ATLAS DISK SECTOR FABRICATION AND SPECIFICATIONS

The fabrication procedures for Pixel Disk Sectors are presented. Procedures for fabricaiton of aluminum-tube sectors and for fabricaiton of sealed-tube sectors are included here. These procedures are preliminary.

Prepared by:	*Checked by:*	*Approved by:*
E. Anderssen, M. Gilchriese, F. Goozen, T. Miller, W.K. Miller, W. O. Miller, D. Uken, J. Wirth		

Distribution List

History of Changes			
Rev. No.	*Date*	*Pages*	*Description of changes*

Table of Contents

1 Introduction

This note describes the fabrication sequence of the ATLAS Pixel Disk Sector. This sequence is still under development and not all steps are specified here. The fabrication of both aluminum-tube and sealed-carbon-carbon-tube sectors are described. Key materials specifications are provided in Appendices as are drawings.

2 Aluminum-tube Sector

2.1 Aluminum Tube, Strain Relief and Tube Connections

3003 aluminum tubes to be supplied in "O" condition.

Measure tube length(record)

Weigh tube(record)

Store in freezer @ -40ºC until preparing for bending.

Fill with wax by gravity in 65ºC oven. Oven cool.

Bend-flatten-rebend as required (bending fixture) (flattening fixture)

Inspect_ go no-go gage & visual

Remove most filler wax by submerging in 70ºC water

Remove remaining wax by submerging in lamp oil at 50ºC (4hrs minimum)

Ultrasonic clean tubes in 'Blue Gold'. Rinse with D.I. water

Weigh tube again (should be same as first) (record)

Cut the tube to length (fixture)

Weigh cut tube (record)

UHV clean square to round tube end transition pieces

Weigh, (record)

UHV clean PEEK tube strain relief pieces

Weigh, (record)

Use Hysol EA9396 to bond tube end transition and strain relief pieces to cut tube (fixture)

Inspect_ go no-go gage & visual (record)

Weigh assembly (record)

Pressurize to 10 bar (in fixture) (record)

Cap and mask both tube ends

Mount in anodize fixture

UHV clean followed by phosphoric acid. anodize (still need to spec. procedure)

Remove plugs and any remaining masking from both tube ends

Weigh tube (record)

Leak test (record)

Store in individual boxes with documentation (flat file)

2.2 Carbon-carbon Facesheets

Inspect raw materials flatness thickness weight @ ºC and %RH (record)

Cut profile and alignment holes on mill (vacuum fixture)

Inspect (Go, No-Go gage) (record)

Ultrasonic clean then bake dry (121ºC 1hr)

Store in individual boxes with documentation (flat file)

2.3 RVC Foam

Inspect raw materials flatness thickness weight @ ºC and %RH (record)

Rough-cut the outer perimeter of foam

Face both sides holding the foam with two sided tape on mylar sheet, which i,s in turn, held by a vacuum chuck on a vertical mill

Ultrasonic clean then bake dry (121ºC 1hr)

Store in individual boxes with documentation (flat file)

2.4 Bond 1st Facesheet to Foam

The outer release sheet of the cyanate ester film will be cut to shape with a film cutter

The release sheet/ester sections representing the tube profile and mounting spacers will be removed prior to application to the facesheet

Weigh the Facesheet @ ºC and %RH (record)

Apply cyanate ester to the inside surface of the facesheet just prior to bonding with reticulated vitreous carbon foam. (position with alignment fixture) chill, remove paper backing, set aside in a protected location to allow condensed moisture to evaporate from facesheet/cyanate ester

Weigh @ ºC and %RH with cyanate ester (record)

Rough position foam on facesheet w/cyanate ester

Place assembly between flat plates w/spacers

Bake @ 250ºC for 3 hrs

Mount assembly onto vacuum fixture in NC mill face to thickness, cut tube slot and clear foam from mounting holes.

Inspect_ go no-go gage & visual (record)

Ultrasonic clean then bake dry (121ºC 1hr)

Weigh @ ºC and %RH (record)

2.5 Bonding of Hard Points

Carbon-carbon hard points to be inspected, UHV cleaned and baked dry

Select a set for one sector

Weigh @ ºC and %RH (record)

Position mold released hard point bonding jig on the above facesheet.

(essentially a mockup of the tube with hard point alignment marks that fits into the foam.

Apply Hysol EA9396 to one surface of each hard point and the corresponding surface on the facesheet

Position each hard point on facesheet next to the appropriate alignment marks on the bonding jig

Cure overnight

Remove bonding jig

Weigh assembly @ ºC and %RH (record)

Inspect hard point height with a captive micrometer (record)

Store in individual boxes with documentation (flat file)

2.6 Prepare 2nd Facesheet for Bonding

Weigh the Facesheet @ ºC and %RH (record)

Apply cyanate ester just prior to bonding with reticulated vitreous carbon foam. (position cyanate ester with alignment fixture) chill, remove paper backing, protect and set aside to allow condensed moisture to evaporate from facesheet/cyanate ester

Record weight @ ºC and %RH with cyanate ester

2.7 Apply CGL with 75µ Glass Beads to Tube

CGL 7018 to be supplied premixed with 3% 75µ glass beads
Fixture tube assembly for CGL application
Tare tube and fixture (record)
Apply CGL to 1st side of tube (CNC stage)
Weigh tube and fixture (record)
Apply CGL to 2nd side of tube (CNC stage)
Weigh tube and fixture (record)
Position 1st facesheet against stops on base of mold released bonding fixture.
Use pins through strain relief tabs to align the cooling tube with CGL onto the facesheet
Position 2nd facesheet against stops on top of the 1st.
position clamping plate on top of the assembly
Fasten both sides of bonding fixture together
Inspect for proper fit
Bake @ 80 ºC for 16 hrs then 250 ºC for 3 hrs
Remove the assembly from the bonding fixture
Record weight @ ºC and %RH
Inspect for flatness thickness and parallel sides
Place sector on milling fixture to take skim cut on spacer washers
Final inspection

2.8 Final Assembly

Mount targets for survey
Seal foam(method is TBD)
Clean(method is TBD)
Attach label - barcode(method is TBD)
Inspect, weigh and record
Survey via optical CMM and record locations of targets relative to mounting buttons
Store in labeled boxes @^{o}C and %RH

2.9 Quality Control

A preliminary summary of quality control items is given in the table below. All length units are mm. All weights are in grams.

Item	***Measurement/Inspection***
Aluminum Tubes and Connections	
Length after initial cutting	
Weight after initial cutting	
Inspect after annealing	
Go/no-go and inspect after bend/flatten	
Weight after bending	
Weight with plugged ends for anodizing	
Weigh after anodizing	
Weight after cutting to length	
Weigh square-to-round pieces	
Weigh PEEK strain relief pieces	
Weigh tube/connection assembly	
Leak/pressure test	
Visual inspection/label	
Carbon-carbon Faceplates	
Inspect raw plates	
Go/no go after cutting faceplates	
Weigh faceplates	
RVC Foam	
Inspect raw materials	
Determine density	
Bond 1st Faceplates to Foam	
Weigh faceplate with cyanate ester	
Inspect after cutting foam	
Weigh after cutting foam	
CGL+Glass Beads	
Weigh tube in fixture	
Weigh tube and fixture after CGL applied side 1	
Weigh tube and fixture after CGL applied side 2	
Bond 2nd Faceplates and Hard Points	
Weigh 2nd faceplate with cyanate ester	
Weigh hard points, spacers and washers	
Weigh after heat cure	
Inspect for thickness	
Inspect for planarity	
Visual inspection after face cut mounting buttons	
Final Assembly	
Inspect after mounting targets and sealing foam	
Weigh after final cleaning	
Survey targets/reference mounting buttons	

3 Appendix A: Carbon-Carbon Sheet Specification

Carbon-carbon panels carbonized and heat-treated to achieved performance parameters listed in Table 1. Panels are to be densified by a CVD carbon process and resin impregnated with RS3 cyanate ester. Scrub plates to remove excess resin.

Panel size: 48.26 cm (19 in.) square or larger.

Number of panels: Preproduction lot a minimum of 2 panels. Production lot of minimum of 24 panels.

Layup: Quasi-isotropic 8 layers: 0/45/-45/90/s

Item	***Specification***	***Range or Comment***
Tensile modulus-0° dir.	*158.6 GPa (23 Msi)*	*Range +/-5%*
Tensile modulus-90° dir.	*151.7 GPa (22 Msi)*	*Range +/-5%*
Tensile strength-0° dir.	*296.4 MPa (43 ksi)*	*Range +/-5%*
Tensile strength-90° dir.	*296.4 MPa (43 Msi)*	*Range +/-5%*
CTE-0° dir.	*-1.2 ppm/K*	*Range +/-10%*
CTE-90° dir.	*-1.2 ppm/K*	*Range +/-10%*
Conductivity K_{ab}-0° dir.	*>170 W/mK*	*Target value: >190 W/mK*
Conductivity K_c-90° dir.	*>170 W/mK*	*Target value: >190 W/mK*
Conductivity K transverse	*>20 W/mK*	*Target value: > 25 W/mK*
Density	*1.75 g/cc*	*Range +5/-2%*
Thickness	*0.406 - 0.457 mm*	

4 Appendix B - Reticulated Vitreous Carbon Foam Specification

Reticulated vitreous carbon foam to be supplied in sheets (size to be specified but typical is 25x25x1 cm). Foam to be densified by chemical vapor deposition to density of 0.1 +/- 0.01 gm/cm^3.

5 Appendix C - Aluminum Tube Specification

Extruded aluminum-tube (3003 alloy). Exact dimensions are to be determined. Tolerance on exterior dimensions is +/- 0.020 microns.

6 Appendix D - Drawings of Aluminum-Tube Sector

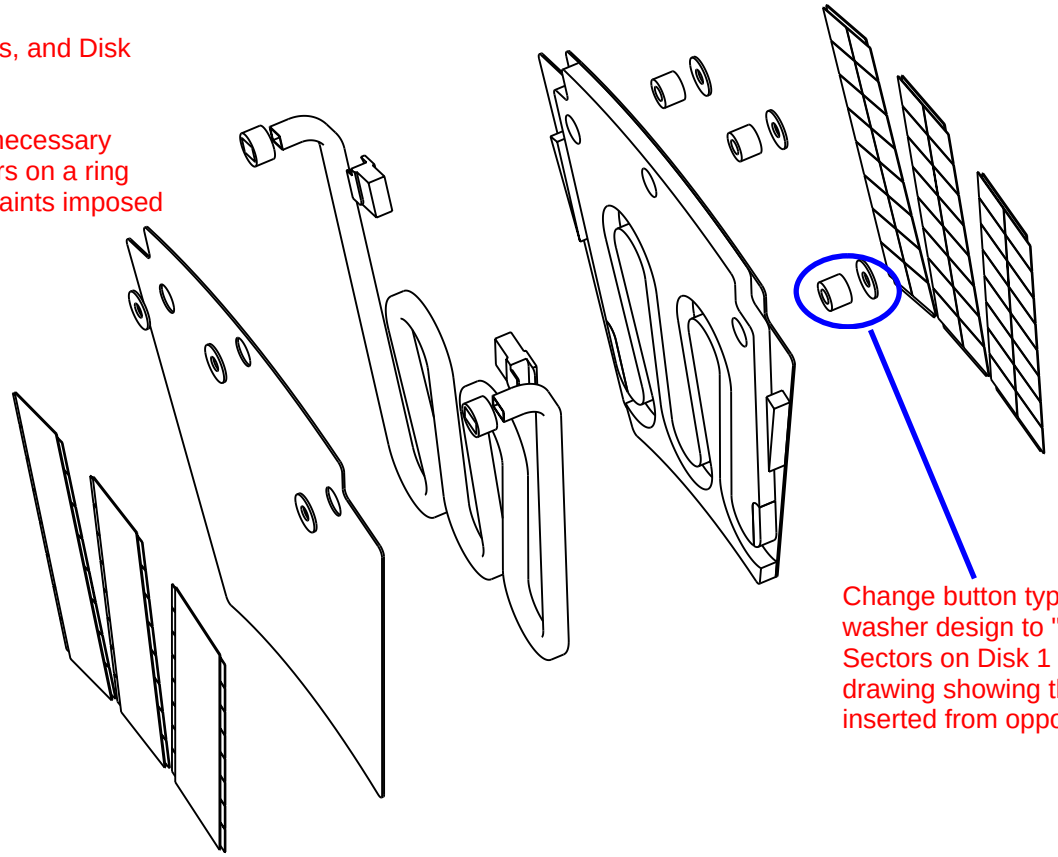
Drawings of the aluminum-tube sector follow.

Want an unexploded assembly with layout dimensions capturing sector dimensions relative to Module placement, and contianing assembled dimensions/tolerances/GD&T

Table with different Thicknesses, and Disk one option to be included

Layout assembly may also be necessary showing two neighboring sectors on a ring segment which captures constraints imposed by assembly

ITEM	PART NO	REQD	DESCRIPTION	MATERIAL



Change button type from dual washer design to "T" washer type. Sectors on Disk 1 need an option drawing showing the washer face inserted from opposite side.

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ± 0.1 | FRAC. ± 1/64 | X.XX ± 0.03 | Angles ± 1.00° | X.XXX ± 0.010 | FINISH 125 √(μin)

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO.	-		
ACCT NO.		NO. REQD	
DATE ISSD	-		
DEL TO		DATE REQD	-
SURFACE TREATMT			
IDENT METHOD	TAG		
PROJECT NUMBER	N/A		
PROJECT NAME	N/A		
DWG BY	David Uken	DATE	05-Apr-00
CHK BY		DATE	
APR BY		DATE	

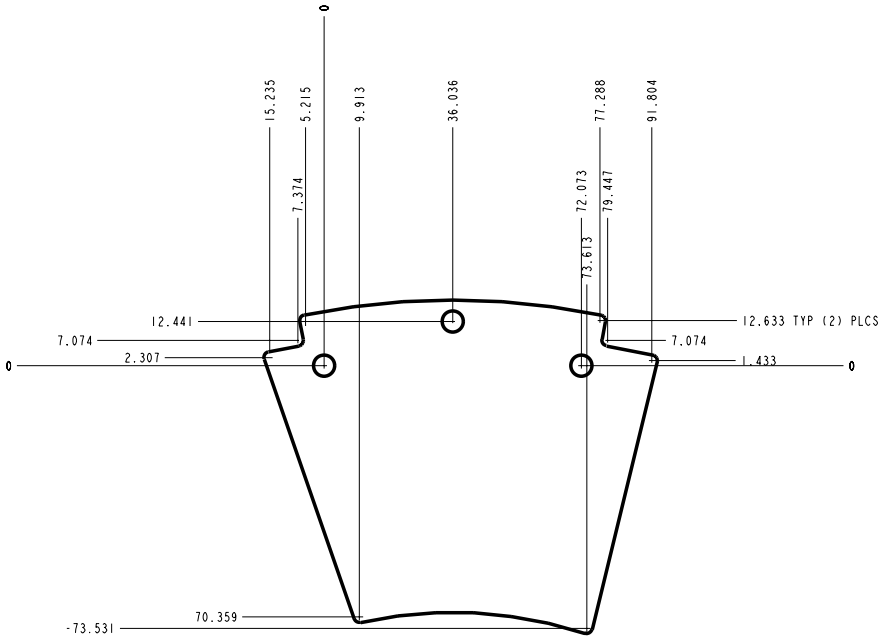
ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

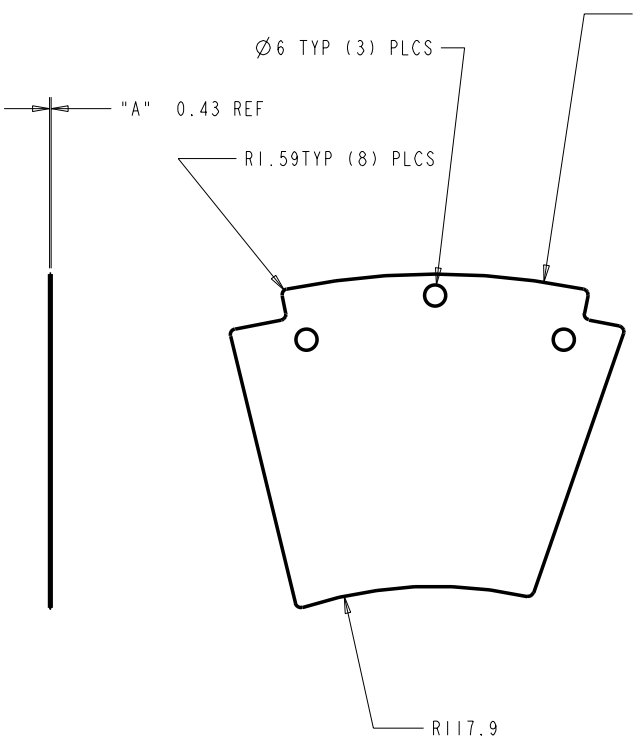
Atlas Pixel Detector
II-Sector Version
Sector II, Exploded View

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1.500	DO NOT SCALE PRINTS
	ASSEM		SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. 3	SIZE / REV.

DWG. NO. 3 SIZE/REV. SH. 2000111

DESCRIPTION	MATERIAL	MAT. LOCATION
		-





Part Number	Description	"A" Thickness
	Original Design	.432
	Proposed Thinner Facing	.300

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ± 0.1 | FRAC. ± 1/64 | X.XX ± 0.03 | Angles ± 1.00° | X.XXX ± 0.010 | FINISH 125 (µin)

DO NOT SCALE PRINT

THREADS ARE CLASS 2

CHAMFER ENDS OF ALL SCREW TREADS 30°

CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS

BREAK EDGES .016 MAX. ON MACHINED WORK

REMOVE BURRS, WELD SPLATTER & LOOSE SCALE

IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO.	-		
ACCT NO.	7916-27	NO. REQD 66	DATE ISSD -
DEL TO	ERIC ANDERSSEN		DATE REQD -
SURFACE TREATMT			
IDENT METHOD	TAG		
PROJECT NUMBER	N/A		
PROJECT NAME	N/A		
DWG BY		DATE	03-Apr-00
CHK BY		DATE	
APR BY		DATE	

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

Sector Facing
11-Sector Version
Atlas Detector

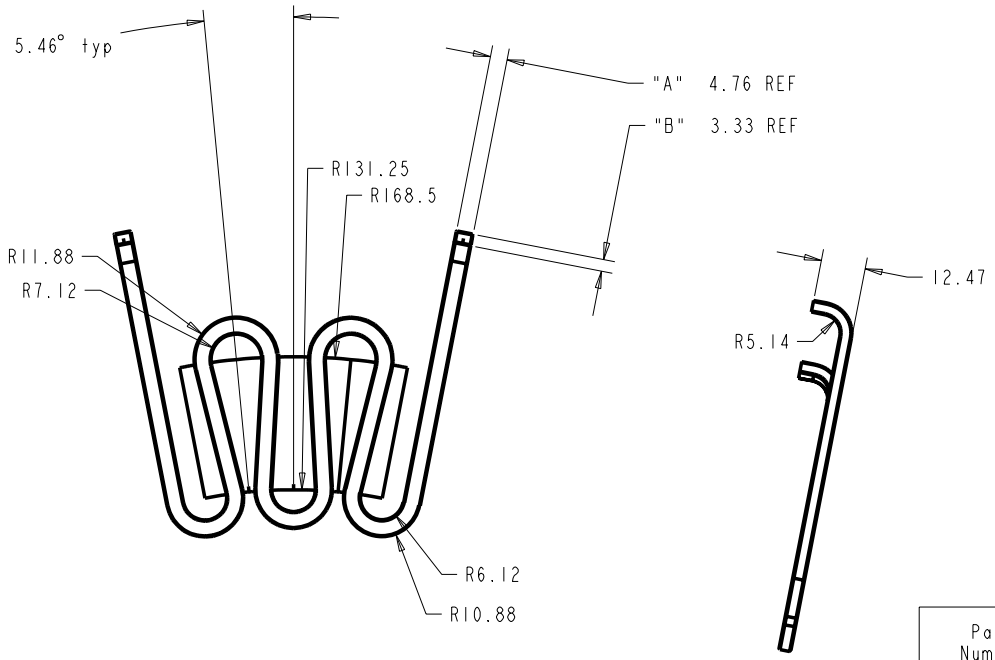
MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1.000 DO NOT SCALE PRINTS
	PART		SHEET 1 OF 1

PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. 3	SIZE	REV. A

DWG. NO. 33 200011 SIZE REV. SH.

Eng. File: Section 11 Facing Model File: Section 11 Facing

DESCRIPTION	MATERIAL	MAT. LOCATION
		-



OVERALL LENGTH = 444.5 MM

Part Number	Description	"A" Width	"B" Height
	Original Cross-Section	4.76	3.33
	Reduced Hydraulic Diameter	4.76	2.28
	Etched Outer Surface	4.55	2.03

DWG. NO. 13 200011 SIZE REV. SH.

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ± 0.1 | FRAC. ± 1/64 | X.XX ± 0.03 | Angles ± 1.00° | X.XXX ± 0.010 | FINISH 125 (µin)

DO NOT SCALE PRINT

THREADS ARE CLASS 2

CHAMFER ENDS OF ALL SCREW TREADS 30°

CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS

BREAK EDGES .016 MAX. ON MACHINED WORK

REMOVE BURRS, WELD SPLATTER & LOOSE SCALE

IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO.	-		
ACCT NO.	7916-27	NO. REQD	33
DEL TO	Eric Anderssen	DATE ISSD	-
		DATE REQD	-
SURFACE TREATMT			
IDENT METHOD	TAG		
PROJECT NUMBER	N/A		
PROJECT NAME	N/A		
DWG BY	David Uken	DATE	03-Apr-00
CHK BY		DATE	
APR BY	Eric Anderssen	DATE	

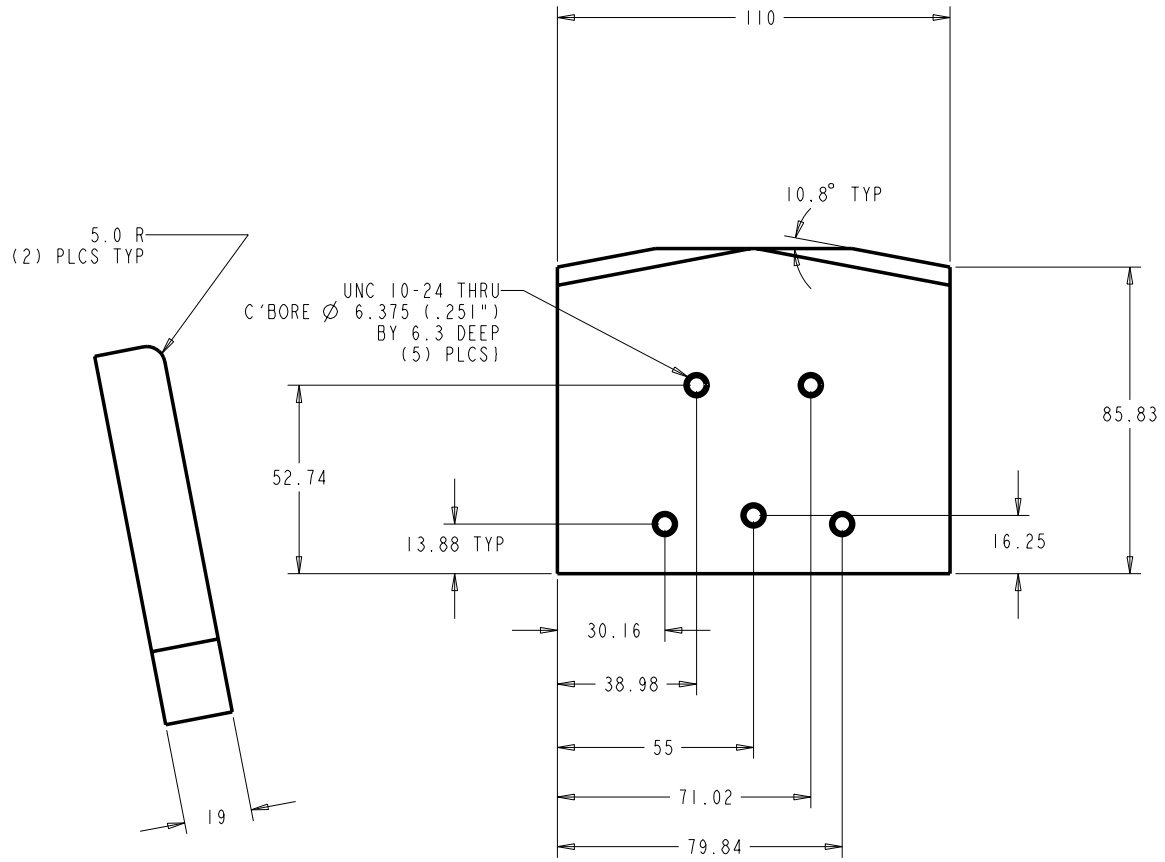
ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

Cooling Tube
11-Sector Version
ATLAS DETECTOR

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1.000 DO NOT SCALE PRINTS
	PART		SHEET 1 OF 1
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. 3 SIZE A REV.

Dwg. File: SECTOR_11_COOLING_TUBE Model File: SECTOR_11_COOLING_TUBE

DESCRIPTION	MATERIAL	MAT. LOCATION
		-



DWG. NO. 23 200011 SIZE REV. SH.

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ± 0.1 | FRAC. ± 1/64 | X.XX ± 0.01 | Angles ± 0.50° | X.XXX ± 0.001 | FINISH 125 (µin)

DO NOT SCALE PRINT

THREADS ARE CLASS 2

CHAMFER ENDS OF ALL SCREW TREADS 30°

CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS

BREAK EDGES .016 MAX. ON MACHINED WORK

REMOVE BURRS, WELD SPLATTER & LOOSE SCALE

IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO. -

ACCT NO. 7916-27 | NO. REQD 1 | DATE ISSD -

DEL TO ERIC ANDERSSEN | DATE REQD -

SURFACE TREATMT

IDENT METHOD TAG

PROJECT NUMBER N/A

PROJECT NAME N/A

DWG BY David Uken | DATE 03-Apr-00

CHK BY | DATE

APR BY Eric Anderssen | DATE

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

Cooling Tube Bending Jig
11-Sector Version
Atlas Detector

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1.000	DO NOT SCALE PRINTS
	PART		SHEET 1 OF 1	

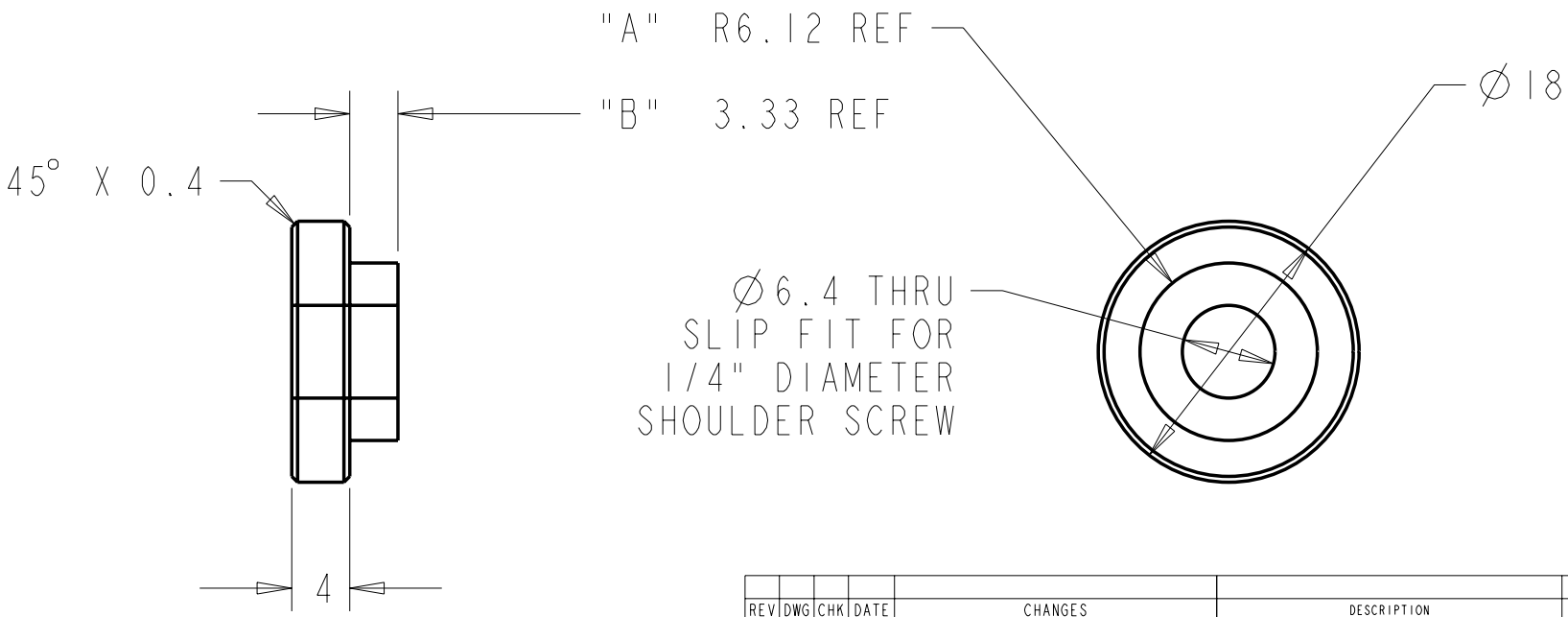
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO.	SIZE	REV.
			3		A

Dwg. File: SECTOR_11_BENDING_JIG Model File: SECTOR_11_BENDING_JIG

DWG. NO.	SIZE	REV.	SH.
1	2000i1		

Part Number	Description	"A" Radius
	Upper Bend	7.12
	Lower Bend	6.12

Part Number	Description	"B" Height
	Original	3.33
	Reduced Dia	2.28
	Etched Surf	2.03



REV	DWG	CHK	DATE	CHANGES	DESCRIPTION	MATERIAL

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ±0.1 | FRAC. ±1/64 | X.XX ±0.01 | Angles ±0.50° | X.XXX ±0.001 | FINISH 125 (µin)

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO.	-		
ACCT NO.	7916-27	NO. REQD	3
DATE ISSD	-		
DEL TO	Eric Anderssen	DATE REQD	-
SURFACE TREATMT			
IDENT METHOD	TAG		
PROJECT NUMBER	N/A		
PROJECT NAME	N/A		
DWG BY	David Uken	DATE	05-Apr-00
CHK BY		DATE	
APR BY	Eric Anderssen	DATE	

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

Atlas Pixel Detector
9 and 11-Sector Versions
5.2 Radius Mandrel, Bending Jig

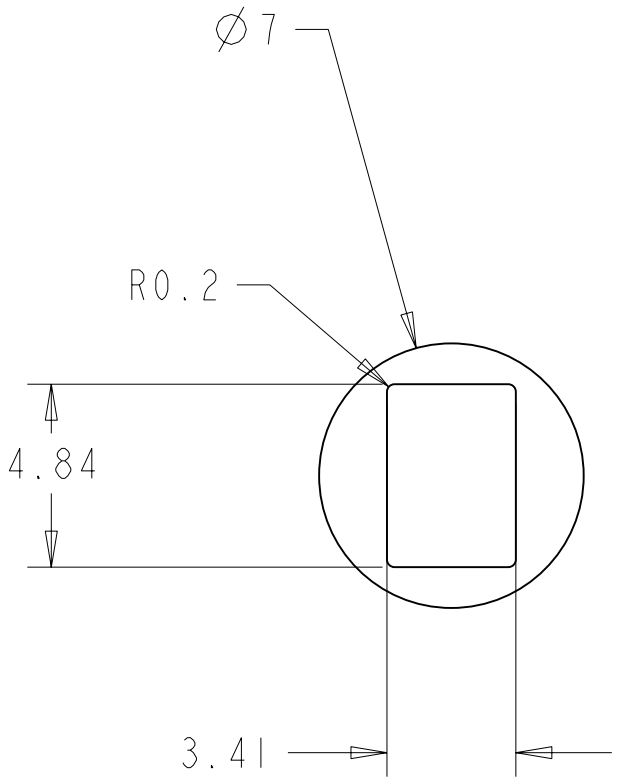
MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 2.000	DO NOT SCALE PRINTS
	PART		SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. 1	SIZE / REV.

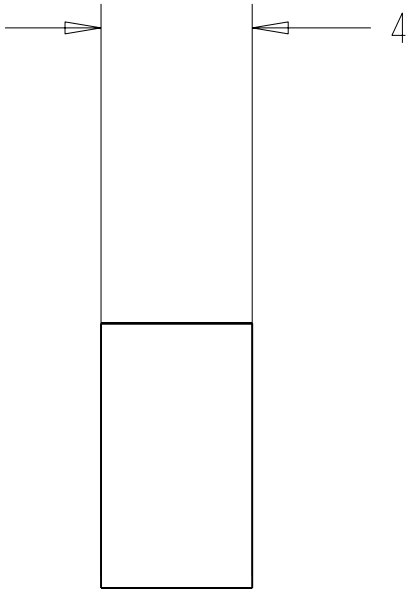
Rev. 1/29/2000 J. R. Osborn

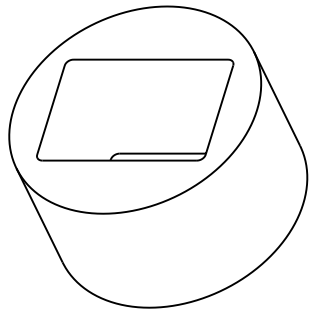
Dwg. File: BENDING_JIG_612R_MANDREL Model File: BENDING_JIG_612R_MANDREL

DWG. NO.	SIZE	REV.	SH.
1	2000i	1	

Part is obsolete







REV	DWG	CHK	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES			
	X.X ±0.1	FRAC. ±1/64	
	X.XX ±0.01	Angles ±0.50°	
	X.XXX ±0.001	FINISH 125 (µin)	

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO.	-		
ACCT NO.	91--	NO. REQD	
DATE ISSD	-		
DEL TO		DATE REQD	-
SURFACE TREATMT			
IDENT METHOD	TAG		
PROJECT NUMBER	N/A		
PROJECT NAME	N/A		
DWG BY	David Uken	DATE	07-Apr-00
CHK BY		DATE	
APR BY	Eric Anderssen	DATE	

DESCRIPTION | MATERIAL

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

Atlas Pixel Detector
9 and 11-Sector Versions
Bushing Adapter, Cooling Tube to Round

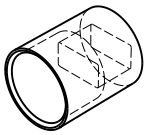
MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 5.000	DO NOT SCALE PRINTS
	PART		SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. 1	SIZE / REV.

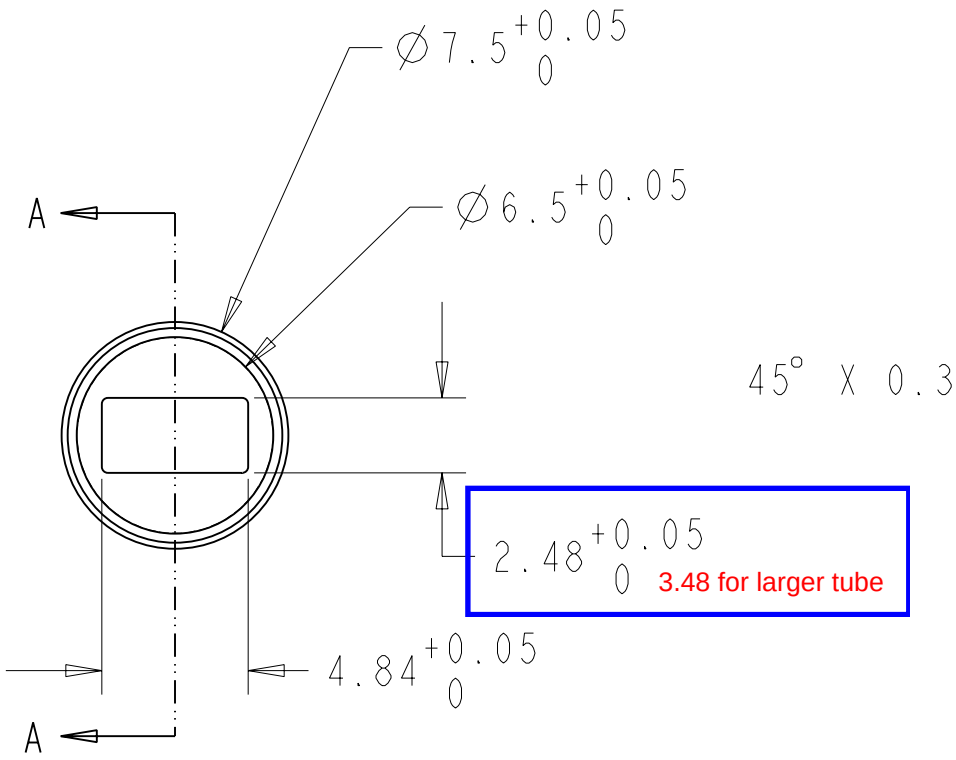
Dwg. File: BUSHING_3B4_4_TUBING Model File: BUSHING_3B4__4TUBING

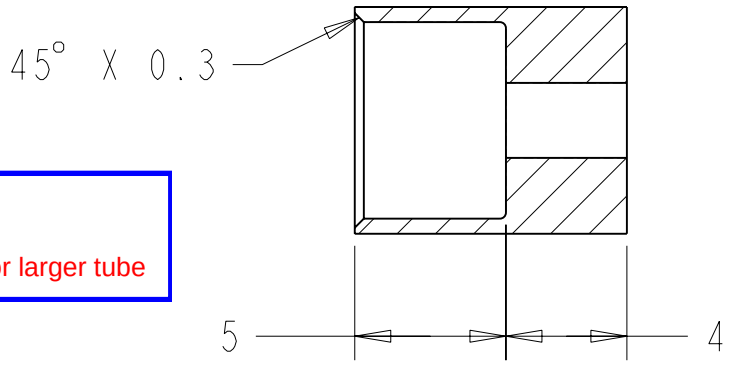
Rev. 1/29/2000 J. R. Osborn

DWG. NO.	SIZE	REV.	SH.
nnXnnn1		A	1

Will forward this part to D Uken for inclusion in sector assembly. It has a family table for different parts, but needs instances added to account for the larger square tube







SECTION A-A

SCALE 4.000

REV	DWG	CHK	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES			
X.X ±0.5	FRAC. ±1/64		
X.XX ±0.05	Angles ±1.00°		
X.XXX ±0.010	FINISH 125 (Ra)		

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS			
ACCT NO. PIAP-12	NO. REQD 15	SER NO. -	
DEL TO PICK UP		DATE ISSD -	DATE REQD -
SURFACE TREATMT -			
IDENT METHOD TAG			
PROJECT NUMBER N/A			
PROJECT NAME N/A			
DWG BY E Anderssen		DATE 18-Apr-00	
CHK BY None		DATE 3/18/00	
APR BY Anderssen		DATE 3/18/00	

-	Aluminum
DESCRIPTION	MATERIAL

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS Pixel Detector
Sector Tubing
TERMINATION FOR SECTOR PROTOTYPE

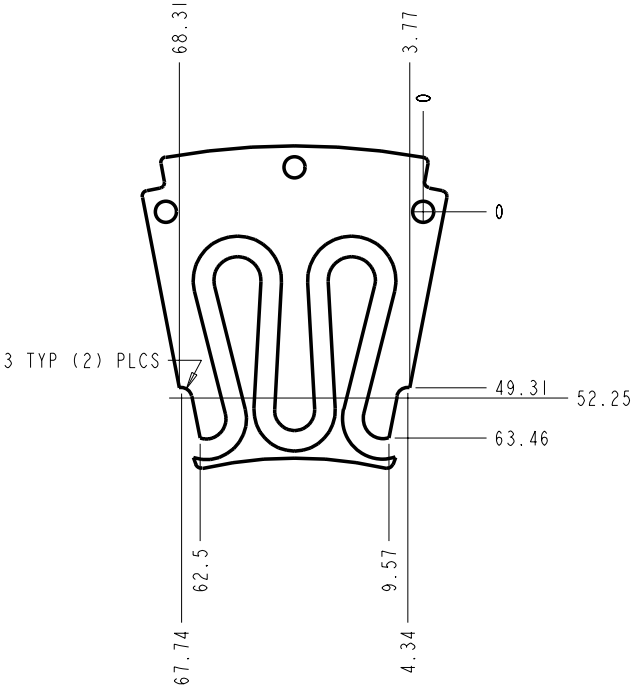
MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 4.000	DO NOT SCALE PRINTS
	nnXnnn	nnXnnn	nnXSHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. nnXnnn1	SIZE / REV.
	PIAP-12	XXnnnn		

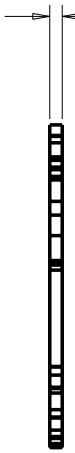
Dwg. File: TUBE_TERMINATION_250 Model File: QUARTER_INCH

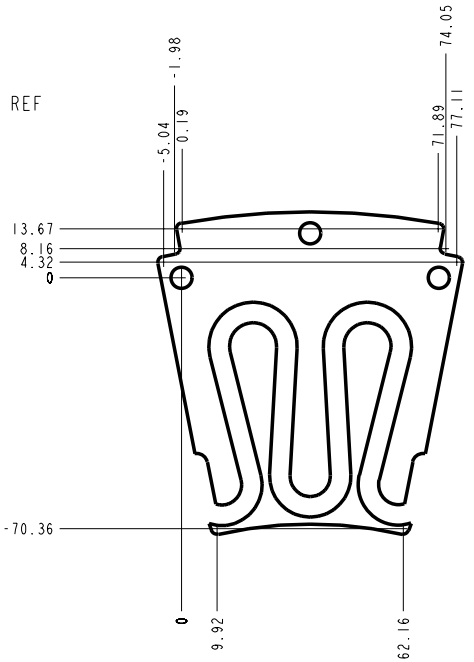
Rev. 1/29/2000 J. R. Osborn

Part Number	Description	"A" Thickness
	Original Tubing	3.48
	Reduced Hydraulic Diameter	2.43
	Etched Outer Surface	2.18

DESCRIPTION	MATERIAL	MAT. LOCATION
		-







REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ± 0.1 | FRAC. ± 1/64 | X.XX ± 0.03 | Angles ± 1.00° | X.XXX ± 0.010 | FINISH 125 (µin)

DO NOT SCALE PRINT

THREADS ARE CLASS 2

CHAMFER ENDS OF ALL SCREW TREADS 30°

CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS

BREAK EDGES .016 MAX. ON MACHINED WORK

REMOVE BURRS, WELD SPLATTER & LOOSE SCALE

IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO.	-		
ACCT NO.	7916-27	NO. REQD 33	DATE ISSD -
DEL TO	ERIC ANDERSSEN		DATE REQD -
SURFACE TREATMT			
IDENT METHOD	TAG		
PROJECT NUMBER	N/A		
PROJECT NAME	N/A		
DWG BY	David Uken	DATE 04-Apr-00	
CHK BY		DATE	
APR BY	Eric Anderssen	DATE	

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

Foam, Perimeter Shape
11-Sector Version
Atlas Detector

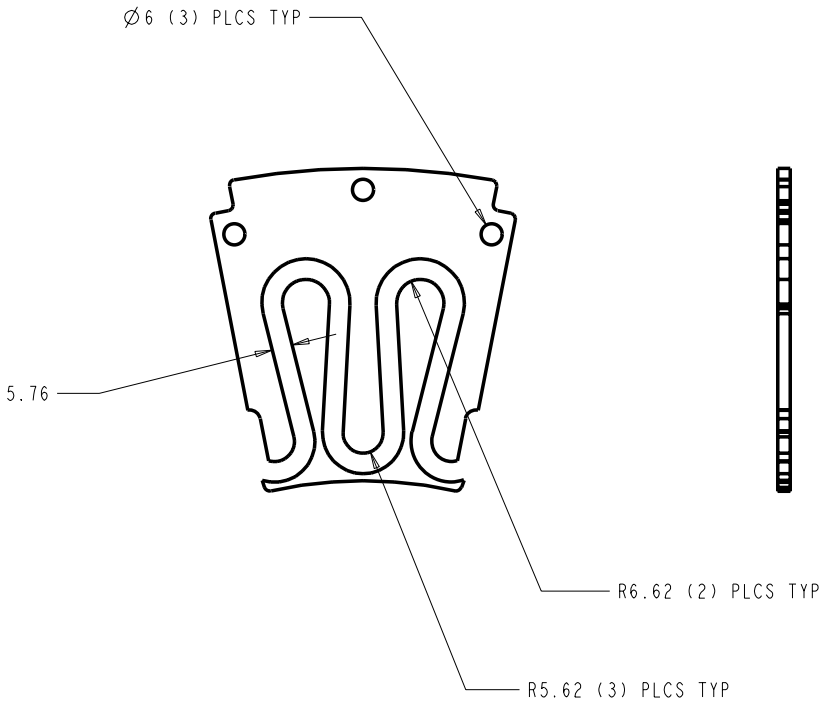
MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1.000 DO NOT SCALE PRINTS
	PART		SHEET 1 OF 2

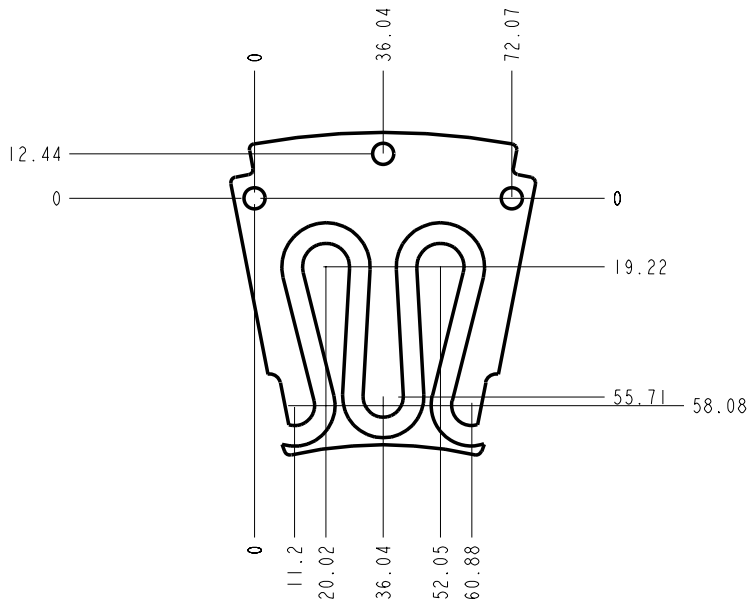
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO.	SIZE	REV.
			3		A

DWG. NO. 43 200011 SIZE REV SH

Dwg. File: SECTOR 11 FOAM Model File: SECTOR 11 FOAM

DESCRIPTION	MATERIAL	MAT. LOCATION
		-





DWG. NO. 43 SIZE REV. LSH. 200011

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.1	FRAC. ± 1/64
	X.XX ± 0.03	Angles ± 1.00°
	X.XXX ± 0.010	FINISH 125 (µin)

DO NOT SCALE PRINT

THREADS ARE CLASS 2

CHAMFER ENDS OF ALL SCREW TREADS 30°

CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS

BREAK EDGES .016 MAX. ON MACHINED WORK

REMOVE BURRS, WELD SPLATTER & LOOSE SCALE

IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO.	-		
ACCT NO.	7916-27	NO. REQD 33	DATE ISSD -
DEL TO	ERIC ANDERSSEN		DATE REQD -
SURFACE TREATMT			
IDENT METHOD	TAG		
PROJECT NUMBER	N/A		
PROJECT NAME	N/A		
DWG BY	David Uken	DATE	04-Apr-00
CHK BY		DATE	
APR BY	Eric Anderssen	DATE	

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

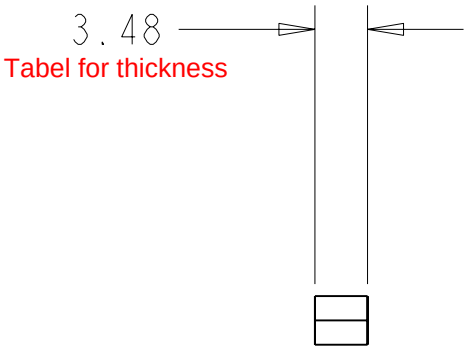
Foam, Interior Cutouts and Holes
11-Sector Version
Atlas Detector

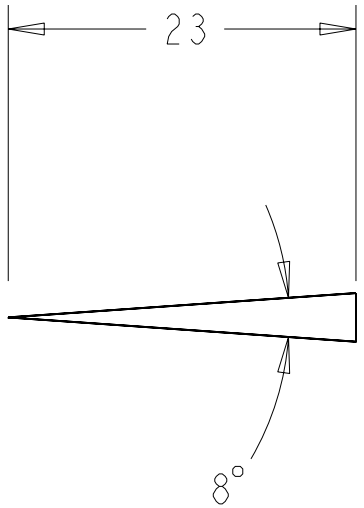
MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1.000 DO NOT SCALE PRINTS
	PART		SHEET 2 OF 2
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. 3 SIZE REV. A

Rev_1.fm: SECTOR-11_FOAM2 Model: 11-Sector_11.iam

DWG. NO.	SIZE	REV.	SH.
81	2000i	1	

Wedge piece must be adjusted for gap between it and tube.





REV	DWG	CHK	DATE	CHANGES	DESCRIPTION	MATERIAL

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ±0.1 | FRAC. ±1/64 | X.XX ±0.01 | Angles ±0.50° | X.XXX ±0.001 | FINISH 125 √(μin)

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO.	-		
ACCT NO.	7916-27	NO. REQD	66
DATE ISSD	-		
DEL TO		DATE REQD	-
SURFACE TREATMT			
IDENT METHOD	TAG		
PROJECT NUMBER	N/A		
PROJECT NAME	N/A		
DWG BY	David Uken	DATE	04-Apr-00
CHK BY		DATE	
APR BY	Eric Anderssen	DATE	

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

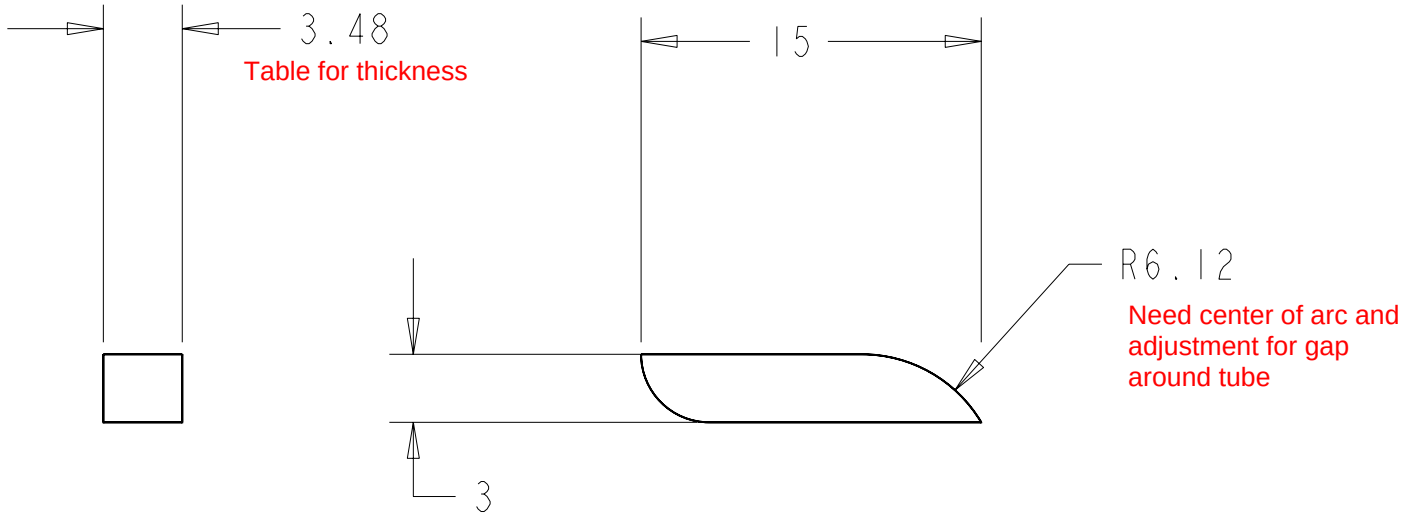
Support Wedge, Outer
II-Sector Version
Atlas Detector

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 2.000	DO NOT SCALE PRINTS
	PART		SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. 1	SIZE / REV.

Dwg. File: SUPPORT_WEDGE_II_OUTER Model File: SUPPORT_WEDGE_II_OUTER

Rev. 1/29/2000 J. R. Osborn

DWG. NO.	SIZE	REV.	SH.
71	2000	i	1



REV	DWG	CHK	DATE	CHANGES	DESCRIPTION	MATERIAL

UNLESS OTHERWISE SPECIFIED

TOLERANCES			
	X.X ±0.1	FRAC. ±1/64	
	X.XX ±0.01	Angles ±0.50°	
	X.XXX ±0.001	FINISH 125 (µin.)	

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO.	-		
ACCT NO.	7916-27	NO. REQD	66
DATE ISSD	-		
DEL TO	Eric Anderssen	DATE REQD	-
SURFACE TREATMT			
IDENT METHOD	TAG		
PROJECT NUMBER	N/A		
PROJECT NAME	N/A		
DWG BY	David Uken	DATE	04-Apr-00
CHK BY		DATE	
APR BY	Eric Anderssen	DATE	

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

Support Wedge, Inner
II-Sector Version
Atlas Detector

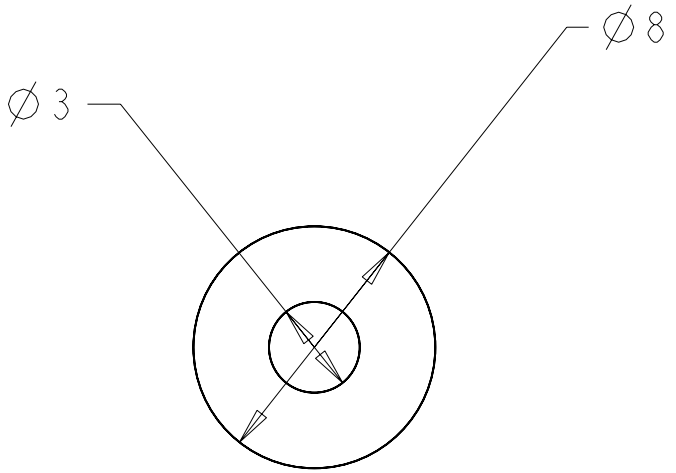
MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 3.000	DO NOT SCALE PRINTS
	PART		SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. 1	SIZE / REV.

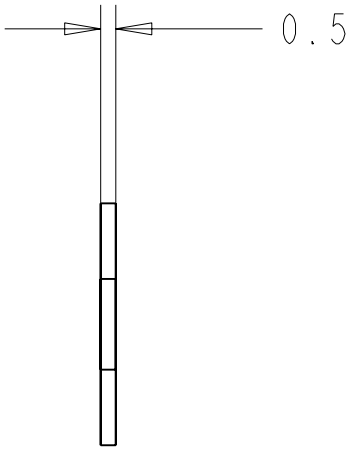
Dwg. File: SUPPORT_WEDGE_II_INNER Model File: SUPPORT_WEDGE_II_INNER

Rev. 1/29/2000 J. R. Osborn

DWG. NO.	SIZE	REV.	SH.
61	2000i	1	

Drawing obsolete, need new model for "T" washer





REV	DWG	CHK	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES:
- X.X ±0.1
- X.XX ±0.03
- X.XXX ±0.010
- FRAC. ±1/64
- Angles ±1.00°
- FINISH 125 (µin)

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO.	-		
ACCT NO.	7916-27	NO. REQD	306
DATE ISSD	-		
DEL TO	Eric Anderssen	DATE REQD	-
SURFACE TREATMT			
IDENT METHOD	TAG		
PROJECT NUMBER	N/A		
PROJECT NAME	N/A		
DWG BY	David Uken	DATE	04-Apr-00
CHK BY		DATE	
APR BY	Eric Anderssen	DATE	

DESCRIPTION | MATERIAL

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

Washer
9 and 11-Sector Versions
Atlas Detector

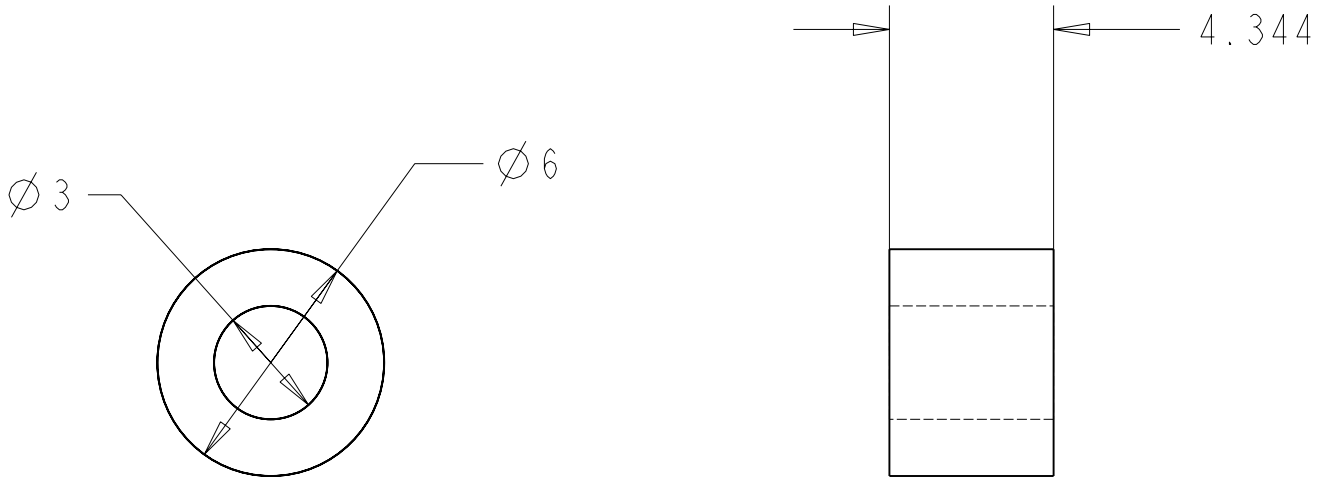
MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 4.000	DO NOT SCALE PRINTS
	PART		SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. 1	SIZE / REV.

Dwg. File: WASHER Model File: WASHER

Rev. 1/29/2000 J. R. Osborn

DWG. NO.	SIZE	REV.	SH.
11	2000	1	

Drawing is obsolete, need drawing for "T" washer



REV	DWG	CHK	DATE	CHANGES

DESCRIPTION	MATERIAL

UNLESS OTHERWISE SPECIFIED

TOLERANCES			
X.X ±0.1	FRAC. ±1/64	FINISH 125 (µin)	
X.XX ±0.03	Angles ±1.00°		
X.XXX ±0.010			

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS

SER NO.	-		
ACCT NO.	7916-27	NO. REQD	153
DATE ISSD	-		
DEL TO	Eric Anderssen	DATE REQD	-
SURFACE TREATMT			
IDENT METHOD	TAG		
PROJECT NUMBER	N/A		
PROJECT NAME	N/A		
DWG BY	David Uken	DATE	04-Apr-00
CHK BY		DATE	
APR BY	Eric Anderssen	DATE	

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

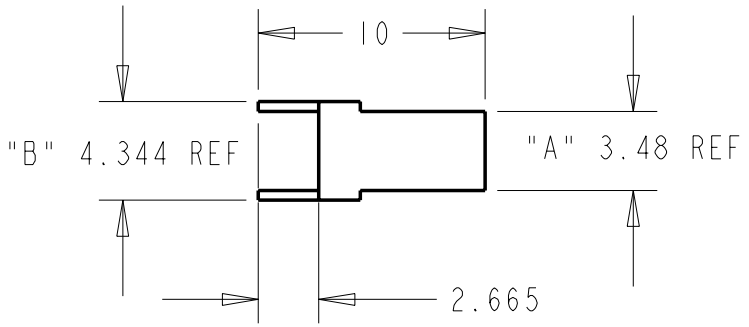
Bushing
9 and 11-Sector Versions
Atlas Detector

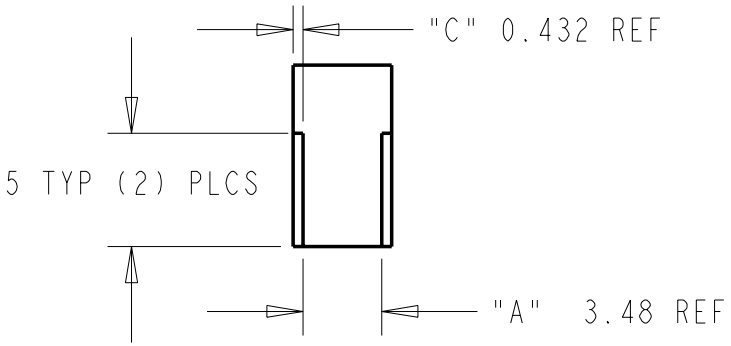
MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 5.000	DO NOT SCALE PRINTS
	PART		SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. 1	SIZE / REV.

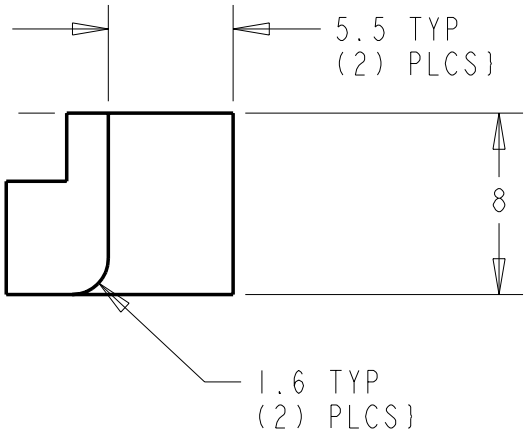
Dwg. File: BUSHING Model File: BUSHING

Rev. 1/29/2000 J. R. Osborn

Part Number	Description	"A" Tubing	"B" Sector	"C" Facing
	.432 Facing, Original Tubing	3.48	4.344	.432
	.423 Facing, Reduced Tube	2.43	3.294	.432
	.432 Facing, Etched Tube	2.18	3.044	.432
	.300 Facing, Original Tube	3.48	4.08	.300
	.300 Facing, Reduce Tube	2.43	3.03	.300
	.300 Facing, Etched Tube	2.18	2.78	.300







REV	DWG	CHK	DATE	CHANGES	DESCRIPTION	MATERIAL

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ±0.1 | FRAC. ±1/64 | X.XX ±0.01 | Angles ±0.50° | X.XXX ±0.001 | FINISH 125 µin

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SHOP ORDERS — SER NO. -

ACCT NO. 7916-27 | NO. REQD 33 | DATE ISSD - | DATE REQD -

DEL TO Eric Anderssen

SURFACE TREATMT

IDENT METHOD TAG

PROJECT NUMBER N/A

PROJECT NAME N/A

DWG BY David Uken — DATE 07-Apr-00

CHK BY — DATE

APR BY Eric Anderssen — DATE

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

Atlas Pixel Detector
II-Sector Version
Strain Relief, Left Side of Cooling Tube

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 3.000	DO NOT SCALE PRINTS
	PART		SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CODE	DWG. NO. 1	SIZE / REV. A

Rev. 1/29/2000 J. R. Osborn

Dwg. File: SECTOR_II_STRAINRELIEF_LT Model File: SECTOR_II_STRAINRELIEF_II

Fabrication Procedure for the HYTEC DOE/SBIR Sector

William K. Miller
August 28, 1999

Abstract

This procedural document details the bond fabrication and final machining procedure for the HYTEC DOE/SBIR Sector.

HYTEC Inc.
110 Eastgate Dr., Ste 100
Los Alamos, NM 87544
(505) 661-3000 / Fax (505) 662-5179

Table of Contents

1. Introduction

Fabrication of a HYTEC Sector includes pre and post weighing all incorporated materials, bonding the individual components (facings, cooling tube, and reinforcement parts) together with adhesive using an oven bake cure, and then a final machining process to obtain the proper finished dimensions.

2. Dimensional check of individual components

A random sample shall be taken and dimensional checks performed on all components that will be used in the fabrication of the Sector. A visual inspection of all components shall be used to discover latent defects. The Sector Facings thickness and flatness should be measured. All checked dimensions should be recorded for further reference. A data sheet shall be filled out with each fabricated Sector and logged for future reference.

2.1 Cooling Tube

Note: The Cooling Tube is a delicate and expensive part. Always use extreme care when handling it. Never twist or flex it. Bending the tube can break it.

Check the cooling Tube's flatness, height, and straightness. Place it on the granite table. Use a feeler gage or a height gage to record data. Take a few diameter measurements of the tube at various points. Compare these values with previously recorded data (other tubes). Record all data and note any significant variations. Hand trace the Tube on a blank sheet of paper and indicate where dimensions were taken.

2.2 Facings, Bushings and Washers

Record the Facings width and flatness. Record the length and diameter of the Bushings and Washers. Visually inspect the perpendicularity of the Bushing on the granite table. Check any recorded dimensions against drawing specifications.

Note: Check finished Facing width vs. Facing material width. Facings may need to be hand sanded down to their final dimension prior to bonding them to any parts. If Facing must be sanded –equal material must be sanded from each side.

2.3 Tube Reinforcement Parts

Inspect and record the dimensions of the Cooling Tube aluminum reinforcement parts.

3. Pre-weigh all components

Any component that will be integrated into the final assembly of a Sectormust be weighed. The components weight should be recorded the nearest tenth of a gram (record in data sheet). Use the precision scale. **Do not forget to calibrate the scale prior to use.** When bonding several Sectors at one time, keep each individual Sector's components separate, so as to track their individual masses correctly.

4. Pre-clean all components

Standard clean procedures must be used prior to bonding. Prepare a clean area for bonding. Rubber gloves must be worn during the clean procedure and at all times after the parts have been cleaned. Skin oils deposited on the parts can interfere with bond adhesion.

4.1 Clean Sector parts

Isopropyl Alcohol and a clean wipe should be used to wipe down all parts prior to bonding. Use new wipes frequently. Place parts on a clean surface, or clean bag in preparation for bonding. Any contaminated parts must be re-cleaned.

4.2 Clean fabrication jig

Use Isopropyl Alcohol to wipe down the Sector fabrication jig parts (Baseplate, Coverplate, and Tube centering jigs) necessary for bonding. Handle the Sector fabrication jigs using appropriate clean procedures.

5. Bond procedure

The Sector is bonded together in separate steps. Each step involves critically locating parts, applying adhesive and then curing the adhesive in climate controlled

convection oven. The subassembly is then allowed to cool and then is repeated until the bonded Sector assembly is complete.

5.1 AIT Technology adhesive

AI Technology, EG7658, a two part epoxy adhesive is used to bond the coolant tube to the Sector's facings. It is an aluminum nitride, filled adhesive that has good thermal conductivity properties (see MSDS specifications). It can be unmanageable to spread – therefore it can be thinned with MEK. MEK is highly volatile and will quickly evaporate. MEK has been found to be a cancer agent so it must be handled appropriately (see manufacturer specifications). Mix epoxy in a 1/1 part (weight) ratio using a scale.

This epoxy is also expensive, so be careful not to mix too much up at once so as not to waste it. Its room temperature cure time is about 1 week so it may be re-thinned with MEK and used within this time period. It may also be stored in the refrigerator to prolong this cure time.

5.2 Bond Facing #1 to Cooling Tube

The positional relationship between the Facings and the Cooling Tube is important. Pins in the Baseplate are used to locate the Facings. Removable Centering Jigs (pinned to the Baseplate) are used to locate the Tube.

Note: Facing #1 and Facing #2 when in position are mirror images of each other.

5.2.1 Position Facing # 1

Place Facing #1 down on the bond Baseplate (note the Facings orientation – see drawing ATLAS-FXT-0020). Slide the Facing down until it's bottom radius indexes on the two bottom pins. While maintaining this contact, rotate Facing #1 until it's right side external notch indexes on the Baseplate's right side pin. Lock Facing #1 down in this position with the Facing lockdown clip on the right side. When done, the Facing should be firmly held in position, and indexed off the two bottom pins and one right side pin. *Check to make sure that the lockdown clip is allowing the facing to sit down flat on the Baseplate.*

5.2.2 Pre-position the Cooling Tube Jigs

After Facing #1 is located and fixed in position, snap the Cooling Tube Tangental Locating Jig (over it's pins) in position. Also put the Cooling Tubes Centering Jig in position and screw it's thumbscrew down loose. The Tube Centering Jig should be able to freely slide up and down when in position. Slide the Centering Jig up to its highest position.

5.2.3 Pre-Position Tube on Facing # 1

Place the Cooling Tube down on Facing #1. Slide the Tube down until two of its bottom bends touch the Cooling Tube Tangental Locator. Slide the Tube Centering Jig down until it just registers and centers the top two bends in the Cooling Tube. Do not impart

any force into the Tube with the Centering Jig; the Jig should not force the Tube to bend open slightly. Mark the Tube where it protrudes past the Facing (both places). Remove Tube and push Centering Jig up to its previous position.

5.2.4 Apply adhesive to Carbon Tube

Mix up some of the EG7658 and thin to the desired consistency. Trowel epoxy (in a "V" shape) to one side of the Cooling Tube, approximately 0.6 gm. Remember to be careful because the Tube is an expensive and delicate part. Do not apply epoxy to the Tube in the areas that protrude past the Facing.

5.2.5 Position Tube on Facing # 1

Position Tube over Facing #1 (in its nominal position) with epoxy facing Facing #1. Place Tube on Facing #1. Index bottom Tube bends against the Tangental Locating Jig. Slide the Tube Centering Jig down until it tangentally touches the top Tube bends. Just use the Centering Jig to align the Tube in its proper position, do not impart any force into the Tube.

5.2.6 Coverplate

Gently put the Coverplate down onto the Tube and Facing #1.

5.2.7 Curing adhesive

The convective oven should have been pre-heated to a temp of 185°F (85°C) for at least 10 minutes. Place the Jig, the Facing, and the Cooling Tube assembly inthe Convective Oven. Apply about 8-10 Lbs. of compressive force to the top of the Coverplate. Cure the assembly in the oven for 1 hour. Remove and allow to cool down before proceding.

5.2.8 Weigh assembly

Weigh the Tube, Facing #1, and Baseplate Assembly. Do not remove the Tube and Facing from the Baseplate.

5.3 Bonding Facing #2

Epoxy will be applied to the Cooling Tube and then Facing #2 will be placed in position. A reminder: Facing #2 is the mirror image of Facing #1. The alignment between Facing #1 and #2 is critical. Any misalignment between the two Facings can cause the Sector assembly on the Composite Ring to be complicated. The Bushings will also be bonded during this phase of the Sector fabrication.

5.3.1 Apply adhesive to Carbon Tube

Trowel epoxy on top of Cooling Tube as described in Step 5.2.4.

5.3.2 Prep the Bushings

Create a ringed fillet of epoxy, (use temperature curing adhesive like Epotek??), around both ends of the O.D. of the Bushing. Repeat for all 3 bushings.

5.3.3 Insert the Bushings

Place the Bushings in the 3 holes in Facing #1. Push the Bushings down until they bottom on the aluminum bond jigs.

5.3.4 Install Facing # 2

Place Facing #2 down on the Cooling Tube (note the Facings orientation). Make sure the both Facing's bottom radii index on the two bottom pins and that the right side external notches on each face index on the Baseplate's right side pin. Observe the adhesive fillet between the Cooling Tube and Facing #2 to determine if there are any voids.

5.3.5 Rotate the Bushings

Twist each Bushing to get a good continuous fillet between the Bushings and the Facings. Closely inspect the fillets between the Bushings and Facings to determine there are no voids. Re-push the Bushings down until they bottom on the aluminum bond jigs.

5.3.6 Remove excess adhesive

Use a square edged scraper to remove any excess adhesive (adhesive fillet) between the outside of Facing #2 and the Carbon Bushing. An adhesive fillet in the corner between these two parts will have to be removed so the Carbon Washers can be correctly bonded in place.

5.3.7 Install the Coverplate

Gently put the Coverplate down onto Facing #2.

5.3.8 Curing adhesive

The convective oven should have been pre-heated to a temperature of 185°F (85°C) for at least 10 minutes. Place the Jig, Facings, and Cooling Tube assembly in the Convective Oven. Apply about 8-10 Lbs. of compressive force to the top of the Coverplate. Cure the assembly in the oven for 1 hour. Remove and allow to cool before proceeding.

5.3.9 Weigh assembly

Weigh the Tube, and Facing Assembly. Mark Bonded Assembly so as not to get multiple Sectors confused.

5.4 Bond Carbon Washers

The Carbon Washers fit on the Carbon Bushing and against the outside of the Facings. It is important to get a good bond using adhesive Epotek??? between the Carbon Washers, the Carbon Bushings, and the Facings.

5.4.1 Pre-Inspection and prep of surfaces

Visually inspect the outside corners between the Carbon Bushings and the Facings. Scrape any excess adhesive from the corners that may prevent the Carbon Washer from sitting flush against both surfaces. Wipe down the surfaces with Isopropyl Alcohol to clean bond area.

5.4.2 Apply adhesive Carbon Bushings and Facings

Mix up some of the Epotek?? and mix to the desired consistency. Apply a light coating of epoxy to the Facings and the diameter of the Carbon Bushings.

5.4.3 Position the Washers

Push the Carbon Washers over the Carbon Bushings. A .004" bond thickness is desired between the outside of the Facings and the Washers. Visually center the Washers around the Bushings. Force adhesive between the Washer and Bushing if voids are visible.

5.4.4 Remove excess adhesive

Carefully remove any excess adhesive from the surfaces. Use a chamfered scraper to scrape around the outside of the Washer. A small adhesive fillet in the corner between the Facings and Washers is desired.

5.4.5 Put assembly in jig

Place the Assembly on the Baseplate. Put the Coverplate on the Assembly.

5.4.6 Curing adhesive

The convective oven should have been pre-heated to a temp of 185°F (85°C) for at least 10 minutes. Place the Jig, Facings, and Cooling Tube assembly in the Convective Oven. Apply about 8-10 Lbs. of compressive force to the top of the Coverplate. Cure the assembly in the oven for 1 hour. Remove and allow to cool down before proceding.

5.4.7 Weigh assembly

Weigh the Bonded Assembly.

5.5 Bonding Cooling Tube Reinforcement Parts

Reinforcement Parts will be bonded to the Carbon Tube for structural strength. First the Carbon Tube must be cut to length, and then a aluminum Sleeve will be bonded on (over) the Carbon Tube. This Carbon Tube and Aluminum Sleeve sub-assembly will then be cut to length. Another reinforcement part will bond the Facings to the Aluminum Sleeve to provide further strength and stability. Finally a 90 degree Head will be bonded to the end of the Aluminum Sleeve which contains a hose barb (or quick disconnect) for

coolant connections. Magnolia 24-4 (or equivalent) is the bond adhesive used to bond the aluminum Reinforcements Parts together.

5.5.1 Installing the Carbon Cooling Tube Cut J igs

Note: The Cooling Tubes are extremely delicate. Care must be taken so as to not impart any bending force into the Tubes with the Cutting J igs. Shim Cutting J igs as required.

Two Cooling Tube cut jigs need to be assembled on the Bonding Baseplate. One Cooling Tube cut Jig, on the left, will be used to cut the Carbon Cooling Tube to length. The right Cooling Tube cut jig will be used to cut both the Carbon Tube and the aluminum Sleeve after they have been bonded together.

5.5.1.1 Position Bonded Sector Assembly on Baseplate
Place bonded Sector Assembly on the Bond Baseplate.

5.5.1.2 Install clamp spacer , washer, and bottom of clamp
Loosely assemble Spacer, Washer, and Bottom half of Clamp to Baseplate using two #4-40 screws.

5.5.1.3 Align clamp to tube
Move radius of Clamp to be tangental to Sector Facings. Orientate Clamp to line up with Cooling Tube. Clamp down Spacer, and Washer using Screws.

5.5.1.4 Shim clamp
The Clamp is now oriented correctly with the Tube, but it may not be set to the correct elevation. If the Clamp is not at the correct vertical elevation it will impart a bending force into the Tube and will break it. Place shims between the bottom half of the Clamp and the Spacer to bring the Clamp to the correct elevation.

5.5.1.5 Finish clamp assembly
Install top half of Clamp using four #4-40 screws. Torque screws finger tight using a allen wrench.

5.5.2 Cut Carbon Tubes to length

Only one Carbon Tube can be cut at a time. Cut one Carbon Tube in the Clamp, unbolt the clamp, flip the Bonded Sector Sub-assembly and cut the second Carbon Tube.

Note: Eye protection and a filter mask must be worn.

5.5.2.1 Cut Carbon Tube #1
Using a new Dremel tool cutting aluminum oxide cutting disk, carefully slice the Carbon Tube to length. The cutting disk is guided by the slot in the Clamp.

5.5.2.2 Cut Carbon Tube #2

Unbolt Clamp. Flip Bonded Sector Assembly. Bolt Clamp and cut Carbon Tube #2.

5.5.2.3 Clean Carbon Tube

Using a can of compressed air, stick the nozzles tube down halfway into the Carbon Tube. Blow air through the Cooling Tube. Repeat this process with the other side of the Cooling Tube. Visually inspect the Carbon Tube for carbon particles, and inspect the cut for problems.

5.5.3 Magnolia 24-4 adhesive

Magnolia 24-4 epoxy a is 2 part room temperature curing adhesive. Each part of the epoxy initially is transparent but becomes opaque when mixed. Mix epoxy in a 1/1 ratio by weight using a scale. Epoxy cure time approximately 24 hours.

5.5.4 Bonding Carbon Tube Aluminum Sleeve

5.5.4.1 Apply adhesive

Apply a generous amount of adhesive to the outside diameter of the Cooling Tubes where they extend past the Sector Facings.

Note: Be careful not to get adhesive in the Carbon Tube.

5.5.4.2 Install aluminum Sleeves

Slide and twist a aluminum Sleeve over the Carbon Tube. Try to concentrically center the Sleeve over the Tube to maintain a continuously uniform bond with free of voids. Bottom the Sleeve on the Carbon Tube. Repeat for second Tube.

5.5.4.3 Remove excess adhesive

Wipe off all excess adhesive at base of Sleeve.

5.5.4.4 Curing adhesive

The bonded Sector assembly should be set upright for the 24 hour curing period. *If a sector was cured on its side gravity would pull the Sleeve down to touch the Tube tangentially thus removing the potential for a concentric bond.*

5.5.5 Cutting the Carbon Tube and Aluminum Sleeve

The procedure for cutting the Carbon Tube with the aluminum Sleeve bonded on is the same as used to cut the Carbon Tube. See Steps 5.5.1.1 to 5.5.2.3. . Remove any aluminum burrs with a knife. Visually inspect the cut Tube ends for bond voids. Apply adhesive to any visible voids as necessary and cure for 24 hours.

5.5.6 Weigh Assembly

Weigh the bonded Sector assembly.

5.5.7 Pressure check Sector Tube

Pressure check Sector Tube to 15 Psi. Connect rubber tubing to both ends of the Sector. One end of the rubber tubing runs to a regulator and air source, the other end will be capped off. Place the Sector under water. Slowly increase the air pressure using the regulator. Constantly rotate the Sector around under water and observe any small bubbles that may be collecting on the Carbon Tube. Look for bubbles at the base of the Aluminum Sleeve where it meets the Sector Facings. Record any potential leaks and the maximum pressure achieved (15 Psi).

5.5.8 Machine Sector

The Sector's finished mounting hole features are machined at this stage. The Sector is positioned (see Step 5.2.1) on the Machining Baseplate (the machining baseplate has through holes instead of counterbores where the Carbon Washers are located). The Coverplate is placed on top of the Bonded Sector Assembly. Four Thumbscrews draw the Coverplate down finger tight.

The machine shop uses the Baseplate surfaces to define the precise locations of the mounting holes. The machine shop also uses the Baseplate and Coverplate face as the Datum from which the washes are machined to their finished thickness.

5.5.9 Weigh Assembly

Weigh the machined Sector assembly.

5.5.10 Bond on Aluminum Reinforcement Part

The Aluminum Reinforcement part is used to structurally reinforce the Cooling Tube to the Facings to prevent breaking the Tube off as it projects out past the Facing. It is adhesively bonded to the O.D. of the Aluminum Sleeve and to the outside of the Facings.

5.5.10.1 Remove excess Adhesive

Visually inspect Bonded Sector for excess adhesive on Sector Facings and the O.D of the Aluminum Sleeve. Slip the Aluminum Reinforcement part in place to check for obstructions. Scrape or sand any excess adhesive away.

5.5.10.2 Prepare bond surfaces

Wipe Sector bonding surfaces with Isopropyl Alcohol. Thoroughly clean the Aluminum Reinforcement parts with Isopropyl Alcohol.

5.5.10.3 Apply Adhesive

Outline areas adhesive is necessary. Apply adhesive to Sector Facings and O.D. of Aluminum Sleeve (next to Facing). Slide Reinforcement piece over aluminum sleeve into position. Bottom Reinforcement part against Facings. If there is some clearance between the Aluminum Reinforcement part slot and the outside dimensions of the Facings, make

sure that the there is no angular clocking between the two parts and that the outside surface of the Reinforcement part is parallel to the outside surface of the Facings.

5.5.10.4 Remove excess Adhesive
Wipe off all excess adhesive.

5.5.10.5 Curing Adhesive
The bonded Sector assembly should be set upright for the 24 hour curing period.

5.5.11 Weigh Assembly

Weigh the Sector .

5.5.12 Bond on Aluminum Sector 90 degree Head

The Sector Head must be bonded on the Tube end and face the correct direction. See Hytec drawing HYT-ATLAS-0030 for reference. The profile of the top Facing identifies the correct bond direction for the Sector Head.

5.5.12.1 Remove excess Adhesive
Visually inspect the Sector O.D of the Aluminum Sleeve for excess adhesive. Scrape or sand any excess adhesive away.

5.5.12.2 Prepare bond surfaces
Wipe end of Aluminum Sleeve with Isopropyl Alcohol. Thoroughly clean the Aluminum Sector Head parts with Isopropyl Alcohol. Wash bonded surface with a caustic alkaline solution like Alconox just before bonding. Final was with distilled water and blow dry. Bond tube connections immediately after.

5.5.12.3 Apply Adhesive
Outline areas adhesive is necessary. Apply adhesive to end of Aluminum Sleeve. Be careful not to get adhesive in Tube. Slide Sector Head over Aluminum Sleeve and twist it 360 degrees to thoroughly mix adhesive. Bottom Sector Head on end of Sector Tube. Make sure that the Sector Heads are orientated perpendicular to the Sector Facing and that the bond between the two parts is concentric.

5.5.12.4 Remove excess Adhesive
Wipe off all excess adhesive.

5.5.12.5 Curing Adhesive
The bonded Sector assembly should be set upright for the 24 hour curing period.

5.5.13 Weigh Assembly

Weigh the final Sector assembly.

5.6 Dimensional Check

Measure the Sector dimensions as a final check. Measure the Bushing/Washer through hole locations, the and the Facings flatness.

Sector Fabrication Data Sheet

1. Introduction

This document is a data sheet for the fabrication of a Hytec Sector. Hytec's Fabrication procedure document has detailed instructions on the fabrication of a Sector.

Hytec Sector No.	Date

Hytec Drawing No.	REV

2. Dimensional check of individual components

2.1 Cooling Tube

	Side A (Avg.)	Side B (Avg.)
Flatness		
Diameter		n/a

2.2 Bushings

	#1	#2	#3
Height			
Diameter(s)			

HYTEC Inc.
110 Eastgate Dr., Ste 100
Los Alamos, NM 87544
(505) 661-3000 / Fax (505) 662-5179

2.2 Washers

	#1	#2	#3	#4	#5	#6
Height						
Diameter(s)						

2.2 Facing Dimensions

	#1	#2
Thickness		
Flatness		
Misc.		

2.3 Aluminum Sleeves

	#1	#2
Length		
Diameter(s)		

2.3 Facing Reinforcement parts

	#1	#2
Slot width		
Diameter		
Misc. Dims		
Misc. Dims		

2.3 Cooling Tube 90 Sector Head

	#1	#2
Counterbore		
Misc. Dims		
Misc. Dims		
Misc. Dims		

3.0 Weights of Individual components

Part	Weight (gm)					
Facings						
Bushings						
Washers						
Tube						
Aluminum Sleeves						
Alum Reinforcements						
Tube 90 Heads						

5.2.8 Weight of Facing #1 and Cooling Tube

(gm)

5.3.9 Weight of Facings, Bushings, and Cooling Tube

(gm)

5.4.7 Weight of Facings, Bushings, Tube and Washers

(gm)

5.5.6 Weight of Bonded Assembly and Alum. Sleeves Cut

(gm)

5.5.7 Pressure check Carbon Tube

	Comments
Pressure 10 psi	

5.5.9 Weight of Machined Sector

(gm)

5.5.9 Weight of Sector with Alum. Reinforcements

(gm)

5.5.12 Weight of Finished Assembly

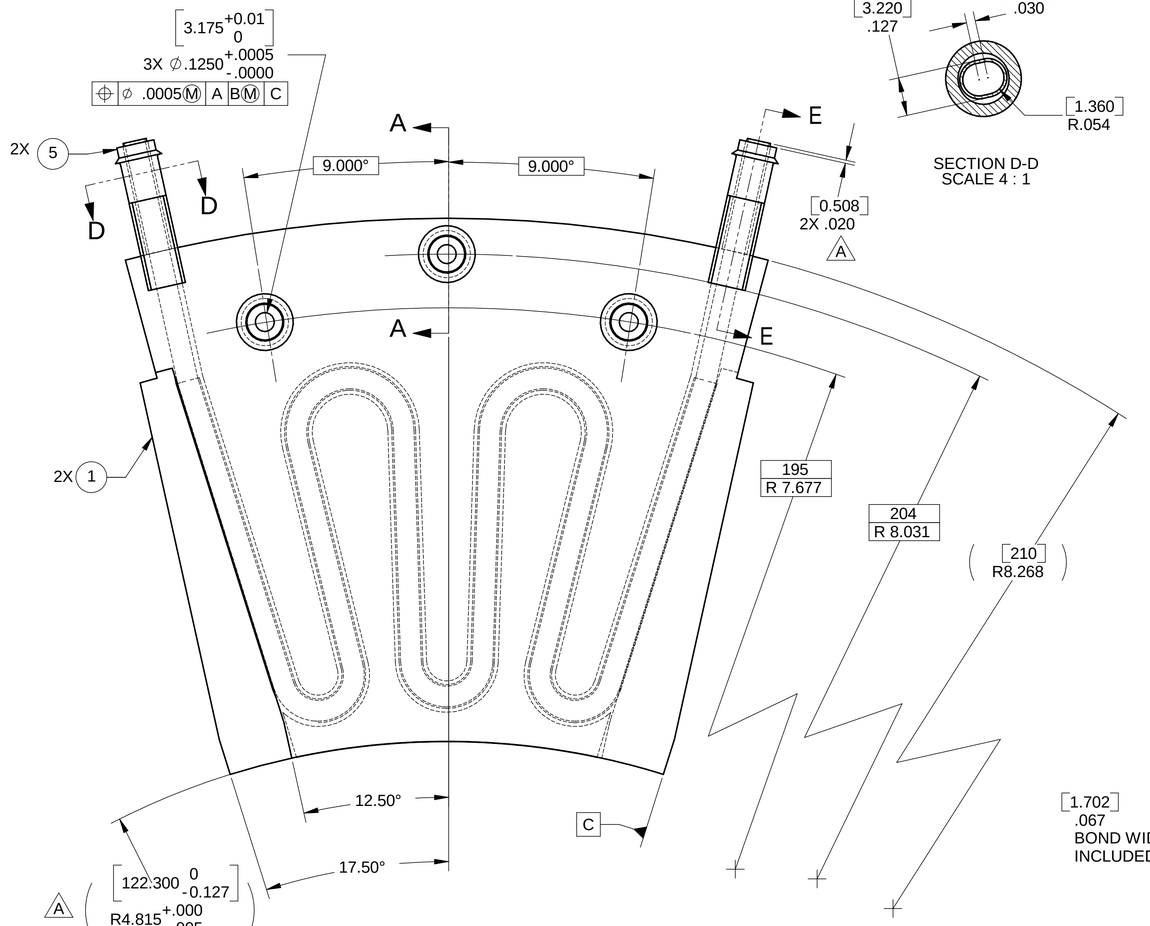
(gm)

5.6 Measured Machine Dimensions

	#1	#2	#3
Bore Dia.			
Length			
Flatness			

	1-2	2-3	1-3
Hole to Hole Dimensions			

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	SEE ECN-HYT-ATLAS-0050-A FOR CHANGES	4/20/99	WKM



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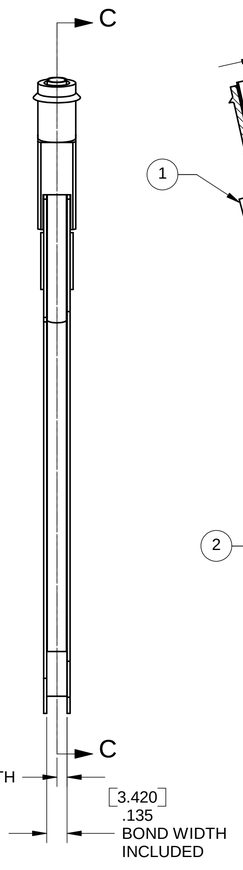

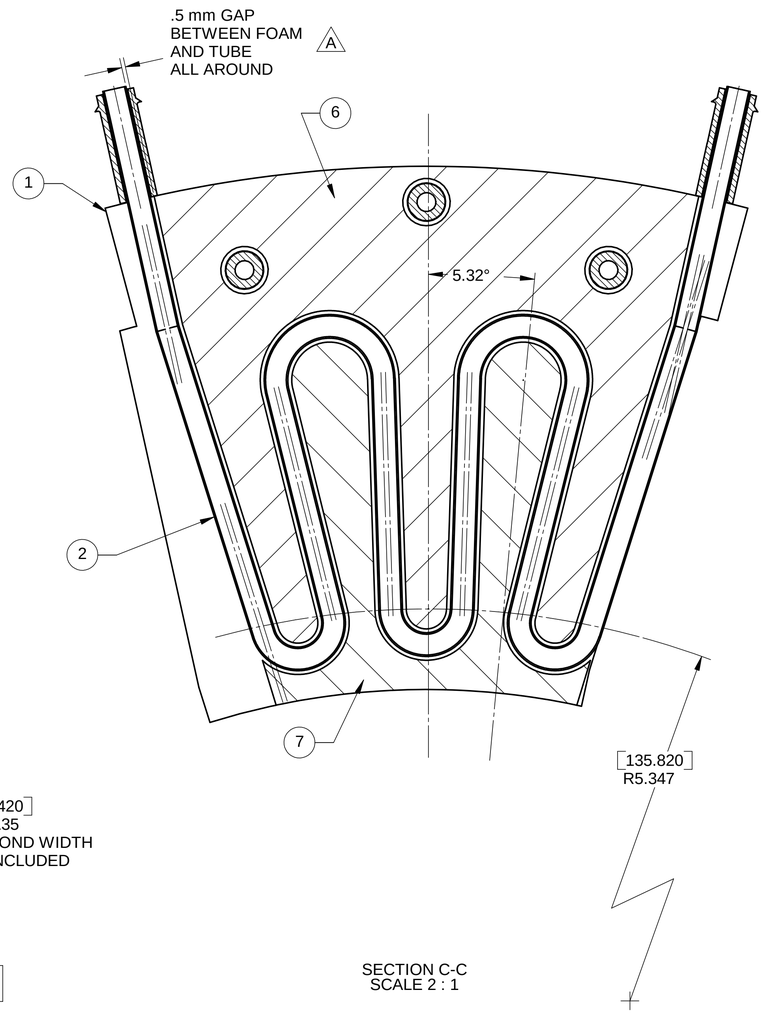

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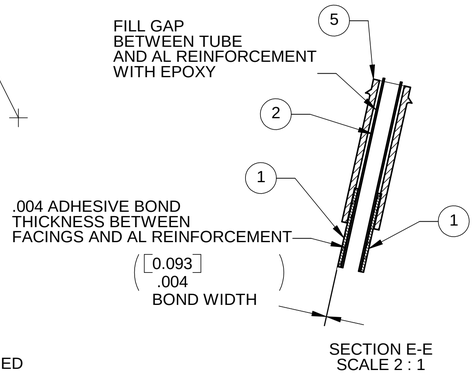

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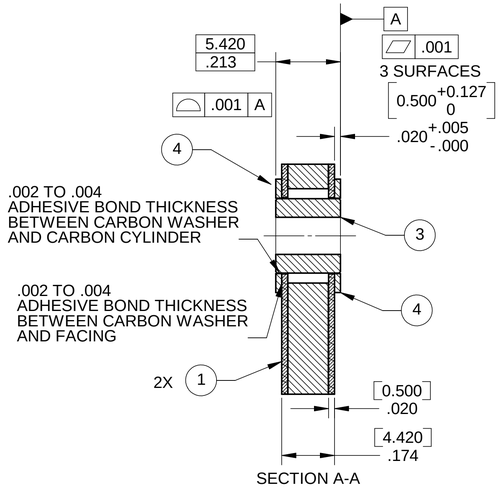


SECTION A-A
SCALE 4 : 1

A

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN INCHES
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. COUNTERSINK 82 DEGREES ALL TAPPED HOLES TO MAJOR DIAMETER
5. COUNTERSINK 82 DEGREES APPROXIMATELY .015 DEEP ALL DRILLED HOLES
6. PARTS TO BE THOROUGHLY CLEANED TO REMOVE ALL OIL, GREASE, DIRT AND CHIPS
7. HYTEC WILL BOND ASSEMBLY TOGETHER

ITEM NO.	QTY.	PART NO.	DESCRIPTION
1	2	HYT-ATLAS-0051	ATLAS -DOE SBIR - SECTOR FACING
2	1	HYT-ATLAS-0052	ATLAS -DOE SBIR - SECTOR COOLING TUBE
3	3	HYT-ATLAS-0053-3	ATLAS -DOE SBIR - SECTOR CYLINDRICAL INSERT
4	6	HYT-ATLAS-0053-1	ATLAS -DOE SBIR - SECTOR WASHER
5	2	HYT-ATLAS-0017	ATLAS -DOE SBIR - SECTOR COOLING TUBE REINFOCEMENT
6	1	HYT-ATLAS-0054-1	ATLAS- DOE SBIR- SECTOR CARBON FOAM
7	1	HYT-ATLAS-0054-3	ATLAS- DOE SBIR- SECTOR CARBON FOAM PART #2

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
-TOLERANCES-

DECIMALS
.XX = +/- .03
.XXX = +/- .010

ANGULAR = +/- 30'

SURFACE FINISH = 250

CAD GENERATED DRAWING,
DO NOT MANUALLY UPDATE
DO NOT SCALE DRAWING

FINISH

PART NO.
HYT-ATLAS-0050

	SIGNATURE	DATE
DESIGNED	W. K. MILLER	4/8/99
DRAWN	W. K. MILLER	4/8/99
CHECKED	HARRY SALAZAR	-
ENGR.	W. O. MILLER	-
APPROVED	- -	-

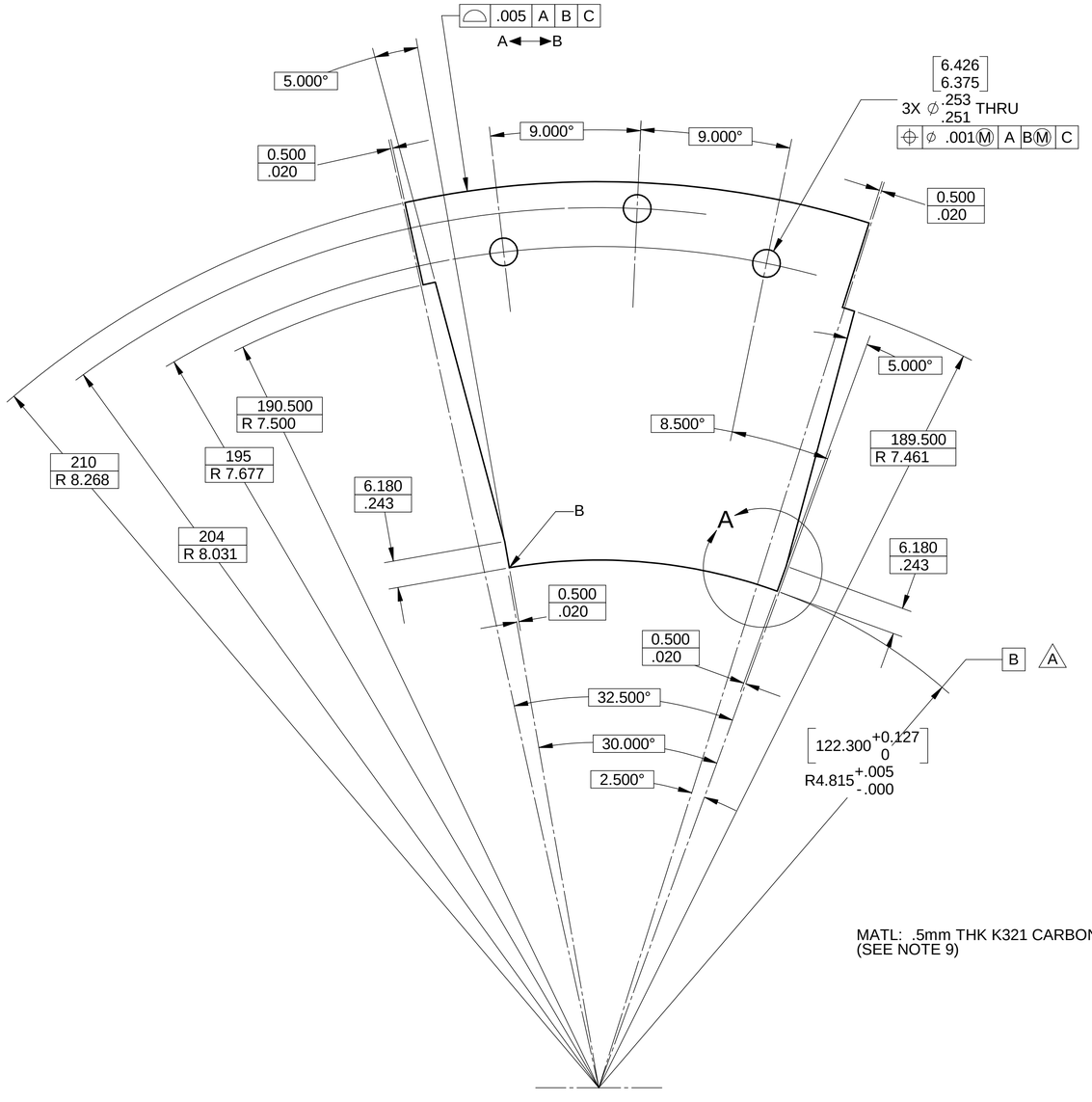
HYTEC, INC

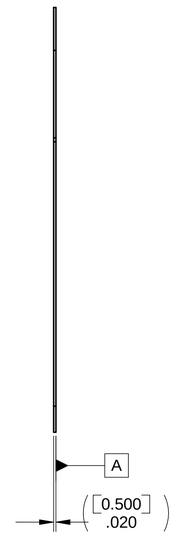
TITLE
ATLAS- DOE SBIR
SECTOR ASSEMBLY

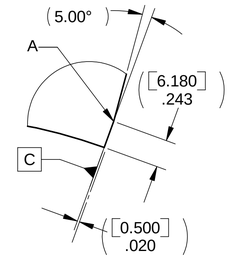
DWG. NO. HYT-ATLAS-0050 | SIZE D | SHEET NO. 1 of 1

SCALE 2/1 | REVISION A

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	SEE ECN HYT-ATLAS-0051-A FOR CHANGES	4/20/99	WKM







DETAIL A
SCALE 1.5 : 1

MATL: .5mm THK K321 CARBON CARBON FACING
(SEE NOTE 9)

A NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN INCHES
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. REMOVE ALL BURRS AND BREAK SHARP EDGES TO A MAXIMUM OF .015
5. COUNTERSINK 82 DEGREES ALL TAPPED HOLES TO MAJOR DIAMETER
6. PARTS TO BE THOROUGHLY CLEANED TO REMOVE ALL OIL, GREASE, DIRT AND CHIPS
7. INSPECTION REPORTS TO BE PROVIDED

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
-TOLERANCES-
DECIMALS
.XX = +/- .03
.XXX = +/- .010
ANGULAR = +/- 30'
SURFACE FINISH = 250

CAD GENERATED DRAWING,
DO NOT MANUALLY UPDATE
DO NOT SCALE DRAWING

FINISH

PART NO.
HYT-ATLAS-0051

	SIGNATURE	DATE
DESIGNED	W. K. MILLER	4-7-99
DRAWN	W. K. MILLER	4-7-99
CHECKED	W. O. MILLER	4/15/99
ENGR.	W. O. MILLER	-
APPROVED	-	-

HYTEC, INC

TITLE
ATLAS DOE SBIR
SECTOR FACING

DWG. NO. HYT-ATLAS-0051 | SIZE D | SHEET NO. 1 of 1

SCALE 2/1 | REVISION A

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
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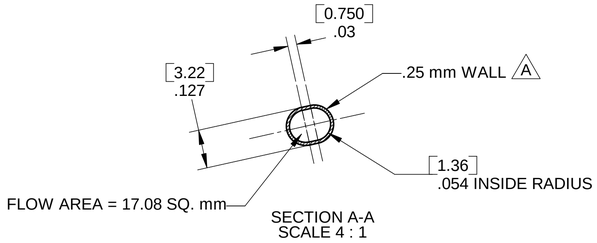

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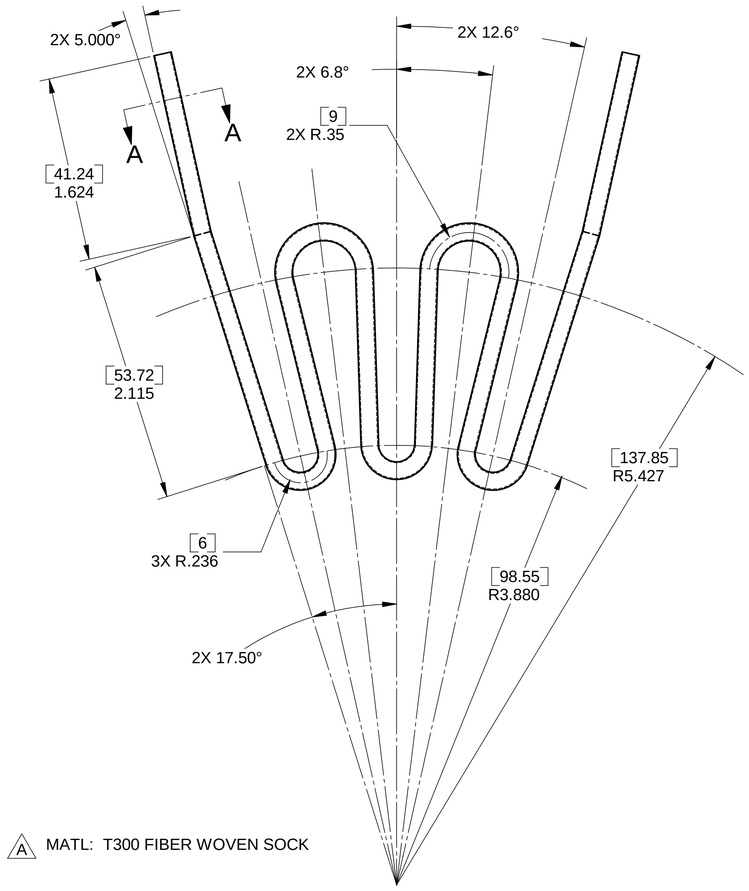


A MATL: T300 FIBER WOVEN SOCK

A

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN INCHES
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. PARTS TO BE THOROUGHLY CLEANED TO REMOVE ALL OIL, GREASE, DIRT AND CHIPS

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
-TOLERANCES-

DECIMALS
.X = +/- .1
.XX = +/- .010

ANGULAR = +/- 30'

SURFACE FINISH = 250

CAD GENERATED DRAWING,
DO NOT MANUALLY UPDATE
DO NOT SCALE DRAWING

FINISH

PART NO.
HYT-ATLAS-052

	SIGNATURE	DATE
DESIGNED	W. K. MILLER	4/7/99
DRAWN	W. K. MILLER	4/7/99
CHECKED	HARRY SALAZAR	-
ENGR.	W. O. MILLER	-
APPROVED	-	-

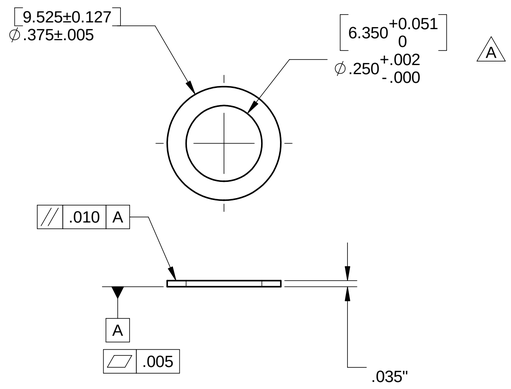
HYTEC, INC

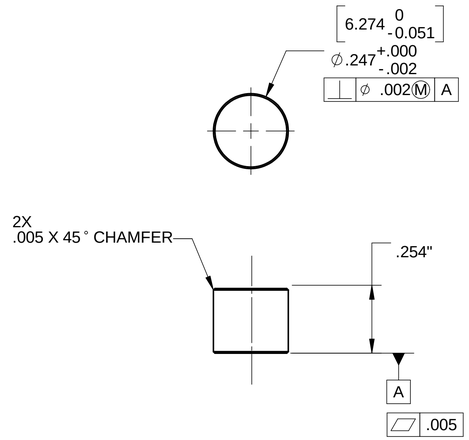
TITLE
ATLAS DOE SBIR
SECTOR COOLING TUBE

DWG. NO. HYT-ATLAS-0052 | SIZE D | SHEET NO. 1 of 1

SCALE 3/2 | REVISION A

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	SEE ECN HYT-ATLAS-0053-A FOR CHANGES	4/20/99	WKM





-1 WASHER
P.N. HYT-ATLAS-0053-1
MATL: CARBON CARBON

-3 CYLINDRICAL INSERT
P.N. HYT-ATLAS-0053-3
MATL: CARBON CARBON

Ⓐ

NOTES: UNLESS OTHERWISE SPECIFIED

1. BOTTOM DIMENSIONS IN INCHES; TOP DIMENSIONS IN MM
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. PARTS TO BE THOROUGHLY CLEANED TO REMOVE ALL OIL, GREASE, DIRT AND CHIPS

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
-TOLERANCES-

DECIMALS
.XX = +/- .03
.XXX = +/- .005

ANGULAR = +/- 30'

SURFACE FINISH = 250

CAD GENERATED DRAWING,
DO NOT MANUALLY UPDATE
DO NOT SCALE DRAWING

FINISH

PART NO.
HYT-ATLAS-0053

	SIGNATURE	DATE
DESIGNED	W. K. MILLER	4/7/99
DRAWN	W. K. MILLER	4/7/99
CHECKED	HARRY SALAZAR	-
ENGR.	W. O. MILLER	-
APPROVED	-	-

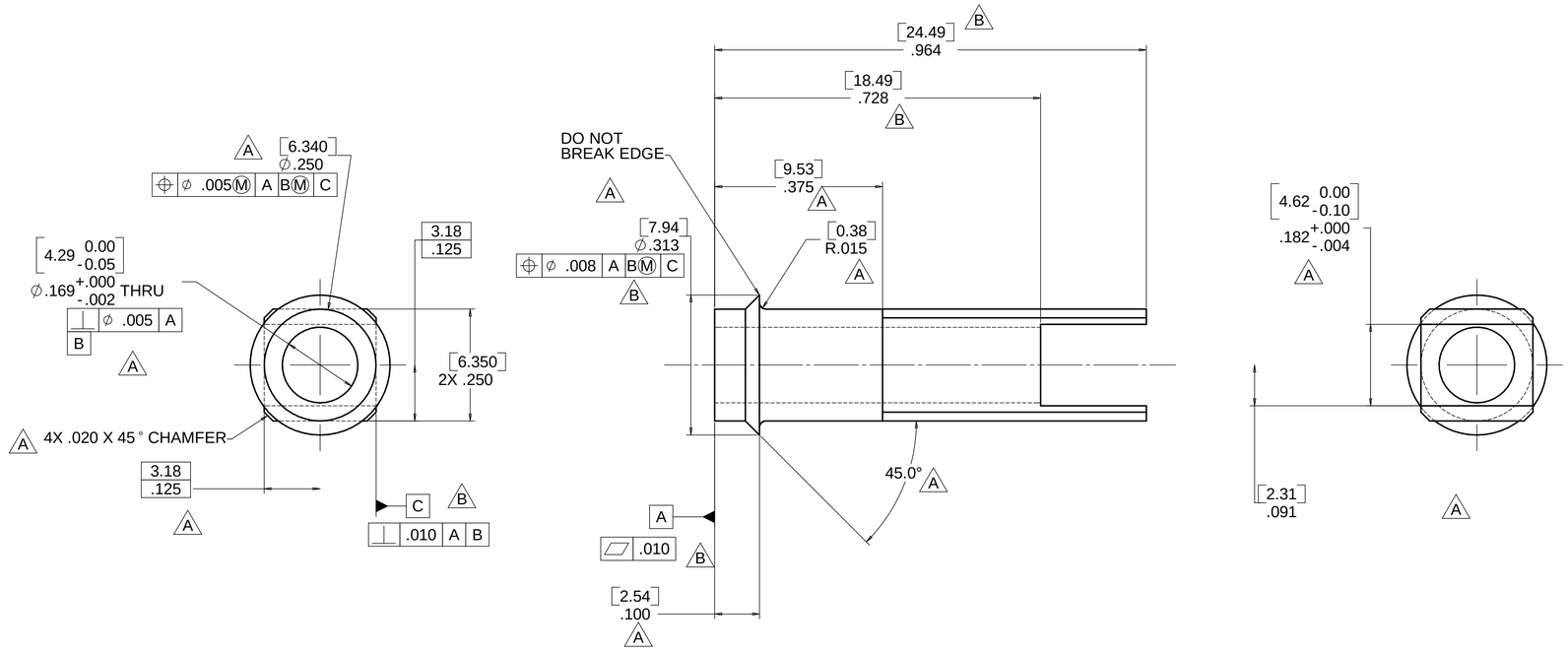
HYTEC, INC

TITLE
ATLAS DOE SBIR
SECTOR MOUNTING PARTS

DWG. NO. HYT-ATLAS-0053 | SIZE D | SHEET NO. 1 of 1

SCALE 4/1 | REVISION A

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	SEE ECN HYT-ATLAS-0017-A FOR CHANGES	4/13/99	WKM
B	SEE ECN HYT-ATLAS-0017-B FOR CHANGES	4/20/99	WKM



MATERIAL: 6061-T6 ALUM.

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN INCHES
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. REMOVE ALL BURRS AND BREAK SHARP EDGES TO A MAXIMUM OF .015
5. ALL INSIDE CORNERS TO BE .015 RADIUS MAX
6. COUNTERSINK 82 DEGREES ALL TAPPED HOLES TO MAJOR DIAMETER
7. COUNTERSINK 82 DEGREES APPROXIMATELY .015 DEEP ALL DRILLED HOLES
8. PARTS TO BE THOROUGHLY CLEANED TO REMOVE ALL OIL, GREASE, DIRT AND CHIPS
9. INSPECTION REPORTS TO BE PROVIDED.

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
-TOLERANCES-

DECIMALS
.XX = +/- .03
.XXX = +/- .010

ANGULAR = +/- 30'

SURFACE FINISH = 250

FINISH

PART NO.
HYT-ATLAS-0017

CAD GENERATED DRAWING,
DO NOT MANUALLY UPDATE
DO NOT SCALE DRAWING

	SIGNATURE	DATE
DESIGNED	ROGER L. SMITH	1-15-99
DRAWN	ROGER L. SMITH	1-15-99
CHECKED	W.O. MILLER	1-15-99
ENGR.	W. O. MILLER	1-15-99
APPROVED	W. O. MILLER	1-15-99

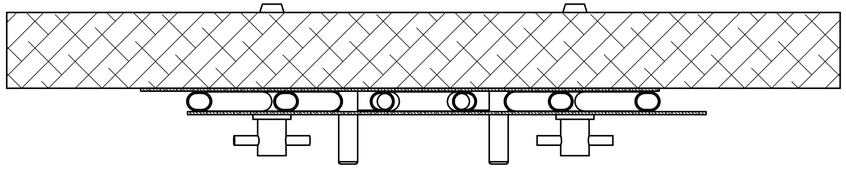
HYTEC, INC

TITLE
ATLAS
SBIR SECTOR
COOLING TUBE
REINFORCEMENT

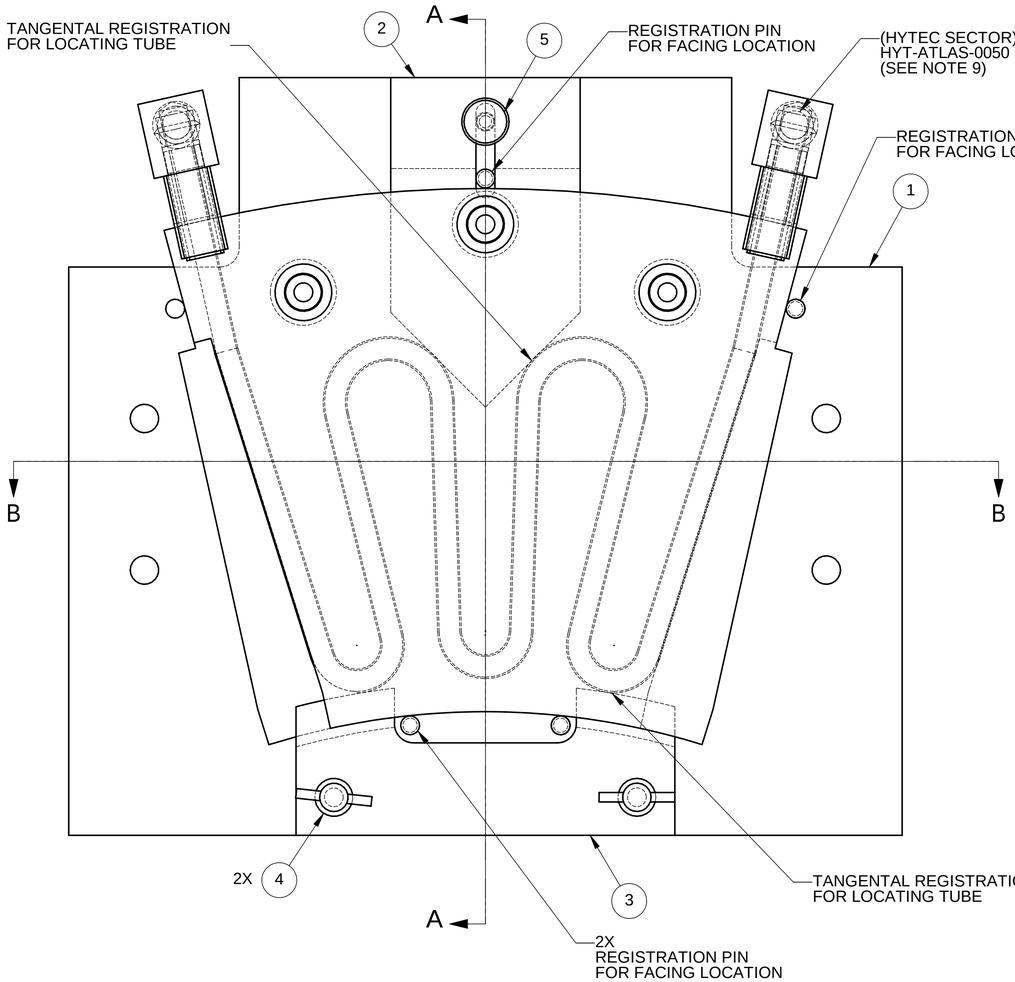
DWG. NO. HYT-ATLAS-0017 | SIZE D | SHEET NO. 1 of 1

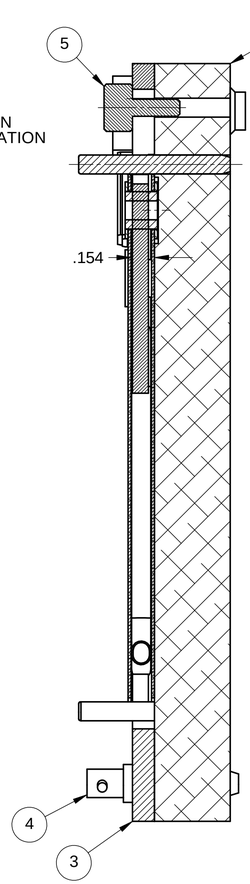
SCALE 6/1 | REVISION B

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED

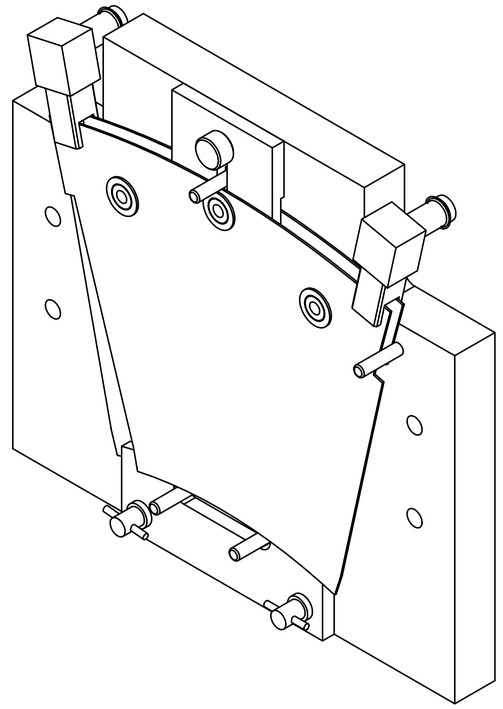


SECTION B-B
SCALE 2 : 1





SECTION A-A
SCALE 2 : 1



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN INCHES
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. REMOVE ALL BURRS AND BREAK SHARP EDGES TO A MAXIMUM OF .015
5. ALL INSIDE CORNERS TO BE .015 RADIUS MAX
6. COUNTERSINK 82 DEGREES ALL TAPPED HOLES TO MAJOR DIAMETER
7. COUNTERSINK 82 DEGREES APPROXIMATELY .015 DEEP ALL DRILLED HOLES
8. PARTS TO BE THOROUGHLY CLEANED TO REMOVE ALL OIL, GREASE, DIRT AND CHIPS
9. HYTEC SECTOR SHOWN FULLY ASSEMBLED
10. COVERPLATE NOT SHOWN
11. PIN DIA. IS .1875 +0/-.0003.

ITEM NO.	QTY.	PART NO.	DESCRIPTION
1	1	ATLAS-FXT-0021-1	SECTOR FAB. JIG BASEPLATE
2	1	ATLAS-FXT-0022-1	SECTOR FAB. JIG TUBE CENTERING JIG
3	1	ATLAS-FXT-0022-3	SECTOR FAB. TANGENT LOCATOR JIG
4	2	McMASTER #98405A006	.188 DIA. LOCATING PIN (SEE NOTE 11)
5	1	McMASTER #91746A113	#4-40 UNC THUMB SCREW
6	1	ATLAS-FXT-0021-3	SECTOR FAB. JIG COVERPLATE (SEE NOTE 10)

PARTS LIST

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-TOLERANCES-

DECIMALS
.XX = +/- .03
.XXX = +/- .010

ANGULAR = +/- 30'

SURFACE FINISH = 250

CAD GENERATED DRAWING,
DO NOT MANUALLY UPDATE
DO NOT SCALE DRAWING

FINISH

PART NO.
ATLAS-FXT-0020-1

	SIGNATURE	DATE
DESIGNED	W. K. MILLER	5/14/99
DRAWN	W. K. MILLER	5/14/99
CHECKED	HARRY SALAZAR	-
ENGR.	W. O. MILLER	-
APPROVED	-	-

HYTEC, INC

TITLE
ATLAS DOE SBIR
SECTOR FABRICATION
JIG ASSEMBLY

DWG. NO. ATLAS-FXT-0020
SIZE D
SHEET NO. 1 of 1

SCALE 1/1
REVISION