

1 Scope of Project

This document describes the specifications for the fabrication of 18 optical elements to be used in the Prime Focus Imaging Spectrograph on the Southern African Large Telescope (SALT). The PFIS optical system consists of a collimator (Figure 1), which collimates the F/4.2 beam over the wavelength range 320 nm - 1.7 microns. The collimated space contains either Fabry-Perot etalons, or a Volume Phase Holographic (transmission) grating. The visible wavelength camera (Fig 2) focuses the wavelength range 320 - 900 nm at F/2.2 onto a focal plane array of three 4096 x 2048 CCD's. The final element, a field flattener, serves as the window of the detector cryostat. NaCl elements are used in these designs to meet requirements for good imaging down to 320 nm. The NaCl elements are embedded within triplet groups, which will be sealed to prevent degradation by moisture. All groups will be coupled by immersion oil. Both collimator and camera are designed to accommodate plano fused silica filters (dashed lines), which will be provided by the customer. More information on SALT and PFIS may be found at the web site <http://www.sal.wisc.edu/PFIS/>

2 Fabricator Statement of Work

The optical blanks will be customer-supplied, and the final coatings will be applied after delivery by another vendor. Blank data is supplied here for reference in section 4.

The job is divided into three lots,

- 1) 11 spherical figure elements excluding the NaCl triplets,
- 2) 6 spherical figure elements in the NaCl triplets, and
- 3) 1 aspherical element on fused silica

For quantity one (1) each of the elements in a lot the optical fabricator will

- a Provide a finished optical element meeting the physical specifications in section 3, using customer-supplied blanks described in section 4, optical finish specifications in section 5, and the specific requirements for each element in the attached drawings and section 6.
- b Measure and document the final surface figures.

Bidder note: Award(s) shall be made on the basis of the lowest net lot total(s) for each lot. Bidders are encouraged to bid on all lots they can provide.

3 Physical specifications

The fabricator is expected to work with the customer to allow utilization of existing test plates and implement any changes that the fabricator might suggest to facilitate production or remedy problems encountered. One surface in the collimator and one in the camera (both in lot 1) will be designated a "Pick-up" surface and should be the last to be fabricated.

The following tables summarize the basic properties of the elements. All surfaces except the first camera surface are spherical. All dimensions are in millimeters. All physical properties are stated at 20° C.

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Table 1: Properties of the Collimator elements

(Grd = Grade; Dia = Diameter (mm); CA = clear aperture (mm); R1, R2 = radius of curvature (mm), CT = center thickness (mm))

<i>Lot</i>	Group	Element	Material	Grd	Dia	CA	R1	R2	CT
<i>1</i>	D1	O-L1	F_quartz	1	130	120	94.1409	64.7932	10
		O-L2	CaF2	1	124	113	64.7932	269.1785	51
	S1	O-L3	F_quartz	2	132	115	-66.7515	198.8691	10
	S2	O-L4	F_quartz	2	154	142	-686.2812	-139.4617	30
<i>2</i>	T	O-L5	CaF2	2	184	171	930.2364	-134.3700	55
		O-L6	NaCl	1	196	185	-134.3700	-228.0297	15
		O-L7	CaF2	2	204	194	-228.0297	-140.1829	37
<i>1</i>	D2	O-L8	F_silica		202	187	Plano	188.1678	15
		O-L9	CaF2	3	202	187	188.1678	-544.9774	53

Table 2: Properties of the Camera elements

<i>Lot</i>	Group	Element	Material	Grd	Dia	CA	R1	R2	CT
<i>3</i>	Q	A-L1	F_silica		238	221	407.5475 asphere *	225.6610	15
<i>1</i>		A-L2	CaF2	2	238	223	225.6610	-355.7677	70
		A-L3	F_silica		244	228	-355.7677	268.3832	15
<i>1</i>		A-L4	CaF2	2	244	230	268.3832	-1777.484	50
<i>1</i>	S1	A-L5	CaF2	2	250	241	464.1057	-365.7249	54
<i>2</i>	T	A-L6	F_silica		210	197	248.3816	Plano	45
		A-L7	NaCl	2	194	183	Plano	120.1303	15
		A-L8	F_silica		170	160	120.1303	488.2939	90
<i>1</i>	S2	A-L9	F_silica		90 x 123 (rect) *	72 x 105 (rect)	-173.1466	539.5584	8

* See section 6

4 Customer-provided optical blanks

The blanks will be oversized by 4 - 5 mm in thickness and 6 mm in diameter.

Table 3: Blanks

Material	Grade	Elements	Diameter	Thickness
CaF₂	1	O-L1	130	62
	2	O-L5	190	60
		O-L7	210	64
	3	O-L9	208	58
		A-L2	244	75
		A-L4	250	55
	A-L5	256	59	
NaCl	1	O-L6	202	56
	2	A-L7	202	56
Fused Quartz	1	O-L2	136	60
	2	O-L3	138	51
		O-L4	160	39
Fused Silica	1	O-L8	208	48
		A-L1	244	52
		A-L3	250	70
		A-L6	216	50
		A-L8	176	100
		A-L9	158	30

4.1 Calcium Fluoride material

- a Grade 1: single crystal, stress birefringence < 1 nm/cm
- b Grade 2: single crystal, stress birefringence < 2 nm/cm
- c Grade 3: polycrystalline, stress birefringence < 10 nm/cm. The CaF₂ boules used to generate the final blanks shall have more than 90% of the volume consisting of less than three crystals

4.2 Sodium Chloride material

- a Grade 1: single crystal, stress birefringence < 7 nm/cm
- b Grade 2: single crystal, stress birefringence < 15 nm/cm

4.3 Fused Quartz material

- a Grade 1: stress birefringence < 1 nm/cm
- b Grade 2: stress birefringence < 2 nm/cm

4.4 Fused Silica material

- a Stress birefringence < 2 nm/cm

5 Optical finish specifications

All 18 elements will be finished to the following specifications in addition to those called out in the drawing notes. Default drawing notes are:

- a All dimensions in millimeters (Dimensions before bevels)

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- b Material- Customer-supplied blank, not generated or edged
- c Surface shape: spherical. Pitch polish to test plate within ±0.5 fringe at 633 nm. Document and report figure. _____
- d Radius Tolerance: ±0.1% unless otherwise indicated _____
- e Contact surfaces: Match to ±5 fringe at 633 nm _____
- f Surface finish: surface roughness 1 nm RMS or better. Report and document measured values _____
- g Surface quality: 60-40 (MIL-0-13830A) _____
- h Diameter and thickness: ±0.075mm unless otherwise noted. Report to ±0.01 mm _____
- i Wedge: < 20 microns Edge Thickness Difference _____
- j Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible. _____
- k Ground surfaces: #400 grit equivalent or finer. _____

6 Optical element specifications

In this section we describe summarize requirements specific to individual elements. Refer to the attached drawings.

a Asphere surface: A-L1

Slope tolerance 2.0×10^{-5} radians. _____

The bidder should describe how the surface figure will be verified per section 5c (for instance, by a null lens test or by profilometer).

The sag for surface R1 is given by

$$z = c r^2 / (1 + (1 - c^2 r^2)^{1/2}) + C_4 r^4 + C_6 r^6 + C_8 r^8$$

with

$$c = \text{curvature} = 1 / 407.5475 \text{ mm}$$

$$C_4 = -8.20788 \times 10^{-9} \text{ mm}^{-4}$$

$$C_6 = -4.76330 \times 10^{-14} \text{ mm}^{-6}$$

$$C_8 = -3.70543 \times 10^{-18} \text{ mm}^{-8}$$

A table of sag vs radial position is shown in Table 5. The maximum aspheric deviation over the clear aperture is 276 μm.

Table 5. Listing of surface sag for asphere

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Title: SALT PFIS

Date : THU DEC 12 18:25:14 2002

Configuration 1 of 3

Units are Millimeters.

Semi diameter of surface 36: 1.190000E+002.

Best Fit Sphere curvature : 2.263498E-003.

Best Fit Sphere radius : 4.417940E+002.

Best Fit Sphere residual : 2.245889E-001. (rms)

	Y-coord	Sag	BFS Sag	Deviation	Remove
	0.000000E+000	0.000000E+000	0.000000E+000	0.000000E+000	2.759570E-001
	5.000000E+000	3.066730E-002	2.829464E-002	-2.372663E-003	2.735844E-001
	1.000000E+001	1.226214E-001	1.131894E-001	-9.432026E-003	2.665250E-001
	1.500000E+001	2.757189E-001	2.547170E-001	-2.100195E-002	2.549551E-001
	2.000000E+001	4.897198E-001	4.529318E-001	-3.678796E-002	2.391691E-001
	2.500000E+001	7.642862E-001	7.079104E-001	-5.637576E-002	2.195813E-001
	3.000000E+001	1.098980E+000	1.019751E+000	-7.922901E-002	1.967280E-001
	3.500000E+001	1.493261E+000	1.388575E+000	-1.046860E-001	1.712710E-001
	4.000000E+001	1.946480E+000	1.814525E+000	-1.319553E-001	1.440018E-001
	4.500000E+001	2.457877E+000	2.297767E+000	-1.601093E-001	1.158477E-001
	5.000000E+001	3.026568E+000	2.838491E+000	-1.880767E-001	8.788034E-002
	5.500000E+001	3.651542E+000	3.436910E+000	-2.146316E-001	6.132543E-002
	6.000000E+001	4.331640E+000	4.093259E+000	-2.383804E-001	3.757662E-002
	6.500000E+001	5.065546E+000	4.807801E+000	-2.577450E-001	1.821201E-002
	7.000000E+001	5.851762E+000	5.580820E+000	-2.709420E-001	5.015033E-003
	7.500000E+001	6.688586E+000	6.412629E+000	-2.759570E-001	0.000000E+000
	8.000000E+001	7.574079E+000	7.303565E+000	-2.705140E-001	5.443067E-003
	8.500000E+001	8.506030E+000	8.253992E+000	-2.520376E-001	2.391946E-002
	9.000000E+001	9.481913E+000	9.264303E+000	-2.176093E-001	5.834775E-002
	9.500000E+001	1.049883E+001	1.033492E+001	-1.639149E-001	1.120422E-001
	1.000000E+002	1.155347E+001	1.146629E+001	-8.718330E-002	1.887737E-001
	1.050000E+002	1.264201E+001	1.265889E+001	1.688446E-002	2.928415E-001
	1.100000E+002	1.376005E+001	1.391325E+001	1.531976E-001	4.291547E-001
	1.150000E+002	1.490252E+001	1.522989E+001	3.273699E-001	6.033269E-001
	1.190000E+002	1.583019E+001	1.632844E+001	4.982541E-001	7.742111E-001

b Flattener/ dewar window: A-L9

Note that this element is rectangular, with a mounting lip for a vacuum seal to the detector cryostat.

7 Documentation Summary

For asphere (lot 3) describe with bid how the surface figure test will be performed. ___ ___

For lots 1-3 Certificate of Compliance with specifications with final product ___ ___

For lots 1-3 Contractor must supply with final product for each element test data called out in section 5: ___ ___

5c: Document and report figure. ___ ___

5f: Report and document measured surface roughness values, at least three independent measurements for each different optical material finished ___ ___

5h: Report thickness and diameter (length and width for A-L9) to ± 0.01 mm ___ ___

8 Delivery

Delivery is desired on or before 26 weeks ARO. Please state in itemized Bid List when delivery will be made. Timeliness of delivery may be used in evaluation for bid award. Order will be made between 1 and 15 April, 2003, and the blanks will be supplied at that time. ___ ___

9 Itemized Bid List

Lot 1

Item	Quantity	Description	Price
1	1	Name: O-L1, Fused quartz, Diam 130 Delivery: _____ weeks (ARO)	\$ _____
2	1	Name: O-L2, CaF2, Diam 124 Delivery: _____ weeks (ARO)	\$ _____
3	1	Name: O-L3, Fused quartz, Diam 132 Delivery: _____ weeks (ARO)	\$ _____
4	1	Name: O-L4, Fused quartz, Diam 154 Delivery: _____ weeks (ARO)	\$ _____
5	1	Name: O-L8, Fused silica, Diam 202 Delivery: _____ weeks (ARO)	\$ _____
6	1	Name: O-L9, CaF2, Diam 202 Delivery: _____ weeks (ARO)	\$ _____

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7	1	Name: A-L2, CaF2, Diam 238 Delivery: _____ weeks (ARO)	\$ _____
8	1	Name: A-L3, Fused silica, Diam 244 Delivery: _____ weeks (ARO)	\$ _____
9	1	Name: A-L4, CaF2, Diam 244 Delivery: _____ weeks (ARO)	\$ _____
10	1	Name: A-L5, CaF2, Diam 250 Delivery: _____ weeks (ARO)	\$ _____
11	1	Name: A-L9, Fused silica, 90x123 Rectangle Delivery: _____ weeks (ARO)	\$ _____

Lot 2: NaCl Triplets

Item	Quantity	Description	Price
1	1	Name: O-L5, CaF2, Diam 184 Delivery: _____ weeks (ARO)	\$ _____
2	1	Name: O-L6, NaCl, Diam 196 Delivery: _____ weeks (ARO)	\$ _____
3	1	Name: O-L7, CaF2, Diam 204 Delivery: _____ weeks (ARO)	\$ _____
4	1	Name: A-L6, Fused silica, Diam 210 Delivery: _____ weeks (ARO)	\$ _____
5	1	Name: A-L7, NaCl, Diam 194 Delivery: _____ weeks (ARO)	\$ _____
6	1	Name: A-L8, Fused silica, Diam 170 Delivery: _____ weeks (ARO)	\$ _____

Lot 3: Asphere

Item	Quantity	Description	Price
1	1	Name: A-L1, Fused Silica, Diam 238 Delivery: _____ weeks (ARO)	\$ _____

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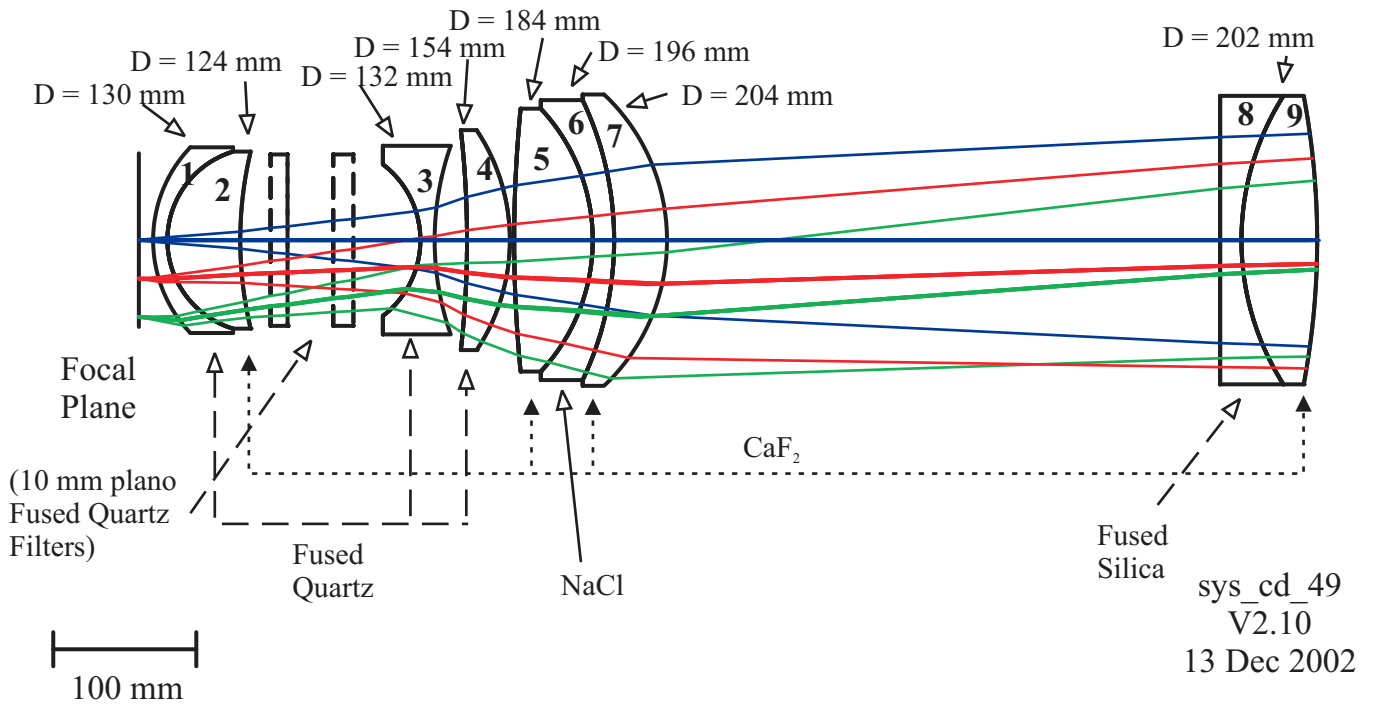


Figure 1. PFIS Collimator

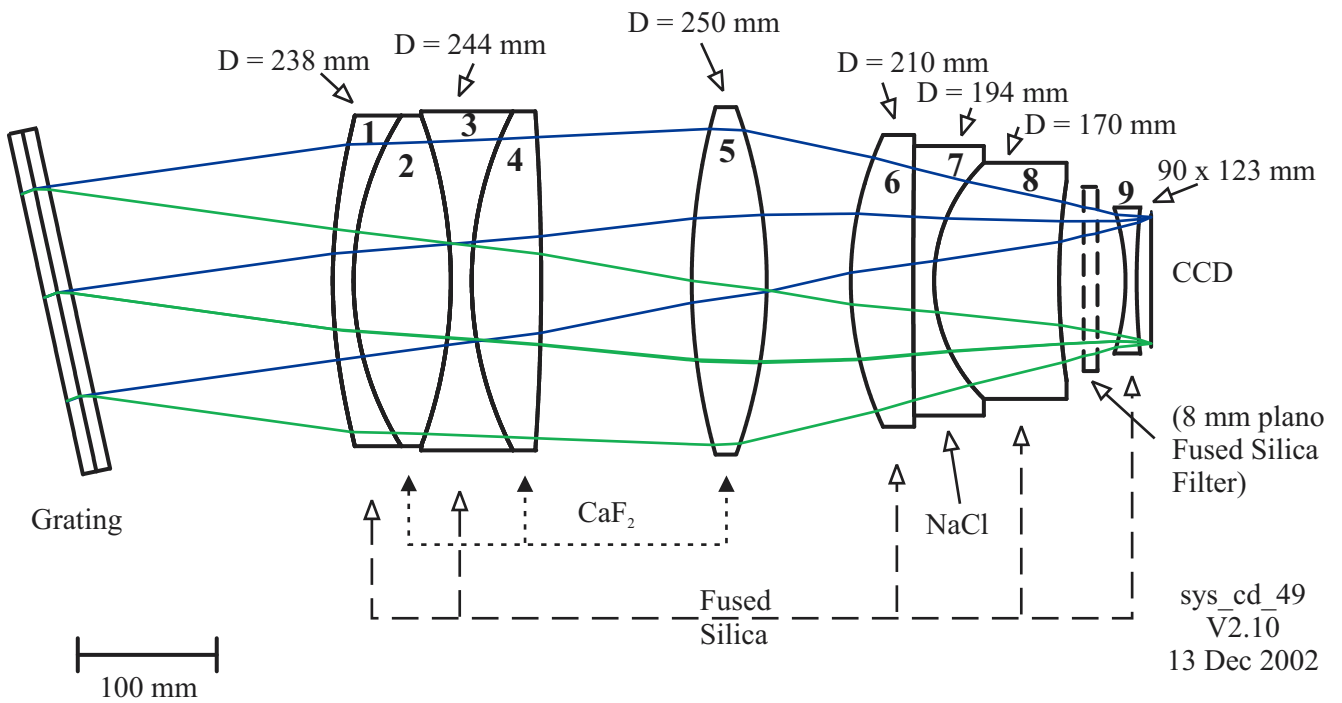
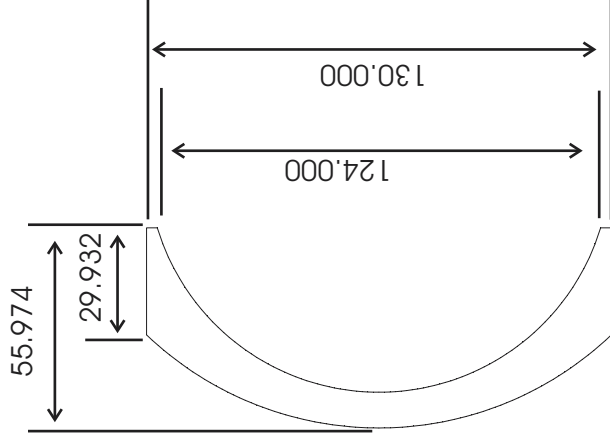


Figure 2. PFIS Camera

Collimator Element Drawings

RADIUS	RAD TOL	IRR TOL	C.A. DIA	EDGE DIA	MATERIAL	THICK	THI TOL
94.1409 CX	0.1%	0.5	119.7	130.0000	F_QUARTZ	10.0000	0.075
64.7932 CC	0.1%	0.5	113.4				

- All dimensions in mm before bevels
- Material- Customer-supplied blank, not generated or edged
- Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm.
Document and report figure.
- Radius Tolerance: +/- 0.1% unless otherwise indicated
- Contact surfaces: Match to +/- 5 fringe at 633 nm
- Surface finish: surface roughness 1 nm RMS or better.
Report and document measured values
- Surface quality: 60-40 (MIL-0-13830A)
- Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
- Wedge: < 20 microns Edge Thickness Difference
- Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
- Ground surfaces: #400 grit equivalent or finer.



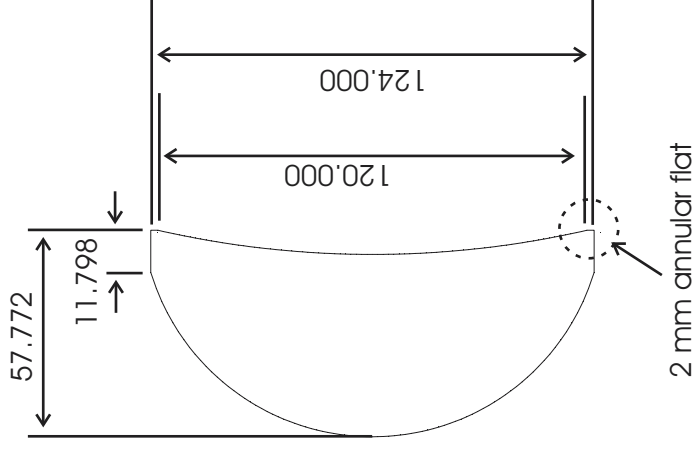
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PROJECT			
SALT PFIS CRITICAL DESIGN DRAWINGS			
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COLLIMATOR ELEMENT #1		2.11	

RADIUS	RAD TOL	IRR TOL	C. A. DIA
64.7932 CX	0.1%	0.5	113.4
269.1785 CC	0.1%	0.5	108.9

EDGE DIA	MATERIAL	THICK	THI TOL
124.0000	CAF2	51.0000	0.075

- All dimensions in mm before bevels
- Material- Customer-supplied blank, not generated or edged
- Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm.
Document and report figure.
- Radius Tolerance: +/- 0.1% unless otherwise indicated
- Contact surfaces: Match to +/- 5 fringe at 633 nm
- Surface finish: surface roughness 1 nm RMS or better.
Report and document measured values
- Surface quality: 60-40 (MIL-0-13830A)
- Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
- Wedge: < 20 microns Edge Thickness Difference
- Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
- Ground surfaces: #400 grit equivalent or finer.

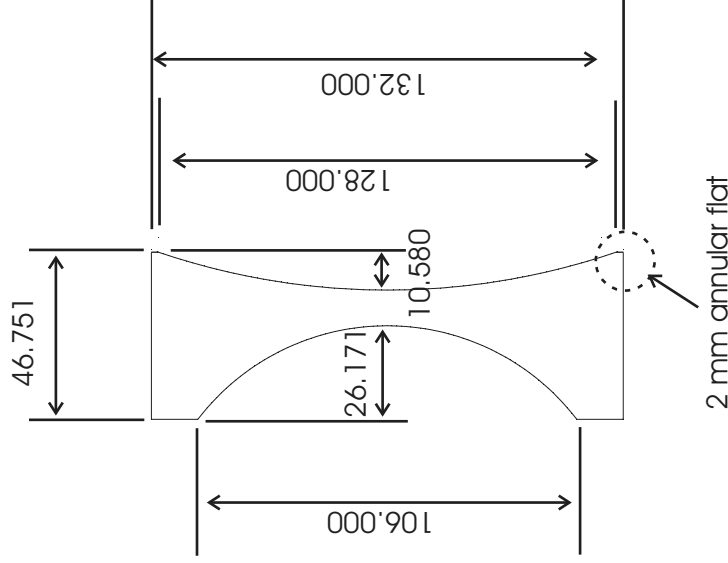


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COLLIMATOR ELEMENT #2	2.11		

RADIUS	RAD TOL	IRR TOL	C.A. DIA
-66.7515 CC	0.1%	0.5	94.9
198.8691 CC	0.1%	0.5	114.7

EDGE DIA	MATERIAL	THICK	THI TOL
132.0000	F_QUARTZ	10.0000	0.075

- All dimensions in mm before bevels
- Material- Customer-supplied blank, not generated or edged
- Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm.
Document and report figure.
- Radius Tolerance: +/- 0.1% unless otherwise indicated
- Contact surfaces: Match to +/- 5 fringe at 633 nm
- Surface finish: surface roughness 1 nm RMS or better.
Report and document measured values
- Surface quality: 60-40 (MIL-0-13830A)
- Diameter +/-0.075 mm; **Thickness: +/-0.038 mm**
Report to +/- 0.01 mm
- Wedge: < 20 microns Edge Thickness Difference
- Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
- Ground surfaces: #400 grit equivalent or finer.



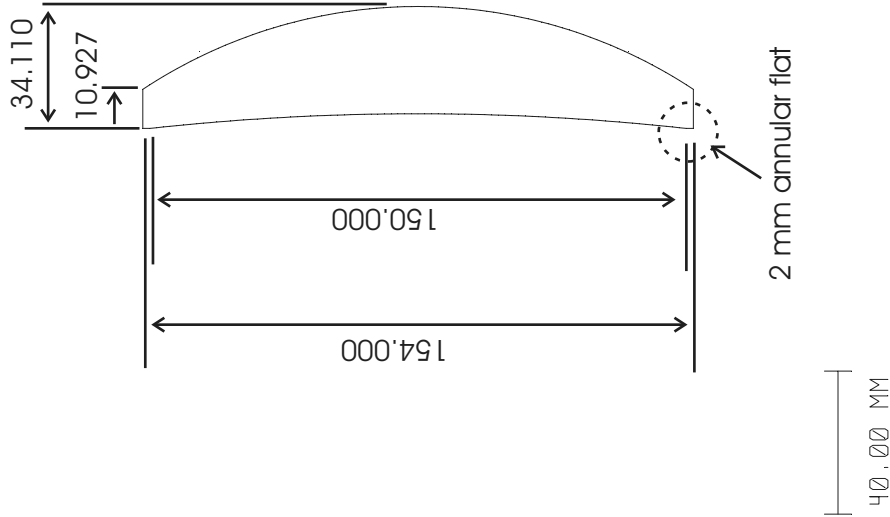
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COLLIMATOR ELEMENT #3		2.11	

RADIUS	RAD TOL	IRR TOL	C.A. DIA
-686.2812 CC	0.1%	0.5	129.6
-139.4617 CX	0.1%	0.5	141.8

EDGE DIA	MATERIAL	THICK	THI TOL
154.0000	F_QUARTZ	30.0000	0.075

- All dimensions in mm before bevels
- Material- Customer-supplied blank, not generated or edged
- Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
- Radius Tolerance: +/- 0.1% unless otherwise indicated
- Contact surfaces: Match to +/- 5 fringe at 633 nm
- Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
- Surface quality: 60-40 (MIL-0-13830A)
- Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
- Wedge: < 20 microns Edge Thickness Difference
- Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
- Ground surfaces: #400 grit equivalent or finer.

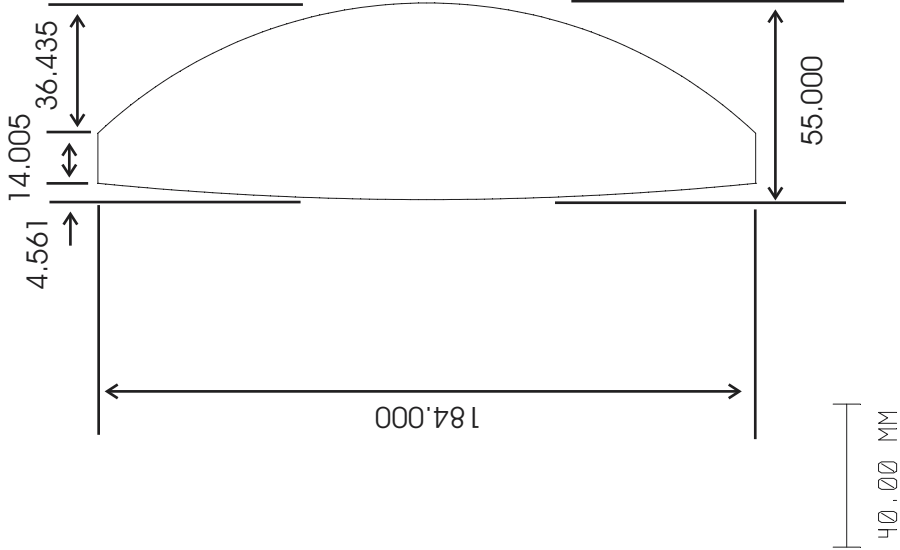


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COLLIMATOR ELEMENT #4		2.11			

RADIUS	RAD TOL	IRR TOL	C.A. DIA
930.2364 CX	0,1%	0.5	161,4
-134,3700 CX	0,1%	0.5	170,6

EDGE DIA	MATERIAL	THICK	THI TOL
184,0000	CAF2	55,0000	0,075

- All dimensions in mm before bevels
- Material- Customer-supplied blank, not generated or edged
- Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm.
Document and report figure.
- Radius Tolerance: +/- 0.1% unless otherwise indicated
- Contact surfaces: Match to +/- 5 fringe at 633 nm
- Surface finish: surface roughness 1 nm RMS or better.
Report and document measured values
- Surface quality: 60-40 (MIL-0-13830A)
- Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
- Wedge: < 20 microns Edge Thickness Difference
- Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
- Ground surfaces: #400 grit equivalent or finer.

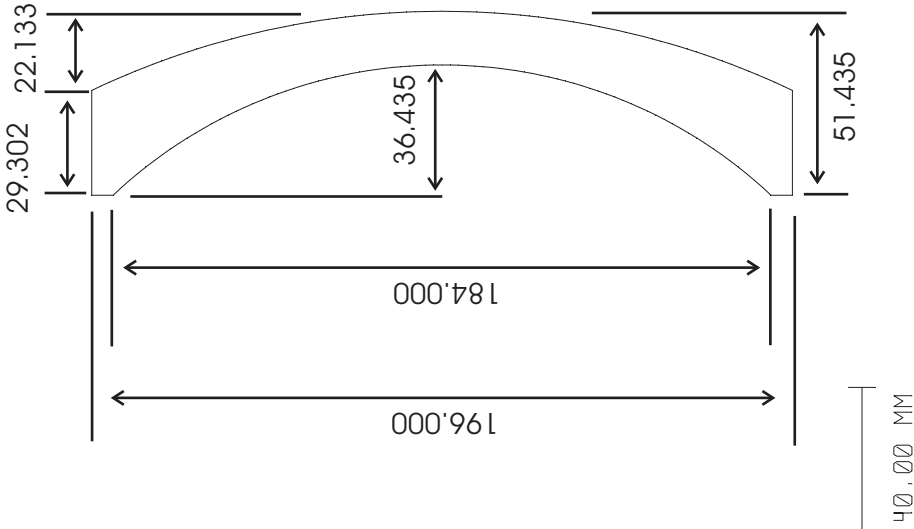


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SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING		REVISION	
COLLIMATOR ELEMENT #5		2.11	

RADIUS	RAD TOL	IRR TOL	C.A. DIA
-134,3700 CC	0,1%	0,5	170,6
-228,0297 CX	0,1%	0,5	184,6

EDGE DIA	MATERIAL	THICK	THI TOL
196,0000	NACL	15,0000	0,075

1. All dimensions in mm before bevels
2. Material- Customer-supplied blank, not generated or edged
3. Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
4. Radius Tolerance: +/- 0.1% unless otherwise indicated
5. Contact surfaces: Match to +/- 5 fringe at 633 nm
6. Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
7. Surface quality: 60-40 (MIL-0-13830A)
8. Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
9. Wedge: < 20 microns Edge Thickness Difference
10. Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
11. Ground surfaces: #400 grit equivalent or finer.

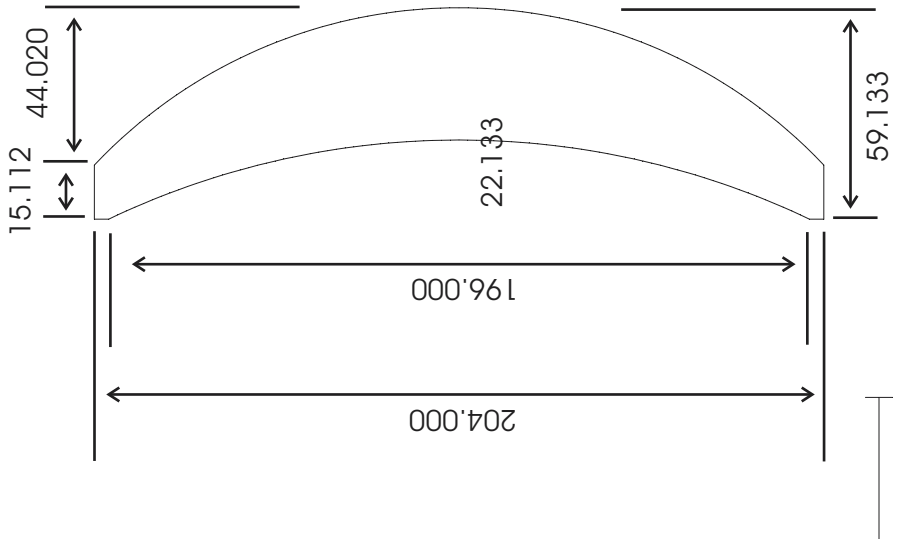


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SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING	REVISION		
COLLIMATOR ELEMENT #6	2, 11		

RADIUS	RAD TOL	IRR TOL	C.A. DIA
-228.0297 CC	0,1%	0,5	184,6
-140,1829 CX	0,1%	0,5	193,6

EDGE DIA	MATERIAL	THICK	THI TOL
204,0000	CAF2	37,0000	0,075

1. All dimensions in mm before bevels
2. Material- Customer-supplied blank, not generated or edged
3. Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
4. Radius Tolerance: +/- 0.1% unless otherwise indicated
5. Contact surfaces: Match to +/- 5 fringe at 633 nm
6. Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
7. Surface quality: 60-40 (MIL-0-13830A)
8. Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
9. Wedge: < 20 microns Edge Thickness Difference
10. Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
11. Ground surfaces: #400 grit equivalent or finer.

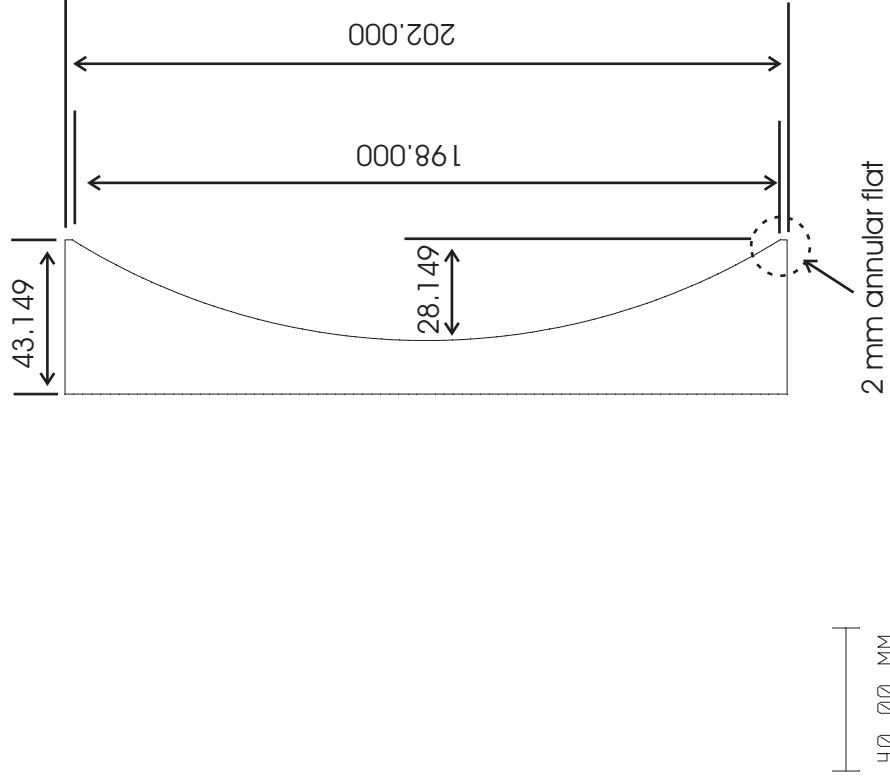


TITLE	DATE	SCALE	DRAWN	APPRV
PFIS COLLIMATOR - SYS_CD_58	FEB 6, 2003	0.5000:1	K. NORDSIECK	
PROJECT				
SALT PFIS CRITICAL DESIGN DRAWINGS				
DRAWING				REVISION
COLLIMATOR ELEMENT #7				2,11

RADIUS	RAD TOL	IRR TOL	C.A. DIA
PLANO	0,1%	0,5	187,1
188,1678 CC	0,1%	0,5	186,9

EDGE DIA	MATERIAL	THICK	THI TOL
202,0000	F_SILICA	15,0000	0,075

- All dimensions in mm before bevels
- Material- Customer-supplied blank, not generated or edged
- Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
- Radius Tolerance: +/- 0.1% unless otherwise indicated
- Contact surfaces: Match to +/- 5 fringe at 633 nm
- Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
- Surface quality: 60-40 (MIL-0-13830A)
- Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
- Wedge: < 20 microns Edge Thickness Difference
- Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
- Ground surfaces: #400 grit equivalent or finer.

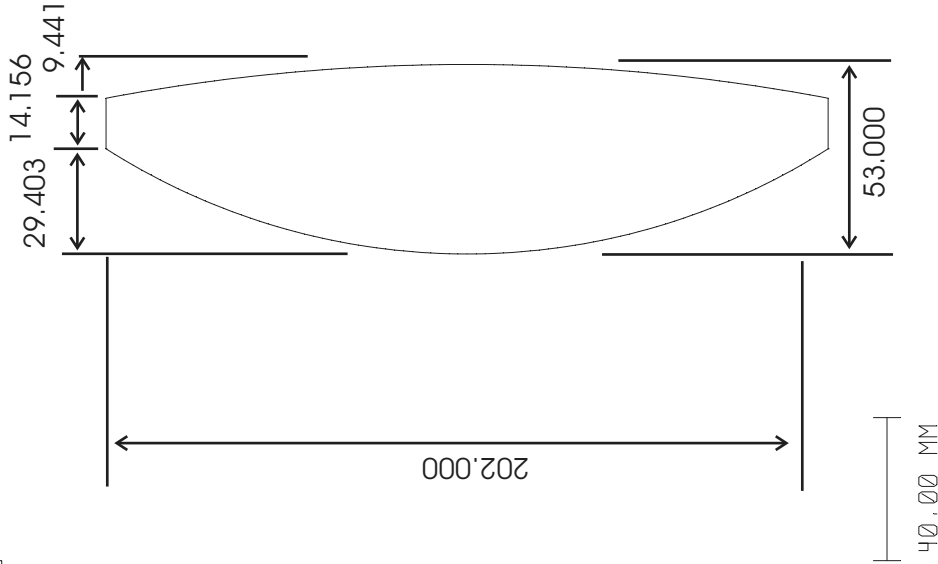


TITLE			
PFIS COLLIMATOR - SYS_CD_58			
DATE	SCALE	DRAWN	APPRV
FEB 6, 2003	0.5000:1	K. NORDSIECK	
PROJECT			
SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING		REVISION	
COLLIMATOR ELEMENT #8		2.11	

RADIUS	RAD TOL	IRR TOL	C.A. DIA
188,1678 CX	0,1%	0,5	186,9
-544,9774 CX	0,1%	0,5	187,3

1. All dimensions in mm before bevels
2. Material- Customer-supplied blank, not generated or edged
3. Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
4. Radius Tolerance: +/- 0.1% unless otherwise indicated
5. Contact surfaces: Match to +/- 5 fringe at 633 nm
6. Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
7. Surface quality: 60-40 (MIL-0-13830A)
8. Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
9. Wedge: < 20 microns Edge Thickness Difference
10. Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
11. Ground surfaces: #400 grit equivalent or finer.

EDGE DIA	MATERIAL	THICK	THI TOL
202.0000	CAF2	53.0000	0.075

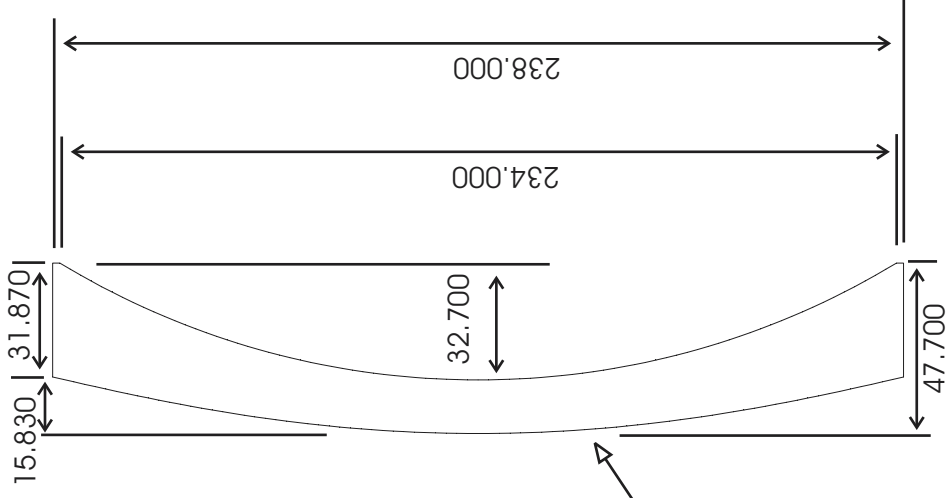


TITLE			
PFIS COLLIMATOR - SYS_CD_58			
DATE	SCALE	DRAWN	APPRV
FEB 6, 2003	0.5000:1	K. NORDSIECK	
PROJECT			
SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING	REVISION		
COLLIMATOR ELEMENT #9	2.11		

Camera Element Drawings

RADIUS	RAD TOL	IRR TOL	C.A. DIA	EDGE DIA	MATERIAL	THICK	THI TOL
407.5475 CX	0.1%	0.5	219.8	238.0000	F_SILICA	15.0000	0.075
225.6610 CC	0.1%	0.5	221.2				

- All dimensions in mm before bevels
- Material- Customer-supplied blank, not generated or edged
- Surface shape:**
 - asphere (see notes following page). Slope error $\leq 2 \times 10^{-5}$ radians.**
 - spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
- Radius Tolerance: +/- 0.1% unless otherwise indicated
- Contact surfaces: Match to +/- 5 fringe at 633 nm
- Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
- Surface quality: 60-40 (MIL-0-13830A)
- Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
- Wedge: < 20 microns Edge Thickness Difference
- Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
- Ground surfaces: #400 grit equivalent or finer.



Asphere coefficients

Coeff on r⁴ : -8.20788e-09
 Coeff on r⁶ : -4.76330e-14
 Coeff on r⁸ : -3.70543e-18

TITLE PFIS CAMERA - SYS_CD_58			
DATE FEB 6, 2003	SCALE 0.5000:1	DRAWN K. NORDSIECK	APPRV
PROJECT SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING CAMERA ELEMENT #1		REVISION 2.11	

Listing of surface sag for asphere

Units are Millimeters.

Semi diameter of surface 36: 1.1900000E+002.
 Best Fit Sphere curvature : 2.263498E-003.
 Best Fit Sphere radius : 4.417940E+002.
 Best Fit Sphere residual : 2.245889E-001. (rms)

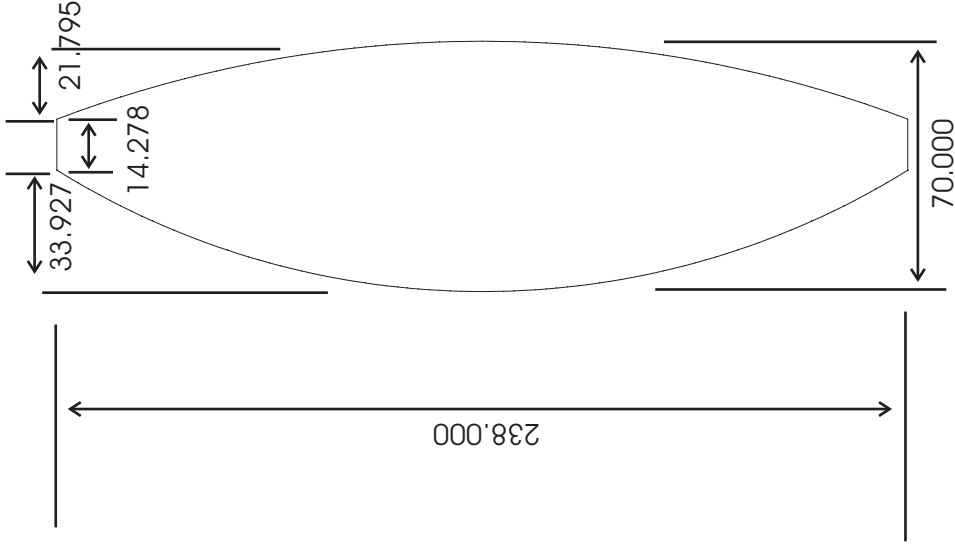
Y-coord	Sag	BFS Sag	Deviation	Remove
0.000000E+000	0.000000E+000	0.000000E+000	0.000000E+000	2.759570E-001
5.000000E+000	3.066730E-002	2.829464E-002	-2.372663E-003	2.735844E-001
1.000000E+001	1.226214E-001	1.131894E-001	-9.432026E-003	2.665250E-001
1.500000E+001	2.757189E-001	2.547170E-001	-2.100195E-002	2.549551E-001
2.000000E+001	4.897198E-001	4.529318E-001	-3.678796E-002	2.391691E-001
2.500000E+001	7.642862E-001	7.079104E-001	-5.637576E-002	2.195813E-001
3.000000E+001	1.098980E+000	1.019751E+000	-7.922901E-002	1.967280E-001
3.500000E+001	1.493261E+000	1.388575E+000	-1.046860E-001	1.712710E-001
4.000000E+001	1.946480E+000	1.814525E+000	-1.319553E-001	1.440018E-001
4.500000E+001	2.457877E+000	2.297767E+000	-1.601093E-001	1.158477E-001
5.000000E+001	3.026568E+000	2.838491E+000	-1.880767E-001	8.788034E-002
5.500000E+001	3.651542E+000	3.436910E+000	-2.146316E-001	6.132543E-002
6.000000E+001	4.331640E+000	4.093259E+000	-2.383804E-001	3.757662E-002
6.500000E+001	5.065546E+000	4.807801E+000	-2.577450E-001	1.821201E-002
7.000000E+001	5.851762E+000	5.580820E+000	-2.709420E-001	5.015033E-003
7.500000E+001	6.688586E+000	6.412629E+000	-2.759570E-001	0.000000E+000
8.000000E+001	7.574079E+000	7.303565E+000	-2.705140E-001	5.443067E-003
8.500000E+001	8.506030E+000	8.253992E+000	-2.520376E-001	2.391946E-002
9.000000E+001	9.481913E+000	9.264303E+000	-2.176093E-001	5.834775E-002
9.500000E+001	1.049883E+001	1.033492E+001	-1.639149E-001	1.120422E-001
1.000000E+002	1.155347E+001	1.146629E+001	-8.718330E-002	1.887737E-001
1.050000E+002	1.264201E+001	1.265889E+001	1.688446E-002	2.928415E-001
1.100000E+002	1.376005E+001	1.391325E+001	1.531976E-001	4.291547E-001
1.150000E+002	1.490252E+001	1.522989E+001	3.273699E-001	6.033269E-001
1.190000E+002	1.583019E+001	1.632844E+001	4.982541E-001	7.742111E-001

TITLE			
PFIS CAMERA - SYS_CD_58			
DATE	SCALE	DRAWN	APPRV
FEB 6, 2003		K. NORDSIECK	
PROJECT			
SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING	REVISION		
CAMERA ELEMENT #1	2.11		

RADIUS	RAD TOL	IRR TOL	C. A. DIA
225.6610 CX	0.1%	0.5	221.2
-335.7677 CX	0.1%	0.5	222.7

1. All dimensions in mm before bevels
2. Material- Customer-supplied blank, not generated or edged
3. Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
4. Radius Tolerance: +/- 0.1% unless otherwise indicated
5. Contact surfaces: Match to +/- 5 fringe at 633 nm
6. Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
7. Surface quality: 60-40 (MIL-0-13830A)
8. Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
9. Wedge: < 20 microns Edge Thickness Difference
10. Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
11. Ground surfaces: #400 grit equivalent or finer.

EDGE DIA	MATERIAL	THICK	THI TOL
238.0000	CAF2	70.00000	0.075



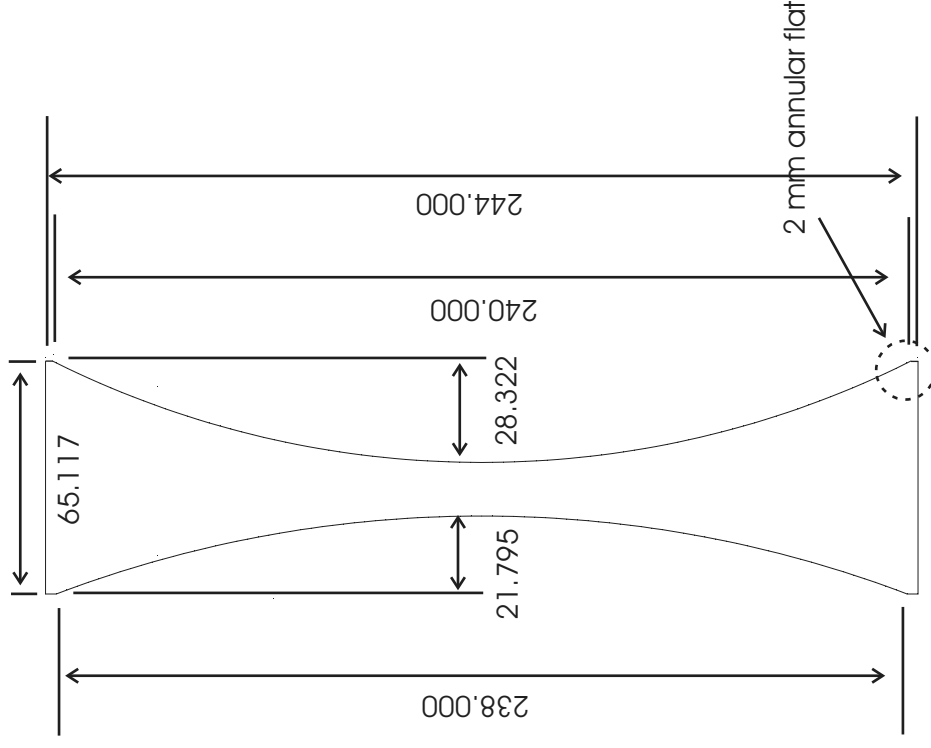
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TITLE PFIS CAMERA - SYS_CD_58			
DATE FEB 6, 2003	SCALE 0.5000:1	DRAWN K. NORDSIECK	APPRV
PROJECT SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING CAMERA ELEMENT #2		REVISION 2.11	

RADIUS	RAD TOL	IRR TOL	C. A. DIA
-335.7677 CC	0.1%	0.5	222.7
268.3832 CC	0.1%	0.5	227.5

- All dimensions in mm before bevels
- Material- Customer-supplied blank, not generated or edged
- Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
- Radius Tolerance: +/- 0.1% unless otherwise indicated
- Contact surfaces: Match to +/- 5 fringe at 633 nm
- Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
- Surface quality: 60-40 (MIL-0-13830A)
- Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
- Wedge: < 20 microns Edge Thickness Difference
- Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
- Ground surfaces: #400 grit equivalent or finer.

EDGE DIA	MATERIAL	THICK	THI TOL
244.0000	F_SILICA	15.0000	0.075



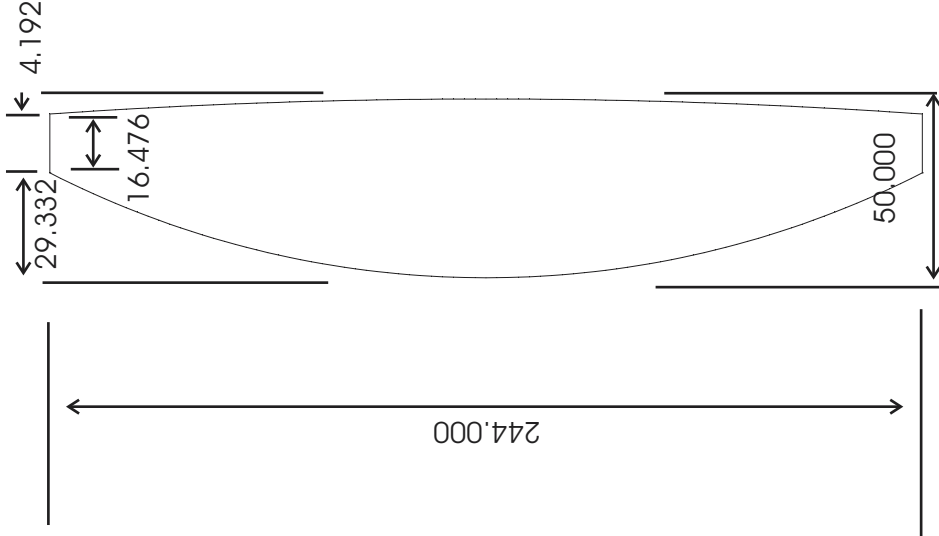
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TITLE			
PFIS CAMERA - SYS_CD_58	SCALE	DRAWN	APPRV
DATE FEB 6, 2003	0.5000:1	K. NORDSIECK	
PROJECT			
SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING		REVISION	
CAMERA ELEMENT #3		2.11	

RADIUS	RAD TOL	IRR TOL	C. A. DIA
268.3832 CX	0.1%	0.5	227.5
-1777.484 CX	0.1%	0.5	229.7

1. All dimensions in mm before bevels
2. Material- Customer-supplied blank, not generated or edged
3. Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
4. Radius Tolerance: +/- 0.1% unless otherwise indicated
5. Contact surfaces: Match to +/- 5 fringe at 633 nm
6. Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
7. Surface quality: 60-40 (MIL-0-13830A)
8. Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
9. Wedge: < 20 microns Edge Thickness Difference
10. Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
11. Ground surfaces: #400 grit equivalent or finer.

EDGE DIA	MATERIAL	THICK	THI TOL
244.0000	CAF2	50.00000	0.075



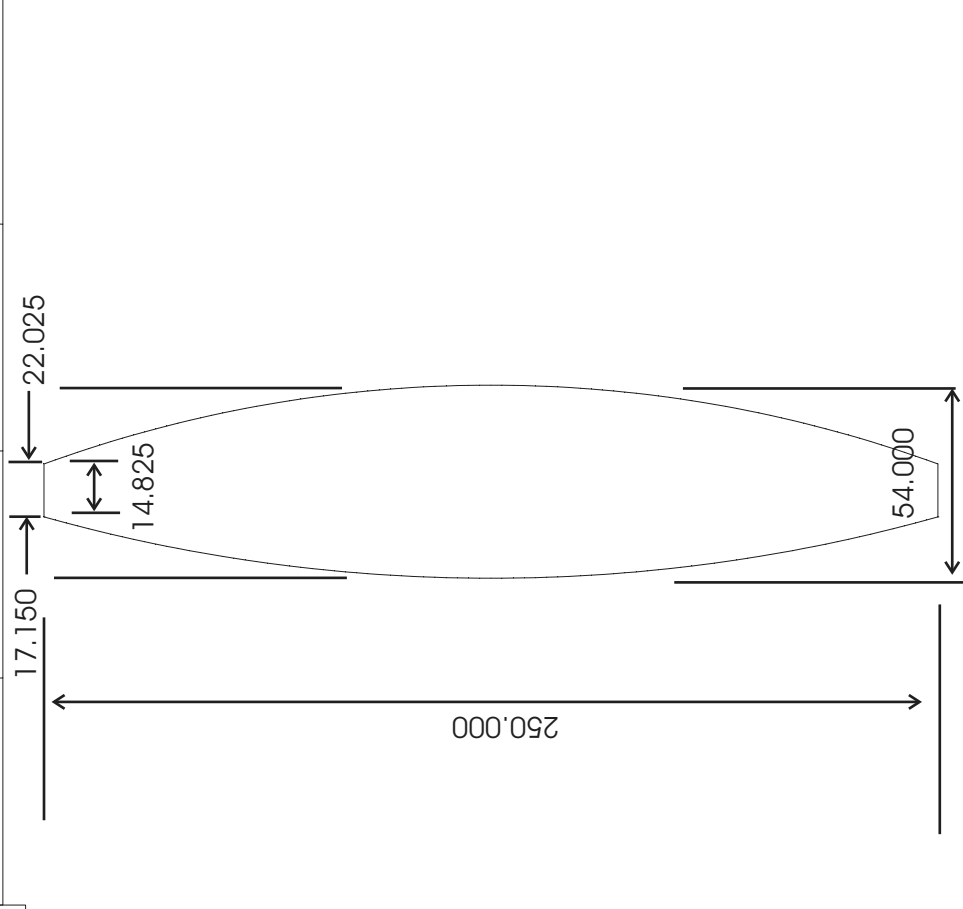
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TITLE PFIS CAMERA - SYS_CD_58			
DATE FEB 6, 2003	SCALE 0.5000:1	DRAWN K. NORDSTIECK	APPRV
PROJECT SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING CAMERA ELEMENT #4		REVISION 2.11	

RADIUS	RAD TOL	IRR TOL	C.A. DIA
464.1057 CX	0.1%	0.5	241.0
-365.7249 CX	0.1%	0.5	239.5

- All dimensions in mm before bevels
- Material- Customer-supplied blank, not generated or edged
- Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
- Radius Tolerance: +/- 0.1% unless otherwise indicated
- Contact surfaces: Match to +/- 5 fringe at 633 nm
- Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
- Surface quality: 60-40 (MIL-0-13830A)
- Diameter and thickness: +/-0.075mm Report to +/- 0.01 mm
- Wedge: < 20 microns Edge Thickness Difference
- Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
- Ground surfaces: #400 grit equivalent or finer.

EDGE DIA	MATERIAL	THICK	THI TOL
250.0000	CAF2	54.0000	0.075



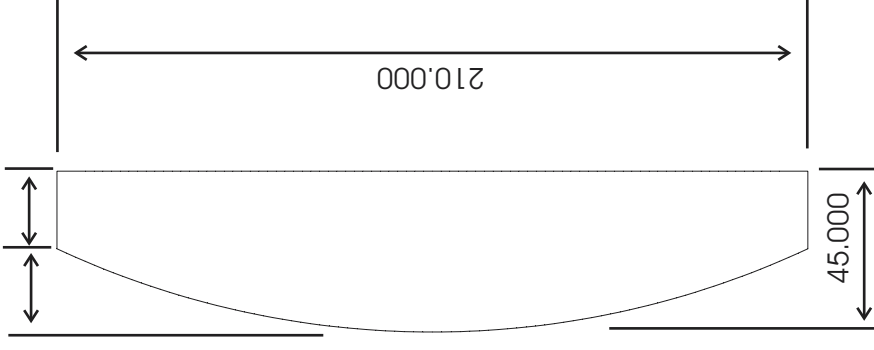
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TITLE PFIS CAMERA - SYS_CD_58			
DATE FEB 6, 2003	SCALE 0.5000:1	DRAWN K. NORDSIECK	APPRV
PROJECT SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING CAMERA ELEMENT #5		REVISION 2.11	

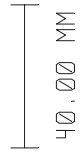
RADIUS	RAD TOL	IRR TOL	C.A., DIA
248.3816 CX	0.1%	0.5	197.1
PLANO	0.1%	0.5	183.4

EDGE DIA	MATERIAL	THICK	THI TOL
210.0000	F_SILICA	45.0000	0.075

23.285 21.715



- All dimensions in mm before bevels
- Material- Customer-supplied blank, not generated or edged
- Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
- Radius Tolerance: +/- 0.1% unless otherwise indicated
- Contact surfaces: Match to +/- 5 fringe at 633 nm
- Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
- Surface quality: 60-40 (MIL-0-13830A)
- Diameter and thickness: +/-0.075mm. Report to +/- 0.01 mm
- Wedge: < 20 microns Edge Thickness Difference
- Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
- Ground surfaces: #400 grit equivalent or finer.

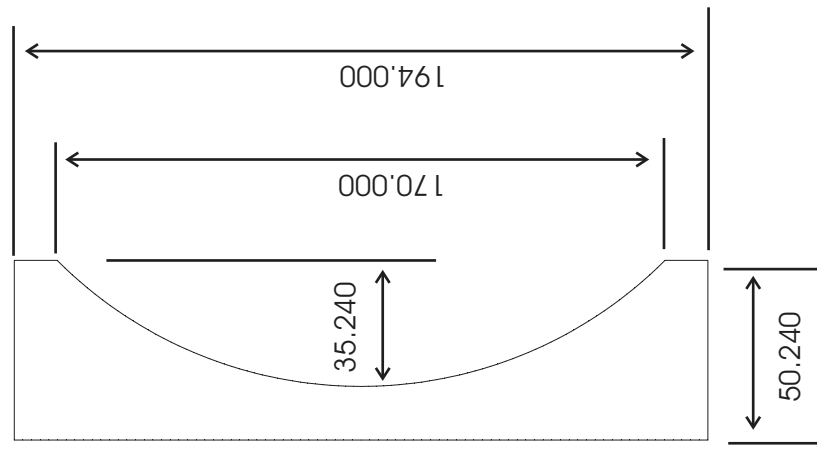


TITLE			
PFIS CAMERA - SYS_CD_58			
DATE	SCALE	DRAWN	APPRV
FEB 6, 2003	0.5000:1	K. NORDSIECK	
PROJECT			
SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING		REVISION	
CAMERA ELEMENT #6		2.11	

RADIUS	RAD TOL	IRR TOL	C.A. DIA
PLANO	0.1%	0.5	183.4
120.1303 CC	0.1%	0.5	159.8

EDGE DIA	MATERIAL	THICK	THI TOL
194.0000	NACL	15.0000	0.075

1. All dimensions in mm before bevels
2. Material- Customer-supplied blank, not generated or edged
3. Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm.
Document and report figure.
4. Radius Tolerance: +/- 0.1% unless otherwise indicated
5. Contact surfaces: Match to +/- 5 fringe at 633 nm
6. Surface finish: surface roughness 1 nm RMS or better.
Report and document measured values
7. Surface quality: 60-40 (MIL-0-13830A)
8. Diameter and thickness: +/-0.075mm. Report to +/- 0.01 mm
9. Wedge: < 20 microns Edge Thickness Difference
10. Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
11. Ground surfaces: #400 grit equivalent or finer.



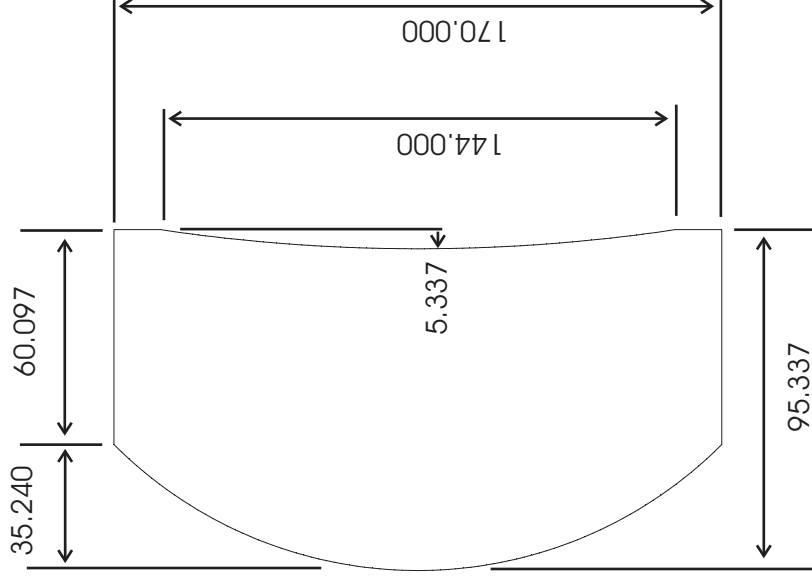
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TITLE PFIS CAMERA - SYS_CD_58			
DATE FEB 6, 2003	SCALE 0.5000:1	DRAWN K. NORDSIECK	APPRV
PROJECT SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING		REVISION	
CAMERA ELEMENT #7		2.11	

RADIUS	RAD TOL	IRR TOL	C.A. DIA
120.1303 CX	0.1%	0.5	159.8
488.2939 CC	0.1%	0.5	130.4

EDGE DIA	MATERIAL	THICK	THI TOL
170.0000	F_SILICA	90.0000	0.075

- All dimensions in mm before bevels
- Material- Customer-supplied blank, not generated or edged
- Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm.
Document and report figure.
- Radius Tolerance: +/- 0.1% unless otherwise indicated
- Contact surfaces: Match to +/- 5 fringe at 633 nm
- Surface finish: surface roughness 1 nm RMS or better.
Report and document measured values
- Surface quality: 60-40 (MIL-0-13830A)
- Diameter and thickness: +/-0.075mm. Report to +/- 0.01 mm
- Wedge: < 20 microns Edge Thickness Difference
- Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
- Ground surfaces: #400 grit equivalent or finer.

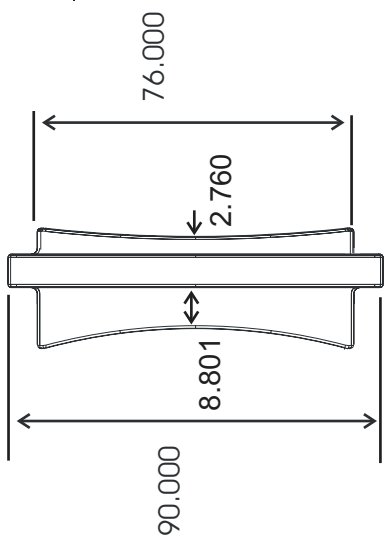
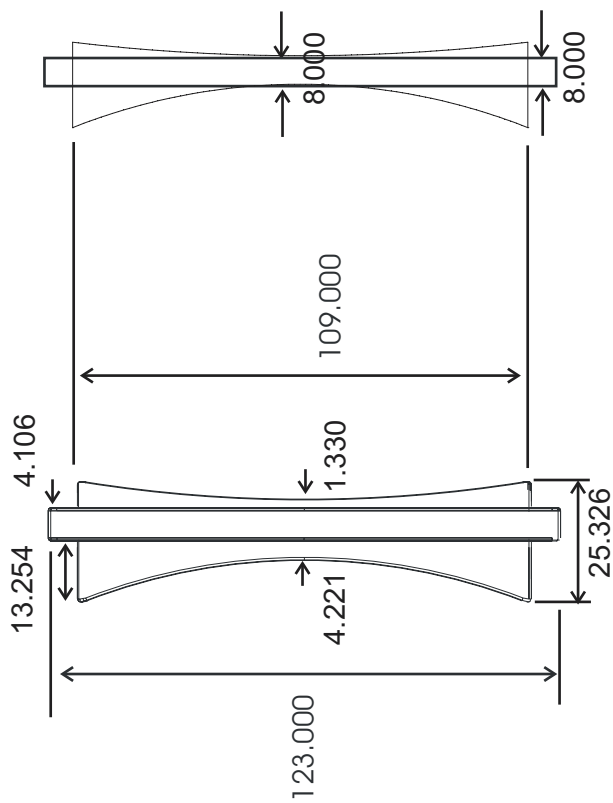


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TITLE PFIS CAMERA - SYS_CD_58			
DATE FEB 6, 2003	SCALE 0.5000:1	DRAWN K. NORDSIECK	APPRV
PROJECT SALT PFIS CRITICAL DESIGN DRAWINGS			
DRAWING CAMERA ELEMENT #8		REVISION 2.11	

RADIUS	RAD TOL	IRR TOL	C.A., ...	EDGE	MATERIAL	THICK	THI TOL
-173.1466 CC	0.1%	0.5	72X105	76x109	F_SILICA	8.0000	0.075
539.5584 CC	0.1%	0.5	65X98				

1. All dimensions in mm before bevels
2. Material- Customer-supplied blank, not generated or edged
3. Surface shape: spherical. Pitch polish to test plate within +/- 0.5 fringe at 633 nm. Document and report figure.
4. Radius Tolerance: +/- 0.1% unless otherwise indicated
5. Contact surfaces: Match to +/- 5 fringe at 633 nm
6. Surface finish: surface roughness 1 nm RMS or better. Report and document measured values
7. Surface quality: 60-40 (MIL-0-13830A)
8. Length, width, and thickness: +/-0.075mm. Report to +/- 0.01 mm
9. Wedge: < 20 microns Edge Thickness Difference
10. Bevel Edges 1 mm at 45 Deg: 1.44 mm max face width; polish if possible.
11. Ground surfaces: #400 grit equivalent or finer.



Geometry: Rectangular with mounting lip



TITLE	PFIS CAMERA - SYS_CD_58		
DATE	SCALE	DRAWN	APPRV
FEB 6, 2003	0.5000:1	K. NORDSIECK	
PROJECT	SALT PFIS CRITICAL DESIGN DRAWINGS		
DRAWING	REVISION		
CAMERA ELEMENT #9	2.11		