SEPT Vibration Re-Test Plan

Doc. No.: STEREO-ETKI-005-b
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1 Scope

This document specifies the qualification vibration re-tests to be performed on the SEPT units. The repetition was made necessary after several repair activities to recover from failures described in IMPACT Problem Reports

- PR-7001 SEPT-DoorOpening 2004-02-20
- PR-7002 SEPT-Detector 2004-03-05
- PR-7003 SEPT-Pinpuller 2004-03-10
- PR-7004 SEPT-Accident 2004-05-04
- PR-7005 SEPT-Counting 200410-10

The vibration tests to be performed include

- low level sine
- acceptance level sine
- acceptance level random

in three axes.

Successful completion of the vibration tests is part of the unit-level qualification tests required to fly the four SEPT units on the two spacecraft of the NASA STEREO mission. The qualification test requirements for STEREO instruments are specified in **AD 1**. The instrument environmental test plan is described in **AD 3**.

1.1 Scope of the document

The scope of the document is to define

- the test objectives
- the specimen, coordinate system, and test configurations
- the test specifications
- the measurement point plan
- the test procedure

1.2 Test objectives

- Verification of general build quality and structural integrity when being subjected to maximum loads expected during launch
- Verification of quasi static loads with margin of safety
- Verification of primary structural vibration modes above 50 Hz (compare to **AD 5**)
- Verification of dynamical loads

2 Applicable Documents

AD 1 STEREO Environment Definition, Observatory, Component and Instrument Test Requirements Document, Doc. No. 7381-9003

AD 2 STEREO Contamination Control Plan, Doc. No. 7381-9006

AD 3 IMPACT Environmental Test Plan, Version D 2003-Dec-30

AD 4 IMPACT Contamination Control Plan, Version A 2003-May-14

AD 5 STEREO SEPT Structural Analysis TOS-MCS/2002/721/ln, January 2003

3 List of Abbreviations

EM	Engineering Model
FM1, FM2	Flight Model 1, 2
GN_2	Dry nitrogen gas
IPA	Isopropanol
MLI	Multi-layer Insulation
NVR	Non-volatile Residue
SEPT-E	Solar Electron and Proton Telescope – Ecliptic
SEPT-NS	Solar Electron and Proton Telescope – North-South
S/C	Spacecraft

4 Cleanliness

Cleanliness of the test environment is of major importance for two reasons:

- SEPT sensors are equipped with contamination sensitive silicon semiconductor detectors of the ion-implanted type. Molecular and particulate contaminants must be avoided.
- Other payload instruments on board of STEREO are equipped with highly sensitive optical surfaces and detectors. Cross contamination must be avoided.

Contamination control shall adhere to the STEREO Contamination Control Plan in **AD 2**. The instrument contamination control plan is described in **AD 4**.

As shakers do not provide the clean environment asked for in **AD 2** and **AD 4**, the instruments will be double bagged:

- one bag surrounding each unit, made of llumalloy
- one tent attached to the mounting cube (or shaker) flushed by GN_2.

Allowed cleaning agents are methanol and ethanol. Use of isopropanol (IPA) close to SEPT is allowed provided that GN_2 purge is applied to the SEPT sensor.

4.1 Environmental conditions at ambient pressure:

Cleanliness :	Class III (10^5 particles/ft^3) when not purged and not in class III clean environment, unit shall be bagged
Temperature:	20 °C +- 3 °C
Relative humidity:	50 % +- 10 %

5 Specimen and test configuration

SEPT consists of two units (SEPT-E and SEPT-NS) per spacecraft, four units in total:

S/C	Instrument Component	Part #
Ahead	SEPT-E	A195 SN1
Ahead	SEPT-NS	A201 SN2
Behind	SEPT-E	A195 SN3
Behind	SEPT-NS	A201 SN4

The four flight units are structurally identical to the EM, which was not subjected to qualification tests, though. The two SEPT-E units are mounted thermally isolated by Ultem bushings to the S/C +Y panel, the two SEPT-NS units are mounted thermally isolated to their brackets on the S/C +Z panel. The units shall be tested in launch configuration (i.e. doors closed) and with thermal hardware attached except for MLI blankets which are not yet made available. Fasteners are staked with Scotch Weld 2216 B/A Gray.

5.1 Test constraints

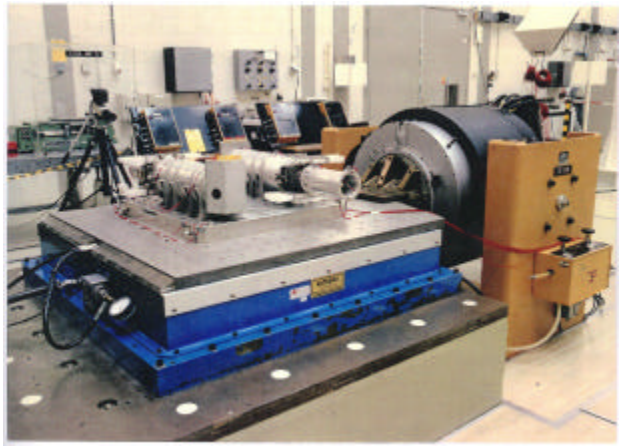
The four SEPT units will be subjected to a vibration test program on the 80 kN Electrodynamic Shaker of the ESTEC test facility operated by European Test Services (ETS) B.V. on November 20 – 23, 2004.

- To reduce test costs, two SEPT units are vibrated together, resulting in a total of 6 test sequences:
  - SEPT-E X-axes FM1 + FM2, SEPT-NS X-axes FM1+ FM2
  - SEPT-E Y-axes FM1 + FM2, SEPT-NS Y-axes FM1+ FM2
  - SEPT-E Z-axes FM1 + FM2, SEPT-NS Z-axes FM1 + FM2
- Each test sequence consists of 4 runs, resulting in a total of 24 runs
  - sine low
  - sine acceptance
  - random acceptance
  - sine low
- A comprehensive test (CPT) is performed after each axis (i.e. once after four runs)

5.2 Test set-up

The 80 kN shaker will be placed in a vertical position (with respect to the position shown in the picture). It is used in vertical configuration for all 3 instrument axes. An aluminium cube of ~ 300 mm side length will be used to support two flight units. By changing the face on which the units are mounted, a different axis will be stimulated each time. No counterweight is needed.

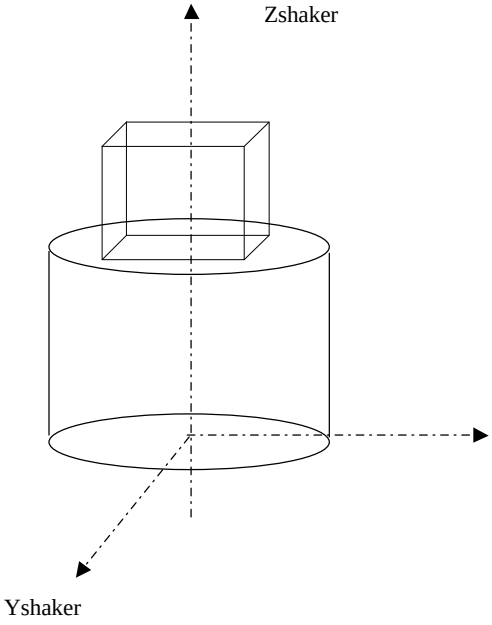
- SEPT-NS is vibrated on its bracket
- The two units on the shaker will be bagged and continuously purged
- The units are not powered
- SEPT-E with Ultem bushings is mounted to the cube with fasteners M4 V2A, (torque 2.6 Nm), mass 770g
- SEPT-NS with Ultem bushings is mounted to the bracket which in turn is mounted to the cube with fasteners M5 V2A (torque 5.1 Nm), mass 1110 g



80 kN Shaker
European Test Services
(ETS) B.V., ESTEC

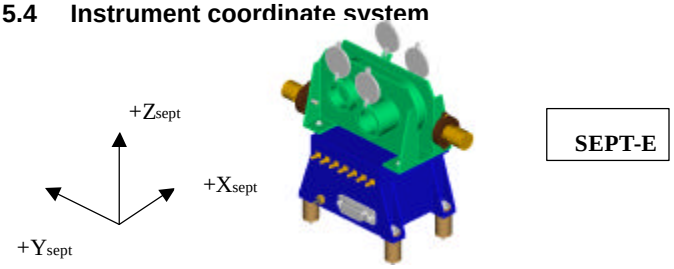
(here shown in horizontal position)

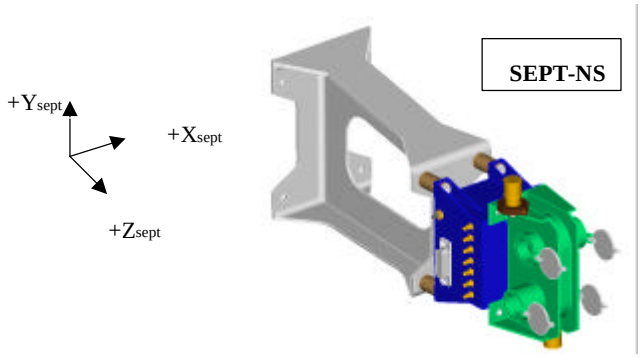
5.3 Shaker coordinate System



The shaker is stimulated along the Zshaker axis

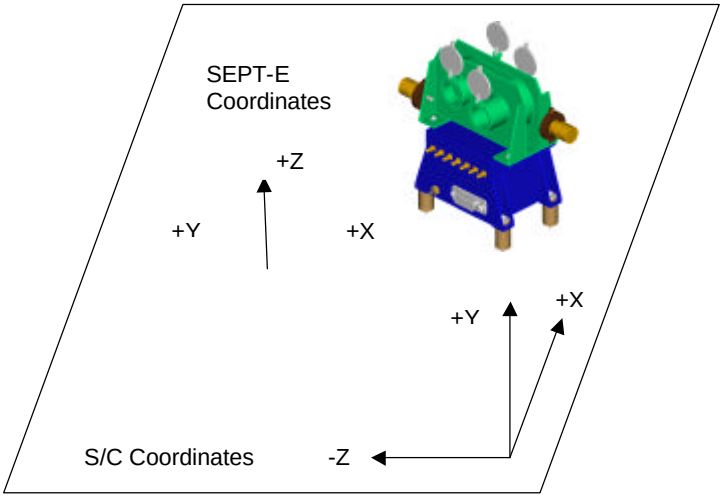
5.4 Instrument coordinate system





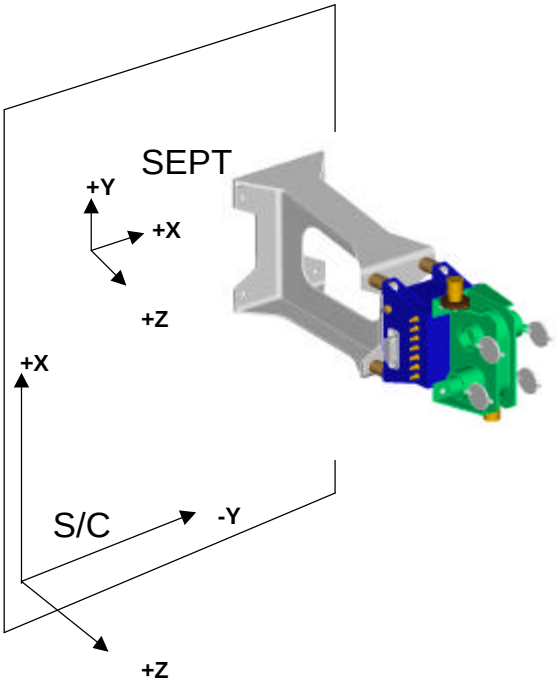
SEPT-E orientation

- View of Ahead S/C +Y panel
  - Thrust in $+X_{S/C}$ direction
  - Apply sine thrust level in both $+X_{SEPT}$ and $+Y_{SEPT}$ direction
  - Apply random perpendicular level in $+Z_{SEPT}$ direction
- For Behind S/C, rotate SEPT by 90° about Z_{SEPT} axis

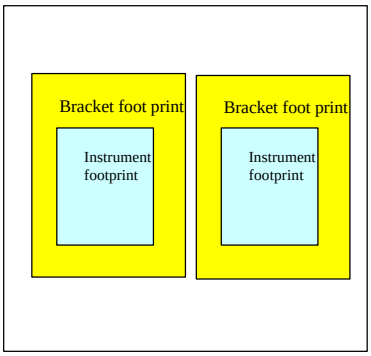


SEPT-NS orientation

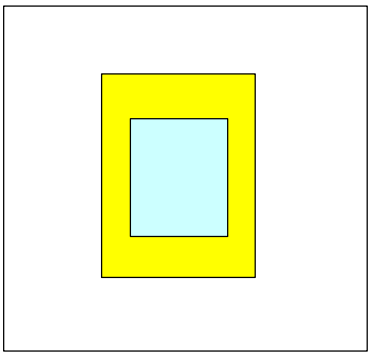
- View of Ahead and Behind S/C +Z panel
- Thrust in $+X_{S/C}$ direction
  - Apply sine thrust level in $+Y_{SEPT}$ direction
  - Apply random perpendicular level in $+Z_{SEPT}$ direction



Orientation on shaker cube

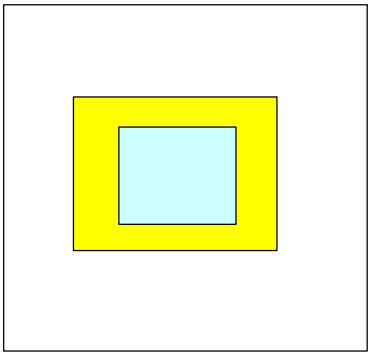


- The Z-face of the cube will be used to stimulate simultaneously the Z_{SEPT} axis of two units of the same kind (i.e. SEPT-E FM1 and SEPT-E FM2 or SEPT-NS FM1 and SEPT-NS FM2)
- Minimum distance between footprints: 15 mm



Zshaker

On two opposite lateral faces of the cube, the footprints allow Y-axis vibration



Zshaker

On the remaining two lateral faces of the cube, the footprints allow Z-axis vibration

5.5 Test levels

Sine-Low	
Frequency (Hz)	Acceleration
5 – 2000	0.25 g
Rate = 4 octaves/min	

Sine Sweep			
Thrust		Lateral	
Frequency (Hz)	Acceleration	Frequency (Hz)	Acceleration
5 to 7.4	0.5 inch (double amplitude)	5 to 6.3	0.5 inch (double amplitude)
7.4 to 23	1.4 g	6.3 to 19	1.0 g
25 to 27	16.0 g	21 to 23	12.0 g
29 to 100	1.4 g	25 to 100	1.0 g
Rate = 4 Octaves/min			

Random Vibration		
Frequency (Hz)	Perpendicular	Parallel
	PSD Level	PSD Level
20	0.0063 g^2/Hz	0.0031 g^2/Hz
20 to 80	+6 dB/oct	+6 dB/oct
80 to 800	0.1 g^2/Hz	0.05 g^2/Hz
800 to 2000	-9 dB/oct	-9 dB/oct
2000	0.0065 g^2/Hz	0.0032 g^2/Hz
Overall Amplitude	10.4 g_{rms}	7.4 g_{rms}
Duration	60 seconds	60 seconds

6 Test Procedure

Run #	Data log name	Level	Unit and axis	Location on cube
1	FM1-E-SL-X-1 FM2-E-SL-X-1	Sine-Low	FM1 SEPT-E Xsept FM2 SEPT-E Xsept	Opposite lateral faces
2	FM1-E-ST-X FM2-E-ST-X	Sine-Thrust	FM1 SEPT-E Xsept FM2 SEPT-E Xsept	Opposite lateral faces
3	FM1-E-RPar-X FM2-E-RPar-X	Random-Parallel	FM1 SEPT-E Xsept FM2 SEPT-E Xsept	Opposite lateral faces
4	FM1-E-SL-X-3 FM2-E-SL-X-3	Sine-Low	FM1 SEPT-E Xsept FM2 SEPT-E Xsept	Opposite lateral faces

Run #	Data log name	Level	Unit and axis	Location on cube
5	FM1-E-SL-Y-1 FM2-E-SL-Y-1	Sine-Low	FM1 SEPT-E Ysept FM2 SEPT-E Ysept	Opposite lateral faces
6	FM1-E-ST-Y FM2-E-ST-Y	Sine-Thrust	FM1 SEPT-E Ysept FM2 SEPT-E Ysept	Opposite lateral faces
7	FM1-E-RPar-Y FM2-E-RPar-Y	Random-Parallel	FM1 SEPT-E Ysept FM2 SEPT-E Ysept	Opposite lateral faces
8	FM1-E-SL-Y-3 FM2-E-SL-Y-3	Sine-Low	FM1 SEPT-E Ysept FM2 SEPT-E Ysept	Opposite lateral faces

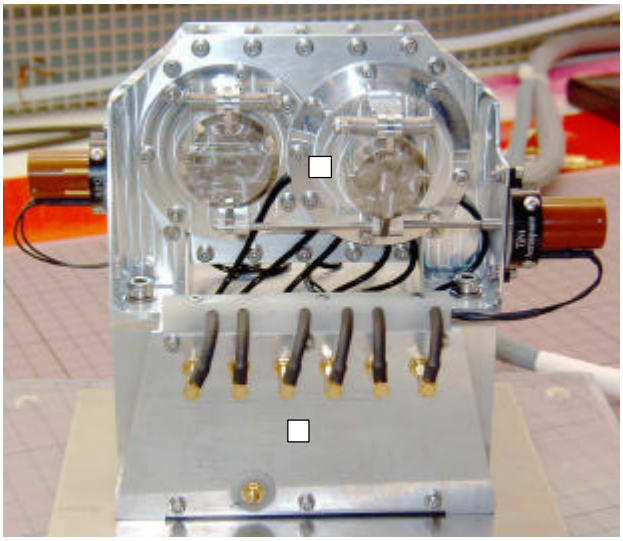
Run #	Data log name	Level	Unit and axis	Location on cube
9	FM1-E-SL-Z-1 FM2-E-SL-Z-1	Sine-Low	FM1 SEPT-E Zsept FM2 SEPT-E Zsept	Both units on top face
10	FM1-E-SLat-Z FM2-E-SLat-Z	Sine-Lateral	FM1 SEPT-E Zsept FM2 SEPT-E Zsept	Both units on top face
11	FM1-E-RPerp-Z FM2-E-RPerp-Z	Random-Perpendicul.	FM1 SEPT-E Zsept FM2 SEPT-E Zsept	Both units on top face
12	FM1-E-SL-Z-3 FM2-E-SL-Z-3	Sine-Low	FM1 SEPT-E Zsept FM2 SEPT-E Zsept	Both units on top face

Run #	Data log name	Level	Unit and axis	Location on cube
13	FM1-NS-SL-X-1 FM2-NS-SL-X-1	Sine-Low	FM1 SEPT-NS Xsept FM2 SEPT-NS Xsept	Opposite lateral faces
14	FM1-NS-SLat-X FM2-NS-SLat-X	Sine-Lateral	FM1 SEPT-NS Xsept FM2 SEPT-NS Xsept	Opposite lateral faces
15	FM1-NS-RPar-X FM2-NS-Rpar-X	Random-Parallel	FM1 SEPT-NS Xsept FM2 SEPT-NS Xsept	Opposite lateral faces
16	FM1-NS-SL-X-3 FM2-NS-SL-X-3	Sine-Low	FM1 SEPT-NS Xsept FM2 SEPT-NS Xsept	Opposite lateral faces

Run #	Data log name	Level	Unit and axis	Location on cube
17	FM1-NS-SL-Y-1 FM2-NS-SL-Y-1	Sine-Low	FM1 SEPT-NS Ysept FM2 SEPT-NS Ysept	Opposite lateral faces
18	FM1-NS-ST-Y FM2-NS-ST-Y	Sine-Thrust	FM1 SEPT-NS Ysept FM2 SEPT-NS Ysept	Opposite lateral faces
19	FM1-NS-RPar-Y FM2-NS-Rpar-Y	Random-Parallel	FM1 SEPT-NS Ysept FM2 SEPT-NS Ysept	Opposite lateral faces
20	FM1-NS-SL-Y-3 FM2-NS-SL-Y-3	Sine-Low	FM1 SEPT-NS Ysept FM2 SEPT-NS Ysept	Opposite lateral faces

Run #	Data log name	Level	Unit and axis	Location on cube
21	FM1-NS-SL-Z-1 FM2-NS-SL-Z-1	Sine-Low	FM1 SEPT-NS Zsept FM2 SEPT-NS Zsept	Both units on top face
22	FM1-NS-SLat-Z FM2-NS-SLat-Z	Sine-Lateral	FM1 SEPT-NS Zsept FM2 SEPT-NS Zsept	Both units on top face
23	FM1-NS-RPerp-Z FM2-NS-RPerp-Z	Random-Perpendicul.	FM1 SEPT-NS Zsept FM2 SEPT-NS Zsept	Both units on top face
24	FM1-NS-SL-Z-3 FM2-NS-SL-Z-3	Sine-Low	FM1 SEPT-NS Zsept FM2 SEPT-NS Zsept	Both units on top face

7 Position and number of accelerometers



1 cube (9x9x9 mm3) with 3 accelerometers on sensor

1 cube (9x9x9 mm3) with 3 accelerometers on E-Box