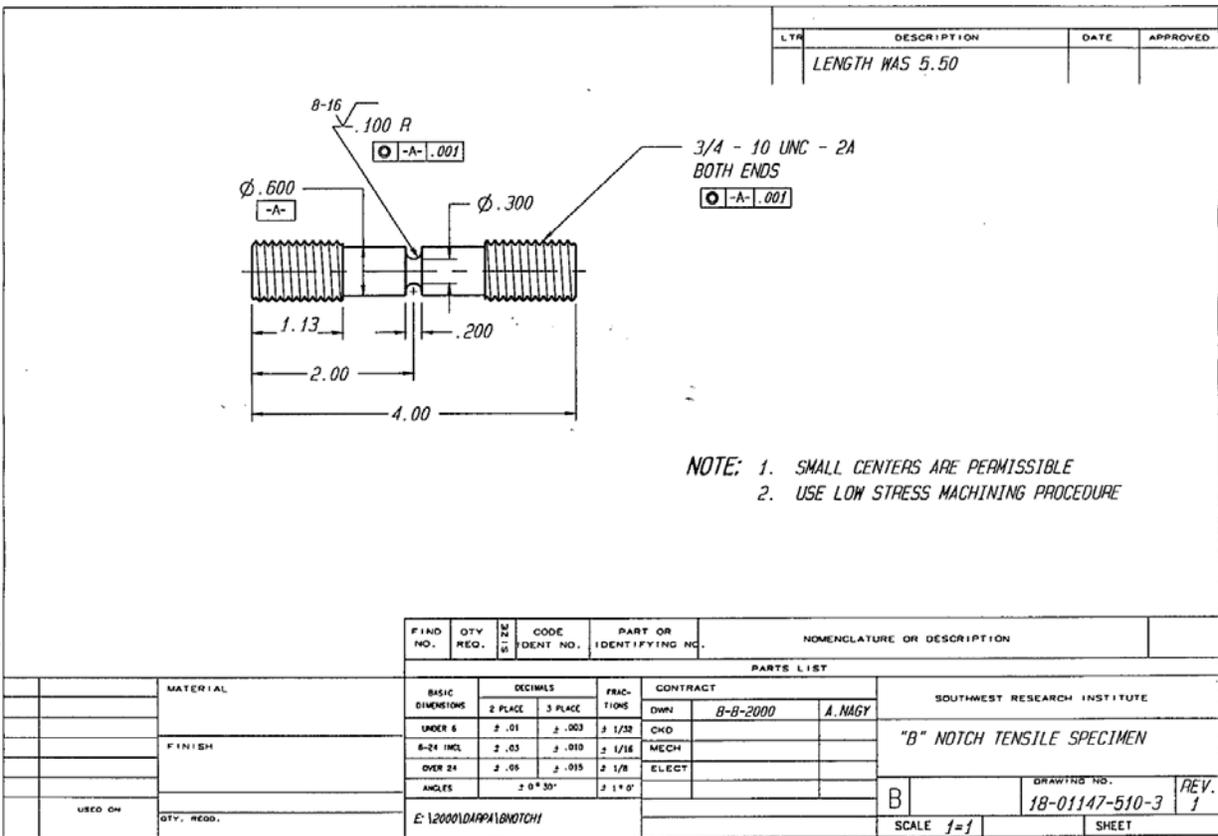
J-C Test Specimen Prints

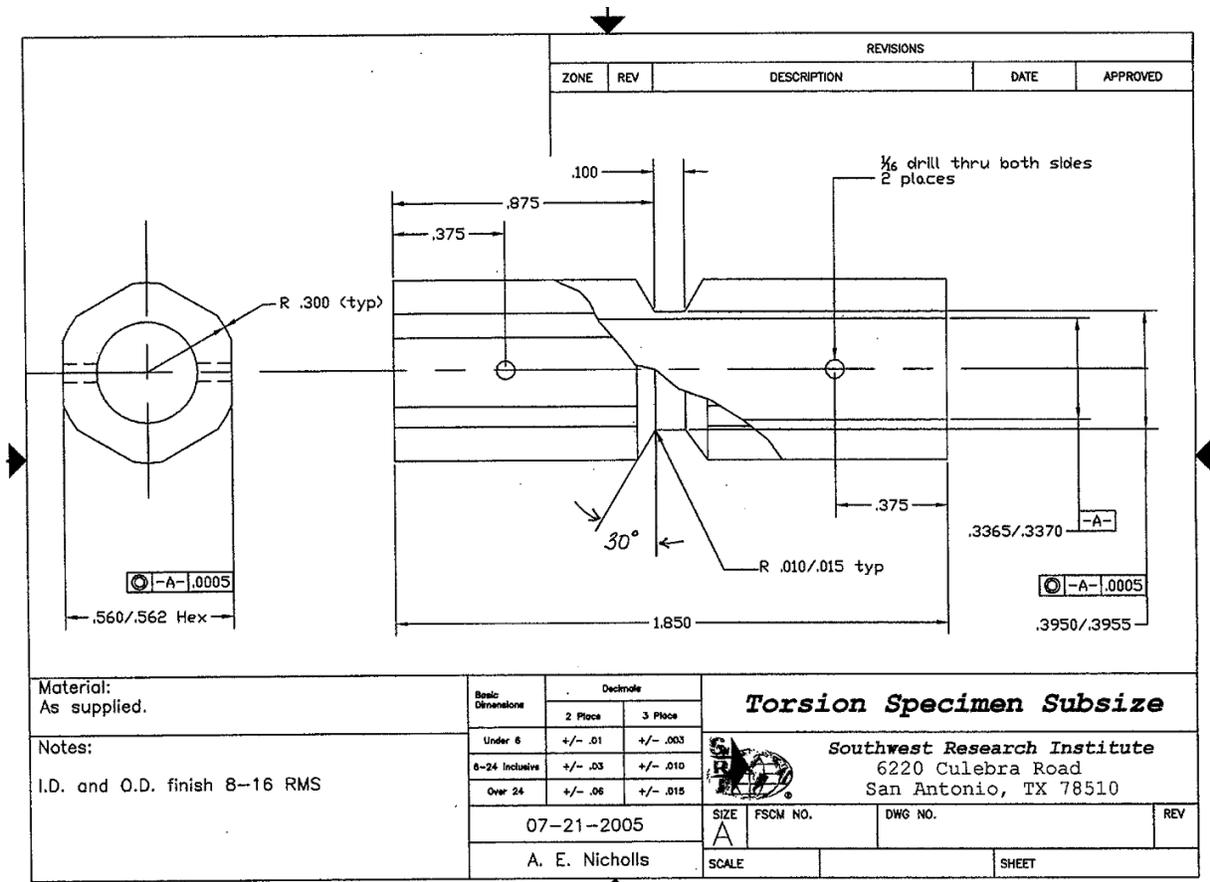
B-1

UNCLASSIFIED









REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

Material:
As supplied.

Notes:
I.D. and O.D. finish 8-16 RMS

Basic Dimensions	Decimals	
	2 Place	3 Place
Under 6	+/- .01	+/- .003
6-24 Inclusive	+/- .03	+/- .010
Over 24	+/- .06	+/- .015

Torsion Specimen Subsize

Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78510

07-21-2005

A. E. Nicholls

SIZE A	FSCM NO.	DWG NO.	REV
SCALE		SHEET	

UNCLASSIFIED

Appendix C

FH-CAT Machining Processes

UNCLASSIFIED

Focus: HOPE Process routing/Shop traveler

Customer: **Southwest Research Institute**
 Street Address:
 City State Zip:

Stock: **4 x 4 1/2 x 1 coupon (8)**

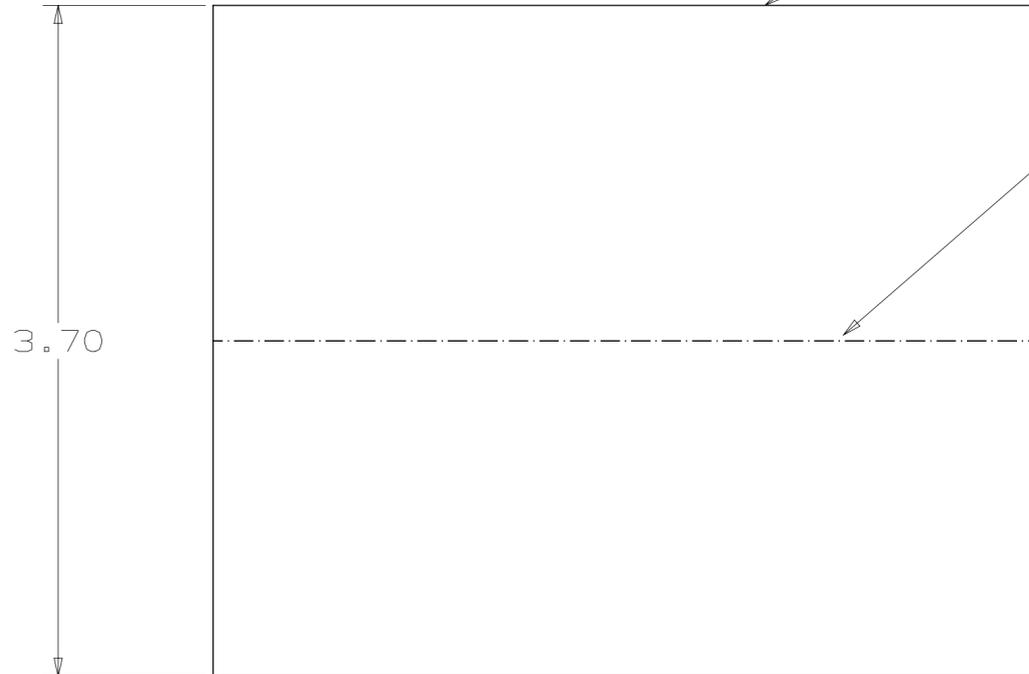
Part Number:
 Description: **Johnson-Cook Test Specimen Blocks 6061/5083**
 Revision:

Op No	Labor Code	Operation Description
10	Height Gage & Scribe	Find, and scribe weld centerline on ends of block.
20	Mill	Mill TOP to 0.875
30	Laser Marker	Mark TOP face of coupon per print (MMMM-X-TOP-NN, Where X=A,W, or R)
40	Mill	Mill BOTTOM to 0.750 thick
50	Mill	Mill coupon to 1.38 from weld centerline (retreating side)
60	Band Saw	Saw Block W .475 (minimum) from weld centerline (retreating side) SET ASIDE CUT OFF BLOCK "R"
70	Mill	Mill coupon to .375 from weld centerline (retreating side)
80	Mill	Flip around (TOP still facing up) and mill coupon to 1.75
90	Band Saw	Saw block at 'A' to .850 and remaining strip 'W' at .900 ref
100	Mill	Mill 'W' to .750 (from saw cut side)
110	Mill	Mill R to .750 (From saw cut side)
120	Mill	Mill A to .750 (from saw cut side)
130		Measurement of finished blocks, per inspection check sheet

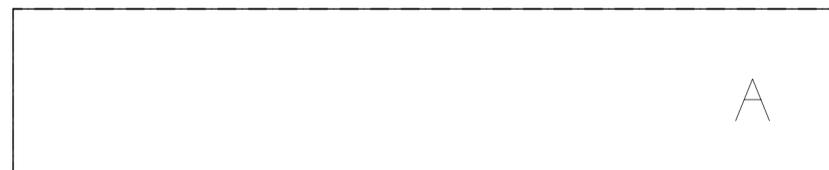
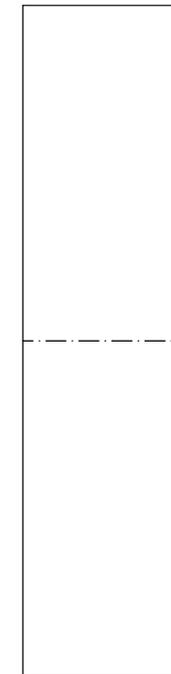
DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



RETREATING SIDE
(CLAMP MARKS)



SCRIBED WELD
CENTELINE
BOTH ENDS



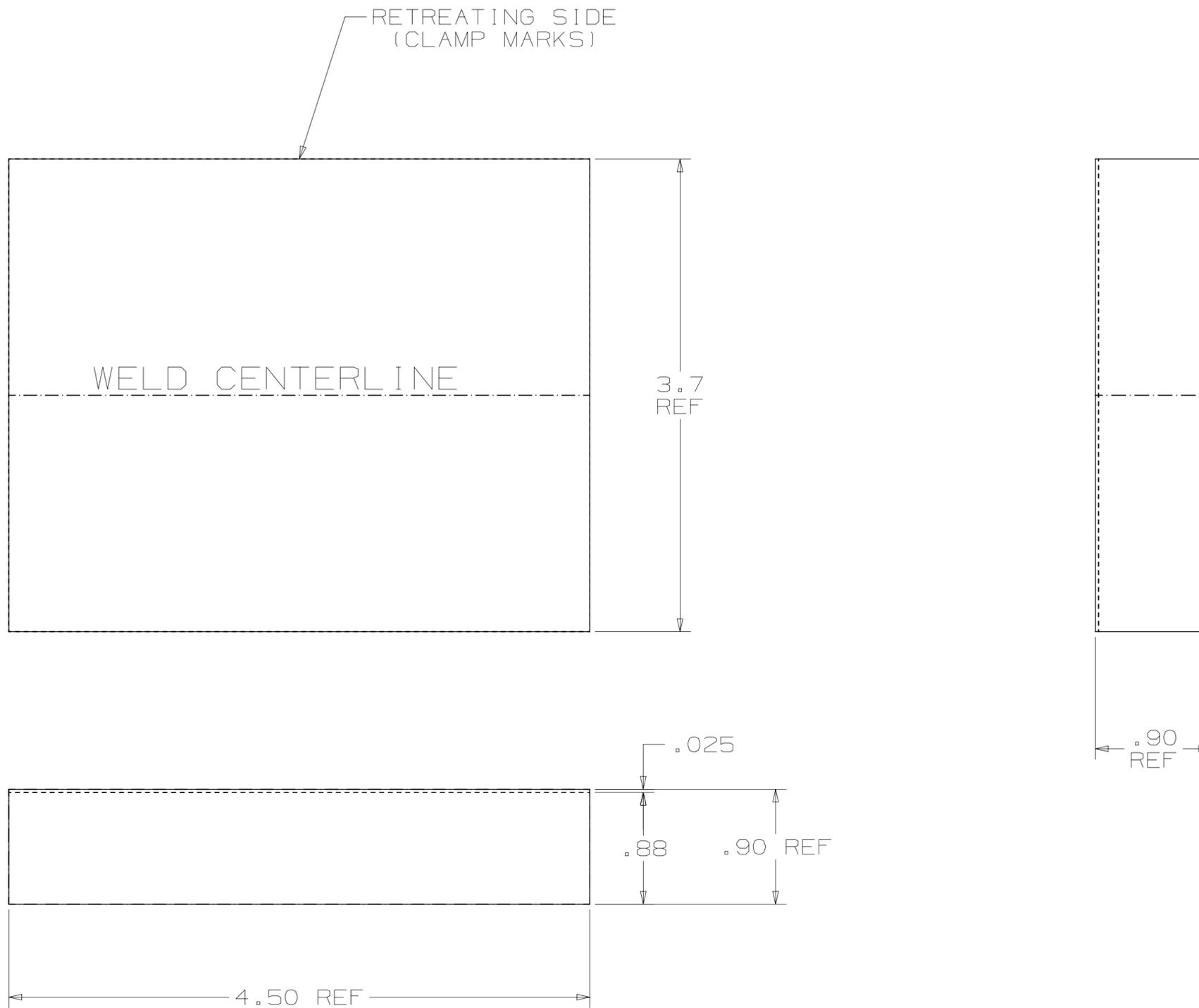
DECIMALS		TOLERANCES	
1 PLACE.....	±.045	ANGULAR	±0° 30'
2 PLACE.....	±.030	FRACTIONS	±1/16
3 PLACE.....	±.015		
4 PLACE.....	±.005		

UNLESS OTHERWISE SPECIFIED
BREAK ALL SHARP EDGES
MATERIAL: 5083 ALUMINUM

IP10
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 9/23/11		PART NAME J C TESTING STRIPS	
CHECKED BY R.Z.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP10_DWG	
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100
		REV	SHEET 1 of 1		

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS	TOLERANCES
1 PLACE.....	±.045
2 PLACE.....	±.030
3 PLACE.....	±.015
4 PLACE.....	±.005

ANGULAR
±0° 30'

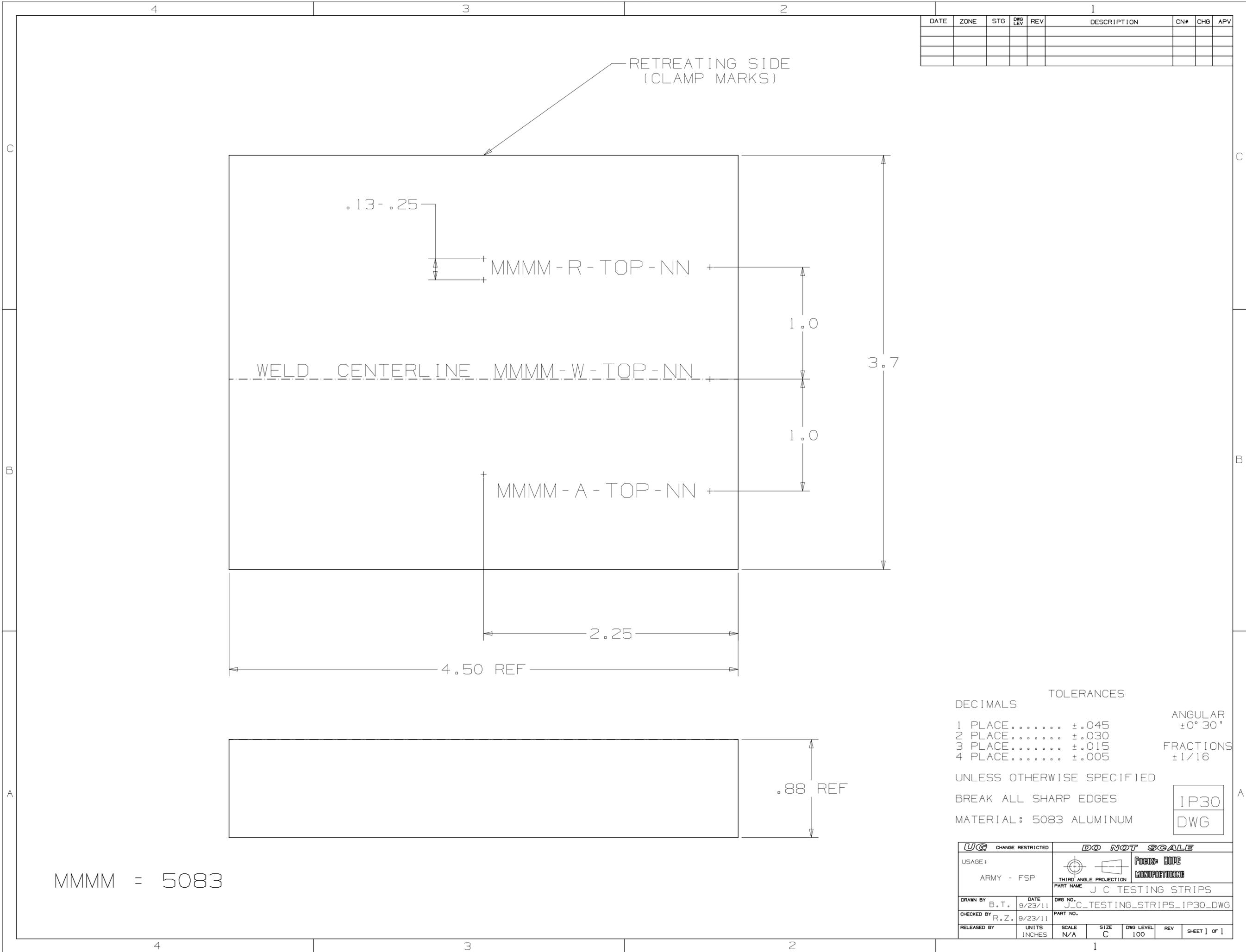
FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED
BREAK ALL SHARP EDGES
MATERIAL: 5083 ALUMINUM

IP20
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME J C TESTING STRIPS					
DRAWN BY B.T.	DATE 9/23/11	DWG NO. J_C_TESTING_STRIPS_IP20_DWG			
CHECKED BY R.Z.		PART NO.			
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



MMMM = 5083

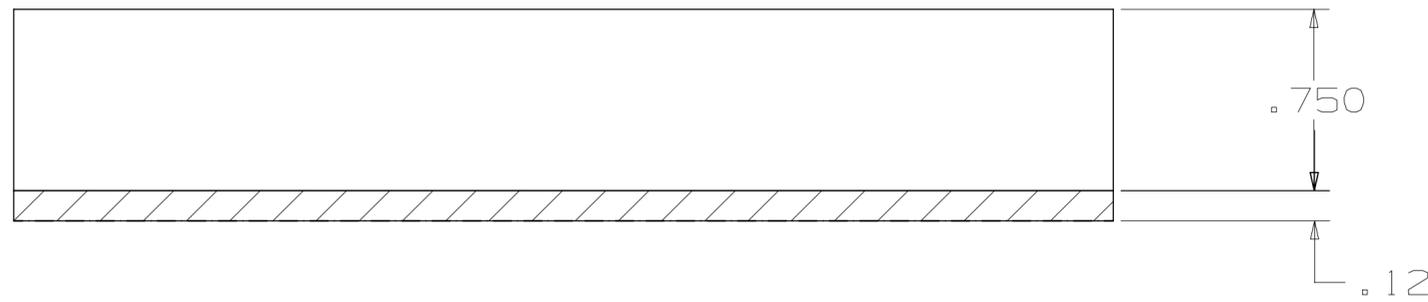
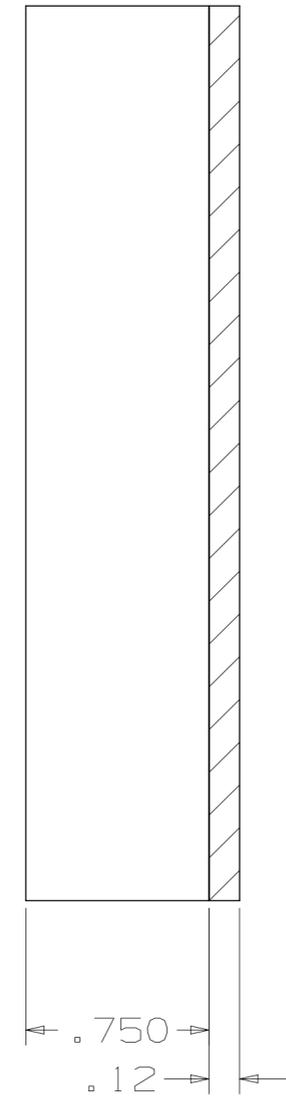
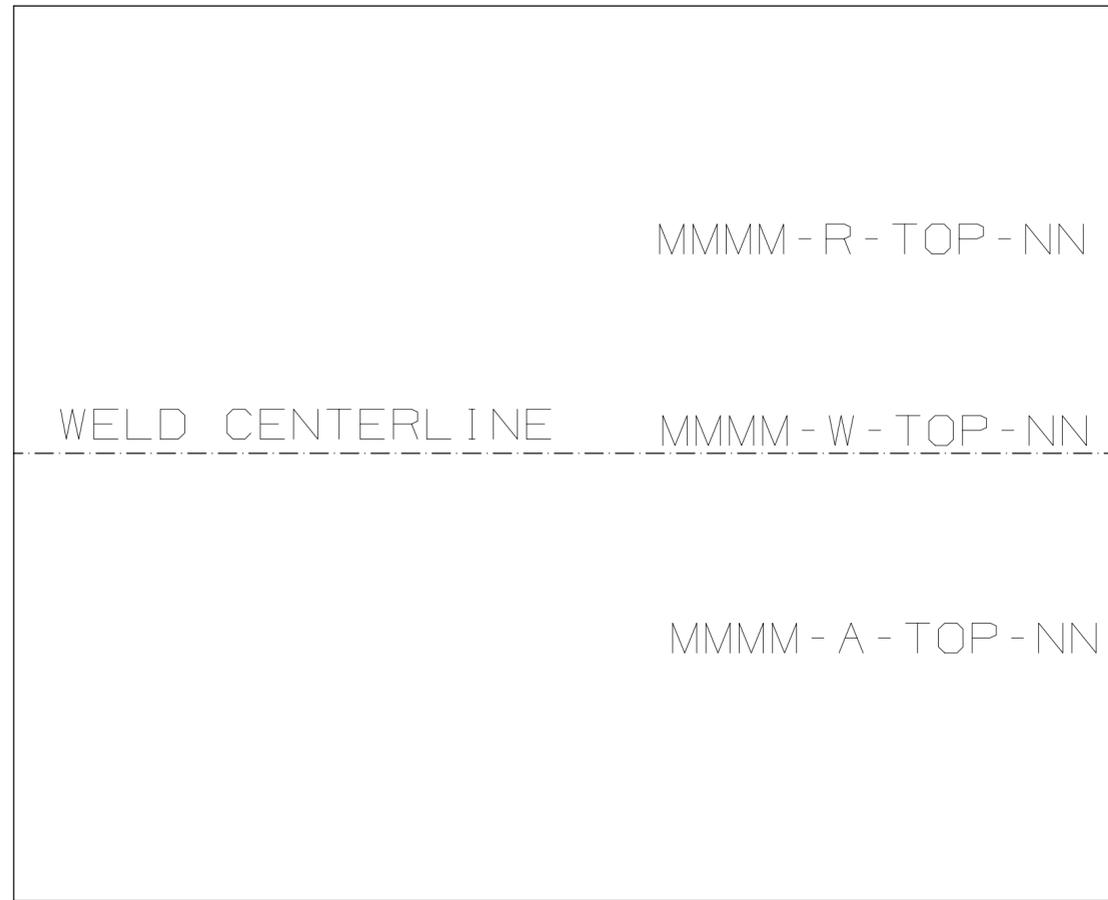
DECIMALS		TOLERANCES	
1 PLACE.....	±.045	ANGULAR	±0° 30'
2 PLACE.....	±.030	FRACTIONS	±1/16
3 PLACE.....	±.015		
4 PLACE.....	±.005		

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL: 5083 ALUMINUM

IP30
 DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP30_DWG	
CHECKED BY R.Z.		DATE 9/23/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



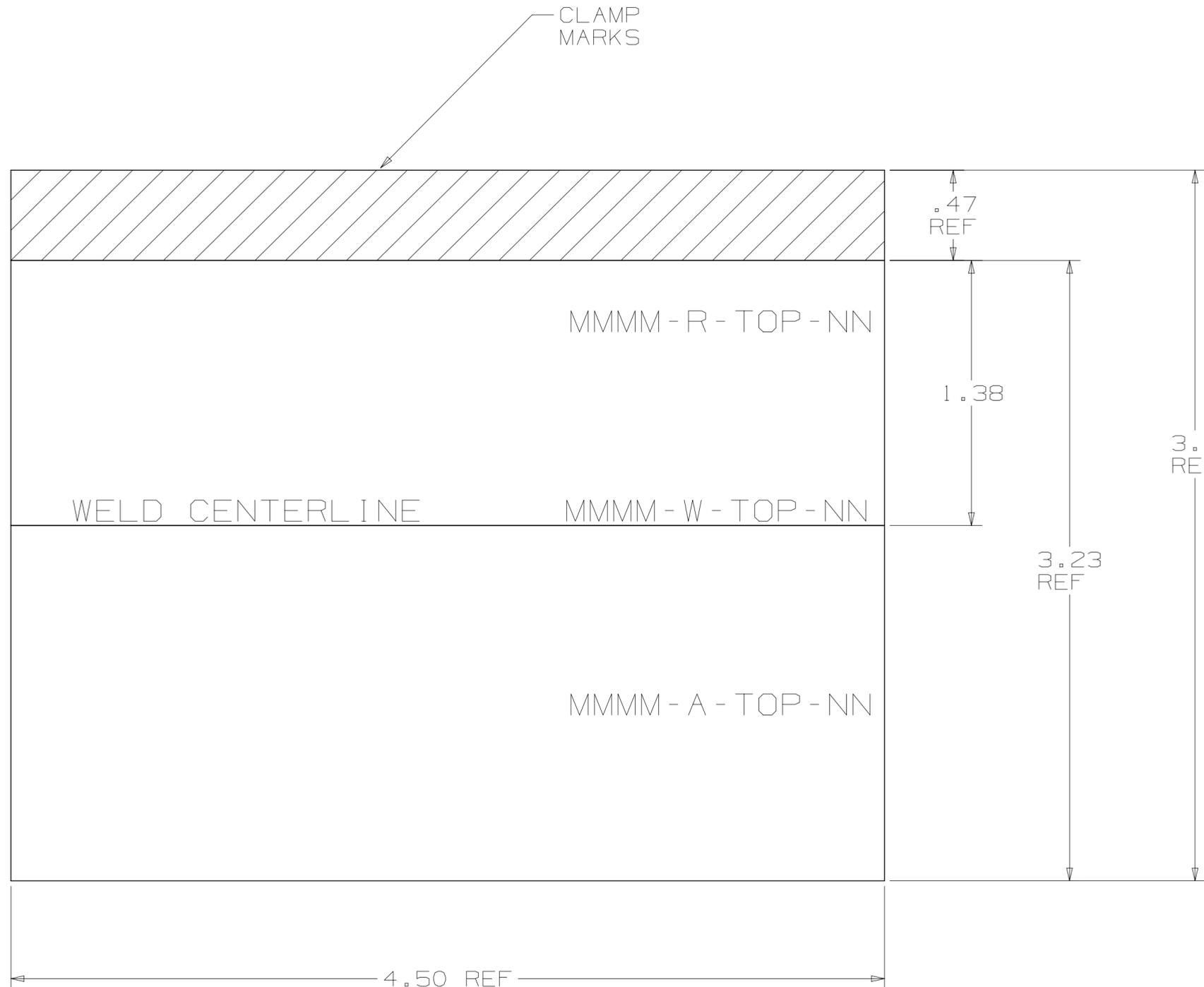
DECIMALS		TOLERANCES	
1 PLACE.....	±.045	ANGULAR	±0° 30'
2 PLACE.....	±.030	FRACTIONS	±1/16
3 PLACE.....	±.015		
4 PLACE.....	±.005		

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL: 5083 ALUMINUM

IP40
 DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 9/23/11		PART NAME J C TESTING STRIPS	
CHECKED BY R.Z.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP40_DWG	
RELEASED BY		UNITS INCHES		PART NO.	
SCALE	N/A	SIZE	C	DWG LEVEL	100
REV		SHEET	1 of 1		

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS	TOLERANCES
1 PLACE.....	±.045
2 PLACE.....	±.030
3 PLACE.....	±.015
4 PLACE.....	±.005

ANGULAR
±0° 30'
FRACTIONS
±1/16

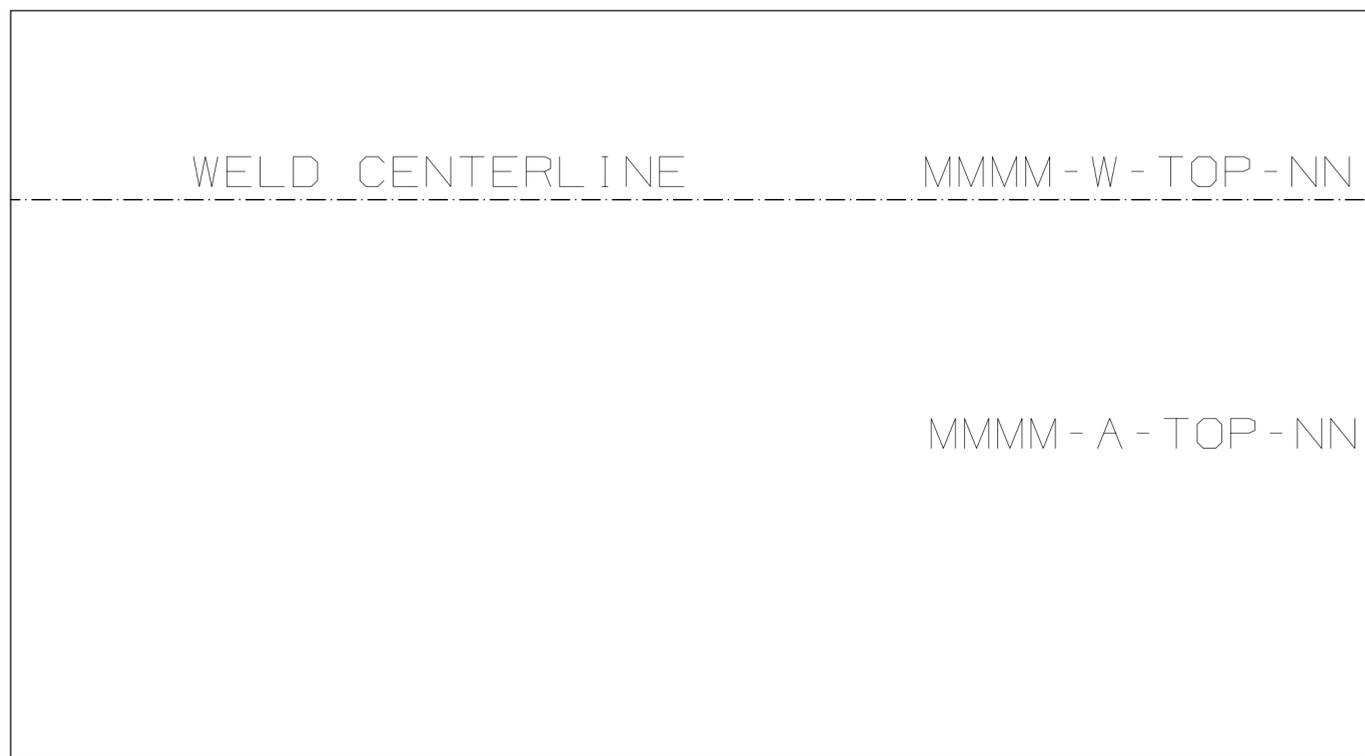
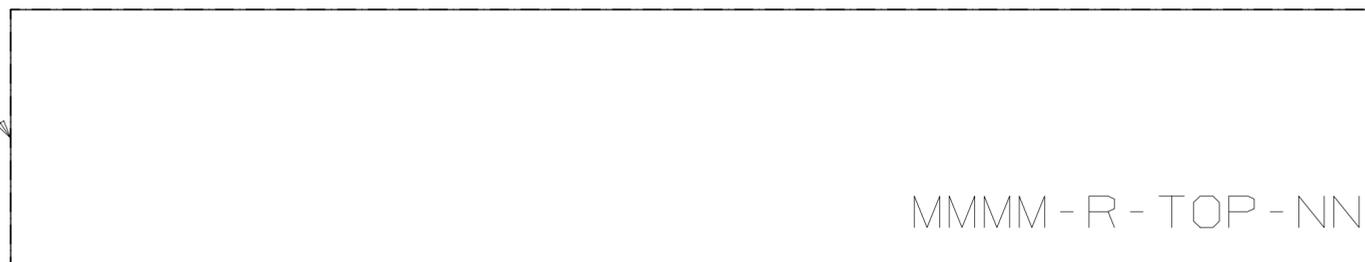
UNLESS OTHERWISE SPECIFIED
BREAK ALL SHARP EDGES
MATERIAL: 5083 ALUMINUM

IP50
DWG

USAGE:		THIRD ANGLE PROJECTION		FOCUS CODE	
ARMY - FSP				MANUFACTURING	
PART NAME J C TESTING STRIPS					
DRAWN BY B.T.	DATE 9/23/11	DWG NO. J_C_TESTING_STRIPS_IP50_DWG			
CHECKED BY R.Z.	DATE 9/23/11	PART NO.			
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

RESULT OF CUT OFF



DECIMALS	TOLERANCES
1 PLACE.....	±.045
2 PLACE.....	±.030
3 PLACE.....	±.015
4 PLACE.....	±.005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED
BREAK ALL SHARP EDGES
MATERIAL: 5083 ALUMINUM

IP60
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP60_DWG	
CHECKED BY R.Z.		DATE 9/23/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

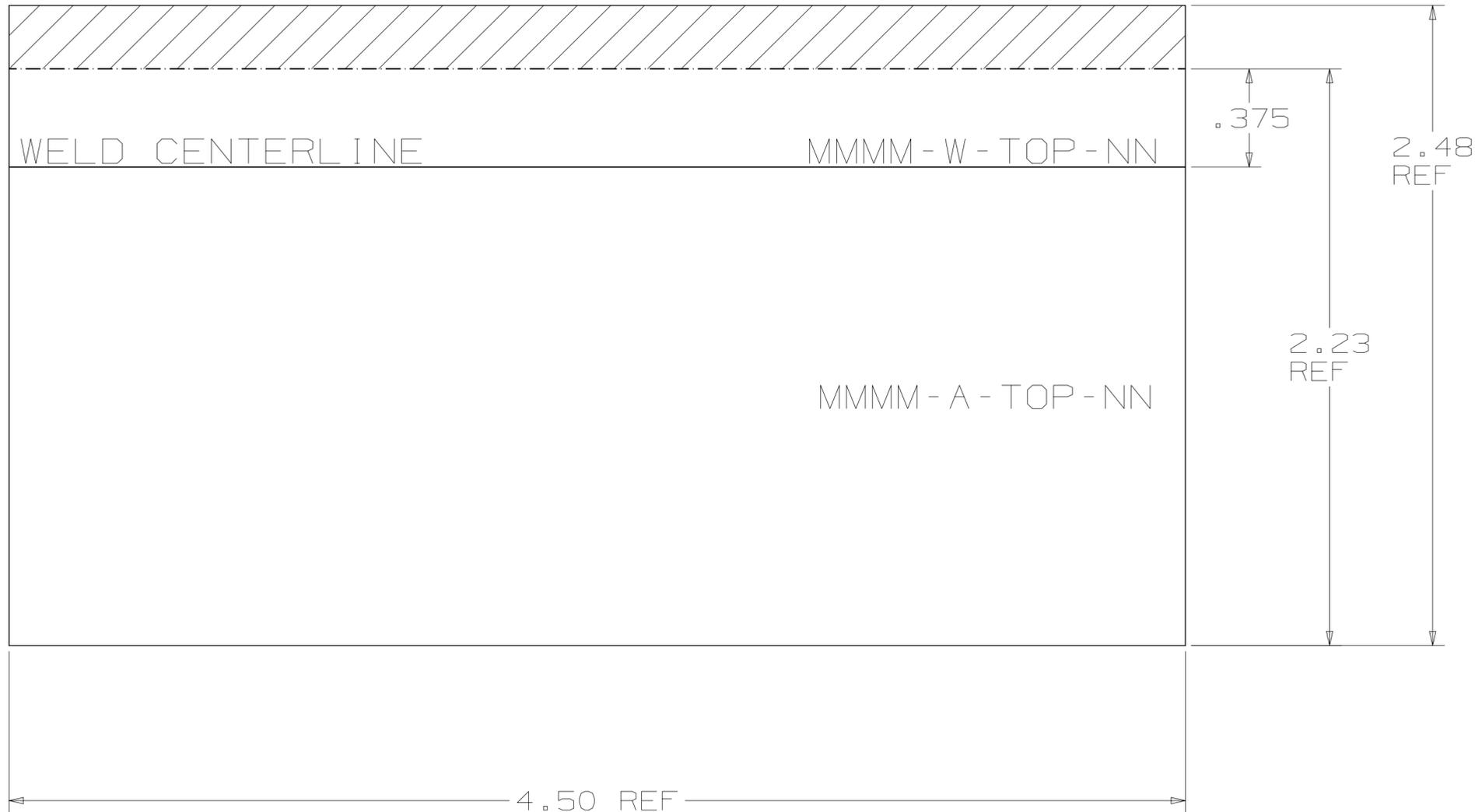
4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



TOLERANCES

DECIMALS

1 PLACE..... ±.045

2 PLACE..... ±.030

3 PLACE..... ±.015

4 PLACE..... ±.005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

IP70
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE:	ARMY - FSP	THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 9/23/11	PART NAME J C TESTING STRIPS		
CHECKED BY R.Z.		DATE 9/23/11	DWG NO. J_C_TESTING_STRIPS_IP70_DWG		
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100
		REV	SHEET 1 of 1		

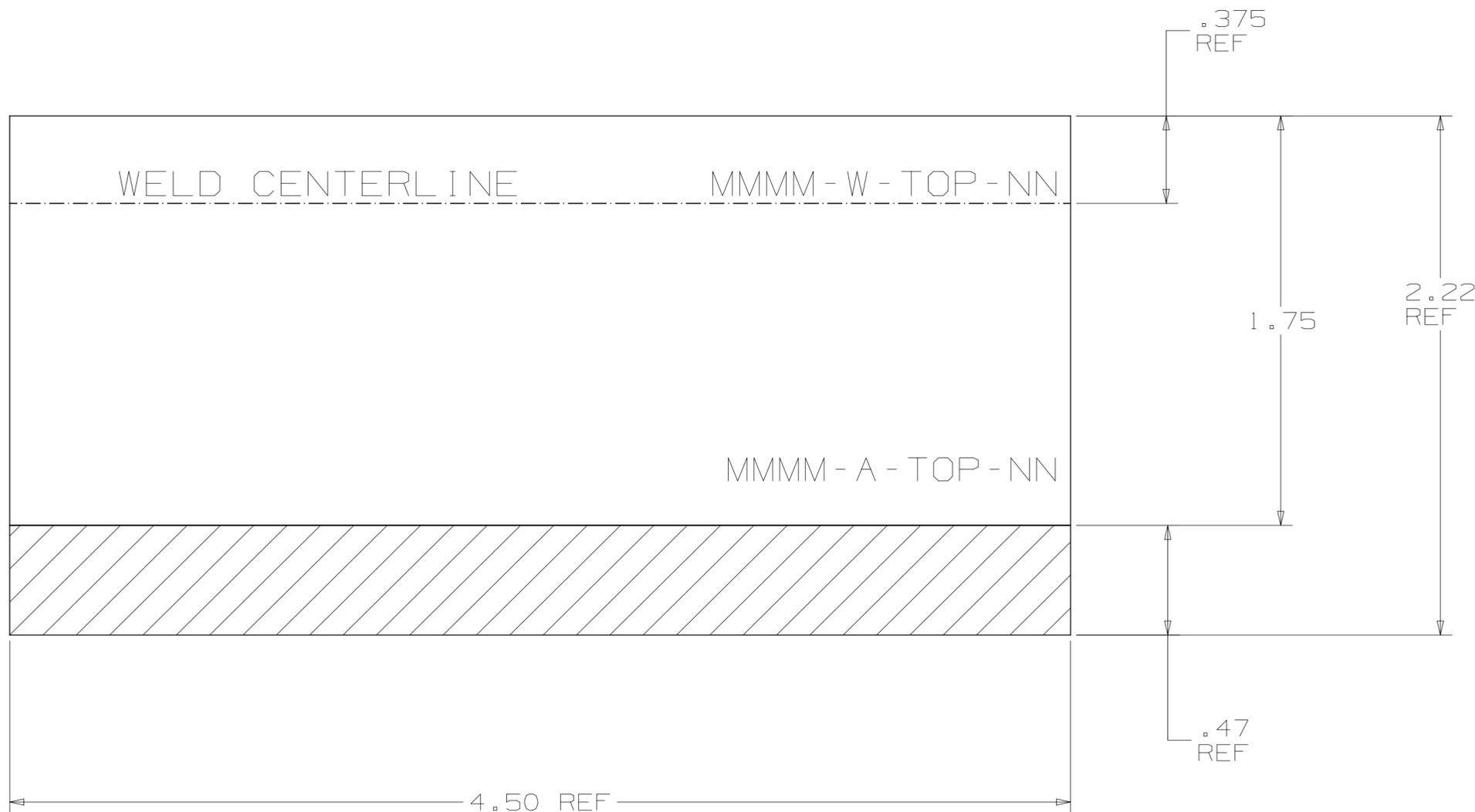
4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



TOLERANCES

DECIMALS

1 PLACE..... ±.045

2 PLACE..... ±.030

3 PLACE..... ±.015

4 PLACE..... ±.005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

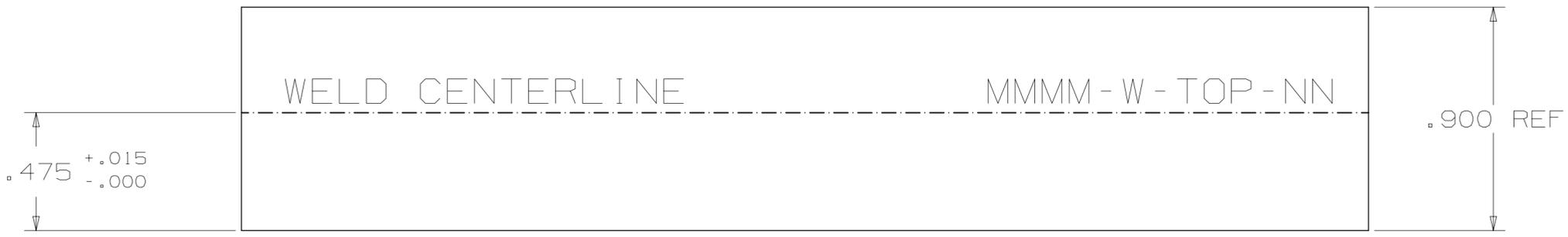
BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

IP80
DWG

CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP				POCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIP_IP80_DWG	
CHECKED BY R.Z.		DATE 9/23/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV
SHEET 1 of 1					

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



TOLERANCES

DECIMALS

1 PLACE..... ±.045

2 PLACE..... ±.030

3 PLACE..... ±.015

4 PLACE..... ±.005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

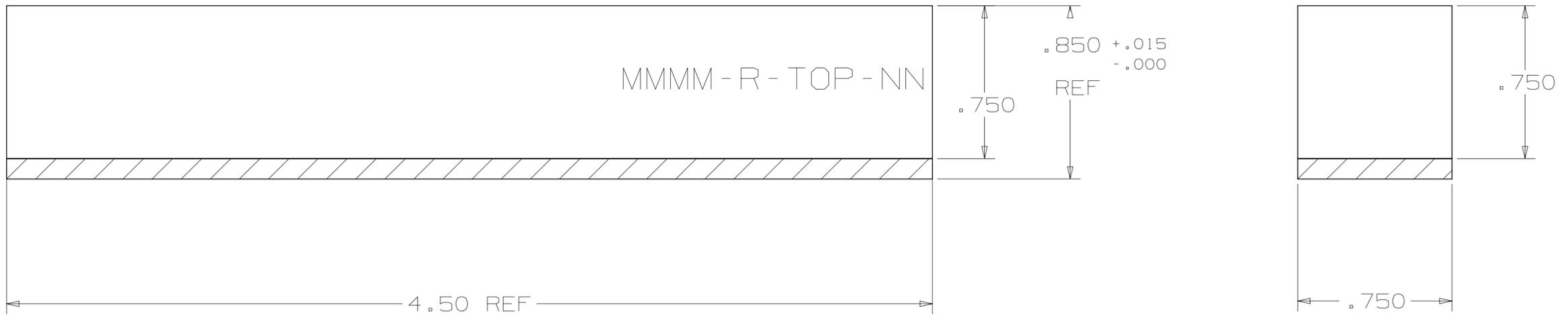
BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

IP90
DWG

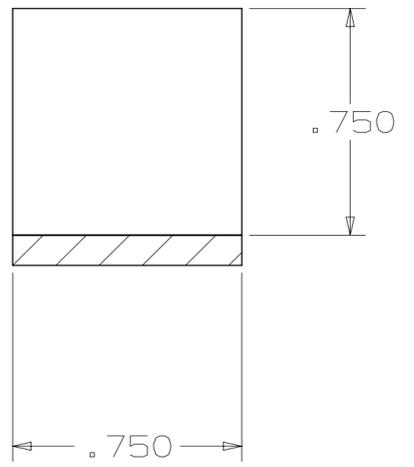
CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP				FOCUS CODE MANUFACTURING	
PART NAME J C TESTING STRIPS					
DRAWN BY B.T.	DATE 9/23/11	DWG NO. J_C_TESTING_STRIPS_IP90_DWG			
CHECKED BY R.Z.		DATE 9/23/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



MMMM-R-TOP-NN

$.850 \begin{matrix} +.015 \\ -.000 \end{matrix}$
 REF
 $.750$



4.50 REF

.750

DECIMALS TOLERANCES

- 1 PLACE..... ±.045
- 2 PLACE..... ±.030
- 3 PLACE..... ±.015
- 4 PLACE..... ±.005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED
BREAK ALL SHARP EDGES
MATERIAL: 5083 ALUMINUM

IP110
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME J C TESTING STRIPS					
DRAWN BY B.T.	DATE 9/23/11	DWG NO. J C TESTING STRIPS_IP110_DWG			
CHECKED BY R.Z.		DATE 9/23/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

C

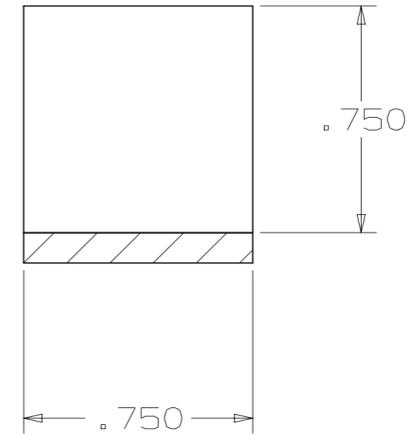
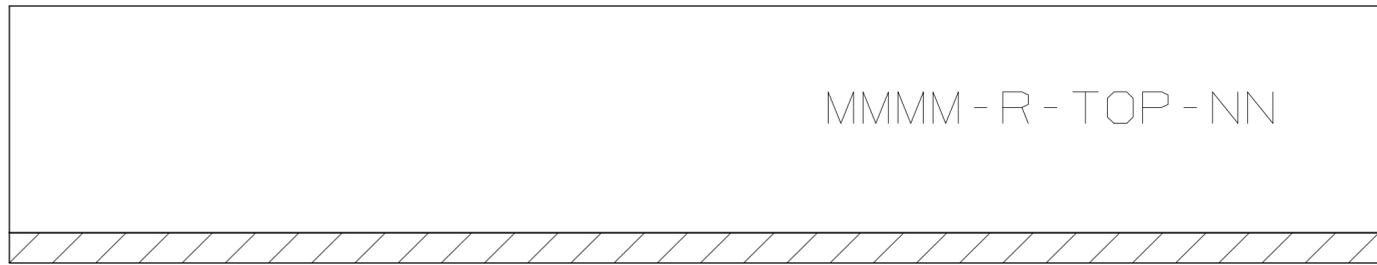
C

B

B

A

A



DECIMALS TOLERANCES

- 1 PLACE..... ±.045
- 2 PLACE..... ±.030
- 3 PLACE..... ±.015
- 4 PLACE..... ±.005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED
BREAK ALL SHARP EDGES
MATERIAL: 5083 ALUMINUM

IP120
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 9/23/11		DWG NO. J_C_TESTING_STRIPS_IP120_DWG	
CHECKED BY R.Z.		DATE 9/23/11		PART NO.	
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100
		REV	SHEET 1 of 1		

4

3

2

1

4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

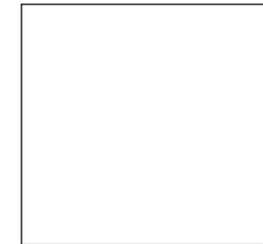
TOP VIEW OF 3 FINISHED BLOCKS



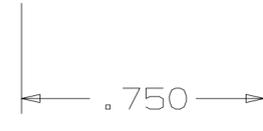
MMMM-R-TOP-NN



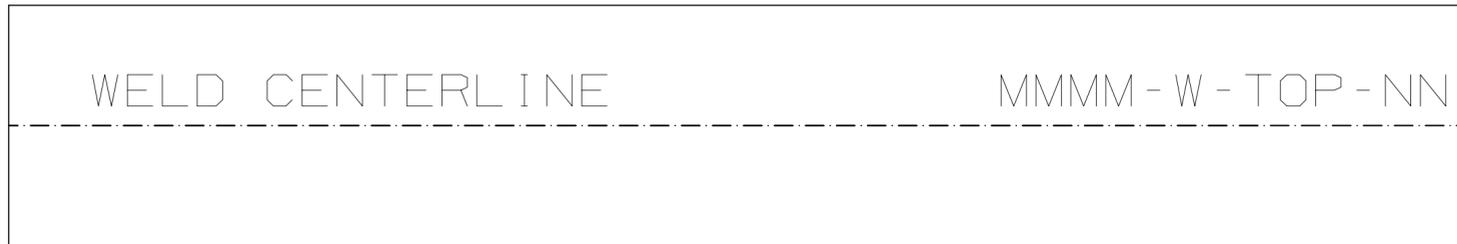
4.50 REF



.750

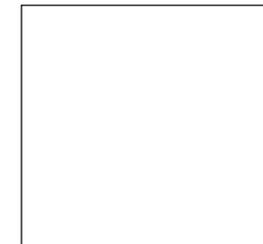


.750

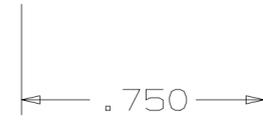


WELD CENTERLINE

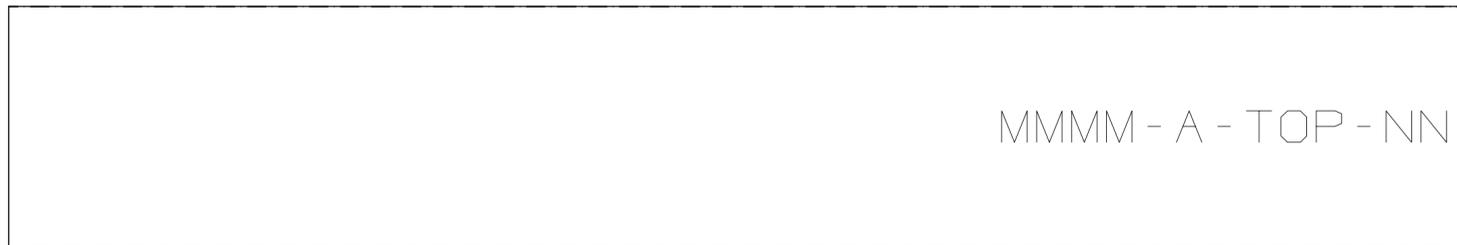
MMMM-W-TOP-NN



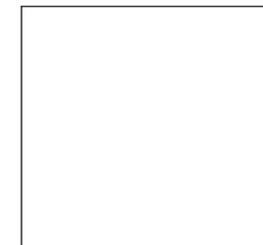
.750



.750



MMMM-A-TOP-NN



.750



.750

IP130
DWG

DECIMALS	TOLERANCES
1 PLACE.....	±.045
2 PLACE.....	±.030
3 PLACE.....	±.015
4 PLACE.....	±.005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 5083 ALUMINUM

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 9/23/11		DWG NO. J.C._TESTING_STRIPS_IP130_DWG	
CHECKED BY R.Z.		DATE 9/23/11		PART NO.	
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV
				UNITS INCHES	SHEET 1 of 1

4

3

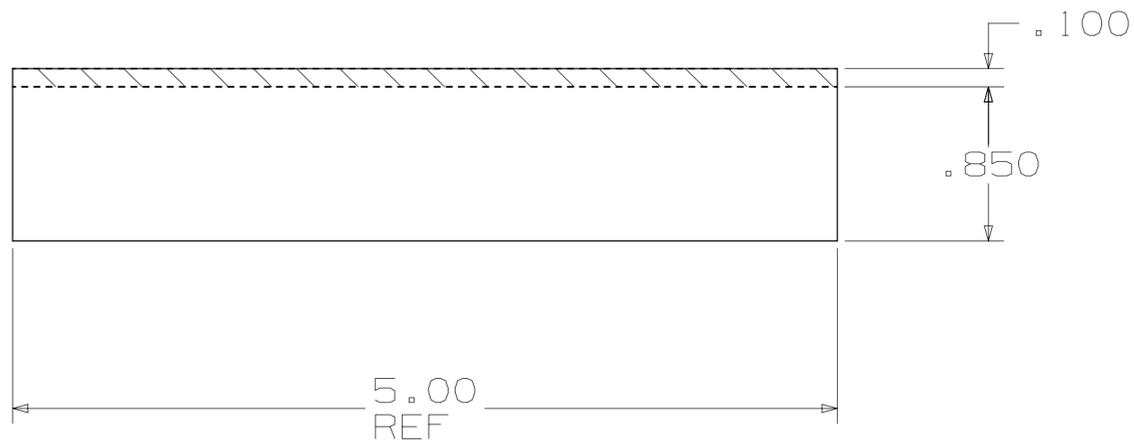
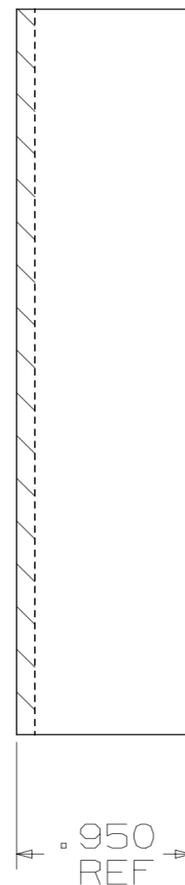
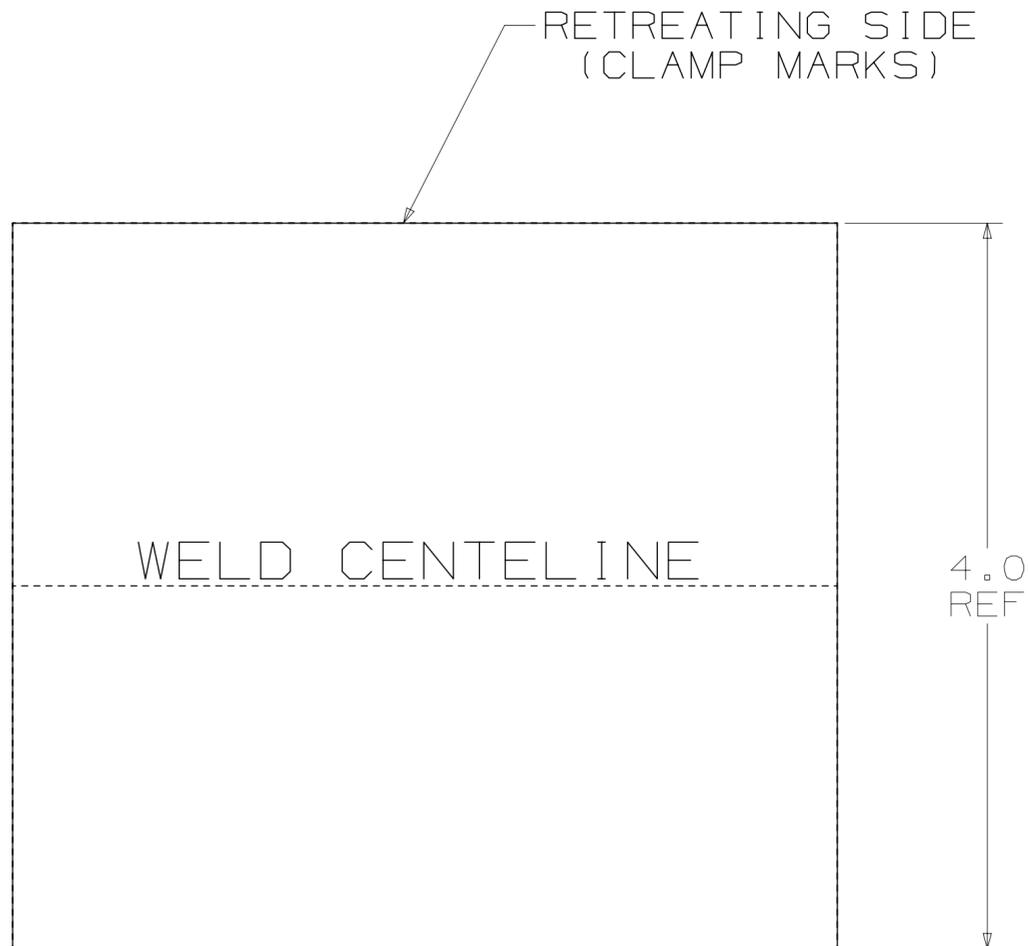
2

1

Focus: HOPE Process routing/Shop traveler

Customer: Southwest Research Institute		
Street Address:		
City State Zip:		
Stock: 4 x 4.850 x .950 coupon (54)		
Part Number: Strips		
Description: Johnson-Cook test specimen blocks (2139)		
Revision:		
Op No	Labor Code	Operation Description
10	Mill	Mill TOP to 0.850
20	Height Gage & Scribe	Find, and scribe weld centerlines on Top and Ends of block.
30	Laser Marker	Mark TOP face of coupon per print (MMMM-X-TOP-NN, Where X=A,W, or R)
40	Mill	Mill BOTTOM to 0.800 thick
50	Mill	Mill coupon to 1.2456 from weld centerline (retreating side)
60	Band Saw	Saw Block R(retreating side) to .675 SET ASIDE
70	Mill	Mill coupon to .400 from weld centerline (retreating side)
80	Mill	Flip around (TOP still facing up) and mill coupon to 1.6456
90	Band Saw	Saw block at 'A' to .675 and remaining strip 'W' at .9706 ref
100	Mill	Mill 'W' to .800 (from saw cut side)
110	Mill	Mill R to .625 (From saw cut side)
120	Mill	Mill A to .625 (from saw cut side)
130	Mill	Mill block 'R' BOTTOM .1375 REF to 0.6535
140	Mill	Mill block 'R' TOP .0285 REF to 0.625
150	Mill	Mill block 'A' BOTTOM .1375 REF to 0.6535
160	Mill	Mill block 'A' TOP .0285 REF to 0.625
170		Measurement of finished blocks, per inspection check sheet

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS	TOLERANCES	ANGULAR
1 PLACE.....	±.030	±0° 30'
2 PLACE.....	±.010	
3 PLACE.....	±.005	FRACTIONS
4 PLACE.....	±.0005	±1/64

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL: 2139 AL

IP10
 DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY-FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME J C TESTING STRIPS					
DRAWN BY B.T.	DATE 11/22/11	DWG NO. J_C_TESTING_STRIPS_IP10			
CHECKED BY R.Z.		PART NO. X			
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

RETREATING SIDE
(CLAMP MARKS)

SCRIBE
LINES

SCRIBE
LINE
(WELD
CENTERLINE)

SCRIBE
LINE

2.0
REF

4.0
REF

5.00 REF

.450
.500

.850
REF

DECIMALS		TOLERANCES	
1 PLACE.....	±.030	ANGULAR	±0° 30'
2 PLACE.....	±.010	FRACTIONS	±1/16
3 PLACE.....	±.005		
4 PLACE.....	±.0005		

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL: 2139 AL

IP20
 DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP	DATE 11/29/11	THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		PART NAME J C TESTING STRIPS			
CHECKED BY R.Z.		DWG NO. J.C._TESTING_STRIPS_IP20_DWG			
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

4

3

2

1

RETREATING SIDE
(CLAMP MARKS)

SCRIBE
LINES

SCRIBE
LINE
(WELD
CENTERLINE)

.13-.25

2139-R-TOP-NN

.9331

2139-W-TOP-NN

4.0
REF

.9331

2139-A-TOP-NN

2.0
REF

2.25

5.00 REF

SCRIBE
LINE

.450

.500

.850
REF

TOLERANCES

DECIMALS

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP30
DWG

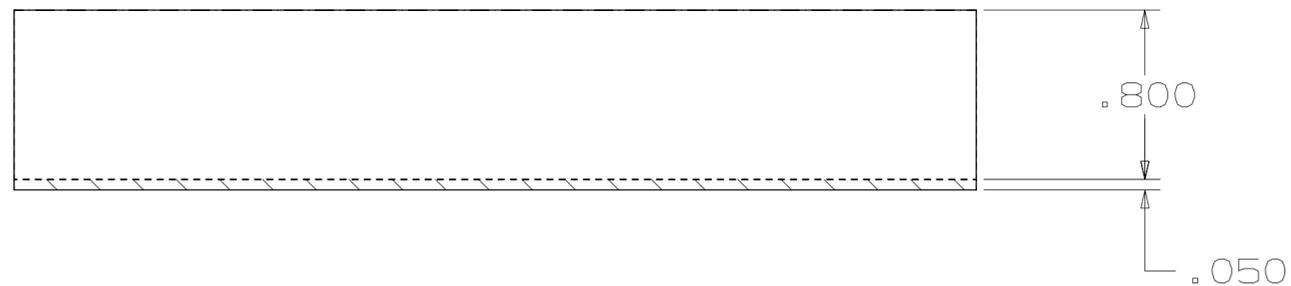
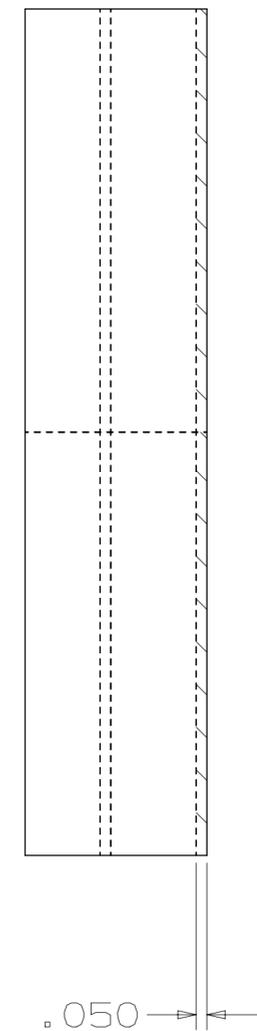
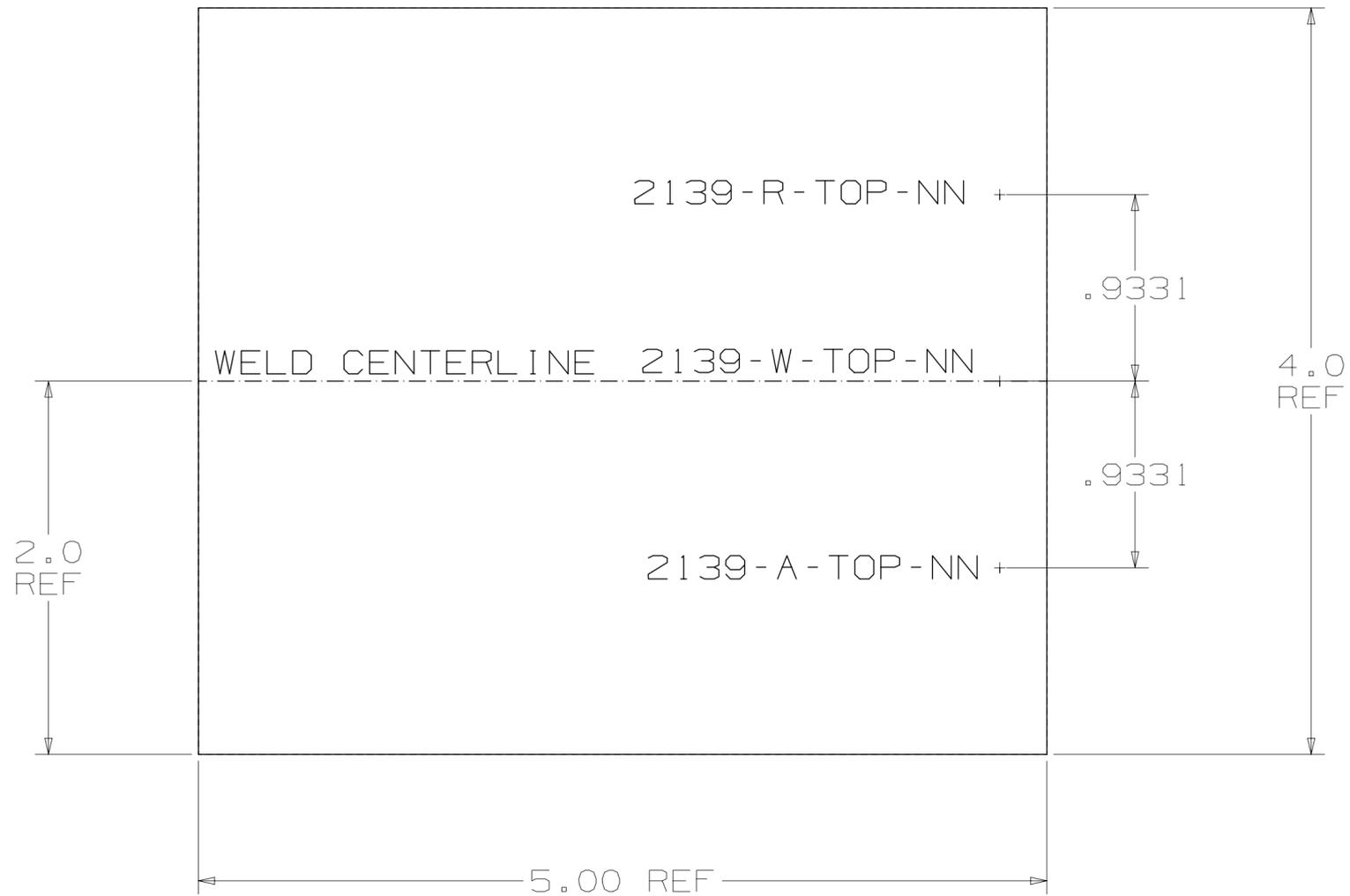
UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		PART NAME J C TESTING STRIPS	
CHECKED BY R.Z.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP30_DWG	
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100
		REV	SHEET 1 of 1		

4

3

2

1



DECIMALS		TOLERANCES	
1 PLACE.....	±.030	ANGULAR	±0° 30'
2 PLACE.....	±.010	FRACTIONS	±1/16
3 PLACE.....	±.005		
4 PLACE.....	±.0005		

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL: 2139 AL

IP40
 DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		PART NAME J C TESTING STRIPS	
CHECKED BY R.Z.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP40_DWG	
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

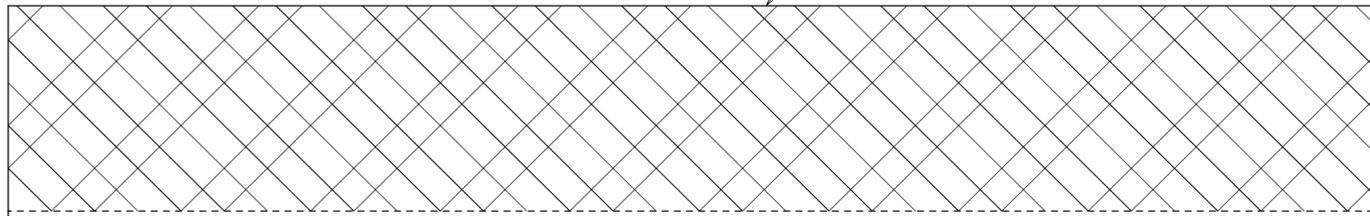
4

3

2

1

CLAMP MARKS



.7544
REF

2139-R-TOP-NN

1.2456

WELD CENTERLINE 2139-W-TOP-NN

3.2456
REF

4.0
REF

2139-A-TOP-NN

5.00 REF

DECIMALS TOLERANCES

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP50
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP50_DWG	
CHECKED BY R.Z.		DATE 11/29/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

RESULT OF CUTOFF



2139-R-TOP-NN

.675 ±.015



WELD CENTERLINE

2139-W-TOP-NN

2139-A-TOP-NN

.4456 ±.015

2.4456

5.00 REF

DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR ±0° 30'

FRACTIONS ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP60
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP60_DWG	
CHECKED BY R.Z.		DATE 11/29/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

C

C

B

B

A

A



DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP70
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C.TESTING_STRIPS_IP70_DWG	
CHECKED BY R.Z.		DATE 11/29/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

4

3

2

1

C

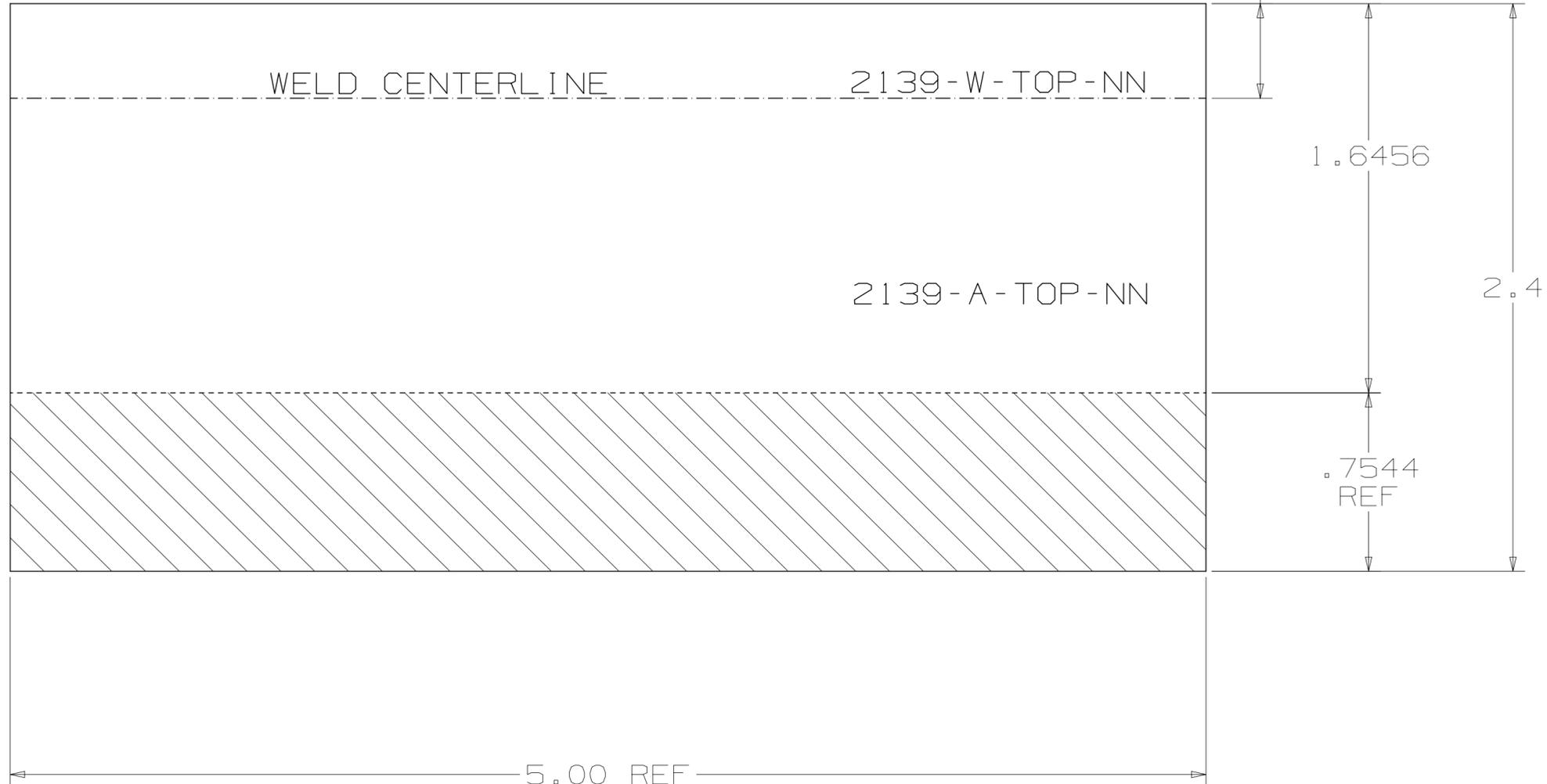
C

B

B

A

A



DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR ±0° 30'

FRACTIONS ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP80
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME J C TESTING STRIPS					
DRAWN BY B.T.	DATE 11/29/11	DWG NO. J.C._TESTING_STRIPS_IP80_DWG			
CHECKED BY R.Z.		PART NO.			
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

4

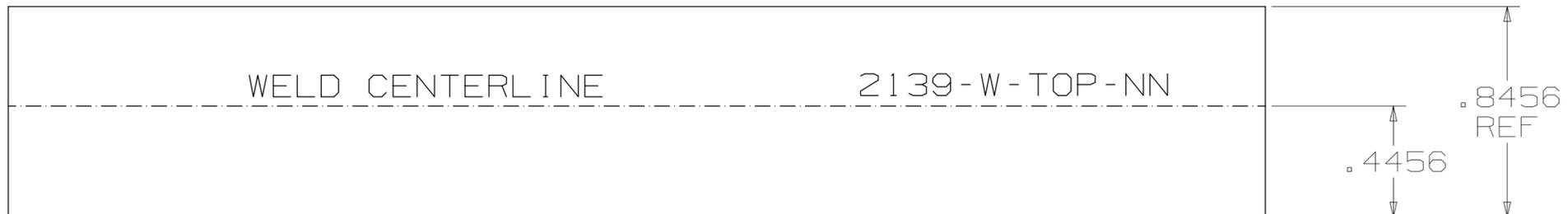
3

2

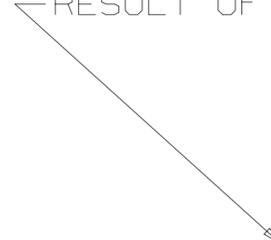
1

C

C



RESULT OF CUTOFF



B

B

A

A

DECIMALS TOLERANCES

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP90
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP90_DWG	
CHECKED BY R.Z.		DATE 11/29/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1



DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP100
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP100_DWG	
CHECKED BY R.Z.		11/29/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

C

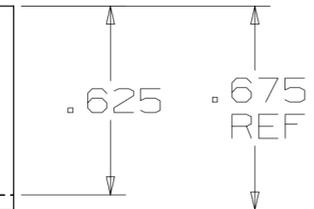
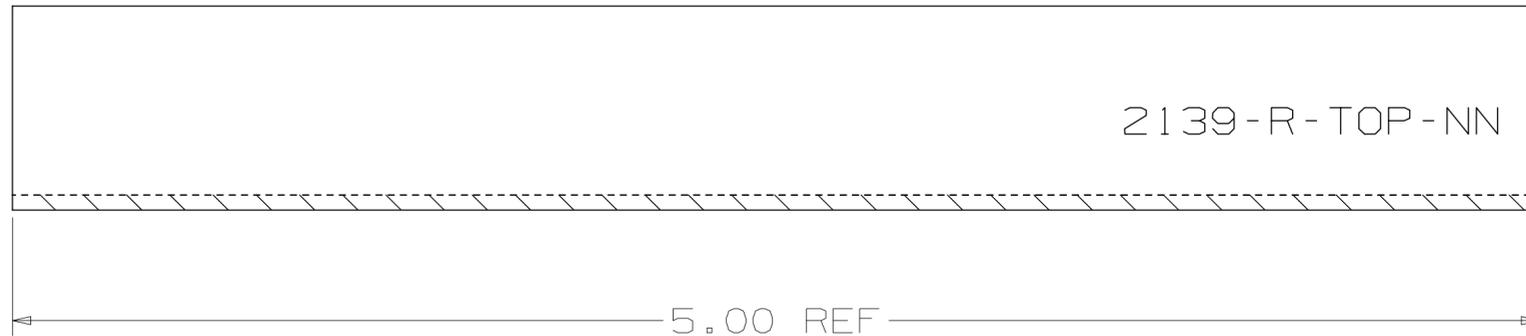
C

B

B

A

A



DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR ±0° 30'

FRACTIONS ±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP110
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP110_DWG	
CHECKED BY R.Z.		11/29/11		PART NO.	
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100
		REV	SHEET 1 of 1		

4

3

2

1

4

3

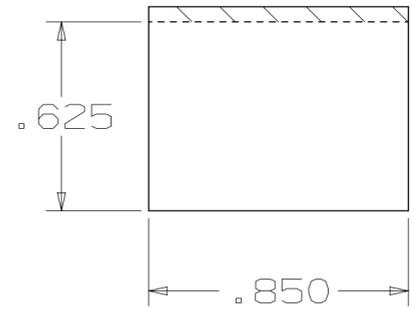
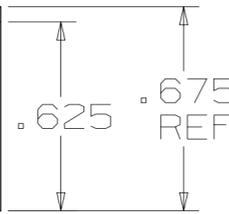
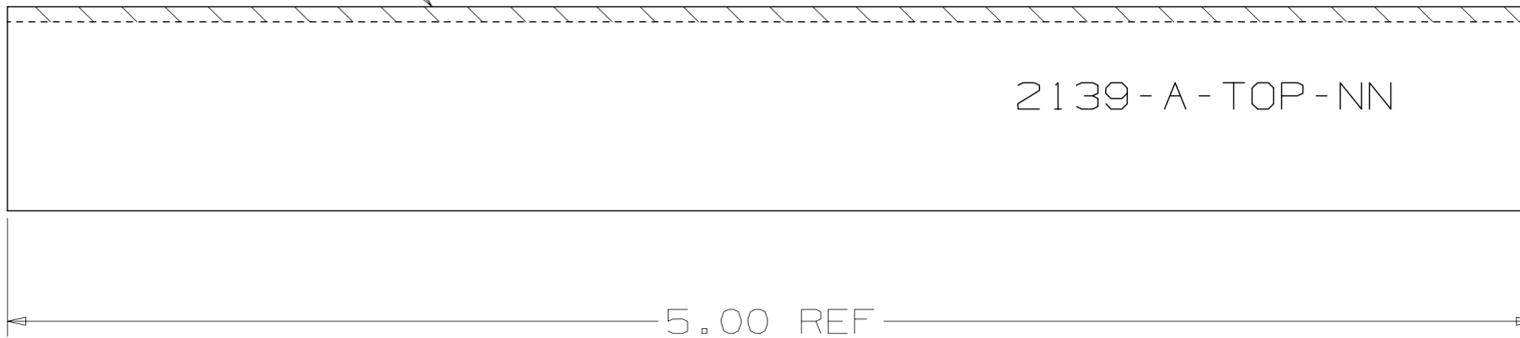
2

1

C

C

SAW CUT



B

B

A

A

DECIMALS TOLERANCES

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP120
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME J C TESTING STRIPS					
DRAWN BY B.T.	DATE 11/29/11	DWG NO. J.C._TESTING_STRIPS_IP120_DWG			
CHECKED BY R.Z.		DATE 11/29/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

4

3

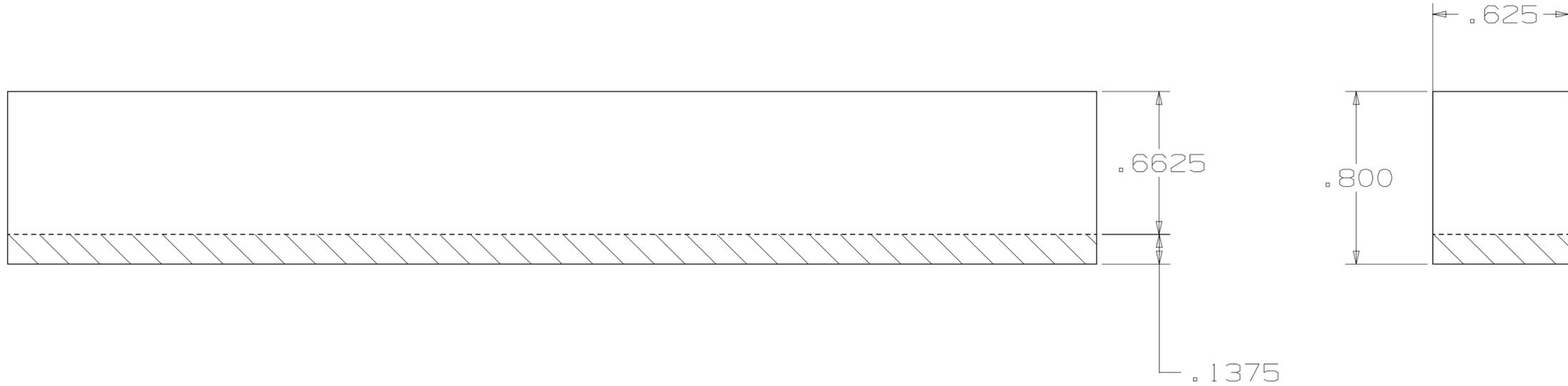
2

1

C

C

2139-R-TOP-NN



B

B

A

A

DECIMALS TOLERANCES

1 PLACE..... ±.030
 2 PLACE..... ±.010
 3 PLACE..... ±.005
 4 PLACE..... ±.0005

ANGULAR
 ±0° 30'

FRACTIONS
 ±1/16

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL: 2139 AL

IP130
 DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP130_DWG	
CHECKED BY R.Z.		DATE 11/29/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

4

3

2

1

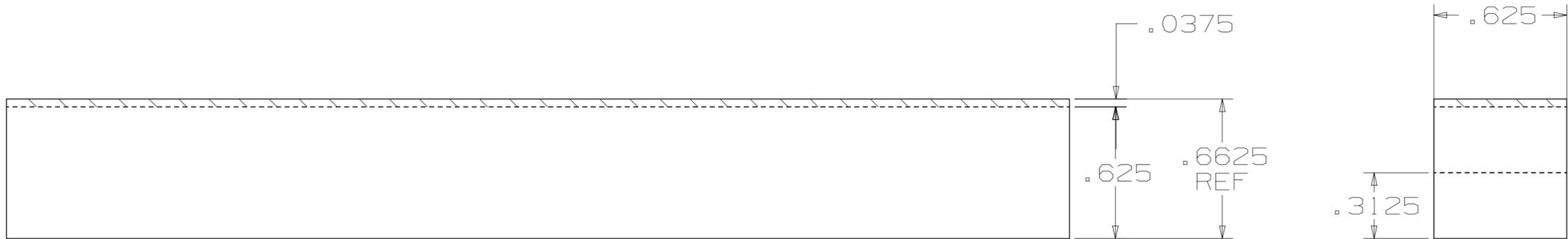
C

C

2139-R-TOP-NN

B

B



A

A

DECIMALS TOLERANCES

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP140
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIP_IP140_DWG	
CHECKED BY R.Z.		11/29/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

4

3

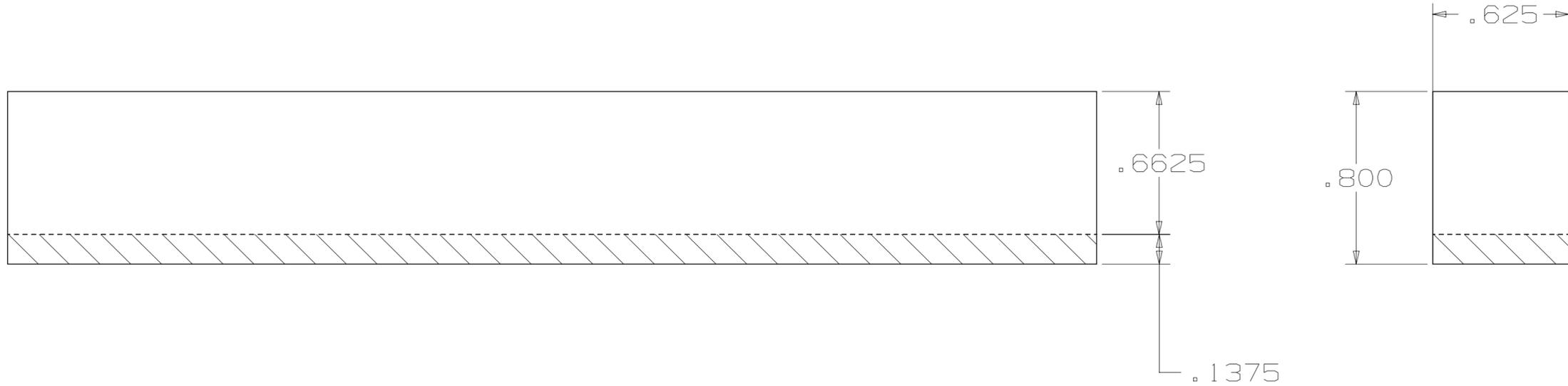
2

1

C

C

2139 - A - TOP - NN



B

B

A

A

DECIMALS TOLERANCES

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP150
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP150_DWG	
CHECKED BY R.Z.		DATE 11/29/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

4

3

2

1

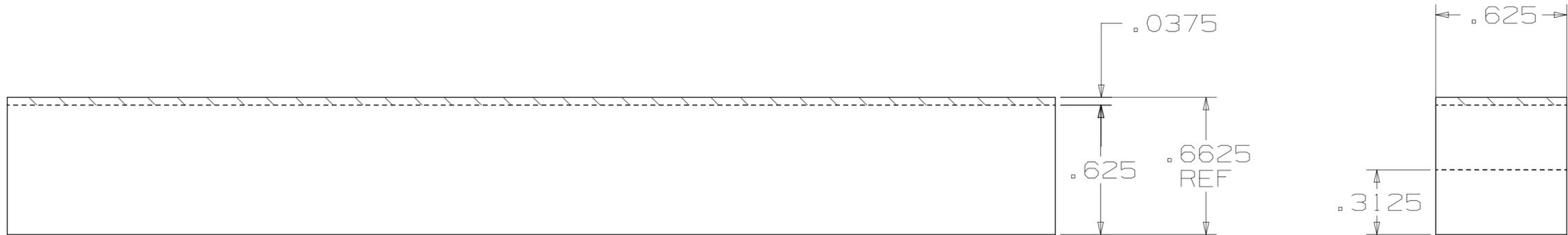
C

C

2139-A-TOP-NN

B

B



A

A

DECIMALS TOLERANCES

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.005
- 4 PLACE..... ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL: 2139 AL

IP160
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/29/11		DWG NO. J.C._TESTING_STRIPS_IP160_DWG	
CHECKED BY R.Z.		11/29/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

2

1

4

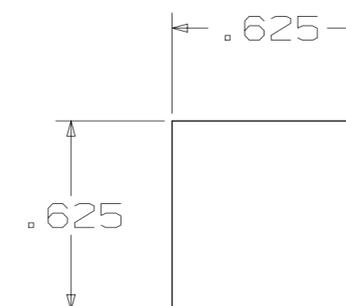
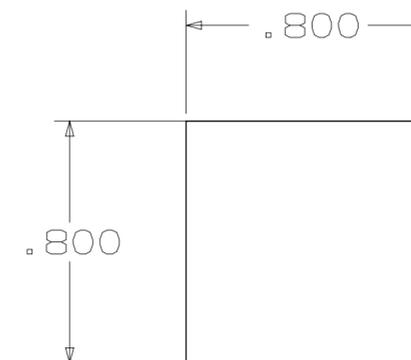
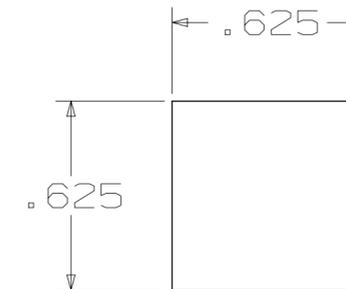
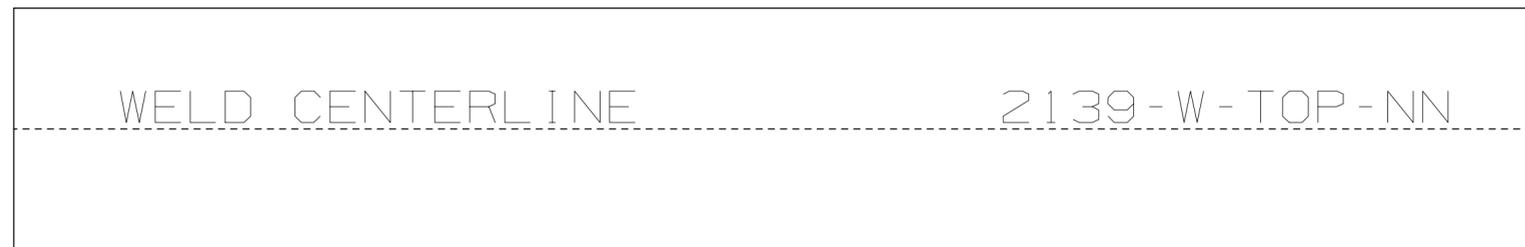
3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

TOP VIEW OF 3 FINISHED BLOCKS



C

C

B

B

A

A

DECIMALS TOLERANCES ANGULAR
 1 PLACE..... ±.030 ±0° 30'
 2 PLACE..... ±.010
 3 PLACE..... ±.005 FRACTIONS ±1/64
 4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL: 2139 AL

IP170
 DWG

CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY-FSP				FOCUS CODE MANUFACTURING	
DRAWN BY B.T. DATE 11/29/11		PART NAME J C TESTING STRIPS			
CHECKED BY R.Z. 11/29/11		DWG NO. J_C_TESTING_STRIPS_IP170_DWG			
RELEASED BY		UNITS INCHES		PART NO. X	
SCALE	N/A	SIZE	C	DWG LEVEL	REV 100
SHEET 1 of 1					

4

3

2

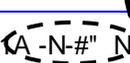
1

Focus: HOPE Process routing/Shop traveler

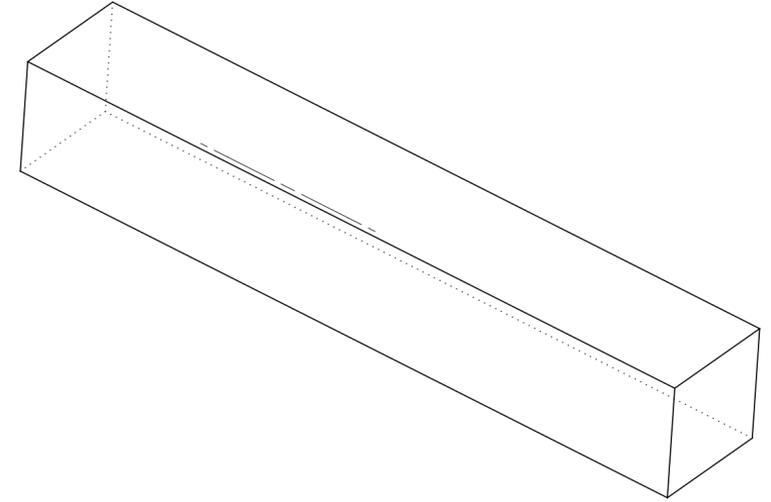
Customer: **Southwest Research Institute**
 Street Address:
 City State Zip:

Stock: **3/4" x 3/4" x 4 1/2" FSW weld coupon (4 RET)**

Part Number: **TAIT specimen**
 Description: **Johnson-Cook test specimens**
 Revision:

Op No	Labor Code	Operation Description
		See 'Strips' Process Sheet for initial specimen extraction operations.
		<i>Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT,</i>
10		Confirm that all specimens are "6061-A" 
20	MILL	Circular interpolate end to .70 dia x .88
30	CNC	Center Drill, Turn square end round to .252/.254 x 1.5, .625 x 1.3; cut-off at 1.375
40		Retrieve and label specimen
		DO NOT mark the final part in any way (laser, paint, etc.)
		Individually bag each part and mark each bag "6061-A-N-#"  for Block Number and # for specimen
50	CNC	rechuck part against shoulder; turn to .252/.254 dia. x 1.5
60	CNC	Turn to .252/.254 dia. x 1.5; cut-off at 1.375
70		Retrieve and label specimens
80	MILL	Face mill each specimen to 1.3
90	MILL	Flip part and face mill 1.250
100		Bag and Label

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



MMMM - X - TOP - NN

4.50
REF

.75
REF

.75
REF

IP10
DWG

DECIMALS TOLERANCES ANGULAR

1 PLACE..... ±.030 ±0° 30'

2 PLACE..... ±.010 FRACTIONS ±1/64

3 PLACE..... ±.003

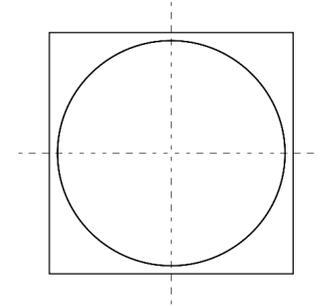
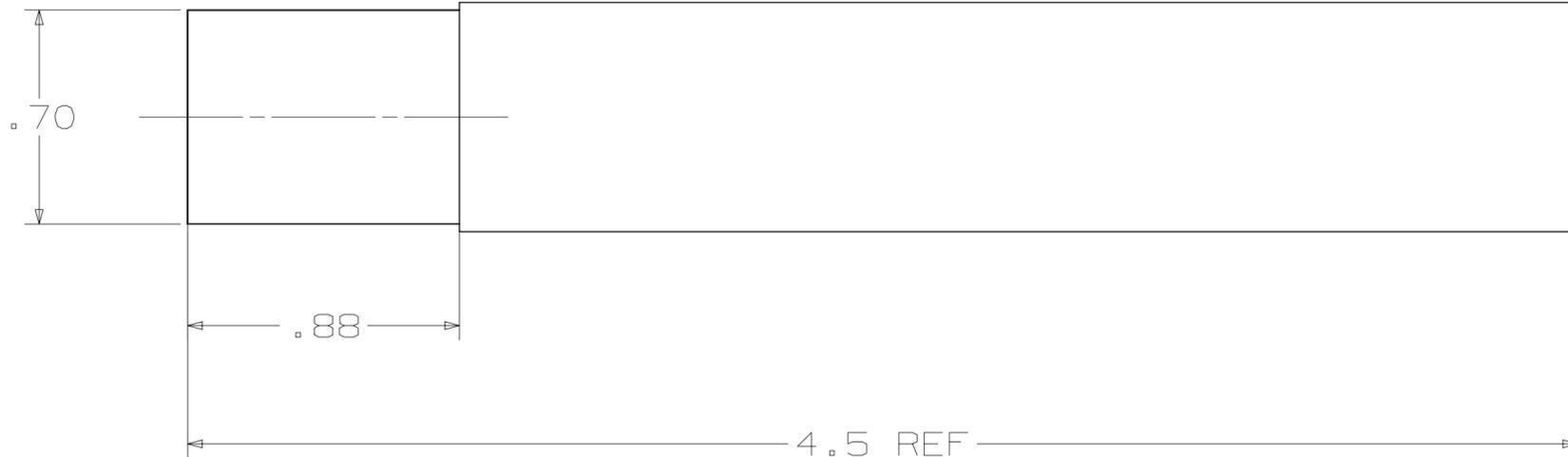
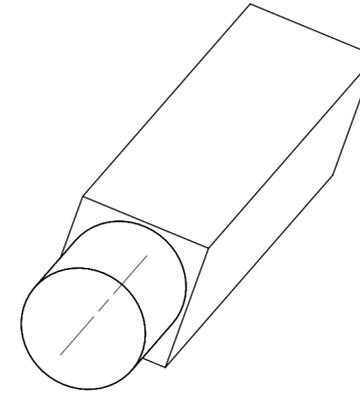
4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

MATERIAL :

UG CHANGE RESTRICTED		DO NOT SCALE	
USAGE: ARMY-FSP		THIRD ANGLE PROJECTION	
DRAWN BY B.T.		DATE 10/5/11	
CHECKED BY R.Z.		DATE 10/5/11	
RELEASED BY		SCALE N/A	
PART NAME T A I T SPECIMEN		DWG NO. T_A_I_T_SPECIMEN_IP10_DWG	
PART NO.		REV	
SIZE C		DWG LEVEL 100	
SHEET 1 of 1		REV	

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES ANGULAR
 1 PLACE..... ±.030 ±0° 30'
 2 PLACE..... ±.010
 3 PLACE..... ±.003 FRACTIONS
 4 PLACE..... ±.0005 ±1/64

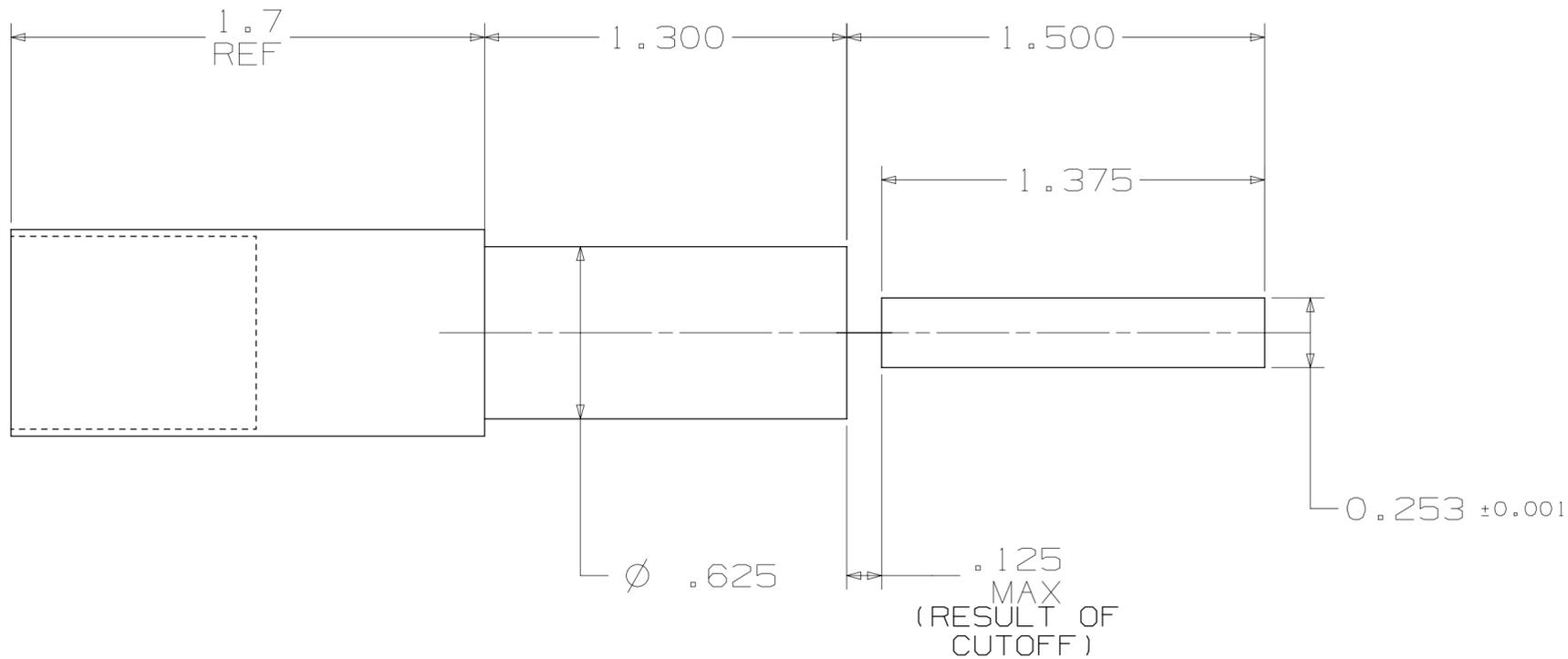
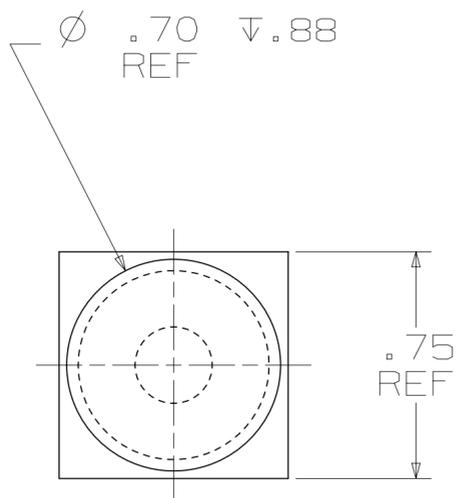
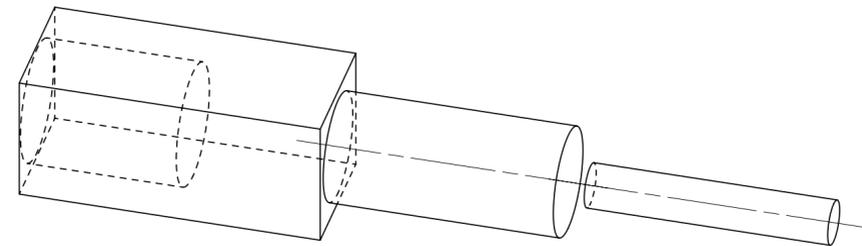
UNLESS OTHERWISE SPECIFIED

MATERIAL :

IP20
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY FSP				FOCUS CODE MANUFACTURING	
PART NAME: T A I T SPECIMEN					
DRAWN BY: B.T.	DATE: 9/27/11	DWG NO.: T_A_I_T_SPECIMEN_IP20_DWG			
CHECKED BY: R.Z.		PART NO.:			
RELEASED BY:		SCALE: N/A	SIZE: C	DWG LEVEL: 100	REV:
SHEET 1 of 1					

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



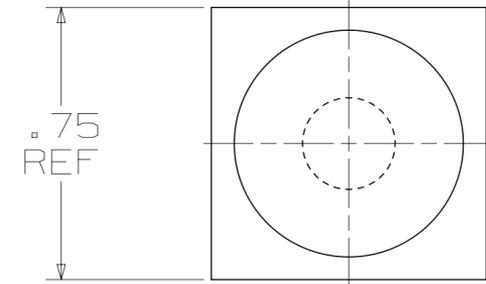
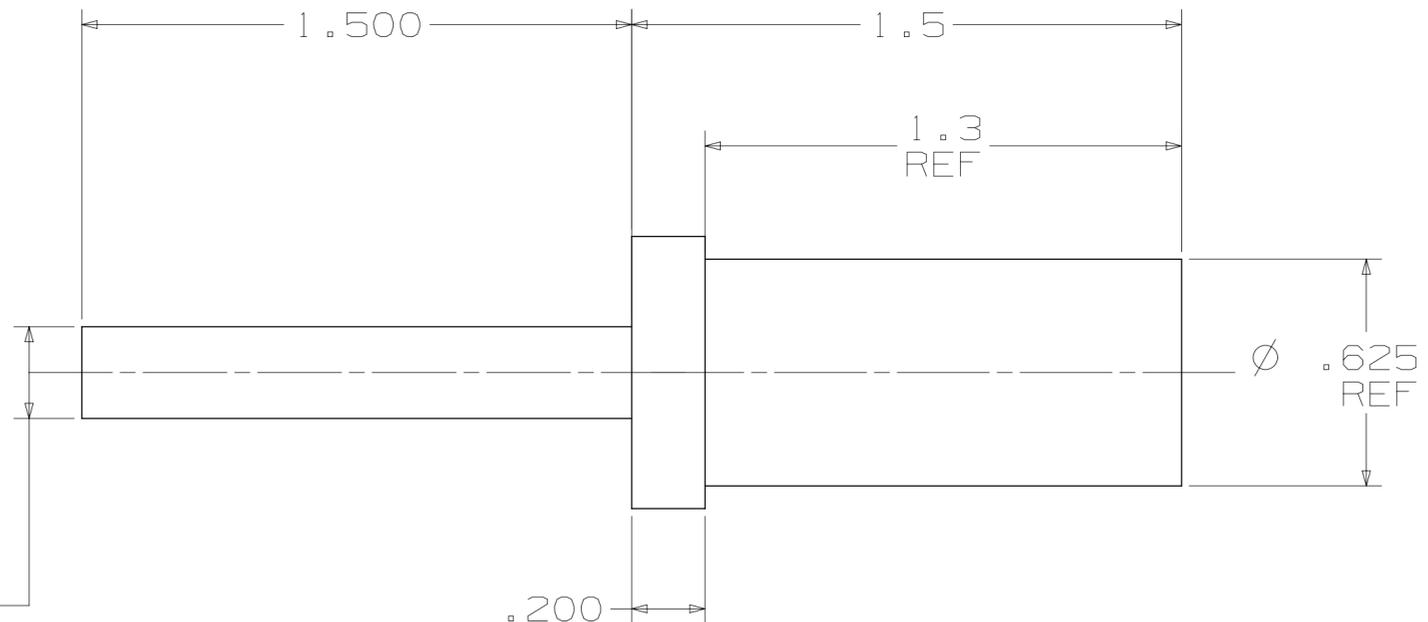
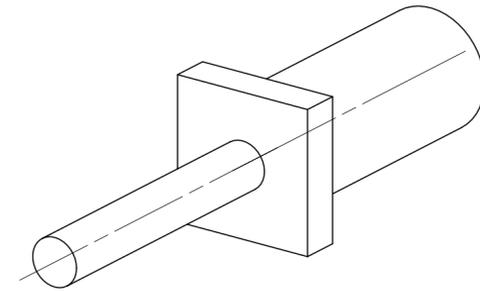
DECIMALS	TOLERANCES	ANGULAR
1 PLACE.....	$\pm .030$	$\pm 0^{\circ} 30'$
2 PLACE.....	$\pm .010$	
3 PLACE.....	$\pm .005$	FRACTIONS
4 PLACE.....	$\pm .0005$	$\pm 1/64$

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL:

IP30
DWG

UG CHANGE RESTRICTED USAGE: ARMY-FSP		DO NOT SCALE THIRD ANGLE PROJECTION PART NAME T A I T SPECIMEN			
DRAWN BY B.T. CHECKED BY R.Z. RELEASED BY	DATE 10/5/11 10/5/11	DWG NO. T_A_I_T_SPECIMEN_IP30_DWG PART NO. X	SCALE N/A SIZE C DWG LEVEL 100	REV	SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES ANGULAR

1 PLACE..... ±.030 ±0° 30'

2 PLACE..... ±.010

3 PLACE..... ±.005

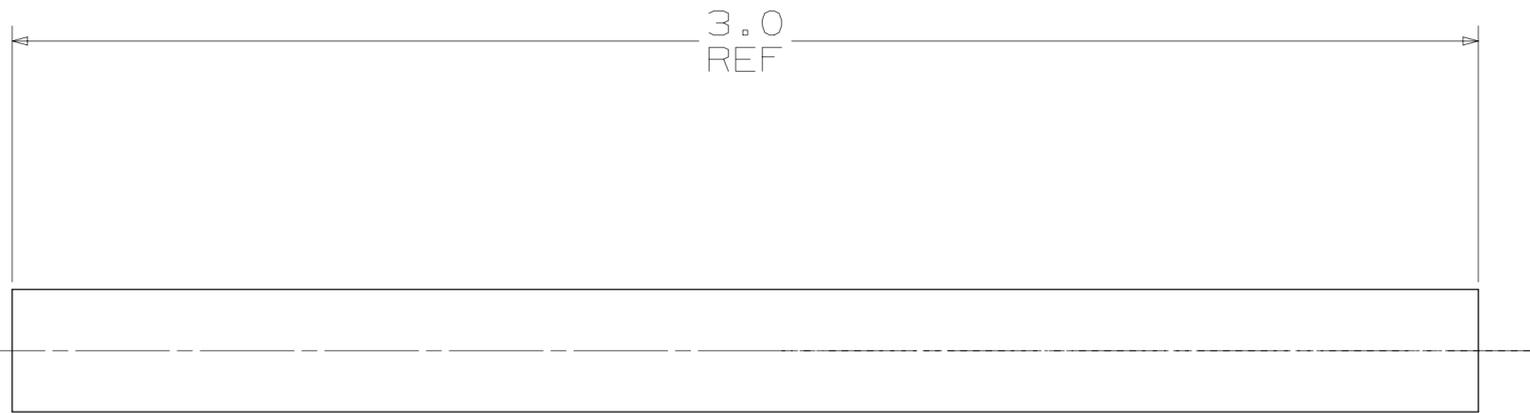
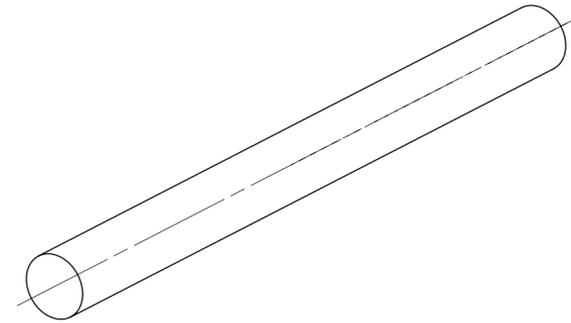
4 PLACE..... ±.0005 FRACTIONS ±1/64

UNLESS OTHERWISE SPECIFIED
BREAK ALL SHARP EDGES
MATERIAL:

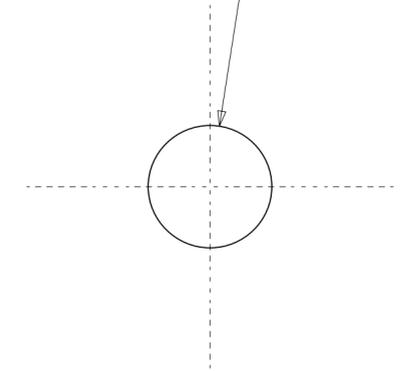
IP50
DWG

CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY-FSP				FOCUS CODE MANUFACTURING	
PART NAME T A I T SPECIMEN					
DRAWN BY B.T.	DATE 10/6/11	DWG NO. T_A_I_T_SPECIMEN_IP50_DWG			
CHECKED BY R.Z.	DATE 10/6/11	PART NO. X			
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



$\varnothing .253 \pm 0.001$



DECIMALS TOLERANCES ANGULAR

1 PLACE..... ±.030 ±0° 30'

2 PLACE..... ±.010

3 PLACE..... ±.005 FRACTIONS ±1/64

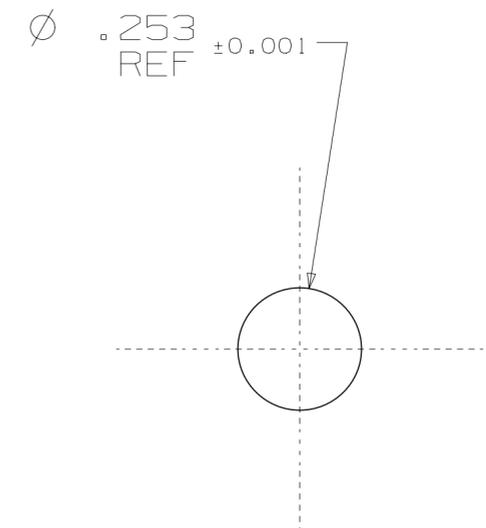
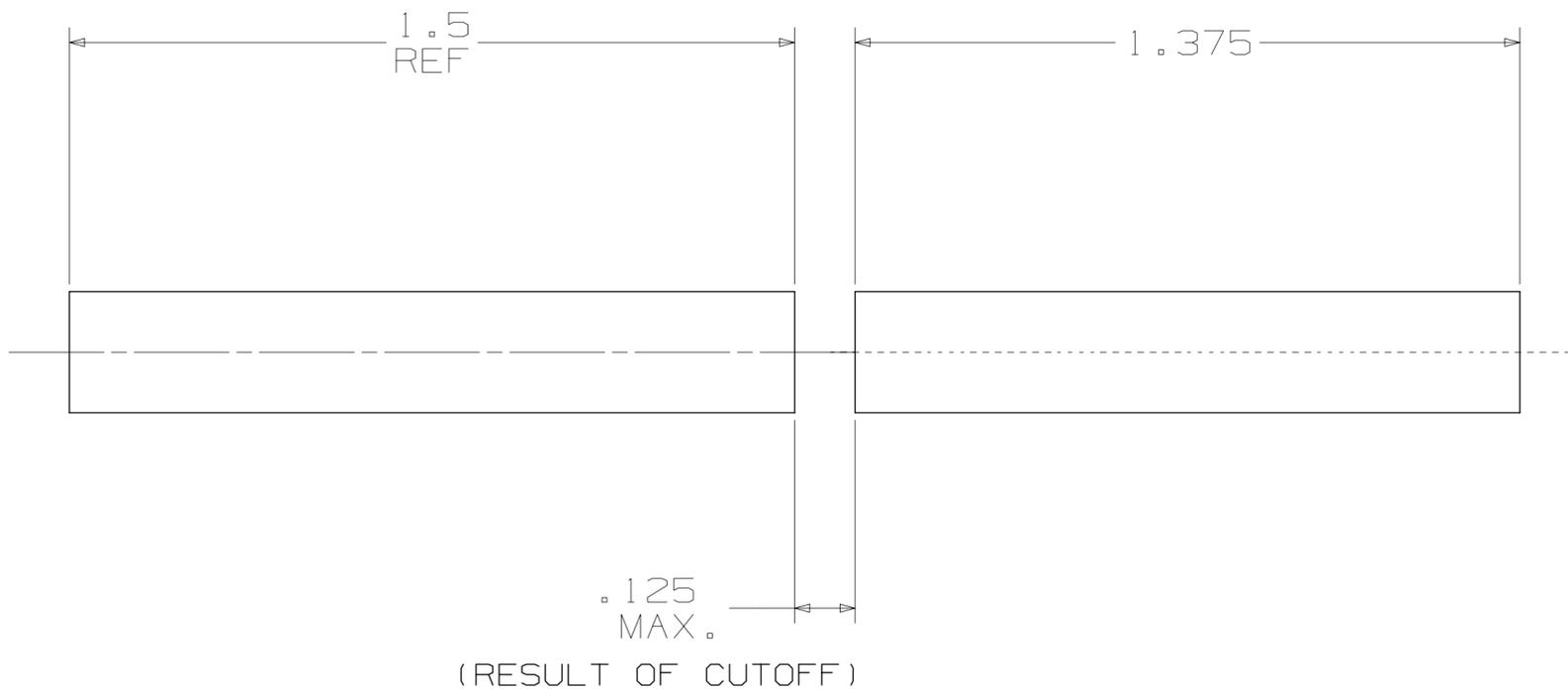
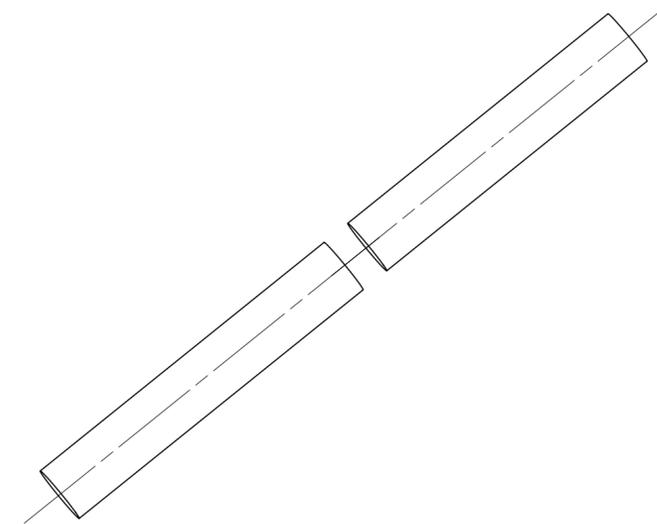
4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL :

IP60A
 DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY-FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 9/27/11		DWG NO. T_A_I_T_SPECIMEN_IP60A_DWG	
CHECKED BY R.Z.		DATE 9/27/11		PART NO. X	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES ANGULAR

1 PLACE..... ±.030 ±0° 30'

2 PLACE..... ±.010

3 PLACE..... ±.005 FRACTIONS ±1/64

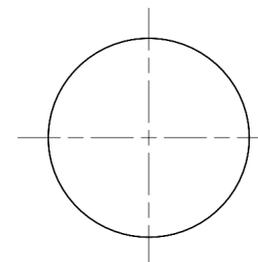
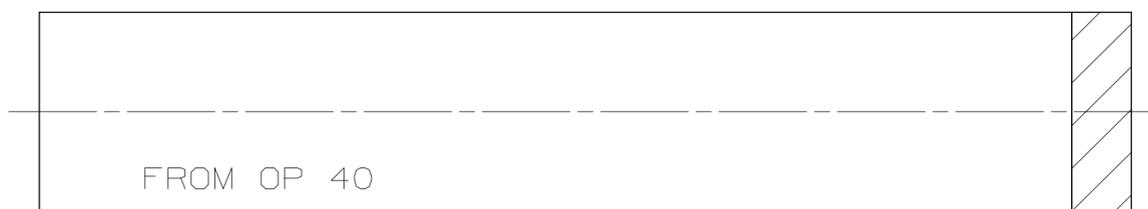
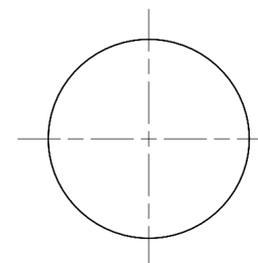
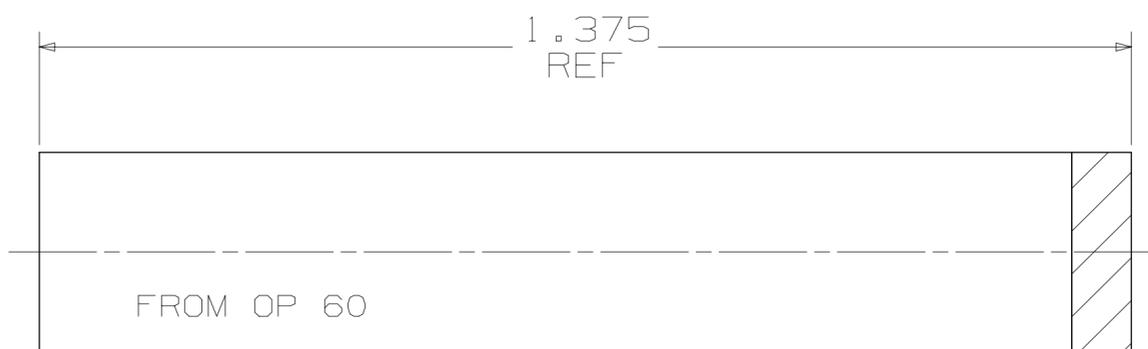
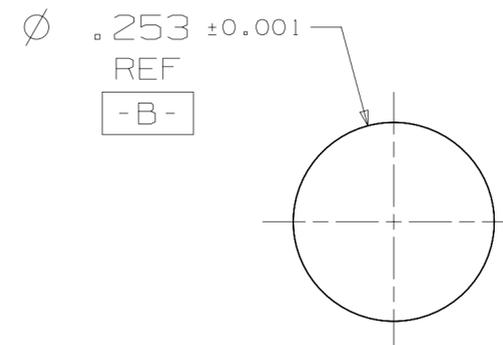
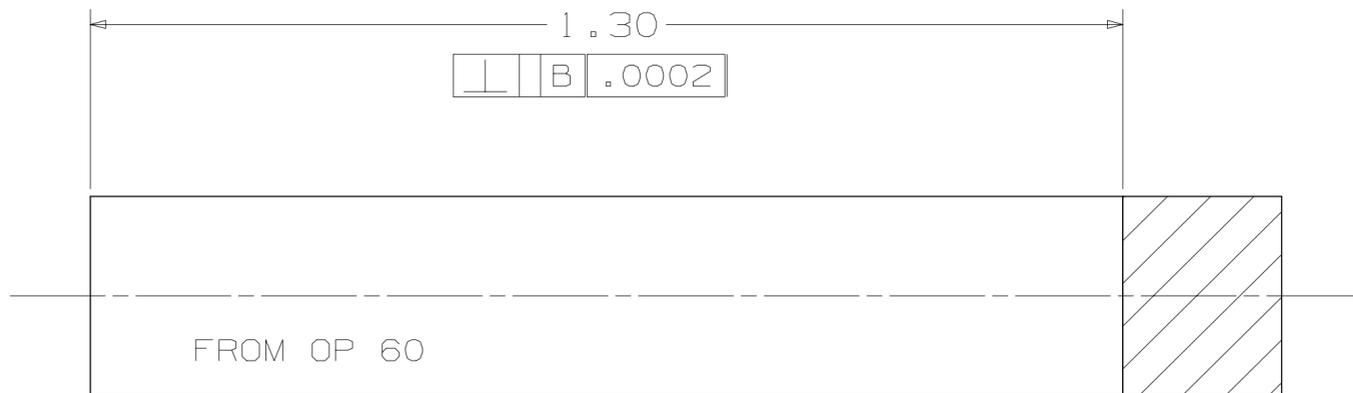
4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL:

IP60B
 DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY-FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME T A I T SPECIMEN					
DRAWN BY B.T.	DATE 10/6/11	DWG NO. T_A_I_T_SPECIMEN_IP60B_DWG			
CHECKED BY R.Z.	DATE 10/6/11	PART NO. X			
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



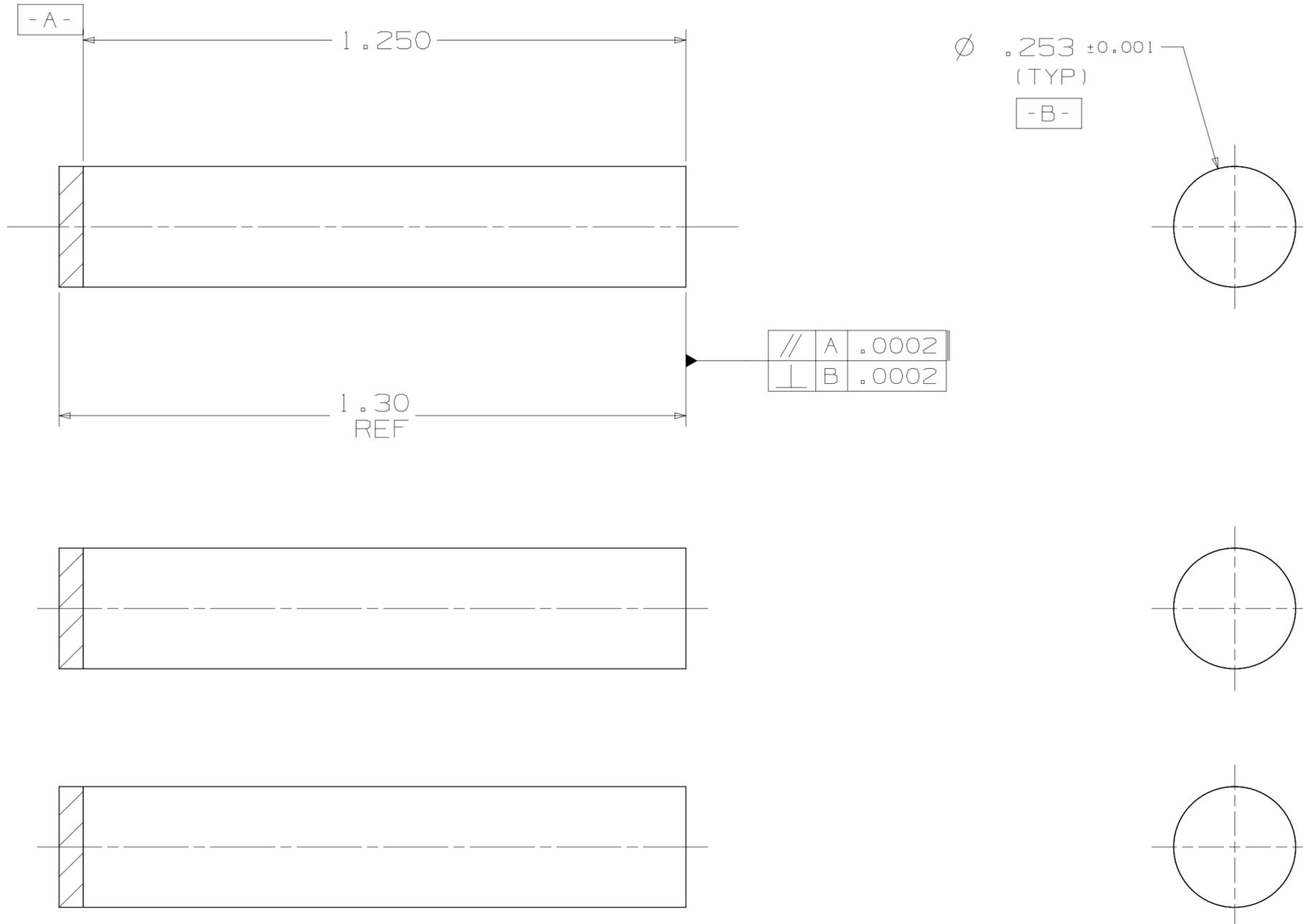
DECIMALS TOLERANCES ANGULAR
 1 PLACE..... ±.030 ±0° 30'
 2 PLACE..... ±.010
 3 PLACE..... ±.005 FRACTIONS
 4 PLACE..... ±.0005 ±1/64

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL:

IP80
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY-FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME T A I T SPECIMEN					
DRAWN BY B.T.	DATE 10/7/11	DWG NO. T_A_I_T_SPECIMEN_IP80_DWG			
CHECKED BY R.Z.	DATE 10/7/11	PART NO. X			
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

COMPLETION OF PROCESS RESULTS IN 3 PIECES



DECIMALS	TOLERANCES	ANGULAR
1 PLACE.....	$\pm .030$	$\pm 0^\circ 30'$
2 PLACE.....	$\pm .010$	
3 PLACE.....	$\pm .005$	FRACTIONS
4 PLACE.....	$\pm .0005$	$\pm 1/64$

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL:

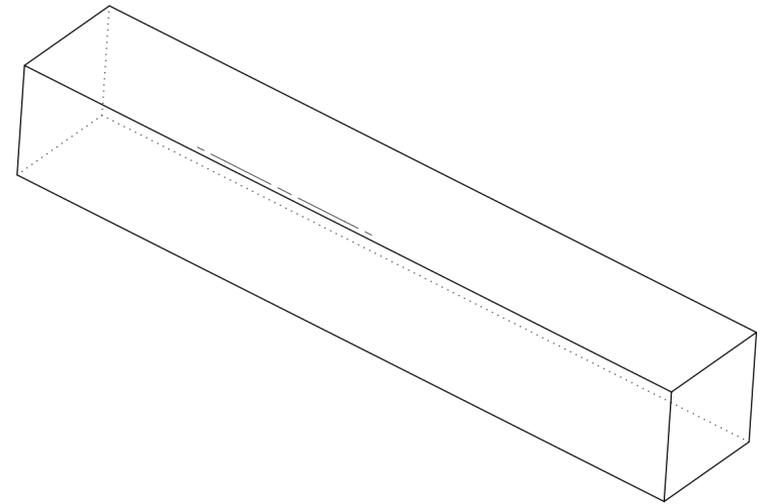
IP90
 DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY-FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME T A I T SPECIMEN					
DRAWN BY B.T.	DATE 10/7/11	DWG NO. T_A_I_T_SPECIMEN_IP90_DWG			
CHECKED BY R.Z.		10/7/11	PART NO. X		
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

Focus: HOPE Process routing/Shop traveler

Customer: Southwest Research Institute		
Street Address:		
City State Zip:		
Stock: 3/4 x 3/4 x 4 1/2 coupon (8)		
Part Number: A-250in_SmoothTensile		
Description: Johnson-Cook test specimen		
Revision:		
Op No	Labor Code	Operation Description
		See 'Strips' Process Sheet for initial specimen extraction operations.
		Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT,
10		Confirm that all material blocks are marked "6061-W"
20	Mill	Square mill end, round (circular interpolate) end to 0.70 dia x 0.88 and center drill
30	Laser	Mark end "61W-#" (where # = 1 thru 8)
40	Mazak	center drill, rough contour turn, final contour turn, single point thread
50	Laser	Mark end "61W-#" (where # = 1 thru 8)
60		Individually bag each part
70		Label Bags
80		Polish Longitudinally
90	Mazak	Cover polished area with rubber hose. Cut-off to final length 3.000

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



MMMM - X - TOP - NN

4.50
REF

.75
REF

.75
REF

IP10
DWG

DECIMALS TOLERANCES ANGULAR

1 PLACE..... ±.030 ±0° 30'

2 PLACE..... ±.010 FRACTIONS ±1/64

3 PLACE..... ±.003

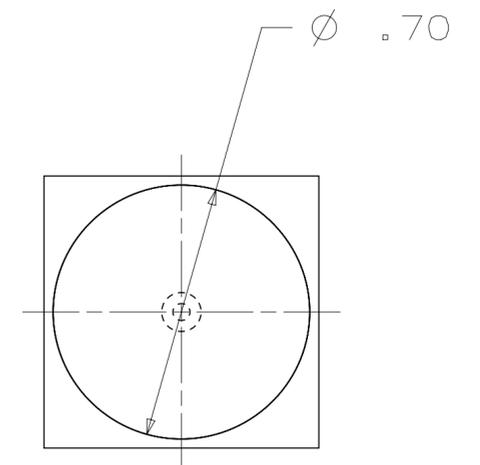
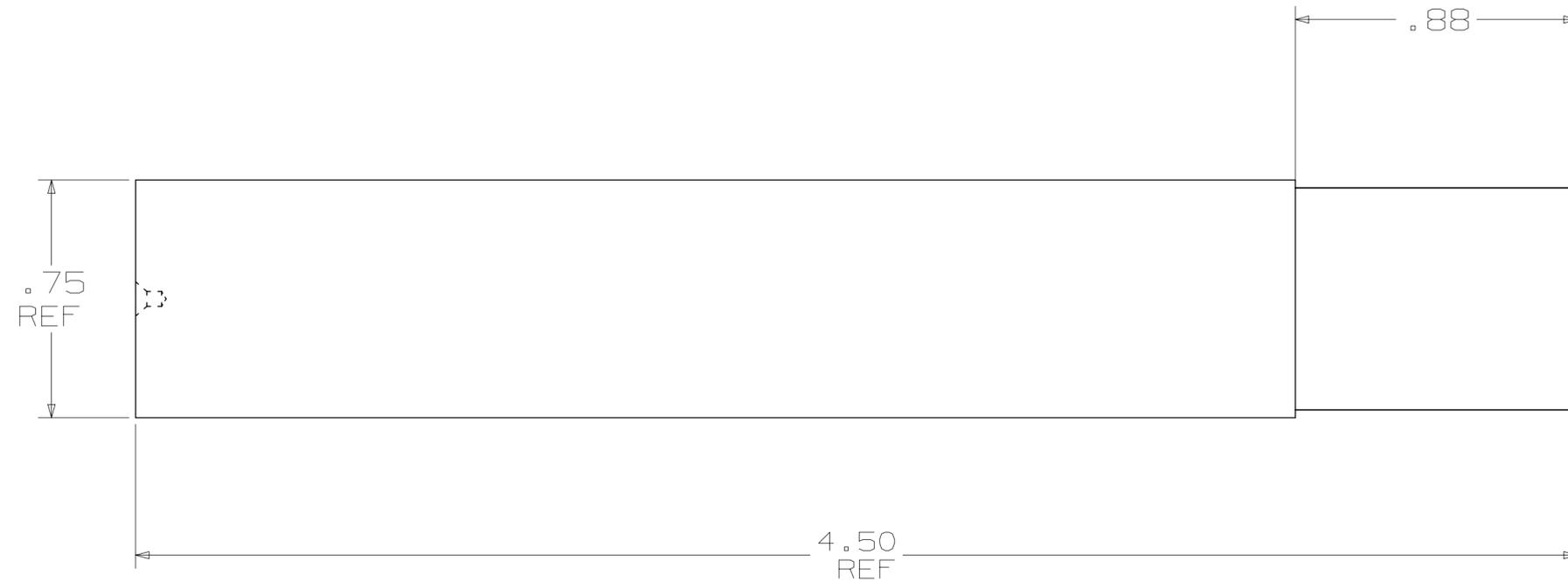
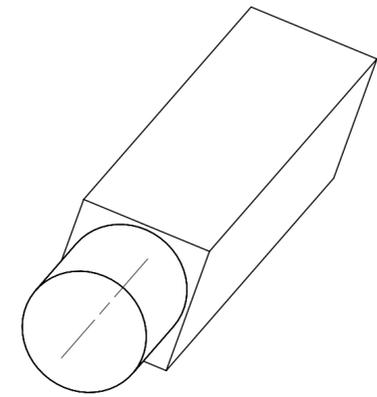
4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

MATERIAL :

UG CHANGE RESTRICTED		DO NOT SCALE	
USAGE: ARMY-FSP		 THIRD ANGLE PROJECTION FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		PART NAME A 2501N SMOOTH TENSILE	
DATE 10/4/11		DWG NO. A_2501N_SMOOTHTENSILE_IP10_DWG	
CHECKED BY R.Z.		PART NO.	
RELEASED BY		SCALE N/A	SIZE C
		DWG LEVEL 100	REV
		SHEET 1 of 1	

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS	TOLERANCES	ANGULAR
1 PLACE.....	±.030	±0° 30'
2 PLACE.....	±.010	
3 PLACE.....	±.003	FRACTIONS
4 PLACE.....	±.0005	±1/64

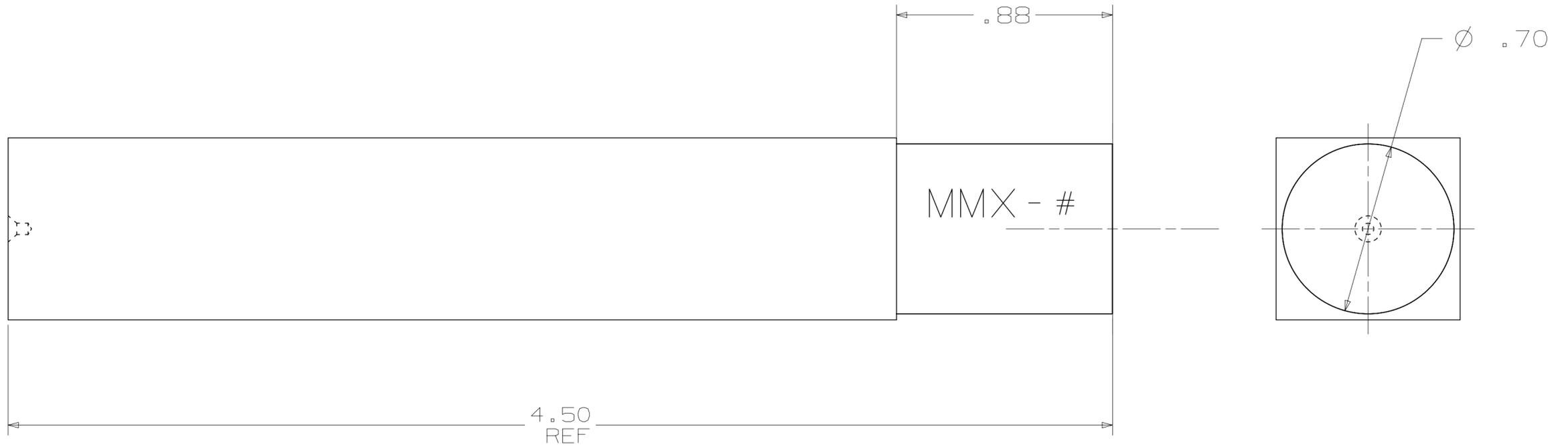
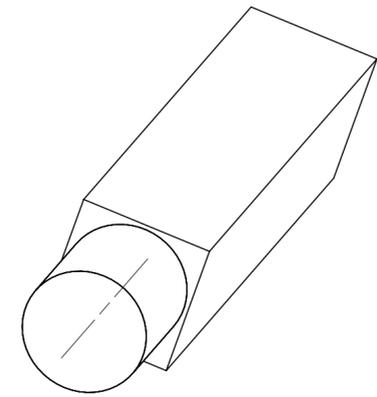
UNLESS OTHERWISE SPECIFIED

MATERIAL :

IP20
DWG

CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY FSP				FOCUS CODE MANUFACTURING	
PART NAME A 250IN SMOOTH TENSILE					
DRAWN BY B.T.	DATE 10/4/11	DWG NO. A_250IN_SMOOTHTENSILE_IP20_DWG			
CHECKED BY R.Z. 10/4/11		PART NO.			
RELEASED BY	SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



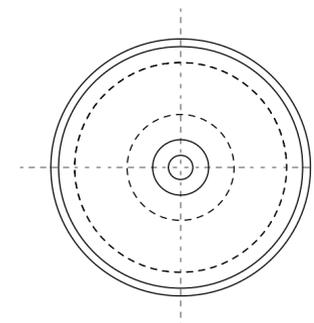
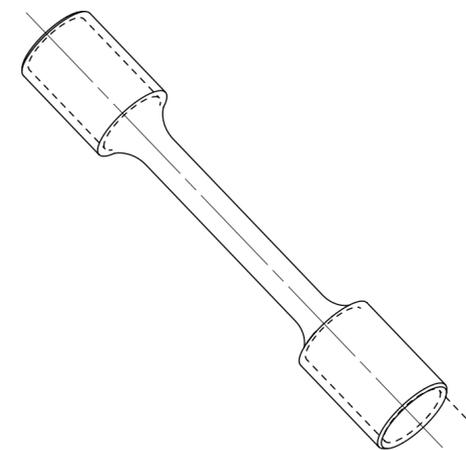
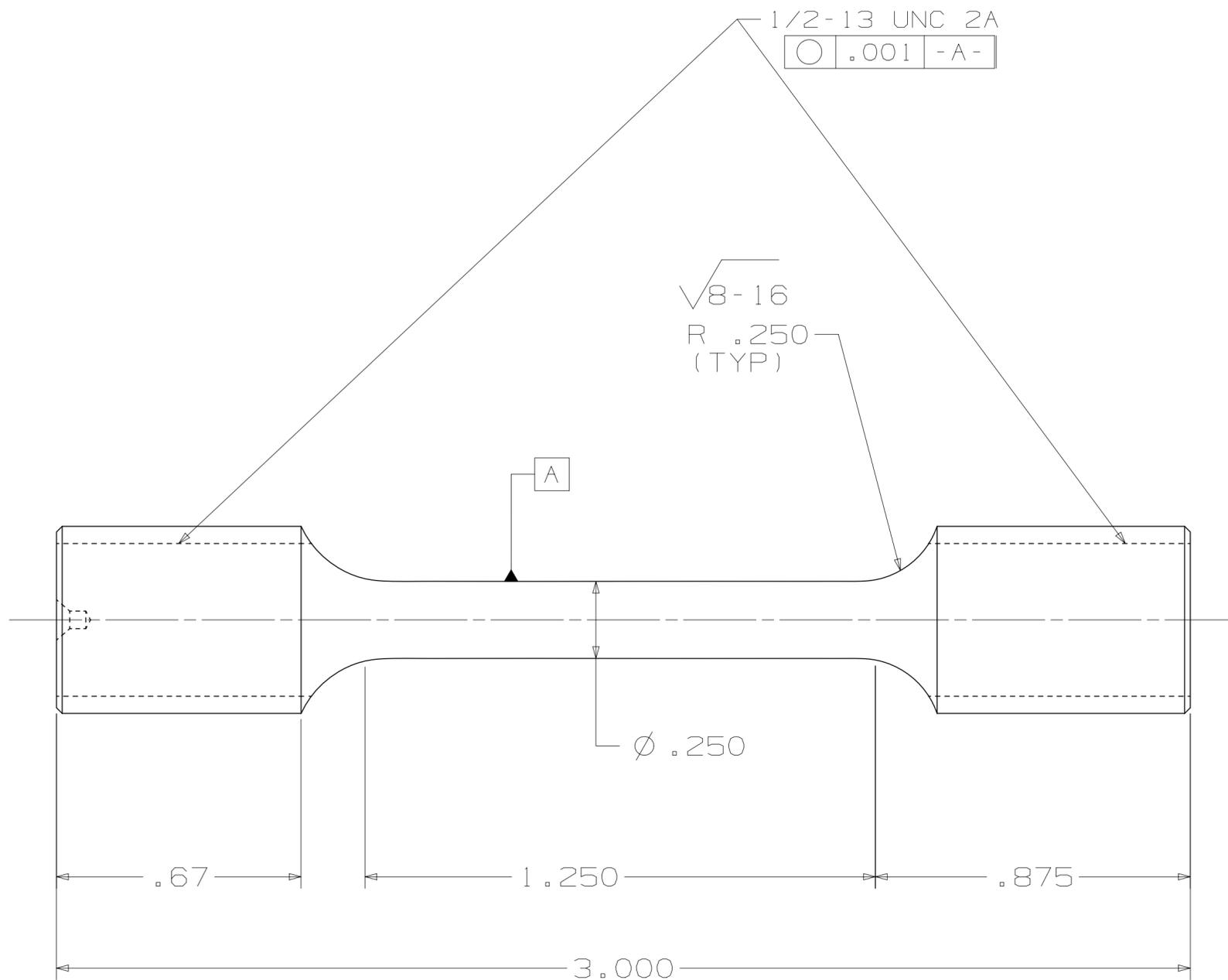
DECIMALS	TOLERANCES	ANGULAR
1 PLACE.....	±.030	±0° 30'
2 PLACE.....	±.010	
3 PLACE.....	±.003	FRACTIONS
4 PLACE.....	±.0005	±1/64

UNLESS OTHERWISE SPECIFIED

MATERIAL :

IP30
DWG

CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY FSP					
PART NAME: A 250IN SMOOTH TENSILE		FOCUS CODE MANUFACTURING			
DRAWN BY B.T.	DATE 10/4/11	DWG NO. A_250IN_SMOOTHTENSILE_IP30_DWG			
CHECKED BY R.Z.	10/4/11	PART NO.			
RELEASED BY	SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1



TOLERANCES (INCH)
DECIMALS

- 1 PLACE..... $\pm .030$
- 2 PLACE..... $\pm .010$
- 3 PLACE..... $\pm .003$
- 4 PLACE..... $\pm .0005$

UNLESS OTHERWISE SPECIFIED

MATERIAL:

ANGULAR
 $\pm 0^{\circ} 30'$

FRACTIONS
 $\pm 1/64$

IP40
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 10/4/11		PART NAME A 250IN SMOOTH TENSILE	
CHECKED BY R.Z.		DATE 10/4/11		DWG NO. A_250IN_SMOOTH TENSILE_IP40_DWG	
RELEASED BY		SCALE N/A		PART NO.	
		SIZE C		DWG LEVEL 100	
		REV		SHEET 1 of 1	

4

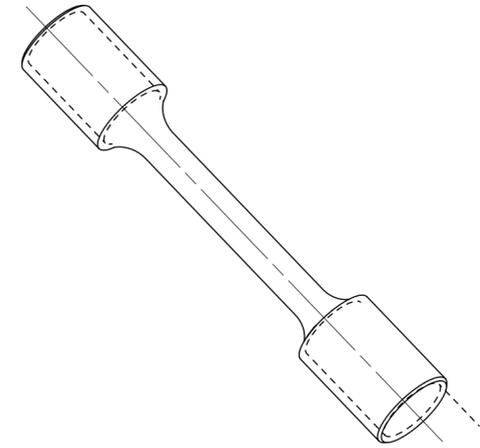
3

2

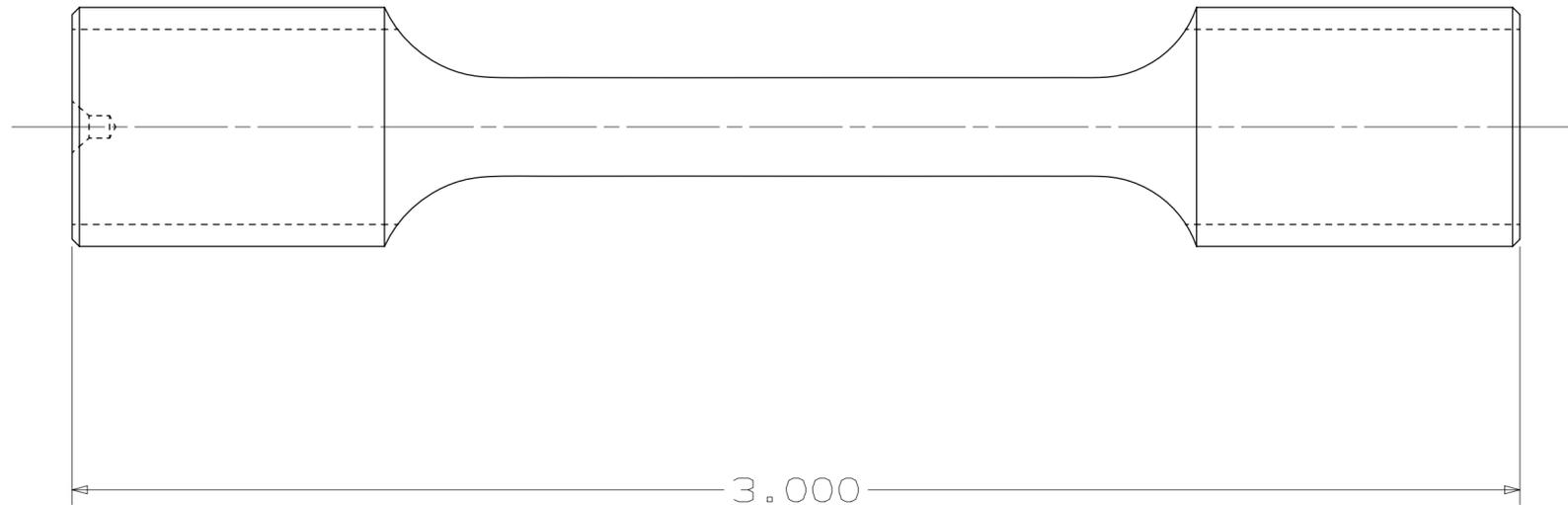
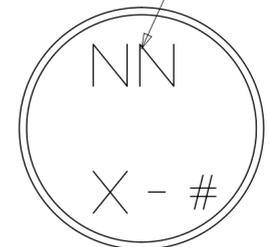
1

C

C



MARK LOCATION



B

B

A

A

IP50
DWG

TOLERANCES (INCH)
DECIMALS

- 1 PLACE..... ±.030
- 2 PLACE..... ±.010
- 3 PLACE..... ±.003
- 4 PLACE..... ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/64

UNLESS OTHERWISE SPECIFIED

MATERIAL :

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 10/4/11		PART NAME A 250IN SMOOTH TENSILE	
CHECKED BY R.Z.		DATE 10/4/11		DWG NO. A_250IN_SMOOTHTENSILE_IP50_DWG	
RELEASED BY		PART NO.		SCALE N/A	
		SIZE C		DWG LEVEL 100	
		REV		SHEET 1 of 1	

4

3

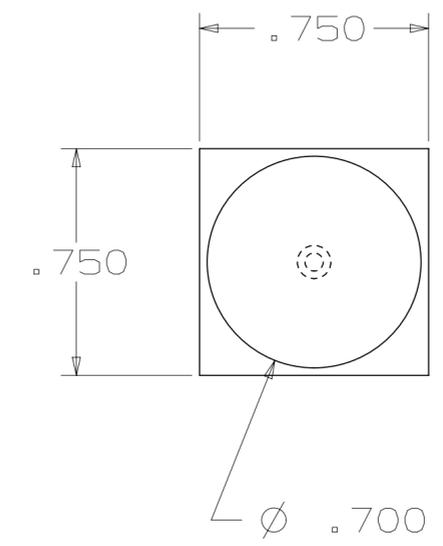
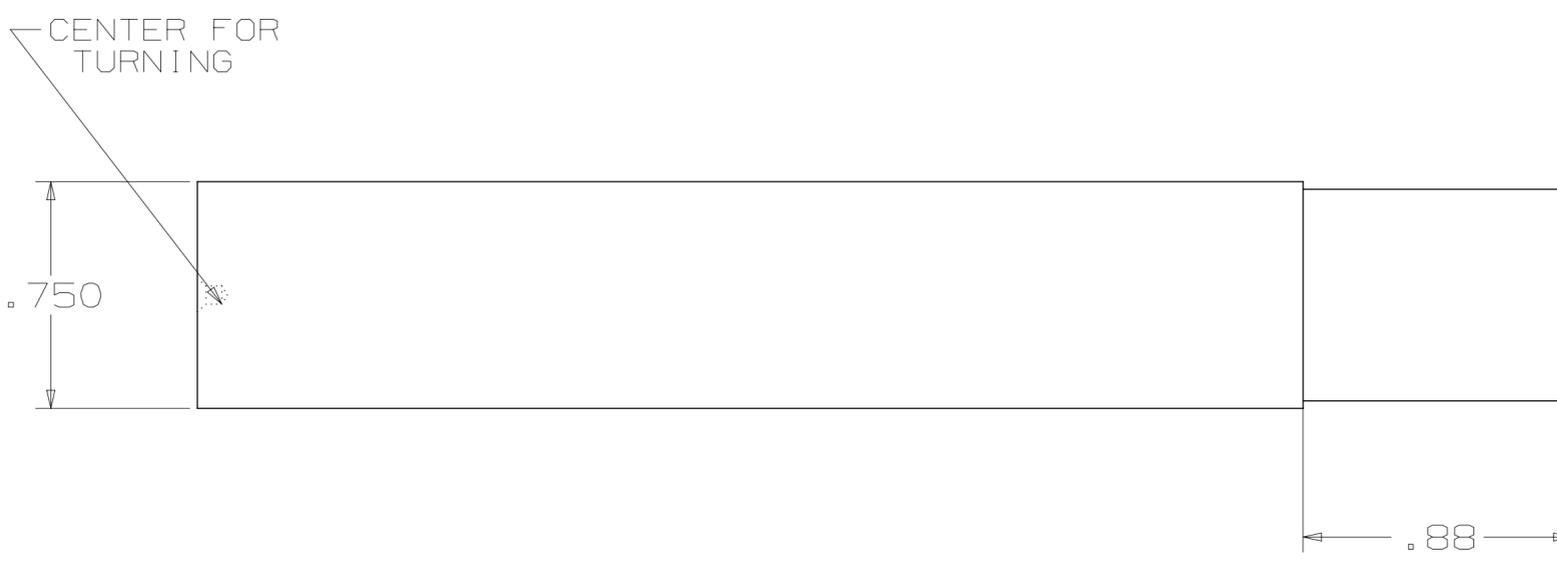
2

1

Focus: HOPE Process routing/Shop traveler

Customer: TACOM Warren Street Address: City State Zip: Stock: .650 x 2.525" FSW weld coupon (4) Part Number: .375 Compression Specimen (SHPBC) Description: Split Hopkinson Pressure Bar test specimen Revision:		
Op No	Labor Code	Operation Description
		See Torsion Process Sheet for initial specimen extraction operations.
		Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT,
10		Confirm that all material blocks are marked "6061-W"
20	CNC	Turn to 0.375 dia x 1.5
30	CNC	Turn to .375 dia.x 1.325; cut-off at 1.2
		DO NOT mark the final part in any way (laser, paint, etc.)
40		Individually bag each part and mark each bag "61W"
50	CNC	Face mill end; clean surface
60	CNC	Face mill end to final length

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS	TOLERANCES
1 PLACE.....	±.030
2 PLACE.....	±.010
3 PLACE.....	±.005
4 PLACE.....	±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL :

IP10
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/2/11		DWG NO. SHPBC_IP10_DWG	
CHECKED BY R.Z.		DATE 11/2/11		PART NO.	
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

3

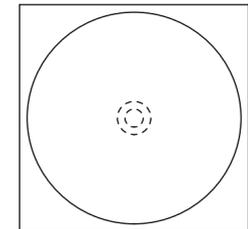
2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



← .098 →



C

C

B

B

A

A

DECIMALS TOLERANCES

1 PLACE..... ±.030

2 PLACE..... ±.010

3 PLACE..... ±.005

4 PLACE..... ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/16

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL :

IP20
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/3/11		DWG NO. SHPBC_IP20_DWG	
CHECKED BY R.Z.		DATE 11/3/11		PART NO.	
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100
		REV	SHEET 1 of 1		

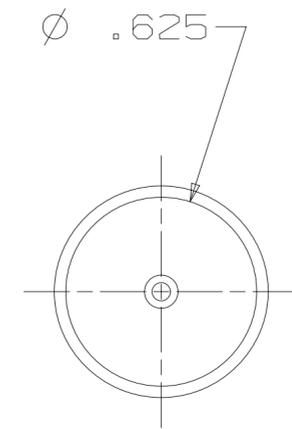
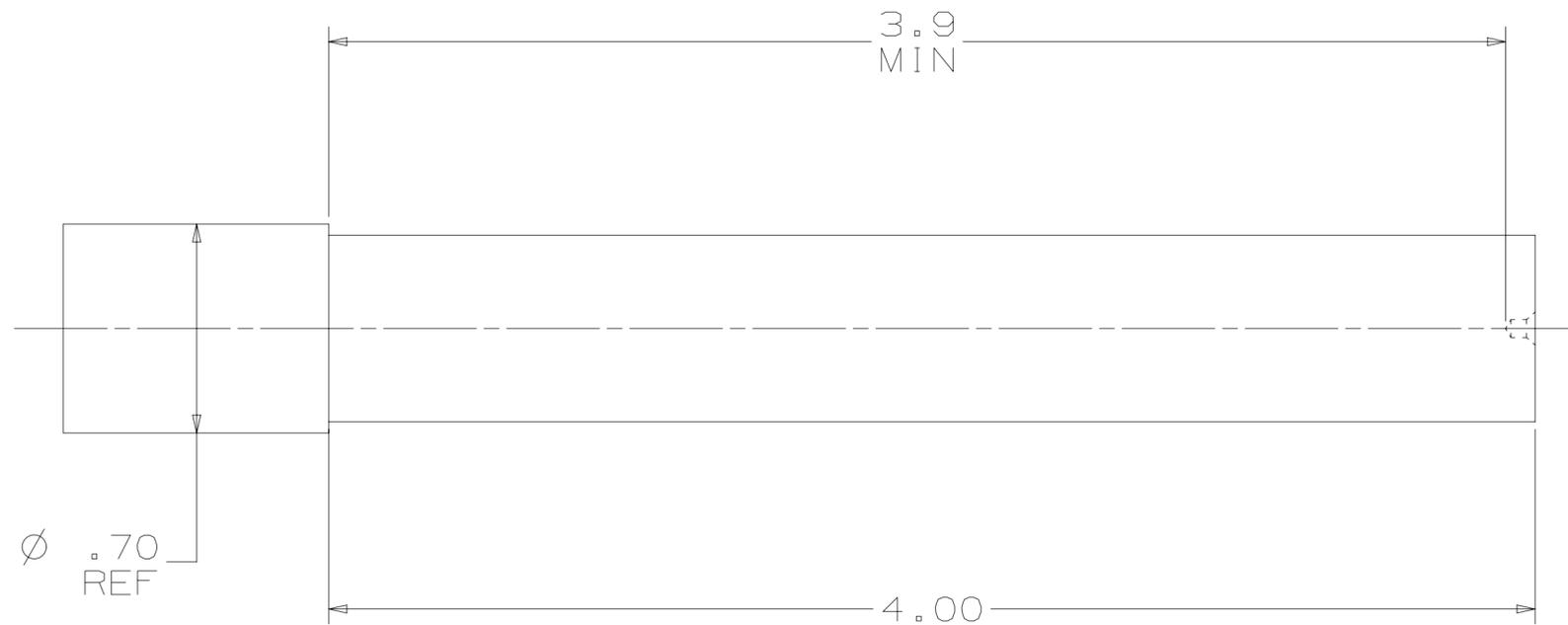
4

3

2

1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES

1 PLACE..... ±.030 ANGULAR ±0° 30'

2 PLACE..... ±.010

3 PLACE..... ±.005 FRACTIONS ±1/16

4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

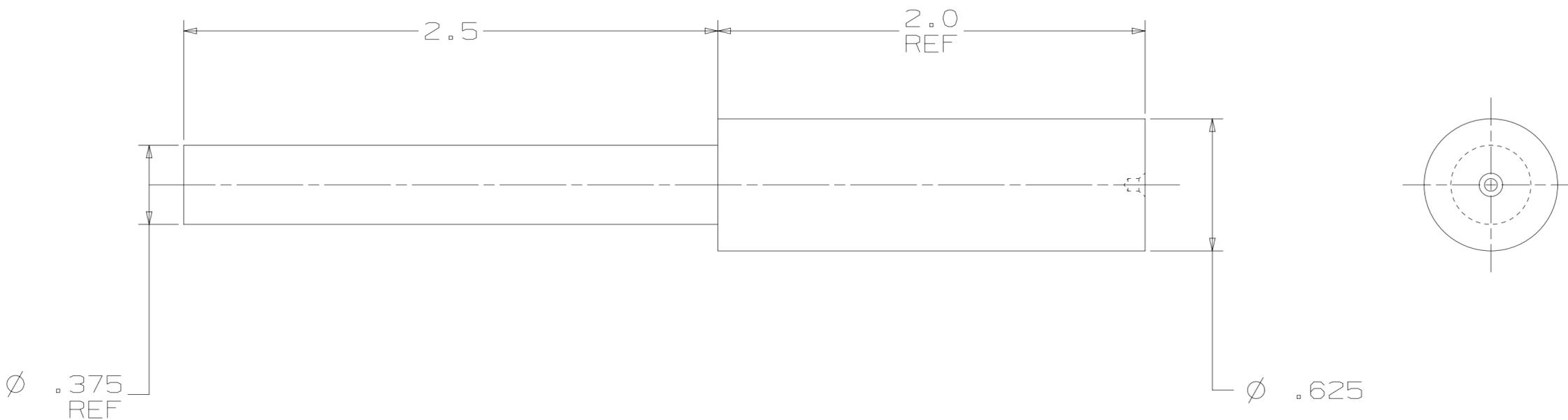
BREAK ALL SHARP EDGES

MATERIAL:

IP30
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/3/11		PART NAME SHPBC	
CHECKED BY R.Z.		DATE 11/3/11		DWG NO. SHPBC_IP30_DWG	
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV
				SHEET 1 of 1	

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES

1 PLACE..... $\pm .030$ ANGULAR $\pm 0^{\circ} 30'$

2 PLACE..... $\pm .010$

3 PLACE..... $\pm .005$ FRACTIONS $\pm 1/16$

4 PLACE..... $\pm .0005$

UNLESS OTHERWISE SPECIFIED

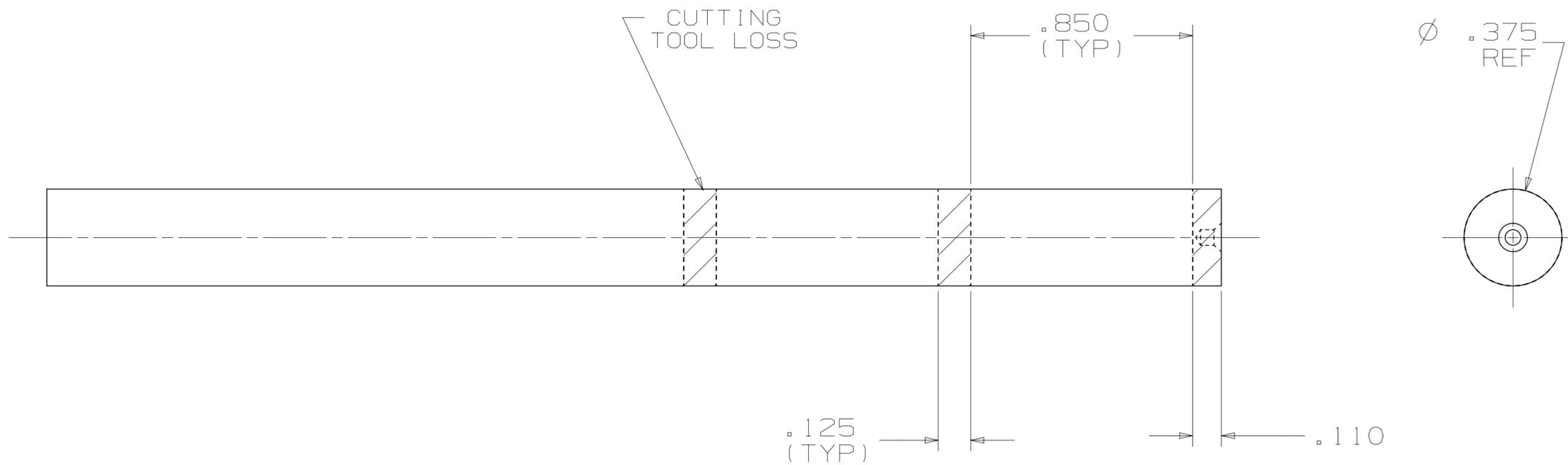
BREAK ALL SHARP EDGES

MATERIAL:

IP40
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME SHPBC					
DRAWN BY B.T.	DATE 11/3/11	DWG NO. SHPBC_IP40_DWG			
CHECKED BY R.Z.	DATE 11/3/11	PART NO.			
RELEASED BY	UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



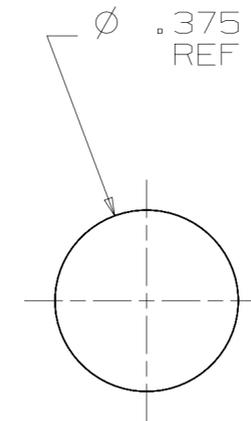
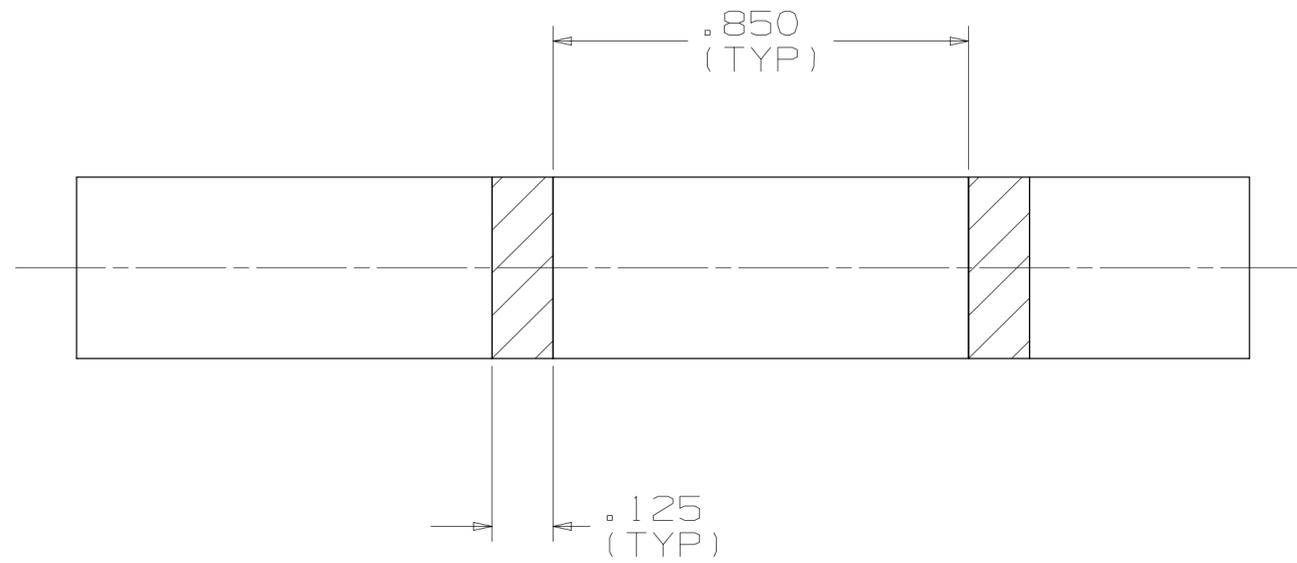
DECIMALS TOLERANCES
 1 PLACE..... ±.030 ANGULAR
 2 PLACE..... ±.010 ±0° 30'
 3 PLACE..... ±.005 FRACTIONS
 4 PLACE..... ±.0005 ±1/16

UNLESS OTHERWISE SPECIFIED
 BREAK ALL SHARP EDGES
 MATERIAL:

IP50
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/3/11		PART NAME SHPBC	
CHECKED BY R.Z.		DATE 11/3/11		DWG NO. SHPBC_IP50_DWG	
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100
		REV	SHEET 1 of 1		

					1			
DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES

1 PLACE..... ±.030 ANGULAR ±0° 30'

2 PLACE..... ±.010 FRACTIONS ±1/16

3 PLACE..... ±.005

4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

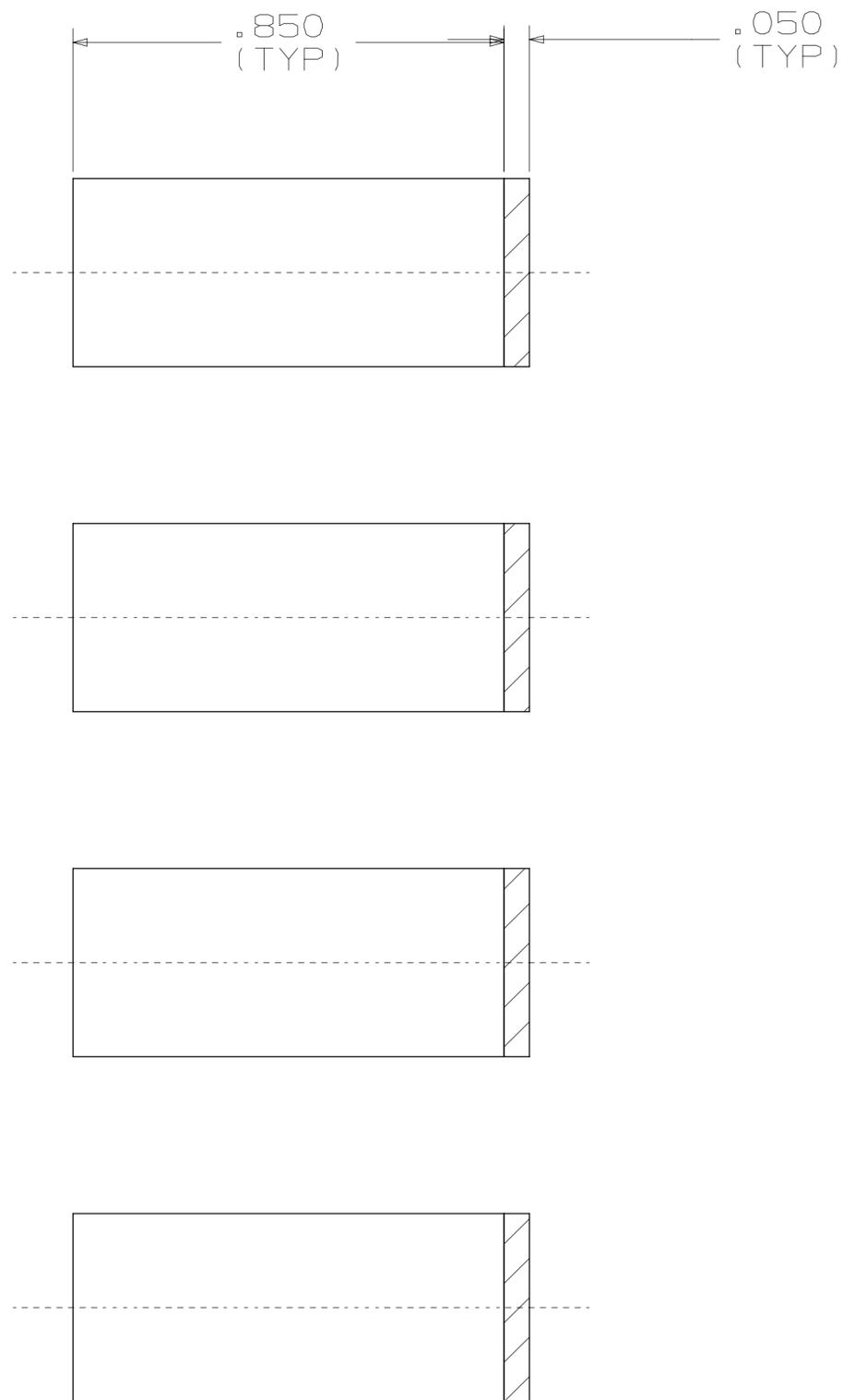
BREAK ALL SHARP EDGES

MATERIAL:

IP60
DWG

UG CHANGE RESTRICTED		DO NOT SCALE					
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING			
DRAWN BY B.T.		DATE 11/3/11		PART NAME SHPBC			
CHECKED BY R.Z.		DATE 11/3/11		DWG NO. SHPBC_IP60_DWG			
RELEASED BY		UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1

					1			
DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS	TOLERANCES	ANGULAR
1 PLACE.....	±.030	±0° 30'
2 PLACE.....	±.010	
3 PLACE.....	±.005	FRACTIONS
4 PLACE.....	±.0005	±1/64

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

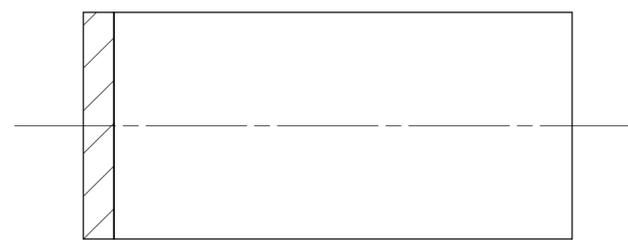
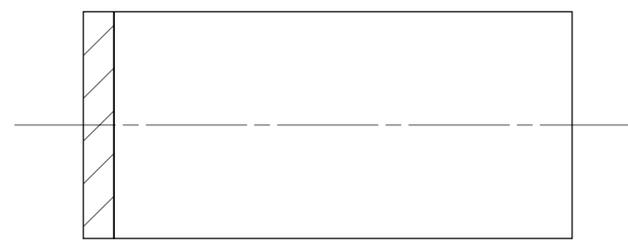
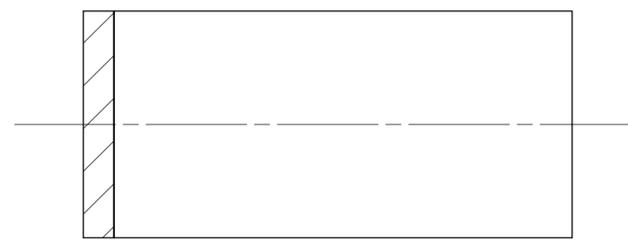
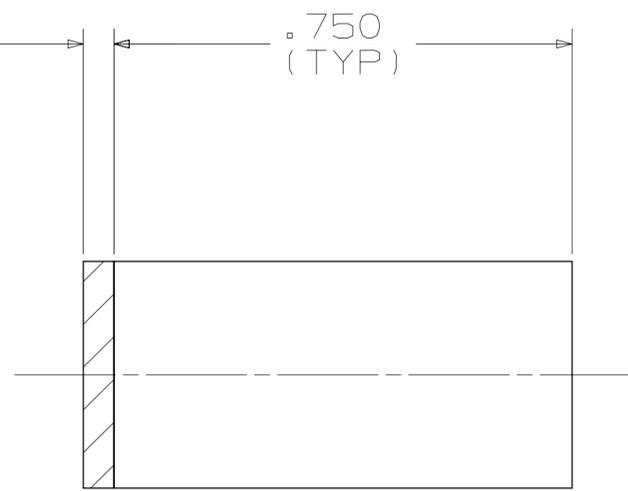
MATERIAL:

IP70
DWG

UG CHANGE RESTRICTED		DO NOT SCALE	
USAGE: ARMY-FSP	THIRD ANGLE PROJECTION	FOCUS CODE MANUFACTURING	
DRAWN BY B.T. DATE 11/3/11		PART NAME SHPBC	
CHECKED BY R.Z. 11/3/11		DWG NO. SHPBC_IP70_DWG	
RELEASED BY		PART NO. X	
UNITS INCHES	SCALE N/A	SIZE C	DWG LEVEL 100
REV	SHEET 1 of 1		

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV

0.050 (TYP) 0.750 (TYP)



TOLERANCES

DECIMALS	ANGULAR
1 PLACE..... ±.030	±0° 30'
2 PLACE..... ±.010	
3 PLACE..... ±.005	FRACTIONS
4 PLACE..... ±.0005	±1/64

UNLESS OTHERWISE SPECIFIED

BREAK ALL SHARP EDGES

MATERIAL:

IP80
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY-FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 11/3/11		PART NAME SHPBC	
CHECKED BY R.Z.		DATE 11/3/11		DWG NO. SHPBC_IP80_DWG	
RELEASED BY		UNITS INCHES		PART NO. X	
SCALE N/A	SIZE C	DWG LEVEL 100	REV	SHEET 1 of 1	

Focus: HOPE Process routing/Shop traveler

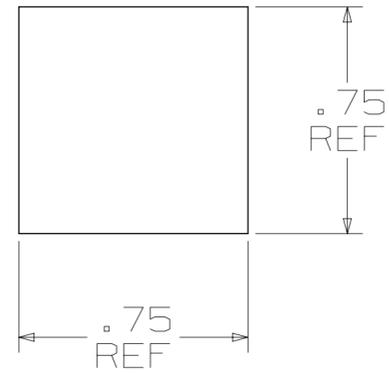
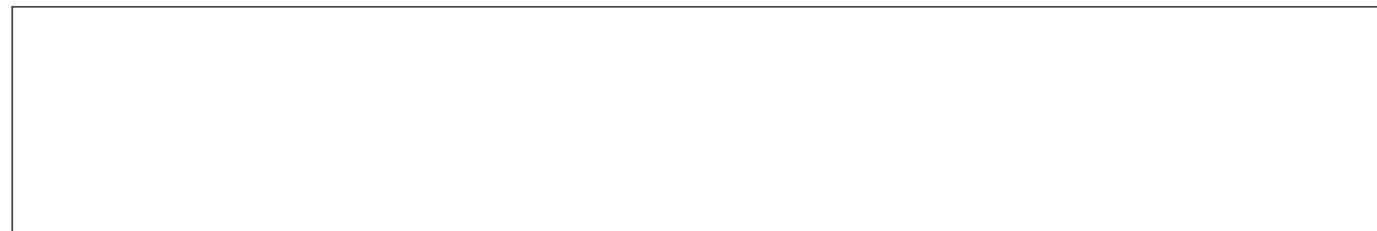
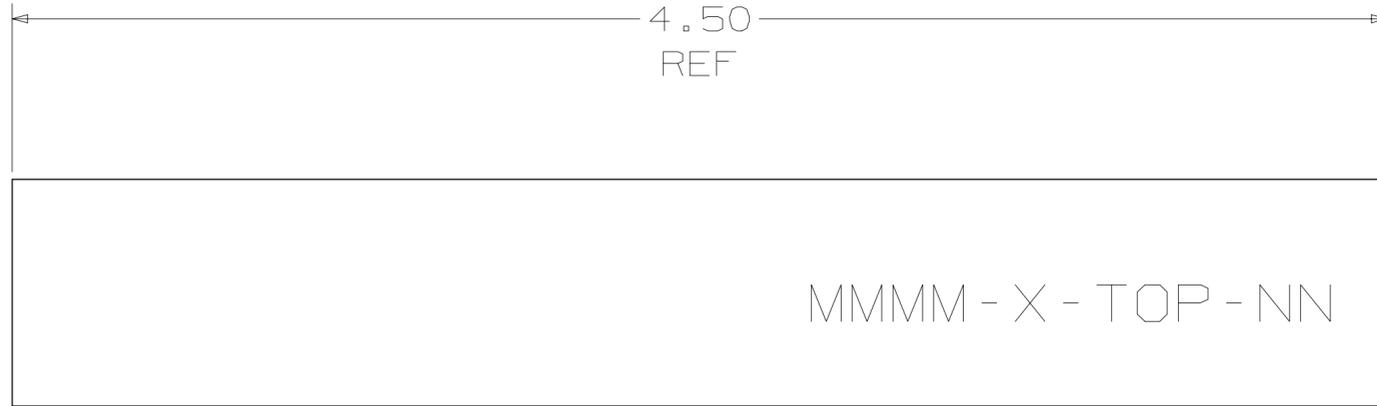
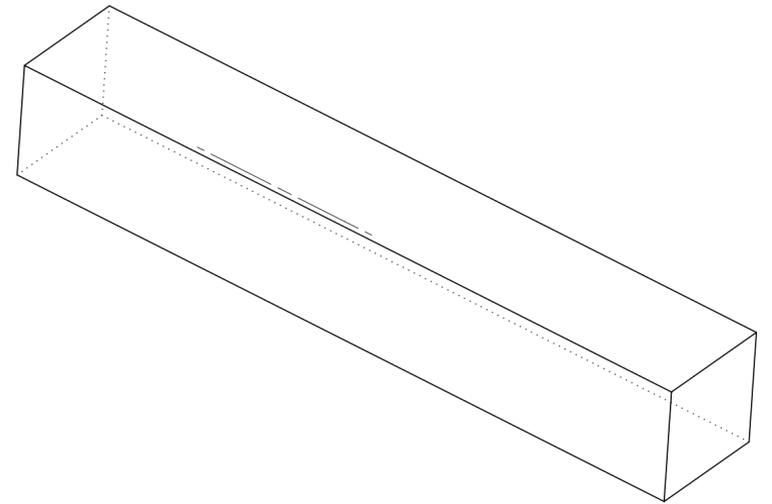
Customer: **Southwest Research Institute**
 Street Address:
 City State Zip:

Stock: **3/4 x 3/4 x 4 1/2 coupon (8)**

Part Number: **SHPB Tensile (5083/6061)**
 Description: **Johnson-Cook test specimen**
 Revision:

Op No	Labor Code	Operation Description
		See 'Strips' Process Sheet for initial specimen extraction operations.
		Extreme care must be taken to keep Specimen Types R, W, and A, and Materials 6061 and 5083 properly segregated. THIS IS EXTREMELY IMPORTANT,
10		Confirm that all material blocks are marked "6061-W"
20	Mill	Square mill end, round (circular interpolate) end to 0.70 dia x 0.88 and center drill
30	Laser	Mark end "61W-#" (where # = 1 thru 8)
40	Mill	Mill end square, center drill, rough contour turn, final contour turn, single point thread, and finally turn thread OD to .490 dia
50	laser marker	Mark 2 Places (ends) "61W-#" (where # = 1 thru 8)
60		Individually bag each part
70		Label Bags
80		Polish Longitudinally
90		Cut-off to final length 2.235

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



IP10
DWG

DECIMALS TOLERANCES ANGULAR

1 PLACE..... ±.030 ±0° 30'

2 PLACE..... ±.010 FRACTIONS ±1/64

3 PLACE..... ±.003

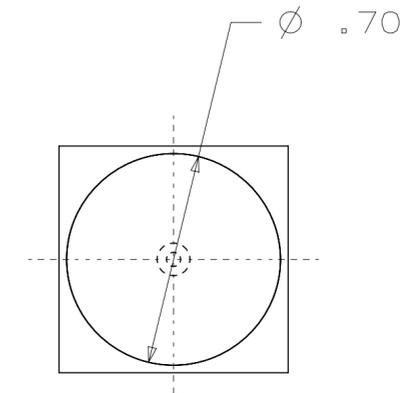
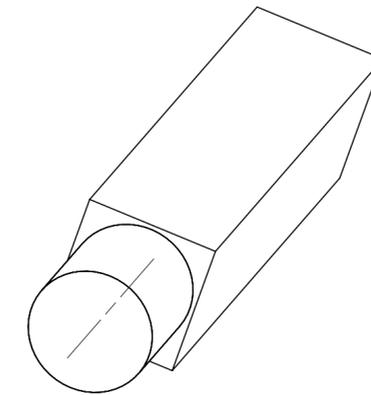
4 PLACE..... ±.0005

UNLESS OTHERWISE SPECIFIED

MATERIAL :

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY - FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME SHPB TENSILE					
DRAWN BY B.T.	DATE 10/6/11	DWG NO. SHPB_TENSILE_IP10_DWG			
CHECKED BY R.Z.		PART NO.			
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES ANGULAR

1 PLACE..... $\pm .030$ $\pm 0^\circ 30'$

2 PLACE..... $\pm .010$

3 PLACE..... $\pm .003$

4 PLACE..... $\pm .0005$

FRACTIONS $\pm 1/64$

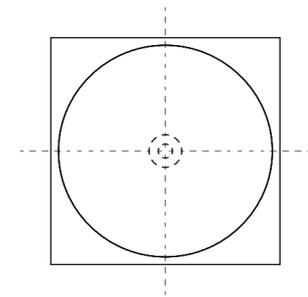
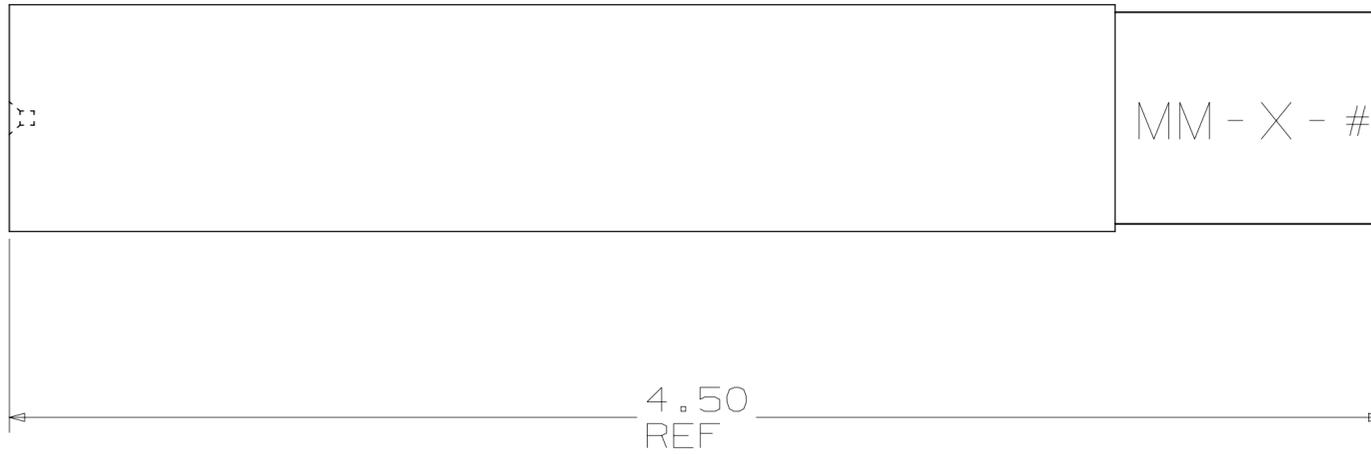
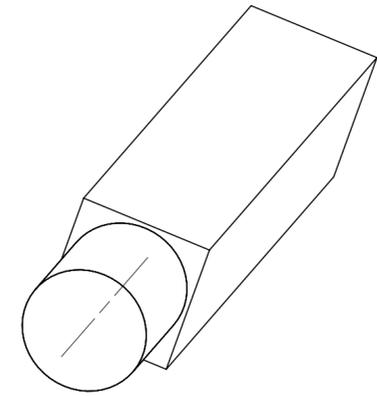
UNLESS OTHERWISE SPECIFIED

MATERIAL :

IP20
 DWG

CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY FSP				FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 10/6/11		DWG NO. SHPB_TENSILE_IP20_DWG	
CHECKED BY R.Z.		DATE 10/6/11		PART NO.	
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

DATE	ZONE	STG	DWG LEV	REV	DESCRIPTION	CN#	CHG	APV



DECIMALS TOLERANCES ANGULAR

1 PLACE..... ±.030 ±0° 30'

2 PLACE..... ±.010

3 PLACE..... ±.003 FRACTIONS

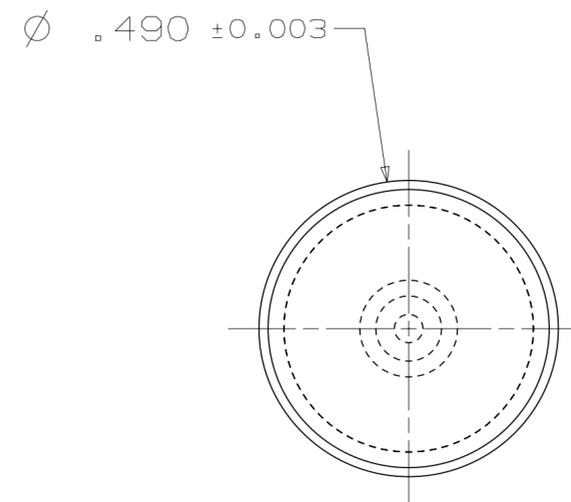
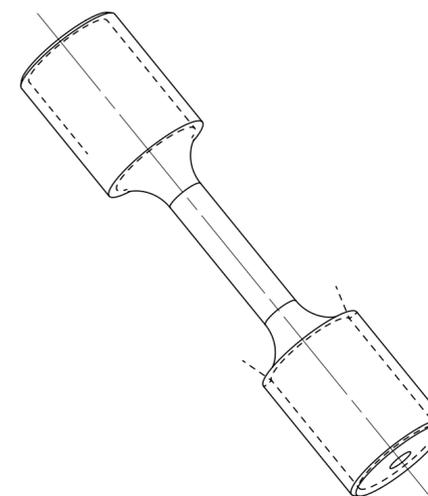
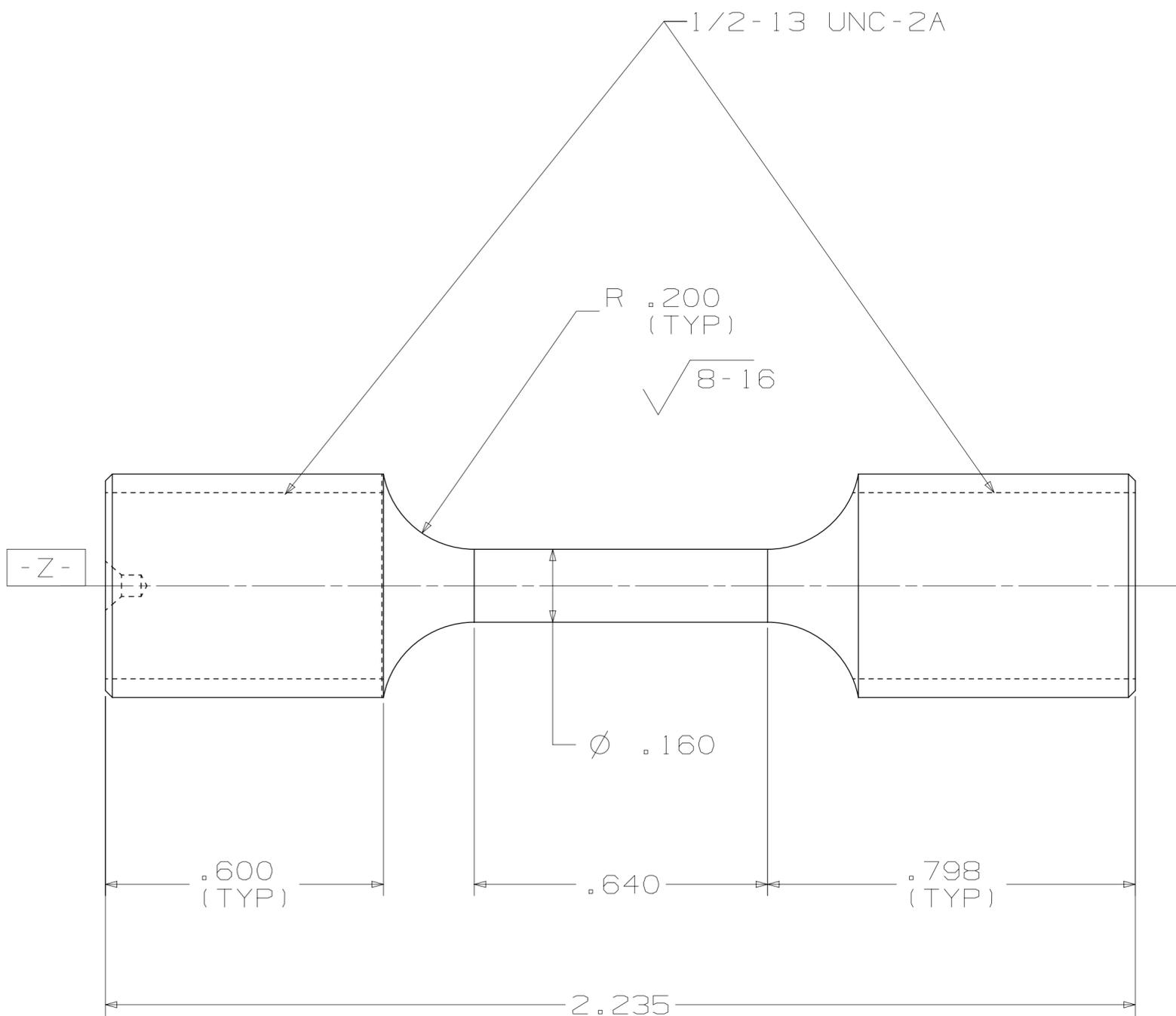
4 PLACE..... ±.0005 ±1/64

UNLESS OTHERWISE SPECIFIED

MATERIAL :

IP30
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME SHPB TENSILE					
DRAWN BY B.T.	DATE 10/6/11	DWG NO. SHPB_TENSILE_IP30_DWG			
CHECKED BY R.Z.		PART NO.			
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1



TOLERANCES (INCH)
DECIMALS

- 1 PLACE ±.030
- 2 PLACE ±.010
- 3 PLACE ±.005
- 4 PLACE ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/64

UNLESS OTHERWISE SPECIFIED

MATERIAL :

IP40
DWG

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
PART NAME SHPB TENSILE					
DRAWN BY B.T.	DATE 10/7/11	DWG NO. SHPB_TENSILE_IP40_DWG			
CHECKED BY R.Z.		PART NO.			
RELEASED BY		SCALE N/A	SIZE C	DWG LEVEL 100	REV SHEET 1 of 1

4

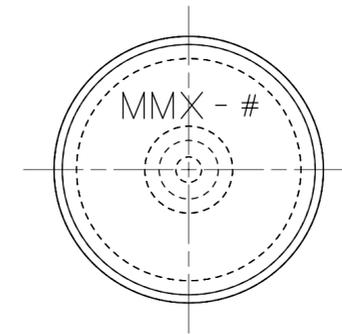
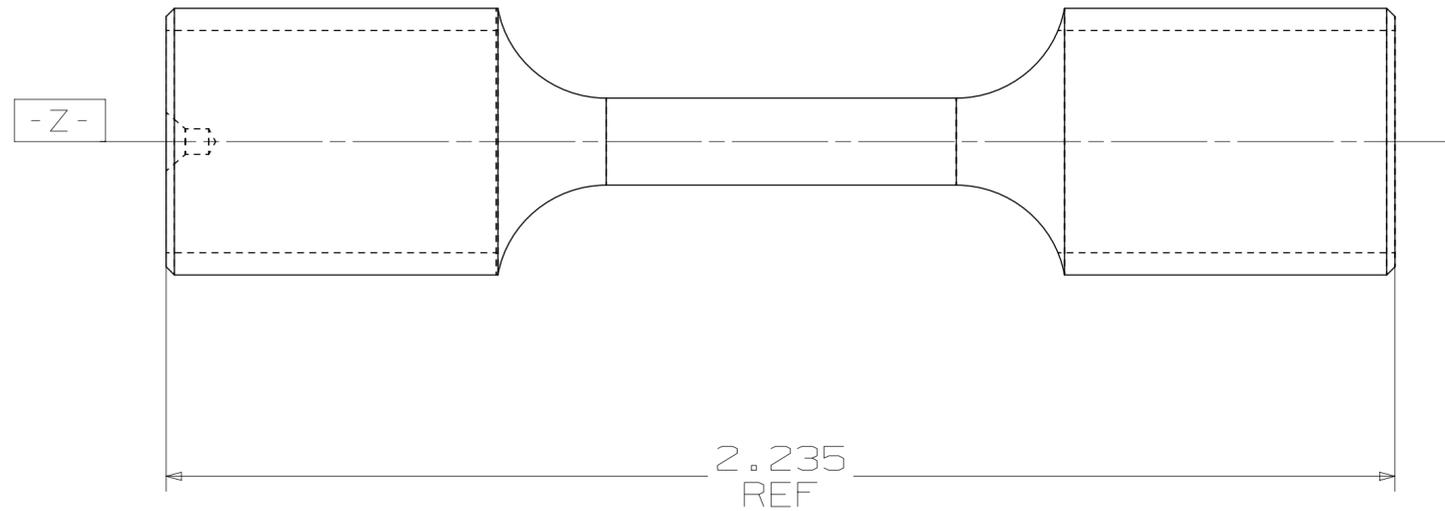
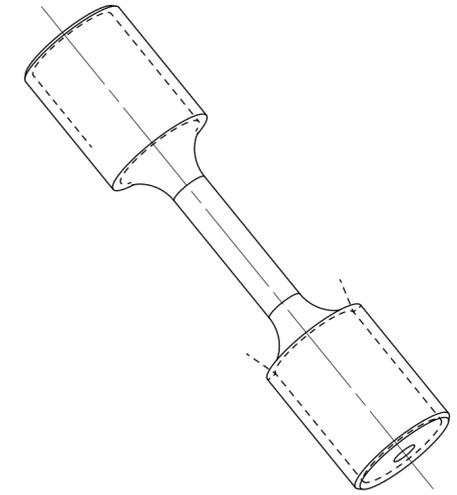
3

2

1

C

C



B

B

-Z-

2.235
REF

A

A

IP50
DWG

TOLERANCES (INCH)
DECIMALS

- 1 PLACE ±.030
- 2 PLACE ±.010
- 3 PLACE ±.005
- 4 PLACE ±.0005

ANGULAR
±0° 30'

FRACTIONS
±1/64

UNLESS OTHERWISE SPECIFIED

MATERIAL :

UG CHANGE RESTRICTED		DO NOT SCALE			
USAGE: ARMY FSP		THIRD ANGLE PROJECTION		FOCUS CODE MANUFACTURING	
DRAWN BY B.T.		DATE 10/7/11		PART NAME SHPB TENSILE	
CHECKED BY R.Z.		DATE 10/7/11		DWG NO. SHPB_TENSILE_IP50_DWG	
RELEASED BY		SCALE N/A		SIZE C	DWG LEVEL 100
				REV	SHEET 1 of 1

4

3

2

1