



Programme: **ELT**

Project: **ELT MCAO Construction – MORFEO**

MORFEO Calibration Unit Optomechanical System – Preliminary Optical Prescriptions

Document Number: E-MAO-PU0-INA-TNO-002

Document Version: 01

Document Type: Technical Note (TNO)

Released On: 2025-01-10

	Name	Signature	Date
Owner :	Gianluca Di Rico		2024-10-18
Approved by PI:	Paolo Ciliegi		2024-10-18
Released by PM:	Andrea Di Rocco		2024-10-18





Authors

Name	Affiliation
Ivan Di Antonio	INAF – OAAb
Gabriele Rodeghiero	INAF – OAAb / OAS
Gianluca Di Rico	INAF – OAAb
Mauro Dolci	INAF – OAAb



Table of Contents

Table of Contents	3
1. Introduction	4
1.1 Content.....	4
1.2 Scope.....	4
1.3 Definitions, Acronyms and Abbreviations.....	4
2. Related Documents.....	5
2.1 Applicable Documents and Files.....	5
2.2 Reference Documents.....	5
3. Preliminary optical prescriptions	6
3.1 Window (W).....	7
3.2 Spherical Mirror (SM)	8
3.3 Pupil Mirror (PM)	9
3.4 Beam Splitter 1 (BS1).....	10
3.5 Beam Splitter 2 (BS2).....	11
3.6 Ellipsoidal Mirror (EM)	12
3.7 LGS Lens 1 (L1).....	13
3.8 LGS Folding Mirror (LFM).....	14
3.9 LGS Doublet 1 (D1).....	15
3.10 LGS Doublet 2 (D2).....	18
3.11 Cube Beam Splitter (CBS).....	21



1. Introduction

1.1 Content

This document reports the preliminary optical prescriptions for all the optical components of the MORFEO Calibration Unit Optomechanical System (PUA), in the form of technical drawings, in agreement with ISO-10110.

1.2 Scope

The scope of this document is providing preliminary technical information for the manufacture of the PUA optical components.

1.3 Definitions, Acronyms and Abbreviations

PUA	MORFEO Calibration Unit Optomechanical System
ELT	Extreme Large Telescope
INAF	Istituto Nazionale di Astro Fisica
MORFEO	Multiconjugate adaptive Optics Relay For ELT Observations
TBD	To Be Defined



2. Related Documents

2.1 Applicable Documents and Files

The following applicable documents and files form a part of the present document to the extent specified herein. In the event of conflict between applicable documents and the content of the present document, the content of the present document shall be taken as superseding.

- AD1 E-MAO-PU0-INA-DER-002_01 MORFEO Calibration Unit Optomechanical System – OFDR Design and Analysis Report
- AD2 E-MAO-PU0-INA-ICD-002_01 MORFEO Calibration Unit Optomechanical System – Optical Interfaces
- AD3 ISO 10110 “Optics and optical Instruments – Preparation of optical drawings for optical elements and systems”
- AD4 E-MAO-PUA-INA-MOD-001_02 MORFEO Calibration Unit - Optical Model (direct)

2.2 Reference Documents

The following documents, of the exact version shown herein, are listed as background references only. They are not to be construed as a binding complement to the present document.

RD1



3. Preliminary optical prescriptions

The drawings reported in the next sub-sections are preliminary and not intended for manufacturing. The values reported in the drawings allow to meet the technical specifications, however they are not binding and should be considered as reference values and as a starting point for the Final Design.

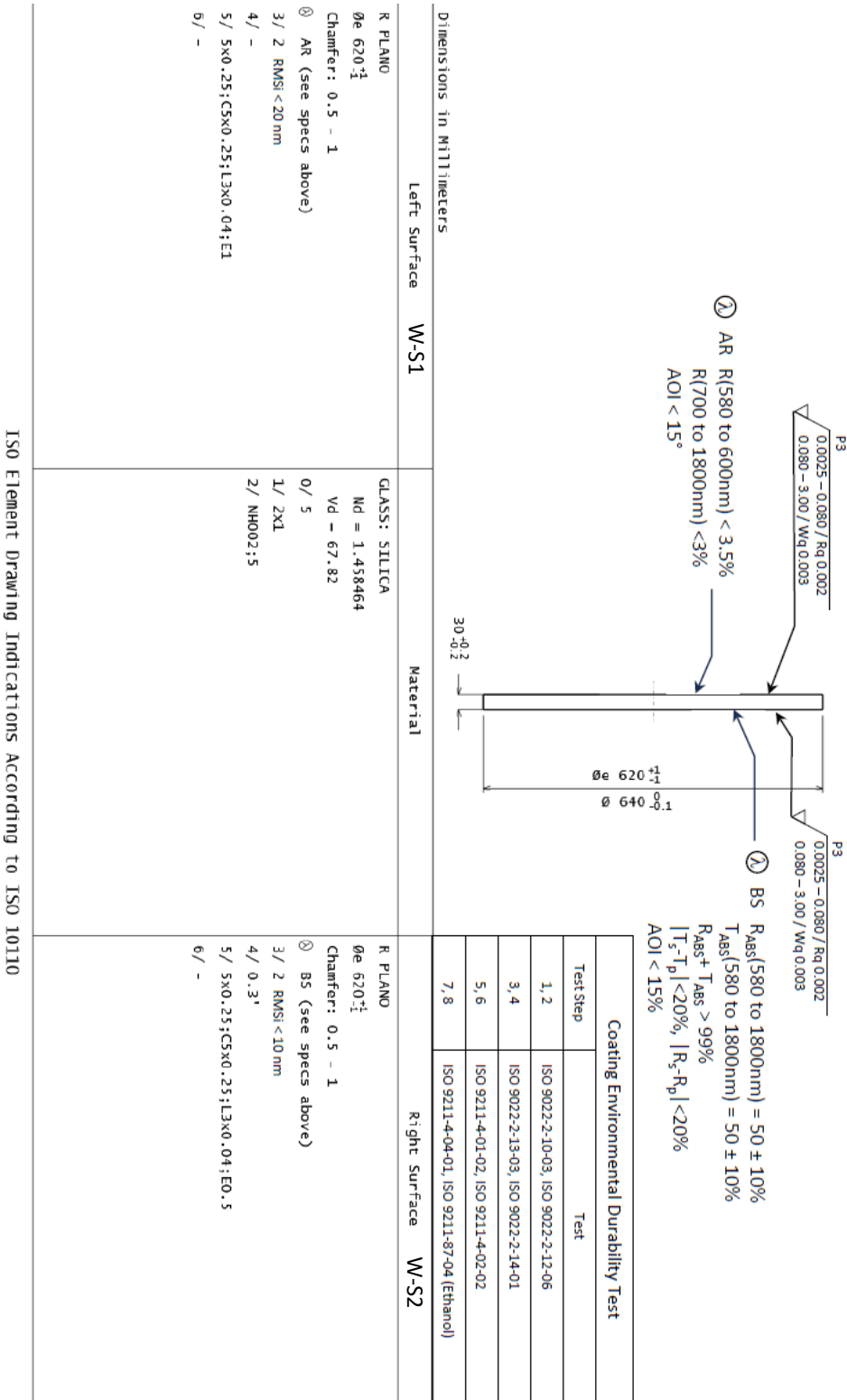
The following table reports the acronyms and a brief description of the PUA optical components, according to AD1, AD2 and AD4.

Table 1. List of the PUA optical components.

Item	Description	Section
W	Window	3.1
SM	Spherical Mirror	3.2
PM	Pupil Mirror	3.3
BS1	Beam Splitter #1	3.4
BS2	Beam Splitter #2	3.5
EM	Ellipsoidal Mirror	3.6
L1	LGS Lens #1	3.7
LFM	LGS Folding Mirror	3.8
D1	LGS Doublet #1	3.9
D1-A	Lens A of Doublet #1	
D1-B	Lens B of Doublet #1	
D2	LGS Doublet #2	3.10
D2-A	Lens A of Doublet #2	
D2-B	Lens B of Doublet #2	
CBS	Cube Beam Splitter	3.11

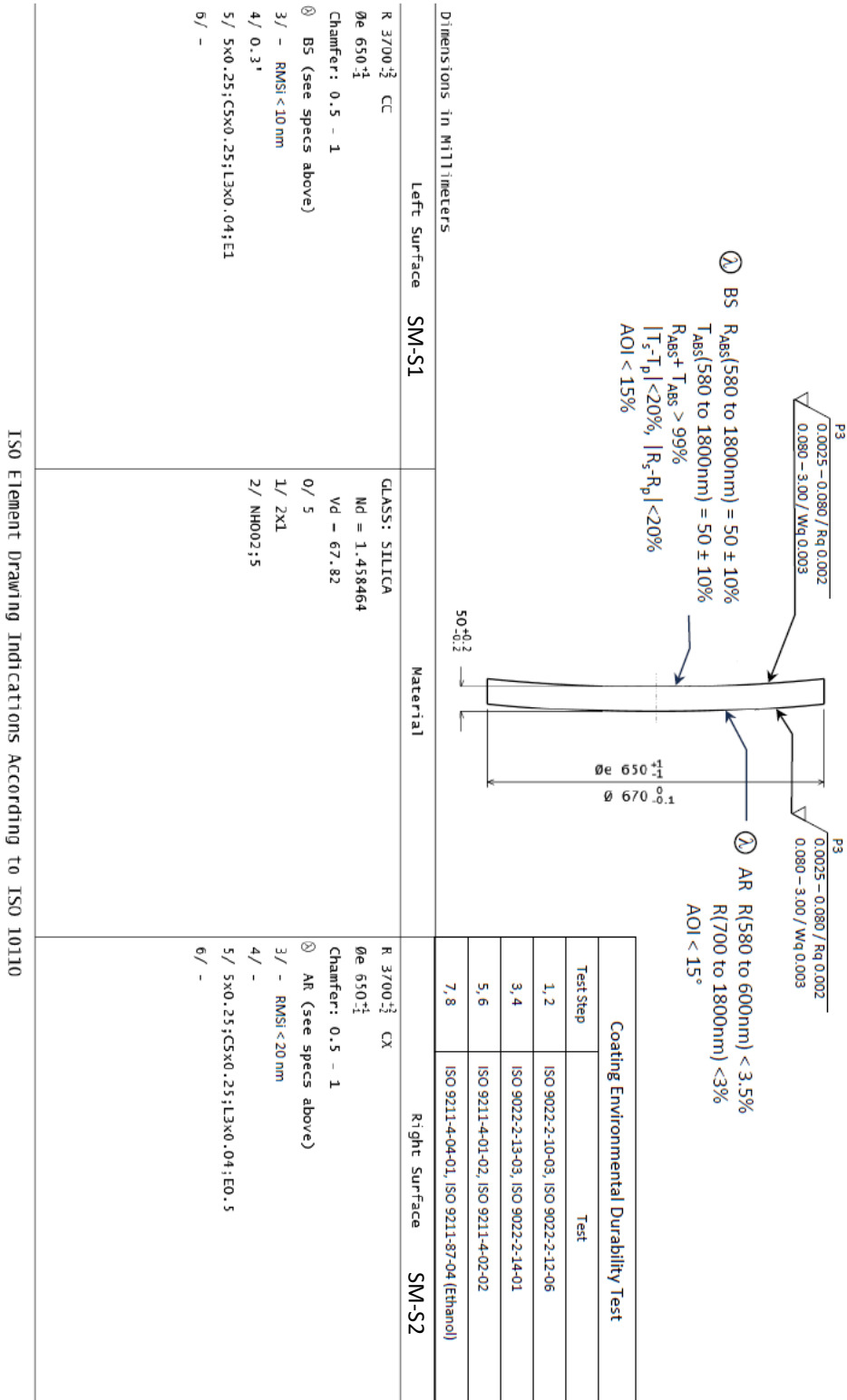


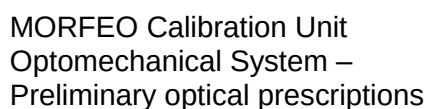
3.1 Window (W)





3.2 Spherical Mirror (SM)

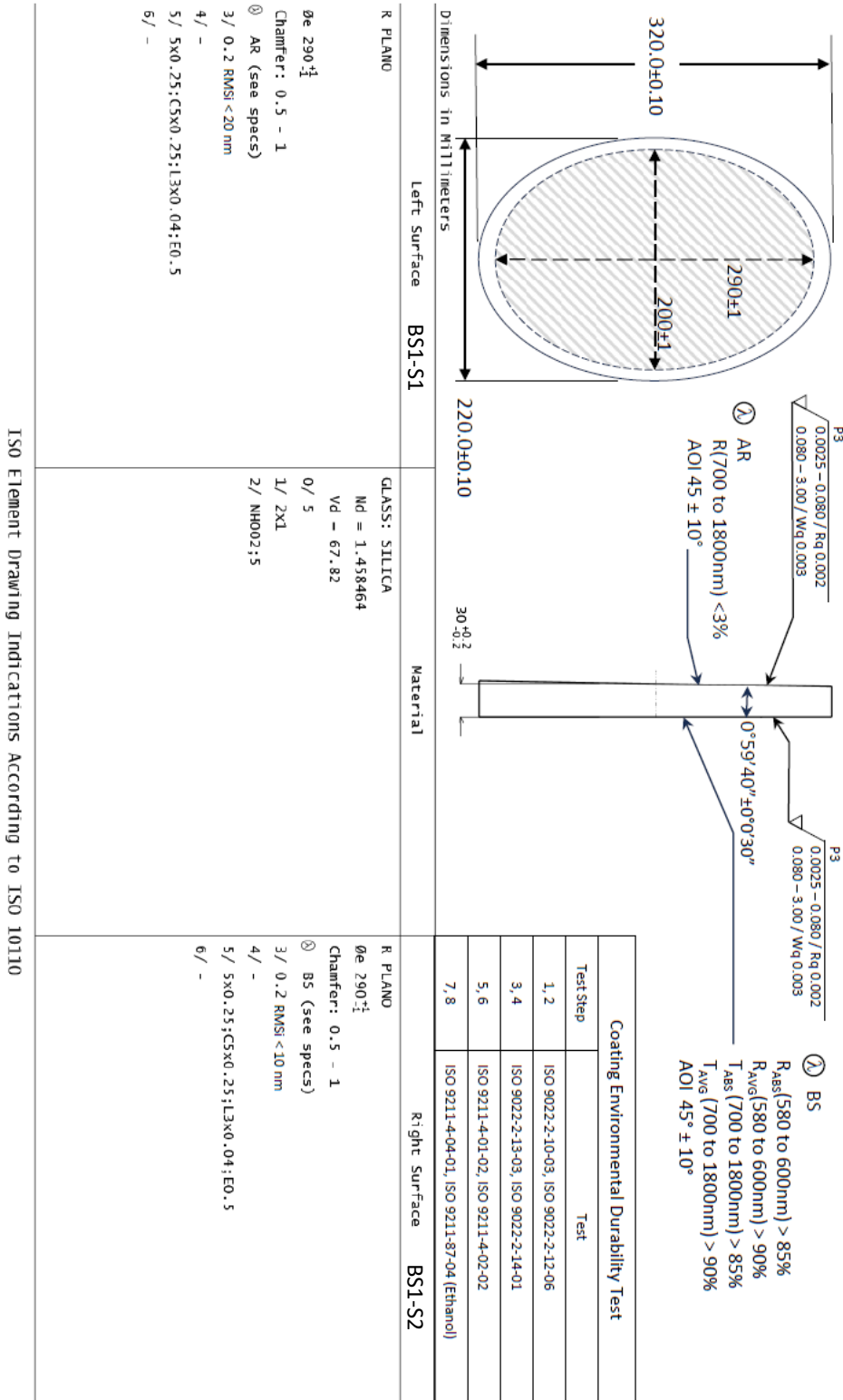




Doc. Number: E-MAO-PU0-INA-TNO-002
Doc. Version: 01
Released on: 2024-10-18
Page: 9 of 22

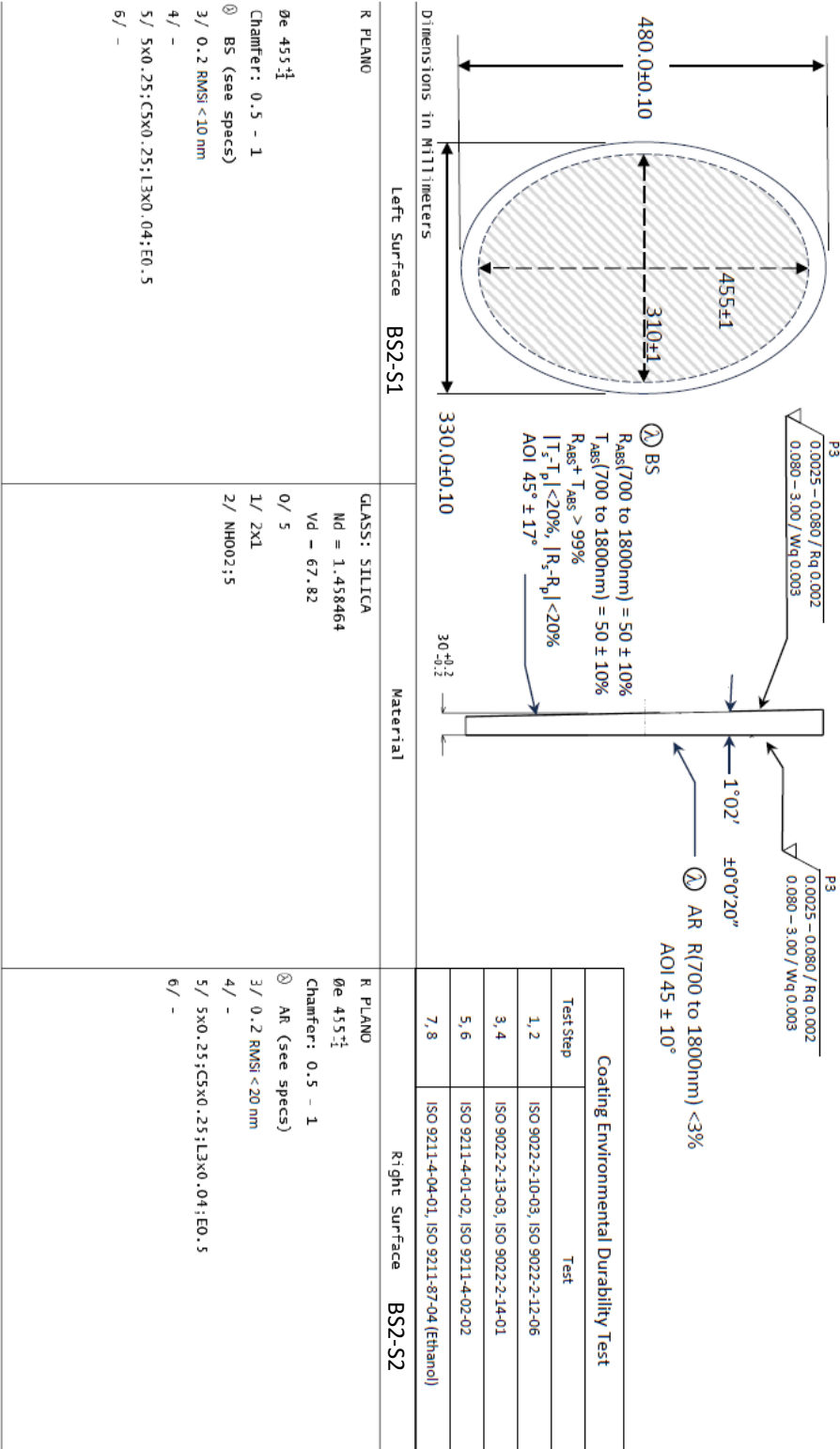


3.4 Beam Splitter 1 (BS1)





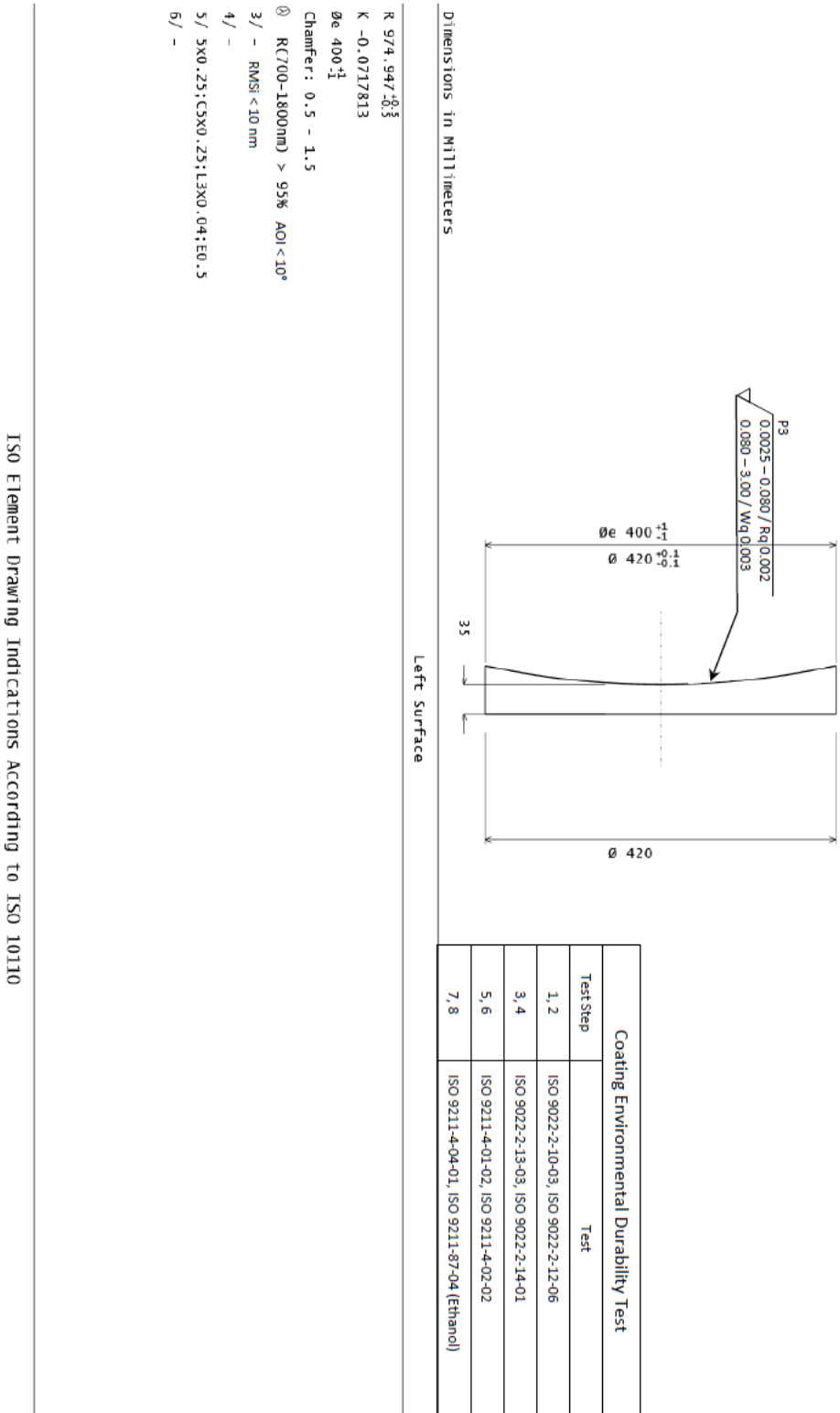
3.5 Beam Splitter 2 (BS2)

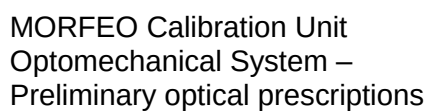


ISO Element Drawing Indications According to ISO 10110

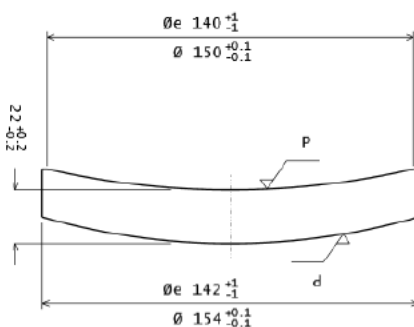


3.6 Ellipsoidal Mirror (EM)





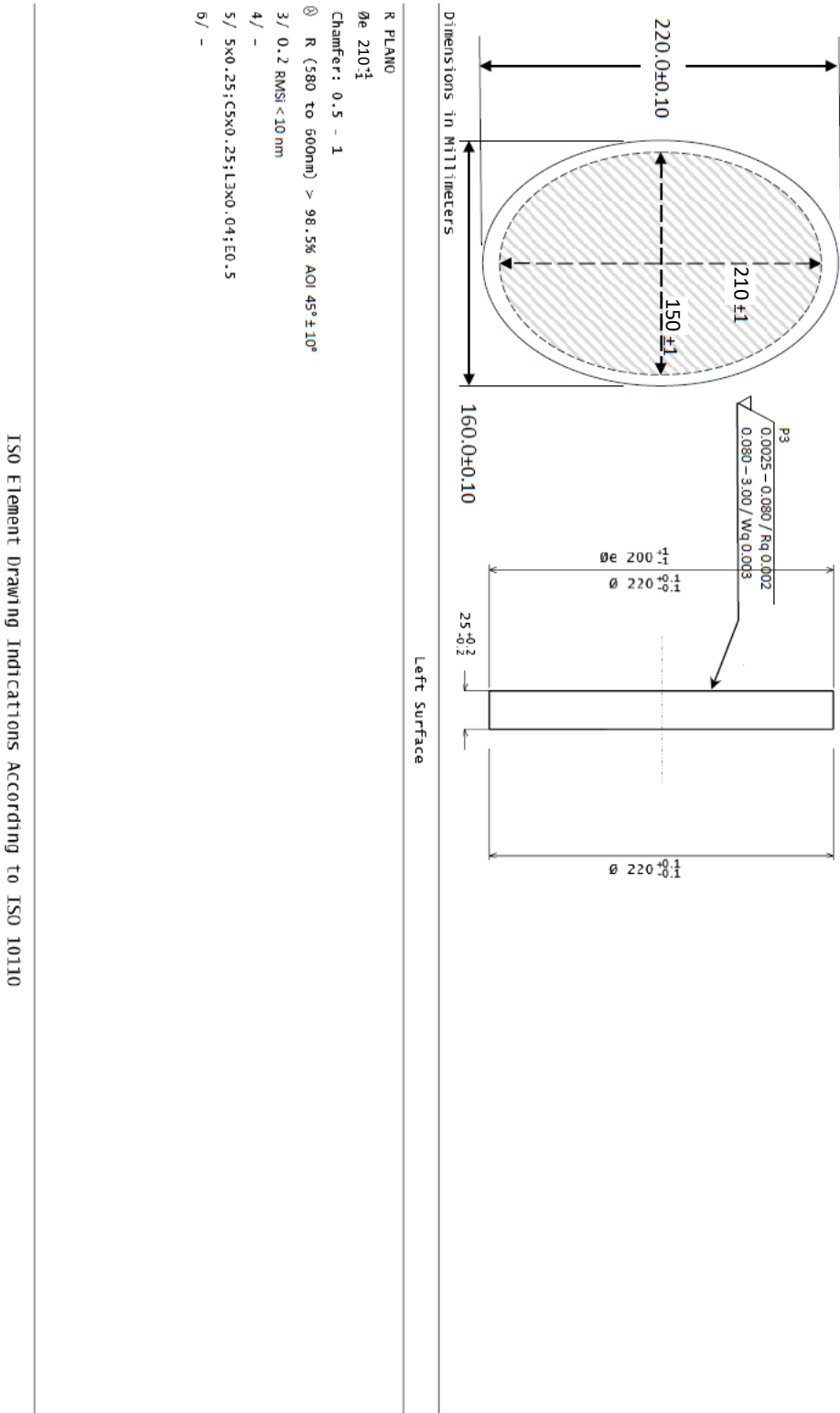
3.7 LGS Lens 1 (L1)



Dimensions in Millimeters		
Left Surface	L1-S1	Material
R 336.9 ^{+0.3} _{-0.3} CC Øe 140 ⁺¹ ₋₁ Chamfer: 0.3 - 0.7 AR R(589 nm) < 0.5% 3/ - RMSI < 10 nm 4/ 1' 5/ 5x0.25;C5x0.25;L3x0.04;EO.5 6/ -	GLASS: 5-BSL/ Nd = 1.516330 ^{+0.0003} _{-0.0003} Vd = 64.14 ^{+0.32} _{-0.32} 0/ 5 1/ 5x0.25 2/ NH010;5	R 279.24 ^{+0.3} _{-0.3} CX Øe 142 ⁺¹ ₋₁ Chamfer: 0.3 - 0.8 AR R(589 nm) < 0.5% 3/ - RMSI < 10 nm 4/ 1' 5/ 5x0.25;C5x0.25;L3x0.04;EO.5 6/ -

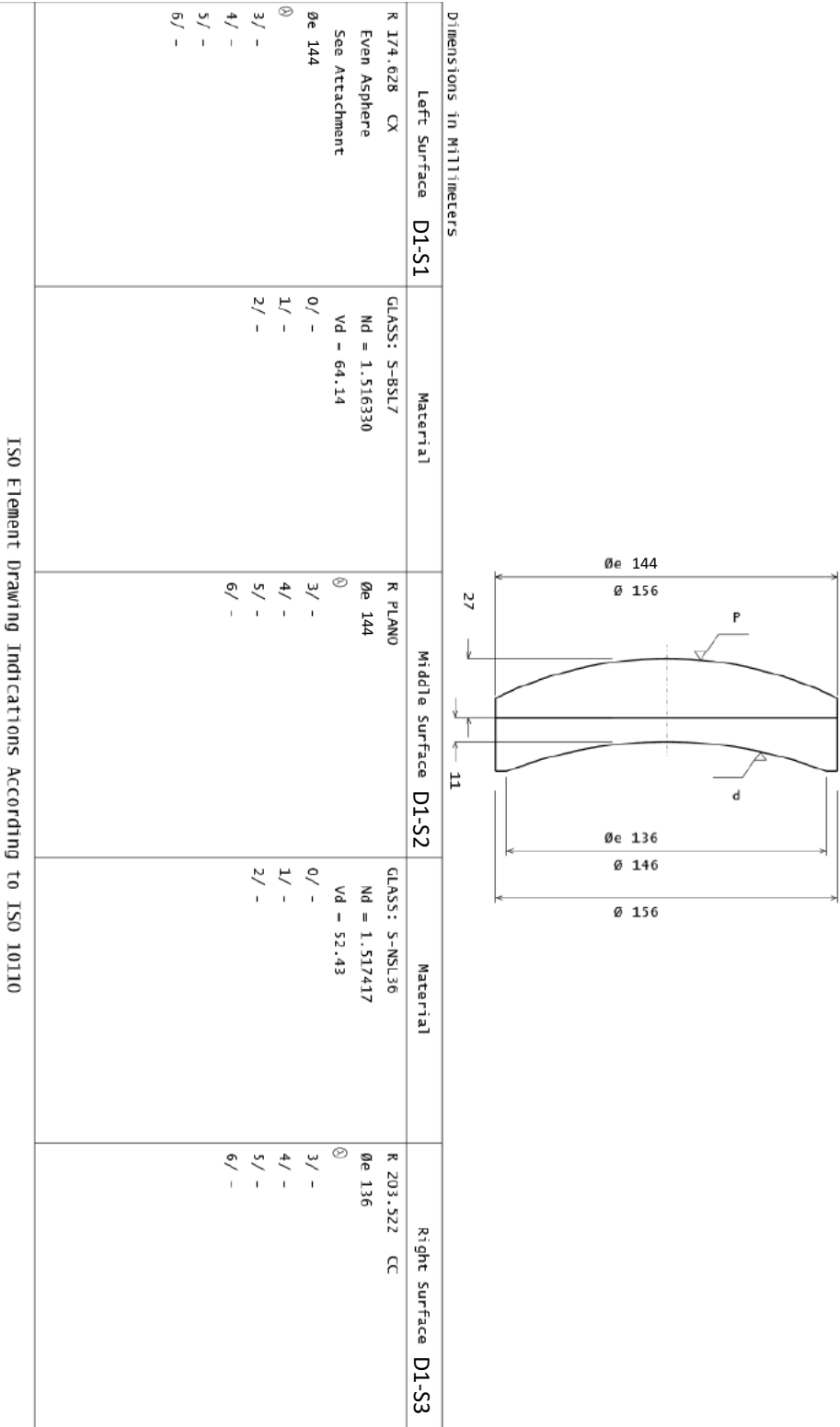


3.8 LGS Folding Mirror (LFM)



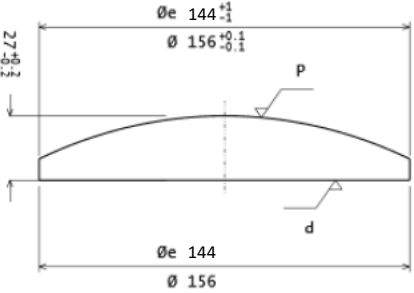


3.9 LGS Doublet 1 (D1)





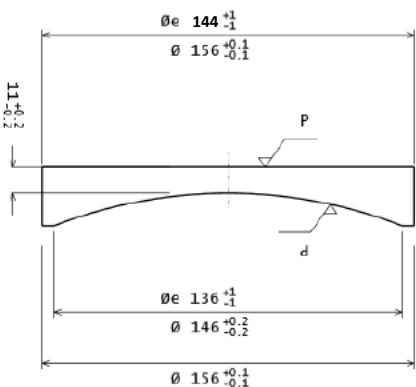
D1-A

Left Surface, Even Asphere 2nd Order Term0.00000E+00 4th Order Term-7.85334E-09 6th Order Term9.13367E-15 8th Order Term-2.33789E-17 Sag Table: Aperture, Sag 0.00000E+000.00000E+00 1.00000E+012.86479E-01 2.00000E+011.14781E+00 3.00000E+012.58983E+00 4.00000E+014.62266E+00 5.00000E+017.26126E+00 6.00000E+011.05259E+01 7.00000E+011.44428E+01																								
Dimensions in Millimeters <table><tr><th>Left Surface</th><th>D1-S1</th><th>Material</th><th>Right Surface</th><th>D1-S2</th></tr><tr><td colspan="5"> R 174.628^{+8.1}_{-8.1} CX Even Asphere See Above Øe 144⁺¹₋₁ Chamfer: 0.3 - 0.7 ⑤ AR R(589 nm) < 0.5% 3/ - RMSI < 20 nm 4/ 1°(0.05) 5/ 5x0.25;C5x0.25;L3x0.04;E0.5 6/ - </td></tr><tr><td colspan="5"> CLASS: S-BSL7 Nd = 1.516330^{+0.0003}_{-0.0003} Vd = 64.14^{+0.32}_{-0.32} 0/ 5 1/ 5x0.25 2/ NH010;5 </td></tr><tr><td colspan="5"> R PLANO Øe 144 Chamfer: 0.3 - 0.7 ⑤ (uncoated) 3/ 0.2 4/ -(0) 5/ 5x0.25;C5x0.25;L3x0.04;E0.5 6/ - </td></tr></table>			Left Surface	D1-S1	Material	Right Surface	D1-S2	R 174.628^{+8.1}_{-8.1} CX Even Asphere See Above Øe 144⁺¹₋₁ Chamfer: 0.3 - 0.7 ⑤ AR R(589 nm) < 0.5% 3/ - RMSI < 20 nm 4/ 1°(0.05) 5/ 5x0.25;C5x0.25;L3x0.04;E0.5 6/ -					CLASS: S-BSL7 Nd = 1.516330^{+0.0003}_{-0.0003} Vd = 64.14^{+0.32}_{-0.32} 0/ 5 1/ 5x0.25 2/ NH010;5					R PLANO Øe 144 Chamfer: 0.3 - 0.7 ⑤ (uncoated) 3/ 0.2 4/ -(0) 5/ 5x0.25;C5x0.25;L3x0.04;E0.5 6/ -						
Left Surface	D1-S1	Material	Right Surface	D1-S2																				
R 174.628^{+8.1}_{-8.1} CX Even Asphere See Above Øe 144⁺¹₋₁ Chamfer: 0.3 - 0.7 ⑤ AR R(589 nm) < 0.5% 3/ - RMSI < 20 nm 4/ 1°(0.05) 5/ 5x0.25;C5x0.25;L3x0.04;E0.5 6/ -																								
CLASS: S-BSL7 Nd = 1.516330^{+0.0003}_{-0.0003} Vd = 64.14^{+0.32}_{-0.32} 0/ 5 1/ 5x0.25 2/ NH010;5																								
R PLANO Øe 144 Chamfer: 0.3 - 0.7 ⑤ (uncoated) 3/ 0.2 4/ -(0) 5/ 5x0.25;C5x0.25;L3x0.04;E0.5 6/ -																								

ISO Element Drawing Indications According to ISO 10110



D1-B

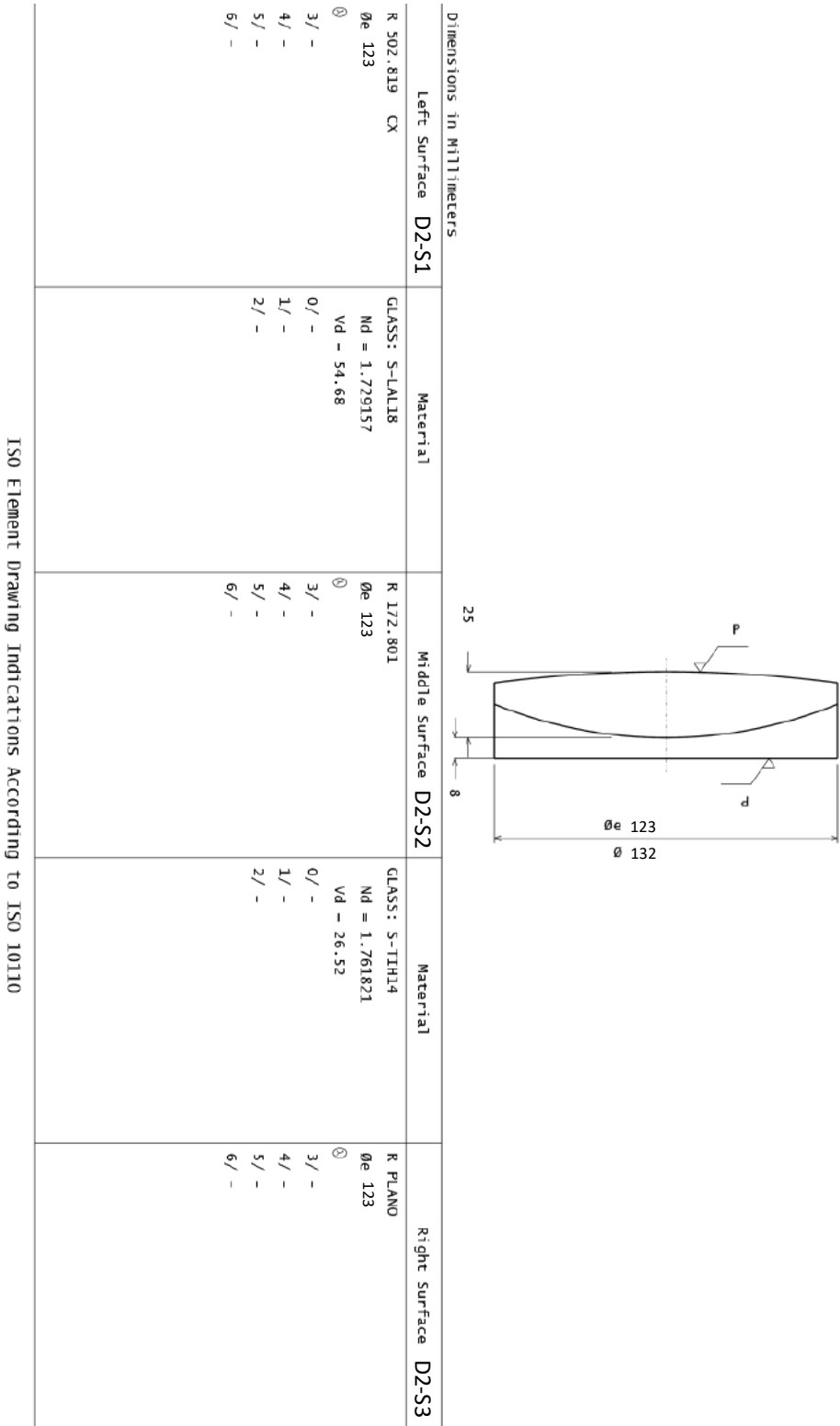
Dimensions in millimeters			
Left Surface		Right Surface	
D1-S2	D1-S3		
			
R PLANO Øe 144 $\begin{smallmatrix} +0.1 \\ -0.1 \end{smallmatrix}$ Chamfer: 0.3 - 0.7 ② (uncoated) 3/ 0.2 4/ 1' 5/ 5x0.25;C5x0.25;L3x0.04;EO.5 6/ -		GLASS: S-NSL36 Nd = 1.517417 $\begin{smallmatrix} +0.0003 \\ -0.0003 \end{smallmatrix}$ Vd = 52.43 $\begin{smallmatrix} +0.26 \\ -0.26 \end{smallmatrix}$ 0/ 5 1/ 5x0.25 2/ NHO10;5 R 203.522 $\begin{smallmatrix} +0.4 \\ -0.4 \end{smallmatrix}$ CC Øe 136 $\begin{smallmatrix} +0.1 \\ -0.1 \end{smallmatrix}$ Chamfer: 0.3 - 0.7 ② AR R(589 nm) < 0.5% 3/ 0.2 RMSI < 20 nm 4/ 1' 5/ 5x0.25;C5x0.25;L3x0.04;EO.5 6/ -	

ISO Element Drawing Indications According to ISO 10110

ISO Element Drawing Indications According to ISO 10110



3.10 LGS Doublet 2 (D2)





D2-A

Dimensions in millimeters		
Left Surface D2-S1	Material	Right Surface D2-S2
R 502.819 ^{+0.3} _{-0.3} CX Øe 123 ⁺¹ ₋₁ Chamfer: 0.3 - 0.7 ② AR R(589 nm) < 0.5% 3/ - RMSI < 20 nm 4/ - 5/ 5x0.25;C5x0.25;L3x0.04;EO.5 6/ -	GLASS: S-LAL18 Nd = 1.729157 ^{+0.0003} _{-0.0003} Vd = 54.68 ^{+0.27} _{-0.27} 0/ 5 1/ 5x0.25 2/ NHO10;5	R 172.801 ^{+0.2} _{-0.2} CX Øe 123 ⁺¹ ₋₁ Chamfer: 0.3 - 0.7 ② (uncoated) 3/ - RMSI < 30 nm 4/ 1' 5/ 5x0.25;C5x0.25;L3x0.04;EO.5 6/ -

ISO Element Drawing Indications According to ISO 10110



D2-B

Dimensions in millimeters			
Left Surface		D2-S2	
R 1/2.801 ^{+0.2} _{-0.2} CC			
Øe 123 ⁺¹ ₋₁			
Chamfer: 0.3 - 0.7			
② (uncoated)			
3/ 0.2 RMSI < 30 nm			
4/ 1°			
5/ 5x0.25;C5x0.25;L3x0.04;E0.5			
6/ -			
Material			
GLASS: S-TIH14 Nd = 1.761821 ^{+0.0003} _{-0.0003} Vd = 26.52 ^{+0.13} _{-0.13} 0/ 5 1/ 5x0.25 2/ NH010;5			
Right Surface		D2-S3	
R PLANO			
Øe 123 ⁺¹ ₋₁			
Chamfer: 0.3 - 0.7			
② AR R(589 nm) < 0.5%			
3/ 1 RMSI < 20 nm			
4/ -			
5/ 5x0.25;C5x0.25;L3x0.04;E0.5			
6/ -			

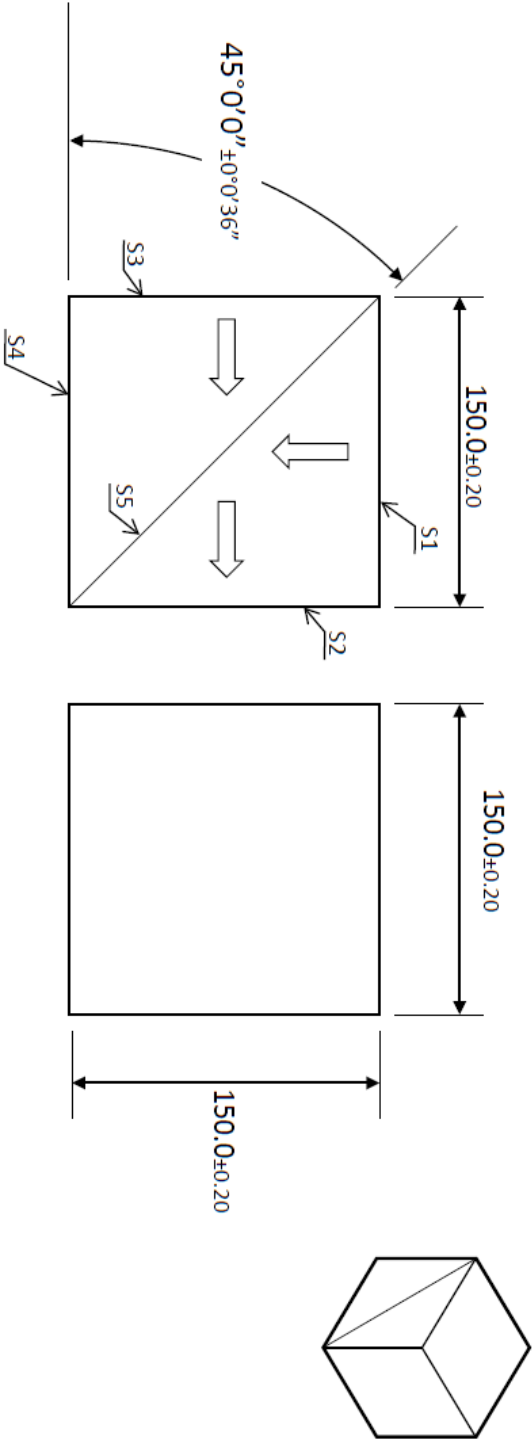
ISO Element Drawing Indications According to ISO 10110

ISO Element Drawing Indications According to ISO 10110



3.11 Cube Beam Splitter (CBS)

- Prescriptions**
- 1. Substrate: N-BK7 or equivalent. Alternative: Fused Silica
 - 2. Homogeneity: <2 ppm (ISO 10110-18 NH002)
 - 3. Striae: no visible striae (ISO 10110-4 Class 5)
 - 4. Bubbles/inclusions: <0.25 mm²/100 cm³
 - 5. Stress birefringence: <10 nm/cm
 - 6. Clear aperture: S1, S4>Ø140 mm, S2>Ø110 mm, S5>125x180 mm
 - 7. Surface quality: 60-40 S/D
 - 8. Transmitted WFE (S3-S2): <35 nm RMS (power removed)
 - 9. Reflected WFE (S1-S5-S2): <35 nm RMS (power removed)
 - 10. Transmitted beam deviation: 0° ± 30 arcsec
 - 11. Reflected beam deviation: 90° ± 30 arcsec
 - 12. Coating (S1,S3,S4): AR, R_{abs}<3.5%, R_{avg}<2%, 580-1800 nm, AoI<10°
 - 13. Coating (S2): R, R_{abs}<2%, R_{avg}<1%, 580-1800 nm, AoI<10°
 - 14. Coating (S5): BS (see "Beam-splitter coating" table)
 - 15. All other surfaces: black absorptive treatment
 - 16. Protective bevels as needed



Beam-splitter coating	
a.	Wavelengths:
	• Band 1: 580-900 nm
	• Band 2: 1500-1800 nm
b.	T _{abs} = 50 ± 10%
c.	R _{abs} = 50 ± 10%
d.	T _{avg} +R _{avg} > 98%
e.	T _{abs} +R _{abs} > 95%
f.	AoI = 45° ± 6°

Note: For convenience, the interval 600-700 nm can be excluded from Band 1.



MORFEO Calibration Unit
Optomechanical System –
Preliminary optical prescriptions

Doc. Number: E-MAO-PU0-INA-TNO-002
Doc. Version: 01
Released on: 2024-10-18
Page: 22 of 22

***** End of document *****