HERSCHEL / PLANCK

Herschel FM Mechanical Tests Specification

H-P-2-ASP-TS-1415

Product Code : 100 000

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1 INTRODUCTION

This document specifies the requirements related to the Mechanical Acceptance tests for the Herschel FM. The purpose of these tests is to establish the acceptance of the FM spacecraft and modules with regard to the specified mechanical environment defined in AD 02, and to verify the good workmanship by comparing the FM behaviour with respect to Tests predictions, and the with respect to STM when relevant. The Levels to be applied and consecutively the notchings would be at acceptance level.

The following tests shall be performed:

- Sine test
- Acoustic test
- Electrical checks
- S/C Switch Off
- Cryostat health checks

The aims of the sine test sequence are to:

- Validate the good workmanship of the FM
- Verify that the first lateral mode is at a frequency higher than 9Hz
- Verify that the first axial mode is at a frequency higher than 31Hz
- Validate the dynamic behaviour of the satellite (frequencies, couplings, internal responses, damping factors).
- Validate the FEM used for the coupled load analyses with the launchers by comparison of these dynamic results with the test predictions.
- Check the electrical state of the S/C remains stable, Cryostat status is healthy before/during/after runs

The aim of the acoustic test is to:

- Validate the good workmanship of the FM
- Check the electrical state of the S/C remains stable, Cryostat status is healthy before/during/after runs

The aims of the Electrical checks are to verify all along sine tests and acoustic tests performance, that a defined number of selected TM parameters, defining the launch configuration as defined in [AD10], does not change during runs.

The aims of the S/C SWITCH OFF test is for safety purpose, to check at least once during the test sequence, that the spacecraft with battery connected, can be completely isolated and put into an un-powered condition.

The aim of the Cryostat health checks are to check behaviour of the cryogenic subsystem.

For ESA information, the following SRS requirements are verified during the tests from VCD output: MISS-015 H/P, SENV-010 H/P, SENV-025 H/P, SENV-030 H/P, SCMD-005 H/P, SCMD-015 H/P, SCMD-035 H/P, SCVE-030 H/P, SCVE-035 H/P, SCVE-070 H/P, SCVE-080 H/P, SMRC-140 H/P.

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

Ref.	*No.*	*Issue/date*	*Title*
AD 1	DCI 10/501 31	Iss.1 Rev.2	DCI
AD 2	H-P-1-ASPI-SP-0030		HERSCHEL / PLANCK ENVIRONMENT AND TESTS REQUIREMENTS
AD 3	H-P-1-ASPI-PL-0055		PA PLAN
AD 4	H-P-1-ASPI-SP-0018		PA REQUIREMENTS FOR SUBCONTRACTORS
AD 5	H-P-1-ASPI-PL-0009		DESIGN AND DEVELOPMENT PLAN
AD 6	H-P-1-ASPI-PL-0225		VERIFICATION PROGRAM PLAN
AD 7	H-P-1-ASP-SP-0008		H-EPLM AIV & HERSCHEL SATELLITE AIT REQUIREMENTS SPECIFICATION
AD 10	H-P-2-ASP-SP-0939		HERSCHEL INTEGRATED SATELLITE TEST SPECIFICATION

2.2 Reference documents

Ref.	*No.*	*Issue/date*	*Title*
RD 1	SCI-PT-IIDA-04624	Iss. 4	Instrument Interface Document, IID Part A
RD 3	H-P-2-ASP-SP-1337	Iss.3	Herschel FM Mechanical Instrumentation
RD 4	H-P-2-ASP-AN-0719	Iss1.	CDR Herschel Dynamic Analysis and Sine Test Prediction Report
RD 5	HP-2-ASED-SP-0014	Iss. 2	Technical Baseline for Herschel Environmental test Facility
RD 8	AEA-S-MA	Iss. 4	Ariane 5 User Manual
RD 9	H-P-2-ASP-SP-1336	Iss. 1	Herschel FM Specification and guidelines for routing of instrumentation harnesses
RD 10	H-P-2-ASP-TN-1271	Iss. 1	Compatibility of XMM Test Adaptor (MTA-A) for HERSCHEL PFM Sine Testing (X AXIS)
RD 11	SCI-PT-RS-05991	Iss. 3.3	System requirement specification
RD 12	SCI-PT-RS-07430		Herschel / Planck Project System AIV Requirements Specification
RD 13	H-P-2-ASP-TS-0997	Issue 01	HERSCHEL FM TV/TB SPECIFICATION
RD 14	H-P-1-ASP-TS-0892	Issue 01	Simulation Liquid Filling and Pressurization
RD 15	ETS/REP/MECH/1693	10 MARCH 2006	HERSCHEL S/C STM ACOUSTIC NOISE TEST FACILITY DATA REPORT
RD 16	HP-2-ASED-TN-0130		HTT Filling Level for STM Sine Vibration Test
RD 17	HP-ASP-MN-7411		TRR for Herschel Acoustic Noise Test
RD 18	HP-2-ASED-TP-0099	ISSUE 2/0	Herschel Cryostat SFT Procedure
RD 19	HP-2-ASED-PR-0099	ISSUE 1/0	Herschel FM S/C Accelerometer Instrumentation Procedure
RD 20	HP-2-ASED-TN-0130	ISSUE 1/0	HTT Filling Level for STM sine Vibration Test
RD 21	H-P-2-ASP-TS-1083	Issue 2/0	Test Specification for Herschel Instruments AVM and FM tests performed at satellite level
RD 22	AE/DC/SC/CR-07-100		HERSCHEL PLANCK MECHANICAL ENVIRONMENT MEETING

3 ORGANISATION AND RESPONSIBILITIES

3.1 General

The responsibility is shared between Thales Alenia Space-F and EADS-astrium as follows:

- Thales Alenia Space-F
  - Test lead,
  - Test specification
  - Interface with launcher authority,
  - Test prediction & evaluation

- EADS-astrium
  - Test management (daily meeting, key points),
  - Spacecraft mechanical assembly and checkouts,
  - Dedicated GSE installation / validations and use,
  - interface between the Satellite and the test facility,
  - Instrumentation installation,
  - Test Procedures,
  - Test Executions,
  - Test Reports,
  - Support for test evaluation regarding H-EPLM, excluding Telescope and Instruments.

All parties furnish tests technicians and the applicable equipment and hardware of their responsibility.

In addition Alenia shall provide a support for test evaluation regarding SVM. ESA shall provide a support for test evaluation regarding instruments, CFE, and Telescope. ASEF shall provide following support regarding Herschel Telescope during the Mechanical tests:

- Engineering support necessary for tests evaluation at ESTEC, and definition of levels for sine
- Telescope inspection before and after the tests

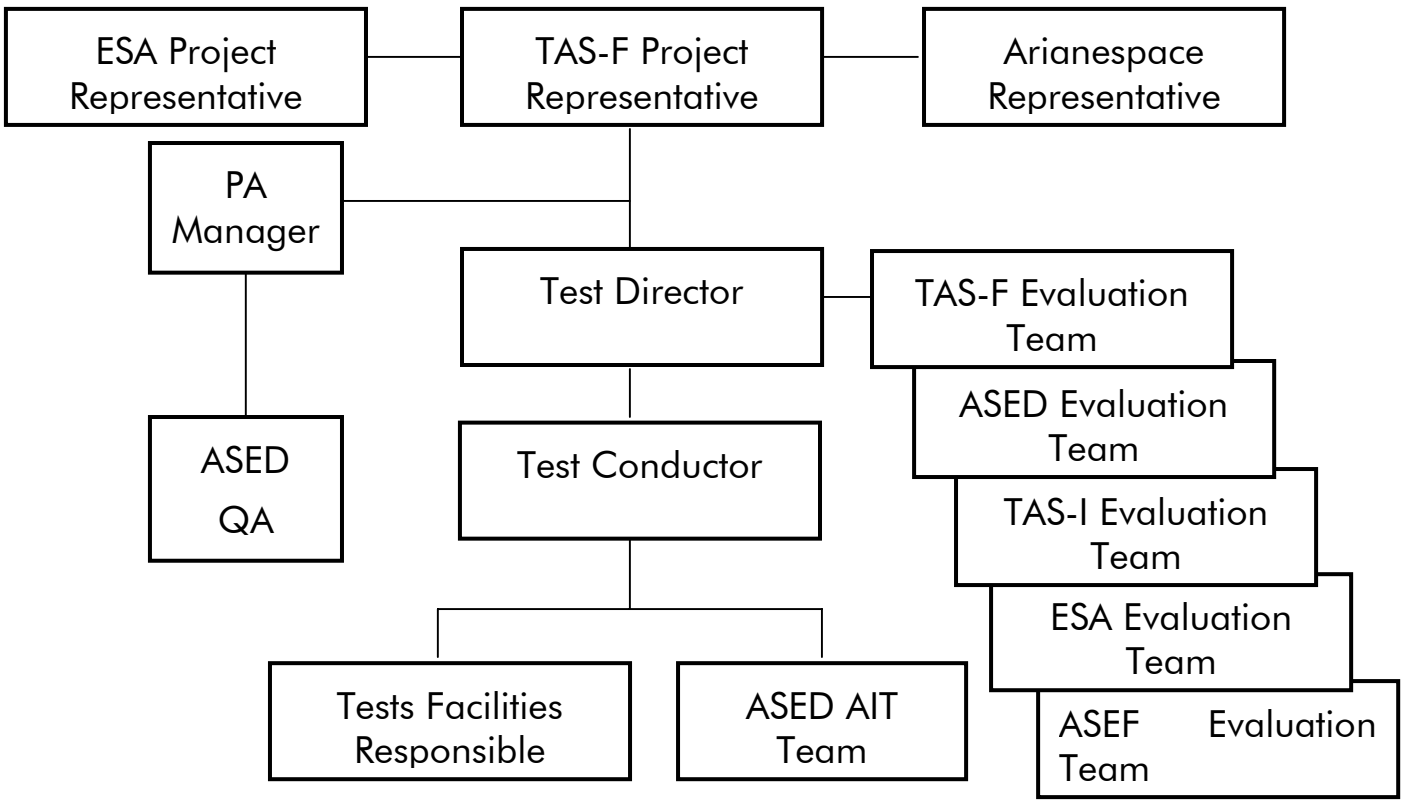
Arianespace representative shall be present to concur in real time to applied notch levels.

3.2 Organisation for Sine, and Acoustic

The Thales Alenia Space project representative will co-ordinate all the tests defined in this document. In addition to above, the overall organization during the test is as follows:

Mechanical Tests Organization

The tasks definition and responsibility during the test are defined here-after. The responsibilities linked to the test progress shall be mentioned in the EADS-astrium test leading procedure.



Title	**Tasks/Responsibility**
ESA Representative	➢ ESA project point of contact ➢ I/F with ESA evaluation team regarding instruments ➢ Approve the test strategy form including the definition of input/notch/limiter for next run
TAS-F Representative	➢ TAS-F project point of contact ➢ I/F with TAS-F Test Director, and Engineering leader ➢ I/F with ESA project representative ➢ I/F with Arianespace representative ➢ Approve the test strategy form including the definition of input/notch/limiter for next run
PA Manager	➢ TAS-F PA point of contact ➢ Manage all NCR raised in the frame of the test campaign ➢ I/F with ESA PA ➢ I/F with EADS-astrium QA ➢ Organization of TRR and running meetings in cooperation/ timing with Tests Director / Conductor and Engineering leader
Test Director	➢ Interface with ESA ➢ Interface with instruments (through ESA) ➢ Coordination of the issuing of the test specifications ➢ Convergence meetings to complete the review loop up to formal approval by ESA of test specifications ➢ Organization of "check-point" meetings for tests preparation ➢ Approval of the Test Procedures for the tests ➢ Report Verification (VCD) to Engineering Team ➢ Support to NCR's review and closure ➢ Issuing the test evaluation report ➢ Organization of TRB to present main outcomes of the test and achievement of all test objectives
Test Conductor	➢ Interface with test facilities ➢ Coordination of the issuing of the test procedures ➢ status of procedures ➢ H/W and S/W status ➢ Facility status ➢ test conduction ➢ Iissuing the test report

Title	Tasks/Responsibility
TAS-F Mechanical Team TAS-F Engineering leader and TAS-F Evaluation Team	➢ Issuing/contributing to the test specifications ➢ Contribution to the test procedure (per procedure check-points decisions) ➢ Test evaluation reports ➢ Support to verification activities (VCD) <u>During the test campaign</u> ➢ Technical Responsible and Technical Interface with Arianespace ➢ Follow-on of the tests ➢ Coordination of mechanical evaluation teams ➢ Define the test strategy form including the definition of input/notch/limiter for next run for approval by all parties involved in evaluation team ➢ Approve the final test strategy and provide to test Conductor ➢ Check and approve the feed-back strategy sheet from the tests facilities ➢ Gives the go-ahead for next steps wrt mechanical aspects ➢ Technical reporting during daily meetings and PTR ➢ Supporting NCR investigation for closure proposal
TAS-F Electrical team	➢ Issuing/contributing to the test specifications for electrical aspects ➢ Contribution to the test procedure (per procedure check-points decisions) ➢ Test evaluation reports ➢ Support to verification activities (VCD) ➢ Gives the go-ahead for next steps wrt electrical aspects ➢ Technical reporting during daily meetings and PTR ➢ Supporting NCR investigation for closure proposal
TAS-I/ASED/ESA Evaluation Team All disciplines	➢ Evaluate the test data in order to help the TAS-F Engineering leader concerning the "key point" status
Mechanical specific	➢ Propose a test strategy for respectively SVM/H-EPLM/ instruments with FPU's particularly, and CFE with Telescope particularly including the definition of input/notch/limiter for next run
EADS-astrium AIT Team All disciplines	➢ Issuing/contributing the test procedures ➢ Executing the tests ➢ performing the NCR investigations defined in NRB ➢ Issuing the test data and reports for engineering evaluations (tests and NCR)

EADS-astrium QA	➢ Management of the quality of operations and hardware ➢ Organise the review (TRR/PTR…) ➢ Minute the running meeting (Key point)
Test Facility Responsible	➢ Operate the Test facilities ➢ Provide blank test results prior to test ➢ Report the calibration status ➢ Confirm instrumentation location ➢ Provide the test data for online evaluation ➢ Issue facility report /calibration status

3.3 Test Readiness Review and Running meeting

The people involved in TRR and running meetings (PTR and Interim PTR's) shall be at least:

- ESA Representative, and ESA Engineering team representative,
- PA Manager
- Test Director,
- Test Conductor,
- Arianespace Representative when relevant,
- Engineering leaders and Evaluation Team representative,
- Test Facility representative.

During running meeting, evaluation of test results shall be presented by TAS-F Engineering leader, as well as the test strategy form for next run approved by all parties for mechanical tests.

4 HERSCHEL FM CONFIGURATION

4.1 Tested model description

4.1.1 General description

Herschel model submitted to mechanical Acceptance tests is the FM model as close as possible from Launch configuration. The first table defines deviations for Mechanical tests configuration (sine, acoustic), and associated checks (electrical, Cryostat health). The second table defines specific configuration aspects for S/C Switch-OFF test.

Mechanical tests and associated checks:

Deviations	H-FM Mechanical testing	H-FM at Launch
Mechanical Instrumentation	Instrumentation with flight and vacuum type accelerometers (ACC). ACC cables are connected to acquisition bay via extension cables. See RD19. Mass difference TB traced.	Instrumentation with flight type accelerometers (ACC), and possibly some vacuum type remain. Extension cables removed. ACC cables ends are terminated and grounded to structure. See RD19 §4.3.10.
Thermal Instrumentation	Mechanical is before Thermal testing: Instrumentation (heaters and thermo-couples (TC's)) is connected to spin box via long length cables. Mechanical is after Thermal testing: same configuration as Launch.	Most of Instrumentation remains (some TC's may be removed). Cables are cut, and ends terminated and grounded to structure.
Electrical parameters	TM rate = 150 kbps	TM rate = 5 kbps
Electrical connections	The S/C is connected to the Power SCOE, TM/TC DFE and Cryo COTE through the umbilical plugs (see section 8.1.1). This has no impact on mechanical testing.	The S/C is connected to the launcher through the umbilical plugs.
S/W	Flight version, or anterior version. No-influent on testing. All S/W version are compatible with Electrical checks, Cryostat health checks.	Flight version.
RCS S/S filling	P.Tank filled 100% with de- mineralized water. No impact on Mechanical testing.	P.Tank filled 100% with Hydrazine.
He S/S filling	HTT is filled HeI. Filling ratio is according §4.1.2. Impact on Mechanical testing is assessed in RD20.	HTT is filled HeII. Filling ratio is according 98% min.
Cryostat valves	V104 opened. V501 and V503 opened, V103 and V106 closed. SV 121 covered by catching device.	V104 is closed. V503 and 506 will be opened at H0 (EPC ignition command) + 50 s, V103 and 106 opened at H0+1240 s. SV 121 not covered.
He exhaust	Big nozzles removed, small nozzles blind flanged exhaust through A-frame.	Exhaust through big nozzles interface.
Red tags	None.	None.
Green tags	Safety caps.(TBC).	Arm plugs.

S/C Switch-OFF test.
FM model configuration for S/C Switch-OFF test is identical to Mechanical test configuration with following differences.

Deviations	**S/C Switch-OFF**	**H-FM Mechanical testing**
Mechanical Instrumentation	Instrumentation status is non-influent.	Instrumentation with flight and vacuum type accelerometers (ACC). ACC cables are connected to acquisition bay via extension cables. See RD19. Mass difference TB traced.
Thermal Instrumentation	Instrumentation status is non-influent.	Mechanical is before Thermal testing: Instrumentation (heaters and thermo-couples (TC's)) is connected to spin box via long length cables. Mechanical is after Thermal testing: same configuration as Launch.
Electrical parameters	S/C OFF, battery connected.	S/C ON, powered by power SCOE through the umbilical plugs.
S/W	Flight version, or anterior version. Non-influent on testing. All S/W version are compatible with S/C switch-OFF.	Flight version, or anterior version.
RCS S/S filling	P.Tank filling is non-influent	P.Tank filled 100% with de- mineralized water. No impact on Mechanical testing.
He S/S filling	He S/S filling is non-influent	HTT is filled HeI. Filling ratio is according §4.1.2. Impact on Mechanical testing is assessed in RD20.
Cryostat valves	Cryostat valves status is non-influent. Safe mode status is recommended.	V104 opened. V501 and V503 opened, V103 and V106 closed. SV 121 covered by catching device.
Red tags	Red tags installation recommended.	None.

4.1.2 Specific description for Mechanical tests

Skin connector and umbilical plug configuration described in section 8.1.1.

RCS Tank filling
The RCS tanks are filled with simulator liquid (de-mineralized water). The RCS tanks will be filled with 128 kg of de-ionized water each (Refer to [RD 14].

Cryostat filling
The Cryostat is in He1 condition.

The Helium state shall be He I. The Helium filling ratio is defined as follows for sine test and acoustic:

	Required HTT Helium fill level [%]	
Sine Test (Refer to [RD 16])	Intermediate Level Runs & Acceptance Level Runs	Signature Level Runs & Low Level Runs
X-axis	98% max, 95% min	- deviation from relevant acceptance run shall be less than 2% - difference between Pre- and Post Low Level runs per axis shall be less than 4 %
Y-axis	95% max, 80% min	
Z-axis	95% max, 80% min	
Acoustic Test (Refer to [RD 17])	95% max, 70% min	

Estimated mass
Estimated S/C Mass = 3425 kg.

S/C Cog is X=1.97m, CoG distance to satellite X-axis= -15 mm along Y-axis / +0 mm along Z-axis.

The mass of the test specimen must be known within 2% by measurement on S/C level using the crane scale.

Nota: AIT responsible (ASED) shall provide the mass of instrumentation and harness implemented on the S/C in order to take into account the mass difference between test predictions and tested model to identify eventual differences in dynamical behavior.

Clampband configuration

Satellite is tested with nominal clampband tension (40 kN). The clampband to be used is XMM Test clampband S/N03.

4.2 Test instrumentation

The H-PLM, Telescope and SVM Test instrumentations are defined in the Instrumentation plan (Refer to the document [RD3]).

4.2.1 Units switching status in Launch phase (Case C4)

The following table shows the switching ON status of the Herschel switchable units during the launch (from Check-Out Test Equipment disconnection up to satellite separation from launcher, according to SOFDIR GEF-004-C in SOFDIR). System Mode is Launch Mode (LAM) and ACMS Mode is Stand By Mode (SBM).

Sub-System	Launch HERSCHEL
CDMS	
	CDMU
ACMS	
	ACC
	GYR
	CRS 1
	CRS 2
TTC	
	XPND1
	XPND2
	TWTA
PCS	
	Battery
	PCDU
RCS	
	Pressure transducer
	LV-A
	LV-B
	20 N Branch A Thrusters (beds heaters)
	20 N Branch B Thrusters (beds heaters)
PACS Instruments	
	Heaters
Thermal Control	
	LPU
Herschel EPLM	
	CCU

5 GENERAL TEST CONFIGURATION

The Mechanical tests shall be performed in the following order: Sine, and Acoustic tests. Associated tests, Electrical checks and Cryostat health checks are to be performed on the specimen in parallel to mechanical al testing. The S/C Switch-ON test is to be performed at any time in-between and outside Mechanical tests performance runs.

5.1 Test configuration

5.1.1 Mechanical tests

- The test and recording facilities are these of ETS (Noordwijk, The Netherlands) dynamics laboratory.
- For Sine, the tested model is mounted on a rigid vibration test adapter. The assembly shall be mounted on the vibration shaker.
- The FMD (Force Measuring Device) is to be used for lateral axis, and axial axis. Deviations shall be approved by the Prime.
- For acoustic, the tested model is mounted on a dolly with bladders from XMM to be provided by ESA as for STM.

5.1.2 Electrical checks

The test model is in Mechanical test configuration, during which it is performed (sine or acoustic). The test model is connected to Power SCOE, TM/TC Data Front End, and Cryo COTE via the two umbilical plugs.

5.1.3 Cryostat Health checks

The test model is in Mechanical test configuration, during which it is performed (sine or acoustic). The test model is connected via TM.

5.1.4 S/C Swith-OFF test

The test model can be in Mechanical test configuration, before which or after which it is performed (sine or acoustic). It can be different than mechanical configuration, with S/C on trolley as an example during transfer phase. The test model shall be inj secure configuration on-ground. The test model is connected to Power SCOE via the two umbilical plug.

5.1.5 GSE List

The following table provides the list of specific GSE used on one hand for FM Mechanical tests, including electrical checks and Cryostat heath checks, and on the other hand for S/C Switch-OFF.

GSE List	sine	acoustic	S/C switch-OFF	
Mechanical	X		X	FMD (Force Measurement Device)
	X			VAS (Herschel vibration test adapter)
	X	X	X	XMM Test CB S/N 03
			X	XMM Handling CB S/N 1
		X	X	XMM bladder
Electrical	X	X	X	Power SCOE
	X	X		TM/TC DFE
	X	X		Cryo.COTE

5.2 Environmental conditions

The following environmental conditions have to be applied during tests (see [AD 02]) :

- Temperature : 22° ± 3°
- Humidity : 55 ± 10%
- Pressure : 970 to 1050 mbar
- Cleanliness : Class 100 000 or better

These environmental conditions shall be controlled and recorded.

5.3 Test accuracy

The following accuracy shall be guarantied:

Sine Vibrations:

Acceleration / Amplitude : 0% / +5%

Frequencies below 50Hz : +/- 0.5Hz

Frequencies above 50 Hz :+/-2%

Acoustic vibrations:

Microphone level : ± 0.5 dB

Acoustic test time : ± 1 s.

Field homogeneity in test volume : ± 2 dBL

Control tolerance of sound field : ± 1.5 dBL overall

Power spectral density (accelerometers and strain gauges) :

± 1.5 dB from 20 to 300 Hz

± 3 dB from 300 to 2000 Hz.

6 SINE VIBRATION TESTS

6.1 Force Measuring Device

As for the STM Sine test campaign, the Force Measuring Device (FMD), to be provided by ETS, shall be used during sine test to evaluate force and moments at the I/F of the satellite under sine environment.

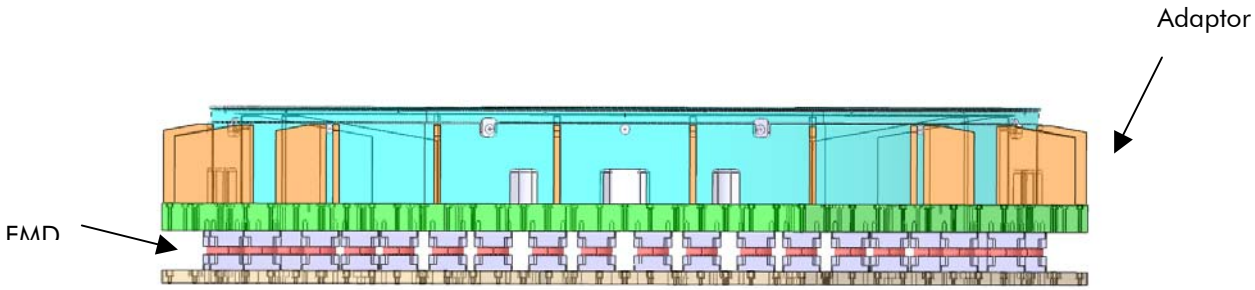


Figure 1: FMD sketch

The following channels shall be monitored:

FxSC	Axial Force X I/F Spacecraft
FySC	Lateral Force Y I/F Spacecraft
FzSC	Lateral Force Z I/F Spacecraft
MxSC	Axial Moment X I/F Spacecraft
MySC	Lateral Moment Y I/F Spacecraft
MzSC	Lateral Moment Z I/F Spacecraft

6.2 Levels to be applied

The sine tests include on 3 satellite axis:

① One low level sine scan for frequency search with application of automatic notching.
② One intermediate level run, with application of notchings defined after the low level.
③ One acceptance level run with notching.
④ One check out low level run.

6.3 Test levels

6.3.1 Low level sine test

The input at the S/C I/F shall be (with the estimated automatic notching levels divided by 2 of the acceptance level, for safety reasons) according to STM sequence :

Low Level Tests		
AXIS	Frequency Range	Base Input Level
axial X	5 – 35 Hz	0.1 g (*)
	35 – 50 Hz	0.05 g (*)
	50 – 100 Hz	0.1 g (*)
	100 – 150 Hz	0.05 g (*)
Lateral Y, Z	5 – 21 Hz	0.06 g (*)
	21 – 100 Hz	0.1 g (*)
	100 – 150 Hz	0.05 g (*)
Sweep Rate :	2 oct. / min	

(*) Inputs for low level test shall be confirmed after the blank test

Manual notch between 35 Hz and 50 Hz is considered to protect Telescope.

6.3.2 Intermediate level run

These tests shall be performed with the acceptance levels divided by 2 with the notching procedure defined after the low level run (with the estimated automatic notching levels divided by 2 of the acceptance level) Manual notches may be introduced additionally to safeguard the S/C.

Intermediate level tests		
AXIS	Frequency Range	Base Input level
axial X	4 - 5 Hz	5.0 mm
	5 - 100 Hz	0.5 g
lateral Y, Z	2 – 5 Hz	4.0 mm
	5 - 25 Hz	0.4 g
	25 - 100 Hz	0.3 g
Sweep Rate :	4 oct / min	

6.3.3 Acceptance level run

These tests shall be performed with the acceptance levels defined in AD 1with the notching procedure defined after the low level run and checked after the intermediate level.

Acceptance level tests		
AXIS	Frequency Range	Base Input level
axial X	4 - 5 Hz	9.9 mm
	5 - 100 Hz	1 g
lateral Y, Z	4 – 5 Hz	8 mm
	5 - 25 Hz	0.8 g
	25 - 100 Hz	0.6 g
Sweep Rate :	4 oct / min	

6.4 Piloting requirements

The specifications of rigid adapter and piloting quality lead to the following requirements:

- All of the tested model fixing points on the adapter have to vibrate :
  - parallel to the excitation axis
  - in phase
  - with homogeneous levels (amplitude 10 %)

  ⎫ in all frequency range

- Cross- coupling shall be considered in the selection of test facilities. Normally, significant cross coupling is not acceptable on the S/C main critical frequencies (see Table below). Impact on the test will be evaluated after the low level runs. Unacceptable levels of cross coupling may lead to a decision to change the shaker to a pre-defined back-up.

MODE	HERSCHEL FREQUENCY
FIRST GLOBAL LATERAL Z	**15 Hz**
First global lateral Y	**16 Hz**
First global longitudinal X	**40 Hz**
Telescope mode X	**43 Hz**
First global torsion X mode	**26 Hz**
Second lateral Z mode	**28 Hz**
Second lateral Y mode	**28 Hz**
PLM X mode	**72 Hz**

For the instrumented fixation points, cross coupling measured levels have to be monitored and shall be compared to the excitation axis.

- Based on these previous requirements, piloting shall be performed on the **maximum** of the 4 pilots on the excitation axis.

6.5 Notching procedure

Notching shall be defined in order not to exceed the subsystems/units acceptance levels. The final tests notching shall be determined by TAS-F evaluation team with support of ASED/TAS-I/ESA teams after low level and intermediate level for each excitation axis, taking into account the test facilities capability:

- Number of available channels
- Limitation of the input

The notchings shall be defined after the final S/C sine predictions and CLA exploitation.

The notching shall be agreed by ESA. / launcher authority

These notchings shall be described in the test report and justified in the evaluation test report.

6.6 Sine test sequence

6.6.1 Pre-test operations

- Blank test
- Control and register of the accelerometers positions and orientations (pictures and positions in Satellite Coordinate System). To be validated by TAS-F.
- Visual external control before tests.
- Electrical checks.
- Cryostat Health checks.

6.6.2 Sine Vibration tests

① Low level pre-run

This test is performed on Herschel FM in order to check the Satellite dynamic behaviour. Test results are required for test evaluation prior to the intermediate level test.

② Intermediate level run

This test enable to foresee the FM levels for the acceptance level test and to determine notching. Test results are required for test evaluation prior to the acceptance level test.

③ Acceptance level test

This test is performed at acceptance level, on basis of STM levels divided by 1.25, with notch correction defined after the low level run and intermediate level run.

④ Check out low level run

This test enables to check the good dynamic behavior of Herschel FM after the acceptance test by comparison with Low level pre-run (allows to identify structural failures).

6.6.3 Post-test operations

- Visual external control after tests.
- Delivery to TAS-F Test Director of the subsystems/units and interface acceleration levels for each test.
- Delivery to TAS-F Test Director of the subsystems/units TM parameters for each test.
  - Electrical checks.
  - Cryostat Health checks.

6.7 Equipment, Instruments and Telescope allowable

6.7.1 General rule

The max acceptance test allowable are defined as equipment qualification test allowable / 1.25, as used during STM testing or derived from STM testing when relevant. During the test, the equipment levels shall not exceed the equipment qualification test allowable.

As a general rule, CFE and Instruments notch are to be managed TAS-F/ESA at CFE and Instruments levels and by ASED/TAS-I at modules Interfaces levels.

6.7.2 Instruments allowable

TBD ESA.

6.7.3 Telescope allowable

TBD ESA.

7 ACOUSTIC TESTS

7.1 Levels to be applied

The acoustic tests sequence include:

① One acoustic low level for frequency search.

② One intermediate acoustic level run.

③ One acceptance acoustic level run.

④ One check out low level run.

7.2 Acoustic test levels

7.2.1 Low level acoustic test

This test shall be performed with the acoustic low level (acceptance level - 8 dB) duration 30 sec

7.2.2 Intermediate acoustic level run

This test shall be performed with the acoustic acceptance level - 4 dB duration 30 sec

7.2.3 Acceptance acoustic level run

THESE TESTS SHALL BE PERFORMED WITH THE FOLLOWING ACCEPTANCE ACOUSTIC LEVELS [AD 1]

Acceptance level test		
OCTAVE BAND CENTRE FREQUENCY (Hz)	**ACCEPTANCE LEVEL (dB) Ref.: 0 dB = 2.10^{-5} Pa**	**TEST TOLERANCE (dB)**
31.5	128dB	-2, +4
63	131dB	-1, +3
125	136dB	-1, +3
250	133dB	-1, +3
500	129dB	-1, +3
1000	123dB	-1, +3
2000	116dB	-1, +3
Integrated level	139.5dB	-1, +3
Test duration :	1 min	

7.2.4 Check out low level acoustic test

This test shall be performed with the acoustic low level (acceptance level - 8 dB) and compared to the first low level test.

7.3 Test piloting

9 omnidirectional microphones shall be laid around the flight model in order to check and pilot the noise levels of the acoustic environment.

The average level of these 9 microphones is the basis for the tolerance check in each octave band.

The test measurements shall be performed at a minimum distance of 1 m from the spacecraft.

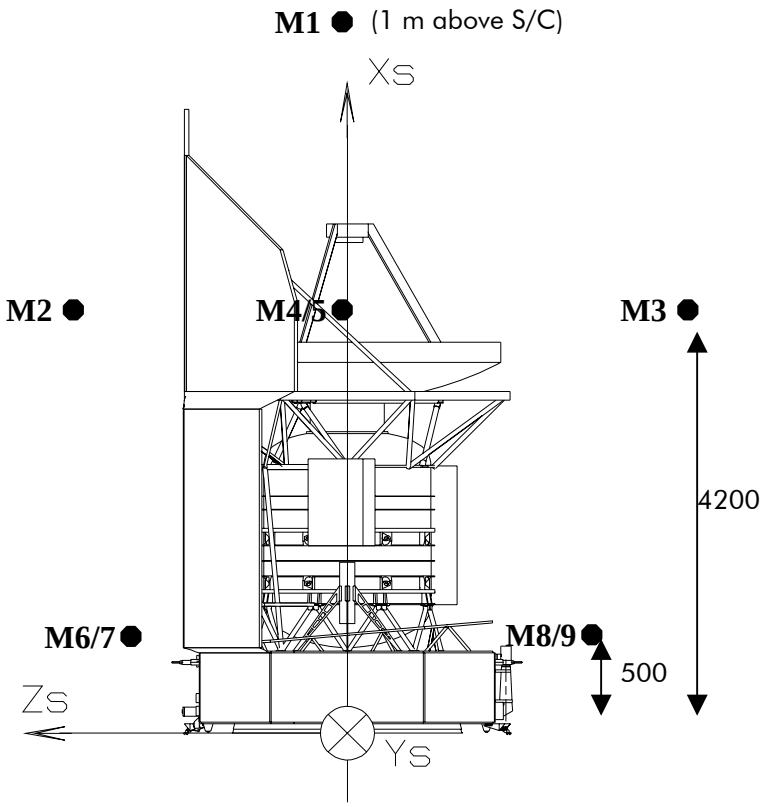


Figure 2 : Acoustic test configuration

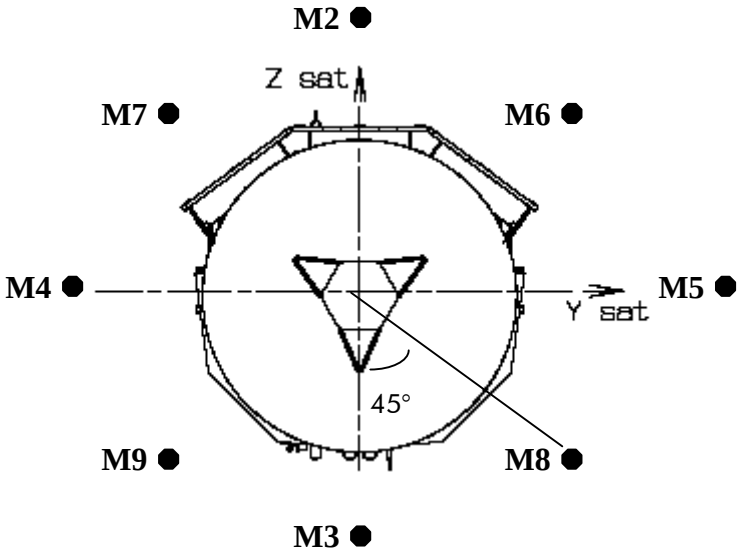


Figure 3 : Acoustic test configuration

7.4 Acoustic sequence

7.4.1 Pre-test operations

- Blank test
- Control and register of the accelerometers positions (pictures and positions in Satellite Coordinate System)
- Visual external control before tests
- Verification of accelerometers and strain gauges
- Location and orientation with respect to acoustic chamber walls as on STM (Refer to [RD 15]).
- Electrical checks.
- Cryostat Health checks.

7.4.2 Acoustic tests

① Low level acoustic test see § 7.2

This test enables to check the test item dynamic behaviour under acoustic loads

② Intermediate level run see § 7.2

③ Acceptance level test. see § 6.2

④ Low level run see § 7.2

This test enables to check the good dynamic behaviour of test item after the acceptance test by comparison with ① (allows to identify structural failures).

7.4.3 Post-test operations

- Visual external control after tests
- Delivery to TAS-F Test Director of the subsystems/units PSD levels for each test
  - Electrical checks.
  - Cryostat Health checks.

8 ELECTRICAL CHECKS

8.1 Nominal checks before, during and after runs

During the mechanical test sequence, Herschel electrical checks shall be performed:

- Before the first sine test,
- After each sine run,
- After each switch ON.

8.1.1 Electrical connections to the EGSEs:

8.1.1.1 Overall EGSE configuration

During the vibrations, Herschel shall be connected through the two umbilical plugs to:

- Power SCOE, to provide power to the S/C,
- TM/TC Data Front End, to send TC and download TM,
- Cryo COTE, to monitor the He I level.

The CCS shall be able to monitor the spacecraft.

8.1.1.2 Umbilical plug configuration

During vibrations, the umbilical plug connection shall be in accordance with the following pin allocation:

Nominal Connector	**#**	**To**
From GSE:		
Shielding COTE Harness	1	SVM
+28V Aux IN 1	29	SVM
+28V Aux IN 2	50	SVM
+28V Aux IN 3	28	SVM
+28V Aux IN 1 RTN	49	SVM
+28V Aux IN 2 RTN	30	SVM
+28V Aux IN 3 RTN	51	SVM
+28V Monitoring1	40	SVM
+28V Monitoring1 RTN	41	SVM
TC Clock +	36	SVM
TC Clock -	19	SVM
TC Data +	35	SVM
TC Data -	18	SVM
TC Squelch +	34	SVM
TC Squelch -	17	SVM
TM Clock +	33	SVM
TM Clock -	32	SVM
TM Data +	31	SVM
TM Data -	52	SVM
Charge Array Disable link	8	SVM
Charge Array Disable link RTN	9	SVM
GHe Exhaust 650W Heater	55	HPLM
GHe Exhaust 650W Heater	56	HPLM
GHe Exhaust 650W Heater RTN	53	HPLM
GHe Exhaust 650W Heater RTN	54	HPLM
HOT heater H701 Nom	15	HPLM
HOT heater Nom H701 RTN	16	HPLM
LHe Level Sensor Signal	23	HPLM
LHe Level Sensor Signal RTN	42	HPLM
LHe Level Sensor Power	3	HPLM

Redundant Connector	**#**	**To**
From GSE:		
Shielding COTE Harness	1	SVM
+28V Aux IN 4	29	SVM
+28V Aux IN 5	50	SVM
+28V Aux IN 6	28	SVM
+28V Aux IN 4 RTN	49	SVM
+28V Aux IN 5 RTN	30	SVM
+28V Aux IN 6 RTN	51	SVM
+28V Monitoring1	40	SVM
+28V Monitoring1 RTN	41	SVM
TC Clock +	36	SVM
TC Clock -	19	SVM
TC Data +	35	SVM
TC Data -	18	SVM
TC Squelch +	34	SVM
TC Squelch -	17	SVM
TM Clock +	33	SVM
TM Clock -	32	SVM
TM Data +	31	SVM
TM Data -	52	SVM
Charge Array Disable link	8	SVM
Charge Array Disable link RTN	9	SVM
GHe Exhaust 650W Heater	55	HPLM
GHe Exhaust 650W Heater	56	HPLM
GHe Exhaust 650W Heater RTN	53	HPLM
GHe Exhaust 650W Heater RTN	54	HPLM
HOT heater H702 Nom	15	HPLM
HOT heater Nom H702 RTN	16	HPLM
LHe Level Sensor Signal	23	HPLM
LHe Level Sensor Signal RTN	42	HPLM
LHe Level Sensor Power	3	HPLM

LHe Level Sensor Power RTN	10	HPLM
V105 Close	11	HPLM
V105 Close RTN	24	HPLM
HOT outlet valve V701	4	HPLM
HOT outlet valve V701 RTN	12	HPLM
Temperature sensor T502	58	HPLM
Temperature sensor T502 RTN	59	HPLM
From Launcher:		
Shielding	6	
Dry Loop Command 1N	20	
Dry Loop Command 1N RTN	39	
Dry Loop Command 2N	37	
Dry Loop Command 2N RTN	38	
Dry Loop Command 3N	60	
Dry Loop Command 3N RTN	61	
Dry Loop Command 4N	43	
Dry Loop Command 4N RTN	44	
Separation Strap 1	13	
Separation Strap 1 RTN	27	
Separation Strap 2	47	
Separation Strap 2 RTN	48	
Separation Strap 5	21	
Separation Strap 5 RTN	22	
Separation Strap 6	25	
Separation Strap 6 RTN	26	
Spare Pins: **2, 5, 7, 14, 45, 46, 47**		

LHe Level Sensor Power RTN	10	HPLM
HOT inlet valve V702	4	HPLM
HOT inlet valve V702 RTN	12	HPLM
Temperature sensor T502	58	HPLM
Temperature sensor T502 RTN	59	HPLM
From Launcher:		
Shielding	6	
Dry Loop Command 1R	20	
Dry Loop Command 1R RTN	39	
Dry Loop Command 2R	37	
Dry Loop Command 2R RTN	38	
Dry Loop Command 3R	60	
Dry Loop Command 3R RTN	61	
Dry Loop Command 4R	43	
Dry Loop Command 4R RTN	44	
Separation Strap 3	13	
Separation Strap 3 RTN	27	
Separation Strap 4	47	
Separation Strap 4 RTN	48	
Separation Strap 7	21	
Separation Strap 7 RTN	22	
Separation Strap 8	25	
Separation Strap 8 RTN	26	
Spare Pins: **2, 5, 7, 14, 45, 46, 47**		

8.1.1.3 Skin connector configuration

During vibrations, the configuration of the skin connectors shall be as defined in the following table:

Skin connector plate	Connector	Description	Configuration
SK01B	J09	Battery-PCDU Power	Flight plug
	J10	Battery-PCDU Power	Flight plug
	J11	BDR1 ON/OFF Command	Flight cap
	J12	BDR2 ON/OFF Command	Flight cap
SK02	J01	1553 Bus A	Flight Plug
	J02	1553 Bus B	Flight Plug
	J03	1553 Bus A	Flight Plug
	J04	1553 Bus B	Flight Plug
	J05	Thruster commands	Not connected
	J06	Thruster commands	Not connected
	J07	Pressure transducer & Tank thermistors	Flight plug
	J08	LV status and Thruster thermocouples	Flight plug
	J09	Quick load	Flight plug
	J10	Quick load	Flight plug
	J11	LV status and Thruster thermocouples	Flight plug
	J12	Thruster heaters	Flight plug
	J13	Thruster heaters	Flight plug
	J14	STR1 commands & status	Flight plug
	J15	STR2 commands & status	Flight plug
	J16	GYR A Commands	Flight plug
	J17	GYR B Commands	Flight plug
SK04	J01	RWL 1 Commands & TM	Flight plug
	J02	RWL 2 Commands & TM	Flight plug
	J03	RWL 3 Commands & TM	Flight plug
	J04	RWL 4 Commands & TM	

SK05	J01	CRS1 Outputs	Flight plug
	J02	CRS2 Outputs	Flight plug
	J03	GYR Serial Test	Flight cap
	J05	AAD Outputs	Flight plug
	J06	SAS1 & 2 Outputs	Flight plug
	J07	SAS1 & 2 Outputs	Flight plug
	J08	AAD Outputs	Flight plug
	J04	CRS Stimuli	Flight cap
SK03	J01	Aux TC Inputs	Flight plug
	J02	Aux TC Inputs	Flight plug
SK06	J01	STR1 stimuli	Flight cap
	J02	STR2 Stimuli	Flight cap
SK01A	J04	Battery connector	Not connected

8.1.2 Switch ON and OFF

Herschel shall be:

- switched ON: before the first sine test,
- switched OFF: before each physical change of the test configuration, but after TM is evaluated by the engineering team,
- switched ON: after each physical change of the test configuration, just before the next run.

Herschel shall be switched ON in launch configuration according to [AD10], sections 5.8.2.4.2 to 5.8.2.4.4. It shall be switched OFF as during the IST.

8.1.3 Electrical verifications

The electrical verification will consist in verifying that the selected TM parameters, defining the launch configuration as defined in [AD10], do not change. They will be verified before and after the run and suitable monitoring shall be put in place to check that they do not change during the runs.

The parameters are the following:

- EPS
  - Battery: both BDRs are ON
  - Heaters groups: HPS 1 to 9 are ON
  - All FCLs ON:
    - CDMU Hot A
    - CDMU Hot B
    - XPND1 Rx
    - XPND2 Rx
    - ACC Hot A
    - ACC Hot B
    - Emergency Heater Line 1 Nom (Battery)
    - Emergency Heater Line 1 Red (Battery)
  - Following LCLs ON (other LCLs are OFF):
    - Gyro A: LCL 13
    - Gyro B: LCL 14
    - CRS 1: LCL 15
    - Cat Bed Heaters Nominal: LCL 17
    - XPND Nom Tx: LCL 23
    - CRS 2: LCL 24
    - LPU Nom: LCL 25
    - LPU Red: LCL 26
    - CDMU PM A: LCL 31
    - CDMU PM B: LCL 32
    - ACC PM A: LCL 33
    - ACC PM B: LCL 34
    - CCU A: LCL 37
    - CCU B: LCL 38
    - TWTA Nom: LCL 49

- CDMS
  - CDMU "active PM" selection relay is set to PM A
  - CDMU PM A is set ON ("PM A relay is ON")
  - CDMU PM B is set OFF ("PM B relay is OFF")
  - CDMU PM A status bit 1 is set
  - CDMU PM B status bit 1 is set
  - RM A and B relays are set to "enable"
  - CIR and SIR relay are set to "disable"
  - Mass memories A and B relays are set
  - Active On Board Time and Telemetry Encoder relays is set to A branch
  - Launch lock: High level commands HL 5 and HL 21
  - TM Encoder is configured to:
    - TM rate = 150 kbps (in order to increase bandwidth, different from flight)
    - Modulation = PSK
    - Sub-carrier frequency = 45884 Hz
  - CDMS in launch mode
  - FDIR in AFS (Autonomous fail safe)

- TT&C
  - TC rate programmed to 4 kbps
  - Tx transponder relays Nom & Red are OFF
  - RFDN configuration:
    - LGA 1 on Rx A, LGA 2 on Rx B for the TC
    - LGA 1 on Tx A for the TM

    This corresponds to a configuration will all the RFDN RF switches in B position.
- ACMS
  - ACC "active PM" selection relay is set to PM A
  - ACC PM A is set ON ("PM A relay is ON")
  - ACC PM B is set OFF ("PM B relay is OFF")
  - ACC PM A status bit 0 (initialisation relay) is set to "Nominal"
  - ACC PM B status bit 0 (initialisation relay) is set to "Survival"
  - Watchdog relays on ACC_RM A and B are set to "disable"
  - RM A and B relays are set to "enable"
  - AIR relay is set to "disable"
  - ACMS in Stand-By Mode
  - FDIR in AFS (Autonomous fail safe)

- RCS
  - Latch valve status: both latch valves shall remain closed

- CVV
  - the following valves are closed: V102, V103, V106, V701, V702, (and mechanical valves)
  - the following valves are open: V104, V105, V501, V503, V504, V505.

- Instruments
  - All instruments are OFF (FPU and WU).
  - SPIRE launch lock: CLOSED. Note: it is also powered as described above (LCL 25, LCL 26, HLC 5, HLC 21). Refer to RD21, section 3.1.4.1.
  - PACS grating lock: CLOSED. Refer to RD21, section 3.1.4.2.

9 S/C SWITCH OFF

The goal of this test is, for safety purpose, to check at least once during the test sequence, that the spacecraft with battery connected, can be completely isolated and put into an unpowered condition.

This test is not related to mechanical testing, but the mechanical sequence offers some periods during which the S/C is OFF and disconnected from the power SCOE. Consequently, this safety test can be done in parallel of the mechanical sequence, outside the schedule critical path.

This test may be performed with the battery in any state of charge.

The Power SCOE connections to the umbilical connections PU1 J01 and PU2 J02 shall be connected (S/C powered via the umbilicals).

The skin connectors SK01B P09 and SK01B P10 have been mated (the real battery is connected to the spacecraft).

1. Starting with the S/C in the nominal launch mode configuration
2. The Power SCOE to be set to 3A per SAS section (6 sections)
3. Switch OFF BCR1 (BCR1_SwOff DC77B170), Switch OFF BCR2 (BCR2_SwOff DC78B170), Switch OFF BCR3 (BCR1_SwOff DC79B170)
4. Verify the Battery Charge current is 0 A (TM Icharge1 WMT10565)
5. Verify that power supplied by the Power SCOE is < 10.5 A
6. Send the BDR1 OFF HLC (HL_N_BDR_OFF DCH10170) and verify in telemetry the BDR1_IN-SW OFF status WMB06565 is OFF
7. Send the BDR2 OFF HLC (HL_N_BDR_OFF DCH40170) and verify in telemetry the BDR1_IN-SW OFF status WMB07565 is OFF
8. Verify the TM_IOUT_BDR1 status WMB07565 is 0 A
9. Verify the TM_IOUT_BDR2 status WMB07565 is 0 A
10. Perform a normal spacecraft OFF sequence
11. Power down the Power SCOE
12. The S/C is now completely unpowered
13. Verify Pins 40 / 41 of PU1 J01 that the +28V power Bus monitor = 0 V

10 CRYOSTAT HEALTH CHECKS

ASED shall check from the S/C telemetry the nominal behaviour of the cryogenic subsystem. Suitable times of the sequence to perform this check and relevant success criteria shall be determined by ASED, according to [RD18] (adapted to TM reading through S/C and not through cryo SCOE).

A live surveillance during the sine and acoustic tests shall be made in order to trigger an emergency abort of the test:

- ASED shall choose two (for redundancy) pressure parameters (e.g. P101, P701) indicating the pressure in the HTT filled with He I and the exhaust pipe.
- If one of the pressure measurements exceeds 1.3 bar absolute (TBC by ASED), the operator shall inform immediately the test conductor to abort the test.
- The acquisition frequency of these two pressure sensors shall be chosen by ASED in order to have the adequate time to react and abort the test.

11 PRODUCT ASSURANCE

The applicable quality provisions for review of the test documents, following the mechanical tests, and the processing of non-conformance, are those provided by [AD 3].

12 FAILURE AND RETEST

If a failure, malfunction or out-of-tolerance performance occurs during or after a test, the test has to be discontinued. Failures shall be properly documented, reported and processed according to relevant PA requirements. The deficiency (including any design defect) shall be corrected, and the pertinent environmental procedures repeated until successfully completed.

Nota : in case of failure, a NRB shall be held.

13 SUCCESS CRITERIA

13.1 Immediate success criteria

The success criteria of Herschel FM mechanical testing which have to be checked after mechanical tests (for each axis) are the following ones :

For sine and acoustic

- The test realisation has to be in accordance with the approved test procedure.
- Initial and final low levels do not show significant discrepancies in frequency (± 5 %) and amplitude (±20%).
- Achieved inputs levels have to be approved Arianespace.
- All data have to be recorded.
- No visible damage.

For Electrical checks

- Verify all the telemetry defined above is available before, during and after launch,
- Verify that the parameters defined in section 9.1.3 remain unchanged during each run,
- Verify that the CEL (Critical Event Log) is downloaded and archived,
- No events generated during runs,
- Stable (no glitch) battery discharge current during runs.

For S/C Switch OFF

- Verify that the satellite remains OFF by checking Pins 40 / 41 of PU1 J01: the +28V power Bus monitor shall remain equal to 0 V.

For Cryostat health checks

- According to [RD18].

13.2 Delayed success criteria

- No damage detected thorough visual inspection following acceptance test.
- The alignment test and AFT's (Abbreviated Functional Tests) after the mechanical tests have to be performed successfully.
- Verify the good workmanship by checking the FM behavior with respect to the predicted
- behavior, and with STM behavior if needed.

14 TEST REPORTING

Main data and discussion during the test campaign shall be reported in relevant "Running Meeting".

14.1 Tests Reports

The test report (tests laboratory responsibility) following Sine / Acoustic tests shall cover the following data :

- Description and views of the effective test sensors positions in satellite coordinate system.
- Test sequences (dates of actual sequences)
- As-run step by step procedure
- Pre-test and Post-test verifications and measurements results
- Summary of discrepancies/deviations
- Summary and Conclusion

For Sine test:

- Data recorded for piloting sensors for each axis and each test.
- Output accelerometers levels (harmonic 1, i.e. filtered and RMS in option) in [5 - 100 Hz] frequency range for low level tests and up to 100 Hz for intermediate and acceptance levels. Moreover the test adapter frequencies have to be identified.
- Piloting sensors phases.
- Evidence of parameters defined in §14.1 (electrical checks).
- Evidence of parameters defined in §14.1 (Cryostat health checks).

For Acoustic test:

- The Noise levels measured by each microphone (octave, 1/3 octave).
- The P.S.D. (Power Spectrum Density) of each accelerometer in narrow band with the overall level (frequency resolution 2Hz).
- Evidence of parameters defined in §14.1 (electrical checks).
- Evidence of parameters defined in §14.1 (Cryostat health checks).

Test Report shall be provided 2 weeks after the tests.

For each test, the data files shall be delivered in universal format (.uff files, format Dataset58) and neutral file format just after each test for exploitation purposes.

Channel name must not exceed 10 characters and must not contain any blank. For sine, pilots must be at the beginning of the file.

The whole mechanical test exploitation shall be performed by TAS-F CANNES Structural Analysis Team, with support of ASED & TAS-I, after test report delivery and shall be followed by a test evaluation report.

Astrium AIT will produce "as-run" AIT procedures for the activities surrounding and guiding each test, and will produce test reports for each test as they are executed, summarizing the quick-look assessments/results and decisions/deviations for each test run.

- Sine Test
- Acoustic Test

The Test Facility (ETS) will produce the test data generated during each test run and at the end an overall Facility Report.

- Sine Test
- Acoustic Test

14.2 Evaluation Reports

TAS-F will provide the overall Assessment Report of each of the Herschel Spacecraft tests.

Astrium will provide assessment inputs of the H-PLM parts

Alenia will provide assessment inputs of the SVM parts

ESA will provide assessment inputs of the instruments and CFE parts

END OF DOCUMENT

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