COS NUV Grating Specification

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Table of Contents

ABBREVIATIONS & ACRONYMS

Å	Angstroms
CASA	Center for Astrophysics and Space Astronomy
COS	Cosmic Origins Spectrograph
CU	University of Colorado
HST	Hubble Space Telescope
ppm	Parts Per Million
rms	Root Mean Square
TBD	To Be Determined
TBS	To Be Specified

1. PURPOSE

This document specifies the optical parameters and the grating performance requirements for the Hubble Space Telescope (HST) Cosmic Origins Spectrograph (COS) G185M, G225M, G285M, and G230L NUV gratings. All aspects of the fabrication process will be controlled and conducted by the contractor.

2. APPLICABLE DOCUMENTS & DRAWINGS

2.1 APPLICABLE DOCUMENTS

2.2 APPLICABLE DRAWINGS & SKETCHES

CASA-COS-1010 COS NUV Grating Substrate

3. REQUIREMENTS

3.1 ITEM DESCRIPTION & DEFINITION

NUV ruled gratings shall be delivered to CU/CASA by the contractor. For each grating type the vendor shall deliver three gratings. Two shall be referred to as "flight" and the third shall be referred to as the "surrogate". The surrogate grating shall undergo all performance testing that requires a metallic coating. The two flight gratings shall be delivered without an optical coating. The flight and surrogate gratings shall be identical in *all* respects excepting the application of the metallic coating to the surrogate grating. The grating substrates are planar and made of fused silica. The substrate dimensions, clear aperture, material, and fiducial marks are presented in drawing CASA-COS–1010.

Each substrate shares a common geometry with the exception of the ruling parameters. See drawing CASA-COS-1010 for the physical dimensions of the grating substrates.

3.1.1 NUV Grating Operational Parameters

Listed below are the basic operation parameters for of the NUV reflection gratings. The parameters shown with a * are for reference only.

3.1.1.1 G185M Operational Parameters

Parameter	Value
Characteristic Groove Density	5870 g/mm
Operational Bandpass	1700-2000 Å
Alpha	34.658 degrees
Beta	33.27 degrees
Blaze Angle*	33.96 ± 2.0 degrees
Blaze Wavelength	1850 Å ± 100 Å

3.1.1.2 G225M Operational Parameters

Parameter	Value
Characteristic Groove Density	4800 g/mm
Operational Bandpass	2000-2500 Å
Alpha	33.621 degrees
Beta	32.23 degrees
Blaze Angle*	32.93 ± 1.6 degrees
Blaze Wavelength	2250 Å ± 100 Å

3.1.1.3 G285M Operational Parameters

Parameter	Value
Characteristic Groove Density	4000 g/mm
Operational Bandpass	2500 - 3200 Å
Alpha	35.707 degrees
Beta	34.32 degrees
Blaze Angle*	35.01 ± 1.4 degrees
Blaze Wavelength	2850 Å ± 100 Å

3.1.1.4 G230L Operational Parameters

Parameter	Value
Characteristic Groove Density	500 g/mm
Operational Bandpass	1700-3200 Å
Alpha	5.565 degrees
Beta	1.088 degrees
Blaze Angle*	3.327 degrees*
Blaze Wavelength	2300 Å ± 100 Å

3.1.2 Drawings

Drawing CASA-COS-1010 are included as part of this specification. These drawings show the grating substrate design.

3.1.3 Grating Coating

There shall be no coating on the two flight gratings. A vapor deposited platinum metallic coating is allowed on the surrogate grating only.

3.1.4 Fabrication Technology

The NUV gratings may be produced using any existing fabrication technology deemed suitable by the contractor. For example, either a mechanically or holographically ruled grating would be acceptable provided it meets or exceeds the performance requirements presented in this document.

3.1.5 Grating Performance Requirements

Every performance specification which requires verification through optical testing shall be verified using the surrogate grating. All gratings must meet or exceed *all* other specifications.

3.1.5.1 Groove Efficiency

The groove efficiency of the surrogate grating shall be measured at a minimum of 3 to 5 wavelengths which cover the majority of the operational bandpass of the grating.

The measurements may be done at a single position on the grating using narrow beam illumination. The groove efficiency of the gratings shall be ≥ 0.45 at all wavelengths within the operational bandpass. The groove efficiency of the grating is

defined to be the measured efficiency of the grating divided by the measured reflectivity of a witness mirror coated simultaneously with the optic under test.

3.1.5.2 Blaze Function

The blaze function of the surrogate grating shall be measured and/or demonstrated. Each grating has a unique blaze wavelength as presented in Sections 3.1.1, 3.1.2, 3.1.3, and 3.1.4. The measurement of the blaze function can be derived using the data acquired during the measurement of the groove efficiency (section 3.3.4.1) or through a direct measurement of the blaze angle of the groove facets through atomic force microscopes or suitable measurement technique. The efficiency of the grating must reach a maximum within ±100 Å of the design blaze wavelength.

If possible atomic force microscope images of the flight gratings shall be acquired to verify the blaze angle of the rulings.

3.1.5.3 Scattered Light

The scattered light of the surrogate grating shall be measured. The scattered light can be measured at a single point on the grating using a narrow beam to illuminate a portion of the grating. The measurement may be done at a suitable wavelength within the operating bandpass of the grating. The scattered light off the grating shall be ≤ $2X10^{-5}$/Å within 10 Å from line center when measured with a monochromatic pencil beam and a goal of ≤ 10^{-5}/Å within 10 Å from line center for the G185M, G255M, and G285M gratings. For the G230L grating the scattered light off the grating shall be ≤ $2X10^{-5}$/Å within 50-80Å from line center when measured with a monochromatic pencil beam and a goal of ≤ 10^{-5}/Å within 50-80Å from line center. The scattered light tests may be conducted using 3510Å light or other UV wavelength with CU approval.

3.1.5.4 Ghost Images

The intensity of any ghost image shall be less than 10^{-4} of any parent image and shall be demonstrated through testing.

3.1.5.5 Polarization

There are no requirements on the performance of the rulings pertaining to polarization.

3.1.5.6 Wedge

The wedge between the front and back surfaces shall be < 30 arc sec with knowledge to 3 arc sec.

3.1.5.7 Wavefront Error

The wavefront error of diffracted light from the surrogate grating shall be ≤ 0.02λ rms measured at 6328Å. The wavefront may be measured using zero order light from the grating.

3.1.5.8 Back Side Surface Quality

The entire back side, defined as the side directly opposite the ruled surface, shall be figured to λ/4 at 6328Å. The surface roughness shall be < 10Å rms.

3.1.5.9 Unspecified Surfaces

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

3.2 MECHANICAL

3.2.1 Substrate Material

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

3.2.2 Dimensions

Physical dimensions of the mirror substrates shall be per Drawings CASA-COS-1010.

3.2.2.1 Dimensional Knowledge

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

3.2.3 Fiducials

Fiducials on the substrates shall be provided in the locations shown on drawings CASA-COS-1010. Fiducials may be scribed, lithographically applied, or implemented through another technology with prior approval from CU/CASA.

Fiducials shall be 0.050mm to 0.100mm wide. An arrowhead shall be used to indicate the blaze direction of the grating.

3.2.4 Serialization & Marking

The grating 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-1010. Since the grating substrates will be subjected to a vacuum environment, the marking method shall not outgas in this environment. Marking method shall be approved by CU prior to application. Witness samples are to be scribed on the backside with the letters CWG- followed by a simple number, i.e. CWG-23.

3.3 ENVIRONMENTAL REQUIREMENTS

Performance of the gratings shall not be degraded when exposed to the following environmental conditions:

3.3.1 Operating:

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

3.3.2 Storage/Handling:

Temperature	-10° C to 40° C
Relative humidity	0 % to 95 % (55 % after coating)
Pressure	8×10^{2} Torr to $<1 \times 10^{-5}$ Torr

3.3.3 Solvents

The grating may not come into contact with any solvent or substance which could damage the optic.

3.3.4 Radiation Susceptibility

The grating must be able to withstand 16 Krad of exposure over an 8 year lifetime with no degradation in the optical or mechanical quality of the substrate.

3.3.5 Silicones

The exposure of the gratings to silicones during any activity during its fabrication process shall be minimized. The presence of silicones in an epoxy bond can drastically reduce the strength of the bonded interface. The COS gratings, when complete, will be bonded into their respective mounts prior to final alignment. Since removal of silicones is extremely difficult the exposure of the grating substrates to silicones shall be minimized where practical.

3.4 SHIPPING & HANDLING

3.4.1 Handling

Once fabricated, the gratings shall be handled only by gloved and gowned individuals in an environment not exceeding class 10,000 in particulate cleanliness or a high quality test environment with appropriate handling procedures (e.g. use of gloves, frocks, masks, etc.).

3.4.2 Shipping

The flight gratings shall be shipped in a shipping container provided by CU/CASA. The flight gratings can only be shipped with the container backfilled with high purity gaseous nitrogen. GN2 from an LN2 boil-off system is acceptable provided the GN2 from the distribution system has been certified to be 99.999% GN2 with < 25 ppm hydrocarbon content.

The surrogate grating shall be packaged in a container provided by the vendor. This container shall follow standard practices used by the vendor for packaging and shipping gratings.

4. ACCEPTANCE & VERIFICATION TESTING

4.1 ACCEPTANCE TEST PROCEDURE

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

a. Groove efficiency versus wavelength.
b. STM (scanning tunneling microscope or equivalent) images of the groove profiles of a representative sample or flight optics.
c. Measurement or demonstration of the blaze angle.

The tests shall be adequate to verify that the surrogate grating satisfies the requirements of this specification. This 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, which may be witnessed by the responsible CU optical engineer and QA representative for each flight optic. Data packages must be available for review at the acceptance test but may be submitted to CU within four weeks of acceptance. 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 3 weeks in advance of each acceptance test. Multiple optics may be tested during the same acceptance test.

4.2.1 Specification Verification Matrix

Section	Description of Requirement	Method of Verification	Verification of Deliverable
3.1.1.1	G185M Blaze Wavelength		
3.1.1.2	G255M Blaze Wavelength		
3.1.1.3	G285M Blaze Wavelength		
3.1.1.4	G230L Blaze Wavelength		
3.1.3	Grating Coating		
3.1.5.1	Groove Efficiency		
3.1.5.2	Blaze Function		
3.1.5.3	Scattered Light		
3.1.5.4	Ghost Images		
3.1.5.6	Wavefront Error		
3.1.5.7	Backside Surface Quality		
3.1.5.8	Unspecified Surfaces		
3.2.1	Substrate Material		
3.2.2.1	Dimensional Knowledge		
3.2.3	Fiducials		
3.3.3	Solvents		
3.3.4	Radiation Susceptibility		
3.3.5	Silicones		

5. WITNESS SAMPLES

The contractor will provide five witness samples with each grating delivered to CU/CASA. Each witness sample shall be processed in a manner consistent with the processing of the flight gratings. The witness mirrors shall be coated simultaneously with the flight gratings. The witness samples will 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)