Jet Propulsion Laboratory **Interoffice Memorandum**

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To: Distribution

From: W. B. Tsoi

Subject: STEREO IMPACT Solar Energetic Particles Package (SEP) Dynamic Test Plan

References: 1) 'STEREO Environment Definition, Observatory, Component and Instrument Test Requirements Document', Applied Physics Laboratory, December 3, 2001.

SUMMARY

This IOM represents the Protoflight (PF) level random vibration and acoustic test plan for the STEREO IMPACT Solar Energetic Particles Package (SEP) and serves as the basis for the related dynamic test procedures.

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STEREO IMPACT

Solar Energetic Particles Package (SEP)

Dynamic Test Plan

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1.0 Test Plan Scope

This plan describes aspects of the STEREO IMPACT Solar Energetic Particles Package (SEP) dynamic tests that are necessary for proper application of the specified environmental requirements, namely, test configuration, dynamic test levels, tolerances and sequence of runs, test facilities and instrumentation locations, data recording and data analysis. This plan does not incorporate those aspects of SEP preparation, handling or functional testing which are under the purview of the cognizant hardware engineer.

2.0 Test Approach and Requirements

The test program will proceed in the following order. Sine vibration tests will be performed first, followed by the random vibration tests and finally acoustic tests.

First, The SEP will be subjected to sine vibration testing in two axes (perpendicular and parallel to mounting plane). A sine vibration survey performed to 0.25 g_{pk} per Table 1 and the test tolerances of section 7.0 shall preceded and follow the sine vibration tests in each axis.

Table 1. SEP Sine Survey

Frequency, Hz	Survey Level
5-2000	0.25 gpk

Sweep Rate: 4 octave/minute, sweep up only, duration

Subsequent sine vibration test runs will be performed at increasing input levels as indicated in Table 2. Test runs may be added, frequency ranges modified or input levels revised as deemed necessary by the test director or the test analyst during the test. Note that sine vibration tests will be force and response limited to16 g (parallel to mounting plane) and 12 g (perpendicular to mounting plane) at any location.

Table 2. SEP Sine Test Input

Test	Frequency (Hz)	Acceleration (zero to peak), Parallel to Mounting Plane	Frequency (Hz)	Acceleration (zero to peak), Perpendicular to Mounting Plane
Run 1	5 to 7.4 7.4 to 23 25 to 27 29 to 100	0.025 in. 0.14 g 1.6 g 0.14 g	5 to 6.3 6.3 to 19 21 to 23 25 to 100	0.025 in. 0.1 g 1.2 g 0.1 g
Run 2	5 to 7.4 7.4 to 23 25 to 27 29 to 100	0.0625 in. 0.35 g 4.0 g 0.35 g	5 to 6.3 6.3 to 19 21 to 23 25 to 100	0.0625 in. 0.25 g 3.0 g 0.25 g
Run 3	5 to 7.4 7.4 to 23 25 to 27 29 to 100	0.125 in. 0.7 g 8.0 g 0.7 g	5 to 6.3 6.3 to 19 21 to 23 25 to 100	0.125 in. 0.5 g 6.0 g 0.5 g
Run 4	5 to 7.4 7.4 to 23 25 to 27 29 to 100	0.25 in. 1.4 g 16.0 g 1.4 g	5 to 6.3 6.3 to 19 21 to 23 25 to 100	0.25 in. 1.0 g 12.0 g 1.0 g

Sweep Rate: 4 octaves / minute, sweep up only
Note: Sine vibration tests will be force and response limited to16 g (parallel to mounting plane) and 12 g (perpendicular to mounting plane) at any location.

Next, the SEP will be subjected to Protoflight (PF) random vibration testing in three axes. Random vibration test in each axis shall be preceded by a 0.25 g_{pk} sine survey [1], Table 1.

PF level random vibration test runs, Table 3 [1], shall be preceded by a PF-18 dB test run in each axis. Test runs at PF-12 dB or PF-6 dB may be added or deleted if deemed necessary by the test director to verify the test input. The full level random vibration test run will be followed by a 0.25 gpk sine survey (Table 1) in each axis.

Table 3. SEP Protoflight Random Vibration

Axis	Frequency, Hz	PF Level
Perpendicular to Mounting Panel	20 20 – 80 80 – 800 800 – 2000 2000 Overall	0.0063 g^2 / Hz + 6 dB / octave 0.1 g^2 / Hz - 9 dB / octave 0.0065 g^2 / Hz 10.4 g_{rms}
Parallel to Mounting Panel	20 20 – 80 80 – 800 800 – 2000 2000 Overall	0.0031 g^2 / Hz + 6 dB / octave 0.05 g^2 / Hz - 9 dB / octave 0.0032 g^2 / Hz 7.4 g_{rms}

Duration: 1 minute per axis, 3 orthogonal axes

Finally, the SEP will be subjected to Protoflight (PF) level acoustic testing. PF acoustic tests shall be performed on all acoustic test articles to requirements and tolerances of Table 4. Full level test runs shall be preceded by a PF-9 dB test run. Intermediate test runs at PF-6 dB and PF-3 dB may be added or deleted if deemed necessary by the test director and the hardware cognizant engineer.

Table 4. SEP Acoustic Test Specifications

1/3 Octave Band Center Frequency (Hz)	PF Sound Pressure Level dB (ref. 20µ Pa)	Acoustic Test Tolerance dB
31.5	122.5	as close as possible
40	125.5	as close as possible
50	129.5	+4, -2
63	131	+4, -2
80	133	+4, -2
100	133	+4, -2
125	133	+4, -2
160	133.5	+4, -2
200	134.5	+4, -2
250	135.5	+4, -2
315	134.5	+4, -2
400	131	+4, -2
500	128	+4, -2
630	125	+4, -2
800	123	+4, -2
1000	121	+4, -2
1250	120	+4, -2
1600	119.5	+4, -2
2000	119	+4, -2
2500	118	as close as possible
3150	116.5	as close as possible
4000	114	as close as possible
5000	110	as close as possible
6300	106	as close as possible
8000	103	as close as possible
10000	101	as close as possible
Overall	143.6	+3, -1

Duration: exposure time is 1 minute

3.0 Test Responsibilities

The cognizant hardware engineer will provide the SEP for dynamic tests in a flight like configuration and set up the appropriate support equipment. The cognizant hardware engineer will have overall cognizance of the test and hardware and will be responsible for all SEP handling.

A test director will be provided by Section 352, who's responsibility is the timely and safe conduct of the dynamic test to the requirements specified herein. The test director will examine all dynamic test data immediately following each test run and, with concurrence of the cognizant hardware engineer, will give the go ahead for successive test runs and test tear down at the end of each vibration test axis. The test director will produce a test report within four weeks of test completion, if requested by the project.

Section 351 shall provide test operators to perform tests as prescribed in this test plan. The section will also provide technicians to install accelerometers and strain gauges and gather data during the acoustic and sine vibration tests.

All test installation and test conduct operations involving flight hardware shall be witnessed by a Quality Assurance representative.

4.0 Pass/ Fail Criteria

The SEP will have successfully passed vibration and acoustic tests if structural integrity is maintained throughout the test program, as verified by visually inspection and functional testing performed by the cognizant hardware engineer.

5.0 Test Configuration and Equipment

For the sine and random vibration tests, the flight, or flight spare SEP, and vibration test fixture supplied by the cognizant hardware engineer will be assembled on the shaker. The adapter fixture shall be drilled for control and monitor accelerometers. The SEP weighs approximately 5.1 kilograms.

SEP random vibration test will be performed at JPL's Dynamics Test facility, building 144, room 102. Power will be provided to the shaker with a solid state amplifier.

Bolts / washers shall be torqued to the appropriate value and will be marked to indicate any backing out of the bolts.

For acoustic testing, the SEP will be suspended up side down at its mounting supports by bungee cords at a distance no less than 1.5 meters above the acoustic chamber floor. The acoustic test of the SEP will be performed inside the JPL 10,000 ft^3 reverberation chamber in Bldg. 144, Room 101. Sound is transmitted into the chamber via gaseous nitrogen, which is flowed through transducers on each horn into the test chamber. **This creates an extremely hazardous atmosphere in the acoustic test chamber that will not support life.** Verification must be obtained from the laboratory operator that an adequate oxygen level has been restored before any personnel may enter the test chamber.

6.0 Test Control, Instrumentation

Force transducer and accelerometer controls will be utilized for all sine and random vibration tests.

The acoustic test spectrum will be controlled by the average signal from four (4) microphones placed about the test article. Each control microphone / monitor microphone pair should be placed approximately 1-1 / 2 to 2 feet from the nearest test article surface as advised by the test director.

The SEP will be instrumented with 9 accelerometers at three locations for all dynamic tests, Table 4, as seen on Figure 1. Accelerometers and / or mounting blocks may be installed on appropriately positioned Kapton tape, if required, with a cyanoacrylate ester type of adhesive (e.g., Eastman 910).

Table 4. SEP Dynamic Tests Response Accelerometer Locations

Accelerometer Designation	Accelerometer Location
A1X, A2Y, A3Z	LET Telescope Top
A4X, A5Y, A6Z	LET Telescope Sensor
A7X, A8Y, A9Z	LET Telescope Base

For vibration tests, a total of six tri-axial force transducers will be installed between the base fixture and the test article, oriented parallel to the assembly coordinate axes, and torqued to an appropriate value. The in-axis transducer signals will be summed to obtain the total in-axis force for each axis of shake.

To minimize over-testing of the assembly, force-limiting shall be employed during random vibration testing. In addition to controlling the acceleration input spectrum, the force transducers will be controlled to limit the reaction force at the base of the assembly. Preliminary force spectral limits may be calculated using the semi-empirical formula in Table 5. Calculated spectral values are subject to modification based on information gathered during the low-level sine sweep.

Table 5. Assembly Random Vibration Force Limit Specification

Frequency (Hz)	Force Specification
$20 – 1.1\ f_o$	$384*F\ \ N^2 / Hz$
$1.1\ f_o – 1000$	- 6dB / Oct

The value f_o is the first predominant resonance frequency in the axis of test with a significant percentage of test item mass participating in the mode. The factor F is the product of the acceleration spectrum (g^2 / Hz) times the square of the total mass of the assembly in kg. (N = Newtons).

All control and response data will be recorded on magnetic tape for all test runs. Other vibration equipment functions which will be recorded include shaker armature current (transformer signal proportional to current), digital control system drive signal (power amplifier input), constant sine (frequency tracking signal), NASA time code and voice annotation. The tape recorder will be operated at a speed sufficient to provide a minimum of 2500 Hz upper frequency response for random vibration testing. All signals going to the tape recorders will be unfiltered and the recording system frequency response shall be flat within $\pm$ 1dB from 5 to 3,000 Hz for random vibration testing.

In parallel to the tape recording, the channels may be displayed on oscillograph recorders to display real time data and possible internal element impacts. The oscillographs will be operated at a paper speed of not less than 0.2 inch / sec.

7.0 Dynamics Test Tolerances

Sine vibration tests shall be conducted within the following tolerances:
- amplitude (wide band): ±5%
- frequency: ±5% or ±1 Hz, whichever is greater
- time: ±5%

Random vibration tests shall be conducted within the following tolerances:
- spectral values: ±3 dB when measured in frequency bandwidths of 25 Hz or less.
- wide band (RMS) level: ±1.5 dB
- frequency: ±5%
- time: ±5%

Acoustic tests shall be conducted within the tolerances of Table 4.

8.0 Test Operations

For random vibration tests, an operational safety survey will be conducted prior to the test. Prior to installation of the SEP on the shaker/fixture, a full level checkout of the shaker/fixture/control system will be conducted to exercise as much of the vibration test equipment as possible. Accelerometers installed on the SEP will be checked for satisfactory operation prior to performing test runs. The instrument engineer shall designate one individual to control a test input kill switch which supplements the facility automatic shaker safety system.

Reduced level test runs will be performed to verify test inputs and responses prior to performing full level random vibration as described below. The order of testing, by axis, will be determined by the cognizant engineer and the test director. SEP functional checks will be performed before and after all testing.

For acoustic test, an operational safety survey will be conducted at least prior to the test.

Prior to installation of the SEP in the acoustic chamber, a complete sequence of runs (including low levels) shall be made to equalize and verify the empty chamber for the PF level test of Table 3. Control and monitor microphones shall be placed approximately in the locations they would be with the V-groove simulator in place. The average and individual microphone SPL's will be analyzed for conformance with the test specification. Monitor microphone levels will be used for confirmation of the control spectrum.

Any anomalous mechanical, electrical or visual behavior of SEP observed during the testing sequence will be reported to the Test Operator and the test run will immediately be terminated. At the test director's discretion, and after consultation with the Cognizant Engineer the testing may be suspended. If the anomaly concerns a test item dynamic response, the Test Director will investigate the cause of the anomaly and advise the Cognizant Engineer on the impact of continuing the test.

9. Test Data Processing

Data reduction will be required for all control data between test runs along with some or all of the response data. All data will be reduced from the full level test runs for inclusion in the test report.

"Quick-look" data will be generated between test runs to make decisions regarding the acceptability of the input, response and data fidelity. All full level data channels will be plotted in the frequency domain with annotation and in a formalized format suitable for inclusion in the final test report.

Sinusoidal survey data will be analyzed and plotted in the following formats, accelerometers - g_{pk} vs. Frequency, force transducers - lb_{pk} vs. frequency and armature current and drive (PA input) - mv vs. frequency.

Random vibration data will be analyzed and plotted in the following formats, accelerometers - g^2 / Hz vs. frequency (20-2000 Hz), force transducers - lb^2 / Hz vs. frequency and armature current and drive (PA input) - $(mv)^2$ / Hz vs. frequency (20-2000 Hz).

Acoustic data will be analyzed and plotted in the following formats, accelerometers - g^2 / Hz vs. frequency, SPL - dB vs. frequency.

10. Photographic Documentation

Digital photographs will be taken to show the overall setup with the RAE fully assembled on the vibration fixture and shaker. Close up photographs will be taken of the accelerometer installation with sufficient detail to allow later accelerometer location identification.

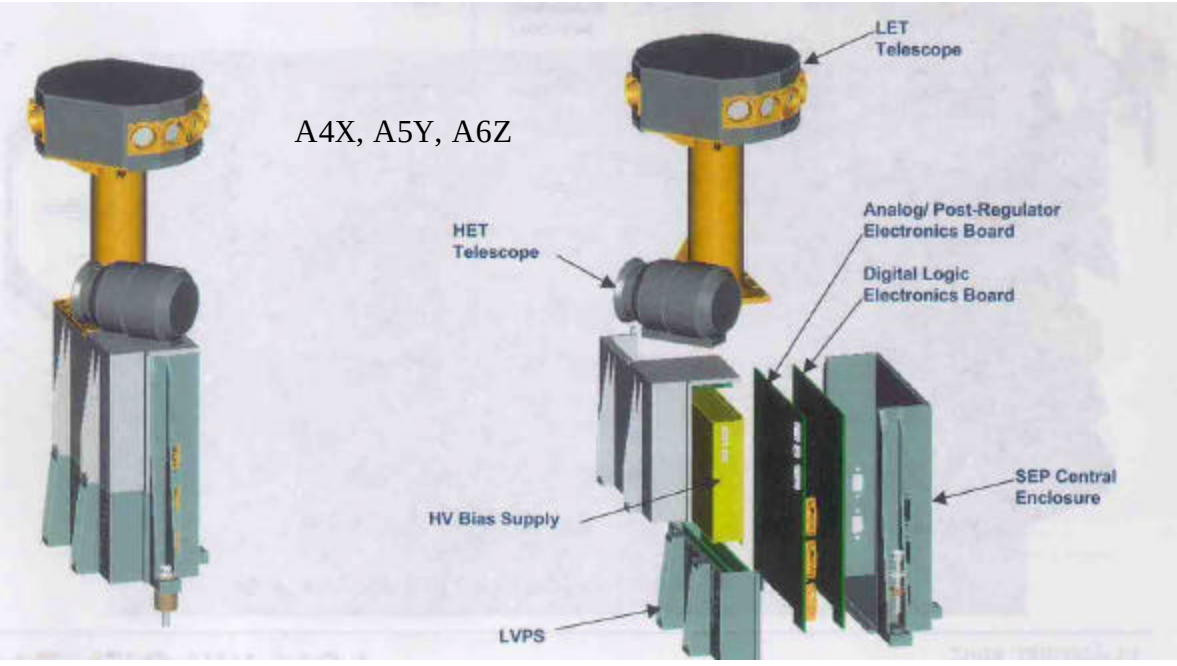

Figure 1. Main SEP Assembly and Approximate Response Accelerometer Location