



**SOLAR ORBITER ENERGETIC PARTICLE DETECTOR
EPT-HET PQM Random-Sine Vibration Test Plan
and Procedure**

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 Christian-Albrechts-Universität zu Kiel	EPT-HET PQM Random-Sine Vibration Test Plan and Procedure	Reference: SO-EPD-KIE-TP-0017 Issue:1 Revision: 1 Date: 17/05/2015 Page: 2 of 20
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TABLE OF CONTENTS

1	INTRODUCTION	5
1.1	Purpose.....	5
1.2	Scope.....	5
2	GLOSARY AND DEFINITIONS	6
2.1	Acronyms and Abbreviations	6
3	APPLICABLE AND REFERENCE DOCUMENTS.....	7
3.1	Applicable Documents	7
3.2	Normative Documents	7
3.3	Reference Documents	7
4	TEST OVERVIEW	8
4.1	Test objectives	8
4.2	Test facility	8
4.3	Environmental conditions.....	8
4.4	Test documentation	8
4.5	Participants	8
4.6	Safety	9
4.7	Equipment under test.....	9
5	TEST SET UP.....	10
5.1	Mechanical interface	10
5.2	Accelerometers.....	10
6	TEST PARAMETERS.....	12
6.1	Test requirements	12
6.2	Test tolerances	13
6.3	Test success criteria	13
7	STEP-BY-STEP TEST PROCEDURE	14
8	GSE	18
9	SPECIAL REMARKS	19
9.1	Anomalies	19
9.2	Test deviations.....	20

1 INTRODUCTION

1.1 Purpose

The aim of this document is to define the vibration test plan and procedure. This test is performed to qualify EPT-HET structural design. The test is conducted on EPT-HET PQM at qualification level and duration.

1.2 Scope

This document applies to all activities related to EPT-HET PQM vibration test campaign performed by all institutions and personnel involved in the test.

2 GLOSARY AND DEFINITIONS

2.1 Acronyms and Abbreviations

CAU	Christian-Albrechts-Universität zu Kiel
CoG	Center of Gravity
EIDA	Experiment Interface Document-Part A
EPD	Energetic Particles Detector
EPT	Electron, Proton Telescope
EUT	Equipment Under Test
HET	High Energy Telescope
MI	Mechanical Interface
MLI	Multi-layer Insulator
Mol	Moment of Inertia
PA	Product Assurance
PQM	Proto-Qualification Model
TBC	To Be Confirmed
TRR	Test Readiness Review
ADS	Airbus Defence & Space

3 APPLICABLE AND REFERENCE DOCUMENTS

3.1 Applicable Documents

ID.	Title	Reference	Iss./Rev.	Date
AD-01	Experiment Interface Document part A	SOL-EST-RCD-0050	5/0	16/03/2015
AD-02	EPT-HET and STEP Assembly, Integration and Test Plan	SO-EPD-KIE-PL-0010	2/1	30/10/2013

3.2 Normative Documents

ID.	Title	Reference	Iss./Rev.	Date
ND-01	Testing	ECSS-E-ST-10-03C		01/06/2012

3.3 Reference Documents

ID.	Title	Reference	Iss./Rev.	Date
RD-01	EPT-HET Structural Analysis Report	SO-EPD-KIE-RP-0040	3/3	23/04/2014
RD-02	Request for Deviation (RFD) for mass properties measurement	SO-EPD-KIE-RD-0001	2/1	06/06/2014
RD-03	Request for Deviation (RFD) for sine-vibration qualification level	SO-EPD-KIE-RD-0002	1/1	21/05/2013
RD-04	Drawing: EPTHET Mechanical Interface Control Drawing EPD_EPTHET_29042014_5-2_SO-EPD-KIE-DR-0001_micd.pdf	SO-EPD-KIE-DR-0001_fm.idw	5/2	29/04/2014
RD-05	Drawing: so_epthet-step_ads-vibetest-adaptor_r01.pdf	ads-vibetest-adaptor	Rev. 01	26/03/2015

4 TEST OVERVIEW

4.1 Test objectives

The objective of the vibration test is to verify the structural design. That is to demonstrate EPT-HET unit will tolerate the induced loads during different mission phases without degradation. The structural requirements and test levels to be verified according to [AD-01] are detailed in section 6.1 of this document. Also, the test results will be compared to the structural analysis report [RD-01].

4.2 Test facility

The vibration tests are conducted in Airbus Defence & Space Test Laboratories in Portsmouth, England.

4.3 Environmental conditions

- Temperature*:
- Relative humidity*:
- Cleanliness: ISO 8 clean room

* Environmental condition to be recorded as-run test performance.

4.4 Test documentation

The approved test procedure will be used during the test to record observations and decisions. A completed test report will be presented after the test. It will include the final as-run test procedure approved by the PA (Product Assurance) responsible and will be accompanied by the accelerometers outputs and test report provided by ADS. Also, appropriate discussion will conclude the success/failure of the conducted test.

4.5 Participants

The test participants and their responsibilities are defined in Table 4-6-1.

Table 4-6-1. Test participants and their responsibilities.

CAU		
#	Name	Responsibility
1	Michael Richards	Quality assurance
2	Shri Kulkarni	Instrument lead
3	Lars Seimetz	Engineering lead
4	Ali Ravanbakhsh	AIVT
ADS (test facility)		
#	Name	Responsibility
1	William Wright	Test conductor

4.6 Safety

ADS facility general safety requirements shall apply during all operations.

Handling, mounting and testing shall be performed by qualified personnel from CAU with support of ADS personnel in accordance with safety requirements of ADS.

4.7 Equipment under test

As seen in Fig. 4-7-1, the EPT and HET sensor heads share a common Ebox. For vibration test, EPT-HET PQM will not be covered by MLI. But, the MLI stand-offs are mounted on EPT-HET PQM for vibration tests.

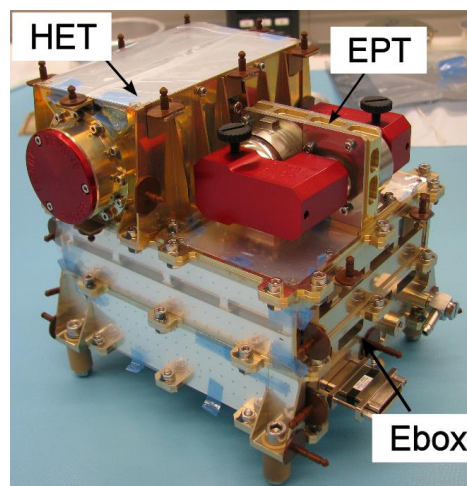


Figure. 4-7-1. EPT-HET PQM.

After the complete assembly of the EPT-HET PQM, its total mass is measured. The other mass properties like CoG and Mol are going to be verified analytically. The RFD, [RD-02], has been submitted for mass properties measurement.

Further information such as exact dimensions etc. can be found in [RD-04].

The EPT-HET PQM will be mounted on the mechanical interface in all of the four instrument feet with the following bolts-nuts-washers:

- Hex socket screw: DIN EN ISO 4762-M5x45-12.9
- Washer: DIN EN ISO 7092-5, 3 Mat:12.9
- Hex nut: DIN EN ISO 4032-M5 Mat:12.9

The torque to be applied is $6.3 \text{ N.m} \pm 0.1$ in order to meet the required preload specification in the flight condition with LN29950 Bolts.

5 TEST SET UP

5.1 Mechanical interface

EIDA R-495: The PI shall ensure that the adaptor shall have a first resonance frequency above 2 kHz in order not to influence the test.

ADS is providing the MI (Mechanical Interface) for vibration test. This test adaptor is shown in Figure 5-1-1. A vibration test (jig test) will be performed on MI in order to verify its characteristics by test before the EUT integration to the MI. Two accelerometers are mounted on MI and an average value will be considered for analysis.

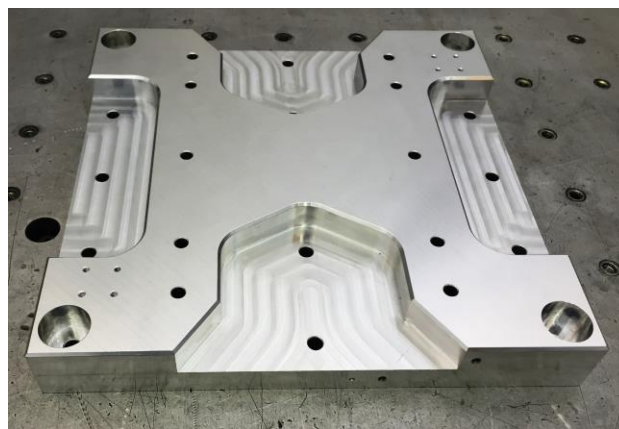


Figure 5-1-1. Mechanical interface for vibration test.

The mechanical interface is mounted on the shaker plate via ten “1/4 UNF” screws with a 7 N.m applied torque. The details of the mechanical interface can be found in [RD-05].

5.2 Accelerometers

ADS uses different types of calibrated 1-axis accelerometers indicated in Table 5-2-1 and their positioning is seen in Figure 5-2-1. Two control accelerometers are used on the MI to measure the frequency input to the EUT.

Table 5-2-1. Accelerometers to be used for EPT-HET PQM vibration test.

	A.1Z	A.2Z	A.3Z	A.4Z	A.5X	A.6Y	A.7X	A.8X	A.9X	A.10Y	A.11Y	A.12Y	A.13Y
Type	2222C 	2222C 	2226C 	2222C 	2222C 	2222C 	2222C 	2226C 	2226C 	2226C 	2226C 	2226C 	2226C 

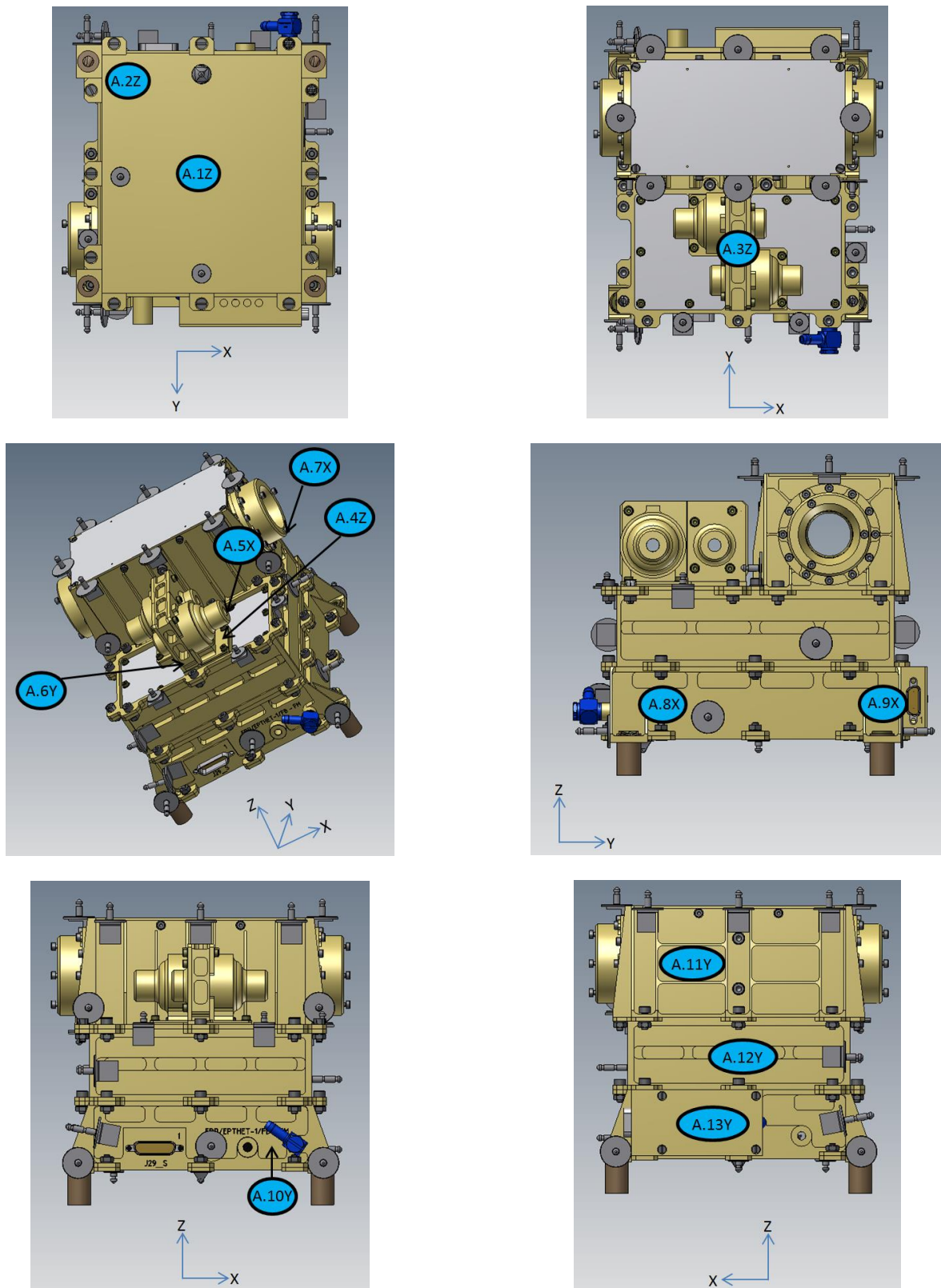


Figure 5-2-1. Accelerometer positioning on the EPT-HET PQM for vibration test.

6 TEST PARAMETERS

6.1 Test requirements

According to [AD-01] the vibration test requirement at qualification level are indicated in Table 6-1-1 and Table 6-1-2.

EIDA R-497: *The PI shall ensure that units mounted on the spacecraft panels are designed to withstand without degradation the sinusoidal environment as defined in table below at unit/structure interface.*

Table 6-1-1: Qualification Levels for Sine Vibration Tests.

Axis	Frequency (Hz)	Qualification
Out of plane	5-20	12 mm*
	20-100	24 g
In plane	5-20	9.9 mm
	20-100	16 g
		2 Oct/min

*[RD-03]

EIDA R-499: *The PI shall ensure that each unit is designed to withstand without degradation the random environment as defined in the table below at unit/structure interface.*

Note: These levels are applicable to units with 0.5 kg <Mass< 3 kg and EPT-HET belongs to this range.

Table 6-1-2: Qualification Levels for Random Vibration Tests.

Axis	Frequency (Hz)	Qualification*
Perpendicular to mounting plane (1 axis)	20-100	+12 dB/Oct
	100-500	1 g ² /Hz
	500-2000	-8 dB/Oct
		26.3 g rms
Parallel to mounting plane**	20-80	+4 dB/Oct
	80-1000	0.1 g ² /Hz
	1000-2000	-3 dB/Oct
		12.8 g rms

*Duration for Qualification is 2 min.

Table 6-1-3: Frequency range and level for Low Sine Sweep Tests.

Axis	Frequency (Hz)	Amplitude
All axis	5-2000	0.5 g 2 Oct/min

6.2 Test tolerances

EIDA R-440: *The PI shall respect the following test tolerances, unless otherwise specified.*

According to **EIDA R-440** the relevant test level tolerances are as below:

Sinusoidal vibration:

- Acceleration, amplitude $\pm 10\%$
- Frequency above 50 Hz $\pm 2\%$

Random vibration:

- Power spectrum density (50 Hz or narrower)
 - 20 to 500 Hz ± 1.5 dB
 - 500 to 2000 Hz ± 3.0 dB
- Overall g rms ± 1.5 dB

6.3 Test success criteria

- ✓ No visual damage.

The visual inspection especially on MLI stand-offs and outer screws.

- ✓ The natural frequencies of the test specimen (up to 2000) Hz shall remain in the same range (considering the $\pm 10\%$ tolerance) in all low sine sweep prior and after each qualification level test.
- ✓ The first natural frequency shall be well-above 140 Hz to ensure compliance with the stiffness requirement:

EIDA R-089: *The PI shall ensure that each instrument unit has all fundamental resonance frequencies above 140 Hz.*

- ✓ The achievement of the correct test level inputs.
- ✓ Successful functional test after the vibration tests.

7 STEP-BY-STEP TEST PROCEDURE

Note:

- During the test, at any circumstances which is suspicious to a total damage/loss of test specimen, ADS has the authority to interfere the mentioned test sequence.
- Before, after and during the test and in different sequences there is the possibility of functional test performance and lower level vibration tests on the EUT which will be included in the as run test report.

Step	Description	Expected result	Date/time	Sign	comment
00	MI (Mechanical Interface) jig test	1 st natural frequency > 2 kHz			
05	Preparation of the test item				
10	Pre-vibration functional test				
15	Preparation of facility instrumentation				
20	Set up the test specimen into the test facility ✓ Mount the accelerometers ✓ Make photos of EUT				
25	Record the environmental conditions				
30	Test set up check				
35	Start test				
40	In plane (X-axis) low sine sweep up to 2000 Hz	1 st natural frequency > 140 Hz			
45	In plane (X-axis) qualification level sine vibration				
50	In plane (X-axis) low sine sweep up to 2000 Hz	1 st natural			

EPT-HET PQM Random-Sine Vibration Test Plan and Procedure

Reference: SO-EPD-KIE-TP-0017
Issue:1 Revision: 1
Date: 17/05/2015
Page: 15 of 20

Step	Description	Expected result	Date/time	Sign	comment
		frequency > 140 Hz			
55	Compare sweep data	< 10% difference in amplitude & frequency			
60	In plane (X-axis) qualification level random vibration				
65	In plane (X-axis) low sine sweep up to 2000 Hz	1 st natural frequency > 140 Hz			
70	Compare sweep data	< 10% difference in amplitude & frequency			
75	In plane (Y-axis) low sine sweep up to 2000 Hz	1 st natural frequency > 140 Hz			
80	In plane (Y-axis) qualification level sine vibration				
85	In plane (Y-axis) low sine sweep up to 2000 Hz	1 st natural frequency > 140 Hz			
90	Compare sweep data	< 10% difference in amplitude & frequency			

EPT-HET PQM Random-Sine Vibration Test Plan and Procedure

Reference: SO-EPD-KIE-TP-0017
Issue:1 Revision: 1
Date: 17/05/2015
Page: 16 of 20

Step	Description	Expected result	Date/time	Sign	comment
95	In plane (Y-axis) qualification level random vibration				
100	In plane (Y-axis) low sine sweep up to 2000 Hz	1 st natural frequency > 140 Hz			
105	Compare sweep data	< 10% difference in amplitude & frequency			
110	Out of plane (Z-axis) low sine sweep up to 2000 Hz	1 st natural frequency > 140 Hz			
115	Out of plane (Z-axis) qualification level sine vibration				
120	Out of plane (Z-axis) low sine sweep up to 2000 Hz	1 st natural frequency > 140 Hz			
125	Compare sweep data	< 10% difference in amplitude & frequency			
130	Out of plane (Z-axis) qualification level random vibration				
135	Out of plane (Z-axis) low sine sweep up to 2000 Hz	1 st natural frequency > 140 Hz			

Step	Description	Expected result	Date/time	Sign	comment
140	Compare sweep data	< 10% difference in amplitude & frequency			
145	Visual inspection and photo documentation				
150	Dismount test set up				
155	Test finish				
160	Connectors electrical connectivity check				
165	Post-vibration functional test				
170	Post-test review with ADS experts				
175	Pack test item				

8 GSE

The complete list of GSE items to be used during the test is indicated in Table 8-1.

Table 8-1: GSE items.

#	Item	Manufacturer	Serial Number	Calibration status
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

9 SPECIAL REMARKS

9.1 Anomalies

Anomalies will be reported in the final approved as-run test procedure as part of the test documentation.

Table 9-1-1: List of anomalies.

#	Anomalous	Comment
1		
2		
3		
4		
5		

9.2 Test deviations

Test deviations will be reported in the final approved as-run test procedure as part of the test documentation.

Table 9-2-1: List of test deviations.

#	Test deviation	Comment
1		
2		
3		
4		
5		