

PŘÍLOHA Č. 1

Měřicí protokol pro optická zrcadla⁴¹



ALMA Band 3 Warm Optics Metrology Summary Sheet

Date submitted: 2011-02-04
Doc #: 35

TITLE: Band 3 warm optics set: #35 Metrology Summary Sheet

Product Tree Number	Item Name	Serial Number	Acceptance Criteria	Pass/Fail	Comments
40.01.03	Elliptical Mirror	100	<ul style="list-style-type: none"> - 60 +/- 0.005 - 9 +/- 0.05 - Surface Accuracy < 30 um p-p - Surface Roughness Ra < 0.035 um - Surface Roughness Rz < 0,35 um - Surface coating: Min. 1 um Ni - Min. 5 um Au 	59,996 / Pass 8,976/ Pass 0.023/ Pass 0.031 / Pass 0.225 Pass Min 5um / Pass Min 5um / Pass	
	Hyperbolic Mirror	087	<ul style="list-style-type: none"> - 8 +/- 0.05 - Surface Accuracy < 30 um p-p - Surface Roughness Ra < 0.035 um - Surface Roughness Rz < 0,35 um - Surface coating: Min. 1 um Ni - Min. 5 um Au 	8.031/Pass 0.025 / Pass 0.025 um / Pass 0.198 / Pass Min 5um / Pass Min 5um / Pass	The lowest point together with the highest point are within tolerance limit.
	Frame	063	<ul style="list-style-type: none"> - 65° +/- 0.1° - 24.095° +/- 0.01° - 23.477° +/- 0.01° - 247.500 +/- 0.10 - 147.500 +/- 0.02 - 130.200 +/- 0.02 - 17.262 +/- 0.05 	64.996/ Pass 24.089/ Pass 23.471/ Pass 247,587/Pass 147,489/Pass 130.194/Pass 17,292/Pass	This frame was produced/measured according to new drawing revision C.
Justification:					
Origin of Requirement / Specification to be waived:					
Requirement #:	Document #:				
N/A	FEND-40.03.01.00-005-C-DWG-1 FEND-40.03.01.00-005-D-DWG-2 FEND-40.03.01.00-005-E-DWG-3				
	Title of Document:				
	Band 3 warm optics Frame Band 3 warm optics Elliptical Mirror Band 3 warm optics Hyperbolic Mirror				

PŘÍLOHA Č. 2

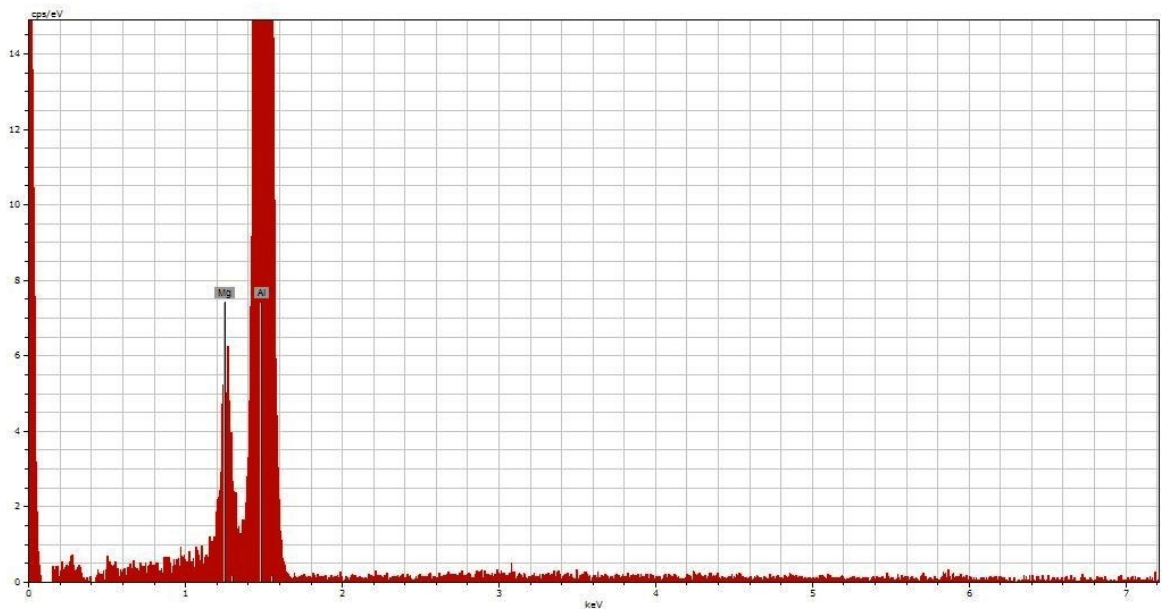
Zpráva z rozborů struktury pomocí elektronového mikroskopu⁴¹

Seda plocha

Tescan



SEM HV: 20.00 kV WD: 15.00 mm VEGA\\ TESCAN
View field: 90.48 μm Det: BSE 20 μm
SEM MAG: 3.33 kx Date(m/d/y): 09/08/09 Performance in nanospace



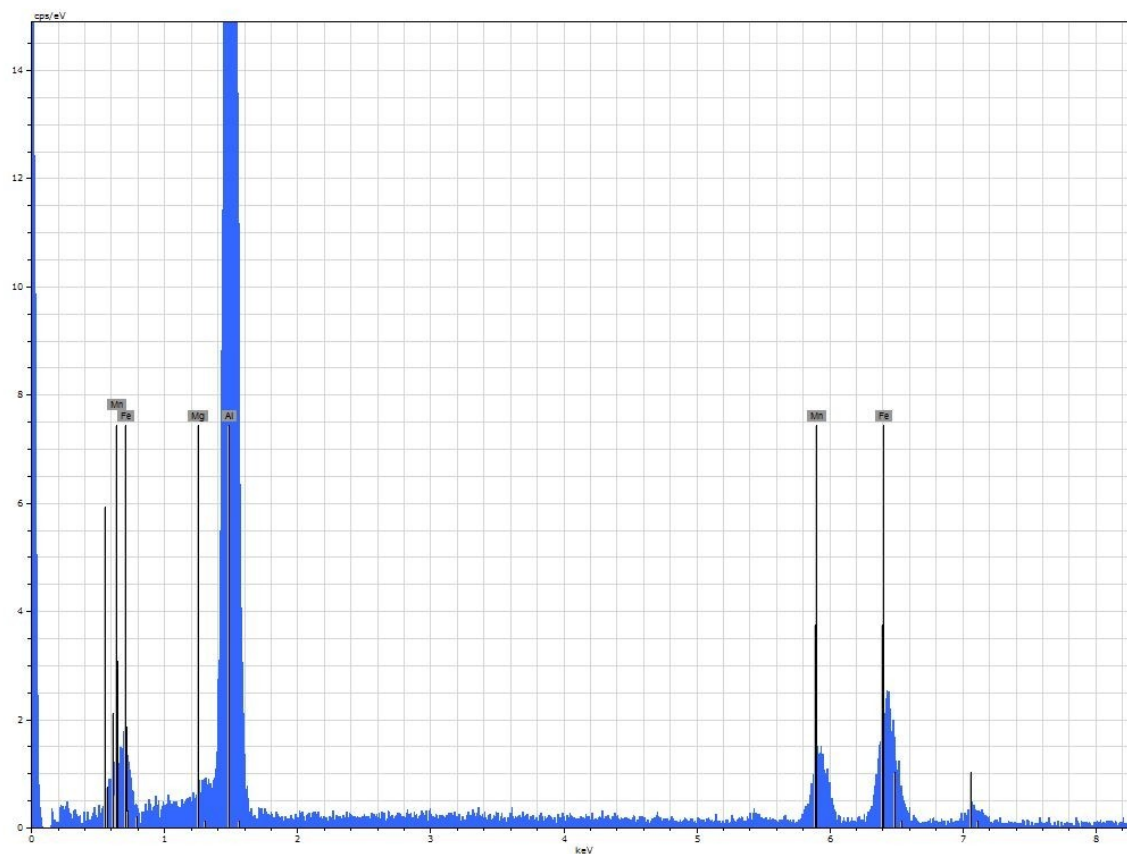
Spectrum: 5083_seda

El	AN	Series	Net un.	C norm.	C Atom.	C Error
			[wt.%]	[wt.%]	[at.%]	[%]
Al	13	K-series	39439	99.70	94.73	4.8
Mg	12	K-series	2714	5.55	5.27	0.4

Total: 105.24 100.00 100.00

Svetla plocha

Tescan

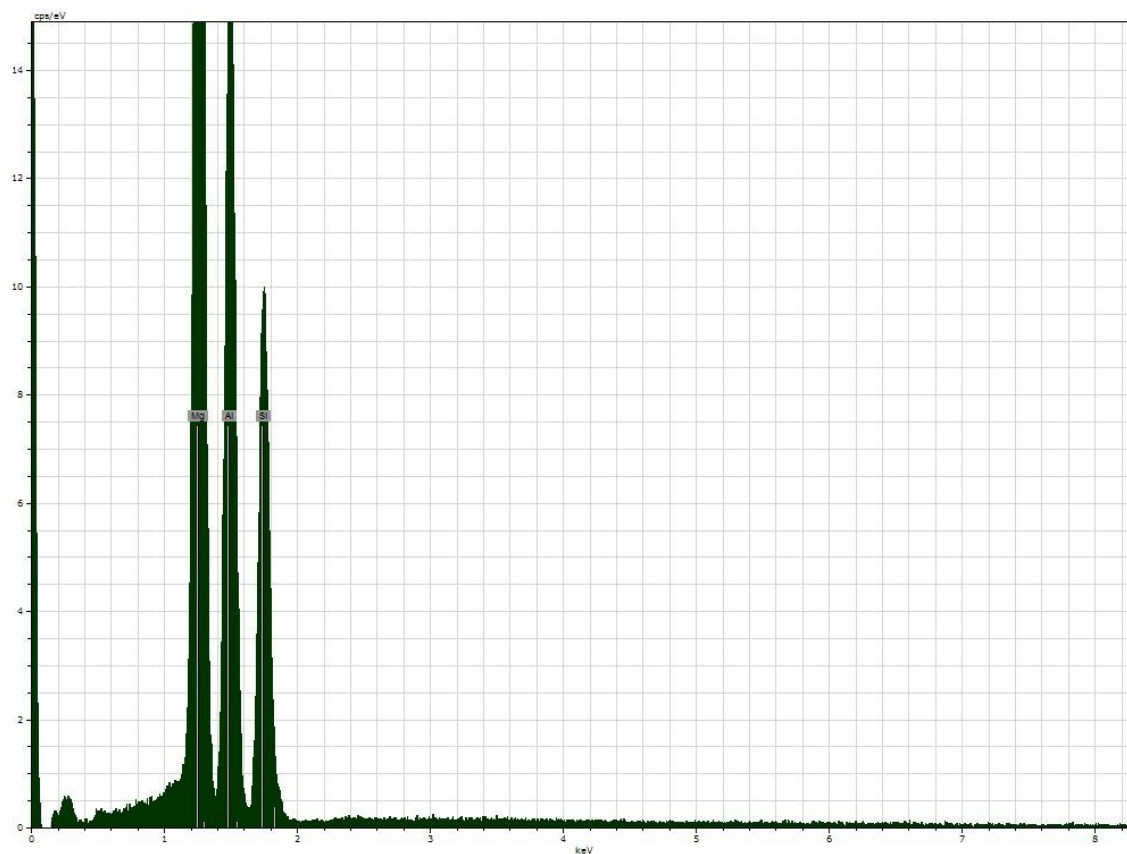


Spectrum: 5083_bila

El	AN	Series	Net un.	C norm.	C Atom.	C Error
			[wt.%]	[wt.%]	[at.%]	[%]
Al	13	K-series	32460	75.26	74.83	85.18 3.7
Fe	26	K-series	2496	14.86	14.78	8.13 0.5
Mn	25	K-series	1761	9.20	9.15	5.12 0.4
Mg	12	K-series	468	1.25	1.24	1.57 0.1
Total:			100.57	100.00	100.00	

Tmava plocha

Tescan



Spectrum: 5083_tmava

El	AN	Series	Net un.	C norm.	C Atom.	C Error	
			[wt.%]	[wt.%]	[at.%]	[%]	
Mg	12	K-series	110262	45.13	40.98	43.90	2.5
Al	13	K-series	55896	39.58	35.94	34.69	1.9
Si	14	K-series	35207	25.43	23.09	21.41	1.1
Total:			110.13	100.00	100.00		

PŘÍLOHA Č. 3

Protokol o měření funkčnosti parabolických antén⁴¹



ALMA Project

Test Report on Band 3 beam measurement with old and new type warm optics

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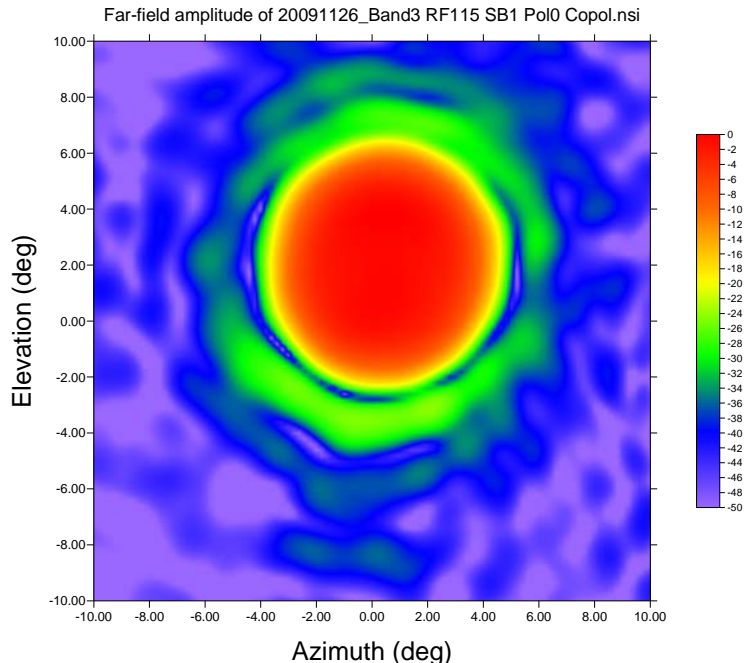


Figure 16: 115 GHz Pol 0 Co-pol. elevation 0°

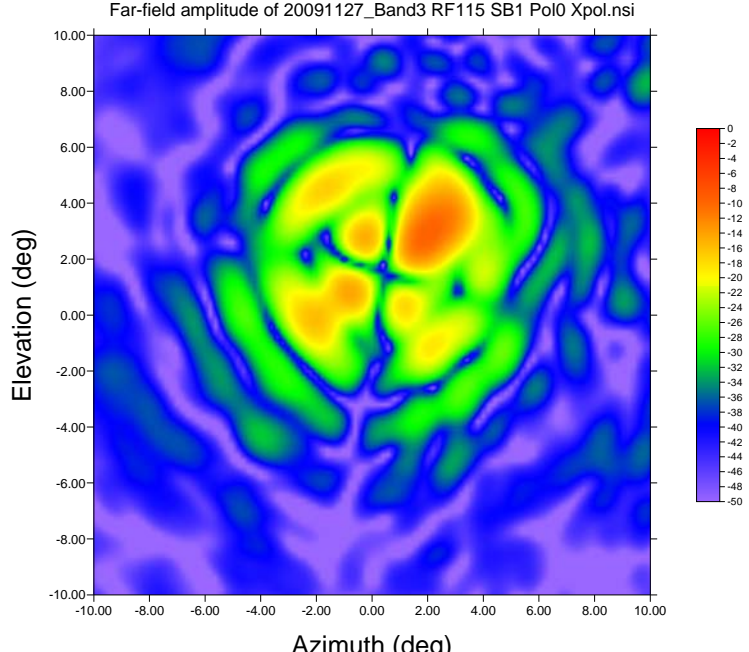



Figure 17: 115 GHz Pol 0 Cross-pol. elevation 0°

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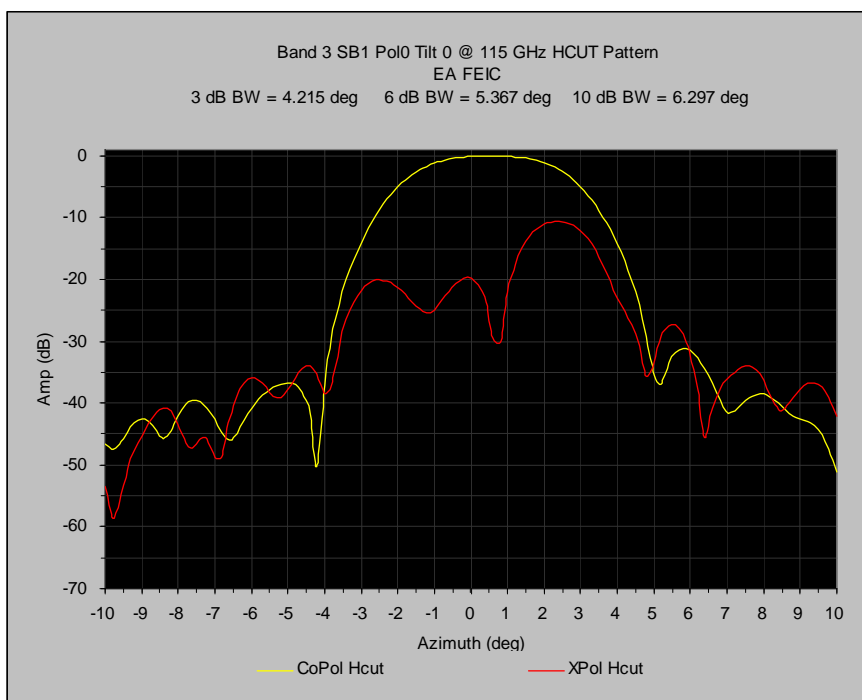


Figure 18: 115 GHz Pol 0, elevation 0°, H cut

2.2 Aperture efficiency FE assembly contribution

[FEND-40.00.00.00-00220-00 / A]


Specification to be verified: The aperture efficiency factor due to the optics of the FE assembly shall exceed 80 % (TBC) for all ten bands, with frequency ranges as defined by requirement [FEND-40.00.00.00-00060-00 / R].

The contribution to the aperture efficiency within the FE assembly is split into the following components:

- Taper efficiency η_t : factor expressing the signal power loss due to 1) non-uniform amplitude distribution over the secondary reflector and 2) the field across the secondary reflector not being in phase everywhere;
- Spillover efficiency η_s : fraction of the total power that is radiated by the tertiary optics, intercepted and collimated by the secondary reflector;
- Polarization efficiency η_p : factor expressing the signal power lost in cross-polarized fields over the antenna aperture plane;
- Focus efficiency η_f : factor expressing the signal power loss due to focus errors, both radial as well as axial, of the tertiary optics relative to the secondary reflector.

The requirement can be summarized by the following expression:

$$\eta_t \cdot \eta_s \cdot \eta_p \cdot \eta_f = \eta_{ap_FE} > 80 \%$$

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The ohmic losses of all tertiary optics and feeds are included in the T_{rx} as specified in section 4.1.1 and do not contribute to an aperture efficiency degradation.

This requirement simultaneously applies to both orthogonally polarized beams of a cartridge.

2.2.1 Band 3 with old type warm optics

Result:

Frequency	Polarization	Tilt Angle (deg)	Aperture Efficiency (%)
100	0	0	78.93
85	0	0	78.67
115	0	0	82.21

2.2.2 Band 3 with new type warm optics

Result:

Frequency	Polarization	Tilt Angle (deg)	Aperture Efficiency (%)
100	0	0	81.57
85	0	0	82.68
115	0	0	84.39

2.3 Taper efficiency

[FEND-40.00.00.00-00222-00 / AT]

Specification to be verified: The taper efficiency of the tertiary optics inside the FE assembly shall exceed 80 % for all ten bands. This requirement simultaneously applies to both orthogonally polarized beams of a cartridge.

2.3.1 Band 3 with old type warm optics

Result:

Frequency	Polarization	Tilt Angle (deg)	Taper Efficiency (%)
100	0	0	84.70
85	0	0	82.68
115	0	0	87.50

2.3.2 Band 3 with new type warm optics

Result:



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Frequency	Polarization	Tilt Angle (deg)	Taper Efficiency (%)
100	0	0	89.66
85	0	0	88.48
115	0	0	91.59

2.4 Spillover efficiency

[FEND-40.00.00.00-00224-00 / AT]

Specification to be verified: The spillover efficiency of the tertiary optics inside the FE assembly shall exceed 80 % for all ten bands. This requirement simultaneously applies to both orthogonally polarized beams of a cartridge.

2.4.1 Band 3 with old type warm optics

Result:

Frequency	Polarization	Tilt Angle (deg)	Spillover Efficiency (%)
100	0	0	97.59
85	0	0	98.35
115	0	0	97.26

2.4.2 Band 3 with new type warm optics

Result:

Frequency	Polarization	Tilt Angle (deg)	Spillover Efficiency (%)
100	0	0	95.42
85	0	0	96.62
115	0	0	95.59

2.5 Polarization efficiency


[FEND-40.00.00.00-00226-00 / AT]

Specification to be verified: The polarization efficiency of the tertiary optics system shall exceed 99.5 % for all ten bands.

This requirement simultaneously applies to both orthogonally polarized beams of a cartridge.

2.5.1 Band 3 with old type warm optics

Result:

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Frequency	Polarization	Tilt Angle (deg)	Peak Cross Polar Level	Polarization Efficiency (%)	Polarization efficiency % (integrated on subreflector)
100	0	0	11.18	93.84	96.47
85	0	0	14.13	95.98	97.91
115	0	0	11.52	94.76	99.30

2.5.2 Band 3 with new type warm optics

Result:

Frequency	Polarization	Tilt Angle (deg)	Peak Cross Polar Level	Polarization Efficiency (%)	Polarization efficiency % (integrated on subreflector)
100	0	0	10.46	91.33	96.40
85	0	0	12.43	93.97	97.70
115	0	0	9.40	92.44	97.29

2.6 Focus efficiency

[FEND-40.00.00.00-00228-00 / AT]

Specification to be verified: The focus efficiency of the tertiary optics system shall comply with the following expression for all ten bands:

$$\eta_f > 80 \% / \eta_t \cdot \eta_s \cdot \eta_p$$


This requirement simultaneously applies to both orthogonally polarized beams of a cartridge.

Determination of the flattest phase profile is difficult and has an error of +/- 25 mm.) In overall efficiency tables defocus efficiency was set to 100 %, as the subreflector can be moved to improve this (by the amount given in the table). The offset is measured from the focal plane towards the subreflector.

2.6.1 Band 3 with old type warm optics

Result:

Frequency	Polarization	Tilt Angle (deg)	Offset from Nominal Focus (mm)	Efficiency (%)	Efficiency = 100% if subreflector moved by mm	Defocus Eff. % if subreflector moved by Avg
100	0	0	-25.901	99.97	-0.0648	99.9782
85	0	0	15.901	99.99	0.0398	99.9916
115	0	0	-14.573	99.99	-0.0364	99.9967

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2.6.2 Band 3 with new type warm optics

Result:

Frequency	Polarization	Tilt Angle (deg)	Offset from Nominal Focus (mm)	Efficiency (%)	Efficiency = 100% if subreflector moved by mm	Defocus Eff. % if subreflector moved by Avg
100	0	0	12.250	99.99	0.0306	99.9774
85	0	0	54.853	99.89	0.1371	99.9766
115	0	0	3.860	100.00	0.0097	99.9571

2.7 Polarization requirements- Beam squint

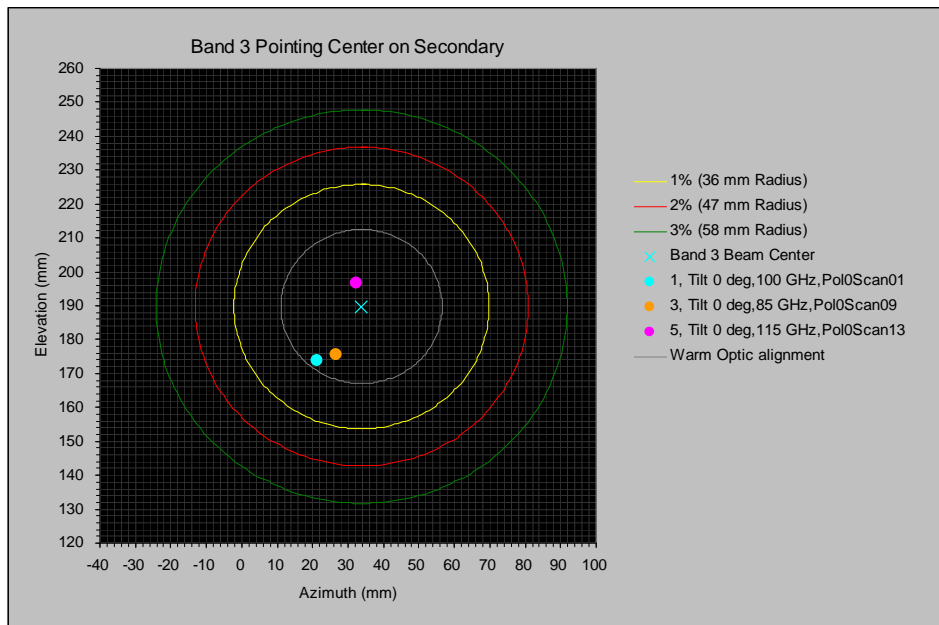
[FEND-40.00.00.00-00272-00 / AT]

Specification to be verified: The co-alignment, on sky, between the beams of the orthogonal polarization channels of one cartridge shall be less than 1/10 of the Full Width at Half Maximum (FWHM) of the primary beam. This requirement is applicable for Bands 1 through 10.

2.7.1 Band 3 with old type warm optics

Result:

On secondary



The 36 mm radius circle is the 1% efficiency loss on the subreflector. The 47 mm and 58 mm circles are the 2% and 3% loss circles respectively.



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On sky

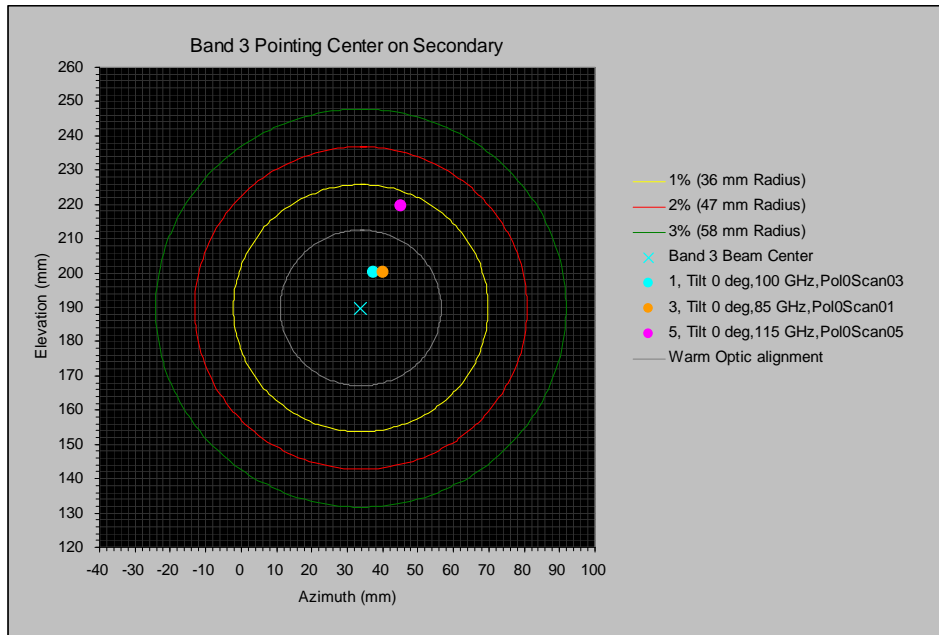
Taking the difference in x, y, z positions in the best focal plane for each frequency (given in the next table).

Frequency	Polarization	Tilt Angle (deg)	X	Y	Z
100	0	0	3.84	11.55	174.10
85	0	0	4.40	14.02	215.90
115	0	0	3.78	12.42	185.43

2.7.2 Band 3 with new type warm optics

Result:

On secondary



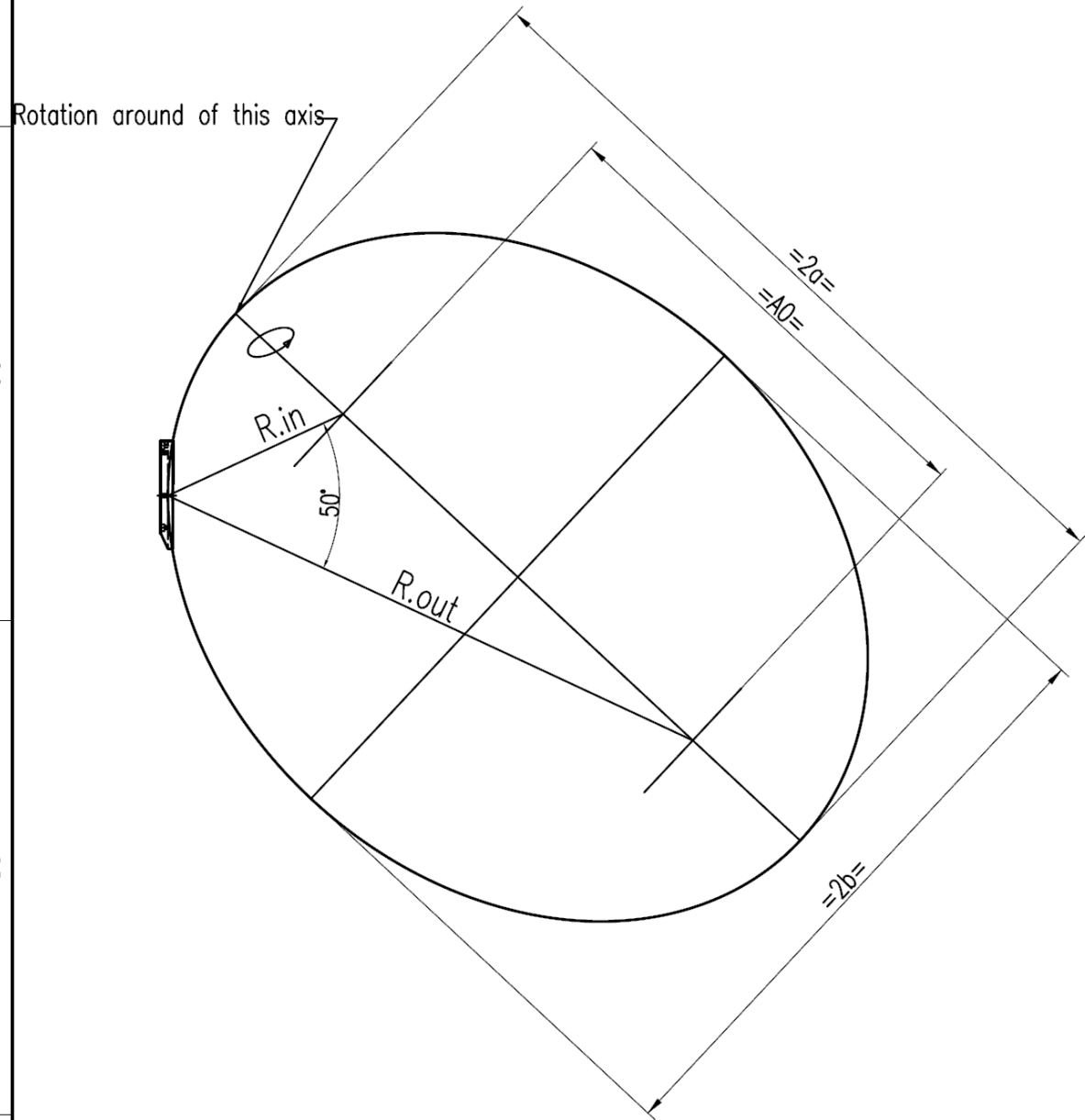
The 36 mm radius circle is the 1% efficiency loss on the subreflector. The 47 mm and 58 mm circles are the 2% and 3% loss circles respectively.

Frequency	Polarization	Tilt Angle (deg)	X	Y	Z
100	0	0	4.42	13.55	212.25
85	0	0	5.36	16.05	254.85
115	0	0	4.69	13.81	203.86

PŘÍLOHA Č. 4

Výkres eliptického a hyperbolického zrcadla⁴¹

Definition of Ellipsoid
Scale: 1/10



$a=466,783158566$

$b=376,64669655$

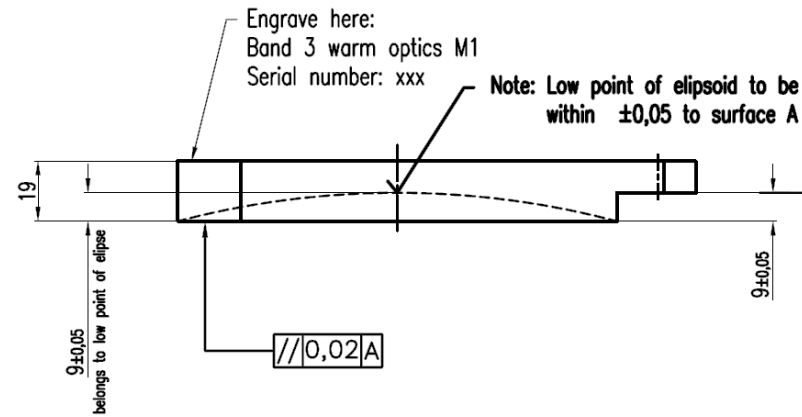
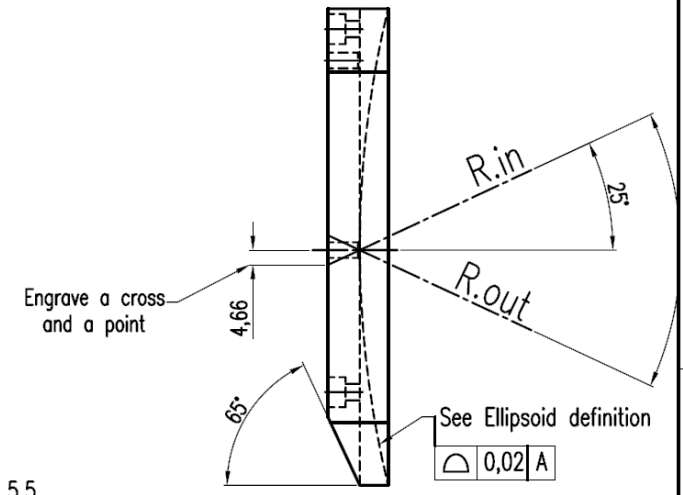
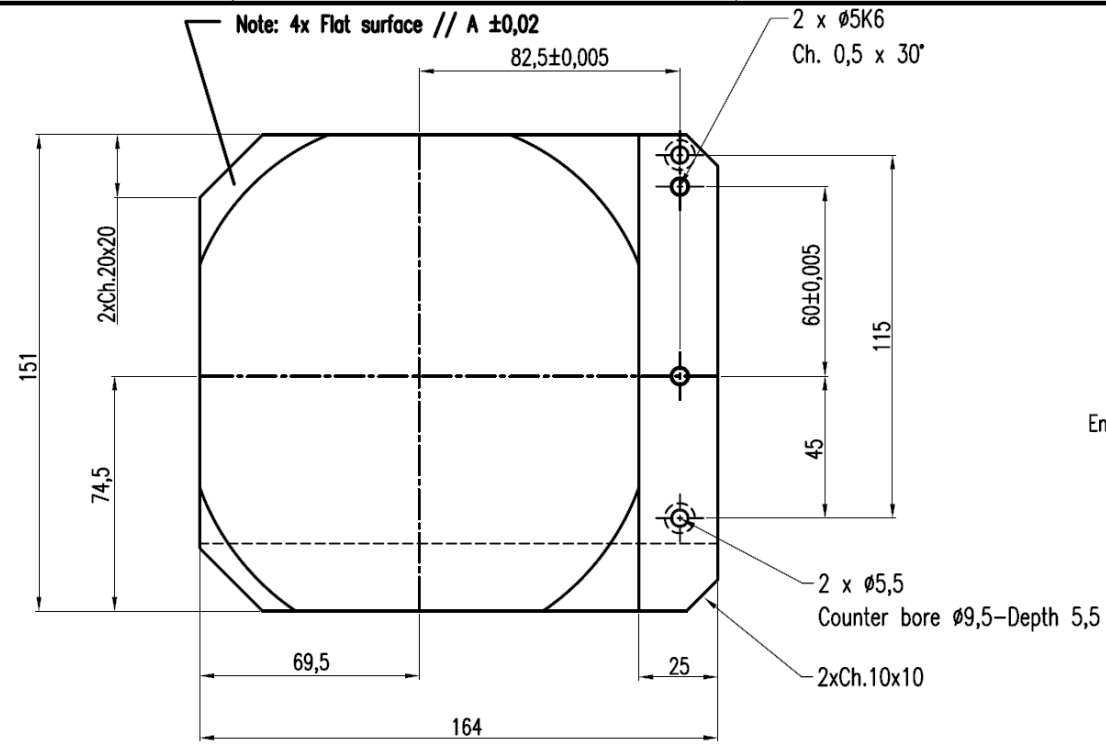
$A0=551,448213702$

$R.in=254,234932388071$

$R.out=679,33138474324$

Mathematical Equation of Ellipsoide:

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} - 1 = 0$$

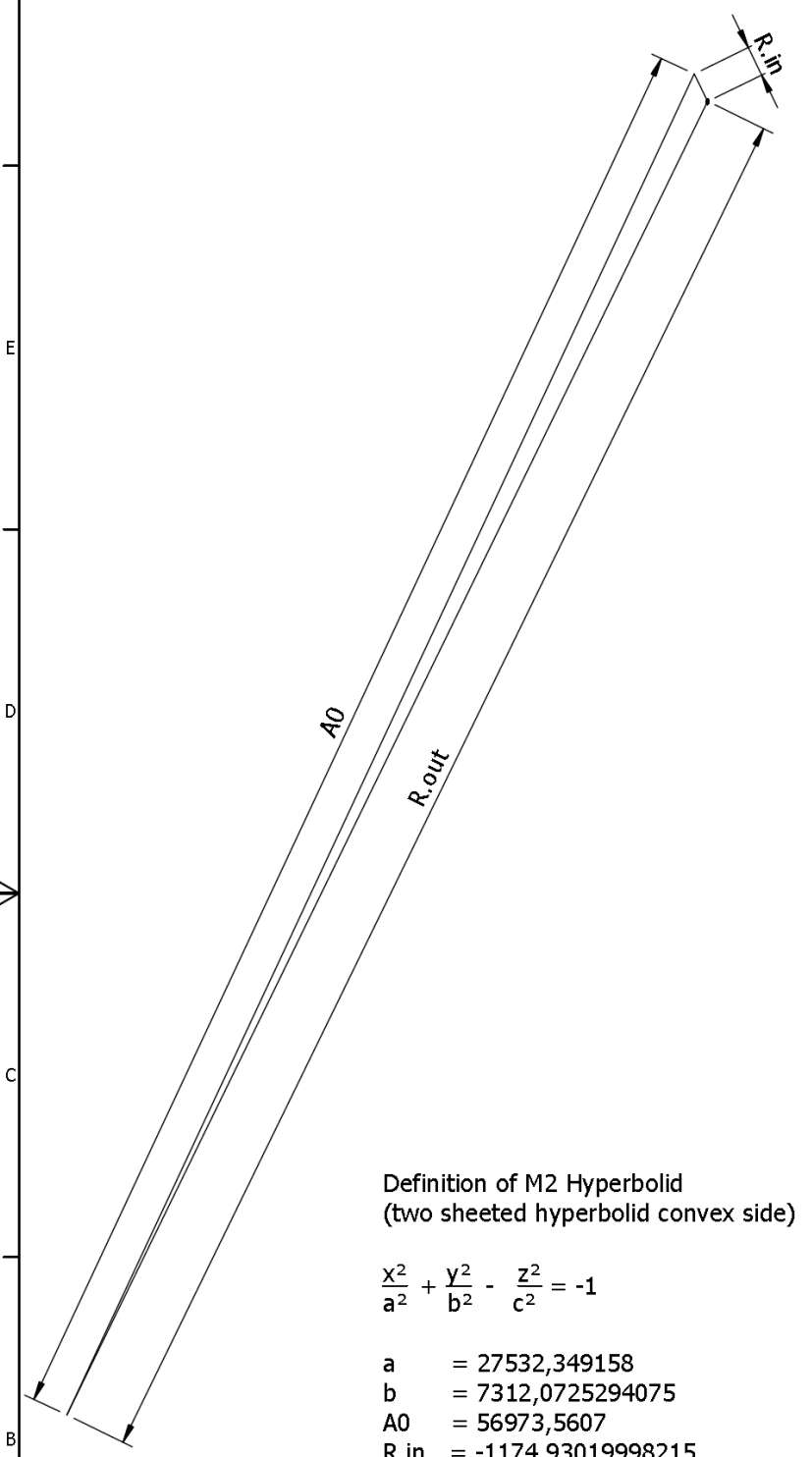


Surface Treatment Specification
 1-Surface Accuracy < 30 microns p-p
 (Large scale variations applied to the whole surface)
 2-Surface Roughness < 0,1 micron p-p
 3-Surface Coating: Layer of minimum 1 micron Ni + 5 microns Au (Ni free) on mirror surface, 1-2 micron AU on other surfaces is acceptable!

Stabilised Before Finishing

		Material: 6061-T651 Do Not Anodise		Surface: See Note on Roughness		Weight: 750 g	
		General Tolerances: ISO 2768-mK		Scale: 2:5		Sub-System:	
		Date:		Name:		Description: ELLIPTICAL MIRROR	
D		Drawn:					
C		Designed:					
B		Checked:					
A		Released:					
Issue		Date		Name		CRE Number	
All units are in mm						Document Number: Sheet 5 of Sheets	

Definition of M2 Hyperboloid (convex side)
Scale 1:200



Definition of M2 Hyperboloid
(two sheeted hyperboloid convex side)

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{z^2}{c^2} = -1$$

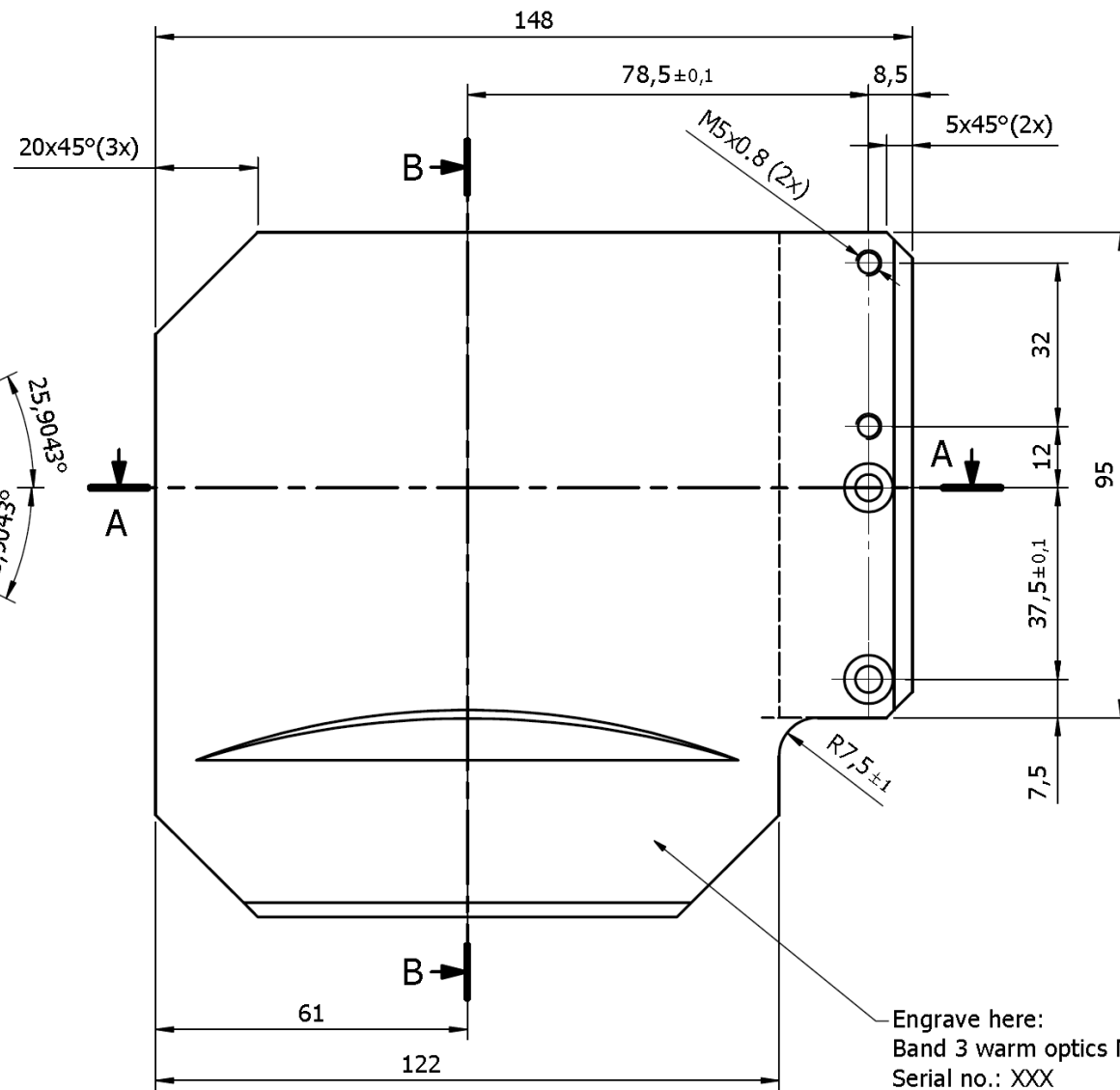
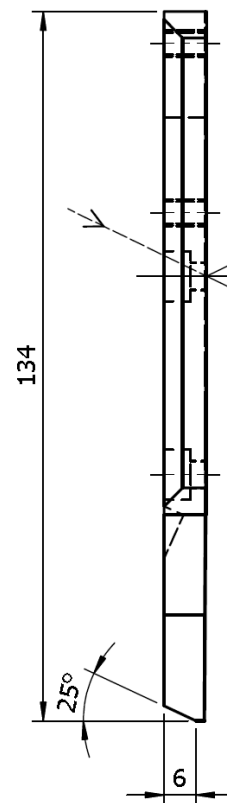
- a = 27532,349158
- b = 7312,0725294075
- A0 = 56973,5607
- R.in = -1174,93019998215
- R.out = 56239,6285161825

Surface Treatment Specification

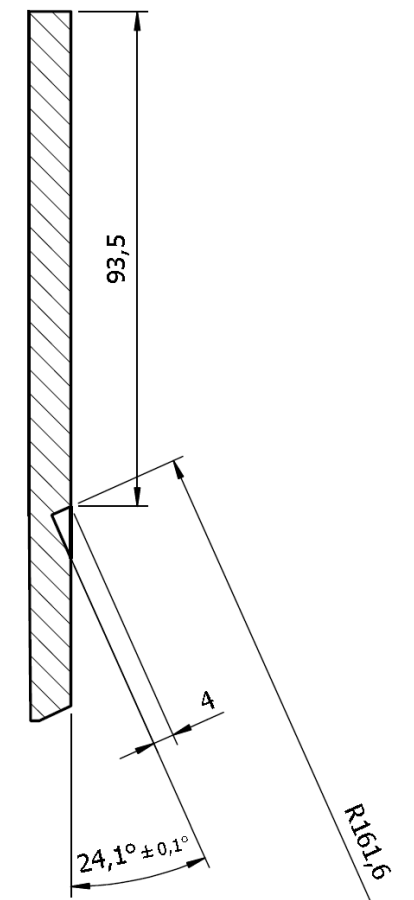
- 1 - Surface Accuracy <30 microns p-p
(Large scale variations applied to the whole surface)
- 2 - Surface roughness <0,1 micron p-p
- 3 - Surface Coating :
Layer of 1 micron min. Ni + 5 microns Au
(Ni free) on mirror surface,
1-2 Au on other surfaces is acceptable.

Stabilised before finishing

Deburr, clean and round all sharp edges, R=1mm

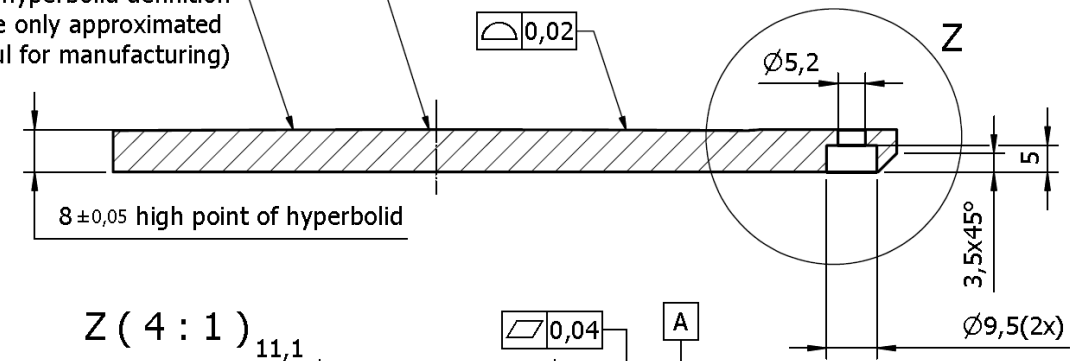


B-B (1 : 1)

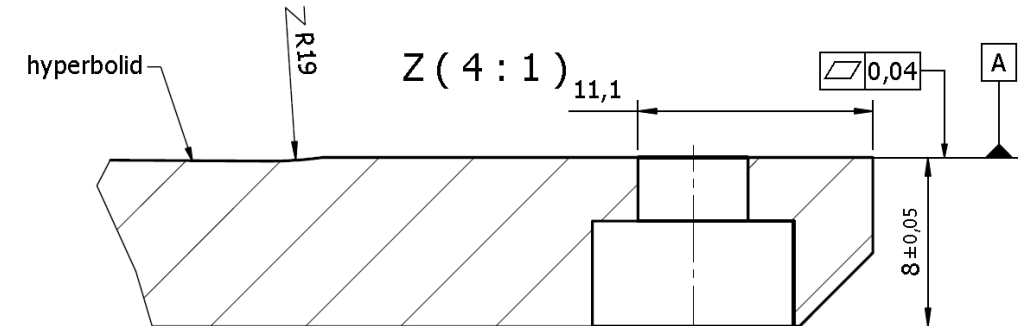


Note: high point of hyperboloid to be within ± 0,05 to surface A

see hyperboloid definition curve only approximated (solidmodel not useful for manufacturing)



A-A (1 : 1)



Issue	Date	Name	CRE Number
E			
D			
C			
B			
A			

Material: 6061-T651 do not anodise		Surface: see note on roughness	Weight: N/A	General Tolerances ISO 2768 - mK	
Program:	Date:	Name:	Product Number/Item	Scale: 1:1	Sheet 1 / 1
Drawn:	Designed:	Released:	Description / Additional Information HYPERBOLIC MIRROR		
Released:	Drawing Status: WorkInProgress		Drawing Number:		
ISO Method E Unless otherwise stated all dimensions in mm DO NOT SCALE			Model Number:	Dwg Issue E	
Copyright reserved acc. ISO 16016			Model Issue D		

PŘÍLOHA Č. 5

Výkres sestavy zrcadel⁴¹

