COS NCM2 Mirror Substrate Specification

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ABBREVIATIONS & ACRONYMS

Å	Angstroms
ATP	Acceptance Test Procedure
CASA	Center for Astrophysics and Space Astronomy
COS	Cosmic Origins Spectrograph
CU	University of Colorado
HST	Hubble Space Telescope
JY	Jobin-Yvon
NCM2	NUV Correcting Mirror 2
NUV	Near Ultraviolet
rms	Root Mean Square
TBD	To Be Determined
TBS	To Be Specified

1. PURPOSE

This specification defines the requirements for manufacture, performance, and verification testing of the NUV channel collimating mirror (NCM2) substrate for the Hubble Space Telescope's (HST) Cosmic Origins Spectrograph (COS). This specification only refers to the mirror substrate and not the optical coatings which will be applied at a later date.

2. APPLICABLE DOCUMENTS & DRAWINGS

2.1 APPLICABLE DRAWINGS

CASA-COS-1006 Substrate, NCM2 Collimating Mirror

3. REQUIREMENTS

3.1 ITEM DESCRIPTION & DEFINITION

The mirror substrates are made of fused silica and incorporate a convex, off-axis, parabolic optical surface, mounting surfaces, and mirrored surfaces for use during installation and alignment of the mirror into the COS instrument. The mirror blank dimensions, clear aperture, material, and fiducial marks are presented in drawings CASA-COS-1006.

3.2 OPTICAL REQUIREMENTS

3.2.1 Optical Surface Specifications

3.2.1.1 Optical Prescription

The off-axis parabolic substrate shall be described by the following parameters:

Optical Parameter	Value	Tolerance
Base Radius	608.355 mm	± 0.25%
Off-axis Distance	53.904 mm	± 0.1mm

3.2.2 Figured Clear Aperture

The figured clear aperture shall be as specified in drawing CASA-COS-1006.

3.2.3 Substrate Surface & Finish

3.2.3.1 Surface Figure

The fused silica mirror substrate shall have a surface figure of ≤ λ/100 rms over the entire clear aperture measured at 6328 Å. This specification shall be met over the following spatial frequencies:

Surface Error Bandwidths	
Surface Errors	Spatial Frequencies
Surface Figure	> 1 mm
Surface roughness	< 0.5 mm

3.2.3.2 Surface Roughness

The clear aperture of each mirror substrate must have a surface roughness < 10 Å rms.

3.2.3.3 Scratch and Dig

The polished clear aperture shall meet or exceed a Scratch & Dig specification of 20-10 per MIL-O-13830H.

3.2.4 Wedge, Offsets, and Substrate Thickness

3.2.4.1 Wedge

The wedge shall be ≤30 arc sec with knowledge to 3 arcsec. For the aspheres, wedge is defined as the complement of the angle between the plane defined by the fiducial surface on the back of the substrate and the normal to the asphere vertex.

3.2.4.2 Offsets

The center of the asphere shall be within ± 0.25 mm of off axis distance from the parent vertex.

3.2.4.3 Back Side Surface Quality

The entire back side, defined as the side directly opposite the optical surface, must be figured to λ/40 rms over 85% of the total area.

3.2.4.4 Unspecified Surfaces

All unspecified surfaces shall be polished for visible inspection of the interior of the substrate. Bevel surfaces are excluded from this requirement.

3.3 MECHANICAL

3.3.1 Substrate Material

The mirror blanks shall be fabricated from fused silica, either Corning 7980 or 7940, inclusion class 2 or better.

3.3.2 Dimensions

Physical dimensions of the mirror substrates shall be per Drawings CASA-COS-1006.

3.3.2.1 Dimensional Knowledge

Optics diameters shall be measured and recorded to a precision of 0.0025 mm. Center thickness shall be measured and recorded to a precision of 0.025 mm

3.3.3 Fiducials

The vendor shall mark the backs of the aspheres with a fine reflective cross (~0.050mm line width) such that the two axis are located to ±0.25° of the aspheric x and y axis and the intersection of the cross is centered to the optic vertex or defined off axis distances to ±0.250mm. Knowledge of the location of this intersection with respect to the optic vertex is required to be ±0.025mm or better. The cross hair ficucials must be a minimum of 1 inch long. A fine line (may be scribed) shall be placed on the side of the optic or stem (if the optic has one) marking the location of the aspheric (+Y) axis to ±0.25°. The side fiducial should cover the entire side of the optic or stem. A second fiducial shall be scribed that is parallel to the back surface as shown in CASA-COS-1006. The distance of the fiducial from the back surface shall be known to ±0.025mm.

3.3.4 Serialization & Marking

The mirror substrates shall be identified by a serial number to retain identification. The serial number shall be sand blasted on the back of the finished element in the location shown on drawings CASA-COS-1006. Witness samples serial numbers are to be scribed on the backside with the letters CW followed by a simple number, i.e. CW 23.

3.4 ENVIRONMENTAL REQUIREMENTS

During the fabrication of the mirror substrates defined in this document no process or materials shall be employed which would preclude the substrate from meeting or exceeding the operational specifications under the environmental conditions presented in Section 3.4.1. The environmental conditions under which the substrate performance must be verified are outlined in Section 4, Acceptance & Verification Testing, of this document.

3.4.1 Operating:

Temperature	15° C to 25° C
Relative humidity	0% to 50 %
Pressure	8×10^{2} Torr to $<1 \times 10^{-5}$ Torr

3.4.2 Solvents

The mirror substrate may not come into contact with any solvent or substance which could damage the optic in any way prior to the application of the optical coating. Such a substance would be hydroflouric acid.

3.4.3 Silicones

The exposure of the mirror substrate to silicones during any activity during it's fabrication process shall be minimized. The presence of silicones in an epoxy bond can drastically reduce the strength of the bonded interface. The COS NCM2 mirrors, when complete, will be bonded into mounts prior to final alignment. Since removal of silicones is extremely difficult the exposure of the mirror substrates to silicones must be minimized where practical. Should the mirror substrates knowingly be exposed to silicones during the fabrication process, the manufacturer shall notify CU/CASA in writing.

3.5 SHIPPING & HANDLING

3.5.1 Handling

During all phases of substrate fabrication suitable precautions must be employed during handling of the optic to insure that it is not damaged in any way which would preclude use of the substrate as a correcting mirror in the COS instrument.

3.5.2 Shipping

At the time of delivery the substrate must meet or exceed class 1000 cleanroom specifications. The clean substrate will be shipped in a shipping container that also meets or exceeds class 1000 cleanroom specifications during installation of the substrate into the shipping container.

3.5.3 Shipping/Handling Environmental Restrictions

The completed blank must be maintained within the following environmental limits:

Temperature	-50 to 100°C
Humidity	≤ 95% relative humidity
Pressure	< 800 Torr.

4. ACCEPTANCE & VERIFICATION TESTING

4.1 ACCEPTANCE TEST PROCEDURE

The supplier shall prepare an acceptance test procedure (ATP) including the following as minimum.

a) Test to be performed and description of accomplishment method.
b) Sequence of tests.
c) Article being tested (i.e., flight article or witness sample).
d) Equipment to be used.
e) Accuracy of measurement.
f) Calibration techniques (as appropriate).
g) Data sheets.

The tests shall be adequate to verify that the mirror satisfies the requirements of this specification per the specification verification matrix shown in Section 6.0 of this

document. The ATP shall be submitted to CU for approval at least four weeks prior to acceptance testing.

4.2 ACCEPTANCE TEST

The supplier shall perform an acceptance test of each flight optic. Data packages must be available for review at the acceptance test but may be submitted to CU at a later date. Interferometric and radius of curvature tests must be witnessed. Other parameters may be verified by data review of previously performed tests and review of as built mechanical data or in process logs. The supplier shall notify CU at least 1 week in advance of each acceptance test. Multiple optics may be tested during the same acceptance test.

CU retains the right for any responsible CU optical engineer, QA representative associated with the HST/COS project, or US government representative to witness any and all acceptance tests; however, it is anticipated that this will occur on a limited basis to accept and approve the ATP.

4.3 ACCEPTANCE TEST ENVIRONMENTAL CONDITIONS

Acceptance testing of the NCM2 substrates may be conducted under normal laboratory operating conditions provided they fall within the environmental limitations presented in Sections 3.4.1 and 3.5.3 It is anticipated that the mirror substrates will be tested at 22.5°C ± 2°C.

4.4 SPECIFICATION VERIFICATION MATRIX

Section	Description of Requirement	Method of Verification	Verification of Deliverable
3.2.1.1	Optical Prescription		
3.2.2	Figured Clear Aperture		
3.2.3.1	Surface Figure		
3.2.3.2	Surface Roughness		
3.2.3.3	Scratch & Dig		
3.2.4.1	Wedge		
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3.4.1	Operating Environments		
3.4.2	Solvents		
3.4.3	Silicones		

5. WITNESS SAMPLES

The supplier shall provide a minimum of five witness samples per deliverable flight optic. Each witness sample shall be made from the same material (lot) as the specified substrate. The witness samples shall have their coated surface polished flat in a similar manner as the optical element specified herein. These witness samples shall be delivered along with the mirrors to CU. The witness samples shall have the following dimensions:

Diameter	25.4 mm ± 0.25 mm
Thickness	3.18 mm ± 0.25 mm
Clear Aperture Diameter	20.32 mm minimum
Bevel	45 deg edge bevel
Surface figure	≤ 1λ PV
Surface finish	Best commercial polish (≤ 30 Å rms goal)