LA-14347

Solid Explosive Plane-Wave Lenses Pressed-to-Shape with Dies

Los Alamos
NATIONAL LABORATORY
EST. 1943

This work was supported by the United States Department of Energy, National Nuclear Security Administration, Campaign 2 Dynamic Materials Properties Program.

Edited by Mable Amador, Group IRM-CAS.
Photocomposition by Deidré A. Plumlee, Group IRM-CAS.

LA-14347
Issued: November 2007

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B. Olinger

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PLANE-WAVE LENSES PRESSED-TO-SHAPE WITH DIES

by
Bart Olinger

ABSTRACT

Solid-explosive plane-wave lenses 1", 2" and 4¼" in diameter have been mass-produced from components pressed-to-shape with aluminum dies. The method used to calculate the contour between the solid plane-wave lens components pressed-to-shape with the dies is explained. The steps taken to press, machine, and assemble the lenses are described. The method of testing the lenses, the results of those tests, and the corrections to the dies are reviewed. The work on the ½", 8", and 12" diameter lenses is also discussed.

INTRODUCTION

Most shock and detonation waves used in physics and engineering experiments are unidirectional and planar in order to avoid divergent effects. This is achieved by planar initiation of the explosive that generates the detonation wave. The most practical planar initiators are solid explosive plane-wave lenses because of the quality of their planar simultaneity, and that they can be manufactured in mass and stored for long periods.

CALCULATING THE INTERFACE SURFACES

If an explosive is initiated at a point, the explosive reaction, or detonation, propagates spherically from that point. If a cone of slower detonating explosive is overlaid with a coating of faster detonating explosive so that the detonation down the surface of the cone reaches its base at the same time as the detonation down the axis of the cone, then a planar detonation wave will propagate along that axis. The length of the sides of the cone are proportional to the detonation velocity of the fast-detonating explosive, V_f, and the height of the cone is proportional to the detonation velocity of the slow-detonating explosive, V_s. This is the basic concept of the solid explosive plane-wave lens.

In Figure 1, the initiation occurs at the apex. Using cylindrical coordinates, the planar detonation front reaches a depth of Z_d for all values of the radius at the same time, t_d. The coordinates of the interface between the fast detonating explosive and the slow are $Z_c(r)$ and r. Therefore,

$$t_d = \frac{\left[Z_c(r)^2 + r^2 \right]^{1/2}}{V_f} + \frac{\left[Z_d - Z_c(r) \right]}{V_s}. \qquad (1)$$

Solving for $Z_c(r)$,

$$Z_c(r) = Z_d - \left(\frac{V_s}{V_f^{\,2} - V_s^{\,2}}\right) \times \left(V_f^{\,2} \times t_d - V_s \times Z_d - \left[V_f^{\,2} \times \left\{Z_d^{\,2} - 2V_s \times Z_d \times t_d + V_s^{\,2} \times t_d^{\,2}\right\} + r^2 \times \left\{V_f^{\,2} - V_s^{\,2}\right\}\right]^{1/2}\right). \tag{2}$$

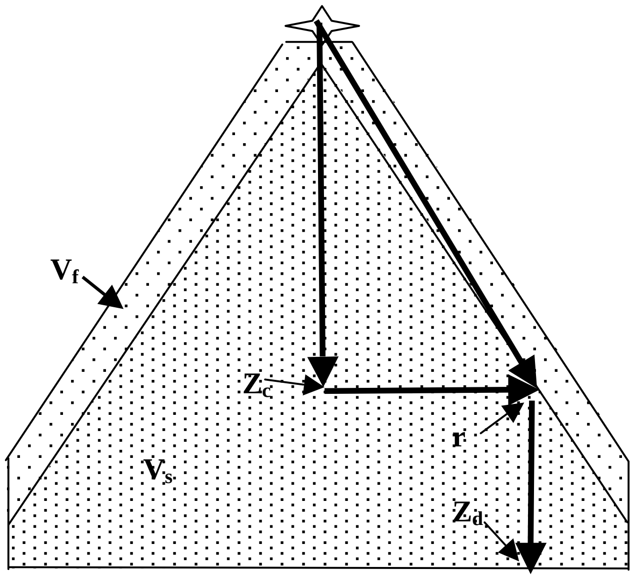

Figure 1. The initiation of the plane-wave lens is in the detonator above the explosive. The detonation front reaches Z_d by traveling through a fast detonating explosive a distance of $(Z_c^{\,2} + r^2)^{1/2}$ at velocity V_f and then by traveling through the slow detonating explosive a distance of $(Z_d - Z_c)$ at velocity V_s. The total times required to reach Z_d for all values of r are the same, t_d.

The depth of the interface, $Z_c\,(r)$, is found for all values of r to the maximum r of interest. The depth or thickness of fast-detonating explosive above the slow at the apex is determined by the choices of Z_d and t_d along the axis. The aspect ratio of lens is determined by V_f and V_s.

PBX 9501 and TNT are the fast and slow detonating explosives currently used for the manufacture of plane-wave lenses. Because TNT is a single component explosive and the quality control for the production of PBX 9501 is tightly controlled, their detonation velocities depend only on their compacted densities.

$$V_{f\ (PBX9501)} = 1.88 + 3.76\rho \text{ mm/}\mu\text{s}, \tag{3}$$

$$V_{s\ (TNT)} = 1.88 + 3.76\rho \text{ mm/}\mu\text{s}. \tag{4}$$

The standard densities for pressed PBX 9501 and TNT are 1.83 g/cm^3 (8.76 mm/μs) and 1.64 g/cm^3 (6.94 mm/μs), respectively. The detonator currently used for plane-wave lens production is the SE-1, or the commercially available RP-1. This detonator has an apparent center-of-initiation 7.2 mm above its face when the detonation wave is measured at some depth in PBX 9501. Because the face of the detonator is usually set 10 mm above the slow detonating component apex on the fast in order to smooth out detonation wave irregularities caused by the detonator, the value of $Z_c (r = 0)$ becomes 17.2 mm.

PRESSING, MACHINING, AND ASSEMBLY

The steel-die press cylindrical diameters available are 1", 1⅝", 2", 2½", and 3" (Savage press), and 4¼", 6", 8", 10", and 12" (Accudyne press). We selected the 4¼" diameter for the initial lens. Dies were machined based on the contours calculated using equation 2 above, the components pressed and assembled, and the lens was tested for simultaneity. (PowerPoint presentation, about Sept. 2005, titled Planarity Measurements of Pressed, High-Explosive Lenses, by Russ Olson, et al.) Based on those results the 4¼" diameter lens dies were corrected and 1", 2", and 4¼" diameter lens dies were machined based on that correction. The tests of the lenses made with these dies and their corrections are now discussed.

The dies consist of convex and concave mandrels machined from 7075 aluminum. The explosive TNT components are pressed using flaked TNT, heated to 65°C, and compacted at 5,000 psi for 5 min., using the concave mandrel. The concave surface is the contour between the faster and slower detonating explosives first calculated and then corrected. The PBX 9501 components were pressed from the stock of PBX 9501 maintained at the Laboratory, heated to 90°C, and compacted twice at 20,000 psi for 5 min. with a brief rest between using the convex mandrel. The concave and convex surfaces have the same contour, line-to-line. Those contours used for the 1", 2" and 4¼" lenses are listed in the "Old" column in the table at the end of this report. The outer conical surface of the PBX 9501 is formed at the same time with a second concave mandrel used with the convex mandrel.

Next, the pressed TNT components' faces are machined flat and perpendicular to their axes using pot chucks machined to match the TNT components contoured surfaces. The components are also machined to specified heights. Those heights are measured and recorded.

The next step is to bond the PBX 9501 and TNT components together. The contour surfaces are first cleaned with isopropyl alcohol. The PBX 9501 components are then inverted and set in cardboard tube pedestals. Their concave contoured surfaces are thinly painted with Aralhex adhesive. The TNT components' convex contoured surfaces are inserted into the PBX 9501 components. Padded weights are placed on the TNT faces until the adhesive sets, after 12 hours. The weights used are 250 g, 1 kg, and 4 kg Cu cylinders for the 1", 2", and 4¼" diameter lenses.

The final step is to machine a surface flat-and-parallel to the TNT face 1 cm above the apex of the slow component whose height was recorded. This surface is for mounting a detonator locator using Aralhex adhesive. The locator must be precisely centered on the lenses' axes. Diagrams of the three assembled lenses are attached.

TESTING AND CORRECTING

Lenses are tested at Chamber 8, TA-40, DE-9. The 1", 2" and 4¼" lenses were bonded to plate glass with 3-mil shim stock sandwiched between. The air gap flashes when the detonation wave arrives at the surface of the lens. A set of slits are placed across the image of the explosive lens face and a Cordin camera sweeps that slit image over the recording film at 12 mm/μs.

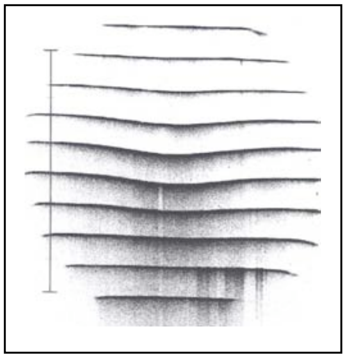

Figure 2. Slit image of a 1" lens. Scale on the left is 12 mm.

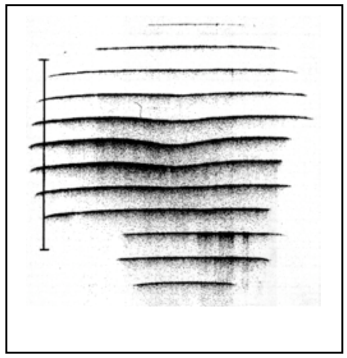

Figure 3. Slit image of a 2" lens. Scale on the left is 12 mm.

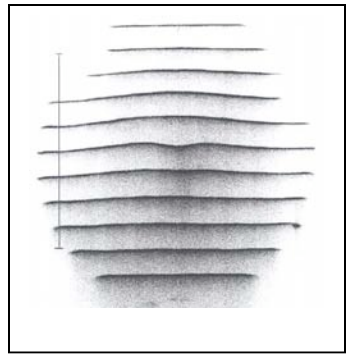

Figure 4. Slit image of a 4¼" lens. Scale on the left is 12 mm.

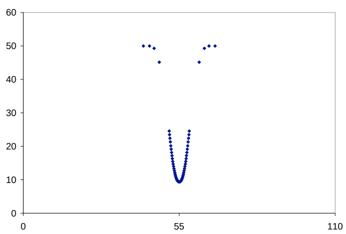

Figure 5. Time of arrival of the detonation wave for the 1" lens. The vertical scale is ns, the horizontal is mm.

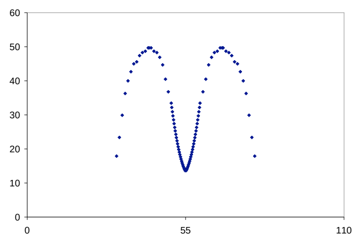

Figure 6. Time of arrival of the detonation wave for the 2" lens. The vertical scale is ns, the horizontal is mm.

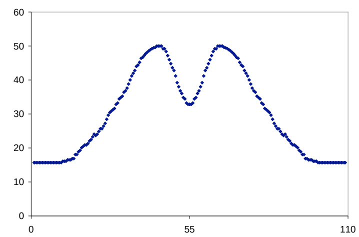

Figure 7. Time of arrival of the detonation wave for the 4¼" lens. The vertical scale is ns, the horizontal is mm.

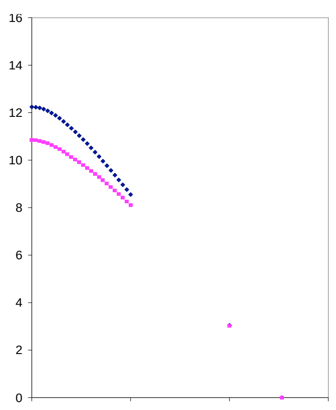

Figure 8. Contour for 1" explosive lens dies. Dark blue is the original contour, pink is the corrected. The vertical axis is the axis of the contour in mm; the horizontal is the contour radius in mm.

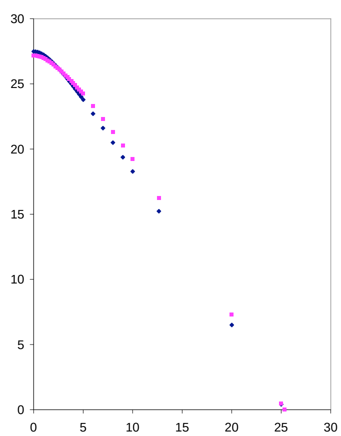

Figure 9. Contour for 2" explosive lens dies. Dark blue is the original contour, pink is the corrected. The vertical axis is the axis of the contour in mm; the horizontal is the contour radius in mm.

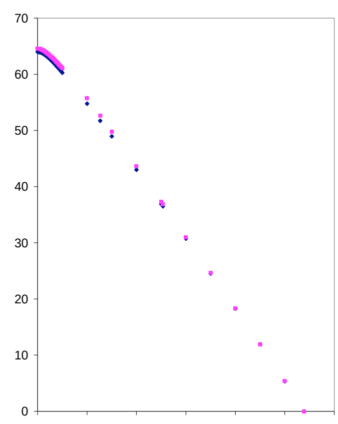

Figure 10. Contour for 4¼" explosive lens dies. Dark blue is the original contour, pink is the corrected. The vertical axis is the axis of the contour in mm; the horizontal is the contour radius in mm.

Figures 2, 3, and 4 are the slit images from a 1", 2" and 4¼" lenses. Two lenses of each size were tested and they were reproducible. Group DE-9 normally analyzes the slit images, but at this time they are developing new software and training a new analyzer. While waiting for their analyses, I blew-up the film images with a microfiche printer and read the central lines with an eye-loupe with an internal scale. During the shot setup, no effort was made to place the central slit on the diameter; therefore, the results are not the true maxima.

In Figures 5, 6, and 7 are plotted the times of arrival of the detonation fronts as a function of the diameter position centered at 55 mm. The initial arrivals are plotted at 50 ns. All three lens sizes were based on the same contour, for the 4¼" lens, therefore, the deviations display the same pattern. The first arrival for all three lens sizes occurs at a radius of about ½" or 12.7 mm. The center of the lens lags behind the first arrival by 40 ns (1"), 37 ns (2"), and 17 ns (4¼"). These data are the deviations from simultaneity, Δt_d, as a function of the radius, r, of the lenses.

Differentiating $Z_c(r)$ with respect to t_d in Equation 2, deviations from the interface that will create a simultaneous detonation wave as a function of the radius can be calculated,

$$\Delta Z_c\left(r\right) = \Delta t_d\left(r\right) \div \left[\frac{1}{V_f} \times \left\{ \frac{Z_c\left(r\right)}{\left[Z_c\left(r\right)^2 + r^2 \right]^{1/2}} \right\} - \frac{1}{V_s} \right]. \qquad (5)$$

These deviations are now used to adjust the interface for the final lens design. Figures 8, 9, and 10 show the corrected contours. The corrected contours are listed in the "New" column in the table below.

THE ½", 8", AND 12" DIAMETER LENSES

Dies for a 1" diameter lenses initiated with RP-3 detonators (the P-25B drawings) were also made. The lenses have 2 mm, rather than 10 mm, of PBX 9501 between the detonator platform and the top of the slow component. Lens components made from these dies were pressed and assembled. The detonator locator for the RP-3 was then attached. The lenses were then reduced in height to 0.45" and in diameter to 0.75", producing a ½" diameter lens. This lens is to be test-fired at Chamber 8.

The 8"-diameter dies were used to press PBX 9501 and TNT components. The TNT components cracked parallel to the flat base. The problem appears to be that the pressure used was too high. Before we could press additional components at lower pressure, the HE pressing facility was closed. The new press, the Accudyne, will begin operation in early 2008. Attempts at pressing the 12" components were postponed until successful 8" components were produced.

DRAWINGS

Engineering drawings of the dies, the pot chucks, and the finished lenses, both tested and not yet tested, are appended to this report.

ACKNOWLEDGEMENTS

Tim Cash, PF-TDI, LANL, created the engineering drawings of the dies and pot chucks. Steve Rivera created the engineering drawings of the lenses. John Morris, Larry, Vaughan, and Bob Meir set up and fired the lens tests with the Cordin sweep camera at the enclosed firing chamber of DE-9, LANL. They were mentored by Larry Hill of the same group. This research is funded by the HE Science Project led by Dan Hooks, DE-9, under LANL's NNSA Campaign 2 Dynamic Materials Properties Program, David J. Funk, DE-DO, Program Manager.

Old and New Contours of the Dies for the 1", 2" and 4¼" Lenses

1" lens		
Old	New	
X	X	Y
mm	mm	mm
12.245	10.852	0.000
12.234	10.841	0.200
12.203	10.814	0.400
12.151	10.770	0.600
12.079	10.711	0.800
11.991	10.640	1.000
11.886	10.556	1.200
11.767	10.462	1.400
11.635	10.359	1.600
11.492	10.248	1.800
11.344	10.137	2.000
11.194	10.027	2.200
11.035	9.911	2.400
10.870	9.793	2.600
10.698	9.671	2.800
10.520	9.547	3.000
10.338	9.421	3.200
10.152	9.295	3.400
9.961	9.155	3.600
9.768	9.016	3.800
9.571	8.872	4.000
9.372	8.726	4.200
9.170	8.574	4.400
8.966	8.420	4.600
8.761	8.262	4.800
8.553	8.099	5.000
3.043	3.031	10.000
0.000	0.000	12.650

2" Lens		
Old	New	
X	X	Y
mm	mm	mm
27.486	27.163	0.000
27.475	27.163	0.200
27.444	27.146	0.400
27.392	27.110	0.600
27.320	27.056	0.800
27.232	26.988	1.000
27.127	26.905	1.200
27.008	26.809	1.400
26.876	26.703	1.600
26.733	26.587	1.800
26.585	26.468	2.000
26.435	26.348	2.200
26.276	26.220	2.400
26.111	26.088	2.600
25.939	25.950	2.800
25.761	25.807	3.000
25.579	25.662	3.200
25.393	25.513	3.400
25.202	25.360	3.600
25.009	25.207	3.800
24.812	25.050	4.000
24.613	24.892	4.200
24.411	24.732	4.400
24.207	24.571	4.600
24.002	24.410	4.800
23.794	24.246	5.000
22.715	23.288	6.000
21.608	22.306	7.000
20.494	21.325	8.000
19.372	20.273	9.000
18.284	19.230	10.000
15.231	16.226	12.650
6.503	7.288	20.000
0.412	0.476	25.000
0.000	0.000	25.336

4¼" Lens		
Old	New	
X	X	Y
mm	mm	mm
63.985	64.569	0.000
63.974	64.561	0.200
63.943	64.534	0.400
63.891	64.485	0.600
63.819	64.418	0.800
63.731	64.334	1.000
63.626	64.235	1.200
63.507	64.121	1.400
63.375	63.995	1.600
63.232	63.859	1.800
63.084	63.718	2.000
62.934	63.575	2.200
62.775	63.424	2.400
62.610	63.267	2.600
62.438	63.104	2.800
62.260	62.935	3.000
62.078	62.763	3.200
61.892	62.587	3.400
61.701	62.407	3.600
61.508	62.225	3.800
61.311	62.040	4.000
61.112	61.853	4.200
60.910	61.664	4.400
60.706	61.473	4.600
60.501	61.282	4.800
60.293	61.088	5.000
54.783	55.710	10.000
51.730	52.604	12.650
48.976	49.779	15.000
43.002	43.602	20.000
36.911	37.313	25.000
36.499	36.889	25.336
30.747	30.990	30.000
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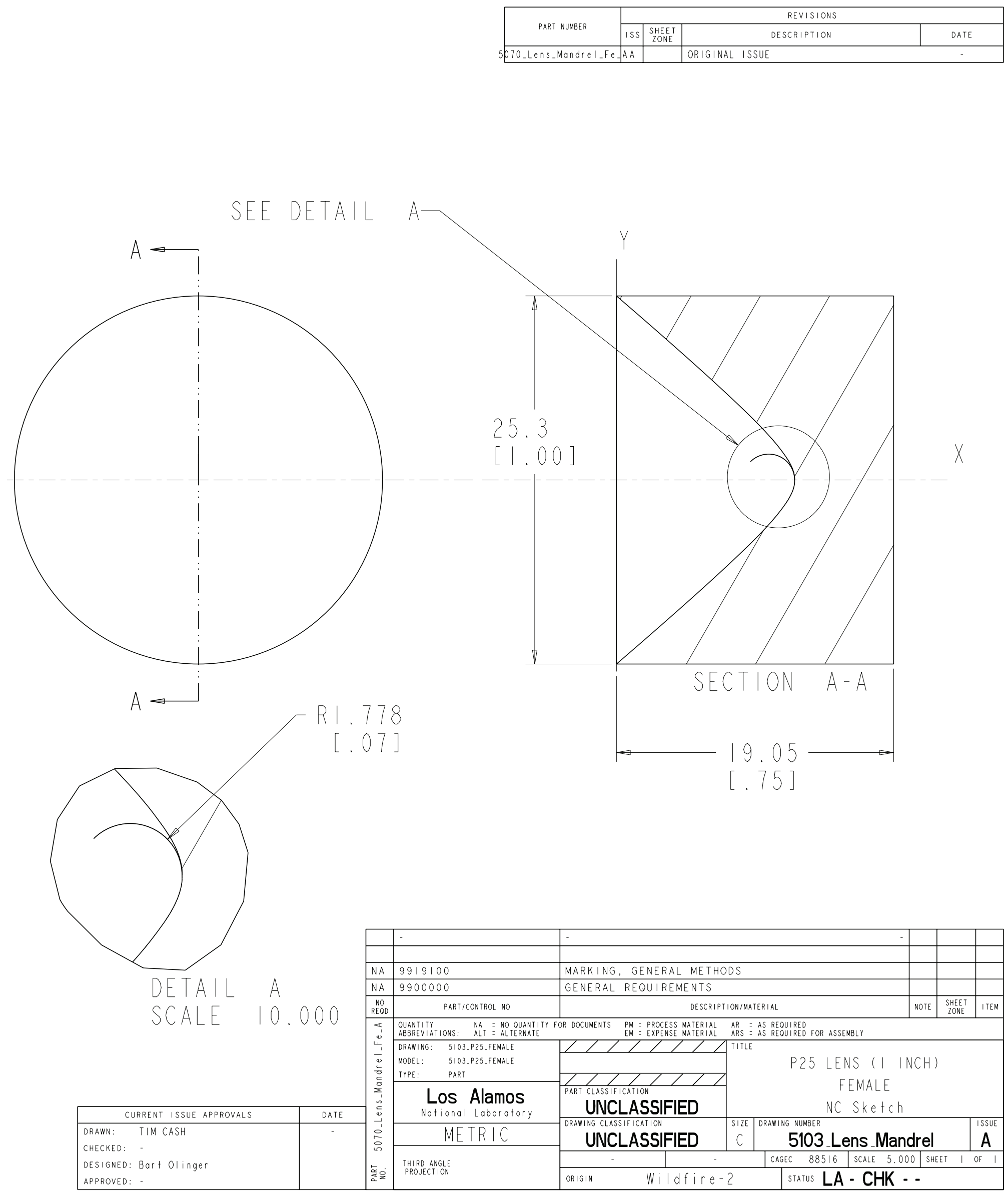

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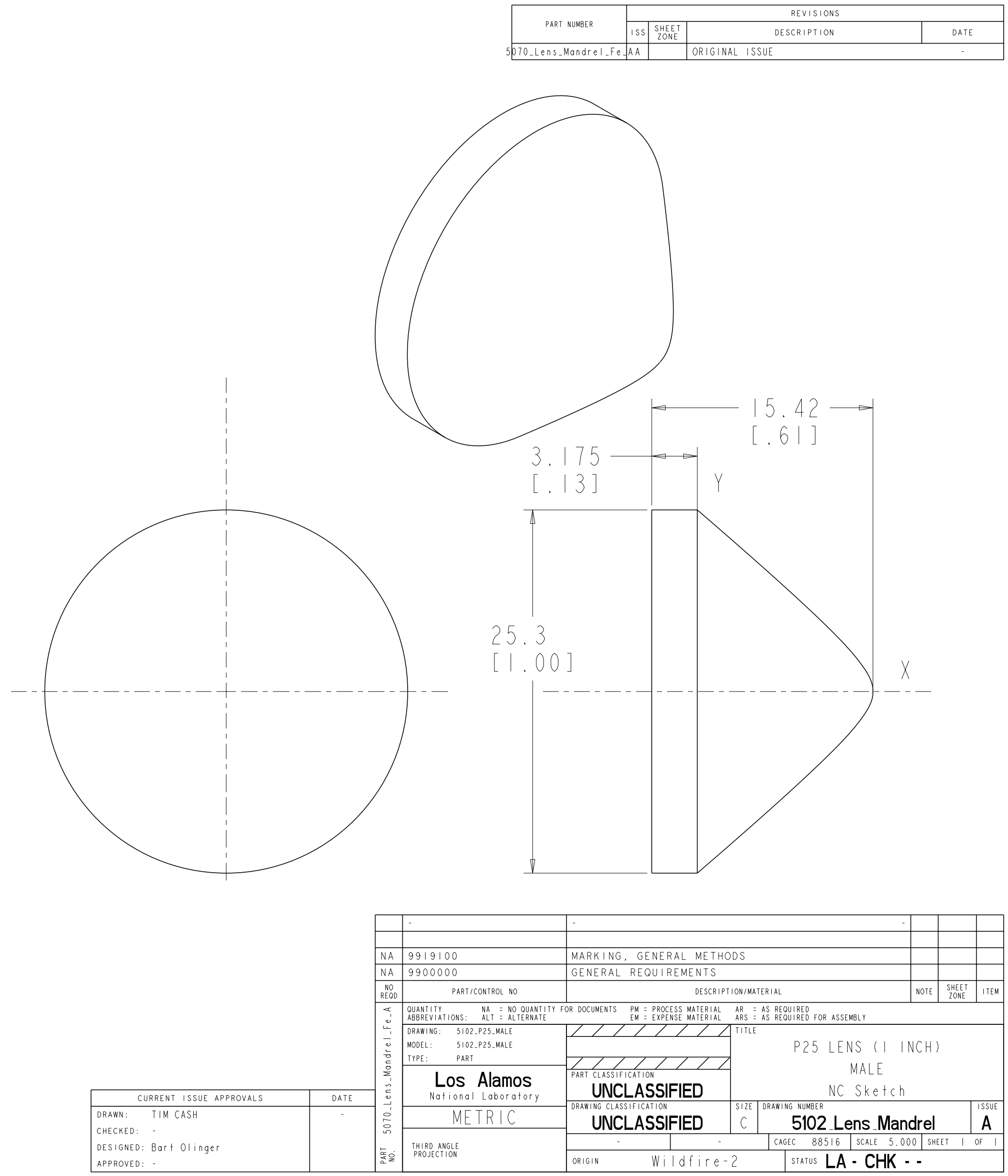

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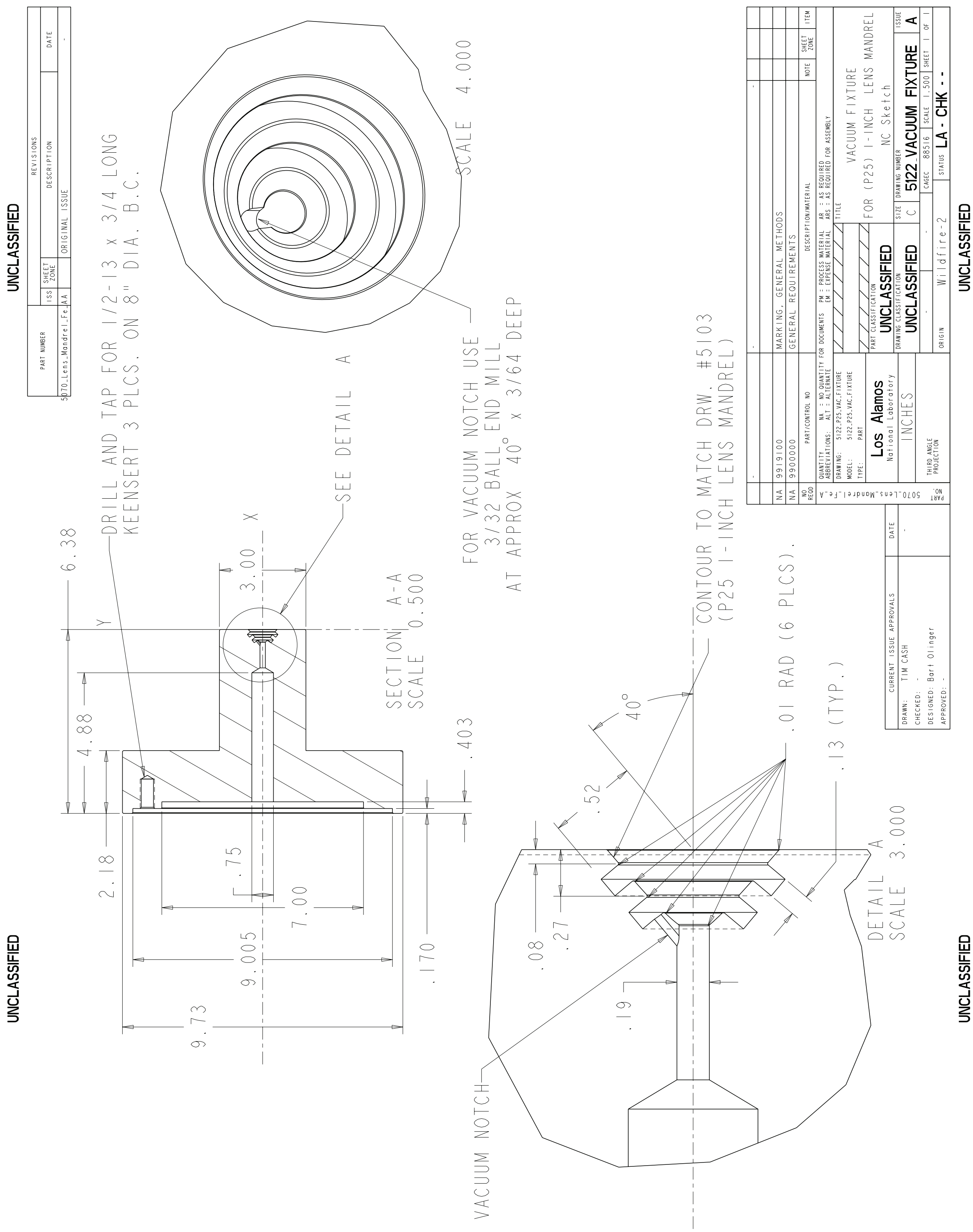

PTS-P25-VACFIX-#5122

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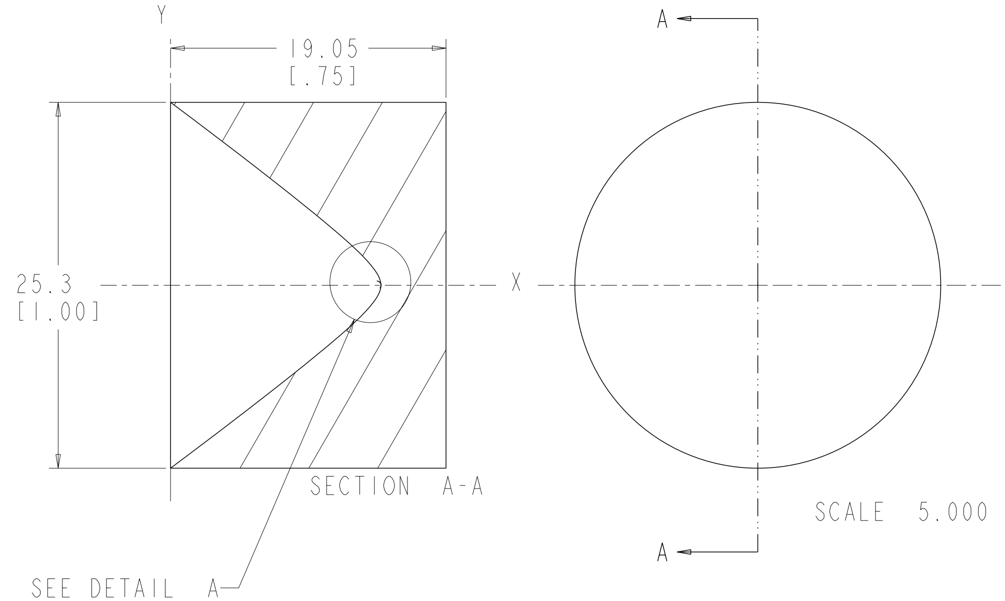

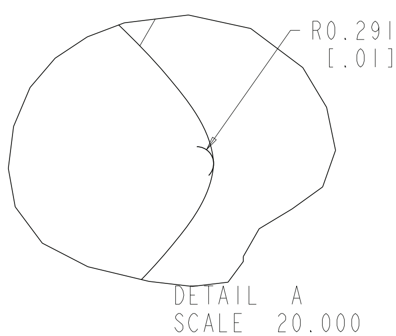

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CHECKED: -	
DESIGNED: Bart Olinger	
APPROVED: -	

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MODEL: 5075_P25B_FEMALE
TYPE: PART

Los Alamos
National Laboratory
METRIC
THIRD ANGLE PROJECTION
PART NO. 5070_Lens_Mandrel_Fe_A

PART CLASSIFICATION UNCLASSIFIED
DRAWING CLASSIFICATION UNCLASSIFIED

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FEMALE
NC Sketch

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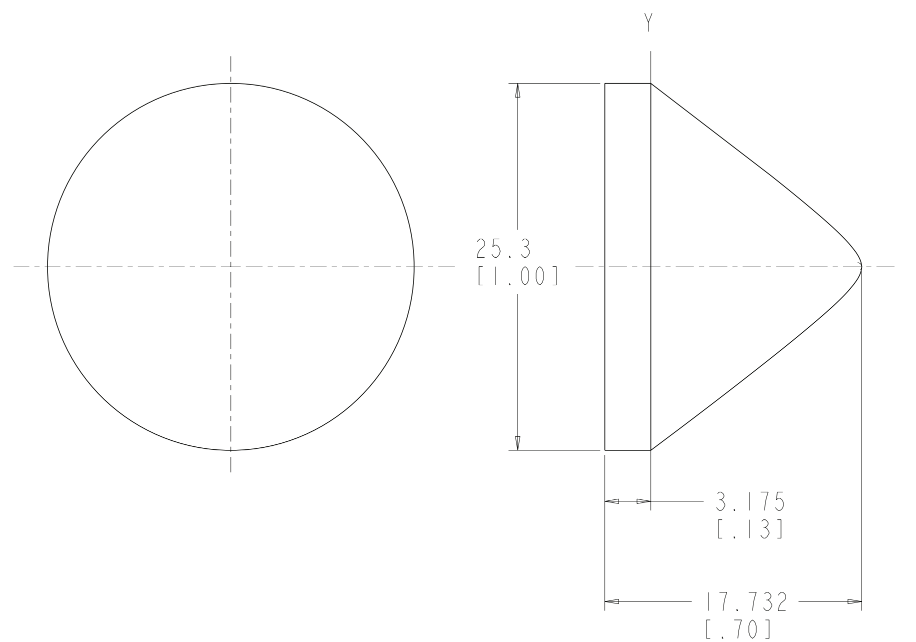
14.46377	0.4395397	0
14.40265	0.5844408	0
14.32971	0.7287077	0
14.24421	0.8723007	0
14.14837	1.015339	0
14.04292	1.157861	0
13.92935	1.299948	0
13.81208	1.441836	0
13.69334	1.583646	0
13.56794	1.725098	0
13.43812	1.866312	0
13.30312	2.007249	0
13.16369	2.147949	0
13.0213	2.288489	0
12.87596	2.428871	0
12.72693	2.569055	0
12.57641	2.70916	0
12.42295	2.849106	0
12.268	2.988972	0
12.11084	3.12872	0
11.9522	3.268389	0
11.79282	3.408018	0
11.63123	3.547527	0
7.362366	7.022987	0
5.001832	8.859721	0
2.874085	10.48667	0
0	12.65	0



CURRENT ISSUE APPROVALS	DATE
DRAWN: TIM CASH	-
CHECKED: -	
DESIGNED: Bart Olinger	
APPROVED: -	

NO REQD	PART/CONTROL NO	DESCRIPTION/MATERIAL	NOTE	SHEET ZONE	ITEM
	-	-			
NA	9919100	MARKING, GENERAL METHODS			
NA	9900000	GENERAL REQUIREMENTS			

QUANTITY ABBREVIATIONS: NA : NO QUANTITY FOR DOCUMENTS; ALT : ALTERNATE; PM : PROCESS MATERIAL; EM : EXPENSE MATERIAL; AR : AS REQUIRED; ARS : AS REQUIRED FOR ASSEMBLY

PART NO. 5070_Lens_Mandrel_Fe_A

DRAWING: 5074_P25B_MALE
MODEL: 5074_P25B_MALE
TYPE: PART

Los Alamos National Laboratory

METRIC

THIRD ANGLE PROJECTION

PART CLASSIFICATION: UNCLASSIFIED

DRAWING CLASSIFICATION: UNCLASSIFIED

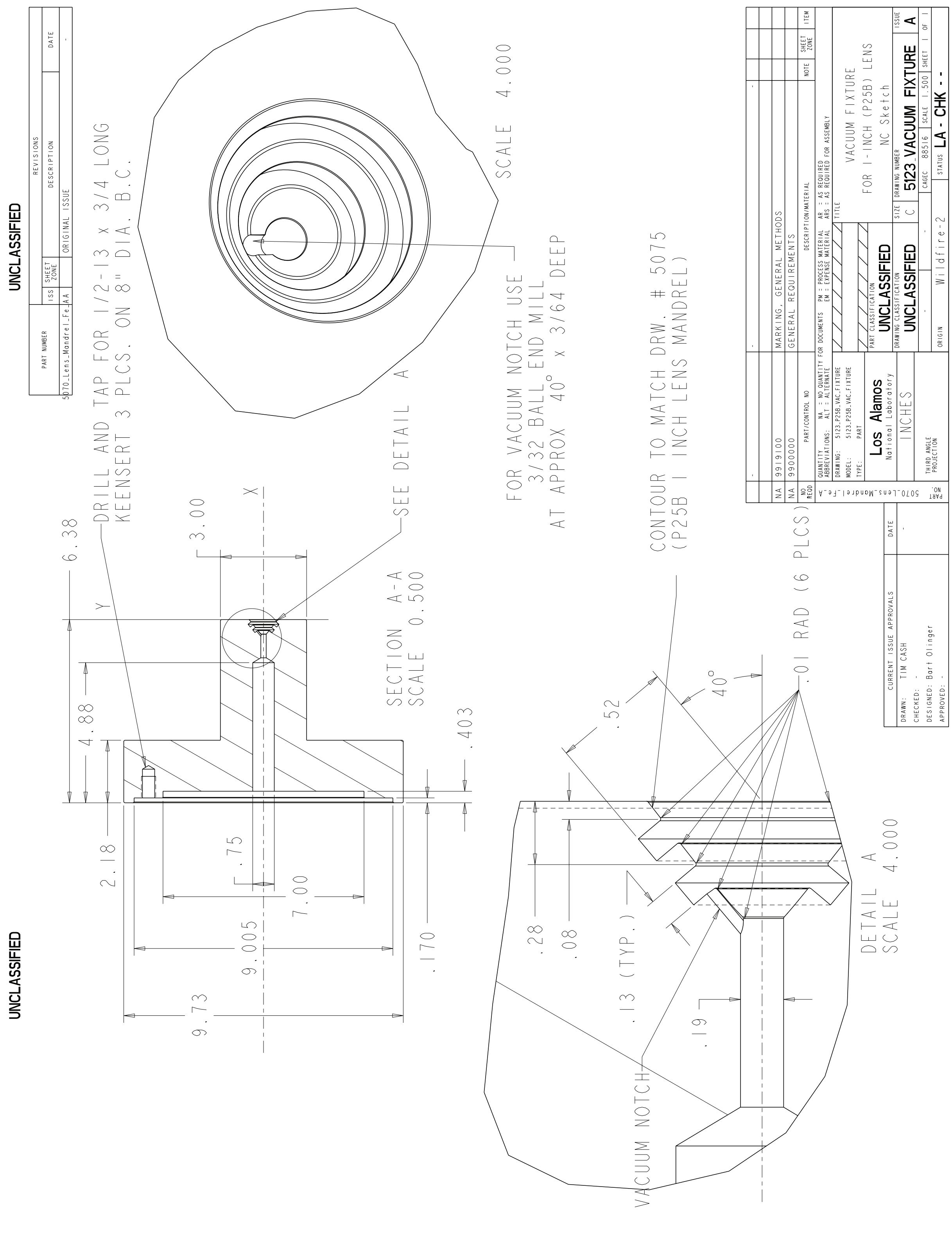
TITLE: P25B LENS (1 INCH) MALE NC Sketch

SIZE: C — DRAWING NUMBER: 5074_Lens_Mandrel — ISSUE: A

CAGEC 88516 — SCALE 5.000 — SHEET 1 OF 1

ORIGIN Wildfire-2 — STATUS LA - CHK - -

UNCLASSIFIED



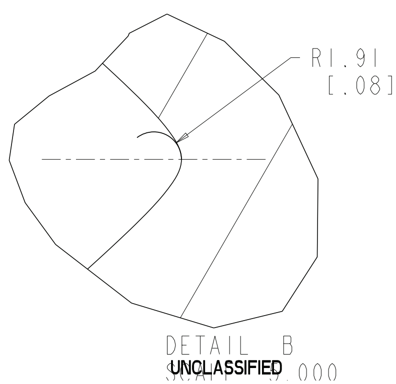
PTS-P25B-VACFIX-#5123

UNCLASSIFIED

Coordinates of spline points:

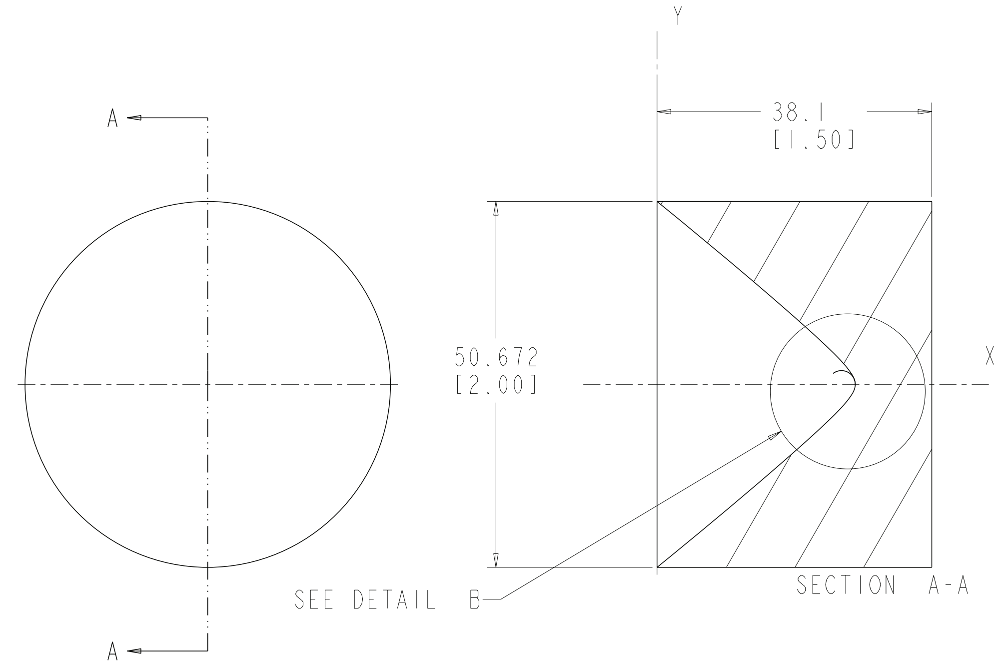
CARTESIAN COORDINATES:

X	Y	Z
27.486	0	0
27.475	0.2	0
27.444	0.4	0
27.392	0.6	0
27.32	0.8	0
27.232	1	0
27.127	1.2	0
27.008	1.4	0
26.876	1.6	0
26.733	1.8	0
26.585	2	0
26.435	2.2	0
26.276	2.4	0
26.111	2.6	0
25.939	2.8	0
25.761	3	0
25.579	3.2	0
25.393	3.4	0
25.202	3.6	0
25.009	3.8	0
24.812	4	0
24.613	4.2	0
24.411	4.4	0
24.207	4.6	0
24.002	4.8	0
23.794	5	0
18.284	10	0
15.231	12.65	0
12.477	15	0
6.503	20	0
0.412	25	0
0	25.336	0



UNCLASSIFIED

PART NUMBER	ISS	SHEET ZONE	DESCRIPTION	DATE
5070_Lens_Mandrel_Fe_A	AA		ORIGINAL ISSUE	-



CURRENT ISSUE APPROVALS	DATE
DRAWN: TIM CASH	-
CHECKED: -	
DESIGNED: Bart Olinger	
APPROVED: -	

NO REQD	PART/CONTROL NO	DESCRIPTION/MATERIAL	NOTE	SHEET ZONE	ITEM
NA	9919100	MARKING, GENERAL METHODS			
NA	9900000	GENERAL REQUIREMENTS			

QUANTITY NA : NO QUANTITY FOR DOCUMENTS PM : PROCESS MATERIAL AR : AS REQUIRED
ABBREVIATIONS: ALT : ALTERNATE EM : EXPENSE MATERIAL ARS : AS REQUIRED FOR ASSEMBLY

DRAWING: 5072_P50_FEMALE
MODEL: 5072_P50_FEMALE
TYPE: PART

Los Alamos National Laboratory

METRIC

THIRD ANGLE PROJECTION

PART NO. 5070_Lens_Mandrel_Fe_A

PART CLASSIFICATION UNCLASSIFIED

DRAWING CLASSIFICATION UNCLASSIFIED

TITLE P50 (2 INCH) LENS FEMALE NC Sketch

SIZE C DRAWING NUMBER 5072_Lens_Mandrel_FE_A ISSUE A

CAGEC 88516 SCALE 2.500 SHEET 1 OF 1

ORIGIN Wildfire-2 STATUS LA - CHK - -

UNCLASSIFIED

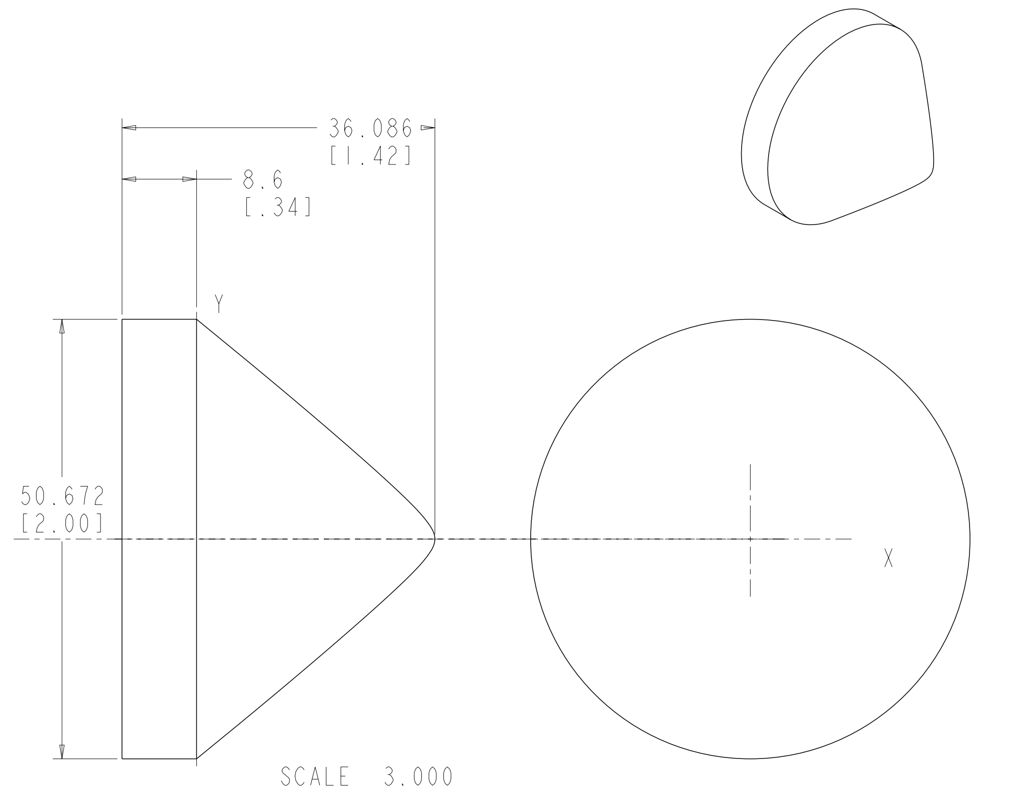
UNCLASSIFIED

PART NUMBER	ISS	SHEET ZONE	REVISIONS DESCRIPTION	DATE
5070_Lens_Mandrel_Fe_A	A		ORIGINAL ISSUE	-

Coordinates of spline points:

CARTESIAN COORDINATES:

X	Y	Z
27.486	0	0
27.475	0.2	0
27.444	0.4	0
27.392	0.6	0
27.32	0.8	0
27.232	1	0
27.127	1.2	0
27.008	1.4	0
26.876	1.6	0
26.733	1.8	0
26.585	2	0
26.435	2.2	0
26.276	2.4	0
26.111	2.6	0
25.939	2.8	0
25.761	3	0
25.579	3.2	0
25.393	3.4	0
25.202	3.6	0
25.009	3.8	0
24.812	4	0
24.613	4.2	0
24.411	4.4	0
24.207	4.6	0
24.002	4.8	0
23.794	5	0
18.284	10	0
15.231	12.65	0
12.477	15	0
6.503	20	0
0.412	25	0
0	25.336	0



NO REQD	PART/CONTROL NO	DESCRIPTION/MATERIAL	NOTE	SHEET ZONE	ITEM
-	-	-			
NA	9919100	MARKING, GENERAL METHODS			
NA	9900000	GENERAL REQUIREMENTS			

QUANTITY ABBREVIATIONS: NA : NO QUANTITY FOR DOCUMENTS; ALT : ALTERNATE; PM : PROCESS MATERIAL; EM : EXPENSE MATERIAL; AR : AS REQUIRED; ARS : AS REQUIRED FOR ASSEMBLY

CURRENT ISSUE APPROVALS	DATE
DRAWN: TIM CASH	-
CHECKED: -	
DESIGNED: Bart Olinger	
APPROVED: -	

PART NO. 5070_Lens_Mandrel_Fe_A

DRAWING: 5073_P50_MALE
MODEL: 5073_P50_MALE
TYPE: PART

Los Alamos National Laboratory

METRIC

THIRD ANGLE PROJECTION

PART CLASSIFICATION: UNCLASSIFIED

DRAWING CLASSIFICATION: UNCLASSIFIED

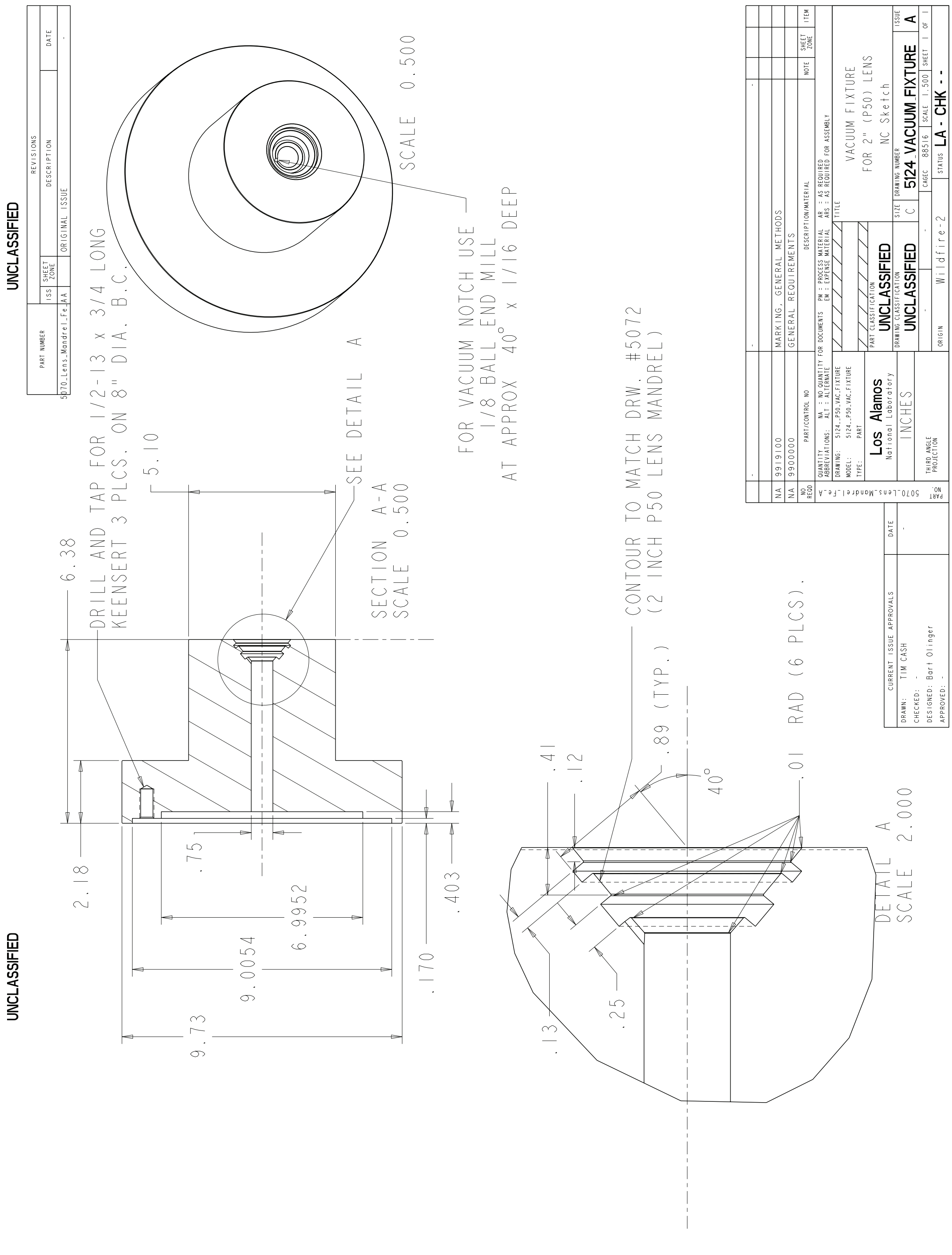
TITLE: P50 (2 INCH) LENS MALE NC Sketch

SIZE: C | DRAWING NUMBER: 5073 Lens Mandrel MALE B | ISSUE: A

CAGEC 88516 | SCALE 1.500 | SHEET 1 OF 1

ORIGIN: Wildfire-2 | STATUS: LA - CHK - -

UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED



PTS-P50-VACFIX-#5124

UNCLASSIFIED

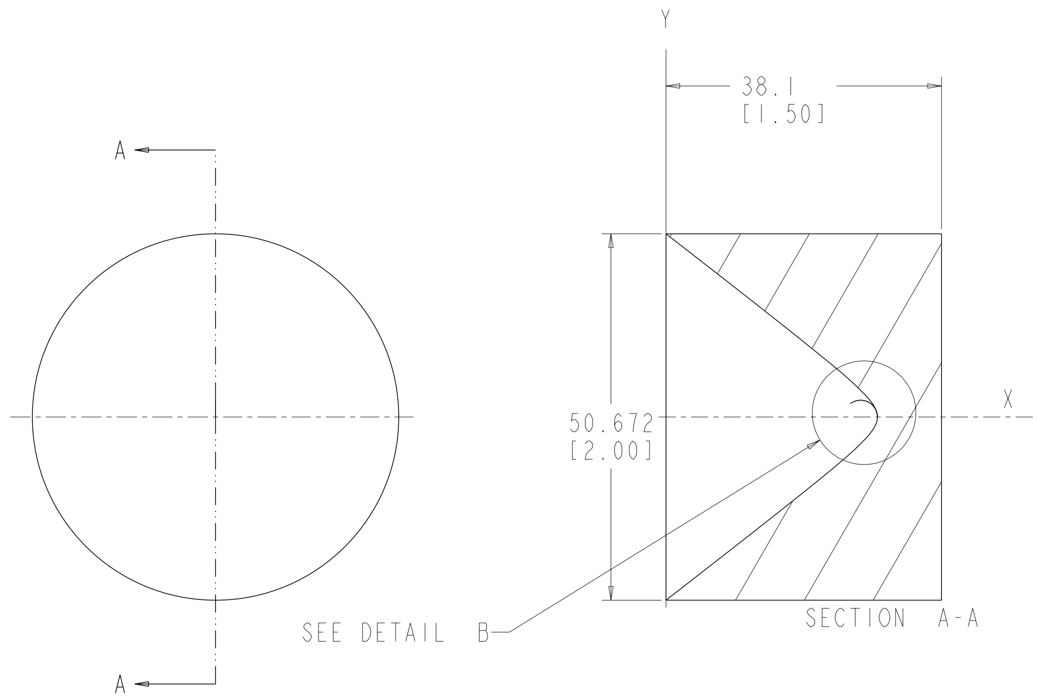
Coordinates of spline points:

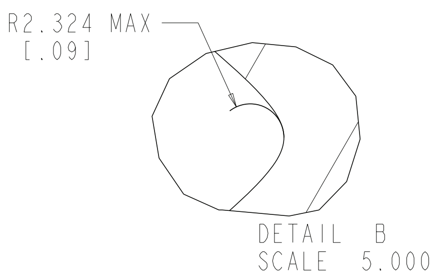
CARTESIAN COORDINATES:

X	Y	Z
29.239	0	0
29.23	0.2	0
29.204	0.4	0
29.16	0.6	0
29.1	0.8	0
29.024	1	0
28.933	1.2	0
28.829	1.4	0
28.711	1.6	0
28.581	1.8	0
28.44	2	0
28.289	2.2	0
28.129	2.4	0
27.961	2.6	0
27.786	2.8	0
27.604	3	0
27.416	3.2	0
27.222	3.4	0
27.023	3.6	0
26.82	3.8	0
26.613	4	0
26.403	4.2	0
26.189	4.4	0
25.972	4.6	0
25.752	4.8	0
25.53	5	0
19.539	10	0
13.24	15	0
6.854	20	0
0.432	25	0
0	25.336	0

UNCLASSIFIED

PART NUMBER	ISS	SHEET ZONE	REVISIONS DESCRIPTION	DATE
5070_Lens_Mandrel_Fe_A	A		ORIGINAL ISSUE	-





CURRENT ISSUE APPROVALS	DATE
DRAWN: TIM CASH	-
CHECKED: -	
DESIGNED: Bart Olinger	
APPROVED: -	

NO REQD	PART/CONTROL NO	DESCRIPTION/MATERIAL	NOTE	SHEET ZONE	ITEM
	-	-			
NA	9919100	MARKING, GENERAL METHODS			
NA	9900000	GENERAL REQUIREMENTS			

QUANTITY ABBREVIATIONS: NA : NO QUANTITY FOR DOCUMENTS ALT : ALTERNATE PM : PROCESS MATERIAL EM : EXPENSE MATERIAL AR : AS REQUIRED ARS : AS REQUIRED FOR ASSEMBLY

PART NO. 5070_Lens_Mandrel_Fe_A

DRAWING: 5105_P50B_FEMALE
MODEL: 5105_P50B_FEMALE
TYPE: PART

Los Alamos
National Laboratory

METRIC

THIRD ANGLE PROJECTION

PART CLASSIFICATION: UNCLASSIFIED
DRAWING CLASSIFICATION: UNCLASSIFIED

TITLE: P50B (2 INCH) LENS FEMALE NC Sketch

SIZE: C DRAWING NUMBER: 5105_Lens_Mandrel_FEMALE ISSUE: A

CAGEC 88516 SCALE 2.500 SHEET 1 OF 1

ORIGIN Wildfire-2 STATUS LA - CHK - -

UNCLASSIFIED

UNCLASSIFIED

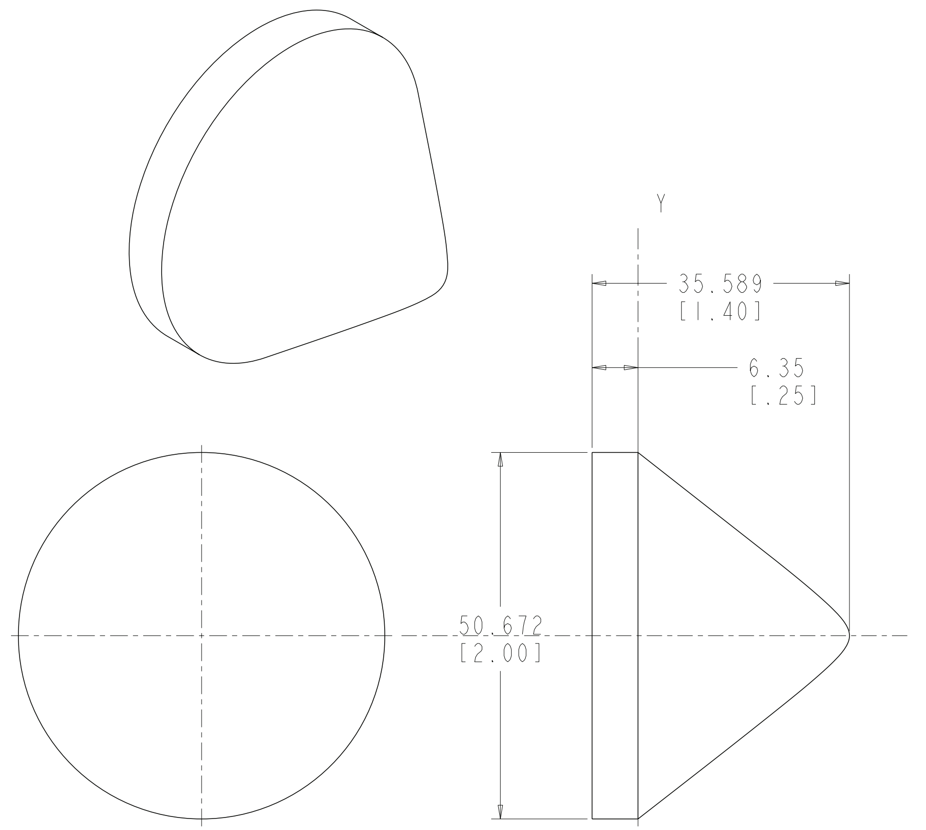
Coordinates of spline points:

CARTESIAN COORDINATES:

X	Y	Z
29.239	0	0
29.23	0.2	0
29.204	0.4	0
29.16	0.6	0
29.1	0.8	0
29.024	1	0
28.933	1.2	0
28.829	1.4	0
28.711	1.6	0
28.581	1.8	0
28.44	2	0
28.289	2.2	0
28.129	2.4	0
27.961	2.6	0
27.786	2.8	0
27.604	3	0
27.416	3.2	0
27.222	3.4	0
27.023	3.6	0
26.82	3.8	0
26.613	4	0
26.403	4.2	0
26.189	4.4	0
25.972	4.6	0
25.752	4.8	0
25.53	5	0
19.539	10	0
13.24	15	0
6.854	20	0
0.432	25	0
0	25.336	0

UNCLASSIFIED

PART NUMBER	ISS	SHEET ZONE	REVISIONS DESCRIPTION	DATE
5070_Lens_Mandrel_Fe_A	A		ORIGINAL ISSUE	-



NO REQD	PART/CONTROL NO	DESCRIPTION/MATERIAL	NOTE	SHEET ZONE	ITEM
	-	-			
NA	9919100	MARKING, GENERAL METHODS			
NA	9900000	GENERAL REQUIREMENTS			

QUANTITY ABBREVIATIONS: NA : NO QUANTITY FOR DOCUMENTS; ALT : ALTERNATE; PM : PROCESS MATERIAL; EM : EXPENSE MATERIAL; AR : AS REQUIRED; ARS : AS REQUIRED FOR ASSEMBLY

PART NO.: 5070_Lens_Mandrel_Fe_A

DRAWING: 5104_P50B_MALE
MODEL: 5104_P50B_MALE
TYPE: PART

Los Alamos National Laboratory

METRIC

THIRD ANGLE PROJECTION

PART CLASSIFICATION: UNCLASSIFIED

DRAWING CLASSIFICATION: UNCLASSIFIED

TITLE: P50B (2 INCH) LENS MALE NC Sketch

SIZE: C | DRAWING NUMBER: 5104_Lens_Mandrel_MALE | ISSUE: A

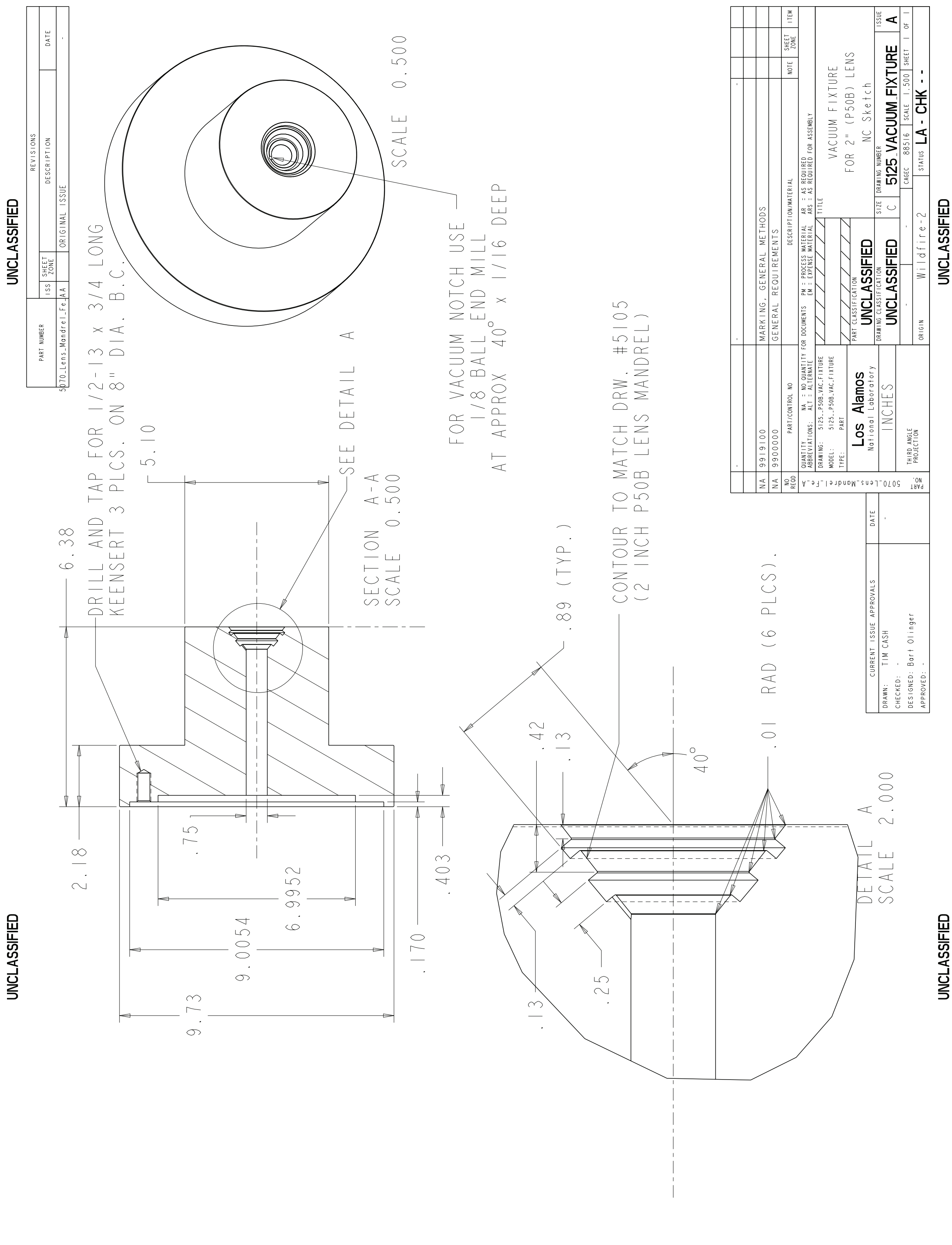
CAGEC 88516 | SCALE 2.500 | SHEET 1 OF 1

ORIGIN: Wildfire-2 | STATUS: LA - CHK - -

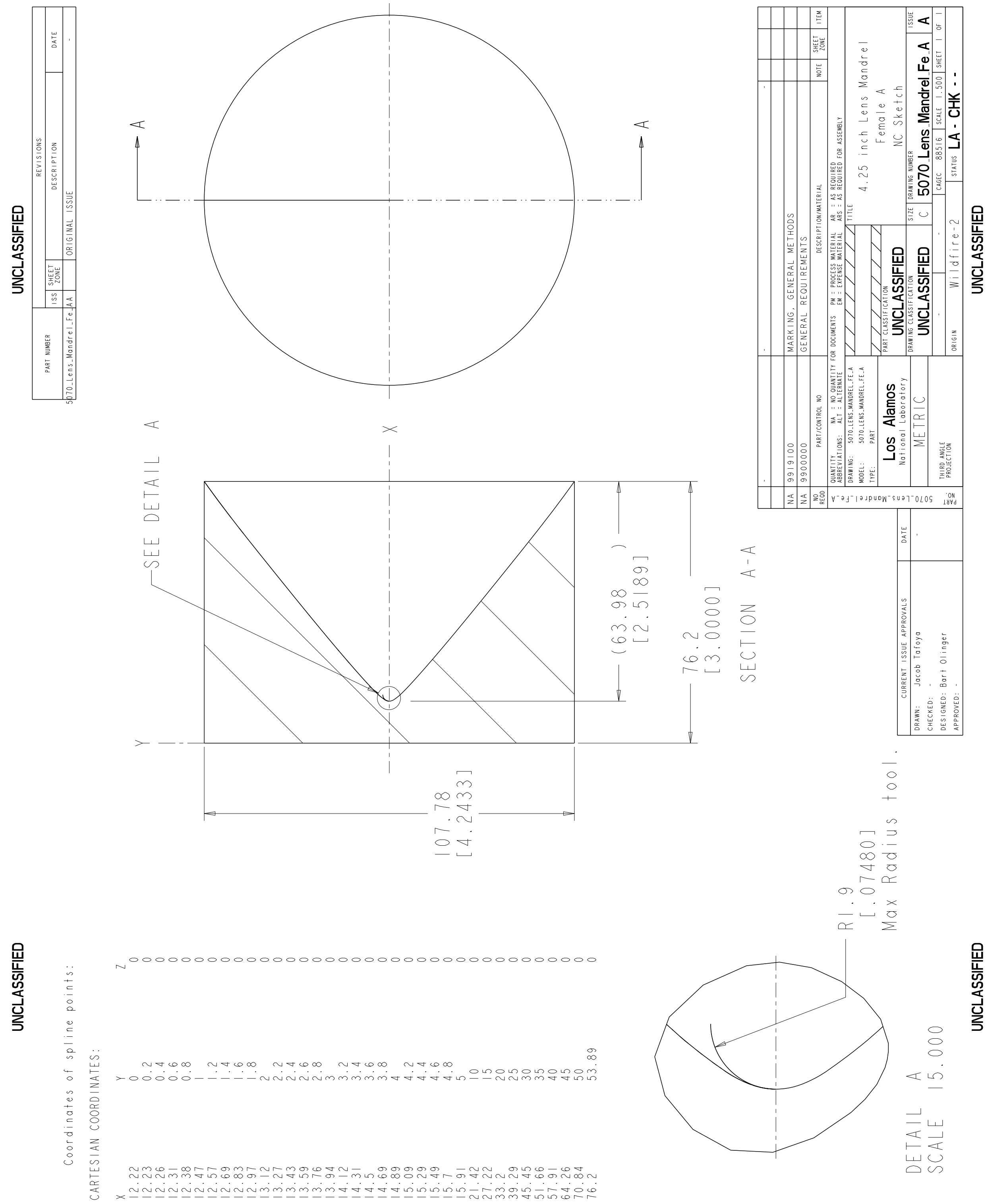
CURRENT ISSUE APPROVALS	DATE
DRAWN: TIM CASH	-
CHECKED: -	
DESIGNED: Bart Olinger	
APPROVED: -	

UNCLASSIFIED

PTS-P50B-CONVEX-#5104



PTS-P50B-VACFIX-#5125



X	Y	Z
12.22	0	0
12.23	0.2	0
12.26	0.4	0
12.31	0.6	0
12.38	0.8	0
12.47	1	0
12.57	1.2	0
12.69	1.4	0
12.83	1.6	0
12.97	1.8	0
13.12	2	0
13.27	2.2	0
13.43	2.4	0
13.59	2.6	0
13.76	2.8	0
13.94	3	0
14.12	3.2	0
14.31	3.4	0
14.5	3.6	0
14.69	3.8	0
14.89	4	0
15.09	4.2	0
15.29	4.4	0
15.49	4.6	0
15.7	4.8	0
15.91	5	0
21.42	10	0
27.22	15	0
33.2	20	0
39.29	25	0
45.45	30	0
51.66	35	0
57.91	40	0
64.26	45	0
70.84	50	0
76.2	53.89	0

PTS-P108-CONCAVE-#5070

UNCLASSIFIED

X	Y	Z
63.9850	0.0000	0.0000
63.9740	0.2000	0.0000
63.9430	0.4000	0.0000
63.8910	0.6000	0.0000
63.8190	0.8000	0.0000
63.7310	1.0000	0.0000
63.6260	1.2000	0.0000
63.5070	1.4000	0.0000
63.3750	1.6000	0.0000
63.2320	1.8000	0.0000
63.0840	2.0000	0.0000
62.9340	2.2000	0.0000
62.7750	2.4000	0.0000
62.6100	2.6000	0.0000
62.4380	2.8000	0.0000
62.2600	3.0000	0.0000
62.0780	3.2000	0.0000
61.8920	3.4000	0.0000
61.7010	3.6000	0.0000
61.5080	3.8000	0.0000
61.3110	4.0000	0.0000
61.1120	4.2000	0.0000
60.9100	4.4000	0.0000
60.7060	4.6000	0.0000
60.5010	4.8000	0.0000
60.2930	5.0000	0.0000
54.7830	10.0000	0.0000
51.7300	12.6500	0.0000
48.9760	15.0000	0.0000
43.0020	20.0000	0.0000
36.9110	25.0000	0.0000
36.4990	25.3360	0.0000
30.7470	30.0000	0.0000
24.5400	35.0000	0.0000
18.2870	40.0000	0.0000
11.9360	45.0000	0.0000
5.3610	50.0000	0.0000
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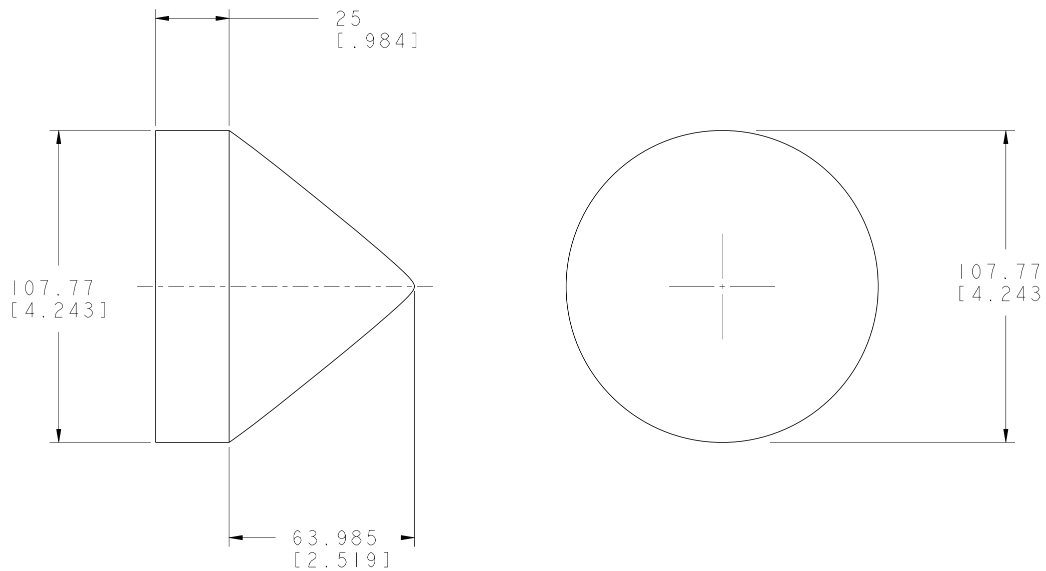
UNCLASSIFIED

PART NUMBER	ISS	SHEET ZONE	DESCRIPTION	DATE
-	A		Rev block description goes here	04-26-2005



NO REQD	PART/CONTROL NO	DESCRIPTION/MATERIAL	NOTE	SHEET ZONE	ITEM
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NA	9919100	MARKING, GENERAL METHODS			
NA	9900000	GENERAL REQUIREMENTS			

QUANTITY ABBREVIATIONS: NA = NO QUANTITY FOR DOCUMENTS; ALT = ALTERNATE; PM = PROCESS MATERIAL; EM = EXPENSE MATERIAL; AR = AS REQUIRED; ARS = AS REQUIRED FOR ASSEMBLY

CONFIRMED TO BE UNCLASSIFIED
CLASSIFIER: -
TITLE: - ORG: -

DRAWING: A5071
MODEL: A5071
TYPE: PART

TITLE: 4.25 INCH LENS MANDREL MALE NC SKETCH

PART CLASSIFICATION: UNCLASSIFIED
DRAWING CLASSIFICATION: UNCLASSIFIED
SIZE: C DRAWING NUMBER: 5071_LENS_MANDREL ISSUE: A
CAGEC - SCALE 1/1 SHEET 1 OF 1
SI METRIC
THIRD ANGLE PROJECTION
ORIGIN PRO/E-WILDFIRE STATUS - - - - 04-26-2005

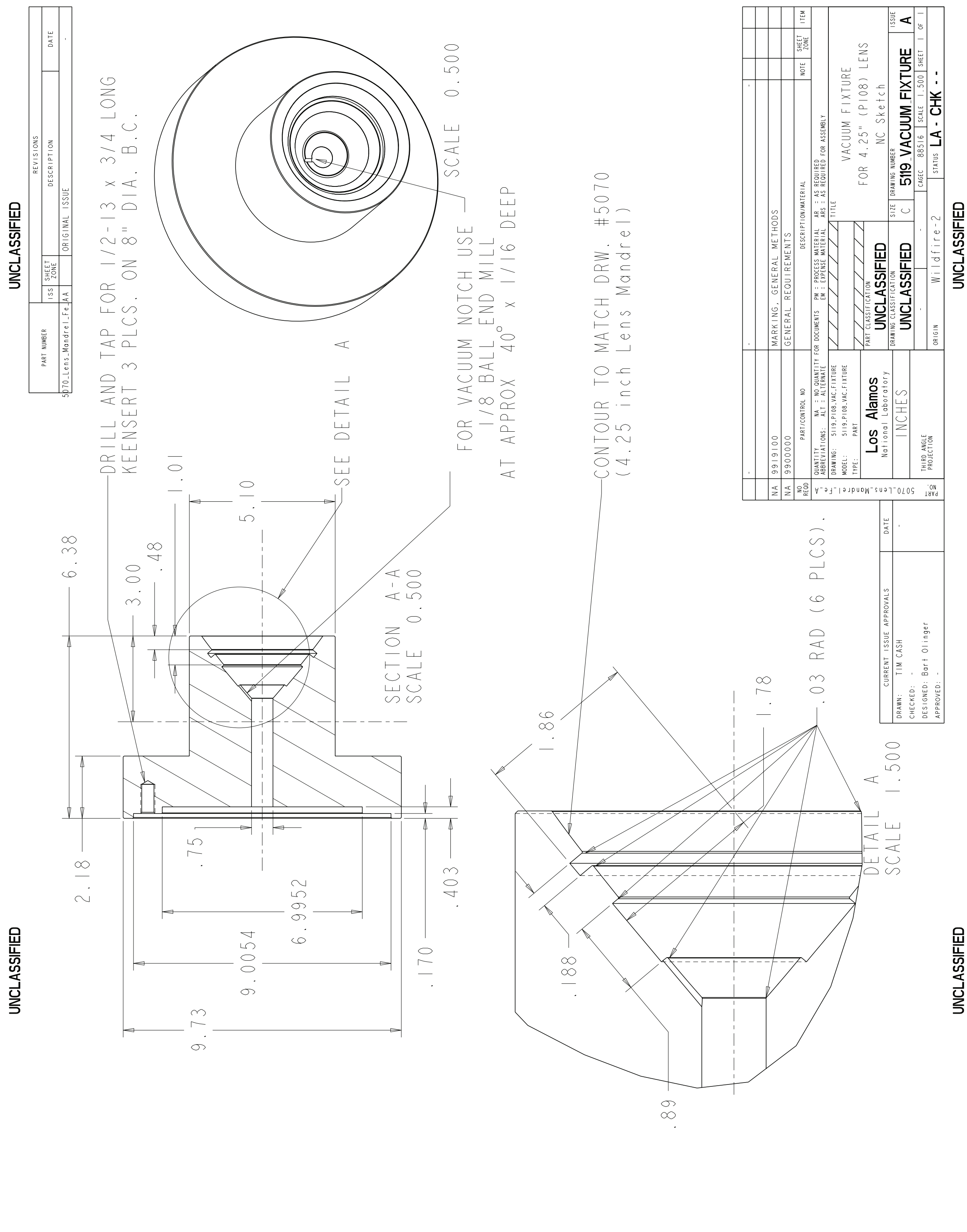
NEXT ASSY:	FINAL ASSY:
PROJECT NAME:	DRAWING LEVEL:

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS. TOLERANCES ARE:
DECIMALS .XX = ± 0.76 .XXX = ± 0.254
ANGULAR = ± 0.5°
MACHINED FINISH = 32

CURRENT ISSUE APPROVALS		DATE
DRAWN:	RMONTOYA	04-26-2005
CHECKED:	-	
DESIGNED:	-	
APPROVED:	-	

PROI	REVISION	VERSION	RELEASE
MODEL:			
DRAWING:			

UNCLASSIFIED
UNCLASSIFIED



PTS-P108-VACFIX-#5199

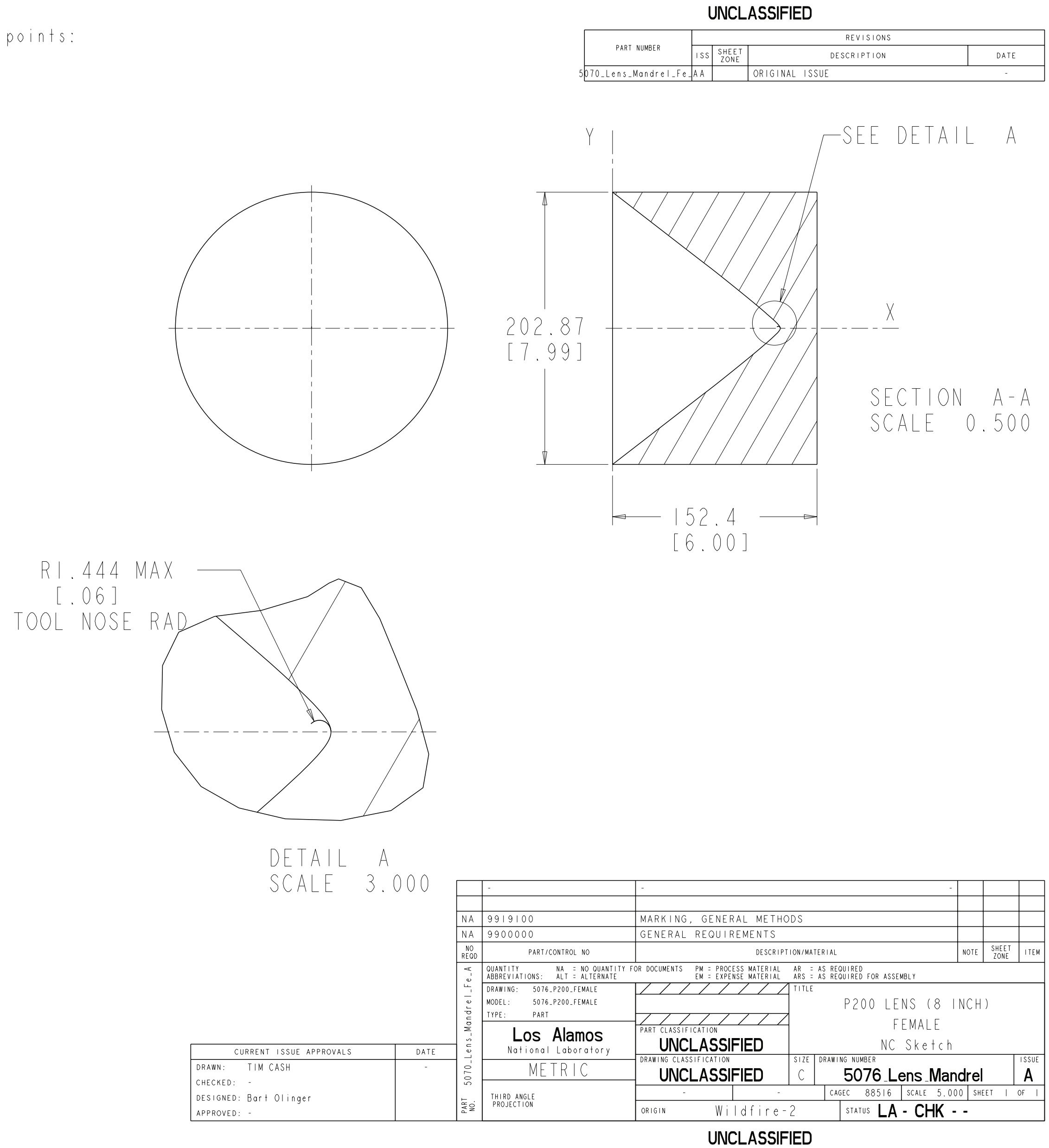
UNCLASSIFIED

Coordinates of spline points:

CARTESIAN COORDINATES:

X	Y	Z
125.027	0	0
125.016	0.2	0
124.985	0.4	0
124.933	0.6	0
124.861	0.8	0
124.773	1	0
124.668	1.2	0
124.549	1.4	0
124.417	1.6	0
124.274	1.8	0
124.126	2	0
123.976	2.2	0
123.817	2.4	0
123.652	2.6	0
123.48	2.8	0
123.302	3	0
123.12	3.2	0
122.934	3.4	0
122.743	3.6	0
122.55	3.8	0
122.353	4	0
122.154	4.2	0
121.952	4.4	0
121.748	4.6	0
121.543	4.8	0
121.335	5	0
115.825	10	0
110.018	15	0
104.044	20	0
97.953	25	0
91.789	30	0
85.582	35	0
79.329	40	0
72.978	45	0
66.403	50	0
59.966	55	0
53.523	60	0
47.074	65	0
40.622	70	0
34.166	75	0
27.708	80	0
21.247	85	0
14.785	90	0
8.321	95	0
1.856	100	0
0	101.435	0

UNCLASSIFIED



PTS-P200-CONCAVE-#5076

UNCLASSIFIED

Coordinates of spline points:

CARTESIAN COORDINATES:

X	Y	Z
125.027	0	0
125.016	0.2	0
124.985	0.4	0
124.933	0.6	0
124.861	0.8	0
124.773	1	0
124.668	1.2	0
124.549	1.4	0
124.417	1.6	0
124.274	1.8	0
124.126	2	0
123.976	2.2	0
123.817	2.4	0
123.652	2.6	0
123.48	2.8	0
123.302	3	0
123.12	3.2	0
122.934	3.4	0
122.743	3.6	0
122.55	3.8	0
122.353	4	0
122.154	4.2	0
121.952	4.4	0
121.748	4.6	0
121.543	4.8	0
121.335	5	0
115.825	10	0
110.018	15	0
104.044	20	0
97.953	25	0
91.789	30	0
85.582	35	0
79.329	40	0
72.978	45	0
66.403	50	0
59.966	55	0
53.523	60	0
47.074	65	0
40.622	70	0
34.166	75	0
27.708	80	0
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14.785	90	0
8.321	95	0
1.856	100	0
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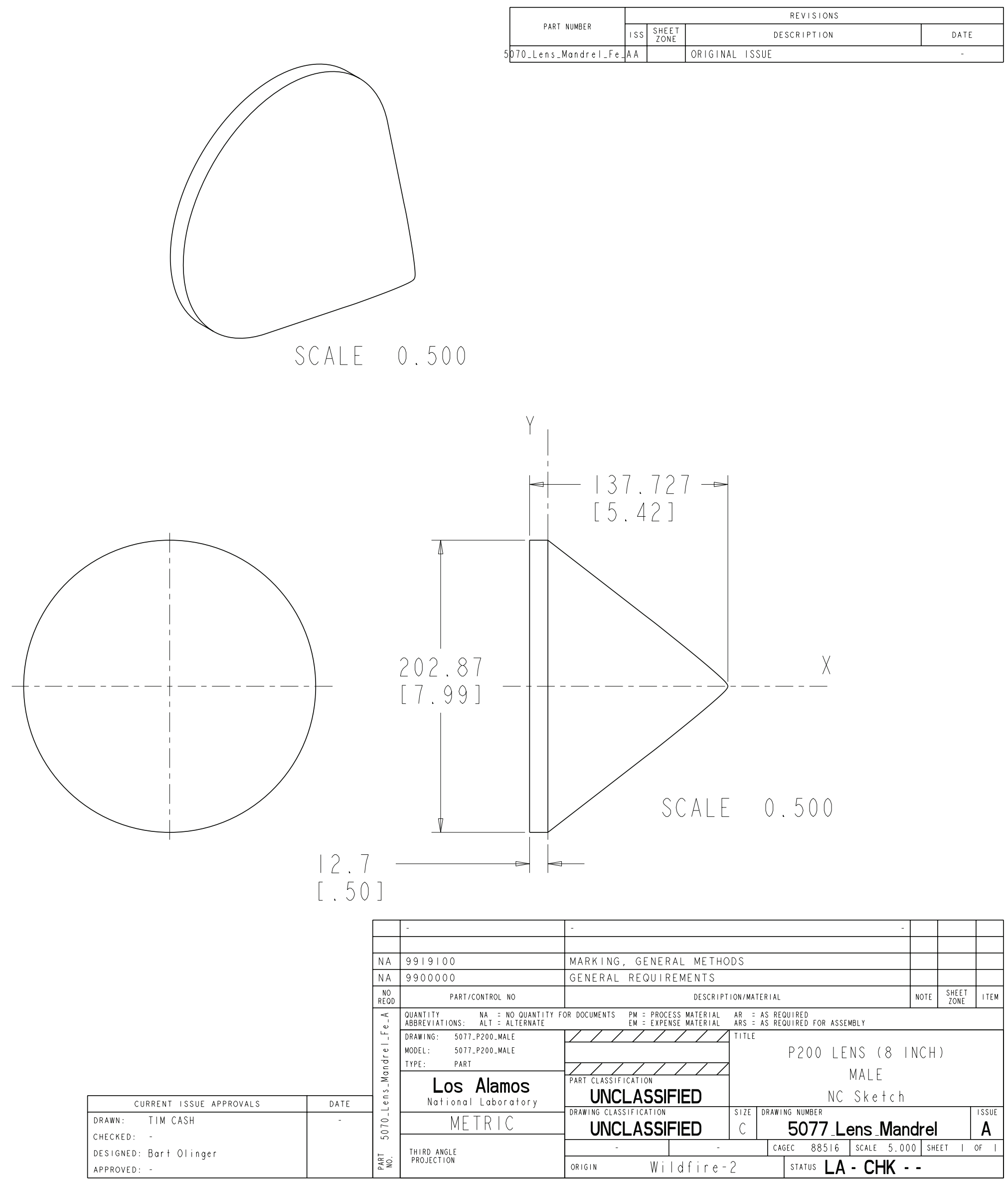
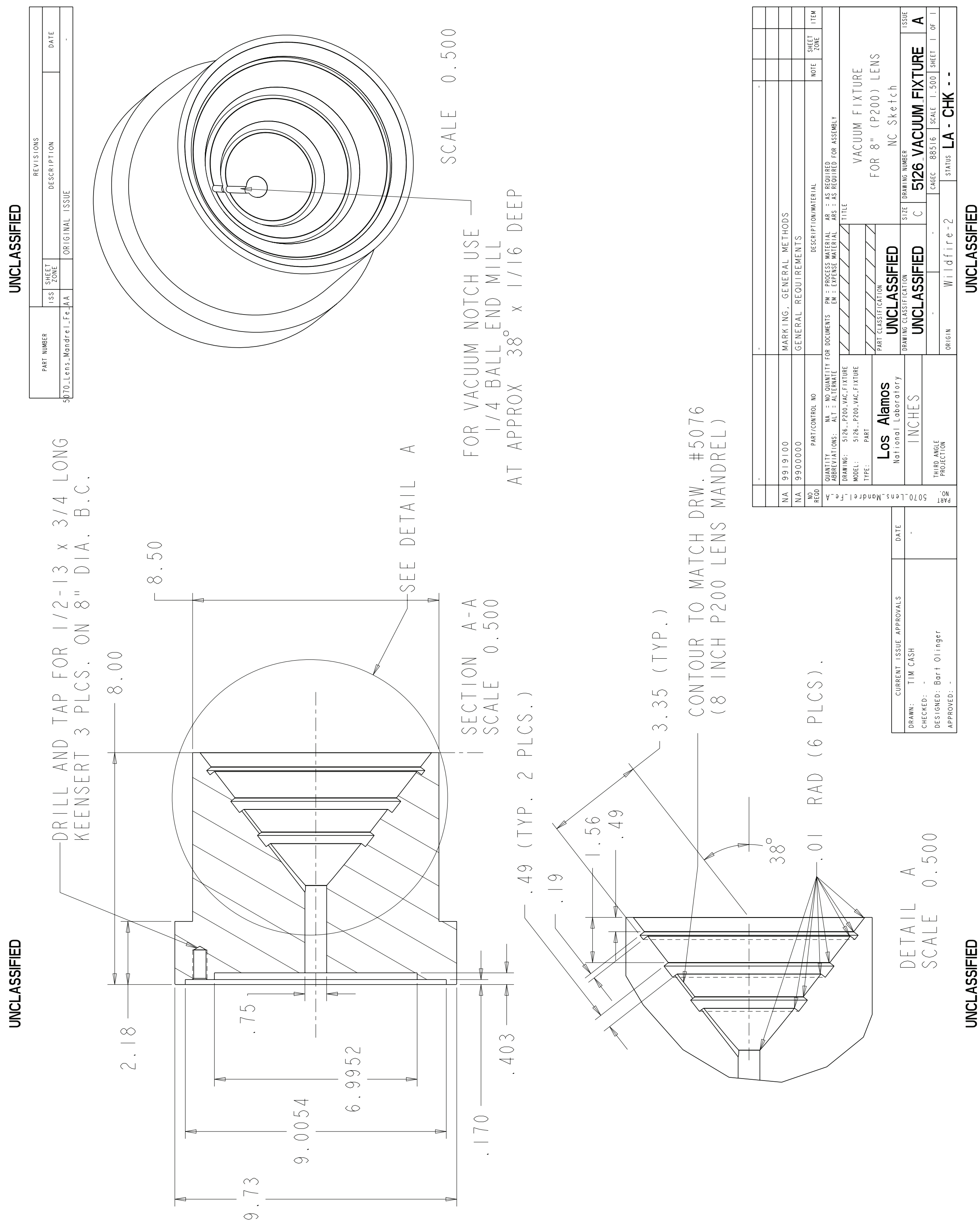
UNCLASSIFIED

UNCLASSIFIED



UNCLASSIFIED

PTS-P200-CONVEX-#5077



PTS-P200-VACFIX-#5126

UNCLASSIFIED

X	Y	Z
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25.1900	0.2000	0.0000
25.2200	0.4000	0.0000
25.2700	0.6000	0.0000
25.3400	0.8000	0.0000
25.4300	1.0000	0.0000
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25.6500	1.4000	0.0000
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25.9300	1.8000	0.0000
26.0800	2.0000	0.0000
26.2300	2.2000	0.0000
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26.5500	2.6000	0.0000
26.7200	2.8000	0.0000
26.9000	3.0000	0.0000
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27.6500	3.8000	0.0000
27.8500	4.0000	0.0000
28.0500	4.2000	0.0000
28.2500	4.4000	0.0000
28.4500	4.6000	0.0000
28.6600	4.8000	0.0000
28.8700	5.0000	0.0000
34.3800	10.0000	0.0000
40.1800	15.0000	0.0000
46.1600	20.0000	0.0000
52.2500	25.0000	0.0000
58.4100	30.0000	0.0000
64.6200	35.0000	0.0000
70.8700	40.0000	0.0000
77.2200	45.0000	0.0000
83.8000	50.0000	0.0000
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103.1300	65.0000	0.0000
109.5800	70.0000	0.0000
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200.1000	140.0000	0.0000
206.5700	145.0000	0.0000
213.0400	150.0000	0.0000
215.9000	152.2100	0.0000

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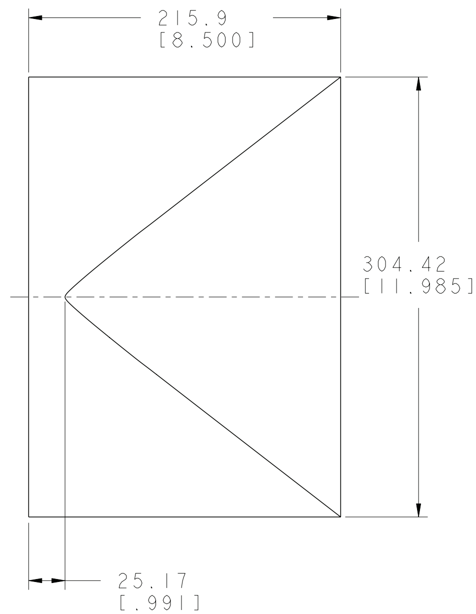
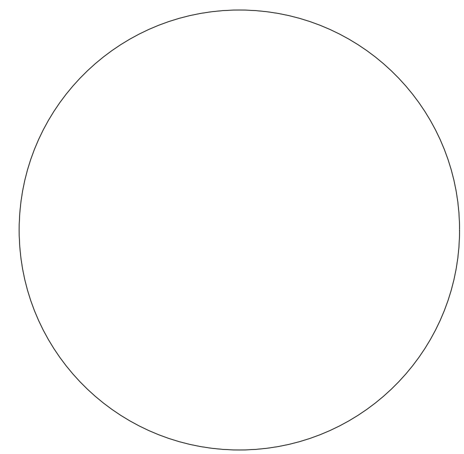
PART NUMBER	ISS	SHEET ZONE	DESCRIPTION	DATE
			REVISIONS	
-	B		ORIGINAL ISSUE	05-10-2005





PROJ	REVISION	VERSION	RELEASE
MODEL:	B	3	CONCEPT
DRAWING:			

NEXT ASSY: | FINAL ASSY:

PROJECT NAME: - | DRAWING LEVEL:

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS.
TOLERANCES ARE:
DECIMALS .XX = ± 0.76 .XXX = ± 0.254
ANGULAR = ± 0.5°
MACHINED FINISH = 32

CONFIRMED TO BE UNCLASSIFIED
CLASSIFIER: -
TITLE: - ORG: -

CURRENT ISSUE APPROVALS		DATE
DRAWN:	RMONTOYA	05-10-2005
CHECKED:	-	
DESIGNED:	-	
APPROVED:	-	

NO REQD	PART/CONTROL NO	DESCRIPTION/MATERIAL	NOTE	SHEET ZONE	ITEM
	-	-			
NA	9919100	MARKING, GENERAL METHODS			
NA	9900000	GENERAL REQUIREMENTS			

QUANTITY ABBREVIATIONS: NA = NO QUANTITY FOR DOCUMENTS, ALT = ALTERNATE, PM = PROCESS MATERIAL, EM = EXPENSE MATERIAL, AR = AS REQUIRED, ARS = AS REQUIRED FOR ASSEMBLY

DRAWING: A5078
MODEL: A5078
TYPE: PART

PART CLASSIFICATION: UNCLASSIFIED

TITLE: 12 INCH LENS MANDREL
FEMALE
NC SKETCH

SI METRIC

DRAWING CLASSIFICATION: UNCLASSIFIED

SIZE: C | DRAWING NUMBER: 5078_LENS_MANDREL | ISSUE: B

CAGEC 88516 | SCALE 1/2 | SHEET 1 OF 1

PART NO. | THIRD ANGLE PROJECTION

ORIGIN PRO/E-WILDFIRE | STATUS LA-CHK - 05-10-2005

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187.6510	4.4000	0.0000
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119.2220	60.0000	0.0000
112.7730	65.0000	0.0000
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99.8650	75.0000	0.0000
93.4070	80.0000	0.0000
86.9460	85.0000	0.0000
80.4840	90.0000	0.0000
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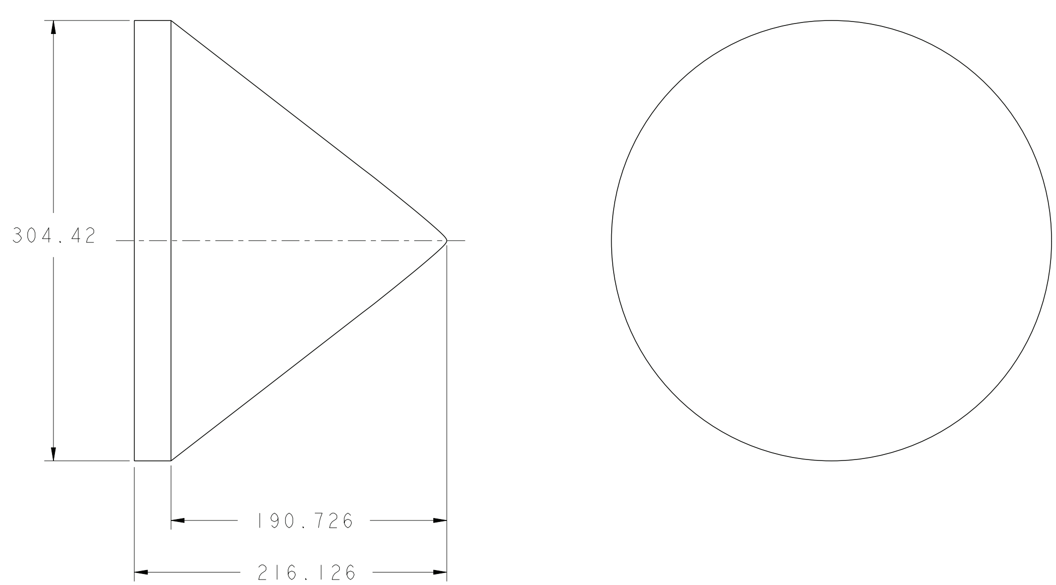
PROJ	REVISION	VERSION	RELEASE
MODEL:	B	3	CONCEPT
DRAWING:			

UNCLASSIFIED

PART NUMBER	ISS	SHEET ZONE	REVISIONS DESCRIPTION	DATE
-	B		ORIGINAL ISSUE	05-13-2005



CONFIRMED TO BE UNCLASSIFIED
CLASSIFIER: -
TITLE: - ORG: -

NEXT ASSY: | FINAL ASSY:
PROJECT NAME: - | DRAWING LEVEL:

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS. TOLERANCES ARE:
DECIMALS .XX = ± 0.76 .XXX = ± 0.254
ANGULAR = ± 0.5°
MACHINED FINISH = 32

CURRENT ISSUE APPROVALS		DATE
DRAWN:	RMONTOYA	05-13-2005
CHECKED:	-	
DESIGNED:	-	
APPROVED:	-	

NO REQD	PART/CONTROL NO	DESCRIPTION/MATERIAL	NOTE	SHEET ZONE	ITEM
	-	- -			
NA	9919100	MARKING, GENERAL METHODS			
NA	9900000	GENERAL REQUIREMENTS			

QUANTITY NA = NO QUANTITY FOR DOCUMENTS PM = PROCESS MATERIAL AR = AS REQUIRED
ABBREVIATIONS: ALT = ALTERNATE EM = EXPENSE MATERIAL ARS = AS REQUIRED FOR ASSEMBLY

DRAWING: A5079
MODEL: A5079
TYPE: PART

PART CLASSIFICATION UNCLASSIFIED
DRAWING CLASSIFICATION UNCLASSIFIED

TITLE 12 INCH MALE LENS PROG A5079 NC SKETCH

SI METRIC

PART NO. -

THIRD ANGLE PROJECTION

SIZE C DRAWING NUMBER 5079_LENS_MANDREL ISSUE B
CAGEC 88516 SCALE 1/2 SHEET 1 OF 1
ORIGIN PRO/E-WILDFIRE STATUS LA-CHK - 05-13-2005

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