Title: **H-EPLM Thermal Model and Analysis**

CI-No: 120 000

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Distribution: See Distribution List (last page)

Issue	Date	Page	Description of Change	Release
1	30.11.01	all	First Issue	
2Draft	11.06.02	all	Draft Issue for PDR Sect. 5.3: - HTT, HOT, TS1 and innermost tank suspension straps implemented in ESARAD Geometry Model, - Heat shield Beam entrance baffles merged to a common baffle with 0.8 emissivity and attached to TS2 only, - Cryostat Baffle Insert with 500 mm diameter introduced, - Telescope opening changed from 360 mm to 560 mm. Sect. 5.4: - +Y Radiator rotated by 14° towards Y axis (to avoid collision with filling port), - emissivity of CVV main radiator changed from 0.8 to 0.7, - emissivity of CVV ±Y and –Z Radiator changed from 0.9 to 0.8. Sect. 5.5: - Waveguides implemented in ESARAD Geometry Model, - LOU harness updated acc. to RD 02, - LOU radiator design updated acc. to ECP HP-2-ASED-CP-001, - Telescope mechanical fixation on CVV changed from GFRP struts to T300 CFRP struts, - BOLA direct mounted on CVV and covered with MLI Sect. 5.6: - Scientific harness updated acc. to RD 02, - Thermalization of SPIRE JFET harness shifted from TS 1 to TS 2. Sect. 5.7: - HSS update acc. to. Drawing Set Status “Begin 2002“. Sect. 5.8: - SVM Thermal Shield modified (+Z half deleted), - SVM top MLI set to 230 K boundary acc. to AD 07, - Cross-section to length ratio of SVM/CVV struts changed from 18.42 mm to 13.05 mm. Sect. 6.1:	

Issue	Date	Page	Description of Change	Release
			- MLI performance data changed based on RD 08 and RD 09.	
2	17.06.02	all	PDR Issue of document	
2.1	10.12.02	30	Table 5.2-2 corrected (typo: JFET dissipation in wrong column)	
		35, 36	Table 5.3-1 corrected (typo: 9 LOU windows instead 7)	
		37	Explanation of CVV radiator model added as requested in PDR RID 8516	
		41	Table 5.4-1 corrected (typo: 9 LOU windows instead 7)	
		47	Table 5.6-2 corrected (typo: JFET harness length)	
		52	Complete data as requested in PDR RID 8517	
		53, 55	Correction of SVM shield skin data acc. to TMM assumptions	
		58-64	References for material data plots completed as requested in PDR RID 8517	
		74	Table 7.4-1 corrected and completed	
		79	Table 7.4-3 completed as requested in PDR RID 8519	
		80	Figure 7.4-5 exchanged (copy and paste error)	
		86	Table 7.4-6 corrected (typo: HOB temperature uncertainty)	
		90	Introduction of Section 7.4.5 to refer to transient analyses described in RD 06	
		91	Lifetime of PDR Collocation Status added	
		Annex 1	Temperature listings for in orbit hot and cold case as well as for ground case added as requested in PDR RID 8517	
		Annex 2	Input Traceability Matrix added	
3	09.09.03	all	Document entirely modified. Major changes: - Restructuring of H-EPLM GMM/TMM to allow Submodel structure - Refinement of CVV lower bulkhead MLI (HP-2-ASPI-TN-0366) - Increase of CVV radiator (upper bulk and Cryostat Baffle). - Refinement of Telescope Geometry based on ASEF catia model ICD-DT0018251-02-00-3D-TELESCOPE_28_05_02. - Refinement/update of ventline modelling. - Implementation of Cryo-Cooled Cover (low emissive cover shield). - Update LEOP Calculation (PPS Sample 5). - Implementation of HIFI coax cable: Precision Tube JS50141,	

Issue	Date	Page	Description of Change	Release
			JN50141. - Refinement/update of beam entrance baffles - Removal of BOLA - Implementation of H-RSVM submodel (ASPI delivery) - Introduction of L3 interfaces. - Update of SVM Thermal Shield material (CFRP panel instead of Al panel). - Removal of Instrument Shield MLI - Introduction of 100 mm EPLM enlargement - Implementation of HSS lower stiffening ribs - Introduction of Safe Mode - Introduction of On-Ground Test Mode (IMT) - Implementation of optimized tank suspension straps - ISO TMM conductance values between suspension bolts and heat shields replaced by physical values - Update/Refinement of LOU TS2 baffle and LOU windows in H-EPLM GMM - Refinement (nodal- break-down) of Cryostat Baffle and Cryostat Baffle MLI - Update of Al 5083 thermal conductivity data (CVV) acc. to NIST data base - Implementation of HSS/SVM closure MLI - Implementation of overall instrument timeline - Update of Lifetime calculation (HP-2-ASED-TN-0065) - Implementation of Instrument Submodels, see below - Integration of PACS RTMM update (delivery date 09.05.2003) - Integration of SPIRE RTMM Issue 2.3 - Integration of HIFI RTMM update (delivery date 28.03.2003)	
4	15.04.04	all	Major changes: - Integration of SPIRE RTMM Issue 2.5 - Refinement of nodal break down of Thermal Shields (in circumferential direction) incl. Ventline and SFW - Implementation of CDR Harness (HP-2-ASED-TN-0010, Issue 3.1) - Update of CVV internal MLI performance data (based on FZ Karlsruhe test results) - Implementation of GFRP and CFRP test data for TSS - Implementation of updated (enlarged) LOU Radiator & LOU - Implementation of Startracker heat load (200mW) - Replacement of L0 thermal link conductance requirements and L1/L3 link conductance by actual geometry and measured (temperature dependent) conductance data - Radiation in filling line - Gas conduction in cover flush line - Update of solar array thermo-optical properties - Merging of the two SPIRE L1 strap I/F points on VL to one I/F - Beam entrance: introduction of TS2 baffle aperture and IMT crown - Update of Pre-Launch/Early Orbit scenario - Update of Lifetime formula	

Issue	Date	Page	Description of Change	Release
			- Introduction of IMT transient timeline - Update of instrument interface temperature & heat flow requirements - Update of CVV radiator thermal properties	
5Draft	16.07.07		Draft issue 5 for H-EPLM MQR session B	

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1 SCOPE

ATTENTION:

PLEASE NOTE THAT THIS IS A DRAFT VERSION OF THE ISSUE 5 THERMAL REPORT. IT CONTAINS SOME SECTIONS/FIGURES/TABLES THAT STILL HAVE ISSUE 4 STATUS AND THEREFORE ARE SPECIAL MARKED LIKE "TO BE UPDATED". IN PARTICULAR, THE COMPLETE CONTENTS OF SECTIONS 4 (MODEL DESCRIPTION), SECTION 5 (MATERIAL PROPERTIES) AND PARTS OF SECTION 6 (GROUND AUTONOMY, IMT, SENSITIVITIES) HAVE NOT BEEN UPDATED YET.

This document describes the HERSCHEL EPLM Detailed Thermal Mathematical Model (DTMM) and Geometrical Mathematical Model (DGMM). It represents the PFM configuration and incorporates the correlation activities performed in the frame of the STM and STM2 test campaigns [RD 45] [RD 46]. The nodal break down and the corresponding assumptions are described in detail. Following the issue numbering of this report, the thermal model is referenced as issue 5 and will be released with the next issue of [RD 47].

Material properties used in the DTMM/DGMM are also reported in this document. Finally, the flight prediction analyses performed with this thermal model are described in detail,. The results are shown basically in form of temperature distribution and heat flow charts. A comprehensive sensitivity analysis is performed with respect to lifetime and EPLM temperatures. Instrument interface temperatures are calculated using a dedicated instrument timeline of 6 x 48h which includes transient operation of and switching between 5 different instrument modes. Finally, lifetime calculations are carried out based on the thermal analysis results including transient in-orbit cool down.

2 Applicable and Reference Documents

2.1 Applicable Documents

AD 01 HERSCHEL/PLANCK Instrument Interface Document IID Part A, Doc. No.: SCI-PT-IIDA-04624, Issue 4, 30.04.2006

AD 02 HERSCHEL/PLANCK Instrument Interface Document IID Part B for PACS, Doc. No.: SCI-PT-IIDB/PACS-02126, Issue 4, 02.06.2006

AD 03 HERSCHEL/PLANCK Instrument Interface Document IID Part B for SPIRE, Doc. No.: SCI-PT-IIDB/SPIRE-02124, Issue 4, 01.04.2006

AD 04 HERSCHEL/PLANCK Instrument Interface Document IID Part B for HIFI, Doc. No.: SCI-PT-IIDB/HIFI-02125, Issue 3.3, 21.10.2005

AD 05 H-EPLM Environment & Test Requirements Specification, Doc. No.: HP-2-ASED-SP-0004, Issue 3, 16.07.2004

AD 06 H-EPLM Requirement Specification, Doc. No.: HP-ASPI-SP-0250, Issue 3.3, 20.10.2004

AD 07 Herschel EPLM Interface Specification; HP-2-ASPI-IS-0039; Issue 6, 07.10.2004

AD 08 Herschel EPLM Thermal Interfaces; HP-1-ASP-TN-0413; Issue 1, 24.10.2002

AD 09 List of Acronyms, HP-1-ASPI-LI-0077, Issue 2, 12.07.2004

AD 10 General Design and Interface Requirements (GDIR), Doc. No.: HP-1-ASPI-SP-0027, Issue 5, 07.10.2004

AD 11 RFD for HIFI Instrument Interface Temperatures, Doc. No.: HP-2-ASED-RD-0040, Issue 2, 27.07.2006

AD 12 RFD for Lifetime calculation approach with changed instrument interfaces, Doc. No.: HP-2-ASED-RD-0047, Issue 1, 27.06.2007

AD 13 Herschel Telescope Specification, Doc. No.: HP-2-ESA-SP-4671 / SCI-PT-RS-04671, Issue 7, 26.07.2004

AD 14 RFD for Instrument Interface Temperatures, Doc. No.: HP-2-ASED-RD-0020, Issue 1, 26.04.2004

AD 15 RFW for Photometer JFET dissipation, Doc. No.: HP-2-RAL-RW-0005, Issue 1, 01.04.2006

2.2 Reference Documents

RD 01 Hypothesis and Methods for Lifetime Calculations; Doc.No.: HP-2-ASED-TN-0065, Issue 2, dated 07.04.2004

RD 02 Harness Inputs for Thermal Analysis Doc.No.: HP-2-ASED-TN-0010, Issue 3.2, dated 21.01.05

RD 03 Reduced PACS Instrument Interface TMM, Issue 3.1, provided by ESA on 26.04.2007

RD 04 Reduced SPIRE Instrument Interface TMM, Issue 2.6, provided by SPIRE on 27.04.2007

RD 05 Reduced HIFI Instrument Interface TMM provided by HIFI on 02.04.2003

RD 06 He System Description, HP-2-ASED-RP-0034, Issue 3, dated 15.03.2004

RD 07 Thermal Mathematical Modelling Methods of HPLM Ventline on Optical Bench, HP-2-ASED-TN-0056, Draft Issue, dated 10.06.02

RD 08 Evaluation of LINDE/ESTEC-MLI Measurements and Transformation to the ISO Cryostat MLI Design, Doc.No.: ISO.TN-B1430.007, dated 12.07.88

RD 09 J. Doenecke: Survey and Evaluation of Multilayer Insulation Heat Transfer Measurement, ICES July 1993

RD 10 PACS FPU Drawing No. PACS-KT-ICD-0000W1.22, dated 04.09.01

RD 11 SPIRE Interface Drawing No. 5264 300, dated 30.07.01

RD 12 HIFI-FPU External Configuration Drawing No. 455-3-001-0, dated 29.05.01

RD 13 H-EPLM Pressure Drop Analysis, HP-2-ASED-TN-0071, Issue 1.1, dated 12.03.2004

RD 14 M. Sander: ISO Thermal Mathematical Model, Submodel VENT, Version 3.00, 24.02.1994

RD 15 Test Report of the Additional Pressure Drop Measurements of DASA Valve #990-11 at Different Mass Flows and Temperatures, ISO-TR-BCGI0.008, Issue 1, 02.11.1993

RD 16 SPIRE Cryogenic Interface Thermal Mathematical Model, SPIRE-RAL-PRJ-000728, Issue 2.5, dated 02.02.2004

RD 17 EPLM Thermal Analysis from Fairing Jettison to Launcher Separation, HP-2-ASED-TN-0096, Issue 1, dated 14.04.2004

RD 18 Electrical Power Analysis and Design Report, Doc.No.: HP-2-GAMI-AN-0014, dated 19.05.03

RD 19 Helium Content Determination in Orbit, HP-2-ASED-AN-0010, Issue 1,dated 20.02.04

RD 20 TSS Design Justification, HP-2-ASED-TN-0081, dated 12.05.2003

RD 21 Procurement Specification for Tank Support Suspensions, HP-2-ASED-PS-0017, Issue 2, dated 25.03.03

RD 22 Procurement Specification for Herschel Spatial Framework, HP-2-ASED-PS-0016, Issue 2.1, dated 14.02.03

RD 23 OBA Specification, HP-2-ASED-PS-0015, Issue 2.1, dated 15.03.04

RD 24 Procurement Specification for H-PLM Internal MLI, HP-2-ASED-PS-0028, Issue 2, dated 07.03.03

RD 25 Procurement Specification for Herschel Support Structures, HP-2-ASED-PS-0026, Issue 1, dated 30.07.02

RD 26 Procurement Specification for SVM Thermal Shield, HP-2-ASED-PS-0034, Issue 1, dated 30.06.02

RD 27 Procurement Specification for Herschel Telescope Mounting Structure, HP-2-ASED-PS-0037 Issue 1, dated 30.07.02

RD 28 Procurement Specification for Herschel External MLI, HP-2-ASED-PS-0029, Issue 1, dated 29.07.02

RD 29 Herschel Telescope Thermal Design and Analysis, MoM SCI-PT-18440, dated 27.05.03

RD 30 Thermal Shields Procurement Specification PFM, HP-2-ASED-PS-0044, Issue 1, dated 04.11.02

RD 31 Procurement Specification for Herschel Cryostat Vacuum Vessel, HP-2-ASED-PS-0003, Issue 4, dated 09.10.02

RD 32 Procurement Specification for Cryostat Cover, Cryostat Baffle and Test Components, HP-2-ASED-PS-0018, Issue 2, dated 18.03.03

RD 33 HIFI LOU Cryoharness - Electrical/Thermal Performance, HP-2-ASED-FX-0553-03, dated 27.06.03

RD 34 RYMSA CDR Data Package

RD 35 Evaluation of Thermal Property Tests for the H-EPLM TMM, HP-2-ASED-RP-0095, Issue 1, dated 15.04.2004

RD 36 Evaluation of Calorimeter Tests for Herschel Internal MLI; HP-2-ASED-TN-0083, Issue 1, dated 01.03.2004

RD 37 HSS Thermal Analysis Report, HP-2-DSSA-AN-0013, Issue 3, Feb. 2004,

RD 38 Strut Fitting Design Update, HP-ASED-FX-0037-04, dated 28.01.2004

RD 39 HP-2-AAE-AN-0004 Issue 2, dated 06.10.2003

RD 40 LEOP HTT Temperature Margins and Verification, HP-ASED-FX-0226-04, dated 31.03.2004

RD 41 Herschel Planck Visit at French Guiana Launch Site, HP-1-AEA-MN-0003

RD 42 Reduced Telescope TMM/GMM, Issue 2.1, provided by ESA on 15.05.2007

RD 43 Barbecue Thermal Analyses, Doc. No.: HP-2-ASED-TN-0112, Issue 1, 07.02.2005

RD 44 SVM Thermal Shield Thermal Analyses, Doc. No.: HP-2-ASED-TN-0119, Issue 1, 25.04.2005

RD 45 H-EPLM TMM Correlation of STM TB/TV Test, Doc. No.: HP-2-ASED-RP-0176, Issue 1, 23.03.2007

RD 46 H-PLM TMM Correlation of Delta STM TB/TV Test, Doc. No.: HP-2-ASED-RP-0230, Issue 1, 12.06.2007

RD 47 H-EPLM Thermal Model Release, Doc. No.: HP-2-ASED-RP-0207, Issue 4, 03.05.2007

RD 48 TMM Correlation for L0 Conductance Measurements, Doc. No.: HP-2-ASED-TN-0138, Issue 1.1, 26.06.2007

RD 49 TMM Correlation for L1 and L3 Performance Measurements, Doc. No.: HP-2-ASED-TN-0147, Issue 1.1, 29.06.2007

Note: Further References concerning material properties are listed in section 5.6 separately.

2.3 Abbreviations

ASED	Astrium GmbH
ASP	Alcatel Space
HSS	Herschel Solar Array & Sunshade
OBA	Optical Bench Assembly
OBP	Optical Bench Plate
SS	Summer Solstice
SSD	Sunshade
TSS	Tank Support Suspensions
TASF	Thales Alenia Space France
WS	Winter Solstice

Further Abbreviations are listed in AD 09.

3 Requirements and Boundary Conditions

3.1 Thermal Requirements

3.1.1 Lifetime

The relevant requirements regarding the H-EPLM lifetime are as follows:

GDGE-210 [AD 10]:

For the Herschel mission, the spacecraft shall have a nominal lifetime of 3. 5 years. This duration is counted from the launch to end of mission. This duration includes an allocation of 6 months for the transfer to the L-2 Lissajous orbit. (SPER-005)

HERS-0530 [AD 06]:

A cryogenic lifetime of 3.5 years shall be achieved. This requirement shall be met including dispersions. Computation of the cryogenic lifetime shall be as defined in Annex 1 of [AD06].

HERS-0535 [AD 06]:

The lifetime computation shall take into account a total conductive heat load of 200 mW via the 6 interface points of the Star Tracker Assembly.

HERS-0540 [AD 06]:

The determination on a half-yearly basis (7 measurements over nominal lifetime) of the remaining mass of helium contained in the main tank over the nominal lifetime shall be included in the lifetime calculation and shall not shorten the lifetime by more than 1%.

HERS-2250 [AD 06]:

The cryostat shall allow for an on-ground autonomy period of 6 days with the helium tank filled and the helium temperature after 6 days below 2.1 K and instruments being non operational.

For the in-orbit lifetime prediction, it has been agreed between ESA, TASF and ASED to replace the formerly used IID-A allocations by IID-B conditions, i.e. to perform the calculations with implemented instrument TMMs [RD 03] [RD 04] [RD 05]. Instrument dissipations meanwhile have been verified in unit level tests, so the IID-B values are considered more realistic than the IID-A allocations. An RFD has been raised against HERS-0530 to formalise this approach [AD 12]. The instruments are operated in average dissipation mode, and an average thermal environment at L2 orbit is used to calculate the average massflow. The corresponding external heat loads are given in Table 3.2-1.

3.1.2 Temperature Requirements of Instruments within Cryostat

The temperature limits required at the instrument interfaces are specified in the instrument interface control documents IIDBs for PACS [AD 02], SPIRE [AD 03] and HIFI [AD 04] and are compiled in Table 3.1-1 to Table 3.1-3 together with the corresponding interface nodes.

Instrument Interface	Temp. Level	TMM Node	Operating		Heat Load	Non-operating	
PACS			Min. [K]	Max. [K]	[mW]	Min.	Max.
Red Detector	L0	724	1.6	1.75	1.0	NA	60°C *) 85°C **)
Blue Detector	L0	723	1.6	2.0	2.2	NA	60°C *) 85°C **)
Cooler Pump	L0	761	1.6	10 5	500 (peak) 2.2	NA	60°C *) 85°C **)
Cooler Evaporator	L0	762	1.6	1.85	15.1	NA	60°C *) 85°C **)
Optics/Structure assy.	L1	781 782 783	2.0	5.0	30	NA	60°C *) 85°C **)
OBA Interface	L2	371	NA	12	0	NA	NA

*) Continuous temperature limit

**) Short-duration temperature limit for bake-out during a maximum of 3 days at 80°C

Table 3.1-1: PACS Temperature Limits

Instrument Interface	Temp. Level	TMM Node	Operating		Heat Load	Non-operating	
SPIRE			Min. [K]	Max. [K]	[mW]	Min.	Max.
Detector Enclosure	L0	814	0	2.0 1.71 (goal)	4.0 1.0 (goal)	NA	60°C *
Cooler Pump	L0	815	0	10 2	500 (peak) 2	NA	
Cooler Evaporator	L0	816	0	1.85 1.75 (goal)	15 15 (goal)	NA	
SPIRE OBA units	L1	800 830	0	5.5 3.7 (goal)	15 13 (goal)	NA	
OBA Interface	L2	381		12 8 (goal)	0 0 (goal)	NA	80°C **
Instrument Shield	L2	315		16	0	NA	80°C **
PM-JFETs	L3	831	0	15	50	NA	80°C **
SM-JFET	L3	832	0	15	25	NA	

*) Continuous temperature limit, but compliant with bake-out temperature of 80°C for 72 h maximum

**) Bake-out temperature for 72 h maximum

Table 3.1-2: SPIRE Temperature Limits

Instrument Interface	Temp. Level	TMM Node	Operating		Heat Load	Non-operating	
HIFI			Min. [K]	Max. [K]	[mW]	Min.	Max.
L0 boundary	L0	949	0	2.1 **	6.8	0 K	60°C *
L1 boundary	L1	939	0	6.4 **	15.5	0 K	60°C *
FPU structure	L2	919	0	20	22	0 K	60°C *

*) Continuous temperature limit, but compliant with the bake-out of 3 days at 80°C

**) Value acc. RFD [AD 11]; L0 was 2.0 K, L1 was 6.0 K before

Table 3.1-3: HIFI Temperature Limits

Temperature Stability for HIFI as specified in AD 04

The following temperature changes shall not be exceeded during operation under the assumption of passive thermal control and with the exception of heat peaks caused by HIFI:

Level 2 parts: 0.015 K per 100 s

Level 1 parts: 0.006 K per 100 s

Level 0 parts: 0.006 K per 100 s

3.1.3 Temperature Requirements for LOU (outside Cryostat)

As specified in AD 04 the HIFI Local Oscillator Unit (LOU) shall not exceed the temperature limits at the mounting interfaces compiled in following Table 3.1-4.

Instrument Interface	Thermal node No.	Operating		Functional testing	Start-up	Switch-off	Non-operating	
		Min. [K]	Max. [K]	Max. [K]	[K]	[K]	Min. [K]	Max. [K]
LOU	4201	90	150	298	80	303	80	328

Table 3.1-4: LOU Temperature Limits

3.1.4 Temperature Requirements for Telescope

For the HERSCHEL Telescope, the following requirements exist [AD 13]:

	Thermal node No.	Operating		Contamination Release (3 weeks)		Non-operating	
		Min. [K]	Max. [K]	Min. [K]	Max. [K]	Min. [K]	Max. [K]
Telescope	8001	70	90	313	323	55	358

Table 3.1-5: Telescope Temperature Limits

3.1.5 Thermal Interface Requirements for SVM

According to HEIF-TH-225 a [AD 7], the maximum thermal flux from HSS to SVM shall be less than 15 W distributed as follows:

- maximum 5 W via HSS CFRP struts, uniformly distributed on each interface point,
- maximum 10 W via Sunshield brackets, uniformly distributed on each interface point.

3.2 Thermal Environment

3.2.1 Ground and Pre-Launch Phase

According to R-EVT-040 [AD 05], the He filled PLM is in a temperature controlled environment at 22±3°C during ground operation.

During transport and storage, different environments apply, ranging from 10°C to 30°C at ambient pressure ranging from 970 mbar to 1070 mbar.

3.2.2 Early Orbit Phase

The thermal loads to be applied for the H-EPLM during the launch and early orbit phase are defined in detail in [AD 05].

Solar constant:

The applicable values of the solar constant for the early orbit phase (BOL) are:

- 1425 W/m² during Winter Solstice (WS)
- 1325 W/m² during Summer Solstice (SS)

The solar aspect angle evolution during launch is shown in Figure 3.2-1 [AD 13] [RD 43] [RD 44].

Albedo is the fraction of incident solar radiation that is reflected from the earth back into space. A value of 0.3 ± 0.05 shall be used.

Earth Infrared Thermal Radiation

The Earth infrared radiation shall be assumed as a black body with a characteristic temperature of 288 K. The average infrared radiation emitted by Earth is 230 W/m^2, with variations between 150 W/m² and 350 W/m².

From the above mentioned data, following load cases can be derived:

Hot Case: WS solar constant, max. Earth IR radiation, 0.35 albedo
BOL thermo-optical properties, Solar power generator in shunt mode

Cold Case: SS solar constant, min. Earth IR radiation, 0.25 albedo
BOL thermo-optical properties, Solar power generator in operating mode

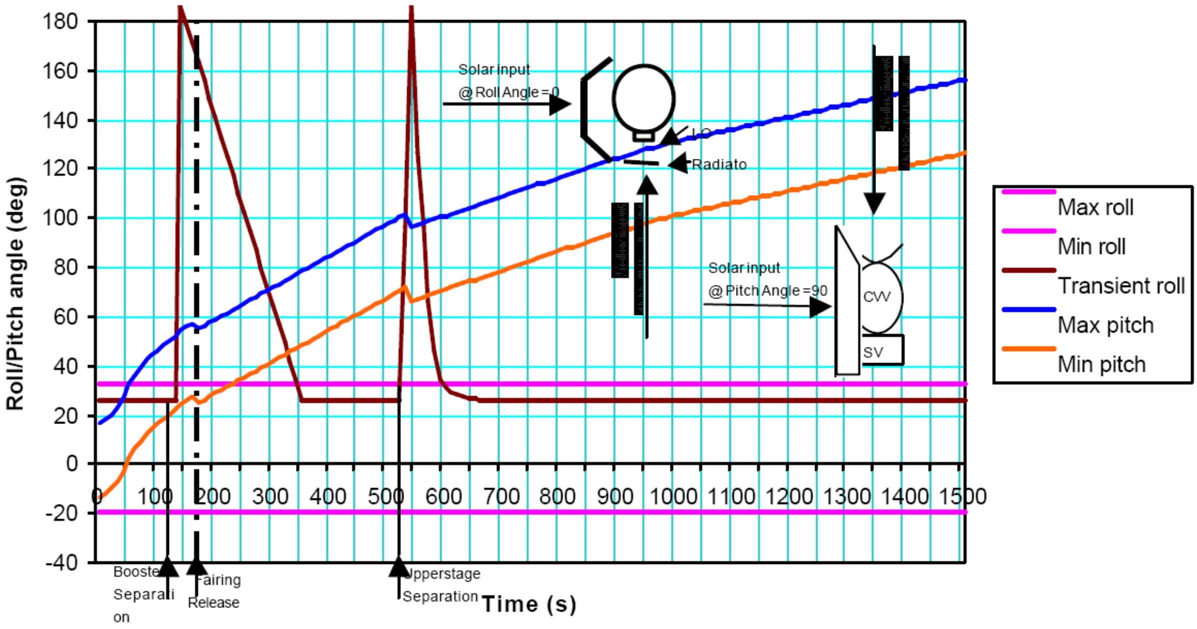


Figure 3.2-1: Roll and Pitch Angle Evolution During Launch

3.2.3 Operation Phase in L2 Orbit

During in-orbit operation at L2 the extremes of solar constant are (section 3.4.3 of [AD 05]):

- 1405 W/m² during Winter Solstice (WS)
- 1287 W/m² during Summer Solstice (SS)

During HERSCHEL mission phases and operational modes, the solar aspect angle will be maintained at ± 30 deg around the Y-axis and at ± 1 deg around the X-axis (HERS-0090 a [AD 06]).

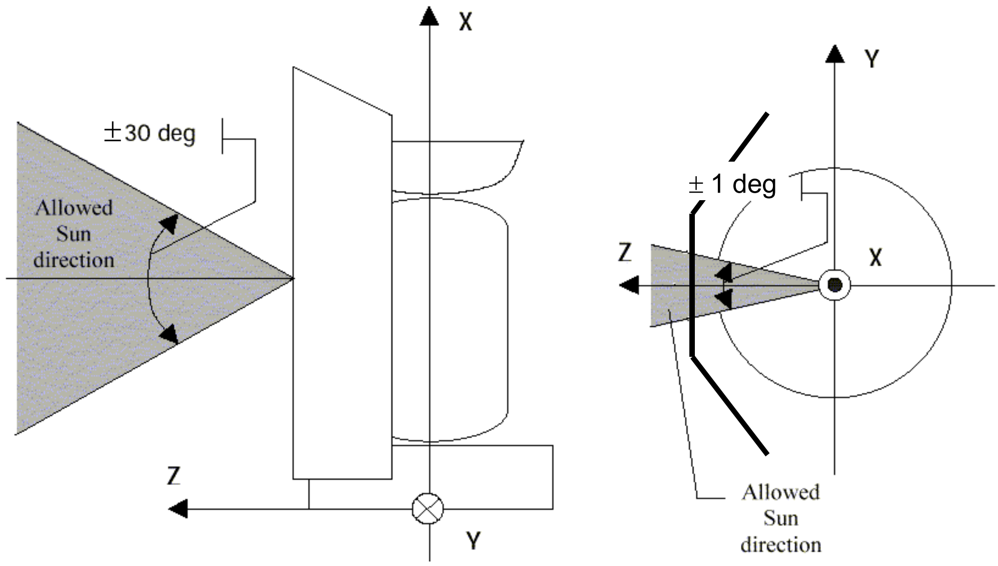


Figure 3.2-2: Solar Aspect Angels on H-EPLM at L2

From the above-mentioned data, the load cases compiled in Table 3.2-1 are derived (extracted from [RD 01]).

	Solar constant	Solar aspect angel SAA, around Y axis	OSR Solar absorptance	SVM I/F for CVV struts	SVM I/F for WG, SIH, CCH, HSS struts, SVM Thermal Shield struts
Cold case	1287 W/m² (SS)	30°	0.1 (BOL)	293 K	266 K
Hot case	1405 W/m² (WS)	0°	0.2 (EOL)	293 K	293 K
Average case	1352 W/m²	17.267°	0.15	293 K	280 K

Table 3.2-1: L2 orbit conditions

The temperatures of the H-EPLM structure attachment points on the SVM (conductive I/F, see also Table 3.2-1) and the temperatures of the SVM outer surfaces like top panel MLI (radiative I/F) are considered according to [AD 07] and [AD 08].

The average case is the basis for the lifetime calculation (see section 6.5), more details to that case are given in [RD 01].

4 Thermal Model Description

SECTION 4 TO BE UPDATED

The H-EPLM is written in ESATAN format V 8.9.2, the geometry model is written in ESARAD format V 5.6.3.

The following main calculation modes can be operated from ESATAN:

G Operation on Ground (steady state)

X Instrument Testing on Ground (steady state)

P Prelaunch: On-Ground Autonomy (SUBCASE=1) and Launch Autonomy (SUBCASE=2), including pre-cooling and HOT refill

L Launch until fairing jettisoning

T In-orbit transient cool down with telescope decontamination heating

O Operation at L2 orbit, including nominal steady state modes (hot, cold), transient orbit timeline, safe mode and a lifetime calculation mode acc. to [RD 01] (adjustable via control variables SUBCASE, IMODE, TRANS)

4.2 EPLM Configuration Breakdown for Thermal Modelling

Thermal Report	**TMM Issue 3** HP-2-ASED-RP-0011, Issue 3.0, dated 09.09.03	**TMM Issue 4** HP-2-ASED-RP-0011, Issue 4.0, dated April 04	**TMM Issue 5** HP-2-ASED-RP-0011, Issue 5.0, dated July 07
Thermal Mathematical Model	TMM (ESATAN): herschel.d, Issue 3, dated 12.05.2003. GMM (ESARAD): HERSCHEL_EOL.erg, Issue 3, dated 12.05.03	TMM (ESATAN): herschel.d, Issue 4, dated 19.03.2004. GMM (ESARAD): HERSCHEL_EOL.erg, Issue 4, dated 19.03.04	TMM (ESATAN): herschel.d, Issue 5, dated. GMM (ESARAD): HERSCHEL.erg, Issue 5, dated
HTT	Herschel HTT Interface Drawing: HP-2-ASED-ID-0001, Issue D, dated 08.08.03	Herschel HTT Interface Drawing: HP-2-ASED-ID-0001, Issue D, dated 08.08.03	Herschel HTT Interface Drawing: HP-2-ASED-ID-0001, Issue D, dated 08.08.03
HOT	Herschel HOT Interface Drawing: HP-2-ASED-ID-0002, Issue C, dated 06.08.03	Herschel HOT Interface Drawing: HP-2-ASED-ID-0002, Issue C, dated 06.08.03	Herschel HOT Interface Drawing: HP-2-ASED-ID-0002, Issue C, dated 06.08.03
OBP including Instrument Shield	Optical Bench Assembly Interface drawing HP-2-ASED-ID-0042, Issue A, dated 31.03.03	Optical Bench Assembly Interface drawing HP-2-ASED-ID-0042, Issue A, dated 31.03.03	Optical Bench Assembly Interface drawing HP-2-ASED-ID-0042, Issue A, dated 31.03.03
L0, L1, L3 Thermal Links	L0 Conductance Values acc. to OBA Specification, HP-2-	AIRL Thermal Analysis HP-2-AIRL-AN-0003, Issue 4, dated	

Thermal Report	TMM Issue 3 HP-2-ASED-RP-0011, Issue 3.0, dated 09.09.03	TMM Issue 4 HP-2-ASED-RP-0011, Issue 4.0, dated April 04	TMM Issue 5 HP-2-ASED-RP-0011, Issue 5.0, dated July 07
and Ventline	ASED-PS-0015, Issue 1.3, dated 17.01.03	13.02.04 and HP-2-AIRL-HO-0010, dated 05.02.04	
PACS	Reduced PACS Instrument TMM provided by PACS on 09.05.2003. ASED made GMM acc. to PACS FPU Drawing No. PACS-KT-ICD-0000W1.22, dated 04.09.01. (IR emissivity of FPU set to 0.26)	Reduced PACS Instrument TMM provided by PACS on 09.05.2003. ASED made GMM acc. to PACS FPU Drawing No. PACS-KT-ICD-0000W1.22, dated 04.09.01. (IR emissivity of FPU set to 0.26)	Reduced PACS Instrument TMM Iss. 3.1 provided by ESA on 26.04.2007. ASED made GMM acc. to PACS FPU Drawing No. PACS-KT-ICD-0000W1.22, dated 04.09.01. (IR emissivity of FPU set to 0.26)
SPIRE	Reduced SPIRE Instrument TMM, Issue 2.3 provided by SPIRE on 28.03.2003. SPIRE RGMM provided by SPIRE on 20.01.03, Issue 2 (IR emissivity of FPU: 0.2)	Reduced SPIRE Instrument TMM, Issue 2.5 provided by SPIRE on 03.02.2004. SPIRE RGMM provided by SPIRE on 03.02.04, Issue 3 (IR emissivity of FPU: 0.2)	Reduced SPIRE Instrument TMM, Issue 2.6 provided by SPIRE on 28.04.2007. SPIRE RGMM provided by SPIRE on 03.02.04, Issue 3 (IR emissivity of FPU STM2 correlated value: 0.05)
HIFI	Reduced HIFI Instrument TMM provided by HIFI on 28.03.2003. ASED made GMM acc. to HIFI-FPU External Configuration Drawing No. 455-3-001-0, dated 29.05.01 (IR emissivity of FPU set to 0.26)	Reduced HIFI Instrument TMM provided by HIFI on 28.03.2003. ASED made GMM acc. to HIFI-FPU External Configuration Drawing No. 455-3-001-0, dated 29.05.01 (IR emissivity of FPU set to 0.26	Reduced HIFI Instrument TMM provided by HIFI on 28.03.2003. ASED made GMM acc. to HIFI-FPU External Configuration Drawing No. 455-3-001-0, dated 29.05.01 (IR emissivity of FPU set to 0.26
Thermal Shields with TS2 Baffle and LOU Baffle	Geometry as Issue 2.1	Thermal Shield Geometry as Issue 2.1, Baffles acc. to. HP-2-ASED-ID-0065, dated Jan 04	
TSS	Dimensions acc. to HP-2-ASED-TN-0081, dated 12.05.2003	Dimensions acc. to HP-2-ASED-TN-0081, dated 12.05.2003	
Cryostat Baffle and Beam Entrance	Drawing No.: HP-2-ASED-ID-0063-01-0A, dated 31.01.03.	Drawing No.: HP-2-ASED-ID-0063, dated 31.01.03 and HP-2-ASED-ID-0095, dated 25.07.03	
Cryo Cover	Drawing No.: HP-2-ASED-ID-0063-01-0A, dated 31.01.03.	HP-2-AAE-IC-0001, Issue 3, dated 18.10.03	
CVV including	Herschel Overall Dimensions,	Herschel CVV Radiator	

Thermal Report	TMM Issue 3 HP-2-ASED-RP-0011, Issue 3.0, dated 09.09.03	TMM Issue 4 HP-2-ASED-RP-0011, Issue 4.0, dated April 04	TMM Issue 5 HP-2-ASED-RP-0011, Issue 5.0, dated July 07
Radiators	HP-2-ASED-ID-0009, Issue B, dated 08.07.03	Assembly, HP-2-APCO-DW-0015-01-0A	
LOU	as Issue 2.1	Thermal Analysis Handout from ABAQUS, dated 28.01.04	
Telescope	ASED made GMM acc. to ASEF catia model DT0018251-02-00-3D-TELESCOPE-28-05-02.model. (IR emissivity of M1 set to 0.01, RD29)	ASED made GMM acc. to ASEF catia model DT0018251-02-00-3D-TELESCOPE-28-05-02.model. (IR emissivity of M1 set to 0.01, RD29)	Reduced TMM/GMM Iss. 2.1 provided by ESA on 15.05.07
Harness	LOU harness: RD 33 HIFI Coax: Precision Tube JS50141 and JN50141 other harness as Issue 2.1	Harness Inputs for Thermal Analysis Doc.No.: HP-2-ASED-TN-0010, Issue 3.1, dated 12.03.04	
Sunshade Panels	Sunshade Panels I/F drawing HP-2-ASED-ID-0051, Issue B, dated 17.03.03	Sunshade Panels I/F drawing HP-2-ASED-ID-0051, Issue B, dated 17.03.03	
Solar Array Panels	Solar Array Panels I/F drawing HP-2-ASED-ID-0043, Issue B, dated 17.03.03	Solar Array Panels I/F drawing HP-2-ASED-ID-0043, Issue B, dated 17.03.03	
EPLM Support Structures	ASED reference design	HP-2-ECAS-AN-0004, Issue 2, dated 28.1103 and Fax HP-ASED-FX-0037-04, 28.01.04	
SVM Thermal Shield	Drawing No.: HP-2-ASED-ID-0056-01-0A, not yet released	Drawing No.: HP-2-ASED-ID-0056, Issue A, dated 14.10.03	
SVM	SVM Submodel provided by ASPI on 24.10.02, HP-2-ASP-TN-0413; Issue 1	SVM Submodel provided by ASPI on 24.10.02, HP-2-ASP-TN-0413; Issue 1	SVM Submodel provided by ASPI on 24.10.02, HP-2-ASP-TN-0413; Issue 1

Table 4.2-1: Drawings and Submodels used for Thermal Modelling

4.3 Optical Bench Assembly, Spatial Framework and Tanks

The Optical Bench Assembly (OBA) is mounted on top of the HTT via the so-called Spatial Framework (SFW). The SFW consists of a frame made of aluminium and struts to the HTT made out of T300 CFRP. The OBA is connected to the aluminium frame by means of Titanium blades. The SFW itself is attached to the CVV structure by the tank suspension straps. The nodal break down of the SFW is shown in Figure 4.3-1 and Figure 4.3-2.

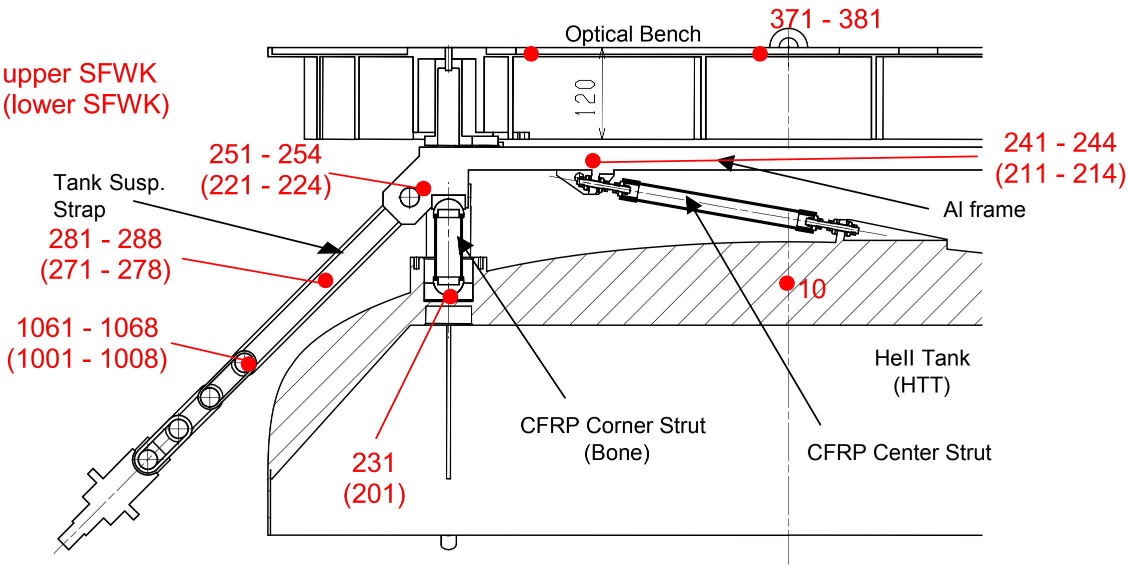


Figure 4.3-1: Nodal Break Down of HTT and SFW

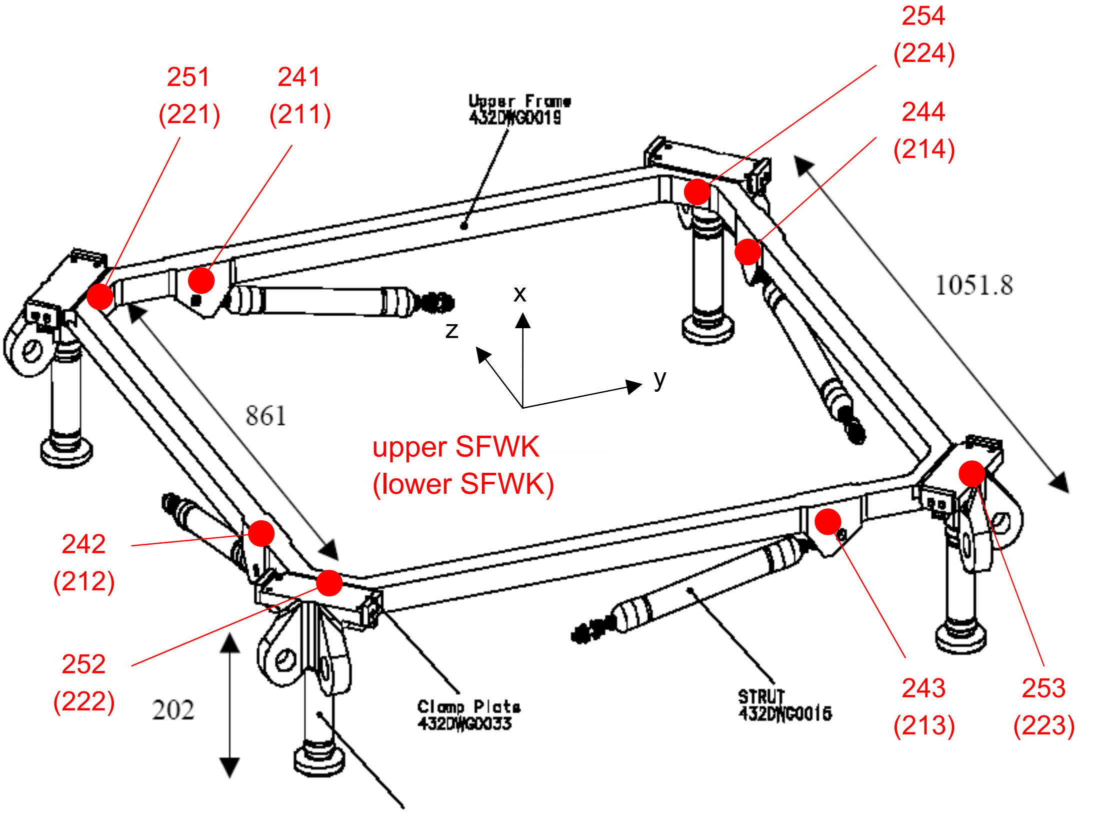


Figure 4.3-2: Nodal Break Down of SFW (detailed)

The OB with the instruments is covered with the Instrument Shield, see Figure 4.3-3. The opening for the beam entrance is modelled with cylindrical baffles, thermally (and mechanically) attached to the Thermal Shield 2 (node 2050) and to the Instrument Shield (node 315). The thermal and material properties are compiled in Table 4.4-1. The Instrument Shield baffle has rectangular cut-outs reflecting the beam pattern for the three instruments, see Figure 4.6-2.

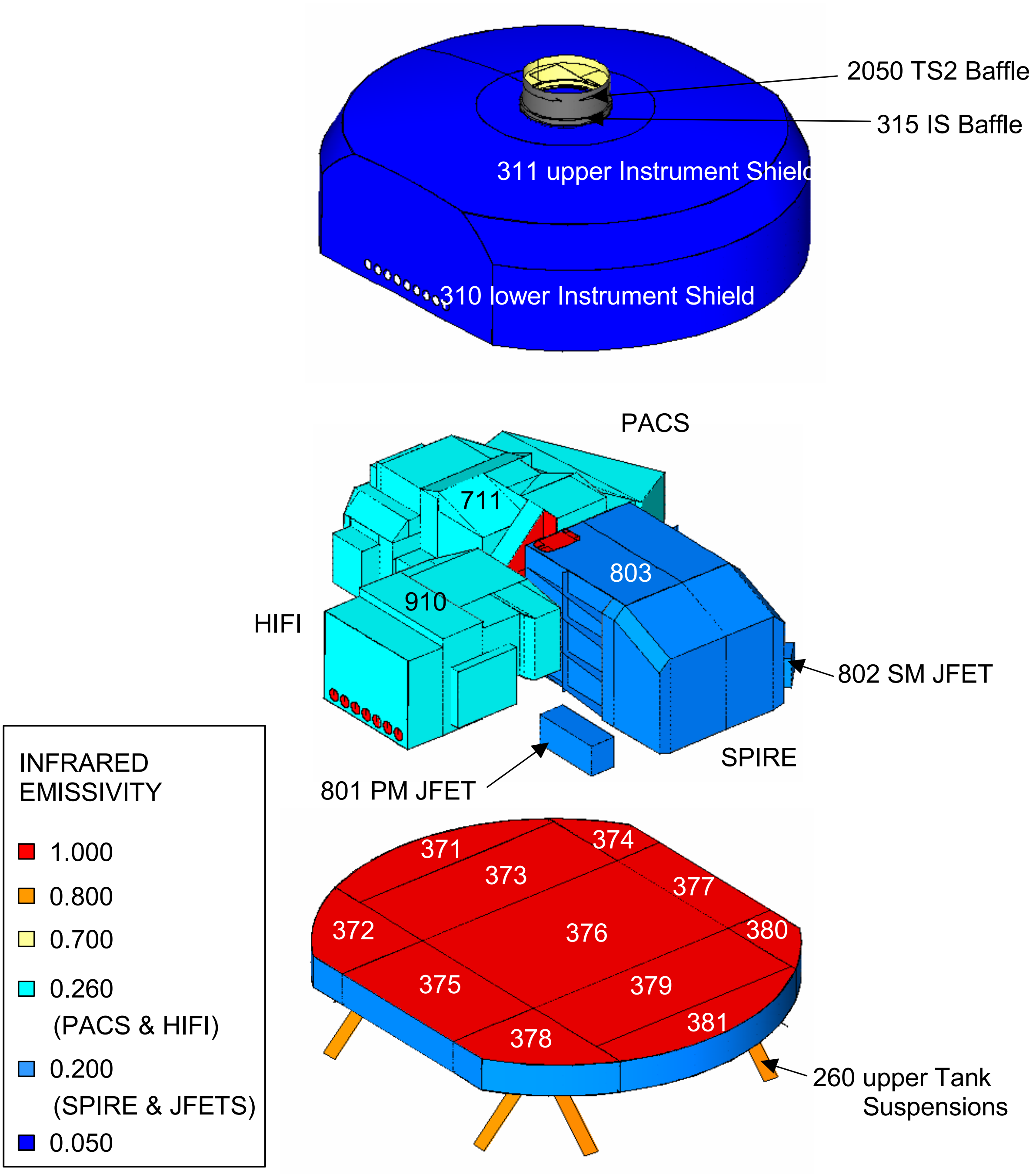


Figure 4.3-3: Nodal Break Down of Optical Bench with Instruments

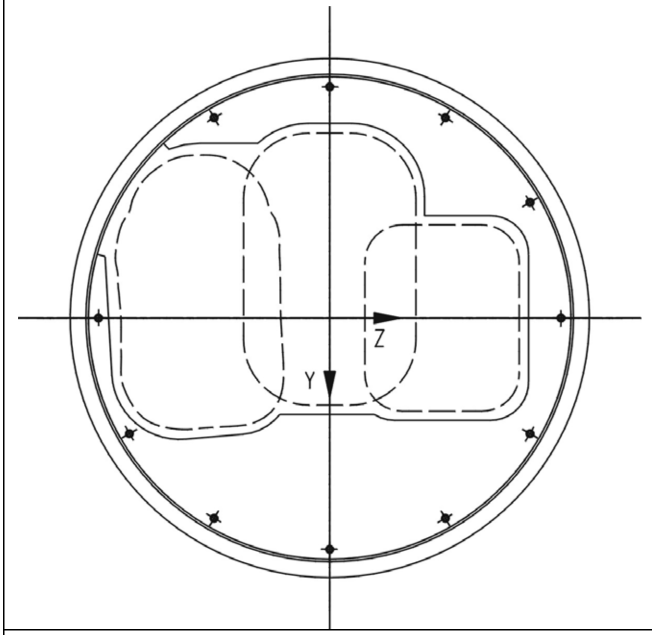
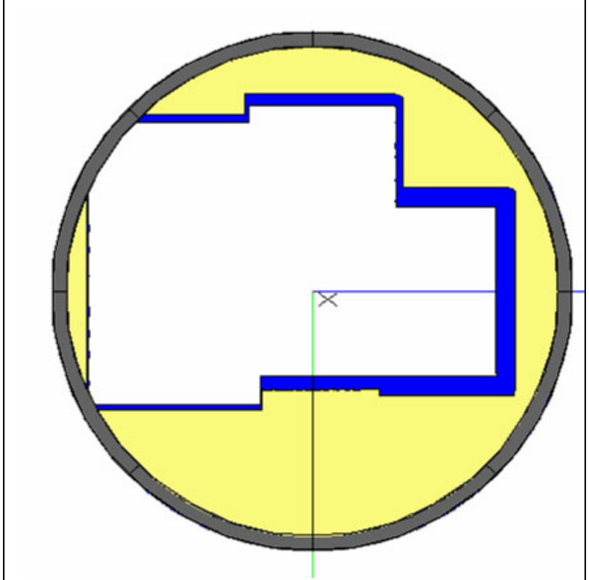
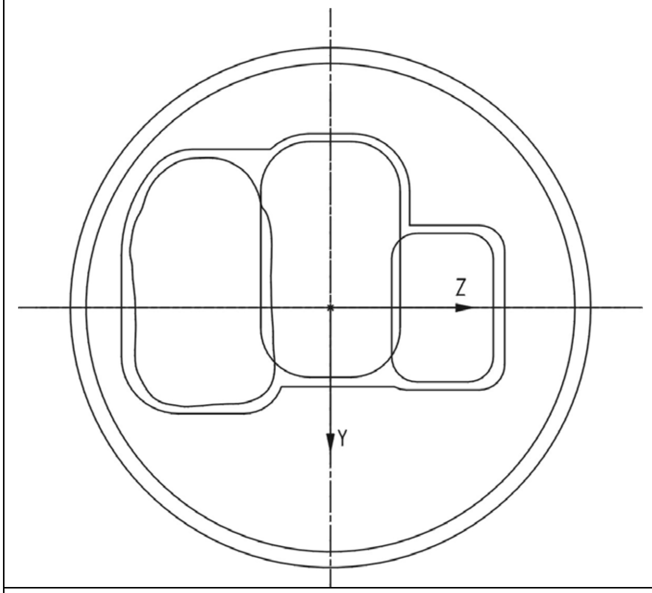
	
	
Apertures of Thermal Shield 2 Baffle (top) and Instrument Shield Baffle (bottom), view from + X	Instrument Shield Baffle (blue, node 315) and Thermal Shield 2 Baffle (yellow, node 2050) in TMM, view from +X

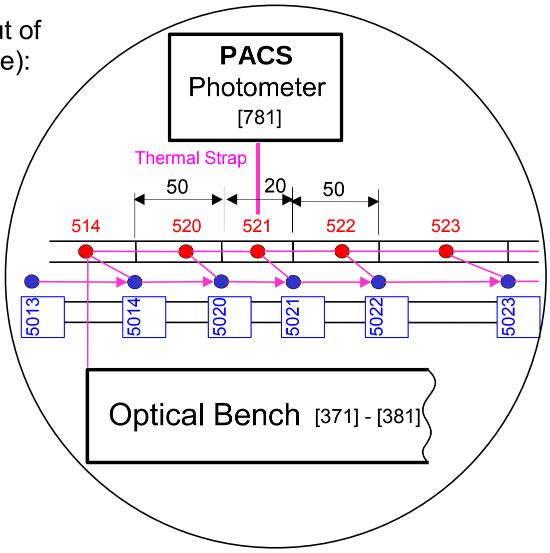
Figure 4.3-4: Beam Pattern for the Three Instruments

A schematic overview of the OB and Thermal Shield ventline modelling is given in following Figure 4.4-1.

4.4 Helium Ventline Subsystem

4.4.1 Modelling of Ventline

Detail (out of next page):



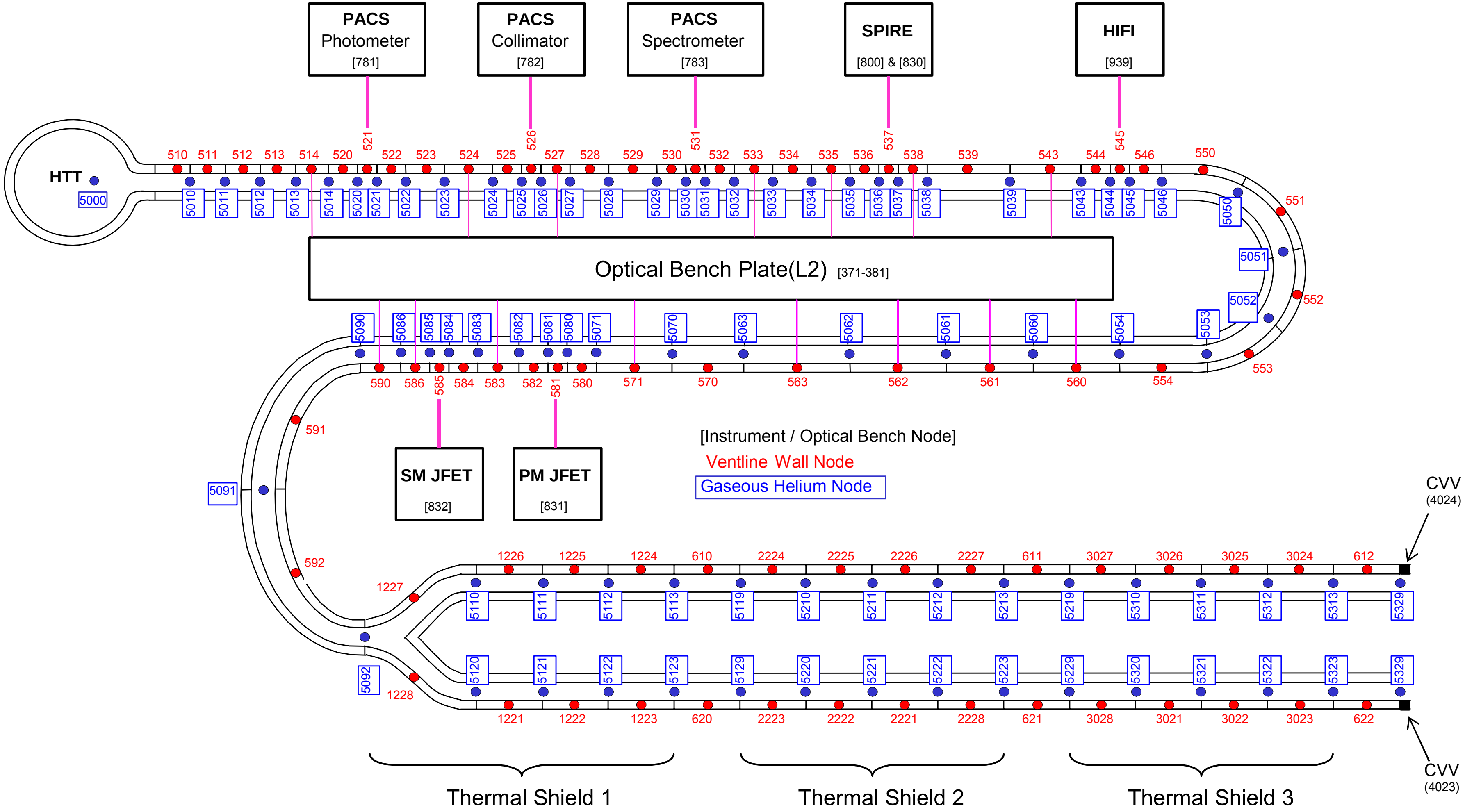


Figure 4.4-1: Nodal Break Down of OB Ventline and Thermal Shield Ventline

Item	Node	Material / Components	Mass	Size	IR Emiss.	Unit Level Requirement	Remark
He II Tank (HTT)	10	superfluid Helium (He II) Al tank (Al 5083, 3.3547)	337 kg 141.8 kg	2367 l (cold volume) D=1.63 m, h=1.352 m			
MLI on He II Tank low cyl. upp.	111 112 113	10 layers	1.1 kg 3.2 kg 1.1 kg	A=3.26m² A=2.91 m² (D=1.63m, h=0.569m) A=2.94m²	0.05	R-INM-0220 [RD 24] R-INM-0230 [RD 24]	
He I Tank (HOT)	20	*90% HeI (=~8.7 kg He on ground) ellipsoid shaped Al tank (Al 5083)	13 kg	78 l (cold volume) D=0.88 m, h=0.252 m			
MLI on He I Tank low upp.	121 122	10 layers	0.45 kg 0.45 kg	A=0.66m² A=0.66m²	0.05	R-INM-0320 [RD 24] R-INM-0330 [RD 24]	
Lower Spatial Framework (HOT)	201-224	Al frame (Al 5083) Corner struts T300 to HTT center struts T300 to HTT		A/L = 4 x 2.825 mm A/L = 4 x 0.736 mm		R-SFW-290 [RD 22] R-SFW-300 [RD 22]	
Upper Spatial Framework (OB)	231-254	Al frame (Al 5083) Corner struts T300 center struts T300		A/L = 4 x 2.825 mm A/L = 4 x 0.736 mm		R-SFW-290 [RD 22] R-SFW-300 [RD 22]	
Optical Bench (OB)	371-381	Aluminium structure 4 Titanium blades to AL frame of SFW	60 kg	D=1.63m,H=70mm,2.5mm skins A/L = 28.6 mm Ti6AlV4	1.0	R-OBA-330 [RD 23] R-OBA-145 [RD 23]	
Instrument Shield	310 311	Al 6061 (cylinder) Al 1100 (top), see Figure 4.3-3	3.3 kg 4.5 kg	A=1.70m², s= 0.8mm A=2.18m², s= 0.8mm	0.05 0.05	R-OBA-326 [RD 23] R-OBA-325 [RD 23]	
Instrument Shield Baffle	315	Al baffle with aperture; cut-out area 0.035 m², see Figure 4.3-4	0.12 kg	D=308 mm, s= 0.8mm	0.05 all parts	R-OBA-410 [RD 23]	
GHe Ventline between HTT and Level 1	510-514	stainless steel tube		cross sect. 44.6mm^2 (D=12.7 mm, d=10.2 mm)			
GHe Ventline Level 1	520-546	Al6063 tube CFRP T300 brackets to OB		cross sect. 112.3mm^2 (D=14.9 mm, d=12 mm), incl. fins A/l = 2.016mm		R-OBA-360 [RD 23]	
GHe Ventline between Level 1 and Level 2	550-554	Al6061 tube (not coupled to OB)		cross sect. 44.6mm^2 (D=12.7 mm, d=10.2 mm)		R-OBA-365 [RD 23]	
GHe Ventline Level 2	560-563	Al tube on OB		cross sect. 112.3mm^2			

Item	Node	Material / Components	Mass	Size	IR Emiss.	Unit Level Requirement	Remark
		Al brackets to OB		(D=14.9 mm, d=12 mm), incl. fins A/l = 19.60mm		R-OBA-370 [RD 23]	
GHe Ventline between Level 2 and Level 3	570-571	Al6061 tube (not coupled to OB)		cross sect. 44.6mm^2 (D=12.7 mm, d=10.2 mm)		R-OBA-365 [RD 23]	
GHe Ventline Level 3	580-586	Al6063 tube CFRP T300 brackets to OB		cross sect. 61.3mm^2 (D=14.9 mm, d=12 mm) A/l = 9.90mm			
GHe Ventline between Level 3 and TS1	590-592	stainless steel tube		cross sect. 17.3mm^2 (D=12.7 mm, d=11.8 mm)			
GHe Ventline between Thermal Shields/CVV	610-612 620-622	stainless steel tube		cross sect. 17.3mm^2 (D=12.7 mm, d=11.8 mm)			
Filling Port / Tubes	440-452	stainless steel		ISO design			
MLI on Filling Tubes	642-652	10 layers				R-INM-0820 [RD 24]	

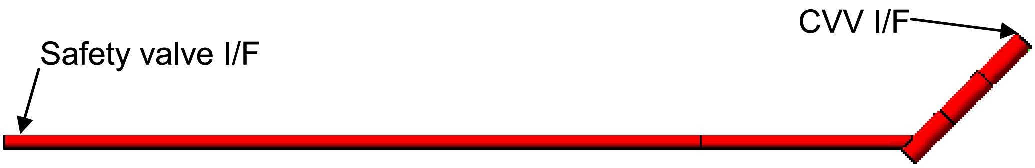
Table 4.4-1: Item List for Tanks, Ventline and Optical Bench

Radiation within filling/safety lines:

To assess the impact of radiation from the CVV interface down the Filling Port and the safety line to the SV123 that is mounted on the HTT a small ESARAD model was established with the following basic assumptions:

- The filling line is invisible from the CVV interface due to the filter and the Joule-Thompson valve in the Filling Port. The filling line is therefore neglected in this model. The FP is closed at the location of the JT valve.
- A straight safety line with the correct length is assumed (conservative wrt bent tube).
- The emissivity of the CVV interface is assumed to be 0.7, the emissivity of the SV123 internal parts is assumed to be 0.9. These assumptions are considered to be conservative.
- The end of the safety line is directly coupled to the HTT, i.e. the heat flow resistance through the SV123 is neglected.
- For the emissivity of the internal surface of the FP and the safety line, a value of 0.05 is assumed. The reflectivity is considered to be 100% specular.

The following picture shows modelling of the Filling Port and the Safety Line in the assessment model.



The calculated radiative coupling is introduced in the Herschel TMM.

4.4.2 Pressure Drop Model

The pressure drop calculation within the ESATAN model uses the detailed numerical pressure drop model as described in [RD 13].

The detailed pressure drop model is based on the pressure drop model used in the ISO TMM [RD 14] for the final flight predictions. In the detailed model, the pressure drop of the individual vent line components (e.g. PPS, straight pipes, bends, t-pieces, valves, heater, nozzles…) is calculated by dedicated subroutines. Most of these subroutines are directly inherited from the ISO model, with the exceptions being

1. PPS: The Herschel phase separator is different from the ISO PPS. A mini-model-type regression function is used to represent the flight model porous plug which was characterised as Sample 5 in the Herschel PPS Pre-Development test campaign. The regression formula is

$$p_{in}^2 - p_{out}^2 = a \cdot \dot{m}^b \cdot T^c$$

with pressure p [mbar], mass flow rate $\dot{m}$ [mg/s], temperature T [K], and fit parameters a=6.039899454, b=1.532479916, and c=0.439538736.

2. Electromagnetic valves: The original valve function from ISO results in unrealistically small pressure drop values (below 10^{-10} Pa per valve) for the Herschel conditions. The function has therefore been replaced by a mini-model type regression which represents the measurements of the external valves (without filters) carried out in the ISO programme [RD 15]. Filters in the external valves are implemented by calling a dedicated filter function. The impedance coefficient of this function is adjusted to the measurements performed with the Herschel TM valve and filters.

3. CVSE Pump: For the nominal ground steady-state case, a cryo vacuum pump is attached to the V502. The characteristic of this pump is represented by a newly introduced function which calculates the inlet pressure depending on the mass flow rate and the gas temperature. This feature is currently not being used within the TMM.

The pressure drop model is called from ESATAN with the following arguments:
CALL CALCMD (TIMEM, MDOT, T10, T546, T563, T586, T1031, T2031, T3031, T4031, IPPS, INOZZ, SUCCES)
This call calculates the mass flow rates depending on the tank temperature and the temperature distribution along the ventline. Input arguments are

TIMEM:	current time step, used for control output
MDOT:	initial value for mass flow rate calculation, new value after calcmd returns
T10-T4031:	temperatures of the individual elements
IPPS:	integer switch: =1 for flow through PPS, =0 for bypass via V104, <0 for closed HTT
INOZZ:	integer switch: =1 for flow through small nozzles, =2 flow through big and small nozzles, <= 0 for flow via V502
SUCCESS:	integer flag: =0 if iteration was successful (calcmd output)

To calculate the tank temperature depending on a given mass flow rate and temperature distribution along the vent line, the pressure drop model is called with the subroutine
CALL CALCTT (TIMEM, MDOT, T10, T546, T563, T586, T1031, T2031, T3031, T4031, IPPS, INOZZ, SUCCES). This subroutine uses the same arguments as for the mass flow calculation routine calcmd.

CALCMD and CALCTT both call the internal subroutine DPVENT and apply the Regula Falsi to iterate the mass flow rate until the pressure drop along the vent line, together with the nozzle inlet pressure calculated from the choked flow conditions, is equal to the pressure in the tank as defined by the tank temperature (or vice versa for CALCTT). The subroutine DPVENT calculates and sums up the respective pressure drop contributions of the individual vent line components one by one going upstream from the external nozzles to the phase separator. Bends in the pipe routing are modelled using equal or smaller bending radii than defined in the drawings. For the two pairs of parallel redundant valves V103/V106 and V501/V503, it is assumed that the respective valve with the shorter pipe routing does not open. Filling and safety lines as well as the filling port are not represented in the current version of the pressure drop model.

The Fortran code for CALCMD, CALCTT, and all functions and routines which are used internally by the pressure drop model is included in the file calcmd.f, which has to be compiled and transformed to an object library named USRLIB.a. The makefile delivered with the TMM automatically performs these tasks. The Esatan pre-processor requires that the calling names of the subroutines provided in the object library be listed in the file USRLIB.DAT.

The detailed pressure drop model is completely coded in Fortran 77. Thus it can be used either as a stand-alone program with the temperatures of the vent line sections being defined as input, or it can be called from the ESATAN Herschel TMM to perform transient analyses with variable mass flow rate.

The dominating contributions to the overall pressure drop in the orbit cool-down and operation phases are generated by the PPS and the external nozzles. The nozzle throat diameters are adjusted for the combination of desired tank temperature, temperature distribution along the vent line and mass flow rate, and are hard-coded in the pressure drop model. Changes with an impact on the mass flow rate or temperatures will therefore also have an impact on the average tank temperature. The nozzle diameters used in the current version are 1.011 mm for two small and 2.121 mm for one big nozzle. With these settings and the calculated mass flow rates, a nominal HTT temperature of 1.65 K for orbit hot case with average instrument dissipation and a maximum mass flow rate below 20 mg/s (as required by the PPS) during the in-orbit cool-down are achieved.

Detailed information on the calculation fundamentals for each vent line component as well as representative results are given in [RD 13].

4.5 Instruments

The Instrument Interface Thermal Mathematical Models (ITMMs) have been supplied by the instrument people [RD 03, RD 04, RD 05] in ESATAN format and are implemented as submodels in the overall H-EPLM TMM structure. SPIRE in addition has delivered an Interface Geometrical Mathematical Model (IGMM) in ESARAD format. Since no IGMMs of PACS and HIFI were available, they had to be established by ASED according to the corresponding FPU drawings in [RD 10] and [RD 12]. The IGMMs are implemented as submodels in the overall H-EPLM GMM.

4.5.1 PACS

The PACS instrument TMM thermal network is illustrated in Figure 4.5-1. The relevant data of each instrument node are compiled in Table 4.5-1 together with the design data of the thermal links to the Level 0 and Level 1 interfaces. The dissipation timeline during PACS operation and sorption cooler recycling is shown in Figure 4.5-2 and Figure 4.5-3.

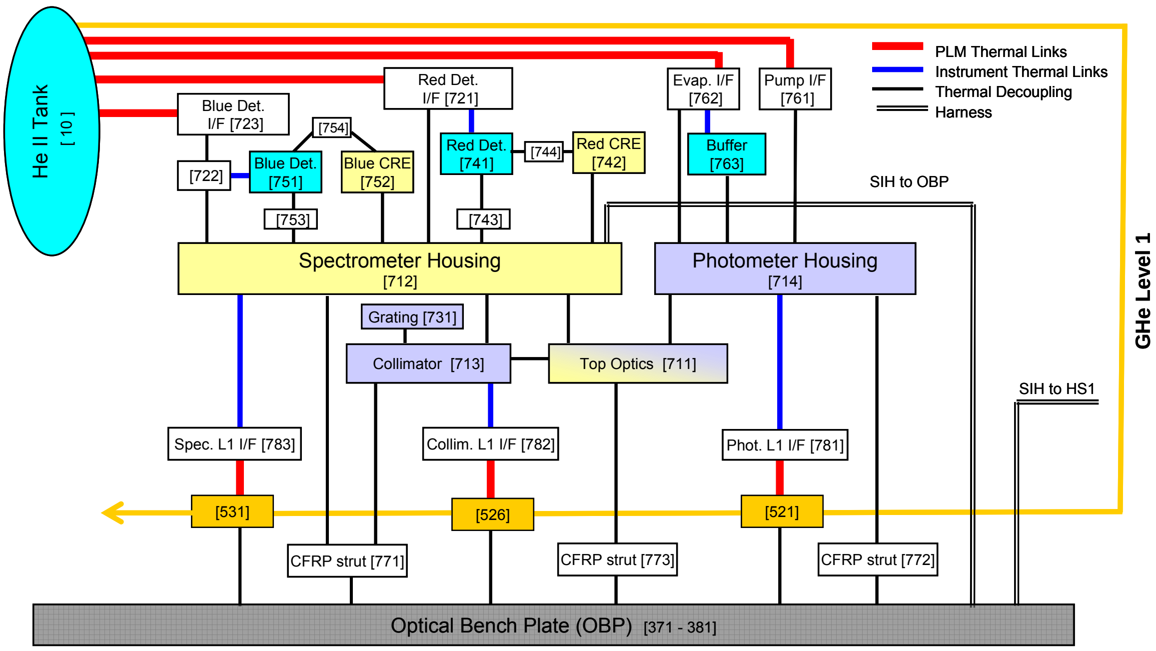


Figure 4.5-1: Reduced PACS Instrument TMM

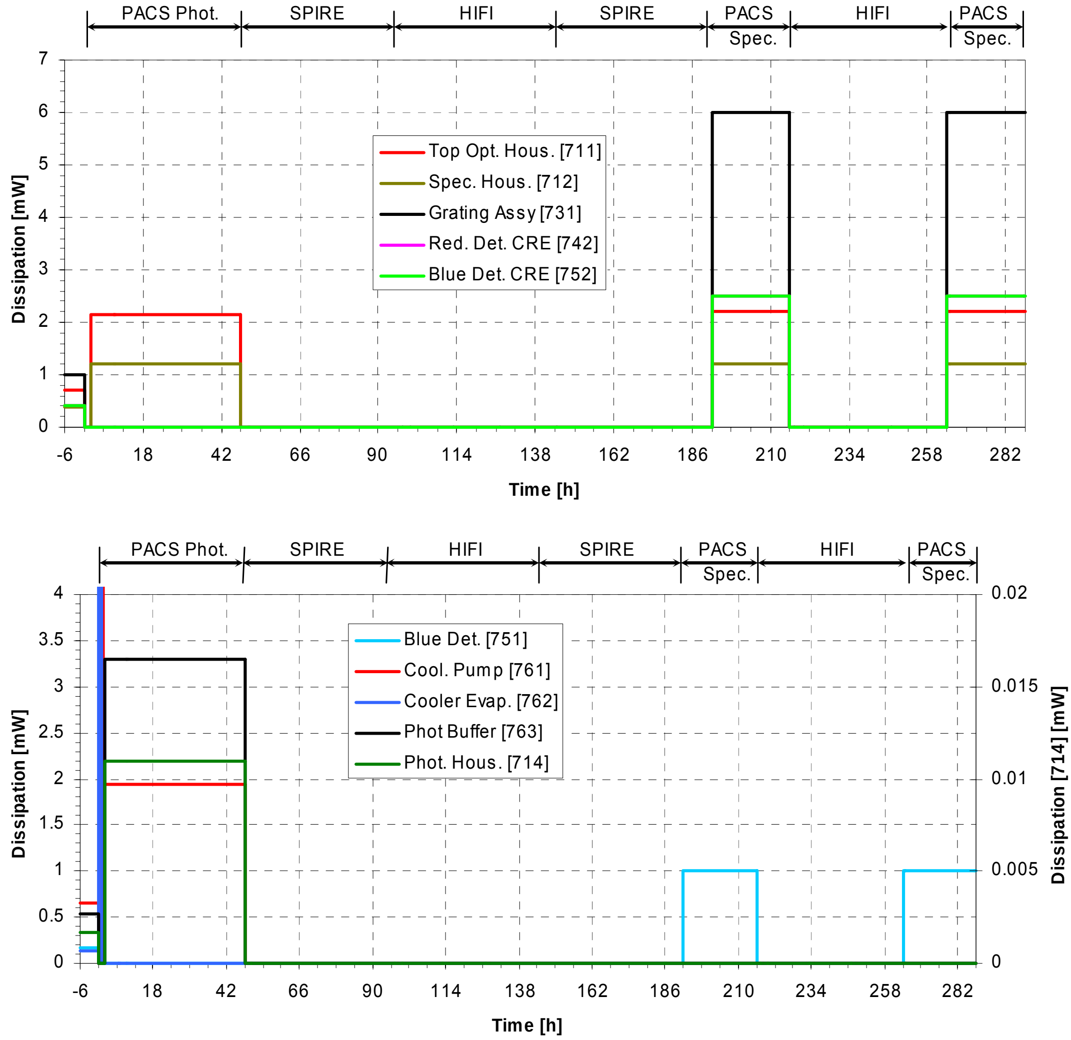


Figure 4.5-2: PACS Dissipation Profile during Operation

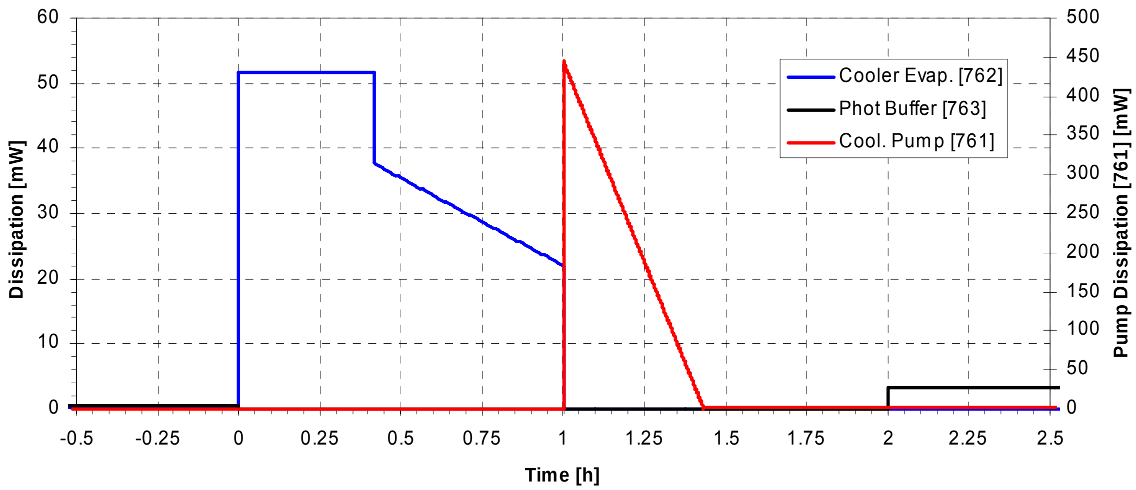


Figure 4.5-3: PACS Dissipation Profile during Recycling

Item	Node	Material / Components	Mass [kg]	Size / Performance	IR Emiss.	Unit Level Requirement	Remark
Red Detector I/F	724	Thermal link to HTT (L0) Cu flexible strap Al 1050 pod	 0.193	2 x M4 at Instr. I/F cross sect.: 200 mm², l=0.136m 4 x M4 cross sect.: 452 mm², l=0.284m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Feed Through Blue Det.	722						
Blue Detector I/F	723	Thermal link to HTT (L0) Cu flexible strap Al 1050 pod	 0.184	2 x M4 at Instr. I/F cross sect.: 88 mm², l=0.222m 4 x M4 cross sect.: 580 mm², l=0.235m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Cooler Pump I/F	761	Cu, Thermal link to HTT (L0) Cu flexible strap Al 1050 pod	 0.151	2 x M4 at Instr. I/F cross sect.: 67 mm², l=0.215m 4 x M4 cross sect.: 1130 mm², l=0.235m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Evaporator I/F	762	Cu, Thermal link to HTT (L0) Cu flexible strap Al 1050 pod	 0.5	2 x M4 at Instr. I/F cross sect.: 200 mm², l=0.216m 4 x M4 cross sect.: 1130 mm², l=0.235m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Buffer	763	Al, PACS cooling strap to Evaporator I/F	1.45				
Blue Detector	751	Al	2.9				
Red Detector	741	Al	2.25				
Blue Det. CRE	752	Al	0.4				
Red Det. CRE	742	Al	0.4				
CFRP strut Blue Det.	753						
CFRP strut Red Det.	743						
Harness Blue Det. Int.	754						

Item	Node	Material / Components	Mass [kg]	Size / Performance	IR Emiss.	Unit Level Requirement	Remark
Harness Red Det. Int.	744						
Spectr. Housing	712	Al	14.6				
Collimator Housing	713	Al	13.5				
Phot. Housing	714	Al, Ti	15.0				
Top Optics	711	Al	14.2	Apertures with filters: 0.002 m²	0.26 1.0		
Grating	731	Al, Cu	4.0				
Phot. L1 I/F	781	Cu Cooling strap to GHe ventline (L1) Cu flexible strap		2 x M4 at Instr. I/F cross sect.: (20x3)mm, l=0.217m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	
Collimator L1 I/F	782	Cu Cooling strap to GHe ventline (L1) Cu flexible strap		2 x M4 at Instr. I/F cross sect.: (20x2)mm, l=0.128m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	
Spec. L1 I/F	783	Cu Cooling strap to GHe ventline (L1) Cu flexible strap		2 x M4 at Instr. I/F cross sect.: (20x3)mm, l=0.227m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	
L2 IF (Phot.)	772	CFRP bracket to OB (L2)		A/L= 7.66 mm			
L2 IF (Top Opt.)	773	CFRP bracket to OB (L2)		A/L= 15.3 mm			
L2 IF (Spec/Coll.)	771	CFRP bracket to OB (L2)		A/L= 23.0 mm			

Table 4.5-1: Item List for PACS

4.5.2 SPIRE

The SPIRE instrument TMM thermal network is illustrated in Figure 4.5-4. All thermal nodes are represented in this sketch and are also compiled in Table 4.5-2, together with the design and performance data of the thermal links to the Level 0, Level 1 and Level 3 interfaces. The dissipation timeline during SPIRE operation and sorption cooler recycling is shown in Figure 4.5-5 and Figure 4.5-6, respectively. A more detailed description of the SPIRE instrument TMM is given in RD 16.

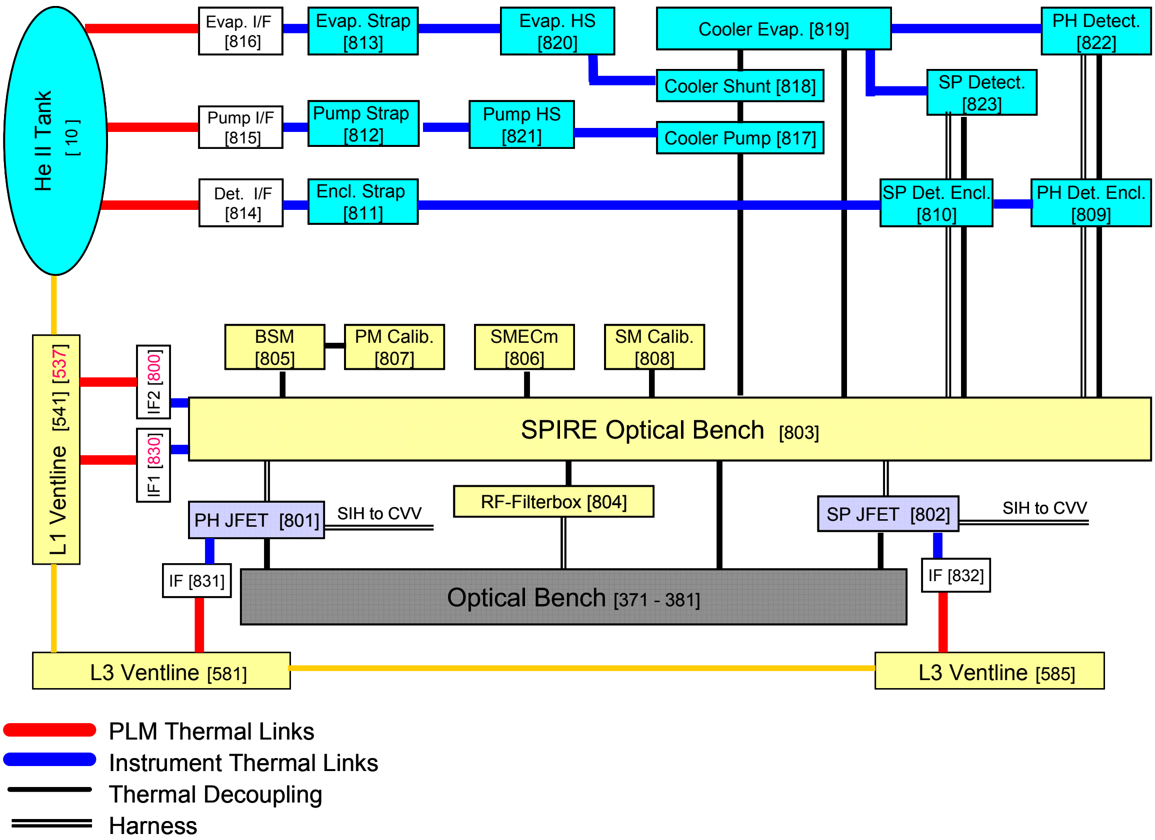


Figure 4.5-4: Reduced SPIRE Instrument TMM

The following radiative couplings (GR) inside the SPIRE TMM exist:
GR (819,820) = 6.619E-3 m²
GR (817,821) = 6.619E-3 m².

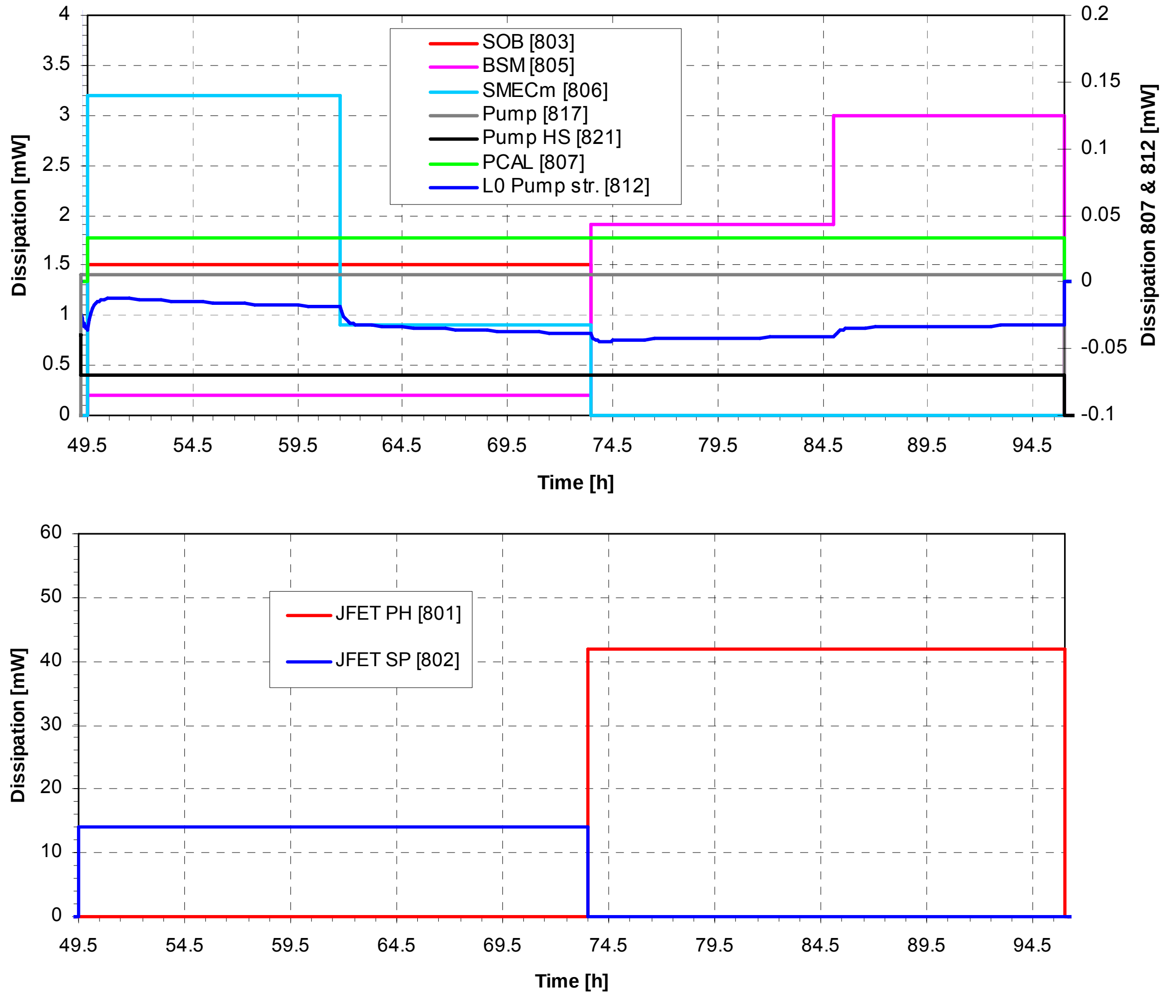


Figure 4.5-5: SPIRE Dissipation Profile during Operation

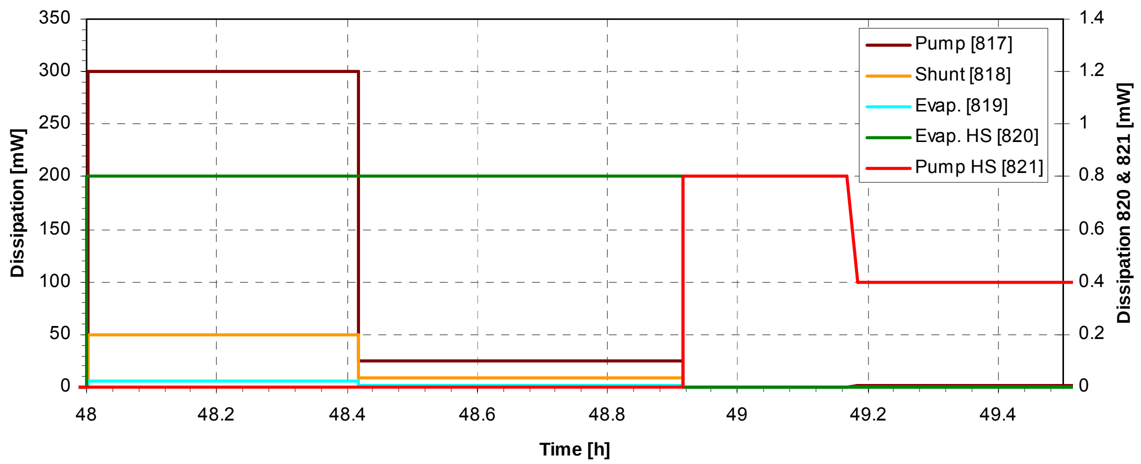


Figure 4.5-6: SPIRE Dissipation Profile during Recycling

Item	Node	Material / Components	Mass [kg]	Size / Performance	IR Emissivity	Unit Level Reqirement	Remark
PM Det. enclosure	809	Al, St. Steel, Invar, Silicon	3.91				
SM Det. enclosure	810	Al, St. Steel, Invar, Silicon	1.70				
Enclosure Strap	811		6.16E-3				
Pump Strap	812		6.16E-3				
Evap. Strap	813		6.16E-3				
Enclosure Strap I/F	814	Thermal link to HTT (L0) Al1050 pod		4 x M4 at Instr. I/F cross sect.: 960 mm², l=0.340m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Pump Strap I/F	815	Thermal link to HTT (L0) Al1050 pod		4 x M4 at Instr. I/F cross sect.: 960 mm², l=0.340m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Evap. Strap I/F	816	Thermal link to HTT (L0) Al1050 pod		4 x M4 at Instr. I/F cross sect.: 960 mm², l=0.340m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Cooler Pump	817	Ti	0.15				
Cooler Shunt	818	Ti	0.01				
Cooler Evaporator	819	Ti	0.084				
Cooler Evapor. HS	820	Ti	0.074				
Cooler Pump HS	821	Ti	0.074				
PM Detector	822	Invar, Cu	1.144				
SM Detector	823	Invar, Cu	0.535				
L1 strap I/F1	800	Cooling strap to GHe ventline (L1) Cu flexible strap		0.5 x M8 + 1 x M4 at Instr. I/F cross sect.: (20x2)mm, l=0.173m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	
L1 strap I/F2	830	Cooling strap to GHe ventline (L1) Cu flexible strap		0.5 x M8 + 1 x M4 at Instr. I/F cross sect.: (20x2)mm, l=0.173m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	
SPIRE Optical Bench (SOB)	803		26.75	 aperture	0.20 1.0		

Item	Node	Material / Components	Mass [kg]	Size / Performance	IR Emissivity	Unit Level Reqirement	Remark
		4 stainless steel brackets to OB *)		A/L= 3.2284 mm x 0.25 *)			
RF Filter box	804	Al casing/structure	1.465				
BSM	805		1.10				
SMECm	806		1.043				
PM Calibration	807		0.03				
SM Calibration	808		2.041E-4				
PM JFET Encl.	801	Al, 4 CFRP T300 brackets to OB	2.348	A/L= 29.30 mm	0.20		
PM JFET I/F	831	Cooling strap to Level 3 Cu flexible strap		2 x M4 at Instr. I/F cross sect.: (20x4)mm, l=0.252m 4 x M4 at ventline I/F			
SM JFET Encl.	802	Al, 5 CFRP T300 brackets to OB	0.81342	A/L= 36.36 mm	0.20		
SM JFET I/F	832	Cooling strap to Level 3 Cu flexible strap		2 x M4 at Instr. I/F cross sect.: (20x4)mm, l=0.308m 4 x M4 at ventline I/F			

*) A factor of 0.25 is applied in the SPIRE TMM to account for new isolating supports

Table 4.5-2: Item List for SPIRE

4.5.3 HIFI

The HIFI instrument TMM thermal network is illustrated in Figure 4.5-7. All thermal nodes are represented in this sketch and are also compiled in Table 4.5-3 together with the design and performance data of the thermal links to the Level 0 and Level 1 interfaces.

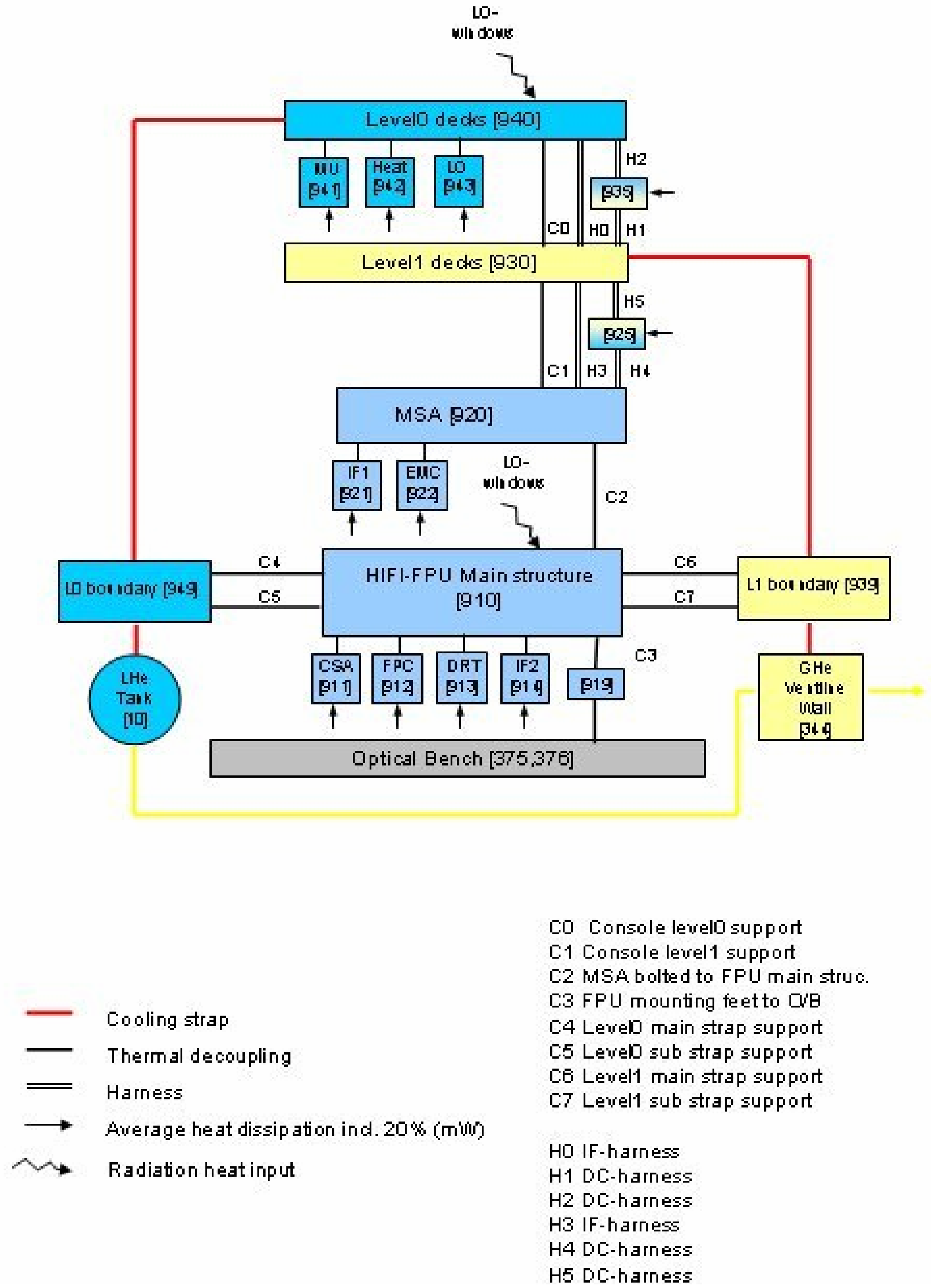


Figure 4.5-7: Reduced HIFI Instrument TMM

The dissipation timeline during HIFI operation is shown in Figure 4.5-8.

The following radiative couplings (GR) from the LOU windows (Node 4090 in H-EPLM TMM) to the HIFI Level 0 exist:
GR (4090 , 940) = 1.02E-5 m²

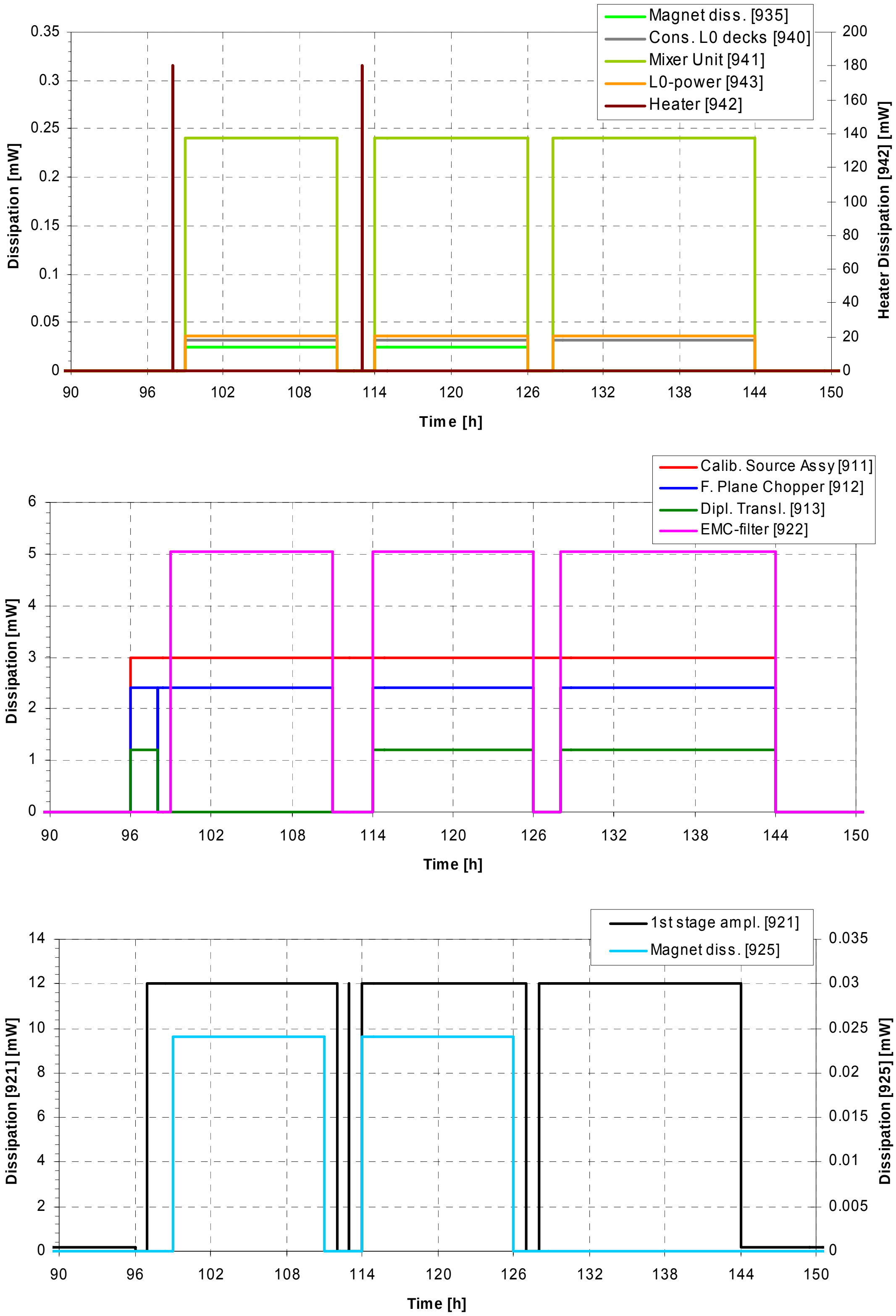


Figure 4.5-8: HIFI Dissipation Profile during Operation

Item	Node	Material / Components	Mass [kg]	Size / Performance	IR Emiss.	Unit Level Requirement	Remark
FPU Structure	910	Al	35.72	Aperture	0.26 1.0		
Calib. Source Assy	911	Al	1.5				
Focal Plane Chopper	912	Al	0.40				
Dipl. Rooftop transl.	913	Al	0.59				
2nd stage amplifier	914	Al	2.30				
L2 boundary	919			thermal coupl. to OB: 1.2 W/K			
Mixer Sub Assy	920	Al	2				
1st stage amplifier	921						
EMC filtering	922						
Magnet current diss.	925						
Console L1 decks	930	Al	0.56				
Magnet current diss.	935						
L1 boundary	939	Al, Cu Cooling strap to GHe ventl. (L1)	0.40	4 x M4 at Instr. I/F cross sect.: (20x3.5)mm, l=0.172m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	
Console L0 decks	940	Al	1.68				
Mixer Unit	941	Al	1.05				
Heater	942						
LO-power	943						
L0 boundary	949	Al, Thermal link to HTT (L0) Cu flexible strap Al 1050 pod	0.40	4 x M4 at Instr. I/F cross sect.: 105 mm², l=0.236m 4 x M4 cross sect.: 392 mm², l=0.404m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	

Table 4.5-3: Item List for HIFI

4.6 Thermal Shields and Tank Suspensions

The tank suspension consists of GFRP and T300 CFRP chains with heat interceptions at each Thermal Shield. The two innermost chains are made out of T300 CFRP; the other ones are made out of S-glass. The cross section and material selection of each chain has been optimized w.r.t. thermal and mechanical performance. The details are described in [RD 20]. The nodal break-down of the chains is shown in Figure 4.6-1 and the relevant data are compiled in Table 4.6-1.

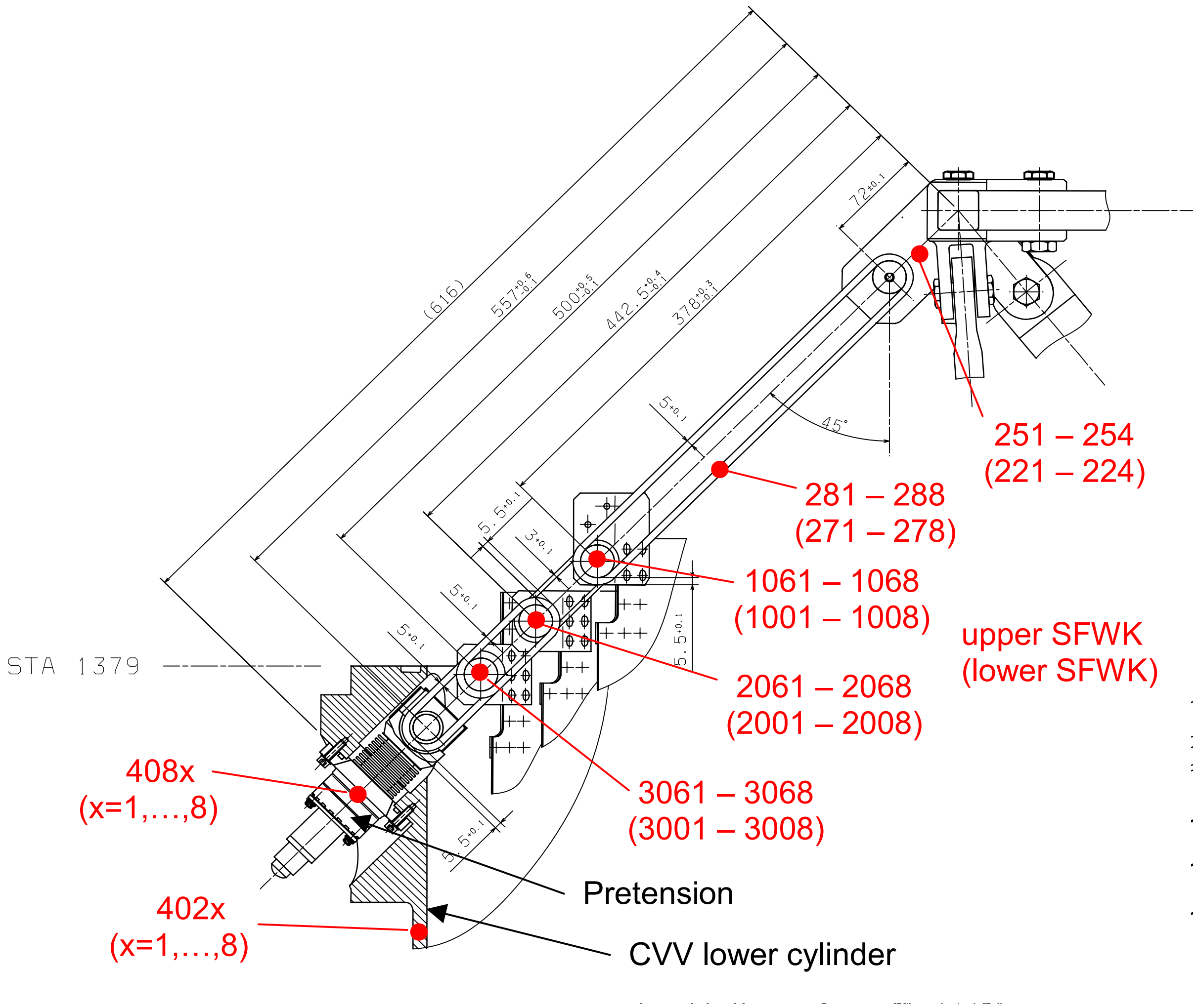


Figure 4.6-1: Nodal Break-Down of Tank Suspensions

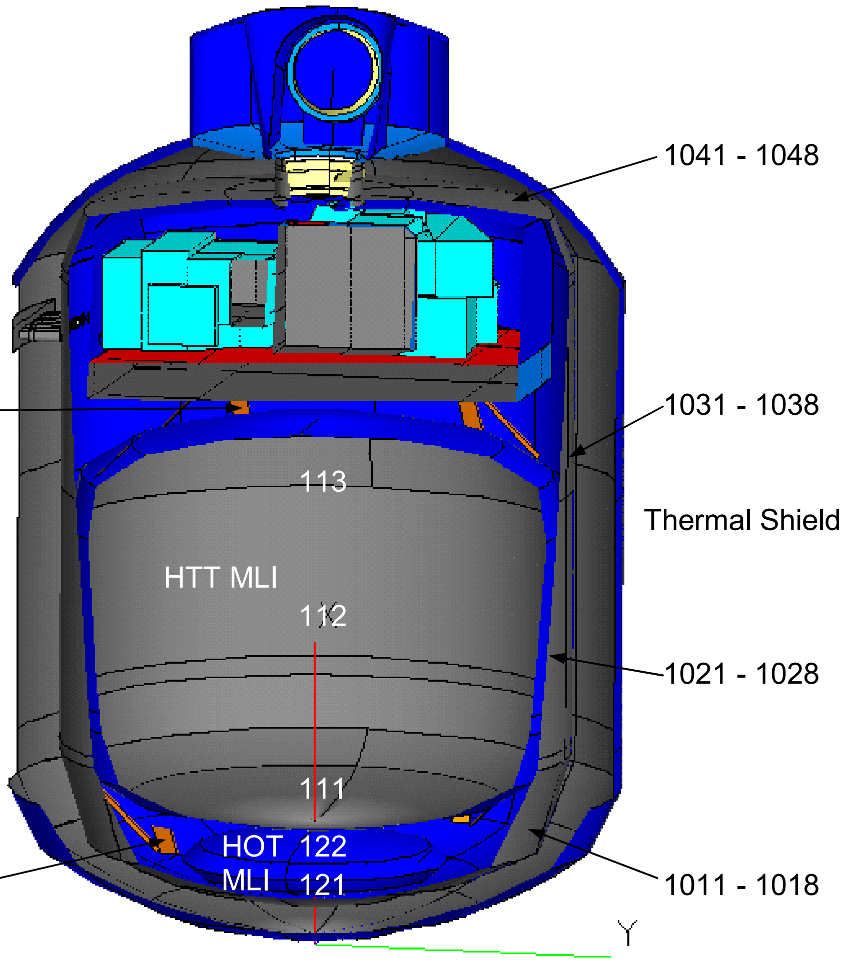


Figure 4.6-2: Nodal Break-Down of Tanks and Thermal Shield 1

Item	Node	Material / Components	Mass [kg]	Size	IR Emiss.	Unit Level Requirement	Remark
Susp. Bolt TS1 lo Susp. Bolt TS1 up	1001-1008 1061-1068	stainless steel stainless steel	0.15 0.15				
Susp. Straps lo Susp. Straps up	271-278 281-288	8 CFRP T300, between TS1 and SFW 8 CFRP T300, between TS1 and SFW		8x137 mm², l= 306 mm 8x137 mm², l= 306 mm	0.8	R-TSS-200 [RD 21]	A)
Thermal Shld 1 low bulk Thermal Shld 1 low cyl. Thermal Shld 1 upp cyl. Thermal Shld 1 upp bulk	1011-1018 1021-1028 1031-1038 1041-1048	Al 6061 CuBe blades to TSS	10.0 12.1 10.0 8.2	A= 3.708 m², s=0.8 mm D=1.69m, h=0.842m, s=0.8 mm D=1.69m, h=0.696m, s=0.8 mm A= 3.021 m², s=0.8 mm	0.05	R-FTS-170 [RD 30]	
Thermal Shield 1 MLI	1111-1118 1121-1128 1131-1138 1141-1148	2 x 5 layers	1.9 2.0 1.9 1.4	A= 3.708 m² D=1.69m, h=0.842m D=1.69m, h=0.696m A= 3.021 m²	0.05	R-INM-0510 [RD 24] R-INM-0530 [RD 24]	B)
Susp. Bolt TS2 lo Susp. Bolt TS2 up	2001-2008 2061-2068	stainless steel stainless steel 2x8 CFRP T300, susp. straps to TS1	0.15 0.15	 2x8x131 mm², l= 64.5 mm		 R-TSS-200 [RD 21]	 A)
Thermal Shld 2 low bulk Thermal Shld 2 low cyl . Thermal Shld 2 upp cyl. Thermal Shld 2 upp bulk	2011-2018 2021-2028 2031-2038 2041-2048	Al 6061 CuBe blades to TSS	11.1 12.6 10.4 9.0	A= 4.124 m², s=0.8 mm D=1.76m, h=0.842m, s=0.8 mm D=1.76m, h=0.696m, s=0.8 mm A= 3.319 m², s=0.8 mm	0.05	R-FTS-173 [RD 30]	
Thermal Shield 2 Baffle	2050	Al baffle with aperture; cut-out area 0.040 m², see Figure 4.3-4		290 mm diameter	0.7 cyl. 0.7 +x side 0.05-x side		
TS 2 LOU Baffle	2090	Al tubes (LOU) Al tubes (Alignment)		7 x 38 mm inner diameter 2 x 31 mm inner diameter	0.7		
Thermal Shield 2 MLI	2111-2118 2121-2128 2131-2138 2141-2148	4 x 5 layers	2.1 2.1 1.9 1.7	A= 4.124 m² D=1.76m, h=0.842m D=1.76m, h=0.696m A= 3.319 m²	0.05	R-INM-0610 [RD 24] R-INM-0630 [RD 24]	B)
Susp. Bolt TS3 lo Susp. Bolt TS3 up	3001-3008 3061-3068	stainless steel stainless steel	0.15 0.15				

Item	Node	Material / Components	Mass [kg]	Size	IR Emiss.	Unit Level Requirement	Remark
		2x8 GFRP suspension straps to TS2 2x8 GFRP suspension straps to CVV		2x8x168 mm², l= 57.5 mm 2x8x167 mm², l= 57 mm		R-TSS-200 [RD 21]	A)
Thermal Shld 3 low bulk Thermal Shld 3 low cyl. Thermal Shld 3 upp cyl. Thermal Shld 3 upp bulk	3011-3018 3021-3028 3031-3038 3041-3048	Al 6061 CuBe blades to TSS	12.2 kg 13.1 kg 10.8 kg 10.5 kg	A= 4.503 m², s=1mm D=1.83m, h=0.842m, s=1mm D=1.83m, h=0.696m, s=1mm A= 3.886 m², s=1mm	0.05	R-FTS-173 [RD 30]	
Thermal Shield 3 MLI	3111- 3148	4 x 5 layers	2.5 kg 4.6 kg 2.1 kg		0.05	R-INM-0710 [RD 24] R-INM-0730 [RD 24]	B)

A) Thermal conductivity of material confirmed by sample tests

B) MLI Performance test data of Forschungszentrum Karlsruhe included (details are reported in [RD 36])

Table 4.6-1: Item List for Thermal Shields

The thermal property data of the cryostat internal MLI are described in Section 5.1.

4.7 Cryostat Vacuum Vessel and Radiators

The nodal break-down of the CVV is shown in Figure 4.7-1. About one half of the cylindrical part and a 90° section of the upper bulkhead of the CVV serve as radiator, this area is called the CVV main radiator. The remaining surface of the CVV is covered with MLI. Three additional radiators are located at the –Z, +Y and –Y sides.

The ±Y radiators shadow the CVV main radiator from the warm Solar Array MLI and increase further the CVV radiative area to space. The radiator (-Z) side of the ±Y radiators (as well as both sides of the –Z radiator) are black anodized with 50 µm thickness. The rear (+Z) sides of the ±Y radiators are covered with MLI.

The ±Y radiators have an area of 350 mm x 1687 mm, respectively. The –Z radiator is split in two parts: the upper part (+X) with 350 mm x 926 mm and the lower part (-X) with 350 mm x 506 mm area. The thermal / mechanical attachment of each radiator to the CVV is provided with M8 bolt connections as listed in Table 4.7-1. The contact conductance between radiators and CVV structure are calculated using the values shown in Figure 5.3-1.

The heat spreading effect on CVV and radiators has been taken into account in the TMM using appropriate formulas in the corresponding “GL” conductance calculations (serial conductance of contact conductance and linear conductance of the corresponding CVV radiator). On the CVV two arithmetic nodes are introduced at the –Z Radiator I/F on the lower (node 4051) and upper part (4052). Thus, node 4051 connects the radiator node 4050 with the CVV nodes 4024 and 4025. Node 4052 connects the radiator node 4053 with the CVV nodes 4034 and 4035.

A cryostat baffle is arranged between the Telescope and the CVV upper bulk. The external surface of this baffle is covered with MLI except a 90° section at the -Z side that serves as radiator area. This area is also black anodized. The internal surface has a low IR emissivity. Inside this cryostat baffle there is an additional internal conical baffle with a low IR surface emissivity.

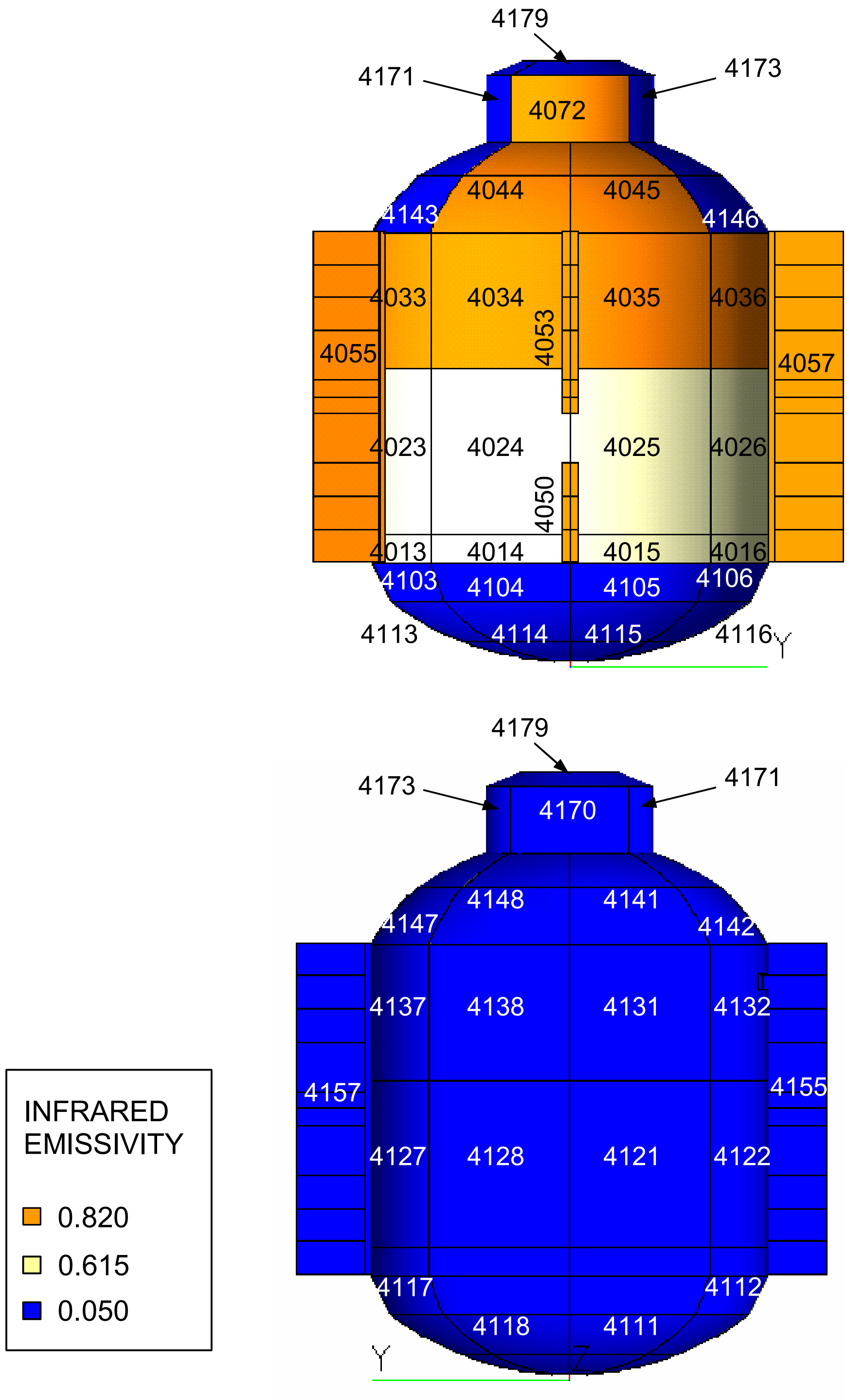
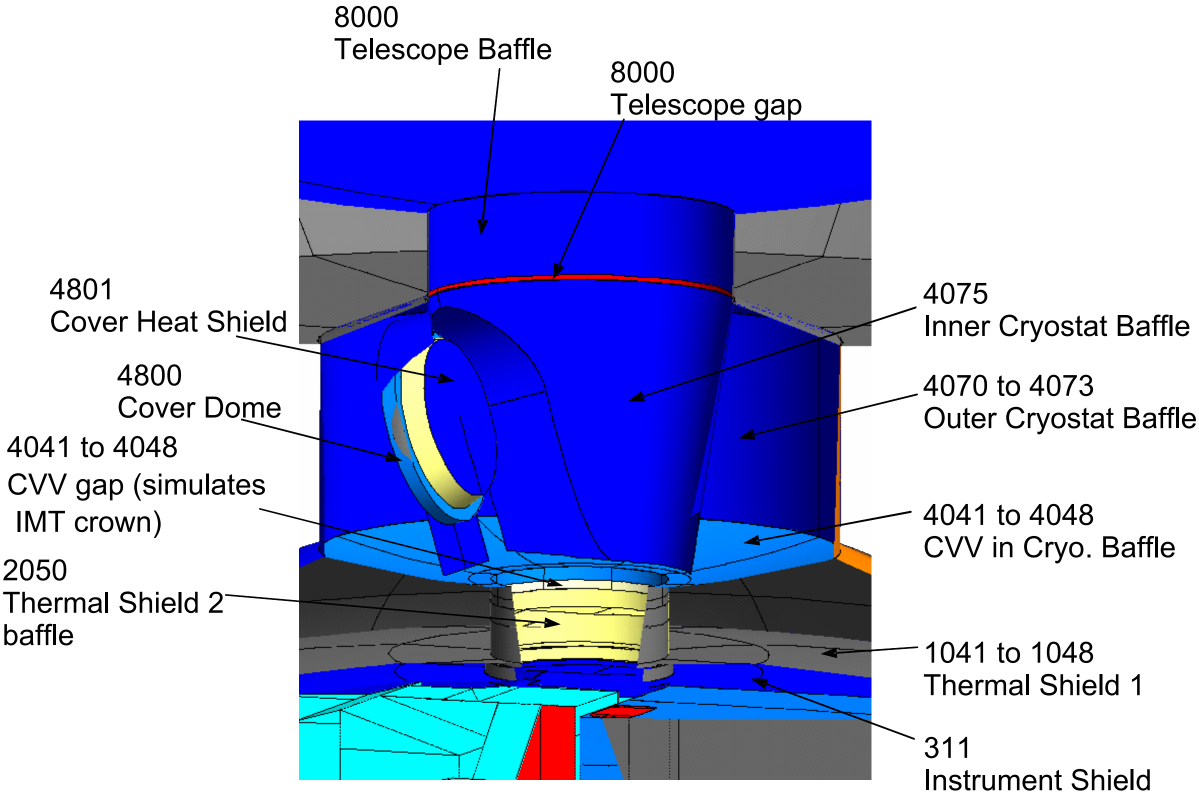


Figure 4.7-1: CVV Nodal Break-Down



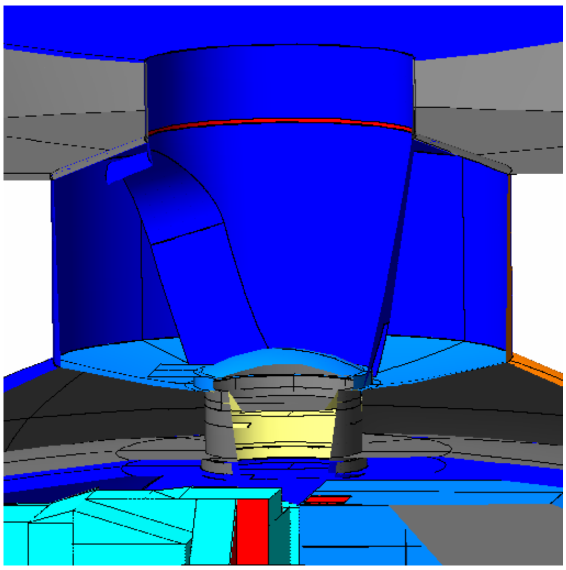


Figure 4.7-2: Cryostat Baffle and Cover Nodal Break-Down (Cover open & closed View)

Thermal conductance due to gaseous Helium in the Cryo Cover flushing line

According to [RD 39], the total linear heat conductance between the Cover and the CHS is 0.00325 W/K. The cited value does not include the heat conduction through the gaseous Helium, which is left in the tube after cover flushing. To avoid leakage of air and water vapour into the flushing lines, the lines will be sealed off with a slight He overpressure inside during the ground hold time / launch autonomy.

For the current worst-case calculation, a Helium pressure of 1.5 bar (150kPa) is assumed. The thermal conductivity of He varies between 0.137 W/mK and 0.156 W/mK for temperatures between 250 K and 300 K according to NIST. Two parallel stainless steel (1.4404) lines, free effective length L = 60 mm, outer diameter da = 5.0 mm, inner diameter di = 4.6 mm. [RD 38]This leads to a pipe wall conductance of 0.0015 W/K.

Since the warm part (Johnston coupling) is above the cold part (CHS), convection will not take place. Conduction in the He gas is:

$$C = 2 \cdot \lambda \cdot \frac{\pi d_i^2}{4L} = 8.30951\text{E-05 W/K}$$

This linear conductor has been implemented in the CDR TMM version.

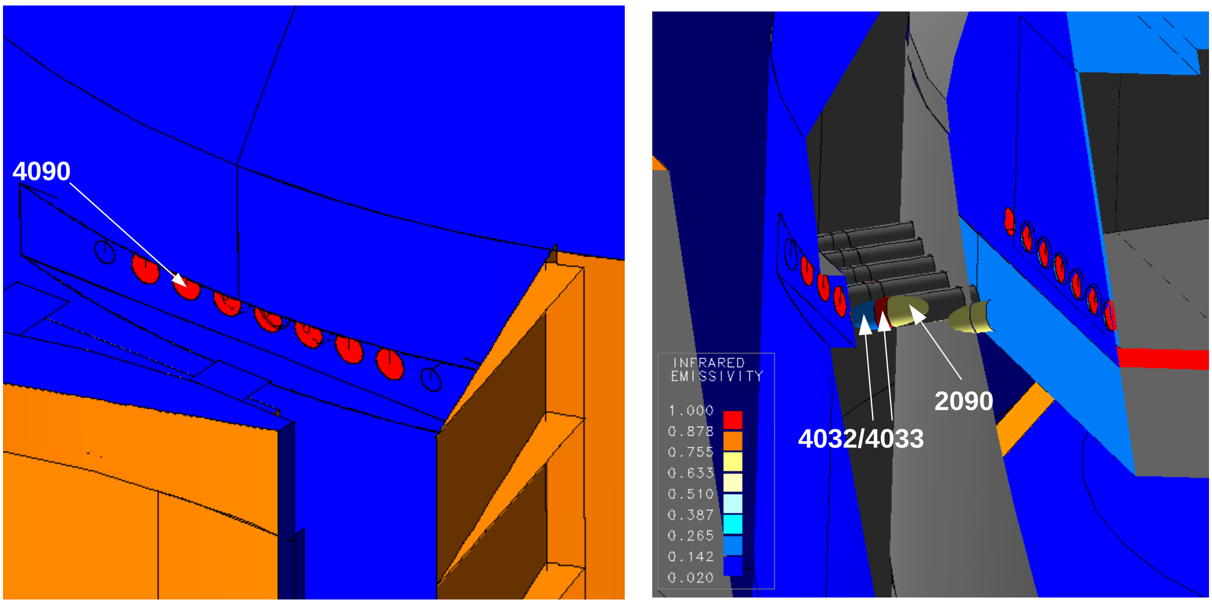


Figure 4.7-3: LOU Windows / Baffles

Item	Node	Material / Components	Mass [kg]	Size	Solar Absorpt.	IR Emiss.	Unit Level Requirement	Remark
CVV lower bulk	4011-4018	Al 5083, 3.3547, outside: black anodized inner side: polished	88.5	A= 8 x 0.585 m² 7 mm thickness (average)	α=0.95	0.75*0.82 0.06	R-CVV-F-640 [RD 31] R-CVV-F-645 [RD 31]	B)
CVV lower cylinder	4021-4028	Al 5083, 3.3547, outside :black anodized inner side: polished	95.0	D = 1.9 m, h=0.842 m 7 mm thickness (average)	α=0.95	0.75*0.82 0.06	R-CVV-F-640 [RD 31] R-CVV-F-645 [RD 31]	B)
CVV upper cylinder	4031-4038	Al 5083, 3.3547, outside: black anodized inner side: polished	78.5	D = 1.9 m , h= 0.696 m 7 mm thickness	α=0.95	0.82 0.06	R-CVV-F-640 [RD 31] R-CVV-F-645 [RD 31]	B)
CVV upper bulk	4041-4048	Al 5083, 3.3547, outside: black anodized inner side: polished	78.1	A= 8 x 0.516 m² 7 mm thickness (average)	α=0.95	0.82 0.06	R-CVV-F-640 [RD 31] R-CVV-F-645 [RD 31]	B)
CVV lower bulk MLI	4111-4118 4103-4106	25 layers (4x6+1)			α=0.13	0.05	R-EXM-530 [RD 28]	A)
CVV lower cyl. MLI	4121-4128	25 layers (4x6+1)			α=0.13	0.05	R-EXM-530 [RD 28]	A)
CVV upper cyl. MLI	4131-4138	25 layers (4x6+1)			α=0.13	0.05	R-EXM-530 [RD 28]	A)
CVV upper bulk MLI	4141-4148	25 layers (4x6+1)			α=0.13	0.05	R-EXM-530 [RD 28]	A)
CVV –Z Radiator (+X)	4053	Al 6063, both sides black anodized		(0.35 x 0.926) m² 15 x M8	α=0.95	0.82	R-CVV-F-480 [RD 31]	B)
CVV –Z Radiator (-X)	4050	Al 6063, both sides black anodized		(0.35 x 0.506) m² 9 x M8	α=0.95	0.82	R-CVV-F-480 [RD 31]	B)
CVV -Y Radiator	4055	Al 6063, -Z side black anodized		(0.35 x 1.687) m² 24 x M8	α=0.95	0.82	R-CVV-F-485 [RD 31]	B)
CVV +Y Radiator	4057	Al 6063, - Z side black anodized		(0.35 x 1.687) m² 24 x M8	α=0.95	0.82	R-CVV-F-485 [RD 31]	B)
CVV -Y Radiat. MLI	4155	25 layers (4x6+1)			α=0.13	0.05	R-EXM-530 [RD 28]	A)
CVV +Y Radiat. MLI	4157	25 layers (4x6+1)			α=0.13	0.05	R-EXM-530 [RD 28]	A)
LOU Windows	4090	Quartz Glass windows (LOU), 5 mm thick Quartz Glass windows (Alignment) 5 mm thick		7 x ∅34 mm opening in CVV 2 x ∅24 mm opening in CVV		0.9		
Cover	4800	If opened: -107° rotated around Y axis	7			0.15	R-CC-090 [RD32]	
Cover Heat Shield	4801	Heat shield rim/short cone	0.46			0.05 0.7	R-CC-080 [RD32]	
Outer Cryostat Baffle	4070,4071, 4073,4079	Al 5083	5	D=850mm		0.15	R-CB-135 [RD32]	

	4072	90° radiator section		0.229 m²		0.82	R-CB-135 [RD32]	B)
Inner Cryostat Baffle	4075	Al 5083 outer surface	1	Conical: D=500, d=300		0.05 0.1	R-CB-135 [RD32]	
Cryostat Baffle MLI	4170,4171, 4173,4179	25 layers (4x6+1)	0.6 0.3		α=0.13	0.05	R-EXM-830 [RD 28]	A)
CVV gap	4041-4048	simulates IMT crown		D = 290mm, h = 14.5mm		0.6		
Pretension 1 - 8	4081-4088	Ti brackets	8 x 0.15					

A) ASED PDR Reference design assumed

B) Test results obtained from sample testing [RD 35], for CVV lower part 75% degraded view factor assumed

Table 4.7-1: Item List for CVV and Cryostat Baffle

The thermal property data of the CVV MLI are described in Section 5.1.

4.8 LOU and Telescope

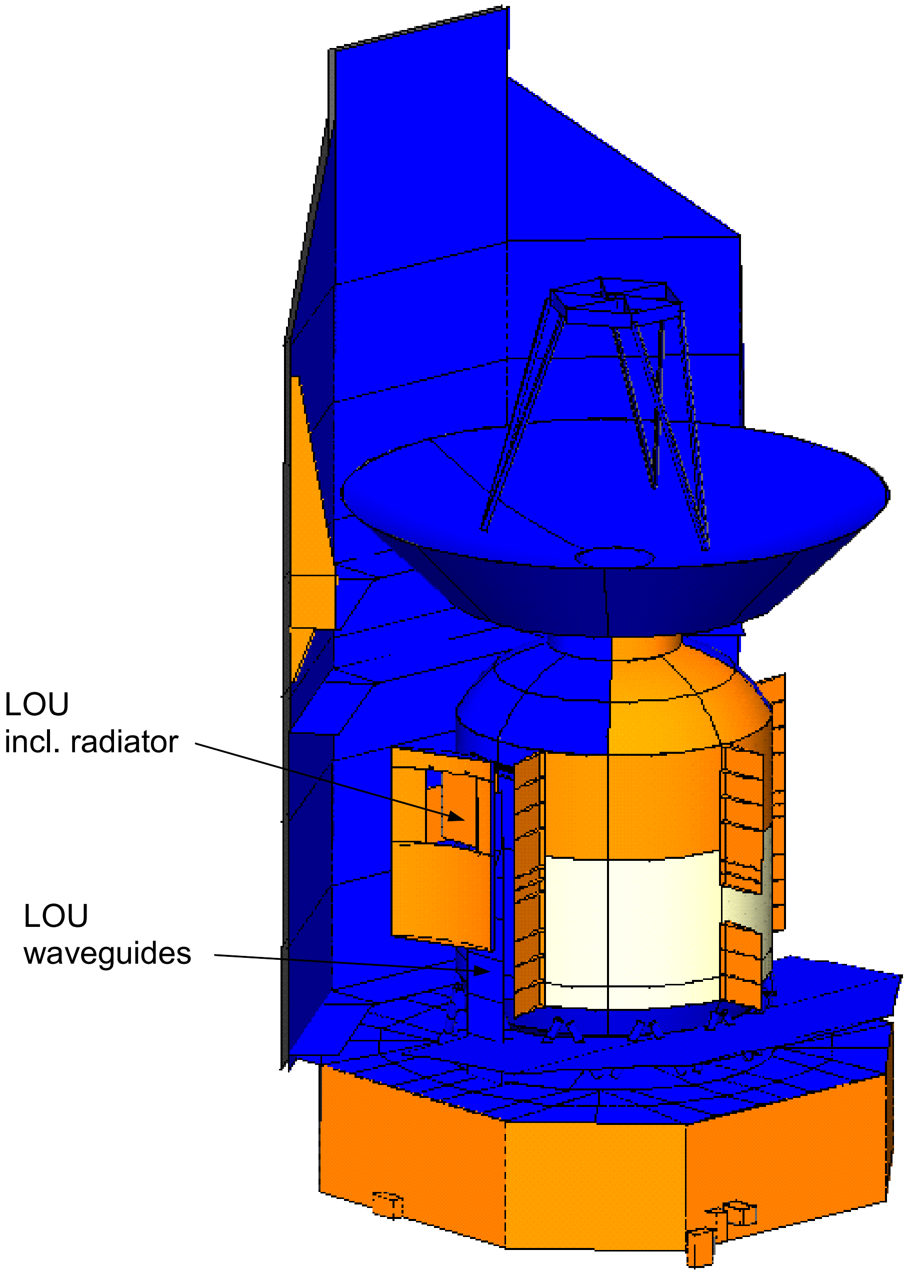


Figure 4.8-1: H-EPLM GMM External Overall View including H-SVM RGMM

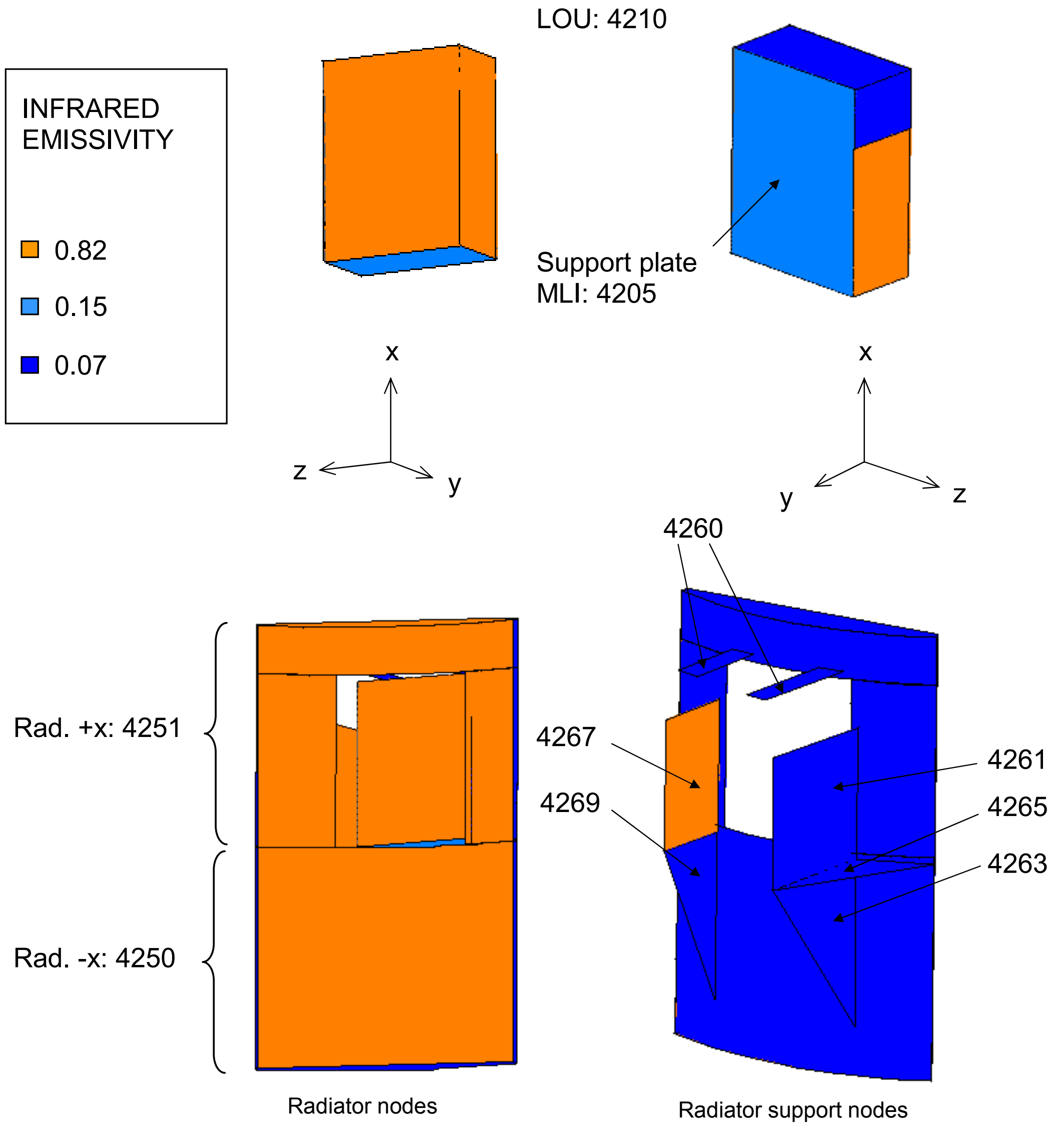


Figure 4.8-2: LOU & LOU Radiator GMM

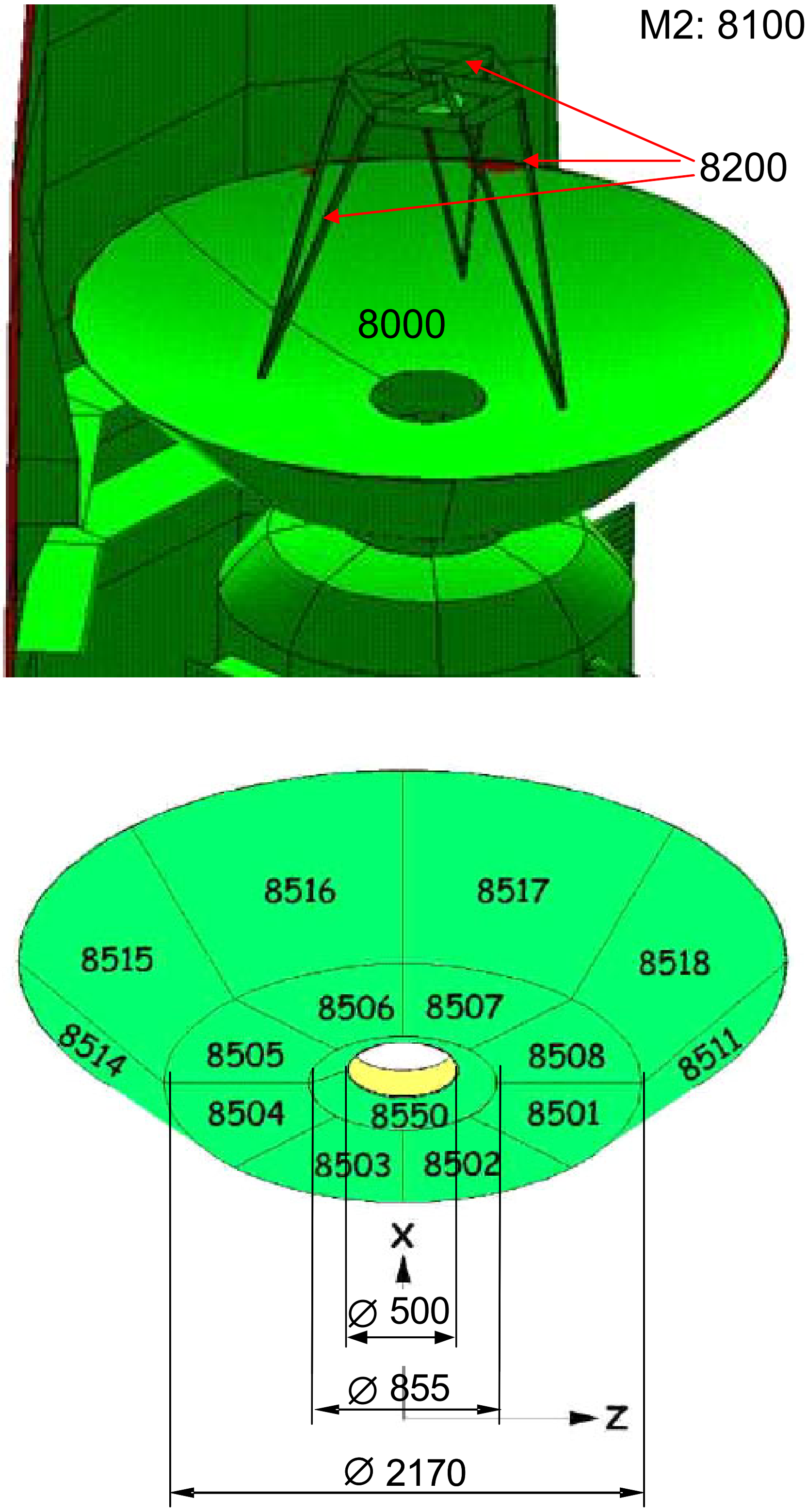


Figure 4.8-3: Telescope GMM

LOU:

The LOU is modelled as one common box connected to the LOU baseplate with 1 W/K and with a heat dissipation of 7 W [AD 01 and AD 04].

The LOU baseplate has a conductive interface to the CVV via 8 GFRP struts with 6.39 mm cross-section to length ratio in total and an assumed conductive coupling to the LOU radiator of 1 W/K.

In addition to the LOU radiator the +X and –Z side of LOU box serve also as radiator, the other sides of the box are covered with MLI.

The LOU Waveguide bundle is subdivided in 6 nodes, see Figure 4.8-4.

Radiative coupling between SVM and LOU via waveguide tubes: GR=0.383E-3 m²

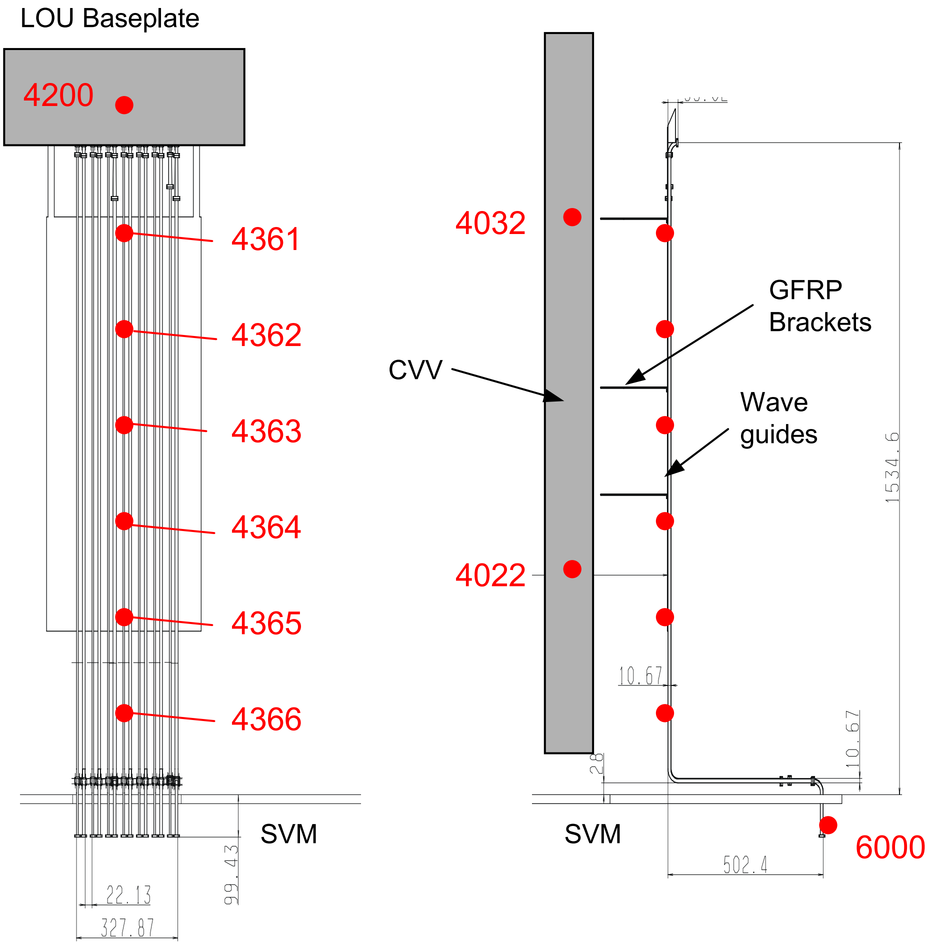


Figure 4.8-4: Nodal Break-Down of LOU Waveguides and Harness

Item	Node	Material / Components	Mass [kg]	Size	Solar Abs.	Emiss.	Unit Level Requirement	Remark
LOU Support Structure	4200	Al 6061 8 GFRP struts to CVV 32xM5 to LOU Baseplate 20xM5+6xM4 to LOU Radiator support		(507x439x10) mm A/L = 6.39 mm GFRP			R-SS-0330 [RD 25]	
LOU radiative area (-Y) +/-Z side (partly) others	4210	thermally equivalent to Al	35	(466x352x170) mm 0.16 m²		 0.82 0.82 0.07-0.15		
LOU +Y MLI	4205	specularity = 0.7 (IR)			0.13	0.15		
LOU Radiator	4250-4251	black painted Al		0.933 m²	0.95	0.82 front 0.07 rear		
LOU Radiat. supp. +X LOU Radiat. supp. +Z,+X LOU Radiat. supp. +Z,-X LOU Radiat. supp. +Z LOU Radiat. supp. -Z,+X LOU Radiat. supp. -Z,-X	4260 4261 4263 4265 4267 4269				0.13	0.07 0.82/0.07 (-Z/+Z) 0.07 0.07 0.82/0.07 (+Z/-Z) 0.07		
LOU Waveguides	4361-4366	13x WR28 + 1xWR34 St. Steel WG's to SVM	1.917	A=168 mm², l=1.47 m		0.1		RD 34
		GFRP WG support brackets on CVV		A/l = 3.6 mm GFRP				
Telescope	8000 8100 8200	Primary Reflector M1 (SiC) Telescope Baffle Gap to internal Cryostat Baffle M2 Mirror (SiC) Hexapod (SiC)	210 20 70	∅3.5 m ∅0.5 m ∅0.5 m x 8 mm		0.01 0.05 1.0 0.01 0.02		
	8400	CFRP T300 struts to CVV GFRP struts to Cryostat Cover		A/L = 12.63 mm CFRP T300 A/L = 1.94 mm GFRP			R-TMS-0330 [RD 27]	
Telesc. M1 MLI	8501-8518, 8550	"Two screen" concept		D = 3.5 m, d = 0.5 m		0.05 0.02		decontamin. nominal in-orbit

Table 4.8-1: Item List for LOU and Telescope

4.9 Harness

The harness implementation principle in the H-EPLM TMM is shown in Figure 4.9-1. Depending on the harness dissipation, the different harness branches are modelled either by dedicated nodes or via a thermal conductance coupling using thermal conductivity integral functions. For the latter ones, the harness dissipation is distributed to the corresponding interface at the cold end. An overview for the CVV internal harness modelling is given in Table 4.9-1.

Instrument	Branches with dedicated nodes	Branches with (integral) thermal conductance	Remark
PACS FPU	3	12	
SPIRE FPU	1	3	
HIFI FPU	5	4 (coax)	
SPIRE JFET Phot.	1	6	
SPIRE JFET Spec.	0	2	

Table 4.9-1: Modelling of the CVV Internal Harness Branches in the EPLM TMM

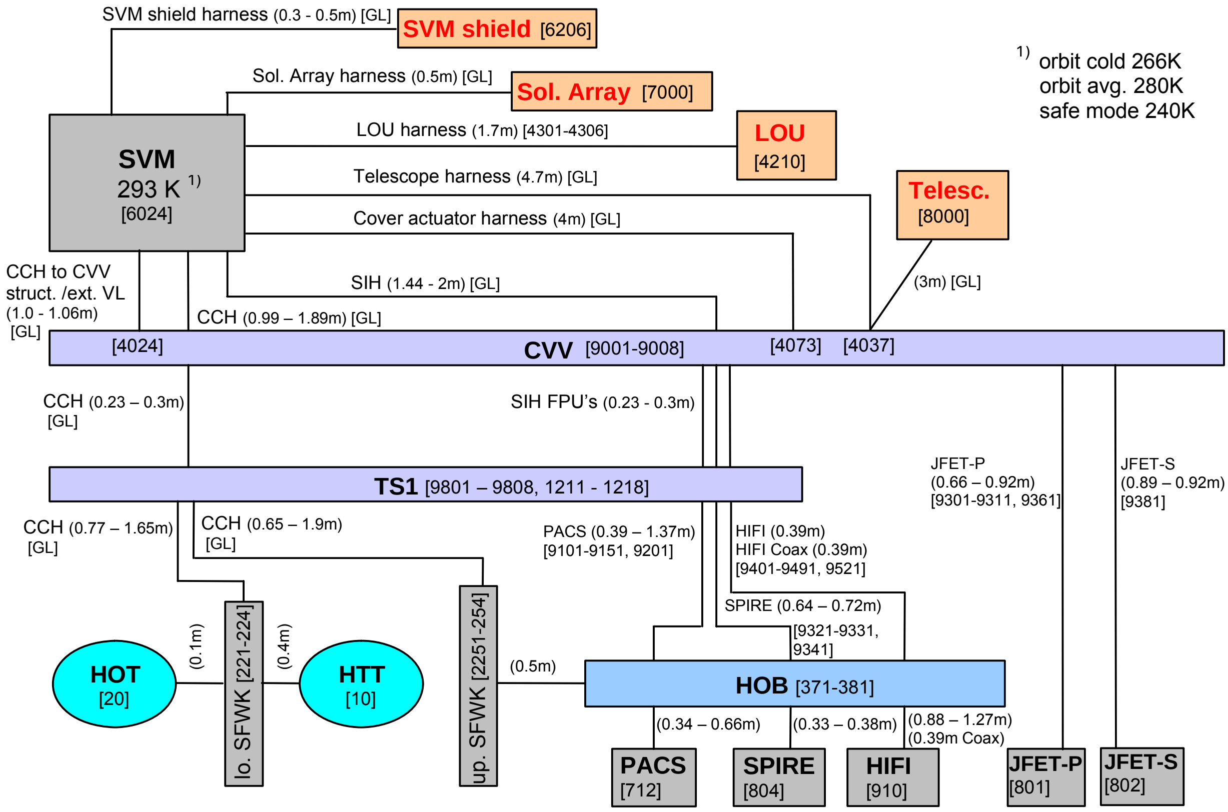


Figure 4.9-1: Harness Chart used in TMM

The LOU waveguides and the LOU harness are located outside the CVV and are subdivided in 6 nodes in x-direction, each. The waveguides are also modelled in the GMM. All other external harness is implemented by means of conductive couplings between the corresponding I/F nodes and the dissipation is distributed to 100% to the corresponding cold end.

The cross-section and dissipation values of the scientific harness (SIH) and the cryostat control harness (CCH) have been evaluated based on the data listed in RD 02. The SIH data are summarized in Table 4.9-2 and Table 4.9-3; the CCH data are listed in Table 4.9-4 and Table 4.9-5.

The thermally isolating harness lengths are defined between the following I/F points, see Figure 4.9-1:

- at SVM: all harness assumed to have SVM temperature at SVM / CVV strut I/F
- at CVV: all harness assumed to have CVV temperature at the CVV / tank suspension strap I/F. Thermal connection via connector brackets, additional thermal connections at CVV internal wall (if necessary)
- at TS1: thermal connection of SIH (except SPIRE JFET harness) and CCH by means of "Stycast brackets", similar as done on ISO
- at OBA: thermal connection of PACS FPU, SPIRE FPU and HIFI FPU harness by means of "Stycast brackets".

Thermal isolation length means the "free" length between the end of the harness thermal connection section at the CVV and the begin of the thermal connection section at the TS 1. The harness routing length between CVV connector brackets and the tank suspension straps is not taken as thermal isolating length, which is a conservative assumption. Harness conduction across the fixation ties on the tank suspension straps is considered to be negligible and therefore not taken into account in the TMM.

The SPIRE JFET harness is directly routed from the CVV to the JFET units.

The thermal contact conductance across a "Stycast bracket" is estimated to 0.05 W/K per branch.

Internal Harness (SIH)	Node	from	to	Length *	Average Dissip at 77K	Spec Mode Dissip at 77K	Phot Mode Dissip at 77K	Stainl. St.	Brass	SiO_2	PTFE
				m	mW/m	mW/m	mW/m	mm^2	mm^2	mm^2	mm^2
PACS FPU	9101-9151, 9201	CVV TS1 OB	TS1 OB FPU	0.228-0.3 0.391-1.366 0.340-0.655	4.32	19.9	6.03	37.594	5.1	-	367
SPIRE FPU	9321-9331, 9341	CVV TS1 OB	TS1 OB FPU	0.3 0.636-0.723 0.327-0.378	1.186	7.116	1.217	11.068	6.216	-	103
SPIRE JFET-P	9301-9311, 9361	CVV	JFET-P	0.658-0.917	0.034	0	0.202	40.792	0.914	-	318
SPIRE JFET-S	9381	CVV	JFET-S	0.888-0.919	0.007	0.043	0	13.306	0.594	-	92
HIFI FPU (incl. coax)	9401-9491, 9521	CVV TS1 OB	TS1 OB FPU	0.236-0.3 0.383-0.394 0.385-1.272	4.55	HIFI on: 13.66		30.805	6.014	21.024	123

*) thermally isolating length

Table 4.9-2: CVV Internal Harness Data for PACS, SPIRE and HIFI

External Harness (SIH)	from	to	Length *	Average Dissip **	Spec Mode Dissip **	Phot Mode Dissip **	Stainl. St.	Brass	Cu	SiO_2	Manganin	PTFE
			m	mW/m	mW/m	mW/m	mm^2	mm^2	mm^2	mm^2	mm^2	mm^2
PACS FPU	SVM	CVV	1.5 - 2.0	2.9	8.21	9.17	37.536	5.132	-	-	17.517	367
SPIRE FPU	SVM	CVV	1.44-2.0	1.96	11.8	2.43	9.646	6.019	-	-	12.1	107
SPIRE JFET-P	SVM	CVV	1.44-2.0	0.0567	0	0.34	28.864	2.942	-	-	26.21	270
SPIRE JFET-S	SVM	CVV	1.44-2.0	0.0475	0.285	0	8.416	1.028	-	-	6.048	83
HIFI FPU	SVM	CVV	1.67-2.0	7.0	HIFI on: 21		30.73	6.014	-	21.02	8.64	121
HIFI LOU (RD 33)	SVM	LOU	1.7	29	LOU on: 86		7.72	0.914	75.12	-	24.31	107

*) thermally isolating length

**) with the exception of LOU harness all dissipation values are valid for 293 K, dissipation at lower temperature expected to be lower

Table 4.9-3: CVV External SIH Data

Internal Harness (CCH)	from	to	Length *	Dissip	Stainl. St.	Brass	PTFE
			m	mW/m	mm^2	mm^2	mm^2
CCH to HOT & HTT	CVV low CB TS1	TS1 low SFW	0.24-0.3 0.77-1.65	0	2.23 2.23	3.05 3.05	34.2 34.2
	low SFW	HOT	0.1		0.552	0.912	9.1
	low SFW	HTT	0.4	0	1.48	2.124	23.4
CCH to OB	CVV upp CB TS1 upp SFW	TS1 up. SFW OB	0.23-0.3 0.65-1.9 0.5	0	1.98 1.62 1.62	-	18 14.7 14.7

*) thermally isolating length

Table 4.9-4: CVV Internal CCH Data

External Harness (CCH and Telescope)	from	to	Length *	Dissip.	Stainl. St.	Brass	Cu	Manganin	PTFE
			m	mW/m	mm^2	mm^2	mm^2	mm^2	mm^2
CCH to CVV lower CB	SVM	CVV low. CB	0.99-1.68	0	2.384	3.0	-	5.3	35.6
CCH to CVV upper CB	SVM	CVV upp. CB	1.46-1.89	0	2.352	-	-	1.992	21.3
CCH to CVV structure/VL	SVM	CVV	1.0-1.06	0	1.12	1.224	2.4	7.02	16.17
CCH to Cover	SVM	CVV /Cover	4		0.128	2.856	-	1.968	8.76
Telescope heater via CVV	SVM CVV	CVV Telescope	4.7 3	0	0.384	-	8.0	3.24	11.17
CCH to SVM Thermal Shield	SVM	SVM Shield	0.3 - 0.5	0	0.128	-	0.6	0.648	1.18

*) thermally isolating length

Table 4.9-5: CVV External CCH Data

4.10 HERSCHEL Solar Array and Sunshade with Struts

The HERSCHEL Solar Array and Sunshade (HSS) is split in two parts, the upper part is the Sunshade (SSD), providing the shade mainly for the telescope and the lower part is the Solar Array (SA), which provides shading for the CVV and the electrical power. The SA +Z side therefore is covered with solar cells and the SSD +Z side is covered with OSRs. The rear side (-Z side) of the HSS is covered with high efficient MLI. The HSS nodal break-down is shown Figure 4.10-1 and the corresponding thermally relevant data are listed in Table 4.10-1.

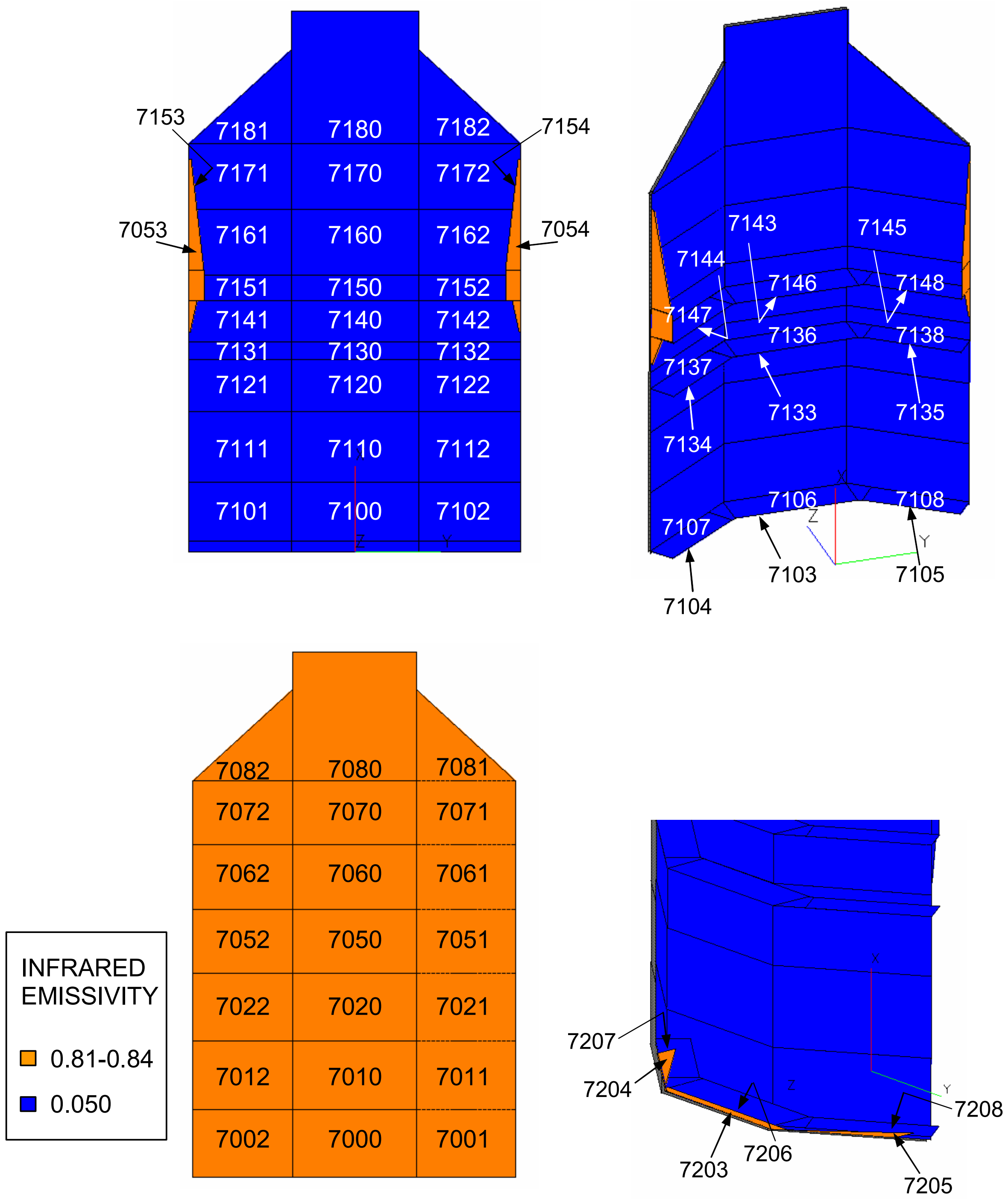


Figure 4.10-1: HSS Nodal Break-Down (upper: MLI nodes, lower: structural nodes)

Item	Node	Material / Components	Mass	Size	Unit Level Requirement	Solar Absorpt.	IR Emiss.	Remark
Solar Array Panels	7000-7022	Solar Cells with cover glass and harness CFRP skins (M55J) * Adhesive for HC Al Honeycomb (16 kg/m³)	1.6 kg/m² 0.83 kg/m² 0.3 kg/m² 0.8 kg/m²	2 x 0.3 mm thick 50 mm thick		α=0.915 [RD 18] -1200 W during Operation	0.81 [RD 18]	
		GFRP struts to CVV M55J CFRP struts with Ti end fittings (Ti6AlV4) to SVM Ti tubes to SVM Power harness to SVM		A/L = 2.515 mm GFRP in total A/L = 1.293 mm M55J with A/L =12.9 mm Ti in serial 0.04 W/K 34.5 mm² Copper, 0.5 m length	R-SS-0330 [RD 25]			[RD 37], [RD 38] [RD 37]
Solar Array Panels MLI	7100-7132	22 layers (4x5+2)	0.65 kg/m²		R-EXM-430 [RD 28]	α=0.13	0.05	
Solar Array Stiffening Frame MLI upper	7133-7138	22 layers (4x5+2)	0.65 kg/m²		R-EXM-430 [RD 28]	α=0.13	0.05	
Solar Array Stiffening Frame MLI lower	7103-7108	22 layers (4x5+2)	0.65 kg/m²		R-EXM-430 [RD 28]	α=0.13	0.05	
Solar Array-SVM Closure MLI	7203-7208	22 layers (4x5+2)	0.65 kg/m²		R-EXM-430 [RD 28]	α=0.13 α=0.8	0.05 0.8	+x side -x side
Sunshade Panels	7050-7082	OSR inclusive Adhesive CFRP skins (M55J) * Al Honeycomb (16 kg/m³) GFRP blades to Solar Array GFRP struts to CVV	1.0 kg/m² 0.83 kg/m² 0.8 kg/m²	2 x 0.2 mm thick 50 mm thick A/L = (10)x16 x 7.86 mm A/L = 2.394 mm GFRP in total	R-SS-0330 [RD 25]	α=0.20 α=0.10	0.84 0.84	EOL BOL
Sunshade +Y Stiffen. Rib	7054					α=0.92	0.8	
Sunshade -Y Stiffen. Rib	7053					α=0.92	0.8	
Sunshade Panels MLI	7140-7142, 7150-7182	20 layers (3x6+1)	0.65 kg/m²		R-EXM-330 [RD 28]	α=0.13	0.05	
Sunshade +Y Rib MLI	7154	20 layers (3x6+1)	0.65 kg/m²		R-EXM-330 [RD 28]	α=0.13	0.05	
Sunshade -Y Rib MLI	7153	20 layers (3x6+1)	0.65 kg/m²		R-EXM-330 [RD 28]	α=0.13	0.05	
Sunshade Stiff Frame MLI	7143-7148	20 layers (3x6+1)	0.65 kg/m²			α=0.13	0.05	

Table 4.10-1: HSS related Items

4.11 SVM with Struts and SVM Thermal Shield

To calculate the radiative couplings of the HERSCHEL CVV/SVM GFRP struts to their environment all 24 struts have been modelled in the ESARAD geometry model with an IR emissivity of 0.03 (e.g. one or a few layer MLI). Each strut has been subdivided into three nodes. The struts and the obtained radiative couplings have been implemented in the H-EPLM ESATAN TMM. The relevant length for the thermal analysis is the total GFRP strut length minus the length of the sections where GFRP tube and the titanium end fitting overlap. The thermally relevant dimensions of the struts are summarized in Table 4.11-1.

The SVM Shield is subdivided into 3 nodes and the MLI on top of the SVM Shield is subdivided accordingly, see Figure 4.11-1. The struts supporting the SVM Thermal Shield are implemented by conductive couplings between SVM and SVM Thermal Shield.

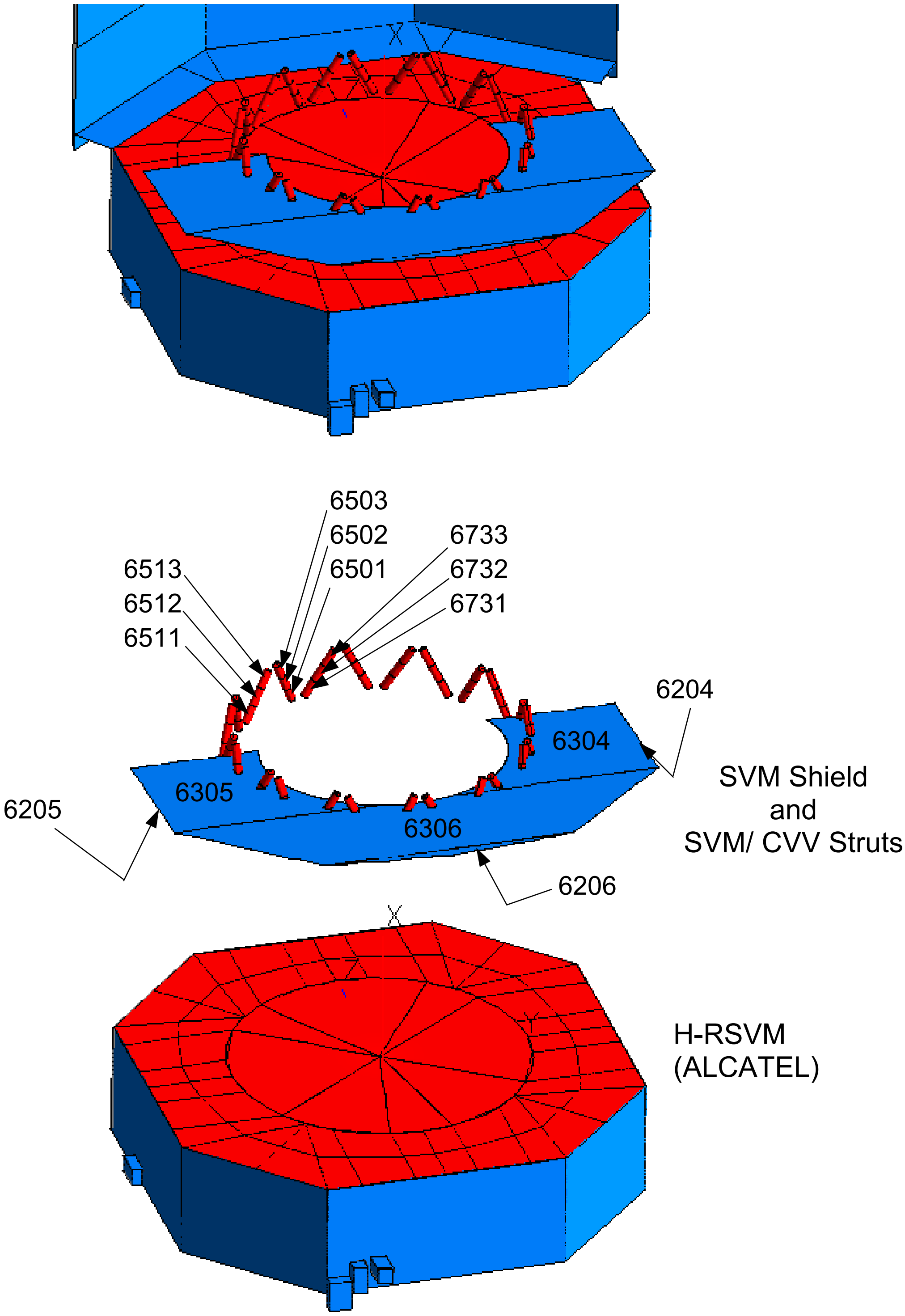


Figure 4.11-1: H-RSVM, SVM Thermal Shield and SVM/CVV Struts

Item	Node	Material / Components	Mass	Size	Unit Level Requirement	Solar Absor.	IR Emiss.	Remark
SVM Module	60XX,61XX 6020-6024 6101-6106	H-RSVM model, Alcatel responsibility Boundary Nodes (conductive) SVM top MLI				α=0.15	0.05	AD 07/08
SVM/CVV struts	6501-6733	GFRP strut tubes Ti fittings for GFRP tubes		A/L = 14.04 mm GFRP (24x D=35x2.1 mm, l=371mm)	R-SS-0330 [RD 25]			[RD 37], [RD 38
SVM Thermal Shield	6204-6206	CFRP T300 face sheets, VDA Kapton Foil on -X side (90% specularity) Al Honeycomb (32 kg/m³)		2 x 0.5 mm thick 19 mm thick	R-STS-0180 [RD 26] R-STS-0190 [RD 26]	α=0.3	0.05	
		GFRP strut tubes to SVM structure Ti fittings for GFRP tubes		A/L = 2.636 mm GFRP	R-STS-0230 [RD 26]		0.05	[RD 37], [RD 38
SVM Thermal Shield MLI	6304, 6305 6306	20 layers (3x6+1)		0.99 m² (+Y/-Z) 0.99 m² (-Y/-Z) 2.04 m² (-Z)	R-EXM-630 [RD 28]	α=0.13	0.05	

Table 4.11-1: SVM and SVM Shield related Items

5 Material Properties

SECTION 5 TO BE UPDATED

2).

5.1 MLI Thermo-Optical Properties and Performance Data

Internal MLI

The heat flux approximations and the thermal performance parameters derived in [RD 36] are compiled in Table 5.1-1 for the "Herschel-type" MLI. This MLI is used for the Thermal Shields MLI. The corresponding values for the "ISO-type" MLI are taken from /1/ and are summarized in Table 5.1-2. The ISO MLI data are used for the HTT and HOT MLI.

The heat fluxes are calculated for different boundary temperatures T_H and T_C. Herewith T_H corresponds to the temperature of the outermost MLI blanket layer while T_C corresponds to the thermal shield temperature the MLI blanket is attached to.

	$q = (a\,(T_H + T_C)/2 + b)\,(T_H - T_C) + \varepsilon\,\sigma\,((T_H^4 - T_C^4)$		
	a	b	ε
10-layer MLI	8.720E-06	2.353E-05	0.00395
20-layer MLI	4.360E-06	1.177E-05	0.001975

Table 5.1-1: Derived MLI Performance Data for Herschel Type MLI

	$q = h\,(T_H - T_C) + \varepsilon\,\sigma\,((T_H^4 - T_C^4)$	
	h (W/m²K)	ε
10-layer "ISO-type" MLI	3.50E-04	0.0030

T_H = "hot" temperature of outermost blanket layer
T_C = "cold" temperature of innermost blanket layer = identical to thermal shield temperature

Table 5.1-2: Derived MLI Performance Data for ISO Type MLI /1/

Degradation factors of integrated MLI have been evaluated in detail for the different MLI sections. The derivation of those factors is also described in [RD 36]. It should be noted that worst-case assumptions have been used for the individual contributions to the total degradation factor, leading to a strictly conservative MLI performance presentation in the TMM. An overview of all CVV internal MLI performance data used in the TMM is compiled in Table 5.1-3.

MLI on	Layers	radiative emissivity (ε_{rad})	linear conductance H [W/m²K]	Integration Factor Orbit	Ground	emissivity of ext. layer (ε_{ext})	specul. of ext. layer (ρ_{ext})
HTT	10	0.003	3.5 E-4	2	2	0.05	0
HOT	10	0.003	3.5 E-4	1	1	0.05	0
TS 1 upper bulk	10	0.00395	H(T) *	1.86	2.57	0.05	0
TS 1 upper cylinder	10	0.00395	H(T) *	2.60	4.05	0.05	0
TS 1 lower cylinder	10	0.00395	H(T) *	1.50	1.99	0.05	0
TS 1 lower bulk	10	0.00395	H(T) *	2.43	2.75	0.05	0
TS 2 upper bulk	20	0.001975	H(T) *	1.66	1.66	0.05	0
TS 2 upper cylinder	20	0.001975	H(T) *	2.05	2.03	0.05	0
TS 2 lower cylinder	20	0.001975	H(T) *	1.42	1.43	0.05	0
TS 2 lower bulk	20	0.001975	H(T) *	1.83	1.80	0.05	0
TS 3 upper bulk	20	0.001975	H(T) *	1.64	1.63	0.05	0
TS 3 upper cylinder	20	0.001975	H(T) *	2.09	2.05	0.05	0
TS 3 lower cylinder	20	0.001975	H(T) *	1.55	1.53	0.05	0
TS 2 lower bulk	20	0.001975	H(T) *	1.60	1.58	0.05	0

*) see Table 5.1-1

Table 5.1-3: Overview on CVV Internal MLI Performance Data

External MLI

To calculate the MLI performance at higher temperature the approach proposed by Doenecke /12/ is used. This approach is valid for a temperature range between 130 K and 410 K and features a calculation procedure for an effective MLI emissivity ε_{eff}. No linear component is foreseen in this approach. This calculation procedure has been taken for the HSS MLI and the SVM Thermal Shield MLI.

MLI on	Layers	radiative and effective emissivity (ε_{rad} and ε_{eff})	linear conductance H [W/m²K]	emissivity of ext. layer (ε_{ext})	specul. of ext. layer (ρ_{ext})	Remark
CVV	25	ε_{rad} = 0.0022	1.093 E-3	0.05	0.8	Ref. /1,11/
Cryostat Baffle	25	ε_{rad} = 0.0022	1.093 E-3	0.05	0.8	Ref. /1,11/
LOU	20	ε_{eff} = 0.02	0	0.05	0.8	
	20	ε_{eff} = 0.02	0	0.15	0.7	Baseplate
Sunshade	20	ε_{eff} = 0.015	0	0.05	0.8	Ref. /12/
Solar Array	22	ε_{eff} = 0.012	0	0.05	0.8	Ref. /12/
SVM Shield +X	20	ε_{eff} = 0.015	0	0.05	0.8	
SVM Shield -X	1	n.a.	n.a.	0.05	0.9	Ref. /10/
SVM Struts	1	n.a.	n.a.	0.03	0	
SVM Top	n.a.	n.a.	n.a.	0.05	0	AD 07 & 08
Telescope, Orbit	n.a.	ε_{eff} = 0.01	n.a.	0.02	0	RD 29
Decontamination	n.a.	ε_{eff} = 0.025	n.a.	0.05	0	

Table 5.1-4: Overview on CVV External MLI Performance Data

5.2 Thermal Conductivity Data

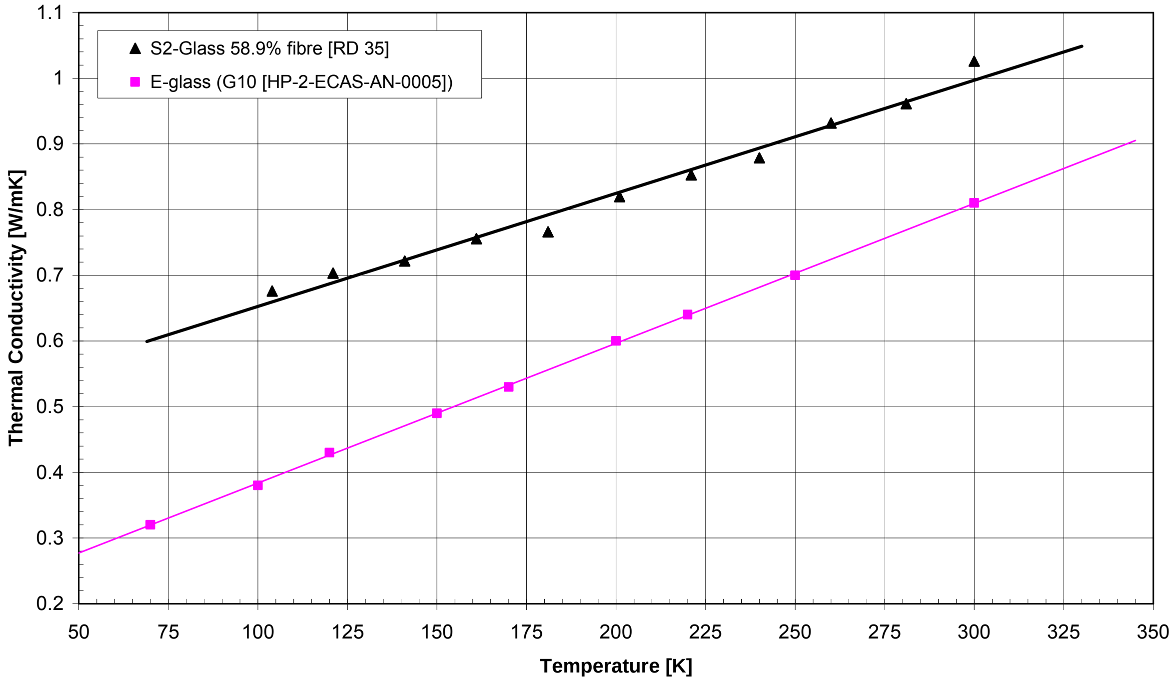


Figure 5.2-1: Thermal Conductivity of S2-Glass and E-Glass GFRP Struts

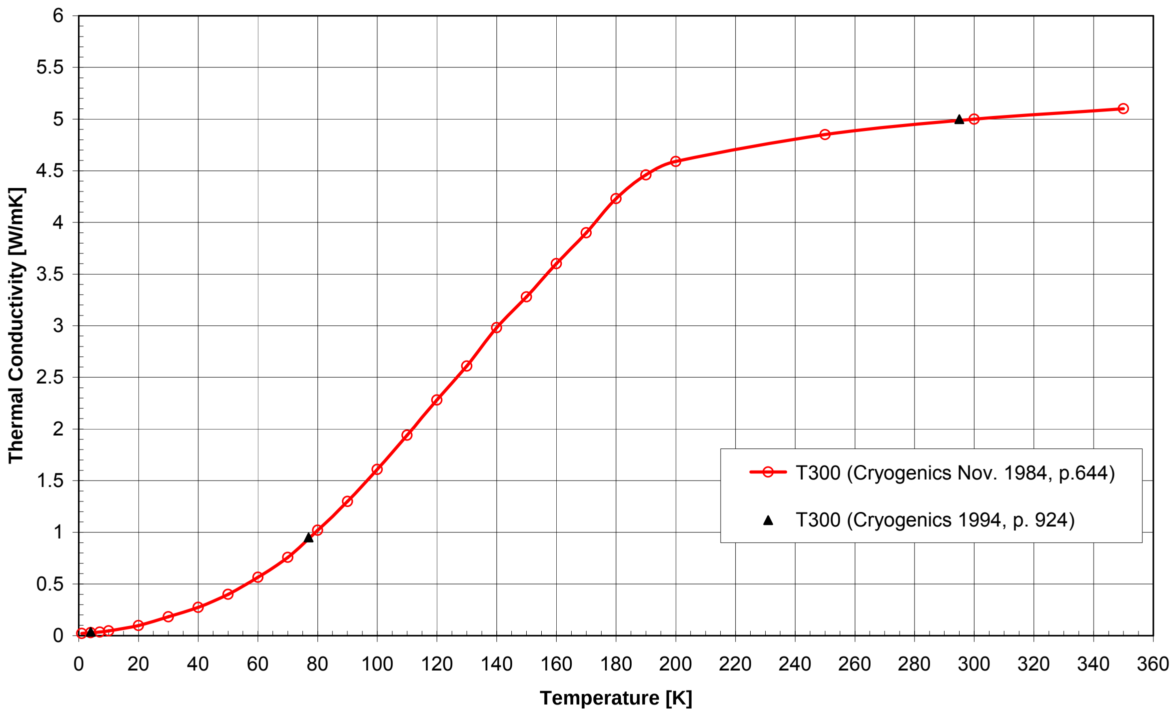


Figure 5.2-2: Thermal Conductivity of CFRP T300 Struts

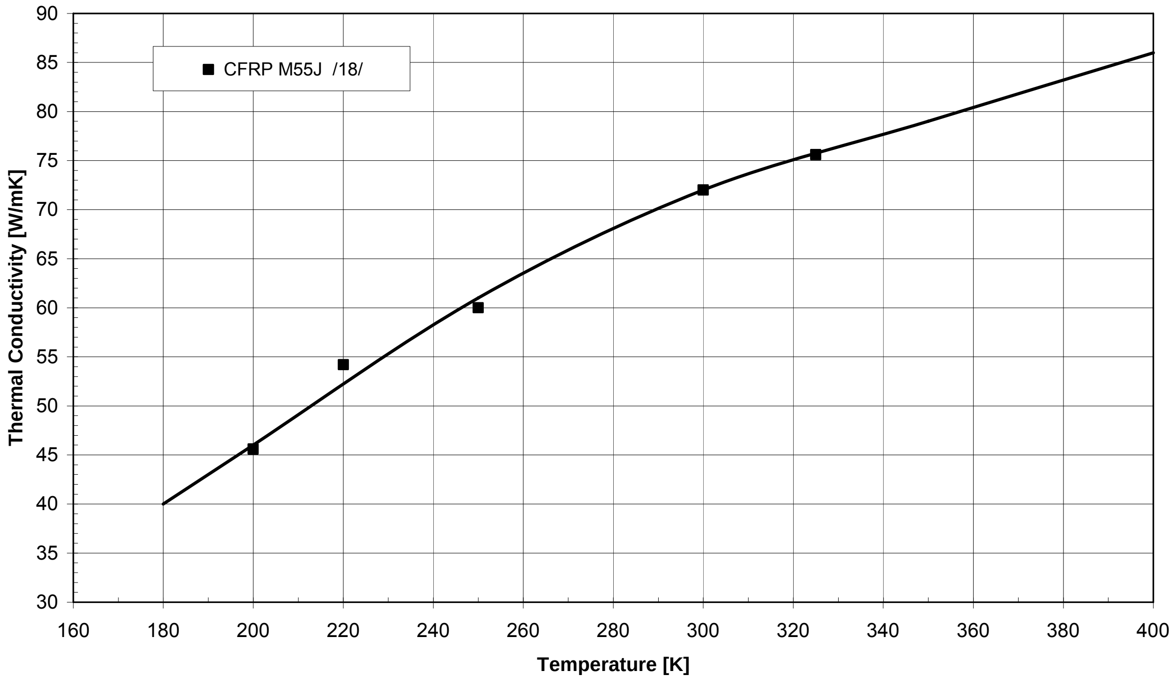


Figure 5.2-3: Thermal Conductivity of CFRP M55J Struts

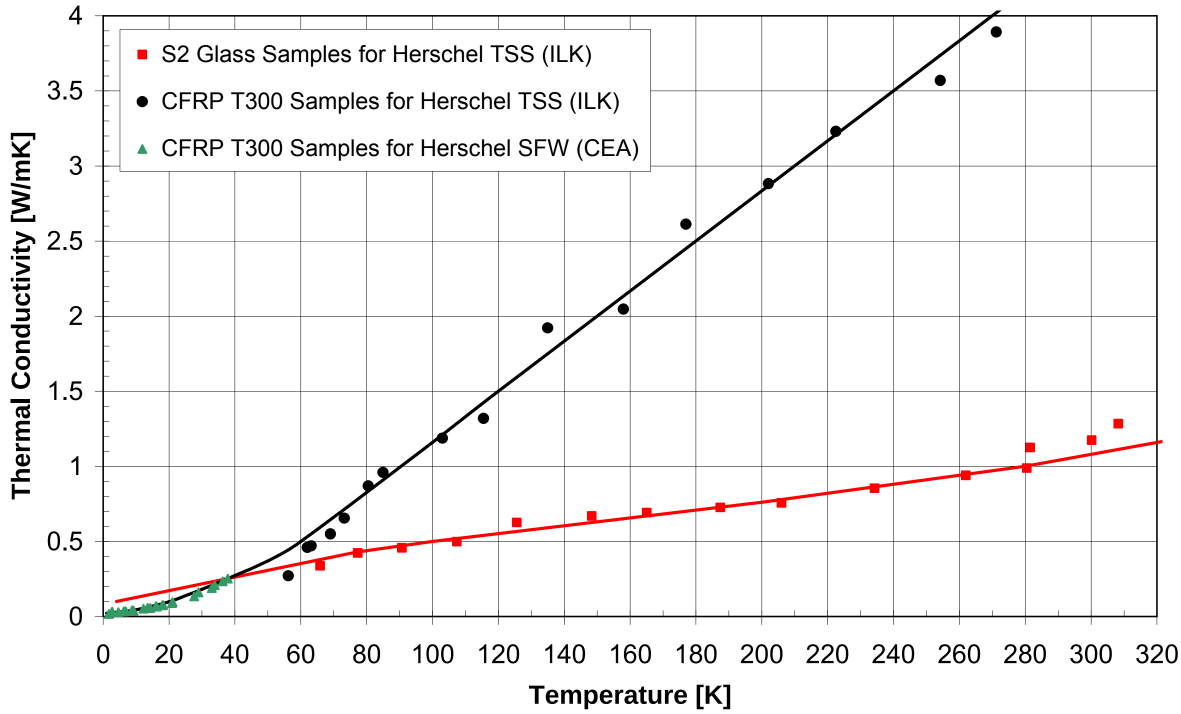


Figure 5.2-4: Thermal Conductivity of CFRP T300 and GFRP (S-glass) Tank Suspensions [RD 35]

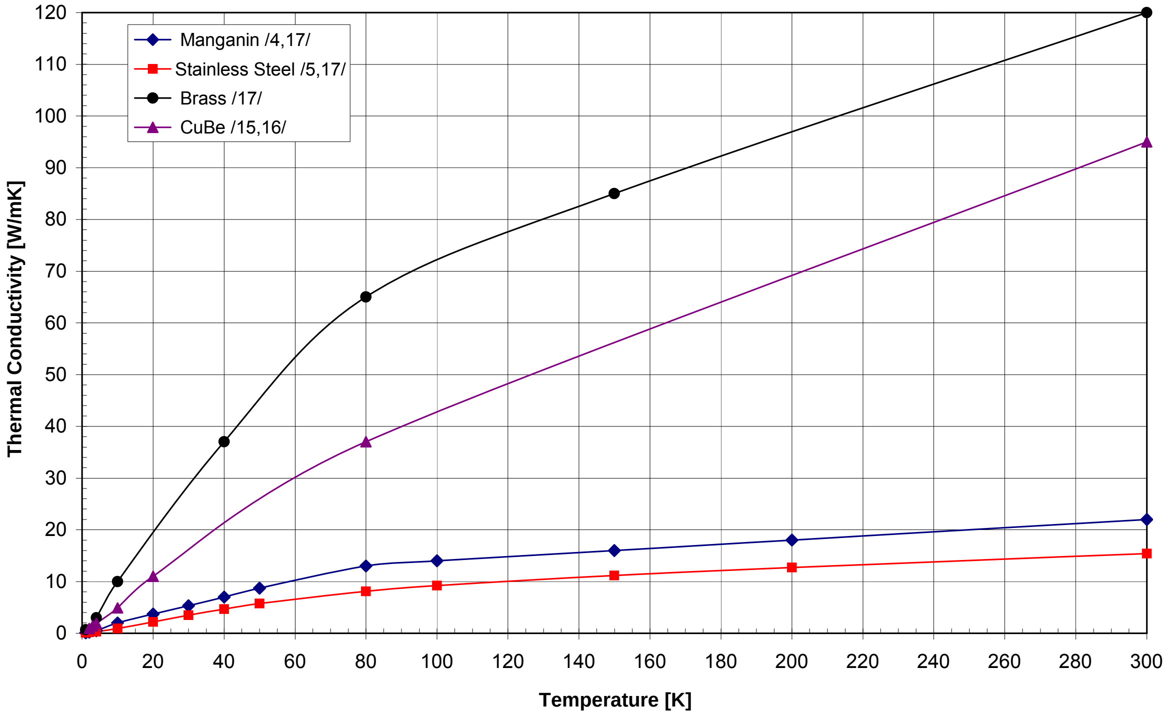


Figure 5.2-5: Thermal Conductivity of Harness Wires

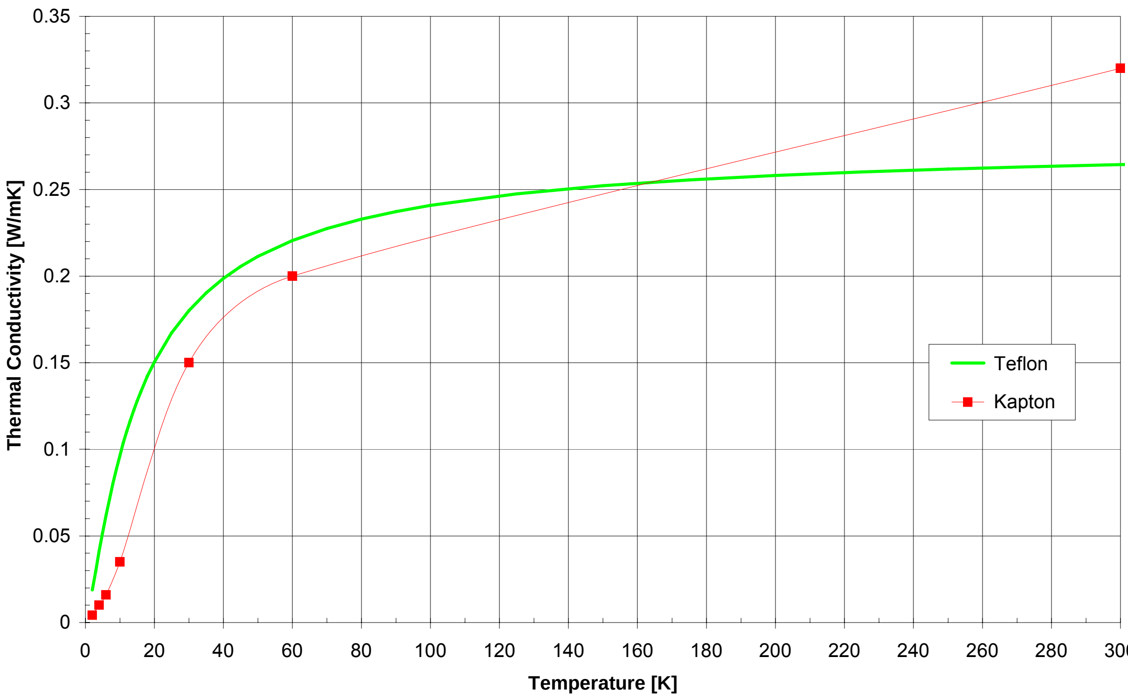


Figure 5.2-6: Thermal Conductivity of Harness Wire Insulation Materials /14/

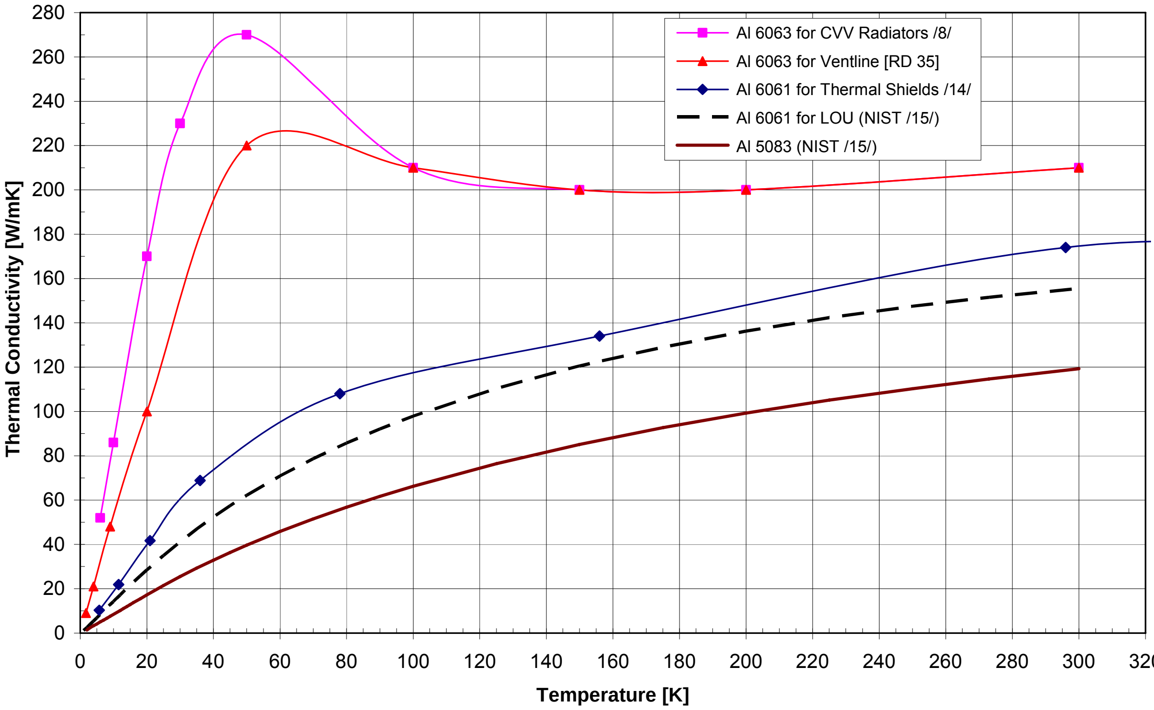


Figure 5.2-7: Thermal Conductivity of Aluminium Alloys

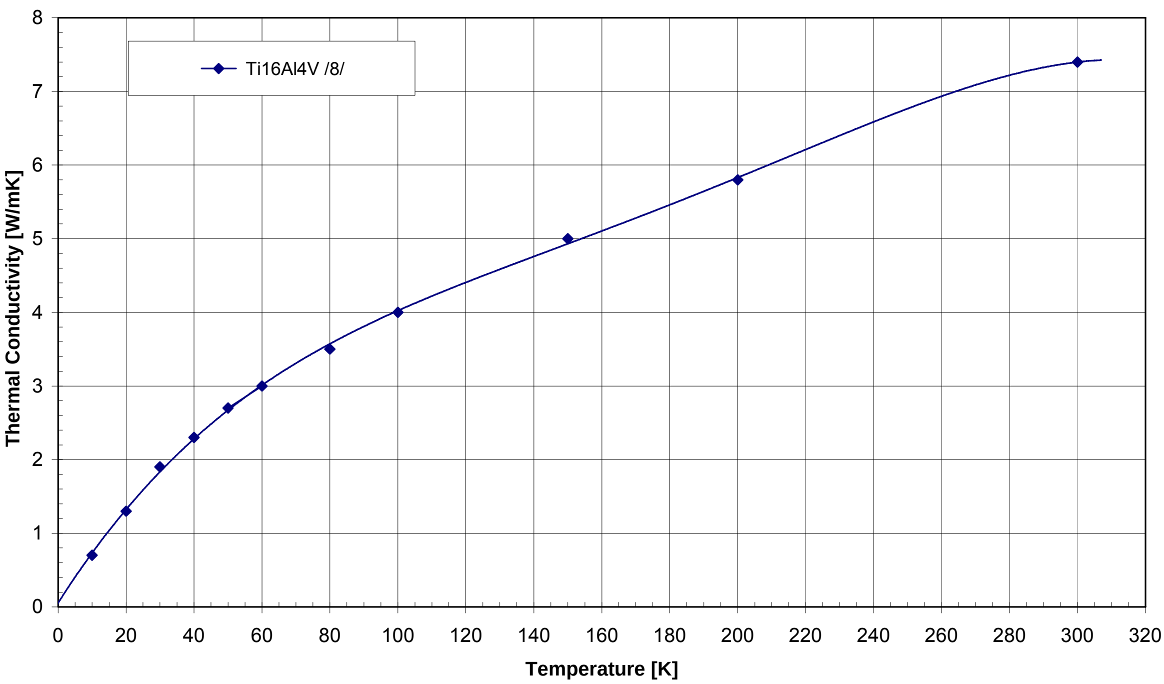


Figure 5.2-8: Thermal Conductivity of Titanium Alloy Ti6Al4V

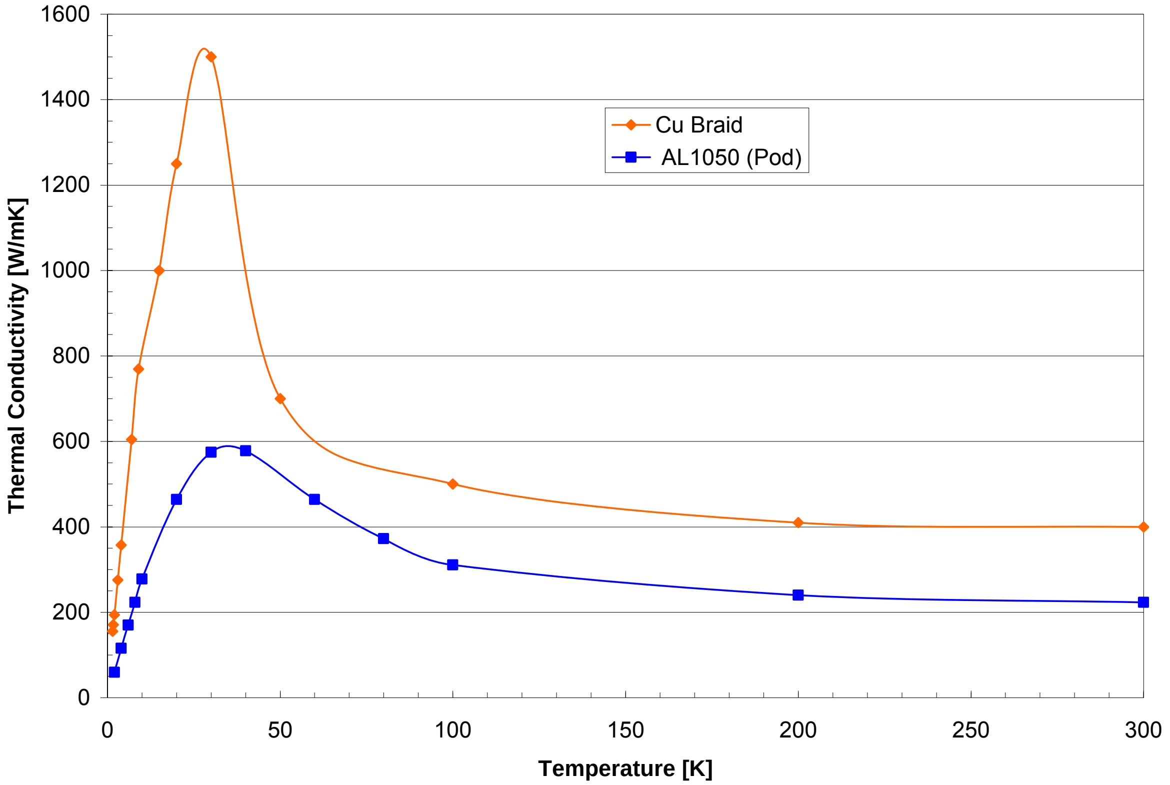


Figure 5.2-9: Thermal Conductivity of Thermal Link Materials [RD 35]

5.3 Thermal Contact Conductance Data

The thermal contact conductance data given in Figure 5.3-1 are related to 1 kN. For calculating the total contact conductance of an interface the following contact forces are applied:

- 2000 N for each M4 bolt with Invar washer
- 3000 N for each M5 bolt with Invar washer
- 10000 N for each M8 bolt with Invar washer

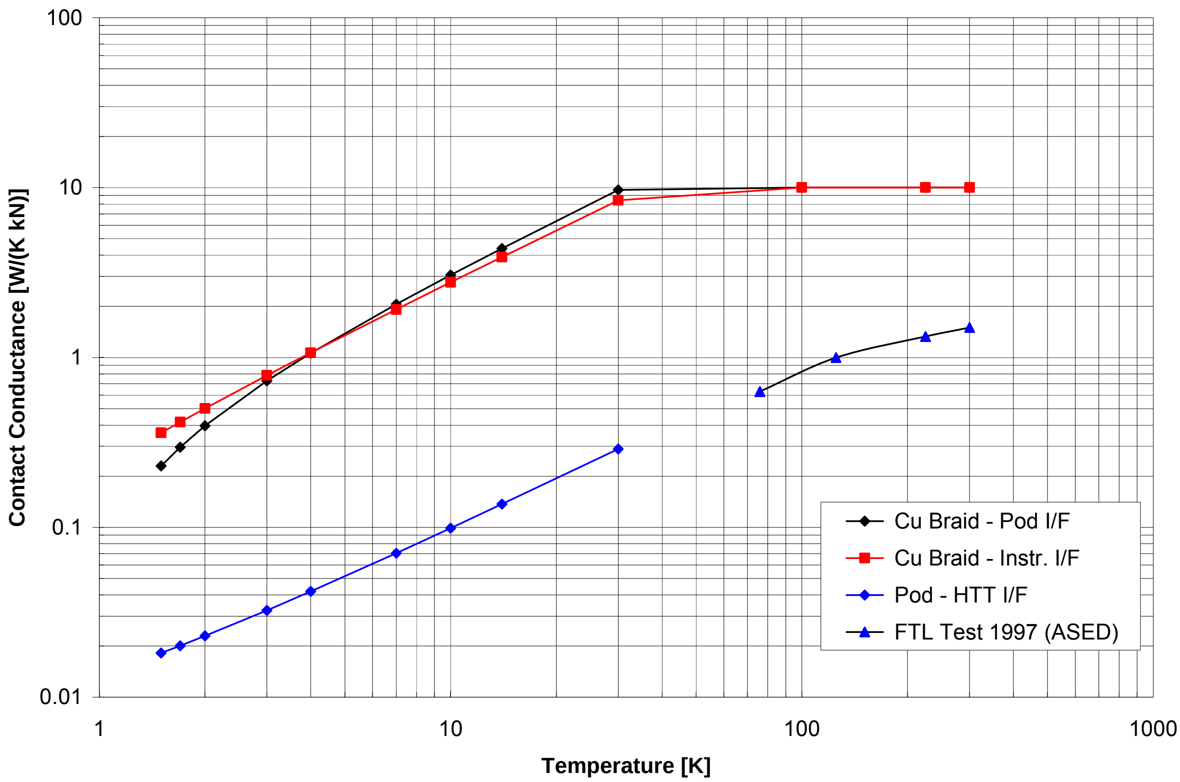


Figure 5.3-1: Thermal Contact Conductance of Thermal Link Interfaces [RD 35]

5.4 Specific Heat Capacity Data

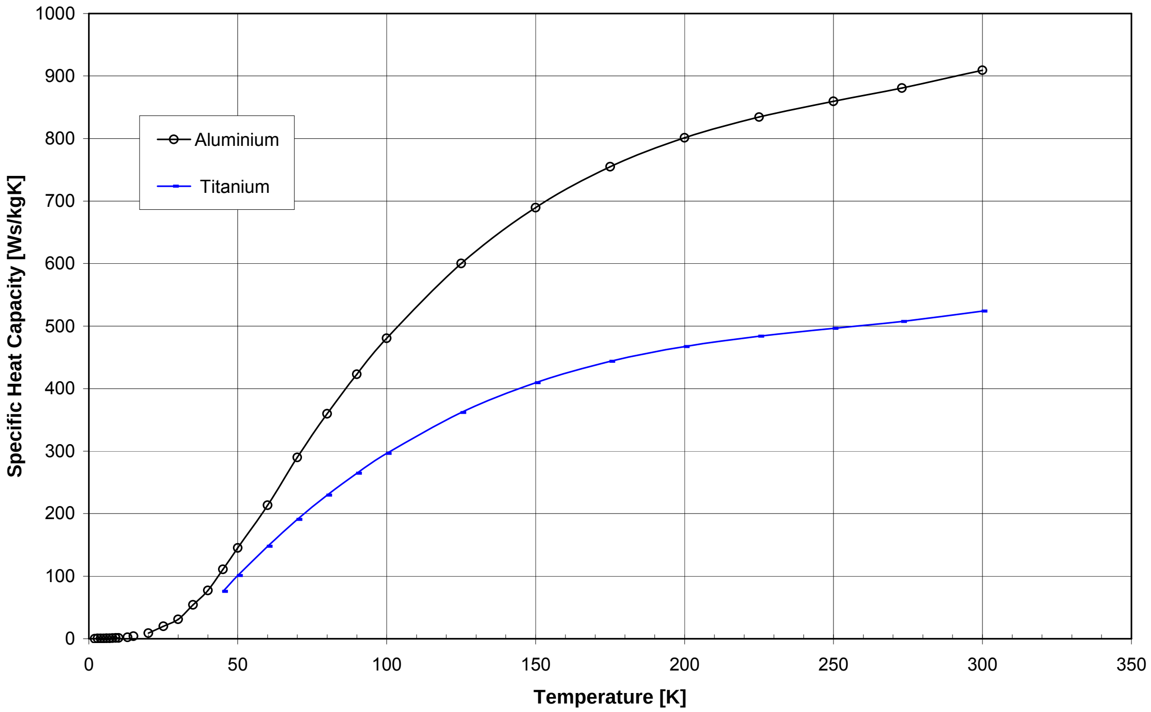


Figure 5.4-1: Specific Heat Capacity of Aluminium and Titanium /14/

5.5 Helium Properties

For the heat of vapourization of Helium different values are found in literature, see Figure 5.5-1. For the TMM calculations the data reported in Ref. /2/ are used.

The specific heat of the gas is 5.1966 kJ/kg/K (almost constant versus temperature).

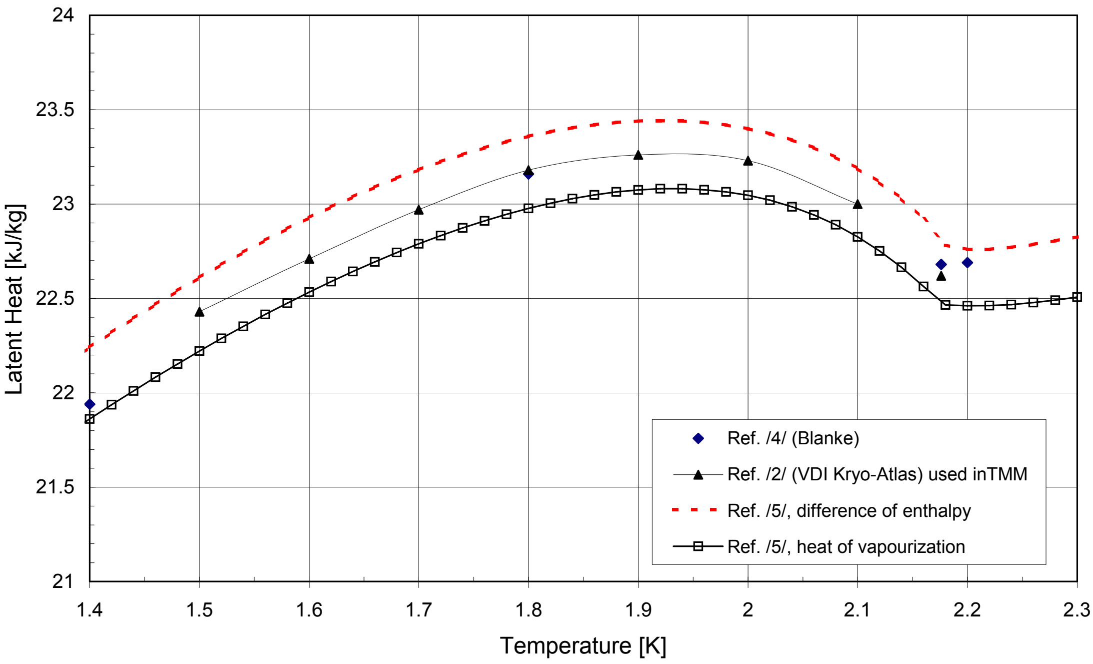


Figure 5.5-1: Heat of Vapourization of Helium 4

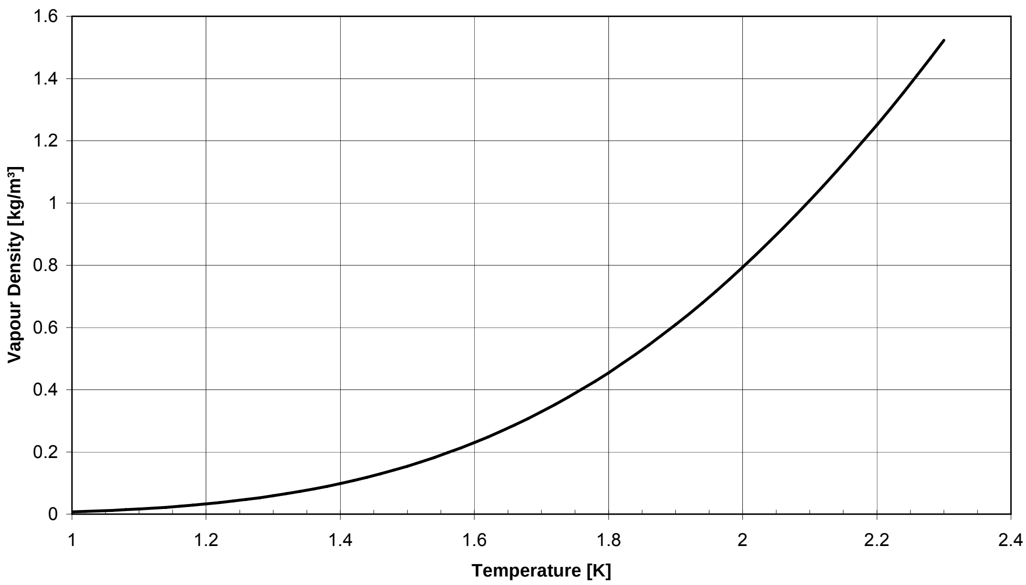


Figure 5.5-2: Vapour Density of Helium (Ref. /5/)

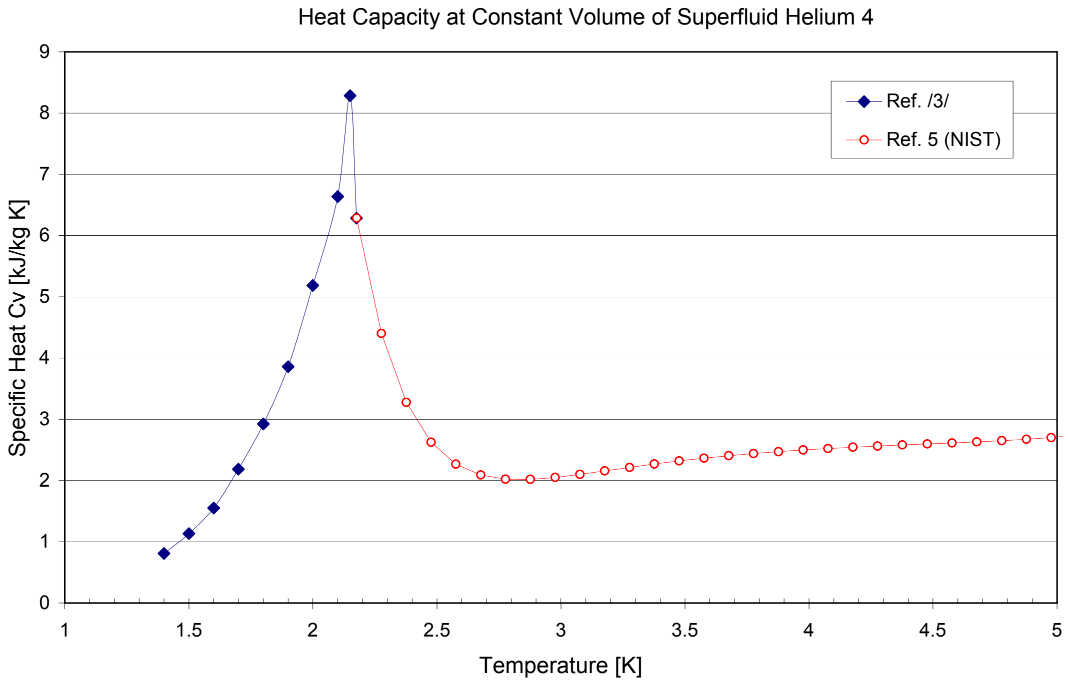


Figure 5.5-3: Volume Specific Heat Capacity of Liquid He on Saturation Line

5.6 References for Material Properties

/1/ Evaluation of LINDE/ESTEC-MLI Measurements and Transformation to the ISO Cryostat MLI Design, Doc.No.: ISO.TN-B1430.007, dated 12.07.88

/2/ VDI Kryoatlas BW 2407

/3/ Thermophysical Properties of Helium from 2 to 1500K with pressures to 1000 Atm (National Bureau of Standards TN 631)

/4/ W. Blanke: Thermophysikalische Stoffdaten, Springer 1989

/5/ NIST Standard Reference Database 12: NIST Thermophysical Properties of Pure Fluids, Version 3.0.

/6/ ASPI fax AS-FAX SE/SP/IS 2244/89, dated 30.01.89

/7/ Hartwig & Knaak, Cryogenics, Nov. 84, p.645

/8/ Touloukian: Thermophysical Properties of Matter, 1972

/9/ MLI Test Report – Linde, Doc.No.: ISO-TR-C130.001, dated 19.02.88

/10/ METOP Mechanical and Thermal Design Requirement Specification, Doc.No.; MO.RS.MMT.SY.0004, Issue 3, June 2000

/11/ Comparative Performance Measurements on MLI Test Samples with different Types of Foils and Studs, Test Report: YCV/BA/136, dated 07.03.88

/12/ Doenecke: Survey and Evaluation of Multilayer Insulation Heat Transfer Measurement, ICES July 1993

/13/ Reed and Golda: Cryogenic composite supports, Cryogenics 1997, p.233

/14/ ISO Thermal Mathematical Model, Version 7.12

/15/ NIST Data Base, http://cryogenics.nist.gov/NewFiles/material_properties.html

/16/ Data delivered by Th. Passvogel, ESA-FAX-PT-01750, dated 23.02.1996

/17/ Guy K. White: Experimental Techniques in Low Temperature Physics, Handbook on Materials for Superconductivity Machinery, 3rd Edition

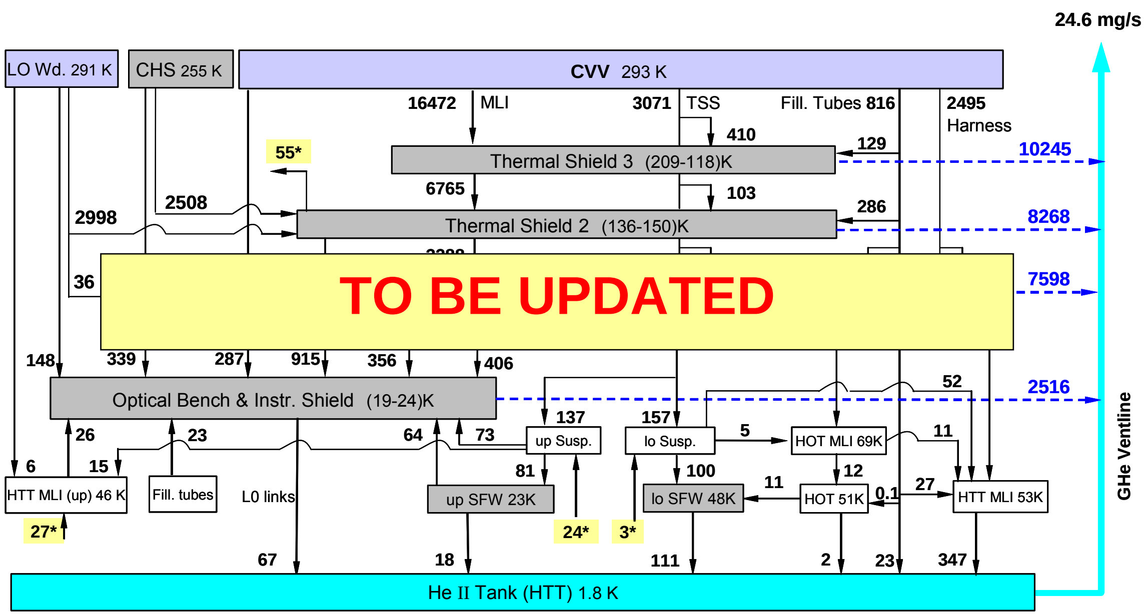
/18/ Thermomechanical Analysis, HP-2-ECAS-AN-0004, Issue 2, dated 28.11.03

6 Thermal Analysis Results

6.1 Operation On Ground

6.1.1 On-Ground Lifetime

A heat flow chart based on ground case analysis and showing the CVV internal main paths is shown in Fig. 7.1-1. The calculated temperatures of the different components as well as the GHe mass flow rate are included.



Only main paths are shown. All values are in [mW]

*) Heat flow from LOU Baffle (mounted on TS2)

Figure 6.1-1: CVV Heat Flow Chart for On-Ground Environment

In Table 6.1-1 the main results of a sensitivity analysis performed for ground case conditions are summarised. The uncertainties for the different items are assumed to be between ±20% for mechanical support structures and ±50% for MLI conductance. In Figure 6.1-2 the heat flow to HTT sensitivity is visualised.

Item			T, TS1 [K] [1021]		T, TS2 [K] [2021]		T, TS3 [K] [3021]		T, HOB [K] [375]		M He [mg/s]		Heat to HTT [mW]	
			+	-	+	-	+	-	+	-	+	-	+	-
Reference			**75.5**		**144**		**218**		**21.59**		**24.615**		**571**	
HTT MLI conductance	k1	±50%	-3.01	8.40	-2.32	6.22	-1.41	3.72	-1.27	4.17	0.379	-1.000	9	-23
Thermal Shield MLI conduct.	k2	±50%	1.87	-5.46	3.33	-10.15	3.23	-13.81	0.24	-0.50	1.387	-3.794	32	-88
TS 1 MLI cond.	k2a	±50%	0.51	-2.07	-1.30	5.11	-0.77	2.97	-0.16	0.71	0.191	-0.735	4	-17
TS 2 MLI cond.	k2b	±50%	0.54	-1.91	2.01	-7.24	-1.65	5.77	0.18	-0.61	0.473	-1.619	11	-38
TS 3 MLI cond.	k2c	±50%	0.73	-2.58	2.53	-9.13	5.67	-21.89	0.21	-0.67	0.646	-2.201	15	-51
HTT center + corner struts (T300)	k3	±20%	-0.43	0.53	-0.33	0.40	-0.20	0.24	-0.20	0.24	0.054	-0.065	1	-2
Inner tank susp. (T300)	k4	±20%	-0.81	0.89	-0.64	0.71	-0.39	0.43	-0.21	0.24	0.104	-0.115	2	-3
TS1/2 tank susp. (T300)	k5	±20%	0.29	-0.34	-1.36	1.56	-0.90	1.02	-0.21	0.25	0.224	-0.255	5	-6
TS2/3 tank susp. (GFRP)	k6	±20%	0.26	0.29	0.63	0.69	0.72	0.79	0.01	0.01	0.233	0.254	5	-6
Outer tank susp. (GFR[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].163	4	-4
Int. harness cross-secti[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].422	10	-10
Int. harness length	k9	±15%	-0.67	0.64	0.23	-0.22	0.53	-0.53	-0.13	0.14	-0.422	0.415	-10	10
Int. harness dissipation	k10	±20%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0	0
He II latent heat	k11	±1%	0.29	-0.30	0.24	-0.24	0.15	-0.15	0.13	-0.13	-0.044	0.045	5	-5
Harness anchoring on TS1	k17	±90%	0.02	-0.34	0.00	0.01	-0.01	0.18	-0.01	0.19	0.01	-0.173	0	-4
Harness anchoring on OBP	k18	±90%	0.00	0.01	0.00	0.01	0.00	0.01	0.02	-0.06	0.00	-0.001	0	0
Sum of mean root square			**+8.7**	**-6.4**	**+7.3**	**-11**	**+5**	**-14**	**+4.2**	**-1.43**	**+1.598**	**-3.991**	**+37**	**-93**

TO BE UPDATED

Values of k2a, k2b, k2c, k17, k18 (written in blue colour) are not included in sum of mean root square

Note: ± 50% means 1.5 x nominal value for + 50%
0.5 x nominal values for -50%

Table 6.1-1: Sensitivities for Operation on Ground

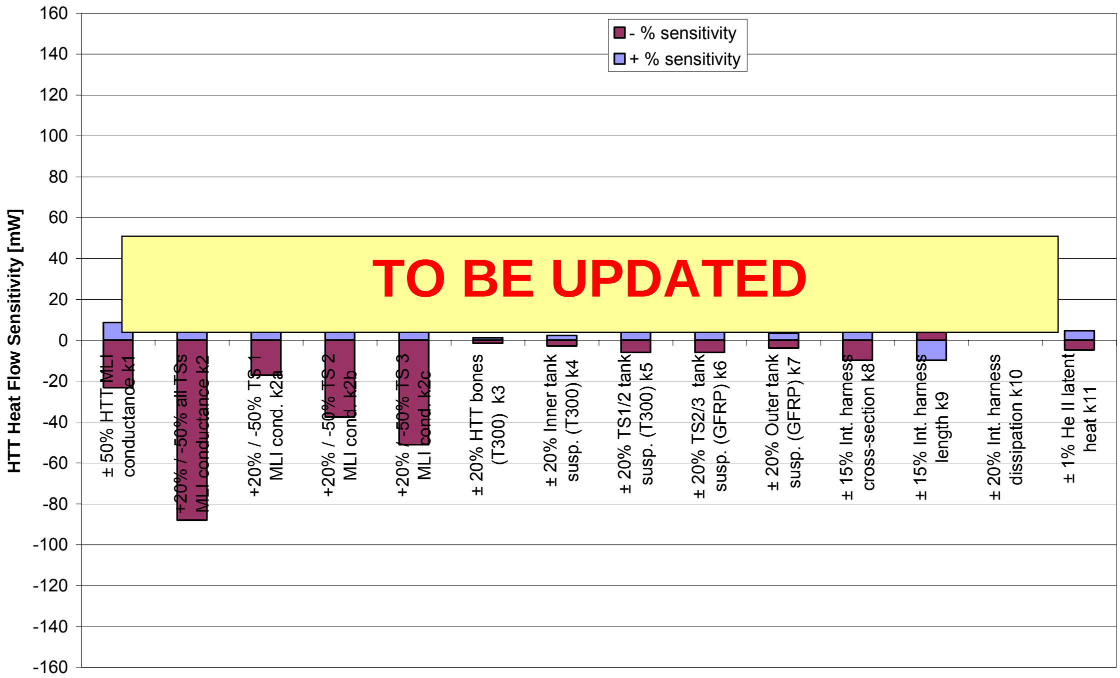


Figure 6.1-2: HTT Heat Flow Sensitivity for Operation on Ground

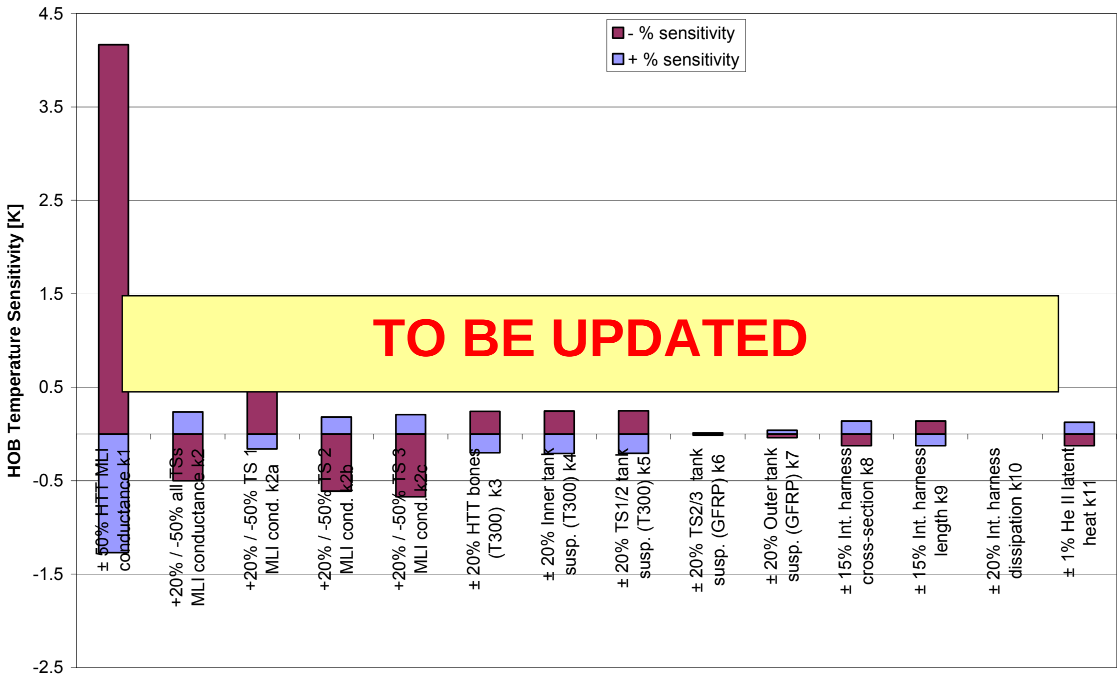


Figure 6.1-3: HOB Temperature Sensitivity for Operation on Ground

6.1.2 On-Ground Autonomy (closed HTT)

SECTION 6.1.2 TO BE UPDATED

the main tank, which shall be below 2.1 K after 6 days.

The on-ground autonomy analysis is based on the following steady state start conditions (time t =0):

- System Pre-cooling with a He mass flow of 1000 mg/s
- HOT He mass flow: 25 mg/s
- Start temperature of HTT: 1.8 K
- Temperature of HOT: 4.3 K (boundary until HOT is empty)
- CVV temperature: 293 K (boundary)

For the transient HTT warm up two scenarios have been investigated: a constant HOT mass flow rate of 25 mg/s (adjusted by HOT heating) and a free floating mass flow rate determined by the parasitic heat load into the HOT only. The results shown in Figure 6.1-4 reveal that for the 25 mg/s scenario the HTT is below 2.1 K after 6 days, for the floating mass flow scenario the HTT exceeds 2.1 K after about 116 hours (4.8 days).

The bend in the 25 mg/s curve indicates that the HOT He reservoir of 8.75 kg is exhausted after 97 hours. In case of the floating mass flow 3.52 kg Helium are consumed after 6 days; i.e. 5.23 kg are still in the tank.

The mass flow evolution for a free floating mass flow due to parasitic heat into the HOT is shown in Figure 6.1-5. The HOT mass flow during 6 days launch autonomy is always less than 25 mg/s. This means, that the HOT tank need to be heated in order to achieve a constant HOT mass flow of 25 mg/s.

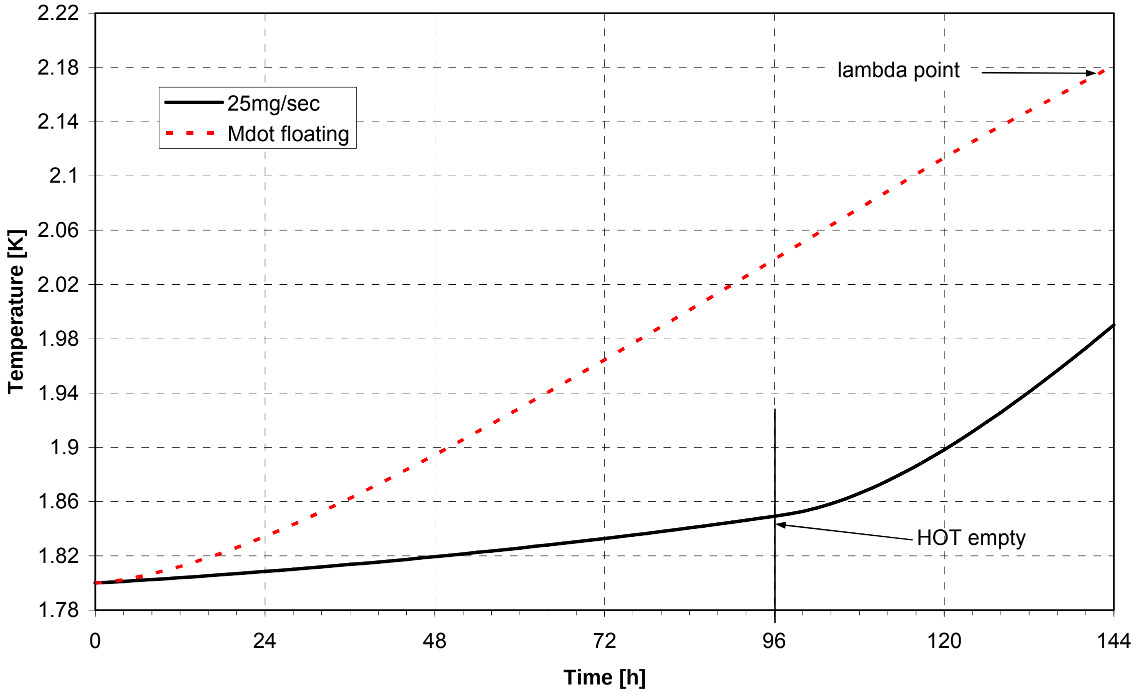


Figure 6.1-4: HTT Temperature Evolution for Different HOT Mass Flow Rates during Ground Autonomy

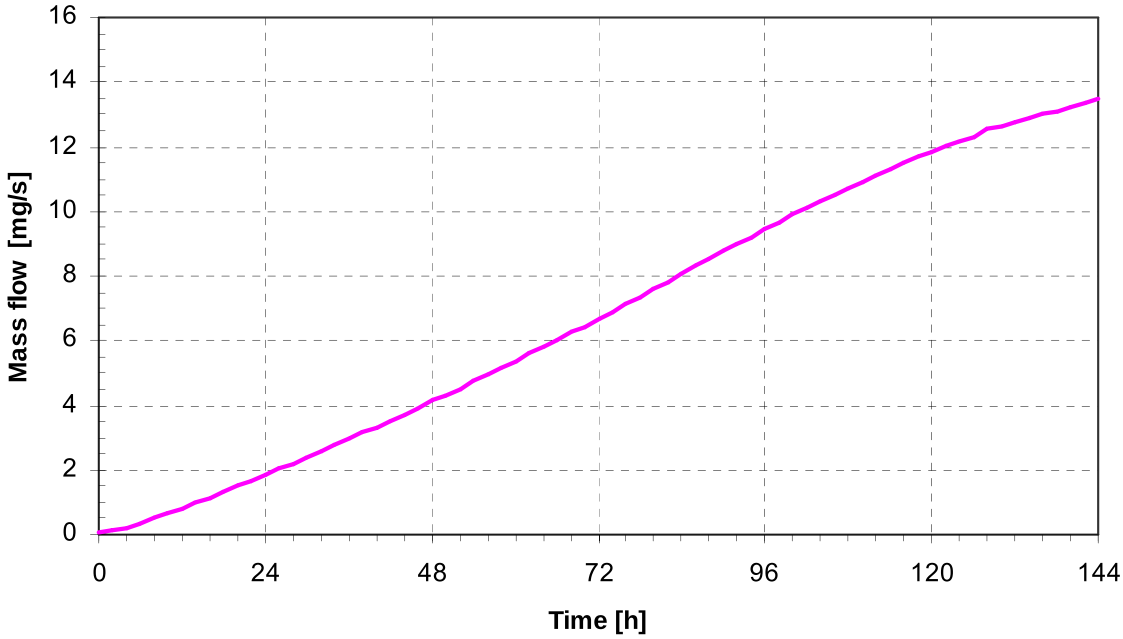


Figure 6.1-5: Floating HOT Mass Flow Rate due to Parasitic Heat Load only

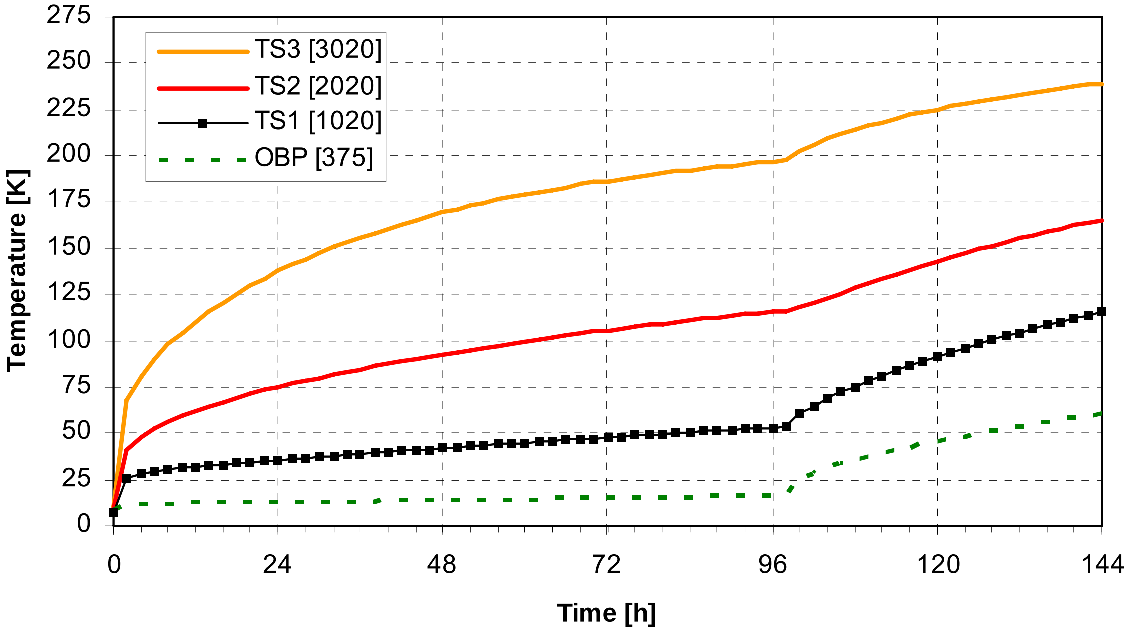


Figure 6.1-6: Thermal Shields Temperature Evolution during Ground Autonomy for 25 mg/s HOT Mass Flow Rate

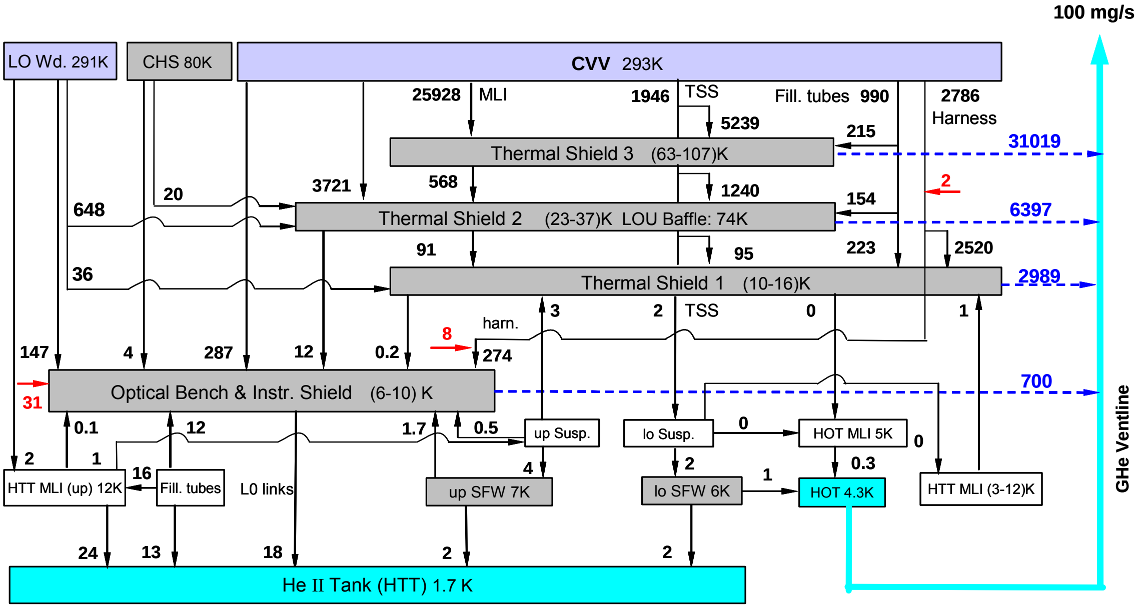
6.1.3 On-Ground Testing (IMT)

SECTION 6.1.3 TO BE UPDATED

- HTT closed with start temperature: 1.7 K
- HOT He mass flow: 100 mg/s
- Temperature of HOT: 4.3 K (boundary)
- CVV temperature: 293 K (boundary)
- Cryo Cover cooled: 80 K (boundary)

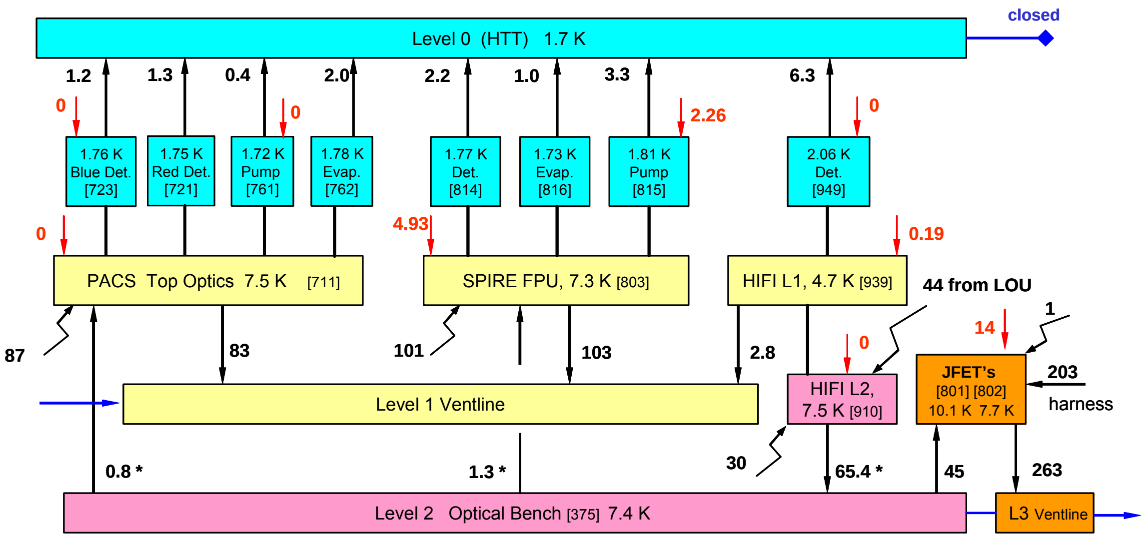
The corresponding I/F temperatures and heat flow charts for the CVV internal and for the OBA with SPIRE in Spectrometer Mode are shown in Figure 6.1-7 and Figure 6.1-8.

Transient calculations have been performed assuming the instrument in-orbit timeline (see section 6.4) also for the on-ground testing. The results are shown in Figure 6.1-9 until Figure 6.1-16.



Only main paths are shown. All values are in [mW]

Figure 6.1-7: CVV Heat Flow Chart for IMT (Spire Spectrometer Mode)



* feet & harness

Figure 6.1-8: OBA Heat Flow Chart for IMT (SPIRE Spectrometer Mode)

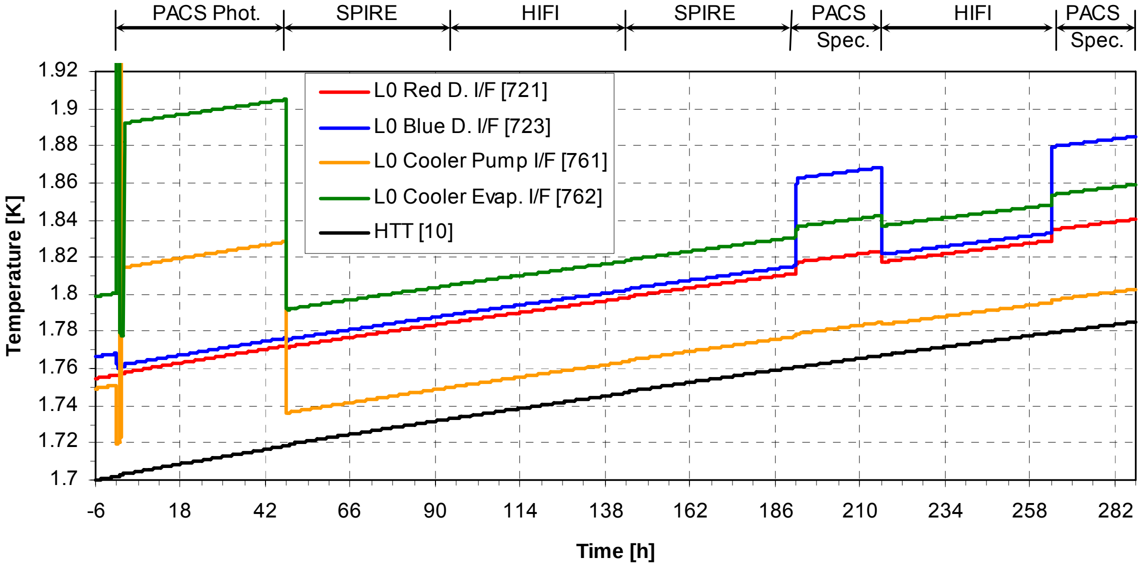


Figure 6.1-9: PACS L0 Interface Temperatures during IMT (based on orbit timeline)

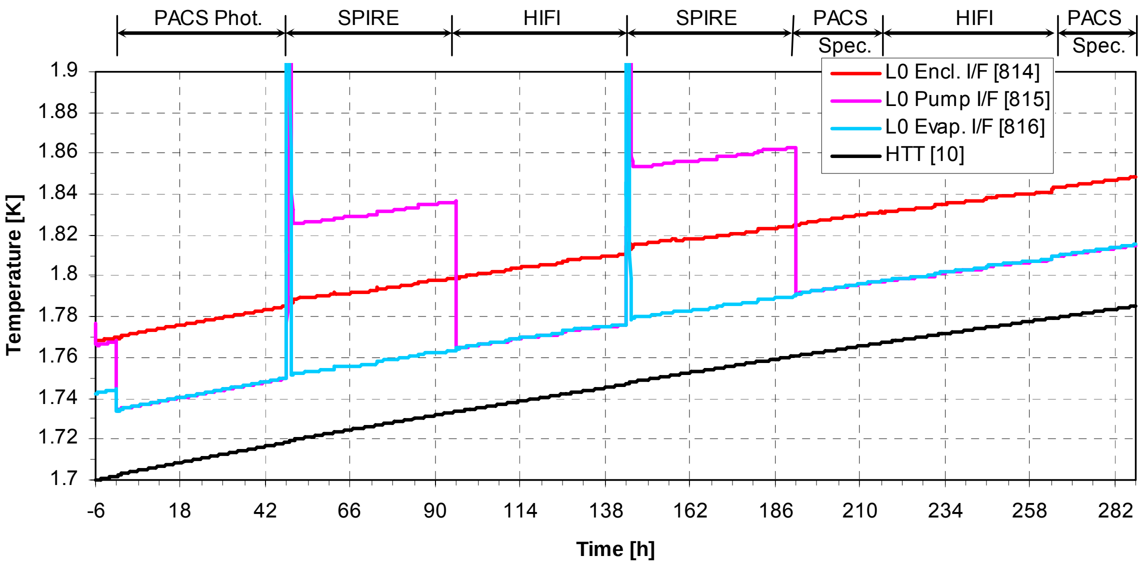


Figure 6.1-10: SPIRE L0 Interface Temperatures during IMT (based on orbit timeline)

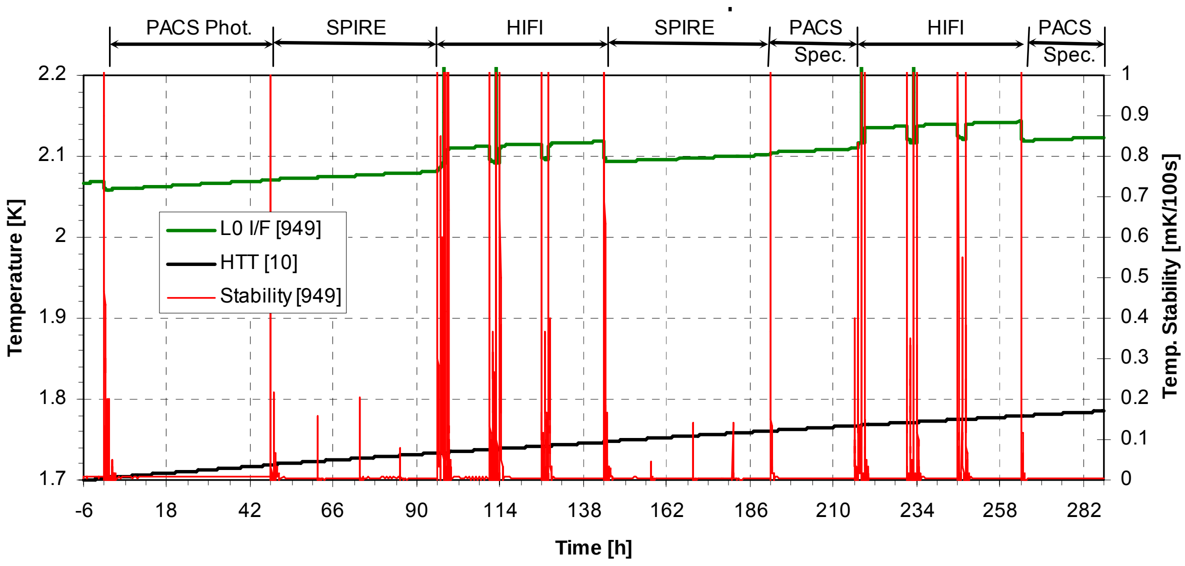


Figure 6.1-11: HIFI L0 Interface Temperatures during IMT (based on orbit timeline)

Note that the temperature change peaks of HIFI are caused by short heat peak phases due to dissipation switching.

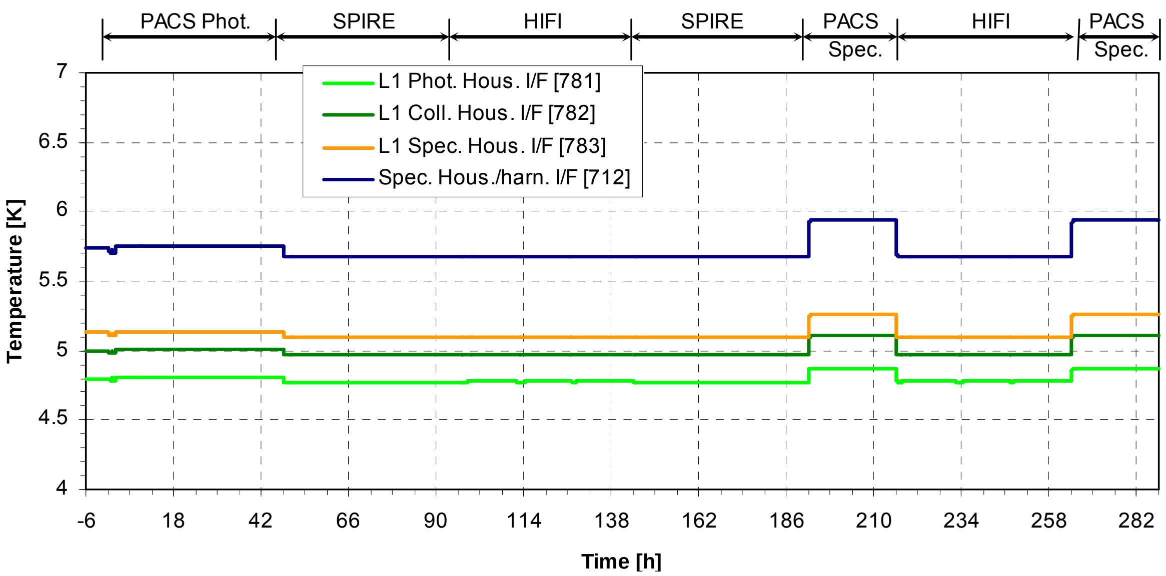


Figure 6.1-12: PACS L1 Interface Temperatures during IMT (based on orbit timeline)

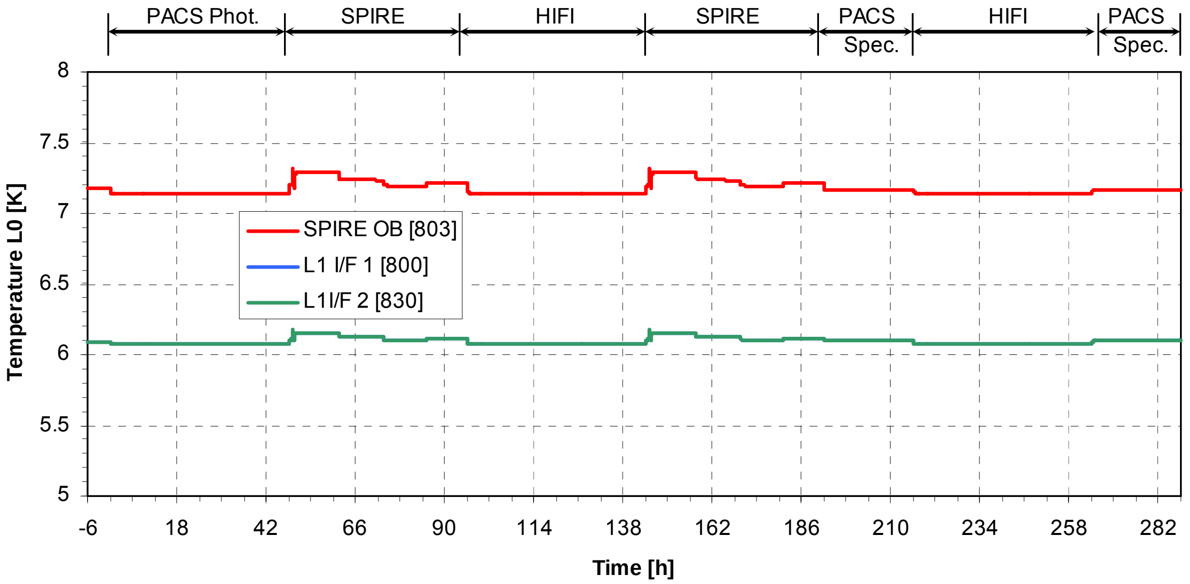


Figure 6.1-13: SPIRE L1 Interface Temperatures during IMT (based on orbit timeline)

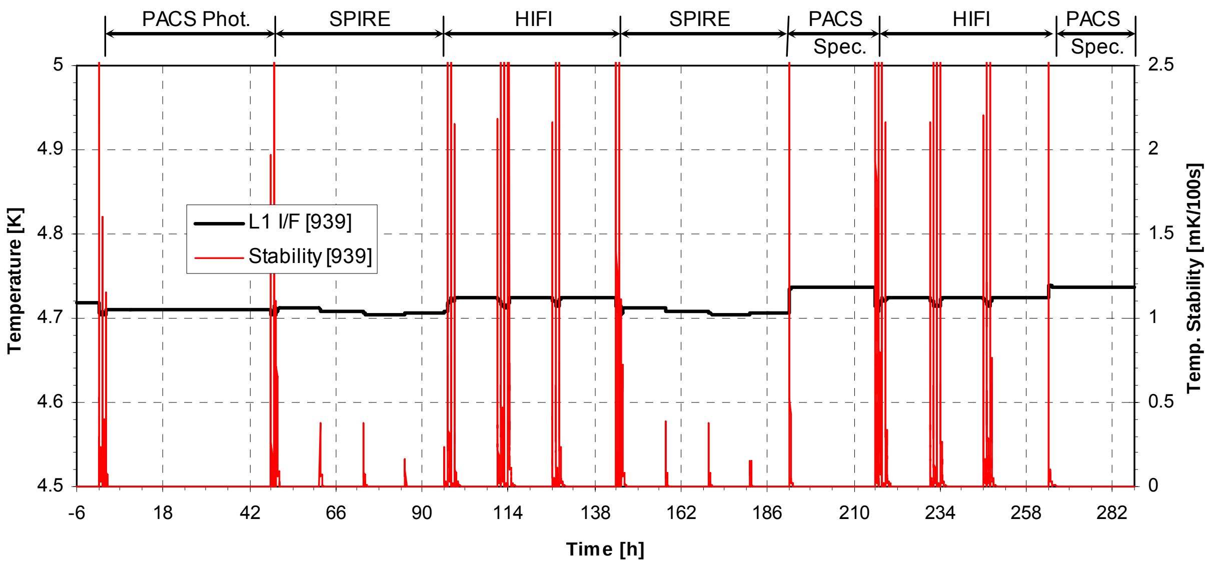


Figure 6.1-14: HIFI L1 Interface Temperature during IMT (based on orbit timeline)

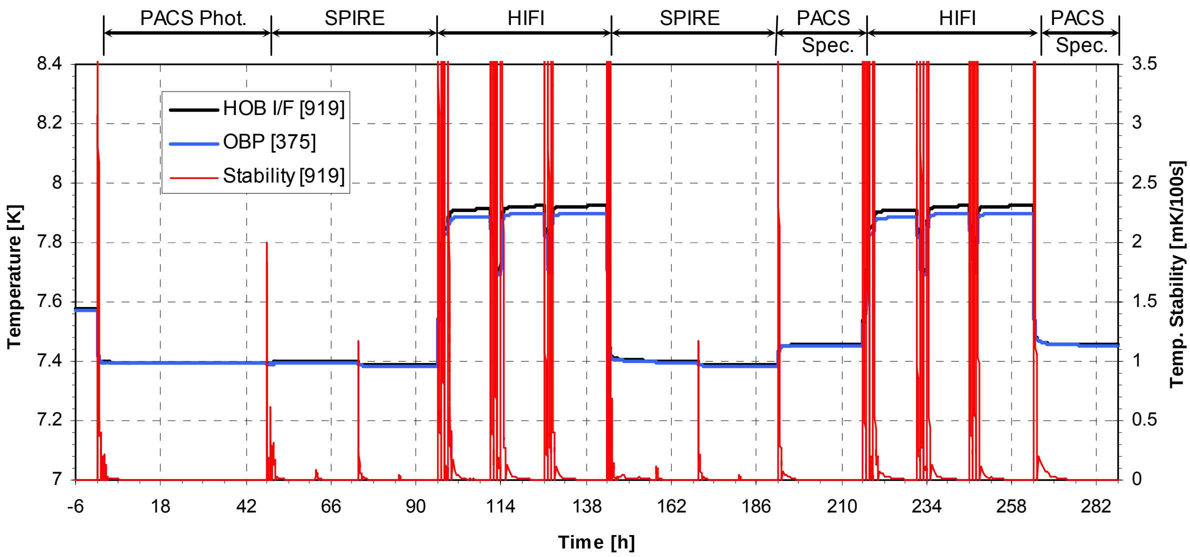


Figure 6.1-15: HIFI L2 and OBP Temperature during IMT (based on orbit timeline)

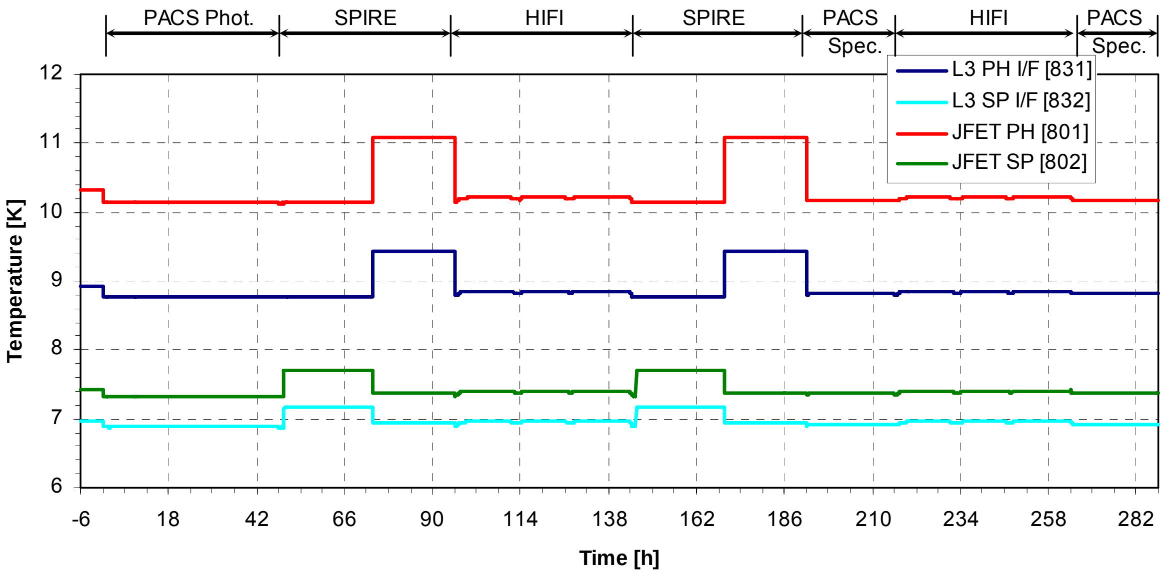


Figure 6.1-16: SPIRE L3 Temperatures during IMT (based on orbit timeline)

6.2 Pre-Launch and Early Orbit Phase

For the pre-launch and early orbit phase three scenarios have been investigated in accordance with the POC operations as discussed with Arianespace [RD 41]:

1. Nominal scenario with no launch delay (acc to Annex 1 of [AD 06]):
   - Helium II top up completed 4 days before launch with a level of 98% and a temperature of 1.8 K
   - Last HOT refill with Thermal Shields subcooling completed two days before launch
   - HOT depletion and heating to 55 K 3 hours before launch
2. Scenario with 25 hours launch delay:
   - Same as 1., but additionally:
   - Launch abort after HOT heating
   - 25 hours hold time with depleted HOT
3. Scenario with degraded internal MLI performance (sensitivity):
   - Same as 2., but:
   - 50% higher MLI conductance (k1 = 1.5 and k2 = 1.5) and simultaneously 15% increased internal harness conductance (k8 = 1.15)

Critical areas that are exposed to an intensive solar as well as aero-thermal flux are investigated in RD 17. The cool-down of the HSS after fairing jettison has been assessed for an extreme S/C attitude, see also RD 17.

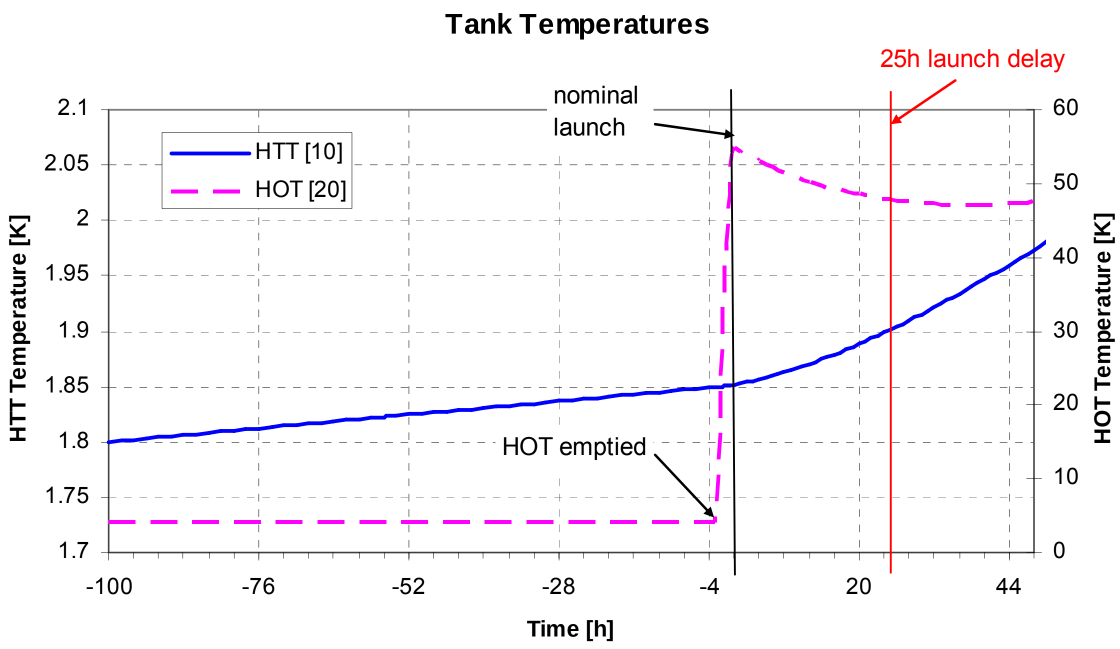


Figure 6.2-1: HTT and HOT Temperature Evolution during Pre-Launch Phase

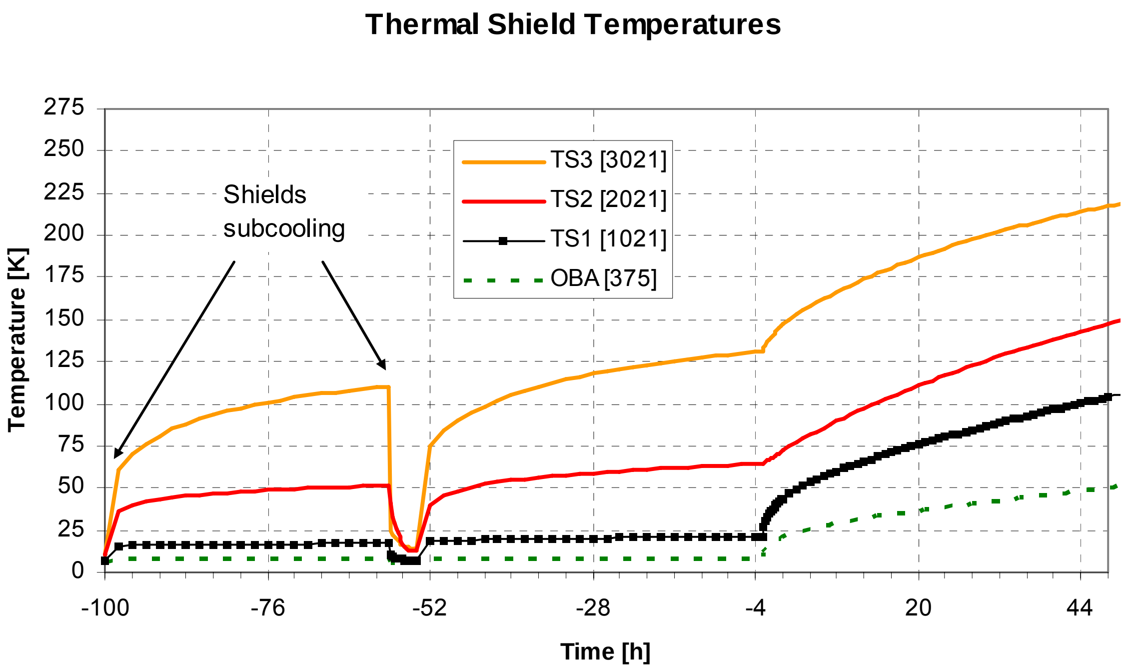


Figure 6.2-2: Thermal Shield Temperature Evolution during Pre-Launch Phase

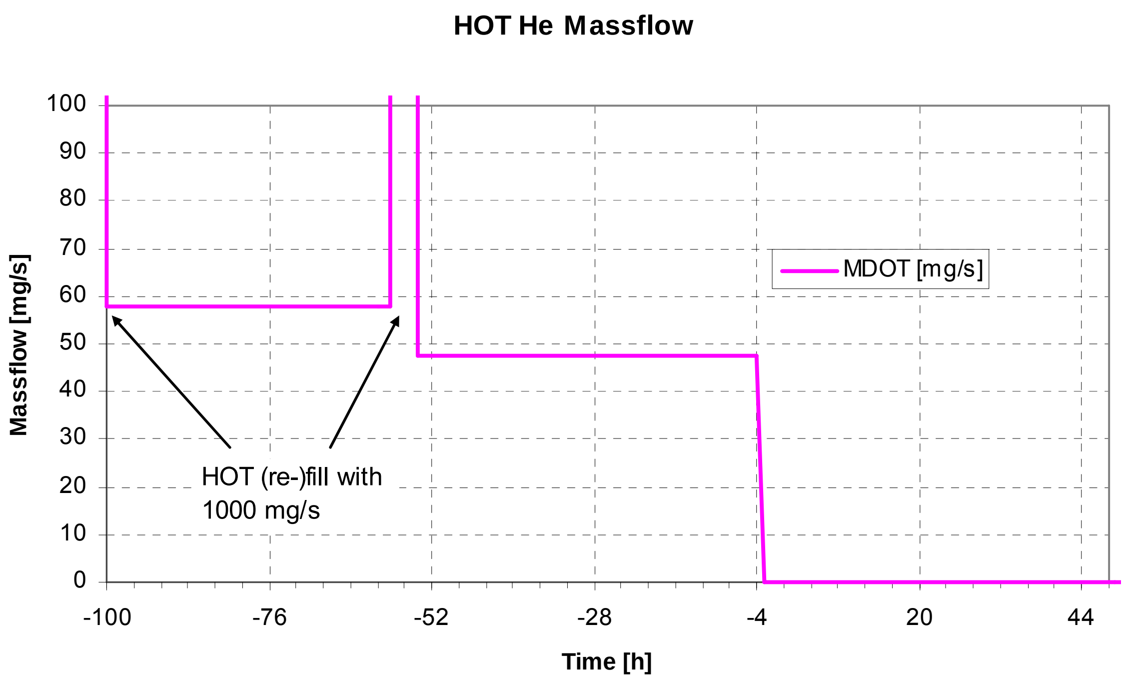


Figure 6.2-3: HOT He Massflow during Pre-Launch Phase

For the launch phase of 200 sec (launch until fairing jettison), a heat flux of 1000 W/m2 radiated by the fairing is assumed [AD 05]. The temperature evolution of some exposed external parts is shown in.

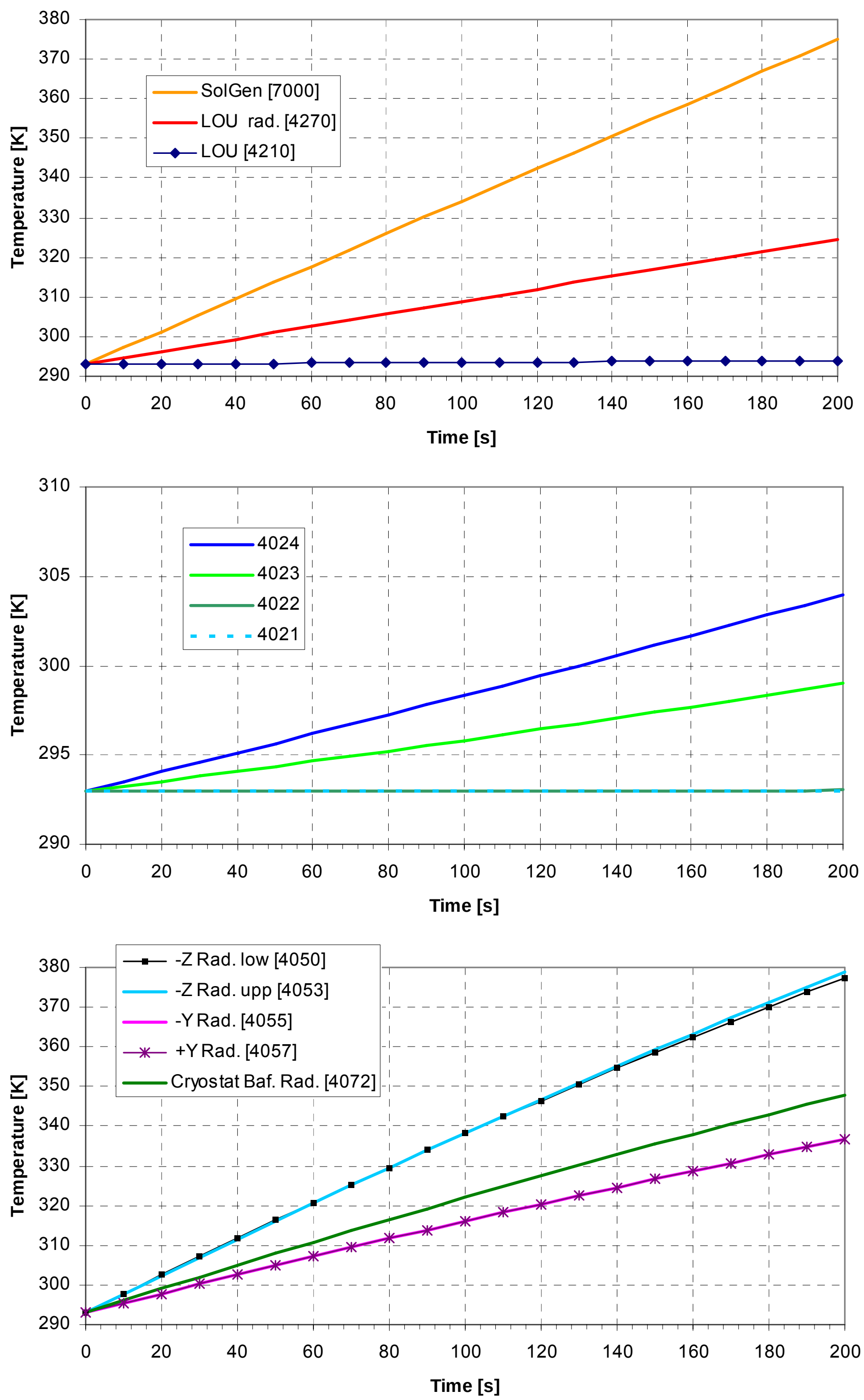


Figure 6.2-4: H-EPLM Temperatures during Launch Phase

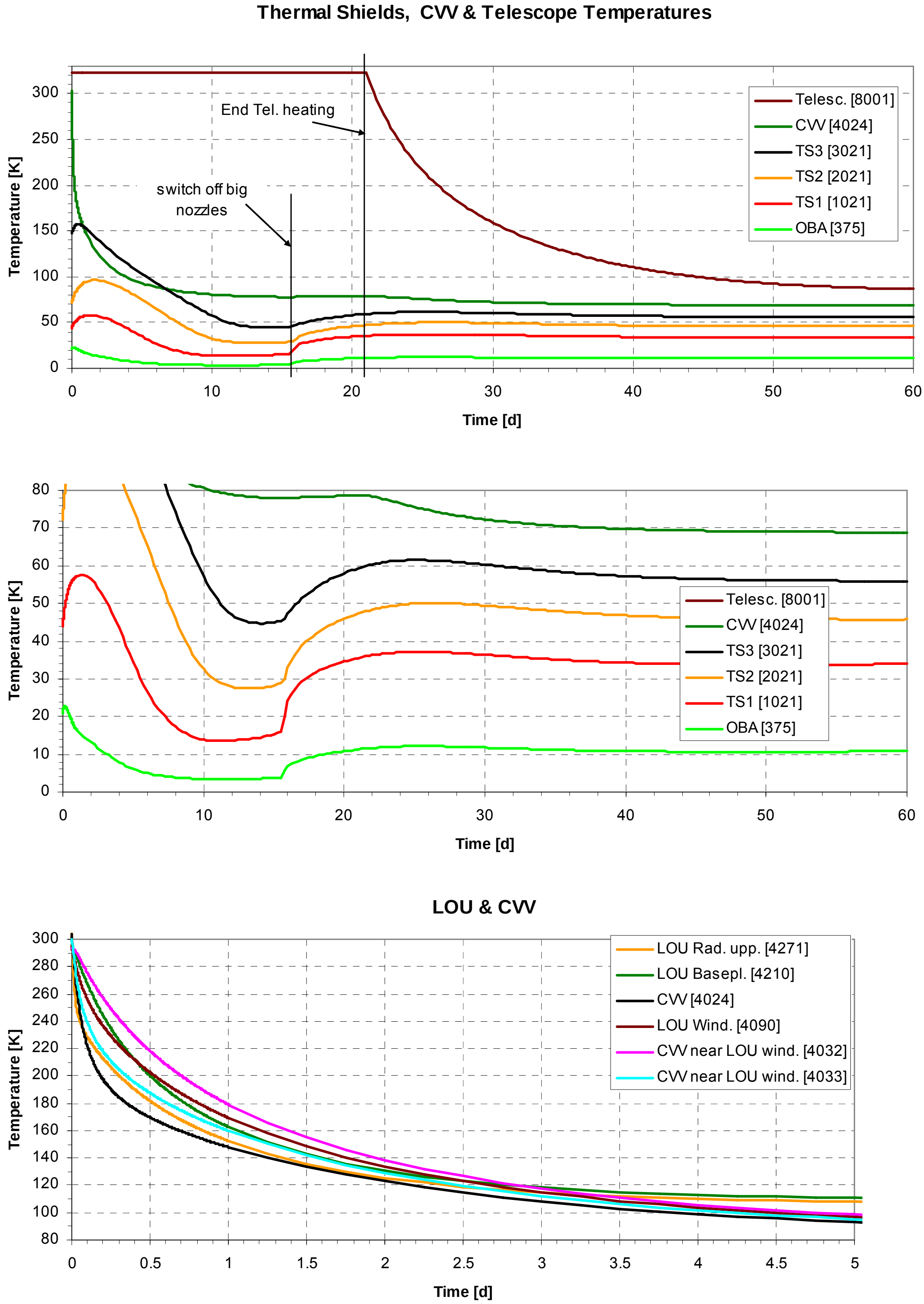


Figure 6.2-5: H-EPLM Temperatures during In-Orbit Cool-Down

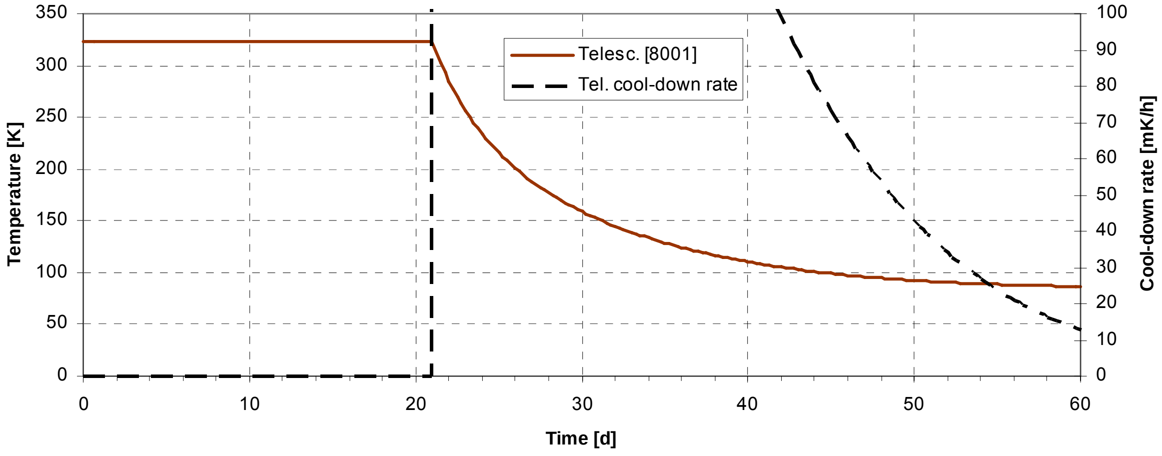


Figure 6.2-6: Telescope Cool-Down Rate after Decontamination (Cover still closed)

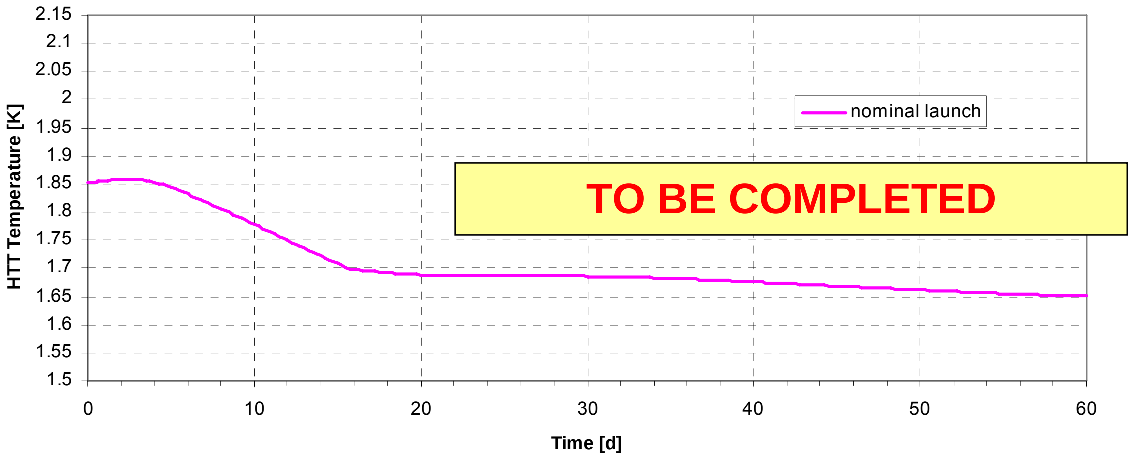


Figure 6.2-7: HTT Temperature during In-Orbit Cool-Down

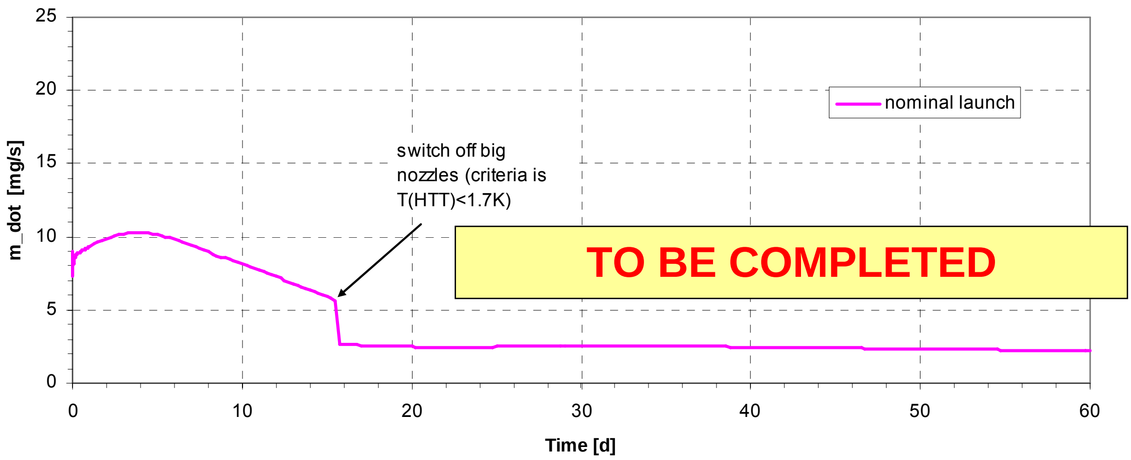


Figure 6.2-8: Helim Massflow during In-Orbit Cool-Down

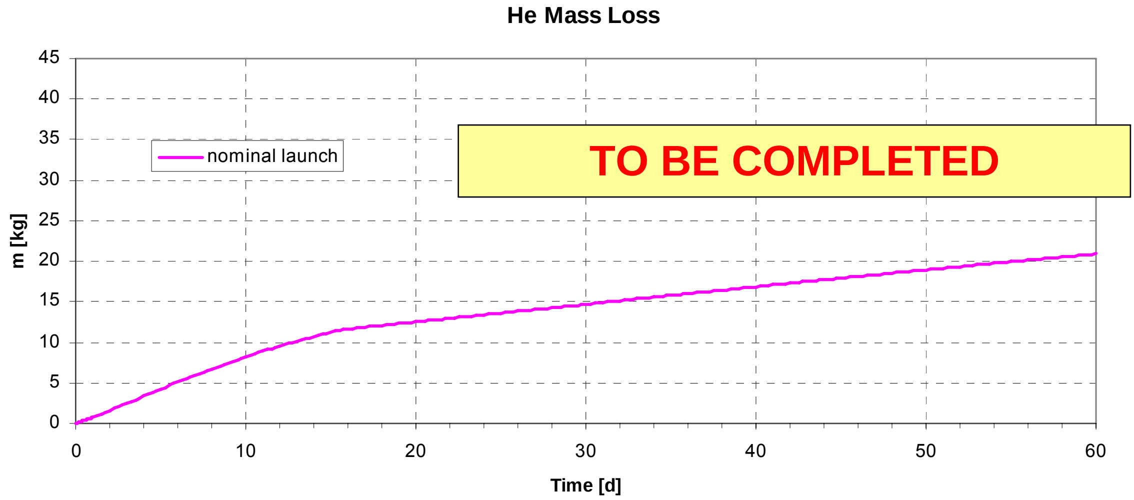


Figure 6.2-9: Helium Mass Loss during In-Orbit Cool-Down

Acc. to [AD 06], the end of the transient cool down phase is reached after

- Telescope decontamination and cool down until a rate of < 0.03 K/hour
- Cryo-cover opening
- Nozzle switch
- HTT has reached 1.65 K

Table 6.2-1 summarises the helium losses and HTT temperatures for the above-described scenarios.

	Nominal launch	Launch delay	Sensitivity launch delay (MLI+harness)	Reference
Duration of transient cool down	60 days (1)	(2)		
He loss during cool down	20.9 kg (1)	(2)		Figure 6.2-9
T (HTT) at launch	1.852 K			Figure 6.2-1
T (HTT, max)	1.858 K			Figure 6.2-7

(1) taken for lifetime analysis, see section 6.5
(2) taken for lifetime uncertainty

Table 6.2-1: Helium loss and HTT temperatures during in-orbit cool down

For the sensitivity launch delay, the margin w.r.t. available Helium enthalpy until the maximum allowable HTT temperature of 2.1 K would be reached is 30% [RD 40], which is considered to be sufficient. **To be updated**

6.3 Spacecraft Operation in L2 Orbit

6.3.1 Steady State Analysis for Hot and Cold Case Conditions

Thermal analyses with implemented instrument models have been performed both for the hot and cold case thermal environment at L2 (for definition see Table 3.2-1).

The main results are summarized in Table 6.3-1. The corresponding heat flow charts showing the CVV external main paths are shown in Figure 6.3-3 for the hot case environment and in Figure 6.3-4 for the cold case environment. The calculated temperatures of the relevant components are included. The internal heat flow chart for the hot case environment is shown in Figure 6.3-5. A detailed listing of all node temperatures is given in the annex.

	T (CVV)	T (TS3)	T (TS2)	T (TS1)	T (OBA)	T (HTT)	He Mass Flow
Hot case	67.4 K	54.9 K	45.5 K	34.2 K	13.0 K	1.65 K / boundary	2.335 mg/s
Cold case	64.3 K	52.5 K	43.6 K	33.2 K	12.8 K	1.639 K	2.180 mg/s
Safe Mode *	60.4 K	50.2 K	42.3 K	32.2 K	11.4 K	1.595 K	1.767 mg/s
Average (IID-B) **	65.9 K	53.8 K	44.6 K	33.7 K	12.9 K	1.65 K / boundary	2.263 mg/s

*) All dissipation set to zero + SVM in safe mode; thermal environment equal to cold case
**) Used for lifetime calculation

Table 6.3-1: Analysis Results for Hot and Cold Case Environment

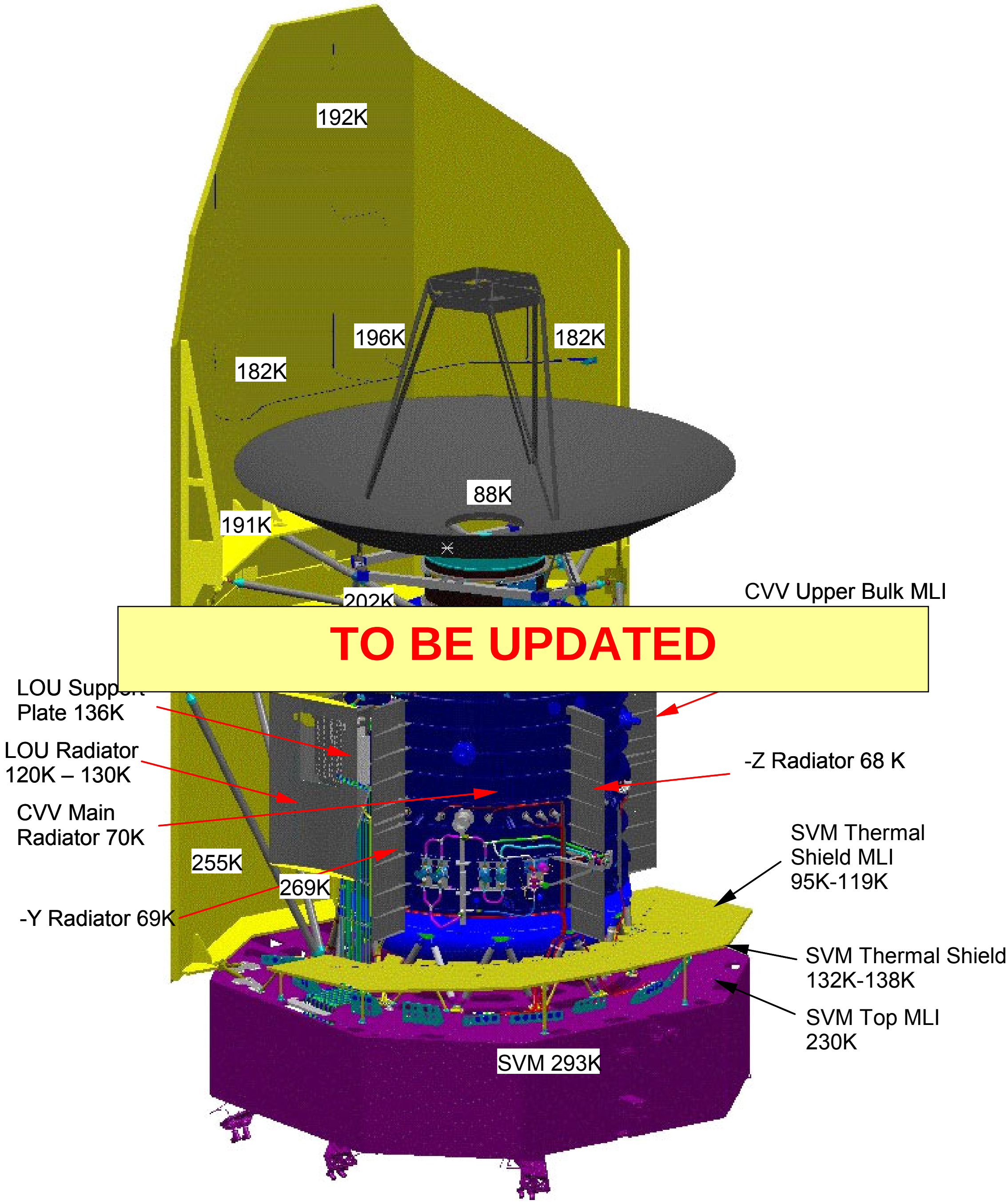


Figure 6.3-1: H-EPLM Temperature Distribution for Hot Case Environment at L2

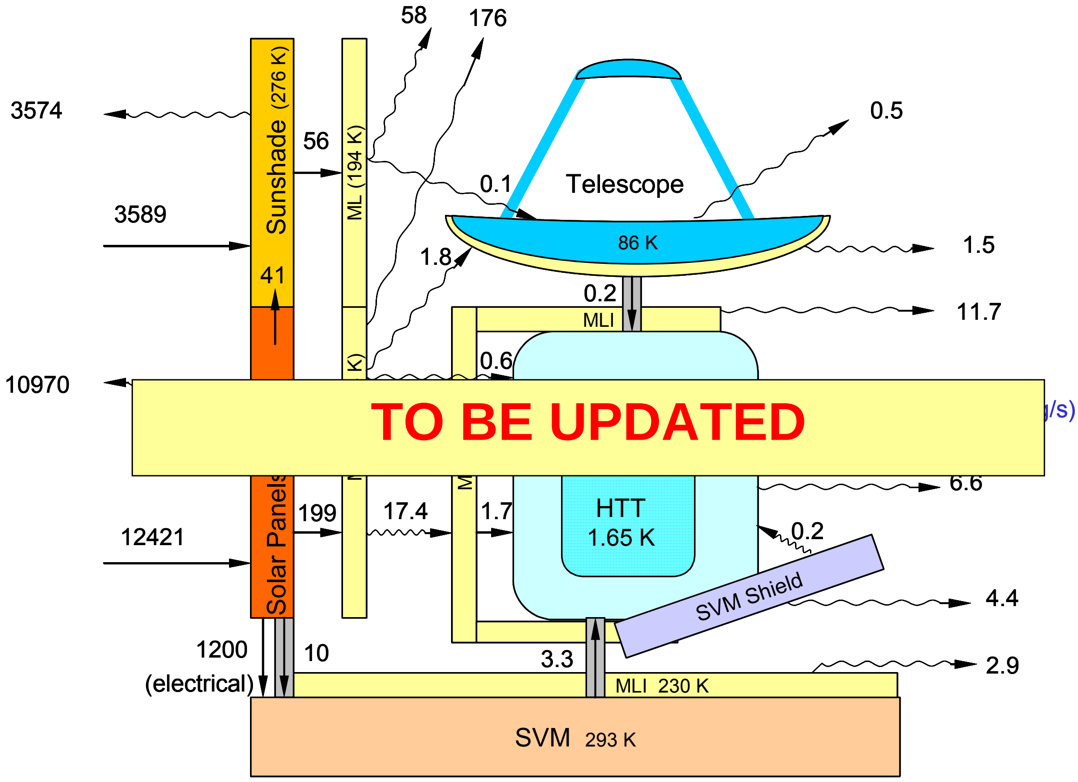


Figure 6.3-2: CVV External Heat Flow Chart in [W] (Hot Case)

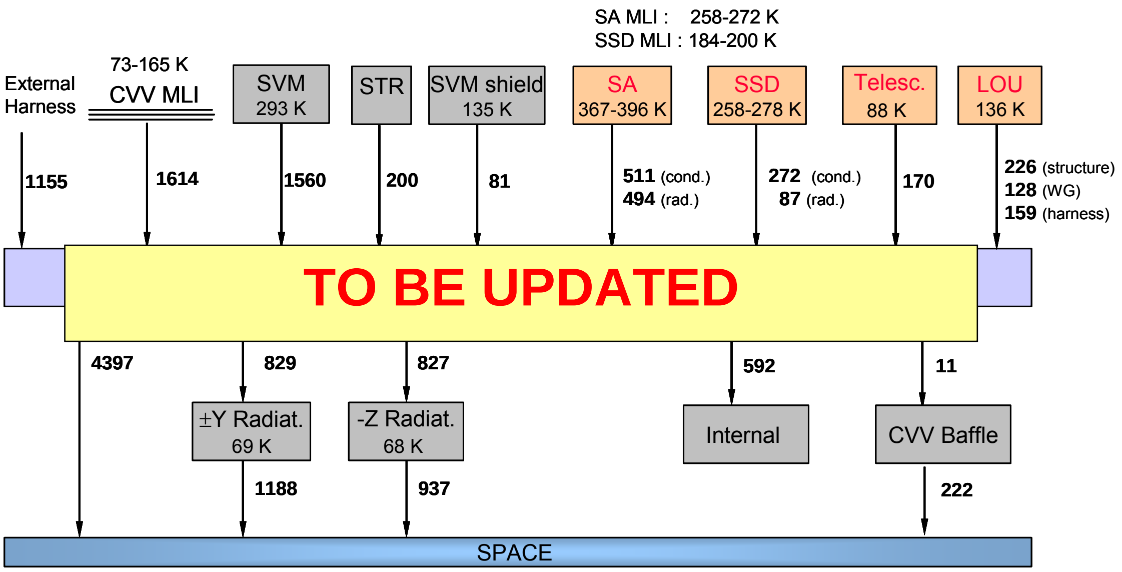
The maximum calculated thermal interface fluxes between SVM and Sunshield (=Solar Panels) are as follows. The

TO BE UPDATED

Flux via CFF

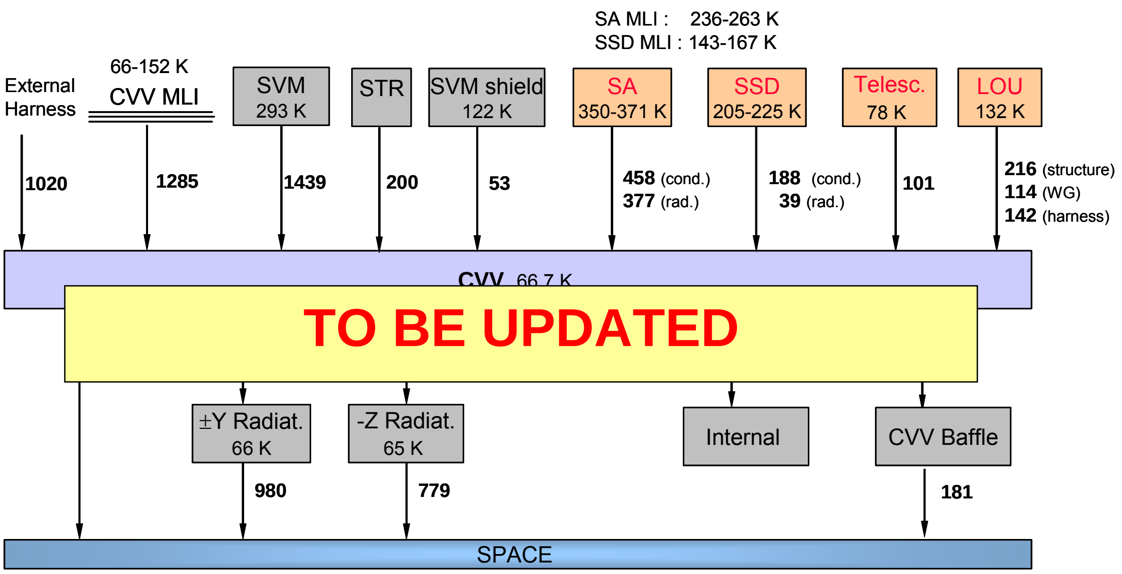
Flux via Sunshield brackets: 3.4 W (<10 W required)

Flux via harness: 2.9 W



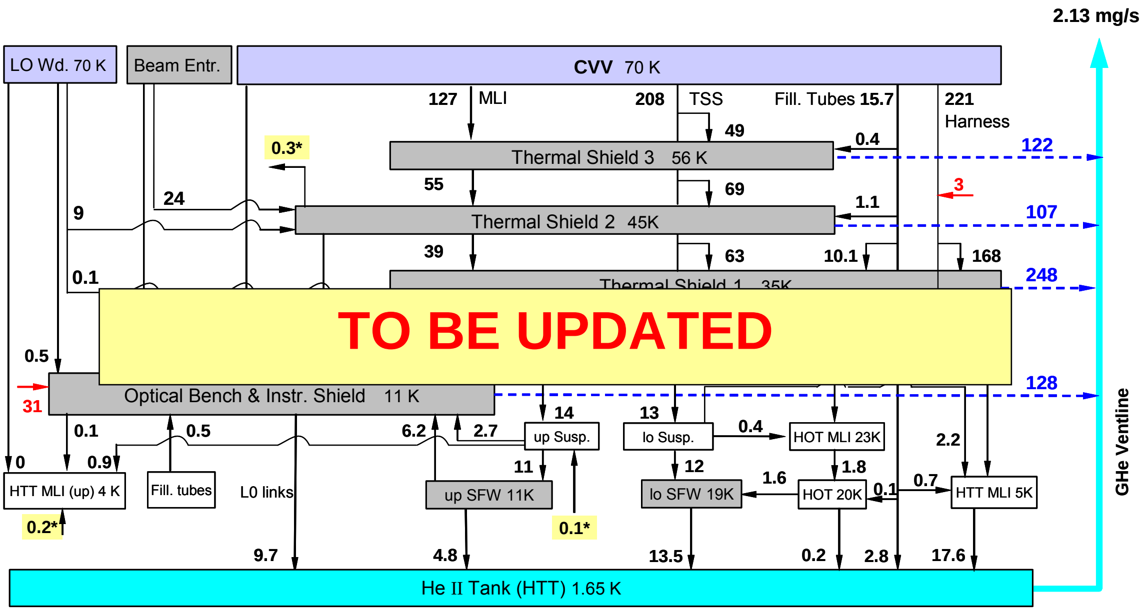
All values are in [mW]

Figure 6.3-3: CVV Heat Flow Chart for Hot Case Environment at L2



All values are in [mW]

Figure 6.3-4: CVV Heat Flow Chart for Cold Case Environment at L2



Only main paths are shown. All values are in [mW]

*) Heat flow from LOU Baffle (mounted on TS2)

Figure 6.3-5: HPLM internal Heat Flow Chart for Average Instrument Dissipation and Hot Case Environment at L2

6.3.2 Sensitivity Analysis for Lifetime and EPLM Temperatures

SECTION 6.3.2 TO BE UPDATED

HSS and Telescope temperatures are visualised in Figure 6.3-6 to Figure 6.3-12.

Item	Sensitivity		T, OBP [K]		M_{He} [mg/s]		Δ Lifetime [days]	
			+	-	+	-	+	-
Reference Case: see Figure 6.3-5			**11.01**		**2.125**		**-**	
HTT MLI conductance	k1	± 50%	-0.001	0.005	0.000	0.000	0	0
Thermal Shield MLI cond.	k2	+20/-50%	-0.006	0.020	0.017	-0.056	-11	39
TS 1 MLI cond.	k2a	+20/-50%	-0.003	0.013	0.003	-0.014	(-2)	(10)
TS 2 MLI cond.	k2b	+20/-50%	-0.001	0.002	0.005	-0.018	(-3)	(12)
TS 3 MLI cond.	k2c	+20/-50%	-0.002	0.007	0.009	-0.029	(-6)	(20)
HTT center and corner struts (T300)	k3	± 20%	-0.209	0.240	0.014	-0.016	-10	11
Inner tank susp. (T300)	k4	± 20%	-0.042	0.055	0.021	-0.022	-14	15
TS1/2 tank susp. (T300)	k5	± 20%	-0.029	0.034	0.023	-0.026	-16	18
TS2/3 tank susp. (GFRP)	k6	± 20%	-0.006	0.007	0.023	-0.027	-16	19
Outer tank susp. (GFRP)	k7	± 20%	-0.005	0.005	0.017	-0.021	-12	14
Int. Harness cross-section	k8	± 15%	0.293	-0.300	0.097	-0.100	-64	72
Int. Harness length	k9	± 15%	-0.300	0.293	-0.100	0.097	72	-64
Int. Harness dissipation	k10	± 20%	0.125	-0.126	0.013	-0.013	-9	9
He II latent heat	k11	± 1%	0.054	-0.055	-0.007	0.007	5	-5
Harness anchoring on TS1	k17	± 90%	-0.004	+0.072	+0.001	-0.019	-1	13
Harness anchoring on OBP	k18	± 90%	0.008	-0.04	0.000	-0.001	0	1
Sum of mean root square			**-0.496**	**0.502**	**0.146**	**-0.161**	**-96**	**115**

Note: Values in ( ) not taken for lifetime uncertainty

Table 6.3-2: In-Orbit Sensitivities due to Uncertainties of Physical Parameters inside CVV

Item	Sensitivity		T, CVV [K]		M He [mg/s]		Δ Lifetime [days]		Remark
			+	-	+	-	+	-	
Reference Case: see Figure 6.3-5			**70.0**		**2.125**		**-**		
CVV MLI conductance	k21	± 50%	1.61	-1.92	0.066	-0.077	-44	55	
Solar Array MLI conduct.	k22	± 50%	1.54	-2.16	0.065	-0.089	-43	64	
Sunshade MLI conduct.	k23	± 50%	0.23	-0.30	0.018	-0.024	-12	16	
SVM Shield MLI conduct.	k24	± 50%	0.06	-0.09	0.003	-0.004	-2	3	
CVV strut conductance	k25	± 20%	0.72	-0.73	0.029	-0.029	-20	20	
HSS strut conductance	k26	± 20%	0.35	-0.36	0.014	-0.014	-10	10	
Ext. Harness cross-section	k27	± 15%	0.39	-0.41	0.020	-0.020	-13	14	
Ext. Harness length	k28	± 15%	-0.41	0.39	-0.020	0.020	14	-13	
Ext. Harness dissipation	k29	± 20%	0.01	-0.02	0.001	-0.001	-1	1	
MLI IR specularity	k30	± 20%	-0.34	0.35	-0.015	0.015	10	-10	
Emissivity of radiator surfaces	k31	± 0.03	-0.38	0.39	-0.015	0.016	11	-11	see RD 35
Emissivity of Sunshade (OSR panels)	k32	± 0.03	-0.04	0.03	-0.002	0.002	2	-2	1)
Emissivity of Solar Array	k33	± 0.03	-0.19	0.19	-0.008	0.008	5	-6	1)
Absorptivity of Sunshade (OSR panels)	k34	± 0.03	0.15	-0.16	0.010	-0.010	-7	7	1)
Absorptivity of Solar Array	k35	± 0.03	0.19	-0.19	0.008	-0.008	-5	5	1)
Telescope emissivity (M1)	k36	±0.005	-0.1	0.1	-0.004	0.005	(2)	(-3)	*from issue 3*
LOU strut conductance	k38	± 20%	0.1		0.002	-0.002	(-1)	(1)	
Sum of mean root square			**2.25**	**-3.13**	**0.108**	**-0.130**	**-72**	**93**	

1) acc. to ECSS-E-30, Part 1A

Note: Values in ( ) not taken for lifetime uncertainty

Table 6.3-3: In-Orbit Sensitivities due to Uncertainties of Physical Parameters outside CVV

The case of 25 hours launch delay has also to be taken into account as uncertainty. As described in Section 6.2 the launch delay leads to a Helium consumption of 23.2 kg in 40.5days compared to 17.2 kg in 48 days for nominal launch. This leads to an additional helium loss of 6 kg and a corresponding lifetime loss of 7.5 days + 6 kg / (2.267 mg/s) = 38 days.

The overall uncertainty of the lifetime is evaluated using the sum of the mean root square of the uncertainty of 38 days due to 25 hours launch delay and the uncertainties shown in Table 6.3-2 and Table 6.3-3, leading to

-126 days for the negative sensitivities

+148 days for the positive sensitivities

Item	Node	T, cold case [K]		T, hot case [K]	
SA MLI, center panel	[7100]	253	+19 / -32 a)	270	+20 / -34
SA MLI side panel	[7101]	241	+18 / -30 a)	258	+19 / -32
SSD MLI, center panel	[7160]	157	+11 / -18 a)	196	+15 / -25
SSD MLI side panel	[7161]	148	+10 / -16 a)	184	+14 / -23
Telescope	[8000]	78.3	+4 / -6 a)	87.8	+5 / -6
LOU support plate	[4200]	132	± 2 a)	136	± 3
Solar Array, center panel	[7000]	371		396	± 5
Solar Array, side panel	[7001]	352		376	± 5
SSD (OSR’s), center panel	[7060]	219		276	± 11
SSD (OSR’s), side panel	[7061]	205		258	± 11
SVM Thermal Shield	[6204]	122		135	± 3

a) sum of mean root square due to MLI sensitivity analysis (k21, k22, k23)

Table 6.3-4: EPLM Temperatures with uncertainties in L2 Orbit

In case the solar cells are in shunt mode and all absorbed solar energy is dumped in the Solar Array, the temperature of the center panel increases to 409 K (136°C). This has been calculated for LEOP and Winter Solstice.

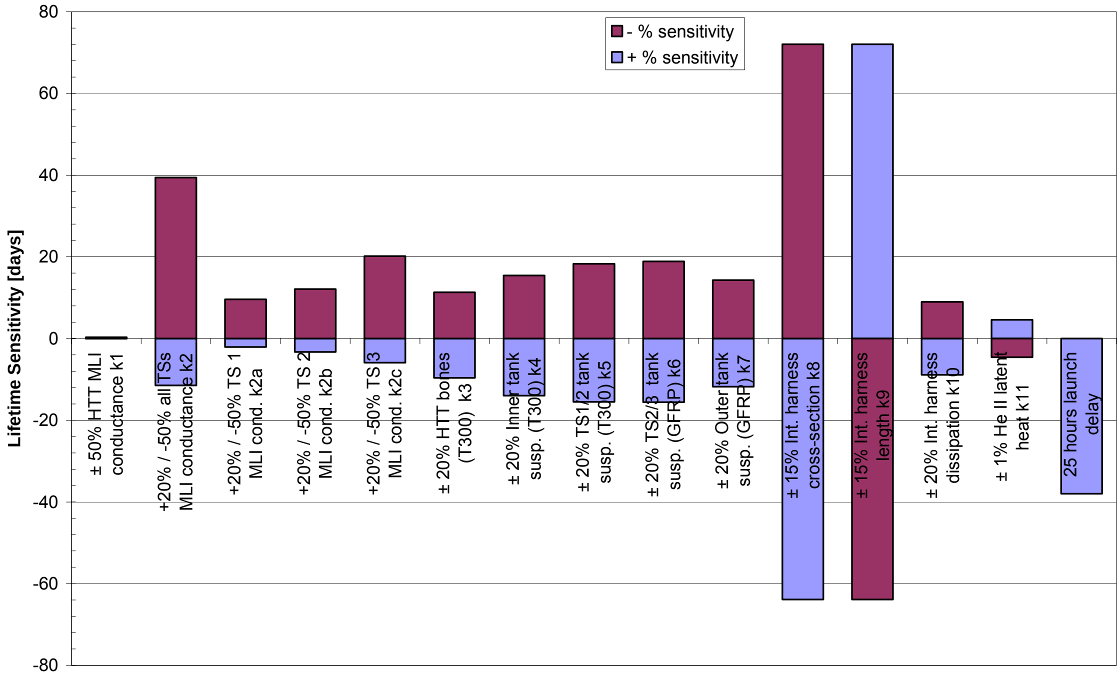


Figure 6.3-6: Lifetime Sensitivity for CVV Internal Parameter Variations

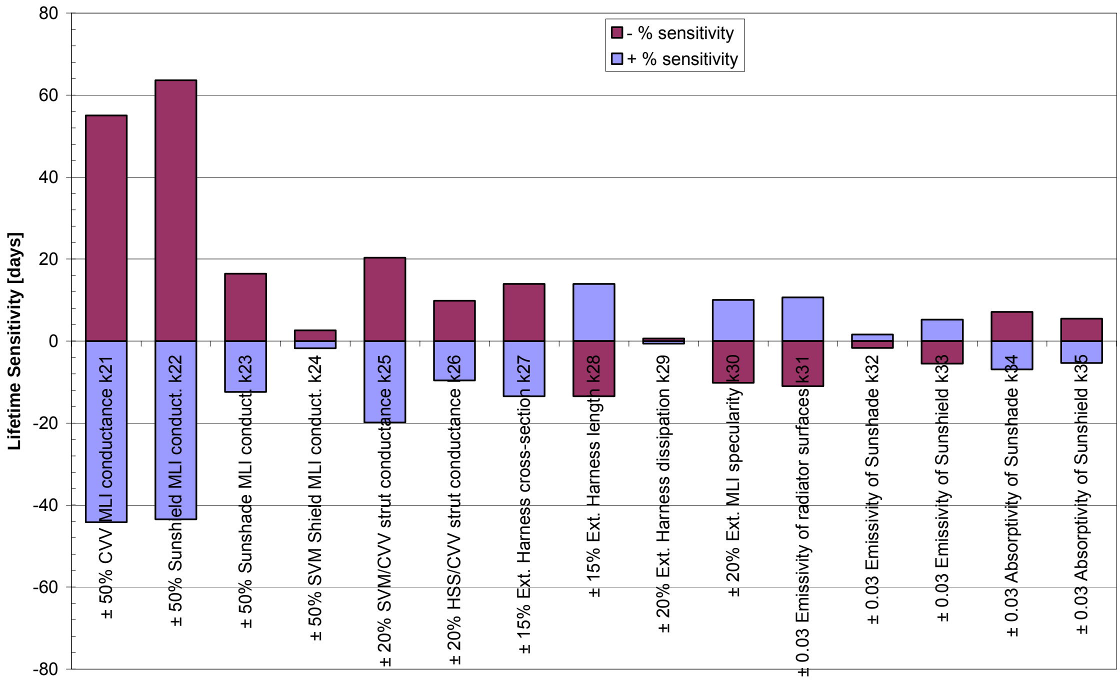


Figure 6.3-7: Lifetime Sensitivity for CVV External Parameter Variations

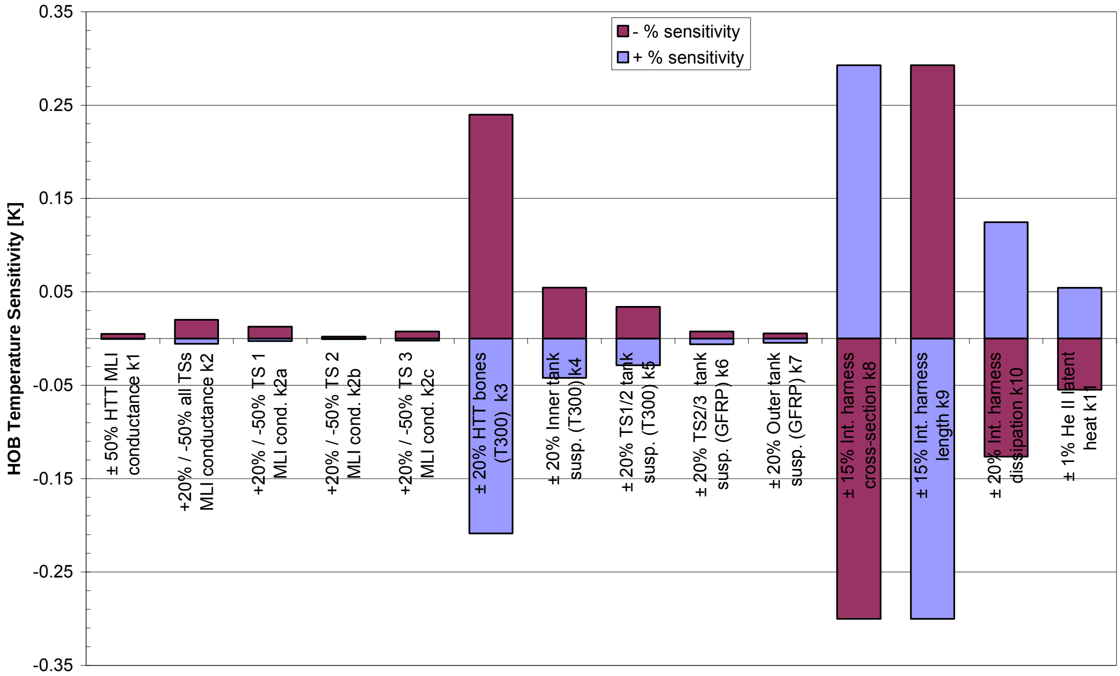


Figure 6.3-8: Sensitivity of HOB Temperature for Operation at L2

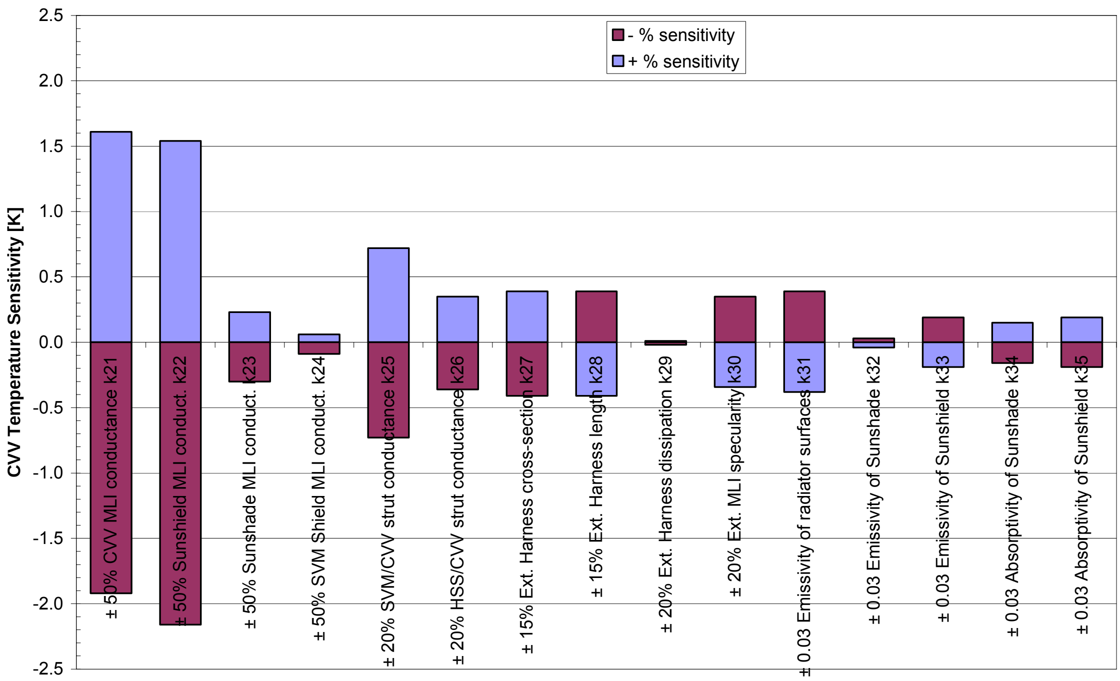


Figure 6.3-9: Sensitivity of CVV Temperature for Operation at L2

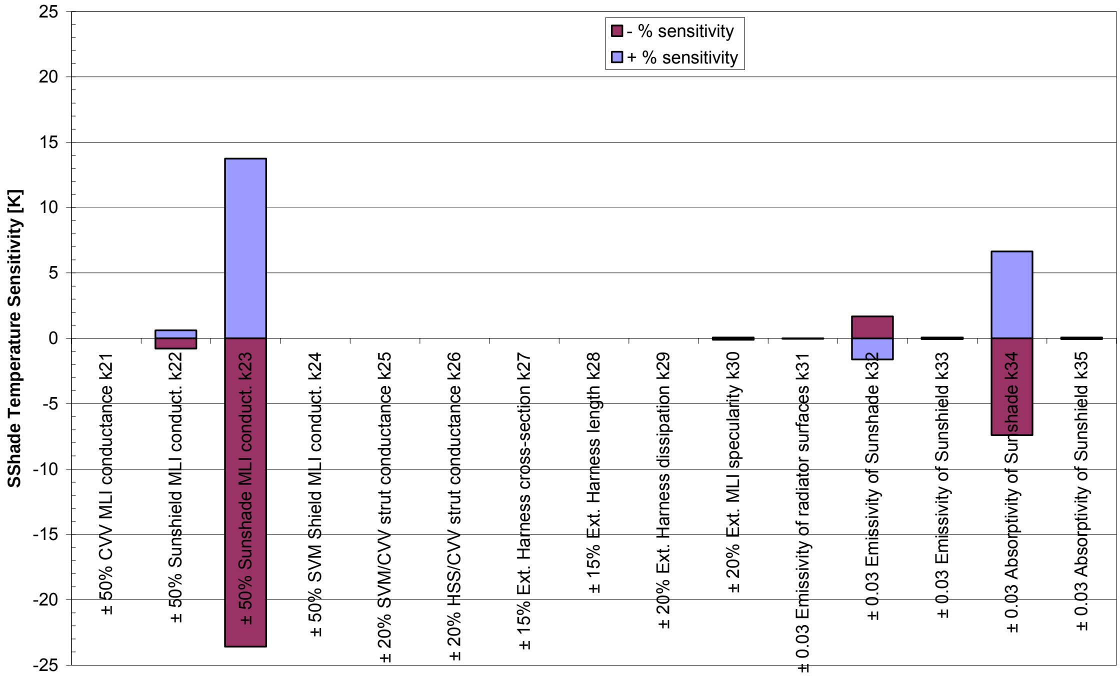


Figure 6.3-10: Sensitivity of Sunshade MLI Temperature for Operation at L2

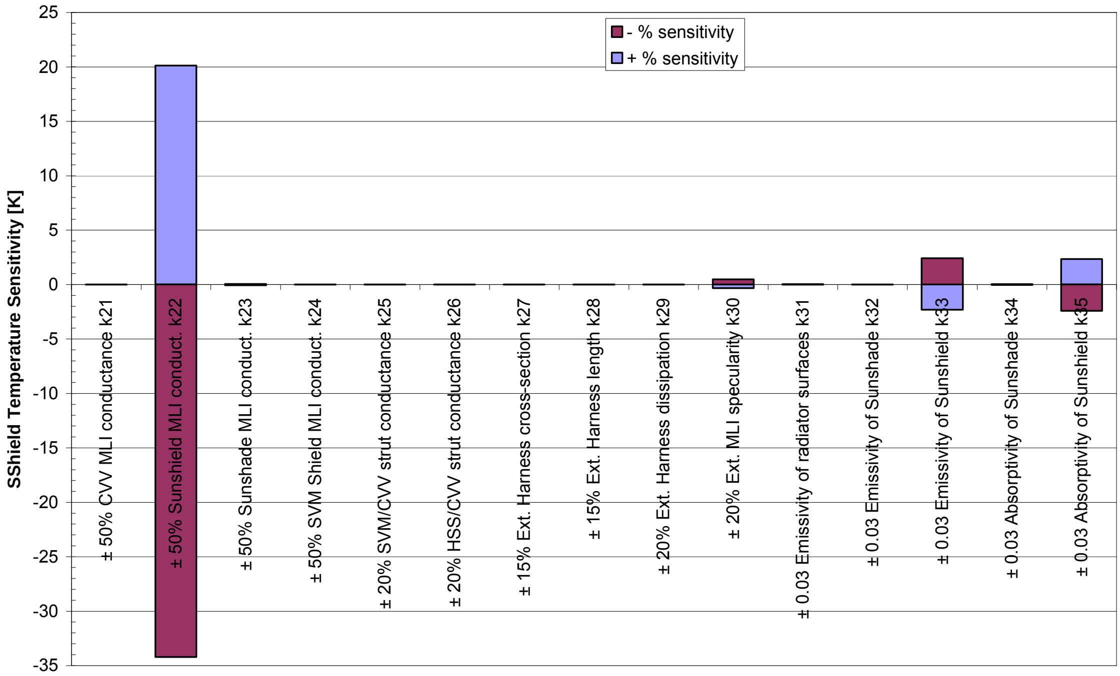


Figure 6.3-11: Sensitivity of Solar Array MLI Temperature for Operation at L2

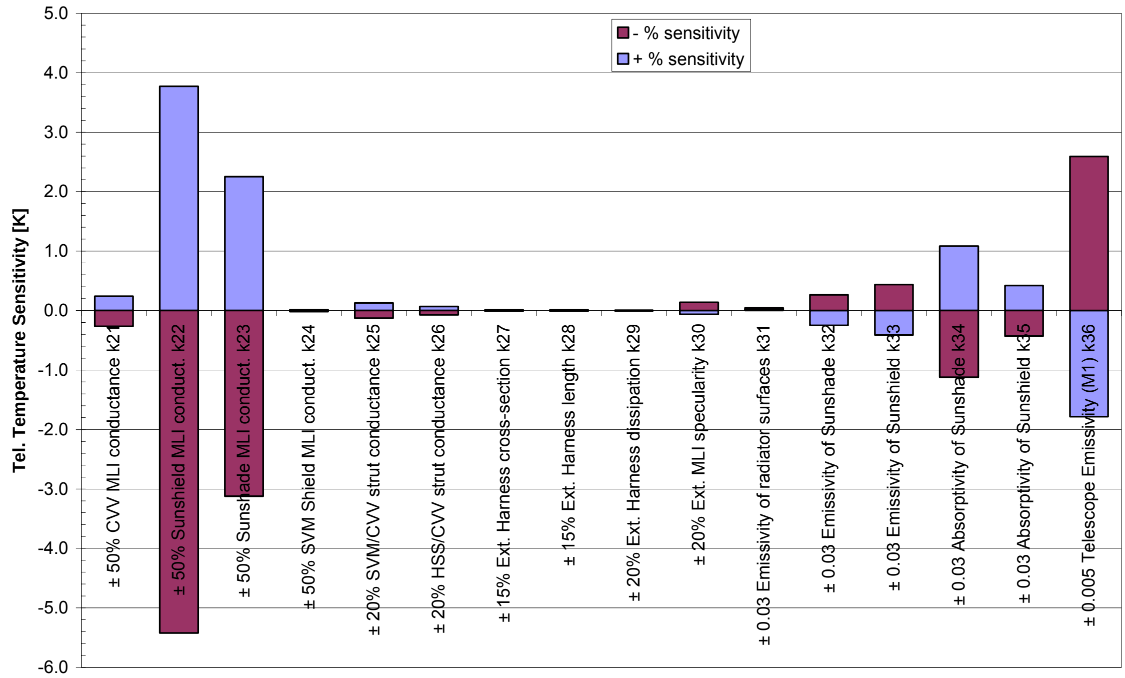


Figure 6.3-12: Sensitivity of Telescope Temperature for Operation at L2

6.3.3 Transient Spacecraft Operations

SECTION 6.3.3 TO BE UPDATED

following figures.

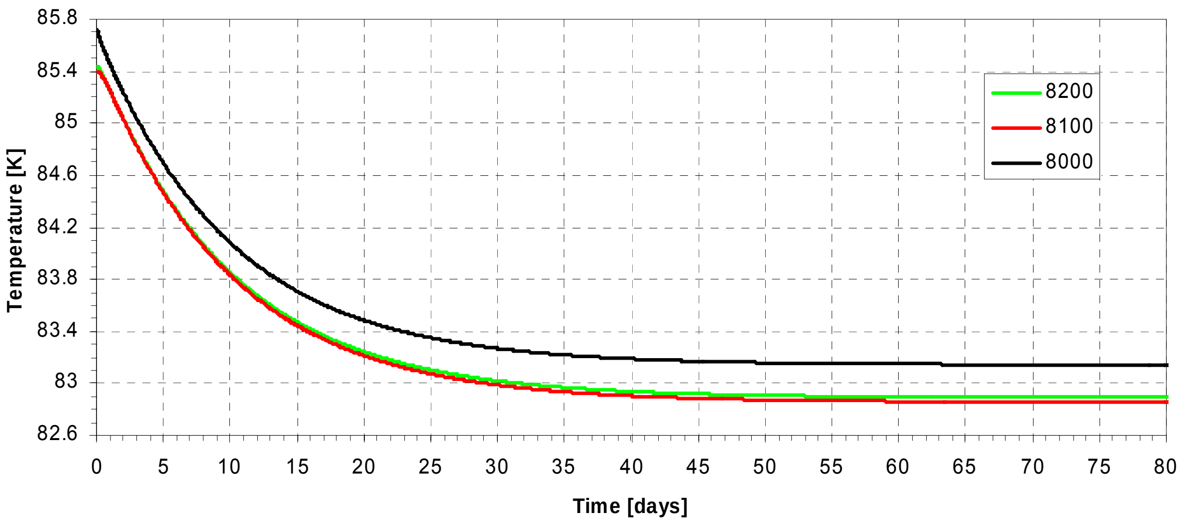


Figure 6.3-13: Transient Cool-Down of Telescope after S/C Rotation 30° around Y-Axis (Issue 3 status)

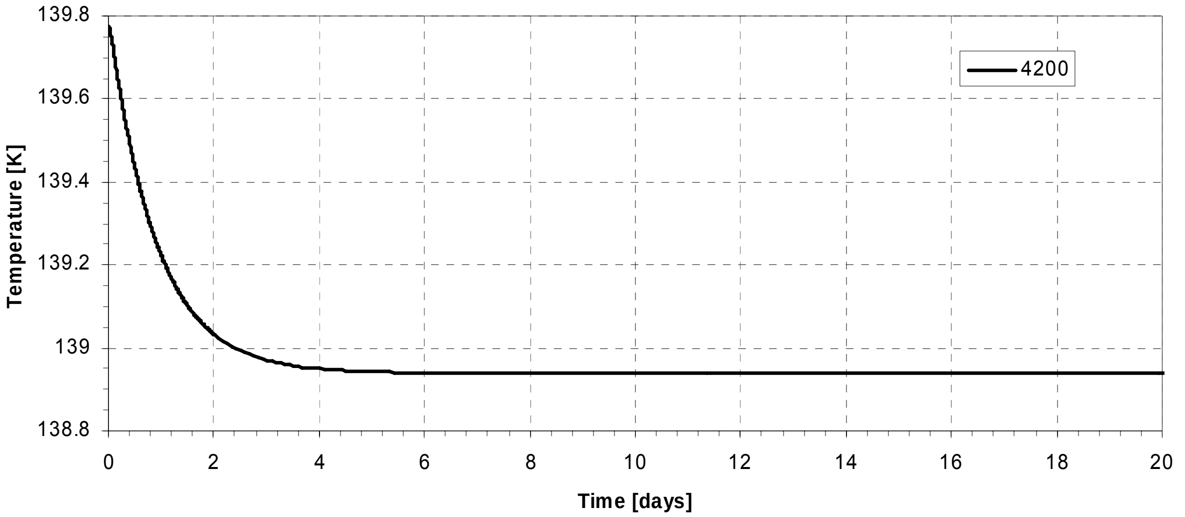


Figure 6.3-14: Transient Cool-Down of LOU Baseplate after S/C Rotation 30° around Y-Axis (Issue 3 status)

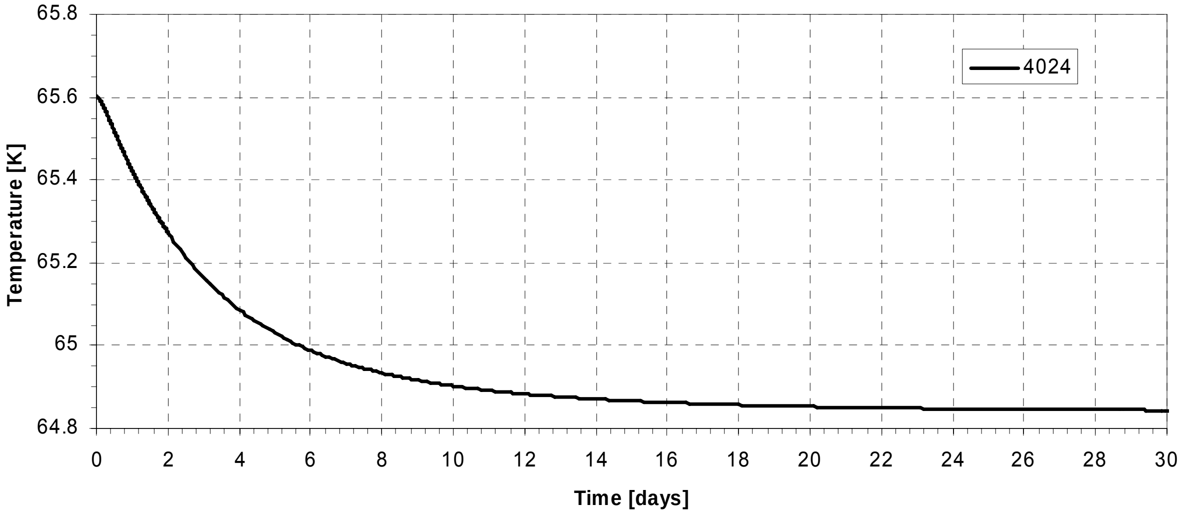


Figure 6.3-15: Transient Cool-Down of CVV after S/C Rotation 30° around Y-Axis (Issue 3 status)

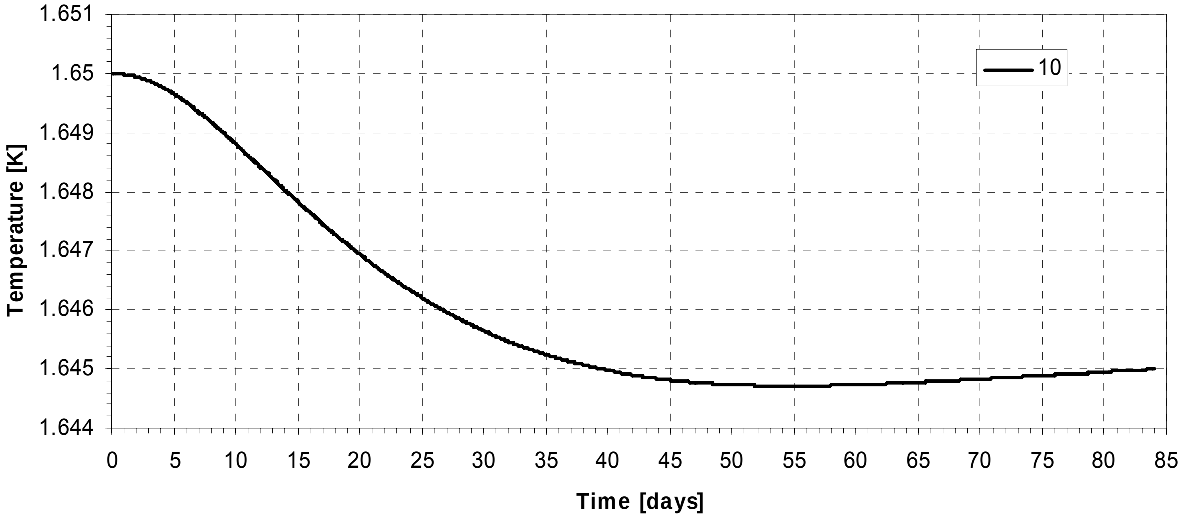


Figure 6.3-16: Transient Cool-Down of HTT after S/C Rotation 30° around Y-Axis (Issue 3 status)

6.4 Instrument Operation in L2 Orbit

The transient temperature and heat flow results for the instrument thermal interface nodes shown in this section are based on the following instrument timeline:

- Start conditions (steady state): Instruments average dissipation
- PACS Photometer Mode (incl. sorption cooler cycle) 48 h
- SPIRE 48 h
- HIFI 48 h
- SPIRE 48 h
- PACS Spectrometer Mode (no sorption cooler cycle) 24 h
- HIFI 48 h
- PACS Spectrometer Mode (no sorption cooler cycle) 24 h

The analysis results shown in Section 6.4.1 to 6.4.4 are performed for hot case conditions (acc. to Table 3.2-1) with a remaining He II mass of 35 kg at the beginning of the simulation.

The uncertainties to be taken into account for the different temperature levels are given in Table 6.6-1.

Further analyses have been performed to investigate the effect of cold case conditions at L2 and to compare the results of an almost empty Helium tank (35 kg) with the performance of an almost full Helium tank (300 kg). Those results are shown in Section 6.4.5.

6.4.1 PACS Interface Temperatures and Heat Flows

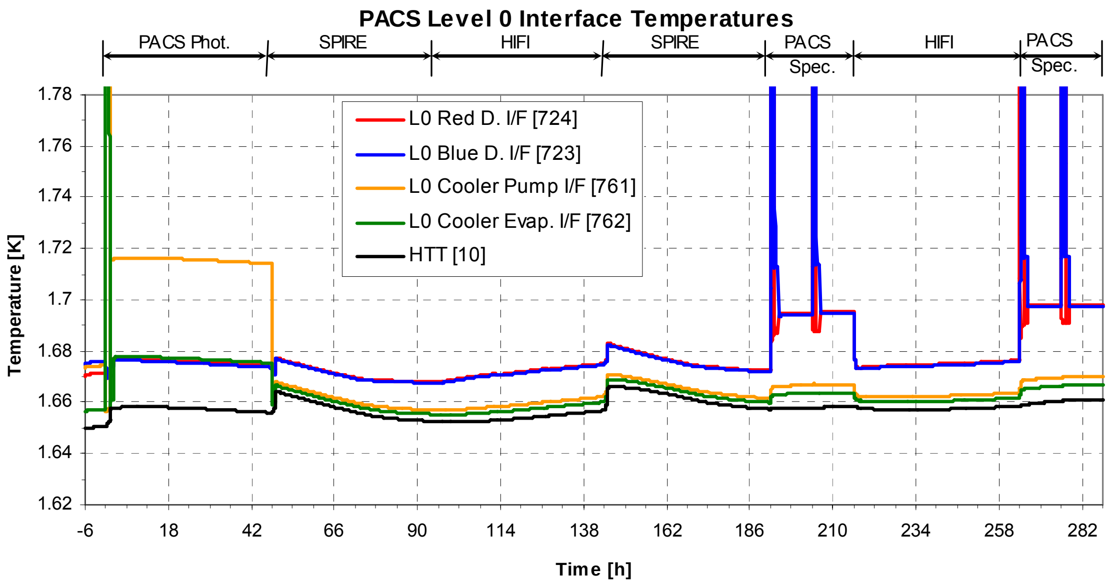


Figure 6.4-1: PACS L0 Interface Temperatures

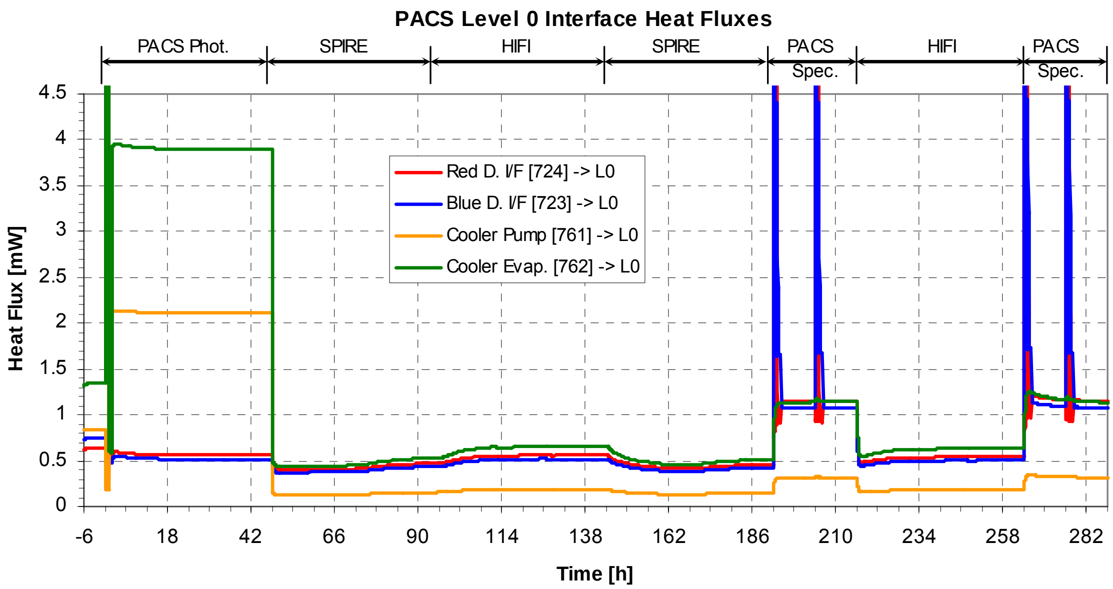


Figure 6.4-2: PACS L0 Interface Heat Flows

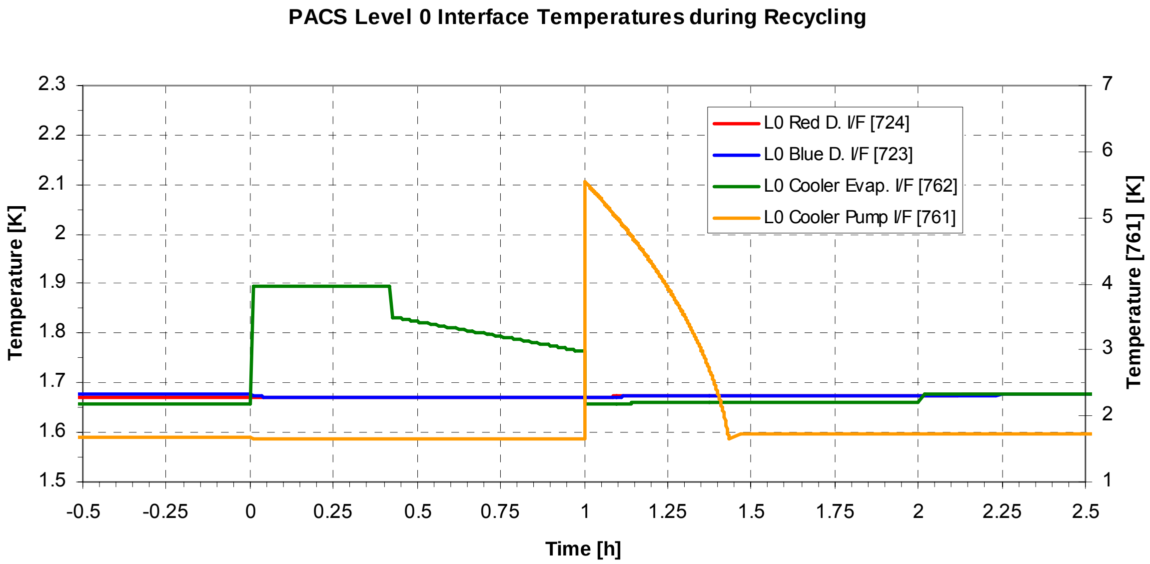


Figure 6.4-3: PACS L0 Interface Temperatures during Recycling

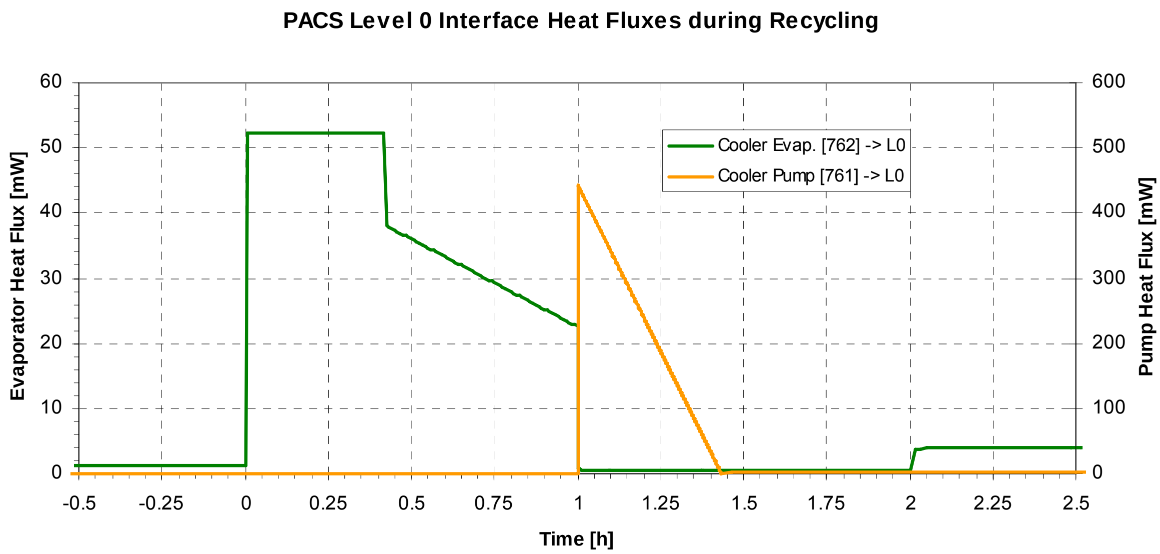


Figure 6.4-4: PACS L0 Interface Heat Flows during Recycling

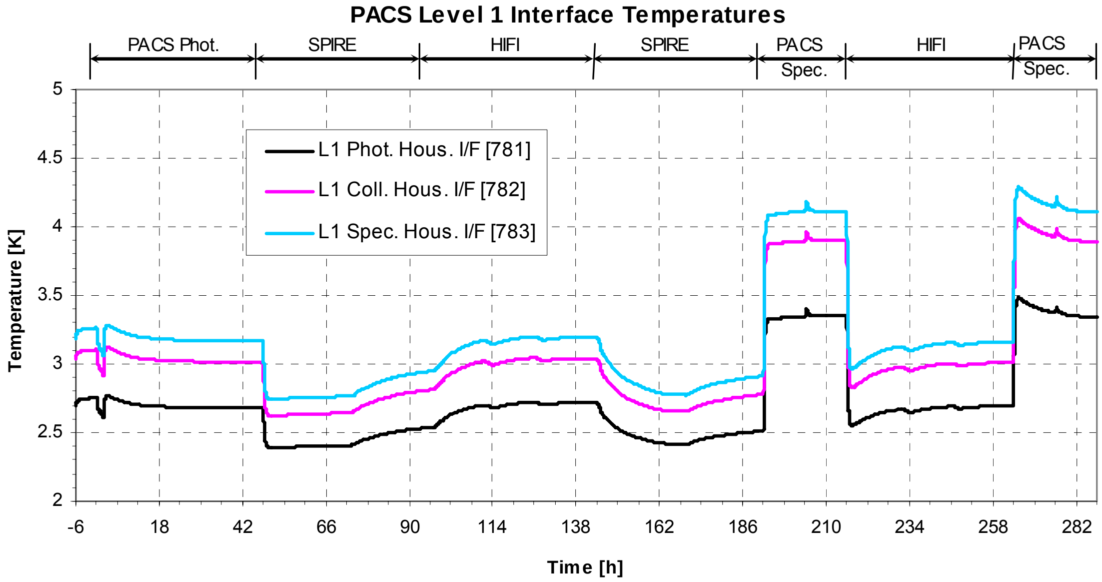


Figure 6.4-5: PACS L1 Interface Temperatures

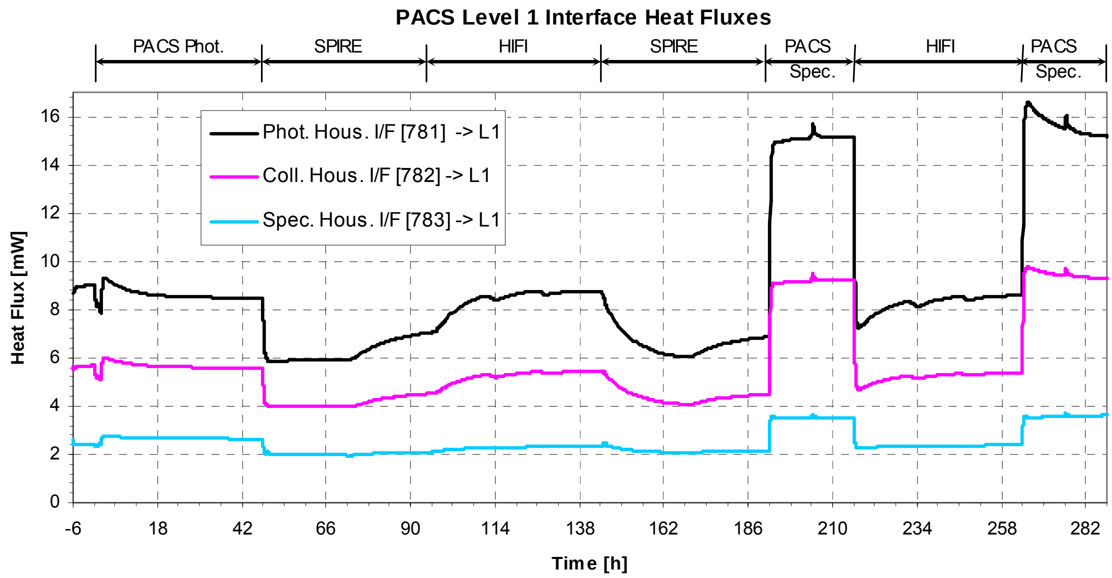


Figure 6.4-6: PACS L1 Interface Heat Flows

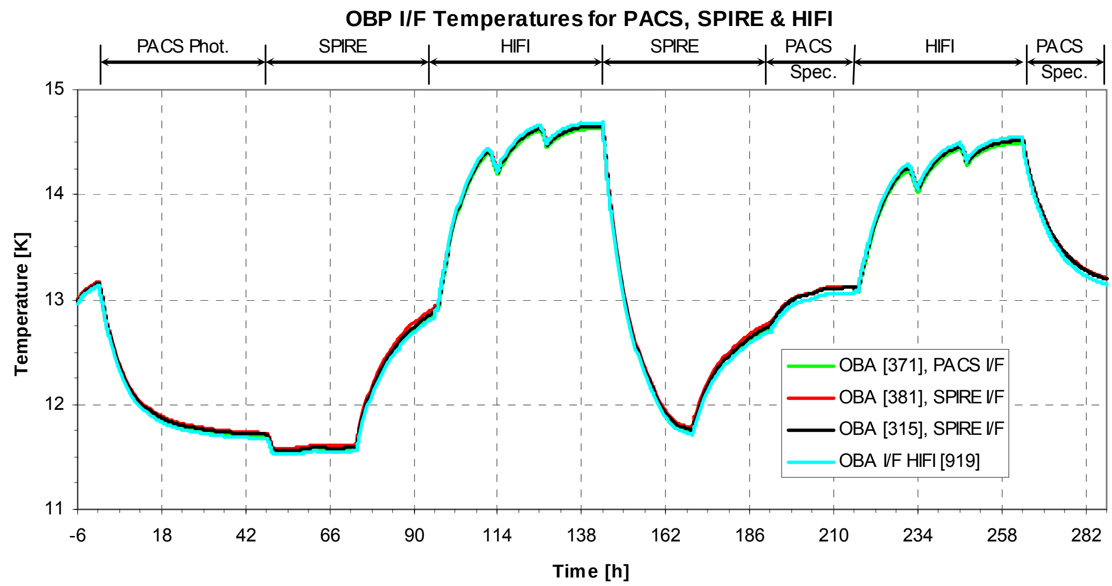


Figure 6.4-7: FPU L2 Interface Temperatures

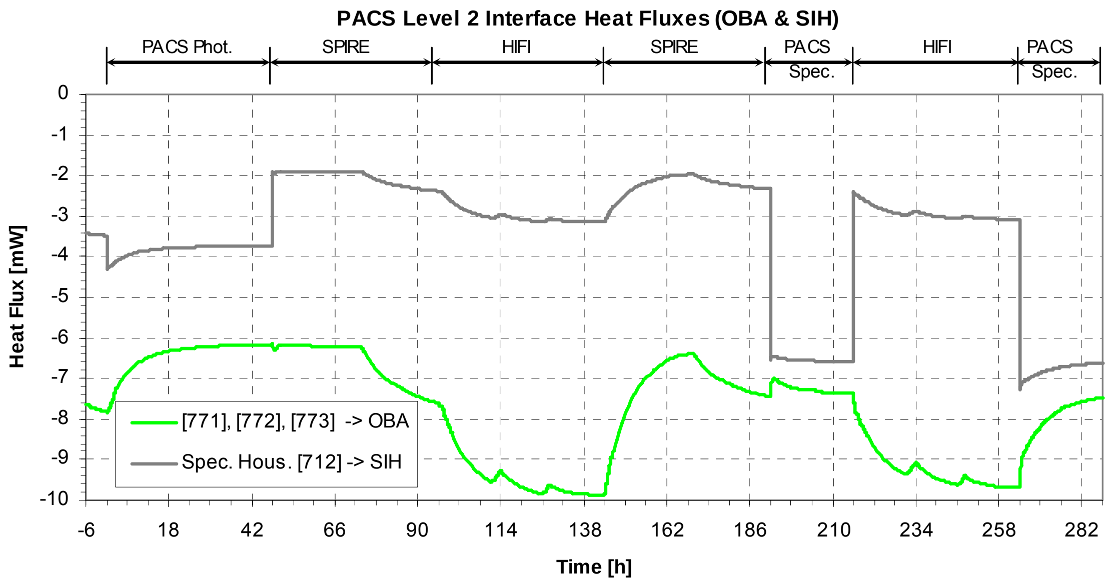


Figure 6.4-8: PACS L2 Interface Heat Flows

6.4.2 SPIRE Interface Temperatures and Heat Flows

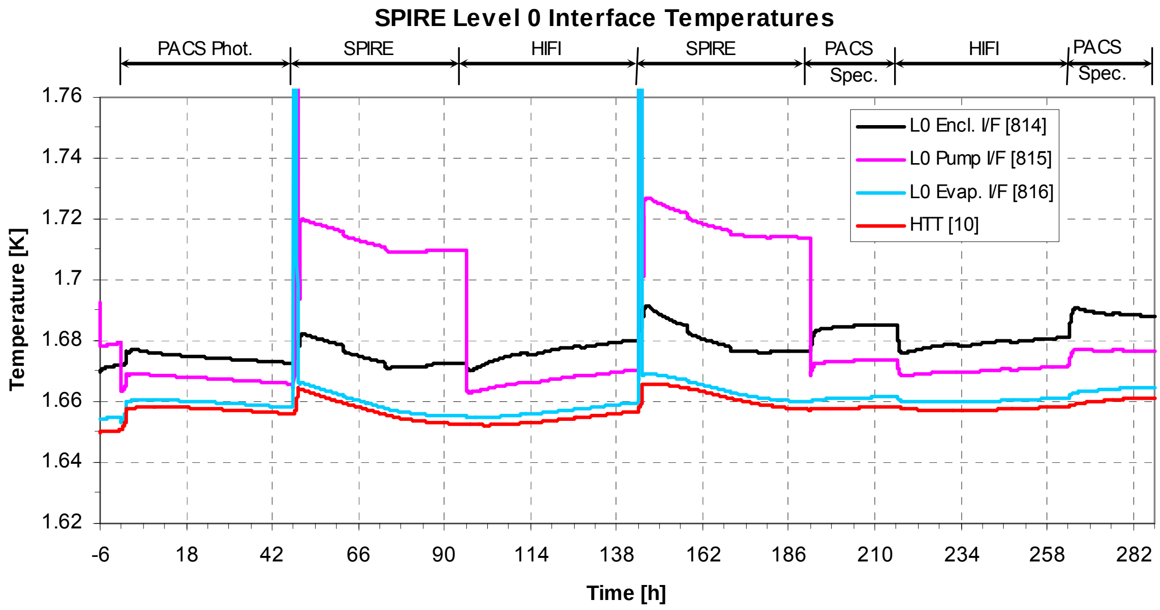


Figure 6.4-9: SPIRE L0 Interface Temperatures

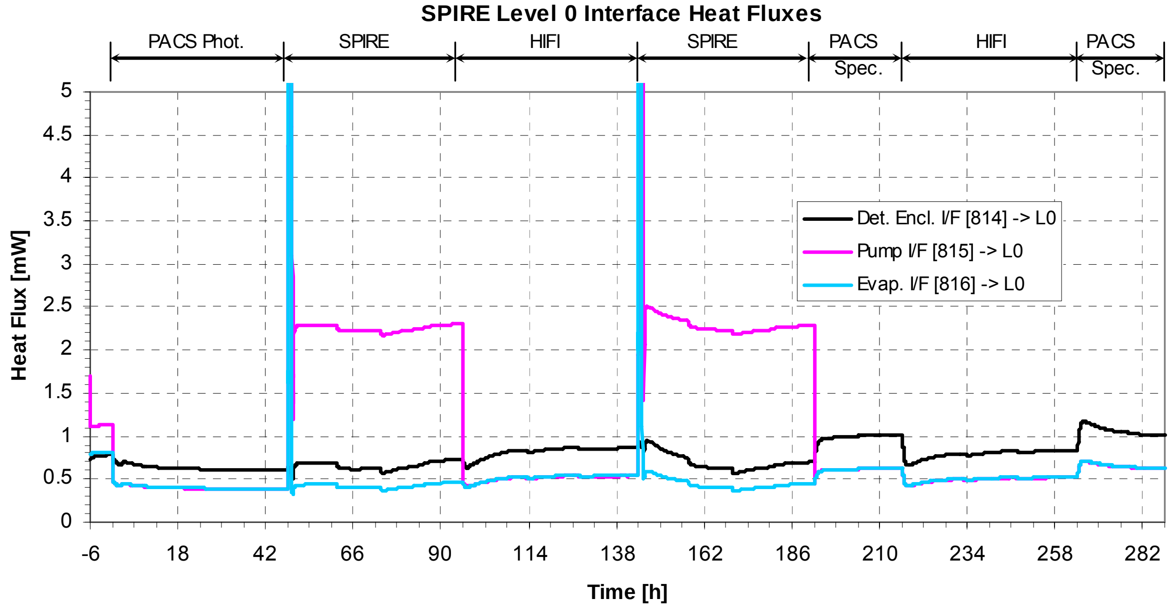


Figure 6.4-10: SPIRE L0 Interface Heat Flows

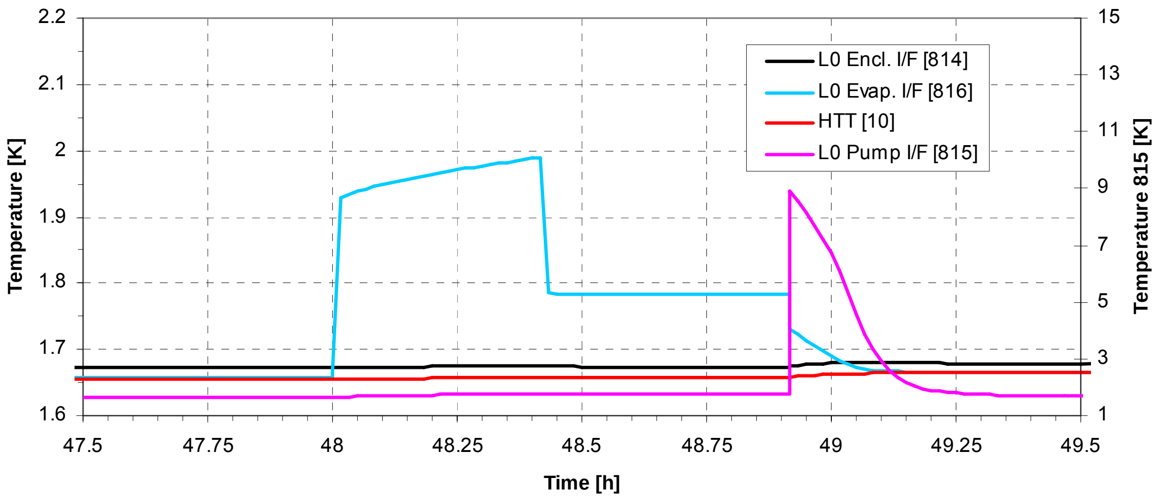


Figure 6.4-11: SPIRE L0 Interface Temperatures during Recycling

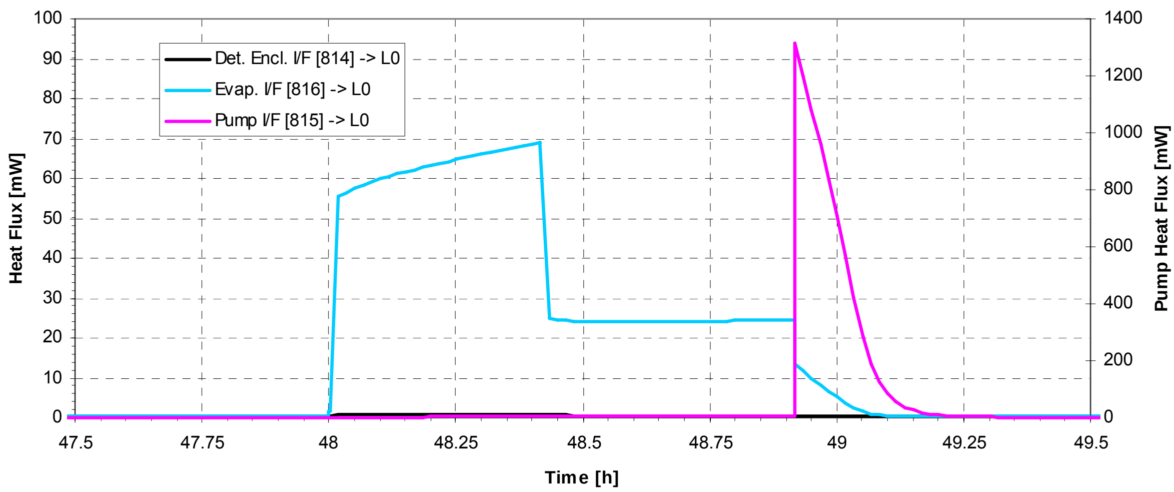


Figure 6.4-12: SPIRE L0 Interface Heat Flows during Recycling

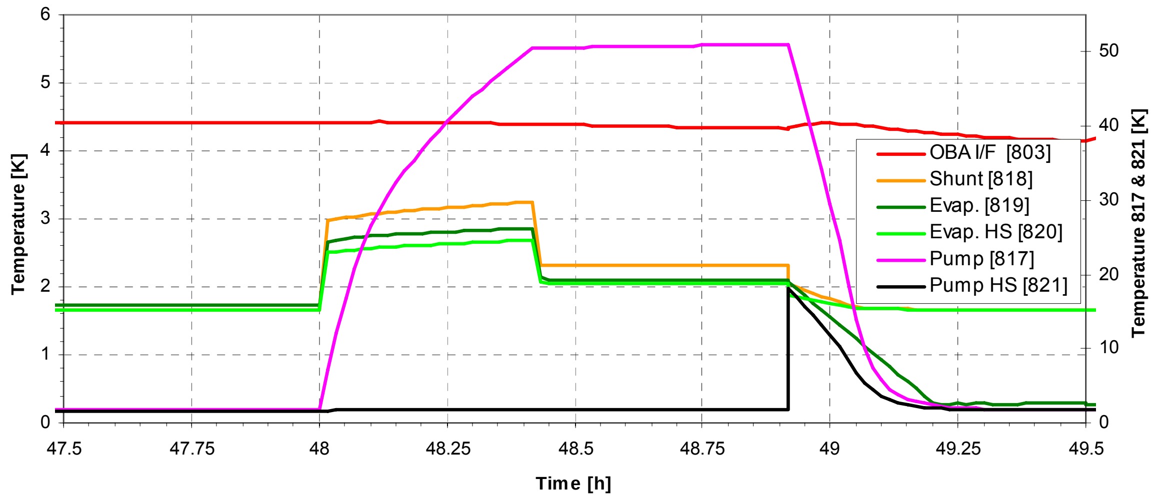


Figure 6.4-13: SPIRE Cooler Temperatures during Recycling (for information)

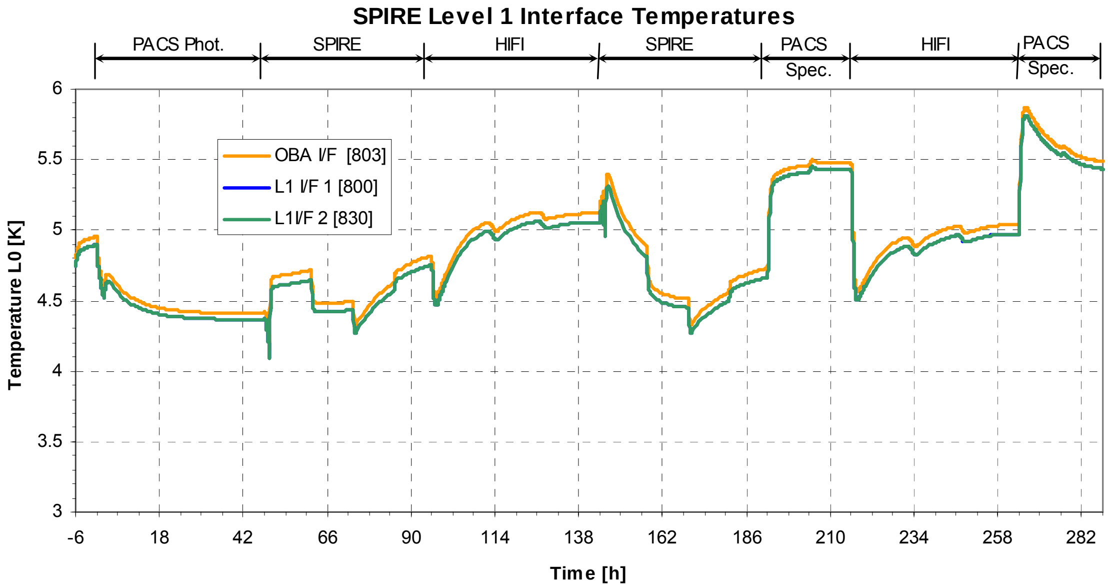


Figure 6.4-14: SPIRE L1 Interface Temperatures

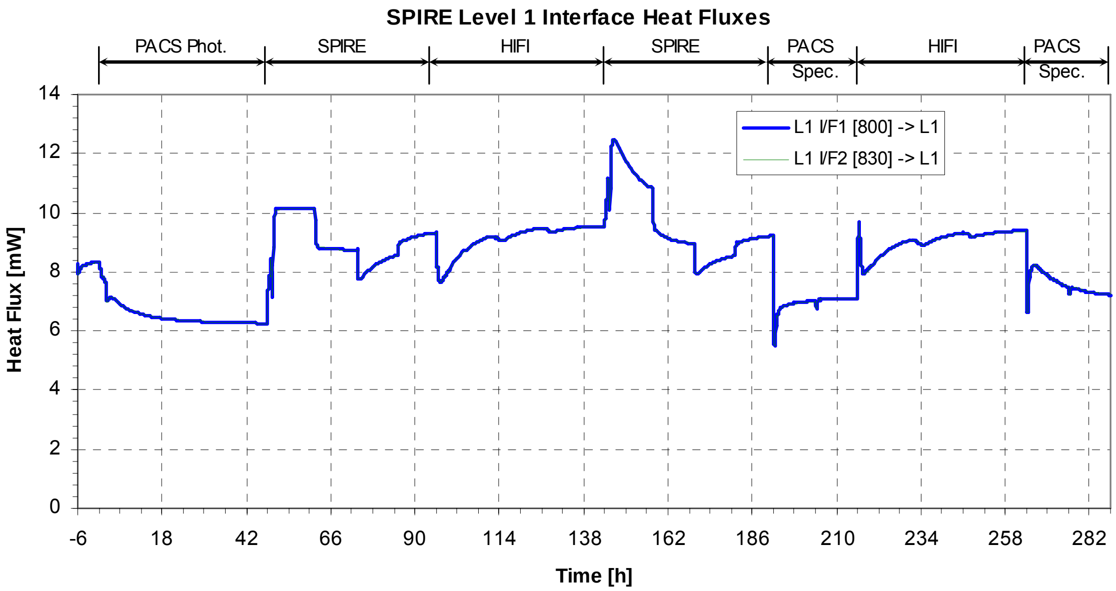


Figure 6.4-15: SPIRE L1 Interface Heat Flows

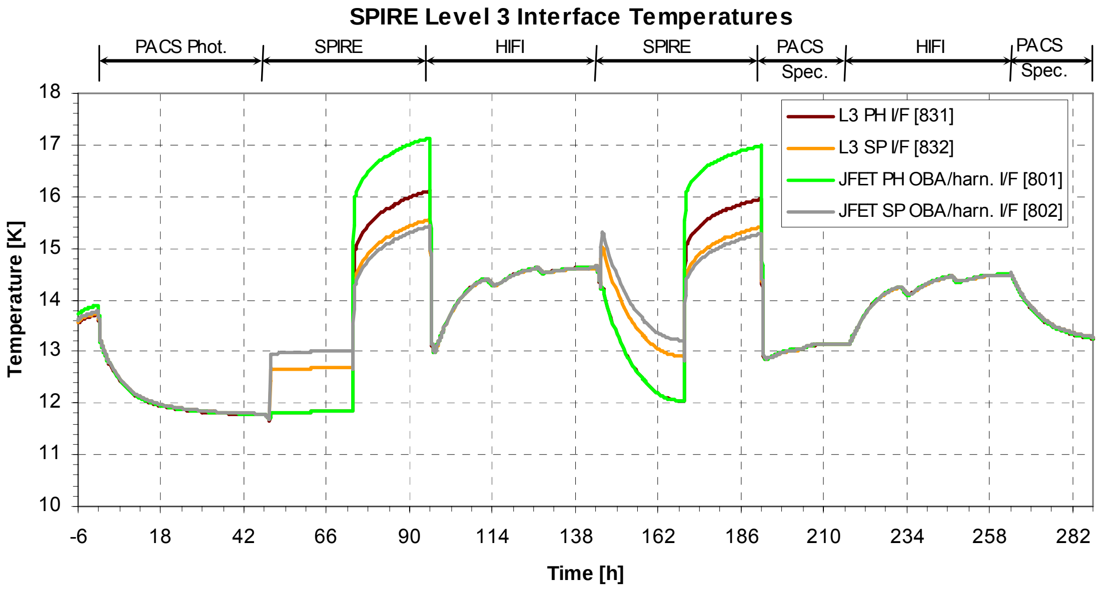


Figure 6.4-16: SPIRE L3 Interface Temperatures

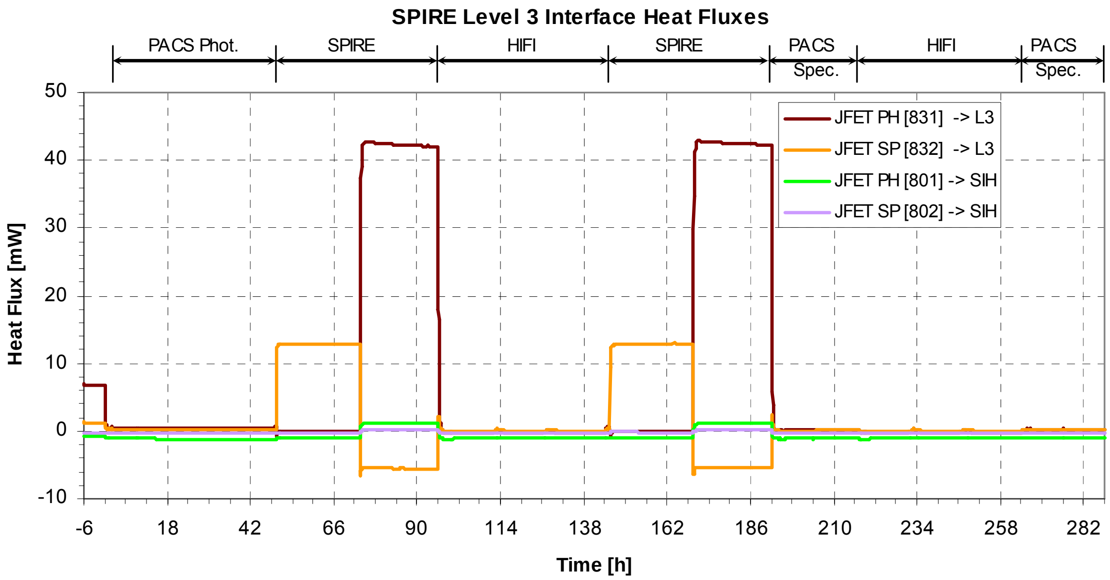


Figure 6.4-17: SPIRE L3 Interface Heat Flows

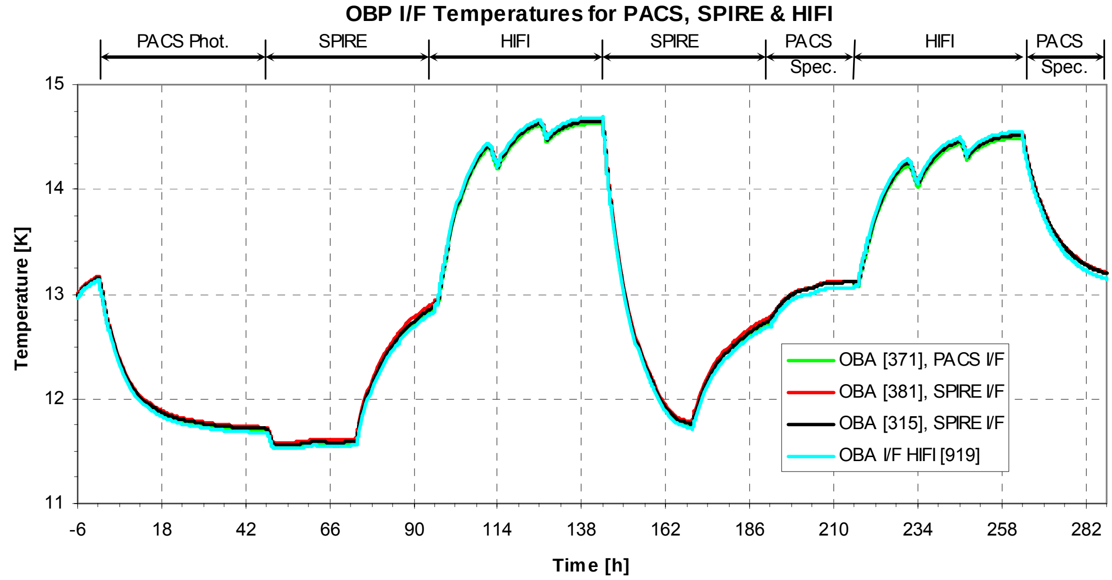


Figure 6.4-18: FPU L2 Interface Temperatures

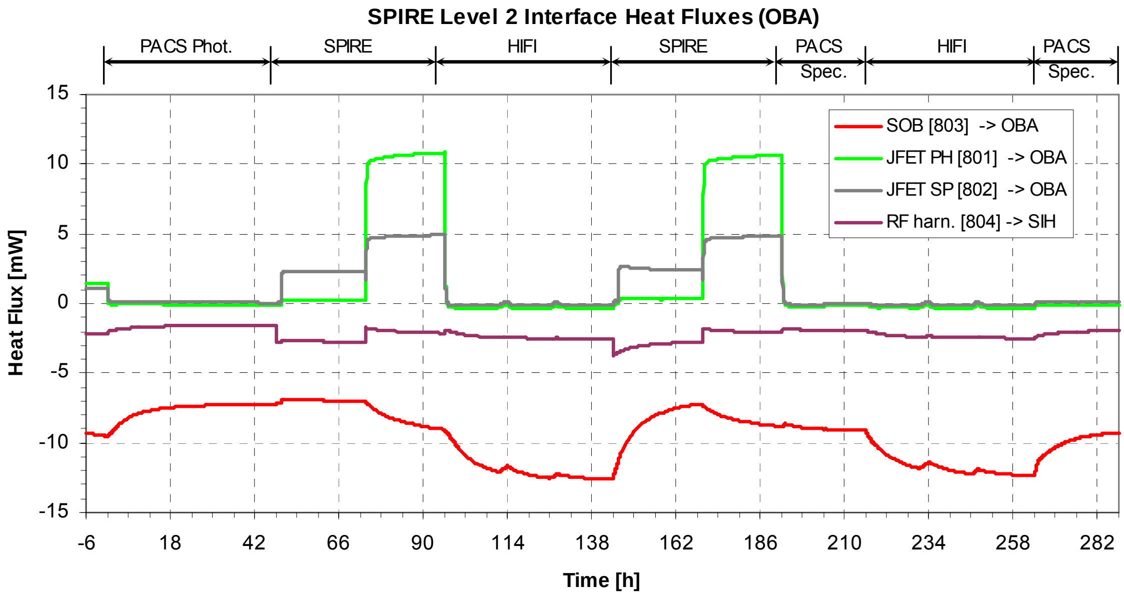


Figure 6.4-19: SPIRE L2 Interface Heat Flows

6.4.3 HIFI Interface Temperatures and Heat Flows

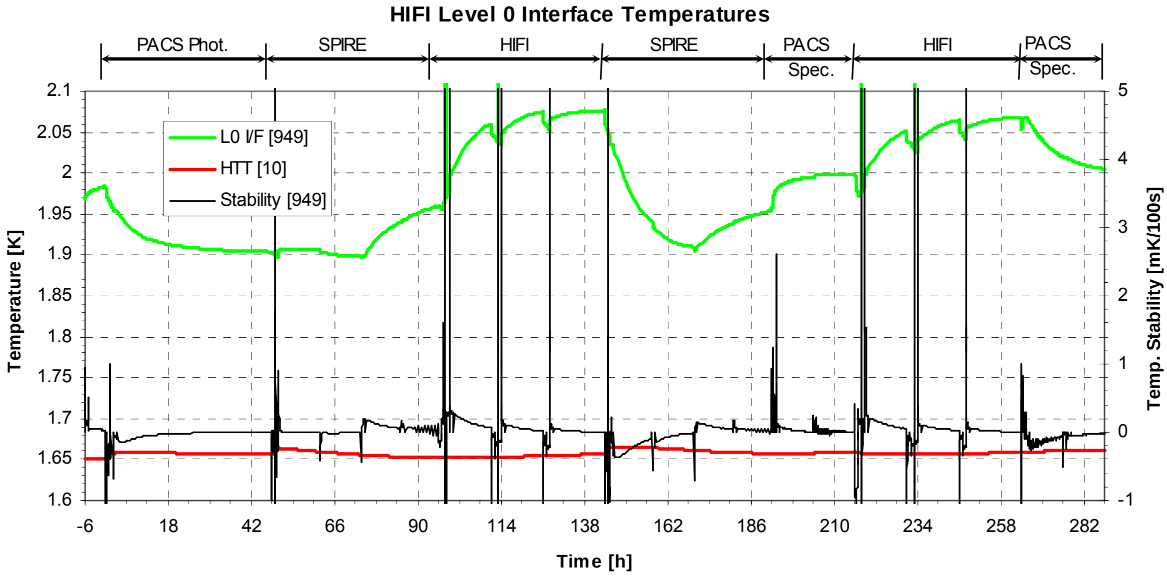


Figure 6.4-20: HIFI L0 Interface Temperature and Stability

Note that the temperature stability peaks of HIFI are caused by short heat peak phases due to dissipation switching.

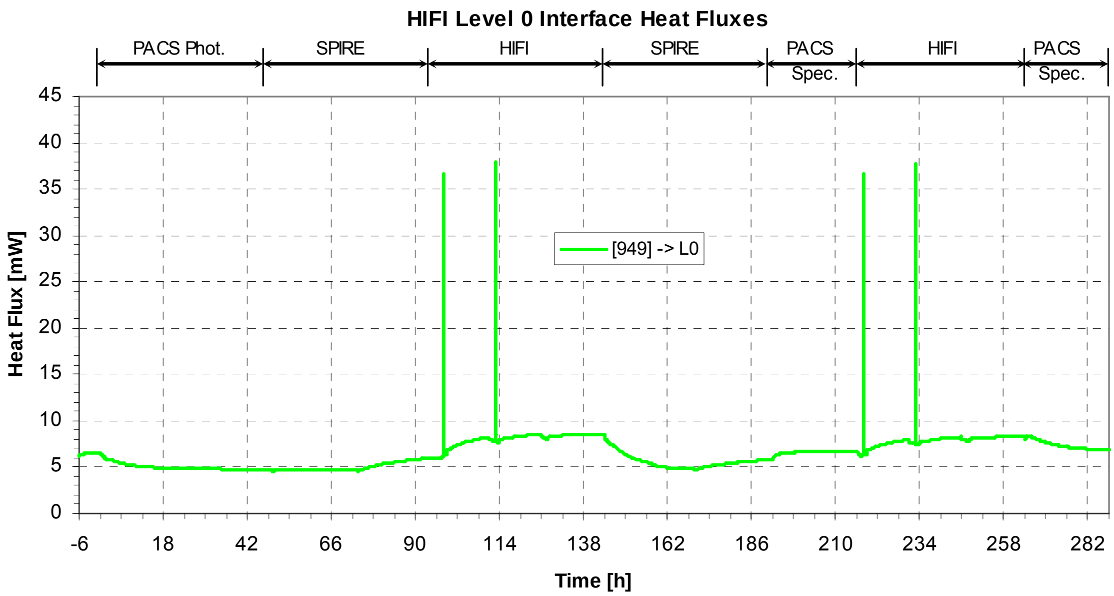


Figure 6.4-21: HIFI L0 Interface Heat Flow

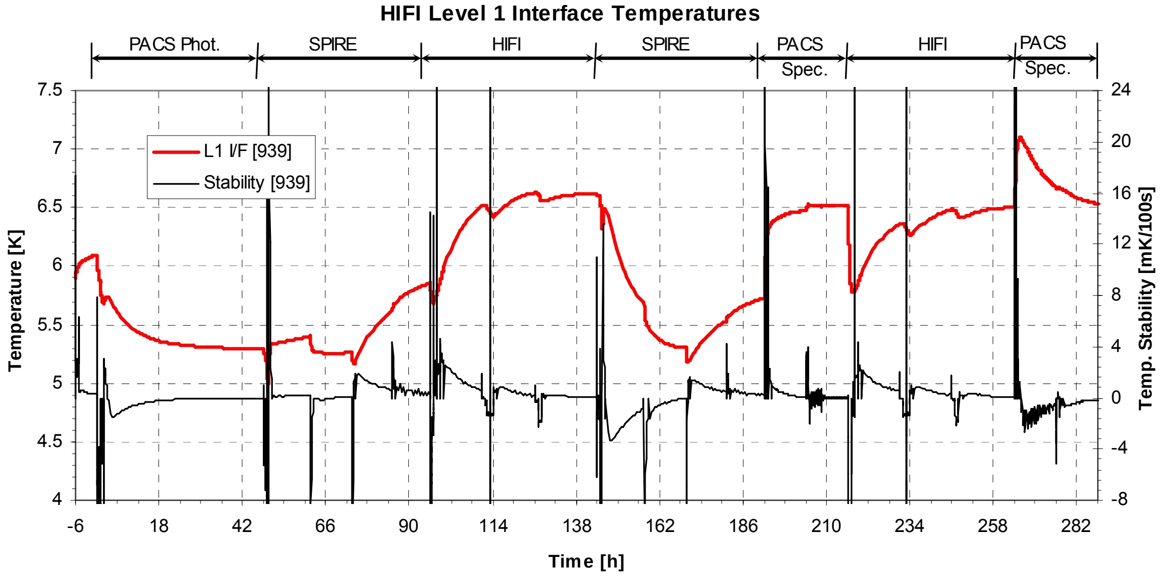


Figure 6.4-22: HIFI L1 Interface Temperature and Stability

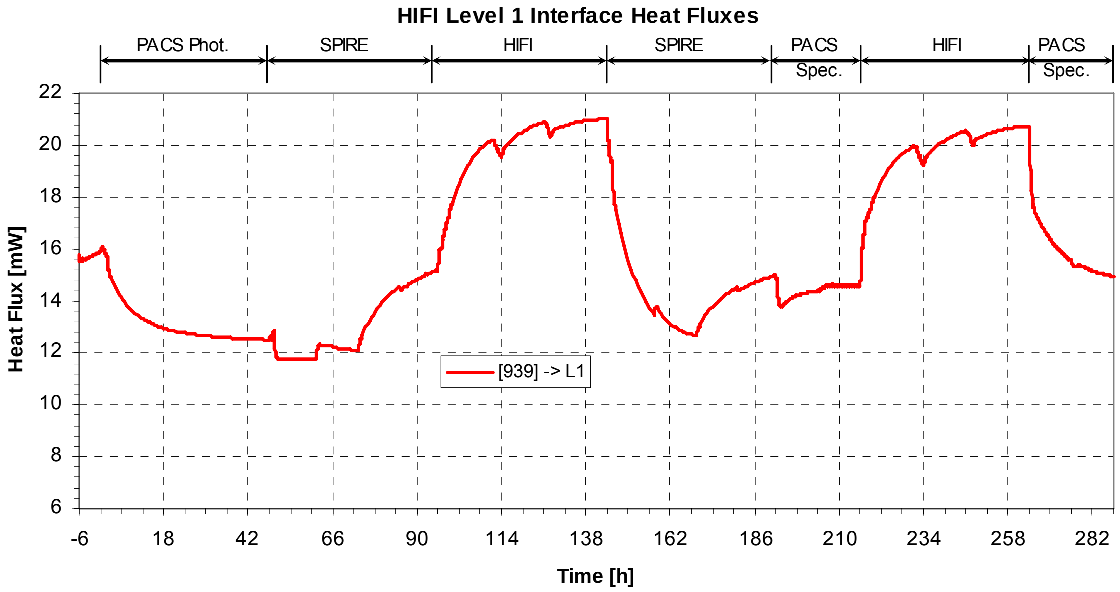


Figure 6.4-23: HIFI L1 Interface Heat Flow

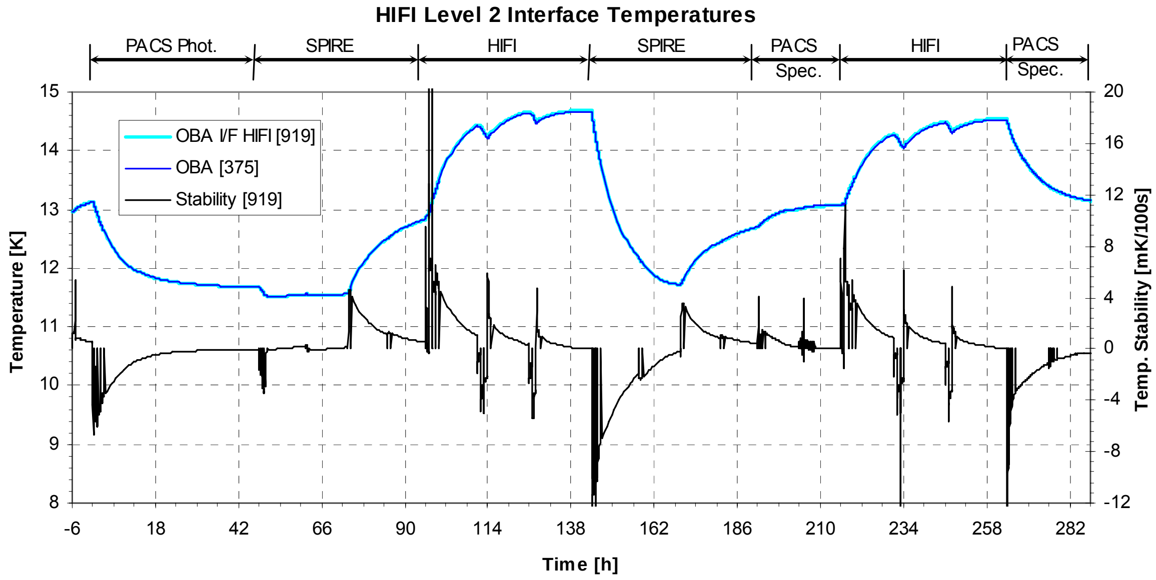


Figure 6.4-24: HIFI L2 Interface Temperature and Stability

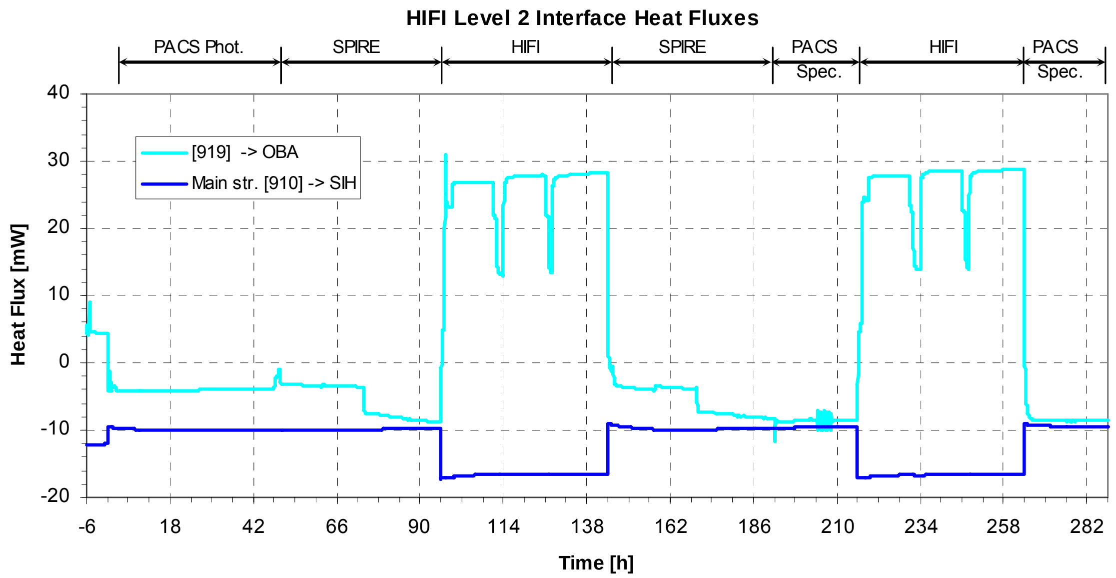
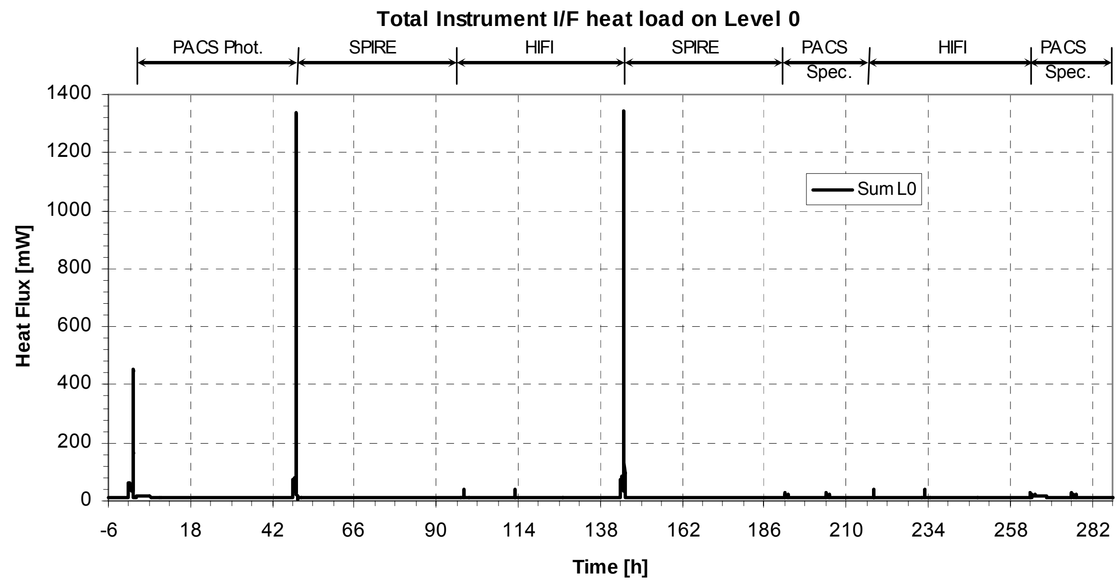


Figure 6.4-25: HIFI L2 Interface Heat Flow

6.4.4 Instrument Heat Load on HTT and He Mass Flow



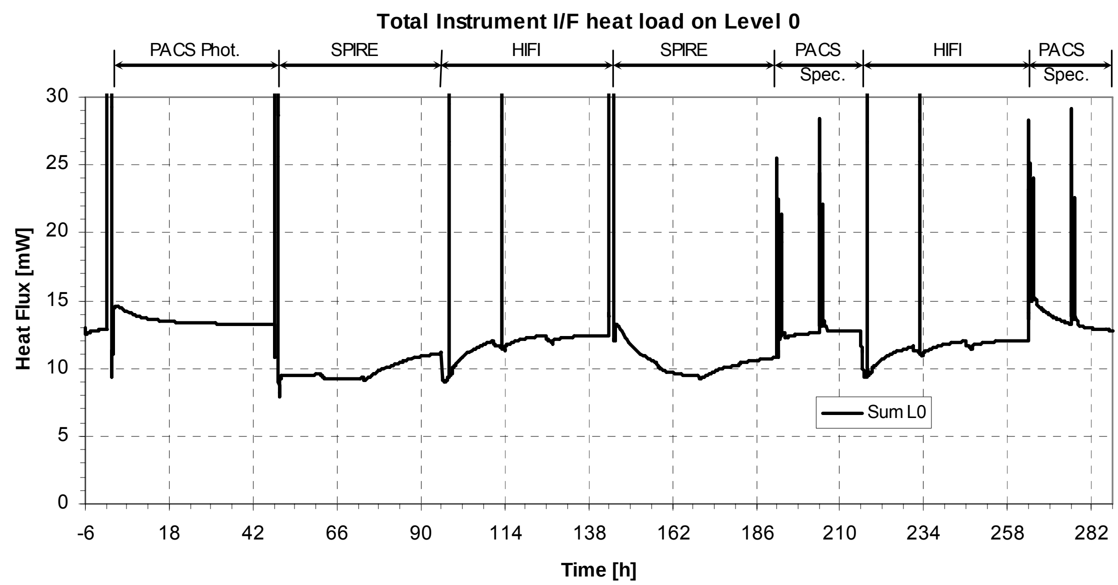


Figure 6.4-26: Total Instrument I/F Heat Load on HTT (different scales on Y-axis)

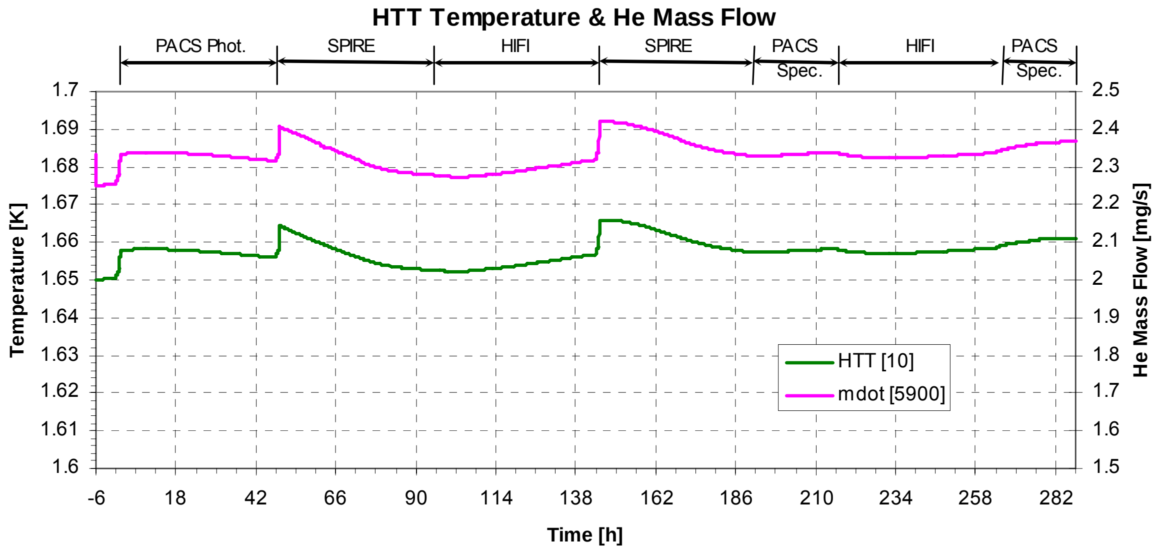


Figure 6.4-27: HTT Temperature and He Mass Flow Rate

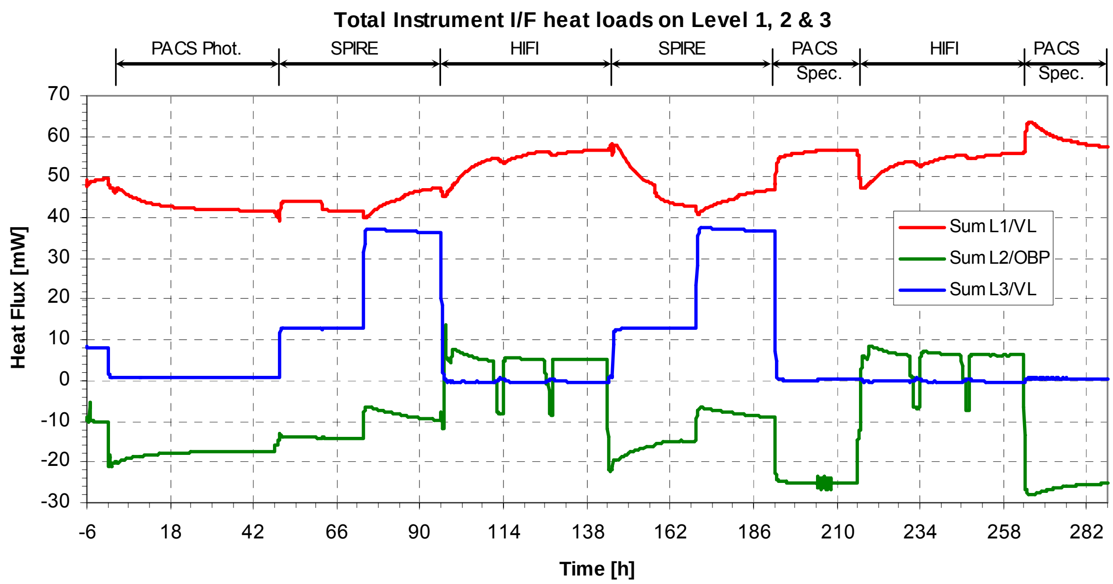


Figure 6.4-28: Total Instrument I/F Heat Load on L1, L2 and L3

6.4.5 Sensitivity Analysis

The following sensitivities have been performed:

- Hot Case with nearly empty HTT: hot case environment at L2 and 35 kg He in the tank (detailed results see sections 6.4.1 to 6.4.4)
- Cold Case with nearly empty HTT: cold case environment at L2 and 35 kg He in the tank
- Hot Case with nearly full HTT: hot case environment at L2 and 300 kg He in the tank

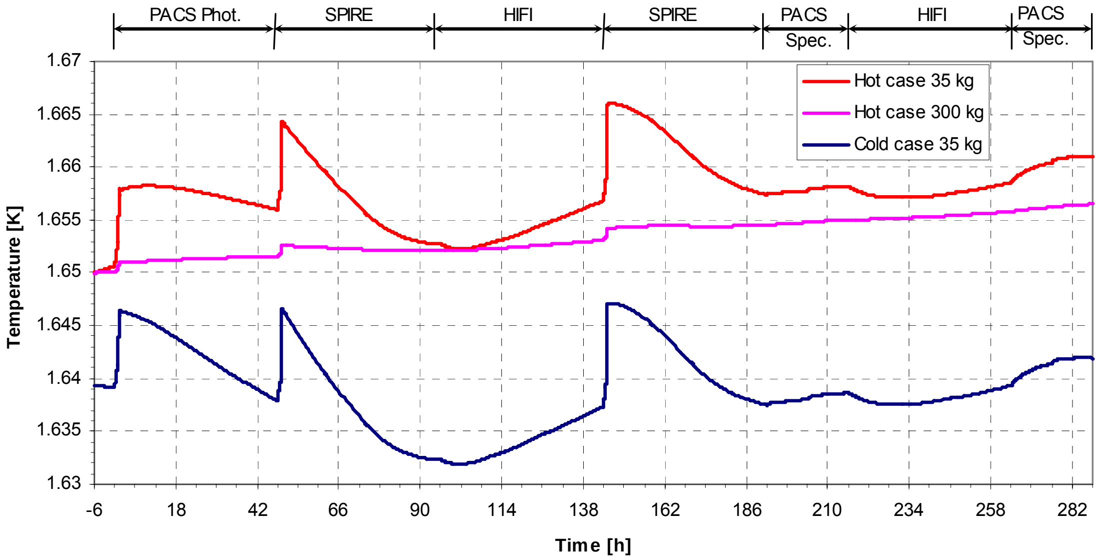


Figure 6.4-29: HTT Temperature for Different Conditions

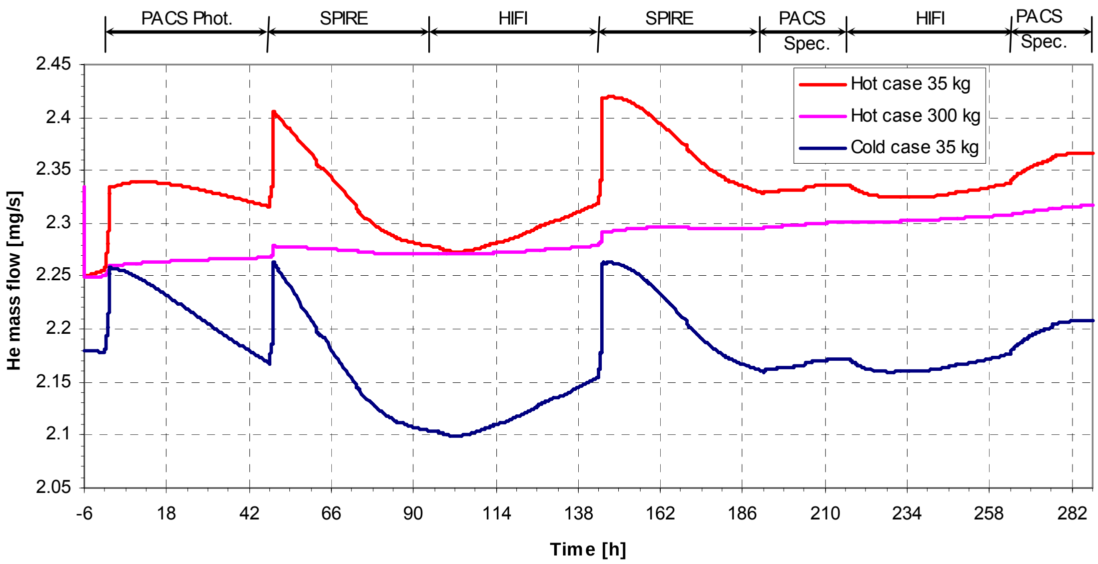


Figure 6.4-30: Helium Mass Flow for Different Conditions

In the following figures some representative temperatures curves are shown for the level 0, 1, 2 and 3 instrument interfaces.

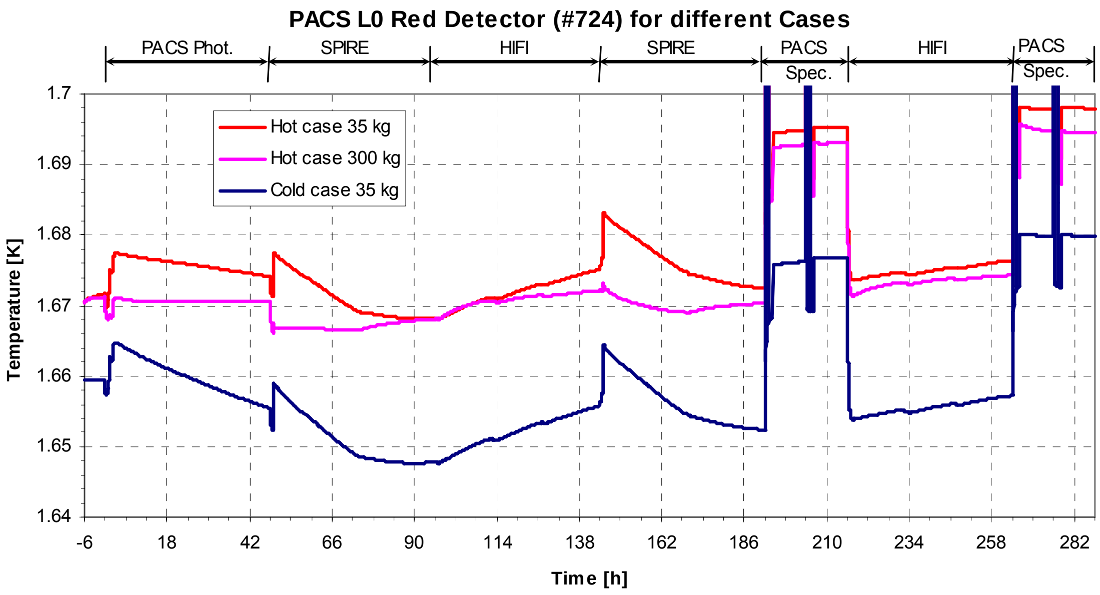


Figure 6.4-31: PACS L0 Temperature for Different Conditions

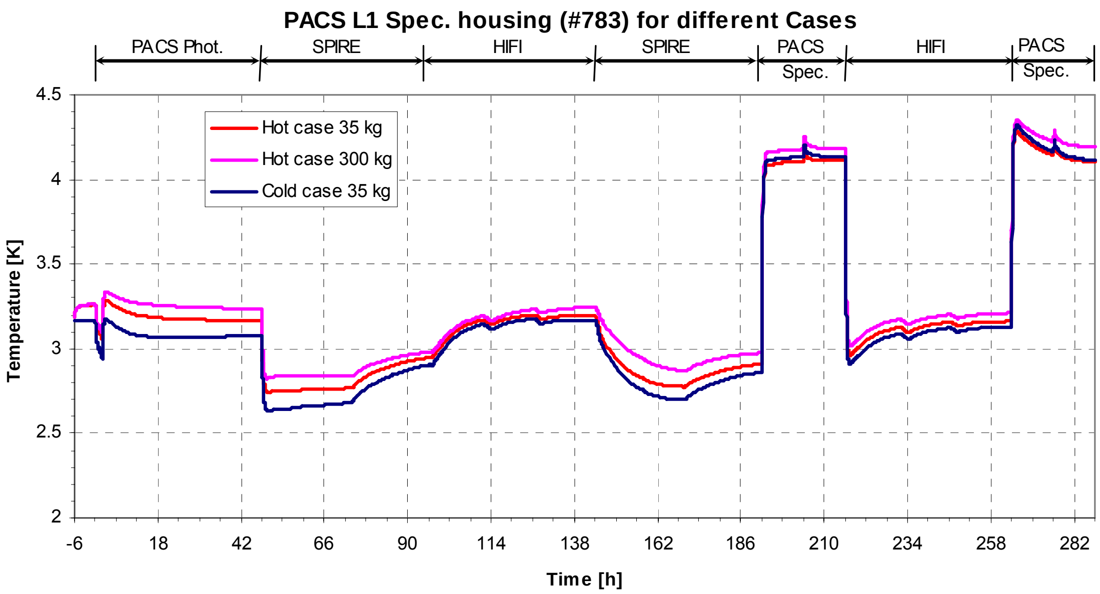


Figure 6.4-32: PACS L1 Temperature for Different Conditions

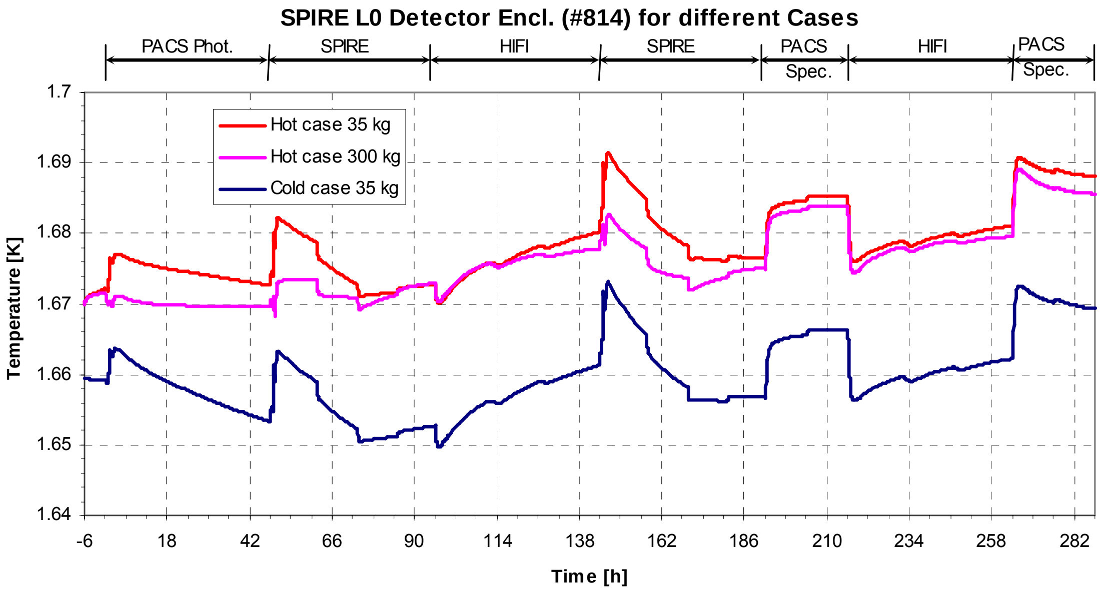


Figure 6.4-33: SPIRE L0 Temperature for Different Conditions

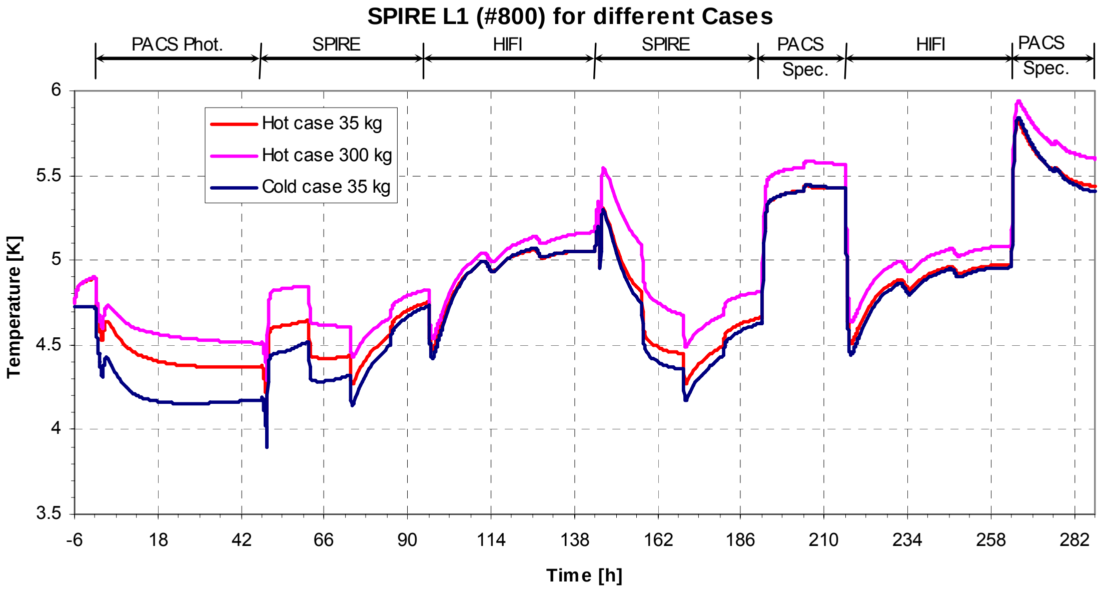


Figure 6.4-34: SPIRE L1 Temperature for Different Conditions

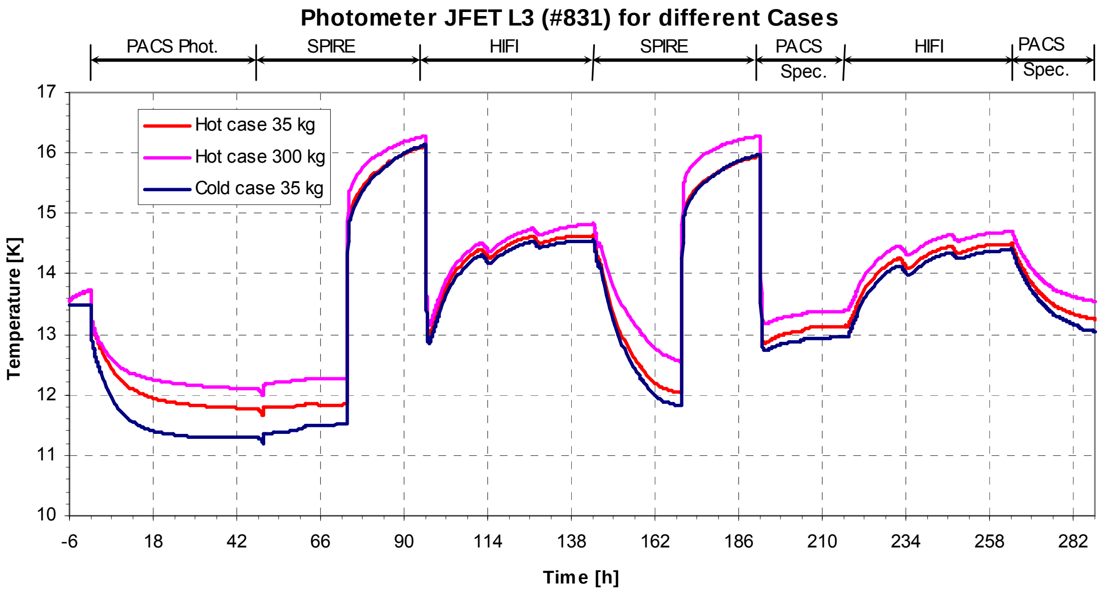


Figure 6.4-35: Photometer JFET L3 Temperature for Different Conditions

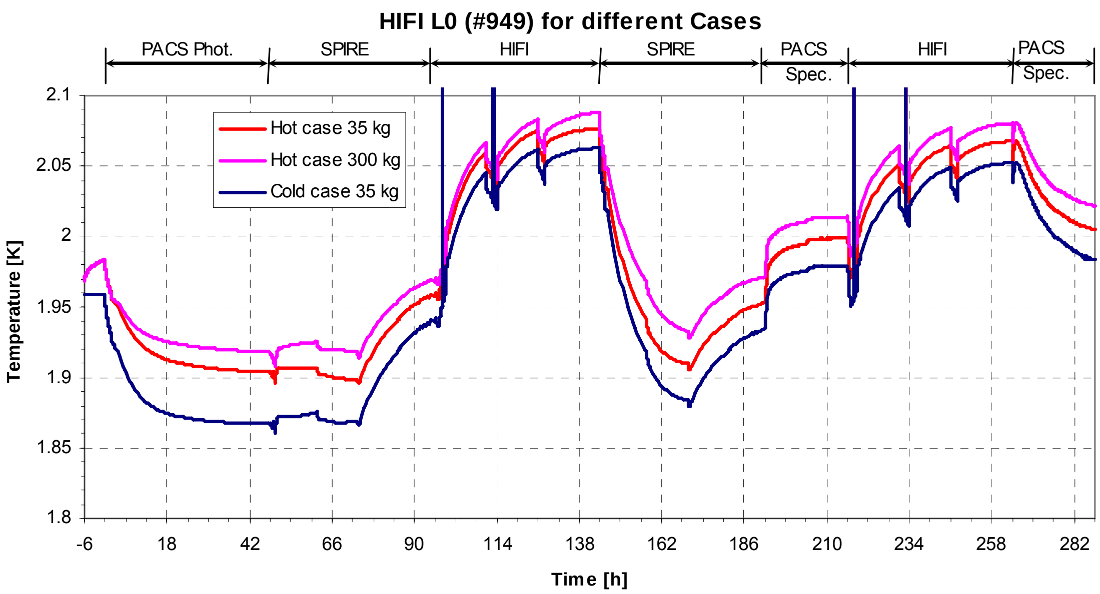


Figure 6.4-36: HIFI L0 Temperature for Different Conditions

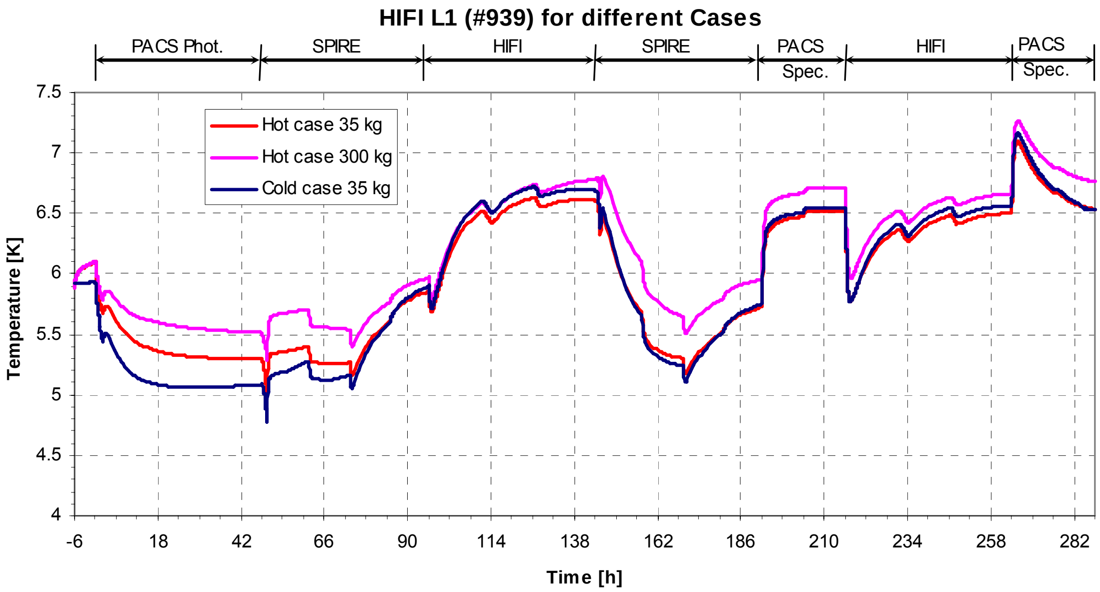


Figure 6.4-37: HIFI L1 Temperature for Different Conditions

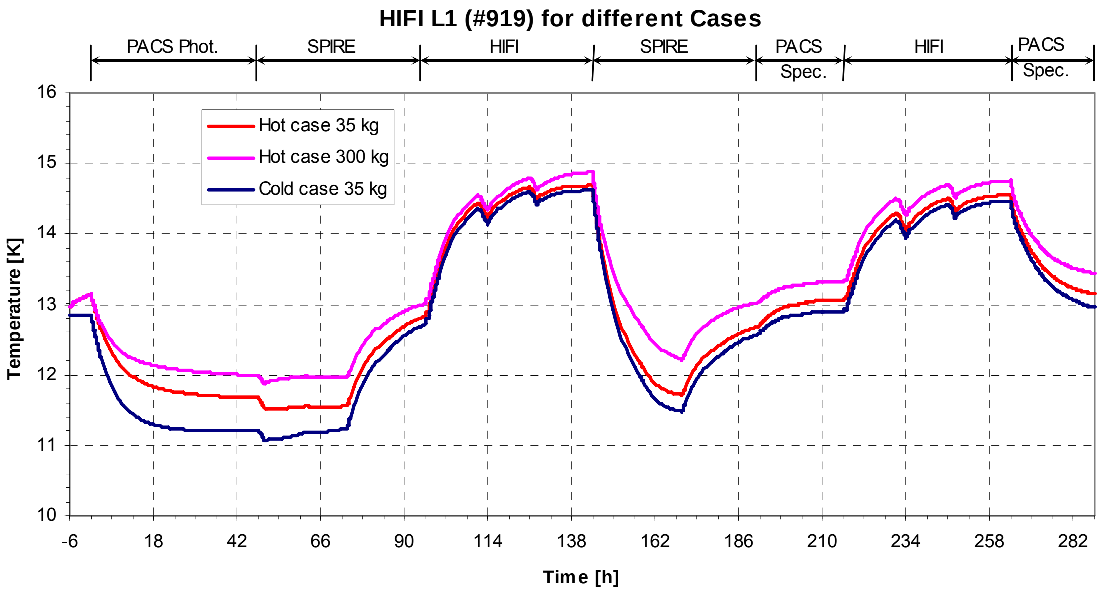


Figure 6.4-38: HIFI L2 Temperature for Different Conditions

6.5 Lifetime Performance

6.5.1 Lifetime Formula

Basically, the lifetime is defined by the total parasitic heat load into the HTT $\sum Q_{HTT}$ and the helium heat of vapourisation h_{vap} for the average environmental conditions at L2 (see Table 3.2-1), leading to an average He massflow $M_{He, avg}$.

Additional parameters determining the lifetime in detail are:

- The nominal initial helium mass m_0 is based on a filling level of 98 % and shall include a margin of 15 %.(HERS-0530 [AD 06])
- The increased helium consumption m_{trans} during the in-orbit cooldown period t_{trans} (transfer orbit) is considered.
- The residual He gas $m_{residual}$ that cannot be used for vapour cooling at the end of the mission is included.
- A lifetime correction factor $t_{uncertainty}$ is applied reflecting parameter variations.
- DLCM in-orbit measurements for determination of the remaining helium mass are considered with a maximum lifetime loss of 0.36% [RD 19].
- The effect of the configuration changes introduced by ESA/ASPI (startracker attached to CVV, SPIRE harness overall shield, LOU radiator enlargement) on the lifetime is included in the TMM, but is compensated in the lifetime calculation by t_{others}.

Finally, the lifetime is calculated according to the following formula:

$$\textbf{Lifetime} = 0.9964*((m_0 - m_{trans} - m_{residual}) / M_{He,avg} + t_{trans} - t_{uncertainty} + t_{others})$$

with

m_0	nominal amount of He at lift off; $m_0 = 0.98/1.15$ * HeII density * HTT volume
m_{trans}	He consumption during in-orbit cool down
$m_{residual}$	residual He gas in HTT at EOL; $m_{residual} = 0.94$ * GHe density * HTT volume
$M_{He, avg}$	mass flow at L2 (at conditions described in section 3.1.1); $M_{He} = \Sigma Q_{HTT} / hv$
t_{trans}	duration of transient cool down until HTT @ 1.65K
$t_{uncertainty}$	Lifetime correction due to RSS input variations
t_{others}	Lifetime compensation

6.5.2 Lifetime Calculation

According to the lifetime formula presented in section 6.5.1, the expected lifetime is calculated by thermal analysis as follows:

m_0 = 0.98 /1.15 * 145.338 kg/m³ * 2.367m³ = 293.16 kg
m_{trans} = 20.9 kg (compare to section 6.2)
$m_{residual}$ = 0.94 * 0.33 kg/m³ * 2.367m³ = 0.73 kg
$M_{He, avg}$ = 2.263 mg/s
t_{trans} = 60 days (compare to section 6.2)
$t_{uncertainty}$ = -126 days (compare to section 6.3.2) **uncertainties to be updated**
t_{others} = +37 days

The lifetime compensation t_{others} is composed of following:

- Enlarged LOU radiator: - 7 days (radiator area increased by about 100 %)
- Startracker on CVV: - 14 days (additional 200 mW heat load to CVV)
- SPIRE overall shield: - 16 days (20 mm² additional stainless steel cross-section for CVV internal harness and 24 mm² additional manganin cross-section for CVV external harness)

Thus, the lifetime formula can be written:

Lifetime [days] =
= 0.9964 * ((293.16 kg – 20.9 kg – 0.73 kg) * 1E6 / ($M_{He, avg}$ [mg/s] * 3600 * 24) + 60 days + 37 days -126 days) =
= 0.9964 * (3142.7 / M_{He} [mg/s] + 97 days – 126 days) = 1355 days = **3.71 years**

With this result the requirement of 3.5 years is fulfilled.

Taking into account all uncertainties (compare to section 6.3.2), the lifetime is predicted in a range of 4.06 years -126 days/+148 days.

Considering a "realistic" lifetime performance, i. e. by neglecting the 15% ESA margin and the lifetime compensation factor "t_others", the predictions end up with 4.57 years -126 days/+148 days.

6.6 Instrument Interface Temperatures for IID-B Allocations

For verification of the instrument interface temperatures according to IID-B some extra calculations have been performed. They are based on hot orbit environmental conditions at L2,. the HTT is fixed at its in-orbit target temperature of 1.65 K.

For analysis the following modes have been calculated:

- PACS nominal operation
- PACS cooler pump (peak) operation
- SPIRE nominal operation in Photometer mode (PH JFET operational)
- SPIRE nominal operation in Spectrometer mode (SP JFET operational)
- SPIRE cooler pump (peak) in Photometer mode (PH JFET operational), including L0 and L1 goals
- SPIRE cooler pump (peak) in Spectrometer mode (SP JFET operational), including L0 and L1 goals
- HIFI nominal operation

The dissipation of the LOU is considered with 7 W for all modes.

All runs stated above have been run with two different mass flows.

The calculation approach is that for each operational mode the corresponding interface heat loads given in Table 6.6-1 are allocated to the interface nodes of the relevant instrument model in the TMM. All other nodes of this instrument are set inactive to avoid thermal contact between the single interfaces and thus additional parasitic interface heat flows.

The given uncertainties (like ±0.006 K for Level 0 interfaces) are adopted from the issue 4 of this Thermal Report. **uncertainties to be updated**

The temperature limits required at the instrument interfaces are specified in the instrument interface control documents (IID-Bs) for PACS [AD 02], SPIRE [AD 03] and HIFI/LOU [AD 04] and are shown in section 3.1. An extract of the in-orbit operating requirements is also given in Table 6.6-1. These can be directly compared to the predicted temperatures, which have been calculated for two different fixed massflow rates: 2.3 mg/s following the in-orbit hot massflow of 2.335 mg/s, and 2.4 mg/s to show the sensitivity.

Compared to the issue 4 of this Thermal Report, the PACS L0 I/F heat loads have slightly increased by 0.2 mW for the Red and Blue Detector and the Cooler Pump, respectively, and by 0.1 mW for the cooler Evaporator. The L0 flexible copper links are now provided by PACS and therefore are part of the updated PACS TMM [RD 03]. The I/F nodes listed in Table 6.6-1 are thus located between PACS flexible links and ASED rigid/open pods, on strap side. SPIRE has also provided an updated TMM [RD 04], the location of the L0 I/F nodes remains unchanged and is similar to PACS. The HIFI TMM is unchanged [RD 05] since the Thermal Report issue 4, the I/F node is located between flex link and FPU, on FPU side.

	Interface	I/F Requirement		Node	Analysis Results	
		Heat Load	Temperature		2.3 mg/s	2.4 mg/s (2)
Level 0	PACS Red Detector	1.0 mW	1.6 K … 1.75 K	724	1.683 K ± 0.06 K	1.683 K ± 0.06 K
	PACS Blue Detector	2.2 mW	1.6 K … 2 K	723	1.724 K ± 0.06 K	1.724 K ± 0.06 K
	PACS Cooler Pump	2.2 mW	1.6 K … 5 K	761	1.711 K ± 0.06 K	1.711 K ± 0.06 K
		500 (peak) mW	1.6 K … 12.06 K (5)		5.844 K ± 0.06 K	5.844 K ± 0.06 K
	PACS Cooler Evapor.	15.1 mW	1.6 K … 1.85 K	762	1.725 K ± 0.06 K	1.725 K ± 0.06 K
	SPIRE Detector	4 mW	< 2 K	814	1.755 K ± 0.06 K	1.755 K ± 0.06 K
		1 mW (goal)	< 1.71 K (goal)		(1.678 K ± 0.06 K)	(1.678 K ± 0.06 K)
	SPIRE Cooler Pump	2 mW	< 2 K	815	1.700 K ± 0.06 K	1.700 K ± 0.06 K
		500 mW (peak)	< 10 K (peak)		5.753 K ± 0.06 K	5.753 K ± 0.06 K
	SPIRE Cooler Evap.	15 mW	< 1.85 K	816	1.729 K ± 0.06 K	1.729 K ± 0.06 K
		15 mW (goal)	< 1.75 K (goal)		(1.729 K ± 0.06 K)	(1.729 K ± 0.06 K)
	HIFI Detector	6.8 mW	< 2.1 K (4)	949	1.993 K ± 0.06 K	1.993 K ± 0.06 K
Level 1	PACS FPU	30 mW	2 K … 5 K	781	3.35 K ± 0.18 K	3.30 K ± 0.18 K
				782	4.00 K ± 0.18 K	3.91 K ± 0.18 K
				783	4.35 K ± 0.18 K	4.23 K ± 0.18 K
	SPIRE FPU	15 mW	< 5.5 K	800	4.77/4.53 K ± 0.35 K	4.51/4.31 K ± 0.35 K
		13 mW (goal)	< 3.7 K (goal)		(4.56/4.39 K ± 0.35 K) (3)	(4.31/4.11 K ± 0.35 K) (3)
	HIFI L1	15.5 mW	< 6.4 K (4)	939	6.14 K ± 0.32 K	5.70 K ± 0.32 K
Level 2	OBP near PACS	0 mW	< 12 K	371	13.6 K ± 0.5 K	12.9 K ± 0.5 K
	OBP near SPIRE	0 mW	< 12 K	381	14.6/13.2 K ± 0.5 K (3)	13.8/12.5 K ± 0.5 K (3)
		0 mW (goal)	< 8K (goal)			
	Instr. Shield/SPIRE	0 mW	< 16 K	315	14.6/13.2 K ± 0.5 K (3)	13.8/12.5 K ± 0.5 K (3)
	HIFI FPU	22 mW	< 20 K	919	14.4 K ± 0.5 K	13.6 K ± 0.5 K
Level 3	SPIRE PM-JFET	56.64 mW (6)	< 15.6 K (5)	831	18.8 K ± 0.5 K	17.9 K ± 0.5 K
	SPIRE SM-JFET	25 mW	< 15 K	832	15.3 K ± 0.5 K	14.5 K ± 0.5 K
LOU	LOU (HIFI)	7000 mW	90 K …150 K	4201	(127/130) K (1) ± 3 K	

(1) cold/hot case environment at L2
(2) sensitivity analysis
(3) Photometer/Spectrometer mode temperatures
(4) value acc. RFD [AD 11]; L0 was 2.0 K, L1 was 6.0 K before
(5) value acc. RFD [AD 14]; PACS L0 was 10 K, PM JFET was 15 K before
(6) value acc. RFW [AD 15]; was 50 mW before

Table 6.6-1: Specified versus calculated instrument interface temperatures for IID-B allocations

The change of interface temperatures compared to CDR /issue 4 status is mainly a consequence of the correlation activities perfomed in the frame of the two STM test campaigns [RD 45] [RD 46] [RD 48] [RD 49]. In particular, the LOU now is about 6 K colder due to modelling the LOU harness also in the GMM (see section 4.8), which helps radiating some parasitic heat.

The instrument interface transient temperatures along a typical timeline are shown in detail in section 6.4 together with their predicted interface heat flows.

7 Summary and Conclusions

The status of the H-EPLM Thermal Model after the two STM test campaigns is described in detail and the corresponding analysis results are reported.

On-Ground autonomy analyses show that starting from 1.8 K, the HTT tank temperature is less than 2.1 K after six days autonomy. Thus, the on-ground autonomy requirement is fulfilled. **TBC**

Calculation of the contractual lifetime using the instrument TMMs according to IID-B conditions [AD 12] leads to 3.71 years including uncertainties, which is compliant to the requirement of 3.5 years, with significant margin. Considering a “realistic” lifetime performance (neglecting 15% ESA margin and lifetime compensation factors “t_others”) the predictions end up with 4.22 years including uncertainties. **Uncertainties to be updated.**

Concerning the instrument interface temperature requirements for L0, L1, L2 and L3, the requirements are met with the following exceptions: PACS Level 2, SPIRE Level 2 and Level 3; when applying uncertainties marginal discrepancies are observed also for HIFI L1. ASED has raised three RFDs on this. Please note that these outcomes are based on hot case, i.e. worst case conditions.

Transient analyses using an instrument power timeline have been conducted for hot and cold case environment at L2 orbit as well as for a nearly full HTT and a nearly empty HTT.

Evaluation of instrument timeline results show that the HIFI temperature stability goals are met.

8 ANNEX 1: Nodal Temperature Listing

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
	HERSCHEL				
99998	INACTIVE_NODE	0	0	0	0
99999	DEEP SPACE	3	3	3	293
	EPLM				
10	MAIN TANK HTT LHe	1.65	1.63932	1.59549	1.8
13	MAIN TANK HTT wall upp	1.65003	1.63935	1.59551	1.80024
20	AUXILIARY TANK HOT	19.69069	18.91928	18.19997	54.65869
75	PACS L1 Photometer T242	2.69586	2.6801	2.42678	6.08194
85	SPIRE L1 T248	4.74593	4.72431	4.14926	11.89764
88	PH JFET L3 T251, T252	13.55096	13.48638	11.4458	20.48005
89	SP JFET L3 T249, T250	13.57632	13.53141	11.45338	20.4151
91	HIFI L0 pod-braid T228	1.86164	1.85191	1.76176	2.36865
92	HIFI L0	1.96666	1.9569	1.8425	2.65308
95	HIFI L1 T244	5.88403	5.92855	5.28251	8.88234
111	MLI ON MAIN TANK LOW	3.54542	3.30469	3.06435	58.99741
112	MLI ON MAIN TANK CYL	3.59547	3.35387	3.10574	58.09178
113	MLI ON MAIN TANK UPP	3.62642	3.3861	3.09066	52.40517
121	MLI ON AUX TANK LOW	22.11303	21.10531	20.17507	70.9139
122	MLI ON AUX TANK UPP	21.40387	20.46774	19.6008	68.04203
201	SF lo strut HTT end	1.65858	1.64725	1.60285	1.89001
211	SF lo belt pZ	19.48617	18.72507	18.01546	54.26199
212	SF lo belt mY	19.50867	18.74739	18.0376	54.30522
213	SF lo belt mZ	19.48744	18.72681	18.01764	54.24549
214	SF lo belt pY	19.47388	18.71333	18.00427	54.21781
221	SF lo corner pZmY	19.4888	18.72774	18.01817	54.26079
222	SF lo corner mZmY	19.51292	18.75182	18.04218	54.29935
223	SF lo corner mZpY	19.47973	18.71946	18.01065	54.21286
224	SF lo corner pZpY	19.47088	18.7105	18.00161	54.20109
231	SF up strut HTT end	1.65435	1.64359	1.59898	1.81356
241	SF up belt pZ	13.60457	13.44184	12.02251	23.61747
242	SF up belt mY	13.73661	13.56237	12.14493	24.7019
243	SF up belt mZ	13.69801	13.52668	12.10263	24.53731
244	SF up belt pY	13.63118	13.46682	12.03631	23.74654
251	SF up corner pZmY	13.60188	13.43942	12.02296	23.58293
252	SF up corner mZmY	13.77099	13.59415	12.17612	24.89088
253	SF up corner mZpY	13.6798	13.51026	12.08434	24.34753
254	SF up corner pZpY	13.61971	13.45697	12.02493	23.52845
271	Susp. Straps pZmY low	28.80075	27.8525	26.9721	73.25015
272	Susp. Straps pZmY low	28.88942	27.93523	27.04601	73.90186
273	Susp. Straps mZmY low	28.93676	27.9789	27.08674	74.32577
274	Susp. Straps mZmY low	28.97284	28.01385	27.11991	74.43873
275	Susp. Straps mZpY low	28.91331	27.95839	27.06976	73.88647
276	Susp. Straps mZpY low	28.80245	27.85431	26.97546	73.16627
277	Susp. Straps pZpY low	28.67893	27.73901	26.87035	72.30343
278	Susp. Straps pZpY low	28.67001	27.73073	26.8621	72.28262
281	Susp. Straps pZmY upp	27.58739	26.80432	25.88495	61.74958
282	Susp. Straps pZmY upp	28.65218	27.8315	26.73691	65.67638
283	Susp. Straps mZmY upp	31.08764	30.1029	29.03316	77.96509
284	Susp. Straps mZmY upp	32.09537	31.04994	29.91685	83.27017
285	Susp. Straps mZpY upp	30.66259	29.71193	28.59158	76.99191
286	Susp. Straps mZpY upp	26.51052	25.73475	24.79152	61.83699

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
287	Susp. Straps pZpY upp	27.90375	27.16598	25.96047	57.27391
288	Susp. Straps pZpY upp	27.67825	26.94615	25.84303	56.59611
291	S. Str. pZmY upp har.IF	23.36877	22.75232	21.70671	47.78119
292	S. Str. pZmY upp har.IF	25.79102	25.08438	23.62627	56.67095
293	S. Str. mZmY upp har.IF	29.79412	28.83937	27.65011	69.41489
294	S. Str. mZmY upp har.IF	31.10116	30.08196	28.83164	74.80078
295	S. Str. mZpY upp har.IF	29.06799	28.17549	26.85809	68.30689
296	S. Str. mZpY upp har.IF	19.44884	18.94513	17.80214	43.04791
297	S. Str. pZpY upp har.IF	25.29429	24.69182	22.79577	45.93338
298	S. Str. pZpY upp har.IF	24.94332	24.34152	22.70987	45.20641
310	Instr. Shield Cyl.	12.97314	12.86251	11.40506	19.87428
311	Instr. Shield Top	12.97546	12.86449	11.40704	19.94707
315	Instr. Shield Baffle	12.97596	12.86488	11.40741	19.97551
371	Opt. Bench +Z	12.9558	12.84714	11.38882	19.20215
372	Opt. Bench +Z -Y	12.70533	12.61826	11.20785	17.10833
373	Opt. Bench +Z mid	12.93824	12.83033	11.37209	19.36208
374	Opt. Bench +Z +Y	12.95785	12.84909	11.39108	19.22065
375	Opt. Bench -Y	12.9555	12.84524	11.37303	20.07968
376	Opt. Bench centre	12.95597	12.84475	11.37206	20.17923
377	Opt. Bench +Y	13.01489	12.90121	11.43742	20.09178
378	Opt. Bench -Z -Y	13.11284	12.99227	11.52711	20.8712
379	Opt. Bench -Z mid	13.00172	12.88851	11.4197	20.3308
380	Opt. Bench -Z +Y	13.0281	12.91358	11.44963	20.16474
381	Opt. Bench -Z	12.99545	12.88302	11.41673	20.23305
400	V102	1.689	1.67226	1.6225	2.83561
401	V103	1.65948	1.64807	1.60435	2.85405
402	V104	1.67625	1.66176	1.61481	1.82986
403	V106	1.65906	1.64772	1.60409	2.33614
404	SV123	2.18275	2.12677	2.04681	6.75102
405	V701	19.47905	18.71808	18.00857	54.2534
406	V702	19.50065	18.73989	18.03057	54.28745
407	V105	19.46787	18.708	17.99953	54.19106
408	SV723	19.45533	18.69528	17.98667	54.18232
411	Tubing HOT-V701 supp 13	2.55669	2.43311	2.29299	20.99631
412	Tubing HOT-V701 supp 12	4.05811	3.76546	3.47677	32.94221
413	Tubing HOT-V701 supp 11	8.34077	7.82031	7.32045	41.45417
414	Tubing HOT-V701 supp 27	16.25823	15.54829	14.8831	51.01814
415	Tubing HOT-V701 supp 09	16.40811	15.67176	14.98028	51.81705
416	Tubing HOT-V701 supp 01	17.53287	16.78164	16.07795	52.96734
417	Tubing HOT-V701 LSFW str	19.69028	18.9189	18.19961	54.65444
421	Tubing HOT-V105 supp 12	11.60599	11.33272	10.90785	29.66362
422	Tubing HOT-V105 supp 11	4.81648	4.59872	4.31248	31.09887
423	Tubing HOT-V105 supp 10	3.62076	3.39419	3.15536	32.6217
424	Tubing HOT-V105 supp 07	8.83601	8.34703	7.87829	41.32419
431	Tubing SV123-L1 supp 75	9.66565	9.12949	8.59168	41.75031
432	Tubing SV123-L1 supp 18	6.32834	5.95006	5.55882	25.52964
433	Tubing V103-L1 @ V103	5.03656	4.74911	4.44972	20.19456
434	Tubing V103-L1 supp 14	4.36215	4.07518	3.77835	1.88426
435	Tubing V103-L1 supp 15	3.0286	2.85245	2.65613	1.8755
440	Filling port outer end	66.27706	63.22503	59.58423	292.00908
441	Filling port middle	65.20225	62.21924	58.66591	277.49505
442	Filling port middle	63.19919	60.34145	56.94621	257.4894
443	Filling port Sline I/F	59.85374	57.19791	54.05965	235.65885
444	Filling port Fline I/F	59.65222	57.00798	53.88305	233.1105
445	Filling port inner end	59.65222	57.00798	53.88305	233.1105

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
451	Safety line @ FP IF	55.7227	53.32228	50.51201	209.22798
452	Safety line	51.39006	49.2489	46.77858	186.5037
453	Safety line	46.7489	44.87404	42.7686	164.42238
454	Safety line	41.6495	40.0583	38.35448	141.73067
455	Safety line @ strap IF	35.83644	34.56018	33.32286	118.30151
456	Safety line	31.55056	30.3876	29.2569	105.07182
457	Safety line support 34	26.46159	25.4111	24.38541	91.04684
458	Safety line	21.88548	20.98461	20.10274	76.35784
459	Safety line support 20	15.58497	14.87589	14.17741	58.23818
461	Tubing SV123 - HTT	2.6765	2.57673	2.45731	1.82977
462	Tubing HTT-V104 supp 6	1.98868	1.94276	1.86281	1.81219
463	Tubing HTT-V104 supp 75	1.96136	1.91862	1.84015	1.82716
471	Filling line @ FP IF	56.05687	53.61362	50.7133	196.64113
472	Filling line	52.44571	50.18373	47.49222	171.48359
473	Filling line	48.70696	46.61733	44.12584	150.4018
474	Filling line supp 35	44.76431	42.84567	40.54136	131.56945
475	Filling line	41.36512	39.60285	37.47738	117.0193
476	Filling line	37.74686	36.12882	34.17514	104.43219
477	Filling line	33.76416	32.28936	30.49985	92.8917
478	Filling line supp 5	29.17826	27.84482	26.2188	81.67948
479	Filling line	24.49518	23.30926	21.86187	71.12256
480	Filling line supp 4	18.25635	17.21068	15.95352	59.76138
481	Filling line	15.67246	14.75929	13.66238	52.39494
482	Filling line	12.3516	11.61331	10.72363	44.10393
483	Filling line supp 2	6.95557	6.41762	5.7763	33.57047
484	Filling line @ V102	5.37482	4.97688	4.50525	25.84296
485	Filling line supp 3	2.27617	2.1983	2.09523	12.09198
494	Filling line supp 31	8.18166	7.53549	6.76583	45.72469
495	Filling line supp 22	4.1481	3.78051	3.36809	42.22931
496	Filling line supp 23	3.48667	3.24427	2.99794	43.67908
497	Filling line supp 24	6.13368	5.69789	5.2766	44.6034
498	Filling line supp 25	9.53211	9.02236	8.53864	46.54152
499	Filling line supp 26	14.69693	14.04025	13.42397	50.67356
505	Supp bracket L1 entrance	2.1539	2.09591	2.01002	6.97376
510	Vline wall HTT-L1 sup 16	1.65267	1.64183	1.59814	16.09661
511	Vline wall HTT-L1	1.65954	1.64813	1.60443	16.76141
512	Vline wall HTT-L1 sup 17	1.66178	1.65025	1.60675	14.15135
513	Vline wall HTT-L1 sup L1	1.66625	1.6544	1.61102	1.88723
514	Vline wall HTT-L1 @L1 IF	1.93021	1.92885	1.85076	2.07828
520	Vline wall PACS I/F 1	2.43713	2.42995	2.24002	4.19592
521	Vline wall PACS I/F 1	2.56566	2.55528	2.33573	5.02662
522	Vline wall PACS I/F 1	2.51854	2.5121	2.30757	4.38624
523	Vline wall PACSI/F1/2	2.44285	2.44724	2.27313	2.98276
524	Vline wall PACSI/F1/2	2.53174	2.5362	2.34272	3.11598
525	Vline wall PACS I/F 2	2.89224	2.88081	2.5905	5.82744
526	Vline wall PACS I/F 2	2.966	2.95028	2.63942	6.52682
527	Vline wall PACS I/F 2	2.94293	2.93059	2.628	5.87971
528	Vline wall PACSI/F2/3	2.91686	2.91138	2.61958	4.35645
529	Vline wall PACSI/F2/3	2.99369	2.98586	2.67349	4.69301
530	Vline wall PACS I/F 3	3.11293	3.09602	2.74883	6.42803
531	Vline wall PACS I/F 3	3.15344	3.13289	2.77367	7.11355
532	Vline wall PACS I/F 3	3.15107	3.13391	2.77813	6.54122
533	Vline wall PACS-SPIRE	3.16654	3.1545	2.80097	5.83261
534	Vline wall PACS-SPIRE	3.26071	3.25785	2.89931	5.53731
535	Vline wall PACS-SPIRE	3.68232	3.69173	3.28665	6.12996

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
536	Vline wall SPIRE IF12	4.49024	4.48134	3.95045	9.97074
537	Vline wall SPIRE IF12	4.65868	4.64341	4.08547	10.99124
538	Vline wall SPIRE IF12	4.64163	4.63239	4.0823	10.30617
539	Vline wall SPIRE-HIFI	4.75716	4.77795	4.24307	8.19274
543	Vline wall SPIRE-HIFI	5.4392	5.49078	4.90383	8.34578
544	Vline wall HIFI I/F	5.66714	5.71707	5.10133	8.56458
545	Vline wall HIFI I/F	5.80664	5.85424	5.22001	8.73574
546	Vline wall HIFI I/F	5.79576	5.8466	5.21555	8.64281
550	Vline wall L1-L2	5.79463	5.84994	5.22171	8.53551
551	Vline wall L1-L2	5.91302	5.98892	5.36686	8.48793
552	Vline wall L1-L2	6.38739	6.49746	5.86506	8.53191
553	Vline wall L1-L2	7.98342	8.10307	7.33793	9.07295
554	Vline wall L1-L2	11.99268	11.95839	10.67323	13.96017
560	Vline wall Lev.2 OB	12.66776	12.58373	11.18011	16.75276
561	Vline wall Lev.2 OB	12.95532	12.84677	11.38878	19.14803
562	Vline wall Lev.2 OB	13.01961	12.90566	11.44186	20.09267
563	Vline wall Lev.2 OB	12.99573	12.88334	11.41687	20.22817
570	Vline wall L2-L3	13.05031	12.94895	11.42019	20.22624
571	Vline wall L2-L3	13.31536	13.24307	11.43462	20.26933
580	Vline wall PM JFET	13.4758	13.41084	11.44244	20.38102
581	Vline wall PM JFET	13.52705	13.46317	11.44487	20.43456
582	Vline wall PM JFET	13.52487	13.46308	11.44507	20.40764
583	Vline wall PM/SM JFET	13.53353	13.48063	11.44751	20.35873
584	Vline wall SM JFET	13.56371	13.51862	11.45197	20.3909
585	Vline wall SM JFET	13.57076	13.52648	11.45288	20.40245
586	Vline wall SM JFET	13.56804	13.52523	11.45282	20.39597
590	Vline wall L3-TS1	13.55945	13.522	11.45293	20.3827
591	Vline wall L3-TS1	13.6013	13.57406	11.53039	20.38694
592	Vline wall L3-TS1	23.90693	23.60682	23.0919	26.54867
610	Vline wall TS1-2 pymz	34.70102	33.61091	32.61522	81.8815
611	Vline wall TS2-3 pymz	45.80052	43.95715	42.55466	146.05189
612	Vline w. TS3-CVV pymz	55.29473	52.86797	50.54475	218.75707
620	Vline wall TS1-2 mypz	34.68569	33.59594	32.59862	82.50597
621	Vline wall TS2-3 mypz	45.80177	43.95779	42.55527	146.84383
622	Vline w. TS3-CVV mypz	55.29474	52.86798	50.54476	218.75707
643	MLI on filling port	46.58927	45.1698	43.46982	138.08604
644	MLI on filling port	46.48848	45.07279	43.37705	136.70574
1001	Susp bolt lo pZmY TS1	34.96836	33.83636	32.79984	90.35767
1002	Susp bolt lo pZmY TS1	35.15754	34.01045	32.95342	92.58641
1003	Susp bolt lo mZmY TS1	35.21604	34.06424	33.00443	93.23865
1004	Susp bolt lo mZmY TS1	35.30356	34.1464	33.0796	93.61595
1005	Susp bolt lo mZpY TS1	35.20451	34.05542	32.99881	92.44032
1006	Susp bolt lo mZpY TS1	34.96785	33.83674	32.80384	90.00614
1007	Susp bolt lo pZpY TS1	34.72999	33.61797	32.60622	87.56211
1008	Susp bolt lo pZpY TS1	34.71677	33.60535	32.59412	87.60643
1011	@TS 1 lower bulk 1	34.24961	33.18862	32.19861	78.81152
1012	@TS 1 lower bulk 2	34.4113	33.33674	32.32968	81.00854
1013	@TS 1 lower bulk 3	34.5007	33.41868	32.40385	82.2726
1014	@TS 1 lower bulk 4	34.54142	33.45682	32.43923	82.49485
1015	@TS 1 lower bulk 5	34.4506	33.37389	32.36627	81.09069
1016	@TS 1 lower bulk 6	34.26445	33.20293	32.21414	78.73584
1017	@TS 1 lower bulk 7	34.09722	33.04947	32.07627	76.78748
1018	@TS 1 lower bulk 8	34.08886	33.04149	32.06828	76.79544
1021	@TS 1 lower cyl 1	34.18077	33.12749	32.1425	76.22368
1022	@TS 1 lower cyl 2	34.46661	33.3893	32.37105	80.48469

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
1023	@TS 1 lower cyl 3	34.51952	33.43649	32.41712	82.11878
1024	@TS 1 lower cyl 4	34.5481	33.46356	32.44393	81.9903
1025	@TS 1 lower cyl 5	34.48612	33.4086	32.39619	80.12765
1026	@TS 1 lower cyl 6	34.15985	33.1088	32.13058	75.76116
1027	@TS 1 lower cyl 7	33.74457	32.72839	31.78795	70.84884
1028	@TS 1 lower cyl 8	33.73877	32.72274	31.78228	70.90403
1031	@TS 1 upper cyl 1	34.12309	33.07494	32.09367	75.41157
1032	@TS 1 upper cyl 2	34.44478	33.36918	32.34982	80.90576
1033	@TS 1 upper cyl 3	34.47372	33.39404	32.37659	82.34088
1034	@TS 1 upper cyl 4	34.47807	33.39884	32.38413	81.4331
1035	@TS 1 upper cyl 5	34.44454	33.3707	32.36027	79.476
1036	@TS 1 upper cyl 6	34.11722	33.07021	32.09413	74.82058
1037	@TS 1 upper cyl 7	33.60178	32.59811	31.66947	68.74148
1038	@TS 1 upper cyl 8	33.59417	32.59081	31.66257	68.84303
1041	@TS 1 upper bulk 1	34.1126	33.06339	32.08256	76.85152
1042	@TS 1 upper bulk 2	34.31491	33.24836	32.24582	79.97515
1043	@TS 1 upper bulk 3	34.39461	33.32097	32.31201	81.31691
1044	@TS 1 upper bulk 4	34.39502	33.32181	32.31463	80.8931
1045	@TS 1 upper bulk 5	34.31396	33.24845	32.25038	79.19415
1046	@TS 1 upper bulk 6	34.11008	33.06179	32.0844	76.32696
1047	@TS 1 upper bulk 7	33.88676	32.85714	31.90065	73.63484
1048	@TS 1 upper bulk 8	33.8862	32.85635	31.89901	73.80207
1061	Susp bolt up pZmY TS1	34.43208	33.35412	32.35119	79.87926
1062	Susp bolt up pZmY TS1	34.8489	33.73741	32.67542	86.25697
1063	Susp bolt up mZmY TS1	34.72091	33.6158	32.58237	86.43733
1064	Susp bolt up mZmY TS1	34.74252	33.63651	32.60416	85.76351
1065	Susp bolt up mZpY TS1	34.871	33.76	32.71299	85.32187
1066	Susp bolt up mZpY TS1	34.33126	33.26111	32.27421	78.6773
1067	Susp bolt up pZpY TS1	33.3882	32.39859	31.49288	67.87668
1068	Susp bolt up pZpY TS1	33.36028	32.37241	31.47182	67.82758
1090	TS 1 LO Baffles.	34.4793	33.39732	32.37554	86.9425
1111	TS 1 lower bulk MLI 1	36.6898	35.32423	34.14703	127.28388
1112	TS 1 lower bulk MLI 2	36.79922	35.428	34.24191	126.5857
1113	TS 1 lower bulk MLI 3	36.85069	35.47799	34.29	125.3844
1114	TS 1 lower bulk MLI 4	36.88213	35.50817	34.31836	125.05889
1115	TS 1 lower bulk MLI 5	36.82943	35.45743	34.27126	125.83952
1116	TS 1 lower bulk MLI 6	36.70084	35.33537	34.15932	126.61461
1117	TS 1 lower bulk MLI 7	36.57976	35.22109	34.05414	127.07407
1118	TS 1 lower bulk MLI 8	36.57347	35.21486	34.0478	127.33166
1121	TS 1 lower cyl MLI 1	37.73001	36.25363	35.01011	130.95308
1122	TS 1 lower cyl MLI 2	37.88495	36.40336	35.14748	129.49331
1123	TS 1 lower cyl MLI 3	37.94265	36.46087	35.20336	126.84282
1124	TS 1 lower cyl MLI 4	37.86666	36.39398	35.15162	124.46234
1125	TS 1 lower cyl MLI 5	37.89876	36.41816	35.16616	127.70846
1126	TS 1 lower cyl MLI 6	37.71527	36.24063	35.00154	129.64435
1127	TS 1 lower cyl MLI 7	37.45113	35.98976	34.76872	130.38019
1128	TS 1 lower cyl MLI 8	37.4475	35.98591	34.76478	130.86606
1131	TS 1 upper cyl MLI 1	36.45004	35.10627	33.94609	122.77552
1132	TS 1 upper cyl MLI 2	36.68102	35.32329	34.13968	124.37271
1133	TS 1 upper cyl MLI 3	36.65438	35.30227	34.12987	120.81647
1134	TS 1 upper cyl MLI 4	36.6494	35.29985	34.13118	117.01516
1135	TS 1 upper cyl MLI 5	36.67843	35.32363	34.14756	119.5917
1136	TS 1 upper cyl MLI 6	36.4448	35.10241	33.94639	120.97756
1137	TS 1 upper cyl MLI 7	36.04812	34.73079	33.60643	120.85443
1138	TS 1 upper cyl MLI 8	36.04233	34.72496	33.60085	121.43618

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
1141	TS 1 upper bulk MLI 1	37.14678	35.72142	34.51527	130.77571
1142	TS 1 upper bulk MLI 2	37.27665	35.84496	34.62795	130.95297
1143	TS 1 upper bulk MLI 3	37.31223	35.88039	34.66366	129.64221
1144	TS 1 upper bulk MLI 4	37.30983	35.8791	34.66418	128.35805
1145	TS 1 upper bulk MLI 5	37.27415	35.84408	34.63069	128.91988
1146	TS 1 upper bulk MLI 6	37.14416	35.71991	34.51641	129.59075
1147	TS 1 upper bulk MLI 7	36.9907	35.57484	34.38284	129.91176
1148	TS 1 upper bulk MLI 8	36.99053	35.57434	34.38167	130.29966
1211	TS 1 low strap I/F 1	34.24241	33.18261	32.1934	78.14212
1212	TS 1 low strap I/F 2	34.4545	33.37691	32.36407	81.15868
1213	TS 1 low strap I/F 3	34.52841	33.44413	32.42632	82.55139
1214	TS 1 low strap I/F 4	34.62547	33.53481	32.50901	83.18118
1215	TS 1 low strap I/F 5	34.50954	33.429	32.41588	81.2695
1216	TS 1 low strap I/F 6	34.24553	33.18614	32.20014	77.93155
1217	TS 1 low strap I/F 7	33.9823	32.94494	31.98302	74.85534
1218	TS 1 low strap I/F 8	33.96698	32.93043	31.96929	74.82188
1221	TS 1 upp strap I/F 1	34.234	33.17851	32.18984	74.21166
1222	TS 1 upp strap I/F 2	34.65799	33.56778	32.51901	81.29256
1223	TS 1 upp strap I/F 3	34.52156	33.438	32.41719	82.35106
1224	TS 1 upp strap I/F 4	34.53736	33.45338	32.43429	81.73409
1225	TS 1 upp strap I/F 5	34.66835	33.57963	32.54691	80.41544
1226	TS 1 upp strap I/F 6	34.1366	33.0889	32.11657	73.11114
1227	TS 1 upp strap I/F 7	33.16053	32.19645	31.30988	61.36777
1228	TS 1 upp strap I/F 8	33.1331	32.17078	31.28889	61.23714
2001	Susp bolt lo pZmY TS2	46.25503	44.39665	42.88098	147.92087
2002	Susp bolt lo pZmY TS2	46.20556	44.3527	42.84527	147.37846
2003	Susp bolt lo mZmY TS2	46.09528	44.25437	42.76558	145.48238
2004	Susp bolt lo mZmY TS2	46.08408	44.24541	42.75824	144.98144
2005	Susp bolt lo mZpY TS2	46.16692	44.31956	42.81846	146.394
2006	Susp bolt lo mZpY TS2	46.21521	44.3618	42.85366	147.14815
2007	Susp bolt lo pZpY TS2	46.24342	44.38632	42.87334	147.03573
2008	Susp bolt lo pZpY TS2	46.25284	44.39458	42.87979	147.32775
2011	@TS 2 lower bulk 1	45.55084	43.72674	42.31547	145.36123
2012	@TS 2 lower bulk 2	45.49496	43.67691	42.27517	144.14602
2013	@TS 2 lower bulk 3	45.4333	43.62224	42.23082	142.49881
2014	@TS 2 lower bulk 4	45.43214	43.62166	42.23018	142.07288
2015	@TS 2 lower bulk 5	45.49352	43.67659	42.27464	143.2676
2016	@TS 2 lower bulk 6	45.54908	43.72595	42.31466	144.61017
2017	@TS 2 lower bulk 7	45.57956	43.75283	42.33649	145.4812
2018	@TS 2 lower bulk 8	45.58027	43.75318	42.33682	145.77192
2021	@TS 2 lower cyl 1	45.53973	43.71382	42.30522	145.41521
2022	@TS 2 lower cyl 2	45.44658	43.63063	42.23819	143.24233
2023	@TS 2 lower cyl 3	45.27308	43.47659	42.11332	138.53213
2024	@TS 2 lower cyl 4	45.26907	43.4741	42.11075	137.38766
2025	@TS 2 lower cyl 5	45.44793	43.63396	42.24018	141.31255
2026	@TS 2 lower cyl 6	45.5384	43.71391	42.30501	144.04201
2027	@TS 2 lower cyl 7	45.57806	43.74878	42.33325	145.41949
2028	@TS 2 lower cyl 8	45.57874	43.74896	42.33348	145.93798
2031	@TS 2 upper cyl 1	45.52084	43.68886	42.28376	147.39905
2032	@TS 2 upper cyl 2	45.43693	43.61236	42.22154	147.9429
2033	@TS 2 upper cyl 3	45.2596	43.45487	42.09391	143.15187
2034	@TS 2 upper cyl 4	45.22925	43.43056	42.07426	138.66083
2035	@TS 2 upper cyl 5	45.42847	43.60897	42.21886	142.47799
2036	@TS 2 upper cyl 6	45.51874	43.68867	42.28348	145.39559
2037	@TS 2 upper cyl 7	45.55498	43.72052	42.30927	146.61954

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
2038	@TS 2 upper cyl 8	45.55574	43.7207	42.30946	147.27459
2041	@TS 2 upper bulk 1	45.50892	43.66985	42.26714	148.62134
2042	@TS 2 upper bulk 2	45.46302	43.62843	42.2335	148.32772
2043	@TS 2 upper bulk 3	45.401	43.5734	42.18888	146.61479
2044	@TS 2 upper bulk 4	45.39364	43.56777	42.18432	145.22688
2045	@TS 2 upper bulk 5	45.45806	43.62566	42.23127	146.15902
2046	@TS 2 upper bulk 6	45.50676	43.66894	42.26636	147.37562
2047	@TS 2 upper bulk 7	45.53023	43.68961	42.28313	148.13254
2048	@TS 2 upper bulk 8	45.53087	43.68986	42.28334	148.53912
2050	@TS 2 baffle	45.52333	43.66946	42.26657	150.16149
2061	Susp bolt up pZmY TS2	45.77402	43.93064	42.48614	146.8839
2062	Susp bolt up pZmY TS2	45.69337	43.85809	42.42804	145.48836
2063	Susp bolt up mZmY TS2	45.2946	43.5031	42.14027	136.06538
2064	Susp bolt up mZmY TS2	45.27899	43.49144	42.12946	133.83852
2065	Susp bolt up mZpY TS2	45.69606	43.86463	42.43248	142.44795
2066	Susp bolt up mZpY TS2	45.76368	43.92305	42.48007	145.17734
2067	Susp bolt up pZpY TS2	45.78236	43.93918	42.49247	145.72773
2068	Susp bolt up pZpY TS2	45.78458	43.94066	42.49365	146.39551
2090	TS 2 LO Baffles.	45.47568	43.63663	42.23626	166.30739
2111	TS 2 lower bulk MLI 1	50.09596	47.81206	45.82026	205.73824
2112	TS 2 lower bulk MLI 2	50.1058	47.81904	45.82162	208.18488
2113	TS 2 lower bulk MLI 3	50.08817	47.80217	45.80538	209.46994
2114	TS 2 lower bulk MLI 4	50.07982	47.79528	45.80009	209.43306
2115	TS 2 lower bulk MLI 5	50.08599	47.80264	45.80917	208.11003
2116	TS 2 lower bulk MLI 6	50.07647	47.79579	45.80805	205.67076
2117	TS 2 lower bulk MLI 7	50.05264	47.77565	45.7958	202.96522
2118	TS 2 lower bulk MLI 8	50.06016	47.78194	45.8005	203.00259
2121	TS 2 lower cyl MLI 1	50.67249	48.3539	46.3106	204.85498
2122	TS 2 lower cyl MLI 2	50.70242	48.37767	46.32238	209.20636
2123	TS 2 lower cyl MLI 3	50.71658	48.39226	46.32772	211.2866
2124	TS 2 lower cyl MLI 4	50.63367	48.31423	46.26607	210.97854
2125	TS 2 lower cyl MLI 5	50.67605	48.3563	46.30611	209.09462
2126	TS 2 lower cyl MLI 6	50.64629	48.33213	46.29419	204.7834
2127	TS 2 lower cyl MLI 7	50.51442	48.21736	46.21382	196.40624
2128	TS 2 lower cyl MLI 8	50.5241	48.22546	46.21992	196.50953
2131	TS 2 upper cyl MLI 1	49.81863	47.54642	45.58366	207.18193
2132	TS 2 upper cyl MLI 2	49.80653	47.53251	45.56779	209.51508
2133	TS 2 upper cyl MLI 3	49.7217	47.4539	45.49996	210.34816
2134	TS 2 upper cyl MLI 4	49.69708	47.43341	45.48343	210.02036
2135	TS 2 upper cyl MLI 5	49.78163	47.51364	45.55368	209.13578
2136	TS 2 upper cyl MLI 6	49.79874	47.53062	45.57194	207.26442
2137	TS 2 upper cyl MLI 7	49.78149	47.51622	45.56422	204.46681
2138	TS 2 upper cyl MLI 8	49.78901	47.52227	45.56871	204.48178
2141	TS 2 upper bulk MLI 1	50.33409	48.02295	46.00561	210.41132
2142	TS 2 upper bulk MLI 2	50.336	48.02328	46.00288	211.91108
2143	TS 2 upper bulk MLI 3	50.31474	48.00347	45.9848	212.69486
2144	TS 2 upper bulk MLI 4	50.30403	47.99468	45.97801	212.61194
2145	TS 2 upper bulk MLI 5	50.3169	48.008	45.99145	211.81207
2146	TS 2 upper bulk MLI 6	50.31736	48.00943	45.99557	210.43177
2147	TS 2 upper bulk MLI 7	50.30998	48.00317	45.99266	209.01477
2148	TS 2 upper bulk MLI 8	50.31649	48.00846	45.99659	209.0079
2211	TS 2 low strap I/F 1	45.56799	43.74187	42.32843	145.47409
2212	TS 2 low strap I/F 2	45.49557	43.67723	42.27626	143.8538
2213	TS 2 low strap I/F 3	45.38217	43.57657	42.19464	140.83139
2214	TS 2 low strap I/F 4	45.37942	43.57488	42.19293	140.08314

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
2215	TS 2 low strap I/F 5	45.49421	43.67753	42.27604	142.50195
2216	TS 2 low strap I/F 6	45.56522	43.7404	42.32706	144.44384
2217	TS 2 low strap I/F 7	45.59975	43.7708	42.35171	145.50737
2218	TS 2 low strap I/F 8	45.60072	43.77132	42.35218	145.90012
2221	TS 2 upp strap I/F 1	45.54938	43.71933	42.31	146.14767
2222	TS 2 upp strap I/F 2	45.45383	43.63356	42.24155	143.84437
2223	TS 2 upp strap I/F 3	45.03276	43.25933	41.93847	132.53124
2224	TS 2 upp strap I/F 4	45.01832	43.24874	41.92835	129.9478
2225	TS 2 upp strap I/F 5	45.46396	43.64674	42.25081	140.28726
2226	TS 2 upp strap I/F 6	45.54714	43.7189	42.3094	144.1673
2227	TS 2 upp strap I/F 7	45.58444	43.75158	42.3357	145.78659
2228	TS 2 upp strap I/F 8	45.58533	43.75188	42.336	146.58075
3001	Susp bolt lo pZmY TS3	55.43591	52.99086	50.56744	217.49075
3002	Susp bolt lo pZmY TS3	55.44608	53.00145	50.57193	220.15162
3003	Susp bolt lo mZmY TS3	55.29144	52.86121	50.45683	221.30339
3004	Susp bolt lo mZmY TS3	55.19614	52.77812	50.38818	221.24076
3005	Susp bolt lo mZpY TS3	55.14936	52.73588	50.35547	220.04138
3006	Susp bolt lo mZpY TS3	55.1539	52.7371	50.36704	217.40938
3007	Susp bolt lo pZpY TS3	55.23002	52.80357	50.42467	213.01645
3008	Susp bolt lo pZpY TS3	55.29902	52.86652	50.47452	213.07958
3011	@TS 3 lower bulk 1	54.89002	52.48265	50.17399	213.94766
3012	@TS 3 lower bulk 2	54.95558	52.54213	50.21822	216.67409
3013	@TS 3 lower bulk 3	54.97813	52.56287	50.23305	218.17324
3014	@TS 3 lower bulk 4	54.96465	52.55098	50.22366	218.16402
3015	@TS 3 lower bulk 5	54.92236	52.51276	50.19508	216.65898
3016	@TS 3 lower bulk 6	54.85755	52.45387	50.15154	213.93416
3017	@TS 3 lower bulk 7	54.78929	52.39181	50.10547	210.94507
3018	@TS 3 lower bulk 8	54.80182	52.40293	50.1141	210.96132
3021	@TS 3 lower cyl 1	54.84486	52.44198	50.14477	211.394
3022	@TS 3 lower cyl 2	54.95429	52.54109	50.21841	216.14609
3023	@TS 3 lower cyl 3	54.98317	52.5677	50.23732	218.36189
3024	@TS 3 lower cyl 4	54.96579	52.55252	50.2254	218.34135
3025	@TS 3 lower cyl 5	54.91225	52.5042	50.18941	216.13999
3026	@TS 3 lower cyl 6	54.80472	52.40664	50.1172	211.40666
3027	@TS 3 lower cyl 7	54.57011	52.19422	49.95795	202.37745
3028	@TS 3 lower cyl 8	54.58493	52.20729	49.96814	202.44932
3031	@TS 3 upper cyl 1	54.91106	52.50071	50.18857	216.32019
3032	@TS 3 upper cyl 2	54.97006	52.55446	50.22838	218.80914
3033	@TS 3 upper cyl 3	54.98557	52.56917	50.23866	220.1097
3034	@TS 3 upper cyl 4	54.96977	52.55553	50.22803	220.09945
3035	@TS 3 upper cyl 5	54.93259	52.52194	50.20301	218.8539
3036	@TS 3 upper cyl 6	54.87649	52.47058	50.16516	216.58577
3037	@TS 3 upper cyl 7	54.80933	52.4092	50.11957	213.43383
3038	@TS 3 upper cyl 8	54.82247	52.42066	50.12846	213.38961
3041	@TS 3 upper bulk 1	54.92792	52.51534	50.19962	218.11371
3042	@TS 3 upper bulk 2	54.96708	52.55115	50.22613	219.74127
3043	@TS 3 upper bulk 3	54.98023	52.56368	50.23507	220.69815
3044	@TS 3 upper bulk 4	54.9682	52.55333	50.22706	220.70293
3045	@TS 3 upper bulk 5	54.93921	52.52714	50.20753	219.78623
3046	@TS 3 upper bulk 6	54.90175	52.49274	50.18214	218.22525
3047	@TS 3 upper bulk 7	54.87095	52.46426	50.16113	216.65204
3048	@TS 3 upper bulk 8	54.88131	52.47321	50.16806	216.61463
3061	Susp bolt up pZmY TS3	55.0999	52.67337	50.31829	216.79675
3062	Susp bolt up pZmY TS3	55.14886	52.71893	50.35101	219.63201
3063	Susp bolt up mZmY TS3	55.08217	52.66037	50.30282	220.44187

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
3064	Susp bolt up mZmY TS3	55.03159	52.6169	50.26768	220.28727
3065	Susp bolt up mZpY TS3	55.00095	52.58893	50.24711	219.44743
3066	Susp bolt up mZpY TS3	54.95946	52.54923	50.22177	216.80327
3067	Susp bolt up pZpY TS3	54.90968	52.50141	50.18811	211.96602
3068	Susp bolt up pZpY TS3	54.94684	52.53462	50.21401	212.01931
3111	TS 3 lower bulk MLI 1	64.64752	61.39772	57.46264	286.79037
3112	TS 3 lower bulk MLI 2	64.33925	61.11348	57.24957	286.92988
3113	TS 3 lower bulk MLI 3	63.71919	60.53581	56.77462	287.00851
3114	TS 3 lower bulk MLI 4	63.35405	60.19027	56.47926	287.00802
3115	TS 3 lower bulk MLI 5	63.32342	60.15954	56.45624	286.92909
3116	TS 3 lower bulk MLI 6	63.66018	60.46686	56.73054	286.78969
3117	TS 3 lower bulk MLI 7	64.34298	61.0995	57.25228	286.64185
3118	TS 3 lower bulk MLI 8	64.65387	61.39714	57.46663	286.64264
3121	TS 3 lower cyl MLI 1	64.00465	60.79357	57.05169	286.8483
3122	TS 3 lower cyl MLI 2	63.69541	60.52806	56.84333	287.07992
3123	TS 3 lower cyl MLI 3	62.82039	59.76071	56.25612	286.89678
3124	TS 3 lower cyl MLI 4	62.26212	59.2608	55.84004	287.19138
3125	TS 3 lower cyl MLI 5	62.1358	59.14799	55.74693	287.07962
3126	TS 3 lower cyl MLI 6	62.49242	59.45224	56.01902	286.8489
3127	TS 3 lower cyl MLI 7	63.5558	60.37942	56.73213	286.44367
3128	TS 3 lower cyl MLI 8	63.92949	60.717	56.99332	286.44672
3131	TS 3 upper cyl MLI 1	62.72614	59.56857	56.04959	285.29061
3132	TS 3 upper cyl MLI 2	62.45633	59.34352	55.85069	285.45757
3133	TS 3 upper cyl MLI 3	61.76544	58.75003	55.38163	285.54672
3134	TS 3 upper cyl MLI 4	60.91182	58.01522	54.81561	285.54601
3135	TS 3 upper cyl MLI 5	60.8555	57.96561	54.7856	285.46061
3136	TS 3 upper cyl MLI 6	61.55543	58.56723	55.2646	285.3082
3137	TS 3 upper cyl MLI 7	62.36218	59.25667	55.81785	285.10292
3138	TS 3 upper cyl MLI 8	62.68494	59.52927	56.02743	285.10009
3141	TS 3 upper bulk MLI 1	63.36385	60.17219	56.64601	286.83195
3142	TS 3 upper bulk MLI 2	63.06186	59.91319	56.42279	286.92141
3143	TS 3 upper bulk MLI 3	62.54044	59.46723	56.06989	286.9748
3144	TS 3 upper bulk MLI 4	61.78531	58.80745	55.54149	286.97506
3145	TS 3 upper bulk MLI 5	61.74337	58.77064	55.51905	286.9239
3146	TS 3 upper bulk MLI 6	62.43309	59.37274	56.01337	286.83802
3147	TS 3 upper bulk MLI 7	62.99499	59.85151	56.39499	286.75303
3148	TS 3 upper bulk MLI 8	63.34013	60.15089	56.63631	286.75103
3211	TS 3 low strap I/F 1	54.88622	52.47971	50.17277	212.81854
3212	TS 3 low strap I/F 2	54.97165	52.5572	50.23025	216.54298
3213	TS 3 low strap I/F 3	54.9913	52.57538	50.24272	218.38354
3214	TS 3 low strap I/F 4	54.97309	52.55944	50.23007	218.36672
3215	TS 3 low strap I/F 5	54.92507	52.51607	50.19767	216.52876
3216	TS 3 low strap I/F 6	54.84141	52.44003	50.14175	212.81539
3217	TS 3 low strap I/F 7	54.69557	52.30773	50.04301	206.80168
3218	TS 3 low strap I/F 8	54.71117	52.32158	50.05382	206.84699
3221	TS 3 upp strap I/F 1	54.89881	52.49053	50.18124	214.17019
3222	TS 3 upp strap I/F 2	54.97868	52.56309	50.23497	217.67929
3223	TS 3 upp strap I/F 3	54.99287	52.57652	50.24378	219.35503
3224	TS 3 upp strap I/F 4	54.97338	52.55961	50.23041	219.33151
3225	TS 3 upp strap I/F 5	54.92972	52.52016	50.20107	217.68765
3226	TS 3 upp strap I/F 6	54.85269	52.44993	50.14955	214.30837
3227	TS 3 upp strap I/F 7	54.71488	52.32473	50.05616	208.47107
3228	TS 3 upp strap I/F 8	54.73082	52.33879	50.06712	208.48371
4011	@CVV LOW BULK 1	69.48439	66.18133	61.87046	293
4012	@CVV LOW BULK 2	69.05358	65.77459	61.54982	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
4013	@CVV LOW BULK 3	68.22274	64.9829	60.86953	293
4014	@CVV LOW BULK 4	67.74031	64.5152	60.45136	293
4015	@CVV LOW BULK 5	67.71658	64.49065	60.43335	293
4016	@CVV LOW BULK 6	68.19434	64.93826	60.84889	293
4017	@CVV LOW BULK 7	69.12568	65.82125	61.60994	293
4018	@CVV LOW BULK 8	69.52711	66.2146	61.90548	293
4021	@CVV LOW CYL 1	68.52569	65.25764	61.18777	293
4022	@CVV LOW CYL 2	68.07343	64.85631	60.85808	293
4023	@CVV LOW CYL 3	66.76088	63.65574	59.87732	293
4024	@CVV LOW CYL 4	66.14062	63.10861	59.41657	293
4025	@CVV LOW CYL 5	65.99159	62.97407	59.30037	293
4026	@CVV LOW CYL 6	66.52464	63.44419	59.73376	293
4027	@CVV LOW CYL 7	68.04426	64.80796	60.8317	293
4028	@CVV LOW CYL 8	68.52969	65.25603	61.19295	293
4031	@CVV UPP CYL 1	68.05258	64.79038	60.87855	293
4032	@CVV UPP CYL 2	67.62706	64.42088	60.53801	293
4033	@CVV UPP CYL 3	66.59802	63.50991	59.78136	293
4034	@CVV UPP CYL 4	65.31703	62.37651	58.86519	293
4035	@CVV UPP CYL 5	65.2538	62.32084	58.83433	293
4036	@CVV UPP CYL 6	66.34825	63.29162	59.64501	293
4037	@CVV UPP CYL 7	67.57924	64.37844	60.5608	293
4038	@CVV UPP CYL 8	68.04134	64.77948	60.88437	293
4041	@CVV UPP BULK 1	67.86842	64.60453	60.79469	293
4042	@CVV UPP BULK 2	67.44223	64.2282	60.45793	293
4043	@CVV UPP BULK 3	66.72368	63.59749	59.93829	293
4044	@CVV UPP BULK 4	65.68105	62.66482	59.161	293
4045	@CVV UPP BULK 5	65.6362	62.62558	59.1388	293
4046	@CVV UPP BULK 6	66.61187	63.49951	59.88482	293
4047	@CVV UPP BULK 7	67.3939	64.18412	60.45282	293
4048	@CVV UPP BULK 8	67.85696	64.59499	60.79753	293
4050	CVV -Z Radiator low cyl.	65.85955	62.84216	59.17638	293
4051	CVV -Z Rad. arithm. low	65.95978	62.93641	59.25981	293
4052	CVV -Z Rad. arithm. upp	64.83984	61.95909	58.5243	293
4053	CVV -Z Radiator upp cyl.	64.65315	61.80313	58.4013	293
4055	CVV -Y Radiator	66.61004	63.52199	59.78237	293
4057	CVV +Y Radiator	66.36735	63.30641	59.64311	293
4070	Cryostat baffle pz	67.31823	64.0893	60.38649	293
4071	Cryostat baffle my	66.88083	63.71038	60.05283	293
4072	Cryostat baffle mz	65.88054	62.81674	59.32132	293
4073	Cryostat baffle py	66.84859	63.68222	60.04405	293
4075	Cryostat inner baffle	66.70532	63.51232	59.91045	293
4079	Cryostat baffle top	66.73143	63.56002	59.94311	293
4081	Pretension 1	66.93455	63.78027	59.92074	293
4082	Pretension 2	66.53883	63.42885	59.63134	293
4083	Pretension 3	65.29307	62.28911	58.69755	293
4084	Pretension 4	64.65964	61.73388	58.22972	293
4085	Pretension 5	64.51973	61.60733	58.1207	293
4086	Pretension 6	65.03128	62.05307	58.53553	293
4087	Pretension 7	66.48803	63.36324	59.59094	293
4088	Pretension 8	66.92244	63.76439	59.91449	293
4090	CVV LOU windows	67.29184	64.10352	60.27978	292.35748
4101	CVV MLI low bulk 1 low	176.80643	161.15308	150.07524	293
4102	CVV MLI low bulk 2 low	168.08707	152.28285	137.4241	293
4103	CVV MLI low bulk 3 low	159.37289	143.32347	124.81927	293
4104	CVV MLI low bulk 4 low	153.14056	137.25389	117.65187	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
4105	CVV MLI low bulk 5 low	151.84705	135.98264	116.29351	293
4106	CVV MLI low bulk 6 low	156.74811	140.74905	122.40896	293
4107	CVV MLI low bulk 7 low	164.93765	149.26001	135.02541	293
4108	CVV MLI low bulk 8 low	176.40267	160.73885	149.72758	293
4111	CVV MLI low bulk 1 upp	170.05653	157.20192	152.45786	293
4112	CVV MLI low bulk 2 upp	142.26729	131.78502	125.59004	293
4113	CVV MLI low bulk 3 upp	122.2386	110.90048	97.63918	293
4114	CVV MLI low bulk 4 upp	121.68468	110.18714	95.50701	293
4115	CVV MLI low bulk 5 upp	120.24532	108.84937	94.04562	293
4116	CVV MLI low bulk 6 upp	118.60013	107.49777	94.81297	293
4117	CVV MLI low bulk 7 upp	137.24205	126.62462	122.11912	293
4118	CVV MLI low bulk 8 upp	169.59519	156.76958	152.22715	293
4121	CVV MLI low cyl 1	165.41498	153.50338	150.5272	293
4122	CVV MLI low cyl 2	140.07417	130.25862	125.74739	293
4127	CVV MLI low cyl 7	133.46916	123.64279	121.02041	293
4128	CVV MLI low cyl 8	164.99898	153.07513	150.24531	293
4131	CVV MLI upp cyl 1	161.56434	149.70553	147.17048	293
4132	CVV MLI upp cyl 2	136.4395	126.6163	122.61636	293
4137	CVV MLI upp cyl 7	130.89273	121.01939	118.79849	293
4138	CVV MLI upp cyl 8	161.20013	149.32936	146.93053	293
4141	CVV MLI upp bulk 1 low	141.34796	128.45866	126.60915	293
4142	CVV MLI upp bulk 2 low	123.00539	111.87013	109.91253	293
4143	CVV MLI upp bulk 3 low	77.08814	70.48646	68.65373	293
4146	CVV MLI upp bulk 6 low	71.63376	65.04241	63.9199	293
4147	CVV MLI upp bulk 7 low	120.84042	109.67515	108.10753	293
4148	CVV MLI upp bulk 8 low	140.69665	127.831	126.12401	293
4151	CVV MLI upp bulk 1 upp	133.74454	120.5362	118.81774	293
4152	CVV MLI upp bulk 2 upp	118.96722	107.5449	105.79071	293
4153	CVV MLI upp bulk 3 upp	87.1862	78.87628	77.36201	293
4156	CVV MLI upp bulk 6 upp	86.51759	78.23572	76.97991	293
4157	CVV MLI upp bulk 7 upp	116.23501	105.11996	103.55792	293
4158	CVV MLI upp bulk 8 upp	133.41143	120.16184	118.45911	293
4170	Cryost. baf. MLI pz	137.09609	124.2381	122.5353	293
4171	Cryost. baf. MLI my	108.31385	98.30768	96.63419	293
4173	Cryost. baf. MLI py	107.18707	97.1817	95.71689	293
4179	Cryost. baf. MLI top	110.82681	100.75594	98.89604	293
4180	Cryo-baf. SLI collar pz	130.05121	118.28456	116.30401	292.99951
4181	Cryo-baf. SLI collar my	112.68131	102.64432	100.59735	292.9993
4182	Cryo-baf. SLI collar mz	92.39404	84.1263	82.39843	292.99981
4183	Cryo-baf. SLI collar py	111.76367	101.70633	99.83714	292.99986
4201	LOU supp. plate LOA1 mx	130.15904	126.678	97.21379	293
4202	LOU supp. plate LOA2 mx	130.20257	126.72006	97.22958	293
4203	LOU supp. plate LOA3 mx	130.21515	126.73219	97.23438	293
4204	LOU supp. plate LOA4 mx	130.21511	126.73211	97.234	293
4205	LOU supp. plate LOA5 mx	130.2148	126.73187	97.2342	293
4206	LOU supp. plate LOA6 mx	130.19957	126.71735	97.2282	293
4207	LOU supp. plate LOA7 mx	130.147	126.66713	97.20855	293
4211	LOU supp. plate LOA1 px	130.17433	126.69277	97.21906	293
4212	LOU supp. plate LOA2 px	130.20404	126.72155	97.23017	293
4213	LOU supp. plate LOA3 px	130.2133	126.73039	97.23334	293
4214	LOU supp. plate LOA4 px	130.20935	126.72644	97.23041	293
4215	LOU supp. plate LOA5 px	130.213	126.73011	97.23319	293
4216	LOU supp. plate LOA6 px	130.20242	126.72005	97.22945	293
4217	LOU supp. plate LOA7 px	130.15944	126.67897	97.21293	293
4260	LOU MLI cap px inside	121.34227	116.9989	95.65021	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
4261	LOU MLI cap px outside	120.42353	110.46656	107.58481	293
4263	LOU_supp_MLI_pY	135.47981	125.89486	120.92826	293
4270	LOU Radiator low.	115.65975	112.74988	91.89208	293
4271	LOU Radiator upp.	124.72994	121.49638	95.34309	293
4279	LOU Rad. straps pX I/F	130.06294	126.58655	97.18153	293
4280	LOU Rad. straps pX	129.03638	125.6043	96.83185	293
4281	LOU Rad. supp. pZpX	126.10792	122.75505	95.85927	293
4283	LOU Rad. supp. pZmX	119.57927	116.37838	93.60268	293
4285	LOU Rad. supp. pZ	123.49133	120.22163	94.90791	293
4287	LOU Rad. supp. mZpX	127.18043	123.82677	96.18386	293
4289	LOU Rad. supp. mZmX	117.55052	114.52687	92.6585	293
4301	LOU_harn_3132 @ LOU I/F	136.24796	131.54491	105.61828	293
4302	LOU_harness_3132	148.27227	141.77196	121.8113	293
4303	LOU_harness_3132	162.3355	154.32042	138.20502	293
4304	LOU_harness_3132	181.99468	171.95785	156.88061	293
4305	LOU_harness_Strut 32	218.05248	203.46069	186.29037	293
4306	LOU harn_Strut 32 @ SVM	255.75428	234.94932	213.21243	293
4311	LOU_harn_3334 @ LOU I/F	135.05244	130.4305	104.91479	293
4312	LOU_harness_3334	143.64528	137.83494	118.26174	293
4313	LOU_harness_3334	154.61118	147.75015	132.01205	293
4314	LOU_harness_3334	171.86199	163.32518	149.02447	293
4315	LOU_harness_Strut 33	205.28395	192.43614	176.58377	293
4316	LOU harn_Strut 33 @ SVM	244.03779	224.94271	204.30954	293
4361	LOU Waveguid 1 @ LOU I/F	131.53677	125.66144	105.29301	293
4362	LOU Waveguid 2	135.02651	127.35097	115.34828	293
4363	LOU Waveguid 3	136.14368	128.37114	120.31515	293
4364	LOU Waveguid 4	147.04977	139.25282	132.06232	293
4365	LOU Waveguid 5	182.42607	172.00853	161.86962	293
4366	LOU Waveguid 6 @ SVM I/F	274.08259	251.59005	229.227	293
4411	CVV MLI low bulk 1 int	87.02436	80.98328	77.16548	293
4412	CVV MLI low bulk 2 int	77.4695	72.73855	68.38388	293
4417	CVV MLI low bulk 7 int	76.89315	72.12499	68.08398	293
4418	CVV MLI low bulk 8 int	87.52543	81.41714	77.66053	293
4421	CVV MLI low cyl 1 int	84.31553	78.66854	75.51011	293
4422	CVV MLI low cyl 2 int	75.84987	71.40287	67.62645	293
4427	CVV MLI low cyl 7 int	74.90526	70.41414	66.9601	293
4428	CVV MLI low cyl 8 int	84.72299	79.00412	75.90915	293
4431	CVV MLI upp cyl 1 int	82.8876	77.2669	74.32351	293
4432	CVV MLI upp cyl 2 int	74.90007	70.46201	66.80674	293
4437	CVV MLI upp cyl 7 int	73.79134	69.35449	66.07495	293
4438	CVV MLI upp cyl 8 int	82.77376	77.15718	74.26275	293
4455	CVV -Y Rad. MLI	131.02108	121.99734	116.72068	293
4456	CVV -Y Rad. MLI int	69.53228	65.33013	61.57027	293
4457	CVV +Y Rad. MLI	143.06174	132.31391	129.74399	293
4458	CVV +Y Rad. MLI int	71.68553	66.89036	64.06418	293
4470	Cryost. baf. MLI pz int	79.04535	73.12516	70.31757	293
4471	Cryost. baf. MLI my int	70.98466	66.50357	63.33819	293
4473	Cryost. baf. MLI py int	70.54793	66.18305	63.0133	293
4541	CVV TS2 gap	67.82269	64.56048	60.762	282.77526
4542	CVV TS2 gap	67.39781	64.18609	60.42651	282.74497
4543	CVV TS2 gap	66.68134	63.55802	59.90847	282.73281
4544	CVV TS2 gap	65.64302	62.62934	59.13378	282.67612
4545	CVV TS2 gap	65.59931	62.59097	59.11228	282.69785
4546	CVV TS2 gap	66.57245	63.4623	59.85675	282.82005
4547	CVV TS2 gap	67.35212	64.14375	60.42283	282.79327

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
4548	CVV TS2 gap	67.81177	64.55121	60.76504	282.76418
4901	H501	61.51252	58.72964	55.80112	288.56307
4902	Tube_4902	60.34757	57.67142	55.09037	237.64449
4903	V502 external	63.16872	60.33255	57.1624	279.49882
4910	LHV_Support_1	66.7403	63.63747	59.86391	292.69467
4911	V501_Support	66.37525	63.30091	59.6104	289.38284
4912	V503_Support	66.42998	63.35101	59.64718	289.92
4913	Tube_4913	63.70577	60.85145	57.83404	256.52404
4914	Tube_4914	63.7072	60.8528	57.83522	256.5639
4915	Tube_Jct4913_14_16	63.7035	60.84931	57.82862	257.45261
4916	Tube_4916	63.69532	60.8416	57.8127	259.79324
4917	Tube_4917	62.38922	59.60393	56.78991	247.71982
4918	Tube_4918	62.34475	59.56577	56.75632	247.67383
4919	Tube_Jct4917_18_02	61.94754	59.18762	56.42346	245.60132
4920	LHV_Support_2	66.12875	63.09837	59.40888	292.88194
4921	V505_Support	66.04846	63.02604	59.35346	292.36945
4922	V504_Support	65.97681	62.95952	59.30872	291.25864
4923	Tube_4923	64.38236	61.49178	58.29688	266.00123
4924	Tube_Jct4916_23_25	64.02755	61.15774	58.04154	264.31645
4925	Tube_4925	63.75766	60.90763	57.83571	266.45541
4926	Tube_Jct4925_37_38	64.25409	61.37261	58.15477	276.66198
4927	Tube_4927	64.65602	61.76147	58.39549	282.12849
4928	Tube_4928	64.81139	61.89615	58.57375	273.66181
4930	SV521_Support	66.13319	63.10225	59.41158	292.98802
4931	V506	66.13287	63.10198	59.41136	292.9876
4932	P501	66.13302	63.10211	59.41146	292.98779
4936	Tube_4936	63.54151	60.64695	57.34807	292.46784
4937	Tube_4937	65.0337	62.09777	58.66347	288.81048
4938	Tube_4938_1	63.82112	60.97388	57.86599	273.30583
4939	Tube_4939	64.56469	61.67365	58.42098	275.51905
4940	A_Frame	66.02461	63.00553	59.33006	292.83547
4941	Support_mY_up	66.02407	63.00525	59.33001	292.85246
4942	Support_mY_low	66.10443	63.07656	59.38983	292.95601
4943	P502_Support_Plate	66.03882	63.01845	59.34121	292.86841
4944	P502	66.03812	63.01785	59.34074	292.86587
4945	Support_pY	66.00074	62.9835	59.31009	292.92131
4946	Tube_4946	65.42574	62.46445	58.97521	281.52664
4947	Tube_4947	65.42582	62.46451	58.97525	281.52801
4948	pY_Nozzle_Support	66.01269	62.99534	59.32277	292.62992
4949	mY_Nozzle_Support	66.01275	62.99539	59.32281	292.62901
4950	mZ_Nozzle_Support	66.01886	63.0007	59.32632	292.81735
4961	V502 internal	59.67495	57.07619	54.54484	233.59966
4962	H501 internal	59.88444	57.26991	54.72249	231.11263
5000	GHe tank outlet	1.65003	1.63935	1.59551	1.80024
5010	GHe Tank-PACS	1.65262	1.6418	1.59812	1.81152
5011	GHe Tank-PACS	1.65913	1.64779	1.60415	1.82663
5012	GHe Tank-PACS	1.66169	1.65018	1.6067	1.87428
5013	GHe Tank-PACS	1.66529	1.65356	1.61032	1.88164
5014	GHe PACS I/F 1	1.88658	1.88687	1.82151	1.99891
5020	GHe PACS I/F 1	2.12323	2.12908	2.02344	2.36742
5021	GHe PACS I/F 1	2.2257	2.23236	2.10671	2.54823
5022	GHe PACS I/F 1	2.35796	2.36328	2.20763	2.84119
5023	GHe PACS I/F 1/2	2.43803	2.44306	2.27068	2.93638
5024	GHe PACS I/F 2	2.52923	2.5341	2.34158	3.07003
5025	GHe PACS I/F 2	2.70658	2.7094	2.47475	3.47965

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
5026	GHe PACS I/F 2	2.77566	2.77661	2.52413	3.68548
5027	GHe PACS I/F 2	2.85921	2.85637	2.58077	4.0198
5028	GHe PACS I/F 2/3	2.91388	2.90893	2.6182	4.219
5029	GHe PACS I/F 3	2.98743	2.98055	2.6703	4.46455
5030	GHe PACS I/F 3	3.05186	3.04241	2.71425	4.7876
5031	GHe PACS I/F 3	3.07962	3.06932	2.73297	4.96402
5032	GHe PACS I/F 3	3.11623	3.10429	2.75844	5.23202
5033	GHe PACS-SPIRE	3.15469	3.14383	2.79271	5.43185
5034	GHe PACS-SPIRE	3.25699	3.2545	2.89677	5.49881
5035	GHe SPIRE I/F 1	3.67837	3.68859	3.28459	5.96627
5036	GHe SPIRE I/F 1	4.16621	4.18087	3.71886	6.80813
5037	GHe SPIRE I/F 1	4.3411	4.35425	3.86645	7.22912
5038	GHe SPIRE I/F 1	4.52629	4.5317	4.01069	7.91312
5039	GHe SPIRE I/F 2	4.75698	4.77777	4.2429	8.15685
5043	GHe HIFI I/F	5.42133	5.47564	4.89362	8.27673
5044	GHe HIFI I/F	5.58505	5.64252	5.04285	8.33869
5045	GHe HIFI I/F	5.67467	5.73447	5.12464	8.37731
5046	GHe HIFI I/F	5.75546	5.81285	5.19063	8.43461
5050	GHe L1-L2	5.7903	5.84669	5.21944	8.47842
5051	GHe L1-L2	5.90067	5.97684	5.35648	8.48303
5052	GHe L1-L2	6.34406	6.45791	5.83372	8.50447
5053	GHe L1-L2	7.87925	8.01523	7.27543	8.75616
5054	GHe L1-L2	11.86191	11.85371	10.61525	11.29169
5060	GHe Lev.2 OB	12.66714	12.58318	11.17968	16.29528
5061	GHe Lev.2 OB	12.9551	12.84657	11.38862	19.11347
5062	GHe Lev.2 OB	13.01956	12.90561	11.44182	20.06399
5063	GHe Lev.2 OB	12.99575	12.88336	11.41689	20.22245
5070	GHe L2-L3	13.05018	12.94885	11.42018	20.22535
5071	GHe PM JFET I/F	13.31478	13.24262	11.4346	20.2579
5080	GHe PM JFET I/F	13.44918	13.38637	11.44151	20.29491
5081	GHe PM JFET I/F	13.49322	13.43402	11.44372	20.31493
5082	GHe PM JFET I/F	13.51869	13.45887	11.44491	20.343
5083	GHe SM JFET I/F	13.53351	13.48061	11.44751	20.35711
5084	GHe SM JFET I/F	13.55763	13.51313	11.45144	20.36761
5085	GHe SM JFET I/F	13.56191	13.52142	11.45239	20.37305
5086	GHe SM JFET I/F	13.56556	13.52468	11.45277	20.38036
5090	GHe L3-TS1	13.55944	13.522	11.45293	20.38245
5091	GHe L3-TS1	13.60126	13.57402	11.53033	20.3868
5092	GHe L3-TS1	23.89907	23.59918	23.08309	25.26811
5110	GHe TS 1 / line pymz	33.15347	32.1899	31.30361	61.33429
5111	GHe TS 1 / line pymz	34.13585	33.08821	32.11595	73.10217
5112	GHe TS 1 / line pymz	34.66795	33.57926	32.54658	80.40987
5113	GHe TS 1 / line pymz	34.53745	33.45347	32.43437	81.73286
5119	GHe TS 1 / line pymz	34.70089	33.61079	32.61508	81.88139
5120	GHe TS 1 / line mypz	33.12606	32.16425	31.28264	61.20359
5121	GHe TS 1 / line mypz	34.23316	33.17773	32.18915	74.20176
5122	GHe TS 1 / line mypz	34.65767	33.56748	32.51876	81.28716
5123	GHe TS 1 / line mypz	34.52166	33.43809	32.41727	82.3501
5129	GHe TS 1 / line mypz	34.68557	33.59582	32.59848	82.50585
5210	GHe TS 2 / line pymz	45.01046	43.2414	41.92125	129.42073
5211	GHe TS 2 / line pymz	45.46362	43.64643	42.25056	140.27898
5212	GHe TS 2 / line pymz	45.54708	43.71884	42.30936	144.16434
5213	GHe TS 2 / line pymz	45.58441	43.75155	42.33568	145.78535
5219	GHe TS 2 / line pymz	45.80035	43.95699	42.5545	146.05169
5220	GHe TS 2 / line mypz	45.02488	43.25197	41.93136	132.00362

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
5221	GHe TS 2 / line mypz	45.45351	43.63327	42.24132	143.83535
5222	GHe TS 2 / line mypz	45.54931	43.71927	42.30995	146.1459
5223	GHe TS 2 / line mypz	45.5853	43.75185	42.33598	146.58042
5229	GHe TS 2 / line mypz	45.80161	43.95764	42.5551	146.84363
5310	GHe TS 3 / line pymz	54.56343	52.18794	49.95231	202.26382
5311	GHe TS 3 / line pymz	54.80454	52.40648	50.11707	211.3997
5312	GHe TS 3 / line pymz	54.91218	52.50413	50.18935	216.13638
5313	GHe TS 3 / line pymz	54.96575	52.55249	50.22537	218.33706
5320	GHe TS 3 / line mypz	54.57824	52.201	49.96249	202.33771
5321	GHe TS 3 / line mypz	54.84466	52.44179	50.14463	211.38711
5322	GHe TS 3 / line mypz	54.95421	52.54101	50.21836	216.14247
5323	GHe TS 3 / line mypz	54.98315	52.56767	50.23731	218.35757
5329	GHe TS 3 out	55.29449	52.86774	50.54451	218.75676
5330	GHe V502 out	59.64993	57.05691	54.53571	229.55614
5331	GHe H501 out	59.88391	57.26942	54.72207	231.10908
5332	GHe ext.Tube 4902 out	60.34652	57.67051	55.08953	237.60959
5333	GHe ext.Tube 4917 out	62.38457	59.59952	56.78603	247.6831
5334	GHe ext.Tube 4918 out	62.3402	59.56144	56.75252	247.63727
5335	GHe ext.Tube 4913/14 out	63.70343	60.84923	57.8322	256.50266
5336	GHe ext.Tube 4916 out	63.69535	60.84161	57.81274	259.73321
5337	GHe ext.Tube 4923 out	64.38081	61.4903	58.29578	265.96127
5338	GHe ext.Tube 4928 out	64.81042	61.89523	58.57311	273.64424
5339	GHe ext.Tube 4927 out	64.65638	61.76177	58.39589	282.10914
5340	GHe ext.Tube 4925 out	63.75753	60.90748	57.83566	266.44007
5341	GHe ext.Tube 4938 out	63.82098	60.97373	57.86592	273.29016
5342	GHe ext.Tube 4939 out	64.56301	61.67206	58.41971	275.42758
5343	GHe ext.Tube 4946 out	65.42378	62.46264	58.97394	281.2827
5344	GHe ext.Tube 4947 out	65.42387	62.4627	58.97398	281.28401
5900	Mass Flow Rate [mg/s]	2.33466	2.18009	1.76656	25.79042
5901	Helium: Init Mass [kg]	337	337	337	337
5902	Helium: Act Mass [kg]	337	337	337	337
5903	Helium: Cons Mass [kg]	0	0	0	0
5950	Lifetime [days]	1444.3952	1540.78772	1881.61136	207.90125
5951	Heat to Tank [mW]	53.39042	49.73892	40.09551	597.71007
6201	SVM SHIELD tip +Y	129.19736	117.26622	105.0768	293
6202	SVM SHIELD tip -Y	132.04364	119.95599	107.6508	293
6204	SVM SHIELD +Y	133.29899	120.48328	107.4592	293
6205	SVM SHIELD -Y	136.52743	123.36905	110.09623	293
6206	SVM SHIELD -Z	123.98554	113.84906	102.8167	293
6301	SVM SHIELD SLI tip +Y	111.2077	102.05739	97.48761	293
6302	SVM SHIELD SLI tip -Y	115.16543	106.13353	100.68145	293
6304	SVM SHIELD SLI +Y	115.51644	105.67832	98.06856	293
6305	SVM SHIELD SLI -Y	122.26289	112.28429	104.12997	293
6306	SVM SHIELD SLI -Z	91.53508	83.82242	75.68763	293
6501	STRUT1_CVVSVM	254.42076	253.25103	216.55811	293
6502	STRUT1_CVVSVM	191.65811	188.56386	164.66383	293
6503	STRUT1_CVVSVM	120.10874	116.45262	103.68045	293
6511	STRUT2_CVVSVM	224.40426	221.74641	193.33096	293
6512	STRUT2_CVVSVM	189.05714	184.16995	161.7228	293
6513	STRUT2_CVVSVM	152.75343	147.50771	128.52921	293
6521	STRUT3_CVVSVM	233.1382	229.16001	200.03895	293
6522	STRUT3_CVVSVM	201.61309	194.74167	171.4347	293
6523	STRUT3_CVVSVM	163.5851	156.51956	136.83209	293
6531	STRUT4_CVVSVM	255.2676	254.38398	216.64982	293
6532	STRUT4_CVVSVM	191.30342	189.14869	163.77032	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
6533	STRUT4_CVVSVM	118.94029	115.93183	102.54564	293
6541	STRUT5_CVVSVM	241.35168	238.47975	207.87819	293
6542	STRUT5_CVVSVM	185.84531	180.91732	161.4739	293
6543	STRUT5_CVVSVM	131.44297	125.73274	114.43733	293
6551	STRUT6_CVVSVM	229.77397	226.39584	198.43751	293
6552	STRUT6_CVVSVM	176.06997	170.93039	153.10529	293
6553	STRUT6_CVVSVM	125.73778	120.13642	109.65255	293
6561	STRUT7_CVVSVM	249.27595	248.02335	214.13724	293
6562	STRUT7_CVVSVM	201.85589	198.42734	176.22705	293
6563	STRUT7_CVVSVM	174.77315	169.4868	152.61834	293
6564	STRUT7_CVVSVM	157.28593	150.60756	136.34891	293
6565	STRUT7_CVVSVM	143.78682	136.45762	123.77537	293
6566	STRUT7_CVVSVM	130.52472	123.43304	112.41731	293
6567	STRUT7_CVVSVM	116.54208	110.12063	100.85374	293
6568	STRUT7_CVVSVM	103.08804	97.45192	89.68307	293
6569	STRUT7_CVVSVM	90.0299	85.12641	78.63704	293
6570	STRUT7_CVVSVM	76.06625	72.09157	66.95872	293
6571	STRUT8_CVVSVM	248.60805	247.51004	213.67173	293
6572	STRUT8_CVVSVM	200.22071	197.17103	175.04823	293
6573	STRUT8_CVVSVM	172.70403	167.83004	151.02204	293
6574	STRUT8_CVVSVM	155.25347	148.86245	134.57144	293
6575	STRUT8_CVVSVM	142.3584	135.00629	122.05746	293
6576	STRUT8_CVVSVM	130.39082	122.8911	111.20342	293
6577	STRUT8_CVVSVM	116.77951	109.89117	99.91473	293
6578	STRUT8_CVVSVM	102.68463	96.81789	88.57883	293
6579	STRUT8_CVVSVM	89.38074	84.41442	77.68331	293
6580	STRUT8_CVVSVM	75.71085	71.73719	66.54534	293
6581	STRUT9_CVVSVM	247.93548	246.95546	213.15387	293
6582	STRUT9_CVVSVM	199.00779	196.21148	173.87261	293
6583	STRUT9_CVVSVM	170.17473	165.59581	148.43615	293
6584	STRUT9_CVVSVM	150.69616	144.45519	129.72349	293
6585	STRUT9_CVVSVM	140.49825	133.36909	119.74221	293
6586	STRUT9_CVVSVM	131.98098	124.51721	111.71352	293
6587	STRUT9_CVVSVM	123.15651	116.06661	104.32416	293
6588	STRUT9_CVVSVM	113.84211	107.46368	96.84333	293
6589	STRUT9_CVVSVM	96.72571	91.38571	82.9501	293
6590	STRUT9_CVVSVM	78.36227	74.21706	68.25577	293
6591	STRUT10_CVVSVM	247.84038	246.95288	213.18328	293
6592	STRUT10_CVVSVM	198.21553	195.70495	173.73543	293
6593	STRUT10_CVVSVM	169.58059	165.48661	148.94335	293
6594	STRUT10_CVVSVM	151.44219	145.91319	131.92138	293
6595	STRUT10_CVVSVM	138.60766	131.95366	119.15661	293
6596	STRUT10_CVVSVM	127.73492	120.45843	108.54871	293
6597	STRUT10_CVVSVM	116.2193	109.17352	98.52621	293
6598	STRUT10_CVVSVM	103.14793	96.88389	87.88751	293
6599	STRUT10_CVVSVM	89.52294	84.2923	77.05433	293
6600	STRUT10_CVVSVM	75.4737	71.38899	66.02045	293
6601	STRUT11_CVVSVM	247.42306	246.53932	212.87623	293
6602	STRUT11_CVVSVM	197.66493	195.06514	173.15799	293
6603	STRUT11_CVVSVM	168.44127	163.92721	147.58013	293
6604	STRUT11_CVVSVM	149.24321	142.5879	129.11253	293
6605	STRUT11_CVVSVM	139.41775	132.16697	119.77433	293
6606	STRUT11_CVVSVM	132.50901	124.85445	113.13	293
6607	STRUT11_CVVSVM	126.98658	119.32894	108.27192	293
6608	STRUT11_CVVSVM	121.54126	114.10605	103.8263	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
6609	STRUT11_CVVSVM	101.62417	95.62338	87.40364	293
6610	STRUT11_CVVSVM	80.26524	75.86833	69.92777	293
6611	STRUT12_CVVSVM	247.46933	246.62157	212.84738	293
6612	STRUT12_CVVSVM	197.15701	194.68824	172.65149	293
6613	STRUT12_CVVSVM	167.34656	163.15463	146.58607	293
6614	STRUT12_CVVSVM	147.43759	141.44834	127.55715	293
6615	STRUT12_CVVSVM	136.69056	129.84398	117.09189	293
6616	STRUT12_CVVSVM	128.38125	121.02161	109.01766	293
6617	STRUT12_CVVSVM	120.77189	113.45839	102.28877	293
6618	STRUT12_CVVSVM	112.54272	105.70379	95.63905	293
6619	STRUT12_CVVSVM	95.589	89.9802	81.98766	293
6620	STRUT12_CVVSVM	77.77148	73.53792	67.8056	293
6621	STRUT13_CVVSVM	247.76874	246.81837	213.14562	293
6622	STRUT13_CVVSVM	199.0954	196.38898	174.23878	293
6623	STRUT13_CVVSVM	170.57872	166.06903	149.24629	293
6624	STRUT13_CVVSVM	151.57673	145.29248	131.12499	293
6625	STRUT13_CVVSVM	142.17735	135.06789	121.88609	293
6626	STRUT13_CVVSVM	134.91094	127.38644	114.86687	293
6627	STRUT13_CVVSVM	127.93073	120.64328	108.9486	293
6628	STRUT13_CVVSVM	120.53327	113.77226	103.0347	293
6629	STRUT13_CVVSVM	101.73767	96.05507	87.3543	293
6630	STRUT13_CVVSVM	80.60306	76.28447	70.08485	293
6631	STRUT14_CVVSVM	247.54025	246.57926	212.90289	293
6632	STRUT14_CVVSVM	199.37813	196.65069	174.06991	293
6633	STRUT14_CVVSVM	170.55529	166.0523	148.39958	293
6634	STRUT14_CVVSVM	150.40601	144.16907	128.73413	293
6635	STRUT14_CVVSVM	142.00884	134.9488	120.41188	293
6636	STRUT14_CVVSVM	135.09445	127.68025	113.73	293
6637	STRUT14_CVVSVM	128.09637	120.84687	107.59181	293
6638	STRUT14_CVVSVM	120.42269	113.71857	101.32257	293
6639	STRUT14_CVVSVM	102.31932	96.56967	86.58119	293
6640	STRUT14_CVVSVM	81.08189	76.69801	69.91779	293
6641	STRUT15_CVVSVM	247.90453	246.88606	213.16914	293
6642	STRUT15_CVVSVM	199.77148	196.91996	174.45119	293
6643	STRUT15_CVVSVM	171.24857	166.61978	149.14052	293
6644	STRUT15_CVVSVM	151.47198	145.23488	130.03266	293
6645	STRUT15_CVVSVM	142.412	135.39526	121.27216	293
6646	STRUT15_CVVSVM	134.41889	127.31337	114.03773	293
6647	STRUT15_CVVSVM	125.83656	119.10213	106.84115	293
6648	STRUT15_CVVSVM	117.8704	111.72778	100.22087	293
6649	STRUT15_CVVSVM	100.29423	94.99112	85.75999	293
6650	STRUT15_CVVSVM	80.32502	76.15409	69.76124	293
6651	STRUT16_CVVSVM	248.42458	247.28462	213.43323	293
6652	STRUT16_CVVSVM	199.77069	196.54015	174.2625	293
6653	STRUT16_CVVSVM	171.19408	165.9004	148.89117	293
6654	STRUT16_CVVSVM	151.63666	144.42589	130.02845	293
6655	STRUT16_CVVSVM	140.68105	132.95042	119.96002	293
6656	STRUT16_CVVSVM	130.44734	122.84498	111.23573	293
6657	STRUT16_CVVSVM	120.09475	112.9909	102.75443	293
6658	STRUT16_CVVSVM	111.79568	104.98796	95.55481	293
6659	STRUT16_CVVSVM	95.27309	89.70425	82.18445	293
6660	STRUT16_CVVSVM	77.95142	73.74291	68.20767	293
6661	STRUT17_CVVSVM	248.61316	247.39439	213.82366	293
6662	STRUT17_CVVSVM	201.48957	198.15165	176.18006	293
6663	STRUT17_CVVSVM	173.43508	168.19764	151.74034	293

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6664	STRUT17_CVVSVM	153.21933	146.49518	133.14143	293
6665	STRUT17_CVVSVM	143.98954	136.84999	125.01723	293
6666	STRUT17_CVVSVM	134.8217	127.67201	117.32236	293
6667	STRUT17_CVVSVM	126.72739	119.8055	110.49048	293
6668	STRUT17_CVVSVM	119.7451	113.01971	104.12285	293
6669	STRUT17_CVVSVM	103.37518	97.27536	89.82558	293
6670	STRUT17_CVVSVM	82.56105	77.83707	72.16523	293
6671	STRUT18_CVVSVM	215.25011	212.14729	185.32339	293
6672	STRUT18_CVVSVM	166.3976	161.94661	145.35447	293
6673	STRUT18_CVVSVM	122.2162	117.07725	107.56946	293
6681	STRUT19_CVVSVM	227.79466	224.51228	196.86605	293
6682	STRUT19_CVVSVM	194.75377	188.98431	167.23209	293
6683	STRUT19_CVVSVM	158.1941	152.19695	133.84937	293
6691	STRUT20_CVVSVM	241.39484	233.9281	206.0969	293
6692	STRUT20_CVVSVM	214.88851	202.65754	181.3134	293
6693	STRUT20_CVVSVM	175.85602	163.59415	145.69348	293
6701	STRUT21_CVVSVM	217.42869	213.35251	186.9866	293
6702	STRUT21_CVVSVM	192.68567	186.27594	164.12811	293
6703	STRUT21_CVVSVM	167.28395	160.65337	140.25142	293
6711	STRUT22_CVVSVM	254.63341	253.54407	216.65375	293
6712	STRUT22_CVVSVM	192.58847	189.82495	165.06	293
6713	STRUT22_CVVSVM	120.73615	117.14503	103.99495	293
6721	STRUT23_CVVSVM	254.67191	253.5731	216.68569	293
6722	STRUT23_CVVSVM	192.607	189.84759	165.09639	293
6723	STRUT23_CVVSVM	120.57294	117.05015	103.92447	293
6731	STRUT24_CVVSVM	254.70707	253.59356	216.70841	293
6732	STRUT24_CVVSVM	192.75205	189.93896	165.18187	293
6733	STRUT24_CVVSVM	120.87854	117.24282	104.10099	293
8401	MLI FRAME_pZ	134.44166	122.09229	120.19828	293
8402	MLI FRAME_CORNER_mY	127.28144	116.05117	113.9216	293
8403	MLI FRAME_mY	94.15667	85.93479	84.18268	293
8404	FRAME_CORNER_mZ	73.64107	67.75845	66.11042	293
8405	MLI FRAME_pY	93.45509	85.20671	83.6778	293
8406	MLI FRAME_CORNER_pY	125.49276	114.28542	112.41064	293
8411	MLI TUBE_to_CVV_mYpZ	132.79228	120.85679	119.0016	293
8412	MLI TUBE_to_CVV_mYmZ	117.89322	107.74763	105.70378	293
8413	TUBE_to_CVV_mZmY	67.36254	62.91527	60.67023	293
8414	TUBE_to_CVV_mZpY	67.1686	62.64456	60.53276	293
8415	MLI TUBE_to_CVV_pYmZ	115.93205	105.80459	104.13816	293
8416	MLI TUBE_to_CVV_pYpZ	131.79537	119.85699	118.14665	293
8608	Tel. harness 02	223.57107	209.57602	188.62572	293
8609	Tel. harness 03	142.18018	135.38371	125.33705	293
8610	Tel. harness 1	104.0903	99.43323	93.16923	293
8611	Tel. harness 2	89.32058	85.55642	80.88114	293
8612	Tel. harness 3	81.31951	77.8546	73.93382	293
8613	Tel. harness 4	77.02944	73.55484	70.06834	293
8614	Tel. harness 5	75.13357	71.43084	68.26185	293
8615	Tel. harness 6	75.42665	70.99337	68.21186	293
8616	Tel. harness 7	77.39229	71.84124	69.49993	293
8620	Tel. CBs on TMS	79.05549	72.55364	70.58488	293
9001	CVV CBs 1	68.39724	65.14922	61.0932	293
9002	CVV CBs 2	68.12384	64.94423	60.90131	293
9003	CVV CBs 3	66.99504	63.84195	60.02093	293
9004	CVV CBs 4	66.14894	63.12315	59.42558	293
9005	CVV CBs 5	65.74349	62.75803	59.09934	293

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9006	CVV CBs 6	66.51873	63.44323	59.73492	293
9007	CVV CBs 7	68.09832	64.88264	60.86982	293
9008	CVV CBs 8	68.56433	65.30676	61.2202	293
9011	IP_08_09_10_11_12	88.63281	85.93817	80.05216	293
9012	IH_02_05	119.76684	117.4161	105.08377	293
9013	IS_04_05	78.37405	74.75406	69.90789	293
9014	IS_03_07_08_09	93.82025	89.5589	84.13568	293
9015	IS_02_11_13	91.50253	87.05776	80.32902	293
9016	IS_10	85.77168	82.26557	76.9296	293
9017	IP_03_04_14	116.23961	112.10855	101.2649	293
9018	IP_13	105.77028	102.99955	91.14233	293
9021	IP Rail2728_Strut24	196.67041	189.88913	167.2942	293
9022	IH Rail2900_Strut29	192.20338	187.53969	163.32966	293
9023	IS Rail3334_Strut38	139.19089	130.39301	117.67401	293
9024	IS Rail3800_Strut38	150.7962	141.18248	129.24468	293
9025	IS Rail3900_Strut38	145.32459	135.16416	122.39403	293
9026	IS Rail4041_Strut40	135.67323	127.92881	115.19487	293
9027	IP Rail2122_Strut22	201.88086	195.61004	173.05145	293
9028	IP Rail2400_Strut24	195.28454	189.19072	165.56294	293
9032	IH_01_03_04	102.38712	99.1965	90.47872	293
9033	IS_06	94.07008	90.16275	84.36087	293
9034	ICE_13_ICE14_Strut36	135.9027	128.42175	114.29573	293
9035	IS Rail3900_Strut39	135.18158	126.64337	113.85204	293
9036	CCH_ICA_10_ICB_10	73.23252	70.3399	66.10221	293
9037	IP_05_06_15	101.87086	99.403	89.18889	293
9038	IP_01_02_07	105.51942	102.24838	93.72541	293
9042	IH Rail3132_Strut30	207.78268	200.30257	176.38144	293
9043	IS Rail3800_Strut38	135.72537	127.48079	115.16504	293
9045	IS_01_12	94.10111	90.36067	84.32164	293
9046	CCH Rail4200_Strut41	132.51357	124.51218	110.20446	293
9047	IP Rail2400_Strut24	194.98961	188.64791	164.85921	293
9048	IP Rail2526_Strut24	194.73909	188.2774	165.5282	293
9055	IS Rail4041_Strut40	146.8921	139.18623	125.96394	293
9056	CCH Rail4200_Strut42	135.03064	128.44144	113.75052	293
9057	ICE_11_ICE12_Strut44	139.61448	132.28477	119.86464	293
9065	ICA_12_ICB12_Strut41	139.24709	132.33522	117.46426	293
9066	CCH_ICE_10_ICE_20	73.70524	70.45684	66.27529	293
9076	CCH Rail4344_Strut43	137.04902	126.97662	113.37552	293
9086	ICA_11_Strut41	137.30925	130.22377	114.57939	293
9096	ICB_11_Strut42	138.57236	131.24252	116.16859	293
9101	PACS int. harn. 11	6.70997	6.66293	5.76126	11.64662
9102	PACS int. harn. 11	9.72096	9.65613	8.43989	14.13512
9103	PACS int. harn. 11	11.84341	11.76224	10.38248	16.2641
9104	PACS int. harn. 11	12.72605	12.63731	11.22642	17.23445
9105	PACS int. harn. 11	17.32542	16.98092	15.74852	32.22099
9106	PACS int. harn. 11	24.01399	23.3555	22.26868	50.73025
9107	PACS int. harn. 11	31.57121	30.60017	29.52973	70.74217
9108	PACS int. harn. 11	34.72575	33.62824	32.57255	79.22751
9109	PACS int. harn. 11	41.75113	40.20495	38.49271	125.17809
9110	PACS int. harn. 11	53.60694	51.26776	48.45541	200.1669
9111	PACS int. harn. 11	63.76613	60.79553	57.1148	263.95529
9121	PACS int. harn. 13	12.07145	12.04694	5.73048	11.61894
9122	PACS int. harn. 13	15.72181	15.68154	8.41181	14.06523
9123	PACS int. harn. 13	15.15821	15.09475	10.36069	16.15617
9124	PACS int. harn. 13	12.71497	12.62789	11.20573	17.10878

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9125	PACS int. harn. 13	13.26221	13.15399	11.38732	19.14037
9126	PACS int. harn. 13	13.57925	13.45241	11.63927	20.31734
9127	PACS int. harn. 13	26.3096	25.65522	23.45852	48.2432
9128	PACS int. harn. 13	33.71145	32.70257	31.73022	67.13013
9129	PACS int. harn. 13	41.20991	39.73519	37.91991	117.19084
9130	PACS int. harn. 13	53.52652	51.22234	48.21005	196.21958
9131	PACS int. harn. 13	63.9037	60.93849	57.12745	262.7868
9141	PACS int. harn. 15	9.42362	9.38923	5.79211	11.91905
9142	PACS int. harn. 15	12.66163	12.60627	8.49235	14.73102
9143	PACS int. harn. 15	13.44322	13.36273	10.45041	17.10372
9144	PACS int. harn. 15	12.84733	12.74917	11.3011	18.17841
9145	PACS int. harn. 15	22.58333	22.36949	14.74999	27.90067
9146	PACS int. harn. 15	28.77789	28.36153	19.98724	41.02755
9147	PACS int. harn. 15	27.68714	26.99468	24.14275	51.28775
9148	PACS int. harn. 15	33.81551	32.79901	31.79966	68.12347
9149	PACS int. harn. 15	41.23771	39.76465	37.89741	117.87791
9150	PACS int. harn. 15	53.378	51.09583	48.05067	196.65156
9151	PACS int. harn. 15	63.55144	60.62271	56.83883	262.93647
9201	PACS int. harn. res.	3.26963	3.23096	2.83083	9.88019
9202	PACS int. harn. res.	12.97601	12.86603	11.40654	19.29497
9206	PACS int. harn. res.	25.14727	24.53625	22.82608	46.01268
9208	PACS int. harn. res.	33.77187	32.75926	31.7764	67.52715
9212	PACS int. harn. res.	12.70957	12.62206	11.2119	17.14028
9213	PACS int. harn. res.	12.95049	12.84232	11.38545	19.13946
9214	PACS int. harn. res.	12.96499	12.8557	11.39577	19.25063
9215	PACS int. harn. res.	13.36059	13.22775	11.73502	20.6786
9216	PACS int. harn. res.	25.06043	24.44391	22.8787	45.74269
9218	PACS int. harn. res.	33.61272	32.61332	31.66079	65.7691
9226	PACS int. harn. res.	23.47783	22.853	21.80372	48.21812
9228	PACS int. harn. res.	34.64859	33.55899	32.51497	78.07429
9301	SPIRE int. harn. 3	14.31714	14.18959	12.19934	23.83997
9302	SPIRE int. harn. 3	15.24579	15.0317	13.34621	28.05507
9303	SPIRE int. harn. 3	16.1111	15.81954	14.39644	31.69982
9304	SPIRE int. harn. 3	16.52201	16.19487	14.89216	33.36944
9305	SPIRE int. harn. 3	23.26045	22.56029	21.2947	56.68516
9306	SPIRE int. harn. 3	32.6466	31.4935	30.11082	88.12906
9307	SPIRE int. harn. 3	41.72854	40.13696	38.5066	125.84508
9308	SPIRE int. harn. 3	45.89345	44.04322	42.23116	152.68072
9309	SPIRE int. harn. 3	49.6563	47.57672	45.39093	179.15875
9310	SPIRE int. harn. 3	56.65846	54.16671	51.31685	227.86266
9311	SPIRE int. harn. 3	63.10071	60.24368	56.81248	272.16641
9321	SPIRE int. harn. 11	7.95287	7.90294	6.45675	14.84857
9322	SPIRE int. harn. 11	10.7158	10.6368	8.85772	17.29204
9323	SPIRE int. harn. 11	12.47919	12.37429	10.68037	19.44132
9324	SPIRE int. harn. 11	13.07544	12.95765	11.48457	20.43411
9325	SPIRE int. harn. 11	20.07003	19.61898	17.78634	40.71595
9326	SPIRE int. harn. 11	28.70804	27.86083	26.28571	66.039
9327	SPIRE int. harn. 11	33.73	32.67048	31.14634	82.56789
9328	SPIRE int. harn. 11	35.64358	34.4804	33.31713	90.13105
9329	SPIRE int. harn. 11	41.85666	40.32815	38.57057	132.87297
9330	SPIRE int. harn. 11	52.46085	50.26347	47.56215	204.01361
9331	SPIRE int. harn. 11	61.58862	58.84602	55.45525	265.09232
9341	SPIRE int. harn. res.	4.86757	4.84143	4.23998	13.17922
9342	SPIRE int. harn. res.	13.05353	12.93674	11.47304	20.35696
9346	SPIRE int. harn. res.	29.12557	28.22963	26.96385	69.26599

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9348	SPIRE int. harn. res.	35.57371	34.41599	33.26804	89.30352
9361	PM JFET int. hn. res.	13.7233	13.65319	11.45252	20.89433
9364	PM JFET int. hn. res.	14.55876	14.34836	12.97579	26.08908
9365	PM JFET int. hn. res.	21.6512	21.03723	19.8189	49.74457
9366	PM JFET int. hn. res.	30.9971	29.93992	28.66961	78.23265
9367	PM JFET int. hn. res.	41.79803	40.21982	38.6977	119.68317
9368	PM JFET int. hn. res.	46.87644	44.95174	43.19274	156.03576
9374	PM JFET int. hn. res.	14.69041	14.47267	13.1066	26.60553
9375	PM JFET int. hn. res.	22.2088	21.57067	20.34351	51.84766
9376	PM JFET int. hn. res.	31.97315	30.87979	29.57584	81.55055
9377	PM JFET int. hn. res.	41.98705	40.41359	38.89226	120.22843
9378	PM JFET int. hn. res.	46.82073	44.91926	43.17626	155.47193
9381	SM JFET int. hn. res.	13.60933	13.56068	11.45633	20.51052
9384	SM JFET int. hn. res.	14.78366	14.56189	13.19152	26.97607
9385	SM JFET int. hn. res.	21.66337	21.0528	19.76379	51.03501
9386	SM JFET int. hn. res.	30.81261	29.7688	28.36267	80.58731
9387	SM JFET int. hn. res.	42.00505	40.41153	38.77907	124.43831
9388	SM JFET int. hn. res.	47.21666	45.27748	43.41234	163.22214
9401	HIFI int. harn. 1	13.59716	13.4945	11.34258	19.97949
9402	HIFI int. harn. 1	13.87116	13.77717	11.30584	18.98909
9403	HIFI int. harn. 1	13.39542	13.3054	11.26898	17.94607
9404	HIFI int. harn. 1	12.75683	12.66639	11.25051	17.402
9405	HIFI int. harn. 1	18.30962	17.92044	16.56365	36.55813
9406	HIFI int. harn. 1	26.09544	25.35724	23.96348	59.51277
9407	HIFI int. harn. 1	32.69505	31.65998	30.40507	80.16053
9408	HIFI int. harn. 1	35.52131	34.36272	33.16913	89.23485
9409	HIFI int. harn. 1	42.25795	40.68285	38.87291	132.1928
9410	HIFI int. harn. 1	53.73712	51.41859	48.55719	203.62023
9411	HIFI int. harn. 1	63.61419	60.69828	57.01032	264.96446
9421	HIFI int. harn. 2	18.04534	17.96561	11.34465	19.99174
9422	HIFI int. harn. 2	20.18053	20.11344	11.31135	19.02406
9423	HIFI int. harn. 2	17.45942	17.38772	11.27797	18.00736
9424	HIFI int. harn. 2	12.78508	12.69381	11.26125	17.47812
9425	HIFI int. harn. 2	18.50429	18.11664	16.56524	36.86984
9426	HIFI int. harn. 2	26.26479	25.52344	24.00743	60.08846
9427	HIFI int. harn. 2	32.83407	31.79834	30.42863	80.6587
9428	HIFI int. harn. 2	35.55651	34.39472	33.19085	89.71232
9429	HIFI int. harn. 2	42.39927	40.81583	38.90966	132.62269
9430	HIFI int. harn. 2	53.91221	51.59004	48.60616	203.9873
9431	HIFI int. harn. 2	63.69814	60.78189	57.03175	265.10713
9441	HIFI int. harn. 3	13.51946	13.41625	11.34254	19.97923
9442	HIFI int. harn. 3	13.75517	13.66046	11.30572	18.98835
9443	HIFI int. harn. 3	13.32514	13.23471	11.26879	17.9448
9444	HIFI int. harn. 3	12.75646	12.66604	11.25029	17.40044
9445	HIFI int. harn. 3	18.30905	17.91997	16.56269	36.54675
9446	HIFI int. harn. 3	26.09387	25.35587	23.96168	59.49036
9447	HIFI int. harn. 3	32.69227	31.6575	30.40258	80.12283
9448	HIFI int. harn. 3	35.51778	34.35952	33.16636	89.189
9449	HIFI int. harn. 3	42.25621	40.68138	38.87093	132.16047
9450	HIFI int. harn. 3	53.73694	51.41856	48.55618	203.60419
9451	HIFI int. harn. 3	63.61439	60.69854	57.01002	264.95976
9461	HIFI int. harn. 4	17.61776	17.5363	11.34454	19.99113
9462	HIFI int. harn. 4	19.59435	19.5256	11.31106	19.02234
9463	HIFI int. harn. 4	17.06693	16.99379	11.2775	18.00436
9464	HIFI int. harn. 4	12.78368	12.69245	11.26068	17.47442

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
9465	HIFI int. harn. 4	18.50742	18.11988	16.56492	36.86612
9466	HIFI int. harn. 4	26.26503	25.52388	24.00543	60.07666
9467	HIFI int. harn. 4	32.83601	31.80037	30.42838	80.6556
9468	HIFI int. harn. 4	35.55668	34.39488	33.19104	89.71145
9469	HIFI int. harn. 4	42.4011	40.81748	38.91083	132.62908
9470	HIFI int. harn. 4	53.9145	51.59219	48.60776	203.9964
9471	HIFI int. harn. 4	63.69913	60.78284	57.03245	265.1111
9481	HIFI int. harn. 5	24.33705	24.27933	11.3384	19.95462
9482	HIFI int. harn. 5	28.48471	28.43864	11.29464	18.91811
9483	HIFI int. harn. 5	23.26948	23.21773	11.25071	17.82177
9484	HIFI int. harn. 5	12.75322	12.66448	11.22868	17.24763
9485	HIFI int. harn. 5	18.99675	18.62377	16.52712	35.74717
9486	HIFI int. harn. 5	26.27959	25.55527	23.83135	58.13525
9487	HIFI int. harn. 5	33.04518	32.02794	30.35253	79.16228
9488	HIFI int. harn. 5	35.48266	34.32917	33.13673	88.42945
9489	HIFI int. harn. 5	42.27771	40.73893	38.76101	131.11799
9490	HIFI int. harn. 5	53.79303	51.50784	48.384	202.4216
9491	HIFI int. harn. 5	63.66865	60.76667	56.93138	264.45784
9501	HIFI int. coax tube	13.7016	13.54146	12.10782	24.87169
9502	HIFI int. coax tube	15.4783	15.21146	13.86274	33.60501
9503	HIFI int. coax tube	16.99602	16.64599	15.32554	38.91276
9504	HIFI int. coax tube	32.76557	31.70659	30.10396	100.78502
9505	HIFI int. coax tube	42.51526	41.00782	39.01794	141.50696
9506	HIFI int. coax tube	51.35939	49.30984	46.73012	186.25626
9507	HIFI int. coax tube	55.97811	53.63195	50.71931	222.33024
9508	HIFI int. coax tube	62.33957	59.58285	56.19393	271.98159
9509	HIFI int. coax tube	64.53958	61.62541	58.05919	283.06743
9510	HIFI int. coax tube	65.81089	62.78553	59.09939	288.4613
9551	HIFI int. coax core	16.60447	16.36229	14.99519	44.06634
9552	HIFI int. coax core	18.94465	18.60071	17.16434	68.19399
9553	HIFI int. coax core	21.48106	21.00919	19.48017	92.38379
9554	HIFI int. coax core	25.60292	24.86098	23.04914	125.6064
9555	HIFI int. coax core	30.98827	29.73977	27.36881	160.66927
9556	HIFI int. coax core	38.11004	36.21042	33.12484	201.31633
9557	HIFI int. coax core	42.623	40.28401	36.68458	226.06473
9558	HIFI int. coax core	48.99355	46.37845	42.48049	259.89937
9559	HIFI int. coax core	54.04984	51.22767	47.30663	275.62165
9560	HIFI int. coax core	60.22115	57.15983	53.23671	286.2686
9700	HOT depl. harness on ISF	19.51408	18.75292	18.04323	54.30319
9801	Styc. Br. on TS1/strap 3	34.60115	33.51628	32.47911	77.3765
9802	Styc. Br. on TS1/strap 4	35.38246	34.23759	33.06654	87.16371
9803	Styc. Br. on TS1/strap 5	34.52156	33.438	32.41719	82.35106
9804	Styc. Br. on TS1/strap 6	34.53736	33.45338	32.43429	81.73409
9805	Styc. Br. on TS1/strap 7	35.40699	34.26498	33.13916	86.71402
9806	Styc. Br. on TS1/strap 8	34.17577	33.1254	32.14915	73.41859
9807	Styc. Br. on TS1/strap 1	33.66184	32.65976	31.69345	65.9508
9808	Styc. Br. on TS1/strap 2	33.55178	32.55809	31.61447	64.93441
9921	Cover Act. harn.	77.85982	74.88169	71.01326	293
9922	Cover Act. harn.	84.90778	81.95016	77.90689	293
9923	Cover Act. harn.	130.50591	123.53067	113.32968	292.99998
9924	Cover Act. harn.	153.68805	146.46347	135.50253	292.99984
18401	FRAME_pZ	88.27456	79.45484	76.87455	293
18402	FRAME_CORNER_mY	82.96569	75.26908	73.29871	293
18403	FRAME_mY	78.64744	71.81043	69.34219	293
18405	FRAME_pY	78.50051	71.6264	69.27078	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
18406	FRAME_CORNER_pY	82.91692	75.22509	73.26676	293
18411	TUBE_to_CVV_mYpZ	76.91674	70.90023	68.11293	293
18412	TUBE_to_CVV_mYmZ	76.03313	70.14454	67.41239	293
18415	TUBE_to_CVV_pYmZ	75.93562	70.04704	67.35534	293
18416	TUBE_to_CVV_pYpZ	76.87984	70.86693	68.09109	293
18421	TUBE_to_FRAME_I/F_mYpZ	82.81397	75.12704	73.1513	293
18422	TUBE_to_FRAME_I/F_mYmZ	82.37171	74.80033	72.85343	293
18423	TUBE_to_FRAME_I/F_mZmY	79.04109	72.51413	70.57647	293
18424	TUBE_to_FRAME_I/F_mZpY	78.90875	72.17989	70.49142	293
18425	TUBE_to_FRAME_I/F_pYmZ	82.33725	74.7692	72.83551	293
18426	TUBE_to_FRAME_I/F_pYpZ	82.79551	75.11192	73.14117	293
22100	Harn. Rail 2100 low	78.94908	73.77282	67.3319	293
22101	Harn. Rail 2100 upp	68.88413	65.57226	61.5837	293
22122	Harn. Rail 2122	68.14517	64.89607	60.89958	293
22300	Harn. Rail 2300	70.86142	67.15809	62.58443	293
22400	Harn. Rail 2400	69.62325	66.28284	61.83071	293
22526	Harn. Rail 2526	68.84353	65.54066	61.39352	293
22728	Harn. Rail 2728	69.12646	65.81777	61.61219	293
22900	Harn. Rail 2900	69.65069	66.32563	61.87068	293
23132	Harn. supp. tube LOU +z	143.21275	134.96413	125.46793	293
23334	Harn. supp. tube LOU -z	135.61294	128.72466	118.16583	293
23800	Harn. Rail 3800	66.72445	63.60456	59.80503	293
23900	Harn. Rail 3900	66.09702	63.05209	59.32565	293
24041	Harn. Rail 4041	66.0332	63.01433	59.31775	293
24132	Harn. Rail 3132	68.88469	65.59287	61.36345	293
24200	Harn. Rail 4200	66.17474	63.14386	59.49355	293
24334	Harn. Rail 3334	66.87139	63.74856	59.94763	293
24344	Harn. Rail 4344	66.43249	63.35655	59.66935	293
65011	STRUT1_CVVSVM_MLI	210.24054	204.37108	179.6811	293
65012	STRUT1_CVVSVM_MLI	205.71477	199.48478	174.23783	293
65013	STRUT1_CVVSVM_MLI	207.0413	200.22319	173.64045	293
65014	STRUT1_CVVSVM_MLI	214.45198	208.98086	181.02782	293
65015	STRUT1_CVVSVM_MLI	180.9382	172.66979	159.09283	293
65016	STRUT1_CVVSVM_MLI	179.35278	170.95684	155.45284	293
65017	STRUT1_CVVSVM_MLI	178.40171	166.9199	152.38631	293
65018	STRUT1_CVVSVM_MLI	178.39322	167.57072	155.50811	293
65019	STRUT1_CVVSVM_MLI	164.41284	153.02436	149.3403	293
65020	STRUT1_CVVSVM_MLI	162.68303	150.94473	145.10194	293
65021	STRUT1_CVVSVM_MLI	166.83455	153.56945	144.67928	293
65022	STRUT1_CVVSVM_MLI	166.40128	154.18203	148.70114	293
65111	STRUT2_CVVSVM_MLI	188.05687	179.75534	162.82019	293
65112	STRUT2_CVVSVM_MLI	189.75701	183.79573	162.26397	293
65113	STRUT2_CVVSVM_MLI	191.79233	183.31831	161.08756	293
65114	STRUT2_CVVSVM_MLI	191.58152	182.1647	163.37317	293
65115	STRUT2_CVVSVM_MLI	175.63836	164.76644	154.63311	293
65116	STRUT2_CVVSVM_MLI	164.98642	155.30403	143.71159	293
65117	STRUT2_CVVSVM_MLI	174.96833	163.00666	148.3436	293
65118	STRUT2_CVVSVM_MLI	178.54105	166.5781	154.05383	293
65119	STRUT2_CVVSVM_MLI	167.39417	155.92528	149.7623	293
65120	STRUT2_CVVSVM_MLI	154.29776	143.86996	137.29744	293
65121	STRUT2_CVVSVM_MLI	166.56986	153.77942	142.95133	293
65122	STRUT2_CVVSVM_MLI	171.5141	158.94779	150.07109	293
65211	STRUT3_CVVSVM_MLI	202.76962	196.15927	172.7986	293
65212	STRUT3_CVVSVM_MLI	190.73446	183.18817	160.2316	293
65213	STRUT3_CVVSVM_MLI	196.55946	187.83485	163.9123	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
65214	STRUT3_CVVSVM_MLI	213.41116	207.20007	180.50299	293
65215	STRUT3_CVVSVM_MLI	176.17512	165.44935	154.29995	293
65216	STRUT3_CVVSVM_MLI	170.78695	159.85722	145.23802	293
65217	STRUT3_CVVSVM_MLI	177.41707	165.10752	148.49929	293
65218	STRUT3_CVVSVM_MLI	179.40746	167.72923	154.53662	293
65219	STRUT3_CVVSVM_MLI	161.4627	150.47074	143.57242	293
65220	STRUT3_CVVSVM_MLI	153.48178	142.44474	131.66303	293
65221	STRUT3_CVVSVM_MLI	164.59325	151.56749	138.11957	293
65222	STRUT3_CVVSVM_MLI	168.70114	156.7078	148.7276	293
65311	STRUT4_CVVSVM_MLI	214.63591	210.24145	179.46543	293
65312	STRUT4_CVVSVM_MLI	224.0161	220.71524	187.11189	293
65313	STRUT4_CVVSVM_MLI	222.91135	218.88635	184.91338	293
65314	STRUT4_CVVSVM_MLI	215.29492	210.28767	179.20558	293
65315	STRUT4_CVVSVM_MLI	163.77739	155.28076	140.96816	293
65316	STRUT4_CVVSVM_MLI	158.18298	150.69589	134.29937	293
65317	STRUT4_CVVSVM_MLI	171.09286	160.6152	143.0279	293
65318	STRUT4_CVVSVM_MLI	174.42438	163.78388	148.27918	293
65319	STRUT4_CVVSVM_MLI	146.02246	135.6492	129.71308	293
65320	STRUT4_CVVSVM_MLI	130.97129	122.02426	115.25622	293
65321	STRUT4_CVVSVM_MLI	153.32097	141.09297	130.67204	293
65322	STRUT4_CVVSVM_MLI	158.76553	146.28106	136.99436	293
65411	STRUT5_CVVSVM_MLI	191.1207	185.0741	161.70394	293
65412	STRUT5_CVVSVM_MLI	192.83509	185.19514	159.83089	293
65413	STRUT5_CVVSVM_MLI	196.78874	188.146	162.98967	293
65414	STRUT5_CVVSVM_MLI	198.8034	191.2934	167.85275	293
65415	STRUT5_CVVSVM_MLI	165.9853	156.38329	142.7856	293
65416	STRUT5_CVVSVM_MLI	170.24688	158.76576	141.71648	293
65417	STRUT5_CVVSVM_MLI	171.19998	159.13117	141.67097	293
65418	STRUT5_CVVSVM_MLI	173.43561	162.26033	148.27842	293
65419	STRUT5_CVVSVM_MLI	144.78872	135.23298	128.8578	293
65420	STRUT5_CVVSVM_MLI	130.41	122.15722	114.39659	293
65421	STRUT5_CVVSVM_MLI	136.31174	126.62325	116.97168	293
65422	STRUT5_CVVSVM_MLI	162.86101	151.75621	143.01194	293
65511	STRUT6_CVVSVM_MLI	200.24425	192.73005	167.14406	293
65512	STRUT6_CVVSVM_MLI	202.79676	197.93696	170.23304	293
65513	STRUT6_CVVSVM_MLI	208.38903	203.11202	175.19637	293
65514	STRUT6_CVVSVM_MLI	198.59636	190.6153	164.89216	293
65611	STRUT7_CVVSVM_MLI	197.6617	193.23435	166.19031	293
65612	STRUT7_CVVSVM_MLI	191.63625	187.02454	159.75748	293
65613	STRUT7_CVVSVM_MLI	195.93441	189.87801	163.09289	293
65614	STRUT7_CVVSVM_MLI	207.79136	203.11712	175.29899	293
65711	STRUT8_CVVSVM_MLI	191.5517	186.93806	159.82536	293
65712	STRUT8_CVVSVM_MLI	192.86974	189.59848	161.78835	293
65713	STRUT8_CVVSVM_MLI	204.22798	200.77735	172.03172	293
65714	STRUT8_CVVSVM_MLI	194.19045	188.56189	161.64722	293
65811	STRUT9_CVVSVM_MLI	192.84957	189.72069	161.74499	293
65812	STRUT9_CVVSVM_MLI	188.10254	184.35175	156.84165	293
65813	STRUT9_CVVSVM_MLI	191.8239	186.72161	159.38671	293
65814	STRUT9_CVVSVM_MLI	204.69687	201.20042	172.4714	293
65911	STRUT10_CVVSVM_MLI	188.43986	184.68049	157.30448	293
65912	STRUT10_CVVSVM_MLI	192.01296	189.39709	161.4908	293
65913	STRUT10_CVVSVM_MLI	203.6785	200.77659	172.0493	293
65914	STRUT10_CVVSVM_MLI	191.35208	186.45616	159.15052	293
66011	STRUT11_CVVSVM_MLI	193.98508	191.45173	163.41943	293
66012	STRUT11_CVVSVM_MLI	186.92999	183.43847	156.03914	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
66013	STRUT11_CVVSVM_MLI	190.09213	185.40066	158.04424	293
66014	STRUT11_CVVSVM_MLI	203.34897	200.26184	171.87029	293
66111	STRUT12_CVVSVM_MLI	186.88582	183.42377	155.93137	293
66112	STRUT12_CVVSVM_MLI	191.81599	189.30546	161.29397	293
66113	STRUT12_CVVSVM_MLI	203.27246	200.34482	171.47348	293
66114	STRUT12_CVVSVM_MLI	189.94266	185.31029	157.85115	293
66211	STRUT13_CVVSVM_MLI	195.70056	193.15861	164.86684	293
66212	STRUT13_CVVSVM_MLI	188.22081	184.47283	157.10944	293
66213	STRUT13_CVVSVM_MLI	191.02362	186.15526	158.83232	293
66214	STRUT13_CVVSVM_MLI	203.00228	199.96787	171.16621	293
66311	STRUT14_CVVSVM_MLI	187.77999	184.10473	156.56084	293
66312	STRUT14_CVVSVM_MLI	195.55362	192.72313	164.41652	293
66313	STRUT14_CVVSVM_MLI	202.77983	199.40815	170.76124	293
66314	STRUT14_CVVSVM_MLI	191.09059	186.17221	158.77891	293
66411	STRUT15_CVVSVM_MLI	192.22431	189.19354	161.29194	293
66412	STRUT15_CVVSVM_MLI	190.19574	185.9165	158.68404	293
66413	STRUT15_CVVSVM_MLI	192.76216	187.42868	160.32807	293
66414	STRUT15_CVVSVM_MLI	202.28126	198.95819	170.23928	293
66511	STRUT16_CVVSVM_MLI	191.64228	187.55197	159.92832	293
66512	STRUT16_CVVSVM_MLI	194.05055	190.27512	162.73785	293
66513	STRUT16_CVVSVM_MLI	204.79078	200.85228	172.53164	293
66514	STRUT16_CVVSVM_MLI	195.2608	189.81358	162.63009	293
66611	STRUT17_CVVSVM_MLI	195.263	191.48373	164.06252	293
66612	STRUT17_CVVSVM_MLI	194.10268	188.81129	162.81694	293
66613	STRUT17_CVVSVM_MLI	196.0803	189.92591	163.82727	293
66614	STRUT17_CVVSVM_MLI	204.99938	201.13223	172.84801	293
66711	STRUT18_CVVSVM_MLI	188.86153	182.9732	157.79444	293
66712	STRUT18_CVVSVM_MLI	197.78805	193.16623	167.72248	293
66713	STRUT18_CVVSVM_MLI	205.6683	201.18999	174.85702	293
66714	STRUT18_CVVSVM_MLI	194.27872	187.76982	162.4704	293
66811	STRUT19_CVVSVM_MLI	176.48934	169.95773	147.93272	293
66812	STRUT19_CVVSVM_MLI	185.67865	177.49565	157.92354	293
66813	STRUT19_CVVSVM_MLI	188.82017	179.54446	157.53613	293
66814	STRUT19_CVVSVM_MLI	188.11888	180.84332	155.99156	293
66815	STRUT19_CVVSVM_MLI	152.83057	144.53037	130.51276	293
66816	STRUT19_CVVSVM_MLI	170.30697	159.45358	146.52571	293
66817	STRUT19_CVVSVM_MLI	174.38442	162.24762	146.37257	293
66818	STRUT19_CVVSVM_MLI	159.17283	149.39637	132.42742	293
66819	STRUT19_CVVSVM_MLI	137.24195	128.03041	120.55192	293
66820	STRUT19_CVVSVM_MLI	158.28398	147.29855	138.38178	293
66821	STRUT19_CVVSVM_MLI	165.48569	152.40983	140.02059	293
66822	STRUT19_CVVSVM_MLI	126.54033	118.11826	108.29622	293
66911	STRUT20_CVVSVM_MLI	202.14573	192.84533	170.45681	293
66912	STRUT20_CVVSVM_MLI	222.31483	213.92401	188.35314	293
66913	STRUT20_CVVSVM_MLI	215.5297	205.9639	180.39169	293
66914	STRUT20_CVVSVM_MLI	199.37001	189.06147	165.79451	293
66915	STRUT20_CVVSVM_MLI	178.38058	165.03982	152.41621	293
66916	STRUT20_CVVSVM_MLI	182.59397	169.26379	157.89279	293
66917	STRUT20_CVVSVM_MLI	176.79342	161.92938	149.08357	293
66918	STRUT20_CVVSVM_MLI	178.34384	163.97715	148.04219	293
66919	STRUT20_CVVSVM_MLI	158.82469	146.55067	137.50397	293
66920	STRUT20_CVVSVM_MLI	166.49663	154.03548	147.25332	293
66921	STRUT20_CVVSVM_MLI	170.11071	156.00671	144.56347	293
66922	STRUT20_CVVSVM_MLI	163.69372	149.89946	136.50697	293
67011	STRUT21_CVVSVM_MLI	179.51215	171.17992	155.27681	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
67012	STRUT21_CVVSVM_MLI	187.39237	177.41548	162.27123	293
67013	STRUT21_CVVSVM_MLI	187.18829	176.53869	158.16715	293
67014	STRUT21_CVVSVM_MLI	188.61701	180.50726	158.96629	293
67015	STRUT21_CVVSVM_MLI	168.08489	157.80643	147.41176	293
67016	STRUT21_CVVSVM_MLI	179.35784	167.57934	156.82538	293
67017	STRUT21_CVVSVM_MLI	178.70197	166.07701	152.01278	293
67018	STRUT21_CVVSVM_MLI	168.85305	157.62881	143.69591	293
67019	STRUT21_CVVSVM_MLI	160.47031	149.76832	142.76643	293
67020	STRUT21_CVVSVM_MLI	172.50445	160.62144	152.82708	293
67021	STRUT21_CVVSVM_MLI	174.04039	160.94419	150.29584	293
67022	STRUT21_CVVSVM_MLI	153.99833	143.38195	134.30048	293
67111	STRUT22_CVVSVM_MLI	206.77305	200.64403	176.25296	293
67112	STRUT22_CVVSVM_MLI	213.84724	208.61391	181.95058	293
67113	STRUT22_CVVSVM_MLI	211.03788	204.88401	177.16131	293
67114	STRUT22_CVVSVM_MLI	205.91256	199.40161	173.01583	293
67115	STRUT22_CVVSVM_MLI	177.43156	167.29064	156.20524	293
67116	STRUT22_CVVSVM_MLI	178.15789	168.06882	157.3743	293
67117	STRUT22_CVVSVM_MLI	179.30065	168.08974	154.12128	293
67118	STRUT22_CVVSVM_MLI	176.59362	165.7022	151.45959	293
67119	STRUT22_CVVSVM_MLI	162.72551	151.37857	146.72871	293
67120	STRUT22_CVVSVM_MLI	164.21188	152.79981	148.93103	293
67121	STRUT22_CVVSVM_MLI	167.25872	154.35629	146.93278	293
67122	STRUT22_CVVSVM_MLI	163.66155	151.04809	142.93415	293
67211	STRUT23_CVVSVM_MLI	209.7014	204.06582	178.99175	293
67212	STRUT23_CVVSVM_MLI	208.14903	201.57475	177.08258	293
67213	STRUT23_CVVSVM_MLI	207.92811	201.07619	174.72872	293
67214	STRUT23_CVVSVM_MLI	213.86694	208.67223	179.97148	293
67215	STRUT23_CVVSVM_MLI	176.84601	166.97535	156.48547	293
67216	STRUT23_CVVSVM_MLI	180.69325	169.98039	158.37383	293
67217	STRUT23_CVVSVM_MLI	180.03131	168.64159	154.45487	293
67218	STRUT23_CVVSVM_MLI	175.64534	165.22719	152.18085	293
67219	STRUT23_CVVSVM_MLI	162.55632	151.29575	147.65499	293
67220	STRUT23_CVVSVM_MLI	167.57165	155.47901	150.29504	293
67221	STRUT23_CVVSVM_MLI	168.70116	155.45826	147.48192	293
67222	STRUT23_CVVSVM_MLI	162.14236	150.13758	144.34841	293
67311	STRUT24_CVVSVM_MLI	208.36455	201.93379	178.01392	293
67312	STRUT24_CVVSVM_MLI	212.77553	207.79233	180.55631	293
67313	STRUT24_CVVSVM_MLI	211.00345	204.84896	177.03066	293
67314	STRUT24_CVVSVM_MLI	207.61646	200.80222	175.27396	293
67315	STRUT24_CVVSVM_MLI	180.57064	170.11966	159.3633	293
67316	STRUT24_CVVSVM_MLI	174.78506	165.03243	153.75254	293
67317	STRUT24_CVVSVM_MLI	178.98204	167.77909	153.60918	293
67318	STRUT24_CVVSVM_MLI	179.83244	168.70729	155.44311	293
67319	STRUT24_CVVSVM_MLI	166.20617	154.53385	150.36663	293
67320	STRUT24_CVVSVM_MLI	160.40809	149.19447	145.10846	293
67321	STRUT24_CVVSVM_MLI	167.13257	154.22592	146.77927	293
67322	STRUT24_CVVSVM_MLI	168.07987	155.24455	148.24501	293
	EPLM:PACS				
711	Top Optic Housing	3.26744	3.22823	2.8298	9.94621
712	Spectrometer Housing	3.26789	3.22923	2.82948	9.87769
713	Collimator Housing	3.25961	3.2213	2.82431	9.83343
714	Photometer Optic Hous.	3.04801	3.01879	2.68065	8.29593
721	2K Feed-Through Red D	1.79413	1.78132	1.69602	2.65119
722	2K Feed-Through Blue D	1.99676	1.98188	1.78575	3.4695

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
723	2K StSt I/F Blue Det.	1.67491	1.66421	1.61009	1.90056
724	2K_StSt I/F Red Det.	1.67032	1.65953	1.61044	1.90279
731	Grating Assy	3.27208	3.23389	2.82431	9.83343
741	Red Detector *	1.8759	1.86241	1.75522	2.96142
742	Red Detector CRE	3.27455	3.23625	2.81545	9.79666
743	CFRP-Strut Red Det.	2.57188	2.54582	2.29235	7.05665
744	Harness Red Det. Int	2.58063	2.55456	2.28847	7.39195
751	Blue Detector *	2.08539	2.07012	1.83712	3.69351
752	Blue Detector CRE	3.27707	3.23876	2.81651	9.80024
753	CFRP-Strut Blue Det.	2.67663	2.64968	2.3333	7.29693
754	Harness Blue Det. Int	2.68514	2.65822	2.32949	7.52192
761	Photometer Cooler Pump	1.67364	1.66319	1.59976	1.83283
762	Photometer Cooler Evap	1.6566	1.64589	1.59793	1.8258
763	Photometer Buffer *	1.70086	1.69004	1.61172	1.99097
771	CFRP-Strut (OB) 1	9.3334	9.2428	8.05302	16.16239
772	CFRP-Strut (OB) 2	9.27181	9.18513	8.01629	15.03332
773	CFRP-Strut (OB) 3	9.33445	9.24365	8.05399	16.18806
781	Level 1,1 I/F	2.69898	2.68309	2.42902	6.10302
782	Level 1,2 I/F	3.03433	3.01317	2.68158	7.45561
783	Level 1,3 I/F	3.18899	3.16274	2.79075	8.11977
	EPLM:SPIRE				
800	L1 Strap IF1 @ SOB	4.74685	4.72517	4.14995	11.90531
801	PH_JFET_ENCLOSURE	13.7229	13.65285	11.45192	20.89011
802	SP_JFET_ENCLOSURE	13.6091	13.56048	11.45605	20.5084
803	FPU_OPTICAL_BENCH	4.80394	4.77832	4.1871	13.15062
804	RF_FILTER_BOXES	4.86621	4.84009	4.23893	13.17698
805	BSM	4.81563	4.79008	4.1871	13.15062
806	SMECm	4.82707	4.80159	4.1871	13.15062
807	PH_CALIB	4.81581	4.79026	4.1871	13.15062
808	SPEC_CALIB	4.80394	4.77832	4.1871	13.15062
809	PH_DETECTOR_ENCLOSURE	1.6928	1.68201	1.62878	2.23667
810	SP_DETECTOR_ENCLOSURE	1.67587	1.66523	1.61612	2.02723
811	L0 Enclosure Flexible S	1.67312	1.6625	1.61398	1.99889
812	L0 Pump Flexible Strap	1.70358	1.69311	1.60738	1.8936
813	L0 Evap Flexible Strap	1.6595	1.6488	1.59982	1.83995
814	L0 Enclosure External S	1.66996	1.65936	1.6116	1.96592
815	L0 Pump External Strap	1.69257	1.68217	1.6051	1.87169
816	L0 Evaporator External	1.65423	1.64355	1.59744	1.81694
817	COOLER_PUMP	1.72883	1.71848	1.76339	3.55128
818	COOLER_SHUNT	1.66083	1.65012	1.60099	1.85235
819	COOLER_EVAP	0.28	0.28	1.6609	2.62172
820	COOLER_EVAP_HS	1.6609	1.65019	1.60094	1.85151
821	COOLER_PUMP_HS	1.70787	1.69741	1.60848	1.9046
822	PH_DETECTORS	0.28152	0.2815	1.6609	2.62164
823	SP DETECTORS	0.28382	0.28377	1.66074	2.61869
830	L1 Strap IF2 @ SOB	4.74685	4.72518	4.14995	11.9054
831	PH_L3 IF	13.55143	13.48684	11.44582	20.48079
832	SP_L3 IF	13.57641	13.53149	11.45339	20.41527
	EPLM:HIFI				
910	HIFI_FPU_Main_structure	12.96503	12.8534	11.36458	20.55157
911	Calibration_source_assem	12.969	12.85742	11.36458	20.55157
912	Focal_Plane_Chopper	12.96821	12.85661	11.36458	20.55157
913	Diplexer_Rooftop_Transla	12.96503	12.8534	11.36458	20.55157

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
914	Second_stage_amplifier	12.98409	12.87266	11.36458	20.55157
919	L2-boundary	12.96038	12.8492	11.36856	20.34051
920	Mixer_Sub_Assembly	12.94178	12.8309	11.33093	20.46493
921	First_stage_amplifier	12.9577	12.84699	11.33093	20.46493
922	EMC-filtering	12.94847	12.83766	11.33093	20.46493
925	Magnet_current_dissipati	10.14278	10.0826	8.94349	15.77036
930	Console_level1_decks	5.91452	5.95784	5.30683	8.94227
935	Magnet_current_dissipati	4.51454	4.54359	4.06624	6.76427
939	L1_boundary	5.88526	5.92974	5.28352	8.8846
940	Console_level0_decks	1.97942	1.96992	1.85233	2.69697
941	Mixer_Unit	1.98428	1.97481	1.85233	2.69697
942	Heater	1.97942	1.96992	1.85233	2.69697
943	LO-power	1.98015	1.97065	1.85233	2.69697
949	L0-boundary	1.96825	1.95849	1.84376	2.65695
	EPLM:CCC				
4800	Cryostat Cover door	66.28101	62.16986	58.96374	293
4801	Cover Heat Shield CHS	65.54877	61.04032	58.12702	237.42108
4802	Internal MLI -X side	65.70045	61.27154	58.29746	251.75313
4803	Internal MLI +X side	66.13946	61.94859	58.79904	284.27397
4810	Inlet Junction	66.21104	62.0613	58.88269	288.27276
4811	Outlet Junction	66.21104	62.0613	58.88269	288.27276
4820	Cover Dewar	4.2	4.2	4.2	4.2
4821	GHe cover dome inlet	5	5	5	5
4822	GHe cover shield outlet	5	5	5	5
4823	GHe cover dome outlet	5	5	5	5
	EPLM:HSS				
7000	SOLGEN CELLS Mid low	396.24218	371.24837	371.17771	293
7001	SOLGEN CELLS -Y low	375.6187	351.93652	351.85806	293
7002	SOLGEN CELLS +Y low	375.70372	352.04482	352.00081	293
7010	SOLGEN CELLS Mid cent	397.53153	372.50356	372.50052	293
7011	SOLGEN CELLS -Y cent	376.4956	352.80091	352.79688	293
7012	SOLGEN CELLS +Y cent	376.49512	352.80106	352.79791	293
7020	SOLGEN CELLS Mid up	395.57017	370.23703	370.23352	293
7021	SOLGEN CELLS -Y up	374.49413	350.36598	350.34342	293
7022	SOLGEN CELLS +Y up	374.48553	350.35706	350.33469	293
7050	SUNSHADE OSR Mid low	277.69929	224.04596	224.0373	293
7051	SUNSHADE OSR -Y low	260.70229	210.66835	210.65855	293
7052	SUNSHADE OSR +Y low	260.69964	210.66454	210.65578	293
7053	SUNSHADE flap -Y	220.43029	182.98197	182.97107	293
7054	SUNSHADE flap +Y	220.43094	182.98129	182.97201	293
7060	SUNSHADE OSR Mid lcen	276.18546	219.38686	219.38486	293
7061	SUNSHADE OSR -Y lcen	258.43187	205.1362	205.13279	293
7062	SUNSHADE OSR +Y lcen	258.43168	205.13568	205.13261	293
7070	SUNSHADE OSR Mid ucen	276.11541	219.09748	219.09727	293
7071	SUNSHADE OSR -Y ucen	258.43893	204.93145	204.92999	293
7072	SUNSHADE OSR +Y ucen	258.43876	204.93115	204.9299	293
7080	SUNSHADE OSR Mid up	276.15398	219.12818	219.12814	293
7081	SUNSHADE OSR -Y up	261.46478	207.41497	207.41478	293
7082	SUNSHADE OSR +Y up	261.46471	207.41489	207.41472	293
7100	SOLGEN MLI Mid low	271.57456	254.03003	253.17514	293
7101	SOLGEN MLI -Y low	258.55638	241.76463	240.55929	293
7102	SOLGEN MLI +Y low	258.12107	241.38401	240.32585	293
7103	SOLGEN -x rib MLI +Z low	282.3901	263.49635	261.24161	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
7104	SOLGEN -x rib MLI -Y low	267.66249	249.6491	246.8595	293
7105	SOLGEN -x rib MLI +Y low	267.50552	249.51525	246.78736	293
7106	SOLGEN -x rib MLI +Z up	269.9387	252.65932	252.24125	293
7107	SOLGEN -x rib MLI -Y up	256.10657	239.71986	239.27412	293
7108	SOLGEN -x rib MLI +Y up	255.8027	239.44865	239.08784	293
7110	SOLGEN MLI Mid cent	269.59695	252.36763	251.90992	293
7111	SOLGEN MLI -Y cent	256.17288	239.78289	239.22926	293
7112	SOLGEN MLI +Y cent	255.84503	239.46957	238.99251	293
7120	SOLGEN MLI Mid up	268.78119	251.3584	250.94062	293
7121	SOLGEN MLI -Y up	255.17771	238.535	238.03028	293
7122	SOLGEN MLI +Y up	254.81107	238.18417	237.75046	293
7130	SOLGEN MLI Mid up2	267.02563	249.57611	249.40933	293
7131	SOLGEN MLI -Y up2	253.24944	236.57766	236.35574	293
7132	SOLGEN MLI +Y up2	253.25659	236.58071	236.38184	293
7133	SOLGEN +x rib MLI +Z low	270.47152	252.88542	252.32578	293
7134	SOLGEN +x rib MLI -Y low	257.06833	240.24674	239.59666	293
7135	SOLGEN +x rib MLI +Y low	256.80545	239.99848	239.41748	293
7136	SOLGEN +x rib MLI +Z up	268.13852	250.38928	250.17653	293
7137	SOLGEN +x rib MLI -Y up	254.64144	237.64907	237.39431	293
7138	SOLGEN +x rib MLI +Y up	254.4916	237.50926	237.27257	293
7140	SUNSHADE MLI Mid low2	202.45109	167.8159	167.20425	293
7141	SUNSHADE MLI -Y low2	191.66558	159.72561	158.92703	293
7142	SUNSHADE MLI +Y low2	191.40776	159.39391	158.69193	293
7143	SSHADE rib MLI +Z low	201.02184	169.32434	168.45496	293
7144	SSHADE rib MLI -Y low	190.7219	161.51203	160.38208	293
7145	SSHADE rib MLI +Y low	190.29448	160.95213	159.96257	293
7146	SSHADE rib MLI +Z up	192.85846	158.26342	157.77688	293
7147	SSHADE rib MLI -Y up	181.72873	149.57346	149.07568	293
7148	SSHADE rib MLI +Y up	181.55438	149.35586	148.89412	293
7150	SUNSHADE MLI Mid low	199.54231	163.44328	162.99417	293
7151	SUNSHADE MLI -Y low	188.47613	155.09104	154.57349	293
7152	SUNSHADE MLI +Y low	188.321	154.87758	154.40458	293
7153	SUNSHADE flap MLI -Y	166.07801	140.78214	140.17226	293
7154	SUNSHADE flap MLI +Y	166.11886	140.82529	140.23219	293
7160	SUNSHADE MLI Mid lcen	195.46802	156.92415	156.66218	293
7161	SUNSHADE MLI -Y lcen	183.66973	147.81887	147.48006	293
7162	SUNSHADE MLI +Y lcen	183.64307	147.7773	147.46051	293
7170	SUNSHADE MLI Mid ucen	191.93348	152.39807	152.38387	293
7171	SUNSHADE MLI -Y ucen	179.971	142.9164	142.87231	293
7172	SUNSHADE MLI +Y ucen	179.92982	142.87245	142.83554	293
7180	SUNSHADE MLI Mid up	191.69515	152.15307	152.14687	293
7181	SUNSHADE MLI -Y up	181.72096	144.22253	144.21184	293
7182	SUNSHADE MLI +Y up	181.71055	144.21299	144.20183	293
7203	SShld SVM gapMLI mX	255.54637	233.79674	212.89855	293
7204	SShld SVM gapMLI mY mX	253.46618	231.95649	211.30789	293
7205	SShld SVM gapMLI pY mX	252.76284	231.30333	210.69653	293
7206	SShld SVM gapMLI pX	229.76685	211.42857	200.25174	293
7207	SShld SVM gapMLI mY pX	216.03634	198.58986	186.63381	293
7208	SShld SVM gapMLI pY pX	215.44898	198.03398	186.18585	293
7301	STRUT_HSSSVM_01_SVM_end	276.29155	259.34865	248.02077	293
7302	STRUT_HSSSVM_01	276.41417	260.70679	251.61317	293
7303	STRUT_HSSSVM_01	279.78569	264.77719	257.56717	293
7304	STRUT_HSSSVM_01	286.49163	271.64588	265.99829	293
7305	STRUT_HSSSVM_01_HSS_end	296.69351	281.45994	277.08264	293
7321	STRUT_HSSSVM_02_SVM_end	274.62433	257.60885	246.0558	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
7322	STRUT_HSSSVM_02	274.42428	258.69148	249.44505	293
7323	STRUT_HSSSVM_02	277.59752	262.59195	255.26999	293
7324	STRUT_HSSSVM_02	284.21837	269.3899	263.65182	293
7325	STRUT_HSSSVM_02_HSS_end	294.43767	279.22565	274.76328	293
7341	STRUT_HSSSVM_03_SVM_end	274.70803	257.68101	246.10279	293
7342	STRUT_HSSSVM_03	274.51706	258.77114	249.49809	293
7343	STRUT_HSSSVM_03	277.6878	262.66921	255.32201	293
7344	STRUT_HSSSVM_03	284.29538	269.45577	263.69551	293
7345	STRUT_HSSSVM_03_HSS_end	294.49412	279.27413	274.79366	293
7361	STRUT_HSSSVM_04_SVM_end	275.38446	258.39992	246.87871	293
7362	STRUT_HSSSVM_04	275.2816	259.53586	250.23409	293
7363	STRUT_HSSSVM_04	278.36191	263.32747	255.89514	293
7364	STRUT_HSSSVM_04	284.69699	269.84986	263.96978	293
7365	STRUT_HSSSVM_04_HSS_end	294.45318	279.25348	274.63416	293
7401	STRUT_HSSCVV_05_CVV_end	91.93056	87.50616	84.65362	293
7402	STRUT_HSSCVV_05	133.64018	127.64102	125.92039	293
7403	STRUT_HSSCVV_05	170.75162	163.79742	162.7978	293
7404	STRUT_HSSCVV_05	215.89201	207.19165	206.68255	293
7405	STRUT_HSSCVV_05_HSS_end	289.03518	275.24916	275.07125	293
7421	STRUT_HSSCVV_06_CVV_end	100.86655	94.67139	91.51366	293
7422	STRUT_HSSCVV_06	144.54329	136.75609	134.76229	293
7423	STRUT_HSSCVV_06	181.154	172.76684	171.56548	293
7424	STRUT_HSSCVV_06	224.66172	214.95249	214.33524	293
7425	STRUT_HSSCVV_06_HSS_end	294.70274	280.2918	280.08055	293
7441	STRUT_HSSCVV_07_CVV_end	101.10759	94.87482	91.65927	293
7442	STRUT_HSSCVV_07	144.95629	137.10575	135.01595	293
7443	STRUT_HSSCVV_07	181.6095	173.15182	171.85687	293
7444	STRUT_HSSCVV_07	224.99871	215.23723	214.55416	293
7445	STRUT_HSSCVV_07_HSS_end	294.80426	280.3799	280.14461	293
7461	STRUT_HSSCVV_08_CVV_end	93.3058	88.5978	85.51588	293
7462	STRUT_HSSCVV_08	134.69365	128.50341	126.57428	293
7463	STRUT_HSSCVV_08	171.95038	164.76112	163.5787	293
7464	STRUT_HSSCVV_08	216.46504	207.66317	207.062	293
7465	STRUT_HSSCVV_08_HSS_end	289.16281	275.35692	275.14997	293
7501	STRUT_HSSCVV_09_CVV_end	85.22964	78.48592	75.44724	293
7502	STRUT_HSSCVV_09	116.47317	104.55165	102.5827	293
7503	STRUT_HSSCVV_09	144.76935	128.17954	126.90947	293
7504	STRUT_HSSCVV_09	175.80558	152.76758	152.04705	293
7505	STRUT_HSSCVV_09_HSS_end	219.47664	184.4495	184.20031	293
7521	STRUT_HSSCVV_10_CVV_end	91.03416	83.21486	80.0527	293
7522	STRUT_HSSCVV_10	126.72343	113.25697	111.12745	293
7523	STRUT_HSSCVV_10	156.14177	138.14879	136.75217	293
7524	STRUT_HSSCVV_10	187.85563	163.43587	162.63418	293
7525	STRUT_HSSCVV_10_HSS_end	233.61201	196.53064	196.2343	293
7541	STRUT_HSSCVV_11_CVV_end	91.24944	83.4125	80.19607	293
7542	STRUT_HSSCVV_11	127.06349	113.58061	111.39589	293
7543	STRUT_HSSCVV_11	156.51924	138.50535	137.05333	293
7544	STRUT_HSSCVV_11	188.12608	163.69959	162.85519	293
7545	STRUT_HSSCVV_11_HSS_end	233.71888	196.63593	196.32177	293
7561	STRUT_HSSCVV_12_CVV_end	85.52285	78.74649	75.63681	293
7562	STRUT_HSSCVV_12	116.92929	104.97208	102.90473	293
7563	STRUT_HSSCVV_12	145.14538	128.54595	127.18706	293
7564	STRUT_HSSCVV_12	176.03307	153.00419	152.22564	293
7565	STRUT_HSSCVV_12_HSS_end	219.52589	184.51198	184.24302	293
7601	STRUT_HSSCVV_13_SSH_end	328.23847	303.40671	303.3714	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
7602	STRUT_HSSCVV_13_SSD_end	276.43764	238.42011	238.39036	293
7621	STRUT_HSSCVV_14_SSH_end	328.26835	303.43244	303.39305	293
7622	STRUT_HSSCVV_14_SSD_end	276.45705	238.43827	238.40416	293
	EPLM:TEL				
8001	TEL_M1_MIRROR	85.10019	76.44798	74.67525	293
8002	TEL_M1_MIRROR	85.12242	76.46321	74.69062	293
8003	TEL_M1_MIRROR	85.05399	76.41309	74.64152	293
8004	TEL_M1_MIRROR	85.07316	76.42599	74.6544	293
8005	TEL_M1_MIRROR	85.09944	76.44726	74.6747	293
8006	TEL_M1_MIRROR	85.12143	76.46231	74.68991	293
8040	TEL_HEXAPOD	82.43116	74.36264	72.79521	293
8050	TEL_M2_MIRROR	82.42604	74.35911	72.79181	293
8060	TEL_M2_SCREEN	66.58367	57.92987	57.02277	293
8070	TEL_M2_HEATER	81.8923	73.84732	72.27908	293
8101	TEL_M1_SLI1	92.58654	83.30377	81.53902	293
8102	TEL_M1_SLI1	92.54938	83.19928	81.43217	293
8103	TEL_M1_SLI1	92.95417	83.69232	81.93122	293
8104	TEL_M1_SLI1	92.05529	82.82598	81.06896	293
8105	TEL_M1_SLI1	92.53954	83.25789	81.49811	293
8106	TEL_M1_SLI1	92.48226	83.13124	81.37368	293
8110	TEL_M1_BAFFLE UP DISC	77.49027	68.39105	67.01089	293
8111	TEL_M1_BAFFLE CYL	88.61119	79.4124	77.75099	293
8112	TEL_M1_BAFFLE LOW DISC	91.72062	82.85483	81.04582	293
8201	TEL_M1_SLI2	103.39937	93.23525	91.41324	293
8202	TEL_M1_SLI2	104.00941	93.44752	91.62011	293
8205	TEL_M1_SLI2	103.24533	93.07972	91.28197	293
8206	TEL_M1_SLI2	103.78276	93.2143	91.42688	293
8301	TEL_M1_SLI3	120.19038	108.96807	106.9282	293
8302	TEL_M1_SLI3	114.81943	102.40919	100.47412	293
8303	TEL_M1_SLI3	88.44094	79.93452	78.20614	293
8304	TEL_M1_SLI3	86.50268	78.03849	76.33308	293
8305	TEL_M1_SLI3	119.40494	108.18336	106.27479	293
8306	TEL_M1_SLI3	114.28595	101.83368	100.01743	293
8311	TEL_M1_SLI3	109.54912	99.22696	97.36108	293
8313	TEL_M1_SLI3	103.864	94.0296	92.21634	293
8315	TEL_M1_SLI3	109.4244	99.0986	97.25636	293
8502	TEL_M1_HEATER	85.45132	76.75783	74.98253	293
8504	TEL_M1_HEATER	85.40554	76.72525	74.95116	293
8506	TEL_M1_HEATER	85.45081	76.75656	74.98172	293
99998	Space	3	3	3	3
	EPLM:LOU				
4210	LOU baseplate	130.21713	126.7341	97.23527	293
4262	LOU mx side MLI	139.5803	131.3031	120.10059	293
	SVM				
6001	SVM wall pZ	318	291	265	293
6002	SVM wall pYpZ	318	291	265	293
6003	SVM wall pY	318	291	265	293
6004	SVM wall pYmZ	318	291	265	293
6005	SVM wall mZ	318	291	265	293
6006	SVM wall mYmZ	318	291	265	293
6007	SVM wall mY	318	291	265	293
6008	SVM wall mYpZ	318	291	265	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit Safe T [K]	Ground T [K]
6020	SVM I/F to CVV struts	293	293	245	293
6021	SVM I/F to SVM shield	293	266	240	293
6022	SVM I/F to Sshld str.	293	266	240	293
6023	SVM I/F to waveguides	293	266	240	293
6024	SVM I/F to harness	293	266	240	293
6051	SVM top pZ	230	203	168	293
6052	SVM top pYpZ	230	203	168	293
6053	SVM top pY	230	203	168	293
6054	SVM top pYmZ	230	203	168	293
6055	SVM top mZ	230	203	168	293
6056	SVM top mYmZ	230	203	168	293
6057	SVM top mY	230	203	168	293
6058	SVM top mYpZ	230	203	168	293
6101	SVM top disc pZ	230	203	168	293
6102	SVM top disc pYpZ	230	203	168	293
6103	SVM top disc pY	230	203	168	293
6104	SVM top disc pYmZ	230	203	168	293
6105	SVM top disc mZ	230	203	168	293
6106	SVM top disc mYmZ	230	203	168	293
6107	SVM top disc mY	230	203	168	293
6108	SVM top disc mYpZ	230	203	168	293
6151	MLI THR pZ	230	203	168	293
6152	MLI THR pY	230	203	168	293
6153	MLI THR mZ	230	203	168	293
6154	MLI THR mY	230	203	168	293
6155	MLI SAS pZ	230	203	168	293
6156	MLI SAS pZ BRK	230	203	168	293
6157	MLI SAS mZ	230	203	168	293
6158	MLI SAS mZ BRK	230	203	168	293
6159	MLI AAD	230	203	168	293
6160	MLI VMC	230	203	168	293
6161	MLI SREM	230	203	168	293

END OF DOCUMENT

	Name	Dep./Comp.		Name	Dep./Comp.
	Alberti von Mathias Dr.	ASG23		Schuler Günter	ASA42
	Baldock Richard	FAE12	X	Schweickert Gunn	ASG23
	Barlage Bernhard	AED13		Sonn Nico	ASG51
	Bayer Thomas	ASA42		Steininger Eric	AED32
	Brune Holger	ASA45	X	Stritter Rene	AED11
	Edelhoff Dirk	AED2		Suess Rudi	OTN/ASA44
	Fehringer Alexander	ASG13		Theunissen Martijn	DSSA
X	Fricke Wolfgang Dr.	AED 65	X	Wagner Klaus	ASG23
	Geiger Hermann	ASA42	X	Wietbrock Walter	AET12
	Grasl Andreas	OTN/ASA44		Wöhler Hans	ASG23
	Grasshoff Brigitte	AET12		Wössner Ulrich	ASE252
	Hamer Simon	Terma			
	Hendry David	Terma			
	Hengstler Reinhold	ASA42			
X	Hinger Jürgen	ASG23			
X	Hohn Rüdiger	AED65			
	Hölzle Edgar Dr.	AED32			
	Huber Johann	ASA42			
	Hund Walter	ASE252			
X	Idler Siegmund	AED312			
	Ivády von András	FAE12			
X	Jahn Gerd Dr.	ASG23			
	Kalde Clemens	ASM2			
	Kameter Rudolf	OTN/ASA42			
X	Kettner Bernhard	AET42			
	Knoblauch August	AET32		Alcatel Alenia Space Torino	AAS-I
	Koelle Markus	ASA43	X	ESA/ESTEC	ESA
	Koppe Axel	AED312	X	Thales Alenia Space Cannes	TSP-F
X	Kroeker Jürgen	AED65			
	La Gioia Valentina	Terma		**Instruments:**	
X	Lang Jürgen	ASE252	X	MPE (PACS)	MPE
	Langenstein Rolf	AED15	X	RAL (SPIRE)	RAL
X	Langfermann Michael	ASA41	X	SRON (HIFI)	SRON
	Martin Olivier	ASA43			
	Maukisch Jan	ASA43			
	Much Christoph	ASA43		**Subcontractors:**	
	Müller Jörg	ASA42		Alcatel Alenia Space Antwerp	ABSP
	Müller Martin	ASA43		Austrian Aerospace	AAE
	Peltz Heinz-Willi	ASG13		Austrian Aerospace	AAEM
	Pietroboni Karin	AED65		BOC Edwards	BOCE
	Platzer Wilhelm	AED2		Dutch Space Solar Arrays	DSSA
	Reichle Konrad	ASA42		EADS Astrium Sub-Subsyst. & Equipment	ASSE
	Runge Axel	OTN/ASA44		EADS CASA Espacio	CASA
X	Schink Dietmar	AED32		EADS CASA Espacio	ECAS
	Schlosser Christian	OTN/ASA44		European Test Services	ETS
	Schmidt Rudolf	FAE12		Patria New Technologies Oy	PANT
	Schmidt Thomas	AED15		SENER Ingenieria SA	SEN