Title:	**Launch Autonomy Test Procedure for FM**
CI-No:	100000

Prepared by:	G. Jahn	Date:	10.09.2008
Checked by:	J. Kroeker		10.9.2008
Product Assurance:	R. Stritter		12.09.08
Configuration Control:	W. Wietbrock		12.09.2008
Project Management:	W. Fricke		10/09/08
Approved by TAS-F	D. Montet		

Distribution:	See Distribution List (last page)

Issue	Date	Sheet	Description of Change	Release
Draft	06.08.08	All	First Issue	
1	10.09.08		Implementation of comments on Draft version (TAS-F comments and H-P-TAS-MN-10781)	
		All	Wording updates	
		1	TAS-F approval	
		5	Mass flow increased from 150 to 430 mg/s tbc	
		7ff	Operate V501/V503 to avoid SV521 activation	
		8	S/C grounding via VIS	
		10+12	Initial temperatures adjusted to higher mass flow	
		15	Abort criterion added for P501 < ambient acc. to discussions at H-P-TAS-MN-10781	

Table of Content

1 Scope

This Test Procedure describes the approach how the *Launch Autonomy Test* will be performed.

The launch autonomy approach has been revised following the HOT leakage NCR [AD10], where the decision was taken to perform the complete test and launch campaign with an evacuated and valved-off HOT. The new approach is based on Thermal Shields cooling from an external dewar during the combined operations until the latest possible moment, followed by a non-cooled phase which is significantly longer than in the original plans (In original plans, the last hot filling was planned at D-2. The non cooled phase was starting after the HOT depletion. In that sense, non cooled phase is longer now, but access to S/C for refilling or cooling is better in the new scenario).

The Launch Autonomy Test will be performed in two parts, the phase with shield cooling from an external dewar being simulated during instrument tests. This phase is performed under control of the shields cooling procedure [AD8].

The second part of the Launch Autonomy Test is performed under control of the current procedure.

It shall be demonstrated that the sequence as foreseen leaves the cryostat in a condition where a launch is possible fulfilling the lifetime requirement, considering a 25 hour launch delay.

2 Objective

During the last days prior to launch only limited access to the Herschel cryostat is possible. To demonstrate that under these constrains, which are discussed with AE, a safe launch of the Herschel satellite is possible the launch autonomy will be tested.

The POC as discussed with Arianespace is reflected in the launch sequence test spec [AD7] and is recalled in the table below:

from	to	from	to	operation
D-4 4:00	D-4 7:00	H0-104h	H0-101h	Dewar disconnection
D-4 16:30	D-4 19:30	H0-91:30h	H0-88:30h	Dewar reconnection with diving board
D-4 19:30	D-2 23:00	H0-88:30h	H0-37h	HTT cooling with Dewar
D-2 23:00	D-1 03:00	H0-37h	H0-33h	Dewar disconnection and S/C final preparation
D-1 03:00	D0 10:00h	H0-33h	H0-2h	no shield cooling
D0 10:00h	D0 13:00h	H0-2h	H0+1h	first launch attempt, LPU switch ON
D0 13:00h	D1 10:00h	H0+1h	H0+22h	no shield cooling, LPU switch OFF
D1 10:00h	D1 13:00h	H0+22h	H0+25h	second launch attempt, LPU switch ON
D1 13:00h	D3 20:00	H0+25h	H0+80h	no shield cooling, LPU switch OFF
D3 20:00		H0+80h		Access to Herschel S/C after roll back

Table 2-1: POC time line

Considering the expected durations of the respective cryo operations, the time line listed in Table 2-2 is derived from this input:

Pos	Time since nominal launch window open hrs	Mass flow until this timestamp [mg/s]	Remarks
1	-110	500	HTT topup end, start pumpdown
2	-102	20	HTT disconnect
3	-88.5	0	Fairing installation until dewar connected
4	-34	430 tbc	Cooling until dewar disconnection start
5	0	0	Nom launch window open
6	25	0	close second launch window
7	82	0	access after rollback without fairing

Table 2-2: Shields cooling mass flow time line for POC

The current procedure covers positions 5, 6, and 7 of Table 2-2, i.e. from the dewar disconnection under the fairing to the acess after rollback, while the testing of steps 1 to 4 is performed in parallel to instrument functional tests under control of [AD8].

3 Documents/Drawings

3.1 Applicable Documents

No.	Document Name	Document Number	Issue/Rev.
AD1	PA-Plan	HP-2-ASED-PL-0007	2-1
AD2	Herschel Cryostat Safety Analysis	HP-2-ASED-AN-0002	1
AD3	Herschel He II top up Procedure	HP-2-ASED-TP-0083	1
AD4	Herschel PFM HOT refilling procedure	HP-2-ASED-PR-0065	1
AD5	CSG Safety Regulations, Vol 1	CSG-RS-10A-cn	Latest issue
AD6	Herschel FM Thermal Test Leading Procedure	HP-2-ASED-TP-0200	1
AD7	Herschel Launch Sequence Test Specification	HP-2-ASP-TS-1646	1
AD8	HERSCHEL PFM SHIELD COOLING	HP-2-ASED-PR-0130	1
AD9	Temperature gradients between Herschel Instr. FPU Thermal I/F L0, L1, L2	H-P-100000-ASP-RW-0013	Rev. 2
AD10	Leak rate of He S/S higher than nominal	H-P-121999 ASED-NC-3952	

3.2 Reference Documents

No.	Document Name	Document Number	Issue/Rev.
RD1	CVSE Setup and Operation Procedure for FM TB/TV Test	HP-2-ASED-PR-0126	
RD2	Herschel Spec	HP-2-ASPI-SP 0250	3.3
RD3	Test Prediction for H-EPLM PFM Launch Autonomy Test	HP-2-ASED-TN-0176	1

3.3 Other Documents

N/A

4 Configuration and Requirements

Refer to section 1.1.2 of [AD6] for a description of the test approach.

4.1 Cryostat Configuration

The Herschel Cryostat is in vertical position. The CVSE is configured according to RD1.

The safety valve SV121 is enabled (retainer plate not mounted, air lock mounted on filling port and connected to safety unit) in order to guarantee safe cryostat conditions under all possible circumstances. The “anaconda” helium pumping line to the (open) V502 is installed with the respective CVSE safety valve. The deer head is attached to the nozzles and closed downstream

Due to the warming of the system after stopping the shield cooling from the external dewar, the pressure inside the helium tubing (with closed external valves V501/V503) will rise until the set pressure of the CVSE safety valve downstream of V502 is reached, which will release small amounts of helium.

To avoid opening of SV521, the external valves V501/V503 shall be opened and re-closed during the actual launch autonomy phase. In order to increase AIT flexibility, a dedicated overpressure valve (set pressure 1.2 bar) will be mounted on the deer head during the test, which will avoid the opening of SV521 in case the LHe valves can not be operated when the S/C is off.

In the predictions, the lambda point is reached shortly after the end of the roll-back period. If the lambda point is exceeded during the test, stratification in the HTT will occur, and the pressure in the HTT might rise above the saturated vapour pressure for the average helium temperature. If a pressure rise above 1.2 bar is observed (monitoring via P101), the HTT outlet valve V104 will be opened to avoid opening of the safety valve SV123. Helium will then be released via the CVSE safety valve downstream of V502.

4.2 S/C Configuration

The S/C is in launch configuration. Any deviation with respect to the launch configuration shall be traced and authorised prior to testing.

During the non-cooled phase of the launch autonomy test, no dissipations on the FPUs are allowed with exception of the launch locks. The LPU switch on/off sequence shall be implemented in the test sequence as follows: (H0 being the nominal launch time) :

- OFF before H0-2h

- ON at H0-2h
- OFF at H0+1h
- ON at H0+22h
- OFF at H0+25h

4.3 EGSE Configuration

For this test the Cryo SCOE is connected to the Cryostat. The set up is identical to the set up used for He II top up. The following software version is implemented.

Cryo SCOE				
HPSDB				

The S/C shall be grounded via the launcher interface and the VIS during the test.

4.4 Environmental Conditions

The tests shall be performed in Cl.100 000 Clean Room Clean room class acc. to Federal Standard 209 E.

4.5 QA Requirements

The PA Plan is applicable (see AD1).

5 Conditions

5.1 Personnel

Responsibility	Name / Organization
Test Conductor	M. Langfermann (tbc)
Test Engineer	Axel Runge/ H. Huber (tbc)
EGSE / CCS Operator	Valentina La Gioia (tbc)
Support Engineer	Gerd Jahn (tbc)
PA Responsible	D. Hendry (tbc)
Test Director	B. Demolder / TAS-F
ESA Representative	To be nominated

5.2 Environmental

Environmental	Nominal	Actual	P	N
Clean Room Class	100 000			
Temperature	(22±3) °C			
Rel. Humidity	40….60 %			
Pressure	ambient			

Note: Clean room class acc. to Federal Standard 209 E

5.3 GSE Equipment and Tools

See above for CVSE equipment.

6 Verification Requirements and Test Success Criteria

Remark:

Before entering into the non-cooled phase of POC the cryostat shall have following condition: (stabilized at selected mass flow rate)

- HTT filling level of 96.5% +0% -2% (tbc)
- HTT LHe temperature at 1.74 K +0.0 K -0.02 K
- TS1 temperature 10 K -3 K +3 K (tbc after LA cooled phase testing)
- TS2 temperature 22 K -5 K +5 K (tbc after LA cooled phase testing)
- TS3 temperature 47 K -8 K +8 K (tbc after LA cooled phase testing)

According to TMM analysis, the above shields temperature ranges can be achieved after ~1 day of shields cooling with mass flow of 430 mg/s.

The Launch Autonomy Test starts with the end of the shield cooling from the external dewar and ends after 116 hours (4d+20hrs).

The TMM predictions for this test are outlined in RD3.

The Launch Autonomy test shall be considered successful if:

- comparison of prediction to test result show that the model is reliable,
- LEOP prediction based on starting conditions obtained at 25h delayed launch time show that a successful launch can be performed.

The roll back test will be considered successful if the gradient requirements on instruments are fulfilled at the end of roll back simulation. The general gradient requirement between L0, L1 and L2 is (refer also to [AD9]:

- below 50K, no requirement
- between 50 and 80K, gradient below 50K
- above 80K, gradient < 35K

Note that according to the predictions the OBA temperature rises above 52 K after ~24 hrs after nominal launch (i.e. before closure of delayed launch window). This success criterion will not be met!!!

Key points will be held:

- at the time of the (virtual) nominal launch to authorise the launch delay, compare prediction to test results.
- at the time of the (virtual) delayed launch to authorise the roll back, compare prediction to test results.

7 Step by Step Procedure

The single steps of this test are driven by the POC sequence starting with end if thermal shields cooling. The latest version of the POC is reflected in Table 2-2. The main activity steps are summarized below:

Step-No.	Integration-Step-Description	Nominal Value	Tolerance	Actual Value		P	N

Step-No.	Integration-Step-Description	Nominal Value	Tolerance	Actual Value		P	N
1	**Check initial conditions after He-II top-up and pumpdown acc. to** HP-2-ASED-TP-0083**:**				HP-2-ASED-TP-0083		
1.1	HTT filled with He II	96.5%	+0% -2 %				
1.2	HTT temperature (DLCM sensors)	1.74 K	+0.0 K -0.02 K		Tbc during test		
1.3	HTT top temperature check T107	T107=T106	+/- 20 mK		Superfluid film on bulk		
1.4	All HTT valves closed	closed			head		
1.5	HOT valves closed	closed					
1.6	Shield temperatures stabilized acc. to selected flushing mass flow rate:						
1.7	TS1 temperature (sensors T421, T422, T423, T424 average)	10 K	-3 K +3 K		Tbc during test		
1.8	TS2 temperature (sensors T441, T442, T443, T444 average	22 K	-5 K +5 K		Tbc during test		
1.9	TS3 temperature (sensors T461, T462, T463, T464 average	47 K	-8 K +8 K		Tbc during test		
2.0	Note exact time in UTC = T0 (beginning of test)						
	Close external valves at end of shield flushing (i.e. with GHe 1 bar in HST)						
	S/C grounding via VIS						

Test location: ETS / LSS	Operator:	PA / QA:	Date:

Step-No.	Integration-Step-Description	Nominal Value	Tolerance	Actual Value		P	N
2	**Launch autonomy non-cooled phase 1**						
2.1	Monitor HTT temperature						
2.2	Monitor TS temperatures						
2.3	Monitor pressure in external vent line P501 (SV521 opens at 0.25 to 0.35 bar differential pressure). Open and re-close V501 when P501 reaches 0.2 bar overpressure.	< 0.35 bar overpressure					
2.4	Switch ON LPU at T0 + 32 hrs						
3	**Nominal launch window closure at T0 + 35 hrs**						
3.1	Note HTT temperature at T0+35 hrs						
3.2	Monitor TS temperatures						
3.3	Switch OFF LPU at T0 + 35 hrs						
3.4	Compare measurements to test predictions						
3.5	Request go-ahead for launch delay simulation from customer representative						

Test location: ETS / LSS	Operator:	PA / QA:	Date:

Step-No.	Integration-Step-Description	Nominal Value	Tolerance	Actual Value		P	N
4	**Delayed launch window closure at T0+59hrs**						
4.1	Monitor HTT temperature						
4.2	Monitor TS temperatures						
4.3	Monitor pressure in external vent line P501. Open and re-close V501 when P501 reaches 0.2 bar overpressure	< 0.25 bar overpressure					
4.4	Monitor gradients between L0, L1, L2 (ΔT<50K for 50K<T<80K)						
4.5	Switch ON LPU at T0 + 55 hrs						
4.6	Switch OFF LPU at T0 + 59 hrs						
4.7	Note HTT temperature at T0+59 hrs	HTT < 1.914 K			tbc		
4.8	TS1 temperature at T0+59 hrs	TS1<105K tbc					
4.9	TS2 temperature at T0+59 hrs	TS2<150 tbc					
4.10	TS3 temperature at T0+59 hrs	TS3<210K tbc					
4.11	Compare measurements to test predictions						
4.12	Request go-ahead for roll-back simulation from customer representative, including violation of L0/L2 temperature gradient requirement (tbc)						

Test location: ETS / LSS	Operator:	PA / QA:	Date:

Step-No.	Integration-Step-Description	Nominal Value	Tolerance	Actual Value		P	N
5	**Roll-back simulation**						
5.1	Monitor HTT temperature						
5.2	Monitor TS temperatures						
5.3	Monitor OBA temperatures						
5.4	Monitor gradients between L0, L1, L2 (ΔT<50K for 50K<T<80K) Note: TMM predicts exceedance of 50K temperature difference at ~T0+58 hrs.	< 50K					
5.5	Monitor pressure in external vent line P501 Open and re-close V501 when P501 reaches 0.2 bar overpressure	< 0.25 bar overpressure					
5.6	Monitor HTT pressure P101	< 1.4 bar					
5.7	If HTT pressure P101 exceeds 1.2 bar: Open HTT outlet valve V104 to avoid opening of SV123 To avoid possible air contamination into the helium subsystem: ABORT TEST IF P501 IS BELOW AMBIENT PRESSURE!!!						
6	**End of Launch Autonomy Test** At T0 + 116 h: check HTT temperature	 < 2.18 K					

8 Summary Sheets

8.1 Procedure Variation Sheet

	Test Change	Curr. No.: Date: Page: of
Test designation FM Launch Autonomy Test	Test Procedure HP-2-ASED-TP-0201	Issue 1
Test step changed	Reason for Change	
Prepared by:	Resp. Test Leader	Project Engineer
PA/QA	Prime	Customer

8.2 Non Conformance Report (NCR) Summary

NCR - No.	NCR - Title	Date	Open Closed	PA sig.

8.3 Sign-off Sheet

	Date	Signature
Test Conductor		
Test Engineer		
PA Responsible		
Test Director		
ESA Representative		

END OF DOCUMENT

	Name	Dep./Comp.		Name	Dep./Comp.
	Baldock Richard	FAE12	X	Sonn Nico	ASG51
	Barlage Bernhard	AED13		Steininger Eric	AED321
X	Bayer Thomas	ASA42	X	Stritter Rene	AED11
	Brune Holger	ASA45		Suess Rudi	OTN/ASA44
	Chen Bing	HE Space	X	Theunissen Martijn	ASA43
X	Davis William	Captec		Vascotto Riccardo	HE Space
	Edelhoff Dirk	AED21	X	Wagner Klaus	ASG23
	Fehringer Alexander	ASG15	X	Wietbrock Walter	AET12
X	Fricke Wolfgang Dr.	AED 65	X	Wöhler Hans	ASG23
	Geiger Hermann	ASA42		Wössner Ulrich	ASE252
	Grasl Andreas	OTN/ASA44		Zumstein Armin	AED15
	Grasshoff Brigitte	AET12			
X	Hamer Simon	Terma			
	Hanka, Erhard	FI522			
	Hendrikse Jeffrey	HE Space			
X	Hendry David	Terma			
	Hengstler Reinhold	ASA42			
X	Hinger Jürgen	ASG23			
X	Hohn Rüdiger	AED65			
	Hopfgarten Michael	AET32			
X	Huber Johann	ASA42			
	Hund Walter	ASE252			
X	Idler Siegmund	AED312			
	Ivády von András	FAE12			
X	Jahn Gerd Dr.	ASG23			
	Jolk Matthias	AET1	X	ESA/ESTEC	ESA
	Klenke Uwe	ASG72	X	Thales Alenia Space Cannes	TAS-F
X	Kölle Markus	ASA43		Thales Alenia Space Torino	TAS-I
	König Werner	AET32			
X	Koppe Axel	AED312			
X	Kroeker Jürgen	AED65		**Instruments:**	
X	La Gioia Valentina	Terma	X	MPE (PACS)	MPE
	Lang Jürgen	ASE252	X	RAL (SPIRE)	RAL
X	Langenstein Rolf	AED15	X	SRON (HIFI)	SRON
X	Langfermann Michael	ASA41			
	Leitermann Stefan	AET12			
	Liberatore Danilo	Rhea		**Subcontractors:**	
	Martin Olivier	Altec		Austrian Aerospace	AAE
	Maukisch Jan	ASA43		Austrian Aerospace	AAEM
X	Much Christoph	ASA43		BOC Edwards	BOCE
X	Müller Martin	ASA43		Dutch Space Solar Arrays	DSSA
	Pietroboni Karin	AED65		EADS Astrium Sub-Subsyst. & Equipment	ASSE
	Reichle Konrad	ASA42		EADS CASA Espacio	CASA
X	Runge Axel	OTN/ASA44		EADS CASA Espacio	ECAS
	Saal Christoph	External		European Test Services	ETS
	Schink Dietmar	AED321		Patria New Technologies Oy	PANT
X	Schmidt Thomas	AED15		SENER Ingenieria SA	SEN
	Schweickert Gunn	ASG23		Thales Alenia Space, Antwerp	TAS-ETCA