SPIRE PFM2

THERMAL BALANCE TEST SPECIFICATION

AND PROCEDURES

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CHANGE RECORD

Issue	Date	Section	Change
Draft A	09/05/05	-	New Document based on the CQM Thermal Balance Test Specification.
Draft B	11/08/05	1.2	Add missing acronyms
		2.1	Update to applicable documents list
		3.1 / 4.2.1 4.3 / 4.4	Replace “instrument modes” by ”hot/cold” cases for consistency.
		5.1	Table 5.1 – Replace the Cryostat L2 temperatures to take into account the cryostat operation limitations.
		6.1 6.8 6.9 6.10	Add missing test summary: Pump Heat Switch Characterisation Cold thermal balance case Hot thermal balance case
		7	Add pictures of the EGSE temperature sensors.
		8	Add detailed test procedures.
Issue 1	13/12/05	8	Red-lined version of the “as run” procedures.
		9	New section – AIV logs added in appendices for reference.

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1 INTRODUCTION

1.1 Scope

This document defines the thermal hardware, instrument set-up and procedures required for the Thermal Balance Test (TBT) campaign of the SPIRE Proto-Flight Model, upgrade 2 (PFM2). This test campaign aims at verifying of the instrument flight thermal design and performances.

1.2 Acronyms

Acronym	***Definition***
218	Lakeshore Monitoring Unit 218
370	Lakeshore Monitoring Unit 370
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
HOB	Herschel Optical Bench
HeI	Helium I
HeII	Helium II
I/F	Interface
IIDB	Instrument Interface Document Part B
IRD	Instrument Requirement Document
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
PCAL	Photometer Calibration Source
PFM2	Proto Flight Model (Upgrade 2)
PJFET	Photometer JFET
RD	Reference Document
SCAL	Spectrometer Calibration Source
SJFET	Spectrometer JFET
SMEC	Spectrometer Mechanism
SOB	SPIRE Optical Bench
SPIRE	Spectral and Photometric Imaging Receiver
TBT	Thermal Balance Test
DTMM	Detailed Thermal Mathematical Model

Table 1-1– Acronym List

2 DOCUMENTS

2.1 Applicable Documents [AD]

ID	Title	Number
AD1	SPIRE PFM2 Build Standard	Issue 2.1 D. Smith
AD2	Temperature Sensor Technical Note	Issue 6 D. Griffin 02/06/05
AD3	PFM2 Thermometers 1.2	Issue 1.2 D. Smith 26/08/05
AD4	Memo on flight sensors	SPIRE-RAL-MEM-002533 A. Goizel 20/07/05
AD5	SPIRE FM1 Sorption Cooler EIDP	SPIRE-SBT-DOC-002221 Issue 1 L. Duband 07/10/04
AD6	Procedure to perform 4-wire measurement on heaters	Heaters.doc Draft 0.2 10/09/04
AD7	PFM1 Performance Test Details DAB-P/S Dark Load Curves or DAL-P/S Optical Load curves Procedure	SPIRE-RAL-NOT-002211 Draft 0.3 23/02/2005
AD8	SPIRE Prime/Redundant Thermometry Harness Swap Procedure	SPIRE-RAL-PRC-002508 Issue 1 Doug Griffin 05/09/05
AD9	SPIRE PFM2 Hardware Command.xls	Working Document
AD10	SCU QM2 Test Report	SEDI-SCU-MM-2005-1 Issue 0.2 21/06/05
AD11	PFM2 Thermometer C2T Issue 1.0.xls	Issue 1 D. Smith 07/07/05
AD12	Cal Table for TFCS MIB -23-Aug-2005.xls	D. Smith 23/8/05
AD13	PFM2 Cold Test – Master Procedure	SPIRE-RAL-PRC- 002468 Issue 0.1 D. Smith 22/07/05

Table 2-1- Applicable Documents

2.2 Reference Documents [RD]

ID	Title	Number
RD1	SPIRE Instrument Interface Document Part B (IIDB)	SPIRE-ESA-DOC-000275 01-Mar-04 Issue 3.2
RD2	SPIRE Instrument Requirement Document (IRD)	SPIRE-RAL-PRJ-000034 Issue 1.3, First Release 14/07/05
RD3	SPIRE Thermal Design Requirements	SPIRE-RAL-PJR-002075 Draft B 13/07/04

Table 2-2 - Reference Documents

3 PFM2 TEST CAMPAIGN OVERVIEW

3.1 PFM2 Thermal Test Campaign Objectives

The objectives of the SPIRE Proto Flight Model, upgrade 2 (PFM2) Thermal Balance Test campaign (TBT) can be summarised as follows:

- **Goal 1** - To validate the instrument thermal heat loads at the Herschel Level-0 and Level-1 Cryostat Interfaces, as described in Table 3-1,
- **Goal 2** - To validate the instrument thermal performances in terms of absolute detector temperature and total cooler heat load (for both hot and cold thermal environments), as described in Table 3-2,
- **Goal 3 -** To provide sets of thermal data for the correlation of the SPIRE Detailed Thermal Mathematical Model (DTMM) and hence allow accurate predictions of the future in-flight instrument performances.

SPIRE Thermal Interface	***Maximum Heat Load***	***Herschel Interfaces Temperature***	***Comments***
Level-0 (L0) Detector Box	4 mW	2 K	This load should be verified with a L1 temperature stage stabilised at 5.5K.
Level-0 (L0) Cooler Pump	2 mW	2 K	
Level-0 (L0) Cooler Evaporator	-	-	Heat load requirement on this interface are only applicable during the cooler recycling and has been verified at unit level [AD5].
Level-1 (L1)	15 mK	5.5 K	This load should be verified with a L2 temperature stage stabilised at 12K.
Level-2 (L2)	-	12K	No Heat Load Requirements.
Level-3 (L3) Photometer	50 mW	15 K	These requirements cannot be directly verified at Instrument Level as they depend on the Astrium L3 ventline design and as well as on the Astrium harness heat loads. The verification will be done by analysis with a correlated SPIRE thermal model and the Astrium Herschel Thermal Model.
Level-3 (L3) Spectrometer	25 mW	15 K	

Table 3-1 - Maximum Heat Loads at the various Herschel Cryostat Interfaces [RD1]

SPIRE High-Level Thermal Requirements	
Absolute Temperature at the Bolometer Detector Arrays (BDA)	< 300 mK
Total Cooler Heat Load	< 30 uW

Table 3-2 - SPIRE High-Level Thermal Requirement [RD3]

3.2 PFM2 Instrument Standard Built

3.2.1 Instrument Description

A detailed description of the PFM2 instrument standard built can be found in AD1.

3.2.2 Thermal Hardware Restrictions

Please note that the following hardware will not be flight representative:

- The three Level-0 (L0) straps

The flight Level-0 straps have recently been redesigned and they do not fit inside the RAL calibration cryostat. The MGSE (Mechanical Ground Support Equipment) L0 straps (which have already been used for the previous CQM test campaigns) will therefore be used again for the PFM2 test campaign. A different set of instrument thermal interface locations will be assumed in this case to compensate for this restriction (see section 5.1 for more details).

- Spectrometer MEChanism (SMEC)

Because of delays in the SMEC development program, the Cryogenic Qualification Model (CQM) version of the SMEC will be used for this test campaign.

- The instrument redundant side will not be connected to the flight electronics.

As the instrument redundant side will not be used, some of its redundant flight sensors will be connected to the Electronic Ground Support Equipment (EGSE), as harnesses and monitoring channels are available on the Lakeshore units. More details are given in section 5.3.2.

3.3 Calibration Cryostat Standard Built

3.3.1 Calibration Cryostat Description

During thermal balance testing, SPIRE is integrated on the Herschel Optical Bench (HOB) simulator in the RAL calibration cryostat. This cryostat has been designed to provide a flight representative thermal environment for the instrument. The various temperature levels of the Herschel cryostat are present in the calibration cryostat with the exception of the Level 3 (~15K), which is a recent change in the flight cryostat design. The calibration cryostat consists of the following temperature stages:

Calibration Cryostat Temperature Stage		***Nominal Operating Temperature Range***	
Vacuum vessel	Room Temperature	300K	
Liquid Nitrogen 2 Shield	LN2 Shield	77K	
Helium Vapour Cooled Shield	L2 Shield/Shroud	10K	18K
HOB Simulator[1]	Level 2 HOB	10K	18K
Cold Black Body Source	CBB	6K	40K
Helium I (HeI) Tank	Level 1	4.2K	6K
Helium II (HeII) Tank	Level 0	1.4K	2.5K

Table 3-3 – SPIRE Calibration Cryostat Temperature Stages

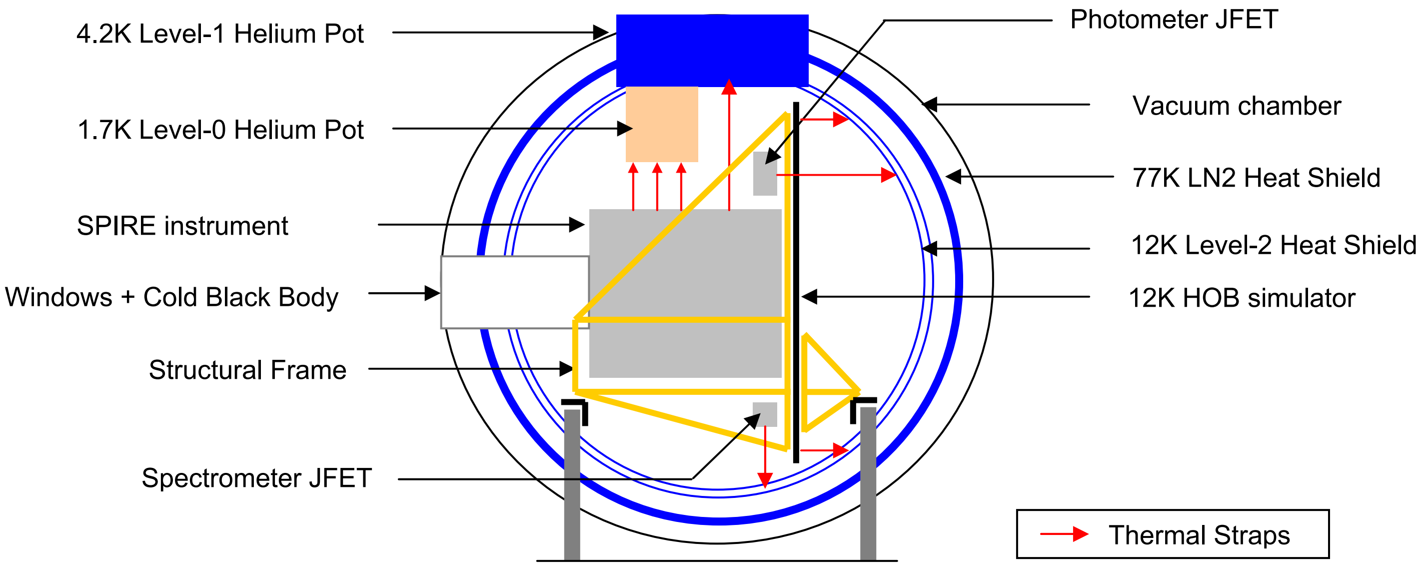

Figure 3-1 – SPIRE Calibration Cryostat Diagram

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[1] The HOB simulator is thermally coupled to the L2 shield with several copper straps.

3.3.2 Thermal Environment Restrictions

The following restrictions apply to the calibration cryostat thermal environment.

- Level-3 Interfaces:

These interfaces are not available in the calibration cryostat. The JFETs (Junction Field Effect Transistor) have been connected to the L2 Shield or "shroud" instead for heat sinking. As the temperature of the L2 shield cannot be controlled independently from the HOB temperature however, it will not be possible to simulate a flight-like thermal environment for the Level-3.

- Radiation:

The radiative environment is different from the Herschel cryostat environment. The instrument radiation loads will be characterised with the correlated thermal model.

- Level-1 Interface:

The SPIRE calibration cryostat provides a single attachment point to the L1 Helium Tank through a flexible aluminium tube. This arrangement provides the instrument with a stable interface temperature of 4.2K, which is not affected by the instrument heat loads. In order to simulate the Herschel in-flight L1 interface temperature in the calibration cryostat, an EGSE heater fitted on the instrument Focal Plane Unit (FPU) will be used in conjunction with a L1 MGSE strap to adapt the required temperature at the instrument L1 thermal interface.

- Level-0 Interfaces:

The SPIRE calibration cryostat can provide a base Level-0 interface temperature of 1.4K. When used in conjunction with a manostat, the L0 temperature stage can be controlled to any temperature ranging from 1.4K to 2.5K. For a given manostat setting however, any variation in instrument L0 heat loads will introduce instabilities in the L0 thermal interface temperatures (i.e. during strap characterisation test and the cooler recycling).

- Cryo-Harness:

The cryo-harness design and heat sinking will be different from the flight configuration therefore the heat loads from the housekeeping and the cryo-harness harnesses will not be flight representative. They will be characterised with the correlated thermal model.

4 PFM2 THERMAL DESIGN VERIFICATION

4.1 Overview

The SPIRE thermal requirements are defined in two high level documents, the "Instrument Interface Document Part B" [RD1] and the "Instrument Requirement Document" [RD2]. Some additional thermal requirements have been derived from both these documents and are described in the SPIRE Thermal Design Requirements document [RD3]. While some of these requirements have already been verified at unit level, the others will be verified at instrument and/or at spacecraft level. The aim of this PFM2 thermal balance test campaign is to verify the thermal requirements presented in section 3.1. A description of the verification method and thermal hardware used is given in the following sections for each requirement.

4.2 Instrument Heat Load Verification

4.2.1 Method

Each temperature stage of the instrument is connected to the calibration cryostat with a thermal strap equipped with two temperature sensors and a 4-wire heater. This setup will allow:

- Each strap conductance to be fully characterised by dissipating known amounts of heat on the strap (using the heater) and measuring the temperature drop between both strap's ends:

$$G = (Q_{H1} + Q_0) \times \Delta T_1$$

$$G = (Q_{H2} + Q_0) \times \Delta T_2$$

$$G = \frac{(Q_{H2} - Q_{H1})}{(\Delta T_2 - \Delta T_1)}$$

Where
- Q_0 is the instrument load initially flowing along the strap in W
- G is the strap conductance in W/K
- Q_H is the heater load applied during the characterisation test in W
- ΔT is the temperature drop between both strap ends in K

Note: this assumes that the strap conductance and the instrument initial load Q_0 remain constant during the characterisation exercise.

- Once the strap conductance is known, the heat load at each of the instrument temperature stage will be fully characterised for both hot and cold thermal environments by measuring the temperature drop between both straps' ends:

$$Q_0 = G \times \Delta T_0$$

Note: For this approach to work, it is important that the temperature measurement is accurate and that the heat load flowing along the strap be well known during the strap characterisation exercise.

4.2.2 Known Limitations

Table 4-1 describes the known limitations of this method.

Items	Description
Temperature measurement	A good temperature measurement should be at least an order of magnitude larger than the sensor accuracy. The temperature sensors maximum accuracy is 10mK[2]. The strap conductance should therefore be characterised for temperature drops no lower than 100mK.
Temperature sensor failure	Should any strap sensor fails, the temperature drop cannot be measured and the heat load cannot be characterised. Therefore, redundant sensors should be implemented on each strap where heat loads need to be characterised.
Strap conductance and Heat Load	The amount of heat that should be applied with the heater during the strap characterisation is highly dependent on the strap conductance. It may well be that measuring an appropriate temperature drop requires the dissipation of a large amount of heat. This would have the following unwanted effects: - Variations of the initial instrument load (Q_0) during the strap characterisation. This variation will need to be estimated with the thermal model and corrected for in the strap conductance calculations. - Strap Temperature drop too small to be measured accurately for the instrument initial load verification case. In this case, extrapolation can be used to provide additional information about the instrument load (with a reduced accuracy) as described in Figure 4-1.

Table 4-1 - SPIRE Heat Load Characterisation - Known Limitations

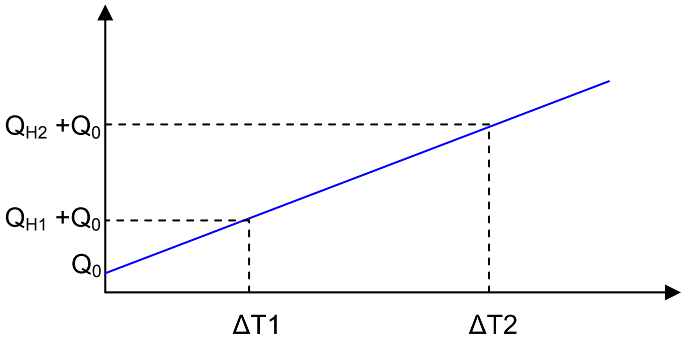

Figure 4-1 - Instrument Load Extrapolation Example

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[2] *This could be more depending on each sensor self-heating and DC offset errors.*

4.2.3 *Required Thermal Hardware*

The following thermal hardware will be used to verify the instrument heat loads during the PFM2 Thermal Balance Test campaign:

Measured Heat Load	**Thermal Strap**	**Heaters**		**Prime**		**Redundant**	
				Temp1	Temp 2	Temp1	Temp 2
L0 detector	L0 Detector Strap	EGSE heater on Photometer L0 enclosure	Up to 10mW	T_L0_DSTR Detector Box L0 Strap Adaptor	T_SL0_1 Spectrometer L0 Enclosure	S32 Detector Box L0 Strap 2	S30 FPU Box Strap I/F
L0 pump	L0 Pump Strap	Pump heater	Up to 400mW	T_L0_PSTR Pump L0 Strap Adaptor	T_CPHP_1 Cooler Pump	S33 Pump L0 Strap 2	S29 FPU Pump Strap I/F
L1 total load	L1 Strap	MGSE heater on FPU	Up to a Few watts	T_SOB_L1STR SOB L1 Strap Interface	-	S35 FPU L1 Adaptor	S26 FPU L1 Strap

Table 4-2 - Thermal Hardware for Heat Loads Measurements

Additional Notes:

- All thermal straps external to the instrument FPU are MGSE straps,
- All heaters use a 4-wire measurement technique,
- All temperature sensors have got some level of redundancy, with the exception of the L1 strap.

4.3 300-mK Detector Absolute Temperature Verification

The absolute Bolometer Detector Arrays (BDA) temperatures can be obtained by running a DC load curve according to the procedure described in [AD7]. In order to validate the instrument detector absolute temperature, this measurement will be done with the instrument operating in a flight representative environment and for both hot and cold thermal environments.

4.4 Total Cooler Heat Load Verification

The total cooler heat load can be estimated from measurements of the cooler pump temperature, the L0 bath temperature and the pump factor derived for the "pump characterisation test". To validate the total cooler load, these measurements will be done for both hot and cold thermal environments.

4.5 Overall Thermal Performance Verification Limitations

Because important changes to the thermal hardware have been implemented between the CQM and the PFM test campaigns, the majority of the instrument thermal performances remain to be validated. Given the restrictions on both the instrument and the calibration cryostat, some aspects of the SPIRE thermal design will not be fully verified as part of the PFM test campaign, as describe in Table 4-3.

In addition, the validation of some instrument thermal requirements will rely on direct performance measurements at instrument level during the test campaign, as well as analysis with the correlated instrument thermal model integrated in the Astrium Herschel cryostat thermal model.

Requirement		Known Restrictions
Cooler Hold Time Cooler Recycle Time Cooler Energy Cycle	[IRD-COOL-R08] [IRD-COOL-R09] [RD1/Sect.5.7.1.3]	These requirements are highly dependent on the flight L0 strap conductances. As the MGSE straps will be used, the instrument won't be flight representative and will not allow a full validation of the cooler performances in terms of hold time and recycling time. The following approach will be used to validate these performances: ▪ In the current test setup the pump and evaporator L0 MGSE thermal strap will be characterised. ▪ The measured performances will be compared against measurements performed at EQM level with flight like straps of known conductance. ▪ Further analysis with the correlated thermal model will finally allow to verify the instrument in flight performance. Note: the flight L0 Strap stand-offs will be used during the PFM2 test to ensure that flight representative heat loads are measured at the instrument L0 interfaces.
L3 Heat Load	[RD1/Sect.5.7.1.3]	These requirements are highly dependent on the Herschel cryostat thermal interface temperature and its L3 harnesses heat loads. This requirement cannot therefore be fully verified at instrument level.
L1 Heat Load	[IRD-SMEC-R11]	The internal dissipation of the flight SMEC will not be verified during this test campaign as the CQM model will be used. Therefore, the instrument L1 heat load will not be fully verified at this stage. Further analysis with the correlated thermal model will be required to predict the instrument flight performances.
Thermal Stability	-	These requirements are highly dependent on the flight cryostat interface thermal stability and therefore cannot be fully verified at instrument level. The measured instrument performances however will be used in conjunction with the correlated thermal model to predict flight performances.

Table 4-3 - SPIRE Thermal Validation Limitations during the PFM2 Test Campaign

5 PFM2 TEST CAMPAIGN CONFIGURATION

5.1 Calibration Cryostat Thermal Interface Definition

Figure 5-1 defines the thermal interfaces of SPIRE with the RAL calibration cryostat. These interface locations will be used as reference temperatures when setting the various cryostat temperature stages during the thermal balance testing. Please note that the L0 thermal interfaces assumed for this test are different from the flight ones. This is to account for the fact that the L0 MGSE straps are being used instead of the flight ones. This approach will allow to verify the instrument performance by analysis (with the correct flight hardware and environment).

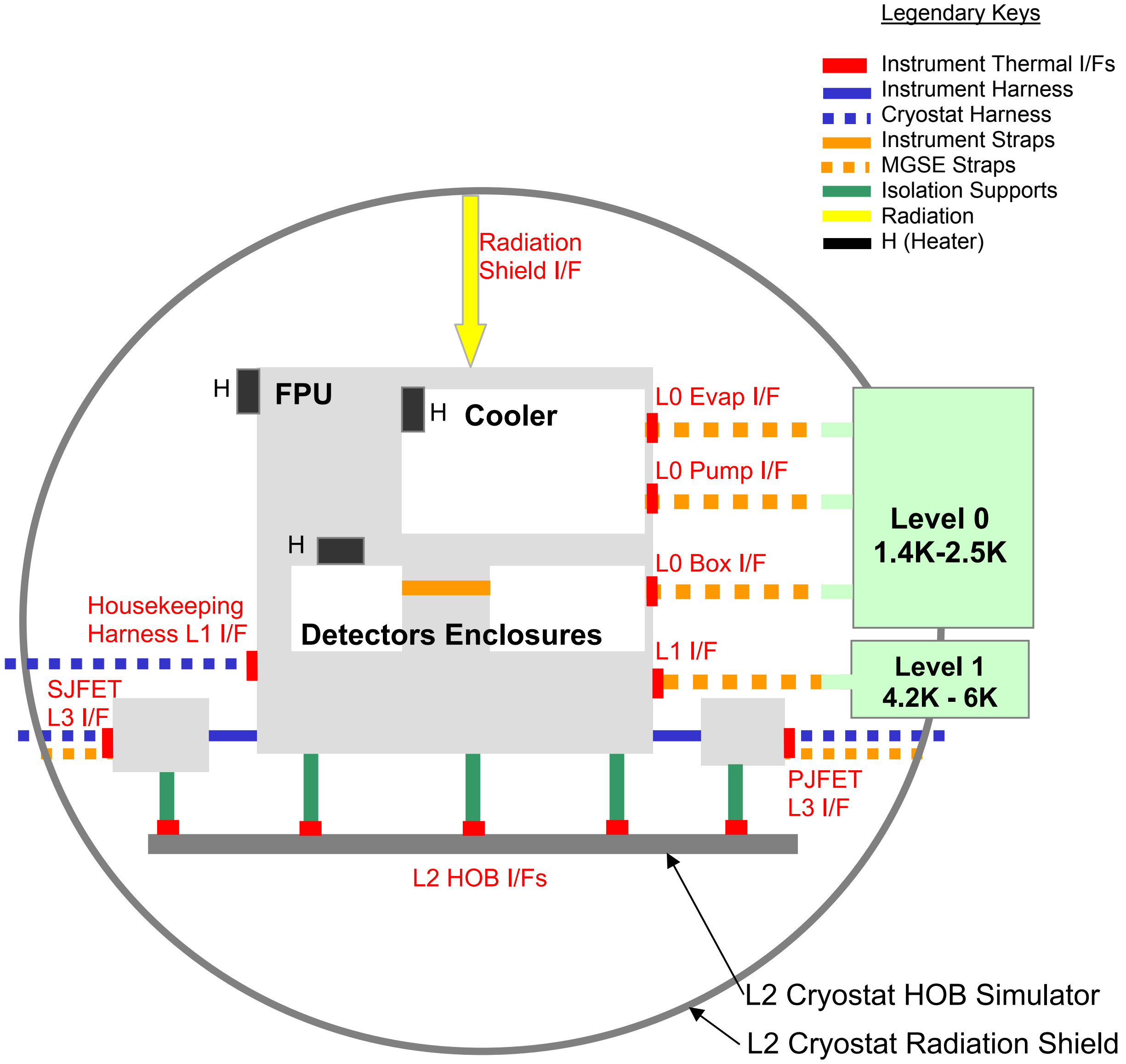

Figure 5-1 - SPIRE PFM2 Thermal Interfaces Definition with Calibration Cryostat

To achieve the thermal test campaign objectives, it is important that the calibration cryostat mimics the Herschel cryostat in-flight environment as much as possible. Table 5-1 describes the various cryostat setups which will be used during the PFM2 test campaign.

Temperature Stages	Interfaces Name	Reference Temp. Sensor	Nominal Cold Case	Nominal Hot Case
Level-2	HOB	FPU Cone Foot I/F FPU +Y Foot I/F FPU -Y Foot I/F	12K	15K
Level-1	L1	T_SOB_L1STR	~4.2K	5.5K
Level-0	L0 Box	T_L0_DSTR	1.7K	2K
	L0 Pump	T_L0_PSTR	1.7K	2K
	L0 Evap	T_L0_ESTR	1.7K	2K

Table 5-1 - Calibration Cryostat Setups During Thermal Balance Testing

Please note that in order to warm the Level-1 interface up to 5.5K, the FPU EGSE heater will be used. This is likely to affect the HOB and radiation shield (or shroud) temperature by slightly cooling them down depending on the amount of heat being dissipated. This can be compensated however by adjusting the heater on the cryostat L1 Helium pot. It could mean however that the setup of the cryostat interface temperatures is quite difficult to achieve for this case.

5.2 Mechanical Ground Support Equipment: Thermal Straps

The instrument is thermally coupled to the calibration cryostat through the following MGSE thermal straps:

- A high purity aluminium strap connects the SPIRE Optical Bench (SOB) to the cryostat Level 1 flexible interface,
- Three thermal straps connect the SPIRE pump, evaporator and spectrometer enclosure to dedicated L0 cryostat flexible interfaces.
- Two additional thermal straps are used to connect the SPIRE JFET units to the cryostat Level 2 Shield.
- A test facility harness connects the external warm electronics to the SPIRE FPU and JFET units. These harnesses are thermally heat sink to the LN2 shield (77K), the Level 2 shield and the HOB (12K) prior to connection with the instrument.

5.3 Electronic Group Support Equipment: Temperature Monitoring

5.3.1 Overview

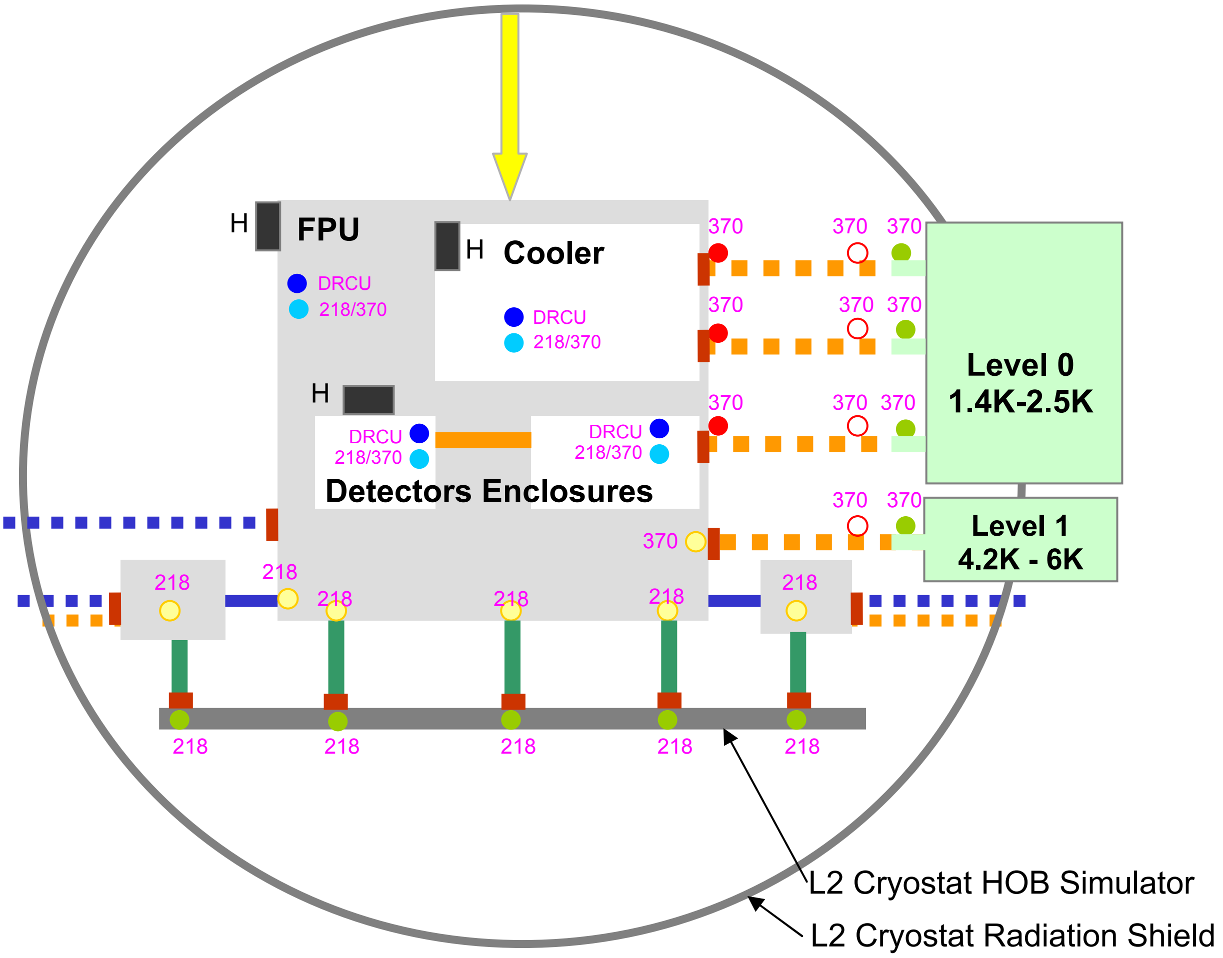

Figure 5-2 - Setup of SPIRE Instrument in Calibration Cryostat Diagram

Legendary Keys

- 🟥 Instrument Thermal Interfaces
- 🟦 Instrument Harness
- ┅ Cryostat Harness
- 🟧 Instrument Straps
- ┅ MGSE Straps
- 🟩 Isolation Supports
- 🟨 Radiation

- ▬ H (Heater)

Temperature Sensor and Harness

- ● Flight Prime Harness
- ● Flight Redundant Harness

- ● L0 Straps Harness
- ○ New Cryostat Back-up Harness
- ● Cryostat Harness
- ● STM External Harness

Temperature Monitoring Units

218 218 Lakeshore Unit
370 370 Lakeshore AC Bridge
DRCU Flight Electronics

5.3.2 *Flight Temperature Sensors*

A total of 34 prime and redundant temperature sensors are present on the SPIRE PFM2, as defined in the IID-B [RD1]. The prime flight sensors will be monitored with the instrument electronics or Digital Readout Control Unit (DRCU) while the some of the redundant sensors will be monitored with the EGSE Lakeshore units on specific occasions.

Level 1

Acronym	Location	TMM Nodes	Type	Provider	Monitoring Unit		Harness	Link to Picture
					Prime	Redundant	Length	
EMCFIL_1	HSFPU Harness Filter Bracket	1900	CX-1030	RAL	DRCU	218/370	N/A	Figure 7-1
T_SUB_1	M3,5,7 Optical Sub Bench	2000	CX-1030	RAL	DRCU	218/370	N/A	Figure 7-2
T_BAF_1	Input Baffle	2150-2180	CX-1030	RAL	DRCU	218/370	N/A	Figure 7-3
T_BSMS_1	BSM/SOB I/F (SOB side)	1010	CX-1030	RAL	DRCU	218/370	N/A	Figure 7-4
T_SCST_1	SCAL Structure	3250	CX-1030	Cardiff	DRCU	-	N/A	-
T_SCL4_1	SCAL 4%	3260-3290	CX-1030	Cardiff	DRCU	-	N/A	-
T_SCL2_1	SCAL 2%	3260-3290	CX-1030	Cardiff	DRCU	-	N/A	-
T_BSMM_1	BSM	2100	CX-1030	RAL	DRCU	218/370	N/A	Figure 7-4
T_FTSM_1	SMEC	3200	CX-1030	LAM	DRCU	-	N/A	-
T_FTSS_1	SMEC/SOB I/F	1120-1210	CX-1030	LAM	DRCU	-	N/A	-

Level 0

Acronym	Location	TMM Nodes	Type	Provider	Monitoring Unit		Harness Length	Link to Picture
					Prime	Redundant		
T_CPHP_1	Cooler Pump	4200	CX-1030	CEA	DRCU	218/370	Not Known	-
T_CSHT_1	Cooler Shunt	4250	CX-1030	CEA	DRCU	218/370	Not Known	-
T_CEV_1	Cooler Evap	4300	CX-1030	CEA	DRCU	-	Not Known	-
T_CPHS_1	Cooler Pump Heat Switch (sieve)	N/A	CX-1030	CEA	DRCU	-	Not Known	-
T_CEHS_1	Cooler Evap Heat Switch (sieve)	N/A	CX-1030	CEA	DRCU	-	Not Known	-
T_PL0_1	Photometer Level 0 Enclosure	2420	CX-1030	RAL	DRCU	218/370	600mm	Figure 7-6
T_SL0_1	Spectrometer Level 0 Enclosure	3400-3410	CX-1030	RAL	DRCU	218/370	500mm	Figure 7-5

Table 5-2- Flight Temperature Sensors [AD3]

In addition to these sensors, the temperature of the instrument BDAs can be obtained by running load curves [AD9].

Note: Because the flight temperature sensor harnesses have a protecting shield up to the sensors' body, no efficient thermal heat sinking of the sensors' leads could be implemented. To limit the parasitic loads down the sensors' leads at the Level-0 stage, stainless steel has been used for the sensor leads and their harness length has been maximized between each temperature stage. All temperature sensors integrated on the Level-1 temperature stage will have isothermal leads, as there are sink at the FPU RF Filter connectors bracket.

5.3.3 *EGSE Temperature Sensors*

A total of 10 EGSE temperature sensors are required to monitor additional instrument temperatures during the thermal balance test. These sensors will be readout with the 218 and the 370 AC Bridge Lakeshore units.

Level 2-3

Acronym	Location	TMM Nodes	Type	Provider	Monitoring Unit	Link to Picture
T_PJFS_CHAS	Photometer JFET Chassis	5020-5070	TVO	RAL	218	Figure 7-14
T_SJFS_CHAS	Spectrometer JFET Chassis	5520-5530	TVO	RAL	218	-

Level 1

Acronym	Location	TMM Nodes	Type	Provider	Monitoring Unit	Link to Picture
T_FPU_PXAF	FPU +X A-Frame Interface	1500	CX1030	RAL	218	Figure 7-11
T_FPU_MXAF	FPU –X A-Frame Interface	1600	CX1030	RAL	218	Figure 7-12
T_SOB_CONE	SOB Cone Interface	1300	TVO	RAL	218	Figure 7-13
T_SOB_L1STR	SOB L1 Strap Interface	1130	TVO	RAL	370	Figure 7-10
T_SOB_L1CON	L1 photo connector bracket	1750	TVO	RAL	218	-

Level 0

Acronym	Location	TMM Nodes	Type	Provider	Monitoring Unit	Link to Picture
T_L0_DSTR	Detector Box L0 Strap Adaptor	6100	CX1030	RAL	370	Figure 7-7
T_L0_PSTR	Pump L0 Strap Adaptor	6200	CX1030	RAL	370	Figure 7-8
T_L0_ESTR	Evaporator L0 Strap Adaptor	6300	CX1030	RAL	370	Figure 7-9

Table 5-3- SPIRE Instrument EGSE Temperature Sensors [AD3]

5.3.4 *Cryostat Temperature Sensors*

A total of 35 sensors are used to monitor and control of the cryostat interface temperatures. These sensors will be read out using the 218 and the 370 AC Bridge Lakeshore units.

Level 2-3

Acronym	Location	TMM Nodes	Type	Provider	Monitoring Unit	Harness	Link to Picture
S1	End Cap 1		Silicon	RAL	218	Cryostat	-
S2	End Cap 2		Silicon	RAL	218	Cryostat	-
S3	Filter Mount		Silicon	RAL	218	Cryostat	-
S4	Inlet Pipe		Silicon	RAL	218	Cryostat	-
S5	Outlet Pipe		Silicon	RAL	218	Cryostat	-
S6	End Cap 1		Silicon	RAL	218	Cryostat	-
S7	End Cap 2		Silicon	RAL	218	Cryostat	-
S8	Cylinder End		Silicon	RAL	218	Cryostat	-
S9	Cylinder Centre		Silicon	RAL	218	Cryostat	-
S10	Cylinder End		Silicon	RAL	218	Cryostat	-
S11	Filter Flange		Silicon	RAL	218	Cryostat	-
S13	Support foot 2		Silicon	RAL	218	Cryostat	-
S14	Support foot 3		Silicon	RAL	218	Cryostat	-
S15	Support foot 4		Silicon	RAL	218	Cryostat	-
S16	FSJFP L3 Strap		Silicon	RAL	218	Cryostat	Figure 7-12
S17	FSJFS L3 Strap		Silicon	RAL	218	Cryostat	Figure 7-11
S18	FSJFP-HOB I/F		Silicon	RAL	218	Cryostat	Figure 7-15
S19	FPU Cone Foot I/F		Silicon	RAL	218	Cryostat	Figure 7-13
S20	FPU +Y Foot I/F		Silicon	RAL	218	Cryostat	Figure 7-11
S12	Support foot 1		Silicon	RAL	218	Cryostat	-
S21	FPU -Y Foot I/F		Silicon	RAL	218	Cryostat	Figure 7-12
S22	FSJFS-HOB I/F		Silicon	RAL	218	Cryostat	Figure 7-16
S23	Harness Sink WE-Ph JFET(L2 Shield Side)		Silicon	RAL	218	Cryostat	Figure 7-17

Level 1

Acronym	Location	TMM Nodes	Type	Provider	Monitoring Unit	Harness	Link to Picture
S24	Vessel Top	11000	Cernox	RAL	370	Cryostat	-
S25	Vessel Bottom	11000	Cernox	RAL	370	Cryostat	-
S26	FPU L1 Strap	11000	Cernox	RAL	370	Cryostat	Figure 7-10
S35	FPU L1 Adaptor	6000	Cernox	RAL	370	Cryostat	Figure 7-10

Level 0

Acronym	Location	TMM Nodes	Type	Provider	Monitoring Unit	Harness	Link to Picture
S27	1.7K Vessel Bottom	10000	Cernox	RAL	370	Cryostat	-
S28	FPU Evap Strap I/F	10000	Cernox	RAL	370	Cryostat	-
S29	FPU Pump Strap I/F	10000	Cernox	RAL	370	Cryostat	-
S30	FPU Box Strap I/F	10000	Cernox	RAL	370	Cryostat	-
S31	Vessel Top	10000	Cernox	RAL	370	Cryostat	-
S34	Detector Box L0 Strap 2	6150	Cernox	RAL	370	Cryostat	Figure 7-7
S33	Pump L0 Strap 2	6250	Cernox	RAL	370	Cryostat	Figure 7-8
S32	Evaporator L0 Strap 2	6350	Cernox	RAL	370	Cryostat	Figure 7-9

Table 5-4- Calibration Cryostat Temperature Sensors [AD3]

5.3.5 Temperature Sensor Monitoring Requirements

5.3.5.1 Temperature Sensors Monitoring Units

The following monitoring units will be used to read out the instrument and cryostat temperature sensors. The acronyms defined in Table 5-5 will be used in subsequent sections to reference each Lakeshore unit.

Acronym	Description	Excitation signal	Readout Frequency
DRCU	Digital Readout Control Unit	Fixed 10mV DC Voltage[3]	10 sec
218	218 Lakeshore unit	Fixed 10uA DC Current	Twice a sec
370	370 AC Bridge Lakeshore unit	Variable AC Voltage	Variable - Depends on the number of channels in use

Table 5-5 - PFM2 Temperature Sensors Monitoring Units

5.3.5.2 Temperature Sensors Accuracy

All sensors on the L0 stage (instrument and cryostat) require an accuracy of 10mK. Such accuracy can only be achieved with:

- Careful integration of the sensors body and heat sinking of their leads (see section 5.3.6 for more details)
- With the use of an AC bridge (370 Lakeshore unit), which reduces the sensors' self-heating errors and cancels out any DC offset voltage errors.

All other sensors require an accuracy in the order of 50mK. The only exception is the sensors on the Level-1 strap interface. Because these sensors will be used to characterise the L1 strap and instrument

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[3] *The only exception is for the evaporator channel where a fixed excitation current on 0.04uA is used [AD10].*

L1 heat load, they need a 10mK accuracy. For this reason, these sensors will be monitored on the Lakeshore 370 AC Bridge as well.

5.3.5.3 Readout Requirements

- Data type

The raw value of the temperature sensors (resistance and count) should be logged at all time to allow the data to be post-processed again if needed in future.

- Frequency

The monitoring frequency shall be at least every 10 seconds during the cooler recycling and characterisation tests while it should only be every 1 minute for all others tests.

- Excitation signal

Both the DRCU and the 218 Lakeshore units have fixed excitation signals of 10mV and 10uA respectively (The only exception is for the evaporator DRCU channel where a fixed excitation current on 0.04uA is used [AD10]). The Lakeshore 370 AC Bridge allows the user to select the excitation signal amplitude. It has been demonstrated during the CQM thermal test campaign that an excitation current of 1uA provides optimal performances.

5.3.5.4 Thermal Balance Test Steady-State Requirements

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 5-6.

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 5-6 - Thermal Steady State Criteria

5.3.6 Temperature Sensor Integration Procedure

The following procedure should be used to integrate the temperature sensors:

- When selecting a location for a temperature sensor, ensure that the sensor's base will be well in contact with the surface to measure once integrated.
- Make sure that the sensors' leads are left bare (no isolation jacket) for about 10 cm starting from the sensor's body,
- If tapped holes cannot be used, use the Aluminium pads provided to this effect [AD2] and glue them on the surface using Stycast 2850FT.
- Once the pad has had time to cure, integrate the sensor with a calibrated torque wrench to a maximum torque of 0.55 N.m.
- Once the sensor is integrated, heat sink the 10cm sensor leads on the surface being measured using Aluminium tape, as described in Figure 5-3. This Aluminium tape also provides radiation shielding for the leads.
- If the sensor leads could not be left bare, heat sinking of the leads will not be possible using the Aluminium foil. In this case, make sure that a maximum amount of sensor lead is left between each temperature stages.

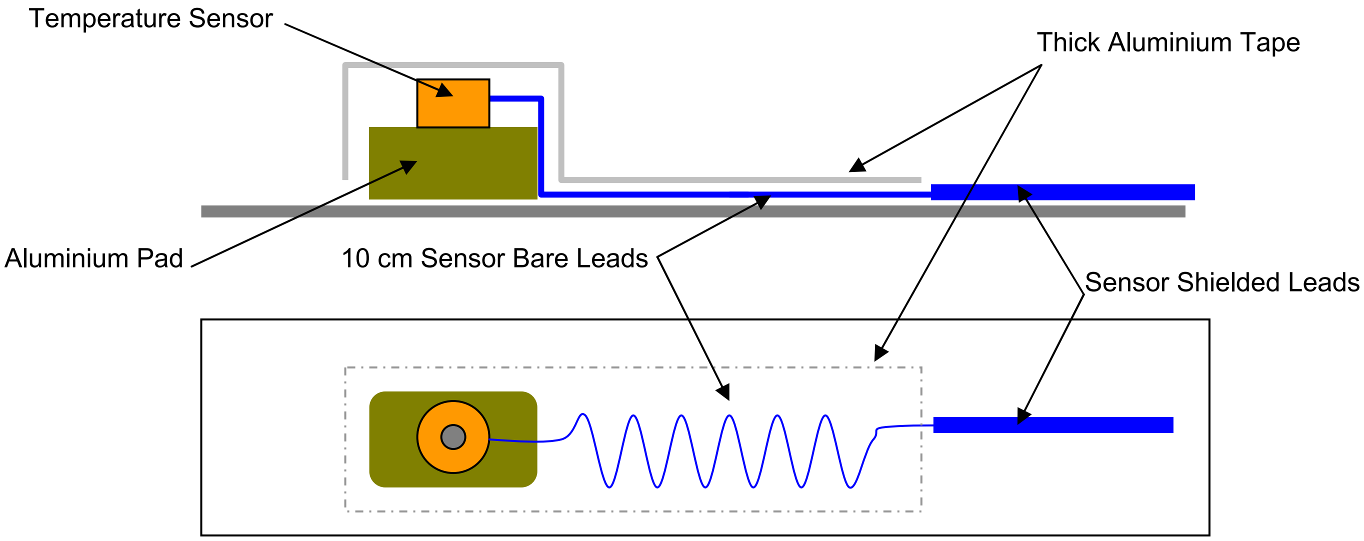


Figure 5-3 - SPIRE PFM2 Temperature Sensors Integration Diagram

Please note that this integration procedure should be used whenever possible (i.e. when the sensors leads have been left bare).

5.4 Instrument Internal Power Dissipation

5.4.1 *Flight Model (FM) Cooler*

There are a total of three heaters mounted inside the cooler, as described in Table 5-7 below [AD5].

Heater	Resistance (ohms)
Pump	402
Evaporator Heat Switch	402
Pump Heat switch	402

Table 5-7 – Cooler FM Heaters [AD5]

All three will be commanded using the instrument flight software/electronics. The following equations will be used to compute the command, which should be sent to the heaters, for a given current setting.

Sorption Pump Heater control
Current Command = $(I + 2.254\times10^{-5}) / 1.21532\times10^{-5}$
Sorption Pump HS Heater control
Current Command = $(I + 2.05\times10^{-6}) / 3.9353\times10^{-7}$
Sorption Evaporator HS Heater control
Current Command = $(I + 2.44\times10^{-6}) / 3.9357\times10^{-7}$

Table 5-8 - Cooler FM Heater Current Commands

Where:

- I is the current in Amps
- Current command is a decimal value for the required current. This value will then be converted into a hexadecimal numbers and will be used as an input to the flight software.

Note: the voltage across each heater is read out by the flight software and is logged as part of the housekeeping data during testing. It can therefore be used to accurately compute the heaters' resistance and dissipated power for a given commanded current.

Table 5-9 to Table 5-11 on next page provide the commands that should be sent to the cooler with the flight software.

Power	Current	Command	Command
mW	A	Decimal	Hexadecimal
0	0	0	0
5	0.003527	292	124
7.5	0.004319	357	165
10	0.004988	412	19C
15	0.006108	504	1F8
20	0.007053	582	246
40	0.009975	823	336
300	0.027318	2250	8C9
400	0.031544	2597	A25

Table 5-9 – Pump Heater Current Commands

Power	Current	Command	Command
mW	A	Decimal	Hexadecimal
0	0	0	0
0.400	0.997572	2540	9EC
0.406	1.005458	2560	A00
0.788	1.40016	3563	DEB
0.800	1.410691	3590	E05

Table 5-10 - Pump Heat Switch Heater Current Commands

Power	Current	Command	Command
mW	A	Decimal	Hexadecimal
0.0	0	0	0
0.4	0.000998	2541	9EC
0.8	0.001411	3591	E06

Table 5-11 – Evaporator Heat Switch Heater Current Commands

5.4.2 Instrument Mechanisms

The instrument consists of two mechanisms, two calibration sources and two electronic boxes which power dissipations participate to the instrument operational heat loads:

- Spectrometer Mechanism (SMEC),
- Beam Steering Mechanism (BSM),
- Photometer and Spectrometer Calibration Sources (PCAL and SCAL respectively),
- Photometer and Spectrometer JFET electronics boxes (PJFET and SJFET respectively).

Each device will be commanded by the flight software. The operation procedures will be defined based on the experience gained from the performance testing carried out during the test campaign.

5.4.3 EGSE Heaters

A total of two EGSE heaters will be used for the straps characterisation exercise. EGSE power supplies will be used to power the heaters. The resistance of both heaters shall be measured at nominal operating temperature using a four-wire measurement [AD6] and a calibrated voltmeter with a minimum accuracy of 0.01 V.

Heater	**Resistance (ohms) Room Temperature**	**Resistance (ohms) Operating Temperature**
FPU	~40 ohms	TBC
Level-0 Photometer	~10 Kohms	TBC

Table 5-12 – SPIRE PFM2 EGSE Heaters

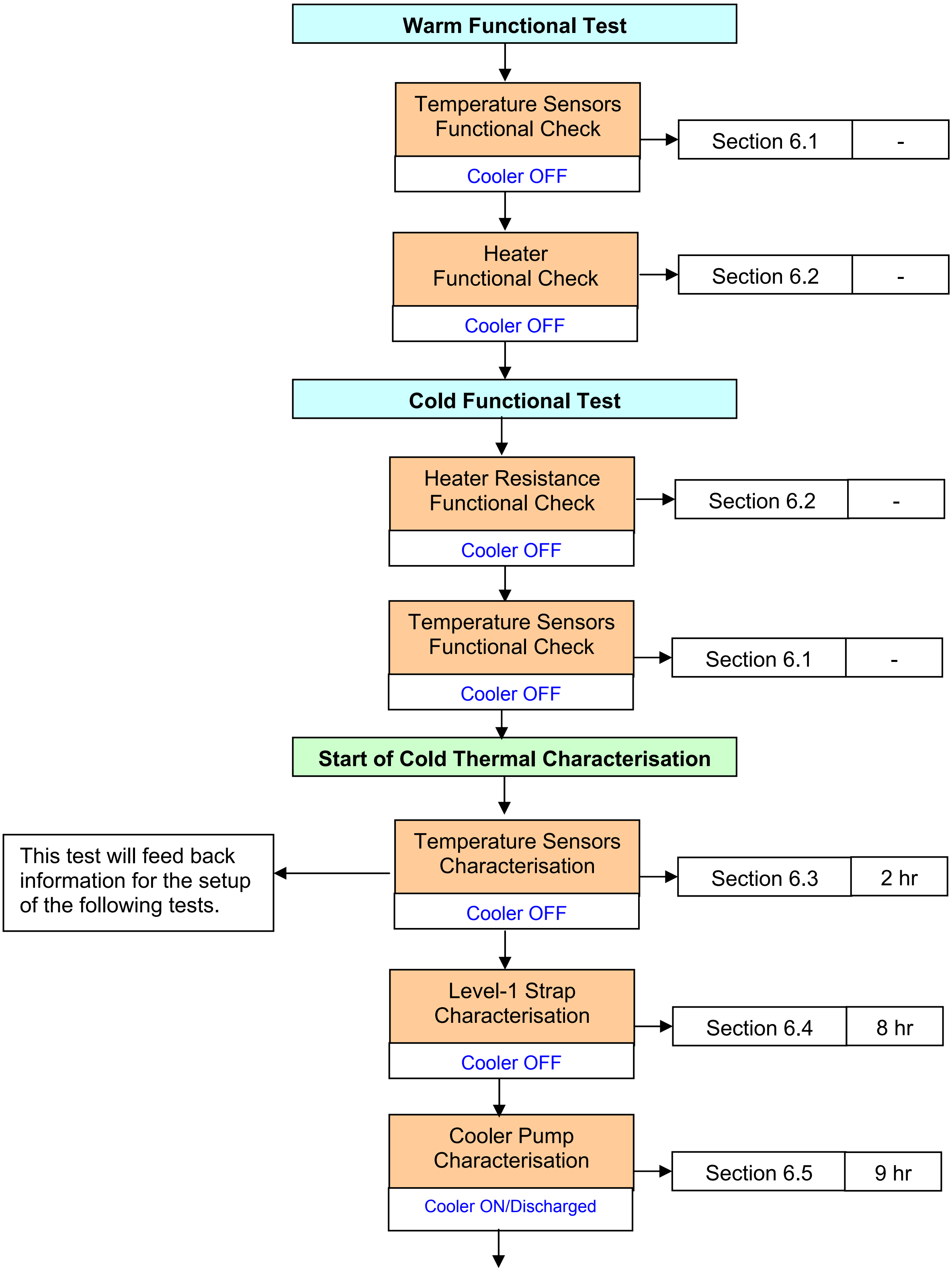
6 PFM2 THERMAL BALANCE TEST PROGRAM

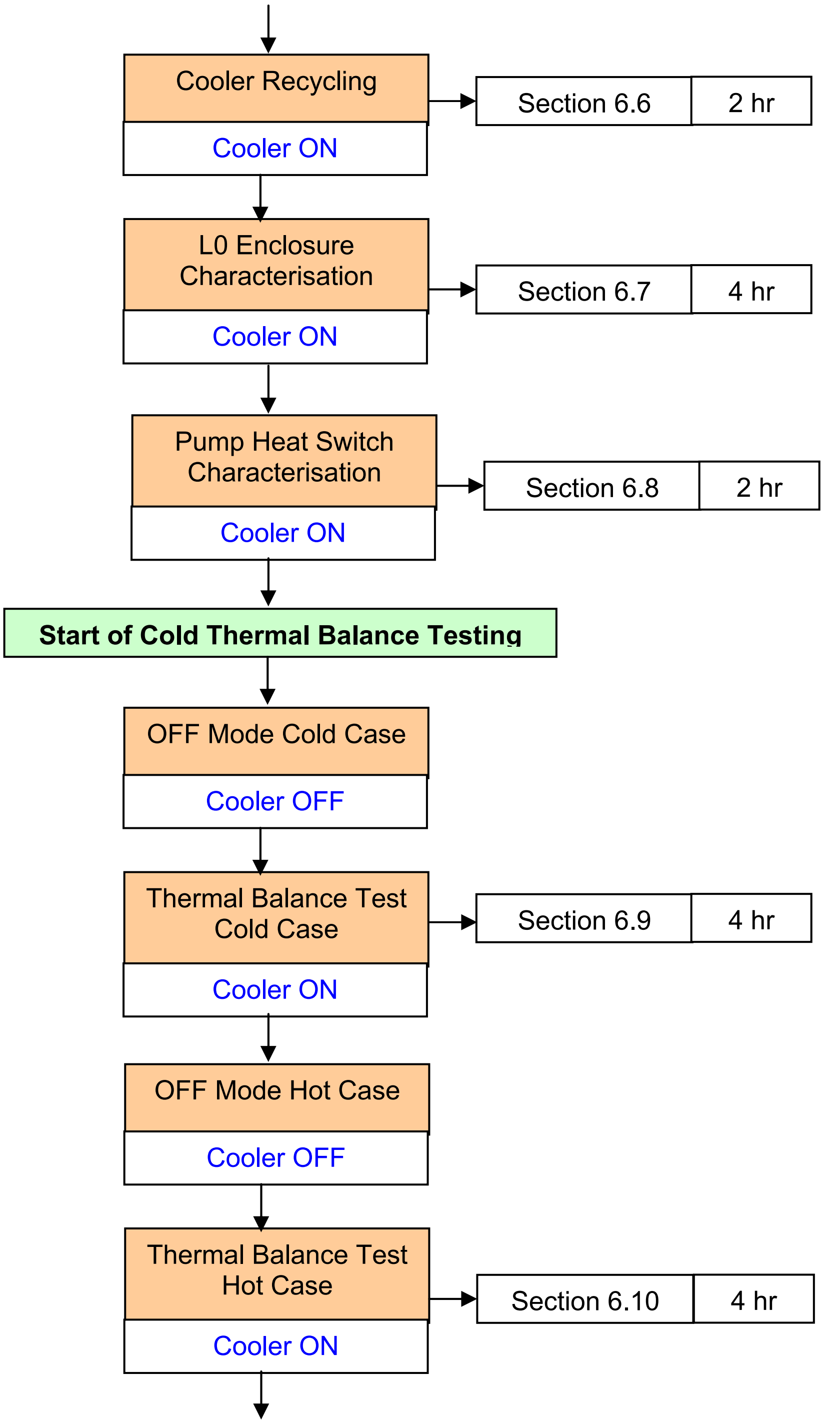
Figure 6-1 (on following page) and Table 6-1 below give an overview of the thermal tests planned for the PFM2 test campaign. Detailed procedures as well as indications of the test data to be recorded during each test are described in the following sections.

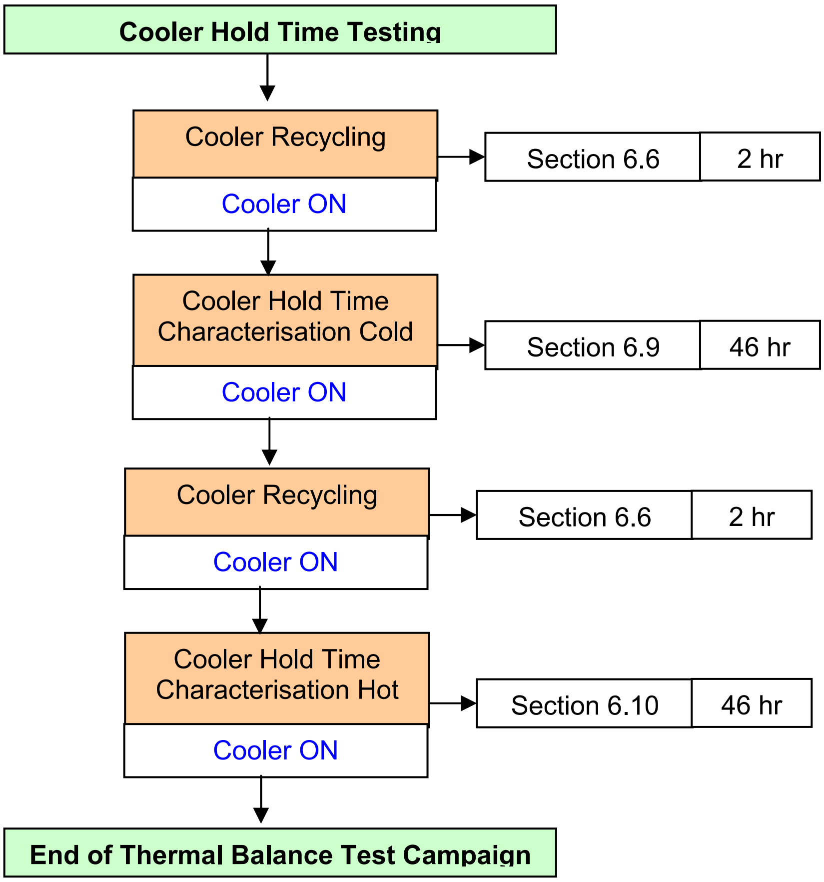
Test Name	Description
EGSE Heater Resistance Characterisation	Measure the EGSE heater resistances at operating temperatures using a 4-wire measurement according to the procedure in AD6.
Temperature Sensors Characterisation	Characterise the temperature measurement errors (self-heating, calibration and DC offset) of the flight prime and redundant sensors as well as of the EGSE sensors.
Cooler Pump Characterisation	Characterise the MGSE L0 pump strap conductance and establish the relation between the pump temperature and its internal power dissipation. The later will be used for future correlation to estimate the total cooler load based on the pump temperature.
Level-0 Detector Strap Characterisation	Characterise the MGSE L0 detector strap conductance.
Level-1 Characterisation	Characterise the MGSE L1 strap conductance.
Cooler Recycling	The operation profile of the cooler during recycling is assessed during this test.
Cooler Hold Time Characterisation	This test assesses the instrument hold time performances for two different thermal environment cases (part of thermal balance test case 2 and 3).
Thermal Balance Case 1 OFF Mode	Instrument left in OFF mode to stabilise with the Level-0 and Level-1 of the cryostat is maintained at 1.7K and 4.2K respectively.
Thermal Balance Case 2	Effectively a COLD Case where the Level-0 and Level-1 of the cryostat is maintained at 1.7K and 4.2K respectively.
Thermal Balance Case 3	Effectively a HOT Case where the Level-0 and Level-1 of the cryostat is maintained at 2K and 5.5K respectively.

Table 6-1 – Overview of the SPIRE PFM2 Thermal Testing

Figure 6-1 - Overview of the SPIRE PFM2 Thermal Testing




Cooler Recycling
Cooler ON
Section 6.6
2 hr
L0 Enclosure Characterisation
Cooler ON
Section 6.7
4 hr
Pump Heat Switch Characterisation
Cooler ON
Section 6.8
2 hr
Start of Cold Thermal Balance Testing
OFF Mode Cold Case
Cooler OFF
Thermal Balance Test Cold Case
Cooler ON
Section 6.9
4 hr
OFF Mode Hot Case
Cooler OFF
Thermal Balance Test Hot Case
Cooler ON
Section 6.10
4 hr


Cooler Hold Time Testing
Cooler Recycling
Cooler ON
Section 6.6
2 hr
Cooler Hold Time Characterisation Cold
Cooler ON
Section 6.9
46 hr
Cooler Recycling
Cooler ON
Section 6.6
2 hr
Cooler Hold Time Characterisation Hot
Cooler ON
Section 6.10
46 hr
End of Thermal Balance Test Campaign

6.1 Temperature Sensors Functional Check (Part of Functional Testing)

Functional checks of the instrument and cryostat temperature sensors should be performed before any thermal testing takes place with the instrument:

- At room temperature, before and after closing the cryostat,
- Cold once the instrument is at 4K,
- Cold with the instrument at the nominal operating temperatures (1.7K and 4K).

All temperature should be logged for future reference, excepted for the room temperature check as calibration curves may not be available for this temperature range. In this case, the sensor resistance must be measured and checked against “expected” resistance values according to the sensor type. Please see master procedure for more details on the warm and cold functional check [AD13].

6.2 Heater Resistance Functional Check (Part of Functional Testing)

Functional checks of the instrument EGSE heaters should be performed before any thermal testing takes place with the instrument:

- At room temperature, before and after closing the cryostat,
- Cold once the instrument is at 4K,
- Cold with the instrument at the nominal operating temperatures (1.7K and 4K).

The heater resistance should be recorded for future reference. Please see master procedure for more details on the warm functional check [AD13].

6.3 Thermal Sensor Characterisation

Test	**Temperature Sensor Characterisation**		
Objective	This test evaluates the following errors in temperature measurements for all sensors and for different thermal environments: ▪ Self-Heating errors ▪ DC Offset Voltage errors ▪ Calibration errors		
Method	1. Log all instrument and cryostat temperatures (I,II,III). 2. Change the 370's excitation current from 1uA to 10uA to assess self-heating errors (I,II,III). 3. Move redundant flight sensors to the 370 to assess the DC offset voltage error (I,II). 4. Change the 370's excitation current from 1uA to 10uA to assess self-heating errors in flight sensors (I,II). These short tests are probably best carried out independently, when an occasion is available with the right cryostat setup: ▪ Test I as part of L1 Strap characterisation ▪ Test II as part of Pump Characterisation + cold test ▪ Test II as part of L0 Enclosure Characterisation + hot test		
Comments	**Stable thermal environment required**		Y
	Steady State Required		N
	Performance Testing allowed		N
	BDA Load Curve Required		N
	Cold Black Body		TBC
	Duration		2 hr
Cryostat Setups	**I**	**II**	**III**
L0 Interface Temperature	4.2K	1.7K	2K
L1 Interface Temperature	4.2K	4.2K	4.2K
L2 Interface Temperature	15K	15K	15K
Manostat Setting			
FPU Heater Setting			
SPIRE Instrument Setup	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**
Cooler			
Status	OFF	OFF	OFF
Pump Heater			
Pump Heat Switch Heater			
Evaporator Heat Switch Heater			
Level-0			
L0 Photometer EGSE Heater			
Level-1			
SCAL Dissipation			

PCAL Dissipation			
SMEC Dissipation			
BSM Dissipation			
Level-2			
Photometer JFET Dissipation			
Spectrometer JFET Dissipation			
Monitoring			
Temperature Readout Frequency	10 sec	10 sec	10 sec

6.4 Level-1 Strap Characterisation

Test	**Level-1 Strap Characterisation**		
Objective	This test evaluates the L1 MGSE Strap thermal conductance. It will also give an indication of the FPU heater load required to warm the L1 up to 5.5K.		
Method	A known heat load will be applied to the FPU and its temperature increase as well as the temperature drop along the strap will be measured for each heat load. It is important that the cryostat L2 interface temperature remains as stable as possible for the duration of the test.		
Comments	**Stable thermal environment required**	Y	
	Steady State Required	Y	
	Performance Testing allowed	N	
	BDA Load Curve Required	N	
	Cold Black Body	TBC	
	Duration	8 hr	
Cryostat Setups	**I**	**II**	**III**
L0 Interface Temperature	4.2K	4.2K	4.2K
L1 Interface Temperature	4.2K	4.2K	4.2K
L2 Interface Temperature	15K	15K	15K
Manostat Setting	TBC	TBC	TBC
FPU Heater Setting	Trials/TBC	Trials/TBC	Trials/TBC
SPIRE Instrument Setup	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**
Cooler			
Status	OFF	OFF	OFF
Pump Heater			
Pump Heat Switch Heater			
Evaporator Heat Switch Heater			
Level-0			
L0 Photometer EGSE Heater			
Level-1			
SCAL Dissipation			
PCAL Dissipation			
SMEC Dissipation			
BSM Dissipation			
Level-2			
Photometer JFET Dissipation			
Spectrometer JFET Dissipation			
Monitoring			
Temperature Readout Frequency	10 sec	10 sec	10 sec

6.5 Cooler Pump Characterisation

Test	Cooler Pump Characterisation		
Objective	This test evaluates the pump temperature versus pump internal load, as well as the L0 Pump MGSE Strap thermal conductance.		
Method	A known heat load will be applied to the pump and its temperature increase as well as the temperature drop along the strap will be measured for each heat load. It is important that the cryostat L0 interface temperature remains as stable as possible. When steady state is reached for each case, the pump redundant flight temperature sensor should be readout on the 370, if previous sensors characterisation test show important reading errors.		
Comments	**Stable thermal environment required**		Y
	Steady State Required		Y
	Performance Testing allowed		N
	BDA Load Curve Required		N
	Cold Black Body		TBC
	Duration		9 hr
Cryostat Setups	**I**	**II**	**III**
L0 Interface Temperature	1.7K	1.7K	1.7K
L1 Interface Temperature	4.2K	4.2K	4.2K
L2 Interface Temperature	15K	15K	15K
Manostat Setting	TBC	TBC	TBC
FPU Heater Setting			
SPIRE Instrument Setup	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**
Cooler			
Status	Discharged	Discharged	Discharged
Pump Heater	15	30	45
Pump Heat Switch Heater	0.402	0.402	0.402
Evaporator Heat Switch Heater	0	0	0
Level-0			
L0 Photometer EGSE Heater			
Level-1			
SCAL Dissipation			
PCAL Dissipation			
SMEC Dissipation			
BSM Dissipation			
Level-2			
Photometer JFET Dissipation			
Spectrometer JFET Dissipation			

Monitoring			
Temperature Readout Frequency	10 sec	10 sec	10 sec

6.6 Cooler Recycling

Test	**Cooler Recycling**		
Objective	This isn't a test but rather a definition of the settings, which should be used for all cooler recycling (with the exception of the one preceding the thermal balance test cases).		
Method	It is important that the cryostat L0 interface temperature remains as sable as possible. The pump redundant flight temperature sensor might need to be checked on the 370 when at 45K during first recycling (TBC).		
Comments	**Stable thermal environment required**	Y	
	Steady State Required	N	
	Performance Testing allowed	N	
	BDA Load Curve Required	N	
	Cold Black Body	TBC	
	Duration	2 hr	
Cryostat Setups	**I**	**II**	**III**
L0 Interface Temperature	1.7K		
L1 Interface Temperature	4.2K		
L2 Interface Temperature	15K		
Manostat Setting	TBC		
FPU Heater Setting			
SPIRE Instrument Setup	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**
Cooler			
Status			
Pump Heater			
Pump Heat Switch Heater			
Evaporator Heat Switch Heater			
Level-0			
L0 Photometer EGSE Heater			
Level-1			
SCAL Dissipation			
PCAL Dissipation			
SMEC Dissipation			
BSM Dissipation			
Level-2			
Photometer JFET Dissipation			
Spectrometer JFET Dissipation			
Monitoring			
Temperature Readout Frequency	10 sec		

6.7 L0 Enclosure Characterisation

Test	**L0 Enclosure Characterisation**		
Objective	This test evaluates the L0 Detector MGSE Strap thermal conductance as well as the interbox strap conductance.		
Method	A known heat load will be applied to the L0 photometer enclosure and its temperature increase as well as the temperature drop along the straps will be measured for each heat load. It is important that the cryostat L0 interface temperature remains as stable as possible. When steady state is reached for each case, the pump and L0 enclosures redundant flight temperature sensor should be readout on the 370, if previous sensors characterisation test show important reading errors.		
Comments	**Stable thermal environment required**		Y
	Steady State Required		Y
	Performance Testing allowed		N
	BDA Load Curve Required		N
	Cold Black Body		TBC
	Duration		4 hr
Cryostat Setups	**I**	**II**	**III**
L0 Interface Temperature	1.7K	1.7K	1.7K
L1 Interface Temperature	4.2K	4.2K	4.2K
L2 Interface Temperature	15K	15K	15K
Manostat Setting	TBC	TBC	TBC
FPU Heater Setting			
SPIRE Instrument Setup	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**
Cooler			
Status	ON	ON	ON
Pump Heater			
Pump Heat Switch Heater	0.402	0.402	0.402
Evaporator Heat Switch Heater			
Level-0			
L0 Photometer EGSE Heater	0	5	10
Level-1			
SCAL Dissipation			
PCAL Dissipation			
SMEC Dissipation			
BSM Dissipation			
Level-2			
Photometer JFET Dissipation			
Spectrometer JFET Dissipation			
Monitoring			

Temperature Readout Frequency	10 sec	10 sec	10 sec

6.8 Pump Heat Switch Characterisation

Test	**Pump Heat switch Characterisation**		
Objective	This test evaluates the impact of reducing the pump heat switch power dissipation on the evaporator temperature.		
Method	Once the cooler is in nominal operating condition with a 0.7mW pump heat switch internal dissipation. This will be reduced to 0.4mW while the evaporator temperature will be monitored for any increase.		
Comments	**Stable thermal environment required**		Y
	Steady State Required		N
	Performance Testing allowed		N
	BDA Load Curve Required		N
	Cold Black Body		TBC
	Duration		2 hr
Cryostat Setups	**I**	**II**	**III**
L0 Interface Temperature	1.7K		
L1 Interface Temperature	4.2K		
L2 Interface Temperature	15K		
Manostat Setting			
FPU Heater Setting			
SPIRE Instrument Setup	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**
Cooler			
Status	ON	ON	
Pump Heater			
Pump Heat Switch Heater	0.7	0.4	
Evaporator Heat Switch Heater			
Level-0			
L0 Photometer EGSE Heater			
Level-1			
SCAL Dissipation			
PCAL Dissipation			
SMEC Dissipation			
BSM Dissipation			
Level-2			
Photometer JFET Dissipation			
Spectrometer JFET Dissipation			
Monitoring			
Temperature Readout Frequency	10 sec	10 sec	

6.9 Cold Thermal Balance Case

Test	**Cold Thermal Balance Case**		
Objective	This test evaluates the instrument nominal heat loads for the worst case "cold thermal environment" as well as cooler hold time and detectors absolute temperature performances.		
Method	Recycle the cooler in the environmental condition as defined in table below. Wait for the temperatures to stabilised and perform a DC load curve to measure the detectors temperature. Leave the cooler to run out to assess the instrument hold time performances for the cold conditions.		
Comments	**Stable thermal environment required**		Y
	Steady State Required		Y
	Performance Testing allowed		N
	BDA Load Curve Required		Y
	Cold Black Body		TBC
	Duration		2+46 hr
Cryostat Setups	**I**	**II**	**III**
L0 Interface Temperature	1.7K		
L1 Interface Temperature	4.2K		
L2 Interface Temperature	15K		
Manostat Setting			
FPU Heater Setting			
SPIRE Instrument Setup	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**
Cooler			
Status	ON		
Pump Heater			
Pump Heat Switch Heater	0.7		
Evaporator Heat Switch Heater			
Level-0			
L0 Photometer EGSE Heater			
Level-1			
SCAL Dissipation			
PCAL Dissipation			
SMEC Dissipation			
BSM Dissipation			
Level-2			
Photometer JFET Dissipation			
Spectrometer JFET Dissipation			
Monitoring			
Temperature Readout Frequency	1 min		

6.10 Hot Thermal Balance Case

Test	**Hot Thermal Balance Case**		
Objective	This test evaluates the instrument nominal heat loads for the worst case "hot thermal environment" as well as cooler hold time and detectors absolute temperature performances.		
Method	Recycle the cooler in the environmental condition as defined in table below. Wait for the temperatures to stabilised and perform a DC load curve to measure the detectors temperature. Leave the cooler to run out to assess the instrument hold time performances for the hot conditions.		
Comments	**Stable thermal environment required**		Y
	Steady State Required		Y
	Performance Testing allowed		N
	BDA Load Curve Required		Y
	Cold Black Body		TBC
	Duration		2+46 hr
Cryostat Setups	**I**	**II**	**III**
L0 Interface Temperature	2K		
L1 Interface Temperature	5.5K		
L2 Interface Temperature	15K		
Manostat Setting			
FPU Heater Setting			
SPIRE Instrument Setup	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**	**[mW] / [mA] / [Hex]**
Cooler			
Status	ON		
Pump Heater			
Pump Heat Switch Heater	0.7		
Evaporator Heat Switch Heater			
Level-0			
L0 Photometer EGSE Heater			
Level-1			
SCAL Dissipation			
PCAL Dissipation			
SMEC Dissipation			
BSM Dissipation			
Level-2			
Photometer JFET Dissipation			
Spectrometer JFET Dissipation			
Monitoring			
Temperature Readout Frequency	1 min		

7 TEMPERATURE SENSOR PICTURES

7.1 Flight Temperature Sensors

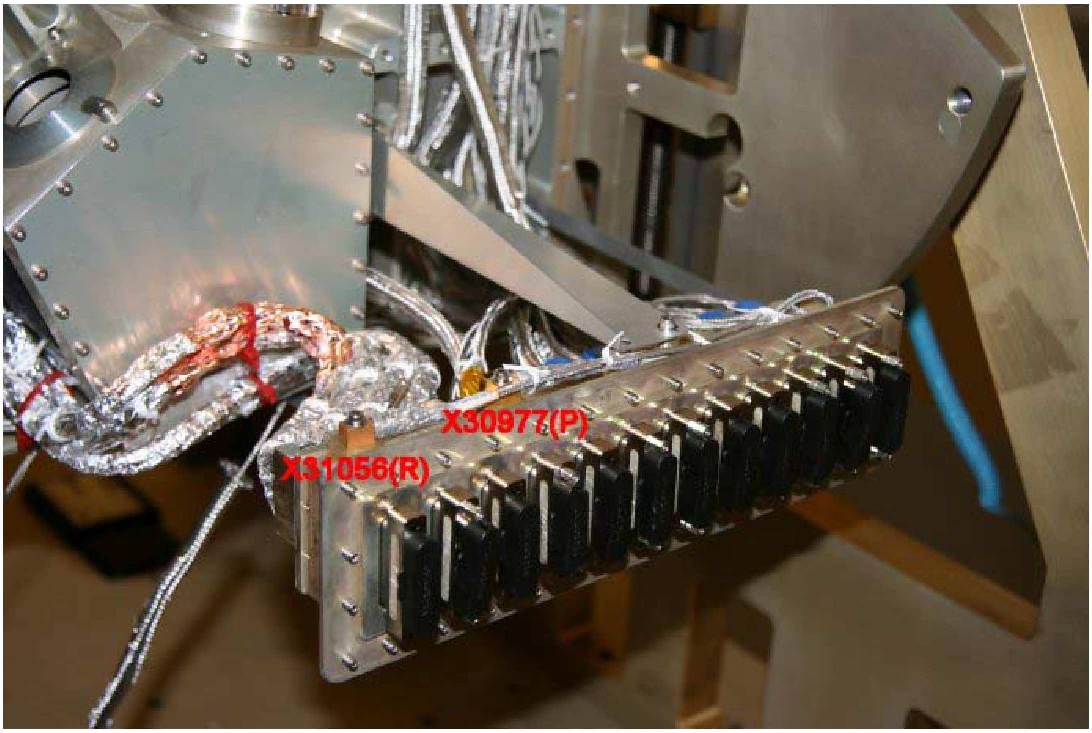


Figure 7-1 - HSFPU EMC Filters Flight Temperature Sensors

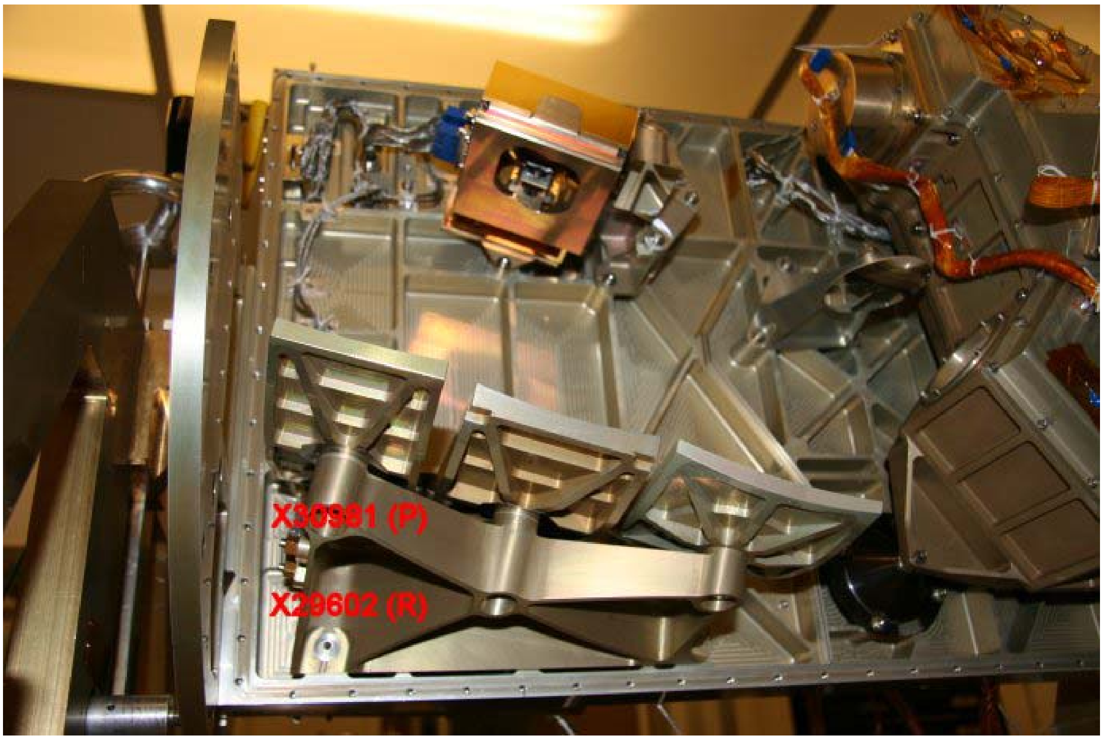


Figure 7-2 - M3,5,7 Optical SubBench Flight Temperature Sensors

Figure 7-3 - HSFPU Input Baffle Flight Temperature Sensors

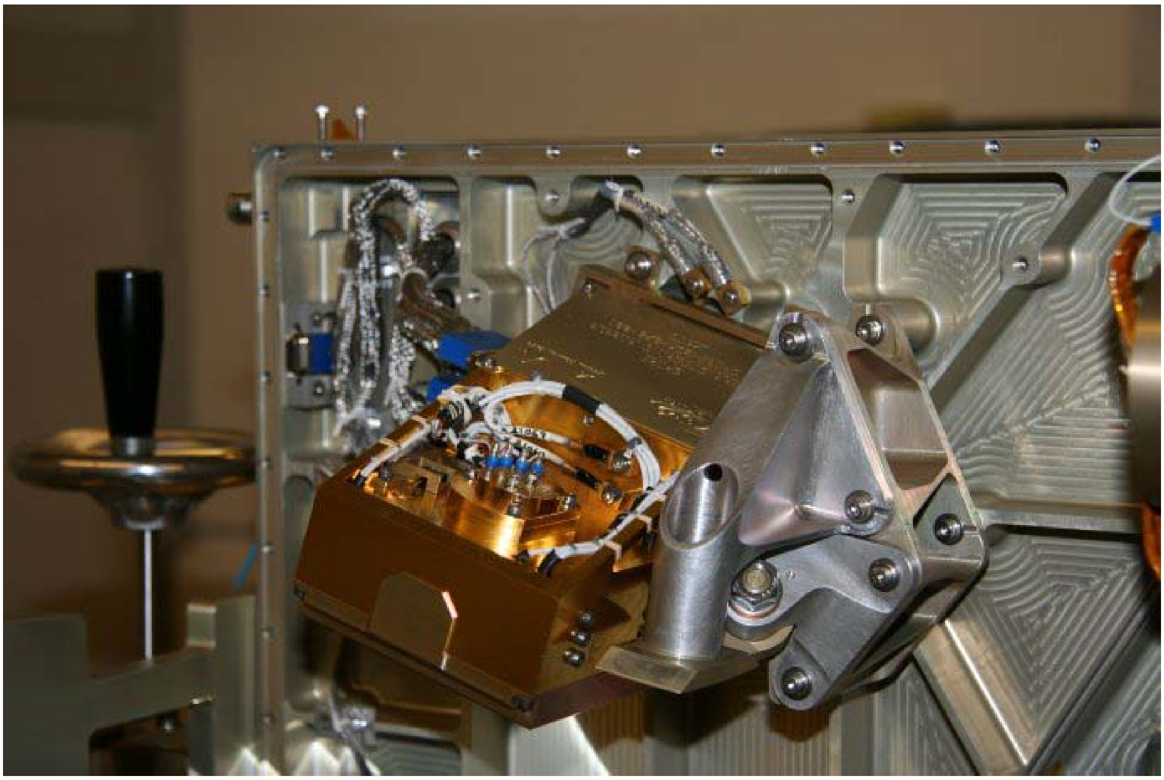


Figure 7-4 - BSM Flight Temperature Sensors

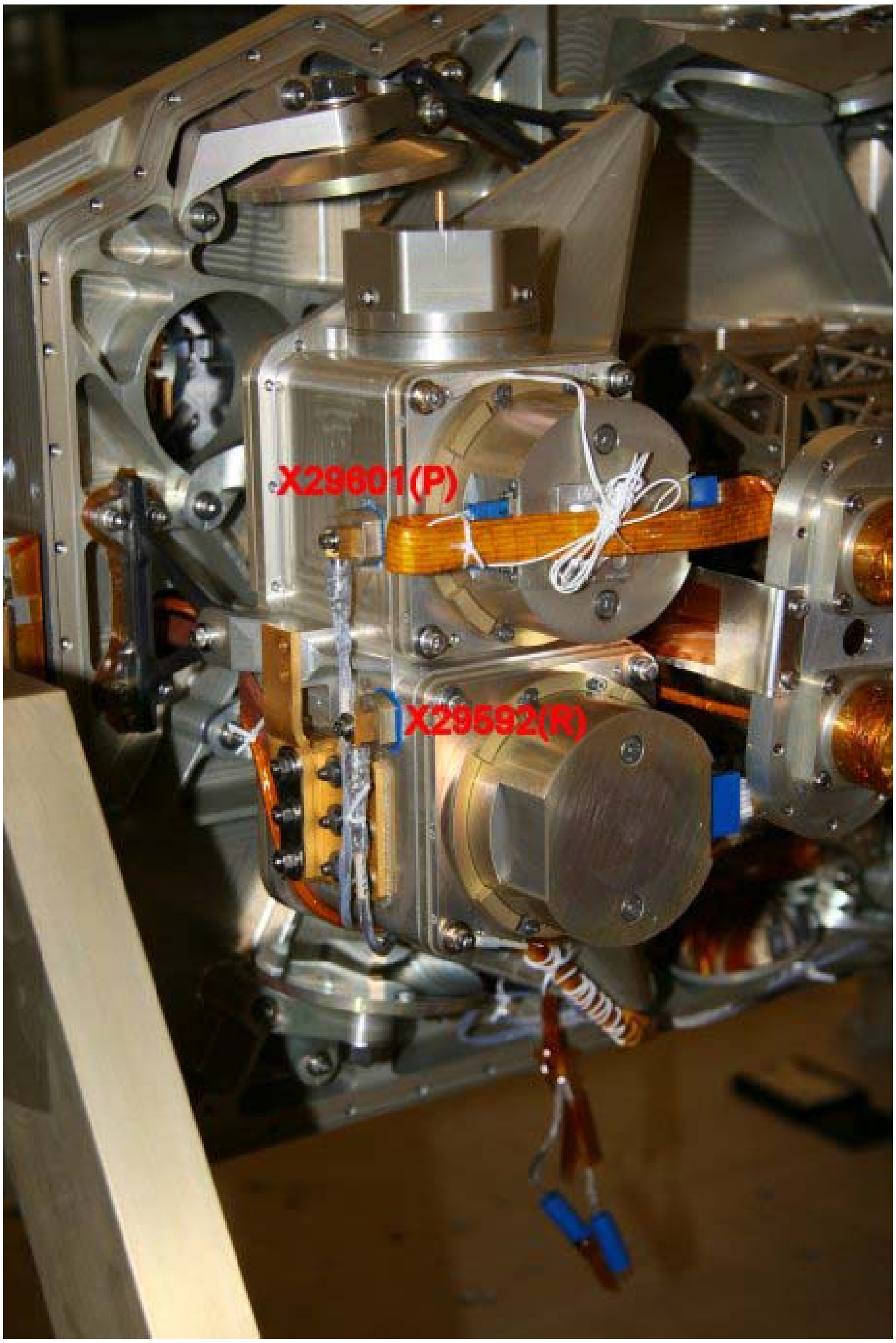


Figure 7-5 - L0 Spectrometer Enclosure Flight Temperature Sensors

Figure 7-6 - L0 Photometer Enclosure Flight Temperature Sensors

7.2 EGSE Temperature Sensors and FPU Heater

Figure 7-7 – L0 Detector Enclosure MGSE Strap Temperature Sensors

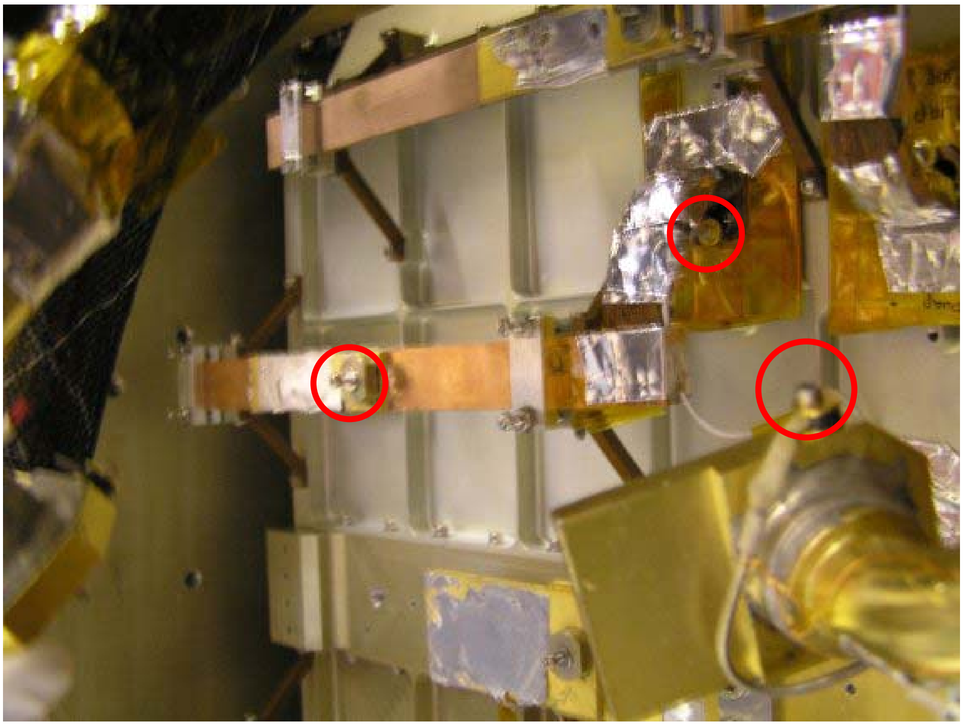


Figure 7-8 - L0 Pump MGSE Strap Temperature Sensors

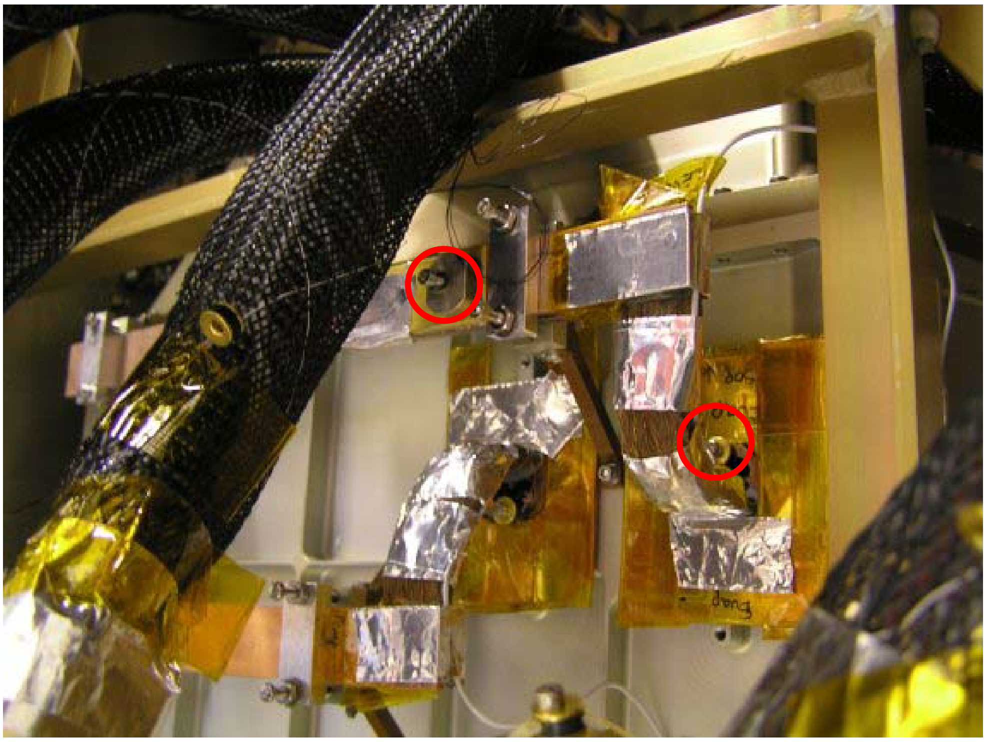


Figure 7-9 - L0 Evaporator MGSE Strap Temperature Sensors

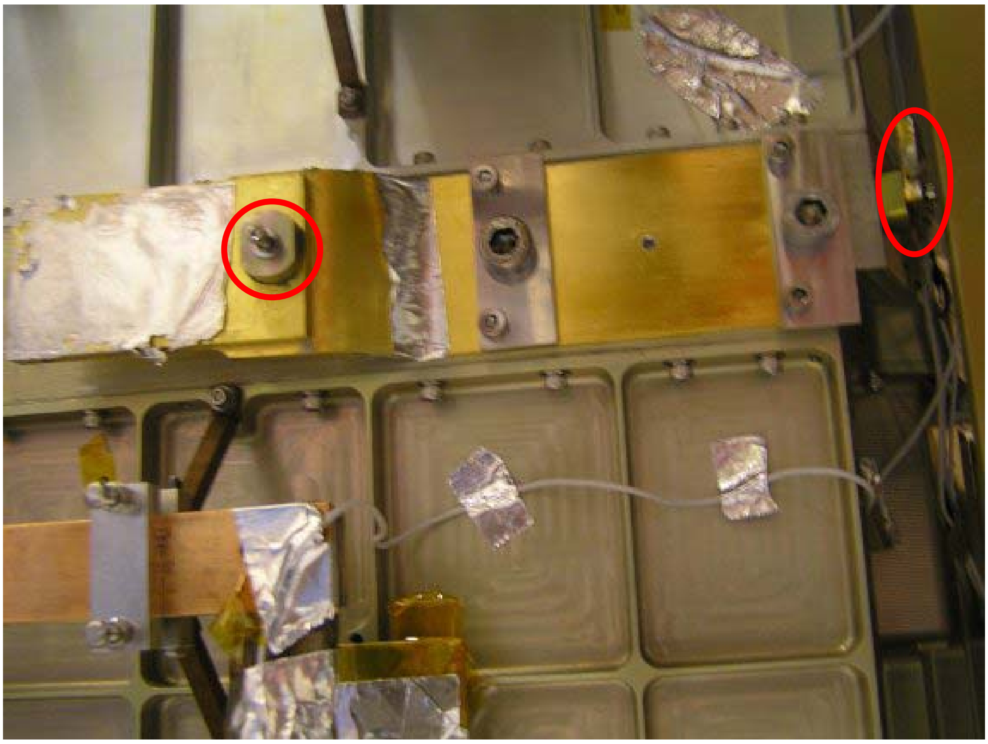


Figure 7-10 – L1 MGSE Strap Temperature Sensors

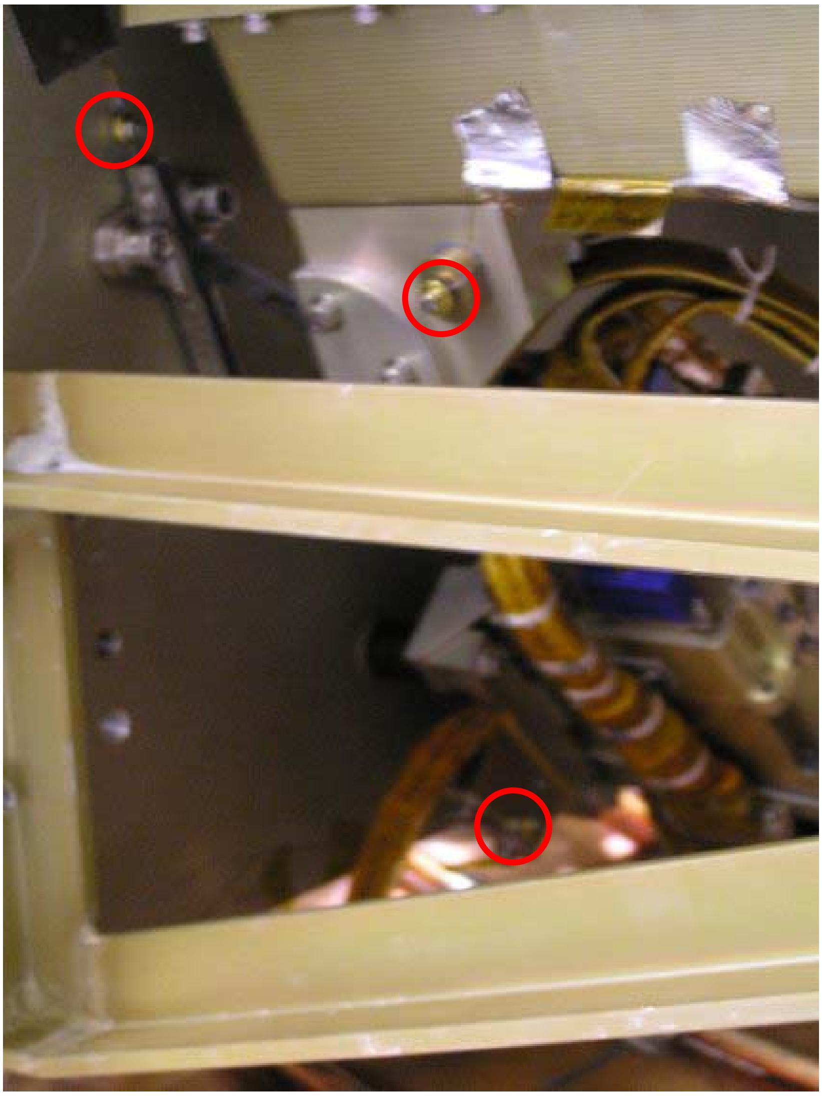


Figure 7-11 – L1 A-Frame Support and SJFET L3 Strap Interface Temperature Sensors

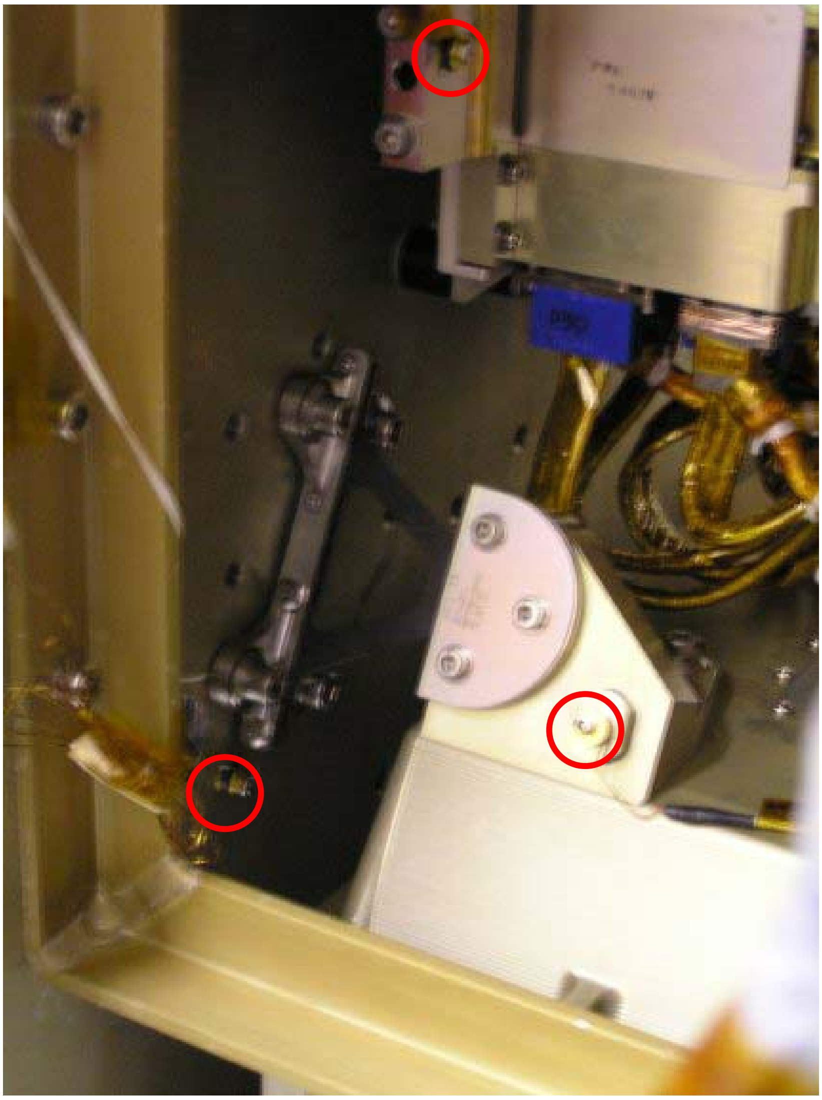


Figure 7-12 - L1 A-Frame Support and PJFET L3 Strap Interface Temperature Sensors

Figure 7-13 – L1 Cone Support Temperature Sensors

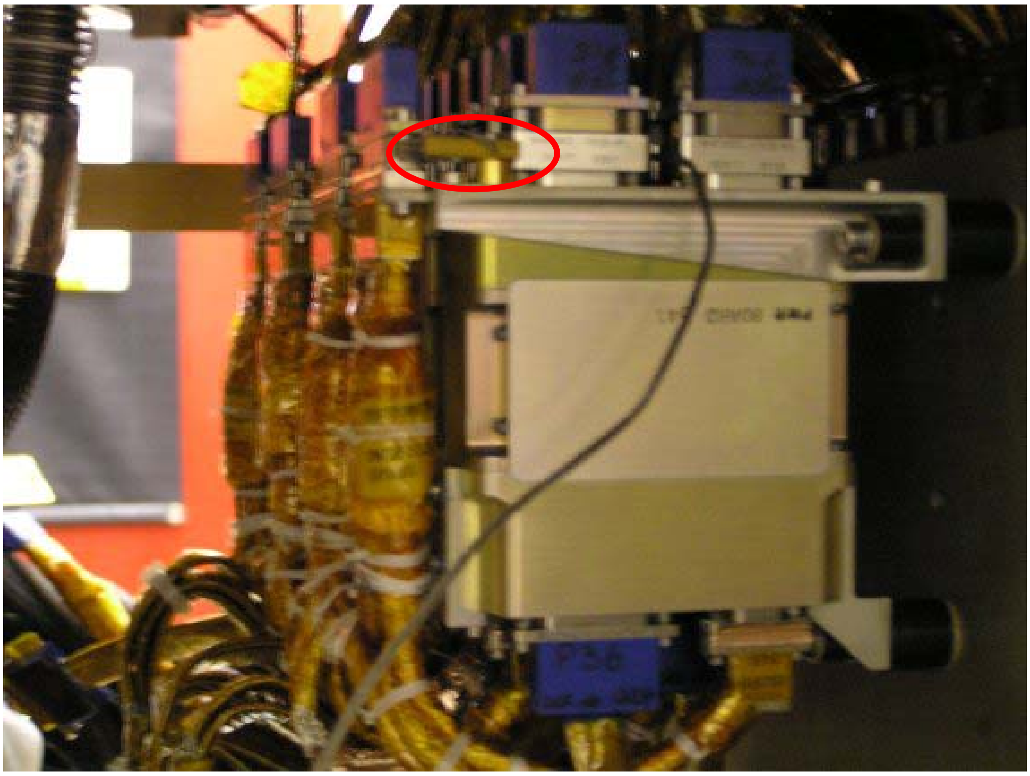


Figure 7-14 – PJFET Temperature Sensor

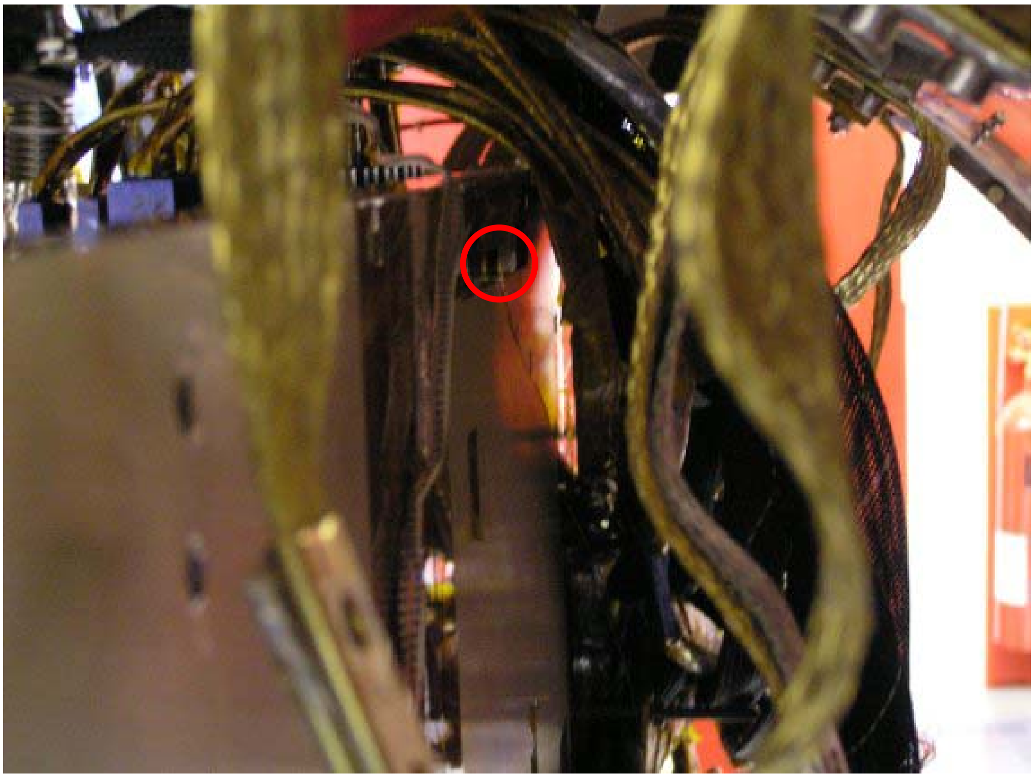


Figure 7-15 – PJFET HOB Interface Temperature Sensor

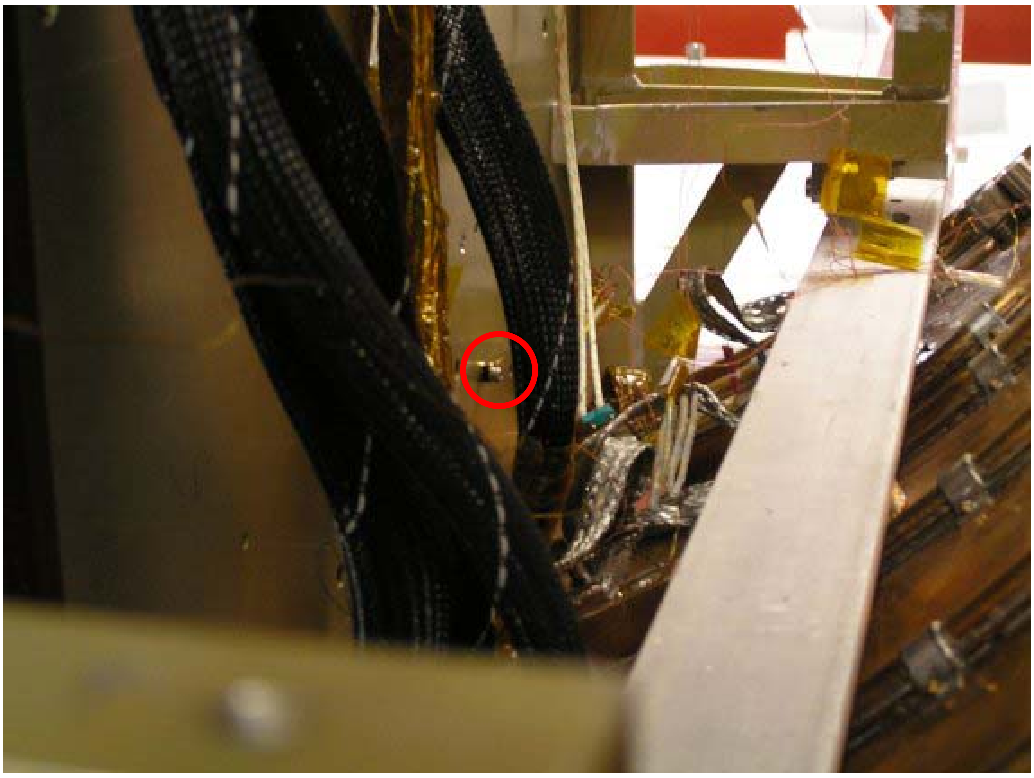


Figure 7-16 - SJFET HOB Interface Temperature Sensor

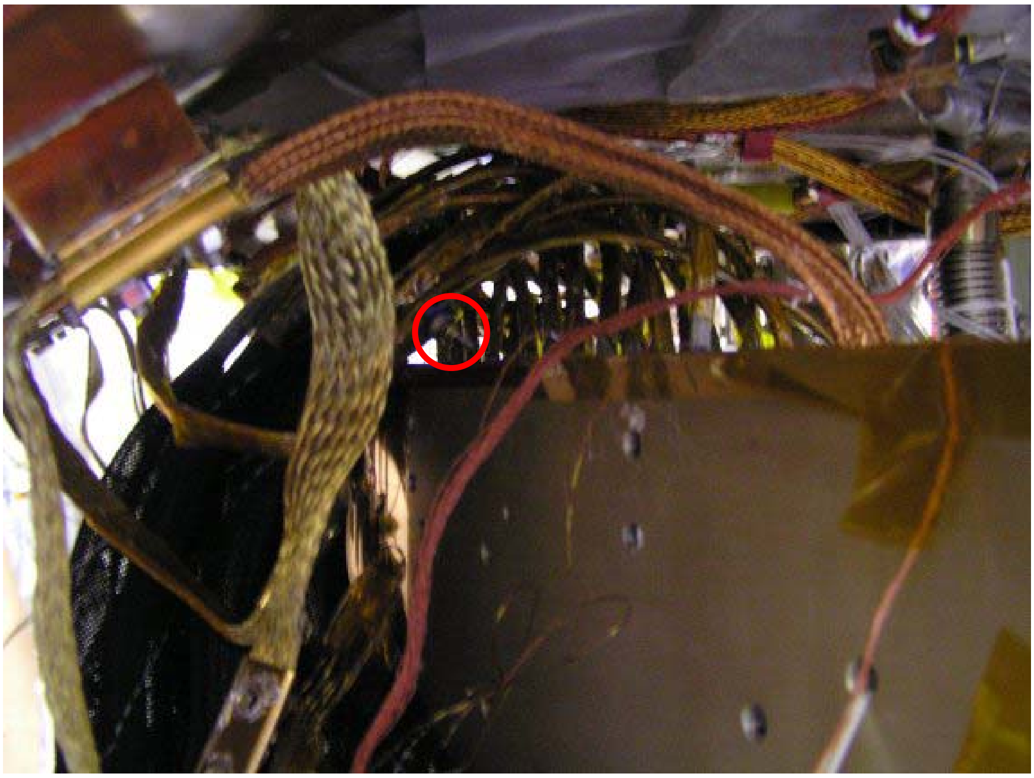


Figure 7-17 – Harness Temperature Sensor

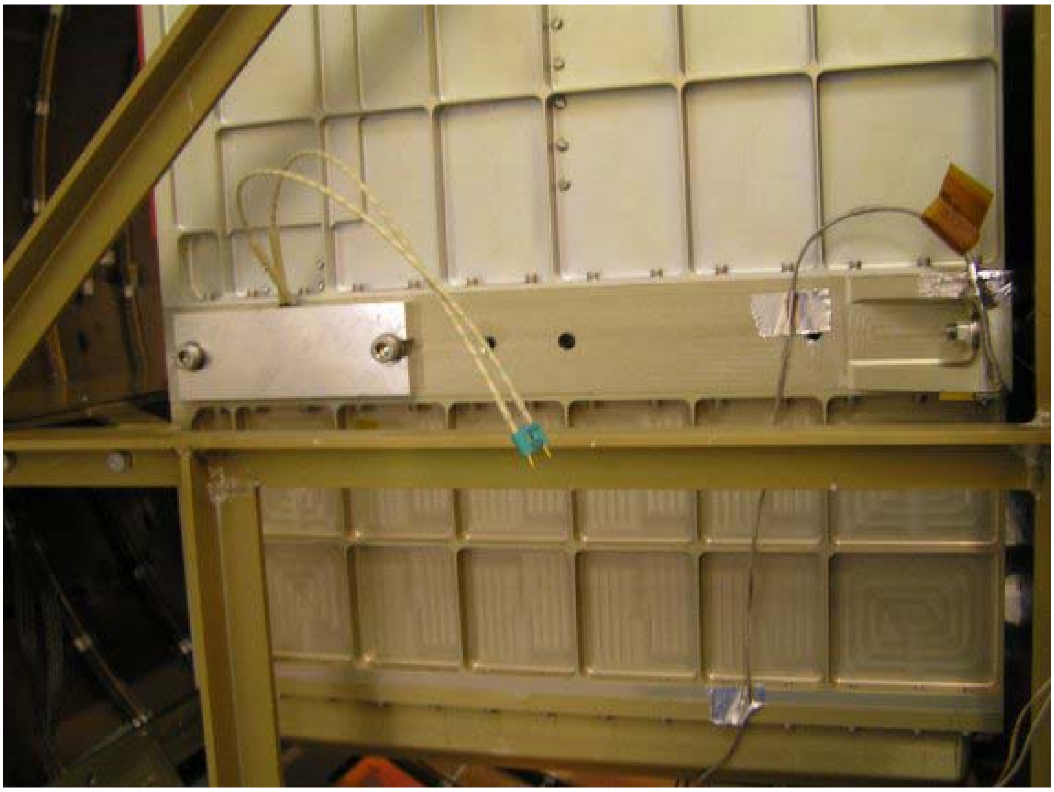


Figure 7-18 – FPU EGSE Heater

8 PFM2 THERMAL BALANCE TEST PROCEDURES

The procedures described in the following pages should be used during the PFM2 thermal balance test campaign. It describes the thermal hardware setup for the various tests and also provides information regarding the types of information that should be logged during each test phases.

Test	Actions	Data				Completed	Comments
6.1	**Temperature Sensors Functional Check**					✓	
6.1.1	**Room Temperature Check**					✓	26/08/05 – See email on 19/08/05
6.1.2	**4K Temperature Check**					✓	05/09/05
6.1.2.1	Wait for instrument temperatures to stabilise at 4K					✓	HOB @ ~20K
6.1.2.2	Log all instrument and cryostat temperature below, identify possible discrepancies and write observations in provided space.					✓	At 13.00 on 05/09/05 Check data as SFT has also been taking place this day i.e. Might explain why the SCAL2 is reading warmer temperature if still cooling down.
	HSFPU Harness Filter Bracket	EMCFIL_1					
	M3,5,7 Optical Sub Bench	T_SUB_1					
	Input Baffle	T_BAF_1					
	BSM/SOB I/F (SOB side)	T_BSMS_1					
	SCAL Structure	T_SCST_1					
	SCAL 4%	T_SCL4_1					
	SCAL 2%	T_SCL2_1					
	BSM	T_BSMM_1					See AIV log in section 9.
	SMEC	T_FTSM_1					
	SMEC/SOB I/F	T_FTSS_1					
	Cooler Pump	T_CPHP_1					
	Cooler Shunt	T_CSHT_1					
	Cooler Evap	T_CEV_1					
	Cooler Pump Heat Switch (sieve)	T_CPHS_1					
	Cooler Evap Heat Switch (sieve)	T_CEHS_1					
	Photometer Level 0 Enclosure	T_PL0_1					

Test	Actions	Data				Completed	Comments
	Spectrometer Level 0 Enclosure	T_SL0_1					
	Photometer JFET Chassis	T_PJFS_CHAS					
	Spectrometer JFET Chassis	T_SJFS_CHAS					
	FPU +X A-Frame Interface	T_FPU_PXAF					
	FPU –X A-Frame Interface	T_FPU_MXAF					
	SOB Cone Interface	T_SOB_CONE					
	SOB L1 Strap Interface	T_SOB_L1STR					
	L1 photo connector bracket	T_SOB_L1CON					
	Detector Box L0 Strap Adaptor	T_L0_DSTR					
	Pump L0 Strap Adaptor	T_L0_PSTR					
	Evaporator L0 Strap Adaptor	T_L0_ESTR					See AIV log in section 9.
	FSJFP L3 Strap	S16					
	FSJFS L3 Strap	S17					
	FSJFP-HOB I/F	S18					
	FPU Cone Foot I/F	S19					
	FPU +Y Foot I/F	S20					
	Support foot 1	S12					
	FPU -Y Foot I/F	S21					
	FSJFS-HOB I/F	S22					
	Harness Sink WE-Ph JFET(L2 Shield Side)	S23					
	FPU L1 Strap	S26					Sensor Out of Calibration
	FPU L1 Adaptor	S35					
	FPU Evap Strap I/F	S28					Sensor Out of Calibration
	FPU Pump Strap I/F	S29					Sensor Out of Calibration
	FPU Box Strap I/F	S30					Sensor Out of Calibration
	Detector Box L0 Strap 2	~~S32~~ S34					
	Pump L0 Strap 2	S33					

Test	Actions	Data				Completed	Comments
	Evaporator L0 Strap 2	~~S34~~ S32					
	Observations						See AIV log in section 9.
		PLO_2 SLO_2					
6.1.3	**Nominal Operation Temperature Check**					✓	06/09/05
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 Lakeshore 370 is using a 1uA excitation current setting					✓	
6.1.3.3	Make sure the cooler is discharged.					✓	
6.1.3.4	Log all instrument and cryostat temperature (and resistance when applicable) below, identify possible discrepancies and write observations in provided space.					✓	At 12.42 (PC) on 06/09/05.
			Temperature	Resistance			
	HSFPU Harness Filter Bracket	EMCFIL_1					
	M3,5,7 Optical Sub Bench	T_SUB_1					
	Input Baffle	T_BAF_1					
	BSM/SOB I/F (SOB side)	T_BSMS_1					
	SCAL Structure	T_SCST_1					
	SCAL 4%	T_SCL4_1					See AIV log in section 9.
	SCAL 2%	T_SCL2_1					
	BSM	T_BSMM_1					
	SMEC	T_FTSM_1					
	SMEC/SOB I/F	T_FTSS_1					
	Cooler Pump	T_CPHP_1					

Test	Actions	Data				Completed	Comments
	Cooler Shunt	T_CSHT_1					
	Cooler Evap	T_CEV_1					
	Cooler Pump Heat Switch (sieve)	T_CPHS_1					
	Cooler Evap Heat Switch (sieve)	T_CEHS_1					
	Photometer Level 0 Enclosure	T_PL0_1					
	Spectrometer Level 0 Enclosure	T_SL0_1					
	Photometer JFET Chassis	T_PJFS_CHAS					
	Spectrometer JFET Chassis	T_SJFS_CHAS					
	FPU +X A-Frame Interface	T_FPU_PXAF					
	FPU –X A-Frame Interface	T_FPU_MXAF					
	SOB Cone Interface	T_SOB_CONE					
	SOB L1 Strap Interface	T_SOB_L1STR					
	L1 photo connector bracket	T_SOB_L1CON					
	Detector Box L0 Strap Adaptor	T_L0_DSTR					See AIV log in section 9.
	Pump L0 Strap Adaptor	T_L0_PSTR					
	Evaporator L0 Strap Adaptor	T_L0_ESTR					
	FSJFP L3 Strap	S16					
	FSJFS L3 Strap	S17					
	FSJFP-HOB I/F	S18					
	FPU Cone Foot I/F	S19					
	FPU +Y Foot I/F	S20					
	FPU -Y Foot I/F	S21					
	FSJFS-HOB I/F	S22					
	Harness Sink WE-Ph JFET(L2 Shield Side)	S23					
	FPU L1 Strap	S26					Sensor Out of Calibration
	FPU L1 Adaptor	S35					
	FPU Evap Strap I/F	S28					Sensor Out of Calibration

Test	Actions	Data				Completed	Comments
	FPU Pump Strap I/F	S29					Sensor Out of Calibration
	FPU Box Strap I/F	S30					Sensor Out of Calibration
	Detector Box L0 Strap 2	~~S32~~ S34					
	Pump L0 Strap 2	S33					
	Evaporator L0 Strap 2	~~S34~~ S32					
	Photometer Level 0 Enclosure (redundant)	T_PL0_2					
	Spectrometer Level 0 Enclosure (redundant)	T_SL0_2					
6.2	**EGSE Heaters Functional Check**					✓	
6.2.1	**Room Temperature Check**					✓	All Heaters OK
6.2.2	**4K Temperature Check**					✓	L0 Photometer EGSE heater was open-circuit. This means that the L0 Enclosure Strap Characterisation test (6.7) cannot be carried out.
6.3	**Temperature Sensors Characterisation**						
6.3.1	**Temperature Sensor Self-Heating Check**					✓	06/09/05
6.3.1.1	Change the Lakeshore 370 excitation current setting to 10uA.					✓	
6.3.1.2	Log all instrument and cryostat temperature and resistance from sensors connected to the 370 Lakeshore.		Temperature	Resistance		✓	At 13.10 on 06/09/05
	SOB L1 Strap Interface	T_SOB_L1STR					
	Detector Box L0 Strap Adaptor	T_L0_DSTR					See AIV log in section 9.
	Pump L0 Strap Adaptor	T_L0_PSTR					

Test	Actions	Data				Completed	Comments
	Evaporator L0 Strap Adaptor	T_L0_ESTR					
	FPU L1 Strap	S26					Sensor Out of Calibration
	FPU L1 Adaptor	S35					
	FPU Evap Strap I/F	S28					Sensor Out of Calibration
	FPU Pump Strap I/F	S29					Sensor Out of Calibration
	FPU Box Strap I/F	S30					Sensor Out of Calibration
	Detector Box L0 Strap 2	~~S32~~ S34					
	Pump L0 Strap 2	S33					See AIV log in section 9.
	Evaporator L0 Strap 2	~~S34~~ S32					
6.3.1.3	Change the Lakeshore 370 excitation current setting back to 1uA.					✓	
6.3.2	**Flight Redundant Temperature Sensor DC Offset Check**					✓	07/09/05
6.3.2.1	Once the instrument temperatures are stable, record the instrument interface temperatures for reference.		Temp			✓	This was done once at the beginning of the test (at 12.00 on 07/09) and once at the end of the test period (at 16.00 on 07/09). This provides information about the interface temperature for the whole test period duration (test of prime and redundant sensors).
	SOB L1 Strap Interface *(outside)*	T_SOB_L1STR					
	FPU L1 Adaptor	L1_SIF_TEMP2					
	Detector Box Level-0 Strap *(outside)*	T_L0_DSTR					
	Pump L0 strap on Adaptor *(outside)*	T_L0_PSTR					
	Evaporator L0 strap on Adaptor *(outside)*	T_L0_ESTR					See AIV log in section 9.
	Detector L0 Strap on Adaptor 2 *(outside)*	L0_DSIF_TEMP2					
	Pump L0 strap on Adaptor 2 *(outside)*	L0_PSIF_TEMP2					

Test	**Actions**	**Data**				**Completed**	**Comments**
	Evaporator L0 strap on Adaptor 2 *(outside)*	L0_ESIF_TEMP2					
6.3.2.2	Connect the following redundant flight temperature sensors to the 370 Lakeshore using the procedure SPIRE-RAL-PRC-002508.					Not applicable!	~~Attention - TFCS will be disabled because the calibration curves will not be consistent anymore. This means that the cryostat/instrument temperatures will not be recorded during the whole period of this test.~~
6.3.2.3	Measure the redundant flight temperature sensors resistance with the AC bridge and the count and temperature values of the prime flight temperature sensors.		Resistance	Count	Temp	✓	At 14.28 on 07/09/05
	HSFPU Harness Filter Bracket	EMCFIL_1					
	M3,5,7 Optical Sub Bench	T_SUB_1					
	Input Baffle	T_BAF_1					
	BSM/SOB I/F (SOB side)	T_BSMS_1					
	SCAL Structure	T_SCST_1	Not connected	-	-		
	SCAL 4%	T_SCL4_1	Not connected	-	-		
	SCAL 2%	T_SCL2_1	Not connected	-	-		
	BSM	T_BSMM_1	Not connected	-	-		
	SMEC	T_FTSM_1	Not connected	-	-		See AIV log in section 9.
	SMEC/SOB I/F	T_FTSS_1	Not connected	-	-		
	Cooler Pump	T_CPHP_1					
	Cooler Shunt	T_CSHT_1					
	Cooler Evap	T_CEV_1					
	Cooler Pump Heat Switch (sieve)	T_CPHS_1					
	Cooler Evap Heat Switch (sieve)	T_CEHS_1	Not connected	-	-		
	Photometer Level 0 Enclosure	T_PL0_1					

Test	Actions	Data				Completed	Comments
	Spectrometer Level 0 Enclosure	T_SL0_1					
6.3.2.4	Reconnect the temperature sensors harnesses as per standard built.					✓	Before, repeated the measurements with a 10uA excitation current (as done with the prime sensors). Completed at 15.00 on 07/09.
6.3.3	**Flight <u>Prime</u> Temperature Sensor DC Offset Check**					✓	07/09/05
6.3.3.1	Once the instrument temperatures are stable, record the instrument interface temperatures for reference.		Temp			✓	At 12.00.
	SOB L1 Strap Interface *(outside)*	T_SOB_L1STR					
	FPU L1 Adaptor	L1_SIF_TEMP2					
	Detector Box Level-0 Strap *(outside)*	T_L0_DSTR					
	Pump L0 strap on Adaptor *(outside)*	T_L0_PSTR					
	Evaporator L0 strap on Adaptor *(outside)*	T_L0_ESTR					See AIV log in section 9.
	Detector L0 Strap on Adaptor 2 *(outside)*	L0_DSIF_TEMP2					
	Pump L0 strap on Adaptor 2 *(outside)*	L0_PSIF_TEMP2					
	Evaporator L0 strap on Adaptor 2 *(outside)*	L0_ESIF_TEMP2					
6.3.3.2	Connect the following prime flight temperature sensors to the 370 Lakeshore using the procedure SPIRE-RAL-PRC-002508.					✓	
6.3.3.3	Measure the prime flight temperature sensors resistance with the AC bridge and their count and temperature values with the DRCU.		Resistance	Count	Temp	✓	At 12.06 on DRCU At 12.47 on AC bridge (1uA excitation current)
	HSFPU Harness Filter Bracket	EMCFIL_1					

Test	Actions	Data				Completed	Comments
	M3,5,7 Optical Sub Bench	T_SUB_1					See AIV log in section 9.
	Input Baffle	T_BAF_1					
	BSM/SOB I/F (SOB side)	T_BSMS_1					
	SCAL Structure	T_SCST_1	Not connected	-	-		
	SCAL 4%	T_SCL4_1	Not connected	-	-		
	SCAL 2%	T_SCL2_1	Not connected	-	-		
	BSM	T_BSMM_1	Not connected	-	-		
	SMEC	T_FTSM_1	Not connected	-	-		
	SMEC/SOB I/F	T_FTSS_1	Not connected	-	-		See AIV log in section 9.
	Cooler Pump	T_CPHP_1					
	Cooler Shunt	T_CSHT_1					
	Cooler Evap	T_CEV_1					
	Cooler Pump Heat Switch (sieve)	T_CPHS_1					
	Cooler Evap Heat Switch (sieve)	T_CEHS_1	Not connected	-	-		
	Photometer Level 0 Enclosure	T_PL0_1					
	Spectrometer Level 0 Enclosure	T_SL0_1					
6.3.3.4	Repeat the resistance measurement with an AC bridge excitation current of 10uA					✓	At 13.22 on 07/09/05
	HSFPU Harness Filter Bracket	EMCFIL_1		-	-		
	M3,5,7 Optical Sub Bench	T_SUB_1		-	-		
	Input Baffle	T_BAF_1		-	-		
	BSM/SOB I/F (SOB side)	T_BSMS_1		-	-		
	SCAL Structure	T_SCST_1	Not connected	-	-		
	SCAL 4%	T_SCL4_1	Not connected	-	-		See AIV log in section 9.
	SCAL 2%	T_SCL2_1	Not connected	-	-		
	BSM	T_BSMM_1	Not connected	-	-		
	SMEC	T_FTSM_1	Not connected	-	-		

Test	Actions	Data				Completed	Comments
	SMEC/SOB I/F	T_FTSS_1	Not connected	-	-		
	Cooler Pump	T_CPHP_1		-	-		
	Cooler Shunt	T_CSHT_1		-	-		
	Cooler Evap	T_CEV_1		-	-		
	Cooler Pump Heat Switch (sieve)	T_CPHS_1		-	-		
	Cooler Evap Heat Switch (sieve)	T_CEHS_1	Not connected	-	-		See AIV log in section 9.
	Photometer Level 0 Enclosure	T_PL0_1		-	-		
	Spectrometer Level 0 Enclosure	T_SL0_1		-	-		
6.3.3.5	Reconnect the temperature sensors harnesses as per standard built.					✓	
6.4	**Level-1 Strap Characterisation**					✓	23/09/05
6.4.1	The cryostat temperature stages should be set as follows: L2 ~ 15K L1 ~ 4.2K L0 ~ 1.7K					✓	
6.4.2	The cryostat temperatures must be stable.					✓	The cryostat took longer to stabilise than usual.
6.4.3	The CBB should be closed.					✓	
6.4.4	Make sure the 370 AC bridge excitation current is set to 1uA.					✓	
6.4.5	The cooler can be ON or OFF.					✓	Cooler was already ON so left it.
6.4.6	The instrument should be in OFF/PHOTSTBY mode.					✓	Instrument was in spectrometer mode at the time so left as is to avoid switching ON/OFF the JFET. Doesn't affect the test.
6.4.7	Wait for the cryostat and instrument					N/A	Not test case, just need stable

Test	Actions	Data				Completed	Comments
	temperatures to stabilise according to the steady-state criteria defined in 5.3.5.4.						conditions, not steady-state criteria.
6.4.8	Measure the cryostat heater H2 voltage and calculate the power dissipation					✓	35V
6.4.9	Measure the following temperatures as a reference test case		Temperature	Resistance		✓	Competed at 09.04 on 23/09. This was done with the FPU heater set to 417.57mV to assess the MGSE L1 strap performances. Based on this, two cases were defined for the L1 strap characterisation: 10mW => voltage 591.8 mV 30mW => voltage 983.1 mV
	SOB L1 Strap Interface *(outside)*	T_SOB_L1STR					
	FPU L1 Adaptor	L1_SIF_TEMP2					
	FPU +X A-Frame Interface	T_FPU_PXAF					
	FPU –X A-Frame Interface	T_FPU_MXAF					
	SOB Cone Interface	T_SOB_CONE					
	L1 photo connector bracket	T_SOB_L1CON					
	HSFPU Harness Filter Bracket	EMCFIL_1					See AIV log in section 9.
	Photometer Level 0 Enclosure	T_PL0_1					
	Spectrometer Level 0 Enclosure	T_SL0_1					
6.4.10	Calculate the L1 thermal strap delta T below						
	SOB L1 Strap Interface - FPU L1 Adaptor						
6.4.11	Set the FPU heater voltage to 0.63V					✓	Different voltages used, see previous comment.
	Record the heater voltage and current at the power supply with a calibrated	Voltage = Current =					

Test	Actions	Data				Completed	Comments
	voltmeter.						
6.4.12	Wait for the temperature to stabilise and make sure the L2 stage temperature doesn’t drift as a result of the H2 power dissipation.					✓	Didn’t change for any the test cases.
6.4.13	Measure the following temperatures		Temperature/ Resistance	Temperature/ Resistance	Temperature/ Resistance	✓	
	SOB L1 Strap Interface *(outside)*	T_SOB_L1STR					
	FPU L1 Adaptor	L1_SIF_TEMP2					
	FPU +X A-Frame Interface	T_FPU_PXAF					
	FPU –X A-Frame Interface	T_FPU_MXAF					
	SOB Cone Interface	T_SOB_CONE					
	L1 photo connector bracket	T_SOB_L1CON					
	HSFPU Harness Filter Bracket	EMCFIL_1					See AIV log in section 9.
	Photometer Level 0 Enclosure	T_PL0_1					
	Spectrometer Level 0 Enclosure	T_SL0_1					
	Calculate the L1 thermal strap delta T below						
	SOB L1 Strap Interface - FPU L1 Adaptor						
6.4.14	Repeat the step 6.4.11 to 6.4.13, doubling the heater power dissipation each time, until the temperature drop along the L1 strap is greater than 0.1K.					✓	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%. Test completed at 16.00on 23/09 for the voltages previously defined.
6.4.15	Set the FPU heater voltage to 0V once					✓	

Test	Actions	Data				Completed	Comments
	the test is completed and make sure the cryostat H2 heater is set back to its original setting if it has been changed.						
6.5	**Cooler Pump Characterisation**					✓	19/09/05
6.5.1	The cryostat temperature stages should be set as follows: L2 ~ 15K L1 ~ 4.2K L0 ~ 1.7K					✓	This test requires careful monitoring of the cryostat manostat as the pump heater power dissipation might introduce instabilities in the cryostat L0 stage.
6.5.2	The cryostat temperatures must be stable.					✓	
6.5.3	The CBB should be closed.					✓	
6.5.4	Make sure the 370 AC bridge excitation current is set to 1uA.					✓	
6.5.5	The cooler must be fully discharged.					✓	
6.5.6	The instrument should be in OFF mode.					✓	
6.5.7	The pump heater should be OFF at the start of the test and the cooler temperature must be stable.					✓	
6.5.8	Turn the Evaporator heat switch OFF.					✓	Was already OFF.
6.5.9	Turn the pump heat switch ON – by applying 788uW on pump HS heater (1.4mA – command [0x0DEB]).					✓	Was already ON and stable.
6.5.10	When the pump heat switch has reached 15K, reduce the pump heat switch heater power to 400uW (1mA –					✓	At 11.13 on 19/09/05

Test	Actions	Data				Completed	Comments
	command [0x09EC]).						
6.5.11	Wait for the temperature to stabilise and log the temperatures and cooler telemetry data in table below.					✓	At 12.18, had to increase the voltage to the pump HS to 396.2mV (command A00) as the pump temperature wouldn't stabilise. I.e the FM cooler behaves a bit differently from the CQM one. Case completed at 12.49 for the 0mW test case, with a pump HS power of 0.406mW.
6.5.12	Set the pump heater power dissipation to 5mW (3.527mA – command [0x0124]).					✓	At 13.09
6.5.13	Wait for the temperature to stabilise and log the temperatures and cooler telemetry data in table below.					✓	Same problem as before so increase the pump HS power back to 0.7mW (DEB). Test completed for the 5mW test case and 0.7mW on HS at 14.00.
6.5.14	Set the pump heater power dissipation to 10mW (4.988mA – command [0x019C]).					✓	At 14.44.
6.5.15	Wait for the temperature to stabilise and log the temperatures and cooler telemetry data in table below.					✓	At 15.23. Error when checking stability criteria. The rate was actually ~twice the required one: 20mK/hr versus 9mK/hr.
6.5.16	Set the pump heater power dissipation to 15mW (6.108mA – command [0x01F8]).					N/A	These test cases were not performed due to time constraints.
6.5.17	Wait for the temperature to stabilise					N/A	These test cases were not

Test	Actions	Data				Completed	Comments
	and log the temperatures and cooler telemetry data in table below.						performed due to time constraints.
6.5.18	Set the pump heater power dissipation to 20mW (7.053mA – command [0x0246]).					N/A	These test cases were not performed due to time constraints.
6.5.19	Wait for the temperature to stabilise and log the temperatures and cooler telemetry data in table below.					N/A	These test cases were not performed due to time constraints.
6.5.20	Increase the pump heat switch heater power to 788uW (1.4mA – command [0x0DEB]).					✓	Already in this state.
6.5.21	Wait for the temperature to stabilise and log the temperatures and cooler telemetry data in table below.					✓	Stable at 16.32 on 19/09
6.5.22	Switch the Pump heater OFF.					✓	
6.5.23	Switch the Pump HS OFF.					N/A	Left it ON as the cooler was in this state at the beginning of the test.
6.5.24	Wait for the temperature to stabilise and log the temperatures and cooler telemetry data in table below.					N/A	
6.5.25	Plot Graph of Pump temperature versus pump heater load					✓	
	Telemetry						
	Pump Heater Power Dissipation [mW]	0	5	10	~~15~~ 0	~~20~~	
	Pump Heater Command [Hex]	0x0000	0x0124	0X019C	0x0000		
	Pump Heater Voltage/Current	0	1.428V	2.016V	0		
	Evaporator HS Command						N/A as OFF for the whole test period duration

Test	Actions	Data				Completed	Comments
	Evaporator HS Voltage/Current						
	Pump HS Command	0x0A00	0x0DEB	0x0DEB	0x0DEB		
	Pump HS Voltage/Current	396.2mV	551.2mV	551.2mV	551.2mV		
	Temperatures						
	T_CPHP_1 (pump)						
	T_CSHT_1 (shunt)						
	T_CEV_1 (evaporator)						
	T_CPHS_1 (Pump Heat Switch)						
	T_CEHS_1 (Evaporator Heat Switch)						
	T_PL0_1						
	T_SL0_1						
	T_PL0_2						
	T_SL0_2						
	T_L0_DSTR						
	T_L0_PSTR						
	T_L0_ESTR						
	T_L0_DSTR2						See AIV log in section 9.
	T_L0_PSTR2						
	T_L0_ESTR2						
	FPU Evaporator Strap Interface						Sensor Out of Calibration
	FPU Pump Strap Interface						Sensor Out of Calibration
	FPU Box Strap Interface						Sensor Out of Calibration
	FPU L1 Interface at cryostat						Sensor Out of Calibration
	FPU L1 Strap						

Test	Actions	Data				Completed	Comments
	L1 Strap Interface at SOB						
6.6	**Cooler Recycling**						
6.6.1	Make sure the cryostat temperature stages have been set as required.						Procedure used each time the cooler needs recycling using a SCOS script.
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 cooler must be fully discharged.						
6.6.6	Turn the pump Heat Switch OFF if previously turned ON.						
6.6.7	Turn the evaporator heat switch ON by applying 1.4mA on evaporator HS heater (command [0x0DEB])						
6.6.8	Wait until the pump heat switch temperature has decreased below 12K.						
6.6.9	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.
6.6.10	Wait for the pump temperature to reach 45K						
6.6.11	Reduce the power on pump heater to						

Test	Actions	Data				Completed	Comments
	~40 mW (command [0x0339])						
6.6.12	Wait for the evaporator temperature to reach 2K.						
6.6.13	Turn the power on the pump heater OFF						
6.6.14	Turn the power on the evaporator heat switch OFF						
6.6.15	Wait for the evaporator HS temperature to cooldown below 16K.						
6.6.16	Turn the pump heat switch ON by applying 1.4mA on pump HS heater (command [0x0DEB]).						
6.6.17	Wait for the evaporator temperature to drop and stabilise at subK temperature.						
6.6.18	Log the evaporator temperature						
6.6.19	Reduce the pump heat switch power to 400 uW (1 mA – command [0x09EC]).						This step is not yet part of the FM SCOS script.
6.7	**L0 Enclosure Strap Characterisation**					N/A	Could not be carried out as the L0 Photometer EGSE heater was open-circuit.
6.7.1	Make sure the cryostat, instrument and monitoring unit are setup as described in table on previous page.						
6.7.2	Set the L0 photometer enclosure heater to 0mW power dissipation	R=	Current=	Voltage =	Power =		
6.7.3	*Calculate the required current according to measured resistance of the heater if applicable.*						

Test	Actions	Data				Completed	Comments
6.7.4	*Set the current on power supply*						
6.7.5	*Measure the voltage on 4-wire measurement*						
6.7.6	*Adjust current if necessary*						
6.7.7	Wait for the temperature to be stable. Make sure the steady-state criterion define in section 5.3.5.4 is met.						
6.7.8	Log the following temperature						
	T_PL0_3						
	T_SL0_3						
	T_L0_DSTR						
	(optical bench) T_SUB_1						
	(scal structure) T_SCST_1						
	T_SOB_L1CON (photo F-harn)						
	T_SOB_1 (Approx. spectro F-harn)						
	T_PL0_1						
	T_SL0_1						
	SUBKTEMP						
	PLW Temperature using load curve						
6.7.9	Set the L0 photometer enclosure heater to 5 mW power dissipation	R=	Current=	Voltage =	Power =		
6.7.10	*Calculate the required current according to measured resistance of the heater*						
6.7.11	*Set the current on power supply*						
6.7.12	*Measure the voltage on 4-wire*						

Test	Actions	Data				Completed	Comments
	measurement						
6.7.13	*Adjust current if necessary*						
6.7.14	Wait for the temperature to be stable. Make sure the steady-state criterion define in section 5.3.5.4 is met.						
6.7.15	Log the following temperature						
	T_PL0_3						
	T_SL0_3						
	T_L0_DSTR						
	(optical bench) T_SUB_1						
	(scal structure) T_SCST_1						
	T_SOB_L1CON (photo F-harn)						
	T_SOB_1 (Approx. spectro F-harn)						
	T_PL0_1						
	T_SL0_1						
	SUBKTEMP						
	PLW Temperature using load curve						
6.7.16	Set the L0 photometer enclosure heater to 10 mW power dissipation	R=	Current=	Voltage =	Power =		
6.7.17	*Calculate the required current according to measured resistance of the heater*						
6.7.18	*Set the current on power supply*						
6.7.19	*Measure the voltage on 4-wire measurement*						
6.7.20	*Adjust current if necessary*						

Test	Actions	Data				Completed	Comments
6.7.21	Wait for the temperature to be stable. Make sure the steady-state criterion define in section 5.3.5.4 is met.						
6.7.22	Log the following temperature						
	T_PL0_3						
	T_SL0_3						
	T_L0_DSTR						
	(optical bench) T_SUB_1						
	(scal structure) T_SCST_1						
	T_SOB_L1CON (photo F-harn)						
	T_SOB_1 (Approx. spectro F-harn)						
	T_PL0_1						
	T_SL0_1						
	SUBKTEMP						
	PLW Temperature using load curve						
6.8	**Pump Heat Switch Characterisation**					✓	26/09/05
6.8.1	The cryostat temperature stages should be set as follows: L2 ~ 15K L1 ~ 4.2K L0 ~ 1.7K					✓	
6.8.2	The cryostat temperatures must be stable.					✓	
6.8.3	The CBB should be closed.					✓	

Test	Actions	Data				Completed	Comments
6.8.4	Make sure the 370 AC bridge excitation current is set to 1uA.					✓	
6.8.5	The cooler must be in operation and its temperatures must be stable.					✓	
6.8.6	The pump heat switch power dissipation should be set to the nominal current operation [Command DEB]					✓	
6.8.7	Once temperature are stable, record the following temperatures:					✓	At 15.49 on 26/09
	Pump HS Command	0x0DEB					
	Pump HS Voltage/Current	551.25mV					
		Temperatures	**Resistance**				
	T_CPHP_1 (pump)						
	T_CSHT_1 (shunt)						
	T_CEV_1 (evaporator)						
	T_CPHS_1 (Pump Heat Switch)						See AIV log in section 9.
	T_CEHS_1 (Evaporator Heat Switch)						
	T_PL0_1						
	T_SL0_1						
	T_L0_PSTR						
	T_L0_ESTR						
	T_L0_PSTR2						
	T_L0_ESTR2						
6.8.8	The pump heat switch power dissipation should be set to the current operation [Command A2A]					✓	At 16.00 on 26/09

Test	Actions	Data				Completed	Comments
6.8.9	Once temperature are stable, record the following temperatures:					✓	At 16.44 on 26/09
	Pump HS Command	0x0A2A					
	Pump HS Voltage/Current	402.67mV					
		Temperatures	Resistance				See AIV log in section 9.
	T_CPHP_1 (pump)						
	T_CSHT_1 (shunt)						
	T_CEV_1 (evaporator)						
	T_CPHS_1 (Pump Heat Switch)						
	T_CEHS_1 (Evaporator Heat Switch)						
	T_PL0_1						
	T_SL0_1						See AIV log in section 9.
	T_L0_PSTR						
	T_L0_ESTR						
	T_L0_PSTR2						
	T_L0_ESTR2						
6.8.10	The pump heat switch power dissipation should be set to the current operation [Command 9EC]					N/A	This additional test case was not required as the previous test showed no change in cooler performances.
6.8.11	Once temperature are stable, record the following temperatures:					N/A	
	Pump HS Command						
	Pump HS Voltage/Current						
		Temperatures	Resistance				
	T_CPHP_1 (pump)						

Test	Actions	Data				Completed	Comments
	T_CSHT_1 (shunt)						
	T_CEV_1 (evaporator)						
	T_CPHS_1 (Pump Heat Switch)						
	T_CEHS_1 (Evaporator Heat Switch)						
	T_PL0_1						
	T_SL0_1						
	T_L0_PSTR						
	T_L0_ESTR						
	T_L0_PSTR2						
	T_L0_ESTR2						
6.9	**Cold Thermal Balance Test**					✓	Started on 19/09/05 at 16.30 and completed at 18.30 on 21/09/05
6.9.1	The cryostat temperature stages should be set as follows: L2 ~ 15K L1 ~ 4.2K L0 ~ 1.7K					✓	
6.9.2	The cryostat temperatures must be stable.					✓	
6.9.3	The CBB should be closed.					✓	
6.9.4	Make sure the 370 AC bridge excitation current is set to 1uA.					✓	
6.9.5	The instrument mechanisms should be left OFF					✓	
6.9.6	Recycle the cooler as per procedure 6.6 except for step 6.6.19 which is not					✓	Started at 16.34 until 18.30 on 19/09.

Test	Actions	Data				Completed	Comments
	applicable in this case.						Please note that the criterion for the temperature of evaporator condensation was set to 2.1K in this case to compensate for the instabilities in the L0 pot temperature when the manostat is open.
6.9.7	Wait for the temperatures to stabilised and make sure no performances testing is carried out during this period.					✓	Please note that performance testing was carried out at the same time given campaign time constraints at the time.
6.9.8	When steady-state criteria are met, run a DC load curve to measure the detectors temperature [AD7].					✓	At 20.04 on 19/09. Additional load curve also carried out at 19.28 on 22/09.
.6.9.9	Write down the time at which the steady state condition has been met for future reference. This completes the COLD thermal balance test case.					✓	Identify period of stability during part of the night where no performance testing was taking place.
6.9.10	Leave the cooler to run out to assess the instrument hold time performances for the cold conditions					✓	
6.9.11	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.					✓	Cooler ran out at 18.30 on 21/09/05, giving a ~48hr hold time.
6.10	**Hot Thermal Balance Test**					✓	Started on 23/09/05 at 18.40 and completed at 08.00 on 25/09/05
6.10.1	The cryostat temperature stages should be set as follows:					✓	The setup of the L1 temperature required the following heater

Test	Actions	Data				Completed	Comments
	L2 ~ 15K L1 ~ 5.5K L0 ~ 2K						setup: L1 heater: 0.135W (2.165V) H2 heater: 1.515W (33.52V)
6.10.2	The cryostat temperatures must be stable.					✓	
6.10.3	The CBB should be closed.					✓	
6.10.4	Make sure the 370 AC bridge excitation current is set to 1uA.					✓	
6.10.5	The instrument mechanisms should be left OFF					✓	
6.10.6	Recycle the cooler as per procedure 6.6 except for step 6.6.19 which is not applicable in this case.					✓	Started at 18.40 until 20.40 on 23/09. Please note that the criterion for the temperature of evaporator condensation was not applicable as the L0 interface temperatures were already close to 2K. The evaporator was left to cool down as much as possible in this specific case.
6.10.7	Wait for the temperatures to stabilised and make sure no performances testing is carried out during this period.					✓	
6.10.8	When steady-state criteria are met, run a DC load curve to measure the detectors temperature [AD7].					✓	At 18.08 on 23/09. The instrument overall temperatures had not had time to stabilise but this was the only time available to run a load curve.
6.10.9	Write down the time at which the steady state condition has been met for					✓	

Test	Actions	Data				Completed	Comments
	future reference. This completes the HOT thermal balance test case.						
6.10.10	Leave the cooler to run out to assess the instrument hold time performances for the cold conditions					✓	
6.10.11	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.					✓	Cooler ran out at 08.00 on 25/09/05, giving a ~34.5hr hold time.

9 PFM2 THERMAL BALANCE TEST AIV LOGFILES

Main Activity	**PFM2 Thermal Balance Testing**	**Location**	**RAL SSTD G56 Clean Room**

Date	**05-September-2005**

Time	Activity	Signature
13.00	**PFM2 TBT Procedure Step 6.1.2 - “4K Temperature Check”**	**ASG**
	Cooler OFF and AC Bridge use 1uA excitation current.	
	Temperature stable, log all the instrument temperatures while L0 stage still at 4K	ASG

		Temp	Comments
HSFPU Harness Filter Bracket	EMCFIL_1	4.37	SOB_TEMP
M3,5,7 Optical Sub Bench	T_SUB_1	4.37	OP_TEMP
Input Baffle	T_BAF_1	4.47	
BSM/SOB I/F (SOB side)	T_BSMS_1	4.35	
SCAL Structure	T_SCST_1	5.86	? Too warm
SCAL 4%	T_SCL4_1	4.61	
SCAL 2%	T_SCL2_1	4.27	
BSM	T_BSMM_1	4.32	
SMEC	T_FTSM_1	4.29	
SMEC/SOB I/F	T_FTSS_1	4.35	
Cooler Pump	T_CPHP_1	6.3	
Cooler Shunt	T_CSHT_1	3.43	? Too Cold
Cooler Evap	T_CEV_1	4.31	
Cooler Pump Heat Switch (sieve)	T_CPHS_1	4.06	On heat switch
Cooler Evap Heat Switch (sieve)	T_CEHS_1	4.12	On heat switch
Photometer Level 0 Enclosure	T_PL0_1	3.54	? Too cold and now working?
Spectrometer Level 0 Enclosure	T_SL0_1	3.49	? Too cold
Photometer JFET Chassis	T_PJFS_CHAS	19.52	
Spectrometer JFET Chassis	T_SJFS_CHAS	19.75	
FPU +X A-Frame Interface	T_FPU_PXAF	4.41	
FPU –X A-Frame Interface	T_FPU_MXAF	4.43	
SOB Cone Interface	T_SOB_CONE	4.55	
SOB L1 Strap Interface	T_SOB_L1STR	4.3	On SOB

Checked By:

Main Activity	**PFM2 Thermal Balance Testing**	**Location**	**RAL SSTD G56 Clean Room**

Date	**05-September-2005**

Time	**Activity**	**Signature**

L1 photo connector bracket	T_SOB_L1CON	4.37	
Detector Box L0 Strap Adaptor	T_L0_DSTR	4.21	
Pump L0 Strap Adaptor	T_L0_PSTR	4.21	
Evaporator L0 Strap Adaptor	T_L0_ESTR	4.21	
FSJFP L3 Strap	S16	Dead	
FSJFS L3 Strap	S17	19.94	
FSJFP-HOB I/F	S18	19.74	
FPU Cone Foot I/F	S19	19.99	
FPU +Y Foot I/F	S20	20.15	
Support foot 1	S12	-	
FPU -Y Foot I/F	S21	Dead	
FSJFS-HOB I/F	S22	19.71	
Harness Sink WE-Ph JFET(L2 Shield Side)	S23	21.99	
FPU L1 Strap	S26	4.39	
FPU L1 Adaptor	S35	4.24	
FPU Evap Strap I/F	S28	4.27	
FPU Pump Strap I/F	S29	4.52	
FPU Box Strap I/F	S30	4.29	
Detector Box L0 Strap 2	~~S32~~ S34	3.87	
Pump L0 Strap 2	S33	3.86	
Evaporator L0 Strap 2	~~S34~~ S32	4	
Observations			
	PLO_2 SLO_2	3.71 3.65	Redundant Flight Sensor on 218 Redundant Flight Sensor on 218

Main Activity	**PFM2 Thermal Balance Testing**	**Location**	**RAL SSTD G56 Clean Room**

Date	**06-September-2005**

Time	**Activity**	**Signature**
12.42 on PC	**PFM2 TBT Procedure Step 6.1.3 – “Nominal Operation Temperature Check”**	**ASG**
	Cooler OFF with both heat switches are in open states	
	Temperature stable, log all the instrument temperatures	ASG
	AC Bridge excitation current 1uA	

		Temperature	Count	Comments
HSFPU Harness Filter Bracket	EMCFIL_1	4.27	-2777	SOB_TEMP
M3,5,7 Optical Sub Bench	T_SUB_1	4.28	-4175	OP_TEMP
Input Baffle	T_BAF_1	4.379	-3088	
BSM/SOB I/F (SOB side)	T_BSMS_1	4.272	-4510	
SCAL Structure	T_SCST_1	5.737	-3782	
SCAL 4%	T_SCL4_1	4.19	-6603	
SCAL 2%	T_SCL2_1	4.52	-6872	
BSM	T_BSMM_1	4.239	-18943	
SMEC	T_FTSM_1	4.197	-22673	
SMEC/SOB I/F	T_FTSS_1	4.26	-5728	
Cooler Pump	T_CPHP_1	2.14	-4434	
Cooler Shunt	T_CSHT_1	1.688	-4760	
Cooler Evap	T_CEV_1	1.78	32400	
Cooler Pump Heat Switch (sieve)	T_CPHS_1	2.91	-	
Cooler Evap Heat Switch (sieve)	T_CEHS_1	2.81	-	
Photometer Level 0 Enclosure	T_PL0_1	1.699	-4501	
Spectrometer Level 0 Enclosure	T_SL0_1	1.687	-4940	
Photometer JFET Chassis	T_PJFS_CHAS	14.26	-	
Spectrometer JFET Chassis	T_SJFS_CHAS	14.46	-	
FPU +X A-Frame Interface	T_FPU_PXAF	4.32	-	
FPU –X A-Frame Interface	T_FPU_MXAF	4.33	-	
SOB Cone Interface	T_SOB_CONE	4.34	-	
SOB L1 Strap Interface	T_SOB_L1STR	4.25	4388.84	
L1 photo connector bracket	T_SOB_L1CON	4.27	-	
Detector Box L0 Strap Adaptor	T_L0_DSTR	1.69	1375.24	

Checked By:

Date	**06-September-2005**

Time	**Activity**	**Signature**

Pump L0 Strap Adaptor	T_L0_PSTR	1.69	699.27	
Evaporator L0 Strap Adaptor	T_L0_ESTR	1.68	781.35	
FSJFP L3 Strap	S16	dead	-	
FSJFS L3 Strap	S17	14.47	-	
FSJFP-HOB I/F	S18	14.26	-	
FPU Cone Foot I/F	S19	14.73	-	
FPU +Y Foot I/F	S20	14.94	-	
FPU -Y Foot I/F	S21	dead	-	
FSJFS-HOB I/F	S22	14.35	-	
Harness Sink WE-Ph JFET(L2 Shield Side)	S23	18.14	-	
FPU L1 Strap	S26	4.39	446.81	
FPU L1 Adaptor	S35	4.23	997.51	
FPU Evap Strap I/F	S28	1.71	2604.69	
FPU Pump Strap I/F	S29	1.82	1241.57	
FPU Box Strap I/F	S30	1.78	1124.82	
Detector Box L0 Strap 2	~~S32~~ S34	1.68	1296.44	
Pump L0 Strap 2	S33	1.68	2264.64	
Evaporator L0 Strap 2	~~S34~~ S32	1.68	3397.81	
Photometer Level 0 Enclosure (redundant)	T_PL0_2	1.7	1981.1	
Spectrometer Level 0 Enclosure (redundant)	T_SL0_2	1.7	1706.2	

13.10 on PC	**PFM2 TBT Procedure Step 6.3.1 – "Temperature Sensor Self-Heating Check"**	**ASG**
	AC Bridge excitation current changed to 10uA.	

SOB L1 Strap Interface	T_SOB_L1STR	4.26	4385.48	FPU warming up slightly as HOB just about stabilising.
Detector Box L0 Strap Adaptor	T_L0_DSTR	1.7	1367.27	
Pump L0 Strap Adaptor	T_L0_PSTR	1.69	697.78	
Evaporator L0 Strap Adaptor	T_L0_ESTR	1.69	779.45	
FPU L1 Strap	S26	4.39	446.63	
FPU L1 Adaptor	S35	4.23	997.18	

Main Activity	**PFM2 Thermal Balance Testing**	**Location**	**RAL SSTD G56 Clean Room**

Date	**06-September-2005**

Time	Activity	Signature
	FPU Evap Strap I/F | S28 | 1.73 | 2572.43 FPU Pump Strap I/F | S29 | 1.83 | 1235.45 FPU Box Strap I/F | S30 | 1.79 | 1120.61 Detector Box L0 Strap 2 | ~~S32~~ S34 | 1.69 | 1290.43 Pump L0 Strap 2 | S33 | 1.69 | 2242.27 Evaporator L0 Strap 2 | ~~S34~~ S32 | 1.7 | 3343.3	
	AC Bridge excitation current changed back to 1uA.	

FPU Evap Strap I/F	S28	1.73	2572.43	
FPU Pump Strap I/F	S29	1.83	1235.45	
FPU Box Strap I/F	S30	1.79	1120.61	
Detector Box L0 Strap 2	~~S32~~ S34	1.69	1290.43	
Pump L0 Strap 2	S33	1.69	2242.27	
Evaporator L0 Strap 2	~~S34~~ S32	1.7	3343.3	

Date	**07-September-2005**

Time	**Activity**	**Signature**
12.00	**Start of Test Period for PFM2 TBT Procedure Step 6.3.3 – "Flight Prime Temperature Sensor DC Offset Check"**	**ASG**
	Prime Sensors on DRCU *Redundant Sensors Disconnected* *TFCS Sensors on AC Bridge*	
12.06	Reference measurement taken with Flight Prime Sensors on DRCU:	ASG
	Prime Sensors on DRCU *Redundant Sensors Disconnected* *TFCS Sensors on AC Bridge*	

	Prime Sensors	**Temp**	**Count**
T_CPHP_1	Cooler Pump	2.13	-4412
T_CSHT_1	Cooler Shunt	1.698	-4792
T_CEV_1	Cooler Evap	1.82	32410
T_CPHS_1	Cooler Pump Heat Switch (sieve)	2.93	-6010
T_CEHS_1	Cooler Evap Heat Switch (sieve)	2.8208	-5816
T_PL0_1	Photometer Level 0 Enclosure	1.708	-4531
T_SL0_1	Spectrometer Level 0 Enclosure	1.696	-4974
EMCFIL_1	HSFPU Harness Filter Bracket	4.28	-2776
T_SUB_1	M3,5,7 Optical Sub Bench	4.28	-4176
T_BAF_1	Input Baffle	4.38	-3088
T_BSMS_1	BSM/SOB I/F (SOB side)	4.27	-4515
T_SCST_1	SCAL Structure	5.743	-3785
T_SCL4_1	SCAL 4%	4.192	-6606

Date	**07-September-2005**

<table>
<tr><th>Time</th><th>Activity</th><th>Signature</th></tr>
<tr><td></td><td>
<table>
<tr><td>T_SCL2_1</td><td>SCAL 2%</td><td>4.523</td><td>-6874</td></tr>
<tr><td>T_BSMM_1</td><td>BSM</td><td>NOT CONN</td><td></td></tr>
<tr><td>T_FTSM_1</td><td>SMEC</td><td>NOT CONN</td><td></td></tr>
<tr><td>T_FTSS_1</td><td>SMEC/SOB I/F</td><td>NOT CONN</td><td></td></tr>
</table>
</td><td></td></tr>
<tr><td>12.19</td><td><i>Switch DRCU and SCU OFF</i>
<i>Prime Sensors Disconnected</i></td><td></td></tr>
<tr><td>12.32</td><td><i>Redundant Sensors on DRCU</i></td><td></td></tr>
<tr><td>12.37</td><td><i>TFCS Sensors Disconnected</i>
<i>Prime Sensors on AC Bridge</i></td><td></td></tr>
<tr><td>12.47</td><td>Take redundant sensors data (~~temp~~ and count) with SCU:
<table>
<tr><th>Redundant on DRCU</th><th>Count</th></tr>
<tr><td>Cooler Pump</td><td>-4823</td></tr>
<tr><td>Cooler Shunt</td><td>-5151</td></tr>
<tr><td>Cooler Evap</td><td>32406</td></tr>
<tr><td>Cooler Pump Heat Switch (sieve)</td><td>-6015</td></tr>
<tr><td>Cooler Evap Heat Switch (sieve)</td><td>-5806</td></tr>
<tr><td>Photometer Level 0 Enclosure</td><td>-4286</td></tr>
<tr><td>Spectrometer Level 0 Enclosure</td><td>-4950</td></tr>
<tr><td>HSFPU Harness Filter Bracket</td><td>-2677</td></tr>
<tr><td>M3,5,7 Optical Sub Bench</td><td>-4091</td></tr>
<tr><td>Input Baffle</td><td>-3047</td></tr>
<tr><td>BSM/SOB I/F (SOB side)</td><td>-4504</td></tr>
</table>
</td><td>ASG
Please note that the temperature data should be ignored as the calibration curves in the SCU was not set for reading the redundant sensors out.</td></tr>
</table>

Date	**07-September-2005**

Time	Activity	Signature
	See also snapshot taken in AIV logfile.	
12.47	Take Prime sensors data on AC bridge with 1uA	ASG

Sensor ID	Sensor Name	R_1uA
		Ohms
T_CPHP_1	Cooler Pump	836.44
T_CSHT_1	Cooler Shunt	1755.85
T_CEV_1	Cooler Evap	1967.74
T_CPHS_1	Cooler Pump Heat Switch (sieve)	916.29
T_CEHS_1	Cooler Evap Heat Switch (sieve)	NOT CONN
T_PL0_1	Photometer Level 0 Enclosure	1871.69
T_SL0_1	Spectrometer Level 0 Enclosure	1694.43
EMCFIL_1	HSFPU Harness Filter Bracket	449.71
T_SUB_1	M3,5,7 Optical Sub Bench	516.87
T_BAF_1	Input Baffle	675.16
T_BSMS_1	BSM/SOB I/F (SOB side)	639.75
T_SCST_1	SCAL Structure	937.82
T_SCL4_1	SCAL 4%	434.54
T_SCL2_1	SCAL 2%	422.58

Time	Activity	Signature
13.22	Take Prime sensors data on AC bridge with 10uA	ASG
	See table overleaf…	

Date	07-September-2005

<table>
<tr><th>Time</th><th>Activity</th><th>Signature</th></tr>
<tr><td></td><td>
<table>
<tr><th rowspan="2">Sensor ID</th><th rowspan="2">Sensor Name</th><th>R_10uA</th></tr>
<tr><th>Ohms</th></tr>
<tr><td>T_CPHP_1</td><td>Cooler Pump</td><td>835.18</td></tr>
<tr><td>T_CSHT_1</td><td>Cooler Shunt</td><td>1743.58</td></tr>
<tr><td>T_CEV_1</td><td>Cooler Evap</td><td>1957.88</td></tr>
<tr><td>T_CPHS_1</td><td>Cooler Pump Heat Switch (sieve)</td><td>915.75</td></tr>
<tr><td>T_CEHS_1</td><td>Cooler Evap Heat Switch (sieve)</td><td>NOT CONN</td></tr>
<tr><td>T_PL0_1</td><td>Photometer Level 0 Enclosure</td><td>1858.3</td></tr>
<tr><td>T_SL0_1</td><td>Spectrometer Level 0 Enclosure</td><td>1683.89</td></tr>
<tr><td>EMCFIL_1</td><td>HSFPU Harness Filter Bracket</td><td>449.61</td></tr>
<tr><td>T_SUB_1</td><td>M3,5,7 Optical Sub Bench</td><td>516.78</td></tr>
<tr><td>T_BAF_1</td><td>Input Baffle</td><td>675.06</td></tr>
<tr><td>T_BSMS_1</td><td>BSM/SOB I/F (SOB side)</td><td>637.75</td></tr>
<tr><td>T_SCST_1</td><td>SCAL Structure</td><td>937.65</td></tr>
<tr><td>T_SCL4_1</td><td>SCAL 4%</td><td>434.36</td></tr>
<tr><td>T_SCL2_1</td><td>SCAL 2%</td><td>422.37</td></tr>
</table>
</td><td></td></tr>
<tr><td>13.41</td><td>Start of Test Period for PFM2 TBT Procedure Step 6.3.2 – “Flight Redundant Temperature Sensor DC Offset Check”</td><td>ASG</td></tr>
<tr><td>13.41</td><td>Take redundant sensors data (~~temp~~ and raw) with DRCU for reference</td><td>ASG
Please note that the temperature data should be ignored as the calibration curves in the SCU was not</td></tr>
</table>

Main Activity	PFM2 Thermal Balance Testing	Location	RAL SSTD G56 Clean Room

Date	07-September-2005

Sensor ID	Redundant Sensor Name	Raw Value
		Count
T_CPHP_1	Cooler Pump	-4815
T_CSHT_1	Cooler Shunt	-5150
T_CEV_1	Cooler Evap	32404
T_CPHS_1	Cooler Pump Heat Switch (sieve)	-6014
T_CEHS_1	Cooler Evap Heat Switch (sieve)	-5808
T_PL0_1	Photometer Level 0 Enclosure	-4287
T_SL0_1	Spectrometer Level 0 Enclosure	-4950
EMCFIL_1	HSFPU Harness Filter Bracket	-2681
T_SUB_1	M3,5,7 Optical Sub Bench	-4091
T_BAF_1	Input Baffle	-3047
T_BSMS_1	BSM/SOB I/F (SOB side)	-4506
T_SCST_1	SCAL Structure	NOT CONN
T_SCL4_1	SCAL 4%	NOT CONN
T_SCL2_1	SCAL 2%	NOT CONN
T_BSMM_1	BSM	-18955
T_FTSM_1	SMEC	-22683
T_FTSS_1	SMEC/SOB I/F	-5731

Time	Activity	Signature
	See also snapshot taken in AIV logfile.	set for the redundant sensors
13.44	Switch DRCU and SCU OFF	
13.45	Redundant Sensors on Disconnected	
13.51	Prime Sensors on DRCU back ON	

Checked By:

Date	**07-September-2005**

Time	**Activity**	**Signature**
13.55	Redundant Sensors on AC Bridge	
14.28	**Start of Test Period for PFM2 TBT Procedure Step 6.3.2 – “Flight Redundant Temperature Sensor DC Offset Check”**	**ASG**
	Take Redundant sensors data on AC bridge with 1uA	ASG

Sensor ID	**Redundant Sensor Name**	**R_1uA**
		Ohms
T_CPHP_1	Cooler Pump	765.85
T_CSHT_1	Cooler Shunt	1636.8
T_CEV_1	Cooler Evap	2003.68
T_CPHS_1	Cooler Pump Heat Switch (sieve)	912.35
T_CEHS_1	Cooler Evap Heat Switch (sieve)	NOT CONN
T_PL0_1	Photometer Level 0 Enclosure	1978.7
T_SL0_1	Spectrometer Level 0 Enclosure	1702.39
EMCFIL_1	HSFPU Harness Filter Bracket	465.76
T_SUB_1	M3,5,7 Optical Sub Bench	527.4
T_BAF_1	Input Baffle	684.25
T_BSMS_1	BSM/SOB I/F (SOB side)	640.85
T_SCST_1	SCAL Structure	NOT CONN
T_SCL4_1	SCAL 4%	NOT CONN
T_SCL2_1	SCAL 2%	NOT CONN
T_BSMM_1	BSM	NOT CONN
T_FTSM_1	SMEC	NOT CONN
T_FTSS_1	SMEC/SOB I/F	NOT CONN

Time	**Activity**	**Signature**
15.00	Take Redundant sensors data on AC bridge with 10uA	ASG

Main Activity	**PFM2 Thermal Balance Testing**	**Location**	**RAL SSTD G56 Clean Room**

Date	**07-September-2005**

Time	**Activity**	**Signature**

Sensor ID	**Redundant Sensor Name**	**R_10uA**
		Ohms
T_CPHP_1	Cooler Pump	765.1
T_CSHT_1	Cooler Shunt	1623.58
T_CEV_1	Cooler Evap	1991.24
T_CPHS_1	Cooler Pump Heat Switch (sieve)	912.08
T_CEHS_1	Cooler Evap Heat Switch (sieve)	NOT CONN
T_PL0_1	Photometer Level 0 Enclosure	1964.77
T_SL0_1	Spectrometer Level 0 Enclosure	1691.22
EMCFIL_1	HSFPU Harness Filter Bracket	466.953
T_SUB_1	M3,5,7 Optical Sub Bench	527.51
T_BAF_1	Input Baffle	684.23
T_BSMS_1	BSM/SOB I/F (SOB side)	639.02
T_SCST_1	SCAL Structure	NOT CONN
T_SCL4_1	SCAL 4%	NOT CONN
T_SCL2_1	SCAL 2%	NOT CONN
T_BSMM_1	BSM	NOT CONN
T_FTSM_1	SMEC	NOT CONN
T_FTSS_1	SMEC/SOB I/F	NOT CONN

15.00	This completes the Temperature Sensor Characterisation Test Period. *Redundant Sensors on Disconnected*	ASG

Checked By:

Date	**07-September-2005**

Time	**Activity**	**Signature**
	Prime Sensors on DRCU *TFCS Sensors on AC Bridge*	
	The table below provides an indication of the cryostat interface temperature rate of change during the whole period of test:	ASG

	Period (UTC)		**Rate of Change**
Instrument EGSE	**12.00**	**16.00**	**[mK/hr]**
T_PJFS_CHAS	14.541	14.931	97.55
T_SJFS_CHAS	14.710	15.102	97.98
T_FPU_MYAF	4.320	4.323	0.70
T_FPU_PYAF	4.332	4.337	1.29
T_SOB_CONE	4.341	4.347	1.35
T_SOB_L1CON	4.273	4.278	1.22
T_SOB_L1STR	4.256	4.258	0.46
T_L0_DSTR	1.697	1.700	0.86
T_L0_PSTR	1.698	1.701	0.87
T_L0_ESTR	1.691	1.694	0.92
T_PL0_2	1.709	1.715	1.55
T_SL0_2	1.705	1.711	1.53
L0_ESIF_TEMP2	1.690	1.693	0.88
L0_PSIF_TEMP2	1.690	1.694	0.86
L0_DSIF_TEMP2	1.691	1.695	0.88
L1_SIF_TEMP2	4.229	4.229	0.01

15.10	Reboot SCU and DRCU	

Date	**19-September-2005**

Time	**Activity**	**Signature**
11.08	**Start of Test Period for PFM2 TBT Procedure Step 6.5 – “Cooler Pump Characterisation”**	
	Instrument is OFF - detectors and mechanisms OFF	
	CBB is OFF with flip mirror viewing internally	
	Cooler OFF with pump heat switch (HS) ON at the start of the test: 550.22mV [command 0x0DEB] ~ 0.753mW TPump = 1.7307K / -3632 TPump HS = 19.66K / -22183 Pump Strap Adapt = 1.726K Pump Strap Adapt2 = 1.707K Tevap = 1.799K	ASG
11.13	Reduce pump HS power dissipation to ~0.4mW [command 0x09EC] Voltage drops from 551.22 mV to 392.9490 mV (SCOS readings) Note: TFCS crashed at the time. Rebooted and worked alright afterwards…	ASG
12.18	Increase the pump HS power dissipation A00 as pump HS < 15K and pump temperature starts warming up. Voltage increases from 392.9490 mV to 396.2mV (SCOS readings) ~0.406mW	ASG
12.49	Temperature stable, log the required data as per test specification: This completes the 0mW pump test case.	ASG

ID	**Name**	**K**	**Count**
T_CPHP_1	Cooler Pump	1.724	-3618
T_CSHT_1	Cooler Shunt	1.709	-5015
T_CEV_1	Cooler Evap	1.801	32407
T_CPHS_1	Cooler Pump Heat Switch (sieve)	14.86	-18773
T_CEHS_1	Cooler Evap Heat Switch (sieve)	2.859	-5886
T_PL0_1	Photometer Level 0 Enclosure	1.72	-4572

Checked By:

Date	**19-September-2005**

<table>
<tr><th>Time</th><th>Activity</th><th>Signature</th></tr>
<tr><td></td><td>
<table>
<tr><td>T_SL0_1</td><td>Spectrometer Level 0 Enclosure</td><td>1.709</td><td>-5014</td></tr>
<tr><td>T_SOB_L1STR</td><td>SOB L1 Strap Interface (outside)</td><td>4.27</td><td>4374.36</td></tr>
<tr><td>T_L0_DSTR</td><td>Detector Box Level-0 Strap Adaptor</td><td>1.709</td><td>1358.77</td></tr>
<tr><td>T_L0_PSTR</td><td>Pump L0 strap on Adaptor</td><td>1.719</td><td>690.02</td></tr>
<tr><td>T_L0_ESTR</td><td>Evaporator L0 strap on Adaptor</td><td>1.703</td><td>773.73</td></tr>
<tr><td>L1_SIF_TEMP2</td><td>FPU L1 Adaptor</td><td>4.24</td><td>994</td></tr>
<tr><td>L0_DSIF_TEMP2</td><td>Detector L0 Strap on Adaptor 2</td><td>1.7035</td><td>1278.14</td></tr>
<tr><td>L0_PSIF_TEMP2</td><td>Pump L0 strap on Adaptor 2</td><td>1.705</td><td>2222.21</td></tr>
<tr><td>L0_ESIF_TEMP2</td><td>Evaporator L0 strap on Adaptor 2</td><td>1.702</td><td>3332.02</td></tr>
<tr><td>T_PL0_2</td><td>Photometer Level 0 Enclosure</td><td>1.723</td><td>1954.8</td></tr>
<tr><td>T_SL0_2</td><td>Spectrometer Level 0 Enclosure</td><td>1.7195</td><td>1684.4</td></tr>
</table>
</td><td></td></tr>
<tr><td>13.09</td><td>Send command to pump heater [0x0124] for 5mW power dissipation case.
Pump Heater voltage: 1.428V</td><td>ASG</td></tr>
<tr><td></td><td>The pump temperature would not stabilise for this case indicating that the switch wasn’t open enough for such dissipation.</td><td>ASG</td></tr>
<tr><td></td><td>Sent command back to pump HS [0x0DEB] ~0.7mW</td><td>ASG</td></tr>
<tr><td>14.00</td><td>Temperature stable, log the required data as per test specification:
This completes the 5mW pump test case.
Note that this case cannot be compared directly with the 0mW case as the power on the pump HS had changed.</td><td>ASG</td></tr>
<tr><td></td><td>
<table>
<tr><th>ID</th><th>Name</th><th>K</th><th>Count</th></tr>
<tr><td>T_CPHP_1</td><td>Cooler Pump</td><td>2.308</td><td>-4735</td></tr>
<tr><td>T_CSHT_1</td><td>Cooler Shunt</td><td>1.711</td><td>-4835</td></tr>
<tr><td>T_CEV_1</td><td>Cooler Evap</td><td>1.8</td><td>32407</td></tr>
<tr><td>T_CPHS_1</td><td>Cooler Pump Heat Switch (sieve)</td><td>19.66</td><td>-2218.2</td></tr>
</table>
</td><td></td></tr>
</table>

Main Activity	**PFM2 Thermal Balance Testing**	**Location**	**RAL SSTD G56 Clean Room**

Date	**19-September-2005**

<table>
<tr><th>Time</th><th>Activity</th><th>Signature</th></tr>
<tr><td></td><td>
<table>
<tr><td>T_CEHS_1</td><td>Cooler Evap Heat Switch (sieve)</td><td>2.91</td><td>-5979</td></tr>
<tr><td>T_PL0_1</td><td>Photometer Level 0 Enclosure</td><td>1.72</td><td>-4575</td></tr>
<tr><td>T_SL0_1</td><td>Spectrometer Level 0 Enclosure</td><td>1.709</td><td>-5015</td></tr>
<tr><td>T_SOB_L1STR</td><td>SOB L1 Strap Interface (outside)</td><td>4.27</td><td>4374.02</td></tr>
<tr><td>T_L0_DSTR</td><td>Detector Box Level-0 Strap Adaptor</td><td>1.709</td><td>1358.29</td></tr>
<tr><td>T_L0_PSTR</td><td>Pump L0 strap on Adaptor</td><td>1.887</td><td>643.8</td></tr>
<tr><td>T_L0_ESTR</td><td>Evaporator L0 strap on Adaptor</td><td>1.704</td><td>773.34</td></tr>
<tr><td>L1_SIF_TEMP2</td><td>FPU L1 Adaptor</td><td>4.24</td><td>994.03</td></tr>
<tr><td>L0_DSIF_TEMP2</td><td>Detector L0 Strap on Adaptor 2</td><td>1.704</td><td>1277.4</td></tr>
<tr><td>L0_PSIF_TEMP2</td><td>Pump L0 strap on Adaptor 2</td><td>1.753</td><td>2139.7</td></tr>
<tr><td>L0_ESIF_TEMP2</td><td>Evaporator L0 strap on Adaptor 2</td><td>1.703</td><td>3331.01</td></tr>
</table>
</td><td></td></tr>
<tr><td>14:39</td><td>Increased current in the pump for an intermediate case at 7.5mW but moved onto 10mW case as not much time.
(0xA0C70165)
Pump Heater voltage: 1.7466V</td><td>ASG</td></tr>
<tr><td>14:44</td><td>Increased current in the pump for the 10mW test case.
(0xA0C7019C)
Pump Heater voltage: 2.016V</td><td>ASG</td></tr>
<tr><td>15.23</td><td>Temperature stable, log the required data as per test specification:
This completes the 10mW pump test case.

Post-Processing of the data showed that the pump temperature was not stable – mistake during stability criteria check!!!
=> ~20mK/hr rate of change versus 9mK/hr.</td><td>ASG</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Main Activity	**PFM2 Thermal Balance Testing**	**Location**	**RAL SSTD G56 Clean Room**

Date	**19-September-2005**

Time	**Activity**	**Signature**

ID	**Name**	**K**	**Count**
T_CPHP_1	Cooler Pump	2.786	-5536
T_CSHT_1	Cooler Shunt	1.713	-4843
T_CEV_1	Cooler Evap	1.816	32406
T_CPHS_1	Cooler Pump Heat Switch (sieve)	19.685	-22196
T_CEHS_1	Cooler Evap Heat Switch (sieve)	2.934	-6022
T_PL0_1	Photometer Level 0 Enclosure	1.722	-4577
T_SL0_1	Spectrometer Level 0 Enclosure	1.711	-5022
T_SOB_L1STR	SOB L1 Strap Interface (outside)	4.27	4374.12
T_L0_DSTR	Detector Box Level-0 Strap Adaptor	1.71	1357.53
T_L0_PSTR	Pump L0 strap on Adaptor	2.035	609.73
T_L0_ESTR	Evaporator L0 strap on Adaptor	1.705	772.96
L1_SIF_TEMP2	FPU L1 Adaptor	4.24	994.11
L0_DSIF_TEMP2	Detector L0 Strap on Adaptor 2	1.705	1276.69
L0_PSIF_TEMP2	Pump L0 strap on Adaptor 2	1.795	2068.66
L0_ESIF_TEMP2	Evaporator L0 strap on Adaptor 2	1.704	3326.72

Time	**Activity**	**Signature**
	No time left for the others cases (15mW and 20mW) but a three-point measurement is acceptable.	ASG
15:45	Switched off the Pump Heater. End of Pump Characterisation Test (0xA0C70000). **A 0mW case with the pump HS power dissipation similar to the 5mW case has been carried out after the 10mW case and just before the cooler recycling started at 16.35. See temperatures below…**	ASG
16.32	0mW case with Pump HS power dissipation set to ~0.7mW [0x0DEB] V ~ 551.22mV	ASG

Checked By:

Main Activity	**PFM2 Thermal Balance Testing**	**Location**	**RAL SSTD G56 Clean Room**

Date	**19-September-2005**

Time	**Activity**	**Signature**
	See table overleaf…	

ID	**Name**	**K**
T_CPHP_1	Cooler Pump	1.7309
T_CSHT_1	Cooler Shunt	1.7095
T_CEV_1	Cooler Evap	1.792
T_CPHS_1	Cooler Pump Heat Switch (sieve)	19.67
T_CEHS_1	Cooler Evap Heat Switch (sieve)	2.887
T_PL0_1	Photometer Level 0 Enclosure	1.72
T_SL0_1	Spectrometer Level 0 Enclosure	1.7087
T_SOB_L1STR	SOB L1 Strap Interface (outside)	4.271
T_L0_DSTR	Detector Box Level-0 Strap Adaptor	1.7085
T_L0_PSTR	Pump L0 strap on Adaptor	1.7272
T_L0_ESTR	Evaporator L0 strap on Adaptor	1.7026
L1_SIF_TEMP2	FPU L1 Adaptor	4.242
L0_DSIF_TEMP2	Detector L0 Strap on Adaptor 2	1.7035
L0_PSIF_TEMP2	Pump L0 strap on Adaptor 2	1.7071
L0_ESIF_TEMP2	Evaporator L0 strap on Adaptor 2	1.7019

16.35	End of Pump Characterisation Test.	

Checked By:

Main Activity	**PFM2 Thermal Balance Testing**	**Location**	**RAL SSTD G56 Clean Room**

Date	**23-September-2005**

Time	**Activity**	**Signature**
09.00 (UTC)	**Start of Test Period for PFM2 TBT Procedure Step 6.4 – "L1 Strap Characterisation"**	**ASG**
	Cryostat Thermal Environment as requested	
	CBB closed (viewing inside @ ~6K)	
	Cooler ON	
	Instrument in standby spectrometer mode (phot requested but could not be implemented to avoid switching the JFETs ON and OFF too often). This should not compromise the test results.	ASG
09.04	Set the FPU heater ON: V = 417.569mV I = 12mA P = 5.011mW => 34.79 ohms	
	Following initial FPU temperature change (giving a first insight about the L1 MGSE strap performances), decided to increase the heater power dissipation to 10mW as to obtain a larger delta T along the L1 strap.	ASG
09.18	Set the FPU heater ON: V = 591.786mV I = 17mA P = 10.06mW => 34.81 ohms	
	Note: 0.02 ohms heater resistance increase for 0.04K increase in FPU temperature	ASG
13.27	Temperature stables for the 10 mW test case. Log the temperatures as per test specification.	ASG

ID	Name	K	Ohms/Count
T_SOB_L1STR	SOB L1 Strap Interface *(outside)*	4.3	4348.76
L1_SIF_TEMP2	FPU L1 Adaptor	4.24	994.41
	Delta T	0.060	-
T_FPU_PXAF	FPU +X A-Frame Interface *(outside)*	4.4	494.6
T_FPU_MXAF	FPU –X A-Frame Interface *(outside)*	4.41	427.6

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Time	**Activity**	**Signature**

T_SOB_CONE	SOB Cone Interface (outside)	4.46	3928.3
T_SOB_L1CON	L1 photo connector bracket *(outside)*	4.35	4138.9
EMCFIL_1	HSFPU Harness Filter Bracket (TSOB)	4.39	-2825
T_PL0_2	Photometer Level 0 Enclosure	1.72	1954.8
T_SL0_2	Spectrometer Level 0 Enclosure	1.72	16.84.4
	Harness Sink WE-Ph JFET(L2 Shield Side)	18.31	-
	FSJFP-HOB I/F (HOB side)	14.69	-
	FPU Cone Foot I/F (HOB side)	15.15	-
	FPU +Y Foot I/F (HOB side)	15.36	-
	FSJFS-HOB I/F (HOB side)	14.76	-
	Detector L0 Strap on Adaptor 2 *(outside)*	1.7	1277.89
T_PJFS_CHAS	Phot JFET Chassis	14.75	2108
T_SJFS_CHAS	Spec JFET Chassis	15.3	2096.8

13.36	Switch FPU Heater OFF for 0mW test case.	ASG
15.04	Temperature stables for the 0 mW test case. Log the temperatures as per test specification.	ASG

ID	**Name**	**K**	**Ohms**
T_SOB_L1STR	SOB L1 Strap Interface *(outside)*	4.26	4384.88
L1_SIF_TEMP2	FPU L1 Adaptor	4.23	997.12
	Delta T	0.030	-
T_FPU_PXAF	FPU +X A-Frame Interface *(outside)*	4.32	500
T_FPU_MXAF	FPU –X A-Frame Interface *(outside)*	4.34	432
T_SOB_CONE	SOB Cone Interface (outside)	4.35	4000.4
T_SOB_L1CON	L1 photo connector bracket *(outside)*	4.28	4192.7
EMCFIL_1	HSFPU Harness Filter Bracket (TSOB)	4.29	-2783

Date	**23-September-2005**

Time	**Activity**	**Signature**

T_PL0_2	Photometer Level 0 Enclosure	1.72	1954.8
T_SL0_2	Spectrometer Level 0 Enclosure	1.72	1684.4
	Harness Sink WE-Ph JFET(L2 Shield Side)	18.43	-
	FSJFP-HOB I/F (HOB side)	14.88	-
	FPU Cone Foot I/F (HOB side)	15.33	-
	FPU +Y Foot I/F (HOB side)	15.54	-
	FSJFS-HOB I/F (HOB side)	14.94	-
	Detector L0 Strap on Adaptor 2 *(outside)*	1.7	1277.76
T_PJFS_CHAS	Phot JFET Chassis	14.92	2099.2
T_SJFS_CHAS	Spec JFET Chassis	15.47	2088.2

15.12	FPU power supply changed as cannot draw enough current to dissipate the 30mW test case. The new power supply doesn't allow a 4-wire measure of the heater voltage. As the heater resistance has been previously measured in a 4-wire manner, this approach was found acceptable even if not ideal.	ASG
	Set voltage to 983.1 mV Assuming a 34.81 ohms heater resistance, the heater power dissipation is ~27.76mW.	ASG
15.53	Temperature stables for the 30 mW test case. Log the temperatures as per test specification.	ASG

ID	**Name**	**K**	**Ohms**
T_SOB_L1STR	SOB L1 Strap Interface *(outside)*	4.38	4285.98
L1_SIF_TEMP2	FPU L1 Adaptor	4.26	989.41
	Delta T	0.120	-
T_FPU_PXAF	FPU +X A-Frame Interface *(outside)*	4.54	485.5
T_FPU_MXAF	FPU –X A-Frame Interface *(outside)*	4.55	420.1

Main Activity	**PFM2 Thermal Balance Testing**	**Location**	**RAL SSTD G56 Clean Room**

Date	**23-September-2005**

Time	**Activity**	**Signature**

T_SOB_L1CON	L1 photo connector bracket *(outside)*	4.49	4047.4
EMCFIL_1	HSFPU Harness Filter Bracket (TSOB)	4.56	-2897
T_PL0_2	Photometer Level 0 Enclosure	1.72	1954.8
T_SL0_2	Spectrometer Level 0 Enclosure	1.72	1684.4
	Harness Sink WE-Ph JFET(L2 Shield Side)	18.47	-
	FSJFP-HOB I/F (HOB side)	14.87	-
	FPU Cone Foot I/F (HOB side)	15.31	-
	FPU +Y Foot I/F (HOB side)	15.53	-
	FSJFS-HOB I/F (HOB side)	14.93	-
	Detector L0 Strap on Adaptor 2 *(outside)*	1.7	1277.33
T_PJFS_CHAS	Phot JFET Chassis	14.94	2098.4
T_SJFS_CHAS	Spec JFET Chassis	15.48	2088.2

16.00	End of test	

Date	**26-September-2005**

Time	**Activity**	**Signature**
14.05	**Start of Test Period for PFM2 TBT Procedure Step 6.8 – "Pump Heat Switch Characterisation"**	**ASG**
	Instrument temperatures stable.	ASG
	L2 cryostat temperatures not quite stable but would not affect the cooler performance so acceptable for this test	ASG
14.07	Wrong command sent to cooler, need to wait for instrument temperatures to stabilise again.	
15.49	Instrument temperatures stable again so log temperature reference as per test specification: Command: DEB Pump HS Voltage = 551.3mV Pump HS Current = 1.40016mA Pump HS Resistance = 393.74 ohms	ASG

ID	**Name**	**K**	**Count**
T_CPHP_1	Cooler Pump	1.908	-3989
T_CSHT_1	Cooler Shunt	1.727	-4888
T_CEV_1	Cooler Evap	0.2888	5517
T_CPHS_1	Cooler Pump Heat Switch (sieve)	19.67	-22190
T_CEHS_1	Cooler Evap Heat Switch (sieve)	2.886	-5934
T_PL0_1	Photometer Level 0 Enclosure	1.736	-4624
T_SL0_1	Spectrometer Level 0 Enclosure	1.725	-5070
T_SOB_L1STR	SOB L1 Strap Interface (outside)	4.26	-
T_L0_PSTR	Pump L0 strap on Adaptor	1.79	670.4
T_L0_ESTR	Evaporator L0 strap on Adaptor	1.72	767.33
L1_SIF_TEMP2	FPU L1 Adaptor	4.23	-
L0_PSIF_TEMP2	Pump L0 strap on Adaptor 2	1.74	2168.21
L0_ESIF_TEMP2	Evaporator L0 strap on Adaptor 2	1.72	3278.54

16.00	Reduce the power on the pump heat switch	ASG

Main Activity	**PFM2 Thermal Balance Testing**	**Location**	**RAL SSTD G56 Clean Room**

Date	**26-September-2005**

Time	**Activity**	**Signature**
16.44	Instrument temperatures stable again so log temperature reference as per test specification: Command: A2A Pump HS Voltage = 402.5mV Pump HS Current = 1.022143mA Pump HS Resistance = 393.78 ohms	ASG

ID	**Name**	**K**	**Count**
T_CPHP_1	Cooler Pump	1.991	-4155
T_CSHT_1	Cooler Shunt	1.724	-4881
T_CEV_1	Cooler Evap	0.2888	5533
T_CPHS_1	Cooler Pump Heat Switch (sieve)	15.14	-18981
T_CEHS_1	Cooler Evap Heat Switch (sieve)	2.863	-5893
T_PL0_1	Photometer Level 0 Enclosure	1.734	-4615
T_SL0_1	Spectrometer Level 0 Enclosure	1.723	-5063
T_SOB_L1STR	SOB L1 Strap Interface (outside)	4.26	-
T_L0_PSTR	Pump L0 strap on Adaptor	1.77	673.39
T_L0_ESTR	Evaporator L0 strap on Adaptor	1.72	768.37
L1_SIF_TEMP2	FPU L1 Adaptor	4.23	-
L0_PSIF_TEMP2	Pump L0 strap on Adaptor 2	1.73	2176.18
L0_ESIF_TEMP2	Evaporator L0 strap on Adaptor 2	1.72	3286.66

Time	**Activity**	**Signature**
	Note: While a 83mK increase in pump temperature has been observed, the evaporator temperature remained unchanged. Pump HS temperature decreased from 19.67K to 15.14K.	ASG
16.44	End of Pump HS characterisation test. Pump heat switch power dissipation left as is as doesn't affect the cooler performance.	ASG

Checked By: