SPIRE CQM

THERMAL BALANCE TEST SPECIFICATION AND PROCEDURE

THERMAL ENGINEERING SECTION				
PREPARED BY:	A.S. GOIZEL	(RAL)	03-09-04	
CHECKED BY:	B. SHAUGHNESSY	(RAL)	03-09-04	

“Page intentionally left blank”

DISTRIBUTION LIST

Institute	Holder	Issue/ Revision and Distribution Date							
		D1 02/12/0	D2 19/12/03	D3 29/01/0	D4 18/08/04	D4.5 03/09/04			
RAL	Delderfield J.	x	x	x	x				
	Swinyard B.	x	x	x	x				
	Griffin D.	x	x	x	x				
	Sawyer E.	x	x	x	x				
	King K.	x	x	x	x				
	Smith D.	x	x	x	x				
	Lim T.	x	x	x	x				
	Shaughnessy B.	x	x	x	x				

CHANGE RECORD

Issue	Date	Section	Change
D1	02/12/03	-	New Document
D2	19/12/03	Acronym	List updated
		4.1	CQM Built Standard updated
		4.3	Section 4.3 moved as section 4.2
		5.1	Flight Thermometers Prime list updated
		5.2	Additional CQM sensors list updated
		5.3	Diagram showing the position of temperature sensor inside the calibration cryostat added.
		6.1	More detailed explanations about Interface Temperature given
		6.1.3	Definition of temperature sensors applicable for steady-state conditions added
D3	29/01/04	Appendix A	Detailed procedures to follow during cold thermal tests added
		Figure 3	Harness Clamping changed slightly to reflect current design
		Table 11	Internal Pump dissipation removed as nothing to do with mechanism power dissipations.
D4	09/08/04	Acronym	List updated
		4.1	Built Standard updated to CQM2 to reflect the refurbishment of the CQM1
		4.2	Section updated to reflect change in SPIRE built standard.
		4.3 / 4.4	Section spit in two for clarity
		5	All changed
		5.1	Sensor List updated to reflect changes in some sensors location and accuracy
		5.2	Sensor List updated to reflect changes in some sensors location and accuracy
		5.3	Sensor List updated to reflect changes in some sensors location and accuracy
		5.4	New section about heaters
		6	New section about test program

CONTENTS

LIST OF TABLES

1. INTRODUCTION

1.1. Scope

This document defines the test program and requirements applicable for the second Thermal Balance Test (TBT) campaign of the SPIRE Cryogenic Qualification Model (CQM). The instrument model used for this test will be denominated as CQM2 herein to differentiate it from the first CQM test campaign (and reflect the “refurbishment” that took place on the instrument in between).

1.2. Acronyms

AM	Alignment Model
BSM	Beam Steering Mechanism
CQM	Cryogenic Qualification Model
FM	Flight Model
FPU	Focal Plane Unit
FS	Flight Spare
HOB	Herschel Optical Bench
IF	Interface
JFET	Junction Field Effect Transistor
L0	Level 0
L1	Level 1
L2	Level 2
L3	Level 3
LN2	Liquid Nitrogen
SM	Structural Model
SMEC	Spectrometer Mechanism
SOB	SPIRE Optical Bench
SPIRE	Spectral and Photometric Imaging Receiver
STM	Structural Thermal Model
TBT	Thermal Balance Test
TMM	Thermal Mathematical Model
TV	Thermal Verification

Table 1-1– Acronym List

2. APPLICABLE DOCUMENTS

ID	Title	Number
AD1	SPIRE Instrument CQM Test Requirements	SPIRE-RAL-DOC-000389, Issue 1 Swinyard B. 30/03/01
AD2	SPIRE AIV PLAN	SPIRE-RAL-DOC-000410 Draft 3 25/05/03
AD3	Thermal Balance Test Specification D4 [STM]	27/01/02
AD4	SPIRE Thermal Stability Requirements	22/01/02 email M.Griffin.
AD5	Thermal Balance Test Geometrical Models SPIRE18.erg CALIBCRYO5_g.erg TBT_g.erg TBT_e.ere	H:\In Tray\Model Log Files\spire\Report\STM-CQM Plan_Procedures\CQM GMM Logfile\SPIRE CQM New Baseline\TBT5
AD6	Thermal Balance Test Thermal Models Spir25ntdm_cqm.d Calib_cryo.d Spire_TBT.d	M:\Thermal_Projects\Esatan_Models\SPIRCQM1 M:\Thermal_Projects\Esatan_Models\SPIRCQM2
AD7	SPIRE/HERSCHEL Thermal Models Spir25ntdm.d Eplmntdm3.d Herschel4.d	M:\Thermal_Projects\Esatan_Models\SPIRFM
AD8	SPIRE CQM1 Thermal Test Balance Report	SPIRE-RAL-REP-002078 Draft A 15/07/04
AD9	SPIRE Thermal Design Requirements	SPIRE-RAL-PJR-002075 Draft B 13/07/04
AD10	CQM Thermometers 1.5.xls	D. Smith Email 06/08/04
AD11	CQM1 Test Logfile	03/02/04 Page 14
AD12	Cooler ICD	HSO-SBT-ICD-012 Issue 1.4 11 June 03
AD13	Procedure to perform 4-wire measurement on heaters	Heaters.doc Draft 0.2 10/09/04

Table 2-1- Applicable Documents

3. TEST OBJECTIVES

The objectives of the SPIRE Cryogenic Qualification Model (CQM) Thermal Balance Test (TBT) are as follows:

- To validate the instrument thermal control concept as far as possible, given hardware limitations (accuracy of the representation of the calibration cryostat with respect to the Herschel cryostat, difference between the SPIRE CQM and Flight Model (FM) hardware, dummy mechanisms and detectors, etc).
- To provide data for correlation of the SPIRE thermal mathematical model (TMM) and hence provide more accurate predictions of the instrument in-flight thermal performances.

To achieve those objectives, the following test set-up is necessary:

- The thermal environment in the SPIRE instrument test cryostat should be as close to the Herschel cryostat as possible.
- The steady-state test phases have been selected in order to examine the instrument performances its various in-flight operating modes (photometer, spectrometer and off modes).

4. TEST CONFIGURATION

4.1. SPIRE CQM2 Standard Built Overview

A detailed built standard of the SPIRE CQM2 instrument is described in [AD2] and more information about the SPIRE model philosophy can be found in [AD1].

The CQM2 Focal Plane Unit (FPU) will have, in addition to the optics and structure from the Structural Model (SM) / Alignment Model (AM) programme:

- The structural models of the Beam Steering Mechanism (BSM) and the Spectrometer mechanism (SMEC) – those mechanisms will not function but include heaters which will be used to simulate their internal power dissipation during operation,
- Working Spectrometer calibration sources,
- A single working photometer Bolometer Detector Array (BDA), the Long Wavelength Photometer or PLW,
- Four Structural Thermal Model (STM) BDAs will be used for the Medium and Short Wavelength Photometer arrays (PMW, PSW) and for the Long and Short Wavelength Spectrometer arrays, (SSW, SLW). Those STM BDAs should simulate the parasitic load that would normally be observed on the cooler cold tip during operation,
- All five BDAs will be connected to a working 300-mK cooler to allow photometer performance and thermal verification testing to be carried out,
- The photometer JFET will consist of one active module to run the P/LW plus STM modules to represent the thermal performance of the other modules,
- The spectrometer JFET only consists of STM modules to represent the thermal performances of the other modules.

This configuration will allow the Thermal Verification (TV) of the instrument and some performance testing on the photometer. No testing will be possible on the spectrometer [AD2].

For information, a detailed description of the SPIRE CQM2 Built standard is given in Table 4-1.

Unit / Component	**CQM**
HSFPU	**Required**
Structure/baffles/standoffs etc	As used on SM
L0 straps	Straps used on CQM1 and dedicated to the CQM test campaign
Mirrors	As used on AM (CQM standard)
Filters	CFIL-1 – CQM PFIL-2 – CQM PFIL-3 – CQM PDIC-1 – AM PDIC-2 – AM All filters are fitted including Spectrometer
Beam steering mirror	STM
3He Cooler	CQM
300 mK thermal straps and supports	CQM
300 mK Thermal control system	Not Fitted
Photometer LW array	CQM
Photometer MW array	Unsuspended STM
Photometer SW array	Unsuspended STM
SMEC	STM
Spectrometer SW array	Unsuspended STM
Spectrometer LW array	Unsuspended STM
Photometer Calibrator	CQM
Spectrometer Calibrator	CQM
FPU RF Filters	CQM
Thermometry	CQM
FPU internal harnesses	CQM/FS
HSJFP	**Required**
JFET Structure	CQM/FS
JFET Modules	2 CQM 5 STM
JFET box RF filter modules	CQM/FS
JFET Backharness	CQM/FS
JFET/FPU Harness	CQM all fitted
HSJFS	**Required**
JFET Structure	CQM/FS
JFET Modules	STM
	no longer fitted
JFET Backharness	CQM
JFET/FPU Harness	CQM

Table 4-1 - SPIRE CQM Built Standard [AD2]

4.2. Variations between the SPIRE CQM1, CQM2 and FM

Recent changes in the SPIRE instrument thermal design and Herschel cryostat design introduced slight variations between the two SPIRE CQMs and the FM built standards. Table 4-2 provides a short description of the various changes in hardware.

Item	CQM1	CQM2	FM
FPU standoffs	Stainless Steel		CFRP 4 times more isolating
L0 Enclosures standoffs	Stainless Steel		CFRP 4 times more isolating
L1 strap	The electrical isolation was incorporated into the L1 strap	The electrical isolation is now implemented on the SOB directly as a glued joint.	
L0 straps	Dedicated CQM straps using a mix of annealed 99.99% and 99.999%5 Ns copper.		Annealed 99.999% strap and increased overall thermal conductance.
L0 2K Interbox Strap	4Ns annealed copper	5Ns annealed copper + new larger glued interface	5Ns annealed copper + new larger glued interface
Cooler Strap to Busbar	Cooler strap to 300-mK Busbar is made of 4Ns annealed copper. Electrical isolation implemented on the photometer side of the cooler interface.		Cooler strap to 300-mK Busbar will be made of 5Ns annealed copper. Electrical isolation will be implemented on the spectrometer side only of the cooler interface.
300-mK Busbar	4Ns un-annealed	5Ns annealed	5Ns annealed

Table 4-2 – Variation between the SPIRE CQM and FM Built Standard

4.3. SPIRE Test Cryostat Overview

During the thermal balance test, the SPIRE CQM is mounted within the Test Cryostat, which 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 SPIRE Calibration cryostat with the exception of the Level 3 (at 12-15K), which is a recent change in the flight cryostat design. The calibration cryostat consists of the following temperatures' stages:

Cryostat Stage	***Temperature***	***Acronym***
Vacuum vessel	300K	N/A
Liquid Nitrogen 2 Shield	78K	LN2 Shield
Helium Vapour Cooled Shield	9K - 15K	Level-2 Shield
HOB Simulator Plate cooled via the Level 2 Shield	9K - 15K	HOB Sim
Helium I Tank	4.2K - 6K	Level 1
Helium II Tank	1.4K - 1.7K	Level 0
Cold Black Body Source	4K - 40K	N/A
Windows and/or filters at the optical interface of the LN2 and Level-2 temperature stages.		

Table 4-3 – SPIRE Calibration Cryostat Temperature Stages

The main differences in interfaces between the calibration and the flight cryostat are given in table 4-4.

Item	**Calibration Cryostat**	**Herschel Flight Cryostat**
Herschel Level-3 Interfaces	Not available. JFETs have been connected to the Level-2 Shield for heat sinking during the CQM test campaign	A single attachment point is available for each JFET on the Herschel Level-3 ventline.
Herschel Level-1 Interface	One clamped interface for a single point of attachment only. Liquid Helium Tank	Double bolted attachment point is available on the Herschel Level 1 ventline. Ventline
Herschel Level-0 Interfaces	Three clamped interfaces which attach directly on the strap main body.	Three dedicated bolted interfaces on aluminium pods.
Cryo-Harness	Slight difference in harness design and harness heat sinking.	

Table 4-4 - Variation between the SPIRE Calibration cryostat and the Herschel cryostat

4.4. SPIRE Instrument Setup in the Calibration Cryostat

The SPIRE CQM2 will interface with the calibration cryostat as follows:

- SPIRE FPU mounted off the Herschel Optical Bench (HOB) Simulator on three isolation supports,
- 1 thermal strap connects the SPIRE Optical Bench (SOB) to calibration cryostat Level 1,
- 3 thermal straps connect the SPIRE Cooler and Spectrometer enclosure to the Level 0,
- Harnessing from external warm electronics to SPIRE FPU and JFET units (these harnesses will be thermally coupled to the 78K, the level 2 and the HOB stages prior to connection with the instrument),
- 2 additional thermal straps were used to connect the SPIRE JFET Units to Cryostat Level 2 Shield as to account for the missing Level 3 stage. However, for the second CQM thermal balance test campaign, it would be preferable to leave the photometer JFET decoupled for the level-2 shield to help with the future correlation of the thermal model. In this new configuration, only the spectrometer JFET will be thermally coupled to the Level-2 shield with a strap.

The pictures on next page describe the SPIRE instrument inside the calibration cryostat including the various temperature stages of the cryostat.

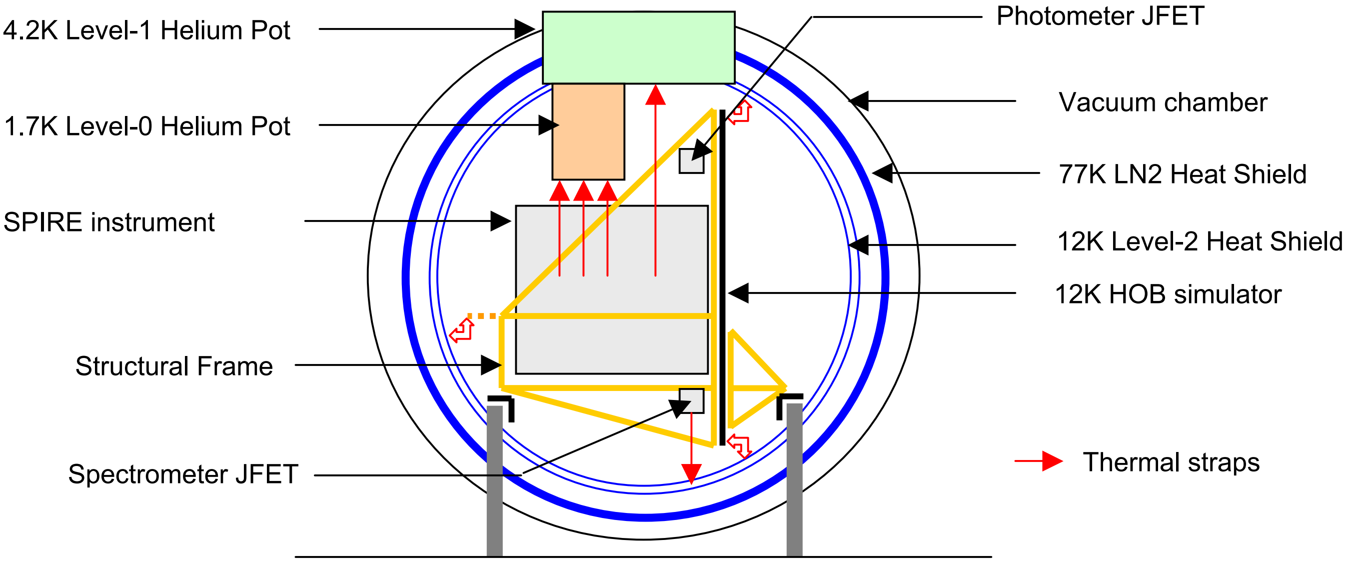


Figure 4-1 – SPIRE CQM2 Instrument inside the Calibration cryostat

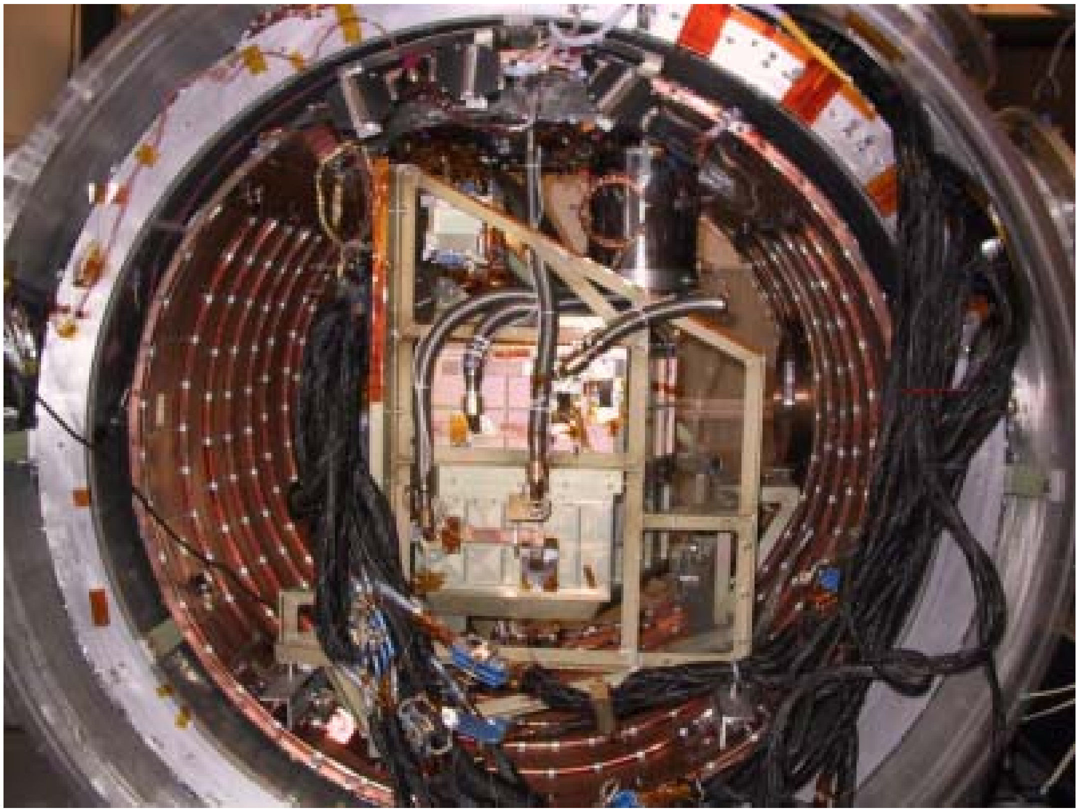


Figure 4-2 – SPIRE CQM2 Instrument inside the Calibration cryostat

5. TEST SUPPORT EQUIPMENT AND DADA LOGGING SECTION

5.1. In-Flight Temperature Sensors

A total of 37 prime and redundant temperature sensors are present on the FM, as defined in the IID-B. Of these only the prime circuits will be required for CQM testing which represents a total of 17 sensors.

Those flight sensors will be monitored using the instrument onboard software, which uses a constant DC voltage excitation signal of 10mV. All sensors data (as well as any instrument housekeeping data) will be logged by the software every 10 sec at a minimum and can be retrieved at any stage afterwards.

Level 1

Acronym	Location	TMM Node	Type	Serial No.	Range (K)	Resolution (mK)	Accuracy (mK)	Provider
T_SOB_1	HSFPU Harness Filter Bracket	1900	CX-1030	X24423	3>100K	25mK	50mK	RAL
T_SUB_1	M3,5,7 Optical Sub Bench	2000	CX-1030	X24416	3>100K	25mK	50mK	RAL
T_BAF_1	Input Baffle	2150-2180	CX-1030	X24421	3>100K	10mK	10mK	RAL
T_BSMS_1	BSM/SOB I/F (SOB side)	1010	CX-1030	X24461	3>100K	10mK	10mK	RAL
T_SCST_1	SCAL Structure	3250	CX-1030	X28261	10>100K	10mK	10mK	Cardiff
T_SCL4_1	SCAL 4%	3260-3290	CX-1030	X14039	10>80K	5mK	5mK	Cardiff
T_SCL2_1	SCAL 2%	3260-3290	CX-1030	X14025	10>80K	5mK	5mK	Cardiff
T_BSMM_1	BSM	2100	CX-1030	X24393	3-20K	10mK	10mK	ATC
T_FTSM_1	SMEC	3200	TVO	TVO-0016	3-20K	10mK	10mK	RAL
T_FTSS_1	SMEC/SOB I/F	1120-1210	TVO	TVO-0017	3-100K	25mK	50mK	RAL

Level 0

Acronym	Location	TMM Nodes	Type	Serial No.	Range (K)	Resolution (mK)	Accuracy (mK)	Provider
T_CPHP_1	Cooler Pump	4200	CX-1030	X14909	3>100K	25mK	25mK	CEA
T_CSHT_1	Cooler Shunt	4250	CX-1030	X25347	0.2>5K	1mK	1mK	CEA
T_CEV_1	Cooler Evap	4300	CX-1030	X16965	0.2>5K	1mK	1mK	CEA
T_CPHS_1	Cooler Pump Heat Switch (sieve)	N/a	CX-1030	X15986	1>50K	5mK	5mK	CEA
T_CEHS_1	Cooler Evap Heat Switch (sieve)	N/a	CX-1030	X15984	1>50K	5mK	5mK	CEA
T_PL0_1	Photometer Level 0 Enclosure At the PLW BDA IF	2420	CX-1030	X24455	1-10K	2mK	2mK	RAL
T_SL0_1	Spectrometer Level 0 Enclosure near interface with A frame (tapped hole already available)	3400-3410	CX-1030	X24454	1-10K	2mK	2mK	RAL

Table 5-1- In-Flight Temperature Sensors used for SPIRE CQM2 [AD10]

5.2. Additional CQM Temperature Sensors

A total of 11 additional sensors are required to monitor the temperature of the CQM FPU during thermal balance testing. Two sensors are required to monitor the JFET Chassis temperatures. Those additional sensors will be monitored using two Lakeshore monitoring units, the 218 and the 370 AC Bridge for sensors that require a minimum accuracy of 10mK.

Level 2-3

Acronym	Location	Harness	TMM Node	Type	Serial No.	Cal Curve	Lakeshore Unit	Lakeshore Channel
T_PJFS_CHAS	Phot JFET Chassis	**STM External**	N5020 N5030 N5040 N5050 N5060 N5070	TVO	TVO-0010	TV0_10_12-SEP-2003.340	7	1
T_SJFS_CHAS	Spec JFET Chassis	**STM External**	N5520 N5530	TVO	TVO-0011	TV0_11_12-SEP-2003.340	7	8

Level 1

Acronym	Location		TMM Node	Type	Serial No.	Cal Curve	Lakeshore Unit	Lakeshore Channel
T_FPU_PXAF	FPU +X A-Frame Interface *(outside)*	**STM External**	N1500	CX1030	X24415		**AC Bridge**	**14**
T_FPU_MXAF	FPU –X A-Frame Interface *(outside)*	**STM External**	N1600	CX1030	X24453		**AC Bridge**	**15**
T_SOB_CONE	SOB Cone Interface **(outside)**	**STM External**	N1300	TVO	TVO-0013	TV0_13_12-SEP-2003.340	7	5
T_SOB_L1STR	SOB L1 Strap Interface *(outside)*	**STM External**	N1130	TVO	TVO-0014	TV0_14_12-SEP-2003.340	**AC Bridge**	**16**
S_SOB_COOL	SOB Cooler Interface *(inside)*	**STM Internal**	N1130	TVO	TVO-15		7	4
T_SOB_L1CON	L1 photo connector bracket *(outside)*	**STM External**	N1750	TVO	TVO-0012	TV0_12_12-SEP-2003.340	7	6

Level 0

Acronym	Location		TMM Node	Type	Serial No.	Cal Curve	Lakeshore Unit	Lakeshore Channel
T_PL0_3	Photometer Level 0 Enclosure at Strap IF (near glued joint)	**STM Internal**	N2400	CX-1030	X24426		**AC Bridge**	**9**
T_SL0_3	Spectrometer Level 0 Enclosure at Strap IF (near glued joint)	**STM Internal**	N3410	CX-1030	X24420		**AC Bridge**	**10**
T_L0_DSTR	Detector Box Level-0 Strap *(outside)*	**Level-0 Strap Harness**	N6100	CX-1030	X24462		**AC Bridge**	**11**
T_L0_PSTR	Pump L0 strap on Adaptor *(outside)*	**Level-0 Strap Harness**	N6200	CX-1030	X24411		**AC Bridge**	**13**
T_L0_ESTR	Evaporator L0 strap on Adaptor *(outside)*	**Level-0 Strap Harness**	N6300	CX-1030	X24465		**AC Bridge**	**12**

Table 5-2- SPIRE Instrument Additional STM Temperature Sensors [AD10]

5.3. Cryostat Temperature Sensors

A total of 31 sensors are used for monitoring and control of the cryostat temperatures. Those additional sensors will be monitored using two Lakeshore monitoring units, the 218 and the 370 AC Bridge for sensors that require a minimum accuracy of 10mK.

Sensor No.	Type	Serial No.	Location	TMM Node	Fischer Connector	D Conn	Lakeshore Unit No.	Channel	MIB Mnemonic
S1	Silicon	D49835	End Cap 1		A	1	1	1	77KSH_END1_TEMP
S2	Silicon	D49837	End Cap 2		A	1	1	2	77KSH_END2_TEMP
S3	Silicon	D49194	Filter Mount		A	1	1	3	77KSH_FFLG_TEMP
S4	Silicon	D49176	Inlet Pipe		A	2	1	5	10KSH_IP_TEMP
S5	Silicon	D49180	Outlet Pipe		A	2	1	6	10KSH_OP_TEMP
S6	Silicon	D47689	End Cap 1		A	2	1	7	10KSH_END1_TEMP
S7	Silicon	D49838	End Cap 2		A	2	1	8	10KSH_END2_TEMP
S8	Silicon	D47583	Cylinder End		A	3	2	1	10KSH_CEND1_TEMP
S9	Silicon	D49179	Cylinder Centre		A	3	2	2	10KSH_CCENT_TEMP
S10	Silicon	D49833	Cylinder End		A	3	2	3	10KSH_CEND2_TEMP
S11	Silicon	D49190	Filter Flange		A	3	2	4	10KSH_FFLG_TEMP
S13	Silicon	D49177	Support foot 2		B	4	2	5	VAC_SOFF2_TEMP
S14	Silicon	D47708	Support foot 3		B	4	2	6	VAC_SOFF3_TEMP
S15	Silicon	D49834	Support foot 4		B	4	2	7	VAC_SOFF4_TEMP
S16	Silicon		FSJFP L3 I/F (L3 strap side)		B	4	2	8	HOB_PJ_ENC_TEMP
S17	Silicon		FSJFS L3 I/F (L3 strap side)		B	5	3	1	HOB_SJ_ENC_TEMP
S18	Silicon		FSJFP-HOB I/F (HOB side)		B	5	3	2	HOB_F1IF_TEMP
S19	Silicon		FPU Cone Foot I/F (HOB side)		B	5	3	3	HOB_F2IF_TEMP

S20	Silicon		FPU +Y Foot I/F (HOB side)		B	5	3	4	HOB_F3IF_TEMP
S12	Silicon	D47710	Support foot 1		A	6	3	5	VAC_SOFF1_TEMP
S21	Silicon		FPU -Y Foot I/F (HOB side)		B	6	3	6	HOB_HS_RFF_TEMP
S22	Silicon		**FSJFS-HOB I/F (HOB side)**		C	6	3	7	HOB_HS_PJ_TEMP
S23	Silicon		Harness Sink WE-Ph JFET(L2 Shield Side)		C	6	3	8	HOB_HS_SJ_TEMP
S24	Cernox	X24031	Vessel Top	11000	B	7	**AC Br**	**1**	4KTOP_TEMP
S25	Cernox	X24025	Vessel Bottom	11000	B	7	**AC Br**	**2**	4KBOTT_TEMP
S26	Cernox	X24053	FPU L1 Strap	11000	B	7	**AC Br**	**3**	4KL1_SIF_TEMP
S27	Cernox	X24079	1.7K Vessel Bottom	10000	C	7	**AC Br**	**4**	1.7K_BOTT_TEMP
S28	Cernox	X19416	FPU Evap Strap Interface	10000	C	8	**AC Br**	**5**	1.7K_ESIF_TEMP
S29	Cernox	X24055	FPU Pump Strap Interface	10000	C	8	**AC Br**	**6**	1.7K_PSIF_TEMP
S30	Cernox	X24029	FPU Box Strap Interface	10000	C	8	**AC Br**	**7**	1.7K_BSIF_TEMP
S31	Cernox	X24059	Vessel Top	10000	C	8	**AC Br**	**8**	1.7K_TOP_TEMP

Table 5-3- Calibration Cryostat Temperature Sensors [AD10]

5.4. Heaters

5.4.1. CQM Cooler

There are a total of three heaters mounted inside the cooler, all described as having 402 ohms resistors [AD12]. Those heaters are summarized in the table below. All three will be commanded using the on-board software.

Heater	***Resistance (ohms)***
Pump	402
Evap Heat Switch	402
Pump Heat switch	402

Table 5-4 – Cooler CQM Heaters [AD12]

The following equations shall be used to compute the command that need to be sent to control the heater currents.

Sorption Pump Heater control

Current Command = (Ia + 2.254x10-5) / 1.21532x10-5

Sorption Pump HS Heater control

Current Command = (Ia + 2.05x10-6) / 3.9353x10-7

Sorption Evaporator HS Heater control

Current Command = (Ia + 2.44x10-6) / 3.9357x10-7

Equation 1 – Cooler Commanding Equations

Note: the voltage across the heat switches and pump heater is read by the on-board software as part of the housekeeping data during testing and can therefore be used to accurately work out the resistance of those heaters for a given commanded current.

5.4.2. BSM and SMEC Mechanisms

A total of two heaters will be used to simulate the mechanisms internal dissipations. Power supplies will be used to power the heaters.

The resistance of both heaters shall be measured at room temperature and at nominal operating temperature using a four-wire measurement [AD13] and a calibrated voltmeter with a minimum accuracy of 0.01 Volts.

Heater	*Resistance (ohms)* *At Room temperature*	*Resistance (ohms)* *At operating Temperature*
BSM	To be completed after measurement	TBC
SMEC	TBC	TBC

Table 5-5 - BSM and SMEC STM Heaters

5.4.3. Photometer and Spectrometer Calibration Sources

Each CQM Photometer and Spectrometer calibration sources contain a dedicated heater that is used to warm the sources to a given temperature during the SPIRE performance testing. Both heaters current will be set with the on-board software. The voltage and current across each heater is also measured by the on-board electronic and stored in the software housekeeping data.

5.4.4. Photometer and Spectrometer JFETs

- 10 STM modules are present in the photometer JFET, each using an 8 Kohm resistance heater,
- 3 STM modules are present in the spectrometer JFET, each using an 8 Kohm resistance heater.

Both photometer and spectrometer CQM and STM JFET units will be commanded using the on-board software. The power dissipated in the photometer STM JFET modules should be calculated using the following equation [AD11]:

Total Power from PJFET STM Module [W] = (V^2 / 8000) x 10

Where V = Vdd – Vss and Vdd = 2.5V [fixed]

An 8-bits word is used to encode the Vss signal which ranges between 0 and - 5 V.

Equation 2 – JFETs Commanding Equations

5.4.5. EGSE Heaters

A total of two heaters will be used to help with the correlation exercise. Power supplies will be used to power the heaters.

The resistance of both heaters shall be measured at room temperature and at nominal operating temperature using a four-wire measurement [AD13] and a calibrated voltmeter with a minimum accuracy of 0.01 V.

Heater	***Resistance (ohms) At Room temperature***	***Resistance (ohms) At operating Temperature***
FPU	To be completed after measurement	TBC
Level-0 Photometer	9970	TBC

Table 5-6 – SPIRE CQM2 EGSE Heaters

6. THERMAL BALANCE TEST PROGRAMME

6.1.1. Description

Figure 6-1 on the following pages and table 6.1 below describes the thermal balance test that will be carried out during the second CQM test campaign. A detailed procedure for each individual test can be found in appendices A to F. For each test, the following information has been defined:

- Test definition/description and cryostat setup applicable to the given test.

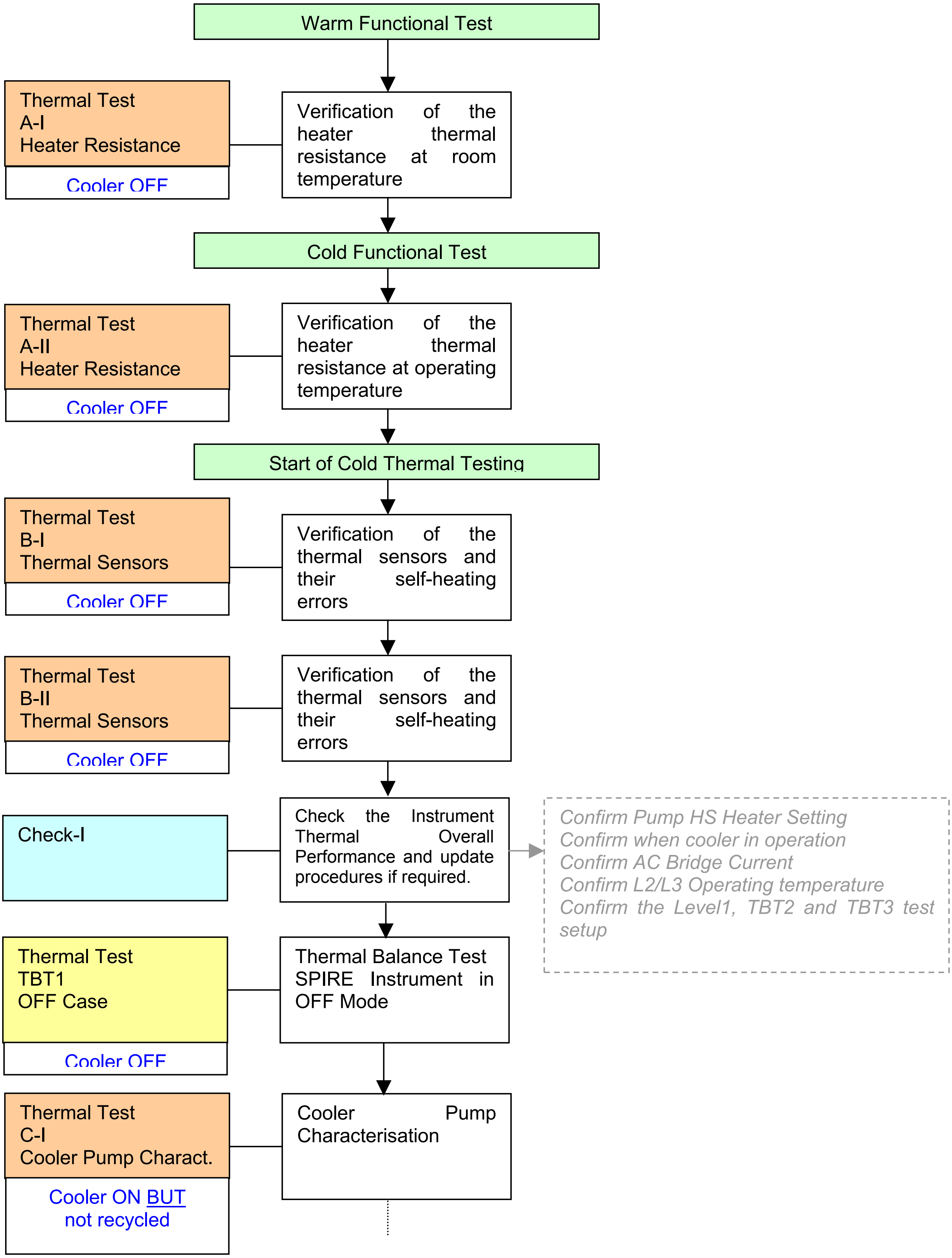
Detailed procedures that must be followed during the test as well as the data that need recording at the time of the test.

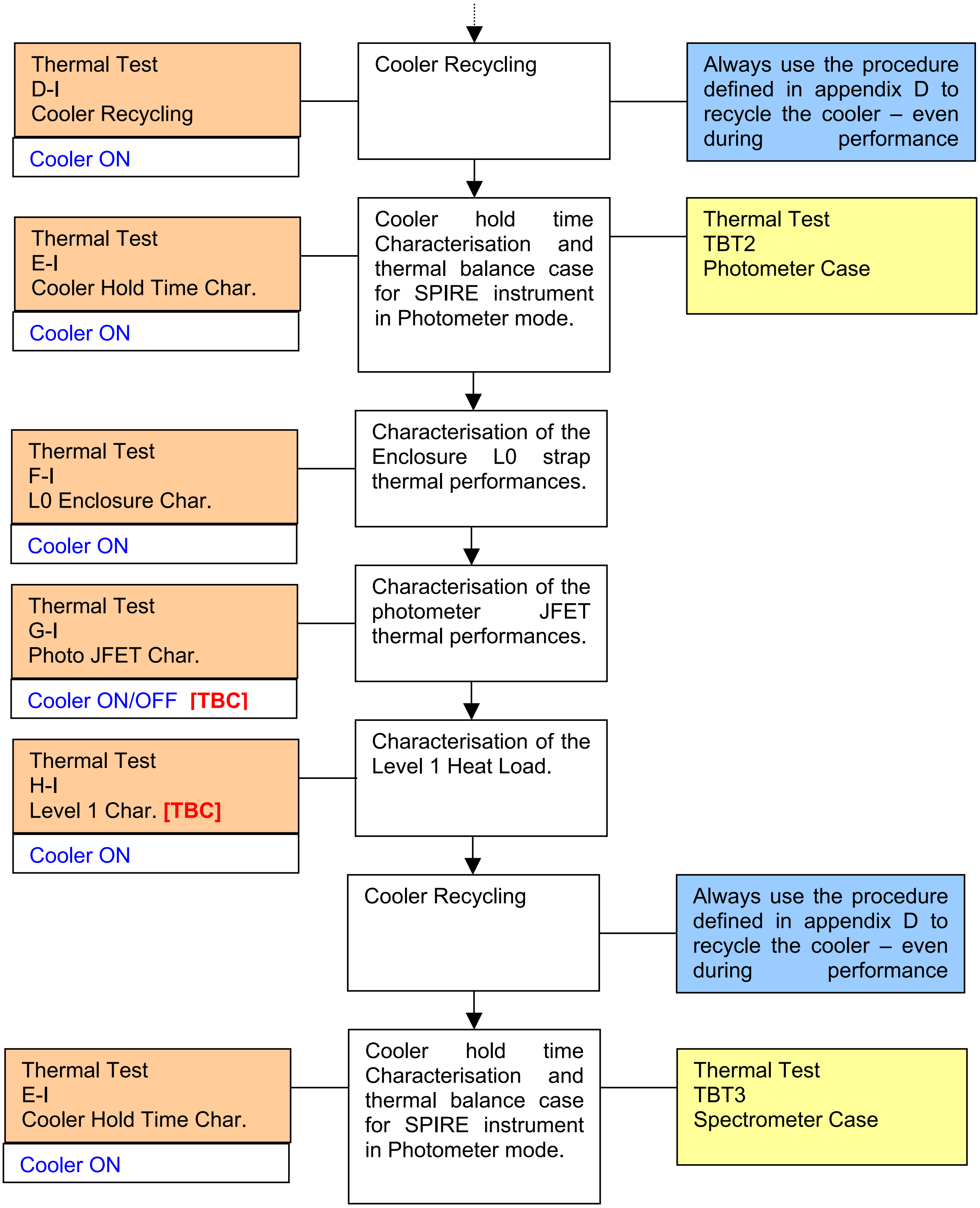
Test ID	Test Name	Description	Steady-State Required	Logging Criterion
A	Heater Resistance Characterisation	Measure the heater resistances at operating temperatures using a 4-wire measurement according to the procedure in AD13.	No	n/a
B	Sensor Self-Heating Characterisation	Evaluate the self heating on some CQM sensors by varying the excitation current of the monitoring unit	Yes	10 sec
C	Cooler Pump Characterisation	Test carried out to help with the correlation of the 300-mK stage of the instrument as well as the cooler thermal performances.	Yes	10 sec
D	Cooler Recycling	The operation profile of the cooler during recycling is feeding back in the hold time characterisation.	n/a	10 sec
E	Cooler Hold Time Characterisation	This test will be carried out during the thermal balance case 2 and 3.	Yes	1 min
F	Level-0 Characterisation	Test carried out to help with the correlation of the Level-0 stage of the instrument	Yes	10 sec
G	PJFET Characterisation	Test carried out to help with the correlation of the Level-2 stage of the instrument	Yes	10 sec
H	Level-1 Characterisation	TBC	TBC	TBC
TBT1	Thermal Balance Case 1 OFF Mode	Instrument left in Off mode to stabilise.	Yes	1 min
TBT2	Thermal Balance Case 2 Photometer Mode	Effectively a COLD Case where the Level-0 of the cryostat is maintained at 1.7K	Yes	1 min
TBT3	Thermal Balance Case 3 Spectrometer Mode	Effectively a HOT Case where the Level-0 of the cryostat is maintained at 2K	Yes	1 min

Table 6-1 – Overview of the SPIRE CQM2 Thermal Tests

The steady-state criteria defined in 6.1.2 must be met for each test where steady state is required.
The order in which the various tests will be performed is also described in figure 6-1 but may be altered for flexibility.

Figure 6-1 ***- Test Procedures for SPIRE CQM2 Thermal Balance Testing***




Thermal Test D-I Cooler Recycling
Cooler ON
Cooler Recycling
Always use the procedure defined in appendix D to recycle the cooler – even during performance
Thermal Test E-I Cooler Hold Time Char.
Cooler ON
Cooler hold time Characterisation and thermal balance case for SPIRE instrument in Photometer mode.
Thermal Test TBT2 Photometer Case
Thermal Test F-I L0 Enclosure Char.
Cooler ON
Characterisation of the Enclosure L0 strap thermal performances.
Thermal Test G-I Photo JFET Char.
Cooler ON/OFF [TBC]
Characterisation of the photometer JFET thermal performances.
Thermal Test H-I Level 1 Char. [TBC]
Cooler ON
Characterisation of the Level 1 Heat Load.
Cooler Recycling
Always use the procedure defined in appendix D to recycle the cooler – even during performance
Thermal Test E-I Cooler Hold Time Char.
Cooler ON
Cooler hold time Characterisation and thermal balance case for SPIRE instrument in Photometer mode.
Thermal Test TBT3 Spectrometer Case

6.1.2. *Steady-State Criterion Definition*

Criteria for completion of dy-state cases refer to specific SPIRE temperature sensors. The criteria for temperature stabilisati are considered to be met when the temperature variations at each stage are as shown in Table 6.1.

Stage	***Max Rate of Change***	***Time (hrs)***	***Applicable Sensors***	***Corresponding Node in TMM***	***Ref***
300mK	0.06 mK/hr (TBC)	2	T_PLW SUBTEMP	[N2750] [N4300]	[AD4]
Level 0	9 mK/hr (TBC)	2	T_PL0_3 T_SL0_3	[N2400] [N3400]	[AD3 -Sect 5.4]
Level 1	120 mK/hr (TBC)	2	T_SUB_1 T_BSMS_1 T_FTSS_1 T_SCST_1	[N2000] [N1010] [N1120] [N3250]	[AD3 -Sect 5.4]
Level 2	70 mK/hr (TBC)	2	C18 C19 C20 C21	[N1003] [N1004] [N1003] [N1009]	[AD3 -Sect 5.4]

Table 6-2 - Thermal Stability Criteria

Use the “SPIRE CQM2 Hardware Command.xls” spreadsheet (located in Q:\Test Team Area\Procedures\2nd Cold Thermal Verification) to calculate the temperature drift and check whether the steady-state criterion has been reached.

APPENDIX A – Heater Resistance Verification Test set-up

Test Code	**A**		
Description	**Heater Resistance Verification**		
Objective	Provide an accurate measurement of the resistance of the various heaters used for the TBT at operating temperature.		
Method	Use a four-wire measurement for each heater defined by the procedure [AD13].		
Cryostat Setup	**A-I**	**A-II**	
Level-0 Temperature	300	1.7	
Level-1 Temperature	300	4.2	
Level-2 Temperature	300	15 **[TBC]**	
Stable Temperature required	x	no	
Performance Testing allowed	x	no	
SPIRE Instrument Power Dissipation Setup	**Q [mW]**	**Current [mA]**	**Command [Hex]**
Cooler - OFF			
Pump Heater	0	0	0
Pump Heat Switch Heater	0	0	0
Evaporator Heat Switch Heater	0	0	0
Level-0			
Level-0 Photometer EGSE Heater	0	0	N/A
Level-1			
SCAL	0	0	0
PCAL	0	0	0
SMEC	0	0	N/A
BSM	0	0	N/A
FPU EGSE	0	0	N/A
Level-2			
Photometer JFET	0	0	0
Spectrometer JFET	0	0	0
Monitoring Unit	**Log**	**Current Setting**	**-**
Lakeshore 218	Resistance	10uA	-
Lakeshore 370	Resistance	10uA	-

APPENDIX A – Heater Resistance Verification Detailed Procedure

Step	**Actions**	**Data I**	**Data II**	**Data III**	**Data IV**	**Completed**	**Comments / Initial**
A-I	**Verification of the resistance of all heaters**						*Takes place during the warm functional testing as well as the cold functional testing*
A-I.1	Make sure the cryostat, instrument and monitoring unit are setup as described on the previous page.						
A-I.2	Are the temperature described below stable? No apparent drift?						
A-I.3	Log resistance of the following heater with a calibrated voltmeter with accuracy better than **TBC**	R [ohms] At 300K	R [ohms] At Op	Sensor	T [K]		
	Pump Heater						
	Pump Heat Switch Heater						
	Evaporator Heat Switch Heater						
	Level-0 Photometer EGSE Heater	9970					
	SCAL						
	PCAL						
	SMEC						
	BSM						
	FPU EGSE						
	Photometer STM JFET						
	Spectrometer STM JFET						
A-I.4	Start again at A-I.1 for difference setting cryostat temperatures.						

APPENDIX B – Thermal Sensors Self-Heating Verification Test set-up

Test Code	**B**		
Description	**Thermal Sensors Self-Heating Verification**		
Objective	Provide an accurate measurement of the error introduced by self-heating in sensors data reading.		
Method	Monitor sensors connected to the 370 AC bridge while varying the excitation current into the sensors.		
Cryostat Setup	**B-I**	**B-II**	
Level-0 Temperature	1.7	1.4 TBC	
Level-1 Temperature	4.2	4.2	
Level-2 Temperature	15 [TBC]	15 [TBC]	
Stable Temperature required	yes	yes	
Performance Testing allowed	no	no	
SPIRE Instrument Power Dissipation Setup	**Q [mW]**	**Current [mA]**	**Command [Hex]**
Cooler - OFF			
Pump Heater	0	0	0
Pump Heat Switch Heater	0	0	0
Evaporator Heat Switch Heater	0	0	0
Level-0			
Level-0 Photometer EGSE Heater	0	0	N/A
Level-1			
SCAL	0	0	0
PCAL	0	0	0
SMEC	0	0	N/A
BSM	0	0	N/A
FPU EGSE	0	0	N/A
Level-2			
Photometer JFET	0	0	0
Spectrometer JFET	0	0	0
Monitoring Unit	**Log**	**Current Setting**	
Lakeshore 218	Resistance	10uA	-
Lakeshore 370	Resistance	10uA-316nA see after	-

APPENDIX B – Thermal Sensors Self-Heating Verification Detailed Procedure

Step	Actions	Data I	Data II	Data III	Data IV	Completed	Comments / Initial
B-I	**Verification of the Thermal Sensors Self-Heating**						
B-I.1	Make sure the cryostat, instrument and monitoring unit are setup as described on previous page.	Level0 @ 1.7K					
B-I.2	Set the 370 AC bridge excitation current to	10uA	3.16uA	1uA	316nA		
B-I.3	Wait for the temperatures to stabilise. Are the temperature below stable? No apparent drift?						
B-I.4	Log temperature of the following sensor temperatures	T [K]	T [K]	T [K]	T [K]		
	T_PL0_3						
	T_SL0_3						
	T_L0_DSTR						
	T_L0_PSTR						
	T_L0_ESTR						
	T_FPU_PXAF						
	T_FPU_MXAF						
	T_SOB_L1STR						
	Vessel Top						
	Vessel Bottom						
	FPU L1 Strap						
	1.7K Vessel Bottom						
	FPU Evap Strap Interface						
	FPU Pump Strap Interface						
	FPU Box Strap Interface						
	Vessel Top						

B-I.5	Start again at B-I.2 for difference setting in current excitation of sensors.						

APPENDIX B – Thermal Sensors Self-Heating Verification Detailed Procedure

Step	**Actions**	**Data I**	**Data II**	**Data III**	**Data IV**	**Completed**	**Comments / Initial**
B-II	**Verification of the Thermal Sensors Self-Heating**						
B-II.1	Make sure the cryostat, instrument and monitoring unit are setup as described on previous page.	Level0 @ 1.4K TBC					
B-II.2	Set the 370 AC bridge excitation current to	316nA	1uA	3.16uA	10uA		
B-II.3	Wait for the temperatures to stabilise. Are the temperature below stable? No apparent drift?						
B-II.4	Log temperature of the following sensors	T [K]	T [K]	T [K]	T [K]		
	T_PL0_3						
	T_SL0_3						
	T_L0_DSTR						
	T_L0_PSTR						
	T_L0_ESTR						
	T_FPU_PXAF						
	T_FPU_MXAF						
	T_SOB_L1STR						
	Vessel Top						
	Vessel Bottom						
	FPU L1 Strap						
	1.7K Vessel Bottom						
	FPU Evap Strap Interface						
	FPU Pump Strap Interface						
	FPU Box Strap Interface						
	Vessel Top						

B-II.5	Do B-II.2 again for difference setting in current excitation of sensors.						
B-II.6	Set the 370 AC bridge excitation current to the level that gives the less self-heating in thermal sensors						
	New excitation current for 370Unit		uA				

APPENDIX C – Cooler Pump Characterisation Test Set-up

Test Code	**C**		
Description	**Cooler Pump Characterisation**		
Objective	Provide an insight of the cooler thermal behaviour for future correlation of the thermal model.		
Method	Plot a curve of pump temperature versus pump heater power for future reference.		
Cryostat Setup	**C-I**		
Level-0 Temperature	1.7		
Level-1 Temperature	4.2		
Level-2 Temperature	15 **[TBC]**		
Stable Temperature required	yes		
Performance Testing allowed	no		
SPIRE Instrument Power Dissipation Setup	**Q [mW]**	**Current [mA]**	**Command [Hex]**
Cooler - ON			
Pump Heater	As after	As after	As after
Pump Heat Switch Heater	As after	As after	As after
Evaporator Heat Switch Heater	OFF	OFF	OFF
Level-0			
Level-0 Photometer EGSE Heater	0	0	N/A
Level-1			
SCAL	0	0	0
PCAL	0	0	0
SMEC	0	0	N/A
BSM	0	0	N/A
FPU EGSE	0	0	N/A
Level-2			
Photometer JFET	0	0	0
Spectrometer JFET	0	0	0
Monitoring Unit	**Log**	**Current Setting**	
Lakeshore 218	Resistance	10uA	-
Lakeshore 370	Resistance	**[TBC]**	-

APPENDIX C – Cooler Pump Characterisation Detailed Procedure

Step	Actions	Data I	Data II	Data III	Data IV	Completed	Comments / Initial
C-I	**Cooler Pump Characterisation**						
C-I.1	Make sure the cryostat, instrument and monitoring units are setup as described in table on previous page.						
C-I.2	Turn the Evaporator heat switch OFF if previously turned ON.						
C-I.3	Turn the pump heater OFF if previously turned ON.						
C-I.4	Turn the pump heat switch ON – by applying 800 uW on pump HS heater (1.4mA – command [0x0DEB]).						
C-I.5	Wait for the pump HS to warm-up to 16K and for the pump temperature to stabilise.						
C-I.6	Reduce the pump heat switch heater power to 400uW (1mA – command [0x09EC]).						
C-I.7	Set the pump heater power dissipation from 0mW to 100mW by step of 15mW. For each case, do the following steps:						
C-I.7.1	Set the pump heater power dissipation						
C-I.7.2	Wait for the temperature to stabilise. Are the temperatures defined below stable? The steady-state criterion NEEDS to be met [see section 6.1.2].						
C-I.7.3	Measure the temperatures and fill in the table define below for each case.						
C-I.8	Plot Graph of Pump temperature versus pump heater load						

Step	**Actions**	**Data I**	**Data II**	**Data III**	**Data IV**	**Completed**	**Comments / Initial**
C-I	**Cooler Pump Characterisation**						
	Pump Heater Power Dissipation	0 mW	15 mW	30 mW	45 mW		
	Pump Heater Command [Hex]	0	1F8	2C8	368		
Pump	*T_CPHP_1*						
Shunt	*T_CSHT_1*						
Evap	*T_CEV_1*						
Pump HS	*T_CPHS_1*						
Evap HS	*T_CEHS_1*						
	T_PL0_1						
	T_SL0_1						
	T_PL0_3						
	T_SL0_3						
	T_L0_DSTR						
	T_L0_PSTR						
	T_L0_ESTR						
	FPU Evap Strap Interface						
	FPU Pump Strap Interface						
	FPU Box Strap Interface						

Step	**Actions**	**Data I**	**Data II**	**Data III**	**Data IV**	**Completed**	**Comments / Initial**
C-I	**Cooler Pump Characterisation**						
	Pump Heater Power Dissipation	60 mW	75 mW	90 mW	105 mW		
	Pump Heater Command [Hex]	3EF	465	4D1	533		
Pump	*T_CPHP_1*						
Shunt	*T_CSHT_1*						
Evap	*T_CEV_1*						
Pump HS	*T_CPHS_1*						
Evap HS	*T_CEHS_1*						
	T_PL0_1						
	T_SL0_1						
	T_PL0_3						
	T_SL0_3						
	T_L0_DSTR						
	T_L0_PSTR						
	T_L0_ESTR						
	FPU Evap Strap Interface						
	FPU Pump Strap Interface						
	FPU Box Strap Interface						

APPENDIX D – Cooler Recycling Test Set-up

Test Code	**D**		
Description	**Cooler Recycling**		
Objective	Recycle the cooler in thermal environment similar to flight to allow a good correlation of the hold time.		
Method	Use identical set of power dissipation and heat switch sequence for all cooler recycling.		
Cryostat Setup	**D-I**		
Level-0 Temperature	1.7		
Level-1 Temperature	4.2		
Level-2 Temperature	15 **[TBC]**		
Stable Temperature required	no		
Performance Testing allowed	no		
SPIRE Instrument Power Dissipation Setup	**Q [mW]**	**Current [mA]**	**Command [Hex]**
Cooler - ON			
Pump Heater	As after	As after	As after
Pump Heat Switch Heater	As after	As after	As after
Evaporator Heat Switch Heater	As after	As after	As after
Level-0			
Level-0 Photometer EGSE Heater	0	0	N/A
Level-1			
SCAL	0	0	0
PCAL	0	0	0
SMEC	0	0	N/A
BSM	0	0	N/A
FPU EGSE	0	0	N/A
Level-2			
Photometer JFET	0	0	0
Spectrometer JFET	0	0	0
Monitoring Unit	**Log**	**Current Setting**	
Lakeshore 218	Resistance	10uA	-
Lakeshore 370	Resistance	**[TBC]**	-

APPENDIX D – Cooler Recycling Detailed Procedure

Step	Actions	Data I	Data II	Data III	Data IV	Completed	Comments / Initial
D-I	**Cooler Recycling**						
D-I.0	Make sure the cryostat, instrument and monitoring unit are setup as described in table on previous page.						
D-I.1	Turn the pump Heat Switch OFF if previously turned ON.						
D-I.2	Turn the evaporator heat switch ON by applying 800 uW on evap HS heater (1.4mA – command 3563 [0x0DEB])						
D-I.3	Apply 300 mW to the pump heater (27 mA – command 2223 [0x08AF])						
D-I.4	Wait for the pump temperature to reach 45K *Has the pump reached 45K?*						
D-I.5	Reduce the power on pump heater to 40 mW (10 mA – command [0x0339])						
D-I.6	Wait for the evaporator temperature to reach 2K. *Has evaporator reached 2K?*						
D-I.7	Turn the power on the pump heater OFF						
D-I.8	Turn the power on the evaporator heat switch OFF						
D-I.9	Wait for the evaporator HS temperature to cooldown below 16K. *Is evaporator heat switch temperature below 16K?*						
D-I.10	Turn the pump heat switch ON by applying 800 uW on pump HS heater (1.4mA – command [0x0DEB]).						

D-I.11	Wait for the evaporator temperature to drop sharply.					
D-I.12	Log the evaporator temperature at start of cooldown.					
D-I.13	Wait for the evaporator cold tip to reach subK temperature. *Has the evaporator temperature stabilised? No apparent drift?*					
D-I.14	Log the evaporator temperature					
D-I.15	Reduce the pump heat switch power to 400 uW (1 mA – command [0x09EC]).					
D-I.16	Calculate the cryo-pumping efficiency					

APPENDIX E – Cooler Hold Time Characterisation Test Set-up

Test Code	**E**		
Description	**Cooler Hold Time Characterisation**		
Objective	Provide an insight of the cooler hold time for a given nominal recycling and operating conditions.		
Method	Recycle cooler has been recycled as per set-up and procedure defined in appendix D. Setup a thermal balance test case if necessary (L2 cryostat temperature and mechanisms power dissipation) The cooler will be recycled only ONCE it has run out of helium.		
Cryostat Setup	**E-I**		
Level-0 Temperature	1.7		
Level-1 Temperature	4.2		
Level-2 Temperature	15 **[TBC]**		
Stable Temperature required	Preferable		
Performance Testing allowed	TBC		
SPIRE Instrument Power Dissipation Setup	**Q [mW]**	**Current [mA]**	**Command [Hex]**
Cooler - ON			
Pump Heater	0	0	0
Pump Heat Switch Heater	0.4	1	0x09EC
Evaporator Heat Switch Heater	0	0	0
Level-0			
Level-0 Photometer EGSE Heater	0	0	N/A
Level-1			
SCAL	**[TBC]**	**[TBC]**	**[TBC]**
PCAL	**[TBC]**	**[TBC]**	**[TBC]**
SMEC	**[TBC]**	**[TBC]**	N/A
BSM	**[TBC]**	**[TBC]**	N/A
FPU EGSE	**[TBC]**	**[TBC]**	N/A
Level-2			
Photometer JFET	**[TBC]**	**[TBC]**	**[TBC]**
Spectrometer JFET	**[TBC]**	**[TBC]**	**[TBC]**
Monitoring Unit	**Log**	**Current Setting**	
Lakeshore 218	Resistance	10uA	-
Lakeshore 370	Resistance	**[TBC]**	-

Note: a thermal balance test can be setup at the beginning of the test (some mechanisms ON) but the thermal environment should remain unchanged for the whole duration of the cooler hold time test.

APPENDIX E – Cooler Hold Time Characterisation Detailed Procedure

Step	**Actions**	**Data I**	**Data II**	**Data III**	**Data IV**	**Completed**	**Comments / Initial**
E-I	**Cooler Hold Time Characterisation**						
E-I.0	Make sure the cryostat, instrument and monitoring unit are setup as described in table on previous page.						
E-I.1	Cooler has been recycled as per procedure defined in appendix D.						
E-I.2	Setup a thermal case if necessary and operate the cooler until it runs out of helium. The instrument and cryostat temperatures MUST be kept as stable as possible.						
E-I.3	During operation, log the following temperature every hour						
Pump	*T_CPHP_1*						
Shunt	*T_CSHT_1*						
Evap	*T_CEV_1*						
Pump HS	*T_CPHS_1*						
Evap HS	*T_CEHS_1*						
	T_PL0_1						
	T_SL0_1						
	T_PL0_3						
	T_SL0_3						
	T_L0_PSTR						
	T_L0_ESTR						
	Cooler Enclosure temperature						
E-I.4	Convert pump temperature into pump heat of adsorption using the function obtained during the						

	cooler pump characterisation test.						
E-I.5	Convert heat of adsorption into average total cooler load (using factor between 45-50)						
E-I.6	Using the temperature from the L1 and L0 cooler interfaces, run prediction for the cooler parasitic loads						
E-I.7	Correlate 300-mK average load with the obtained cooler hold time, cryo-pumping efficiency and predicted load profile.						

APPENDIX F – Enclosure L0 Strap Characterisation Test Set-up

Test Code	**F**		
Description	**Enclosure L0 Straps Characterisation**		
Objective	Validate the thermal design for the enclosures L0 straps as well as provide thermal data for correlation of the F-harness, the L0 supports and 300-mK load with the thermal model.		
Method	A heater mounted on the L0 photometer enclosure will be used to dissipate a known load along the L0 enclosure strap. The operation will be repeated for different loads.		
Cryostat Setup	**F-I**		
Level-0 Temperature	1.7		
Level-1 Temperature	4.2		
Level-2 Temperature	15 **[TBC]**		
Stable Temperature required	yes		
Performance Testing allowed	no		
SPIRE Instrument Power Dissipation Setup	**Q [mW]**	**Current [mA]**	**Command [Hex]**
Cooler			
Pump Heater	0	0	0
Pump Heat Switch Heater	0.4	1	0x09EC
Evaporator Heat Switch Heater	0	0	0
Level-0			
Level-0 Photometer EGSE Heater	0-10mW see after	see after	N/A
Level-1			
SCAL	0	0	0
PCAL	0	0	0
SMEC	0	0	N/A
BSM	0	0	N/A
FPU EGSE	0	0	N/A
Level-2			
Photometer JFET	0	0	0
Spectrometer JFET	0	0	0
Monitoring Unit	**Log**	**Current Setting**	
Lakeshore 218	Resistance	10uA	-
Lakeshore 370	Resistance	**[TBC]**	-

APPENDIX F – Enclosure L0 Straps Characterisation Detailed Procedure

Step	Actions	Data I	Data II	Data III	Data IV	Completed	Comments / Initial
F-I	**Enclosure L0 Straps Characterisation**						
F-I.0	Make sure the cryostat, instrument and monitoring unit are setup as described in table on previous page.						
F-I.1	Set the L0 photometer enclosure heater to 0mW power dissipation	R=	Current=	Voltage =	Power =		
F-I.1.1	*Calculate the required current according to measured resistance of the heater*						
F-I.1.2	*Set the current on power supply*						
F-I.1.3	*Measure the voltage on 4-wire measurement*						
F-I.1.4	*Adjust current if necessary*						
F-I.2	Wait for the temperature to be stable. Are the temperature described below stable? The steady-state criterion NEEDS to be met [see section 6.1.2].						
F-I.3	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						

Step	Actions	Data I	Data II	Data III	Data IV	Completed	Comments / Initial
F-I	**Enclosure L0 Straps Characterisation**						
F-I.4	Set the L0 photometer enclosure heater to 5 mW power dissipation	R=	Current=	Voltage =	Power =		
F-I.4.1	*Calculate the required current according to measured resistance of the heater*						
F-I.4.2	*Set the current on power supply*						
F-I.4.3	*Measure the voltage on 4-wire measurement*						
F-I.4.4	*Adjust current if necessary*						
F-I.5	Wait for the temperature to be stable. Are the temperature described below stable? The steady-state criterion NEEDS to be met [see section 6.1.2].						
F-I.6	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						

Step	Actions	Data I	Data II	Data III	Data IV	Completed	Comments / Initial
F-I	**Enclosure L0 Straps Characterisation**						
F-I.7	Set the L0 photometer enclosure heater to 10 mW power dissipation	R=	Current=	Voltage =	Power =		
F-I.7.1	*Calculate the required current according to measured resistance of the heater*						
F-I.7.2	*Set the current on power supply*						
F-I.7.3	*Measure the voltage on 4-wire measurement*						
F-I.7.4	*Adjust current if necessary*						
F-I.8	Wait for the temperature to be stable. Are the temperature described below stable? The steady-state criterion NEEDS to be met [see section 6.1.2].						
F-I.9	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						

APPENDIX G – Photometer JFET Characterisation Test Set-up

Test Code	**G**		
Description	**Photometer JFET Characterisation**		
Objective	Validate the thermal design for the JFET isolation supports and provide thermal data for correlation of the F-harness with the thermal model.		
Method	Heaters mounted on the PJFET STM modules will be used to dissipate a known load inside the PJFET enclosure. The operation will be repeated for different loads.		
Cryostat Setup	**G-I**		
Level-0 Temperature	1.7		
Level-1 Temperature	4.2		
Level-2 Temperature	15 **[TBC]**		
Stable Temperature required	yes		
Performance Testing allowed	no		
SPIRE Instrument Power Dissipation Setup	**Q [mW]**	**Current [mA]**	**Command [Hex]**
***Cooler – ON or OFF* [TBC]**			
Pump Heater	0	0	0
Pump Heat Switch Heater	**[TBC]**	**[TBC]**	**[TBC]**
Evaporator Heat Switch Heater	0	0	0
Level-0			
Level-0 Photometer EGSE Heater	0	0	N/A
Level-1			
SCAL	0	0	0
PCAL	0	0	0
SMEC	0	0	N/A
BSM	0	0	N/A
FPU EGSE	0	0	N/A
Level-2			
Photometer JFET	0 - 40 mW See after	0	0
Spectrometer JFET	0	0	0
Monitoring Unit	**Log**	**Current Setting**	
Lakeshore 218	Resistance	10uA	-
Lakeshore 370	Resistance	**[TBC]**	-

APPENDIX G – Photometer JFET Characterisation Detailed Procedure

Step	Actions	Data I	Data II	Data III	Data IV	Completed	Comments / Initial
G-I	**Photometer JFET Characterisation**						
G-I.0	Make sure the cryostat, instrument and monitoring unit are setup as described in table on previous page.						
G-I.1	Set the PJFET STM modules to 0 mW power dissipation with the CQM module to zero						
G-I.1.1	*Calculate the required voltage Vss*	Vss = 0					
G-I.1.2	*Convert to appropriate command format*	Hex = 0					
G-I.1.3	*Measure the voltage across lines with 4-wires*	V =					
G-I.2	Wait for the temperature to be stable. Are the temperature described below stable? The steady-state criterion NEEDS to be met [see section 6.1.2].						
G-I.3	Log the following temperature						
	T_PJFS_CHAS						
	FSJFP_HOB IF						
	FSJFP L3 IF						
	T_SOB_L1CON						
	Harness Sink WE-Ph JFET (L2 shield side)						
	End cap 2						

Step	**Actions**	**Data I**	**Data II**	**Data III**	**Data IV**	**Completed**	**Comments / Initial**
G-I	**Photometer JFET Characterisation**						
G-I.4	Set the PJFET STM modules to 20 mW power dissipation with the CQM module to zero						
G-I.4.1	*Calculate the required voltage Vss*	Vss = -1.5 V					
G-I.4.2	*Convert to appropriate command format*	Hex = 4C					
G-I.4.3	*Measure the voltage across lines with 4-wires*	V =					
G-I.5	Wait for the temperature to be stable. Are the temperature described below stable? The steady-state criterion NEEDS to be met [see section 6.1.2].						
G-I.6	Log the following temperature						
	T_PJFS_CHAS						
	FSJFP_HOB IF						
	FSJFP L3 IF						
	T_SOB_L1CON						
	Harness Sink WE-Ph JFET (L2 shield side)						
	End cap 2						

Step	**Actions**	**Data I**	**Data II**	**Data III**	**Data IV**	**Completed**	**Comments / Initial**
G-I	**Photometer JFET Characterisation**						
G-I.7	Set the PJFET STM modules to 40 mW power dissipation with the CQM module to zero						
G-I.7.1	*Calculate the required voltage Vss*	Vss = -3.157					
G-I.7.2	*Convert to appropriate command format*	Hex = A1					
G-I.7.3	*Measure the voltage across lines with 4-wires*	V =					
G-I.8	Wait for the temperature to be stable. Are the temperature described below stable? The steady-state criterion NEEDS to be met [see section 6.1.2].						
G-I.9	Log the following temperature						
	T_PJFS_CHAS						
	FSJFP_HOB IF						
	FSJFP L3 IF						
	T_SOB_L1CON						
	Harness Sink WE-Ph JFET (L2 shield side)						
	End cap 2						

APPENDIX H – Level-1 Characterisation Test Set-up

Test Code	**H**		
Description	**Level 1 Characterisation**		
Objective	[TBC]		
Method			
Cryostat Setup	**H-I**		
Level-0 Temperature			
Level-1 Temperature			
Level-2 Temperature			
Stable Temperature required			
Performance Testing allowed			
SPIRE Instrument Power Dissipation Setup	**Q [mW]**	**Current [mA]**	**Command [Hex]**
Cooler			
Pump Heater			
Pump Heat Switch Heater			
Evaporator Heat Switch Heater			
Level-0			
Level-0 Photometer EGSE Heater			
Level-1			
SCAL			
PCAL			
SMEC			
BSM			
FPU EGSE			
Level-2			
Photometer JFET			
Spectrometer JFET			
Monitoring Unit	**Log**	**Current Setting**	
Lakeshore 218	Resistance	10uA	-
Lakeshore 370	Resistance	[TBC]	-

TBT1 – Thermal Balance Test 1 – OFF Mode

Test Code	**TBT1**		
Description	**OFF Mode**		
Objective	Provide thermal data for correlation of the thermal model.		
Method	Leave the instrument temperature to stabilise with none of the mechanism, calibration sources and electronic working.		
Cryostat Setup	**G-I**		
Level-0 Temperature	1.7		
Level-1 Temperature	4.2		
Level-2 Temperature	15		
Stable Temperature required	yes		
Performance Testing allowed	no		
SPIRE Instrument Power Dissipation Setup	**Q [mW]**	**Current [mA]**	**Command [Hex]**
Cooler			
Pump Heater	0	0	0
Pump Heat Switch Heater	0	0	0
Evaporator Heat Switch Heater	0	0	0
Level-0			
Level-0 Photometer EGSE Heater	0	0	N/A
Level-1			
SCAL	0	0	0
PCAL	0	0	0
SMEC	0	0	N/A
BSM	0	0	N/A
FPU EGSE	0	0	N/A
Level-2			
Photometer JFET	0	0	0
Spectrometer JFET	0	0	0
Monitoring Unit	**Log**	**Current Setting**	
Lakeshore 218	Resistance	10uA	-
Lakeshore 370	Resistance	**[TBC]**	-

TBT2 – Thermal Balance Test 2 – Photometer Mode

Test Code	**TBT2**		
Description	**Photometer Mode**		
Objective	Provide thermal data for correlation of the thermal model.		
Method	Set the instrument mechanism, calibration sources and electronic in a representative photometer mode.		
Cryostat Setup	**G-I**		
Level-0 Temperature	1.7		
Level-1 Temperature	4.2		
Level-2 Temperature	[TBC]		
Stable Temperature required	no		
Performance Testing allowed			
SPIRE Instrument Power Dissipation Setup	**Q [mW]**	**Current [mA]**	**Command [Hex]**
Cooler			
Pump Heater	[TBC]	0	0
Pump Heat Switch Heater	[TBC]	0	0
Evaporator Heat Switch Heater	[TBC]	0	0
Level-0			
Level-0 Photometer EGSE Heater	[TBC]	0	N/A
Level-1			
SCAL	[TBC]	0	0
PCAL	[TBC]	0	0
SMEC	[TBC]	0	N/A
BSM	[TBC]	0	N/A
FPU EGSE	[TBC]	0	N/A
Level-2			
Photometer JFET	[TBC]	0	0
Spectrometer JFET	[TBC]	0	0
Monitoring Unit	**Log**	**Current Setting**	
Lakeshore 218	Resistance	10uA	-
Lakeshore 370	Resistance	[TBC]	-

TBT3 – Thermal Balance Test 3 – Spectrometer Mode

Test Code	**TBT3**		
Description	**Spectrometer Mode**		
Objective	Provide thermal data for correlation of the thermal model.		
Method	Set the instrument mechanism, calibration sources and electronic in a representative spectrometer mode.		
Cryostat Setup	**G-I**		
Level-0 Temperature	1.7		
Level-1 Temperature	4.2		
Level-2 Temperature	[TBC]		
Stable Temperature required	no		
Performance Testing allowed			
SPIRE Instrument Power Dissipation Setup	**Q [mW]**	**Current [mA]**	**Command [Hex]**
Cooler			
Pump Heater	[TBC]	0	0
Pump Heat Switch Heater	[TBC]	0	0
Evaporator Heat Switch Heater	[TBC]	0	0
Level-0			
Level-0 Photometer EGSE Heater	[TBC]	0	N/A
Level-1			
SCAL	[TBC]	0	0
PCAL	[TBC]	0	0
SMEC	[TBC]	0	N/A
BSM	[TBC]	0	N/A
FPU EGSE	[TBC]	0	N/A
Level-2			
Photometer JFET	[TBC]	0	0
Spectrometer JFET	[TBC]	0	0
Monitoring Unit	**Log**	**Current Setting**	
Lakeshore 218	Resistance	10uA	-
Lakeshore 370	Resistance	[TBC]	-