SEPT Thermal Vacuum Re-Test Plan

Doc. No.: STEREO-ETKI-006b
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1 Scope

This document specifies the qualification thermal vacuum 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 TV tests to be performed include

- TV cycling
- Temperature-time bake-out

Successful completion of the TV 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 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 after thermal cycling
- Verification of expected in-orbit temperatures
- Verification of compliance with cleanliness requirements

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

3 List of Abbreviations

CDE	?
CPT	Comprehensive Performance Test
EM	Engineering Model
FM1, FM2	Flight Model 1, 2
FTIR	Fourier Transform Infrared Spectrometer
GN_2	Dry nitrogen gas
IPA	Isopropanol
LIVAF	Little Vacuum Facility, ESTEC
MLI	Multi-layer Insulation
NVR	Non-volatile Residue
RT	Room Temperature
SEPT-E	Solar Electron and Proton Telescope – Ecliptic
SEPT-NS	Solar Electron and Proton Telescope – North-South
S/C	Spacecraft
TBS	To be supplied

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**. Contamination control during TV must be achieved for two reasons:

- Certify that the TV chamber itself is not a significant source of contamination.
- Give evidence that SEPT itself is not a significant source of contamination.

The LIVAF is not equipped with cryo pumps, but with a combination of primary rotary forepump and secondary turbo-molecular pump. In order to certify the chamber, a measurement of the residual gas composition is carried out as well as a NVR swab analysis with FTIR.

To ensure that SEPT itself is not a source of contamination, a materials list is compiled and reviewed, material data sheets are provided and samples are submitted for analysis where available data was insufficient. Non-flight items like special vacuum harness will be baked out separately prior to testing with SEPT.

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 %

4.2 Environmental conditions after pump-down:

Pressure:	1 x 10^{-5} torr (0.0013 Pa) or less
Temperature:	constrained by sensor, applicable thermistor channel: SEPT-E S/C TEMP and TEMP RTN, connector J2, pin 25 /26 and SEPT-NS S/C TEMP and TEMP RTN, connector J2, pin 25/26 high temperature limit at +50 °C +-1 °C low temperature limit at -40 °C +- 1 °C
Contamination:	contaminants will be trapped by a cold finger. During transitions from cold to hot, SEPT shall not stay colder than surrounding to prevent deposition of contaminants (slow transition, when warming up, shroud temperature lags thermal plate temperature). Backfilling the chamber for re-pressurization will be with GN_2.

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 to the S/C +Y panel, the two SEPT-NS units are mounted thermally isolated to their brackets on the S/C +Z panel.

5.1 Test constraints

The four SEPT units will be subjected to a thermal vacuum test program in the Little Vacuum Facility (LIVAF) of the Mechanical Systems Laboratory, ESTEC Test Centre, in week 48 and 49, 2004. At this time, procurement of thermal hardware is complete except for flight MLI blankets. Contrary to the first TV test run in weeks 10 and 11 of 2004, thermostats and film heaters are now installed. However, they will not be monitored or operated. This task will be done during the thermal balance test at GSFC.

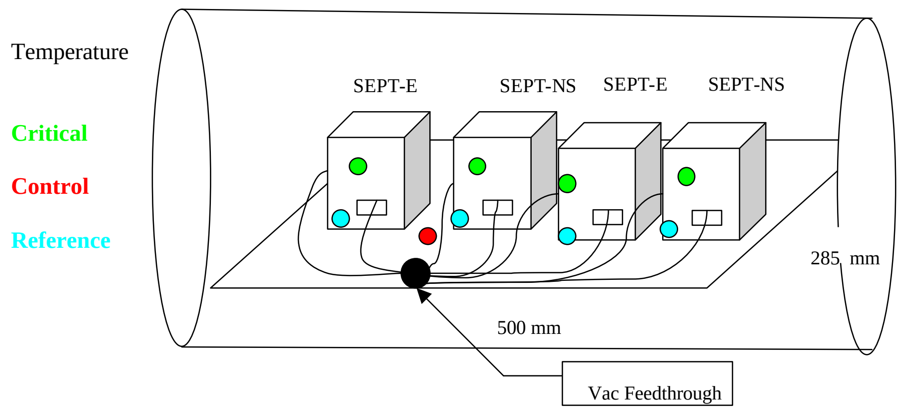
The four SEPT units shall undergo 6 powered operational cycles, 1 survival cycle. To reduce test costs, all four SEPT units are TV cycled together, resulting in only one test run.

To quickly achieve thermal equilibrium, SEPT-E and SEPT-NS are mounted directly to the temperature controlled plate, i.e. without brackets and thermal isolators (Ultem).

Actuation of SEPT cover release shall be exercised in hot and cold soak. As doors are opened by one-time actuators which require manual restow, 2 (out of 4) doors per unit will be opened at cold soak, the other 2 at hot soak.

5.2 Test set-up

Four SEPT units are mounted side by side on a thermal plate (length 500 mm, width 285 mm, see Fig. below). Each unit is fixed by four M4 screws (torque 2.6 Nm) to the temperature controlled plate. Aluminium washers (2 mm thick) under the mounting lugs provide clearance for operational and survival heaters on the bottom lid.



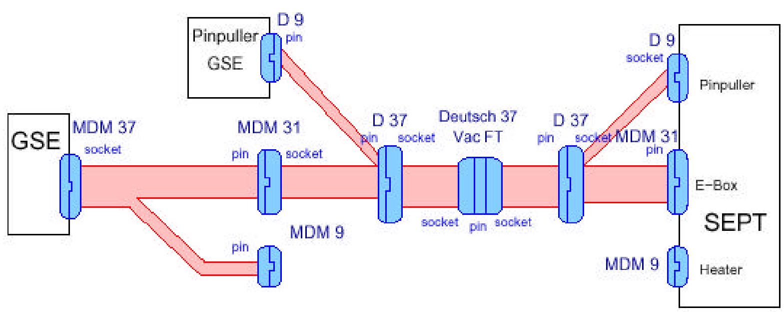
5.3 Test equipment

The TV test will be performed in the Little Vacuum Facility (LIVAF) of the Mechanical Systems Laboratory, ESTEC Test Centre. The pumping system of the facility consists of a combination of primary rotary forepump (pump speed 40 m^3/h) and secondary turbo-molecular pump (pump speed 600 l/s). The turbo-molecular pump is connected to the vacuum vessel with in-between a gate valve. Vacuum level: < 10^{-5} mbar, pump-down time: ~ 8 hours.

The facility is equipped with a shroud (door, horizontal cylinder, back). The emissivity of the shroud is e = 0.88. The nominal temperature range of the shroud is -180 °C to +80 °C. There is a cold trap at -80 °C between specimen and pump exit.

5.4 Test harness

Four identical test harnesses are fabricated which allow simultaneous testing with two EGSE sets. They shall undergo a separate bake-out prior to TV testing.



5.5 Test levels

The temperatures of the following table are based on the thermal analysis by the IMPACT thermal engineer John Hawk/GSFC. As the SEPT TV test precedes the thermal balance test (see test constraints above), the thermal model is not yet verified. Hence the qualification temperatures must include a 10 °C margin to the max and min predicted operating temperatures.

Unit	Operating	Survival	Qualification
SEPT-E [°C]	-30 to +40	-40 to +50	-40 to +50
SEPT-NS [°C]	-30 to +40	-40 to +50	-40 to +50

5.5.1 Definition of temperature limits

TNO-MAX	Non-operating temperature	+50 °C
TO-MAX	Operating temperature	+50 °C
TNO-MIN	Non-operating temperature	- 40 °C
TSU-MIN	Cold startup temperature	- 40 °C
TO-MIN	Operating temperature	- 40 °C

5.5.2 Transition rates and stability criteria

The maximum rate of temperature change is 3 °C/min. Care must be exercised not to overshoot TNO-MAX or undershoot TNO-MIN. Temperature stability is achieved when the temperature is within 3 °C of the plateau and the rate of change is less than 1 °C/hour.

5.6 Definition of temperature measurement points

Control Temperature	thermocouple on thermal plate
Reference Temperature	4 thermocouples on side wall close to bottom lid of E-box, one per unit
Criteria Temperature	4 thermocouples on sensor close to detectors, one per unit
Sensor temp. FM1 SEPT-E	S/C powered thermistor, analog signal on connector J2, pin 25/26
Sensor temp. FM1 SEPT-NS	S/C powered thermistor, analog signal on connector J2, pin 25/26
E-Box temp. FM1 SEPT-E	Instrument powered thermistor, digital signal in housekeeping data
E-Box temp. FM1 SEPT-NS	Instrument powered thermistor, digital signal in housekeeping data
Sensor temp. FM2 SEPT-E	S/C powered thermistor, analog signal on connector J2, pin 25/26
Sensor temp. FM2 SEPT-NS	S/C powered thermistor, analog signal on connector J2, pin 25/26
E-Box temp. FM2 SEPT-E	Instrument powered thermistor, digital signal in housekeeping data
E-Box temp. FM2 SEPT-NS	Instrument powered thermistor, digital signal in housekeeping data

5.7 Test Sequence

The SEPT thermal vacuum test sequence is given in the figures below which are taken from **AD 1**.

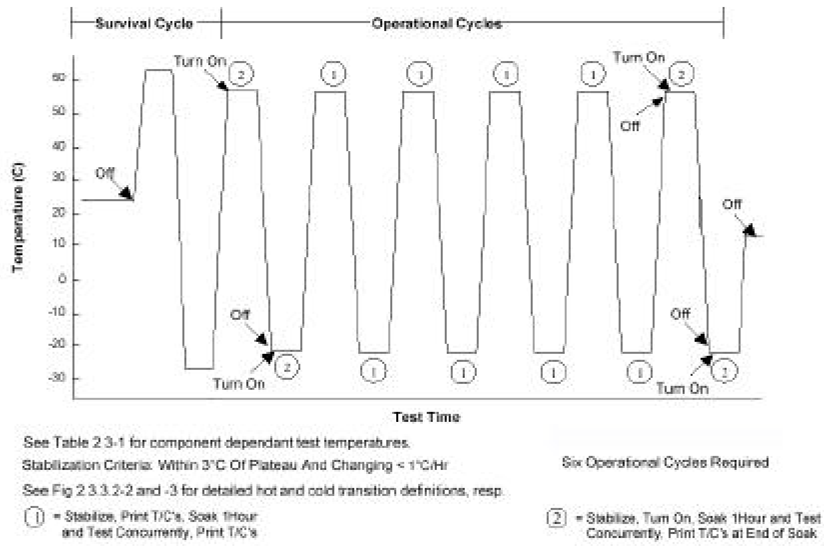


Figure 3.3.2.1–1 Typical Spacecraft Component Thermal Vacuum Profile

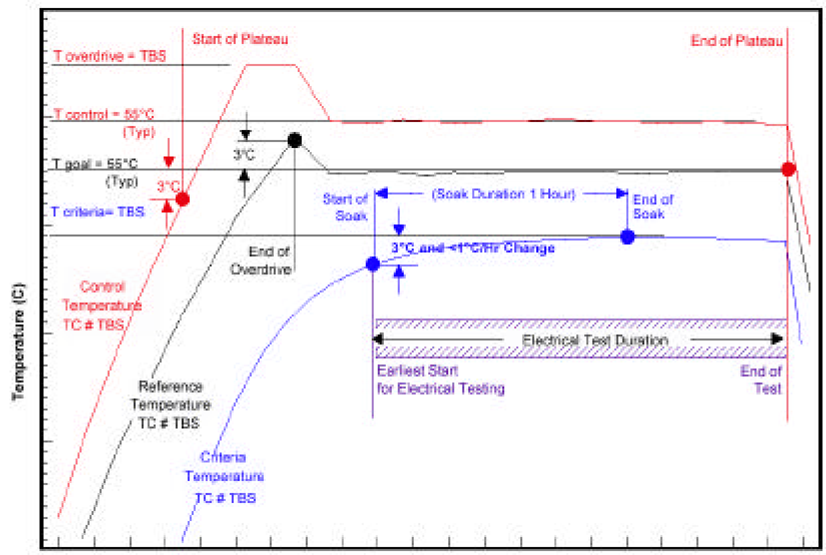


Figure 3.3.2.1–2 Detailed Hot Transition Definition

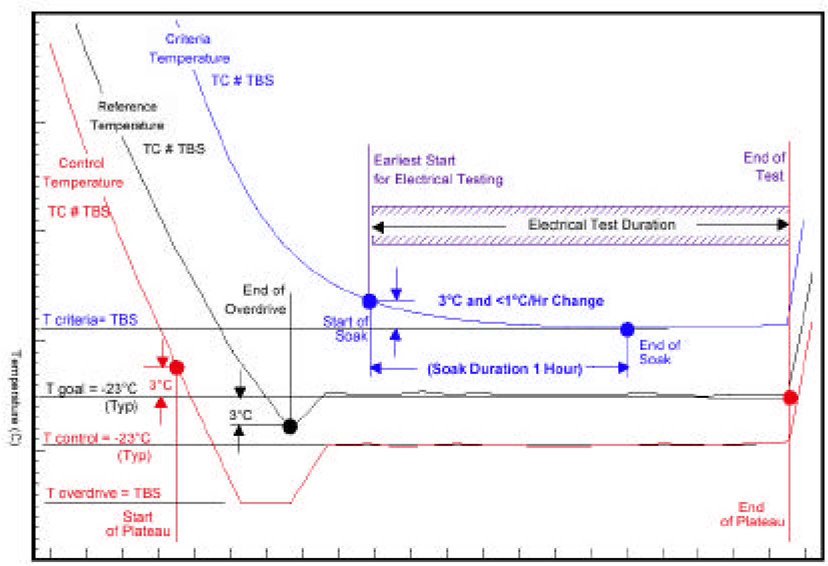


Figure 3.3.2.1–3 Detailed Cold Transition Definition

6 Test Procedure

Caution:

SEPT uses high voltage (-80 V). Do not power SEPT unless the pressure is at ambient or below 10^{-3} torr. Should the pressure unexpectedly rise while SEPT is powered (e.g. leak) use SEPT emergency switch-off.

6.1 Step-by-step sequence:

(time TBC by facility responsible):

Step	Cycle #	Time	Plate temperature	Activity
1	0	T0 - 100 h	+80 °C	Pressure < 10^{-5} torr. Start CDE by ramping LIVAF w/mechanical support equipment from RT to 80 °C, bake out for 48 h
2	0	T0 - 52 h	+60 °C	Return to RT, re-pressurize, install electrical support equipment, ramp to TNO-MAX + 10 °C, bake out for 48 h
3	0	T0 - 4 h	RT	Return to RT, re-pressurize, install FM1+2, turn on FM1+2, perform CPT prior to TV, turn off FM1+2, close chamber
4	1	**T0**	RT	Start pump-down to < 10^{-5} torr.
5	1	T0 + 4 h	+50 °C	Start hot ramp
6	1	T0 + 8 h	+50 °C	Hot soak (survival), at end of hot soak turn-on FM1, run nominal mode for 10 minutes, turn FM1+2 off
7	1	T0 + 9 h	-40 °C	Start cold ramp
8	1	T0 + 10 h	-40 °C	Cold soak (survival)
9	2	T0 + 11 h	+50 °C	Start hot ramp
10	2	T0 + 12 h	+50 °C	Hot soak, turn on FM1+2, CPT
11	2	T0 + 13 h	-40 °C	Start cold ramp
12	2	T0 + 14 h	-40 °C	Turn off FM1+2, cold soak, cold start-up FM1+2, CPT
13	3	T0 + 15 h	+50 °C	Start hot ramp
14	3	T0 + 16 h	+50 °C	Hot soak, CPT, vary supply rails to min and max voltage, Test generator mode
15	3	T0 + 17 h	-40 °C	Start cold ramp
16	3	T0 + 18 h	-40 °C	Cold soak, CPT, vary supply rails to min and max voltage, Test generator mode
17	4	T0 + 19 h	+50 °C	Start hot ramp
18	4	T0 + 20 h	+50 °C	Hot soak, CPT

19	4	T0 + 21 h	-40 °C	Start cold ramp
20	4	T0 + 22 h	-40 °C	Cold soak, CPT
21	5	T0 + 23 h	+50 °C	Start hot ramp
22	5	T0 + 24 h	+50 °C	Hot soak, CPT
23	5	T0 + 25 h	-40 °C	Start cold ramp
24	5	T0 + 26 h	-40 °C	Cold soak, CPT
25	6	T0 + 27 h	+50 °C	Start hot ramp
26	6	T0 + 28 h	+50 °C	Hot soak, CPT, open front doors SEPT-E, open rear doors SEPT-NS with minimum current (0.79 A)
27	6	T0 + 29 h	-40 °C	Start cold ramp
28	6	T0 + 30 h	-40 °C	Cold soak, CPT, open rear doors SEPT-E, open front doors SEPT-NS with minimum current (0.79 A)
29	7	T0 + 31 h	+50 °C	Start hot ramp
30	7	T0 + 32 h	+50 °C	Turn off FM1+2, hot soak, turn on FM1+2, CPT
31	7	T0 + 33 h	-40 °C	Start cold ramp
32	7	T0 + 34 h	-40 °C	Turn off FM1+2, cold soak, turn on FM1+2, CPT
33		T0 + 35	+50 °C	Start hot ramp
34		T0 + 36	+50 °C	Temperature-time bake-out for 48 h
35		T0 + 84	RT	Turn off FM1+2, return to RT, re-pressurize, open chamber, turn on FM1+2, perform CPT after TV, turn off FM1+2, verify doors are open, remove FM1+2, close doors, open doors with maximum current (1.38 A), close doors
36		T0 + 88	RT	End test FM1+2