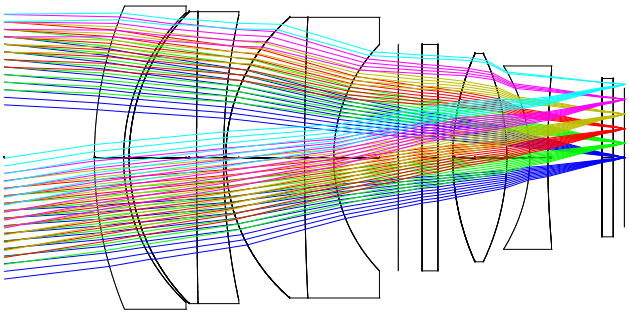


Optical Material Specification And Procurement For The SALT Imaging Camera: SALTICAM

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SAAO

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Chapter 1

Introduction, Scope And Background

1.1 Introduction

The Southern African Large Telescope (SALT) is a 10-m class optical/infrared telescope to be constructed and sited at Sutherland in South Africa. Construction and operations is being carried out by the SALT Foundation. Webcam photographs of the construction site are visible on the Web at http://www.salt.ac.za/pr/cam.html. Further information may be found from the web site: http://www.salt.ac.za

SALT needs an acquisition camera to enable the telescope operators to recognize celestial targets and position them in the entrance apertures of the scientific instruments. In addition, the acquisition camera is to be used as a scientific imager. The South African Astronomical Observatory (SAAO) (hereafter "the Customer") is to provide SALT with this acquisition camera, called SALTICAM.

1.2 Scope Of This Document

The purpose of the present document is to provide a technical specification for the procurement of optical material for the lenses of SALTICAM.

This document also solicits:

- Expressions of interest from potential suppliers (hereafter called the "Optical Material Vendor") to supply the optical blank material described herein.
- Pricing for the optical blank material;
- Delivery time for the optical blank material;
- Comments on any anticipated technical difficulty;

Responses may be made by email (dod@saao.ac.za), fax (+27-21-447-3639), or airmail postage (SAAO, PO Box 9, Observatory 7935, Cape Town, South Africa), marked for the attention of Dr. D. O'Donoghue. Responses within two weeks of receipt of this document would be appreciated.

1.2.1 Optical Materials

Excellent image quality and high ultraviolet throughput are strong drivers for the design. The design wavelength range is 320 to 950 nm, so the materials used were restricted to fused silica, CaF_2 and BaF_2. Of course, CaF_2 and especially BaF_2 are materials vulnerable to damage from scratching, staining, thermal or mechanical shock and moisture.

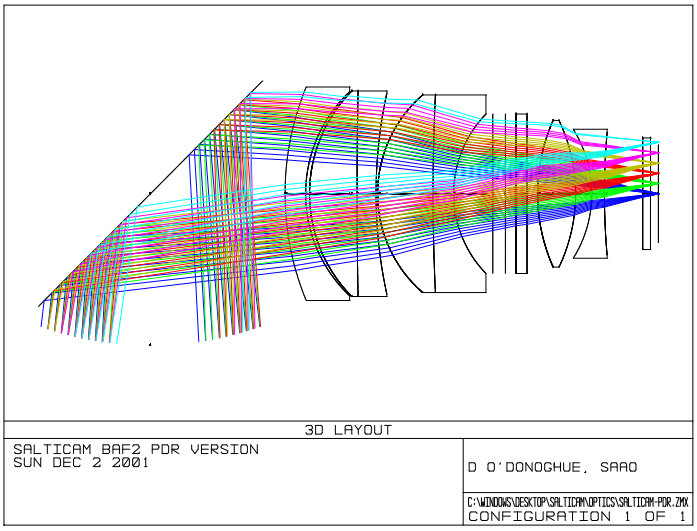


Figure 1.1: SALTICAM optical layout. Light from the telescope leaves the exit pupil at bottom left, and is folded by the flat mirror indicated. SALTICAM optics comprise 5 (air-spaced) lens groups: in order of the optical path (from left to right) a singlet, two doublets, an optically flat filter and two singlets. In addition, the optically flat window into the evacuated CCD cryostat is shown, along with the CCD at the focal surface on the extreme right. The two thin solid lines indicate the volume occupied by the shutter.

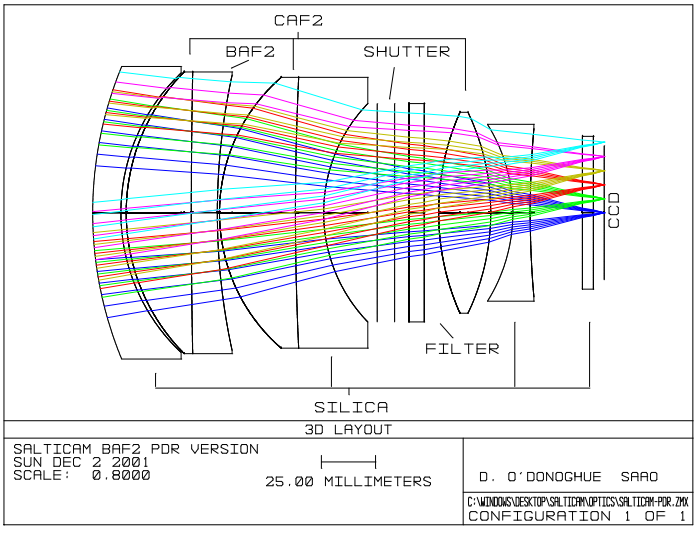


Figure 1.2: SALTICAM detailed optical layout. Magnified view of the optics in Fig. 1.1. Materials are as indicated.

Table 1.1: Numerical surface data for the SALTICAM optics

Surface Number	Type	Comment	Radius (mm)	Thickness (mm)	Glass	Clear Aperture Diameter (mm)	Conic Constant
Object				Infinity			
Stop	spherical	SALT Primary	-26165.0	-12829.67	Mirror	11000.0	0
2		Hole in M3		-641.787		100	
3	conic	M2	1432.343	641.787	Mirror	600	0.9297352
4	gen asph	M3	-2098.823	-641.787	Mirror	596	0
5		Hole in M2		-75.000		144	
6		Hole in M5		-171.597		100	
7	conic	M4	-242.868	171.597	Mirror	98	-2.859464
8	conic	M5	-375.750	-171.597	Mirror	375	-0.1984524
9		Obstr by M4		-420.0			
10		Exit Pupil		-95.0			
12		Fold Mirror		85.0	Mirror		
14		Singlet 1	174.600	13.0	Silica	130	
15			87.646	2.451		124	
16		Doublet 1	91.221	30.0	CaF2	125	
17		Doublet 1	3244.182	12.0	BaF2	124	
18			295.563	1.0		121	
19		Doublet 2	81.820	35.0	CaF2	120	
20		Doublet 2	1299.05	13.0	Silica	114	
21			71.601	24.681		96	
22		Shutter		8.0		96	
23				6.659		96	
24		Filter		7.0	Silica	96	
25				6.660		96	
26		Singlet 2	112.694	24.0	CaF2	89	
27			-106.268	10.203		87	
28		Singlet 3	-75.977	8.0	Silica	77	
29			440.171	24.096		73	
30		Window		5.0	Silica	70	
31				5.0		70	
Image		Focal Plane				61.4	

M3 aspheric coefficients: $a_2 = -2.425618 \times 10^{-4}$
$a_4 = 9.1127326 \times 10^{-10}$
$a_6 = 8.7170021 \times 10^{-16}$
$a_8 = -2.6460378 \times 10^{-21}$

1.2.2 Environmental Conditions

SALT and its associated instrumentation are intended to operate without degradation over the temperature range 0 to 20 degrees Celsius, to operate with 10 per cent performance degradation allowed over the temperature range -10 to 25 degrees Celsius and to survive in the temperature range -20 to 45 degrees Celsius. Occasional exposure to condensing conditions may be experienced.

The camera will be located on the Payload which rides the Tracker on the top hexagon of the telescope structure. However, it is planned to seal the Payload to enable clean dry air with positive pressure to be fed through it. Light entering the Payload will *not* pass through a sealing window. Thus, while the camera will not be nakedly exposed to dome air, some dust and moisture must inevitably find its way to the immediate environs of the camera.

1.3 SALTICAM optical design

SALTICAM is to be fed light using a folding flat mirror located just after the exit pupil of the telescope. An optical design which meets the requirements for the instrument appears in Fig. 1.1. The exit pupil of the telescope is shown at lower left, with the fold mirror immediately above it. SALTICAM comprises seven elements in five lens groups (in order of optical path from left to right): a singlet, two doublets and two singlets. Fig. 1.1 also shows an optically flat filter between the rear doublet and the first rear singlet, as well as the optically flat window into the evacuated CCD cryostat, and the CCD detector at the focal plane. This document is limited to the specification of blank material for the seven elements.

Fig. 1.2 shows the five lens groups in greater detail and indicates the materials mentioned in the last section.

Table 1.1 gives numerical information in ZEMAX "spreadsheet" format for the design. The numerical information includes the whole telescope, with 11 m spherical primary, and 4-mirror spherical aberration corrector (surfaces numbered 1 to 8). The exit pupil is surface 10 and the fold mirror is surface 12. SALTICAM optics run from surfaces 14 to 29, although the last element is the flat cryostat window which is not included in this specification. All surfaces in the SALTICAM optics are spherical.

Chapter 2

Optical Material Requirements

Blanks material requirements for the 7 elements are collected in Table 2.1. Stress birefringence of the material shall be smaller than 10 nm/cm. Refractive index homogeneity shall be smaller than 5×10^{-5}. The diameters and thicknesses listed in Table 2.1 are 4 mm larger than the physical diameters and thicknesses of the finished elements (see Table 1.1).

Element drawings suitable for fabrication of the 7 items in Table 2.3 appear in Figs. 2.1 to 2.7.

Table 2.1: SALTICAM Optical Material Requirement

Item	Material	Thickness Of Blank (mm)	Physical Diameter Of Blank (mm)
1	Silica	44.0	138.0
2	CaF_2	34.0	133.0
3	BaF2	24.0	133.0
4	CaF_2	39.0	128.0
5	Silica	37.0	128.0
6	CaF_2	24.0	96.0
7	Silica	24.0	85.0

2.1 Optical Material Statement Of Work

The Statement of Work requires the Optical Material Vendor to:

1. Supply optical blank material with the stress birefringence and refractive index homogeneity specified as above, and of size as listed in Table 2.1.
2. Report metrology of the manufactured items.

If the Optical Material Vendor has the capability and wishes to undertake the task, the Customer would be willing to consider expanding the scope of work to include shaping the blank material with the required radii of curvature. Radii of curvature are indicated in Table 2.3 and tolerances on the finished elements are listed in Table 2.2.

Table 2.2: Tolerances On Manufacture Of SALTICAM Optics

Tolerance on	Tolerance
Radius of Curvature	within 0.1 % of nominal
Lens Thickness	± 0.10 mm
Wedge	< 30 arcseconds
Decentration	< 25 microns
Surface Irregularity	< 1/4 wave P-V
Scratch/Dig	60/40

Table 2.3: SALTICAM Optics For Manufacture

Item	Material	Entrance Radius of Curvature (mm)	Exit Radius of Curvature (mm)	Centre Thickness (mm)	Physical Diameter (mm)	Clear Aperture Diameter (mm)
1	Silica	174.600 CX	87.646 CC	13.0	134.0	130.0 124.0
2	CaF2	91.221 CX	3244.182 CC	30.0	129.0	125.0 124.0
3	BaF2	3244.182 CX	295.563 CC	12.0	129.0	124.0 121.0
4	CaF2	81.820 CX	1299.05 CC	35.0	124.0	120.0 114.0
5	Silica	1299.05 CX	71.601 CC	13.0	124.0	114.0 96.0
6	CaF2	112.694 CX	106.268 CX	24.0	92.0	89.0 87.0
7	Silica	75.977 CC	440.171 CC	8.0	81.0	77.0 73.0

2.2 Optical Manufacturing Deliverables

The manufacturing deliverables comprise:

- Optical blanks as specified in Section 2 and with physical sizes as listed in Table 2.1.
- Metrology reports for each of the blanks.

The blanks should be supplied to the Optical Fabricator or to the Customer (the Optical Material Vendor will be notified in good time).

2.3 Summary Of Responses Desired From This Document

As mentioned at the outset, this document contains a specification and design suitable for a Preliminary Design Review for the instrument. Therefore, it is hoped that the document will interest potential Optical Material Vendors in the work described in the Statements of Work (Section 2.1); prices and delivery schedules for the work are also solicited, and comment invited on any technical difficulties foreseen.

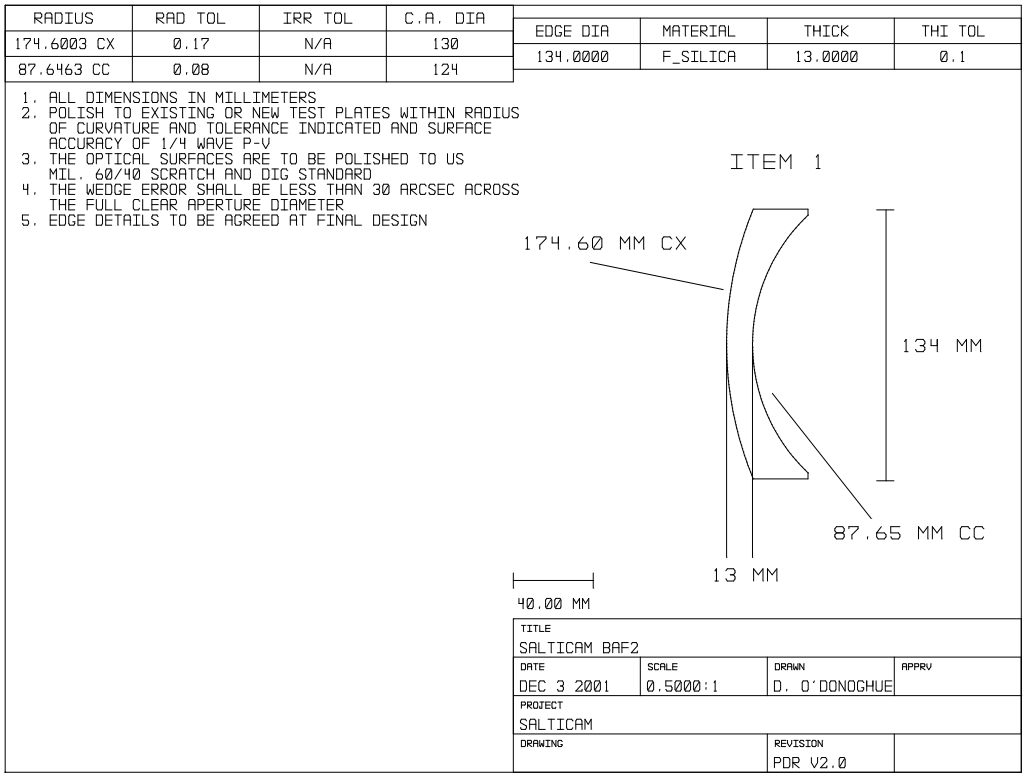


Figure 2.1: Element drawing for Item 1.

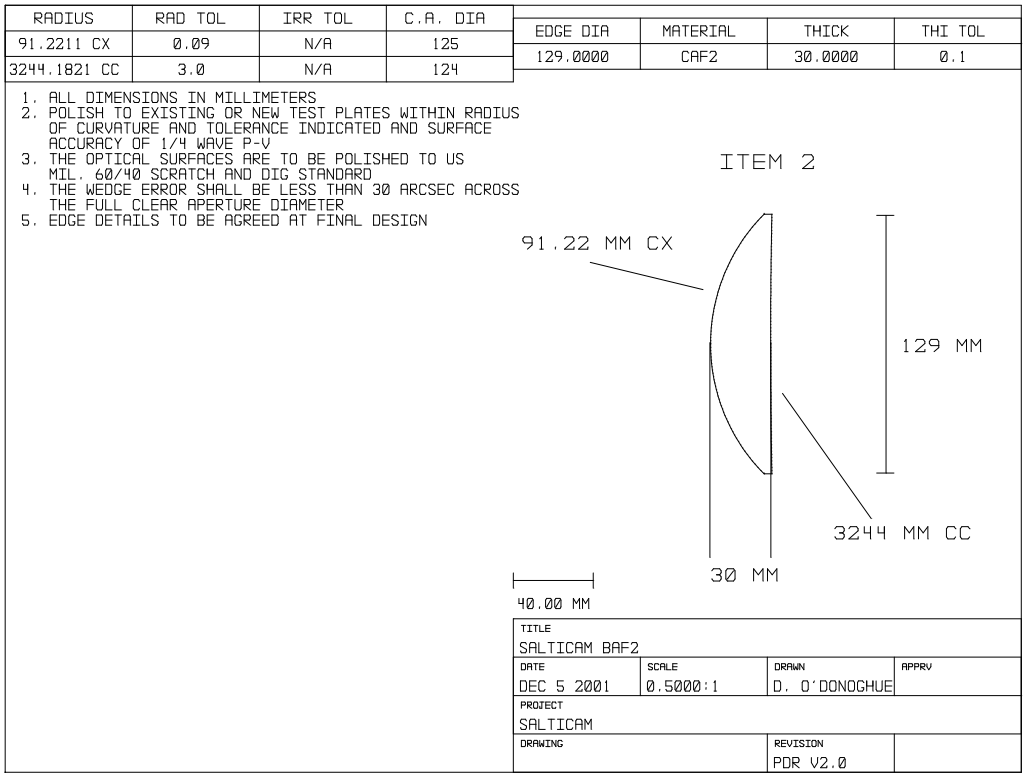


Figure 2.2: Element drawing for Item 2.

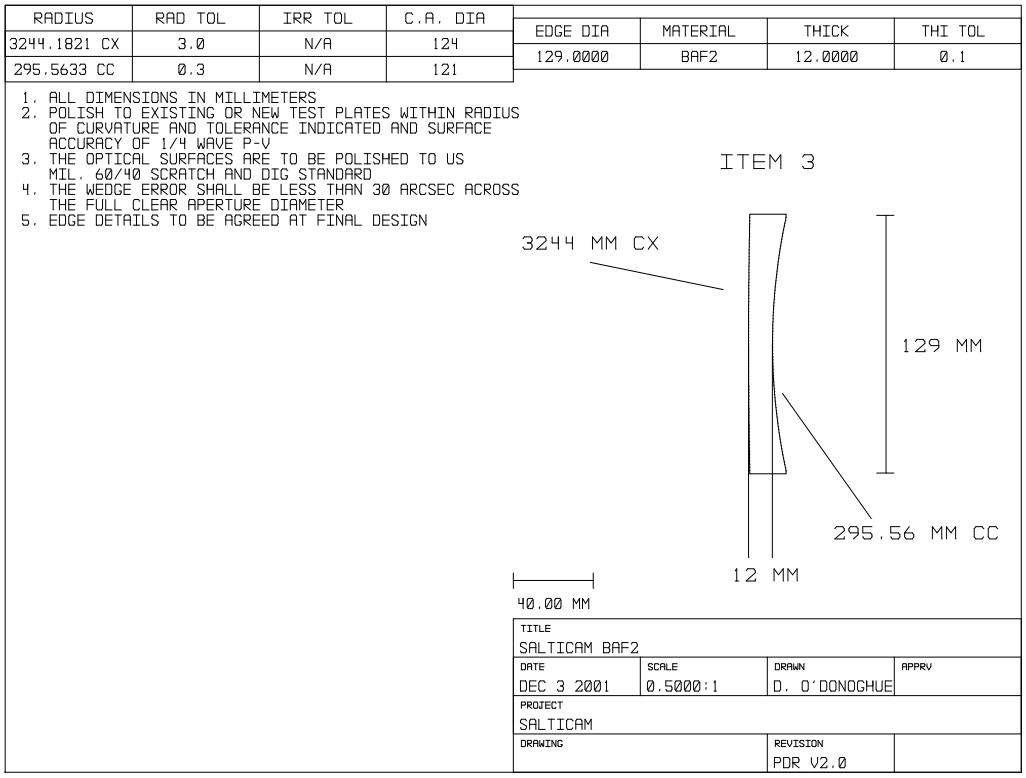


Figure 2.3: Element drawing for Item 3.

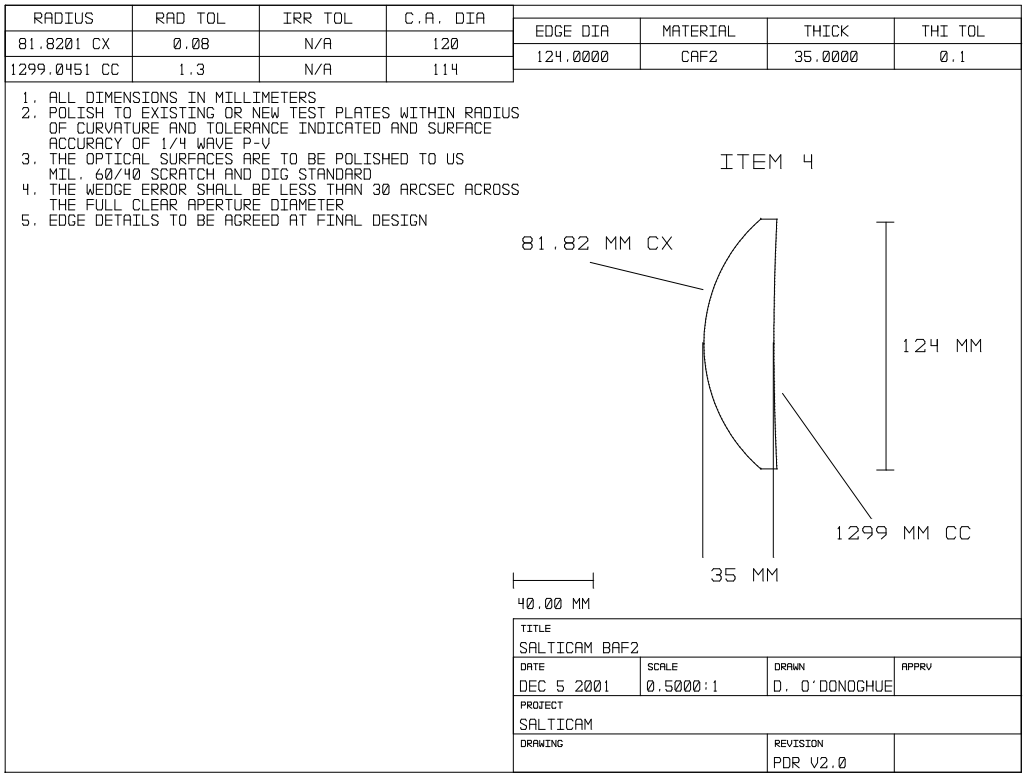


Figure 2.4: Element drawing for Item 4.

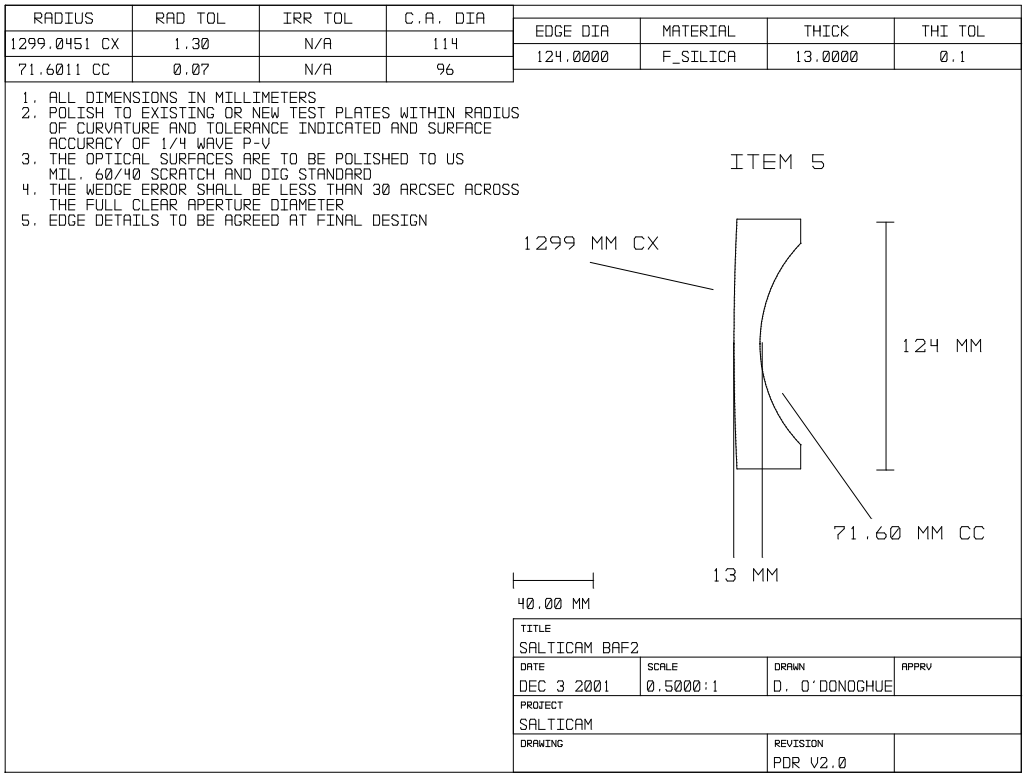


Figure 2.5: Element drawing for Item 5.

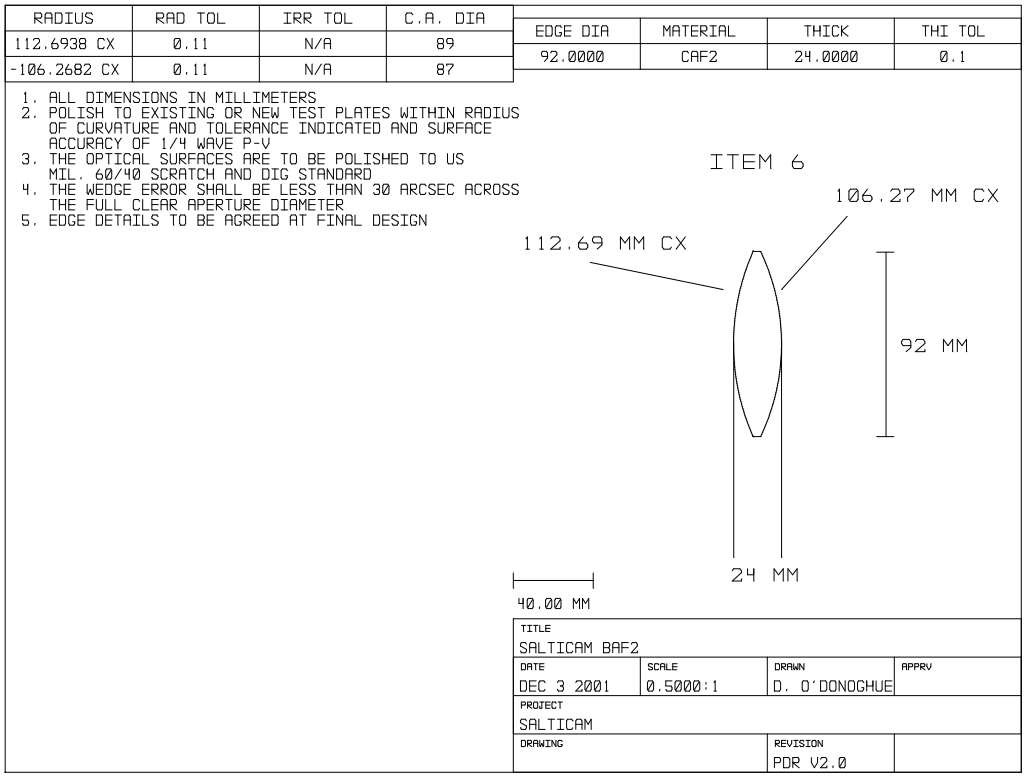


Figure 2.6: Element drawing for Item 6.

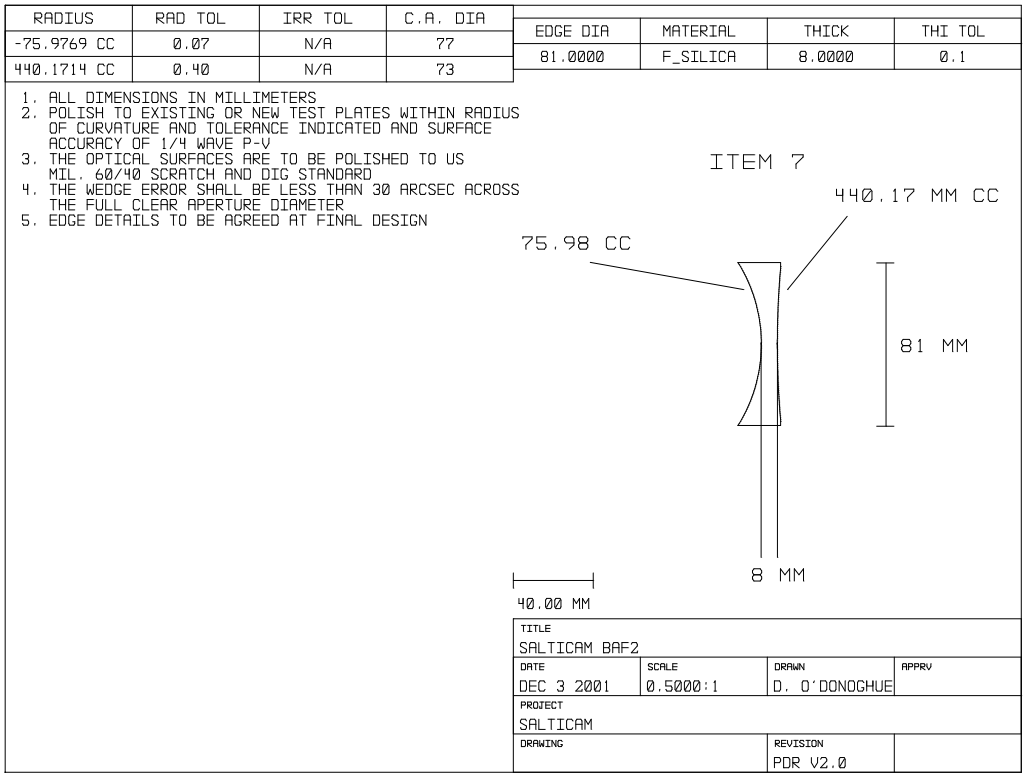


Figure 2.7: Element drawing for Item 7.