Statement of Requirements for the HST/COS FUV Detector

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Prepared By:	E. Wilkinson	3-23-99
	Dr. E. Wilkinson, COS Instrument Scientist, CU/CASA	Date
Reviewed By:	B. Osborne	4-8-99
	Mr. Brian Osborne, COS Systems Engineer, BATC	Date
Reviewed By:	G. Murphy	4-9-99
	Mr. Gerry Murphy, Engineer, Design_Net Engineering	Date
Reviewed By:	B. Donakowski	3-19-99
	Mr. Bill Donakowski, COS FUV Detector Mechanical Lead, UCB/EAG	Date
Reviewed By:	G. Gaines	3-19-99
	Mr. Geoff Gaines, COS FUV Detector Systems Lead, UCB/EAG	Date
Reviewed By:	D. Buzasi	3-19-99
	Dr. Derek Buzasi, COS FUV Detector Technical Lead, UCB/EAG	Date
Reviewed By:	J. Zaninovich	3-19-99
	Mr. Jurge Zaninovich, COS FUV Detector Electrical Engineer, UCB/EAG	Date
Reviewed By:	J. Penegor	3-19-99
	Mr. Jerry Penegor, COS FUV Detector Electrical Engineer, UCB/EAG	

Approved By:	D. Hood	4-8-99
	D. Hood, COS Program Manager, BATC	Date
Approved By:	J. Andrews	3-25-99
	J. Andrews, COS Experiment Manager, CU/CASA	Date
Approved By:	J. Green	4-9-99
	Dr. J. Green, COS Principal Investigator, CU/CASA	Date
Approved By:	J. Vallerga	3-19-99
	Dr. John Vallerga, COS FUV Detector Operations Scientist, UCB/EAG	
Approved By:	B. Welsh	3-19-99
	Dr. Barry Welsh, COS FUV Detector Project Manager, UCB/EAG	
Approved By:	O. Siegmund	3-19-99
	Dr. Oswald Siegmund, COS FUV Detector Prinicpal Investigator, UCB/EAG	

Center for Astrophysics & Space Astronomy
University of Colorado
Campus Box 593
Boulder, Colorado 80309

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ABBREVIATIONS & ACRONYMS

Å	Angstroms
ATP	Acceptance Test Procedure
BASD	Ball Aerospace Systems Division
BOL	Beginning of Life
CASA	Center for Astrophysics and Space Astronomy
CDR	Critical Design Review
Cmd	Command
CMOS	Complementary metal oxide semiconductor
CMP	Configuration Management Plan
COS	Cosmic Origins Spectrograph
CTE	Coefficient of Thermal Expansion
CU	University of Colorado
dB	Decibel
DCE	Detector Control Electronics
DEB	Detector Electronics Box
DL	Delay Line
DQE	Detection Quantum Efficiency
DUT	Device Under Test
DVA	Detector Vacuum Assembly
EAG	Experimental Astrophysics Group
EOL	End of Life
ESD	Electro Static Discharge
EVM	Environmental Verification Matrix
FEM	Finite Element Model
FMEA	Failure Modes & Effects Analysis
FPGA	Field Programmable Gate Array
FUSE	Far Ultraviolet Spectrographic Explorer
FUV	Far Ultraviolet
FWHM	Full Width Half Maximum
GSE	Ground Support Equipment
g	9.8 m/s^2
HK	Housekeeping
HST	Hubble Space Telescope
H/W	Hardware
ICD	Interface Control Document
I/F	Interface
Krad	Kilorad

ABBREVIATIONS & ACRONYMS

LEO	Low Earth Orbit
LET	Linear Energy Transfer
LISN	Line Impedance Simulation Network
LL	Limit Load
MCP	Microchannel Plate
MEB	Main Electronics Box
MHz	10^6 cycles/sec
PI	Principal Investigator
PSD	Power Spectral Density
QA	Quality Assurance
QE	Quantum Efficiency
RDM	Radiation Design Margin
RH	Relative Humidity
rms	Root Mean Square
SAA	South Atlantic Anomaly
S/C	Spacecraft
SEE	Single Event Effect
SEU	Single Event Upset
SI	Science Instrument
SIPE	Science Instrument Protective Enclosure
SMP	Software Management Plan
SOS	Silicon on Sapphire
SoW	Statement of Work
SRD	Software Requirements Document
S/W	Software
TBD	To Be Determined
TBS	To Be Specified
TDC	Time to Digital Converter
UCB	University of California, Berkeley

1. PURPOSE

This document defines the requirements for the manufacture, performance, and characterization and verification testing of the FUV detector for the Hubble Space Telescope (HST) Cosmic Origins Spectrograph (COS). This document specifies all performance and testing requirements of the detector. The HST Performance Assurance Requirements Document specifies all quality, reliability, and design assurance related items. Together with the Contract and SOW, these three documents specify the entire requirements levied on UCB. This document does not constitute an Interface Control Document (ICD). That document shall be prepared separately between BASD and UCB and approved by CASA prior to its release.

2. APPLICABLE DOCUMENTS & DRAWINGS

2.1 APPLICABLE DOCUMENTS

Document #	Title	Revision
STE-63	Critical End-Item Specification for the COS	Current Rev.
UCB-COS-001	COS FUV Detector Interface Control Document	Current Rev.
COS-10-0001	SoW for the HST/COS DDL FUV Detector System	Current Rev.
SCM-1050	HST COS Data Requirements Document	Current Rev.
STR-43	HST STIS & NICMOS Performance Assurance Requirements	Current Rev.
ST-ICD-08E	Science Instrument to Science Instrument Command & Data Handling (SI to SI C&DH) ICD	Current Rev.
ST-ICD-02E	Axial Science Instrument to Optical Telescope Assembly and Systems Support Module	Current Rev.
GEVS-SE	General Environmental Verification Specification for Space Transportation Systems and Expendable Launch Vehicle Payloads, Subsystem, and Components	Current Rev.
PPL21	GSFC Preferred Parts List	Current Rev.
Ball SER-013	FUV Detector Mass & Structural Requirements	Current Rev.
IN0090-109	COS Fracture Control Implementation Plan	Current Rev.
TBD	COS Contamination Control Plan	In Preparation
STR-29	HST Servicing Mission Contamination Control Requirements	Current Rev.
MIL-STD-462	Measurement of Electromagnetic Interference Characterization	Current Rev
DM-03	SI Flight Software Documentation	Current Rev
UCB-COS-004	UCB Software Requirements Document	Current Rev

3. PERFORMANCE REQUIREMENTS

3.1 ITEM DESCRIPTION & DEFINITION

The COS detector is a microchannel plate detector with dual axis, time delay readouts. The long axis provides ≤25 μm FWHM spatial resolution. The short provides ≤50μm FWHM spatial resolution. The active area is configured as two segments each being approximately 85 X 10 mm. The segments are oriented such that the total active area of the detector is approximately 170 X 10 mm with a 7-10 mm gap between the segments. Each segment consists of three MCPs in a Z-stack configuration.

The FUV detector system consists of three components; the Detector Vacuum Assembly (DVA), the Detector Electronics Box (DEB), and their interconnecting harness. The DVA consists of the MCPs, anodes, vacuum box, high voltage filter module, and charge amplifiers. The DEB consists of the time to digital converters, high and low voltage power supplies, communication electronics, control electronics, and analog to digital converters. The two components can be mounted in separate locations to facilitate packaging.

The following definitions are used in document. An assembly is a completed portion of a component. For example, a populated printed circuit board or a fully functional vacuum door assembly shall be considered assemblies. A component shall be the DVA, DEB, or interconnecting harness. The FUVS Sub-system shall be the three components electrically integrated and fully functional.

3.2 PIXEL FORMAT

The digitized pixel format of the FUV detector shall be 16384 (dispersion axis) X 1024 (cross-dispersion axis) for each segment.

3.3 DIGITIZED PIXEL SIZE

The digitized pixel size shall be <8μm (dispersion axis) and <15μm (cross-dispersion axis).

3.4 OPERATIONAL WAVELENGTH RANGE

3.4.1 FUV Radiation

The FUV detector shall be capable of detecting photons between 900Å - 2050Å when the vacuum door is open.

3.4.2 NUV Radiation

The FUV detector shall be capable of detecting radiation with wavelengths 2000Å to 3000Å with the vacuum door closed, provided a light source with sufficient photons is employed.

3.5 QUANTUM EFFICIENCY

The detector front surface MCP shall be coated with a photocathode to increase the detection quantum efficiency of the detector to FUV light. The photocathode selected by the instrument development team and UCB/EAG shall provide the minimum DQEs presented in Table 3.1. The quoted DQE assumes a QE enhancement grid will be implemented in the detector.

The absolute DQE shall be measured at a minimum of one point per detector segment using, as a minimum, the test wavelengths shown in Table 3.1. The relative DQE shall be measured at a minimum of 10 points across each segment of the detector \using the same wavelengths used to measure the absolute DQE.

Table 3.1

Wavelength	Absolute Detection Quantum Efficiency
1152 Å	44%
1216 Å	32%
1335 Å	25%
1463 Å	19%
1560 Å	17%
1710 Å	11%

3.5.1 DQE Degradation Due to Grid Shadowing

Local decreases in DQE are expected due to shadowing of the incident radiation by the DQE enhancement grid and ion repeller grid. The DQE along individual wire shadows shall not be less than 70% DQE in the unshadowed active area, when illuminated by a f/24 beam.

The placement of the QE enhancement grid shall minimize the number of wires present over the central 5 x 85mm of each detector segment, especially those wires running perpendicular to the long axis of the detector active area. The final design shall be presented to CU/CASA for final approval.

3.5.2 Visible Light Rejection

The visible light rejection of the FUV detector is largely determined by the photocathode deposited onto the top MCP of the detector. The DQE of the FUV detector to all wavelengths of light between 4000Å and 6500Å shall be $<10^{-6}$.

3.6 ACTIVE AREA

The active area of the COS FUV detector shall consist of 2 segments, each being ≥ 85mm X 10mm. The panels shall be oriented such that the total length of the detector active area shall be approximately 180mm X 10mm, including a 7-10 mm gap between the panels.

3.6.1 Non Active Area Between The MCPs

The 7-10 mm gap between the MCP panels shall be designed to ensure that diffracted light from the COS optic in the light path incident upon this region will not be scattered or reflected directly onto the active area of the FUV detector.

3.7 SPATIAL RESOLUTION

The spatial resolution of the FUV detector along the long axis shall be ≤31µm FWHM over 80% of the active area and for event rates up 10 kHz per segment as measured using a slit mask agreed upon by CU/CASA and UCB. The slit mask to be used shall have three rows of slits which are aligned parallel to the long axis of the detector. Each row shall be separated by 2.5mm with the middle row positioned at the center of the detector active area in the short axis. Each row shall consist of 25µm X 500µm slits uniformly spaced at 200µm intervals.

The spatial resolution of the FUV detector along the short axis shall be ≤50µm FWHM as measured using a pinhole mask with 10µm diameter pinholes spaced at periodic intervals ≥1mm. This resolution requirement shall be met over 80% of the total height (10 mm) of each detector segment.

3.8 SPATIAL LINEARITY

3.8.1 Integral Non-Linearity

The integral non-linearity of the FUV detector shall be defined as the difference between the measured and true location of test induced features with 1mm spacing. These variations shall not exceed ±100 microns over 80% of the detector active area.

3.8.2 Differential Non-Linearity

The differential non-linearity of the FUV detector system shall be defined as the variation in pixel response to a uniform illumination and occurs over scales greater than or equal to 1 pixel and less than 1mm. Differential non-linearity shall be measured at two in-band UV wavelengths with illumination uniform to ±5% across a ≥1mm^2.

At delivery of the detector to integration and test the differential linearity shall be characterized over the full detector at the pixel level to better than or equal to 10% after taking into account source non-uniformity. This requirement translates to flat fields with ≥100 counts per pixel over the portion of the detector utilized during science operations. This requirement may be met by a single flat field formed through the co-addition of multiple flat fields taken under the same test conditions. However, this requirement on the number of photons /pixel is under consideration and may change as the measured performance of the MCPs is made available.

3.9 DARK COUNT RATE

The dark rate of the FUV detector shall be ≤0.5 cnts/cm^2/sec across the detector during integration and test activities on the ground.

3.10 LOCALIZED ANOMALIES

Localized anomalies are defined as areas <1mm^2 where the performance of the detector drops below the acceptable performance criteria. Such features would include hot spots or dead spots on the detector. The localized anomalies shall not compromise more than 2% of the spectrum when the detector has been installed into the COS instrument. The number, location, count rate, and feature density of the localized anomalies shall be reviewed and accepted or rejected by the COS PI during and/or after the selection of the flight MCPs.

3.10.1 Dead Spots

Dead spots are small, localized regions of the MCPs having less than 50% DQE of the local average. The number, location, and density of the dead spots shall be measured during the selection of the flight MCPs. The COS PI will accept or reject in writing the dead spot characteristics of the flight MCPs as selected by UCB.

3.10.2 Hot Spots

Hot spots are regions of the detector where the count rate exceeds the background limit of 0.5 cnts/cm^2/sec. The number, location, count rate, and density of the hot spots shall be measured during the selection of the flight MCPs. The COS PI will accept or reject in writing the hot spot characteristics of the flight MCPs as selected by UCB.

3.11 MAXIMUM GLOBAL COUNT RATE

The FUV detector electronics shall be capable of processing a maximum count rate of 40,000 counts/sec/segment for a total count rate of 80,000 cnts/sec.

3.12 MAXIMUM LOCAL COUNT RATE

The FUV detector shall be capable of supporting maximum local count rates of 5cnts/sec/pore over a circular illuminated region approximately 1000μm^2.

3.13 DEADTIME PERFORMANCE

The deadtime of the detector shall be calibrated prior to delivery. Deadtime is defined to be 1– (output count rate/input count rate). The output count rate is the number of science data events transmitted per second as measured by the science data counter in the detector electronics. The input count rate is measured by the fast event counter in the detector electronics. The detector system deadtime shall be ≤10% with an input count rate of 10,000 counts/sec/segment and no greater than 60% with an input count rate of 100,000 counts/sec/segment. The deadtime shall be calibrated with random input pulse rate averages varying from 10 Hz to 200,000 Hz.

3.14 LIFETIME

The microchannel plates shall be conditioned such that at BOL the rate of gain sag versus charge extraction shall be ≤100%/coulomb/cm^2. For example, for every 0.5 coulomb/cm^2 there will be a 50% decrease in the modal gain of the pulse height distribution. BOL is defined to be delivery of the COS instrument to GSFC after environmental testing and calibration.

This specification implies that the FUV detector shall be capable of accepting a total flux of ~3.5 X 10^9 photons/ cm^2 with <1% degradation in the DQE over the active area of the detector at BOL.

3.15 IMAGE THERMAL STABILITY

The temperature stability of the detector is critical to supporting the spectral resolution of the COS FUV instrument. It is known that the plate scale (physical size of each pixel) varies with temperature of the time delay anode and the time to digital converter. The temperature sensitivity of the FUV detector system, as measured by the variations in the digitized location of the electronic stimulus centroid, shall be ≤30µm/°C.

3.16 FLAT FIELD STABILITY

The flat field shall be stable to ≤1% at the spectrograph resolution element level (35µm) over a minimum of 80mm X 0.5mm of the detector active area per segment. This requirement may be met by demonstrating that the residual error in dividing two flat fields, each with sufficient signal to noise and after compensation for thermally induced image distortions, is ≤1% RMS. The two flat field exposures shall be acquired such that there is a difference of 5 deg. C in both the DVA and DEB as measured using the appropriate flight thermistors at the DVA and time-to-digital converter (TDC). The temperatures of the DEB and DVA shall remain within the operational limits described elsewhere in this document during acquisition of the flat field data.

3.17 ENVIRONMENTAL CONSTRAINTS

3.17.1 Storage & Handling

The detector system shall be able to be stored without degradation in the following external environmental conditions. In a stored state, the detector system is unpowered, the door is closed, and the ion pumps are powered through a GSE power supply to maintain the vacuum environment within the DVA.

- Temperature: -25 to +50 deg. C with a rate of change no more than 5 deg. C/hr.
- Humidity: 50% RH at standard pressure and temperature.
- Pressure: P < 760 Torr. It is understood that upon delivery of the FUV detector system, power must be maintained to the GSE ion pumps to maintain a high vacuum in the DVA.

3.17.2 Operation

The detector system shall meet or exceed the performance requirements presented in this document in the following external environmental conditions. The DVA shall be operable in two modes; 1) the vacuum door closed, DVA interior at P <$1X10^{-5}$ Torr, and the DVA exterior at P > 500 Torr and, 2) the vacuum door open and the DVA at P <$1X10^{-5}$ Torr. Note, the internal environment of the DVA must always be maintained at P <$1X10^{-5}$ Torr.

- Temperature: 10 to 40 deg. C
- Humidity: 0 to 50% RH. This corresponds to laboratory and flight conditions.
- Pressure :
  1) With the detector in a high vacuum environment (P <$1X10^{-5}$ Torr) the detector shall meet or exceed specified performance requirements).
  2) With the vacuum door closed and the DVA in an ambient pressure environment (P > 500 Torr) the detector shall be operable, including application of HV to the MCP stack. However, in this configuration demonstration that the detector meets or exceeds the performance specifications presented in this document is not required.
  3) To avoid coronal discharge external to the detector, operation of the HV system between $1X10^{-5}$ Torr <P < 500 Torr shall be forbidden.
  4) Power must be maintained to the GSE ion pumps to maintain a high vacuum environment in the DVA during all ground processing of the DVA and the COS instrument. Final removal of the ion pump power is expected to occur when COS is installed into the SIPE for the final time, approximately 2 months before launch. Ion pump power supplies may be turned off for periods of time not to exceed 1 hour to facilitate cabling changes and transport.

3.18 ELECTRONIC STIMULATION

The FUV detector subsystem shall have a self contained electronic stimulation capability which can verify the electronic functionality of the detector subsystem without application of HV to the mcp stack. The electronic stimulation system shall emulate a minimum of 2 point sources outside the active area of the mcps. The electronic stimulation system shall support a minimum 0 Hz, 2 Hz, ~100 Hz, and ~1000 Hz. Operation of the electronic stimulation system shall be fully supported in flight.

4. RESOURCE REQUIREMENTS

4.1 MECHANICAL

4.1.1 Mass Properties

The mass allocations for the FUV detector components are presented in Table 4-1.

Table 4-1

Component	Maximum Allowable Mass
DVA	21.5 kg
DEB	15.3 kg
UCB Provided Cables	3.4 kg

4.1.2 Center of Gravity Requirements

There are no requirements on the center of gravity and inertial properties of the FUV detector DEB, DVA, or electrical harness. The CG (modeled) shall be reported to BASD as part of the mechanical properties within the ICD and any changes from that initial value that exceed 6.4mm shall be reported and an ICD change notice issued.

4.1.3 Volume and Physical Envelope

The allowable volume and envelope for the DVA, DEB, and interconnect harnessing shall be negotiated between UCB and BASD. The agreed upon volume and envelope shall be captured and controlled in the FUV Detector ICD. Any deviations from the volume and envelope specified in the ICD shall require a waiver.

4.2 ELECTRICAL

4.2.1 Power Budget

The FUV detector power requirements shall not exceed 62 Watts for more than 5 minutes and shall not exceed 53 Watts during normal operation. This does not include external heater power. UCB shall report to BASD as part of the ICD the power consumptions as a function of subassembly element for purposes of thermal modeling/control.

4.2.2 Data Rate Requirements

The detector system shall support a maximum science data output rate of 40,000 counts/sec/segment. The detector system shall provide the housekeeping data necessary to maintain and provide knowledge into the health and safety of the FUV detector system. The details shall be negotiated and captured in the FUV detector ICD.

5. ENVIRONMENTAL DESIGN AND TEST REQUIREMENTS

The COS FUV Detector subsystem shall be designed and tested in accordance with the requirements established in section 3.0 of the HST STIS/NICMOS PAR, GSFC Document STR-43. In the event this document conflicts with STR-43, the requirements in STR-43 shall take precedence unless otherwise agreed to by the CU/CASA COS Program Office and the NASA/GSFC HST Program Office.

5.1 STRUCTURAL & MECHANICAL DESIGN & TEST

All testing shall be conducted in a controlled manner using project approved procedures to verify the requirements called out below. Preliminary, low-level tests (including a sine-sweep survey at 0.25 g from 20 to 2,000 Hz) shall be performed to recover component responses at various frequencies. These data shall be analyzed and reviewed prior to higher level testing. A BASD and/or GSFC environmental test engineer shall be informed as to when testing is to occur and shall be given the opportunity to witness the testing and/or review all accumulated data. At the conclusion of all three axes qualification or acceptance tests, another low-level sine-survey shall be performed and compared to the one taken prior to testing. Pass/fail criteria for all tests shall be established and stated in the test procedures.

5.1.1 Load Definitions & Application

The anticipated limit loads for the COS FUV Detector hardware elements are a static load of 7.76 g's (applied in 3 orthogonal axes) and random vibration loading as shown by the spectrum given in Table 5.1. Note that for purposes of qualifying hardware elements, a load of 1.25 times the limit load is applied during test. Furthermore, in order to comply with safety and performance criteria, the strength qualification test shall be accompanied by a stress analysis that predicts no ultimate failure will occur at loads equal to 1.40 times the limit loads.

Table 5-1: Random Vibration Environment for COS FUV Detector Subsystem

Frequency (Hz)	**PSD (g^2/Hz)**
20	0.010
20-40	+ 10 dB/Oct.
40-80	0.100
80-150	-1.07 dB/Oct.
150-250	0.080
250-2000	-3.01 dB/Oct.
2000	0.010
g-RMS	7.8

5.1.2 Structural Qualification Testing

The DVA design shall be qualified by undergoing a static acceleration test at 1.25 times the Limit Load (1.25* LL = ±9.7 g's) in 3 orthogonal axes. It is acceptable to meet this requirement via a "quasi-static" load test (such as sine-burst), provided the test plan is pre-approved by CU/GSFC/BASD. The hardware configuration of the test article shall also be approved by CU/GSFC/BASD prior to test.

The DEB flight units shall be qualified by undergoing a static acceleration test at 1.25 times the limit load (1.25*LL = ±9.7 g's) in 3 orthogonal axes. It is acceptable to meet this requirement via a "quasi-static" load test (such as sine-burst), provided the test plan is pre-approved by CU/GSFC/BASD.

5.1.3 Structural Acceptance Testing

The flight DVA shall undergo a static acceleration test at the limit loads, ±7.76 g's, in 3 orthogonal axes. It is acceptable to meet this requirement via a "quasi-static" load test (such as a sine burst test) provided CU/GSFC/BASD approves the method. The flight DEB units fulfill the acceptance structural qualification test requirements by being tested to the qualification levels identified in section 5.1.2.

5.1.4 Vibro-Acoustic Qualification Testing

The DVA design shall be qualified for vibro-acoustic loading by using the above mentioned test article, which shall be exposed to a random vibration environment for 1 minute in each axis. The test spectrum for DVA qualification is shown in Table 5.1. Although the DEB design has been tested to a higher overall g-rms for the FUSE program, the COS flight DEB shall be tested to the levels indicated in Table 5.1 for one minute in each axis.

5.1.5 Vibro-Acoustic Acceptance Testing

The flight DVA unit shall undergo a random vibration test in 3 orthogonal axes. Test durations shall be 1 minute per axis. The test spectrum, which is the FUSE acceptance level spectrum, shall be as given in Table 5.2. This spectrum can be modified to minimize the risk of damaging the flight DVA. Any proposed modifications, including notching, shall be reviewed and approved by the CU/GSFC/BASD team. The flight DEB unit fulfills the acceptance test requirement by passing the qualification test at the levels shown in Table 5.1.

Table 5-2 Flight DVA Random Vibration Test Spectrum

Frequency (Hz)	**PSD (g^2/Hz)**
20	0.010
20- 50	+4.6 dB/Oct.
50-500	0.040
500-2000	-3 dB/Oct.
2000	0.010
g-RMS	6.82

5.1.6 Stiffness

The minimum primary resonances for the DVA and DEB are presented in Table 5-3. This requirement shall be verified by either a sine survey and -12dB random described above. In the event that the DVA is unable to meet the specification in Table 5-3 further investigation shall be required to evaluate the potential impact on the COS. A BASD stress analyst shall be responsible for this analysis.

Table 5-3

Component	**Minimum Primary Resonance Frequency**
DVA	125 Hz
DEB	75 Hz

5.1.7 Shock

There are no shock test requirements being levied on the FUV detector subsystem.

5.1.8 Mechanical Function

See the requirements established in STR-43, section 3.4.4.

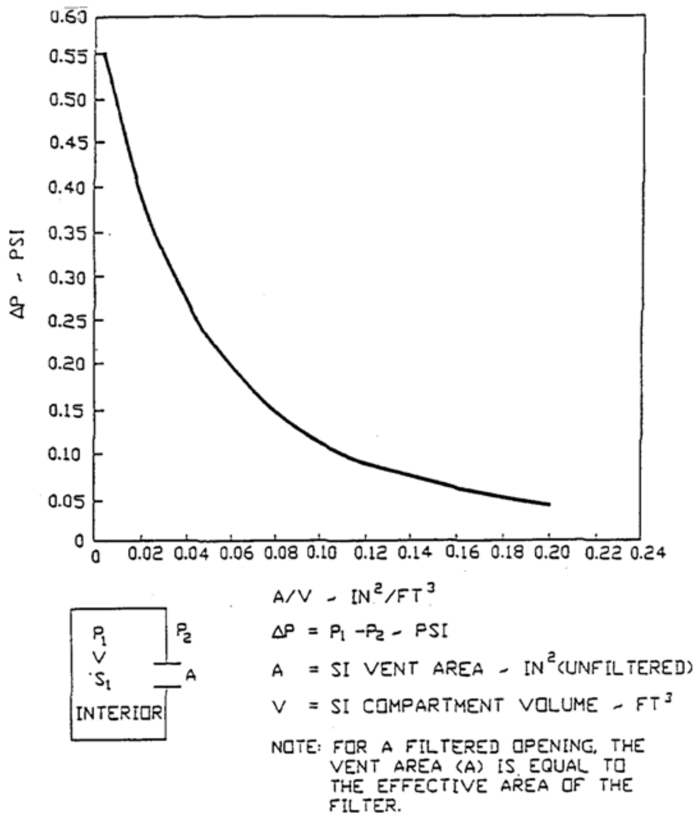


Figure 5-1 Maximum SI Wall Differential Pressure Versus a Ratio of Vent Area to Volume

5.2 EXTERNAL PRESSURE ENVIRONMENT

5.2.1 Absolute Pressure

The FUV detector components shall be designed to operate between 780 Torr and the LEO vacuum environment with the HST science instrument. The MCPs shall be maintained in a high vacuum environment within the DVA at all times after delivery. Operation of the HV system between 500 Torr and $1X10^{-5}$ Torr is forbidden.

5.2.2 Differential Pressure

The FUV detector components shall be designed to vent and survive the differential pressure across the walls of the COS instrument enclosure during launch ascent. The maximum pressure differential curve versus a ratio of vent area to volume is presented in Figure 5-1.

5.3 MAGNETIC ENVIRONMENT

5.3.1 Magnetic Susceptibility

The FUV detector sub-system shall be designed to operate and achieve all performance requirements when exposed to the HST and LEO magnetic environment specified in ICD-02-E. In summary, the total static magnetic field of the HST at the FUV detector anode is less than 2 Gauss and the total time varying component of the magnetic field is less than ±1.5 Gauss peak-to-peak. At this time, there is no information regarding the frequency of the time varying component of the magnetic field.

5.3.2 Magnetic Emission

UCB shall work with BASD and CU to ensure that the FUV detector subsystem shall comply with the magnetic emission specification levied on the COS instrument by ICD-02E.

5.4 RADIATION

The following design and performance requirements are based on the HST radiation environment and use a radiation design margin of 2. A minimum wall thickness of 2.5mm of aluminum or equivalent on all electronics boxes shall be used.

5.4.1 Total Dose Environment

If a part is shown to have a radiation tolerance of 10 krad (Si), it must be shown that the local radiation environment of the part is <5krad. GSFC is responsible for part buys, and shall attempt to procure parts to a hardness of 10 krad (Si). In circumstances where parts are unavailable at this level of hardness, spot shielding may be employed to assure that the part's local environment (given analysis based on actual shielding) allows an RDM of 2 over its rated hardness. The hardness of the parts shall be noted in the parts list and those requiring special treatment such as spot shielding shall be identified. CASA and BASD will assist UCB is selection of parts where the 10 krad selection criterion creates design obstacles.

5.4.2 SEE Environment

Cosmic Rays, energetic trapped protons, and Solar Particle Events can all contribute to SEE. Unlike the situation with total dose effects, protection from the damaging effects of these events must occur at several levels:

1) Parts—parts must be selected to provide as high immunity as possible (e.g. circuits built on epi or SOS exhibit high immunity to latchup whereas normal bulk CMOS is quite "ion-soft")
2) Local Circuit Protection—local circuitry can be used to detect and reset events such as latchup;
3) Scrubbing—either hardware, software, or a combination of both may be used to detect and correct soft errors that occur in memory. Consideration must be given to single and double errors and the likelihood of their occurrence in selecting the protection scheme;
4) Reset—hardened circuits containing watchdogs can be used to detect and reset an entire assembly where errors not detected by scrubbing can lead to software execution errors.

For the HST COS mission, the FUV detector is mission critical, therefore the following requirements apply:

1) No circuit deemed critical and non-redundant by FMEA shall contain parts which can latch in an inoperable state (latchup immunity to a LET of 37 is acceptable). Any part used in such an application shall require a waiver. No part shall be used whose latch condition is destructive.
2) All digital circuits utilizing FPGAs, memories, processors, discrete logic, etc., shall be designed to be SEU tolerant, that is, where an SEU occurs, the system shall remain undamaged and shall revert to a safe operational state assuring no propagation of the error to a higher order interface. Autonomous correction of the error and continued operation in the planned state is desirable but for some situations may be impractical.
3) SEE protection schemes shall be employed which assure uninterrupted circuit/functional operation through the SAA at greater than the 95% confidence level.
4) All digital devices shall be selected with SEU rate considerations in mind. As a rule of thumb SEU immunity up to 28 is best, immunity up to 14 is highly desirable and immunity to direct protons (LET of 3) is the minimum acceptable if other external protection is provided.
5) FMEA shall consider SEE when calculating failure probability and failure consequences.

5.4.3 Parts and Testing Requirements

All parts procurement shall be conducted consistent with the above requirements. Any special testing shall be done under the review and approval of both the GSFC parts procurement branch and the COS project office at CASA. GSFC shall procure active parts and GSFC QA shall be the ultimate authority in approving parts that need a waiver for their use.

5.5 VACUUM & THERMAL DESIGN AND TEST REQUIREMENTS

FUV detector sub-system thermal design and verification has the following elements and responsible parties:

1) Establish temperature limits associated with the in-spec operations and survival of the DVA and DEB elements (electrical, electro-mechanical, optical, etc.) These requirements shall be listed in UCB-COS-001.
2) Characterize and model the "external" environment (sources and sinks) and using allocated power dissipation, define the interface temperatures to the FUV detector components—BASD;
3) Execute the detailed thermal design to assure operation of critical elements over the entire range of environmental inputs within constraints established in (1) , and environment determined by (2) and with margin specified in the section below—BASD/UCB;
4) Produce a test plan, generate detailed test procedures, and conduct the testing that will serve to validate the design—UCB.

5.5.1 Temperature Definitions and Limits

The FUV thermal environment will be defined by BASD. BASD will propagate the external thermal environment back to the thermal interface between the FUV components (DVA and DEB) and the instrument to determine the range of interface temperatures using UCB power dissipation values. BASD will work with UCB to assure the various design constraints can be met.

For purposes of design, UCB together with CASA shall define the following temperature limits for each performance critical element of the FUV subsystem and include a table specifying these mutually agreed-to limits in the ICD:

5.5.1.1 In-Spec Temperature

The temperature range within which an element must be maintained to assure the FUV will operate while complying with the performance requirements established in section 3 of this document. The FUV detector sub-system shall maintain its calibration at any given temperature within the entire in-spec temperature range.

5.5.1.2 Operational Temperature

The temperature range over which the elements can be operated (have power applied). The elements will work but not necessarily meet all specifications. This would also dictate the extremes over which the unit could be tested with power applied. The low end of the Operational Temperature range is the minimum turn-on temperature, which dictates where survival heater set points must be established.

5.5.1.3 Survival Range

The survival range is the temperature range over which the elements may be exposed (in a non-operating mode, i.e. with no power applied) without suffering permanent degradation. The survival range for the entire assembly (DVA and DEB) shall be dictated by the most sensitive element of the assembly and how effectively the thermal design is balanced.

5.5.1.4 Non-Temperature Sensitive Items

FUV assemblies which consist of *non-temperature* sensitive elements (typically electronic or mechanical assemblies or sub-assemblies which do not have operational or storage limits dictated by some sensitive detector assembly or electromechanical device) shall have their temperature ranges as follows at local atmospheric pressure:

Operational = -20C to +65C
Survival: = -25C to +75C

5.5.1.5 Thermal Design Requirements

Given the thermal environments and interfaces, temperature ranges for the various FUV assemblies, and power consumption of those assemblies, there will be an iterative process whereby the BASD thermal designer and UCB will find a mutually compatible design. The thermal model shall meet the following requirements:

1) Under worst case conditions the thermal analysis shall predict that all FUV assemblies are maintained at least 5C inside their in-spec values.
2) For contingency or survival operations where the FUV is OFF, thermal analysis and design shall assure that all FUV assemblies are held above the

minimum turn-on temperature by 5C margin when no heaters are used and by 2C margin when heaters are used.

3) At no time during ground testing or during flight shall electronic part junction temperatures be permitted to exceed 100C or that specified by the manufacturer (and suitably de-rated) whichever is less.
4) With exception of short duration excursions for test, thermal design shall assure that junction temperatures in flight shall be held to less than 100C.

To help achieve these design requirements and aid in the design process, BASD will provide board level thermal analysis for the FUV sub-system. UCB shall work with BASD to assure that they have the right data needed to do this analysis in a timely manner.

5.5.1.6 Required Reports

UCB shall provide the following reports to CU related to thermal design and test:

1) Top level thermal analysis report (prepared by BASD) indicating predicted flight temperatures under nominal and off-nominal conditions for BOL and EOL cases.
2) Engineering reports showing the predicted junction temperatures for all power dissipating components on the various circuit board assemblies—(part of the packaging review for each circuit board assembly). - BASD
3) A Test plan (part of the required Environment Test Verification Matrix). - UCB
4) Test Reports from each test after first application of power (these may be in the form of a summary page, test timeline, and "filled out" test procedures that reference certain data files). - UCB

5.5.2 Thermal Monitoring and Control Hardware

UCB shall install thermal monitoring devices in the necessary places so that temperatures that are critical for calibration or operation can be monitored. There shall be a master thermal drawing that references each thermal monitoring device by name, and depicts its location. This shall be contained in the FUV Detector ICD.

UCB shall work with the BASD thermal designer to assure sufficient and appropriately placed heaters and thermistors are included in the FUV components such that all design and margin requirements are met. BASD shall be responsible for the procurement and installation of external heaters and thermistors after delivery.
UCB mechanical drawings shall indicate the placement of a bracket that will hold the external heater cable connector.

5.5.3 Test Requirements

An appropriate set of thermal tests (delineated in the Environment Test & Verification matrix) shall be undertaken with the objective of:

1) Demonstrating the performance (with margin specified above) of each component over a range of temperature beyond what is expected in flight;
2) Demonstrating that all assemblies and components of the FUV detector which must function together in flight do so satisfactorily over a temperature range beyond what is expected in flight;
3) Verifying the compatibility of the thermal design with the expected environment (this may be satisfied by system level testing after integration with the instrument);
4) Assuring that the quality of workmanship is such that it will withstand the rigor of the system test, launch, and flight environments;
5) Uncovering any incipient problems and infant mortality associated with electronic and or electromechanical parts and assembly processes.

To achieve these objectives UCB shall conduct the following set of tests:

A) Voltage Margin Test
B) Thermal cycle (non-vacuum)
C) Thermal Soak (vacuum or non-vacuum)
D) Thermal Vacuum
E) Thermal balance (done at the system level)

The Verification Matrix will be used to describe how these tests are to be used to verify all requirements for design and reliability.

5.5.3.1 Voltage Margin Testing

The voltage margin test is a reliable replacement for worst case analysis when implemented at the board or subassembly level and supports test objective number one in Section 5.5.3. The purpose of the test is to verify the robustness of the design, and assure that no circuits are on the "edge" and operating only marginally at the beginning of life. The FMEA shall call out which boards and circuits will have worst case analysis performed and which will have voltage margin testing done.

The following is a guideline for voltage margin testing. The actual conditions shall be specified on a case by case basis and included in the test procedures.

1) The test should be carried out at the upper and lower qualification temperatures (+65C and –25C in a non-vacuum environment);
2) Each element under test shall be powered from a regulated supply that has the ability to vary the voltage (on the order of 1% accuracy is advised);

3) The element shall be tested at both temperature extremes at the nominal and at ±7% of nominal supply voltage (for boards with a built in regulator, the regulator shall be by passed);
4) In-Spec operation shall be verified in all cases.
5) These procedures do not apply to power supply boards.

5.5.3.2 Temperature Testing

Thermal testing of the FUV detector components and subsystem shall be carried out using the temperature limits described in Table 5-4.

Table 5-4: Thermal Test Temperatures

	Assembly Level	FUV Sub-System Level (interface temperatures)
Cold Survival	*-25 C*	*-25 C*
COLD TURN–ON (OPERATE)	**-20 C**	**-20 C**
Cold Test	**-20 C**	**5 C**
Cold In-Spec	**TBS (case by case basis)**	**10 C**
Hot In-Spec	**TBS (case by case basis)**	**40 C**
Hot Test	**65 C**	**45 C**
Hot Turn-on (operate)	**65 C**	**45 C**
Hot Survival	*75 C*	*50 C*

- **Bold text**: powered testing
- *Italicized text*: unpowered testing
- Assembly level testing is assumed to be conducted at local atmospheric pressure
- Sub-system level testing is assumed to be conducted at a high vacuum environment

5.5.3.3 Non-Vacuum Thermal Cycle

This test shall be performed at the assembly level as a way of meeting objective 4 in Section 5.5.3.1. It is critical to note any limitations imposed by differential CTE of various materials. The magnitude of the temperature cycle shall be at least 50C and less than 100C and shall consider the specified operational limits of the hardware. The number of cycles shall be 4 or more. Temperature transitions should be limited to 2C/min. Details shall be specified in the test plan subject to CASA/ BASD approval. Non-vacuum thermal cycling shall not be performed on completely assembled DVA and DEB due to thermal lag and the different materials that may be present which may lead to inclusion of incipient failures.

5.5.3.4 Component and Assembly Level Thermal-Vac

A thermal vacuum cycle/soak shall be performed as the final qualification on both the DVA and DEB. Due to temperature extreme limitations of certain assemblies, it is advisable to have performed a thermal or thermal vacuum soak on individual electronic assemblies prior to the thermal vacuum testing at the FUV subsystem level.

Each electronic assembly that fits in the "non-sensitive" definition of section 5.5.1.4 shall undergo a powered thermal vacuum soak at +65C for at least 144hr and a cold soak at –25C for 24 hours. Because of time and resource constraints it is recommended that the test be performed at the highest level of assembly practical (e.g. doing all three DCE boards at once or all 4 TDC boards at once). The operational time accumulated on this test counts towards the error free operation requirement prior to delivery and integration with the instrument. For cases where it is impractical to do the test in vacuum, consider an increase of 10 on the hot side and doing the test in air.

The FUV detector subsystem thermal vacuum shall consist of at least 4 cycles with a total duration of at least 96 hours. All mechanisms shall be operated at their specified extremes and at least one cold start and one hot start are required. The test should comply with the test temperatures described in Section 5.5.3.2. Temperatures shall be limited by that assembly with the tightest operational and survival constraints. Prior to starting the test, a test plan and profile shall be submitted for approval by CASA.

6. ELECTRICAL REQUIREMENTS

6.1 INSTRUMENT INTERFACE VOLTAGE

The FUV detector shall operate nominally and perform within specifications with an input voltage between 21Vdc and 29 Vdc. The FUV detector shall be designed to survive, but not operate within specification, with input voltages between 18 – 21 Vdc and 29-32 Vdc. Note that this accounts for up to a 3 volt drop through harness and circuitry between the SI interface to the S/C and the FUV instrument.

6.2 IN-RUSH CURRENT

The in-rush current to the FUV detector during turn-on shall not exceed the envelope defined in Figure 6.1. The Rate of rise shall not exceed 6.0 amperes per microsecond. These values apply at 27.0± 0.5 Vdc at the input to the FUV detector. This specification has been derived from the ICD 02E requirement by scaling from a 20 amp fuse (at the SI interface) to a 5 amp fuse (at the FUV detector interface.)

6.3 GROUND LOCATION

Each FUV detector component shall provide a place for attachment of a ground strap that provides a single point chassis connection to the COS instrument. The placement of the straps shall be called out on the appropriate ICD mechanical interface drawing. BASD shall provide the ground strap from each individual component to chassis. The ground straps shall meet the requirements described in paragraph 4.7.8 of ICD-02E.

Since the structure to which these components are attached is a composite, the FUV system shall not depend on the structure to provide an adequate low inductance chassis for signal references. It may be necessary for the FUV subsystem to provide a low inductance ground cable between the two components (DEB and DVA). The need for a DVA/DEB ground cable shall be determined by a systems electrical assessment and documented in the grounding diagram in the FUV Detector ICD.

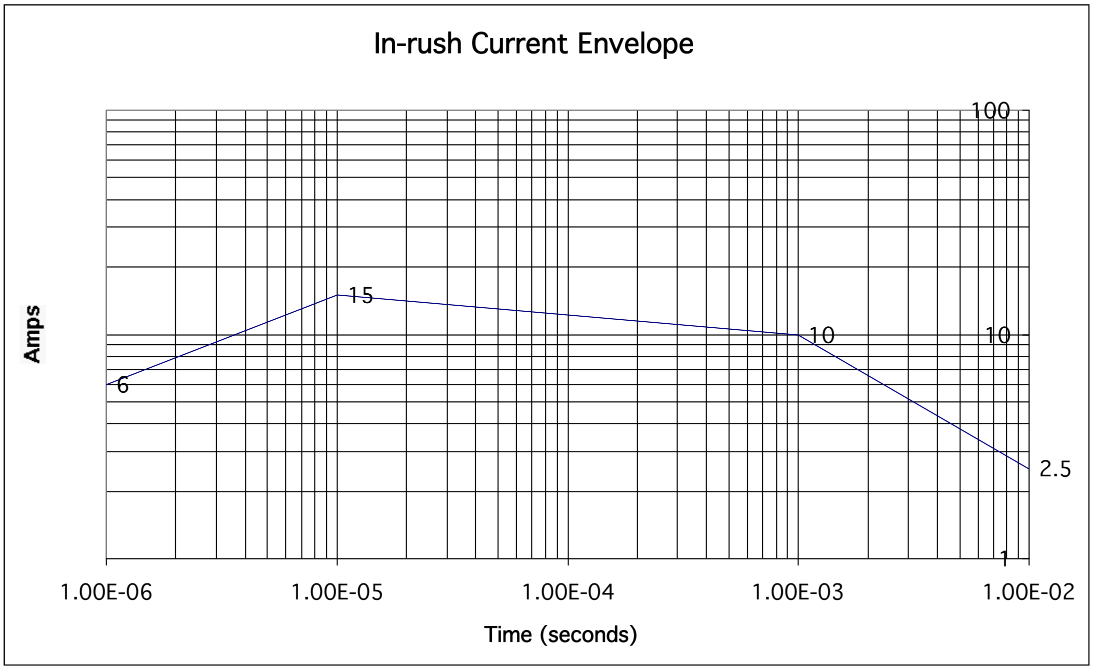


Figure 6-1 : In-rush Current Envelope

6.4 POWER SUPPLY SPECIFICATIONS

In addition to meeting the operational voltage and turn-on/off transient requirements described above, it is important that the main power converter (when operated under nominal load) meet all EMI requirements (Mil-Std 461C subset) described in the following sections, which come from ICD 02E. It is suggested that, since this is a heritage system, data from FUSE EMC tests shall be supplied to BASD and CU/CASA for evaluation prior to CDR.

6.4.1 Input Voltage

When operated under nominal load conditions, the Power Supply shall perform within specification between 21 and 29Vdc input. The supply shall survive inputs in the range of 18 to 32Vdc and return to normal operation when the voltage returns to its operational range. This requirement shall be verified by test. This is based on ICD 02E with intermediate losses taken into account.

6.4.2 In-rush Current

The power supply shall have the same in-rush current transient requirements as delineated in Figure 6.1. This shall be defined under nominal load conditions, at the highest nominal voltage (29V) and at 25C, and shall be verified by test.

6.4.3 Isolation

The primary return for the Power Converter shall exhibit isolation from instrument chassis of at least 1MΩ. Likewise, capacitance between primary side inputs and chassis ground shall be less than 1µf. Capacitance between primary +28 and chassis and between primary return and chassis must be balanced to 20%.
Primary to secondary common shall exhibit isolation >1MΩ.

6.5 EMI/EMC

The following requirements dictate those design and test rules that will help assure electromagnetic compatibility and inter-component operability at the instrument level.

6.5.1 Cabling

Interfaces *between* the two FUV components shall provide a well-defined signal return path. Power supplied from one component to another shall be by shielded twisted pair or shielded coaxial cable of the appropriate gauge and all current shall have a single ground path back to the power converter.

Any *signals* that use chassis as a reference shall be specifically noted in the grounding diagram.

It is recommended that all cables between the DVA and DEB be shielded with the shield terminated on both ends.

UCB shall provide detailed cabling drawings for the inter-component cables that call out grounding, signal return, and chassis separately.

6.5.2 Grounding

UCB shall provide a grounding diagram of the FUV subsystem. The grounding diagram shall be finalized at FUV Detector CDR. This shall be submitted to BASD and CASA for review and approval and included in the ICD.

The diagram shall include the following information:

1) An indication of the method and location of ground(s) for the secondary side of the main power converter;
2) An indication of the method and location of the ground for all high voltage supplies;
3) A schematic showing the relationship between the signal and power grounds for each component as well as harness connection for inter-component cabling;
4) An indication of the type and location of shield grounds for inter-component cabling;
5) Distinctions between analog and digital grounds;
6) Input impedance and first circuit interfaces for all interface lines with the instrument;
7) Indication of any "options" that exist in the grounding implementation and how those options have been exercised;
8) Notation of any elements of the subsystem which "float" with respect to others.

On any power lines where secondary common is isolated from chassis, a bleed resistor to protect against ESD shall be installed.

All Critical analog signals shall have a well-defined ground reference that is tied to chassis at a single point.

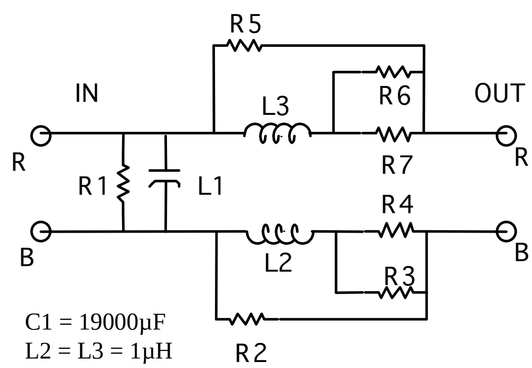
6.5.3 Test Requirements

The following requirements delineate the testing that must be performed at the FUV sub-system level prior to delivery and acceptance.

6.5.3.1 Emissions

6.5.3.1.1 Conducted Emissions

The following tests are to be applied to the FUV power cables only. Both differential and common mode tests are performed at the COS Instrument to FUV interface. All tests are to be performed at 28Vdc input (unless otherwise noted) and with the LISN specified in Figure 6-2. These tests should be performed (to whatever extent possible) with High Voltage on (at a safe level) and with the instrument stims active. This represents as close as possible to the actual operation without requiring external stimulus.



C1 = 19000µF
L2 = L3 = 1µH
R1 = 330, 5W
R2 = R5 = 24ž
R3 = R6 = 0.1ž
R4 = R7 = 0.3ž

Figure 6-2
LISN for EMC conducted Emissions Testing

CE01—Narrowband Conducted Emissions from 30Hz to 15kHz: Tests shall be performed according to procedures described in Mil-Std 462 and the differential and common mode emission levels shall not exceed those illustrated in Figure 6-3.

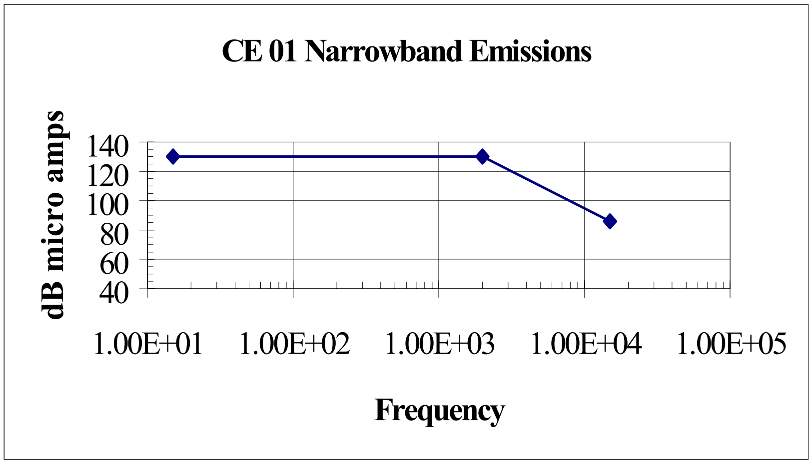


Figure 6-3

CE03—Narrowband Conducted Emissions from 15kHz to 50MHz: Tests shall be performed on specified cables according to Mil-Std 462 procedures and differential and common mode emissions shall not exceed those illustrated in Figure 6-4. *Broadband emissions tests shall not be required at the sub-system level unless CASA/BASD determine a particular need for such a test.*

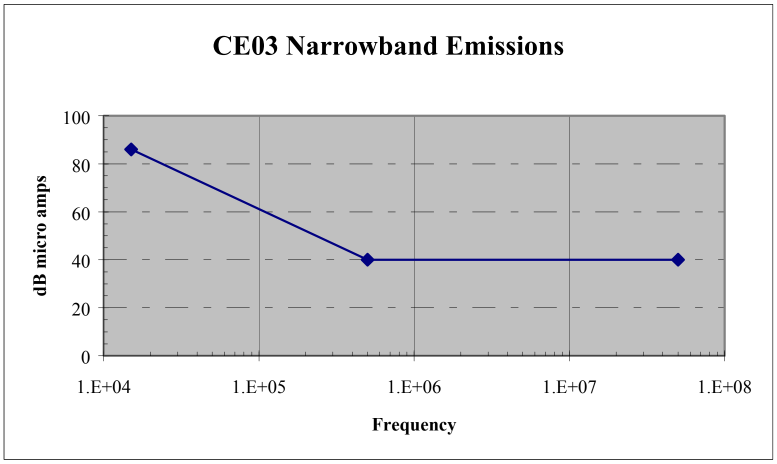


Figure 6-4

CE07—Time Domain Transients: Using a LISN specified in Figure 6-2 to simulate the Instrument Power Bus, tests shall be performed according to Mil-Std 462 procedures to determine spikes and switching transients generated by the FUV. Turn on transients must meet the specification in Section 6.4.2. Repetitive spikes should not exceed 0.5 volts (peak to peak) with a duration less than 50µs. Ripple shall not exceed 350mV peak to peak in the 30Hz to 100MHz bandwidth. These tests shall be applied to the positive input power line only.

6.5.3.1.2 Radiated Emissions

If, after reviewing the grounding and cabling configuration and finding that it meets all requirements, Radiated Emissions testing shall be waived on the FUV prior to delivery. Should any design issue develop which indicates the need for this test CASA reserves the right to re-instate this requirement. UCB will be given ample notice should the need arise for this testing.

6.5.3.2 Susceptibility

Susceptibility testing shall be limited to the 28v input power lines. Testing shall again be carried out with the instrument in as close to a nominal operational mode as is practical. Criteria for passage shall be defined in the test plan.

6.5.3.2.1 Conducted Susceptibility

The FUV subsystem shall be capable of operation without degradation when subjected to the CS01/CS02 tests at the level of 1.5v peak to peak superimposed on the power line from 15Hz to 50Mhz and according to Mil-Std 462 procedures. Tests shall be conducted at an input power line voltage of 21Vdc.

The completed FUV subsystem shall have input power lines tested to CS06 modified (spikes) and shall be capable of continuous operation. Three separate spikes are required on the +28 power line: 1) width = 10μs, Amplitude=60V; 2) width = 100μs, Amplitude =10v; 3) width = 10ms,Amplitude = 1V. Only one spike type is required on the return line: width = 10μs, Amplitude = 15v. These voltages are both positive and negative and superimposed on the test voltage of 21Vdc. Pulse rep rates shall be 2 to 6 per second. Procedures are in accordance with Mil-Std 462.

6.5.3.2.2 Radiated Susceptibility

Radiated Susceptibility testing at the subsystem level shall be waived for COS FUV. Should a particular issue arise which may dictate the need or desirability for such a test, CASA reserves the right to re-instate the requirement. UCB will be given ample notice should the need arise.

6.6 COMMUNICATIONS INTERFACE

6.6.1 Functional Requirements

The FUV subsystem shall have three communications interfaces with the COS Instrument. One shall handle command strings from the Instrument MEB to the FUV and include a dedicated reset line. The second shall handle low rate housekeeping data. The third shall handle science or "event" data. All interfaces shall be differential. The Science I/F shall be designed to handle the maximum science data output rate of 40,000 32-bit events per sec per detector segment at a 4MHz clock rate. The HK / Cmd I/F shall be designed to handle an appropriate level of HK data and commands as deemed required for reliable operation and monitoring. These interfaces shall be specified in detail in the FUV to Instrument ICD.

These interfaces shall be redundant. The FUV shall be capable of receiving command strings from either of the two MEBs and shall broadcast data to both.

6.6.2 Verification Requirements

The Interfaces shall be verified prior to Integration of the FUV into the instrument. Not only hardware but also software shall be verified. The following paragraphs describe the testing required.

6.6.2.1 Verification Testing

Using the GSE described in the following paragraphs UCB and BASD shall conduct a series of three verification tests prior to the start of integration activity:

1) Using the BASD FUV and MEB emulators, an interface test shall be performed to verify the hardware interface and all handshaking protocols;
2) As part of verification of the flight software interface, use a breadboard MEB and breadboard DCE to verify the housekeeping, command, and science database. A test shall be performed that verifies the command, housekeeping, and science databases and the serial housekeeping interface to the extent possible (considering that not all HK parameters are available if the DVA is unavailable).
3) A "pre-integration" test of the flight or flight-like MEB and FUV subsystem shall be performed at a TBD location at least 4 months prior to the scheduled start of integration activity. All commands, HK data, Science data, and autonomous activity shall be checked at that time.

These early tests will allow identification of any errors, omissions, or misunderstandings so that when the serial integration flow begins, very few interface problems should delay the activity.

UCB and BASD shall work with CU/CASA to determine the proper time and venue for these tests. These tests shall be included in the UCB FUV Test and Verification Plan.

6.6.2.2 Ground Support Equipment

Several key pieces of equipment are needed for verification of electrical, optical, and performance parameters of the FUV subsystem.

1) UCB GSE—This GSE that can both operate the FUV and log its science data will be a critical component of the FUV subsystem. It will likely be used in all three of the tests described above. The GSE communications S/W and hardware interfaces shall be under configuration control prior to controlling or interfacing with any flight hardware. The management of the GSE s/w and h/w should be discussed in the configuration management plan and the software verification plan.

2) BASD FUV emulator—This emulator is used both at BASD and will travel with the COS Instrument to pre-launch testing and integration activity. The specifications of such a system should be available for review by both the CASA and UCB teams.

7. DESIGN REQUIREMENTS

7.1 OPTICAL REQUIREMENTS

7.1.1 Focal Plane Match

The radius of curvature of the curved active area must not deviate from the design radius of 826mm by more than ±100µm at 25°C ± 5°C. There are no specifications on the spatial frequency or distribution of the deviations.

7.1.2 Light Baffles

The FUV detector shall provide light baffles above the vacuum door. BASD shall have final approval of the optical design of the baffles.

7.1.3 Optical Metrology

The FUV detector shall have optical and translational datums to aid in the installation and alignment of the detector. The orientation of the optical and translational datums with respect to the curved MCP surface shall be calibrated prior to the delivery of the detector. These data shall be available at delivery of the detector to integration and test. The accuracy of the calibration data shall be ≤ 1 arc minute in rotation and ≤0.050mm in translation.

7.2 FRACTURE CONTROL

Design, fabrication, testing, and handling of the FUV detector components shall meet the requirements of the COS Fracture Control Implementation Plan (IN0090-109).

7.3 INSTALLATION, INTERCHANGABILITY, & SERVICABILITY

To support a change out of the FUV detector system during integration and test with no degradation of the optical performance, the translational differences in the location of the MCP surfaces with respect to the mounting points between the flight and spare FUV detector systems shall be ≤0.076mm.

7.3.1 Connector Hardware

All connector hardware shall use appropriate capture mechanisms to ensure that during installation or removal of any harness all connector hardware will not separate from the harness.

7.4 CONTAMINATION

Design, fabrication, testing, handling, and certification of the FUV detector components shall meet the requirements of the COS Contamination Control Plan.

7.5 OPTICAL CUBE RESTRAINTS

A mechanical restraint shall be used to ensure that the optical cube cannot detach from the FUV detector back-plate. The mechanical restraint shall provide an unobstructed view of 80% of the primary optical surfaces used for installation and alignment of the DVA.

8. FUV ACCEPTANCE & VERIFICATION TESTING

8.1 DOCUMENTATION

UCB/EAG shall perform the full series of acceptance tests for the flight and spare FUV detector systems. Data packages may be submitted to CU after the test has been completed. Given the nature of the FUV detector system development, a series of acceptance tests may be more appropriate as the system is developed. This can be worked out as part of the ATP definition process.

CU retains the right for any responsible CU personnel, 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.

8.1.1 Acceptance and verification plan

The supplier shall prepare an acceptance test procedure (ATP) which includes the following at a minimum:

Test to be performed and description of accomplishment method.

1) Sequence of tests.
2) Article being tested (i.e. flight article or witness sample).
3) Equipment to be used.

4) Accuracy of measurement.
5) Calibration techniques to be used (as appropriate).
6) Data sheets.

The tests shall be adequate to verify that the FUV detector system satisfies the requirements of this specification. The ATP shall be submitted to CU for approval at least four weeks prior to acceptance testing.

8.1.2 Environmental Verification matrix

The Environmental Verification Matrix (EVM) describes how those requirements in the section 5 will be verified. (It also describes the verification of electrical interface requirements in section 6). The EVM is a short-form way of writing a verification plan. It describes in tabular format each of the requirements, indicates if they are verified by test, analysis, or inheritance, and describes the test or analysis to be performed. When signed by the project engineer and by CASA and BASD, it constitutes approval to proceed with the test program. When testing, analysis etc. is complete the same matrix evolves to become the "as-run" EVM and adds columns which reference data and place of the test, test procedures, test reports, and identify any anomalies which may have occurred. CASA will support UCB in the development of this matrix. This test matrix shall be approved by GSFC and CASA prior to proceeding with testing of any flight hardware.

8.2 CALIBRATION

8.2.1 Calibration Plan

UCB shall submit to CU for review and approval a detailed plan describing how each of the performance specifications listed in section 3 of this document shall be verified.

8.2.2 Calibration Data

UCB shall provide to CU a complete set of the raw and processed calibration data for each flight unit.

8.3 SOFTWARE VERIFICATION

8.3.1 Software Requirements

The Software Requirements Document (SRD: UCB-COS-004) shall describe the Detector Control Electronics (DCE) flight software requirements and include a matrix showing where the requirements are derived from. This document shall be prepared by UCB and reviewed by CU and Ball with initial delivery to CU four weeks prior to the COS software requirements review. Upon initial delivery, the document shall be placed under configuration control where all subsequent changes are approved by a COS program configuration control board. A complete and approved SRD shall be delivered to CU before the start of the DCE flight software preliminary design.

8.3.2 Software Management Plan

The Software Management Plan for the Cosmic Origins Spectrograph (included in DM-03) shall describe the UCB implementation of the following software specific tasks supporting both flight and ground support software: configuration management, reviews, development and test methods, and quality assurance. This document shall be prepared by UCB and reviewed by CU and Ball with initial delivery to CU four weeks prior to the COS software requirements review. A complete and approved SMP shall be delivered to CU before the start of the DCE flight software preliminary design.

8.3.3 Software Test Plan

The Software Test Plan (STP) shall describe the scope and specifications for final qualification testing of the DCE flight software. This document shall define the: test schedule, resources required, and contain a test verification matrix showing where each of the flight software requirements is being verified. This document shall be prepared by UCB and reviewed by CU and Ball with initial delivery to CU seven months before the COS critical design review. A complete and approved STP shall be delivered to CU at the COS program critical design review.

9. QUALITY ASSURANCE AND RELIABILITY

The FUV Detector design, fabrication, assembly, and test efforts shall be conducted in compliance to all requirements set forth in NASA/GSFC document STR-43, HST STIS and NICMOS Performance Assurance Requirements. UCB shall develop and maintain a Quality Assurance program in compliance with STR-43.