SPIRE FLIGHT THERMAL PERFORMANCE PREDICTIONS

THERMAL ENGINEERING GROUP				
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CHANGE RECORD

Issue	Date	Section	Change
Draft A	14/03/07	-	New Document.
Issue 1	20/03/07	-	First Issue

ACRONYMS

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

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1 INTRODUCTION

1.1 Scope

This report presents the results from the SPIRE flight thermal performance prediction analysis. These predictions have been carried out with the SPIRE detailed thermal mathematical model (correlated against test data gathered during the instrument and its subsystems test campaigns) integrated in the Herschel detailed thermal mathematical model Issue 4.6 delivered by ESA in September 2006 (which has been correlated against test data gathered during the cryostat STM1 test campaign).

1.2 Documents

1.2.1 Applicable Documents

ID	Title	Number
AD1	SPIRE Thermal Design Requirements	SPIRE-RAL-PJR-002075
AD2	SPIRE Instrument Interface Document Part B (IIDB)	SPIRE-ESA-DOC-000275

Table 1-1- Applicable Documents

1.2.2 Reference Documents

ID	Title	Number
RD1	SPIRE Flight Thermal Model Correlation Report	SPIRE-RAL-REP-002723
RD2	SPIRE CQM1/2 Thermal Test Balance Report	SPIRE-RAL-REP-002078
RD3	SPIRE PFM2 Thermal Balance Test Report	SPIRE-RAL-REP-002534
RD4	SPIRE PFM3 Thermal Balance Test Report	SPIRE-RAL-REP-002684
RD5	SPIRE PFM4/PFM5 Thermal Balance Test Report	SPIRE-RAL-REP-002784
RD6	SPIRE Verification Science Review Thermal Performance	SPIRE-RAL-REP-002557

Table 1-2 - Reference Documents

2 ANALYSIS

2.1 SPIRE High Level Thermal Requirements

Requirements applicable to the SPIRE thermal design can be found in [AD1] and [AD2]. The main SPIRE high level requirements are summarised in Table 2-1 hereafter.

Parameter	Reqt	Goal
Minimum Cooler Hold Time [hr]	46	46
Maximum Detector Absolute Temperature [mK]	310	310
Maximum L0 Enclosure Heat Load [mW]	4	1
Maximum L0 Pump Heat Load [mW]	2	2
Maximum L1 Heat Load [mW]	15	13
Maximum PJFET L3 Heat Load [mW]	50	50
Maximum SJFET L3 Heat Load [mW]	25	25

Table 2-1 –SPIRE High Level Thermal Requirements

Important notes:

- The heat load requirements guarantee a maximum interface temperature at the various Herschel temperature stages. These have been defined such that SPIRE meets its 46hr holdtime.
- Should the SPIRE operating loads at one/several of these interfaces be higher than required, the Herschel interface temperatures will increase and this could compromise the instrument overall performance. It is therefore important that the SPIRE thermal design ensures that operating heat loads remain within the requirements at all times.
- The heat load requirements also represent the maximum allowable average operating heat loads for SPIRE over the whole mission lifetime. It is important that the SPIRE average loads do not exceed the requirements in order for the Herschel cryostat to meet its 3.5 years mission lifetime.

2.2 SPIRE Thermal Testing and Verification

The SPIRE instrument underwent a total of 6 thermal balance test campaigns (as part of the instrument level testing) and a number of reports have been produced (RD2 to RD5), each summarising the outcome and results from the tests carried out during each of the test campaign.

The “SPIRE Verification Science Review Thermal Performance” (RD6) summarises the outcome of each test campaign and also contains the Thermal Requirement Verification Matrix.

2.3 SPIRE Flight Thermal Model

The SPIRE detailed thermal model has been correlated against test data gathered at unit and instrument level testing. A summary of the main correlation factors is given in Table 2-2 hereafter. Additional details about the thermal model correlation can be found in RD1.

Parameter	Correlation Factors
JFET Isolation Supports Conductance	1.1
L3 Isolation Interface Conductance	0.3
JFET Chassis Conductance	0.333
FPU Isolation Joint	0.14
Cooler Heat Switches OFF Conductance	1.3795
Cooler Shunt to Evaporator Titanium Tube Conductance	0.8
L0 Straps Cu/Cu Bolted Interface Conductance	0.588
Support CFRP Thermal Conductivity	2
PLW Feedhorn to Cover Interface Conductance	1.2
PMW Feedhorn to Cover Interface Conductance	0.93
PSW Feedhorn to Cover Interface Conductance	1.83
SLW Feedhorn to Cover Interface Conductance	1.07
SSW Feedhorn to Cover Interface Conductance	1.15
PSW Kapton Harness Conductance	1
PMW Kapton Harness Conductance	0.55
PLW Kapton Harness Conductance	0.87
SSW Kapton Harness Conductance	0.87
SLW Kapton Harness Conductance	3.51
Cooler Cold tip Absolute Temperature	-10mK

Table 2-2 – SPIRE Flight Thermal Model Correlation Factors Summary

The SPIRE thermal model which has been used for this analysis can be found on the Thermal_Models network drive at the Rutherford Appleton Laboratory under:

\\Thermal_Models\TD-01-02-SPIRE\DTMM\SPIRE_TMM_FM_3-1\SPIRE_TMM_FM_3-1.d

The thermal model logfile can be found at:
\\Thermal_Models\TD-01-02-SPIRE\DTMM\ SPIRE_TMM_FM_Logfile.xls

Note: Issue 4.6 of the correlated Herschel cryostat detailed thermal model (delivered by ESA in September 2006) has been used in conjunction with SPIRE_TMM_FM_3-1 for this analysis.

2.4 Instrument Power Dissipations

This section summarises all power dissipated in SPIRE at L1 and L3 for the photometer and spectrometer observation modes.

2.4.1 Photometer Mode and Power Budget

Table 2-3 describes the various operations mode of SPIRE when in photometer observation mode.

OBSERVATION	OBSERVATORY FUNCTION	Name	Comments
Point source photometry	POF1	Chop without jiggling	Accurate pointing and source position
	POF2	Seven-point jiggle map	Inaccurate pointing or source position
Jiggle mapping	POF3	n-point jiggle map	Field mapping
	POF4	Raster map	Extended field mapping
Scan mapping	POF5	Scan map without chopping	Large-area mapping
	POF6	Scan map with chopping	Large area mapping (with 1/f noise)
Peak-up	POF7	Photometer peak-up (TBD)	Determination of pointing offsets
Calibrate	POF8	Photometer calibrate	Responsivity tracking
Engineering modes	POF9	Special engineering/ commissioning modes (TBD)	TBD

Table 2-3 - Photometer Observatory Functions (SPIRE-RAL-DOC-000320, Issue 3)

Observations in photometer mode consist mainly of POF1, POF2, POF3, POF5 and POF8.

Table 2-4 hereafter describes the power dissipated by the SPIRE PCAL, BSM and PJFET when operating in photometer mode. The dissipations represent the “average power” dissipated during a given mode of observation i.e. the power dissipated by the BSM at the various chop/jiggle positions of the 7pt jiggle map varies between 0mW and 0.7mW, the 0.3mW given in the table represents the average dissipation for all positions for a single map. The duty cycle gives an indication of the amount of time which will be allocated to the various operation modes for a nominal observation period of 46hr i.e. the chopping mode is to be used for only a quarter of the overall 46hr period.

Mechanisms	Ref	Average Dissipation [mW]	Duty Cycle [%] (*)
BSM – POF8 – Calibration with PCAL	2	0.0243	100
BSM Sensors	1	0.8	100
BSM Motor - POF1 – Chopping (+/-63")	1	0.548	25
BSM Motor - POF2 – 7pt Jiggle Map	1	0.3	25
BSM Motor - POF3 – 64pt Jiggle Map	1	1.55	25
BSM Motor – POF5 – Scan	1	0.0	25
Extra power component during BSM dynamic switching	1	0.25	100
Photometer JFETs	3	56.64	100

(*) Over a nominal 46hr observation period in photometer mode.

Table 2-4 – SPIRE Mechanisms and Calibration Sources Dissipations in Photometer Mode

Notes:

- It is currently assumed that POF1, POF2, POF3 and POF5 will be equally used. This will depend on the scientific community needs.
- The 64pt Jiggle Map is currently the worse case power dissipation for the steady-state analysis.
- The reference given in the table can be found in section 2.4.3.

2.4.2 Spectrometer Mode and Power Budget

Table 2-5 describes the various operations mode of SPIRE when in spectrometer observation mode.

Observation	Observatory Function	Name	Comments
Point source spectrometry	SOF1	Continuous Scan	Accurate pointing & source posn.
	SOF3	Step-and-Integrate	Accurate pointing & source posn.
Mapping spectrometry	SOF2	Continuous Scan	Field mapping
	SOF4	Step-and-Integrate	Field mapping

Table 2-5 – Spectrometer Observatory Functions (SPIRE-RAL-DOC-000320, Issue 3)

Table 2-6 hereafter describes the power dissipated by the SPIRE SMEC, SCAL, BSM, PCAL and SJFET when operating in spectrometer mode. The dissipations represent the "average power" dissipated during a given mode of observation i.e. the power dissipated by the SMEC actuator during a high resolution scan varies quadratically between 0 and ~17mW. The 3.56mW given in the table represents the integrated power dissipation of the actuator over the full scan range. The duty cycle gives an indication of the amount of time which will be allocated to the various observation modes for a nominal observation period of 46hr i.e. the SMEC HI resolution mode is to be used half the time of the overall 46hr period.

Mechanisms	Ref	Average Dissipation [mW]	Duty Cycle [mW] (*)
SCAL2 at 80K	2	2	100
Extra power component during SCAL dynamic switching	2	0.87	50
SMEC Actuator R1000 (HI Resolution)	4	3.56	50
SMEC Actuator R100 (MED Resolution)	4	0.46	25
SMEC Actuator R10 (L0 Resolution)	4	0.43	25
SMEC Encoder (Level 2)	4, 5	1.2	100
SMEC LVDT	5	0.112	100
BSM Sensors	1	0.8	100
BSM Motor – POF3 – 64pt Jiggle Map	1,6,7	1.55	50
Extra power component during BSM dynamic switching	1, 6	0.25	50
BSM Calibrator (PCAL)	2	0.0243	100
Spectrometer JFETs	3	**15.17**	**100**

(*) Over a nominal 46hr operation period in Spectrometer mode.

Table 2-6 – SPIRE Mechanisms and Calibration Sources Dissipations in Spectrometer Mode

Notes:
- The High Scan Resolution map is currently the worse case power dissipation for the steady-state analysis.
- The reference given in the table can be found in section 2.4.3.

2.4.3 Power Dissipation References

[1] – Measured at unit level on PFM unit, please refer to Bryan Stobie's email on 09/02/04.

[2] – Measured as part of instrument PFM3 test campaign, please refer to PFM3 Thermal Test Report, section 4.8.1.

[3] – Measured as part of instrument PFM3 test campaign, please refer to HR-SP-RAL-RFW-005v1.

[4] – Measured as part of instrument PFM4 test campaign, please refer to PFM4 Thermal Test Report (including short section on latest PFM5 test results).

[5] – Measured at unit level on CQM unit, please refer to SMEC CQM Cryogenic Test Results (LAM.ELE.SPI.PRV.040731_01).

[6] – Emails from Bruce Swinyard on 05/12/05.

[7] – SPIRE Operating Modes Document (SPIRE-RAL-DOC-000320, Issue 3).

2.5 Cooler Recycling

Figure 2-1 describes the cooler pump heater power dissipation during a nominal automated cooler recycling.

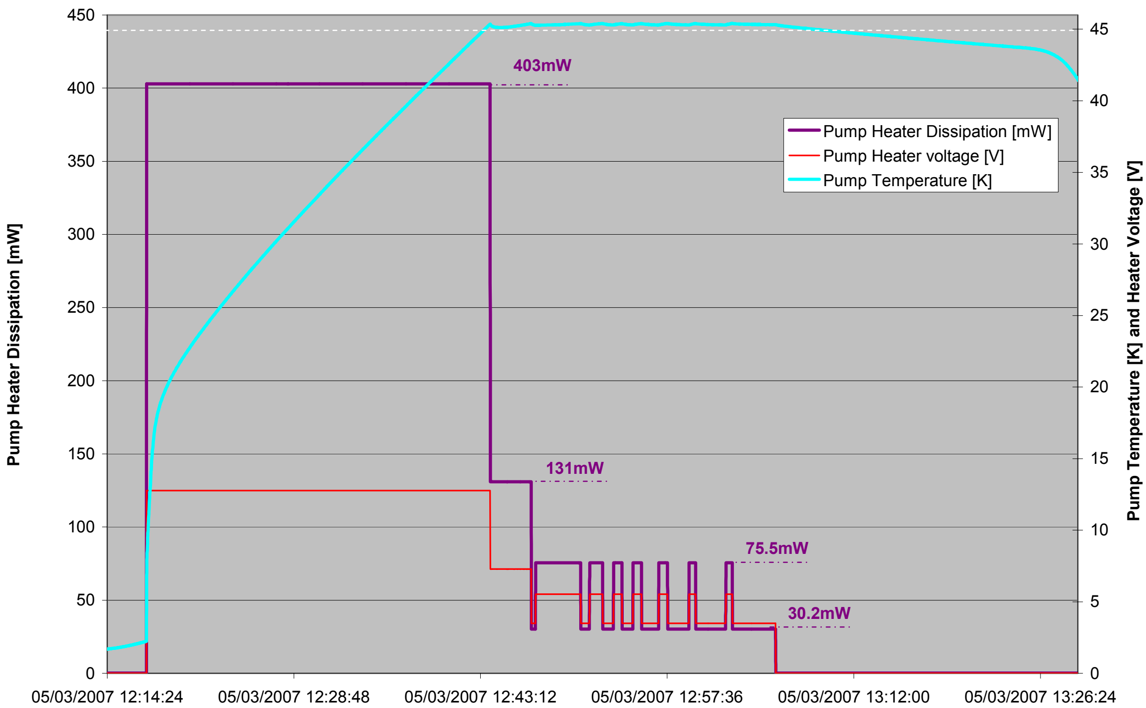

Figure 2-1 – Cooler Pump Heater Dissipation Profile during Nominal Automated Cooler Recycling

2.6 SPIRE Photometer Mode – Steady-State Analysis

2.6.1 Power Dissipation in Worse Case Photometer Mode

The table below summarises the power dissipation for the SPIRE mechanisms, calibration source and electronic boxes, including their duty cycle for the worse case operating mode when in photometer mode.

BSM – POF8 – Calibration with PCAL	[mW]	0.024	100%	0.024
SCAL2 at 80K	[mW]	2.000	0%	0.000
Extra power component during SCAL dynamic switching	[mW]	0.870	0%	0.000
SMEC Actuator – R10	[mW]	0.430	0%	0.000
SMEC Actuator – R100	[mW]	0.460	0%	0.000
SMEC Actuator – R1000	[mW]	3.560	0%	0.000
SMEC Encoder (Level 2)	[mW]	1.200	0%	0.000
SMEC LVDT	[mW]	0.112	0%	0.000
BSM Sensors	[mW]	0.800	100%	0.800
BSM Motor – POF1 – Chopping (+/-63")	[mW]	0.548	0%	0.000
BSM Motor – POF2 – 7pt Jiggle Map	[mW]	0.300	0%	0.000
BSM Motor – POF3 – 64pt Jiggle Map	[mW]	1.550	100%	1.550
BSM Motor – POF5 – Scan	[mW]	0.000	0%	0.000
Extra power component during BSM dynamic switching	[mW]	0.250	100%	0.250
Total L1 Dissipation	[mW]	-	-	**2.624**
PJFET Dissipation	[mW]	56.64	100.0%	**56.64**
SJFET Dissipation	[mW]	15.17	0.0%	**0.000**

Table 2-7 – Worse Case Power Dissipation in Photometer Mode

2.6.2 Heat Loads in Worse Case Photometer Mode

The table below summarises the SPIRE heat loads at the various interfaces for the worse case operating mode in photometer mode.

		Performance	Reqt	Goal
Cooler Total Load	[uW]	**29.4 (*)**	**30**	**30**
Cooler Hold Time	[hr]	**49.4**	**46**	**46**
L0 Evaporator Heat Load	[mW]	**0.44**	-	-
L0 Pump Heat Load	[mW]	**2.3**	**2**	**2**
L0 Enclosure Heat Load	[mW]	**0.7**	**4**	**1**
L1 PJFET Harness Parasitic	[mW]	2.17	-	-
L1 SJFET Harness Parasitic	[mW]	0.29	-	-
L1 Isolation Supports	[mW]	7.97	-	-
L1 Housekeeping Harness	[mW]	1.62	-	-
L1 Radiation Load	[mW]	3.64	-	-
L1 Dissipation	[mW]	2.64	-	-
Total L1 Heat Load	[mW]	**16.75**	**15**	**13**
L3 PJFET Heat Load	[mW]	**41.96**	**50**	**50**
L3 SJFET Heat Load	[mW]	**-5.34**	**25**	**25**

Table 2-8 – SPIRE Heat Load Performance in Worse Case Photometer Mode

Notes:

- Please note that the Herschel L0 HeII interface temperature is assumed to be at 1.65K.
- The cooler total heat load includes a 1uW (*) for PTC operation.
- The results presented do not include any margin.

Observations:

- The heat load at the pump L0 interface exceeds the 2mW requirement but the heat loads from the L0 Enclosure is much lower than the requirement.
- The total L1 heat load exceeds the 15mW requirement in this case but the instrument still meets its hold time requirements.

2.6.3 Temperatures in Worse Case Photometer Mode

Table 2-9 summarises the temperatures experienced at the various Herschel interfaces (for the operating heat loads described in section 2.6.2) while Table 2-10 gives an overview of the instrument temperatures.

Herschel Interface Temperature [K]	Photometer Mode
PJFET L3 IF	15.532
SJFET L3 IF	14.944
HOB - 371	12.098
HOB - 372	11.842
HOB - 373	12.08
HOB - 374	12.1
HOB - 375	12.094
HOB - 376 [-> SPIRE Cone]	12.097
HOB - 377	12.177
HOB - 378	12.308
HOB - 379	12.176
HOB - 380	12.193
HOB - 381 [-> SPIRE A-Frames]	12.173
L1 Strap IF #1	4.481
L1 Strap IF #2	4.567
HeII Tank	1.65

Table 2-9 – Herschel Interface Temperature in Worse Case Photometer Mode

SPIRE Temperature [K] (*)	Photometer Mode
Cold Tip (adjusted for self-heating on sensor)	0.28
PLW BDA Detector	296
PMW BDA Detector	298
PSW BDA Detector	299
SLW BDA Detector	301
SSW BDA Detector	294
Cooler Pump	1.851
Cooler Shunt	1.656
L0 Photometer Enclosure	1.68
L0 Spectrometer Enclosure	1.67
SOB	4.8
PJFET Chassis	16.75
SJFET Chassis	14.85

(*) Mean temperature for enclosures

Table 2-10 - SPIRE Temperature in Worse Case Photometer Mode

Observations:

- All detectors are within the required 310mK absolute temperature.

2.7 SPIRE Spectrometer Mode – Steady-State Analysis

2.7.1 Power Dissipation in Worse Case Spectrometer Mode

The table below summarises the power dissipation for the SPIRE mechanisms, calibration source and electronic boxes, including their duty cycle for the worse case operating mode when in spectrometer mode.

BSM – POF8 – Calibration with PCAL	[mW]	0.024	100%	0.024
SCAL2 at 80K	[mW]	2.000	100%	2.000
Extra power component during SCAL dynamic switching	[mW]	0.870	50%	0.435
SMEC Actuator – R10	[mW]	0.430	0%	0.000
SMEC Actuator – R100	[mW]	0.460	0%	0.000
SMEC Actuator – R1000	[mW]	3.560	100%	3.560
SMEC Encoder (Level 2)	[mW]	1.200	100%	1.200
SMEC LVDT	[mW]	0.112	100%	0.112
BSM Sensors	[mW]	0.800	100%	0.800
BSM Motor – POF1 – Chopping (+/-63")	[mW]	0.548	0%	0.000
BSM Motor – POF2 – 7pt Jiggle Map	[mW]	0.300	0%	0.000
BSM Motor – POF3 – 64pt Jiggle Map	[mW]	1.550	50%	0.775
BSM Motor – POF5 – Scan	[mW]	0.000	0%	0.000
Extra power component during BSM dynamic switching	[mW]	0.250	50%	0.125
Total L1 Dissipation	[mW]	-	-	**9.031**
PJFET Dissipation	[mW]	56.64	0.0%	**0.000**
SJFET Dissipation	[mW]	15.17	100.0%	**15.170**

Table 2-11 – Worse Case Power Dissipation in Spectrometer Mode

2.7.2 Heat Loads in Worse Case Spectrometer Mode

The table below summarises the SPIRE heat loads at the various interfaces for the worse case operating mode in spectrometer mode.

		Performance	Reqt	Goal
Cooler Total Load	[uW]	**29.1**	**30**	**30**
Cooler Hold Time	[hr]	**49.9**	**46**	**46**
L0 Evaporator Heat Load	[mW]	**0.53**	-	-
L0 Pump Heat Load	[mW]	**2.38**	**2**	**2**
L0 Enclosure Heat Load	[mW]	**0.86**	**4**	**1**
L1 PJFET Harness Parasitic	[mW]	0.91	-	-
L1 SJFET Harness Parasitic	[mW]	0.21	-	-
L1 Isolation Supports	[mW]	6.66	-	-
L1 Housekeeping Harness	[mW]	2.42	-	-
L1 Radiation Load	[mW]	3.65	-	-
L1 Dissipation	[mW]	9.05	-	-
Total L1 Heat Load	[mW]	**20.91**	**15**	**13**
L3 PJFET Heat Load	[mW]	**0.48**	**50**	**50**
L3 SJFET Heat Load	[mW]	**12.63**	**25**	**25**

Table 2-12 – SPIRE Heat Load Performance in Worse Case Spectrometer Mode

Notes:

- Please note that the Herschel L0 HeII interface temperature is assumed to be at 1.65K.
- The results presented do not include any margin.

Observations:

- The heat load at the pump L0 interface exceeds the 2mW requirement but the heat loads from the L0 Enclosure is much lower than the requirement.
- The total L1 heat load exceeds the 15mW requirement in this case but the instrument still meets its hold time requirements.

2.7.3 Temperatures in Worse Case Spectrometer Mode

Table 2-13 summarises the temperatures experienced at the various Herschel interfaces (for the operating heat loads described in section 2.7.2) while Table 2-14 gives an overview of the instrument temperatures.

Herschel Interface Temperature [K]	Spectrometer Mode
PJFET_L3 IF	11.785
SJFET_L3 IF	12.687
HOB - 371	11.492
HOB - 372	11.273
HOB - 373	11.475
HOB - 374	11.494
HOB - 375	11.482
HOB - 376 [-> SPIRE Cone]	11.485
HOB - 377	11.565
HOB - 378	11.64
HOB - 379	11.539
HOB - 380	11.581
HOB - 381 [-> SPIRE A-Frames]	11.535
L1 Strap IF #1	4.885
L1 Strap IF #2	4.985
HeII Tank	1.65

Table 2-13 – Herschel Interface Temperature in Worse Case Spectrometer Mode

SPIRE Temperature [K] (*)	Spectrometer Mode
Cold Tip (adjusted for self-heating on sensor)	0.28
PLW BDA Detector	296
PMW BDA Detector	298
PSW BDA Detector	300
SLW BDA Detector	301
SSW BDA Detector	294
Cooler Pump	1.86
Cooler Shunt	1.66
L0 Photometer Enclosure	1.70
L0 Spectrometer Enclosure	1.68
SOB	5.4
PJFET Chassis	11.8
SJFET Chassis	13

(*) Mean temperature for enclosures

Table 2-14 - SPIRE Temperature in Worse Case Spectrometer Mode

Observations:

- All detectors are within the required 310mK absolute temperature.

2.8 SPIRE Steady-State Average Performance during Mission

2.8.1 Average Power Dissipation during Mission

The table below summarises the power dissipations for the SPIRE mechanisms, calibration source and electronic boxes, including their duty cycle for all operating modes during the mission lifetime.

PACS Mode	**-**	**-**	**ON Spectro**	**ON Photo**	**OFF**	**OFF**	**OFF**	**OFF**	**OFF**
HIFI Mode	**-**	**-**	**OFF**	**OFF**	**ON**	**OFF**	**OFF**	**OFF**	**OFF**
SPIRE Mode	**-**	**-**	**OFF**	**OFF**	**OFF**	**ON Photo**		**ON Spectro**	
BSM – POF8 – Calibration with PCAL	[mW]	0.024	0	0	0	100%	0.024	100%	0.024
SCAL2 at 80K	[mW]	2.000	0	0	0	0%	0	100%	2.000
Extra power component during SCAL dynamic switching	[mW]	0.870	0	0	0	0%	0	50%	0.435
SMEC Actuator – R10	[mW]	0.430	0	0	0	0%	0	25%	0.108
SMEC Actuator – R100	[mW]	0.460	0	0	0	0%	0	25%	0.115
SMEC Actuator – R1000	[mW]	3.560	0	0	0	0%	0	50%	1.780
SMEC Encoder (Level 2)	[mW]	1.200	0	0	0	0%	0	100%	1.200
SMEC LVDT	[mW]	0.112	0	0	0	0%	0	100%	0.112
BSM Sensors	[mW]	0.800	0	0	0	100%	0.800	100%	0.800
BSM Motor – POF1 – Chopping (+/-63")	[mW]	0.548	0	0	0	25%	0.137	0%	0.000
BSM Motor – POF2 – 7pt Jiggle Map	[mW]	0.300	0	0	0	25%	0.075	0%	0.000
BSM Motor – POF3 – 64pt Jiggle Map	[mW]	1.550	0	0	0	25%	0.388	50%	0.775
BSM Motor – POF5 – Scan	[mW]	0.000	0	0	0	25%	0.000	0%	0.000
Extra power component during BSM dynamic switching	[mW]	0.250	0	0	0	100%	0.250	50%	0.125
Total L1 Dissipation	[mW]	-	**0**	**0**	**0**	-	**1.674**	-	**7.474**
PJFET Dissipation	[mW]	56.64	**0**	**0**	**0**	100%	**56.64**	0%	**0**
SJFET Dissipation	[mW]	15.17	**0**	**0**	**0**	0%	**0**	100%	**15.17**

Table 2-15 - Average SPIRE Dissipation during Mission

Observations:

- One can see that in this case the average power dissipation at L1 in photometer mode is 1.67mW versus 2.62mW for the worse case power dissipation.

- One can see that in this case the average power dissipation at L1 in spectrometer mode is 7.47mW versus 9.03mW for the worse case power dissipation.

2.8.2 Average Heat Loads during Mission

PACS Mode	**-**	**ON Spectro**	**ON Photo**	**OFF**	**OFF**	**OFF**			
HIFI Mode	**-**	**OFF**	**OFF**	**ON**	**OFF**	**OFF**			
SPIRE Mode	**-**	**OFF**	**OFF**	**OFF**	**ON Photo**	**ON Spectro**			
Mission Duty Cycle	**[%]**	**16.65**	**16.65**	**33.3**	**16.65**	**16.65**	**Mission Average**	**Reqt**	**Goal**
L0 Evaporator Heat Load	[mW]	0.62	0.37	0.48	0.44	0.53	**0.49**	-	-
L0 Pump Heat Load	[mW]	0.61	0.37	0.47	2.3	2.38	**1.10**	**2**	**2**
L0 Enclosure Heat Load	[mW]	1.00	0.59	0.78	0.7	0.86	**0.79**	**4**	**1**
L1 PJFET Harness Parasitic	[mW]	1.00	0.83	1.36	2.17	0.91	-	-	-
L1 SJFET Harness Parasitic	[mW]	0.18	0.15	0.24	0.29	0.21	-	-	-
L1 Isolation Supports	[mW]	7.89	6.3	11.01	7.97	6.66	-	-	-
L1 Housekeeping Harness	[mW]	1.38	1.4	1.85	1.62	2.42	-	-	-
Radiation Load	[mW]	3.65	3.58	3.76	3.64	3.65	-	-	-
Total L1 Dissipation	[mW]	0.00	0.00	0.00	1.67	7.47	-	-	-
Total L1 Heat Load	[mW]	11.84	10.62	16.45	16.75	20.91	**15.5**	**15**	**13**
L3 PJFET Heat Load	[mW]	-0.04	0.12	-0.318	41.96	0.48	**6.98**	**50**	**50**
L3 SJFET Heat Load	[mW]	0.06	0.08	0.033	-5.34	12.63	**1.25**	**25**	**25**

Table 2-16 – Average SPIRE Heat Loads During Mission

Notes:

- Please note that the Herschel L0 HeII interface temperature is assumed to be at 1.65K.
- The results presented do not include any margin.

Observations:

- One can see that the SPIRE L1 heat load exceeds the 15mW requirement by 0.5mW.