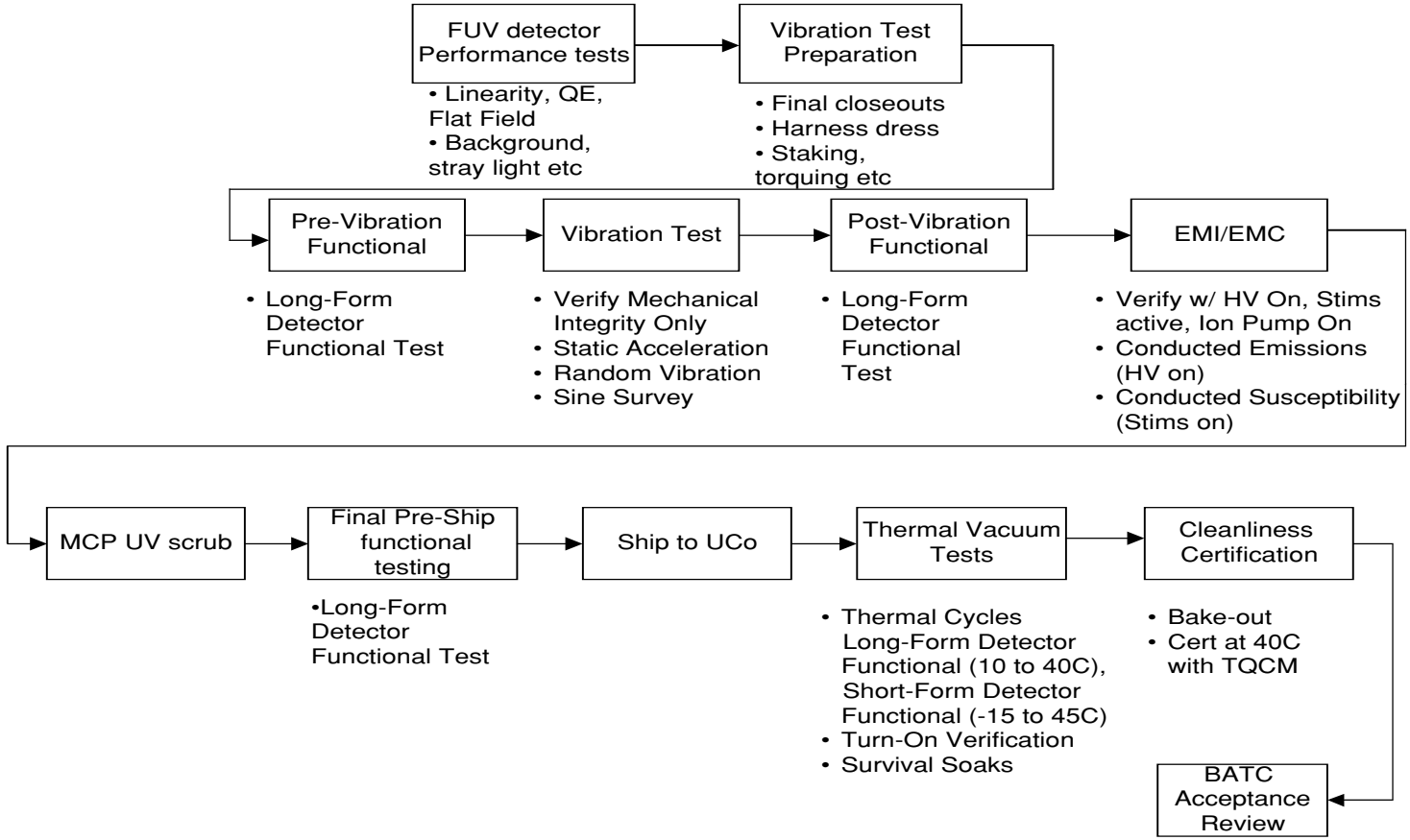
FUV Detector System
Environmental Qualification Overview

Dr. Barry Welsh
FUV Project Manager

FUV Detector System Test Flow



FUNCTIONAL TEST DESCRIPTION

- Short Functional System Test (no photons)
  - Power on, record currents
  - Record housekeeping (temperatures, voltages, etc.)
  - "+28 volt" margin test (±7 volt)
  - Interface redundancy test
  - TDC settings (walks, thresholds, stretches and shifts to nominal values)
  - Acquire stims and analyze position and FWHM
  - Verify counters
  - Auxiliary power and door motor test
  - HV operation (ramp HV to safe level)
  - Power down

FUNCTIONAL TEST DESCRIPTION

- Long Functional System Test (no photons)
  - Same as short functional system test with additions
  - TDC command comprehensive test (all bits exercised)

- Long Functional System Test with Photons (in vacuum)
  - Same as above with additions
  - Exercise door motor
  - Exercise door actuator (limited life item, perform once during TV)
  - HV to nominal operational voltage
    - Acquire background image
    - Perform gain versus voltage characterization
    - Brief flat field

FUV SYSTEM ENVIRONMENTAL QUALIFICATION OVERVIEW

- FUV detector environmental test requirements specified in the COS Statement of Requirements Document (COS-08-0003). Test plan outlined in the Environmental Verification Plan (COS-UCB-007).

- Summary of Environmental Test Requirements:
  - EMI/EMC system compliance per MIL-STD-462 & MIL-STD-461C
  - Vibration test compliance per GEVS-SE
  - Magnetics test compliance per ST-ICD-02E
  - Radiation: TID and SEE requirements per ST-ICD-02E
    - Parts procured and screened by GSFC
  - Contamination/Cleanliness compliance per IN0090-111
  - Thermal operational & survival limits per COS-08-0003

Center for Astrophysics and Space Astronomy

COS-UCB-007 APPENDIX A: Environmental Verification Matrix

Requirement	Description	Qualification			Assembly Level	Analysis/Test Description	Test Facility Date	Test Procedure	Test Report #	PFR #
		A	T	I						
SOR 5.1.2	Structural Qualification		X		DEB flight/DVA test components	Sine-burst vibration test in 3 orthogonal axes at 1.25 times the Limit Load, _9.7 g's	AMES			
SOR 5.1.3	Structural Acceptance		X		DVA flight component	Sine-burst vibration test in 3 orthogonal axes at the Limit Load, _7.8 g's	AMES			
SOR 5.1.4	Vibro-Acoustic Qualification		X		DVA qualification test components	1 minute exposure in 3 orthogonal axes to the random vibration environment stated in Table 5-1, COS-08-0003	AMES			
SOR 5.1.5	Vibro-Acoustic Acceptance		X		DEB /DVA flight components	1 minute exposure in 3 orthogonal axes to the random vibration test spectrum stated in Table 5-2, COS-08-0003	AMES			
SOR 5.1.6	Stiffness		X		DEB /DVA flight components	Sine survey tests demonstrating natural frequency greater than the primary resonance stated in Table 5-3, COS-08-0003 (>75 Hz for DEB, > 125 Hz for DVA)	AMES			
SOR 5.1.7	Shock	-	-	-	N/A	No shock requirements	N/A			
SOR 5.1.8	Mechanical Function		X		Door assembly	Identical FUSE door motor mechanism was life tested > 3000 cycles (Report A00605), and won't be repeated. Door function tested during assembly, & verified in Thermal-Vac.	UCB			
SOR 5.2.1	Absolute Pressure		X		DVA/DEB sub-assembly	Proper operation verified at atmospheric pressure and at high vacuum.	UCB			
SOR 5.2.2	Differential Pressure	X			DEB sub-assembly	Components designed in accordance with conservative rule of thumb 1 in^2 vents 1 ft^3 volume.	UCB			
SOR 5.3.1	Magnetic Susceptibility		X		DVA sub-assembly	Shield design performance verified at static magnetic field of 2 Gauss and time varying component of +/- 1.8 Gauss	UCB 4/99	COS-990426-JV	COS-990426-JV	N/A
SOR 5.3.2	Magnetic Emission		X		DVA sub-assembly	Strongest magnetic field strength is < 0.25 Gauss at a distance of 3cm form the ion pump housing	UCB			
SOR 5.4.1	Total Dose Environment	X		X	DEB /DVA sub-assembly	Parts selected by GSFC/UCB to meet hardness > 10 krad	GSFC			
SOR 5.4.2	SEE Environment			X	DEB /DVA sub-assembly	Critical circuits have latch-up immunity to a LET of 37 Digital devices selected with SEU immunity of at least 28	UCB/GSFC		FMECA	
SOR 5.5.1.1	In-Spec Temperature		X		DEB /DVA flight components	Thermal-Vac: Short-form functional for 3 cycles between -10C and +45C. Long-form functional between +10C and +40C (@ 10 deg intervals).	UCB/SSL			
SOR 5.5.1.2	Operational Temperature		X		DEB /DVA flight components	Thermal-Vac: Short-form functional for hot turn-on verification at +45C Short-form functional for cold turn-on verification at –20C	UCB/SSL			

Requirement	Description	Qualification			Assembly Level	Analysis/Test Description	Test Facility Date	Test Procedure	Test Report #	PFR #
		A	T	I						
SOR 5.5.1.3	Survival Range		X		DEB /DVA flight components	Thermal-Vac: Hot survival soak at +50C Cold survival soak at –25C	UCB/SSL			
SOR 5.5.1.4	Non-Temperature Sensitive Items		X		DEB/ DVA board level	Non-vacuum thermal cycles	UCB			
SOR 5.5.1.5	Thermal Design Requirements	X			DEB /DVA board level	BASD Thermal Model	BASD			
SOR 5.5.2	Thermal Monitoring and Control			X	DEB /DVA flight components	Heaters and thermisters controlled and monitored per Section 7.5, COS-UCB-001 (FUV Detector ICD)	UCB/SSL			
SOR 5.5.3.1	Voltage Margin Testing		X		Board or Sub-Assembly	+65C to –25C, Regulated Supply 1% Accuracy	UCB	Ref. in UCB/ EAG Electronics Assembly and Test Flow Chart		
SOR 5.5.3.2	Temperature Testing		X		Sub-Assembly, FUV Sub-System	Electronic Assembly: Non-Vacuum Thermal Soak at +80C max for 144 hrs, -25C min for 24 hrs. FUV Sub-System: Thermal-Vac testing (See Verification Matrix for SOR 5.5.1.1,2,3)	UCB	Ref. in UCB/ EAG Electronics Assembly and Test Flow Chart		
SOR 5.5.3.3	Non-Vacuum Thermal Cycle		X		Sub-Assembly	6 to 12 cycles, 2C per minute, for 96 hrs. Soak for 2 hrs at each extreme (-20C to 65C).	UCB	Ref. in UCB/ EAG Electronics Assembly and Test Flow Chart		
SOR 5.5.3.4	Thermal-Vacuum Testing		X		Sub-Assembly, FUV Sub-System	Electronic Assembly: Thermal Vacuum Soak +65C max for 144 hrs, -25C min for 24 hrs. FUV Sub-System: See Verification Matrix for SOR 5.5.1.1,2,3.	CASA	Ref. in UCB/ EAG Electronics Assembly and Test Flow Chart		
SOR 6.1	Interface Voltage		X		DEB flight components	Bench Tests	UCB			
SOR 6.2	In-Rush Current		X		DEB flight components	Bench Tests	UCB			
SOR 6.3	Ground Location			X	FUV Sub-System	Single-point ground per Section 7.3, COS-UCB-001	UCB			
SOR 6.4	Power Supply Specifications		X	X	Power Supply Board Level	Tests performed at Battel Engineering, documentation supplied with flight unit delivery to UCB	Battel Engineering			
SOR 6.5.1	Cabling Interfaces		X	X	DEB /DVA flight components	Connector pin-outs provided in Appendix C, COS-UCB-001. Safe-to-mate test prior to connection.	UCB			
SOR 6.5.2	Grounding			X	DEB /DVA board level	Grounding requirements per Section 7.3, COS-UCB-001	UCB			
SOR 6.5.3.1.1	Conducted Emissions		X		FUV Sub-System	Narrowband conducted emissions tests on cabling from 30Hz to 15kHz (CE01) and from 15kHz to 50MHz (CE03). Transient tests per CE07.	EMCE Engineering	Mil-Std-462		

Requirement	Description	Qualification			Assembly Level	Analysis/Test Description	Test Facility Date	Test Procedure	Test Report #	PFR #
SOR 6.5.3.1.2	Radiated Emissions	-	-	-	Instrument	N/A at FUV Detector System level (Waived)	N/A	N/A	N/A	N/A
SOR 6.5.3.2.1	Conducted Susceptibility		X		FUV Sub-System	CS01/CS02 tests at 1.5V peak-to-peak from 15Hz to 50MHz	EMCE Engineering	Mil-Std-462		
SOR 6.5.3.2.2	Radiated Susceptibility	-	-	-	N/A	Waived	N/A	N/A	N/A	N/A
SOR 6.6	Communication Interface		X		FUV Sub-System	Hardware Interface Test using UCB DCE and BASD MEB simulators. Software Interface detailed in Software Verification Plan.	BASD			
SOR 7.4	Contamination		X		FUV Sub-System	Component level Bakeout. System certification at 40C with TQCM at –20C.	CASA			

FUV SYSTEM VIBRATION TESTING

- TEST OBJECTIVES
  - Demonstrate both the DVA & DEB are structurally sound such that their functionality is not degraded after vibration, static load & acceleration testing
    - Functionality includes system electronic performance & mechanical performance
- TEST LEVEL DESCRIPTION
  - Vibration test levels taken from GEVS-SE

	Item				SOR Requirement	Test Performed
	DVA1	DVA2	DEB1	DEB2		
Structural Qualification	X		X		9.7g	Sine Burst *(15 Hz, 1 sec envelope, 5-10 cycles at peak)*
Vibro-Acoustic Qualification	X		X		SOR Table 5-1	Random Vibration *(1 min per axis)*
Structural Acceptance		X		X	7.8g	Sine Burst *(15 hz for 1 sec)*
Vibro-Acoustic Acceptance		X		X	SOR Table 5-2	Random Vibration *(1 min per axis)*
Stiffness	X	X	X	X	>125Hz for DVA >75Hz for DEB	Sine Sweep

DETECTOR VIBRATION TEST PLAN

- Facilities
  - Test to be carried out at the NASA AMES test facility
- Plan/Status
  - First Subsystem vibration test to be to Qualification Levels (proto-flight)
  - Delicate DVA interior hardware passed early Qualification Level vibration :
    - Brazed Body Assembly (BBA)
    - Anode Cradle/Pogo/Bellows assembly
    - Ion Repeller Grid
- Second Subsystem vibration to acceptance levels
- Test Configuration
  - Sine survey performed before and after each axis vibration
  - Ion Pumps powered throughout testing via external HV supply
  - Units attached to shake fixture at their flight structural I/F's
  - UCB and GSFC QA representative in attendance throughout

VIBRATION TEST PROCEDURE FLOW

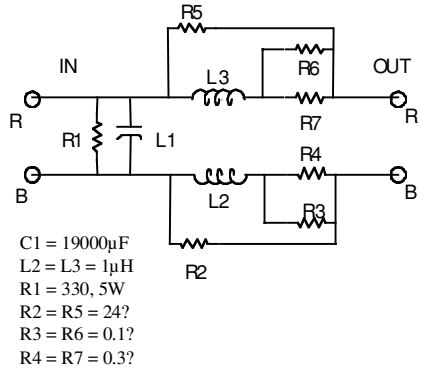
- Detector System Long Functional Test performed at UCB prior to shake
  - Detector door operation verified in vacuum chamber
  - Detector electronic performance verified
- Detector system (bagged, with N_2) driven to NASA AMES on shipping plate
- DVA and DEB max dummies vibrated immediately prior to flight items
- Comparison Sine sweep before and after each shake axis
- Ion Pump current monitored throughout DVA shake (monitors DVA pressure)
- Hardware visually inspected prior to and after each axis shake

FUV DETECTOR EMI/EMC TESTING

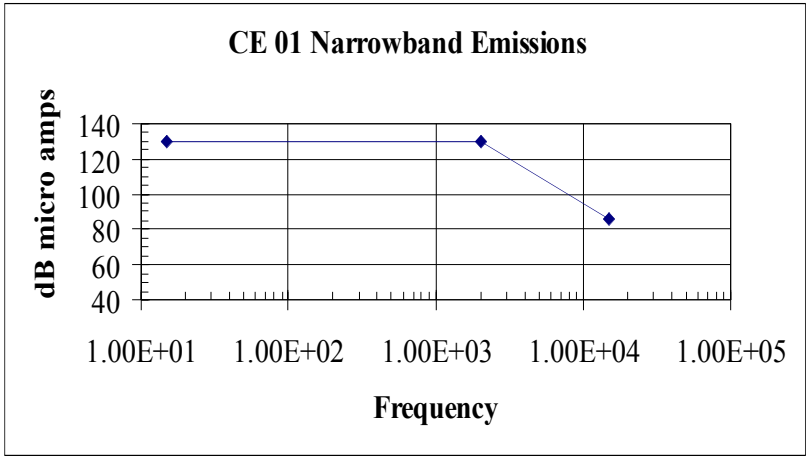
- TEST OBJECTIVES
  - Demonstrate that the FUV system is compliant with selected conducted emission & susceptibility tests defined per MIL-STD-461C and MIL-STD-462
    - Radiated emissions & susceptibility have been deemed not applicable *at the FUV Detector sub-system level* by the HST project.

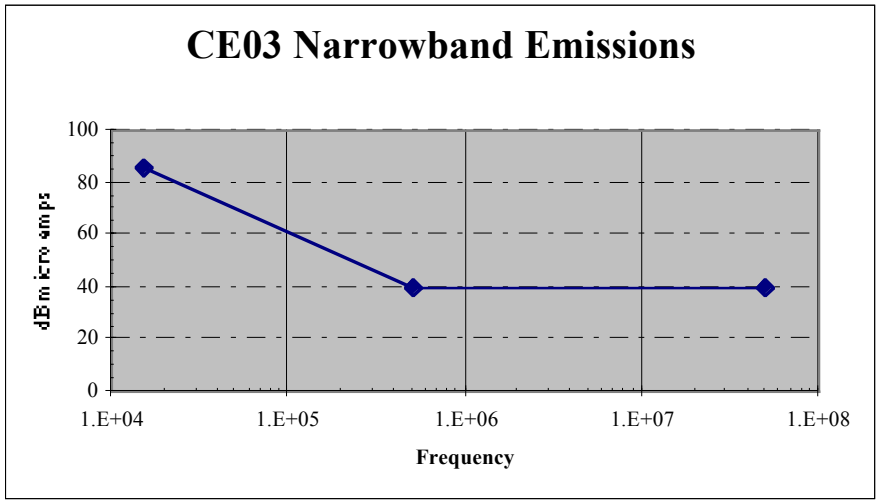
- TEST LEVELS DESCRIPTION
  - Conducted Emission test methods CE01, CE03 & CE07 on the 28V primary power input line
  - Conducted Susceptibility test methods CS01,CS02 & CS06 (modified) on the 28V primary power line at a test voltage of 21V
    - Voltages and currents measured as specified in the HST-COS FUV Detector EMC Control Plan & Performance Requirements Specification (UCB-COS-PLN-1137)
    - Performance susceptibility assessed from STIM data (position and FWHM)
    - Emissions assessed with HV applied to detector (at a safe level)

EMI/EMC Test Circuit & Test Levels



LISN for conducted emission testing





EMI/EMC TEST PLAN

- Facilities
  - Tests to be carried out at EMCE Engineering (Fremont, CA) who performed a more extensive set of EMI/EMC tests on the FUSE detector system in 1996 (FUSE test report available for inspection)
  - LISN circuit provided by UCB
- Test Configuration
  - DVA and DEB with flight configured harnessing attached to the shipping plate
  - Ion Pumps powered throughout testing via IPGSE to maintain DVA vacuum. Power may be removed for brief periods during conducted emissions testing as required.
  - Detector HV applied only at “safe” turn-on level
  - Data logged with FUV EGSE & Assembly Travelers
  - UCB and GSFC QA representative in attendance throughout

EMI/EMC TEST PROCEDURE FLOW

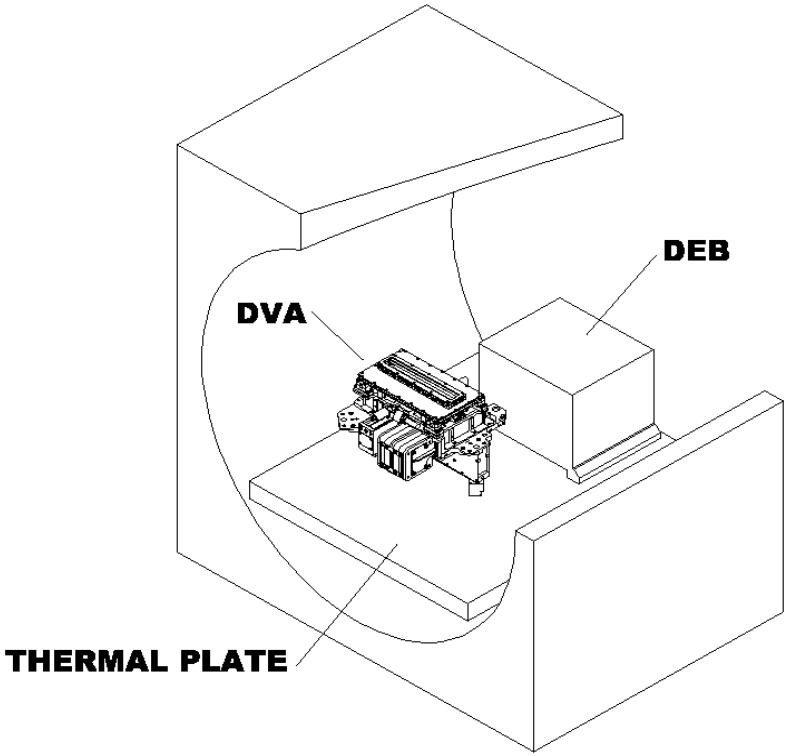
- FUV "Short" Functional test performed at UCB prior to delivery to EMCE
  - Stim (X,Y) positions and FWHM
  - Housekeeping T/M values logged
- Pre-EMI/EMC "Short" Functional test performed upon arrival at EMCE
  - Compare with UCB values
- CE-01, CE-03,CE-07 performed with detector at safe HV
- CS-01 and CS-02 performed with continuous collection of stim data
- Post EMI/EMC "Short" Functional test performed at UCB after completion of testing at EMCE

FUV SYSTEM THERMAL VACUUM TESTING

- TEST OBJECTIVES
  - Demonstrate both the DVA & DEB can:
    - Survive after soaks at hot and cold temperature extremes
    - Perform nominally throughout thermal vacuum temperature cycling

- TEST LEVELS
  - Hot Survival = 50C, Cold Survival = -25C
  - Hot Operate Limit = 45C, Cold Operate Limit = -20C
  - Hot In-Spec Limit = 40C, Cold In-Spec Limit = 10C
  - Will perform 1 hot & cold survival soak cycle followed by 5 thermal cycles between 0C and 40C

FUV Thermal Vacuum Test Configuration



COS DETECTOR SYSTEM

THERMAL VACUUM QUAL TEST CONFIGURATION

FLIGHT THERMAL LIMITS and PREDICTIONS

- Flight Temperature Limits *per COS-UCB-001*

ITEMS	HOT SURVIVAL	HOT OPERATING	HOT IN-SPEC	COLD IN-SPEC	COLD OPERATING	COLD SURVIVAL
DVA	+50°C	+40°C	+40°C	+10°C	-20°C	-25°C
DEB	+60°C	+50°C	+40°C	+10°C	-20°C	-25°C

All temperatures are as measured at the component thermal interfaces.

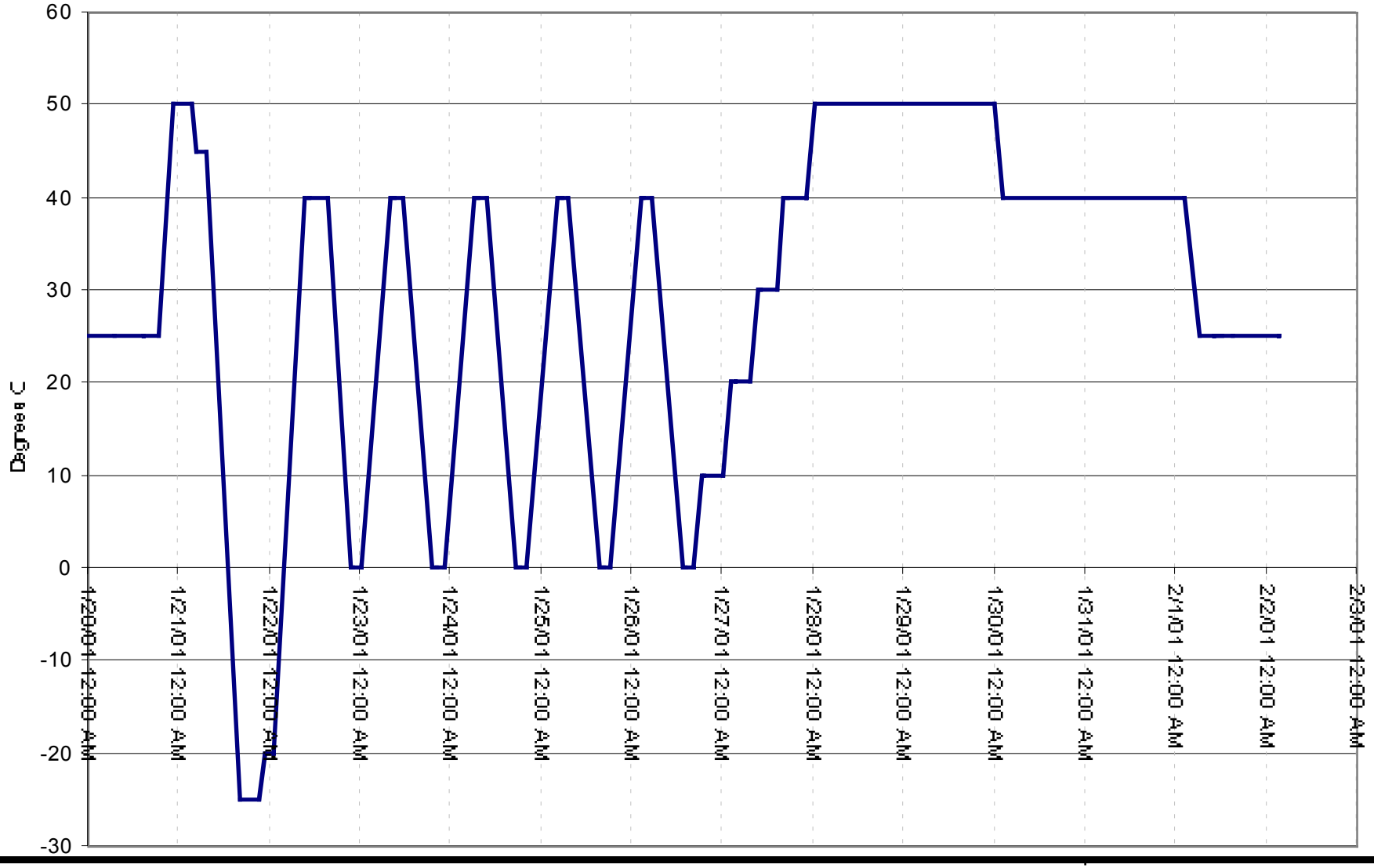
In-Spec Limits are the temperatures within which the detector subsystem will be verified to operate within the specifications defined by COS-08-0003 *Statement of Requirements for the HST-COS FUV Detector.*
Operating Limits are temperatures within which the detector subsystem may be safely operated.
Survival Limits are the temperatures beyond which detector components may be damaged.

- Below we give the BATC predictions for in-flight temperatures (°C) of the key components of the FUV system:

Component	**With ACS**			**Without ACS**	
	Hot Op	**Cold Op**	**Cold safe**	**Cold Op**	**Hot Op**
DVA	**26**	**25**	**13**	**27**	**32**
Charge Amps	**28**	**26**	**9**	**27**	**34**
DVA I/F	**21**	**20**	**2**	**20**	**29**
DEB TDC's	**28**	**23**	**-14**	**19**	**36**
DEB I/F	**17**	**13**	**-14**	**10**	**26**

FUV THERMAL CYCLE PROFILE

COS Detector T-V & Cleanliness Test Profile



- Facilities
  - Tests to be carried out in the University of Colorado "Betty" T-V chamber at CASA
  - UCB to supply T-V mounting plate for the DEB and DVA
  - UCB to provide all EGSE and external HV supply for ion pumps
  - FUV system contains thermistors that monitor each electronics board temperature and several DVA temperatures, U of Co to provide extra thermistors for additional temperature monitoring
  - UCB to provide a UV lamp (ex-FUSE flight stimulation lamp) that will be powered in the T-V chamber to provide a UV photon stimulus to the detector

FUV SYSTEM CLEANLINESS CERTIFICATION

- TEST OBJECTIVES
  - Ensure that the FUV systems (DEB + DVA) meets the cleanliness and outgassing requirements of the COS Contamination Control Plan (IN0090-111)

- TEST LEVELS
  - Particulates
    - Meet level 150A (mil Std 1246) - interior surfaces
    - Meet level 400A (mil Std 1246) - exterior surfaces
  - Molecular
    - Outgassing rate < 4.3 x 10^{-13} g/cm^3 (TQCM at -20C, hardware at 40C)
    - Actual measured frequency change of TQCM expected from system in the certification set-up outlined in memo COS-000503-MAG

CLEANLINESS CERTIFICATION PLAN

- TEST FACILITIES
  - Certification to be carried out inside the U of Co “Betty” T-V chamber
  - Faraday Labs TQCM mounted on chamber plate, held at -20C
- TEST PLAN (Outgassing)
  - FUV system (power off) heated to 50C and baked out for 72 hours (temperature limit defined by detector door paraffin actuator)
  - Temperature lowered to 40C and TQCM certification performed
- TEST PLAN (Particulates)
  - Prior to insertion into T-V chamber, FUV system inspected for particulates using UV black lamp and tape lifts

FUV Detector Shipping Plan

- All shipment activities governed by :
  - Handling Procedures (ESD etc)
  - Contamination Control
  - Detector Safety (constant power to ion pumps to maintain vacuum)

- Transportation Configuration
  - DEB and DVA (double bagged)) mounted at their flight interfaces to a shipping plate (same as the T-V mounting plate)
  - Shipping plate mounts on vibration damper supports within a shipping container
  - Require accelerometers to be mounted to frame
  - Container placed on wooden blocks and strapped to the shipping truck floor
  - EGSE and IPGSE racks padded and strapped to wall of truck
  - Other GSE shipped in crates
  - No special environmental requirements (humidity, temperature etc)

Detector Shipping Plan (cont)

- Power to detector ion pumps
  - UPS Battery supplies AC voltage to Ion Pump GSE Controllers which in turn power the detector ion pumps to maintain vacuum within the DVA
  - UPS lifetime ~ 48 hours (also powered during overnight stay)

- Truck
  - Rental truck (2 drivers)
  - Supported by car (2 drivers) in cell phone communication with truck