INPUT TO THE SPIRE
PFM3 THERMAL BALANCE TEST SPECIFICATION

THERMAL ENGINEERING GROUP				
PREPARED BY	A.S. GOIZEL	(RAL)	12-05-06	Signature Not Verified. Digitally signed by Anne-Sophie Goizel Date: 2006.05.12 14:42:01 +01'00'
CHECKED BY	B. SHAUGHNESSY	(RAL)	Signature Not Verified. Digitally signed by Bryan Shaughnessy Date: 2006.05.15 09:10:59 +01'00'	
SPIRE PROJECT				
APPROVED BY	E. SAWYER	(RAL)		

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CHANGE RECORD

Issue	Date	Section	Change
Draft D	28/03/06	-	New Document.
Draft E	12/05/06	2.2	Add new reference documents.
		3.2	Add missing reference to documents.
		3.3	Reword requirement for pump temperature during condensation phase.
		3.4.2	Changed wording to clarify the meaning and need for “pump regulation”.
		3.4.5	Updated Table 3.3 to reflect new temperature sensors names.
1	12/05/06	None	Issue as formal document.

ACRONYMS

Acronym	*Definition*
AD	Applicable Document
BDA	Bolometer Detector Arrays
BSM	Beam Steering Mechanism
CBB	Cold Black Body
CQM	Cryogenic Qualification Model
DRCU	Digital Readout Control Unit
DTMM	Detailed Thermal Mathematical Model
EGSE	Electronic Ground Support Equipment
FM	Flight Model
FPU	Focal Plane Unit
FS	Flight Spare
HCSS	Herschel Common Science System
HeI	Helium I
HeII	Helium II
HOB	Herschel Optical Bench
I/F	Interface
IIDB	Instrument Interface Document Part B
IRD	Instrument Requirement Document
ILT	Instrument Level Testing
JFET	Junction Field Effect Transistor
L0	Level-0
L1	Level-1
L2	Level-2
L3	Level-3
LN2	Liquid Nitrogen
MGSE	Mechanical Ground Support Equipment
PFM	Proto Flight Model
RD	Reference Document
SMEC	Spectrometer Mechanism
SCU	Subsystem Control Unit
SOB	SPIRE Optical Bench
SPIRE	Spectral and Photometric Imaging Receiver
SVR	Science Verification Review
TBT	Thermal Balance Test

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1 SCOPE

This memo describes the thermal tests that will be carried out as part of the SPIRE PFM3 test campaign. Detailed procedures required to run the various tests are also given. This document should be read in conjunction with the "SPIRE PFM2 Thermal Balance Test Specification" [RD1] as most of the instrument thermal hardware and test equipment build standard remain the same. Any changes in the instrument and/or equipment will be summarised in later sections of this document.

2 DOCUMENTS

2.1 Applicable Documents

ID	Title	Number
AD1	Instrument Interface Document Part A	SCI-PT-IIDA-04624 3.3
AD2	Instrument Interface Document Part B - SPIRE Instrument	SCI-PT-IIDB/SPIRE-02124 Issue 3.2
AD3	SPIRE Instrument Requirement Document	SPIRE-RAL-PRJ-000034 Issue 1.3
AD4	SPIRE Cryogenic Thermal Design Requirements	SPIRE-RAL-PJR-002075 Issue 1

Table 2-1 - Applicable Documents

2.2 Reference Documents

ID	Title	Number
RD1	SPIRE PFM2 Thermal Balance Test Specification	SPIRE-RAL-DOC-002435 Issue 1
RD2	SPIRE Verification Science Review Thermal Performance	SPIRE-RAL-REP-002557 Issue 1 13/01/06
RD3	PFM3 Thermal Test Inputs	Email from A. Goizel 30/01/06
RD4	SPIRE PFM2 Thermal Test Report	SPIRE-RAL-REP-002534 Issue 1 06/03/06
RD5	SPIRE PFM Thermal Performance Flight Predictions	SPIRE-RAL-NOT-002588 Issue 1 08/03/06
RD6	PFM3 Cold Test – Master Procedure	SPIRE-RAL-PRC-002582 Issue 1 D. Smith
RD7	PFM3 Thermometers 2 0 - For PFM-3 2nd Run.xls	D. Smith
RD8	As Built Configuration List	SPIRE-RAL-DOC-002326 Issue 2.2 E. Sawyer
RD9	PTC Test Procedure PFM3	D. Griffin

Table 2-2- Reference Documents

3 PFM3 THERMAL TEST PLAN

3.1 Objectives

The primary objective of the PFM-3 test campaign is to verify that the performance of the SPIRE flight model has not been degraded following the cold vibration testing at CSL in December 2005. The PFM3 test campaign will include repeats of some of the tests performed during the PFM-2 campaign to ensure the instrument is still performing as expected. It is also an opportunity to continue activities that were not successfully completed in earlier test campaigns (because of time, thermal hardware and/or test equipment limitations).

3.2 Changes to the Build Standard

The following changes have been implemented between the PFM2 and the PFM3 test campaigns:

- The instrument L1 cone isolation support was replaced with the SST version after a failure of the CFRP cone during the cold vibration test. Both L1 A-frames were replaced with the spare CFRP supports.
- The L1 electrically isolating glued joint was implemented on the SOB after the PFM2 test campaign.
- The 4N copper L1 MGSE strap has been used instead of the aluminium one.

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- The flight temperature sensor calibration curves have been updated to correct for the inconsistencies detected as part of the PFM2 test campaign.
- The SCAL transfer function calibration has been extended to cover a temperature range up to 80K.
- Some of the EGSE sensors locations have changed since PFM2 and some new sensors have been lost through handling. Please refer to [RD7] for additional information about the sensors configuration.

Further details about the PFM3 master test procedure and the instrument standard build can be found in [RD6] and [RD8] respectively.

3.3 Lessons Learnt from and since the PFM2 Test Campaign

The following points summarise the lessons learnt from the PFM2 test campaign [RD4]:

- Make sure that all flight temperature sensors are readout on the AC Bridge (in addition to the SCU) for each steady-state case.
- Make sure that load curves are done for both the photometer and spectrometer detectors for each steady-state case.
- Make sure that a 4-wire measurement method is used throughout the L1 characterisation test cases. The use of a Keithley 236 power supply has been suggested for the PFM3 test campaign.
- The cooler recyclings need to be improved such that:
  - They are “repeatable” - a way of limiting instabilities from taking place in the L0 Helium pot during the recycling should be investigated.
  - They are “optimal” - the pump temperature should be no less than 45K during the condensation phase.
- DC offset errors are present on the flight temperature sensors. The measured temperatures will need to be corrected for this offset before being used for thermal correlation.

The following points summarise the lessons learnt from the correlation of the PFM2 test results with the thermal model [RD5]:

- The “pump characterisation” test currently underestimates the cooler total load by 9%. New ways of assessing the cooler load should therefore be considered if necessary i.e. using the PTC (up to 20uW). A recent correlation of the PFM2 cooler hold time performance with predictions from thermal model showed a good level of agreement. The cooler total load could therefore be estimated using the correlated thermal model and cross checked with the cooler hold time measured during testing.
- The L0 interbox strap conductance has been characterised as part of the CQM2 test campaign. This test was planned to be repeated as part of the PFM2 test campaign but the failure of the EGSE heater prevented it. The temperature drops observed along the L0 detector and interbox straps were very small however (in the order of few “mK” only) following the change of L0 supports from SST to CFRP after the CQM2 test campaign. Based on these observations, it was decided that the EGSE heater would not be implemented as part of the PFM3 test campaign for the following reasons:
  - Such small temperature gradients would not allow an accurate characterisation of the heat load flowing along the L0 detector strap,
  - The time available for testing during the PFM3 test campaign is very limited and should therefore be dedicated to the high-level priority thermal tests identified during the SVR review.
- A nominal thermal balance test case was run as part of the PFM2 test campaign. Following the correlation of this test results with the thermal model, new predictions for the worst case Herschel interface temperatures could be derived and should be used as the hot test case during PFM3.

3.4 Thermal Tests Suggested during Science Verification Review

3.4.1 Overview

Table 3.1 describes the list of thermal tests which have been suggested for the PFM3 test campaign during the instrument Science Verification Review (SVR) held on January, 27th 2006 at RAL.

Test Name	Description	Applicable Requirement	Priority
Cooler Pump characterisation	This test will ensure that the instrument thermal performance has not degraded following the cold vibration testing done at CSL.	All	High
Thermal Balance Test Nominal and Worst Hot Case	This test will ensure that the instrument thermal performance has not degraded following the cold vibration testing done at CSL.	All	High
L1 Strap Characterisation	This test will characterize the change in L1 heat load following the change of the L1 cone support from CFRP to Stainless Steel as well as the L1 glued interface which was not present during the PFM2 test campaign.	IRD-STRC-R14 IRD-STRC-R15	High
PTC Operation	This test will assess the impact of the PTC operation on the cooler total load and detector temperature stability.	IRD-COOL-R02 IRD-COOL-R04 IRD-COOL-R05	High
Mechanisms and Calibration Sources Operation	This test will assess the impact of mechanisms operation on the instrument L1 interface temperature and stability, as well as confirm the instrument L1 heat load for all operational modes. This test will also allow to check for any overall mechanisms temperature increase for all operational modes.	IRD-BSMP-R11 IRD-BSMP-R12 IRD-CALP-R12 IRD-CALS-R09 IRD-CALS-R12 IRD-CALS-R16 IRD-SMEC-R11	High
Cooler Recycling in Close-Loop	This test will allow the tuning of the PID parameter that will be used to maintain the pump temperature at 45K during the cooler recycling.	None	High
L0 Detector Strap Heat Load	Characterisation of the heat load on L0 Detector box strap.	IRD-STRS-R09	Medium
Photometer Detector Temperature	This test would measure the temperature of the photometer detector for L0 enclosures held at ~2K test.	-	Medium
Flight Temperature Sensors Characterisation	Some of the flight sensors could not be checked out for DC offset and self-heating errors.	IRD-STRC-R07 IRD-CALS-R15 IRD-SMEC-R13 IRD-COOL-R18	Low

Table 3-1 – Thermal Tests Suggested during the SVR [RD2]

Since the SVR review, the analysis and correlation of the PFM2 test results suggested that the accuracy of the results obtained with the "pump characterisation test" is not satisfactory. For this reason, it was decided that this test would not be carried out as part of the PFM3 test campaign. Due to time constraints, only tests with a "High" priority will be carried out during the PFM3 test campaign.

3.4.2 Optimization of Cooler Recycling

During the SVR review, it was suggested that the procedure used to recycle the cooler should be reviewed to ensure that all recycling performed in the RAL calibration cryostat are repeatable and that a pump regulation scheme be implemented to optimize the cooler recycling efficiency. These will be addressed as part of the PFM3 test campaign and will be briefly discussed in the following sections.

3.4.2.1 Repeatable Recyclings

The RAL calibration cryostat uses a manostat to control the temperature of the L0 temperature stage at 1.7K. During recycling, a large amount of heat is released by the cooler, which introduces instabilities in the L0 pot unless the manostat is opened to release the heat faster. The side effect is that as a result of the manostat opening, the L0 stage temperature starts to drop sharply, driving the evaporator temperature down. During thermal testing, one aimed at recycling the cooler with an evaporator condensation temperature of no less than 2K. This has proven challenging given the requirement to open the manostat and the repeatability of the recycling was therefore compromised.

During PFM2, the cooler was also recycled with warmer L0 interface temperatures at about 2K to reflect a “hot” case environment as described in Figure 3.1. In this specific manostat setup, the instabilities introduced by the recycling process were limited and the manostat only required to be opened at such a late stage in the recycling that it didn’t have any effect on the evaporator temperature. It is therefore suggested that a similar approach be used to recycle the cooler during the PFM3 thermal testing. The following procedure would be used:

- set the manostat to operate at ~2K when closed,
- recycle the cooler and open the manostat towards the end of recycling (only if necessary),
- When the recycling is completed, open the manostat to adjust the L0 back to the temperature required for the thermal test i.e. 1.7K.

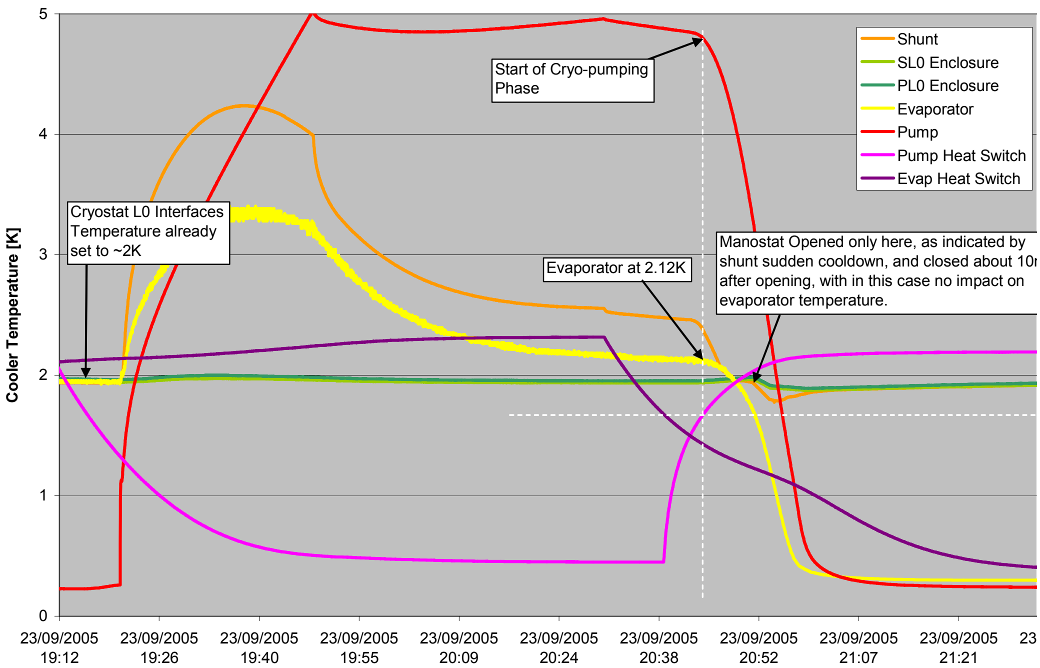


Figure 3-1 – Cooler Recycling in Warm Environment during PFM2 Test Campaign

This way the evaporator temperature at the end of the condensation phase is unlikely cool down further than 2.1K.

3.4.2.2 Pump Temperature Regulation during Recycling

Some test at unit level with the cooler have indicated that the pump temperature has an impact on the cooler recycling efficiency and that it is therefore favourable to maintain the pump at 45K during the whole condensation phase i.e. the higher the pump temperature, the larger the amount of Helium desorbed and available for condensation. Overall, about n x 1% of hold time is lost for a pump temperature n x 1K lower than 45K. It is therefore of interest to try and maintain the pump temperature at or above 45K as much as possible. Two approaches are possible, both with their pros and cons as described in Table 3.2.

Method	Pros	Cons
PID controller	>Robust >Flexible - Doesn't need to be updated if the environment and/or thermal hardware changes. >Minimal Heat Load input to L0 Stage	>Important effort would be required for the development of the PID script. >Some concerns were raised during the EQM review meeting about using a fully automated cooler recycling.
Open Loop	>No changed in current recycling script required (excepted for the pump heater dissipation commands) >The pump heater dissipation commands can be deduced from cooler recyclings done during S/C ground testing or during the flight commissioning phase.	>The pump heater dissipation would need to be re-adjusted after environment and/or thermal hardware changes. >Possible increase of energy released per cooler recycling cycle (TBC based on PFM3 test results).

Table 3-2 – Pump Regulation Schemes

Given the time restriction applicable to the PFM3 test campaign, the open-loop approach was considered to be the best option for now and the following approach has been suggested:

- The cooler will be recycle as during the PFM2 test campaign to first check that the cooler performance has not been degraded after the cold vibration.
- During the second recycling, the heat applied on the pump (once it has reached 45K) will be increased by a few mW from the current 40mW to limit the cooling rate of the pump until the start of the cryo-pumping phase. Based on this second recycling, the optimal heater setting should be defined.

The following needs to be kept in mind:

1 – The only change in hardware/environment will take place between the instrument ILT and testing at spacecraft level. This means that new parameters for the cooler recycling will have to be defined as part of the spacecraft level testing. Once identified, these parameters should also be applicable for recycling while in flight.

2 – A trade-off analysis will be required to assess how much additional heat is going into the L0 stage as a result of the pump regulation process. As the pump temperature increases, the load flowing on the flight L0 evaporator strap is also increasing, which depending on the performance of the L0 pod plus strap thermal links, might increase the temperature of the evaporator at the end of the condensation phase (and thus have a negative impact on the recycling efficiency).

3.4.3 L1 Strap Characterisation

The aim of the L1 strap characterisation is to characterise the strap conductance to estimate the parasitic loads coming from the instrument L1 stage. The measurement of this heat load will then be used as part of a correlation exercise to estimate the performance of the instrument in terms of:

- L1 isolation joint conductance,
- Impact of the change from CFRP to SST Cone support,
- Impact of the instrument L1 temperature stage on the L0 enclosure temperature and hence cooler hold time.

3.4.4 PTC Operation

The Photometer Thermal Control (PTC) is used to control both the thermal stability and absolute temperature of the photometer detectors during the cold operation phase at 300mK. The following aspects of the PTC operation need to be verified during the PFM3 test campaign:

- Validation of the control scheme and script used to operate the PTC,
- Estimation of the PTC additional load on cooler evaporator for a 46hr operation period,
- 300-mK detectors performance in term of thermal stability response to disturbances.

This PTC test has been defined as a “performance” test rather than a thermal test and a detailed description of the test procedure can be found in [RD9].

3.4.5 Thermal Balance Test - Nominal and Hot Cases

The thermal balance test aims at verifying the overall instrument thermal performance in terms of detector absolute temperatures and cooler hold time and this for two thermal environments:

- The nominal case represents the best case scenario in term of interface temperatures and is based on the “Goal” thermal interfaces defined in the IIDB [*],

- The hot case represents the worst case scenario in term of interface temperatures and is based on the “Requirement” thermal interfaces defined in the IIDB.

Table 3.3 described the cryostat interface temperatures which should be used for each thermal balance test cases:

Required Interface Temperature	Temperature Sensor	Nominal	Hot
During recycling	T_L0_ESTR1	1.9K	1.9K
At end of Condensation Phase	T_CEV_1	2.1K	2.2K
During low-phase operation	T_L0_DSTR1	1.71K	1.78K
	T_SOB_L1STR	4.3K	5.5K

Table 3-3 – Cryostat Setup during Thermal Balance Test Cases

Note: It is important to note that the instrument L1/L0 thermal stability performance cannot be checked in the RAL calibration cryostat.

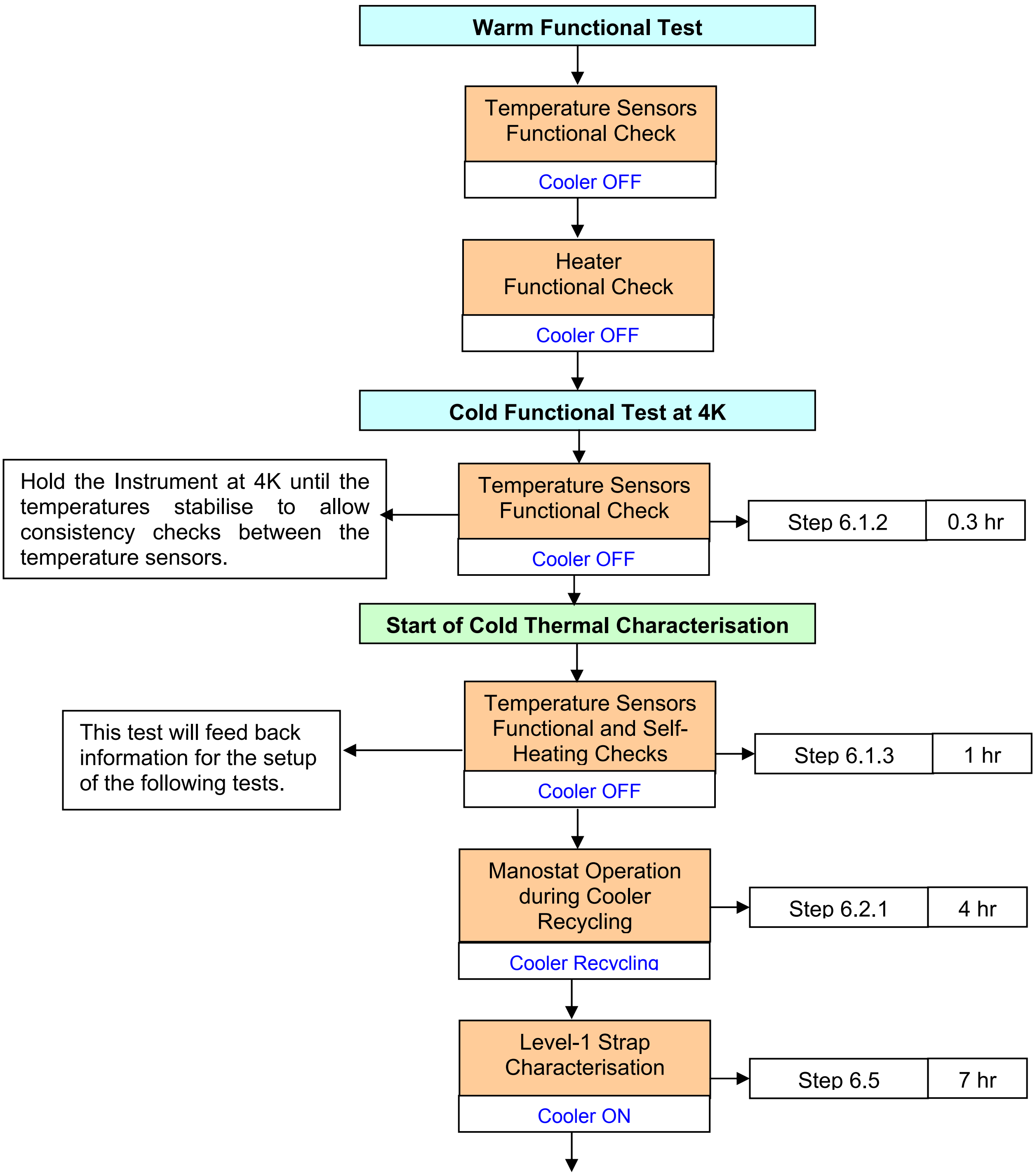
[*] Please note that the goal L1 interface temperature is actually 3.7K but that the RAL calibration cryostat L1 temperature stage cannot be lower than 4.2K.

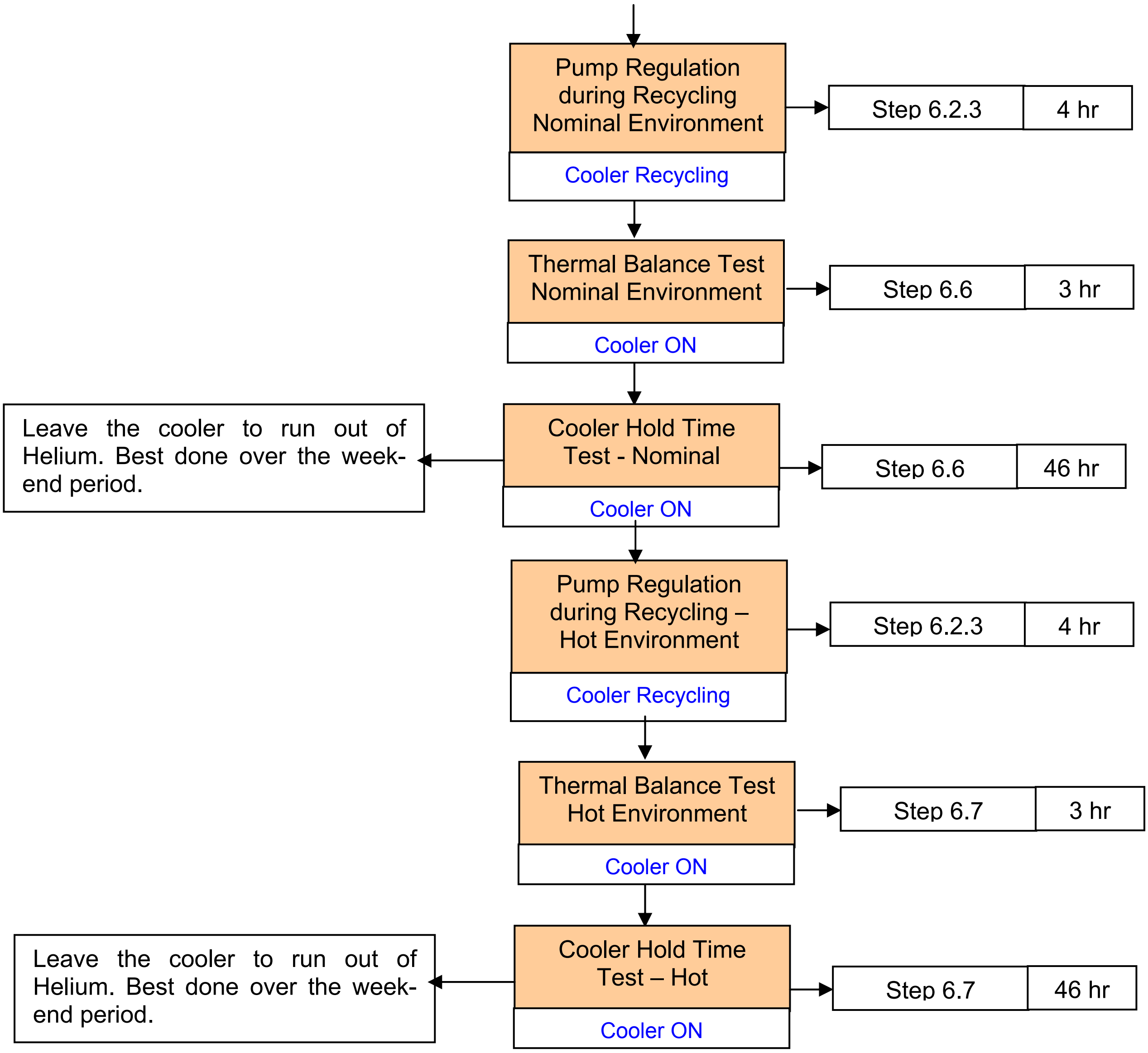
3.4.6 Mechanisms and Calibration Sources Operation

As part of the mechanisms and calibration source tuning activities, the following performances will be monitored:

- Dissipation at L1,
- Temperature gradient on SOB.

3.5 PFM3 Thermal Test Sequences





Note: The duration of each thermal test has been defined in hours to help with the planning of the various tests within a day's shift pattern. Please note that the durations are applicable only once the cryostat has reached stable conditions i.e. as cryostat top-ups are required every morning, thermal tests are not expected to start before lunch time.

3.6 Additional Information

3.6.1 *Steady-State Criteria*

The completion of a thermal balance test is defined by a steady state criterion, which describes the maximum allowable temperature rate of change over a period of time for a given temperature sensor. Each temperature stage of the instrument has a different requirement as described in Table 3.4.

Stage	Rate of Change	Period	Applicable Sensor	Equivalent TMM Node
300mK	0.1 mK/hr	2 hr	T_PLW	2750
			SUBTEMP	4300
Level 0	9 mK/hr	2 hr	T_PL0_1	2400
			T_SL0_1	3400
Level 1	120 mK/hr	2 hr	T_SOB_L1STR	1130
			T_FPU_MXAF	1600
			T_FPU_PXAF	1500
			T_SOB_CONE	1300
Level 2	70 mK/hr	2 hr	T_PJFS_CHAS	5040
			T_SJFS_CHAS	5530

Table 3-4 - Thermal Steady State Criteria

3.6.2 *Team Support and Tasks Breakdown*

Tasks/Operations	Support
Cryostat, Lakeshores and Heaters	Dave/Anneso
Instrument/Mechanisms	Sunil/Ed/Tim/Davide
PTC	Ken/Doug/Anneso Sunil/Ed/Tim/Davide
Normal Recycling	Sunil/Ed/Tim/Davide
Optimised Recycling	Dave/Anneso Sunil/Ed/Tim/Davide

Table 3-5 – Tasks Breakdown and Team Support

4 FM3 THERMAL TEST PROCEDURES

The procedures described in the following pages should be used during the PFM3 thermal balance test campaign. It describes the thermal test setup for the various tests and also provides information regarding the types of information that should be logged during each test phases.

Please see excel spreadsheet “PFM3 Test Procedures - Draft E.xls” for the detailed procedures.

Test	Actions	Data			Task Completed	Comments	Duration [Hr]
6.1	**Temperature Sensors Functional Check**						
6.1.1	**Room Temperature Check**						
6.1.2	**4K Temperature Check**						**0.3**
6.1.2.1	Wait for instrument temperatures to stabilise at 4K						
6.1.2.2	Log all instrument and cryostat temperature below, identify possible discrepancies and write observations in provided space.	Temperature	Resistance/Count				**0.3**
	HSFPU Harness Filter Bracket						
	M3,5,7 Optical Sub Bench						
	Input Baffle						
	BSM/SOB I/F (SOB side)						
	SCAL Structure						
	SCAL 4%						
	SCAL 2%						
	BSM						
	SMEC						
	SMEC/SOB I/F						
	Cooler Pump						
	Cooler Shunt						
	Cooler Evap						
	Cooler Pump Heat Switch (sieve)						
	Cooler Evap Heat Switch (sieve)						
	Photometer Level 0 Enclosure						
	Spectrometer Level 0 Enclosure						
	Photometer JFET Chassis						
	Spectrometer JFET Chassis						
	FPU +X A-Frame Interface						

	FPU –X A-Frame Interface						
	SOB Cone Interface						
	SOB L1 Strap Interface						
	L1 photo connector bracket						
	Detector Box L0 Strap Adaptor						
	Pump L0 Strap Adaptor						
	Evaporator L0 Strap Adaptor						
	Phot JFET L3 I/F Block						
	Spect JFET L3 I/F Block						
	HOB Cone I/F (Rear)						
	HOB +Y A-Frame I/F						
	HOB -Y A-Frame I/F						
	FPU L1 Adaptor						
	Detector Box L0 Strap on Adaptor 2						
	Pump L0 Strap 2 on Adaptor 2						
	Evaporator L0 Strap 2 on Adaptor 2						
6.1.3	**1.7K/4KTemperature Check**						**1.0**
6.1.3.1	Wait for instrument L1 temperatures to stabilise at 4K and L0 temperatures to stabilise at 1.7K.						
6.1.3.2	Make sure the cooler is discharged.					Discharged while the cryostat is stabilising if needed	
6.1.3.3	Make sure the Lakeshore 370 is using a 1uA excitation current setting						
6.1.3.4	Log all instrument and cryostat temperature (and resistance when applicable) below, identify possible discrepancies and write observations in provided space.						**0.3**
		Temperature	Resistance/Count				
	HSFPU Harness Filter Bracket						
	M3,5,7 Optical Sub Bench						

	Input Baffle						
	BSM/SOB I/F (SOB side)						
	SCAL Structure						
	SCAL 4%						
	SCAL 2%						
	BSM						
	SMEC						
	SMEC/SOB I/F						
	Cooler Pump						
	Cooler Shunt						
	Cooler Evap						
	Cooler Pump Heat Switch (sieve)						
	Cooler Evap Heat Switch (sieve)						
	Photometer Level 0 Enclosure						
	Spectrometer Level 0 Enclosure						
	Photometer JFET Chassis						
	Spectrometer JFET Chassis						
	FPU +X A-Frame Interface						
	FPU –X A-Frame Interface						
	SOB Cone Interface						
	SOB L1 Strap Interface						
	L1 photo connector bracket						
	Detector Box L0 Strap Adaptor						
	Pump L0 Strap Adaptor						
	Evaporator L0 Strap Adaptor						
	Phot JFET L3 I/F Block						
	Spect JFET L3 I/F Block						
	HOB Cone I/F (Rear)						
	HOB +Y A-Frame I/F						
	HOB -Y A-Frame I/F						
	FPU L1 Adaptor						

	Detector Box L0 Strap on Adaptor 2						
	Pump L0 Strap 2 on Adaptor 2						
	Evaporator L0 Strap 2 on Adaptor 2						
	Photometer Level 0 Enclosure (redundant)						
	Spectrometer Level 0 Enclosure (redundant)						
6.1.3.5	Change the Lakeshore 370 from 1uA to 10uA excitation current setting						**0.1**
6.1.3.6	Wait for 20 min for the temperature to stabilise						**0.3**
6.1.3.7	Log all the temperature and resistance for the following sensors, identify possible discrepancies and write observations in provided space.	Temperature	Resistance				**0.3**
	SOB L1 Strap Interface						
	Detector Box L0 Strap Adaptor						
	Pump L0 Strap Adaptor						
	Evaporator L0 Strap Adaptor						
	FPU L1 Adaptor						
	Detector Box L0 Strap on Adaptor 2						
	Pump L0 Strap 2 on Adaptor 2						
	Evaporator L0 Strap 2 on Adaptor 2						
6.1.3.8	Change the Lakeshore 370 from 10uA to 1uA excitation current setting						**0.1**
6.2	**Optimal Cooler Recycling**						
6.2.1	**Manostat Operation during Cooler Recycling**						**4.0**
6.2.1.1	The cooler must be discharged to start with.					Discharged while the cryostat is stabilising if needed	

6.2.1.2	Set the L0 temperature stage to operate at 1.9K with the manostat close. (Goal Interface Temperature expected at S/C level)					Use the temperature from the "Evaporator L0 Strap Adaptor" (T_L0_ESTR1) to monitor the manostat temperature settings.	**2.0**
6.2.1.3	Run a normal recycling as defined by procedure 6.3 with the following new conditions:						**2.0**
6.2.1.4	Try to leave the manostat closed for the whole recycling duration. If not possible, wait until after the start of the cryo-pumping phase (if acceptable)					Open the manostat only if obvious that the cryostat L0 pot has become instable.	
6.2.1.5	Please note that the steps 6.3.1 and 6.3.3 is not applicable in this specific test.						
~~**6.2.2**~~	~~**Pump Regulation 1 During Recycling**~~					**N/A Anymore as too demanding in term of Energy**	**0.0**
6.2.3	**Pump Regulation 2 During Recycling**					**Planned for the 31/03/06 - Shift C**	**4.0**
6.2.3.1	The cooler must be discharged to start with.					Discharged while the cryostat is stabilising if needed	
6.2.3.2	Set the L0 temperature stage to operate at 1.9K with the manostat close. (Goal Interface Temperature expected at S/C level)					Use the temperature from the "Evaporator L0 Strap Adaptor" (T_L0_ESTR1) to monitor the manostat temperature settings.	**2.0**
6.2.3.3	Run a normal recycling as defined by procedure 6.3 with the following new conditions:						**2.0**

6.2.3.4	Try to leave the manostat closed for the whole recycling duration. If not possible, wait until after the start of the cryo-pumping phase (if acceptable)						
6.2.3.5	Reduce the power on pump heater to ~45 mW (command [0x0XXX]) instead of 40mW in step 6.3.13.						
6.2.3.6	Please note that the steps 6.3.1 and 6.3.3 is not applicable in this specific test.						
6.2.4	**Define Optimal Parameters for Recycling**						**0.0**
6.2.4.1	Based on the results obtained during the recycling 6.2.3, define the following optimal recycling parameters:						
6.2.4.2	Pump Regulation Scheme						
6.2.4.3	Recycling optimal timing sequence						
6.3	**Normal Cooler Recycling**					**As defined by PFM2 script - should be used when normal recycling are required**	**2.0**
6.3.1	Make sure the cryostat temperature stages have been set at ~1.7K.						
6.3.2	Make sure the 370 AC bridge excitation current is set to 1uA.						
6.3.3	The cooler must be discharged to start with.					Discharged while the cryostat is stabilising if needed	
6.3.4	Log the recycling start time in the AIV log						
6.3.5	Turn the pump Heat Switch OFF if previously turned ON.						

6.3.6	Turn the evaporator heat switch ON by applying 1.4mA on evaporator HS heater (command [0x0DEB])						
6.3.7	Wait until the pump heat switch temperature has decreased below 12K.						
6.3.8	Apply ~400 mW to the pump heater (command [0x0A25])					Please note that the cryostat manostat requires to be opened as soon as the cryostat L0 He Pot temperature becomes instable. This affects the L0 interface temperatures stability but cannot be avoided.	
6.3.9	Wait for the pump temperature to reach 45K						
6.3.10	Log the time at which the pump has reached 45K in the AIV log						
6.3.11	Reduce the power on pump heater to ~40 mW (command [0x0339])						
6.3.12	Wait for the evaporator temperature to reach 2K					Please note that the required temperature would be 2.1K for the nominal thermal test case and 2.2K for the hot thermal test case.	
6.3.13	Log the time at which the evap has reached 2K in the AIV log						
6.3.14	Turn the power on the pump heater OFF						
6.3.15	Turn the power on the evaporator heat switch OFF						
6.3.16	Wait for the evaporator HS temperature to cooldown below 16K						
6.3.17	Turn the pump heat switch ON by applying 1.4mA on pump HS heater (command [0x0DEB]).						
6.3.18	Wait for the evaporator temperature to drop and stabilise at subK temperature.						

6.3.19	Log the evaporator cold base temperature and recycling end time in the AIV log						
6.4	**Optimal Cooler Recycling**						**3.0**
6.4.1	Set the cryostat L0 pot to run at 1.9K with manostat close (Goal Interface Temperature expected at S/C level)					Use the temperature from the "Evaporator L0 Strap Adaptor" (T_L0_ESTR1) to monitor the manostat temperature settings.	**1.0**
6.4.2	Make sure the 370 AC bridge excitation current is set to 1uA.						
6.4.3	The cooler must be discharged to start with.					Discharged while the cryostat is stabilising if needed	
6.4.4	Log the recycling start time in the AIV log						
6.4.5	Turn the pump Heat Switch OFF if previously turned ON.						
6.4.6	Turn the evaporator heat switch ON by applying 1.4mA on evaporator HS heater (command [0x0DEB])						
6.4.7	Wait until the pump heat switch temperature has decreased below 12K.					Could be relaxed to 14K to save time?	
6.4.8	Apply ~400 mW to the pump heater (command [0x0A25])						
6.4.9	Wait for the pump temperature to reach 45K						
6.4.10	Log the time at which the pump has reached 45K in the AIV log						
6.4.11	Reduce the power on pump heater to ~XX mW (command [0x0XXX])					To be confirmed as part of the Cooler Tuning Test	
6.4.12	Wait for the evaporator temperature to reach 2.1K/2.2K depending on test case.						
6.4.13	Log the time at which the evap has reached 2K in the AIV log						
6.4.14	Turn the power on the pump heater OFF						

6.4.15	Turn the power on the evaporator heat switch OFF						
6.4.16	Wait for the evaporator HS temperature to cooldown below 15K ~~16K~~.					Should now be 15K for the FM cooler according to the HSO-SBT-TN-120	
6.4.17	Turn the pump heat switch ON by applying 1.4mA on pump HS heater (command [0x0DEB]).						
6.4.18	Wait for the evaporator temperature to drop and stabilise at subK temperature.						
6.4.19	Log the evaporator cold base temperature and recycling end time in the AIV log						
6.4.20	Reduce the pump heat switch power to 400 uW (1 mA – command [0x09EC]).					Should we use 0.42mW as suggested in HSO-SBT-TN-120	
6.5	**Level-1 Strap Characterisation**						**7.0**
6.5.1	The cryostat temperature stages should be set as follows:						
6.5.2	L2	~ 15K					
6.5.3	L1	~ 4.2K				Use the temperature from the "SOB L1 Strap Interface" (T_SOB_L1STR) to monitor the manostat temperature settings.	
6.5.4	L0	~1.7K				Use the temperature from the "Detector L0 Strap Adaptor" (T_L0_DSTR1) to monitor the manostat temperature settings.	
6.5.6	Make sure the 370 AC bridge excitation current is set to 1uA.						
6.5.7	The cooler must be ON						
6.5.8	The instrument should be in PHOTSTBY mode.						

6.5.9	Wait for the cryostat temperatures to stabilise according to the steady-state criteria					Requires to wait until about lunchtime before this test can be started	
6.5.10	Measure the cryostat heater H2 voltage	H2 =					
6.5.11	Wait for the instrument temperatures to stabilise according to the steady-state criteria					Requires to wait until about lunchtime before this test can be started	
6.5.12	Log time at which steady-state was reached	Reference Case	10mW	30mW			
6.5.13	Measure the following temperatures for the Reference test case.	Temperature/ Resistance	Temperature/ Resistance	Temperature/ Resistance			**0.3**
	SOB L1 Strap Interface *(outside)*						
	FPU L1 Adaptor						
	FPU +X A-Frame Interface						
	FPU –X A-Frame Interface						
	SOB Cone Interface						
	FPU Cone Foot I/F						
	FPU +Y Foot I/F						
	FPU -Y Foot I/F						
	L1 photo connector bracket						
	HSFPU Harness Filter Bracket						
	Photometer Level 0 Enclosure						
	Spectrometer Level 0 Enclosure						
	Detector Box L0 Strap Adaptor						
	Detector Box L0 Strap 2						
6.5.14	Calculate the L1 thermal strap delta T below	SOB L1 Strap Interface - FPU L1 Adaptor					
6.5.15	Set the FPU heater voltage to 591.8mV ~10mW						**0.3**

6.5.16	Record the heater voltage and current.	Voltage = 0mV	591.8mV	983.1 mV		Values to be reviewed as the L1 MGSE strap is different from the PFM2 test campaign	
		Current = 0mA					
		Power = 0mW					
6.5.17	Make sure the L2 stage temperature doesn't drift as a result of the H2 power dissipation. If it does, adjust H2						
6.5.18	Repeat the step 6.5.11 to 6.5.14 for the 10mW test case.						**3.0**
6.5.19	Set the FPU heater voltage to 983.1 mV ~30mW					Make sure the FPU average temperature doesn't exceed 5.2K in the process or the instrument initial parasitic load (Qo) would vary by more than 10%.	**0.3**
6.5.20	Make sure the L2 stage temperature doesn't drift as a result of the H2 power dissipation. If it does, adjust H2						
6.5.21	Repeat the step 6.5.11 to 6.5.14 for the 30mW test case.						**3.0**
6.5.22	Set the FPU heater voltage to 0V once the test is completed and make sure the cryostat H2 heater is set back to its original setting if it has been changed.						**0.3**
6.6	**Nominal Thermal Balance Test**						**7.0**
6.6.1	The cryostat temperature stages should be set as follows:						
	L2	~15K					
	L1 at SOB L1 I/F	~4.3K				Use the temperature from the "SOB L1 Strap Interface" (T_SOB_L1STR) to monitor the manostat temperature settings.	

6.6.2	The cryostat temperatures must be stable.						
6.6.3	The CBB should be closed.						
6.6.4	Make sure the 370 AC bridge excitation current is set to 1uA.						
6.6.5	The instrument mechanisms should be left OFF						
6.6.6	Recycle cooler according the procedure 6.4 and using a 2.1K temperature criteria for the step 6.4.12						**3.0**
6.6.7	When the recycling has been completed, open the manostat to reset the L0 stage temperature as follows:						**1.0**
	L0 at L0 enclosure adaptor	~1.71K				Use the temperature from the "Detector L0 Strap Adaptor" (T_L0_DSTR1) to monitor the manostat temperature settings.	
6.6.8	Wait for the temperatures reached steady-state criteria and make sure no performances testing is carried out during this period.						**2.0**
6.6.9	When steady-state criteria are met, run a DC load curve to measure the phot detectors temperature [AD7] as well as the PTC.						**0.5**
6.6.10	When steady-state criteria are met, mesured all the flight temperature sensors on the AC bridge						**0.5**
6.6.11	Write down the time at which the steady state condition has been met for future reference. This completes the COLD thermal balance test case.						

6.6.12	Leave the cooler to run out during the week-end to assess the cooler total load and hold time performance for the nominal conditions						**46.0**
6.6.13	Log the time at which the evaporator started warming-up back from ~300mK to 1.7K and take note of the cooler hold time. This completes the COLD cooler hold time characterisation.						**0.3**
6.7	**Worst Case Thermal Balance Test**						**7.0**
6.7.1	The cryostat temperature stages should be set as follows:						
	L2	~15K					
	L1 at SOB L1 I/F	~5.5K				Use the temperature from the "SOB L1 Strap Interface" (T_SOB_L1STR) to monitor the manostat temperature settings.	
6.7.2	The cryostat temperatures must be stable.						
6.7.3	The CBB should be closed (TBC)						
6.7.4	Make sure the 370 AC bridge excitation current is set to 1uA.						
6.7.5	The instrument mechanisms should be left OFF						
6.7.6	Recycle cooler according the procedure 6.4 and using a 2.2K temperature criteria for the step 6.4.12						**3.0**
6.7.7	When the recycling has been completed, open the manostat to reset the L0 stage temperature as follows:						**1.0**
	L0 at L0 enclosure adaptor	~1.78K				Use the temperature from the "Detector L0 Strap Adaptor" (T_L0_DSTR1) to monitor the manostat temperature settings.	

6.7.8	Wait for the temperatures reached steady-state criteria and make sure no performances testing is carried out during this period.						**2.0**
6.7.9	When steady-state criteria are met, run a DC load curve to measure the photometer and the spectrometer detectors temperature [AD7].						**0.5**
6.7.10	When steady-state criteria are met, mesured all the flight temperature sensors on the AC bridge						**0.5**
6.7.11	Write down the time at which the steady state condition has been met for future reference. This completes the HOT thermal balance test case.						
6.7.12	Leave the cooler to run out to assess the instrument hold time performances for the hot conditions						**42.0**
6.7.13	Log the time at which the evaporator started warming-up back from ~300mK to 1.7K and take note of the cooler hold time. This completes the HOT cooler hold time characterisation.						
6.8	**Mechanisms and Calibration Sources Operation**					**Done as part of the performance tests**	
6.8.1	Log the time at which tuning of the mechanism/calibration source starts in the AIV log						
6.8.2	As the mechanism/calibration is operated record the following temperatures and the time in the AIV log						
	HSFPU Harness Filter Bracket						

	M3,5,7 Optical Sub Bench						
	Input Baffle						
	BSM/SOB I/F (SOB side)						
	SCAL Structure						
	SCAL 4%						
	SCAL 2%						
	BSM						
	SMEC						
	SMEC/SOB I/F						
	SOB L1 Strap Interface						
	FPU L1 Adaptor						
6.8.3	Also log the following mechanism/calibration operating settings as applicable in the AIV log.						
	current						
	voltage						
	duty cycle						