REPORT

TITLE: SVM TCS THERMAL ANALYSIS REPORT

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1. INTRODUCTION

The purpose of this document is the description of the geometric and thermal mathematical model built for HERSCHEL and PLANCK Service Modules as well as the presentation of the temperature results derived from the thermal analysis performed for both satellites.

1.1 Note on RCS Model

The RCS model is not presented in this document both for HERSCHEL and PLANCK. A detailed study on RCS network is presented in AD28.

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1 APPLICABLE DOCUMENTS

AD1	Herschel/Planck Environment and Tests Requirements	H-P-1-ASPI-SP-0030
AD2	General Design & Interface Requirements	H-P-1-ASPI-SP-0027
AD3	SVM Mechanical Interface control document	H-P-IC-AI-0001
AD4	Reduced Geom. RGMM and Thermal RTMM Math. Models Requirements	H-P-RQ-AI-0002
AD5	SVM Requirement Specification	H-P-4-ASPI-SP-0019
AD6	SVM Interface Specification	H-P-4-ASPI-IS-0042
AD7	TCS Design Description	H-P-RP-AI-0039
AD8	PLANCK HEAT-PIPES Network Definition and Interfaces	H-P-TN-AI-0020
AD9	Thermal Interface control document	H-P-IC-AI-0002
AD10	Instrument Interface Document, Part B (IID-B): High Frequency Instrument	SCI-PT-IIDB/HFI-04141
AD11	Instrument Interface Document, Part B (IID-B): Low Frequency Instrument	SCI-PT-IIDB/LFI-04142
AD12	Instrument Interface Document, Part B (IID-B): Photo-conductor Instrument	SCI-PT-IIDB/PACS-2126
AD13	Instrument Interface Document, Part B (IID-B): Instrument "HIFI"	SCI-PT-IIDB/HIFI-2125
AD14	HERSCHEL AND PLANCK SAS Design and Analysis report	HP-4-TNO-RP-S004
AD15	HERSCHEL AND PLANCK AAD Design and Analysis Report	HP-4-TNO-RP-A004
AD16	THERMAL ANALYSIS FOR LGA OF HERSCHEL-PLANCK	HP-AN-RY-0020
AD17	THERMAL ANALYSIS FOR MGA OF HERSCHEL-PLANCK	HP-AN-RY-0021
AD18	PLM interface with HERSCHEL STR i01	H-P-ASP-LT-3814
AD19	PLANCK SVM Thermal Interfaces	H-P-1-ASP-TN-0417
AD20	HERSCHEL SVM Thermal Interfaces	H-P-1-ASP-TN-0418
AD21	UNCERTAINTY THERMAL ANALYSIS	H-P-TN-AI-0045
AD22	HEATER POWER UNCERTAINTY THERMAL ANALYSIS	H-P-TN-AI-0055
AD23	FINE CONTROL LAW ANALYSIS	H-P-TN-AI-0060
AD24	HERSCHEL THERMAL ANALYSIS RESULTS AND BREAKDOWN	H-P-TN-AI-0065
AD25	PLANCK THERMAL ANALYSIS RESULTS AND BREAKDOWN	H-P-TN-AI-0066
AD26	Autonomous Star Tracker Thermal and Thermo-elastic analysis Report	H-P-4-GAF-RP-0009
AD27	Reduced thermal mathematical model (SYNDA) Northrop Grumman	654056 09/12/03
AD28	RCS LINES & UNITS THERMAL ANALYSIS AND HEATER SIZING	HP-TN-AI-0080

2.2 REFERENCE DOCUMENTS

RD1 Thermal Conductivity of Metallic Honeycomb Sandwich Panels NLR, Amsterdam, NL

RD2 Analytical/Experimental Semiempirical Evaluation of Spacelab MLI Thermal Conductance
RP-AI-0237, dated 13/09/78

RD3 Survey and Evaluation of Multilayer Insylation Heat Transfer Measurements
J.Doenecke (DASA), 23rd ICES, July 1993 - paper n.SAE 932117

RD4 A Systematic Approach to Thermal Balance Test Evaluation and Thermal Mathematical Model Correlation for Spacecraft Thermal Design, L.Costamagna, V.Perotto, E.Sacchi (Alenia Spazio), 4th European Symposium on Space Environmental and Control Systems, October 1991.

2.3 LIST OF ACRONYMS

AAD : Attitude Anomaly Detector
BOL : Beginning of Life
EOL : End of Life
GMM : Geometrical Mathematical Model
GYRO : Gyroscope
HPLM : Herschel Payload Module
H/W : Hardware
LGA : Low Gain antenna
MGA : Medium Gain antenna
MLI : Multi Layer Insulation
OSR : Optical Solar Reflector
PPLM : Planck Payload Module
P.Tanks : Propellant Tanks
PTSS : Propellant Tank Support Structure
rpm : revolution per minute
S/C : Spacecraft or Satellite
SAS : Sun Acquisition sensor
SCC : Sorption Cooler Compressors
STR : Star Trackers
TBC : To Be Confirmed
TBD : To Be Defined
TMM : Thermal Mathematical Model
VDA : Vacuum Deposited Aluminum

3. MODELS DESCRIPTION

Herschel and Planck are two satellites dedicated to the observation of the universe.

- Herschel key science targets are focused on the formation of stars and galaxies. It will complement the successful progress of ISO ('95-'98) and SIRTF (to be launched this year).
- Planck mission objective is to provide major source of information relevant to several cosmological and astrophysical issues such as the testing theories of the early universe and the origin of cosmic structure.

The satellites are planned to operate from Lissajous orbits around the Langragian point L2 of the Sun / Earth system. This point is aligned with the Earth and the Sun and located at 1.5 10^6 Km from the Earth.

Both satellites are planned to be launched by ARIANE 5 dual launch.

The main modules are:

- The Service Module (SVM)
- The Payload Module (PLM), carrying the scientific instruments and telescopes and relevant electronic units
- The Sunshields, protecting the Payload or the S/C and used also as Solar Arrays.

3.1 Geometric and Thermal Mathematical Model

The Geometric models detail all the satellite surfaces and their thermo-optical properties, in order to evaluate the radiative exchange factors among nodes and, only for the external nodes, the fluxes (solar, albedo and Earth shine) on spacecraft surfaces during the orbit. Due to the huge distance of the HERSCHEL and PLANCK orbit from the Earth, solar, albedo and earth fluxes have been considerate as one global flux in the thermal analysis.

3.1.1 HERSCHEL description

The Geometric Mathematical Model (GMM) of HERSCHEL satellite has been built using Esarad (version 5.3.2) software and it is composed by two models, which describe respectively the internal enclosures of the spacecraft and the external environment of the spacecraft. A reduced model of the Payload Module, furnished by ALCATEL (AD20), has been introduced in the external GMM.

The Thermal Mathematical Model (TMM) of HERSCHEL has been prepared with Esatan software and contains the thermal node description, the thermal conductivity network and the unit and heater dissipation.
3456 nodes compose it:
2711 are Geometrical Nodes: 1593 nodes are in the External GMM, 1132 nodes are in the Internal GMM, 30 nodes are in the External GMM coming from the Payload Module, 683 are Mathematical Nodes.

The termo-optical properties of the material used in theGMM/TMM are listed in Table 3.1.1-1.
The nodes of GMM/TMM with Number, Label, Area, Capacity, Material and thermal properties of each node at BOL / EOL conditions are provided in the AD24.

The only thermal property assumed to change during the satellite life is the solar absorptivity of the OSR and of the Silver Teflon Tape and also the PLM Temperatures that are fixed in our analysiys according to the AD20.
The nodal breakdown of the GMM is reported in AD24.

Table 3.1.1-1 HERSCHEL – Service Module Thermal Properties Materials

SURFACES	MATERIALS	α	α	ε	Reference
		BOL	EOL		
GMM INTERNAL					
High Emissivity surfaces (Internal panels & units)	Aeroglaze Z306			0.87	ALS
Internal Panels –Y-Z, -Y	Aluminium			0.05	ALS
FPDPU/HSDPU/FHICU	Alodine			0.172	ICD Data (AD9)
FHFCU	Alodine			0.13	ALS
CCU	Alodine			0.2	ICD Data (AD9)
FHWOV/FHWOH	Aluminium			0.05	ALS
HRV/WEV/WEH/HRH/LCU	Black paint			0.8	ICD Data (AD9)
FH3DV/FH3DH	Goldized			0.05	ICD Data (AD9)
LV1/LV2/LF	Aluminium Tape (titanium)			0.05	ALS
PT	Aluminium Tape (steel)			0.05	ALS
FHWIH IF cables	Kapton Tape			0.7	ALS assumption
CFRP Surfaces (Bottom Floor, Top Floor, Shear Panels & Cone)	CFRP			0.87	ALS
Internal Launcher Adaptor Ring	Aluminium Tape			0.05	ALS
Internal MLI (-Y Panel, -Y-Z Panel, Internal STR baffle, Tanks)	VDA Kapton (Aluminized)			0.05	ALS
Bottom closure internal side	1/3 CFRP – 2/3 VDA Kapton (Aluminized)			0.33	Average α / ε values
GMM EXTERNAL					
VMC lens		0.9	=	0.9	ALS Assumption
SREM		0.52	=	0.12	Integral data
SAS housing/pyramid		0.96	=	0.83	HP-4-TNO-RP-S004
SAS chip		0.9	=	0.82	HP-4-TNO-RP-S004
MGA / LGA	Alodine 1200 S	0.46	=	0.1	HP-AN-RY-0020-21
MGA	Germanium	0.6	=	0.72	HP-AN-RY-0021
LGA	White paint	0.6	=	0.88	HP-AN-RY-0020
AAD top surface		0.96	=	0.83	HP-4-TNO-RP-A004
AAD chip		0.9	=	0.013	HP-4-TNO-RP-A004
Thrusters nozzle		0.5	=	0.12	Integral data
Thrusters heat barrier / head plate		0.5	=	0.3	Integral data
Thrusters bracket		0.15	=	0.05	Integral data
Thrusters FCV				0.7	Integral data
External Launcher Adaptor Cone	Cromic Acid/Aluminium	0.234	=	0.158	Average α / ε values
External Launcher Adaptor Edge	Alodine/Aluminium	0.203	=	0.069	Average α / ε values
Lat Panels +Y+Z, +Y, -Y, –Y+Z, STR	OSR	0.1	0.18	0.8	ALS
Others Lat Panels	Aeroglaze Z307	0.96	=	0.87	ALS
MLI STR Radiator, Units and Baffles	Silver Teflon Tape (ITO)	0.09	0.24	0.75	ALS
MLI to HPLM and MLI truss to CVV	VDA Kapton (Aluminized)	0.15	=	0.05	ALS
External STR secondary baffle	Silver Teflon Tape	0.09	0.24	0.75	ALS
External MLI (Bottom Floor, Launcher Adaptor, Radiator Panels, External units)	Carbon Filled Kapton	0.92	=	0.86	ALS

An overall view of HERSCHEL satellite is presented in the following figures.

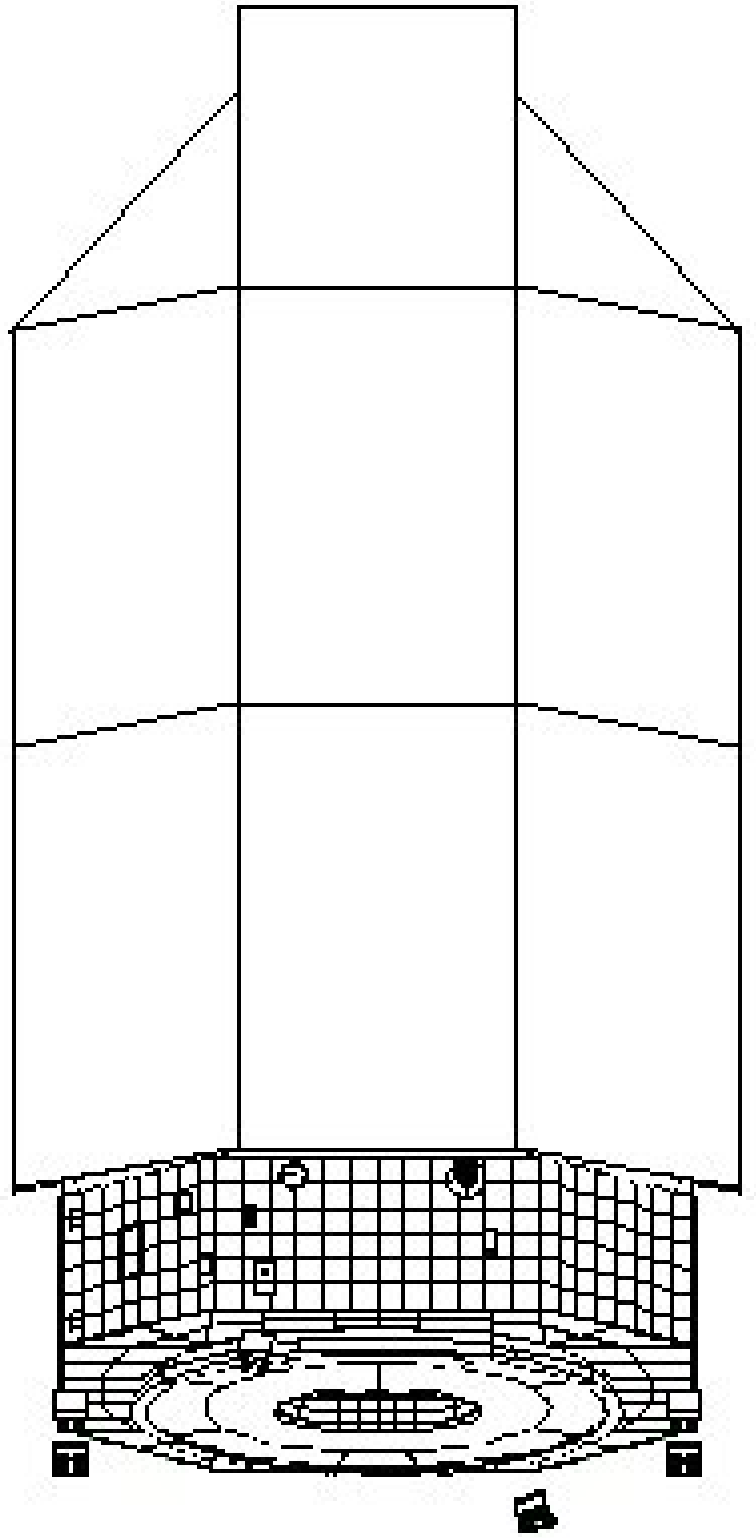


Figure 3.1.1-1 HERSCHEL – Overall view +Z

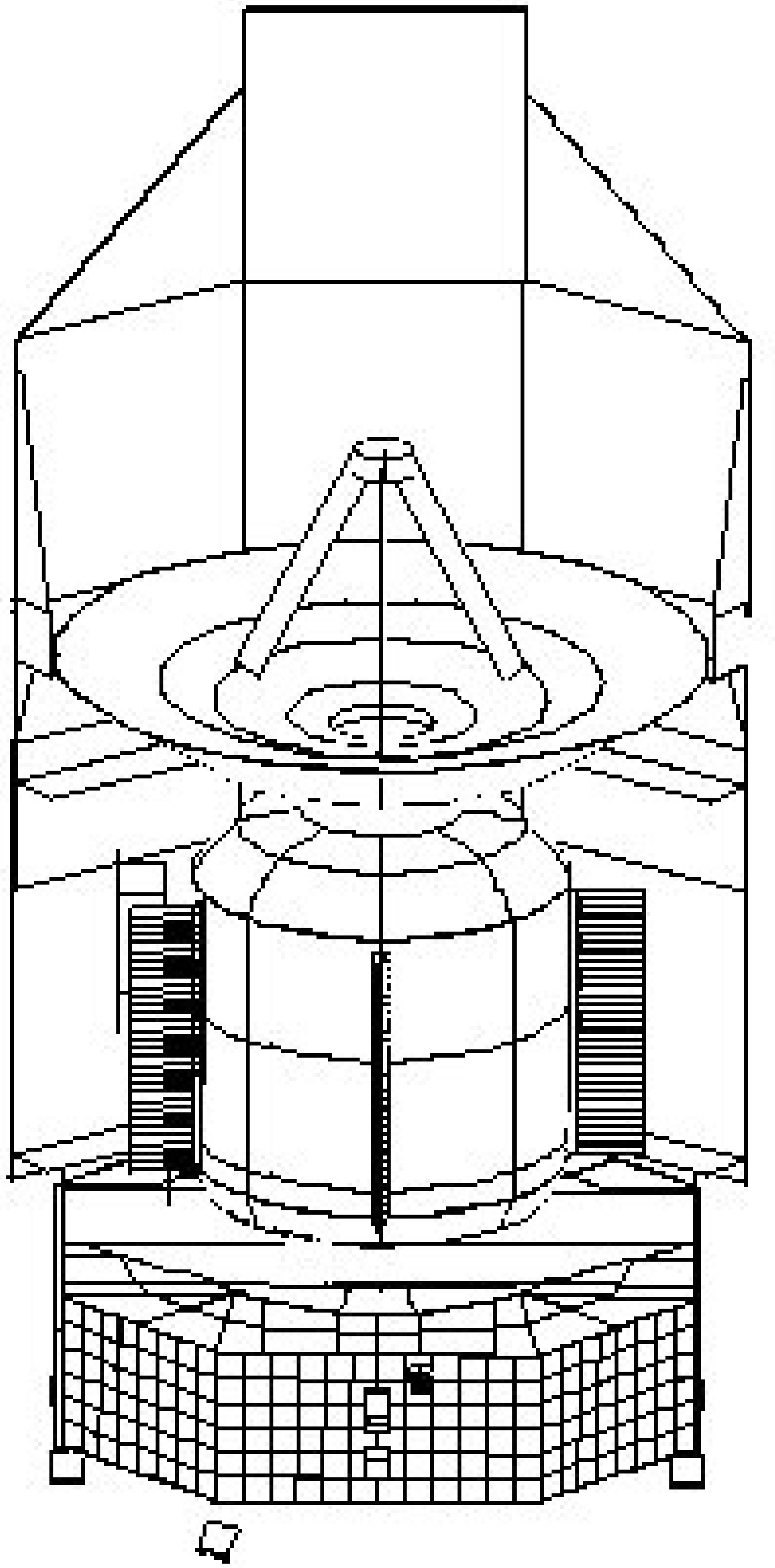


Figure 3.1.1-2 HERSCHEL – Overall View –Z

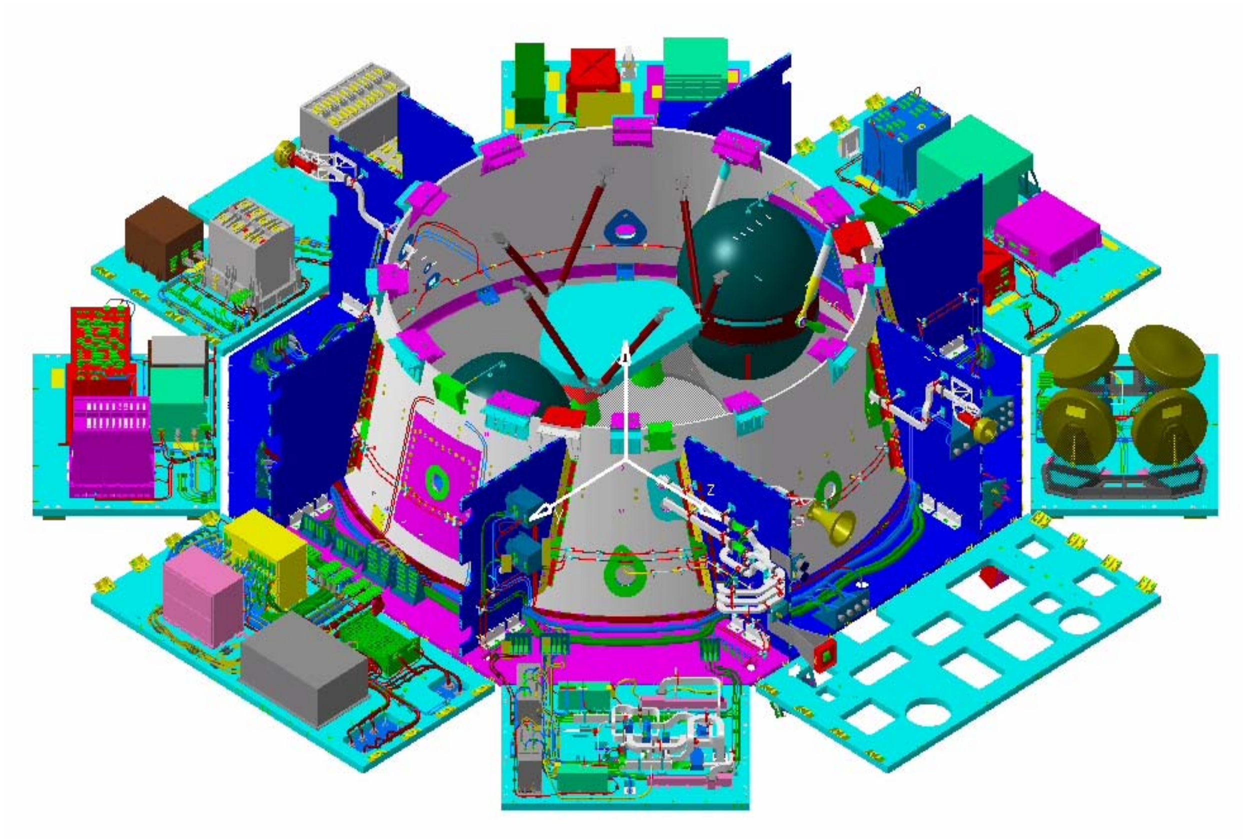


Figure 3.1.1-3 HERSCHEL – Internal overall View

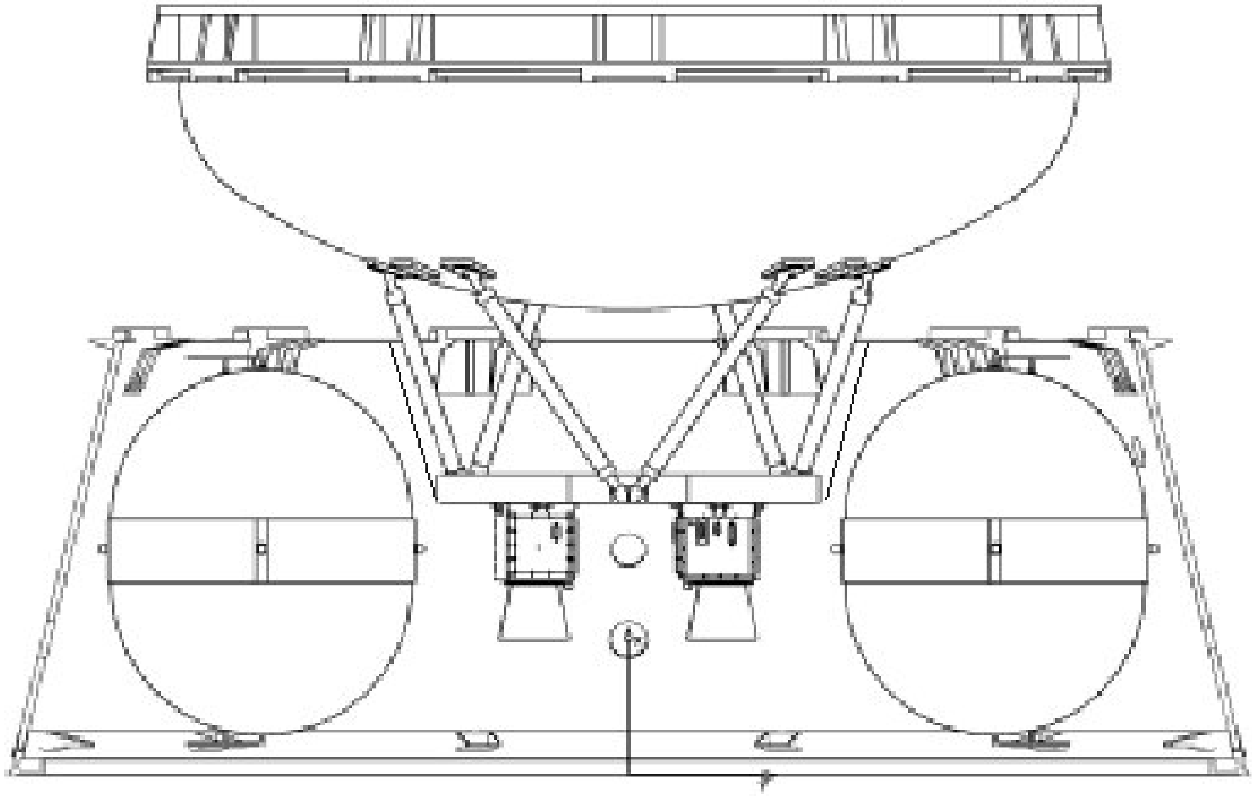


Figure 3.1.1-4 HERSCHEL – Internal STR assembly View

3.1.1.1 GMM and TMM variation considered after SYSTEM CDR Data Package (July 2004)

A summary of the variation applied on GMM and TMM models, due to the SYSTEM CDR RID disposition is here reported.

GMM Variation

- The geometry of the STR assembly has been reviewed in some details according to OG
- The STR baffle unit has been modelled in the external GMM with electrodag properties α=0.96 ε=0.83 given by OG
- The Teflon properties (on the secondary baffle external surface) are given by OG as α_{BOL}=0.09 α_{EOL}=0.16 ε=0.8
- The emissivity of the FHLSU has been set at ε=0.87
- The radiator areas on the SVM –Y-Z Panel and on the –Y Panel have been increased according to the power dissipations given in the HIFI IIDB 3.2 and they are showed in AD24.

TMM Variation

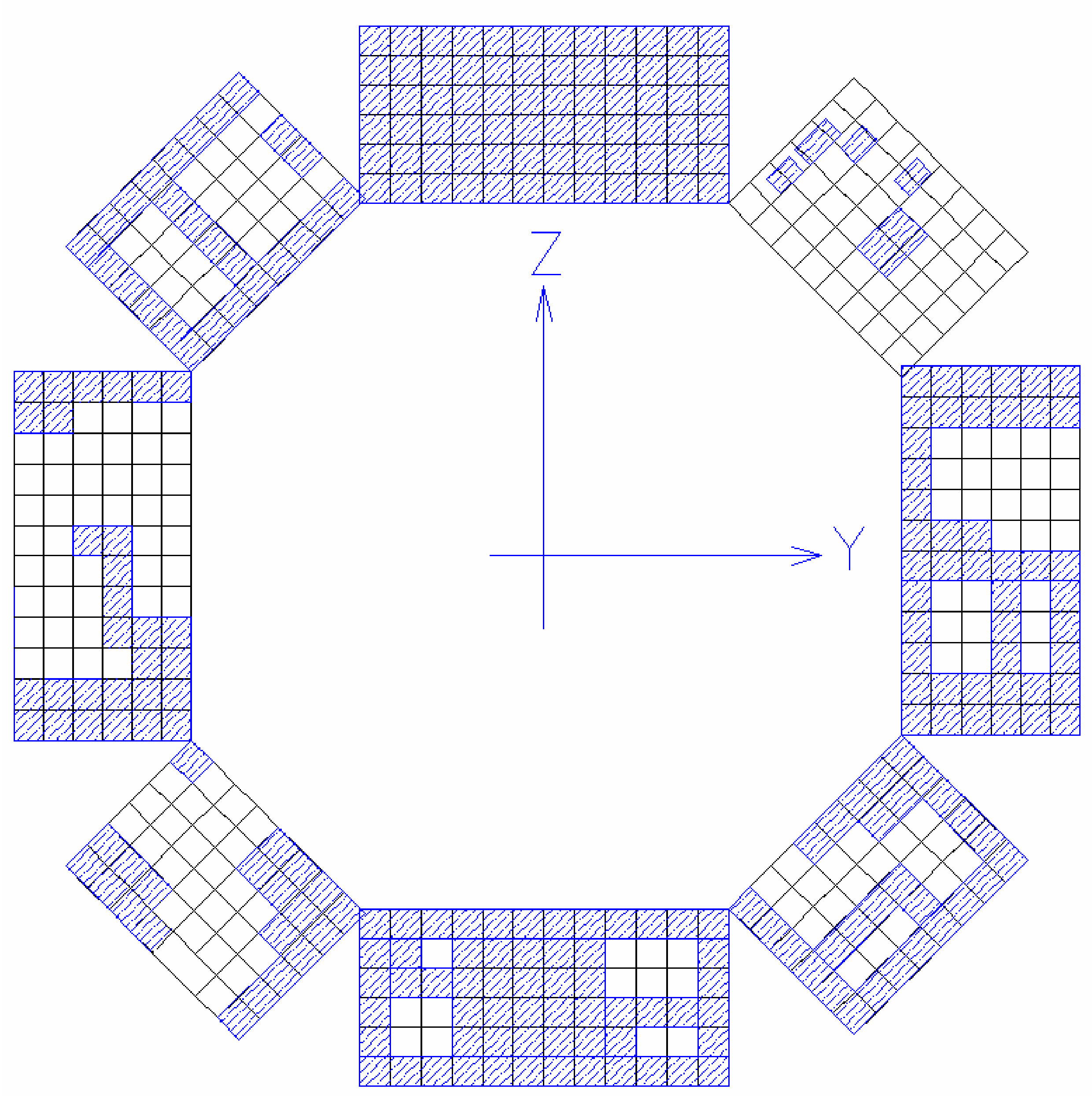
All the analysis has been performed in Transient condition, and the minimum and maximum temperatures reached during the run have been considered in this analysis. No steady state analysis has been performed.

- RCS model described in HP-TN-AI-0080 issue2
- STR local model reviewed according to OG data (GL of baffle node 80052 increased to 0.0025W/K and 80051 increased to 0.2525W/K)
- STR baseplate remodelled with a –Z edge in Titanium
- STR Baseplate: -X Side KXY = 24.15 instead of 34.84
- STR Baseplate: +X Side KXY = 12.72 instead of 24.15
- STR Baseplate: KZ =1.21 instead of 1.25
- STR Secondary baffle thickness 0.0008 m instead of 0.0018 m
- Node 3536 3545 3626 3634 3638 3668 3669 3670 on –Y-Z Panel and –Y Panel not covered by MLI
- Variation of the power dissipation of following units
  - ✓ FHWOV FHWOH 1.7W vs 2.2W
  - ✓ FHHRV FHHRH 69.7W vs 63.3W
  - ✓ FHICU 34.5W vs 29.6W
  - ✓ FHFCU 14.3W vs 13W
  - ✓ FHWEV FHWEH 29.7W vs 27W
  - ✓ FHIFV FHIFH 0.4W vs 0.25W
  - ✓ FHLCU 43.7W vs 35.4W
  - ✓ FHLSU 50.3W vs 45.8W
- Variation of heater distribution power for the following lines
  - ✓ Line38 HTR100NS 8 heaters instead of two with 45.22W of total power installed on the baseplate node.
  - ✓ Line28 HTR507NS instead of spare Line, 1 heater with 11.39W of total power installed

3.1.1.2 Radiator Panels data

The S/C design has been made analyzing same sizing cases that cover all the worst In-Orbit conditions.
An overall view of the disposition of the radiative area on lateral panel of the SVM is presented in Figure 3.1.1.1-1. The drawing is viewed from +X axis and the radiative panels are viewed from internal side, the radiative areas are projected on the internal panels. The outlining represents the MLI and white colour represents the radiative area.

Figure 3.1.1.2-1 HERSCHEL - Radiative areas overall view



in the table 3.1.1.1-1 we report the amounts of total area, MLI and radiative areas on the eight Lateral Equipment Panels.

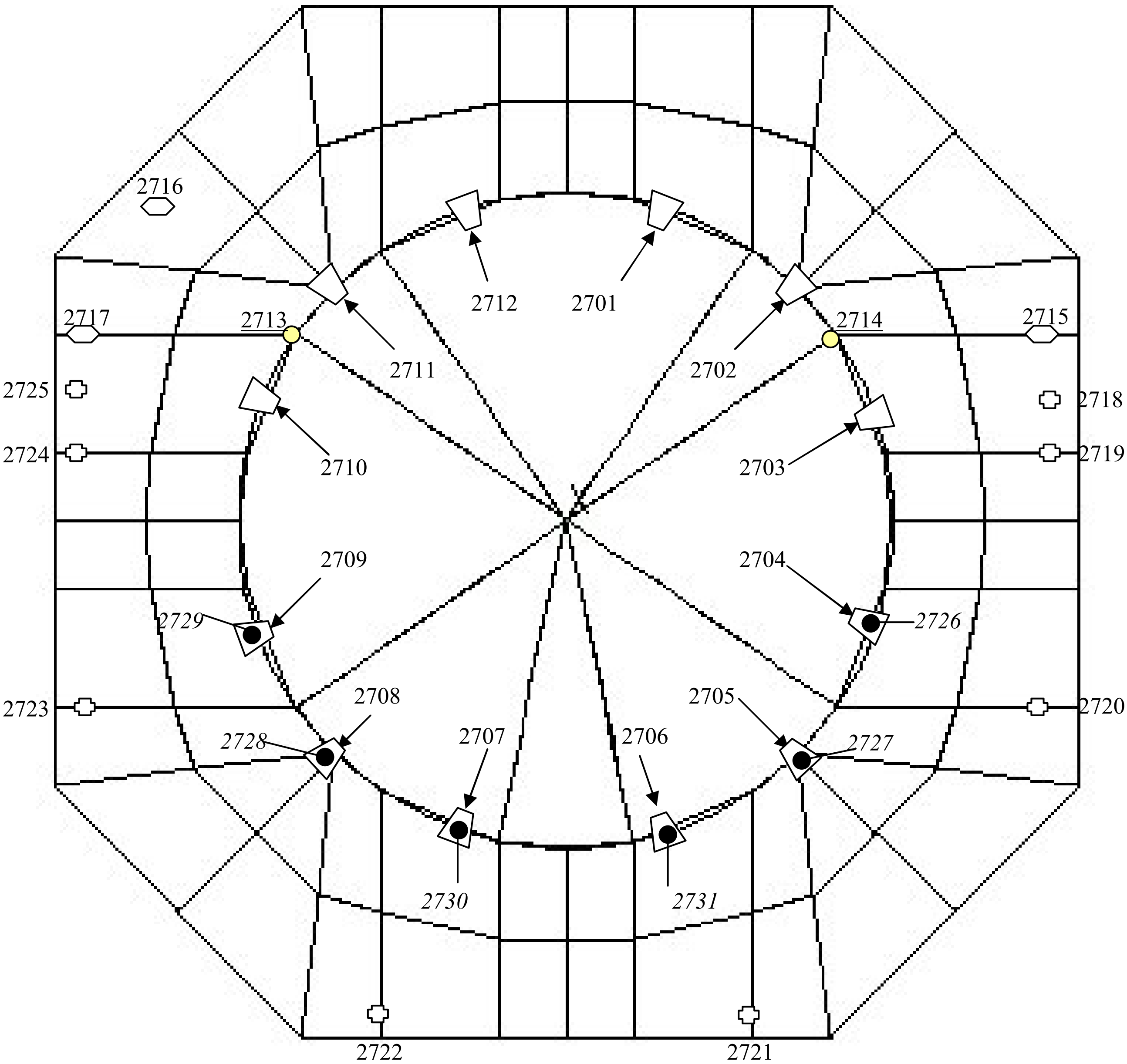
Table 3.1.1.1-1 HERSCHEL – Radiative and MLI Areas

Panel Location	Total Panel Area [m²]	MLI Area [m²]	Radiative Area [m²]	Rad. Area / Total panel %
+Z	1.462	1.462	0.000	0%
+Y +Z	0.974	0.122	0.869	89%
+Y	1.462	0.914	0.548	38%
+Y –Z	0.974	0.589	0.386	40%
-Z	1.462	1.198	0.264	18%
-Y –Z	0.974	0.426	0.548	56%
-Y	1.462	0.589	0.873	60%
-Y +Z	0.974	0.528	0.447	46%
Total	9.744	5.826	3.918	

3.1.1.3 PLM I/F attachment points

In the figure 3.1.1.2-1 the attachment points with the PLM are shown.
Complessively the interface nodes are:
2701÷12: CVV I/F
2713÷14: I/F SH1-2 SSH BRACKETS
2715÷17: I/F SSH STRUTS
2718÷25: I/F SVM SHIELD
2726÷2731: I/F SS1÷6 SVM SHIELD

Figure 3.1.2.2-1 HERSCHEL – I/F points with PLM



3.1.2 PLANCK description

The Geometric Mathematical Model (GMM) of PLANCK satellite has been built using Esarad (version 5.3.2) software and it is composed by two models, which describe respectively the internal enclosures of the spacecraft and the external environment of the spacecraft. A reduced model of the Payload Module, furnished by ALCATEL (AD19), have been introduced in the external GMM.

The Thermal Mathematical Model (TMM) of PLANCK has been prepared with Esatan software and contains the thermal node description, the thermal conductivity network and the unit and heater dissipation.
2516 nodes compose it:
1973 are Geometrical Nodes: 948 nodes are in the External GMM, 1025 nodes are in the Internal GMM, 6 nodes are in the External GMM coming from the Payload Module given by AD19. 537 are Mathematical Nodes

The termo-optical properties of the material used in the GMM/TMM are listed in Table 3.1.2.
The nodes of GMM/TMM with Number, Label, Area, Capacity, Material and thermal properties of each node at BOL / EOL conditions are provided in the AD25.

The only thermal property assumed to change during the satellite life is the solar absorptivity of the Solar array and of the Silver Teflon Tape.
The nodal breakdown of the GMM is reported in AD25.

3.1.2.1 GMM and TMM variation after SYSTEM CDR Data Package (July 2004)

A summary with a brief description of the variation applied on GMM and TMM models, since the last issue of the document, is here reported.

GMM Variation

- Modified the T-structure inside the Cone under the Subplatform (nodes 27xx).
- Removed external harness on panel +Y (ex-node 4926)
- The external side of the SAS –X housing (node 4950) have been modified to MLI blanket (alpha=0.92 epsilon=0.86) instead of Silver Teflon tape.
- Modified the radiative area on external panel +Y+Z due to the routing of the SREM harness. The following figure shows the radiative area considered on +Y+Z panel. The surface of radiative area has been maintained the same as in the previous configuration (0.406 m²)

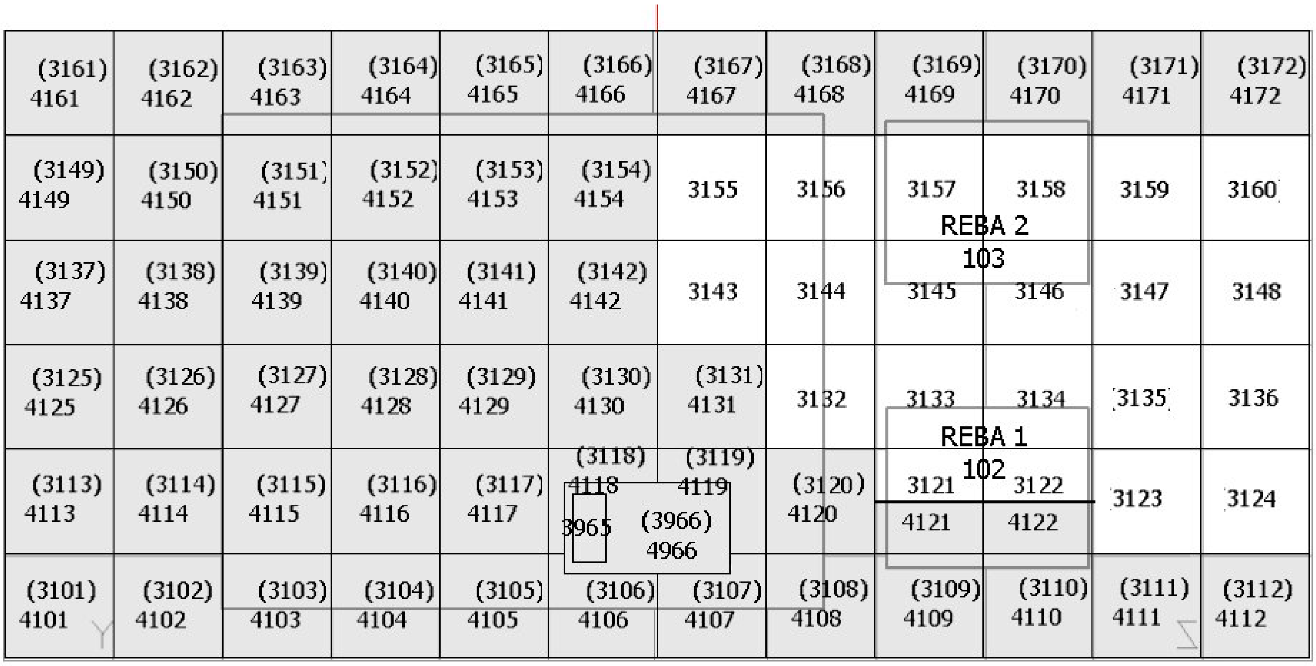


Figure 3.1.3.1-1 Panel +Y+Z external radiative area

- Introduced external MLI blankets covering the Wave Guides on panels –Y, -Y-Z, +Y. The following sketches show the nodal breakdown of the added MLI blankets.

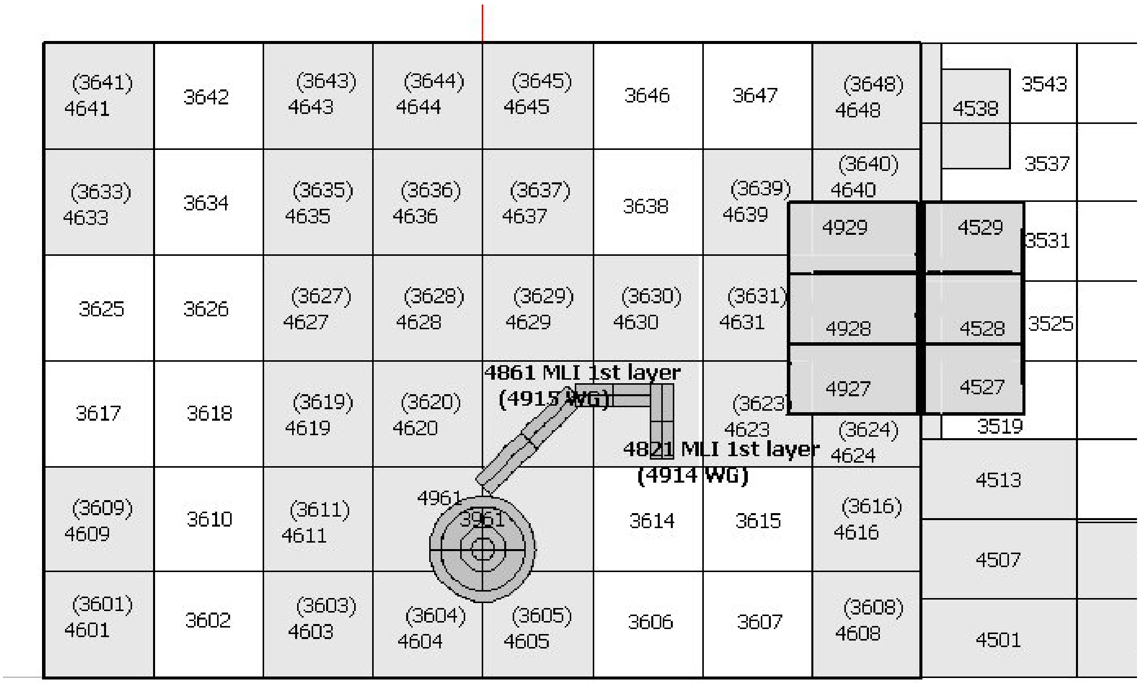


Figure 3.1.3.1-2 Wave Guides MLI blankets on panels –Y , -Y-Z

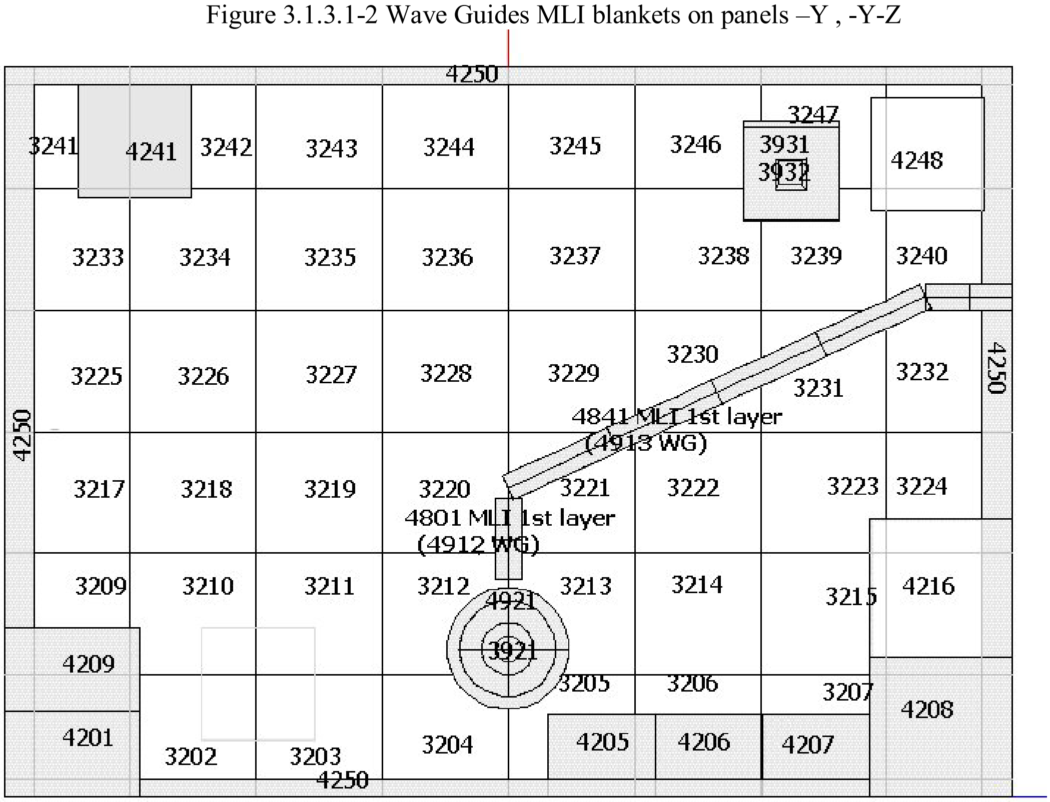


Figure 3.1.3.1-3 Wave Guides MLI blankets on panels +Y

- Introduction of 1mm doubler on +Y panel under 4K CCU and 4K CAU. See on next figure the nodal breakdown of doubler (Nodes 6251–6294). The doubler emissivity is 0.9

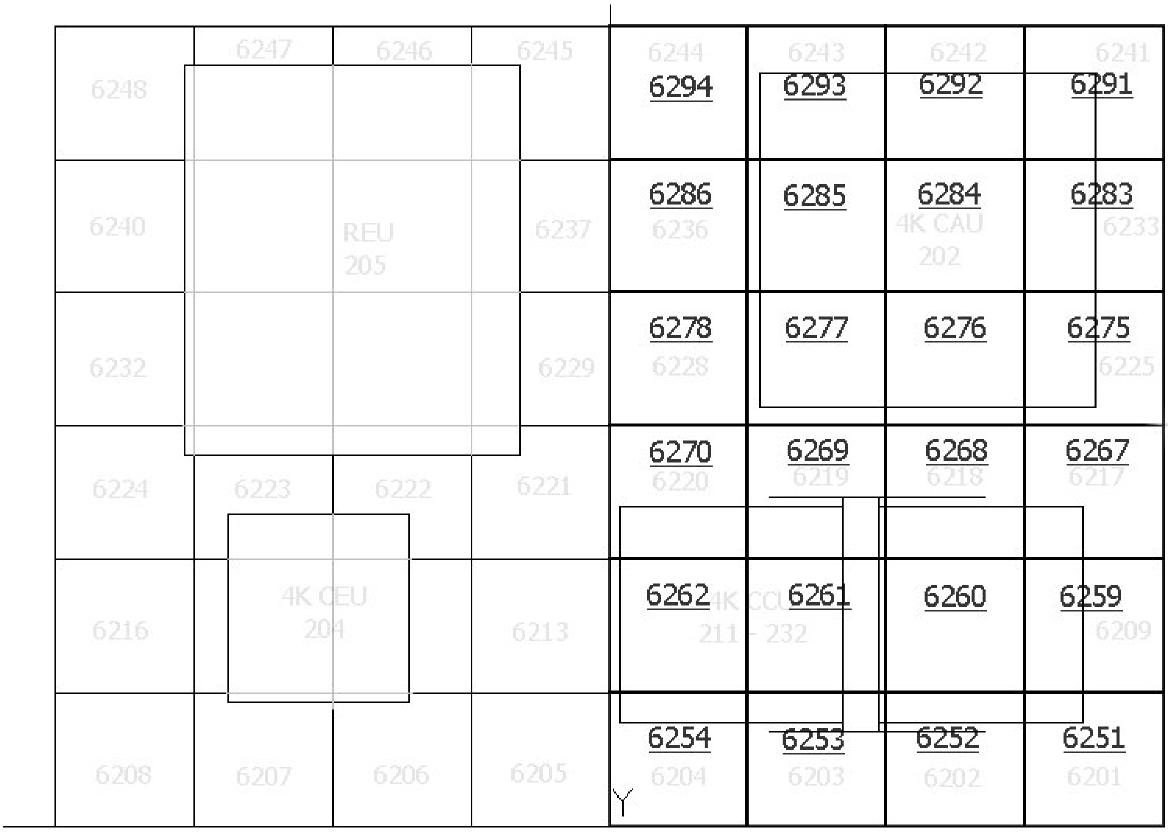


Figure 3.1.3.1-4 Thermal doubler under 4K CCU and 4K CAU on +Y panel

TMM Variation

All the analysis have been performed in Transient condition, and the minimum and maximum temperatures reached during the run have been considered in this analysis.

- Update of the RCS model according to AD28. It includes linear couplings between RCS and structure, heater power distribution, setting of the thermostat thresholds in order to control every part of the lines within the operative limits.
- Variation of heater distribution power for the following lines
  - ✓ Helium Tank added a new line on +Y Tank of 0.77 W
    added a new line on -Z Tank of 1.54 W
    added a new line on +Z Tank of 0.77 W
- Variation of heater threshold for the following lines:

  SCC Heat Pipes Nominal and Survival cases
  Line 07 -13°/-12°C
  Line 08 -14°/-13°C
  Line 09 -15°/-14°C
  Line 10 -16°/-15°C
  Line 11 -17°/-16°C
  Line 12 -18°/-17°C
  Line 13 -19°/-18°C

  Propellant Tank in Survival Case 14°/17°C
  FCV Thruster 14°/17°C
- Introduced cold Case analysis P2 (verifying stability requirements) with SCC2 operative.
- Update linear conductors of T-structure inside the Cone.
- Introduced Wave Guides models.
- Introduced 1mm doubler on +Y panel under 4K CCU and 4K CAU. TMM updated accordingly
- FOG power dissipation changed from 20W to:
  - BOL dissipation (3 channels) 16.5W
  - EOL dissipation (4 channels) 26.8W

  The design temperatures of the unit have been modified to 0° / +45°C (was 0°/+40°C) and in Non operative condition to -40°/+75°C.

Table 3.1.3 PLANCK – Service Module Thermal Properties Materials

SURFACES	MATERIALS	α	α	ε	Reference
		BOL	EOL		
GMM INTERNAL					
Internal panels, floors, cone, web	Black Paint Z306			0.87	ALS
He Tank -Y				0.86	
He Tank +Z,-Y,-Z	Aluminized tape			0.05	
MLI on Cone / Shear 5 and 8 of SCC enclosure , S/A disc int.side, Propellant Tank				0.05	ALS
Top and bottom floor of SCC enclosure				0.1	ALS assumption
SCC panels (HP and Aluminium skin)				0.18	ALS assumption
4K PREREG, 4K CCU, BEU, CDMU, ACC	Black paint			0.9	
EPC				0.88	
DPU, DCCU, REBA, FOG, 4K CAU, CEU, REU, DAE POWER, CRS, TWTA, BATTERY, PCDU, SCE	Black Paint Z306			0.87	ALS
XPND,RFDN				0.85	
Doubler under 4KCCU – 4KCAU				0.9	
BEU enclosure MLI (int.side)				0.76	
1N Thruster				0.4	
GMM EXTERNAL					
AAD top surface		0.96	=	0.83	HP-4-TNO-RP-A004
AAD chip		0.9	=	0.013	HP-4-TNO-RP-A004
External panels	Black Paint Z307	0.96	=	0.87	ALS
MLI to PPLM/ MLI BEU and PAU	VDA Kapton (Al side)	0.15	=	0.05	
MLI	Carbon Filled Kapton	0.92	=	0.86	
BEU/PAU radiators	Black Paint	0.9	=	0.9	
Thrusters nozzle		0.5	=	0.12	Integral data
Thrusters heat barrier / head plate		0.5	=	0.3	Integral data
Thrusters bracket		0.15	=	0.05	Integral data
Thrusters FCV				0.7	Integral data
Launcher adaptor ring	Chromic acid	0.5	=	0.5	
Launcher adaptor edge	Silver teflon / alodine	0.157	0.241	0.601	Average α / ε values
SAS housing/pyramid		0.96	=	0.83	HP-4-TNO-RP-S004
SAS chip		0.9	=	0.82	HP-4-TNO-RP-S004
SAS –X housing external edge	Carbon Filled Kapton	0.92	=	0.86	
SREM		0.52	=	0.12	Integral data
Solar Array ext disc		0.8	=	0.84	
Solar Array central disc		0.86	0.83	0.84	
PLM Groove shield		0.15	=	0.05	HP-1-ASP-TN-0417
PLM struts		0.85	=	0.85	HP-1-ASP-TN-0417
MGA / LGA	Alodine 1200 S	0.46	=	0.1	HP-AN-RY-0020/21
LGA	White paint	0.6	=	0.88	HP-AN-RY-0020
MGA	Germanium	0.6	=	0.72	HP-AN-RY-0021

An overall view of PLANCK satellite is presented in the following figures.

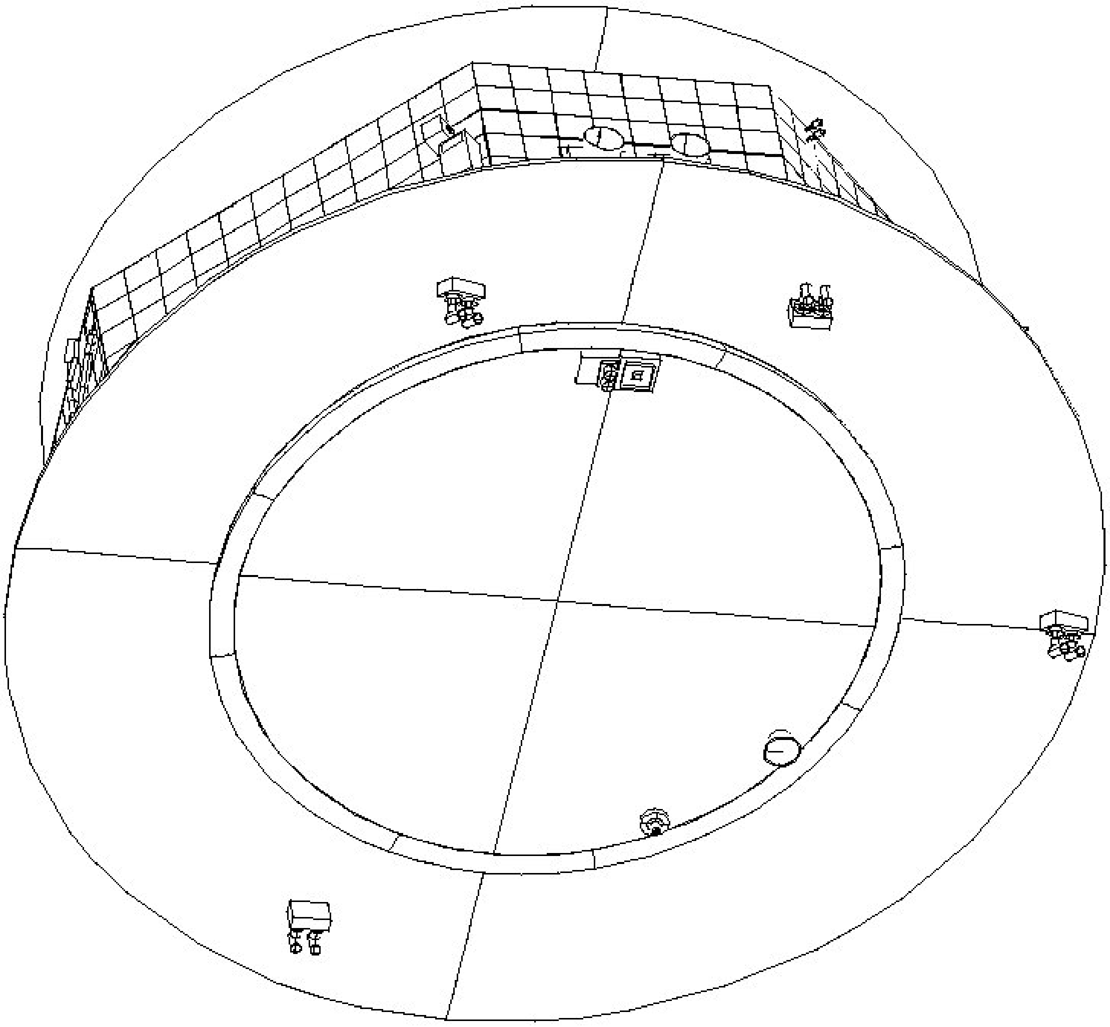


Figure 3.1.3-1 PLANCK - Overall view

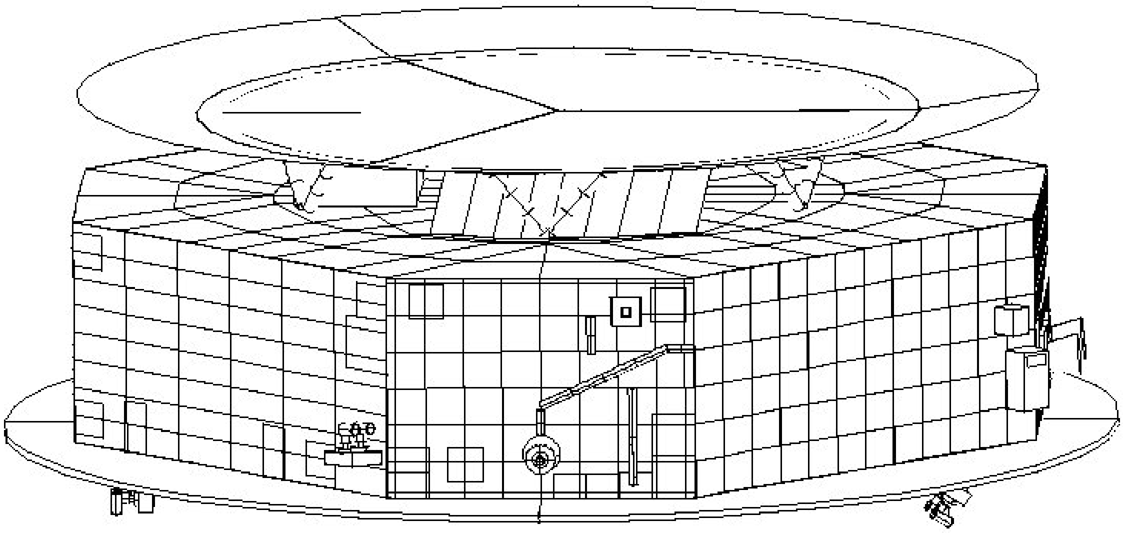


Figure 3.1.3-2 PLANCK - Overall view

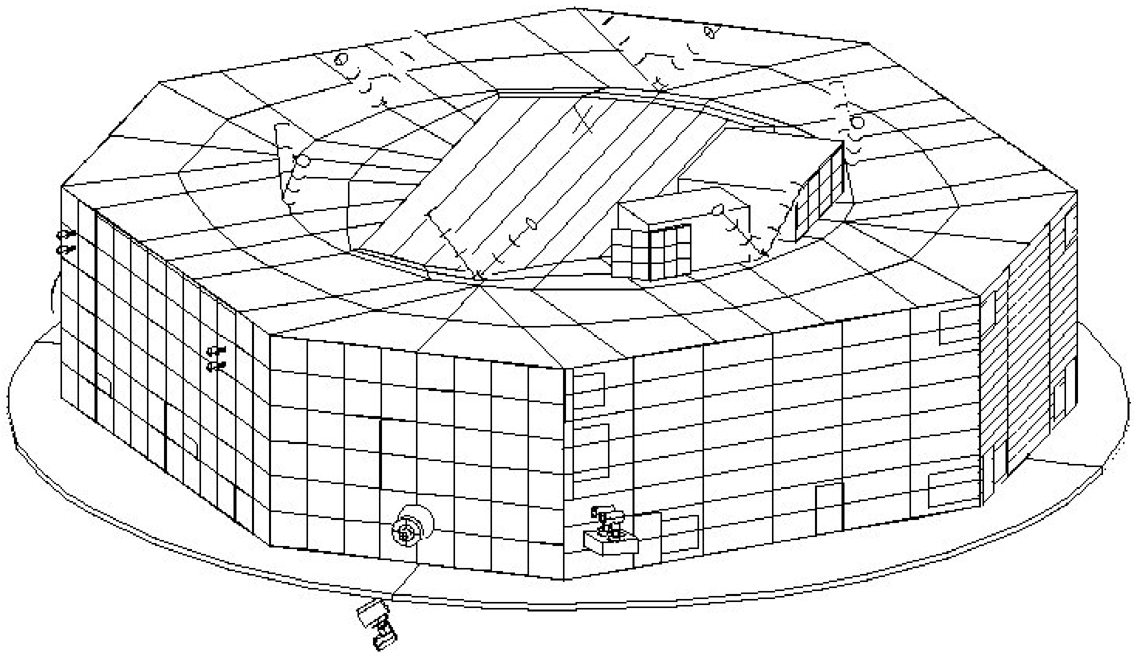


Figure 3.1.3-3 PLANCK - Overall view (Groove shield not plotted)

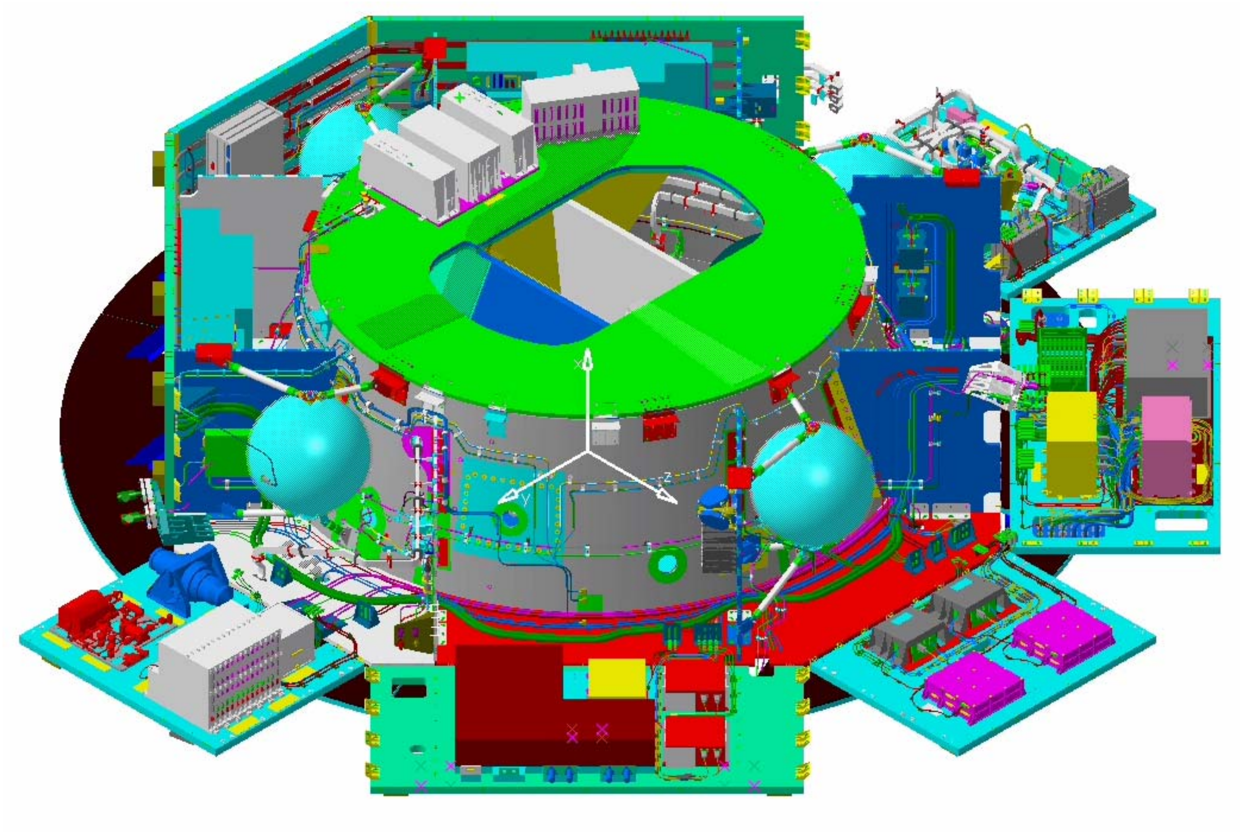
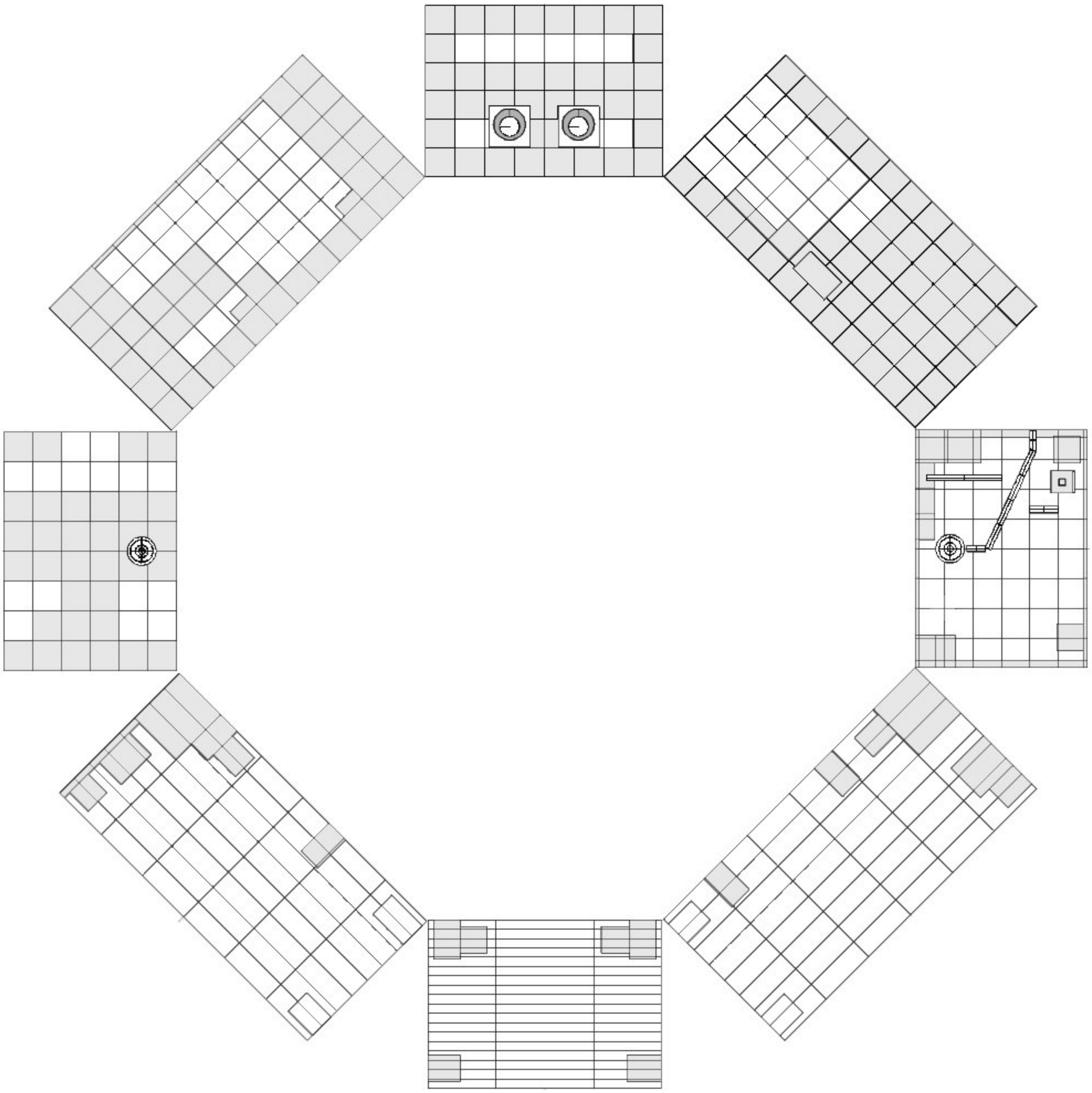


Figure 3.1.3-4 PLANCK – Internal overall View

3.1.2.2 Radiator Panels data

The S/C design has been made analyzing same sizing cases that cover all the worst In-Orbit conditions.
An overall view of the disposition of the radiative area on lateral panel of the SVM is presented in Figure 3.1.3.2-1. The drawing is viewed from +X axis and the radiative panels are viewed from internal side, the radiative areas are projected on the internal panels. Grey colour represents the MLI and white colour represents the radiative area.

Figure 3.1.3.2-1 PLANCK - Radiative areas overall view



In the following Table we report the amounts of total area, MLI and radiative areas on the eight Lateral Equipment Panels.

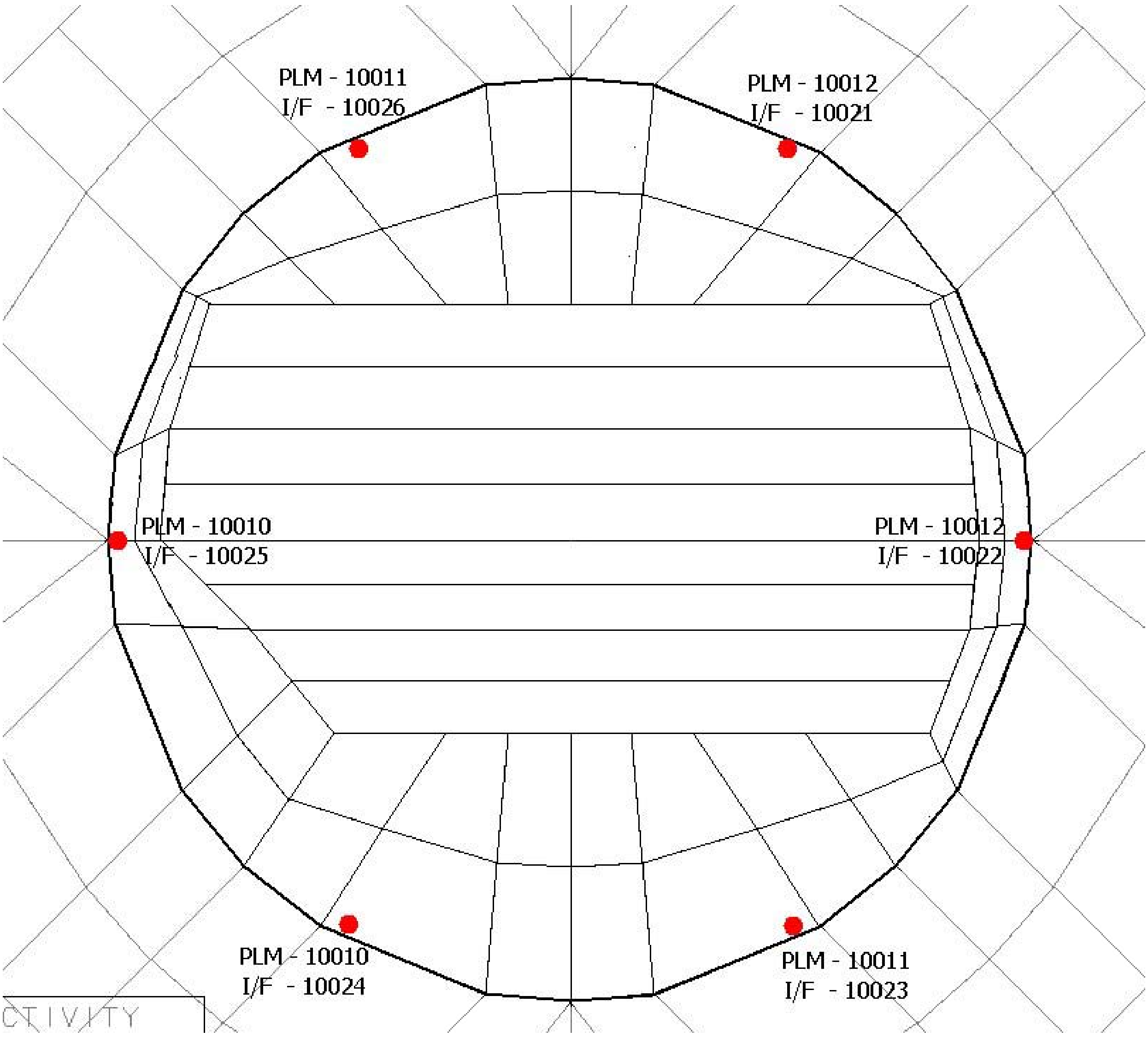
Table 3.1.1.1-1 PLANCK – Radiative and MLI Areas

Panel Location	Total Panel Area [m²]	MLI Area [m²]	Radiative Area [m²]	Rad. Area / Total panel %
+Z	0.974	0.771	0.203	21%
+Y +Z	1.462	1.056	0.406	28%
+Y	0.974	0.275	0.699	72%
+Y -Z	1.462	0.269	1.193	82%
-Z	0.974	0.129	0.845	87%
-Y –Z	1.462	0.276	1.186	81%
-Y	0.974	0.67	0.304	31%
-Y +Z	1.462	0.831	0.632	43%
Total Panels	9.744	4.277	5.468	56%
BEU	-	-	0.1026	
PAU	-	-	0.0608	

3.1.2.3 PLM I/F attachment points

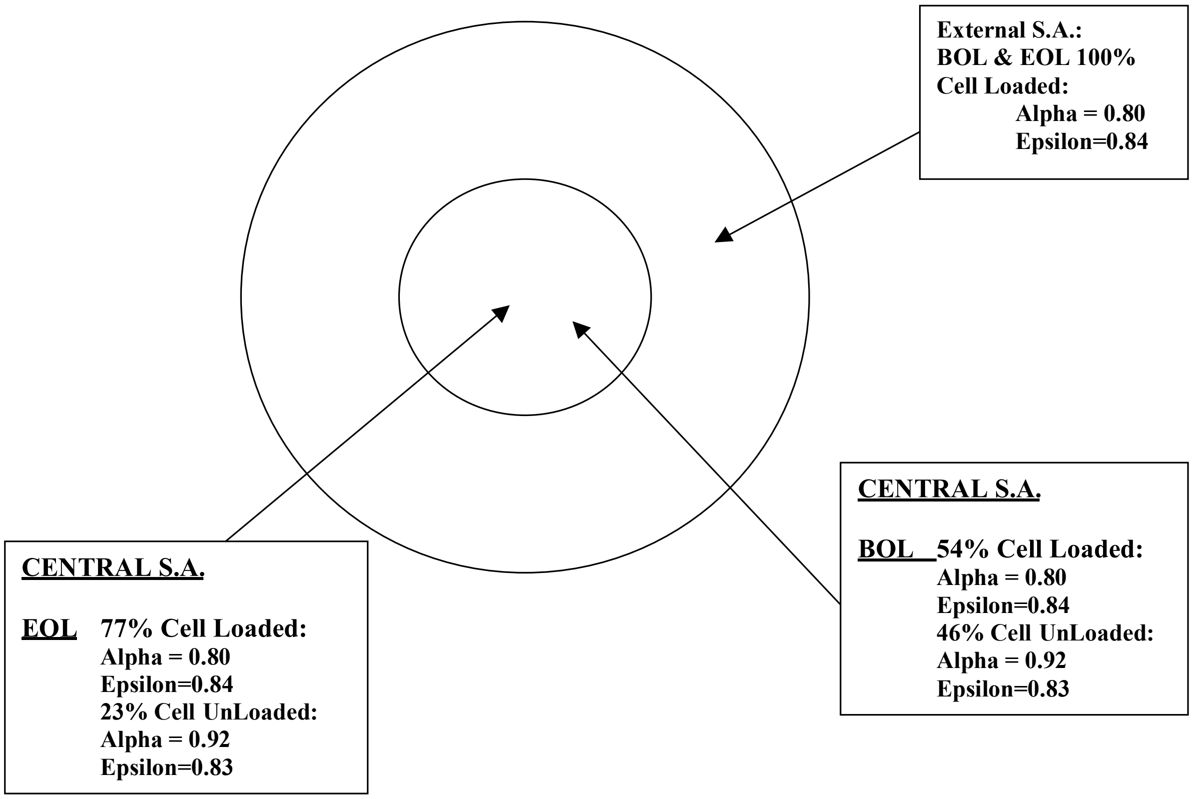
In the figure 3.1.2.2-1 the attachment poits with yhe PLM are shown.
Complessively the interface nodes are:
10001-10004-10005 – Groove Shield
10010-10011-10012 – Mechanical struts
10021 ÷ 10026 PLM I/F nodes

Figure 3.1.3.3-1 PLANCK - PLM I/F attachment points



3.1.2.4 Solar Array Thermo optical properties

In the figure 3.1.3.4-1 the thermo optical properties of the Loaded and Unloaded cells of Solar Array (External Ring and Central Disc) are displayed. Concerning the Central Disc, in the Geometrical Model the average of the thermo-optical properties are considered. (see table 3.1.3).



3.2 Conductive Couplings

3.2.1 MLI conductivity

A temperature variable Conductive Coupling (non linear) array simulates the MLI blanket behaviour.
The different arrays used in the TMM, applicable to different MLI compositions are given in the following Table.
They are part of Alenia Spazio heritage. They are calculated with a semi-empirical curve derived from test data on Spacelab program (RD-2.2) and extensively used on several programs (Italsat, Artemis, Integral, MPLM, Atlantic Bird-1, Columbus, Nodes).
The used semi-empirical correlation was substantially confirmed through the Thermal Balance Tests performed on the above programs and by a dedicated test on a MPLM MLI sample.
By the way, Alenia used formula is in good agreement with the empirical correlation proposed in the RD-2.3.

MLI thermal conductivity is depending on the different number of layers. Application is:

- HERSCHEL
  - 20 layers MLI composition is used on the Top of the Satellite facing to HPLM
  - 10 layers MLI composition is used on all the other external surfaces:
  - 7 layers MLI composition is used on HIFI units, internal –Y –Z Panel, Internal –Y Panel, STR baffle and on the Tanks
- PLANCK
  - 20 layers MLI composition is used on the Top of the Satellite facing to PPLM and on the rear of Solar Array
  - 10 layers MLI composition is used on all the other external surfaces:
  - 7 layers MLI composition is used on the Tanks and on the SCC panels
  - 15 layers MLI – External layers Kapton 1 mil plus 13 layers of embossed 0.3 mil Kapton covering the Wave Guides on +Y and –Y panels (derived from Thruster impingement analysis see AD.29).

Table 3.2-1 HERSCHEL/PLANCK - MLI Thermal Conductivity for different number of layers

Temperature [°C]	20 Layers [W/m2°C]	10 Layers [W/m2°C]	7 Layers [W/m2°C]
-100	0.0175	0.0233	0.0314
-90	0.0212	0.0275	0.0362
-80	0.0251	0.0320	0.0413
-70	0.0292	0.0366	0.0468
-60	0.0334	0.0416	0.0527
-50	0.0378	0.0469	0.0590
-40	0.0424	0.0524	0.0659
-30	0.0473	0.0584	0.0733
-20	0.0523	0.0647	0.0812
-10	0.0577	0.0714	0.0898
0	0.0633	0.0785	0.0990
10	0.0692	0.0861	0.1088
25	0.0786	0.0984	0.1250
30	0.0819	0.1027	0.1308
40	0.0888	0.1118	0.1430
50	0.0960	0.1214	0.1560
60	0.1036	0.1317	0.1699
70	0.1116	0.1425	0.1848
80	0.1200	0.1540	0.2006
90	0.1288	0.1661	0.2174
100	0.1381	0.1789	0.2352

3.2.2 Unit-Panel Conductivity

The calculation of the linear conductor between units and panel is performed considering in general two contributions: the conduction due at the contact area, and the spreading effect presents when the mounting node area is bigger than contact area.
The linear conductor due at the contact area is evaluated by means the formula:

$$GL = G_c * A_c \ [W/°C] \qquad (1)$$

Where:

With filler

for contact area between 30 and 1000 cm^2 we have

$G_c = 50000 * C_c^{-0.9}$ (C_c = contact area in cm^2)
A_c = contact area in m^2

for contact area major than 1000 cm^2 we have

$G_c = 100$
A_c = contact area in m^2

Without filler

for contact area between 30 and 500 cm^2 we have

$G_c = 50 * \frac{800 - Cc}{150 + Cc}$ (Cc = contact area in cm^2)
A_c = contact area in m^2

The above formulas are based on data from dedicated test performed on Olympus program (1988) and successfully used in the Alenia programs since then.
Thermal Balance Test correlations of Italsat-1/2, SAX, TSS-1/2, Artemis, Integral, Atlantic Bird-1, confirmed the applicability of the used formulas.

Regards the spreading effect the Thermal Balance Test correlations on previous programs have shown that the spreading calculation is necessary when the contact area is smaller than about 45 % of mounting node area.
The spreading effect is represented from by an equivalent linear conductor (G_{spread}) that will be put in series at the linear conductor (GL) evaluated by means the previous formulas.

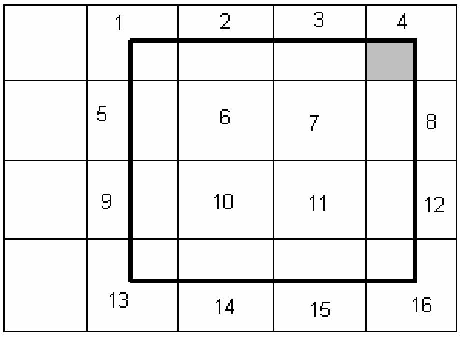
For the units with a small contact area by means of feet, the linear conductor for each foot will be calculated multiplying the contact area in m^2 for a contact constant, considering filler, of 2000 $W/m^2/K$. Of course the eventual spreading effect will be put in series if necessary.

When the contact area of an unit covers more mounting nodes, the spreading effect is evaluated considering the contribution of each portion of contact area on relevant mounting node (ex. in figure below, the portion of contact area on the node number 4 is highlighted in gray).
For each mounting node the linear conductor will be calculated as series of the following conductors:

1. The linear conductor (GL) obtained proportionally at the contact area projected on the mounting node of the total linear conductor calculated by the formula (1)
2. The relevant spreading effect (G_{spread}).

In the example of figure below, the spreading effect will be securely present in the mounting nodes 1,4,13 and 16 (portion of contact area less than 45% of node area) and will not be present in the mounting nodes 6,7,10 and 11.

For the other nodes if the percentage of area of mounting node covered from the unit will be lower than 45% the spreading effect will be calculated otherwise no spreading effect will be present
Details of Unit – Panel Contact Conductances (including spreading effect if applicable) are given in Table 3.2.2-1



for HERSCHEL and Table 3.2.2-2 for PLANCK.

Table 3.2.2-1 HERSCHEL – Unit-Panel Contact Conductances

LABEL	NODE	PANEL	CAPACITY	CONTACT AREA [CM2]	CONTACT TYPE	GL TMM [W/°C]
VMC	4	EXTERNAL +Z	360	77	Metal-Metal	1.23
SAS+Z	5	EXTERNAL +Z	130	7.44	Metal-Metal	0.749 with bracket (AD14)
MGA+Z	16	EXTERNAL +Z	69.2		Washer	0.0682 (AD17)
LGA+Z	21	EXTERNAL +Z	110		Washer	0.0667 (AD16)
LGA-Z	41	EXTERNAL -Z	110		Washer	0.0667 (AD16)
SAS-Z	45	EXTERNAL -Z	130	7.44	Metal-Metal	0.749 with bracket (AD14)
SREM	49	EXTERNAL -Z	2160	295	Metal-Metal	0.7 (integral data)
AAD	56	EXTERNAL +Z	76.2	5.2	Metal-Metal	0.524 with bracket (AD15)
GYRO	81	SHEAR +Z+Y	4800	202	Filler	8.5
RFDN	101	+ Y + Z	3920	317(*)	Filler	2
EPC1	102	+ Y + Z	1287	118.5	Filler	6.33
EPC2	103	+ Y + Z	1287	118.5	Filler	3.58
XPND1	104	+ Y + Z	3688	109.2	Filler	5.77
XPND2	105	+ Y + Z	3688	109.2	Filler	5.77
TWTA1	106	+ Y + Z	442	136	Filler on Doubler	6.09
TWTA2	107	+ Y + Z	442	136	Filler on Doubler	6.09
CRS1	110	SHEAR +Y+Z	1523	29.6(*)	Filler	1.16
CRS2	111	SHEAR +Y+Z	1523	29.6(*)	Filler	1.16
PCDU	201	+ Y	23490	1802	Filler	18.0
CDMU	202	+ Y	12000	551	Filler	8.38
ACC	203	+ Y	10640	513	Filler	8.25
BATT	204	+ Y	5520	19.6(*)	Filler	0.57
FPSPU1-2	301	+ Y – Z	7000	510	Filler	8.92
FPDPU	303	+ Y – Z	7177	664	Filler	8.92
FPBOLC	304	+ Y – Z	17500	1105	Filler	10.65
FPMECDEC	305	+ Y – Z	18400	1736	Filler	16.52
CCU	401	- Z	6790	720	Filler	8.43
HSDCU	404	- Z	18369	282	Filler	8.62

LABEL	NODE	PANEL	CAPACITY	CONTACT AREA [CM2]	CONTACT TYPE	GL TMM [W/°C]
HSDPU	405	- Z	7177	644	Filler	8.9
HSFCU	406	- Z	17900	500	Filler	9.32
FHWOV	501	- Y – Z	5100	2.4(*)	Filler	0.213
FHHRV	502	- Y – Z	10950	1102	Filler on Doubler	10.93
FHICU	503	- Y – Z	7621	644	Filler	8.3
FHFCU	504	- Y – Z	7300	763	Filler	9.55
FHWEV	506	- Y – Z	6600	38.5(*)	Filler on Doubler	6.84
FHIFV	507	- Y – Z	480	49	Filler	1.5
FHWOH	601	- Y	5100	2.4(*)	Filler	0.213
FHWEH	602	- Y	6600	38.5(*)	Filler on Doubler	6.84
FHHRH	603	- Y	10950	1102	Filler	10.92
FHLCU	604	- Y	12000	750	Filler	9.34
FHLSU	605	- Y	11200	970	Filler	9.52
FHIFH	606.0	- Y	480	49	Filler	1.86
RW1	701	- Y + Z	4400		Metal-Metal	0.13 (Integral data)
RW2	702	- Y + Z	4400		Metal-Metal	0.13 (Integral data)
RW3	703	- Y + Z	4400		Metal-Metal	0.11 (Integral data)
RW4	704	- Y + Z	4400		Metal-Metal	0.11 (Integral data)
THR1	8133	+Z	92.1		Filler	0.8
THR2	8233	+Y+Z	92.1		Filler	0.8
THR3	8333	+Y-Z	92.1		Filler	0.8
THR4	8433	-Z	92.1		Filler	0.8
THR5	8533	-Y-Z	92.1		Filler	0.8
THR6	8633	-Y+Z	92.1		Filler	0.8
STR1					Metal-Metal	1.13 / 1.65 (AD26)
STR2					Metal-Metal	1.13 / 1.65 (AD26)

(*) On feet

Table 3.2.2-2 PLANCK – Unit-Panel Contact Conductances

LABEL	NODE	PANEL	CAPACITY	CONTACT AREA [CM2]	CONTACT TYPE	GL TMM [W/°C]
SREM	3966	EXTERNAL +Y+Z	2160	295	Metal-Metal	0.7
SAS-X	3951	EXTERNAL -X	130	7.44	Metal-Metal	0.749 with bracket (AD14)
AAD	3970	EXTERNAL -X	76.2	5.2	Metal-Metal	0.524 with bracket (AD15)
MGA-X	3986	EXTERNAL -X	69.2		Washer	0.0682 (AD17)
LGA-X	3991	EXTERNAL -X	110		Washer	0.0667 (AD16)
LGA-Y	3961	EXTERNAL -Y	110		Washer	0.0667 (AD16)
LGA+Y	3921	EXTERNAL +Y	110		Washer	0.0667 (AD16)
SAS+Y	3931	EXTERNAL +Y	130	7.44	Metal-Metal	0.749 with bracket (AD14)
RFDN	605	-Y	5150	350	Filler	2.4
EPC1	606	-Y	1230	118.5	Filler	6.06
EPC2	607	-Y	1230	118.5	Filler	3.52
TRANSX1	601	-Y	3688	109.2	Filler	5.84
TRANSX2	602	-Y	3688	109.2	Filler	5.84
TWTA1	603	-Y	448	136	Filler	3.28
TWTA2	604	-Y	448	136	Filler	3.28
CRS1	705	SHEAR -Y+Z	1523	29.6(*)	Filler	0.276
CRS2	706	SHEAR -Y+Z	1523	29.6(*)	Filler	0.119
CRS3	551	SHEAR –Y-Z	1523	29.6(*)	Filler	0.119
PCDU	704	-Y+Z	23490	1802	Filler	18.0
CDMU	701	-Y+Z	14004	551	Filler	8.35
ACC	702	-Y+Z	12400	513	Filler	8.32
BATT	703	-Y+Z	5463	19.6(*)	Filler	0.758
DPU1	13	+Z	5520	813	Filler	9.34
DPU2	14	+Z	5520	813	Filler	9.34
DCCU	101	+Y+Z	20000	5280	Filler	52.8
REBA1	102	+Y+Z	4200	510	Filler	8.5
REBA2	103	+Y+Z	4200	510	Filler	8.5
FOG (GEU)	104	SHEAR +Y+Z	3360	358	Filler	6.55
FOG (ICU)	105	SHEAR +Y+Z	1920	6 bolts	Metal-Metal	0.06
4K CAU	202	+Y	5680	1225	Filler	12.14
4K PRE REG	203	+Y	2200	400	Filler	6.87
CEU	204	+Y	4550	402	Filler	7.87
REU	205	+Y	26800	1460	Filler	13.59
4K CCU	211-232	+Y	15870	98	Filler	2.6
SCC1	311-336	+Y-Z	Array value		On Heat Pipe	63.5 each bed
SCE1	401	-Z	6800		On Heat Pipe	33.75
SCE2	402	-Z	6800		On Heat Pipe	33.75
SCC2	511-536	-Y-Z	Array value		On Heat Pipe	63.5 each bed
BEU	519	EXTERNAL SUBPLATFORM	6704	500	Filler	9.41
BEU	520	EXTERNAL SUBPLATFORM	7656	720	Filler + Doubler	9.76

LABEL	NODE	PANEL	CAPACITY	CONTACT AREA [CM2]	CONTACT TYPE	GL TMM [W/°C]
BEU	521	EXTERNAL SUBPLATFORM	6704	500	Filler	9.41
PAU	522	EXTERNAL SUBPLATFORM	8000	1055	Filler	10.55
DAE	525	EXTERNAL SUBPLATFORM	5032	400	Filler	1.95
Thr 1N		EXTERNAL –Y+Z	92.1		Filler	0.1
Thr 1N		EXTERNAL –Y+Z	92.1		Filler	0.1
THR1		+Z	92.1		Filler	0.8
THR2		+Y+Z	92.1		Filler	0.8
THR3		+Y-Z	92.1		Filler	0.8
THR4		-Z	92.1		Filler	0.8
THR5		-Y-Z	92.1		Filler	0.8
THR6		-Y+Z	92.1		Filler	0.8
STR1	5401-5486	+Z			Metal-Metal	1.13 / 1.65 (AD26)
STR2	5501-5586	+Z			Metal-Metal	1.13 / 1.65 (AD26)

(*) On feet

3.2.3 Honeycomb Panel Conductivity

- Conductive couplings across honeycomb panel (identified as "Z" direction) are calculated by multiplying the effective thermal conductivity Kz and the cross section between two thermal nodes (panel internal / external sides):

$$GL(int,ext) = KZ * A(node) / d$$

  where
  KZ = thermal conductivity across the honeycomb [W/m°C]
  A(node) = node area [m2]
  d = overall thickness of the honeycomb panel [m]

- Lateral thermal conductance of honeycomb panel (identifeied as "XY" direction) is calculated by multiplying the effective thermal conductivity Kxy by the cross section and dividing it by the distance between the two thermal nodes.

$$GL(xxx,yyy) = KXY * A(cross\ section) / d$$

  where
  KXY = in plane conductivity of the honeycomb
  A(cross section) = cross section between the two nodes
  d = distance of the center of mass of the two adjacent nodes

Structural characteristcs and thermal conductivity (Kz, Kxy) of the panels are reported in table 3.2.3-1 for HERSCHEL and 3.2.3-2 for PLANCK (Remark: the conductivity evaluation has been made as per RD.2-1).

Table 3.2.3-1 HERSCHEL – SVM Honeycomb panels & structural parts thermal properties

LOCATION	H/C TYPE	SKIN TYPE	SKIN Conducib. W/mK	THICK. SKIN [mm]	THICK. CORE[mm]	KXY [W/mK]	KZ [W/mK]
Upper and Lower Closure	3/16-5056-.0007	M18/G801	20	0.4	20	1.21	1.19
Lateral	3/16-5056-.0007	AA7075T6	130	0.3	35	2.64	1.17
Top Platform central disc	3/16-5056-.0007	M18/G801	20	0.3	20	1.03	1.18
Shear Web	3/16-5056-.001	M18/G969	20	0.76	15	2.43	1.78
Cone	3/16-5056-.001	M40/914	20	0.54	15	1.95	1.74
Reinforced Cone	1/8-5056-.002	M40/914	20	1.08	13.92	4.39	5.32
STR baseplate +X	3/16-5056-.0007	HCF(*)	350 eq	2	55	24.15	1.25
STR baseplate -X	3/16-5056-.0007	HCF(*)	350 eq	3	55	34.84	1.25

(*) High conductivity Carbon Fiber.

The struts to CVV are made in glass fiber with titanium blade, the K is variable as in the following table:

T [°C]	K [W/m/K]
-150	0.38
-140	0.40
-110	0.44
-90	0.48
-70	0.55
-50	0.64
-30	0.75

Table 3.2.3-1a HERSCHEL – SVM struts conductivity

Table 3.2.3-2 PLANCK – SVM Honeycomb panels thermal properties

LOCATION	H/C TYPE	SKIN TYPE	SKIN Conducib. W/mK	THICK. SKIN [mm]	THICK. CORE[mm]	KXY [W/mK]	KZ [W/mK]
Top & Bottom Floor	3/16-5056-.0007	M18/G801	20	0.4	20	1.21	1.19
Radiator Panels and SCC Panels	3/16-5056-.0007	AA7075T6	130	0.3	35	2.64	1.17
Radiator Panel +Y	3/16-5056-.0007	AA7075T6	130	0.6	35	4.75	1.19
Payload Subplatform	3/16-5056-.0007	AA7075T6	130	0.3	19.4	4.34	1.18
Shear Web	3/16-5056-.0007	M18/G969	20	0.76	15	2.25	1.26
Cone	3/16-5056-.001	M40/914	20	0.54	15	1.95	1.74
Reinforced Cone	1/8-5056-.002	M40/914	20	1.08	13.92	4.39	5.32
Solar Array	Al	M55	20	0.18	20	0.825	1.31

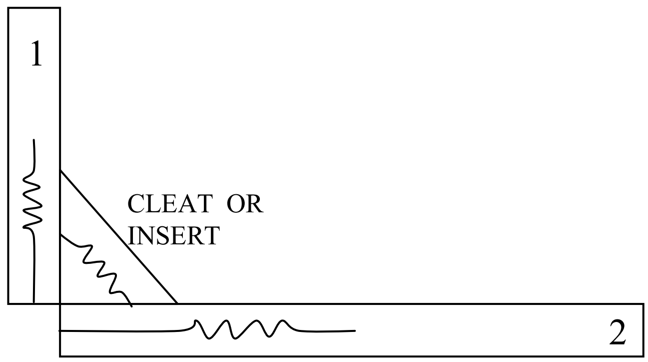
3.2.4 Doubler – panel conductivity

The linear conductor between doubler and panels has been calculated by means the formula (1) (para 3.2.2) for the case with filler.
In the linear conductor computation the spreading effect has not been considered because the doubler nodes have the same sizing of the underneath panel nbodes.

3.2.5 Cleats linear conductivity

The linear couplings between panels and between panels and platforms have been calculated between the two elements (1 and 2) as a serie of three linear thermal conductors:

GL half part of the element 1 = K*A/d
GL of the link cleat or insert (see example)
GL half part of element 2 = K*A/d



The different couplings are listed hereafter with the corresponding type of link. The link can be a cleat or an insert, and they are in Titanium (indicate with W before) on the HIFI panels (-Y and –Y-Z panel).

The GL has been calculated studiing the different geometry and the different type of contact for each cleat or insert. The drawings are given in H-P-IC-AI-0001 issue4.
The contact conductance and the screw conductance are added and put in serie with the cleat material conductance to evaluate the global linear conductance GL due to the link.
The various GL are indicated in table for the different cleats/insert geometry:

HERSCHEL		
LINKED PANELS	**TYPE OF LINK**	**GL**
		[W/K]
Lateral panel-lateral panel	CLEAT1	0.39
Lateral panel-lateral panel –Y and –Y-Z	WCLEAT1	0.08
Lateral panel-top floor and lateral panel-bottom floor	INSERT	0.21
Lateral panel-top floor and lateral panel-bottom floor –Y and –Y-Z	WINSERT	0.1
Shear web-top floor and shear web-bottom floor	INSERT1	0.32
Shear web-lateral panel	INSERT2	0.33
Shear web-lateral panel -Y	WINSERT2	0.09
Shear web-cone	CLEAT2	0.43
Cone-bottom floor	CLEAT3SCREW	0.36

Cone-bottom floor –Y and –Y-Z	CLEAT4SCREW	0.48
Adaptor ring-bottom closure panel	CLEAT_ADAPT_RCS	0.43
PLANCK		
LINKED PANELS	**TYPE OF LINK**	**GL**
		[W/K]
SCC panel - Top, Bottom and Shear Web	KINSERT3	0.0185
SCC panel - other Lateral Panels	CLEAT3	0.031

3.2.6 PLANCK Heat Pipes conductivity

The heat pipes network has been perfomed as reported in AD8 with the following updating coming from the CDR discussion:

Correction of thermal capacity
RID CDR-TCS-ASP-ENG-067

ALS has again calculated, using the data from the EHP MRR DP, the updated value for the thermal capacity.

The new data are:	Horizontal H.P. 400 J/K*m	was 800 J/K*m
	Vertical H.P. 360 J/K*m	was 420 J/K*m

Correct GL HP vertical I/F – HP vertical evaporator
RID CDR-TCS-ASP-ENG-064

ALS update the GL between HP vert.I/F(nodes 811-825, 861-875) and HP vert. Evaporator (nodes 8011-8025, 8061-8075) considering a contact area for each conductor of (0.0508+spreading 45°) * 0.025 =1.645e-03 m². Previous value was computed considering a contact area for each conductor of (0.78 * 0.025) = 19.5e-03 m².

Consider GL HP vertical I/F at the extremity
RID CDR-TCS-ASP-ENG-109

ALS update the TMM considering the GL between the HP vert. I/F at the extremity (nodes 811,826,861,876) and the SCC Outer Shell (nodes 311-316, 511-516) reduced by half due to the reduced contact area of the HP located at the extremity.

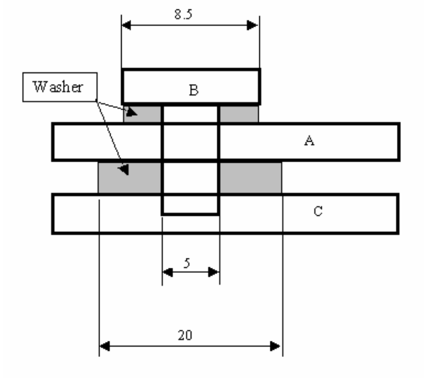
Heat pipes conductive couplings
RID CDR-TCS-ASP-ENG-121

The conductors between HP hor (nodes 801-808,851-858) and SCC radiators have been updated considering the dimension taken from the EHP drawings issued on 1st March 2004. The values are:

Nodes 801-808 to SCC panel +Y-Z :	Gc = 50000 * $Ac^{-0.9}$ = 222 W/m²	was 213.27 W/m²
Nodes 801-808 to SCC panel -Z :	Gc = 50000 * $Ac^{-0.9}$ = 304.88 W/m²	was 324.14 W/m²
Nodes 851-858 to SCC panel -Y-Z :	Gc = 50000 * $Ac^{-0.9}$ = 220.7 W/m²	was 213.27 W/m²

3.2.7 PLANCK Solar Array conductivity

Figure 3.2.7-1 PLANCK – sketch of connection by means screw



External Solar Array

Each external solar array panel has two kinds of connections:
1. External solar array panel with Lower Closure Panel
2. External solar array panel with Lateral Panel by means a bracket

1) External solar array panel with Lower Closure Panel

For each first kind connection is used (12 points in total):
- One thermal washer in vetronite (thickness 1 mm) under the screw head;
- One thermal washer in vetronite (thickness 19 mm) in the I/F between Solar array panel and lower closure panel

On the basis of figure 3.2.7-1 we have:
- between A and B a vetronite washer of 1 mm
- between A and C a vetronite washer of 19 mm
- K screw : 15 W/m °C; K washer: 0.288 W/m2 °C
- thickness A (solar array) 25 mm

GL A-B = 0.0107 W/°C
GL B-C (by screw) = 0.0065 W/°C

Therefore the GL A-C, between the parts A and C (by screw), is the series of GL A-B and GL B-C.

GL A-C (by screw) = 0.0041 W/°C
GL A-C (by washer) = 0.0045W/°C

GL A-C (total) = **0.0085 W/°C** for each screw.

2) External solar array panel with Lateral Panel by means a bracket

For each second kind connection is used (16 points in total):

- One thermal washer in vetronite (thickness 1 mm) under the each screw head;
- One thermal washer in vetronite (thickess 5 mm) for each screw, in the I/F between external Solar Array panel and Solar Array lateral bracket.
- One tharmal washer in vetronite (thickness 3 mm) for each screw between Solar Array lateral bracket and lateral panel

For each point the Solar array is connected to panels by means a bracket in titanium fixed to solar array with 4 titanium screws M5 (GL1) and to panels with 3 titanium screws M5 (GL2). Considering the linear conductor of the bracket as GL3, the total linear conductor between solar array and panel is the series of GL1, GL2 and GL3**.**

On the basis of figure 3.2.7-1 we have:

GL1 (external solar array with bracket):

- between A and B a vetronite washer of 1 mm
- between A and C a vetronite washer of 5 mm
- K screw : 15 W/m °C; K washer: 0.288 W/m2 °C
- thickness A (bracket) 3 mm

GL A-B = 0.0107 W/°C
GL B-C (by screw) = 0.0327 W/°C

Therefore the GL A-C, between the parts A and C (by screw), is the series of GL A-B and GL B-C.

GL A-C (by screw) = 0.0081 W/°C
GL A-C (by washer) = 0.0170 W/°C

GL1 = GL A-C (total) = 0.0250 W/°C. Considering 4 screws = 0.1 W/°C

GL2 (by bracket):

- In titanium (K=15 W/m °C)
- width: 90 mm
- thickenss: 3 mm
- Length: 300 mm

GL2 = 0.0135 W/°C

GL3 (panel and bracket)

- between A and B a vetronite washer of 1 mm
- between A and C a vetronite washer of 3 mm
- K screw: 15 W/m/°C; K washer: 0.288 W/m2 °C
- thickness A (bracket) 3 mm

GL A-B = 0.0107 W/°C
GL B-C (by screw) = 0.0421 W/°C

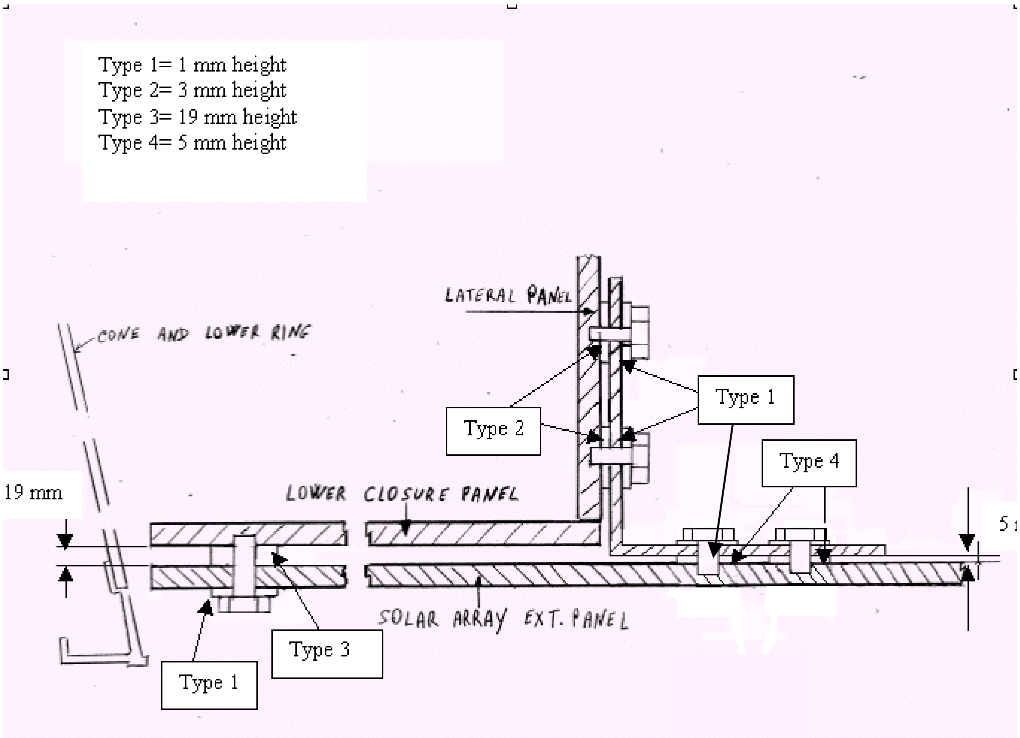
Therefore the GL A-C, between the parts A and C (by screw), is the series of GL A-B and GL B-C.

GL A-C (by screw) = 0.0085 W/°C
GL A-C (by washer) = 0.0283 W/°C

GL3 = GL A-C (total) = 0.0368 W/°C. Considering 3 screws = 0.1104 W/°C

The total GL as series of GL1, GL2 and GL3 = **0.0107 W/°C**

A sketch of the connections is reported below.



Central Solar Array

The central Solar array is connected by means 12 aluminum brackets to internal cone.
I/F between bracket and solar array is performed by means a titanium screw M5 with a vetronite washer of 2 mm under the head screw and a vetronite washer of 5 mm between solar array and bracket.
I/F between bracket and cone is performed by means 4 steel screws (K=36 W/m/°C). Each screw has a vetronite washer of 3 mm between bracket and cone. The total linear conductor is obtained as series of linear conductors of the bracket and of the two connections: solar array side and cone side.

On the basis of figure 3.2.7-1 we have:

GL1 (between bracket and cone):
- between A and B no washer (assumed a contact conductivity of 1000 W/m2 °C)
- between A and C a vetronite washer of 3 mm
- K screw : 36 W/m °C; K washer: 0.288 W/m2 °C
- thickness A (bracket) 3 mm

GL A-B = 0.0371 W/°C
GL B-C (by screw) = 0.1178 W/°C

Therefore the GL A-C, between the parts A and C (by screw), is the series of GL A-B and GL B-C.

GL A-C (by screw) = 0.0282 W/°C
GL A-C (by washer) = 0.0283 W/°C

GL1 = GL A-C (total) = 0.0565 W/°C. Considering 4 screws = 0.226 W/°C

GL2 (by bracket):
- In aluminum (K=150 W/m °C)
- width: 115 mm
- thickness: 3 mm
- Length: 100 mm

GL2 = 0.518 W/°C

GL3 (solar array and bracket)
- between A and B a vetronite washer of 2 mm
- between A and C a vetronite washer of 5 mm
- K screw: 15 W/m/°C; K washer: 0.288 W/m2 °C
- thickness A (bracket) 3 mm

GL A-B = 0.0053 W/°C
GL B-C (by screw) = 0.0295 W/°C

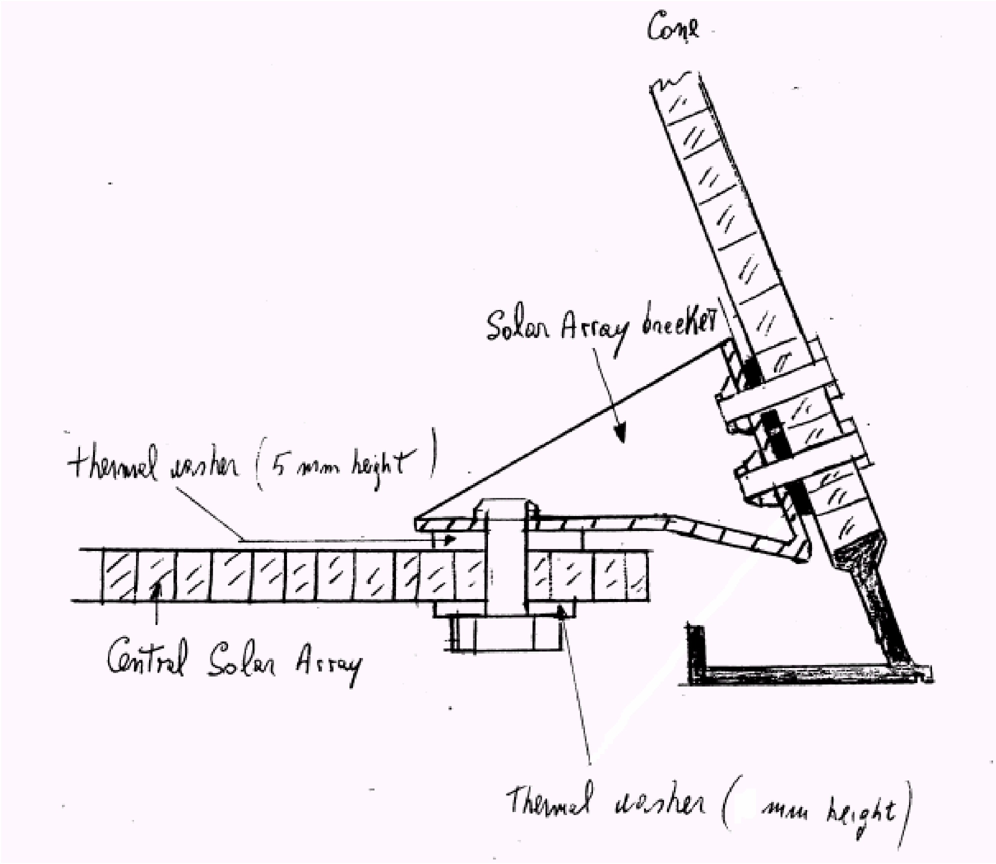
Therefore the GL A-C, between the parts A and C (by screw), is the series of GL A-B and GL B-C.

GL A-C (by screw) = 0.0045 W/°C
GL A-C (by washer) = 0.0170 W/°C

GL3 = GL A-C (total) = 0.0215 W/°C.

The total GL as series of GL1, GL2 and GL3 = **0.0189 W/°C**

A sketch of the connections is reported below.



3.3 HERSCHEL & PLANCK MASS UPDATING

The thermal capacities of HERSCHEL and PLANCK satellites have been updated on the basis of the:

- BEE mechanical mass budget (H-P-BD-AI-0006 issue 2) relatively to the masses used to define the thermal capacity of the structure (panel, shear web, cone, adaptor ring etc.)
- Thermal ICD or dedicated RTMM relatively to the unit thermal capacities.

Starting from the mechanical mass budget, the masses (subdivide for panel) of the structure, brackets, filler, paint, radiator and harness have been identified and reported in the tables 3.3-2 for Herschel and 3.3-3 for Planck.
In the table 3.3-1 the comparison between the total mass of the satellites derived from mechanical mass budget and the total equivalent mass derived from the TMM is shown.

Table 3.3-1 PLANCK – Summary mass comparison between TMM and mechanical mass budget

	Total BEE Mass Budget [Kg]	Total thermal Capacity in TMM [J/°C]	Equivalent Mass of thermal Capacity [Kg] (*)
HERSCHEL	891	742268	825
PLANCK	1103	841289	935

(*) considering a heat capacity of 900 J/Kg °C

Table 3.3-2 - HERSCHEL – Mass Updating from BEE mechanical mass budget

Description	Node	Brackets, filler, paint, radiator [Kg]	Harness [Kg]	SVM structure [Kg]	SVM Spread [Kg]	Thermal Capacity [J/°C] (*)
Panel +Z	30XX,60XX	0.13		6.3	7.02	12105
Panel +Y+Z	31XX, 61XX	0.34	3.27	4.99	4.67	10962
Panel +Y	32XX, 62XX	1.43	21.02	7.12	7.02	26625
Panel +Y-Z	33XX, 63XX	0.37	2.81	4.93	4.67	10659
Panel –Z	34XX, 64XX	0.39	3.7	7.4	7.02	15549
Panel -Y-Z	35XX, 65XX	0.23	3.66	5.36	4.67	11430
Panel –Y	36XX, 66XX	0.44	3.66	8.07	7.02	16173
Panel -Y+Z	37XX, 67XX	0.69	1.24	5	4.67	10068
Shear Web +Y(+Z)	526X	0.1		2.72		2538
Shear Web +Y(-Z)	528X			2.51		2259
Shear Web +Z(+Y)	507X	0.18		2.36		2286
Shear Web +Z(-Y)	505X	1.66		2.84		4050
Shear Web -Y(+Z)	568X			2.51		2259
Shear Web –Y(-Z)	566X			2.88		2592
Shear Web -Z(+Y)	546X			1.97		1773
Shear Web -Z(-Y)	548X			1.93		1737
Adaptor ring	201X,211X,202X, 212X,200X,210X, 205X,215X	3.6		32.5		32490
Cone	25XX,26XX			53.8		48420
Lower Closure	16XX	7	42.43	26.62		55716
Subplatform	24XX			5.29		4761
TH closure struct.	74XX	1.28		5.17		5805
Upper Closure	76XX	41.23	34.18	29.37		84048
Attached point	27XX			23.6		21240
Total		59.07	115.97	245.24	46.76	385545

(*) Considering the following specific heat: 600 J/Kg/°C for the harness; 900 J/Kg/°C for the other parts

Note: the Herschel star tracker baseplate has been considered, in the TMM, with a thermal capacity of 3597 J/°C, corresponding to a mass of 4.9 Kg. In the mechanical mass budget the mass of the STR structure with harness and bracket is of 5.43 Kg. About the star tracker unit the same mass has been considered both in the TMM and in the mechanical mass budget (3.12 Kg).

Table 3.3-3 - PLANCK – Mass Updating from BEE mechanical mass budget

Description	Node	Brackets, filler, paint, radiator [Kg]	Harness [Kg]	SVM structure [Kg]	SVM Spread [Kg]	Thermal Capacity [J/°C] (*)
Panel +Z	30XX,60XX	0.29	2.8	4.16	7.25	12210
Panel +Y+Z	31XX, 61XX	0.26	5.48	7.26	10.87	19839
Panel +Y	32XX, 62XX	0.29	8.47	4.72	7.25	16116
Panel +Y-Z	33XX, 63XX	0.18		7.47	10.87	16668
Panel -Z	34XX, 64XX	0.09	1.43	4.66	7.25	11658
Panel -Y-Z	35XX, 65XX	0.18	2	7.13	10.87	17562
Panel -Y	36XX, 66XX	0.25	3.42	4.68	7.25	13014
Panel -Y+Z	37XX, 67XX	0.84	24.78	6.89	10.87	31608
Shear Web +Y+Z(+Z)	515X,516X	0.01	6.21	2.85		6300
Shear Web +Y-Z(+Y)	525X,526X	0.7		2.85		3195
Shear Web +Y-Z(-Z)	527X,528X			2.69		2421
Shear Web -Y+Z(+Z)	507X,508X			2.46		2214
Shear Web +Y+Z(+Y)	517X,518X	0.45		2.59		2736
Shear Web -Y+Z(-Y)	505X,506X	0.21		2.73		2646
Shear Web -Y-Z(-Y)	535X,536X			2.74		2466
Shear Web -Y-Z(-Z)	537X,538X	0.24		2.63		2583
Adaptor ring	2XXX	3.4		32.5		32310
Cone	25XX,26XX	0		68.44		61596
Lower panel	16XX	6.68	40.26	19.45		47673
Subplatform	73XX,74XX,27XX	0.28	24.5	51		60852
Upper closure	76XX			21.08		18972
Attached point	1002X			15.9		14310
Total		14.35	119.35	276.88	72.48	398949

(*) Considering the following specific heat: 600 J/Kg/°C for the harness; 900 J/Kg/°C for the other parts

4. SVM INTERFACE REQUIREMENTS

4.1 Herschel requirements

The HERSCHEL SVM interface requirements are listed below:

REQUIR.	DESCRIPTION	RESULT	STATUS
ITP-030-H	CVV total negative conductive loads onto the SVM of 5W uniformely distributed on each point	Total negative flux of 5W on the 12 I/F CVV POINTS (2701÷2712) in the TMM	C
ITS-021-H	Sunshield total positive loads onto SVM of 5W from Sunshield CFRP struts and 10W from Sunshield brackets uniformely distributed on each point	Total positive flux of 5W on the 3 I/F SUNSHIELD STRUTS (2715÷2717) and 10W on the 2 I/F SUNSHIELD BRACKETS (2713-2714) in the TMM	C
ITP-040-H	SVM shield total negative loads onto SVM of 1W uniformely distributed on each point	Total negative flux of 1W on the 14 I/F SVM SHIELD POINTS (2718÷2731) in the TMM	C
ITP-050-H	Total negative loads onto FHLSU via wave-guides of 1W	Total negative flux of 1W on the FHLSU (605) in the TMM	C
ITP-060-H	Negative heat loads onto the SVM connector brackets of the upper panels < 1W	connector brackets not modelled	N/A
ITP-090-H	MLI on top SVM max decoupling	Low Emissivity (ε=0.05) and MLI 20 layers used	C
ITP-100-H	MLI on top SVM composition ε<0.05, infra-red specular ratio>90%, α 0.13±0.02, solar specular reflectivity 0.82±0.02 and external layer T average (wighted by areas) < 220K (-43.6°C) for any pitch in the range [-30°,0°]	Composition and T <220K for nodes 7001÷7078 and 7201÷7260 for any pitch in the range [-30°,0°] Average Temp = -43.6 °C (Table 4.1-1)	NC
ITP-120-H	CVV truss attachement points T < 293K (20°C) for any pitch in the range [-30°,0°]	T< 293K on the 4 I/F CVV POINTS for any pitch in the range [-30°,0°] Average Temp = 25.7 °C (Table 4.1-2)	NC
ITP-130-H	SVM shield attachement points T < 293K (20°C) for any pitch in the range [-30°,0°]	T< 293K on 6 I/F SVM SHIELD POINTS for any pitch in the range [-30°,0°] Average Temp = 22.8 °C (Table 4.1-3)	NC
ITP-135-H	Thermal conductive leak from the STR Assembly to HPLM < 150mW	Flux to CVV (Table 4.1-4)	C
ITI-020-H	Temp. design range and stability req.	Stability results: see Tables 4.1-5/6	PC
		Temp. design range: see conclusions	PC
ACP-060-H	Maximum rate of temperature variation not exceeding 0.25 °C/100 sec at STR mounting plate	Detail see AD23 (Table 4.1-7/8)	C
	Amplitude of temperature variation within 0.5 °C around any setpoint of STR	Detail see AD23 (Table 4.1-9/10)	PC
	The maximum temperature gradient generated by STR at baseplate between mounting feet ≤ 0.4 °C	Detail see AD23 (fig. 4.1-1 and 4.1-2)	C
THP-095-H	During observation period max temperature gradient between SVM/PLM I/F point < 8°C	Table 4.1-13	C

C=Compliance; NC= Not Compliance; PC= Partially Compliance

ITP-100-H:
SVM Top external layer T average (wighted by areas) < 220K (-53°C) for the hottest pitch in the range [-30°,0°] and for the hottest dissipation case: EOL in Winter pitch 0° and Telecom MODE1

Table 4.1-1 HERSCHEL - REQ ITP-100-H

HERSCHEL ITP-100-H						
WORST CASE: EOL Rotx=-1 Roty=0 Winter Telecom MODE1						
NODE	**LABEL**	**T**	**UFP**	**T+UFP**	**AREA**	**(T+UFP)*AREA**
		[°C]	**[°C]**	**[°C]**	**[m2]**	**[°C*m2]**
7001	MLI SVM Top +Z	-58.32	24.6	-33.72	0.1385	-4.67
7002	MLI SVM Top +Z	-47.32	21.6	-25.72	0.1385	-3.56
7003	MLI SVM Top +Z	-56.98	24.4	-32.58	0.0703	-2.29
7004	MLI SVM Top +Z	-45.89	21.4	-24.49	0.0703	-1.72
7005	MLI SVM Top +Z	-56.45	24.3	-32.15	0.0703	-2.26
7006	MLI SVM Top +Z	-45.4	21.5	-23.9	0.0703	-1.68
7007	MLI SVM Top +Z	-57.52	24.7	-32.82	0.1385	-4.55
7008	MLI SVM Top +Z	-44.79	21.5	-23.29	0.1385	-3.23
7011	MLI SVM Top +Y+Z	-60.59	24.5	-36.09	0.0801	-2.89
7012	MLI SVM Top +Y+Z	-47.25	21.4	-25.85	0.1015	-2.62
7013	MLI SVM Top +Y+Z	-61.2	24.6	-36.6	0.0530	-1.94
7014	MLI SVM Top +Y+Z	-49.66	21.8	-27.86	0.1591	-4.43
7015	MLI SVM Top +Y+Z	-62.34	24.8	-37.54	0.0530	-1.99
7016	MLI SVM Top +Y+Z	-53.7	23.2	-30.5	0.1591	-4.85
7017	MLI SVM Top +Y+Z	-63.19	25	-38.19	0.0801	-3.06
7018	MLI SVM Top +Y+Z	-60.67	25.1	-35.57	0.1015	-3.61
7021	MLI SVM Top +Y	-65.99	25.4	-40.59	0.1385	-5.62
7022	MLI SVM Top +Y	-66.27	25.6	-40.67	0.1385	-5.63
7023	MLI SVM Top +Y	-67.05	25.3	-41.75	0.0703	-2.94
7024	MLI SVM Top +Y	-67.82	25.5	-42.32	0.0703	-2.98
7025	MLI SVM Top +Y	-67.72	25.4	-42.32	0.0703	-2.98
7026	MLI SVM Top +Y	-68.23	25.7	-42.53	0.0703	-2.99
7027	MLI SVM Top +Y	-68.9	25.6	-43.3	0.1385	-6.00
7028	MLI SVM Top +Y	-68.52	26	-42.52	0.1385	-5.89
7031	MLI SVM Top +Y-Z	-71.31	25.7	-45.61	0.0801	-3.65
7032	MLI SVM Top +Y-Z	-73.27	25.9	-47.37	0.1015	-4.81
7033	MLI SVM Top +Y-Z	-71.57	25.8	-45.77	0.0530	-2.43
7034	MLI SVM Top +Y-Z	-73.66	26	-47.66	0.1591	-7.58
7035	MLI SVM Top +Y-Z	-71.11	25.8	-45.31	0.0530	-2.40
7036	MLI SVM Top +Y-Z	-70.82	25.8	-45.02	0.1591	-7.16
7037	MLI SVM Top +Y-Z	-71.28	25.8	-45.48	0.0801	-3.64
7038	MLI SVM Top +Y-Z	-71.35	26	-45.35	0.1015	-4.60
7039	MLI SVM Top +Y-Z	-72.07	26	-46.07	0.1385	-6.38
7040	MLI SVM Top +Y-Z	-72.17	26.1	-46.07	0.1385	-6.38
7041	MLI SVM Top -Z	-73.11	26	-47.11	0.0703	-3.31
7042	MLI SVM Top -Z	-73.12	26.1	-47.02	0.0703	-3.31
7043	MLI SVM Top -Z	-72.92	26.2	-46.72	0.0703	-3.29
7044	MLI SVM Top -Z	-73.07	26.2	-46.87	0.0703	-3.30
7051	MLI SVM Top -Z-Y	-72.26	26.1	-46.16	0.1385	-6.39
7052	MLI SVM Top -Z-Y	-71.94	26.3	-45.64	0.1385	-6.32
7053	MLI SVM Top -Z-Y	-72.06	26.1	-45.96	0.0801	-3.68

HERSCHEL ITP-100-H						
WORST CASE: EOL Rotx=-1 Roty=0 Winter Telecom MODE1						
NODE	LABEL	T	UFP	T+UFP	AREA	(T+UFP)*AREA
		[°C]	[°C]	[°C]	[m2]	[°C*m2]
7054	MLI SVM Top -Z-Y	-72.4	26.2	-46.2	0.1015	-4.69
7055	MLI SVM Top -Z-Y	-72.13	26	-46.13	0.0530	-2.45
7056	MLI SVM Top -Z-Y	-73.92	25.3	-48.62	0.1591	-7.74
7057	MLI SVM Top -Z-Y	-71.89	25.9	-45.99	0.0530	-2.44
7058	MLI SVM Top -Z-Y	-73.25	25.6	-47.65	0.1591	-7.58
7059	MLI SVM Top -Y	-71.29	25.8	-45.49	0.0801	-3.64
7060	MLI SVM Top -Y	-73.06	25.8	-47.26	0.1015	-4.80
7061	MLI SVM Top -Y	-69.47	26	-43.47	0.1385	-6.02
7062	MLI SVM Top -Y	-72.13	25.4	-46.73	0.1385	-6.47
7063	MLI SVM Top -Y	-69.47	26	-43.47	0.0703	-3.06
7064	MLI SVM Top -Y	-72.71	25.1	-47.61	0.0703	-3.35
7065	MLI SVM Top -Y	-68.09	25.9	-42.19	0.0703	-2.97
7066	MLI SVM Top -Y	-70.64	24.8	-45.84	0.0703	-3.22
7067	MLI SVM Top -Y	-66.03	25.8	-40.23	0.1385	-5.57
7068	MLI SVM Top -Y	-67.17	25.5	-41.67	0.1385	-5.77
7071	MLI SVM Top -Y+Z	-62.62	25.5	-37.12	0.0801	-2.97
7072	MLI SVM Top -Y+Z	-58.94	25.5	-33.44	0.1015	-3.40
7073	MLI SVM Top -Y+Z	-61.88	25.2	-36.68	0.0530	-1.95
7074	MLI SVM Top -Y+Z	-53.27	23.2	-30.07	0.1591	-4.78
7075	MLI SVM Top -Y+Z	-60.93	25.1	-35.83	0.0530	-1.90
7076	MLI SVM Top -Y+Z	-51.08	22.2	-28.88	0.1591	-4.59
7077	MLI SVM Top -Y+Z	-59.91	25	-34.91	0.0801	-2.79
7078	MLI SVM Top -Y+Z	-48.37	21.7	-26.67	0.1015	-2.71
7200	MLI SVM Top Disc Int +Z	-61.44	24.6	-36.84	0.5144	-18.95
7201	MLI SVM Top Disc Int +Z+	-63.72	24.9	-38.82	0.1580	-6.13
7202	MLI SVM Top Disc Int +Y	-67.69	25.4	-42.29	0.5144	-21.76
7203	MLI SVM Top Disc Int +Y-	-72.29	26.3	-45.99	0.3250	-14.94
7204	MLI SVM Top Disc Int -Z	-72.91	26.6	-46.31	0.1787	-8.28
7205	MLI SVM Top Disc Int -Z-	-72.3	26.4	-45.9	0.3216	-14.76
7206	MLI SVM Top Disc Int -Y	-66.84	25.7	-41.14	0.5144	-21.16
7207	MLI SVM Top Disc Int -Y+	-63.29	25	-38.29	0.1580	-6.05
7210	MLI Cyl STR Int +Z	-62.24	22.9	-39.34	0.2513	-9.89
7211	MLI Cyl STR Int +Z+Y	-63.14	23.2	-39.94	0.0771	-3.08
7212	MLI Cyl STR Int +Y	-67.21	22.2	-45.01	0.2513	-11.31
7213	MLI Cyl STR Int +Y-Z	-65.3	22.3	-43	0.1586	-6.82
7214	MLI Cyl STR Int -Z	-65.57	22.2	-43.37	0.0880	-3.82
7215	MLI Cyl STR Int -Z-Y	-65.36	22.7	-42.66	0.1580	-6.74
7216	MLI Cyl STR Int -Y	-67.25	22.3	-44.95	0.2513	-11.30
7217	MLI Cyl STR Int -Y+Z	-62.43	23.3	-39.13	0.0771	-3.02
7220	MLI Disc STR Int +Z	-94.94	15.1	-79.84	0.1853	-14.80
7221	MLI Disc STR Int +Z+Y	-87.26	17.2	-70.06	0.0569	-3.98
7222	MLI Disc STR Int +Y	-81.67	17.9	-63.77	0.1853	-11.82
7223	MLI Disc STR Int +Y-Z	-99.48	17.1	-82.38	0.1170	-9.64
7224	MLI Disc STR Int -Z	-74.61	18.4	-56.21	0.0647	-3.63
7225	MLI Disc STR Int -Z-Y	-92.17	17.7	-74.47	0.1161	-8.65
7226	MLI Disc STR Int -Y	-83.04	18	-65.04	0.1853	-12.05

HERSCHEL ITP-100-H						
WORST CASE: EOL Rotx=-1 Roty=0 Winter Telecom MODE1						
NODE	**LABEL**	**T**	**UFP**	**T+UFP**	**AREA**	**(T+UFP)*AREA**
		[°C]	**[°C]**	**[°C]**	**[m2]**	**[°C*m2]**
7227	MLI Disc STR Int -Y+Z	-87.93	17.1	-70.83	0.0569	-4.03
7230	MLI Rec STR dx	-86.13	23	-63.13	0.0101	-0.64
7231	MLI Rec STR dx	-87.4	21	-66.4	0.0101	-0.67
7232	MLI Rec STR dx	-87.44	20	-67.44	0.0101	-0.68
7233	MLI Rec STR dx	-87.05	18.9	-68.15	0.0101	-0.69
7234	MLI Rec STR dx	-86.63	18.4	-68.23	0.0101	-0.69
7235	MLI Rec STR dx	-86.57	18.1	-68.47	0.0101	-0.69
7236	MLI Rec STR dx	-85.27	18.1	-67.17	0.0101	-0.68
7237	MLI Rec STR dx	-84.5	18.4	-66.1	0.0101	-0.67
7238	MLI Rec STR dx	-83.57	18.8	-64.77	0.0101	-0.65
7239	MLI Rec STR dx	-82.11	20.4	-61.71	0.0101	-0.62
7240	MLI Rec STR dx	-79.62	21.4	-58.22	0.0101	-0.59
7250	MLI Rec STR sx	-86.33	23	-63.33	0.0101	-0.64
7251	MLI Rec STR sx	-87.29	21.1	-66.19	0.0101	-0.67
7252	MLI Rec STR sx	-87.53	19.9	-67.63	0.0101	-0.68
7253	MLI Rec STR sx	-86.85	19	-67.85	0.0101	-0.68
7254	MLI Rec STR sx	-86.65	18.1	-68.55	0.0101	-0.69
7255	MLI Rec STR sx	-86.29	17.7	-68.59	0.0101	-0.69
7256	MLI Rec STR sx	-85.23	18.2	-67.03	0.0101	-0.68
7257	MLI Rec STR sx	-83.93	18.4	-65.53	0.0101	-0.66
7258	MLI Rec STR sx	-83.35	19.1	-64.25	0.0101	-0.65
7259	MLI Rec STR sx	-81.92	20	-61.92	0.0101	-0.62
7260	MLI Rec STR sx	-79.15	21.3	-57.85	0.0101	-0.58
	Average					
	Total				11.6779	-509
	Weighted on Areas					**-43.59**

ITP-120-H:
CVV truss attachement points T <293 K (20°C) for the hottest pitch in the range [-30°,0°] and for the hottest dissipation case: EOL in Winter pitch 0° and Telecom MODE1

Table 4.1-2 HERSCHEL - REQ ITP-120-H

HERSCHEL ITP-120-H				
WORST CASE: EOL Rotx=-1 Roty=0 Wnter Telecom MODE1				
NODE	**LABEL**	**T**	**UFP**	**T+UFP**
		[°C]	**[°C]**	**[°C]**
2701	I/F CVV	24.52	7.0	31.52
2702	I/F CVV	21.2	7.2	28.40
2703	I/F CVV	18.66	7.4	26.06
2704	I/F CVV	18	7.4	25.40
2705	I/F CVV	13.87	7.6	21.47
2706	I/F CVV	13.72	7.6	21.32
2707	I/F CVV	13.42	7.5	20.92
2708	I/F CVV	13.49	7.5	20.99
2709	I/F CVV	17.62	7.5	25.12
2710	I/F CVV	18.46	7.5	25.96
2711	I/F CVV	21.99	7.5	29.49
2712	I/F CVV	24.27	7.1	31.37
	Average	**18.27**		**25.67**

ITP-130-H:
SVM shield attachement points T < 293 K (20°C) for the hottest pitch in the range [-30°,0°] and for the hottest dissipation case: EOL in Winter pitch 0° and Telecom MODE1

Table 4.1-3 HERSCHEL - REQ ITP-130-H

HERSCHEL ITP-130-H				
WORST CASE: EOL Rotx=-1 Roty=0 Wnter Telecom MODE1				
NODE	**LABEL**	**T**	**UFP**	**T+UFP**
		[°C]	**[°C]**	**[°C]**
2718	I/F R1 SVM SHIELD +Y	19.73	7.4	27.13
2719	I/F T1 SVM SHIELD +Y	17.79	7.5	25.29
2720	I/F T2 SVM SHIELD +Y	14.92	7.5	22.42
2721	I/F T3 SVM SHIELD -Z	14.53	7.7	22.23
2722	I/F T4 SVM SHIELD -Z	15.04	7.5	22.54
2723	I/F T5 SVM SHIELD -Y	12.77	7.2	19.97
2724	I/F T6 SVM SHIELD -Y	13.62	7.3	20.92
2725	I/F R2 SVM SHIELD -Y	18.19	7.5	25.69
2726	I/F SS1 SVM SHIELD +Y	17.67	7.4	25.07
2727	I/F SS2 SVM SHIELD +Y-Z	13.53	7.6	21.13
2728	I/F SS3 SVM SHIELD -Y-Z	13.15	7.5	20.65
2729	I/F SS4 SVM SHIELD -Y	17.27	7.5	24.77
2730	I/F SS5 SVM SHIELD -Z	13.08	7.5	20.58
2731	I/F SS6 SVM SHIELD -Z	13.38	7.6	20.98
	Average	**15.33**		**22.81**

ITP-135-H:
Thermal conductive leak from the STR assembly to the HPLM for all the Sizing Cases defined in AD9 < 150mW

Table 4.1-4 HERSCHEL REQ ITP-135-H

HERSCHEL ITP-135-H						
Case		**Description**	**SEASON**	**POWER**	**Analysis type**	**Flux to CVV**
						[mW]
A	EOL	RotX=+1, RotY=-30	Winter	TelecomE/mode 1	Transient	125
B	EOL	RotX=+1, RotY=-30	Winter	TelecomE/mode 2 photometry	Transient	126
C	EOL	RotX=+1, RotY=-30	Winter	TelecomE/mode 2 spectroscopy	Transient	126
D	EOL	RotX=-1, RotY=-30	Winter	TelecomE/mode 1	Transient	125
E	EOL	RotX=-1, RotY=-30	Winter	TelecomE/mode 2 photometry	Transient	126
F	EOL	RotX=-1, RotY=-30	Winter	TelecomE/mode 2 spectroscopy	Transient	126
G	BOL	RotX=-1, RotY=+30	Summer	Scientific/mode 3	Transient	109
H	BOL	RotX=-1, RotY=+30	Summer	Scientific/mode 1	Transient	109
I	BOL	RotX=+5, RotY=0	Summer	SurvivalB	Transient	100

Table 4.1-5 HERSCHEL stability requirement (Cold case)

COLD CASE P				
Node number	**Unit name**	**Max [K/s]**	**Req. [K/s]**	**Compl/Not-Compl**
404	HSDCU	0.000242	0.000833333	Compl.
405	HSDPU	0.000172	0.000833333	Compl.
406	HSFCU	0.0002	0.000833333	Compl.
501	FHWOV	0.000066	0.0003	Compl.
502	FHHRV	0.000065	0.0003	Compl.
503	FHICU	0.000067	0.0014	Compl.
504	FHFCU	0.000067	0.0014	Compl.
506	FHWEV	0.000061	0.0003	Compl.
507	FHIFV	0.000861	0.0003	Not Compl.
508	FHWIH IFV-HRV	0.000103	0.0014	Compl.
509	FHWIH IFV-WEV	0.0001	0.0014	Compl.
510	FHWIH WEV-WOV	0.000107	0.0014	Compl.
511	FHWIH HRV-HRH	0.000121	0.0014	Compl.
601	FHWOH	0.00009	0.0003	Compl.
602	FHWEH	0.0001	0.0003	Compl.
603	FHHRH	0.000088	0.0003	Compl.
604	FHLCU	0.0001	0.0003	Compl.
605	FHLSU	0.000094	0.0003	Compl.
606	FHIFH	0.000133	0.0003	Compl.
607	FHWIH IFH-HRH	0.000124	0.0014	Compl.
608	FHWIH IFH-WEH	0.000123	0.0014	Compl.
609	FHWIH WEH-WOH	0.000103	0.0014	Compl.

Table 4.1-6 HERSCHEL stability requirement (Hot case)

HOT CASE Q				
Node number	**Unit name**	**Max [K/s]**	**Req. [K/s]**	**Compl/Not-Compl**
404	HSDCU	0.000273	0.000833333	Compl.
405	HSDPU	0.000198	0.000833333	Compl.
406	HSFCU	0.000228	0.000833333	Compl.
501	FHWOV	0.000069	0.0003	Compl.
502	FHHRV	0.000075	0.0003	Compl.
503	FHICU	0.000073	0.0014	Compl.
504	FHFCU	0.000076	0.0014	Compl.
506	FHWEV	0.000088	0.0003	Compl.
507	FHIFV	0.000827	0.0003	Not Compl.
508	FHWIH IFV-HRV	0.000113	0.0014	Compl.
509	FHWIH IFV-WEV	0.000109	0.0014	Compl.
510	FHWIH WEV-WOV	0.000115	0.0014	Compl.
511	FHWIH HRV-HRH	0.000136	0.0014	Compl.
601	FHWOH	0.000091	0.0003	Compl.
602	FHWEH	0.000115	0.0003	Compl.
603	FHHRH	0.0001	0.0003	Compl.
604	FHLCU	0.000113	0.0003	Compl.
605	FHLSU	0.000111	0.0003	Compl.
606	FHIFH	0.000147	0.0003	Compl.
607	FHWIH IFH-HRH	0.000145	0.0014	Compl.
608	FHWIH IFH-WEH	0.000144	0.0014	Compl.
609	FHWIH WEH-WOH	0.000117	0.0014	Compl.

ACP-060-H:
Maximum rate of temperature variation not exceeding 0.25 °C/100 sec at STR mounting plate I/F:

Table 4.1-7 HERSCHEL STR stability requirement (Cold case)

COLD CASE P				
Node number	**Unit name**	**Max ΔT/Δt [K/s]**	**Req. [K/s]**	**Compl/Not-Compl**
20014	STR Mounting plate I/F	0.000882	0.0025	Compl
20015	STR Mounting plate I/F	0.0012	0.0025	Compl
20022	STR Mounting plate I/F	0.000805	0.0025	Compl
20023	STR Mounting plate I/F	0.001153	0.0025	Compl
80027	STR Foot	0.000387	0.0025	Compl
80028	STR Foot	0.000289	0.0025	Compl
80029	STR Foot	0.000373	0.0025	Compl
80030	STR Foot	0.000309	0.0025	Compl

Table 4.1-8 HERSCHEL STR stability requirement (Hot case)

HOT CASE Q				
Node number	**Unit name**	**Max ΔT/Δt [K/s]**	**Req. [K/s]**	**Compl/Not-Compl**
20014	STR Mounting plate I/F	0.000832	0.0025	Compl
20015	STR Mounting plate I/F	0.00117	0.0025	Compl
20022	STR Mounting plate I/F	0.000753	0.0025	Compl
20023	STR Mounting plate I/F	0.001111	0.0025	Compl
80027	STR Foot	0.000366	0.0025	Compl
80028	STR Foot	0.000278	0.0025	Compl
80029	STR Foot	0.000361	0.0025	Compl
80030	STR Foot	0.000292	0.0025	Compl

ACP-060-H:
Amplitude of temperature variation within 0.5 °C around any setpoint of STR

Table 4.1-9 HERSCHEL STR stability requirement (Cold Case)

UNIT	Max variation during transient[°C]	Req. [°C]	Compl/Not-Compl
STR feet	80027 = 0.21 80028 = 0.244 80029 = 0.245 80030 = 0.236	0.5	Compl

Table 4.1-10 HERSCHEL STR stability requirement (Hot Case)

UNIT	Max variation during transient[°C]	Req. [°C]	Compl/Not-Compl
STR feet	80027 = 0.301 80028 = 0.336 80029 = 0.339 80030 = 0.330	0.5	P. Compl

ACP-060-H:
The maximum temperature gradient generated by STR at baseplate between mounting feet ≤ 0.4 °C

Table 4.1-11 HERSCHEL STR stability requirement (Cold Case)

UNIT	Temp. gradient between the mounting feet [°C]	Req. [°C]	Compl/Not-Compl
STR mount. Feet	See Fig 4.1-1	0.4	Part. Compl.

Table 4.1-12 HERSCHEL STR stability requirement (Hot Case)

UNIT	Temp. gradient between the mounting feet [°C]	Req. [°C]	Compl/Not-Compl
STR mount. Feet	See Fig 4.1-2	0.4	Compl.

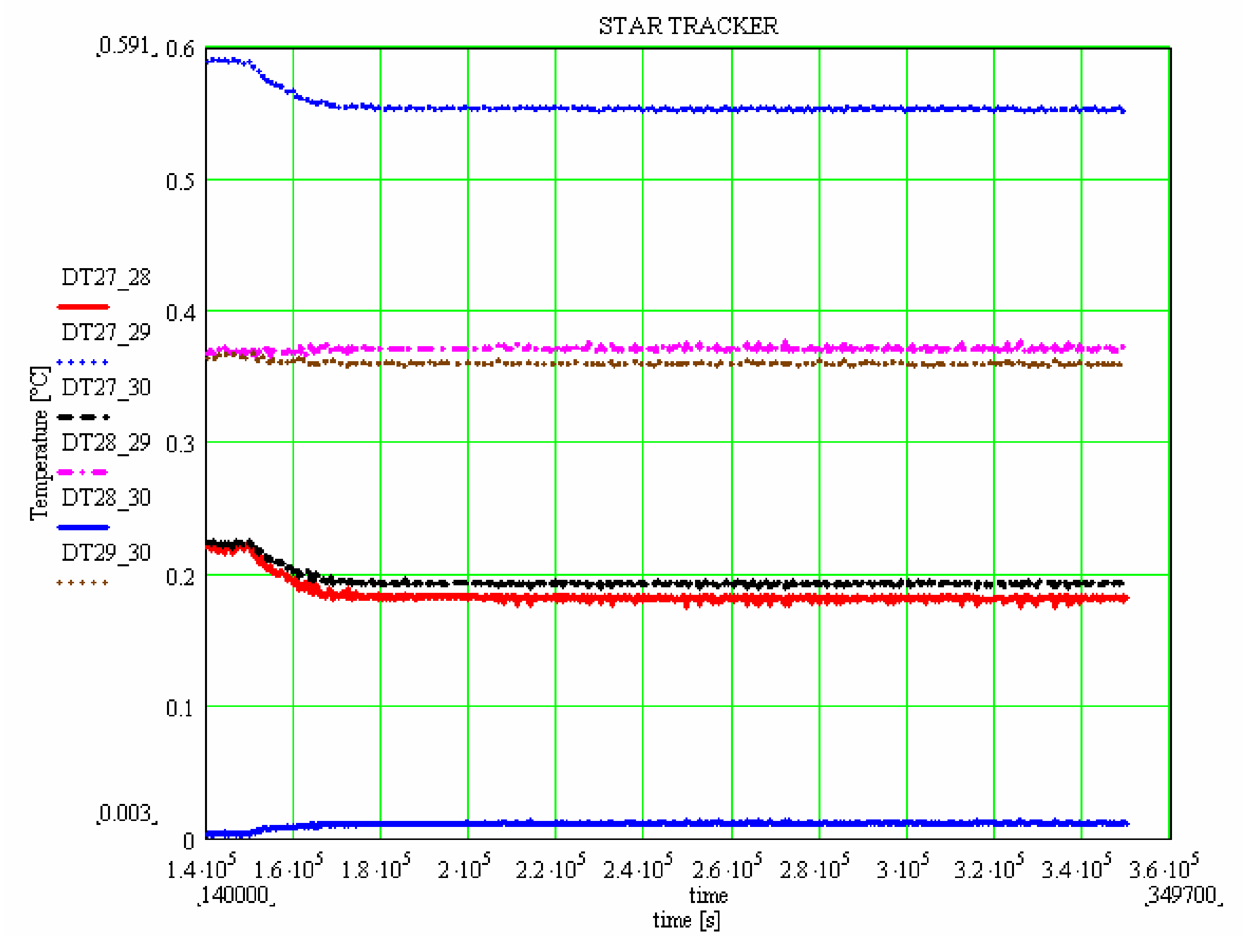


Figure 4.1-1 HERSCHEL STR feet temperature gradient (COLD CASE)

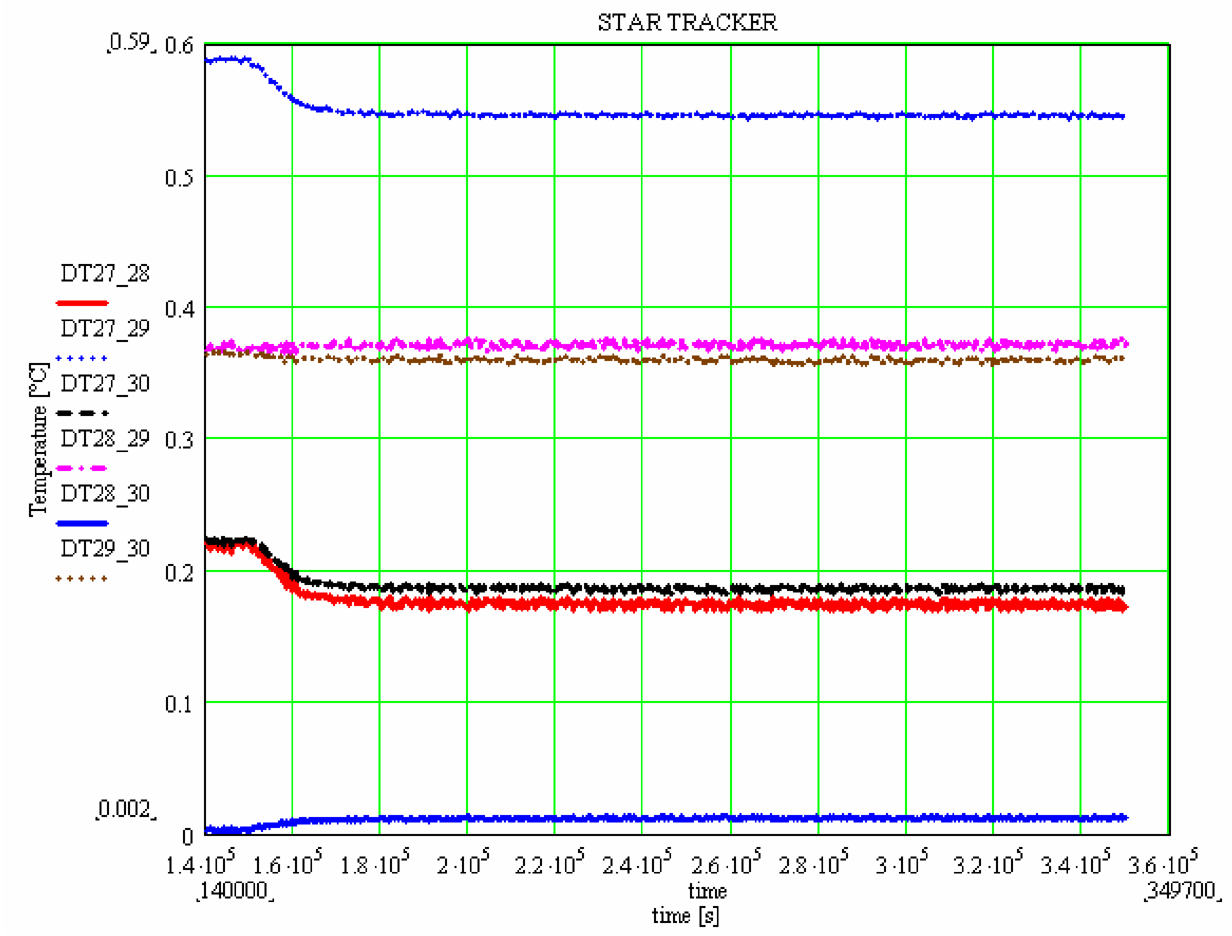


Figure 4.1-2 HERSCHEL STR feet temperature gradient (HOT CASE)

The requirement relevant to the maximum variation of the gradient of the I/F points, has been evaluated during a change of attitude both in COLD and HOT case comparing couples of I/F points covering all the combinations.

Table 4.1-13 HERSCHEL temperature gradient of SVM/PLM I/F points

Intf. point #1	Intf. point #2	COLD CASE P Max gradient variation [°C]	HOT CASE Q Max gradient variation [°C]
2701	2702	2.316	2.068
2701	2703	4.538	4.25
2701	2704	4.597	4.383
2701	2705	4.052	4.133
2701	2706	4.196	4.305
2701	2707	2.784	3.072
2701	2708	2.431	2.753
2701	2709	1.856	2.181
2701	2710	1.976	2.256
2701	2711	1.233	0.945
2701	2712	0.448	0.386
2702	2703	2.677	4.425
2702	2704	2.19	4.575
2702	2705	4.027	4.419
2702	2706	4.205	4.616
2702	2707	3.995	4.854
2702	2708	3.522	4.532
2702	2709	2.349	2.679
2702	2710	2.576	2.111
2702	2711	2.863	2.896
2702	2712	2.763	2.428
2703	2704	0.194	0.218
2703	2705	1.851	1.754
2703	2706	1.929	1.933
2703	2707	3.434	3.215
2703	2708	3.496	3.277
2703	2709	2.003	3.463
2703	2710	2.095	3.411
2703	2711	4.349	3.961
2703	2712	4.848	4.454
2704	2705	1.793	1.699
2704	2706	1.808	1.718
2704	2707	3.122	3.161
2704	2708	3.007	3.19
2704	2709	2.346	3.489
2704	2710	2.567	3.437
2704	2711	3.858	4.042

Intf. point #1	Intf. point #2	COLD CASE P Max gradient variation [°C]	HOT CASE Q Max gradient variation [°C]
2704	2712	4.91	4.569
2705	2706	0.106	0.143
2705	2707	1.822	1.8
2705	2708	2.001	2.004
2705	2709	2.784	2.77
2705	2710	2.787	2.74
2705	2711	3.804	3.555
2705	2712	4.235	4.247
2706	2707	1.859	1.852
2706	2708	2.077	2.095
2706	2709	2.822	2.84
2706	2710	2.81	2.795
2706	2711	3.902	3.7
2706	2712	4.365	4.41
2707	2708	0.359	0.387
2707	2709	1.104	1.15
2707	2710	1.076	1.099
2707	2711	1.481	2.175
2707	2712	2.869	2.925
2708	2709	0.9	0.913
2708	2710	0.919	0.904
2708	2711	1.043	1.868
2708	2712	2.523	2.547
2709	2710	0.144	0.151
2709	2711	1.209	1.237
2709	2712	1.902	1.918
2710	2711	1.312	1.311
2710	2712	2.015	2.048
2711	2712	2.015	2.048

4.2 Planck requirements

The PLANCK SVM interface requirements are listed below:

REQUIR.	DESCRIPTION	RESULT	STATUS
ITP 140-P	MLI blankets with high efficiency installed on the top of SVM upper panels.	Node 7001-7008 : ε=0.05; 20 layers	C
ITP-150-P	Specific characteristic of the subplatform MLI blankets Ext layer temperature <220K (< -53.15 °C)	Nodes 7201-7238 α=0.15 / ε=0.05 Avg Max temperature –40.8°C (Table 4.2-2)	NC
ITP-170-P	Radiative load from BEU-PAU ≤ 2.3W	Max heat flux = 2.45W (Table 4.2-6)	NC
ITP-180-P	Specific characteristic of BEU/PAU MLI blankets Ext layer temperature <235K (< -38.15 °C)	Nodes 7521-7522 α=0.15 / ε=0.05 Max temperature –28.4°C (Table 4.2-3)	NC
ITP-190-P	Back side of Solar Array must be covered with MLI	MLI nodes 8101-8104	C
ITP-200-P	Specific characteristic of the MLI blankets on the back side of the Solar Array Ext layer temperature <300K (< 26.85 °C)	Nodes 8101-8104 α=0.15 / ε=0.05 Max temperature 39.9°C (Table 4.2-4)	NC
ITP-210-P	The temperature of P-PLM truss attachment points < 310K (<36.85 °C)	Nodes 10021-10026 Max temperature 29.9°C (Table 4.2-5)	C
ITP-220-P	Temperature stability at I/F truss point ≤ 0.02K	Nodes 10021 – 10026 Results in Table 4.2-7	C
ITP-230-P	Temperature stability at radiative panels level ≤ 0.01K Hz½	Results in Table 4.2.8	C
ITI-030-P	Keep HFI and LFI instruments in their design range and under maximum temperature stability requirements. PAU: • Requirement: ±3 K/hour • Goal : ±1.1 K/hour BEU, DAE: • Requirement: ±3 K/hour • Goal : ±0.2 K/hour	See temperature results of HFI and LFI units Stability requrement in table 4.2-9	C
ITI-040-P	SCC: - use a very emissive coating for radiative panels - discouple SCC panels - make use of a heat pipe network	- panels with ε=0.87 - titanium cleats between SCC panel and contiguous parts - heat pipe network AD8	C
ITP-070-P	SVM compatible with PPLM as described in AD19	Model taken from doc. AD19	C
ITP-080_P	SVM compatible with negative load of 5W distributed over 6 nodes	Negative load flux applied onto nodes 10021-10026	C
ITI-010-P	SVM compatible with negative heat flow on BEU through wave guides (15W cold case / 0W hot case)	Applied on power dissipation value	C
SCC Stability	Bed fluctuation: ± 3K for first adjacent element ± 1K for the next adjacent element ± 0.5 for next most element	Results in tables 4.2-10	NC

REQUIR.	DESCRIPTION	RESULT	STATUS
TANK stability	The gradient between each tank shall be less than 0.1 over one hour, 0.25 °C over one day and 1.5 °C over life	Results in Table 4.2.11	PC

C=Compliance; NC= Not Compliance; PC= Partially Compliance

Table 4.2-2 PLANCK –ITP-150-P Temperature Results

PLANCK ITP-150-P						
WORST HOT CASE: EOL Rotx=-10						
NODE	LABEL	Temperature	UFP	T+UFP	Area	T+UFP * Area
		[°C]	[°C]	[°C]	[m²]	
7201	MLI SVM Top Disc +Y+Z	-60.49	24.7	-35.79	0.041	-1.467
7202	MLI SVM Top Disc +Y+Z	-62.02	24.7	-37.32	0.0481	-1.795
7203	MLI SVM Top Disc +Y+Z	-62.40	24.5	-37.90	0.0475	-1.800
7204	MLI SVM Top Disc +Y+Z	-63.75	24.9	-38.85	0.0805	-3.127
7205	MLI SVM Top Disc +Y+Z	-64.11	24.8	-39.31	0.0385	-1.513
7206	MLI SVM Top Disc +Y+Z	-64.66	24.8	-39.86	0.0414	-1.650
7207	MLI SVM Top Disc +Y+Z	-65.37	24.7	-40.67	0.0387	-1.574
7208	MLI SVM Top Disc +Y+Z	-65.92	24.7	-41.22	0.0304	-1.253
7209	MLI SVM Top Disc +Y+Z	-65.84	24.4	-41.44	0.0282	-1.169
7210	MLI SVM Top Disc +Y+Z	-65.69	24.5	-41.19	0.0255	-1.050
7211	MLI SVM Top Disc +Y+Z	-64.88	24.3	-40.58	0.0374	-1.518
7212	MLI SVM Top Disc +Y+Z	-64.03	24.3	-39.73	0.0312	-1.240
7213	MLI SVM Top Disc +Y+Z	-64.42	24.5	-39.92	0.029	-1.158
7214	MLI SVM Top Disc +Y+Z	-63.01	24	-39.01	0.0505	-1.970
7215	MLI SVM Top Disc +Y+Z	-63.67	24.1	-39.57	0.0514	-2.034
7216	MLI SVM Top Disc +Y+Z	-51.93	16.3	-35.63	0.0578	-2.059
7217	MLI SVM Top Disc +Y+Z	-54.88	18.3	-36.58	0.0968	-3.541
7218	MLI SVM Top Disc +Y+Z	-43.63	*24*	-19.63	0.0488	-0.958
7219	MLI SVM Top Disc +Y+Z	-37.54	*24*	-13.54	0.0573	-0.776
7220	MLI SVM Top Disc +Y+Z	-43.08	*24*	-19.08	0.0488	-0.931
7221	MLI SVM Top Disc +Y+Z	-37.76	*24*	-13.76	0.0573	-0.788
7222	MLI SVM Top Disc +Y+Z	-50.19	15.7	-34.49	0.0578	-1.994
7223	MLI SVM Top Disc +Y+Z	-51.32	17.5	-33.82	0.0968	-3.274
7224	MLI SVM Top Disc +Y+Z	-52.44	21.1	-31.34	0.0505	-1.583
7225	MLI SVM Top Disc +Y+Z	-45.67	20.6	-25.07	0.0514	-1.289
7226	MLI SVM Top Disc +Y+Z	-51.59	21.8	-29.79	0.031	-0.923
7227	MLI SVM Top Disc +Y+Z	-44.34	18.2	-26.14	0.0374	-0.978
7228	MLI SVM Top Disc +Y+Z	-63.35	24.2	-39.15	0.0334	-1.308
7229	MLI SVM Top Disc +Y+Z	-56.80	20.4	-36.40	0.0541	-1.969
7230	MLI SVM Top Disc +Y+Z	-63.36	23.7	-39.66	0.044	-1.745
7231	MLI SVM Top Disc +Y+Z	-64.11	23.9	-40.21	0.0282	-1.134
7232	MLI SVM Top Disc +Y+Z	-65.24	24.8	-40.44	0.0304	-1.229
7233	MLI SVM Top Disc +Y+Z	-65.11	24.5	-40.61	0.0387	-1.572
7234	MLI SVM Top Disc +Y+Z	-63.62	24.6	-39.02	0.0385	-1.502
7235	MLI SVM Top Disc +Y+Z	-64.66	24.7	-39.96	0.0414	-1.654

PLANCK ITP-150-P						
WORST HOT CASE: EOL Rotx=-10						
NODE	**LABEL**	**Temperature**	**UFP**	**T+UFP**	**Area**	**T+UFP * Area**
		[°C]	**[°C]**	**[°C]**	**[m²]**	
7236	MLI SVM Top Disc +Y+Z	-61.76	24.8	-36.96	0.0475	-1.756
7237	MLI SVM Top Disc +Y+Z	-63.95	24.7	-39.25	0.0805	-3.160
7238	MLI SVM Top Disc +Y+Z	-60.32	24.9	-35.42	0.041	-1.452
7239	MLI SVM Top Disc +Y+Z	-61.97	25.3	-36.67	0.0481	-1.764
7245	SVM Top Disc MLI	-70.09	22.9	-47.19	1.7492	-82.545
		AVG T		**AVG T+UFP**	**Σ Area**	**Σ T+UFP*Area**
		-58.72		-35.55	3.586	-146.2
	Weigthed avg T: °C	**-63.59**		**Weigthed avg T+UFP: °C**		**-40.77**

(*) Assumed

Table 4.2-3 PLANCK –ITP-180-P Temperature Results

PLANCK ITP-180-P				
WORST HOT CASE: EOL Rotx=-10				
NODE	**LABEL**	**T**	**UFP**	**T+UFP**
		[°C]	**[°C]**	**[°C]**
7521	MLI on BEU	**-58.9**	24.0	-34.9
7522	MLI on PAU	**-51.7**	23.3	-28.4
	Max temperature	**-51.7**		**-28.4**

Note: 24°C of UFP on BEU MLI is assumed.

Table 4.2-4 PLANCK –ITP-200-P Temperature Results

PLANCK ITP-200-P				
WORST HOT CASE: EOL Rotx=-10				
NODE	**LABEL**	**T**	**UFP**	**T+UFP**
		[°C]	**[°C]**	**[°C]**
8101	MLI Solar Array vs. sate	**11.0**	27.7	38.7
8102	MLI Solar Array vs. sate	**13.0**	26.9	39.9
8103	MLI Solar Array vs. sate	**12.3**	27.2	39.5
8104	MLI Solar Array vs. sate	**11.0**	27.3	38.3
	Max temperature	**13.0**		**39.9**

Table 4.2-5 PLANCK –ITP-210-P Temperature Results

PLANCK ITP-210-P				
WORST HOT CASE: EOL Rotx=-10				
NODE	LABEL	T	UFP	T+UFP
		[°C]	[°C]	[°C]
10021	I/F PLM/SVM strut1	**20.1**	7.9	28.0
10022	I/F PLM/SVM strut2	**18.7**	7.9	26.6
10023	I/F PLM/SVM strut3	**21.1**	8.8	29.9
10024	I/F PLM/SVM strut4	**19.7**	8.8	28.5
10025	I/F PLM/SVM strut5	**18.7**	7.9	26.6
10026	I/F PLM/SVM strut6	**20.0**	7.9	27.9
	Max temperature	**21.1**		**29.9**

Table 4.2-6 PLANCK –ITP-170-P Flux Results

PLANCK ITP-170-P – Temperature considered without uncertainty							
		CASE A1	CASE A2	CASE A3	CASE B1	CASE B2	CASE C
NODES	GR	Heat Flow	Heat Flow	Heat Flow	Heat Flow	Heat Flow	Heat Flow
		[W]	[W]	[W]	[W]	[W]	[W]
GR(D561,B10001)	7.99E-05	1.762E-02	1.463E-02	1.669E-02	2.089E-02	2.088E-02	1.238E-02
GR(D561,B10004)	1.45E-04	3.444E-02	2.899E-02	3.274E-02	4.039E-02	4.036E-02	2.491E-02
GR(D561,B10010)	1.38E-05	2.717E-03	2.200E-03	2.556E-03	3.281E-03	3.279E-03	1.814E-03
GR(D561,B10011)	4.31E-05	9.637E-03	8.020E-03	9.134E-03	1.140E-02	1.140E-02	6.810E-03
GR(D562,B10001)	8.65E-05	2.376E-02	1.940E-02	2.240E-02	2.819E-02	2.818E-02	1.627E-02
GR(D562,B10004)	1.44E-04	4.193E-02	3.466E-02	3.966E-02	4.931E-02	4.928E-02	2.946E-02
GR(D562,B10010)	1.55E-05	3.892E-03	3.111E-03	3.649E-03	4.687E-03	4.684E-03	2.552E-03
GR(D562,B10011)	2.96E-05	8.221E-03	6.728E-03	7.755E-03	9.740E-03	9.734E-03	5.658E-03
GR(D563,B10001)	8.35E-05	2.292E-02	1.872E-02	2.159E-02	2.719E-02	2.718E-02	1.570E-02
GR(D563,B10004)	1.42E-04	4.125E-02	3.411E-02	3.900E-02	4.850E-02	4.848E-02	2.898E-02
GR(D563,B10010)	2.64E-05	6.629E-03	5.301E-03	6.210E-03	7.980E-03	7.976E-03	4.345E-03
GR(D563,B10011)	1.53E-05	4.235E-03	3.467E-03	3.993E-03	5.017E-03	5.015E-03	2.915E-03
GR(D564,B10001)	7.98E-05	1.755E-02	1.464E-02	1.651E-02	2.080E-02	2.079E-02	1.234E-02
GR(D564,B10004)	1.47E-04	3.462E-02	2.928E-02	3.272E-02	4.059E-02	4.057E-02	2.505E-02
GR(D564,B10010)	3.87E-05	7.604E-03	6.195E-03	7.101E-03	9.181E-03	9.175E-03	5.077E-03
GR(D564,B10011)	1.43E-05	3.192E-03	2.670E-03	3.005E-03	3.775E-03	3.773E-03	2.256E-03
GR(D566,B10001)	1.21E-04	2.631E-02	2.186E-02	2.493E-02	3.120E-02	3.118E-02	1.852E-02
GR(D566,B10004)	1.95E-04	4.580E-02	3.859E-02	4.356E-02	5.372E-02	5.369E-02	3.317E-02
GR(D566,B10010)	1.79E-05	3.482E-03	2.821E-03	3.276E-03	4.206E-03	4.203E-03	2.325E-03
GR(D566,B10011)	7.29E-05	1.610E-02	1.341E-02	1.526E-02	1.905E-02	1.904E-02	1.139E-02
GR(D567,B10001)	1.31E-04	3.221E-02	2.652E-02	3.042E-02	3.812E-02	3.811E-02	2.237E-02
GR(D567,B10004)	1.92E-04	5.026E-02	4.194E-02	4.765E-02	5.891E-02	5.888E-02	3.585E-02
GR(D567,B10010)	2.27E-05	5.025E-03	4.044E-03	4.717E-03	6.045E-03	6.042E-03	3.327E-03
GR(D567,B10011)	3.68E-05	9.119E-03	7.527E-03	8.619E-03	1.077E-02	1.077E-02	6.363E-03

PLANCK ITP-170-P – Temperature considered without uncertainty							
NODES	GR	CASE A1 Heat Flow [W]	CASE A2 Heat Flow [W]	CASE A3 Heat Flow [W]	CASE B1 Heat Flow [W]	CASE B2 Heat Flow [W]	CASE C Heat Flow [W]
GR(D568,B10001)	1.29E-04	3.158E-02	2.603E-02	2.978E-02	3.738E-02	3.735E-02	2.193E-02
GR(D568,B10004)	1.95E-04	5.088E-02	4.251E-02	4.816E-02	5.964E-02	5.961E-02	3.630E-02
GR(D568,B10010)	2.98E-05	6.610E-03	5.327E-03	6.193E-03	7.953E-03	7.947E-03	4.376E-03
GR(D568,B10011)	2.36E-05	5.837E-03	4.823E-03	5.507E-03	6.896E-03	6.892E-03	4.073E-03
GR(D569,B10001)	1.23E-04	2.674E-02	2.234E-02	2.516E-02	3.171E-02	3.169E-02	1.883E-02
GR(D569,B10004)	1.94E-04	4.528E-02	3.835E-02	4.279E-02	5.310E-02	5.307E-02	3.282E-02
GR(D569,B10010)	6.06E-05	1.175E-02	9.584E-03	1.097E-02	1.420E-02	1.419E-02	7.855E-03
GR(D569,B10011)	1.70E-05	3.733E-03	3.126E-03	3.515E-03	4.418E-03	4.415E-03	2.643E-03
GR(D571,B10001)	1.48E-04	3.185E-02	2.648E-02	3.018E-02	3.776E-02	3.775E-02	2.244E-02
GR(D571,B10004)	1.80E-04	4.175E-02	3.521E-02	3.971E-02	4.895E-02	4.893E-02	3.028E-02
GR(D571,B10010)	1.99E-05	3.820E-03	3.097E-03	3.595E-03	4.616E-03	4.613E-03	2.553E-03
GR(D571,B10011)	1.05E-04	2.293E-02	1.912E-02	2.174E-02	2.713E-02	2.712E-02	1.624E-02
GR(D572,B10001)	1.56E-04	3.602E-02	2.979E-02	3.406E-02	4.259E-02	4.257E-02	2.518E-02
GR(D572,B10004)	1.78E-04	4.409E-02	3.697E-02	4.184E-02	5.160E-02	5.157E-02	3.169E-02
GR(D572,B10010)	2.61E-05	5.408E-03	4.366E-03	5.079E-03	6.506E-03	6.502E-03	3.596E-03
GR(D572,B10011)	3.75E-05	8.754E-03	7.258E-03	8.282E-03	1.033E-02	1.033E-02	6.151E-03
GR(D573,B10001)	1.54E-04	3.538E-02	2.931E-02	3.338E-02	4.184E-02	4.181E-02	2.474E-02
GR(D573,B10004)	1.78E-04	4.394E-02	3.690E-02	4.161E-02	5.142E-02	5.139E-02	3.159E-02
GR(D573,B10010)	2.78E-05	5.765E-03	4.664E-03	5.401E-03	6.936E-03	6.931E-03	3.834E-03
GR(D573,B10011)	2.39E-05	5.567E-03	4.623E-03	5.255E-03	6.570E-03	6.566E-03	3.912E-03
GR(D574,B10001)	1.47E-04	3.155E-02	2.638E-02	2.969E-02	3.741E-02	3.739E-02	2.225E-02
GR(D574,B10004)	1.86E-04	4.279E-02	3.627E-02	4.043E-02	5.016E-02	5.014E-02	3.107E-02
GR(D574,B10010)	8.06E-05	1.537E-02	1.254E-02	1.435E-02	1.857E-02	1.856E-02	1.028E-02
GR(D574,B10011)	1.70E-05	3.699E-03	3.101E-03	3.483E-03	4.376E-03	4.374E-03	2.623E-03
GR(D581,B10001)	3.31E-05	9.497E-03	8.940E-03	7.532E-03	1.065E-02	1.064E-02	6.422E-03
GR(D581,B10004)	7.50E-05	2.272E-02	2.146E-02	1.827E-02	2.533E-02	2.532E-02	1.576E-02
GR(D581,B10005)	6.44E-06	1.932E-03	1.824E-03	1.550E-03	2.156E-03	2.155E-03	1.334E-03
GR(D581,B10010)	8.62E-05	2.269E-02	2.124E-02	1.757E-02	2.568E-02	2.567E-02	1.469E-02
GR(D582,B10001)	3.25E-05	9.247E-03	8.706E-03	7.338E-03	1.036E-02	1.036E-02	6.260E-03
GR(D582,B10004)	7.57E-05	2.278E-02	2.152E-02	1.834E-02	2.539E-02	2.538E-02	1.582E-02
GR(D582,B10005)	7.95E-06	2.369E-03	2.236E-03	1.902E-03	2.642E-03	2.641E-03	1.638E-03
GR(D582,B10010)	5.45E-05	1.423E-02	1.333E-02	1.103E-02	1.611E-02	1.610E-02	9.221E-03
GR(D583,B10001)	2.98E-05	8.303E-03	7.822E-03	6.609E-03	9.297E-03	9.293E-03	5.645E-03
GR(D583,B10004)	7.58E-05	2.236E-02	2.113E-02	1.805E-02	2.488E-02	2.487E-02	1.559E-02
GR(D583,B10005)	9.06E-06	2.643E-03	2.497E-03	2.128E-03	2.945E-03	2.943E-03	1.836E-03
GR(D583,B10010)	4.73E-05	1.207E-02	1.130E-02	9.377E-03	1.364E-02	1.364E-02	7.848E-03
GR(D584,B10001)	3.73E-05	8.650E-03	8.192E-03	7.015E-03	9.583E-03	9.580E-03	6.060E-03
GR(D584,B10004)	7.18E-05	1.784E-02	1.696E-02	1.469E-02	1.964E-02	1.964E-02	1.285E-02
GR(D584,B10005)	6.91E-06	1.695E-03	1.610E-03	1.392E-03	1.868E-03	1.867E-03	1.215E-03
GR(D584,B10010)	9.69E-05	2.021E-02	1.902E-02	1.596E-02	2.263E-02	2.262E-02	1.348E-02

PLANCK ITP-170-P – Temperature considered without uncertainty							
NODES	GR	CASE A1 Heat Flow [W]	CASE A2 Heat Flow [W]	CASE A3 Heat Flow [W]	CASE B1 Heat Flow [W]	CASE B2 Heat Flow [W]	CASE C Heat Flow [W]
GR(D585,B10001)	3.69E-05	8.487E-03	8.039E-03	6.890E-03	9.401E-03	9.397E-03	5.955E-03
GR(D585,B10004)	7.43E-05	1.830E-02	1.740E-02	1.509E-02	2.014E-02	2.014E-02	1.320E-02
GR(D585,B10005)	9.21E-06	2.242E-03	2.130E-03	1.843E-03	2.470E-03	2.469E-03	1.610E-03
GR(D585,B10010)	6.07E-05	1.254E-02	1.180E-02	9.912E-03	1.404E-02	1.404E-02	8.374E-03
GR(D586,B10001)	3.64E-05	8.216E-03	7.787E-03	6.686E-03	9.092E-03	9.089E-03	5.785E-03
GR(D586,B10004)	7.34E-05	1.777E-02	1.690E-02	1.468E-02	1.954E-02	1.953E-02	1.287E-02
GR(D586,B10005)	9.45E-06	2.261E-03	2.149E-03	1.863E-03	2.488E-03	2.487E-03	1.629E-03
GR(D586,B10010)	4.53E-05	9.157E-03	8.623E-03	7.254E-03	1.025E-02	1.024E-02	6.133E-03
GR(D587,B10001)	4.82E-05	1.006E-02	9.552E-03	8.245E-03	1.108E-02	1.107E-02	7.169E-03
GR(D587,B10004)	6.65E-05	1.496E-02	1.426E-02	1.246E-02	1.637E-02	1.636E-02	1.098E-02
GR(D587,B10005)	6.39E-06	1.419E-03	1.352E-03	1.179E-03	1.554E-03	1.554E-03	1.036E-03
GR(D587,B10010)	1.05E-04	1.935E-02	1.826E-02	1.543E-02	2.157E-02	2.156E-02	1.309E-02
GR(D588,B10001)	4.67E-05	9.675E-03	9.191E-03	7.940E-03	1.065E-02	1.065E-02	6.907E-03
GR(D588,B10004)	6.74E-05	1.506E-02	1.437E-02	1.256E-02	1.648E-02	1.647E-02	1.107E-02
GR(D588,B10005)	7.87E-06	1.734E-03	1.652E-03	1.442E-03	1.899E-03	1.898E-03	1.268E-03
GR(D588,B10010)	6.22E-05	1.142E-02	1.078E-02	9.109E-03	1.272E-02	1.272E-02	7.735E-03
GR(D589,B10001)	4.49E-05	9.162E-03	8.708E-03	7.534E-03	1.008E-02	1.008E-02	6.559E-03
GR(D589,B10004)	7.00E-05	1.542E-02	1.471E-02	1.288E-02	1.686E-02	1.685E-02	1.137E-02
GR(D589,B10005)	1.01E-05	2.191E-03	2.089E-03	1.825E-03	2.397E-03	2.397E-03	1.606E-03
GR(D589,B10010)	4.40E-05	7.951E-03	7.506E-03	6.354E-03	8.855E-03	8.851E-03	5.399E-03
GR(D590,B10001)	2.04E-05	5.183E-03	4.897E-03	4.176E-03	5.774E-03	5.772E-03	3.588E-03
GR(D590,B10004)	9.94E-05	2.689E-02	2.549E-02	2.198E-02	2.977E-02	2.976E-02	1.911E-02
GR(D590,B10005)	5.84E-05	1.562E-02	1.480E-02	1.274E-02	1.731E-02	1.731E-02	1.105E-02
GR(D590,B10010)	1.01E-04	2.336E-02	2.194E-02	1.836E-02	2.630E-02	2.629E-02	1.544E-02
GR(D591,B10001)	1.78E-05	4.499E-03	4.250E-03	3.627E-03	5.011E-03	5.010E-03	3.117E-03
GR(D591,B10004)	9.39E-05	2.532E-02	2.401E-02	2.071E-02	2.803E-02	2.802E-02	1.801E-02
GR(D591,B10005)	7.27E-05	1.939E-02	1.838E-02	1.582E-02	2.149E-02	2.148E-02	1.373E-02
GR(D591,B10010)	1.49E-04	3.425E-02	3.217E-02	2.693E-02	3.855E-02	3.854E-02	2.266E-02
GR(D592,B10001)	2.47E-05	5.366E-03	5.091E-03	4.388E-03	5.925E-03	5.923E-03	3.806E-03
GR(D592,B10004)	9.49E-05	2.217E-02	2.112E-02	1.842E-02	2.432E-02	2.432E-02	1.618E-02
GR(D592,B10005)	5.95E-05	1.374E-02	1.307E-02	1.138E-02	1.509E-02	1.508E-02	9.975E-03
GR(D592,B10010)	1.03E-04	1.993E-02	1.878E-02	1.586E-02	2.225E-02	2.225E-02	1.343E-02
GR(D593,B10001)	1.91E-05	4.102E-03	3.894E-03	3.361E-03	4.528E-03	4.527E-03	2.918E-03
GR(D593,B10004)	9.20E-05	2.123E-02	2.023E-02	1.766E-02	2.328E-02	2.327E-02	1.553E-02
GR(D593,B10005)	7.19E-05	1.640E-02	1.561E-02	1.361E-02	1.800E-02	1.799E-02	1.194E-02
GR(D593,B10010)	1.38E-04	2.643E-02	2.492E-02	2.106E-02	2.950E-02	2.949E-02	1.786E-02
GR(D594,B10001)	3.29E-05	6.578E-03	6.254E-03	5.423E-03	7.231E-03	7.228E-03	4.728E-03
GR(D594,B10004)	8.93E-05	1.928E-02	1.840E-02	1.615E-02	2.105E-02	2.104E-02	1.427E-02
GR(D594,B10005)	6.36E-05	1.354E-02	1.292E-02	1.131E-02	1.480E-02	1.479E-02	9.971E-03
GR(D594,B10010)	1.16E-04	2.045E-02	1.931E-02	1.638E-02	2.275E-02	2.274E-02	1.393E-02
GR(D595,B10001)	2.23E-05	4.404E-03	4.189E-03	3.637E-03	4.838E-03	4.837E-03	3.173E-03

PLANCK ITP-170-P – Temperature considered without uncertainty							
		CASE A1	CASE A2	CASE A3	CASE B1	CASE B2	CASE C
NODES	GR	Heat Flow	Heat Flow	Heat Flow	Heat Flow	Heat Flow	Heat Flow
		[W]	[W]	[W]	[W]	[W]	[W]
GR(D595,B10004)	8.60E-05	1.838E-02	1.755E-02	1.542E-02	2.005E-02	2.004E-02	1.363E-02
GR(D595,B10005)	8.50E-05	1.791E-02	1.709E-02	1.499E-02	1.956E-02	1.956E-02	1.322E-02
GR(D595,B10010)	1.39E-04	2.408E-02	2.275E-02	1.932E-02	2.678E-02	2.677E-02	1.644E-02
GR(D595,B10011)	4.33E-06	8.658E-04	8.242E-04	7.170E-04	9.498E-04	9.497E-04	6.272E-04
Total Heat Flux [W] :		**1.836**	**1.620**	**1.627**	**2.109**	**2.108**	**1.291**

PLANCK ITP-170-P – Temperature considered with uncertainty							
		CASE A1	CASE A2	CASE A3	CASE B1	CASE B2	CASE C
NODES	GR	Heat Flow	Heat Flow	Heat Flow	Heat Flow	Heat Flow	Heat Flow
		[W]	[W]	[W]	[W]	[W]	[W]
GR(D561,B10001)	7.87E-05	2.068E-02	1.734E-02	1.964E-02	2.431E-02	2.430E-02	1.482E-02
GR(D561,B10004)	1.45E-04	4.000E-02	3.392E-02	3.811E-02	4.661E-02	4.658E-02	2.935E-02
GR(D561,B10010)	9.07E-06	3.245E-03	2.668E-03	3.065E-03	3.872E-03	3.869E-03	2.234E-03
GR(D561,B10011)	5.02E-05	1.129E-02	9.483E-03	1.073E-02	1.325E-02	1.324E-02	8.127E-03
GR(D562,B10001)	8.47E-05	2.755E-02	2.271E-02	2.604E-02	3.244E-02	3.243E-02	1.923E-02
GR(D562,B10004)	1.44E-04	4.823E-02	4.017E-02	4.572E-02	5.639E-02	5.636E-02	3.438E-02
GR(D562,B10010)	1.21E-05	4.571E-03	3.704E-03	4.301E-03	5.448E-03	5.445E-03	3.081E-03
GR(D562,B10011)	2.53E-05	9.518E-03	7.861E-03	9.002E-03	1.120E-02	1.119E-02	6.669E-03
GR(D563,B10001)	8.63E-05	2.657E-02	2.191E-02	2.510E-02	3.129E-02	3.128E-02	1.855E-02
GR(D563,B10004)	1.43E-04	4.745E-02	3.954E-02	4.496E-02	5.547E-02	5.544E-02	3.382E-02
GR(D563,B10010)	2.04E-05	7.784E-03	6.311E-03	7.321E-03	9.277E-03	9.273E-03	5.246E-03
GR(D563,B10011)	1.74E-05	4.904E-03	4.051E-03	4.635E-03	5.767E-03	5.765E-03	3.436E-03
GR(D564,B10001)	7.87E-05	2.060E-02	1.735E-02	1.944E-02	2.421E-02	2.420E-02	1.477E-02
GR(D564,B10004)	1.44E-04	4.022E-02	3.426E-02	3.810E-02	4.686E-02	4.683E-02	2.952E-02
GR(D564,B10010)	3.85E-05	9.083E-03	7.510E-03	8.522E-03	1.084E-02	1.083E-02	6.257E-03
GR(D564,B10011)	9.09E-06	3.739E-03	3.157E-03	3.531E-03	4.388E-03	4.385E-03	2.693E-03
GR(D566,B10001)	1.24E-04	3.090E-02	2.592E-02	2.935E-02	3.633E-02	3.631E-02	2.218E-02
GR(D566,B10004)	1.95E-04	5.323E-02	4.517E-02	5.072E-02	6.203E-02	6.199E-02	3.910E-02
GR(D566,B10010)	2.02E-05	4.161E-03	3.424E-03	3.932E-03	4.967E-03	4.964E-03	2.868E-03
GR(D566,B10011)	7.19E-05	1.887E-02	1.586E-02	1.793E-02	2.215E-02	2.213E-02	1.360E-02
GR(D567,B10001)	1.30E-04	3.754E-02	3.122E-02	3.556E-02	4.409E-02	4.407E-02	2.657E-02
GR(D567,B10004)	1.99E-04	5.806E-02	4.880E-02	5.515E-02	6.764E-02	6.761E-02	4.201E-02
GR(D567,B10010)	2.51E-05	5.945E-03	4.853E-03	5.603E-03	7.075E-03	7.071E-03	4.052E-03
GR(D567,B10011)	3.94E-05	1.061E-02	8.841E-03	1.006E-02	1.244E-02	1.244E-02	7.541E-03
GR(D568,B10001)	1.32E-04	3.681E-02	3.064E-02	3.480E-02	4.323E-02	4.320E-02	2.605E-02
GR(D568,B10004)	1.91E-04	5.878E-02	4.946E-02	5.575E-02	6.848E-02	6.844E-02	4.253E-02

PLANCK ITP-170-P – Temperature considered with uncertainty							
NODES	GR	CASE A1 Heat Flow [W]	CASE A2 Heat Flow [W]	CASE A3 Heat Flow [W]	CASE B1 Heat Flow [W]	CASE B2 Heat Flow [W]	CASE C Heat Flow [W]
GR(D568,B10010)	3.27E-05	7.820E-03	6.393E-03	7.357E-03	9.307E-03	9.301E-03	5.331E-03
GR(D568,B10011)	1.69E-05	6.792E-03	5.665E-03	6.426E-03	7.965E-03	7.961E-03	4.827E-03
GR(D569,B10001)	1.16E-04	3.141E-02	2.649E-02	2.964E-02	3.693E-02	3.691E-02	2.256E-02
GR(D569,B10004)	1.93E-04	5.263E-02	4.488E-02	4.985E-02	6.132E-02	6.129E-02	3.869E-02
GR(D569,B10010)	5.71E-05	1.405E-02	1.163E-02	1.318E-02	1.677E-02	1.676E-02	9.691E-03
GR(D569,B10011)	1.36E-05	4.376E-03	3.699E-03	4.133E-03	5.137E-03	5.134E-03	3.156E-03
GR(D571,B10001)	1.44E-04	3.743E-02	3.143E-02	3.556E-02	4.400E-02	4.398E-02	2.690E-02
GR(D571,B10004)	1.81E-04	4.854E-02	4.124E-02	4.627E-02	5.655E-02	5.652E-02	3.571E-02
GR(D571,B10010)	1.47E-05	4.570E-03	3.763E-03	4.319E-03	5.455E-03	5.453E-03	3.153E-03
GR(D571,B10011)	9.34E-05	2.689E-02	2.263E-02	2.557E-02	3.156E-02	3.155E-02	1.941E-02
GR(D572,B10001)	1.54E-04	4.211E-02	3.517E-02	3.992E-02	4.939E-02	4.937E-02	3.001E-02
GR(D572,B10004)	1.75E-04	5.104E-02	4.311E-02	4.855E-02	5.937E-02	5.935E-02	3.722E-02
GR(D572,B10010)	2.42E-05	6.425E-03	5.265E-03	6.059E-03	7.642E-03	7.639E-03	4.403E-03
GR(D572,B10011)	3.70E-05	1.021E-02	8.549E-03	9.690E-03	1.196E-02	1.196E-02	7.311E-03
GR(D573,B10001)	1.60E-04	4.136E-02	3.460E-02	3.913E-02	4.852E-02	4.849E-02	2.949E-02
GR(D573,B10004)	1.81E-04	5.087E-02	4.303E-02	4.828E-02	5.917E-02	5.914E-02	3.710E-02
GR(D573,B10010)	3.62E-05	6.850E-03	5.624E-03	6.445E-03	8.149E-03	8.143E-03	4.695E-03
GR(D573,B10011)	2.23E-05	6.496E-03	5.445E-03	6.149E-03	7.609E-03	7.604E-03	4.650E-03
GR(D574,B10001)	1.46E-04	3.708E-02	3.131E-02	3.500E-02	4.359E-02	4.357E-02	2.667E-02
GR(D574,B10004)	1.85E-04	4.975E-02	4.248E-02	4.713E-02	5.796E-02	5.793E-02	3.664E-02
GR(D574,B10010)	8.01E-05	1.839E-02	1.523E-02	1.725E-02	2.195E-02	2.194E-02	1.270E-02
GR(D574,B10011)	1.50E-05	4.339E-03	3.671E-03	4.098E-03	5.092E-03	5.090E-03	3.135E-03
GR(D581,B10001)	3.16E-05	1.084E-02	1.023E-02	8.681E-03	1.210E-02	1.209E-02	7.458E-03
GR(D581,B10004)	7.57E-05	2.576E-02	2.438E-02	2.087E-02	2.861E-02	2.860E-02	1.810E-02
GR(D581,B10005)	6.25E-06	2.193E-03	2.074E-03	1.773E-03	2.438E-03	2.437E-03	1.536E-03
GR(D581,B10010)	7.28E-05	2.618E-02	2.459E-02	2.056E-02	2.946E-02	2.944E-02	1.738E-02
GR(D582,B10001)	3.15E-05	1.056E-02	9.963E-03	8.460E-03	1.178E-02	1.178E-02	7.271E-03
GR(D582,B10004)	7.55E-05	2.583E-02	2.445E-02	2.095E-02	2.868E-02	2.868E-02	1.818E-02
GR(D582,B10005)	7.15E-06	2.689E-03	2.544E-03	2.176E-03	2.988E-03	2.987E-03	1.885E-03
GR(D582,B10010)	5.65E-05	1.643E-02	1.543E-02	1.291E-02	1.848E-02	1.847E-02	1.092E-02
GR(D583,B10001)	2.96E-05	9.694E-03	9.149E-03	7.769E-03	1.082E-02	1.081E-02	6.677E-03
GR(D583,B10004)	7.78E-05	2.589E-02	2.451E-02	2.100E-02	2.875E-02	2.874E-02	1.822E-02
GR(D583,B10005)	9.68E-06	3.065E-03	2.900E-03	2.481E-03	3.406E-03	3.405E-03	2.149E-03
GR(D583,B10010)	4.91E-05	1.427E-02	1.341E-02	1.122E-02	1.605E-02	1.605E-02	9.486E-03
GR(D584,B10001)	3.65E-05	1.186E-02	1.120E-02	9.532E-03	1.322E-02	1.321E-02	8.203E-03
GR(D584,B10004)	7.23E-05	2.403E-02	2.276E-02	1.954E-02	2.665E-02	2.663E-02	1.698E-02
GR(D584,B10005)	7.37E-06	2.289E-03	2.167E-03	1.858E-03	2.541E-03	2.540E-03	1.612E-03
GR(D584,B10010)	8.88E-05	2.854E-02	2.683E-02	2.250E-02	3.208E-02	3.206E-02	1.905E-02
GR(D585,B10001)	3.68E-05	9.840E-03	9.341E-03	8.058E-03	1.085E-02	1.085E-02	7.014E-03
GR(D585,B10004)	7.40E-05	2.103E-02	2.002E-02	1.744E-02	2.307E-02	2.306E-02	1.534E-02

PLANCK ITP-170-P – Temperature considered with uncertainty							
NODES	GR	CASE A1 Heat Flow [W]	CASE A2 Heat Flow [W]	CASE A3 Heat Flow [W]	CASE B1 Heat Flow [W]	CASE B2 Heat Flow [W]	CASE C Heat Flow [W]
GR(D585,B10005)	8.84E-06	2.579E-03	2.455E-03	2.134E-03	2.832E-03	2.831E-03	1.874E-03
GR(D585,B10010)	6.33E-05	1.477E-02	1.395E-02	1.183E-02	1.643E-02	1.643E-02	1.012E-02
GR(D586,B10001)	3.49E-05	9.632E-03	9.146E-03	7.896E-03	1.062E-02	1.062E-02	6.876E-03
GR(D586,B10004)	7.53E-05	2.063E-02	1.964E-02	1.712E-02	2.262E-02	2.261E-02	1.507E-02
GR(D586,B10005)	1.01E-05	2.628E-03	2.502E-03	2.177E-03	2.885E-03	2.884E-03	1.912E-03
GR(D586,B10010)	4.09E-05	1.092E-02	1.031E-02	8.759E-03	1.215E-02	1.214E-02	7.490E-03
GR(D587,B10001)	4.86E-05	1.252E-02	1.190E-02	1.029E-02	1.380E-02	1.379E-02	8.972E-03
GR(D587,B10004)	6.69E-05	1.836E-02	1.750E-02	1.528E-02	2.012E-02	2.011E-02	1.346E-02
GR(D587,B10005)	6.18E-06	1.746E-03	1.663E-03	1.450E-03	1.915E-03	1.914E-03	1.275E-03
GR(D587,B10010)	1.21E-04	2.471E-02	2.335E-02	1.987E-02	2.747E-02	2.746E-02	1.700E-02
GR(D588,B10001)	4.74E-05	1.124E-02	1.070E-02	9.307E-03	1.233E-02	1.233E-02	8.154E-03
GR(D588,B10004)	6.65E-05	1.732E-02	1.655E-02	1.453E-02	1.889E-02	1.889E-02	1.287E-02
GR(D588,B10005)	8.00E-06	1.998E-03	1.907E-03	1.672E-03	2.181E-03	2.180E-03	1.478E-03
GR(D588,B10010)	7.07E-05	1.350E-02	1.279E-02	1.093E-02	1.495E-02	1.495E-02	9.394E-03
GR(D589,B10001)	4.51E-05	1.073E-02	1.021E-02	8.887E-03	1.176E-02	1.176E-02	7.789E-03
GR(D589,B10004)	6.78E-05	1.786E-02	1.706E-02	1.499E-02	1.947E-02	1.947E-02	1.328E-02
GR(D589,B10005)	8.90E-06	2.541E-03	2.427E-03	2.129E-03	2.774E-03	2.773E-03	1.883E-03
GR(D589,B10010)	4.29E-05	9.485E-03	8.983E-03	7.681E-03	1.050E-02	1.050E-02	6.605E-03
GR(D590,B10001)	1.91E-05	4.802E-03	4.575E-03	3.987E-03	5.263E-03	5.261E-03	3.497E-03
GR(D590,B10004)	9.92E-05	2.503E-02	2.393E-02	2.106E-02	2.728E-02	2.727E-02	1.867E-02
GR(D590,B10005)	5.78E-05	1.453E-02	1.388E-02	1.220E-02	1.585E-02	1.584E-02	1.079E-02
GR(D590,B10010)	1.04E-04	2.147E-02	2.034E-02	1.742E-02	2.376E-02	2.375E-02	1.499E-02
GR(D591,B10001)	1.80E-05	5.171E-03	4.896E-03	4.206E-03	5.734E-03	5.732E-03	3.641E-03
GR(D591,B10004)	9.17E-05	2.887E-02	2.742E-02	2.377E-02	3.185E-02	3.184E-02	2.078E-02
GR(D591,B10005)	6.67E-05	2.214E-02	2.102E-02	1.820E-02	2.445E-02	2.444E-02	1.588E-02
GR(D591,B10010)	1.45E-04	3.989E-02	3.759E-02	3.180E-02	4.462E-02	4.460E-02	2.705E-02
GR(D592,B10001)	2.51E-05	7.137E-03	6.759E-03	5.808E-03	7.916E-03	7.913E-03	5.028E-03
GR(D592,B10004)	9.47E-05	2.898E-02	2.753E-02	2.387E-02	3.198E-02	3.197E-02	2.088E-02
GR(D592,B10005)	5.93E-05	1.801E-02	1.710E-02	1.480E-02	1.989E-02	1.988E-02	1.292E-02
GR(D592,B10010)	1.10E-04	2.730E-02	2.573E-02	2.177E-02	3.054E-02	3.053E-02	1.852E-02
GR(D593,B10001)	1.95E-05	4.785E-03	4.551E-03	3.951E-03	5.261E-03	5.259E-03	3.452E-03
GR(D593,B10004)	9.09E-05	2.451E-02	2.338E-02	2.050E-02	2.680E-02	2.679E-02	1.810E-02
GR(D593,B10005)	7.36E-05	1.896E-02	1.808E-02	1.583E-02	2.075E-02	2.075E-02	1.395E-02
GR(D593,B10010)	1.52E-04	3.136E-02	2.967E-02	2.533E-02	3.480E-02	3.479E-02	2.172E-02
GR(D594,B10001)	3.14E-05	8.126E-03	7.732E-03	6.721E-03	8.931E-03	8.928E-03	5.878E-03
GR(D594,B10004)	8.85E-05	2.348E-02	2.241E-02	1.967E-02	2.566E-02	2.565E-02	1.738E-02
GR(D594,B10005)	6.53E-05	1.653E-02	1.577E-02	1.381E-02	1.808E-02	1.807E-02	1.219E-02
GR(D594,B10010)	1.06E-04	2.590E-02	2.452E-02	2.095E-02	2.874E-02	2.873E-02	1.798E-02
GR(D595,B10001)	2.07E-05	5.143E-03	4.902E-03	4.280E-03	5.629E-03	5.628E-03	3.760E-03
GR(D595,B10004)	8.70E-05	2.122E-02	2.029E-02	1.790E-02	2.310E-02	2.309E-02	1.589E-02
GR(D595,B10005)	8.21E-05	2.072E-02	1.981E-02	1.744E-02	2.258E-02	2.257E-02	1.546E-02

PLANCK ITP-170-P – Temperature considered with uncertainty							
		CASE A1	CASE A2	CASE A3	CASE B1	CASE B2	CASE C
NODES	GR	Heat Flow	Heat Flow	Heat Flow	Heat Flow	Heat Flow	Heat Flow
		[W]	[W]	[W]	[W]	[W]	[W]
GR(D595,B10010)	1.41E-04	2.867E-02	2.717E-02	2.332E-02	3.169E-02	3.168E-02	2.009E-02
GR(D595,B10011)	4.74E-06	1.009E-03	9.623E-04	8.418E-04	1.103E-03	1.103E-03	7.409E-04
Total Heat Flux [W] :		**2.148**	**1.906**	**1.911**	**2.453**	**2.452**	**1.534**

Table 4.2-7 PLANCK - ITP-220-P

PLANCK ITP-220-P						
	Requirement		Results			
NODE	FFT @ 1/5000 Hz	FFT @ 1/60 Hz	FFT @ 1/5000 Hz	Status	FFT @ 1/60 Hz	Status
	[K]	[K]	[K]		[K]	
COLD CASE						
10021	0.02	0.02	$2.527*10^{-6}$	Compl.	$1.252*10^{-9}$	Compl.
10022	0.02	0.02	$2.269*10^{-6}$	Compl.	$9.485*10^{-10}$	Compl.
10023	0.02	0.02	$4.539*10^{-6}$	Compl.	$2.048*10^{-9}$	Compl.
10024	0.02	0.02	$4.277*10^{-6}$	Compl.	$8.639*10^{-10}$	Compl.
10025	0.02	0.02	$1.932*10^{-5}$	Compl.	$9.234*10^{-10}$	Compl.
10026	0.02	0.02	$2.200*10^{-6}$	Compl.	$1.531*10^{-9}$	Compl.
HOT CASE						
10021	0.02	0.02	$3.441*10^{-6}$	Compl.	$1.93*10^{-9}$	Compl.
10022	0.02	0.02	$3.103*10^{-6}$	Compl.	$1.656*10^{-9}$	Compl.
10023	0.02	0.02	$5.553*10^{-6}$	Compl.	$1.874*10^{-9}$	Compl.
10024	0.02	0.02	$5.157*10^{-6}$	Compl.	$2.077*10^{-9}$	Compl.
10025	0.02	0.02	$1.902*10^{-5}$	Compl.	$3.275*10^{-9}$	Compl.
10026	0.02	0.02	$2.918*10^{-6}$	Compl.	$3.473*10^{-9}$	Compl.

Table 4.2-8 PLANCK - ITP-230-P

PLANCK ITP-230-P					
Panels	Requirement	COLD CASE		HOT CASE	
	SD @ 1/60 Hz	SD @ 1/60 Hz	Status	SD @ 1/60 Hz	Status
	[K/Hz^0.5]	[K/Hz^0.5]		[K/Hz^0.5]	
Pan +Z (3001-3048)	0.01	$3.361*10^{-7}$	Compl	$3.702*10^{-7}$	Compl
Pan +Y+Z (3101-3172)	0.01	$2.721*10^{-6}$	Compl	$5.518*10^{-6}$	Compl
Pan +Y (3201-3248)	0.01	$2.404*10^{-7}$	Compl	$3.32*10^{-7}$	Compl
Pan +Y-Z (3301-3372)	0.01	$2.279*10^{-6}$	Compl.	$2.473*10^{-6}$	Compl.
Pan -Z (3401-3448)	0.01	$3.097*10^{-6}$	Compl.	$3.835*10^{-6}$	Compl.
Pan -Y-Z (3501-3572)	0.01	$1.937*10^{-5}$	Compl.	$1.131*10^{-6}$	Compl
Pan -Y (3601-3648)	0.01	$2.046*10^{-6}$	Compl	$2.894*10^{-6}$	Compl
Pan -Y+Z (3701-3772)	0.01	$1.046*10^{-6}$	Compl	$2.686*10^{-6}$	Compl

Table 4.2-9 PLANCK - ITI-030-P

PLANCK ITI-030-P					
COLD CASE					
Node	**Unit**	**Max [K/s]**	**Req. [K/s]**	**Status**	**Margin [k/s]**
522	PAU	0.000028	0.000833	Compl.	
519/520/521	BEU	0.000016	0.000833	Compl.	
525	DAE	0.000029	0.000833	Compl.	
Node	**Unit**	**Max [K/s]**	**GOAL [K/s]**	**Status**	**Margin [k/s]**
522	PAU	0.000028	0.000305556	Compl.	
519/520/521	BEU	0.000016	$5.55556*10^{-5}$	Compl.	
525	DAE	0.000029	$5.55556*10^{-5}$	Compl.	
HOT CASE					
Node	**Unit**	**Max [K/s]**	**Req. [K/s]**	**Status**	**Margin [k/s]**
522	PAU	0.000029	0.000833	Compl.	
519/520/521	BEU	0.00002	0.000833	Compl.	
525	DAE	0.000029	0.000833	Compl.	
Node	**Unit**	**Max [K/s]**	**GOAL [K/s]**	**Status**	**Margin [k/s]**
522	PAU	0.000029	0.000305556	Compl.	
519/520/521	BEU	0.00002	$5.55556*10^{-5}$	Compl.	
525	DAE	0.000029	$5.55556*10^{-5}$	Compl.	

In the following table 4.2-10 the maximum value of BED fluctuation for every single absorbing bed is reported, both in cold (cases P1 and P2) and hot cases (cases Q1 and Q2).

Table 4.2-10 PLANCK – SCC STABILITY

CASE	Cooling BED	BED#1	BED#2	BED#3	BED#4	BED#5	BED#6
P1 – BOL SCC1 on	5		4.35	4.36	6.88		
	6			4.37	4.38	6.71	
	1				4.43	4.43	6.75
	2	6.78				4.37	4.38
	3	4.38	6.82				4.37
	4	4.37	4.38	6.86			
P2 – BOL SCC2 on	5		4.56	4.57	7.26		
	6			4.58	4.58	7.10	
	1				4.58	4.59	7.13
	2	7.16				4.58	4.59
	3	4.91	7.20				4.90
	4	4.71	4.72	6.82			
Q1 – EOL SCC1 on	5		4.87	4.88	7.98		
	6			4.89	4.90	7.79	
	1				4.89	4.90	7.83
	2	7.87				4.90	4.90
	3	4.90	7.91				4.90
	4	4.90	4.90	7.95			
Q2 – EOL SCC2 on	5		5.12	5.12	8.39		
	6			5.13	5.14	8.22	
	1				5.13	5.14	8.25
	2	8.29				5.13	5.14
	3	5.14	8.33				5.13
	4	5.12	5.13	8.37			

Table 4.2.11 PLANCK – gradient between each tank

	BOL SCC1 on (COLD case)	
	Requirement	Requirement
	[0.1°C / hr]	[0.25°C / day]
Max Delta T 920-925	**0.009**	**-0.120**
Max Delta T 920-930	**-0.042**	**-0.145**
Max Delta T 925-930	**-0.034**	**-0.028**
	BOL SCC2 on(COLD case)	
	Requirement	Requirement
	[0.1°C / hr]	[0.25°C / day]
Max Delta T 920-925	**-0.008**	**-0.103**
Max Delta T 920-930	**-0.042**	**-0.141**
Max Delta T 925-930	**-0.034**	**-0.040**
	EOL SCC1 on (HOT case)	
	Requirement	Requirement
	[0.1°C / hr]	[0.25°C / day]
Max Delta T 920-925	**0.008**	**-0.107**
Max Delta T 920-930	**-0.042**	**-0.131**
Max Delta T 925-930	**-0.035**	**-0.034**
	EOL SCC2 on (HOT case)	
	Requirement	Requirement
	[0.1°C / hr]	[0.25°C / day]
Max Delta T 920-925	**0.009**	**-0.134**
Max Delta T 920-930	**-0.042**	**-0.132**
Max Delta T 925-930	**-0.035**	**-0.011**
	BOL – EOL SCC1 on	BOL – EOL SCC2 on
	Requirement	Requirement
	[1.5°C / life]	[1.5°C / life]
Max Delta T 920-925	**1.650**	**1.624**
Max Delta T 920-930	**-0.469**	**-0.463**
Max Delta T 925-930	**-1.809**	**-1.761**

5. THERMAL ANALYSIS

In the thermal analysis, the presence of heater, controlled by means thermistors, has been simulated comparing the temperature with two fixed threshols. The simulation of this control is relatively simply in the transient case: if the controlled node has a temperature below the on-threshold the heater dissipation is considered in the TMM; if the temperature is above the off-threshold the heaters dissipation is set at 0 W; if the temperature is within the "on threshold" and "off threshold" the heater status of "on" or "off" doesn't change.

5.1 HERSCHEL Thermal Analysis

5.1.1 Herschel cases

Two fins on the +Y and –Y Panel have been designed to eliminate the Solar Flux on the two Panels as described in the Design Report AD7.
Due to the use of these fins, the difference on the Temperature results between the case with a rotation of +1deg. and –1deg.° around X-axis, is lower then 1 °C.
For this reason, the Cold Cases were performed using only one position (Rot X= –1°).

TRANSIENT CASE

According to AD9, the following sizing cases have been performed:
Case A÷F = Hot Cases in worst Attitude (-30° around the Yaxis and +/- 1° on the Xaxis) and in operating Modes:

- Mode 1 (sizing for HIFI units)
- Mode 2 (sizing for PACS units) in Photometry or Spectroscopy
- TT&C in Nominal mode (21h in Telecom 3h in Scientific)

Case G÷H = Cold Cases in worst Attitude, (+30° around the Yaxis) and in operating Modes:

- Mode 1 (sizing for HIFI)
- Mode 3 (sizing for SPIRE)
- TT&C in Nominal Mode (21h in Telecom 3h in Scientific)

Case I = Cold Case in Survival Attitude, (+5° around the Yaxis) and in operating Modes:

- Survival = all warm units are Switched-Off
- TT&C in Telecom Mode

In all the Nominal Cases from A to H some control are activated:

- the HIFI units FHWOV and FHWOH are controlled by a Fine Control Law at the set point 9°C
- the STR baseplate is controlled by a Fine Control Law at the set point –2.2°C
- the GYRO unit is controlled at the set point 63°C within 1°C

Solar constant values are defined in AD9.

Table 5.1.1-1 HERSCHEL – Analysis Cases

CASE	BOL/ EOL	SUN ON PANEL	SAA	ATTITUDE	SOLAR CONSTANT	DISSIPATION MODE
			[deg]		[W/m²]	
A	EOL	+X+Y	30	Rot X = +1 Rot Y = -30	Winter: 1405	TT&C Nominal / MODE1
B	EOL	+X+Y	30	Rot X = +1 Rot Y = -30	Winter: 1405	TT&C Nominal / MODE2 Photometry
C	EOL	+X+Y	30	Rot X = +1 Rot Y = -30	Winter: 1405	TT&C Nominal / MODE2 Spectroscopy
D	EOL	+X-Y	30	Rot X = -1	Winter: 1405	TT&C Nominal / MODE1

CASE	BOL/ EOL	SUN ON PANEL	SAA	ATTITUDE	SOLAR CONSTANT	DISSIPATION MODE
			[deg]		[W/m²]	
				Rot Y = -30		
E	EOL	+X-Y	30	Rot X = -1 Rot Y = -30	Winter: 1405	TT&C Nominal / MODE2 Photometry
F	EOL	+X-Y	30	Rot X = -1 Rot Y = -30	Winter: 1405	TT&C Nominal / MODE2 Spectroscopy
G	BOL	+X-Y	30	Rot X = -1 Rot Y = +30	Summer: 1285	TT&C Nominal / MODE3
H	BOL	+X-Y	30	Rot X = -1 Rot Y = +30	Summer: 1285	TT&C Nominal / MODE1
I	BOL	+X-Y	5	Rot X = 0 Rot Y = +5	Summer: 1285	TT&C Telecom / SurvivalBOL

TRANSIENT WITH ATTITUDE CHANGE

Two Cases with an Attitude Change have been performed with the Warm Units in MODE1: P and Q.
The scope of these transients is to verify the stability requirements. As reported in Requirements paragraph, the stability is reached for all the units that have a requirement.
A fine control law is implemented on the STR, –Y Panel Unit FHWOH and on the -Y-Z Unit FHWOV the units that require a dedicated heater power in nominal conditions.

The analysed cases are:

- P: Cold Transient:
- Starting from a temperature level corresponding to a BOL with Sun on +X -Y axis, SAA=+30°/-1° in Summer season
- Ending to a BOL case with Sun on -X -Y axis, SAA=-30°/-1° in Summer season
- Warm Units in MODE1
- TT&C units: 21 hours Scientific Mode and 3 hours Telecom Mode
- Nominal heater dissipations
- Fine control law on Units: FHWOV, FHWOH, STR.
- GYRO controlled within 1°C at set-point
- Duration of change of attitude (7°/min): 514s
- Overall duration of transient case: 130 h

- Q: Hot Transient:
- Starting from a temperature level corresponding to a EOLcase with Sun on +X -Y axis, SAA=+30°/-1° in Winter season
- Ending to a EOL case with Sun on -X -Y axis, SAA=-30°/-1° in Winter season
- Warm Units in MODE1
- TT&C units: 21 hours Scientific Mode and 3 hours Telecom Mode
- Nominal heater dissipations
- Fine control law on Units: FHWOV, FHWOH, STR.
- GYRO controlled within 1°C at set-point
- Duration of change of attitude (7°/min): 514s
- Overall duration of transient case: 130 h

REDUNDANCY TRANSIENT ANALYSIS

A series of additional analysis have been performed to verify the temperatures behaviour when the redundancy units are activated. The analysis results are reported in paragraph 5.1.5.4

5.1.2 Herschel Power Dissipation

Herschel Payload Operating Modes are the following (as per AD9):

MODE	HIFI	PACS	SPIRE	COMMENTS
1	Prime	Standby	Standby	
2	Standby	Prime	Standby	Photometry / Spectrometry in PACS Prime
3	Standby	Standby	Prime	

Power dissipations used in the analysis cases are shown in Table 5.1.2-1.

Cold Case analyses (G and H) has been performed considering the TT&C units in Nominal mode, the Warm Units in MODE1 and MODE3.
Hot Case analyses (A, B, C, D, E and F) have been performed considering the TT&C units in Nominal mode, the Warm Units in MODE1 or MODE2 and within the MODE2, Photometry and Spectroscopy.

Table 5.1.2-1 HERSCHEL - Units Power Dissipations

		A	B	C	D	E	F	G	H	I
		EOL	EOL	EOL	EOL	EOL	EOL	BOL	BOL	BOL Survival
NODE	LABEL	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]
EXTERNAL										
4	VMC	0	0	0	0	0	0	0	0	0
5	SAS+Z	0	0	0	0	0	0	0	0	0
16	MGA+Z	3-0(*)	3-0(*)	3-0(*)	3-0(*)	3-0(*)	3-0(*)	3-0(*)	3-0(*)	0
21	LGA+Z	0	0	0	0	0	0	0	0	3
41	LGA-Z	0	0	0	0	0	0	0	0	0
45	SAS-Z	0	0	0	0	0	0	0	0	0
49	SREM	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	0
56	AAD	0	0	0	0	0	0	0	0	0
INTERNAL										
70	TANK1	0	0	0	0	0	0	0	0	0
71	TANK2	0	0	0	0	0	0	0	0	0
SHEAR +Z										
100	GYRO	(**)	(**)	(**)	(**)	(**)	(**)	(**)	(**)	(**)
SHEAR +Y										
110	CRS1	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
111	CRS2	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
PANEL +Z+Y										
101	RFDN	11.8-0(*)	11.8-0(*)	11.8-0(*)	11.8-0(*)	11.8-0(*)	11.8-0(*)	11.8-0(*)	11.8-0(*)	11.8-0(*)
102	EPC1	9-0(*)	9-0(*)	9-0(*)	9-0(*)	9-0(*)	9-0(*)	9-0(*)	9-0(*)	9-0(*)
103	EPC2	0	0	0	0	0	0	0	0	0
104	XPND1	23-21(*)	23-21(*)	23-21(*)	23-21(*)	23-21(*)	23-21(*)	23-21(*)	23-21(*)	23-21(*)
105	XPND2	10-10(*)	10-10(*)	10-10(*)	10-10(*)	10-10(*)	10-10(*)	10-10(*)	10-10(*)	10-10(*)
106	TWTA1	37-0(*)	37-0(*)	37-0(*)	37-0(*)	37-0(*)	37-0(*)	37-0(*)	37-0(*)	37-0(*)
107	TWTA2	0	0	0	0	0	0	0	0	0
PANEL +Y										
201	PCDU (***)	(***)	(***)	(***)	(***)	(***)	(***)	(***)	(***)	(***)
202	CDMU	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7
203	ACC	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1

		A	B	C	D	E	F	G	H	I
		EOL	EOL	EOL	EOL	EOL	EOL	BOL	BOL	BOL Survival
NODE	LABEL	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]
204	BATT	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	6
PANEL +Y-Z										
PACS										
301	FPSPU1_2	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	0
303	FPDPU	24	24	24	24	24	24	24	24	0
304	FPBOLC	**6.6**	**48.6**	**6.6**	**6.6**	**48.6**	**6.6**	**6.6**	**6.6**	0
305	FPMECDEC	**20.9**	**21.6**	**65**	**20.9**	**21.6**	**65**	**20.9**	**20.9**	0
PANEL –Z										
401	CCU	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	0
SPIRE										
404	HSDCU	37	37	37	37	37	37	37	37	0
405	HSDPU	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	0
406	HSFCU	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	0
PANEL –Y-Z										
HIFI										
501	FHWOV	1.7	1.5	1.5	1.7	1.5	1.5	1.5	1.7	0
502	FHHRV	69.7	63.3	63.3	69.7	63.3	63.3	63.3	69.7	0
503	FHICU	34.5	29.0	29.0	34.5	29.0	29.0	29.0	34.5	0
504	FHFCU	14.3	13	13	14.3	13	13	13	14.3	0
506	FHWEV	29.7	27	27	29.7	27	27	27	29.7	0
507	FHIFV	0.4	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0
PANEL –Y										
HIFI										
601	FHWOH	1.7	1.5	1.5	1.7	1.5	1.5	1.5	1.7	0
602	FHWEH	29.7	27	27	29.7	27	27	27	29.7	0
603	FHHRH	69.7	63.3	63.3	69.7	63.3	63.3	63.3	69.7	0
604	FHLCU	**43.7**	**37.6**	**37.6**	**43.7**	**37.6**	**37.6**	**37.6**	**43.7**	0
605	FHLSU	50.3	45.8	45.8	50.3	45.8	45.8	45.8	50.3	0
606	FHIFH	0.4	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0
PANEL –Y+Z										
701	RWL1	**16**	**16**	**16**	**16**	**16**	**16**	**5**	**5**	0
702	RWL2	**16**	**16**	**16**	**16**	**16**	**16**	**5**	**5**	0
703	RWL3	**16**	**16**	**16**	**16**	**16**	**16**	**5**	**5**	0
704	RWL4	**16**	**16**	**16**	**16**	**16**	**16**	**5**	**5**	0
STR ASSEMBLY										
80014-68	STR1	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	0
81014-68	STR2	0	0	0	0	0	0	0	0	0
THRUSTERS										
8102	A1A	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
8122	A1B	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
8202	C2A	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	5.68
8222	C2B	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84
8302	C1A	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	5.68
8322	C1B	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84
8402	A2A	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
8422	A2B	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71

		A	B	C	D	E	F	G	H	I
		EOL	EOL	EOL	EOL	EOL	EOL	BOL	BOL	BOL Survival
NODE	LABEL	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]
8502	C4A	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	5.68
8522	C4B	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84
8602	C3A	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	5.68
8622	C3B	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84

(*) TT&C power: in Telecom mode (21h) the first value, in Scientific mode (3h) the second one
(**) GYRO power is depending from the temperature level of the baseplate see A.D.27
(***) In Telecom Mode PCDU have a dissipation of 76.2W in BOL and 80.0W in EOL
In Scientific Mode PCDU have a dissipation of 72.8W in BOL and 76.5W in EOL
In Survival Mode PCDU have a dissipation of 63.2W in BOL and 66.5W in EOL

5.1.3 Herschel Heater Sizing and Breakdown

A heater definition approach was followed in order to define the heater power needed by the TCS.
For this scope a heater power uncertainty analysis has been performed (AD22).

The Heater circuit breakdown with the heater power impressed on the TMM nodes is shown in Table 5.1.3-1

Table 5.1.3-1 HERSCHEL – Heater Circuits Breakdown and Temperature Thresholds

Heater line	TCS ID	HEATER's location	Heaters on Node	Power on node [W]	Power line @27 V [W]	UNIT ON Threshold [°C]	UNIT OFF or survival Threshold [°C]
TCS Line 01	HTR104NS	close to XPND1	6134	11.39	11.39	-9/-6	-19/-16
TCS Line 02	HTR105NS	close to XPND2	6110	11.39	11.39	-9/-6	-19/-16
TCS Line 03	HTR204NS	inside BATTERY	204	14.9	14.90	1/4	1/4
TCS Line 05	HTR301S	close to FPSPU, FPDPU	6309	15.51	31.00	N/A	-29/-26
			6313	15.51			
TCS Line 06	HTR304NS	close to FPBOLC	6338	4.7	9.40	-14/-11	-29/-26
			6324	4.7			
TCS Line 08	HTR305S	close to FPDECMEC	6342	11.39	27.48	-14/-11	-29/-26
			6320	11.39			
			6344	4.7			
TCS Line 09	HTR1523NS	Pipes	-	-	5.82	-	-
TCS Line 10	HTR401S	close to CCU, HSDCU, HSFCU	6402	4.7	44.50	-9/-6	-19/-16
			6417	8.1			
			6428	8.1			
			6446	15.51			
			6421	8.1			
TCS Line 11	HTR1562	Pipes	-	-	6.35	-	-
TCS Line 12	HTR501NS	Close to FHWOV	6547	11.39	22.80	C.L.	-24/-21
			6532	11.39			
TCS Line 13	HTR502S	Close to FHHRV	6501	8.1	39.00	-9/-6	-24/-21
			6517	8.1			
			6503	11.39			
			6519	11.39			

Heater line	TCS ID	HEATER's location	Heaters on Node	Power on node [W]	Power line @27 V [W]	UNIT ON Threshold [°C]	UNIT OFF or survival Threshold [°C]
TCS Line 14	HTR504S	close to FHFCU	6541	4.7	20.79	-9/-6	-24/-21
			6527	11.39			
			6533	4.7			
TCS Line 15	HTR506S	close to FHWEV, FHICU	6537	8.1	35.70	1 / 4	-24/-21
			6530	11.39			
			6521	8.1			
			6506	8.1			
TCS Line 16	HTR601NS	close to FHWOH	6606	8.1	32.40	C.L.	-24/-21
			6620	8.1			
			6608	8.1			
			6618	8.1			
TCS Line 17	HTR602S	close to FHWEH	6603	8.1	32.40	1 / 4	-24/-21
			6605	8.1			
			6615	8.1			
			6617	8.1			
TCS Line 18	HTR603S	close to FHHRH	6663	11.39	39.00	-9/-6	-24/-21
			6665	8.1			
			6639	8.1			
			6641	11.39			
TCS Line 19	HTR604S	close to FHLCU, FHIFH	6634	8.1	20.90	-9/-6	-24/-21
			6670	8.1			
			6636	4.7			
TCS Line 20	HTR605S	close to FHLSU	6654	8.1	29.00	11/14	-24/-21
			6656	8.1			
			6630	8.1			
			6632	4.7			
TCS Line 21	HTR702NS	on RWL2	702	11.39	11.39	+1/+4	+1/+4
TCS Line 22	HTR704NS	on RWL4	704	11.39	11.39	+1/+4	+1/+4
TCS Line 23	HTR701NS	on RWL1	701	11.39	11.39	+1/+4	+1/+4
TCS Line 24	HTR703NS	on RWL3	703	11.39	11.39	+1/+4	+1/+4
TCS Line 25	HTR70NS	on TANK +Y	70	6.17	6.17	11/14	11/14
TCS Line 26	HTR71NS	on TANK –Y	71	6.17	6.17	11/14	11/14

Heater line	TCS ID	HEATER's location	Heaters on Node	Power on node [W]	Power line @27 V [W]	UNIT ON Threshold [°C]	UNIT OFF or survival Threshold [°C]
TCS Line 27	HTR20000NS	close to STR's	20002	1.32	21.10	C.L.	-29/-26
			20003	1.32			
			20006	1.32			
			20007	1.32			
			20009	1.32			
			20012	1.32			
			20013	1.32			
			20016	1.32			
			20017	1.32			
			20020	1.32			
			20021	1.32			
			20024	1.32			
			20026	1.32			
			20027	1.32			
			20030	1.32			
			20031	1.32			
TCS Line 28	HTR507NS	on FH3DV	6544	11.39	11.39	C.L.	-24/-21
TCS Line 29	HTR8133NS	on FCV A1A	8133	2.35	2.35	11/14	11/14
TCS Line 30	HTR8233NS	on FCV C2A	8233	2.35	2.35	11/14	11/14
TCS Line 31	HTR8333NS	on FCV C1A	8333	2.35	2.35	11/14	11/14
TCS Line 32	HTR8433NS	on FCV A2A	8433	2.35	2.35	11/14	11/14
TCS Line 33	HTR8533NS	on FCV C4A	8533	2.35	2.35	11/14	11/14
TCS Line 34	HTR8633NS	on FCV C3A	8633	2.35	2.35	11/14	11/14

Heater line	TCS ID	HEATER's location	Heaters on Node	Power on node [W]	Power line @27 V [W]	UNIT ON Threshold [°C]	UNIT OFF or survival Threshold [°C]
TCS Line 35	HTR1544NS	Pipes			5.23		
TCS Line 37	HTR1554NS	Pipes			6.04		
TCS Line 38	HTR100NS	on GYRO	81	45.22	45.22	62.5/63	-24/-21
TCS Line 39	HTR8134NS	on FCV A1B	8134	2.35	2.35	11/14	11/14
TCS Line 40	HTR8234NS	on FCV C2B	8234	2.35	2.35	11/14	11/14
TCS Line 41	HTR8334NS	on FCV C1B	8334	2.35	2.35	11/14	11/14
TCS Line 42	HTR8434NS	on FCV A2B	8434	2.35	2.35	11/14	11/14
TCS Line 43	HTR8534NS	on FCV C4B	8534	2.35	2.35	11/14	11/14
TCS Line 44	HTR8634NS	on FCV C3B	8634	2.35	2.35	11/14	11/14
TCS Line 45	HTR1513NS	Pipes	-	-	5.75	-	-
TCS Line 46	HTR1506NS	Pipes	-	-	4.16	-	-
TCS Line 47	HTR1535NS	Pipes	-	-	5.66	-	-
TCS Line 48	HTR1550NS	PT LV1 LV2 LF	-	-	4.9	-	-

5.1.4 Thermal stability

In order to meet the stabilty requirement for the units having an heater control (501 FHWOV, 601 FHWOH, Star trackers) an adequate control law has been designed.

A dedicated set of thermal analyses (transient cases) has been performed in order to verify the stability requirement. The description of the control law criterion with the thermal analysis results is reported in AD23

5.1.5 Herschel Thermal analysis results

5.1.5.1 Transient Results

The temperature results hereafter presented (Tables 5.1.5.1-1 to 4) refer to the Sizing Cases reported in paragraph 5.1.1. The Temperatures values are reported with and without uncertainty for all the Units according to the uncertainty analysis AD21. The units activelly controlled don't have any uncertainty: GYRO, FHWOV, FHWOH, STR1.

The temperature uncertainty used is generally 8 °C (AD21, with control law case) except for the units:

- With uncertainty higher than 8°C. The real value is considered.
- With temperature higher than maximum limit. The real value is considerd.

For the survival case the reference uncertainty is always takes from AD21 but for the case without control law.
The Gyro has to be controlled in temperature in way that its temperature not changes more than 1 °C.
For this reason calculated the maximum temperature in EOL (Hot case) the threshold of heater switch-on has been defined about 1°C less (62°C). Of course when the analysis condition request heater no uncertainty will be applied at the Gyro, while if the temperature is higher than the heater threshold value will be applied the uncertainty calculated without control (8.5 °C, see AD21).
The Tables contain for the main S/L items, the relevant TMM node, its description, the temperature results in the transient nominal analysis with the minimum values reported for the Cold cases and the maximum values reported for the Hot cases, the uncertainty applied, the temperature with the relative uncertainty applied, the heater enabled according to the case analysed are identified by the "h" reported near the temperature value, the operative and non operative limits. All the temperatures are in degree Celsius.

Table 5.1.5.1-1 HERSCHEL - Units Temperature results: Sizing Case BOL Nominal G and H.

											TEMPERATURE LIMIT			
NODE	LABEL	G TEMP	G PW	H TEMP	H PW	UFP	HTR NOM	HTR SURV	G TEMP -UFP	H TEMP-UFP	MIN OPER.	MAX OPER.	MIN N.OPER	MAX N.OPER
		[°C]	[W]	[°C]	[W]	[°C]			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
4	VMC	**4.0**	0.0	**4.3**	0.0	7.4			-3.4	-3.1	-10	50	-20	60
5	SAS +Z	**17.2**	0.0	**17.4**	0.0	8			9.2	9.4	-70	80	-80	90
16	MGA+Z	**61.3**	0.6	**61.4**	0.6	12.4			48.9	49.0	-150	150	-150	150
21	LGA+Z	**56.4**	0.0	**56.5**	0.0	8			48.4	48.5	-150	120	-150	120
41	LGA-Z	**-65.2**	0.0	**-64.9**	0.0	8			-73.2	-72.9	-150	120	-150	120
45	SAS -Z	**-16.9**	0.0	**-16.3**	0.0	8			-24.9	-24.3	-70	80	-80	90
49	SREM	**6.1**	2.6	**6.7**	2.6	8			-1.9	-1.3	-10	50	-45	90
56	AAD	**26.7**	0.0	**26.9**	0.0	8			18.7	18.9	-70	70	-80	80
70	TANK1	**11.0**	0.0	**11.0**	0.0	8	N	S	11.0h	11.0h	10	45	-20	55
71	TANK2	**11.0**	0.0	**11.0**	0.0	8	N	S	11.0h	11.0h	10	45	-20	55
81	GYRO	**62.2**	0.0	**62.2**	0.0	0	N	S	62.2	62.2	-20	55	-30	65
101	RFDN	**-4.6**	11.8	**-4.4**	11.8	8			-12.6	-12.4	-25	55	-35	65
102	EPC1	**-0.3**	9.0	**-0.2**	9.0	8			-8.3	-8.2	-20	60	-30	70
103	EPC2	**-13.4**	0.0	**-13.3**	0.0	8.2			-21.6	-21.5	-20	60	-30	70
104	XPND1	**6.9**	23.0	**7.0**	23.0	7.6	N	S	-0.7	-0.6	-10	45	-20	55
105	XPND2	**-5.8**	10.0	**-5.6**	10.0	8	N	S	-5.8h	-5.6h	-10	45	-20	55
106	TWTA1	**-6.4**	37.0	**-6.3**	37.0	8			-14.4	-14.3	-20	60	-30	70
107	TWTA2	**-16.0**	0.0	**-15.9**	0.0	8.1			-24.1	-24.0	-20	60	-30	70
110	CRS1	**14.4**	8.3	**14.6**	8.3	7.3			7.1	7.3	0	50	-10	60
111	CRS2	**14.9**	8.3	**15.1**	8.3	7.3			7.6	7.8	0	50	-10	60
201	PCDU	**9.2**	76.2	**9.4**	76.2	8			1.2	1.4	-10	47	-20	57
202	CDMU	**8.6**	37.7	**8.8**	37.7	8			0.6	0.8	-10	45	-20	55
203	ACC	**10.6**	32.1	**10.8**	32.1	8			2.6	2.8	-10	45	-20	55
204	BATT	**1.0**	2.3	**1.0**	2.3	8	N	S	1.0h	1.0h	0	35		
301	FPSPU1_2	**10.8**	30.3	**11.0**	30.3	8		S	2.8	3.0	-15	45	-30	60
303	FPDPU	**11.2**	24.0	**11.5**	24.0	8		S	3.2	3.5	-15	45	-30	60
304	FPBOLC	**-8.2**	6.6	**-7.9**	6.6	8	N	S	-8.2h	-7.9h	-15	45	-30	60
305	FPMECDEC	**-3.7**	20.9	**-3.3**	20.9	8		S	-11.7	-11.3	-15	45	-30	60
401	CCU	**2.4**	5.4	**3.3**	5.4	8		S	-5.6	-4.7	-10	40	-20	50

											TEMPERATURE LIMIT			
NODE	LABEL	G TEMP	G PW	H TEMP	H PW	UFP	HTR NOM	HTR SURV	G TEMP -UFP	H TEMP-UFP	MIN OPER.	MAX OPER.	MIN N.OPER	MAX N.OPER
		[°C]	[W]	[°C]	[W]	[°C]			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
404	HSDCU	**8.9**	37.0	**9.8**	37.0	8		S	0.9	1.8	-15	45	-35	60
405	HSDPU	**5.3**	15.3	**5.7**	15.3	8		S	-2.7	-2.3	-15	45	-35	60
406	HSFCU	**8.3**	42.9	**8.7**	42.9	8		S	0.3	0.7	-15	45	-35	60
501	FHWOV	**9.0**	1.5	**9.0**	1.7	0	N	S	9.0	9.0	5	15	-25	55
502	FHHRV	**18.8**	63.3	**25.4**	69.7	9		S	9.8	16.4	-10	40	-25	55
503	FHICU	**16.6**	29.0	**25.0**	34.5	8.3		S	8.3	16.7	-25	40	-30	60
504	FHFCU	**9.4**	13.0	**14.7**	14.3	8		S	1.4	6.7	-10	40	-25	55
506	FHWEV	**12.0**	27.0	**16.7**	29.7	8		S	4.0	8.7	0	30	-25	55
507	FHIFV	**7.0**	0.00	**7.0**	0.40	8		S	-1.0	-1.0	-10	40	-25	55
508	IFV-HRV	**10.8**	0.00	**15.6**	0.00	9		S	1.8	6.6	-10	40	-25	55
509	IFV-WEV	**11.2**	0.00	**16.0**	0.00	9		S	2.2	7.0	-10	40	-25	55
510	WOV-WEV	**9.7**	0.00	**13.7**	0.00	9		S	0.7	4.7	-10	40	-25	55
511	HRV-HRH	**10.8**	0.00	**15.8**	0.00	9		S	1.8	6.8	-10	40	-25	55
601	FHWOH	**8.9**	1.5	**8.9**	1.7	0	N	S	8.9	8.9	5	15	-25	55
602	FHWEH	**8.5**	27.0	**13.8**	29.7	7.8		S	0.7	6.0	0	30	-25	55
603	FHHRH	**15.2**	63.3	**21.4**	69.7	8.8		S	6.4	12.6	-10	40	-25	55
604	FHLCU	**13.4**	37.6	**20.3**	43.7	8		S	5.4	12.3	-10	40	-25	55
605	FHLSU	**13.5**	44.7	**19.1**	49.3	8		S	13.5h	11.1	10	40	-25	55
606	FHIFH	**2.3**	0.00	**8.2**	0.40	8		S	-5.7	0.2	-10	40	-25	55
607	IFH-HRH	**9.7**	0.00	**14.6**	0.00	9		S	0.7	5.6	-10	40	-25	55
608	IFH-WEH	**9.7**	0.00	**14.6**	0.00	9		S	0.7	5.6	-10	40	-25	55
609	WEH-W0H	**10.2**	0.00	**15.2**	0.00	9		S	1.2	6.2	-10	40	-25	55
701	RWL1	**1.0**	5.0	**1.1**	5.0	8	N	S	1.0h	1.1h	0	55	-10	65
702	RWL2	**1.0**	5.0	**1.0**	5.0	8	N	S	1.0h	1.0h	0	55	-10	65
703	RWL3	**1.0**	5.0	**1.0**	5.0	8	N	S	1.0h	1.0h	0	55	-10	65
704	RWL4	**1.8**	5.0	**2.4**	5.0	8	N	S	1.8h	2.4h	0	55	-10	65
8133	FCV MAIN	**11.0**	OP	**11.0**	OP	8	N	S	11.0h	11.0h	10	60	10	60
8233	FCV MAIN	**11.0**	OP	**11.0**	OP	8	N	S	11.0h	11.0h	10	60	10	60
8333	FCV MAIN	**11.0**	OP	**11.0**	OP	8	N	S	11.0h	11.0h	10	60	10	60
8433	FCV MAIN	**11.0**	OP	**11.0**	OP	8	N	S	11.0h	11.0h	10	60	10	60
8533	FCV MAIN	**11.0**	OP	**13.1**	OP	8	N	S	11.0h	11.0h	10	60	10	60
8633	FCV MAIN	**11.0**	OP	**11.0**	OP	8	N	S	11.0h	11.0h	10	60	10	60
8134	FCV RED	**11.0**	OP	**11.0**	OP	8	N	S	11.0h	11.0h	10	60	10	60
8234	FCV RED	**11.0**	OP	**11.0**	OP	8	N	S	11.0h	11.0h	10	60	10	60
8334	FCV RED	**11.0**	OP	**11.0**	OP	8	N	S	11.0h	11.0h	10	60	10	60
8434	FCV RED	**10.9**	OP	**11.0**	OP	8	N	S	10.9h	11.0h	10	60	10	60
8534	FCV RED	**12.7**	OP	**15.1**	OP	8	N	S	12.7h	15.1h	10	60	10	60
8634	FCV RED	**11.0**	OP	**11.0**	OP	8	N	S	11.0h	11.0h	10	60	10	60
80029	STR1+X FOOT	**1.1**	OP	**1.1**	OP	0	N	S	1.1	1.1	-20	40	-30	50
81029	STR2+X FOOT	**-5.0**	OP	**-5.0**	OP	3.8	N	S	-8.8	-8.8	-20	40	-30	50
1501	RCS_INT_CONE	**23.1**	OP	**23.1**	OP	8	N	S	15.1	15.1	10	50		
1502	RCS_INT_CONE	**25.8**	OP	**25.9**	OP	8	N	S	17.8	17.9	10	50		
1503	RCS_INT_CONE	**34.8**	OP	**34.7**	OP	8	N	S	26.8	26.7	10	50		
1504	RCS_INT_CONE	**19.5**	OP	**19.6**	OP	8	N	S	11.5	11.6	10	50		
1505	RCS_INT_CONE	**24.8**	OP	**24.9**	OP	8	N	S	16.8	16.9	10	50		
1506	RCS_INT_CONE	**19.0**	OP	**19.0**	OP	8	N	S	11.0	11.0	10	50		
1507	RCS_INT_CONE	**21.6**	OP	**21.5**	OP	8	N	S	13.6	13.5	10	50		
1508	RCS_INT_CONE	**22.0**	OP	**21.7**	OP	8	N	S	14.0	13.7	10	50		
1509	RCS_INT_CONE	**19.7**	OP	**19.5**	OP	8	N	S	11.7	11.5	10	50		
1510	RCS_INT_CONE	**22.9**	OP	**22.6**	OP	8	N	S	14.9	14.6	10	50		
1511	RCS_INT_CONE	**19.1**	OP	**18.9**	OP	8	N	S	11.1	10.9	10	50		
1512	RCS_INT_CONE	**18.5**	OP	**18.7**	OP	8	N	S	10.5	10.7	10	50		
1513	RCS_INT_CONE	**19.0**	OP	**19.0**	OP	8	N	S	11.0	11.0	10	50		
1514	RCS_INT_CONE	**21.1**	OP	**21.4**	OP	8	N	S	13.1	13.4	10	50		
1515	RCS_SHEAR+Z-Y	**21.5**	OP	**21.5**	OP	8	N	S	13.5	13.5	10	50		
1516	RCS_SHEAR+Z-Y	**21.5**	OP	**21.5**	OP	8	N	S	13.5	13.5	10	50		
1517	RCS_BOT_FLOOR	**31.0**	OP	**30.9**	OP	8	N	S	23.0	22.9	10	50		
1518	RCS_BOT_FLOOR	**31.0**	OP	**30.9**	OP	8	N	S	23.0	22.9	10	50		

											TEMPERATURE LIMIT			
		G	G	H	H	UFP	HTR	HTR	G	H	MIN	MAX	MIN	MAX
NODE	LABEL	TEMP	PW	TEMP	PW		NOM	SURV	TEMP -UFP	TEMP- UFP	OPER.	OPER.	N.OPER	N.OPER
		[°C]	[W]	[°C]	[W]	[°C]			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
1519	RCS_SHEAR+Z+Y	**36.0**	OP	**35.8**	OP	8	N	S	28.0	27.8	10	50		
1520	RCS_BOT_FLOOR	**32.7**	OP	**32.4**	OP	8	N	S	24.7	24.4	10	50		
1521	RCS_SHEAR+Z+Y	**18.1**	OP	**18.3**	OP	8	N	S	10.1	10.3	10	50		
1522	RCS_SHEAR+Z+Y	**39.6**	OP	**39.6**	OP	8	N	S	31.6	31.6	10	50		
1523	RCS_SHEAR+Z+Y	**34.9**	OP	**34.9**	OP	8	N	S	26.9	26.9	10	50		
1524	RCS_SHEAR+Z+Y	**20.7**	OP	**20.8**	OP	8	N	S	12.7	12.8	10	50		
1525	RCS_BOT_FLOOR	**31.5**	OP	**31.5**	OP	8	N	S	23.5	23.5	10	50		
1526	RCS_BOT_FLOOR	**30.5**	OP	**30.2**	OP	8	N	S	22.5	22.2	10	50		
1527	RCS_SHEAR-Z+Y	**24.5**	OP	**24.6**	OP	8	N	S	16.5	16.6	10	50		
1528	RCS_BOT_FLOOR	**28.3**	OP	**28.4**	OP	8	N	S	20.3	20.4	10	50		
1529	RCS_SHEAR-Y-Z	**23.9**	OP	**23.9**	OP	8	N	S	15.9	15.9	10	50		
1530	RCS_BOT_FLOOR	**32.5**	OP	**35.5**	OP	8	N	S	24.5	27.5	10	50		
1531	RCS_SHEAR+Y+Z	**33.2**	OP	**33.0**	OP	8	N	S	25.2	25.0	10	50		
1532	RCS_SHEAR+Y+Z	**30.6**	OP	**30.4**	OP	8	N	S	22.6	22.4	10	50		
1533	RCS_SHEAR+Y+Z	**30.0**	OP	**29.8**	OP	8	N	S	22.0	21.8	10	50		
1534	RCS_BOT_FLOOR	**30.0**	OP	**29.7**	OP	8	N	S	22.0	21.7	10	50		
1535	RCS_SHEAR-Y+Z	**23.8**	OP	**23.8**	OP	8	N	S	15.8	15.8	10	50		
1536	RCS_BOT_FLOOR	**24.5**	OP	**24.0**	OP	8	N	S	16.5	16.0	10	50		
1541	RCS_SHEAR+Y-Z	**27.2**	OP	**27.2**	OP	8	N	S	19.2	19.2	10	50		
1542	RCS_SHEAR+Y-Z	**26.7**	OP	**26.7**	OP	8	N	S	18.7	18.7	10	50		
1543	RCS_SHEAR+Y-Z	**22.4**	OP	**22.5**	OP	8	N	S	14.4	14.5	10	50		
1544	RCS_BOT_FLOOR	**18.9**	OP	**19.0**	OP	8	N	S	10.9	11.0	10	50		
1550	PT	**19.0**	OP	**19.0**	OP	8	N	S	11.0	11.0	10	50		
1551	LV1	**25.0**	OP	**25.0**	OP	8	N	S	17.0	17.0	10	50		
1552	LV2	**26.6**	OP	**26.6**	OP	8	N	S	18.6	18.6	10	50		
1553	LF	**24.5**	OP	**24.5**	OP	8	N	S	16.5	16.5	10	50		
1554	RCS_SHEAR-Z+Y	**21.9**	OP	**21.9**	OP	8	N	S	13.9	13.9	10	50		
1555	RCS_SHEAR-Z+Y	**23.4**	OP	**23.4**	OP	8	N	S	15.4	15.4	10	50		
1556	RCS_SHEAR-Z+Y	**24.5**	OP	**24.5**	OP	8	N	S	16.5	16.5	10	50		
1557	RCS_SHEAR-Z+Y	**22.8**	OP	**22.7**	OP	8	N	S	14.8	14.7	10	50		
1558	RCS_SHEAR-Z+Y	**22.8**	OP	**22.8**	OP	8	N	S	14.8	14.8	10	50		
1559	RCS_SHEAR-Z+Y	**24.2**	OP	**24.1**	OP	8	N	S	16.2	16.1	10	50		
1561	RCS_EXT_CONE	**33.3**	OP	**33.4**	OP	8	N	S	25.3	25.4	10	50		
1562	RCS_EXT_CONE	**26.9**	OP	**26.9**	OP	8	N	S	18.9	18.9	10	50		
1563	RCS_EXT_CONE	**38.1**	OP	**37.9**	OP	8	N	S	30.1	29.9	10	50		
1564	RCS_EXT_CONE	**22.7**	OP	**23.0**	OP	8	N	S	14.7	15.0	10	50		
1565	RCS_EXT_CONE	**20.9**	OP	**21.1**	OP	8	N	S	12.9	13.1	10	50		
1566	RCS_EXT_CONE	**24.4**	OP	**24.1**	OP	8	N	S	16.4	16.1	10	50		
1567	RCS_EXT_CONE	**20.0**	OP	**19.7**	OP	8	N	S	12.0	11.7	10	50		
1568	RCS_EXT_CONE	**21.2**	OP	**20.9**	OP	8	N	S	13.2	12.9	10	50		
1571	RCS_SHEAR-Y-Z	**22.4**	OP	**22.8**	OP	8	N	S	14.4	14.8	10	50		
1572	RCS_SHEAR-Y-Z	**22.1**	OP	**23.4**	OP	8	N	S	14.1	15.4	10	50		
1573	RCS_SHEAR-Y-Z	**27.2**	OP	**28.4**	OP	8	N	S	19.2	20.4	10	50		
1574	RCS_BOT_FLOOR	**23.2**	OP	**23.9**	OP	8	N	S	15.2	15.9	10	50		
1575	RCS_BOT_FLOOR	**23.9**	OP	**24.5**	OP	8	N	S	15.9	16.5	10	50		
1576	RCS_BOT_FLOOR	**28.8**	OP	**32.5**	OP	8	N	S	20.8	24.5	10	50		
1581	RCS_SHEAR-Y+Z	**25.6**	OP	**25.6**	OP	8	N	S	17.6	17.6	10	50		
1582	RCS_SHEAR-Y+Z	**22.3**	OP	**22.4**	OP	8	N	S	14.3	14.4	10	50		
1583	RCS_SHEAR-Y+Z	**24.0**	OP	**24.4**	OP	8	N	S	16.0	16.4	10	50		
1584	RCS_BOT_FLOOR	**20.3**	OP	**20.1**	OP	8	N	S	12.3	12.1	10	50		
1591	RCS_SHEAR+Z-Y	**37.3**	OP	**37.3**	OP	8	N	S	29.3	29.3	10	50		
1592	RCS_SHEAR+Z-Y	**36.2**	OP	**36.1**	OP	8	N	S	28.2	28.1	10	50		

Table 5.1.5.1-2 HERSCHEL - Units Temperature results: Sizing Case BOL Survival I.

								TEMPERATURE LIMIT			
		I	I	UFP	HTR	HTR	I	MIN	MAX	MIN	MAX
NODE	LABEL	TEMP	PW		NOM	SURV	TEMP-UFP	OPER.	OPER.	N.OPER	N.OPER
		[°C]	[W]	[°C]			[°C]	[°C]	[°C]	[°C]	[°C]

4	VMC	**-2.7**	0.0	8.6			-11.3	-10	50	-20	60
5	SAS +Z	**6.5**	0.0	8.0			-1.5	-70	80	-80	90
16	MGA+Z	**63.8**	0.0	12.8			51.0	-150	150	-150	150
21	LGA+Z	**76.0**	0.0	8.0			68.0	-150	120	-150	120
41	LGA-Z	**-73.9**	1.7	8.0			-81.9	-150	120	-150	120
45	SAS -Z	**-30.1**	0.0	8.1			-38.2	-70	80	-80	90
49	SREM	**-21.1**	0.0	8.5			-29.6	-10	50	-45	90
56	AAD	**21.9**	0.0	8.7			13.2	-70	70	-80	80
70	TANK1	**11.0**	0.0	8.5	N	S	11.0h	10	45	-20	55
71	TANK2	**11.0**	0.0	8.4	N	S	11.0h	10	45	-20	55
81	GYRO	**2.0**	0.0	8.5	N	S	-6.5	-20	55	-30	65
101	RFDN	**3.0**	11.8	8.6			-5.6	-25	55	-35	65
102	EPC1	**17.0**	9.0	8.2			8.8	-20	60	-30	70
103	EPC2	**-9.9**	0.0	9.0			-18.9	-20	60	-30	70
104	XPND1	**15.1**	23.0	8.3	N	S	6.8	-10	45	-20	55
105	XPND2	**-2.6**	10.0	8.7	N	S	-2.6h	-10	45	-20	55
106	TWTA1	**26.3**	37.0	8.9			17.4	-20	60	-30	70
107	TWTA2	**-12.5**	0.0	9.1			-21.6	-20	60	-30	70
110	CRS1	**13.8**	8.3	8.3			5.5	0	50	-10	60
111	CRS2	**14.4**	8.3	8.3			6.1	0	50	-10	60
201	PCDU	**3.1**	63.2	8.0			-4.9	-10	47	-20	57
202	CDMU	**1.5**	37.7	8.0			-6.5	-10	45	-20	55
203	ACC	**3.6**	32.1	8.0			-4.4	-10	45	-20	55
204	BATT	**1.0**	6.0	8.2	N	S	1.0h	0	35		
301	FPSPU1_2	**-29.4**	0.0	8.2		S	-29.4h	-15	45	-30	60
303	FPDPU	**-28.1**	0.0	8.3		S	-28.1h	-15	45	-30	60
304	FPBOLC	**-26.6**	0.0	8.2	N	S	-26.6h	-15	45	-30	60
305	FPMECDEC	**-29.0**	0.0	8.1		S	-29.0h	-15	45	-30	60
401	CCU	**-9.1**	5.4	8.2		S	-9.1h	-10	40	-20	50
404	HSDCU	**-22.4**	0.0	8.3			-30.7	-15	45	-35	60
405	HSDPU	**-21.4**	0.0	8.2			-29.6	-15	45	-35	60
406	HSFCU	**-24.8**	0.0	8.2			-33.0	-15	45	-35	60
501	FHWOV	**-24.3**	0.0	9.2	N	S	-24.3h	5	15	-25	55
502	FHHRV	**-24.2**	0.0	9.5		S	-24.2h	-10	40	-25	55
503	FHICU	**-24.6**	0.0	9.3		S	-24.6h	-25	40	-30	60
504	FHFCU	**-24.1**	0.0	8.4		S	-24.1h	-10	40	-25	55
506	FHWEV	**-24.2**	0.0	8.8		S	-24.2h	0	30	-25	55
507	FHIFV	**-24.2**	0.0	8.0		S	-24.2h	-10	40	-25	55
508	IFV-HRV	**-22.3**	0.0	9.0			-22.3h	-10	40	-25	55
509	IFV-WEV	**-22.3**	0.0	9.0			-22.3h	-10	40	-25	55
510	WOV-WEV	**-21.5**	0.0	9.0			-21.5h	-10	40	-25	55
511	HRV-HRH	**-21.5**	0.0	9.0			-21.5h	-10	40	-25	55
601	FHWOH	**-24.2**	0.0	9.1	N	S	-24.2h	5	15	-25	55
602	FHWEH	**-24.5**	0.0	8.8		S	-24.5h	0	30	-25	55
603	FHHRH	**-24.2**	0.0	9.4		S	-24.2h	-10	40	-25	55
604	FHLCU	**-26.5**	0.0	8.3		S	-26.5h	-10	40	-25	55
605	FHLSU	**-24.2**	0.0	9.3		S	-24.2h	10	40	-25	55
606	FHIFH	**-12.5**	0.0	8.0		S	-20.5	-10	40	-25	55
607	IFH-HRH	**-22.3**	0.0	9.0			-22.3h	-10	40	-25	55
608	IFH-WEH	**-22.5**	0.0	9.0			-22.5h	-10	40	-25	55
609	WEH-W0H	**-22.9**	0.0	9.0			-22.9h	-10	40	-25	55
701	RWL1	**-9.0**	0.0	8.5	N	S	-9.0h	0	55	-10	65
702	RWL2	**-9.0**	0.0	8.4	N	S	-9.0h	0	55	-10	65
703	RWL3	**-9.0**	0.0	8.6	N	S	-9.0h	0	55	-10	65
704	RWL4	**-9.0**	0.0	8.4	N	S	-9.0h	0	55	-10	65
8133	FCV MAIN	**11.0**	OP	8.3	N	S	11.0h	10	60	10	60
8233	FCV MAIN	**20.0**	OP	8.6	N	S	11.4	10	60	10	60
8333	FCV MAIN	**11.0**	OP	8.3	N	S	11.0h	10	60	10	60
8433	FCV MAIN	**10.9**	OP	8.3	N	S	10.9h	10	60	10	60
8533	FCV MAIN	**11.0**	OP	8.4	N	S	11.0h	10	60	10	60
8633	FCV MAIN	**11.5**	OP	8.3	N	S	11.5h	10	60	10	60
8134	FCV RED	**11.0**	OP	8.5	N	S	11.0h	10	60	10	60
8234	FCV RED	**15.0**	OP	8.6	N	S	15.0h	10	60	10	60

NODE	LABEL	I TEMP [°C]	I PW [W]	UFP [°C]	HTR NOM	HTR SURV	I TEMP-UFP [°C]	TEMPERATURE LIMIT MIN OPER. [°C]	MAX OPER. [°C]	MIN N.OPER [°C]	MAX N.OPER [°C]
8334	FCV RED	**11.0**	OP	8.3	N	S	11.0h	10	60	10	60
8434	FCV RED	**10.9**	OP	8.4	N	S	10.9h	10	60	10	60
8534	FCV RED	**10.9**	OP	8.4	N	S	10.9h	10	60	10	60
8634	FCV RED	**11.0**	OP	8.3	N	S	11.0h	10	60	10	60
80029	STR1+X FOOT	**-29.2**	0.0	8.0	N	S	-29.2h	-20	40	-30	50
81029	STR2+X FOOT	**-29.1**	0.0	8.0	N	S	-29.1h	-20	40	-30	50
1501	RCS_INT_CONE	**19.4**	OP	8	N	S	11.4	10	50		
1502	RCS_INT_CONE	**21.7**	OP	8	N	S	13.7	10	50		
1503	RCS_INT_CONE	**34.8**	OP	8	N	S	26.8	10	50		
1504	RCS_INT_CONE	**18.3**	OP	8	N	S	10.3	10	50		
1505	RCS_INT_CONE	**24.2**	OP	8	N	S	16.2	10	50		
1506	RCS_INT_CONE	**18.9**	OP	8	N	S	10.9	10	50		
1507	RCS_INT_CONE	**21.2**	OP	8	N	S	13.2	10	50		
1508	RCS_INT_CONE	**27.1**	OP	8	N	S	19.1	10	50		
1509	RCS_INT_CONE	**22.9**	OP	8	N	S	14.9	10	50		
1510	RCS_INT_CONE	**27.4**	OP	8	N	S	19.4	10	50		
1511	RCS_INT_CONE	**21.5**	OP	8	N	S	13.5	10	50		
1512	RCS_INT_CONE	**20.8**	OP	8	N	S	12.8	10	50		
1513	RCS_INT_CONE	**22.9**	OP	8	N	S	14.9	10	50		
1514	RCS_INT_CONE	**21.6**	OP	8	N	S	13.6	10	50		
1515	RCS_SHEAR+Z-Y	**24.2**	OP	8	N	S	16.2	10	50		
1516	RCS_SHEAR+Z-Y	**24.2**	OP	8	N	S	16.2	10	50		
1517	RCS_BOT_FLOOR	**43.0**	OP	8	N	S	35.0	10	50		
1518	RCS_BOT_FLOOR	**43.0**	OP	8	N	S	35.0	10	50		
1519	RCS_SHEAR+Z+Y	**38.0**	OP	8	N	S	30.0	10	50		
1520	RCS_BOT_FLOOR	**37.4**	OP	8	N	S	29.4	10	50		
1521	RCS_SHEAR+Z+Y	**20.6**	OP	8	N	S	12.6	10	50		
1522	RCS_SHEAR+Z+Y	**44.9**	OP	8	N	S	36.9	10	50		
1523	RCS_SHEAR+Z+Y	**36.0**	OP	8	N	S	28.0	10	50		
1524	RCS_SHEAR+Z+Y	**19.7**	OP	8	N	S	11.7	10	50		
1525	RCS_BOT_FLOOR	**46.8**	OP	8	N	S	38.8	10	50		
1526	RCS_BOT_FLOOR	**35.0**	OP	8	N	S	27.0	10	50		
1527	RCS_SHEAR-Z+Y	**31.6**	OP	8	N	S	23.6	10	50		
1528	RCS_BOT_FLOOR	**36.0**	OP	8	N	S	28.0	10	50		
1529	RCS_SHEAR-Y-Z	**32.9**	OP	8	N	S	24.9	10	50		
1530	RCS_BOT_FLOOR	**30.6**	OP	8	N	S	22.6	10	50		
1531	RCS_SHEAR+Y+Z	**34.1**	OP	8	N	S	26.1	10	50		
1532	RCS_SHEAR+Y+Z	**32.6**	OP	8	N	S	24.6	10	50		
1533	RCS_SHEAR+Y+Z	**32.4**	OP	8	N	S	24.4	10	50		
1534	RCS_BOT_FLOOR	**35.0**	OP	8	N	S	27.0	10	50		
1535	RCS_SHEAR-Y+Z	**26.8**	OP	8	N	S	18.8	10	50		
1536	RCS_BOT_FLOOR	**22.8**	OP	8	N	S	14.8	10	50		
1541	RCS_SHEAR+Y-Z	**35.1**	OP	8	N	S	27.1	10	50		
1542	RCS_SHEAR+Y-Z	**34.8**	OP	8	N	S	26.8	10	50		
1543	RCS_SHEAR+Y-Z	**27.8**	OP	8	N	S	19.8	10	50		
1544	RCS_BOT_FLOOR	**18.9**	OP	8	N	S	10.9	10	50		
1550	PT	**18.9**	OP	8	N	S	10.9	10	50		
1551	LV1	**23.4**	OP	8	N	S	15.4	10	50		
1552	LV2	**22.8**	OP	8	N	S	14.8	10	50		
1553	LF	**21.6**	OP	8	N	S	13.6	10	50		
1554	RCS_SHEAR-Z+Y	**20.9**	OP	8	N	S	12.9	10	50		
1555	RCS_SHEAR-Z+Y	**22.4**	OP	8	N	S	14.4	10	50		
1556	RCS_SHEAR-Z+Y	**22.6**	OP	8	N	S	14.6	10	50		
1557	RCS_SHEAR-Z+Y	**23.2**	OP	8	N	S	15.2	10	50		
1558	RCS_SHEAR-Z+Y	**21.8**	OP	8	N	S	13.8	10	50		
1559	RCS_SHEAR-Z+Y	**20.0**	OP	8	N	S	12.0	10	50		
1561	RCS_EXT_CONE	**38.6**	OP	8	N	S	30.6	10	50		
1562	RCS_EXT_CONE	**26.9**	OP	8	N	S	18.9	10	50		
1563	RCS_EXT_CONE	**37.2**	OP	8	N	S	29.2	10	50		

								TEMPERATURE LIMIT			
		I	I	UFP	HTR	HTR	I	MIN	MAX	MIN	MAX
NODE	LABEL	TEMP	PW		NOM	SURV	TEMP-UFP	OPER.	OPER.	N.OPER	N.OPER
		[°C]	[W]	[°C]			[°C]	[°C]	[°C]	[°C]	[°C]
1564	RCS_EXT_CONE	**24.3**	OP	8	N	S	16.3	10	50		
1565	RCS_EXT_CONE	**25.4**	OP	8	N	S	17.4	10	50		
1566	RCS_EXT_CONE	**33.9**	OP	8	N	S	25.9	10	50		
1567	RCS_EXT_CONE	**22.1**	OP	8	N	S	14.1	10	50		
1568	RCS_EXT_CONE	**25.9**	OP	8	N	S	17.9	10	50		
1571	RCS_SHEAR-Y-Z	**28.1**	OP	8	N	S	20.1	10	50		
1572	RCS_SHEAR-Y-Z	**23.0**	OP	8	N	S	15.0	10	50		
1573	RCS_SHEAR-Y-Z	**31.9**	OP	8	N	S	23.9	10	50		
1574	RCS_BOT_FLOOR	**26.4**	OP	8	N	S	18.4	10	50		
1575	RCS_BOT_FLOOR	**30.0**	OP	8	N	S	22.0	10	50		
1576	RCS_BOT_FLOOR	**19.8**	OP	8	N	S	11.8	10	50		
1581	RCS_SHEAR-Y+Z	**28.8**	OP	8	N	S	20.8	10	50		
1582	RCS_SHEAR-Y+Z	**23.9**	OP	8	N	S	15.9	10	50		
1583	RCS_SHEAR-Y+Z	**25.8**	OP	8	N	S	17.8	10	50		
1584	RCS_BOT_FLOOR	**20.0**	OP	8	N	S	12.0	10	50		
1591	RCS_SHEAR+Z-Y	**46.0**	OP	8	N	S	38.0	10	50		
1592	RCS_SHEAR+Z-Y	**41.9**	OP	8	N	S	33.9	10	50		

(*) Units with dedicated heater control properly sized; their minimum temperature is the analysis temperature without uncertainty.

Table 5.1.5.1-3 HERSCHEL - Units Temperature results: Sizing Case EOL Nominal A, B and C.

														TEMPERATURE LIMIT			
NODE	LABEL	A TEMP	A PW	B TEMP	B PW	C TEMP	C PW	UFP	HTR NOM	HTR SURV	A TEMP +UFP	B TEMP +UFP	C TEMP +UFP	MIN OPER.	MAX OPER.	MIN N.OPER	MAX N.OPER
		[°C]	[W]	[°C]	[W]	[°C]	[W]	[°C]			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
4	VMC	**41.3**	0.0	**41.9**	0.0	**41.9**	0.0	7.4			48.7	49.3	49.3	-10	50	-20	60
5	SAS +Z	**43.5**	0.0	**44.1**	0.0	**44.1**	0.0	8			51.5	52.1	52.1	-70	80	-80	90
16	MGA+Z	**129.6**	0.6	**129.9**	0.6	**129.9**	0.6	12.4			142.0	142.3	142.3	-150	150	-150	150
21	LGA+Z	**86.5**	0.0	**86.6**	0.0	**86.6**	0.0	8			94.5	94.6	94.6	-150	120	-150	120
41	LGA-Z	**-54.3**	0.0	**-52.7**	0.0	**-52.2**	0.0	8			-46.3	-44.7	-44.2	-150	120	-150	120
45	SAS -Z	**3.0**	0.0	**4.9**	0.0	**5.5**	0.0	8			11.0	12.9	13.5	-70	80	-80	90
49	SREM	**29.6**	2.6	**32.0**	2.6	**32.8**	2.6	8			37.6	40.0	40.8	-10	50	-45	90
56	AAD	**52.8**	0.0	**53.5**	0.0	**53.4**	0.0	8			60.8	61.5	61.4	-70	70	-80	80
70	TANK1	**34.6**	0.0	**35.6**	0.0	**35.8**	0.0	8	N	S	42.6	43.6	43.8	10	45	-20	55
71	TANK2	**32.4**	0.0	**34.5**	0.0	**34.5**	0.0	8	N	S	40.4	42.5	42.5	10	45	-20	55
81	GYRO	**63.3**	0.0	**63.3**	0.0	**63.3**	0.0	0	N	S	63.3	63.3	63.3	-20	55	-30	65
101	RFDN	**33.2**	11.8	**34.0**	11.8	**33.9**	11.8	8			41.2	42.0	41.9	-25	55	-35	65
102	EPC1	**41.7**	9.0	**42.5**	9.0	**42.4**	9.0	8			49.7	50.5	50.4	-20	60	-30	70
103	EPC2	**18.6**	0.0	**19.4**	0.0	**19.3**	0.0	8.2			26.8	27.6	27.5	-20	60	-30	70
104	XPND1	**39.3**	23.0	**40.2**	23.0	**40.0**	23.0	7.6	N	S	46.9	47.8	47.6	-10	45	-20	55
105	XPND2	**24.6**	10.0	**25.6**	10.0	**25.4**	10.0	8	N	S	32.6	33.6	33.4	-10	45	-20	55
106	TWTA1	**51.9**	37.0	**52.6**	37.0	**52.5**	37.0	7.9			59.8	60.5	60.4	-20	60	-30	70
107	TWTA2	**18.0**	0.0	**18.7**	0.0	**18.6**	0.0	8.1			26.1	26.8	26.7	-20	60	-30	70
110	CRS1	**40.8**	8.3	**42.4**	8.3	**42.1**	8.3	7.3			48.1	49.7	49.4	0	50	-10	60
111	CRS2	**41.6**	8.3	**43.2**	8.3	**42.9**	8.3	7.3			48.9	50.5	50.2	0	50	-10	60
201	PCDU	**29.6**	80.0	**31.7**	80.0	**31.3**	80.0	8			37.6	39.7	39.3	-10	47	-20	57
202	CDMU	**29.4**	37.7	**33.2**	37.7	**32.2**	37.7	8			37.4	41.2	40.2	-10	45	-20	55
203	ACC	**31.0**	32.1	**35.2**	32.1	**33.8**	32.1	8			39.0	43.2	41.8	-10	45	-20	55
204	BATT	**17.8**	2.3	**20.3**	2.3	**19.8**	2.3	8	N	S	25.8	28.3	27.8	0	35		
301	FPSPU1_2	**27.9**	30.3	**32.3**	30.3	**34.7**	30.3	8		S	35.9	40.3	42.7	-15	45	-30	60
303	FPDPU	**27.9**	24.0	**32.9**	24.0	**34.5**	24.0	8		S	35.9	40.9	42.5	-15	45	-30	60
304	FPBOLC	**13.4**	6.6	**31.0**	48.6	**20.5**	6.6	8	N	S	21.4	39.0	28.5	-15	45	-30	60
305	FPMECDEC	**16.8**	20.9	**23.7**	21.6	**32.7**	65.0	8		S	24.8	31.7	40.7	-15	45	-30	60
401	CCU	**26.3**	5.4	**27.4**	5.4	**27.8**	5.4	8		S	34.3	35.4	35.8	-10	40	-20	50
404	HSDCU	**31.3**	37.0	**32.3**	37.0	**32.7**	37.0	8			39.3	40.3	40.7	-15	45	-35	60
405	HSDPU	**23.7**	15.3	**27.6**	15.3	**30.0**	15.3	8			31.7	35.6	38.0	-15	45	-35	60
406	HSFCU	**28.4**	42.9	**32.2**	42.9	**33.7**	42.9	8			36.4	40.2	41.7	-15	45	-35	60
501	FHWOV	**9.0**	1.7	**9.1**	1.5	**9.1**	1.5	0	N	S	9.0	9.1	9.1	5	15	-25	55
502	FHHRV	**32.3**	69.7	**26.4**	63.3	**26.5**	63.3	9		S	41.3	35.4	35.5	-10	40	-25	55
503	FHICU	**31.5**	34.5	**23.8**	29.0	**23.9**	29.0	8.3		S	39.8	32.1	32.2	-25	40	-30	60
504	FHFCU	**21.5**	14.3	**16.8**	13.0	**16.9**	13.0	8		S	29.5	24.8	24.9	-10	40	-25	55
506	FHWEV	**23.5**	29.7	**19.4**	27.0	**19.5**	27.0	8		S	31.5	27.4	27.5	0	30	-25	55
507	FHIFV	**7.0**	0.4	**7.0**	0.0	**7.0**	0.0	8		S	15.0	15.0	15.0	-10	40	-25	55
508	IFV-HRV	**25.0**	0.0	**21.1**	0.0	**21.2**	0.0	9			34.0	30.1	30.2	-10	40	-25	55
509	IFV-WEV	**25.1**	0.0	**21.2**	0.0	**21.3**	0.0	9			34.1	30.2	30.3	-10	40	-25	55
510	WOV-WEV	**23.9**	0.0	**20.8**	0.0	**20.9**	0.0	9			32.9	29.8	29.9	-10	40	-25	55
511	HRV-HRH	**28.0**	0.0	**23.9**	0.0	**24.0**	0.0	9			37.0	32.9	33.0	-10	40	-25	55
601	FHWOH	**9.4**	1.7	**9.1**	1.5	**9.1**	1.5	0	N	S	9.4	9.1	9.1	5	15	-25	55
602	FHWEH	**24.2**	29.7	**19.4**	27.0	**19.5**	27.0	7.8		S	32.0	27.2	27.3	0	30	-25	55
603	FHHRH	**30.6**	69.7	**25.0**	63.3	**25.1**	63.3	8.8		S	39.4	33.8	33.9	-10	40	-25	55
604	FHLCU	**30.1**	43.7	**24.1**	37.6	**24.2**	37.6	8		S	38.1	32.1	32.2	-10	40	-25	55
605	FHLSU	**28.2**	49.3	**23.2**	44.7	**23.2**	44.7	8		S	36.2	31.2	31.2	10	40	-25	55
606	FHIFH	**19.1**	0.4	**14.1**	0.0	**14.2**	0.0	8		S	27.1	22.1	22.2	-10	40	-25	55
607	IFH-HRH	**27.2**	0.0	**23.2**	0.0	**23.3**	0.0	9			36.2	32.2	32.3	-10	40	-25	55
608	IFH-WEH	**27.1**	0.0	**23.0**	0.0	**23.1**	0.0	9			36.1	32.0	32.1	-10	40	-25	55
609	WEH-W0H	**25.6**	0.0	**21.2**	0.0	**21.3**	0.0	9			34.6	30.2	30.3	-10	40	-25	55
701	RWL1	**43.7**	16.0	**44.1**	16.0	**44.2**	16.0	8	N	S	51.7	52.1	52.2	0	55	-10	65
702	RWL2	**42.9**	16.0	**43.1**	16.0	**43.2**	16.0	8	N	S	50.9	51.1	51.2	0	55	-10	65
703	RWL3	**44.3**	16.0	**44.7**	16.0	**44.7**	16.0	8	N	S	52.3	52.7	52.7	0	55	-10	65
704	RWL4	**44.3**	16.0	**44.4**	16.0	**44.4**	16.0	8	N	S	52.3	52.4	52.4	0	55	-10	65
8133	FCV MAIN	**41.7**	OP	**42.4**	OP	**42.3**	OP	8	N	S	49.7	50.4	50.3	10	60	10	60
8233	FCV MAIN	**42.8**	OP	**43.9**	OP	**43.7**	OP	8	N	S	50.8	51.9	51.7	10	60	10	60

														TEMPERATURE LIMIT			
NODE	LABEL	A TEMP	A PW	B TEMP	B PW	C TEMP	C PW	UFP	HTR NOM	HTR SURV	A TEMP +UFP	B TEMP +UFP	C TEMP +UFP	MIN OPER.	MAX OPER.	MIN N.OPER	MAX N.OPER
		[°C]	[W]	[°C]	[W]	[°C]	[W]	[°C]			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
8333	FCV MAIN	34.7	OP	41.1	OP	38.7	OP	8	N	S	42.7	49.1	46.7	10	60	10	60
8433	FCV MAIN	37.2	OP	37.5	OP	37.8	OP	8	N	S	45.2	45.5	45.8	10	60	10	60
8533	FCV MAIN	42.0	OP	40.8	OP	40.9	OP	8	N	S	50.0	48.8	48.9	10	60	10	60
8633	FCV MAIN	47.0	OP	46.9	OP	47.0	OP	8	N	S	55.0	54.9	55.0	10	60	10	60
8134	FCV RED	41.3	OP	42.0	OP	41.9	OP	8	N	S	49.3	50.0	49.9	10	60	10	60
8234	FCV RED	42.4	OP	43.6	OP	43.4	OP	8	N	S	50.4	51.6	51.4	10	60	10	60
8334	FCV RED	35.1	OP	41.5	OP	39.0	OP	8	N	S	43.1	49.5	47.0	10	60	10	60
8434	FCV RED	46.2	OP	46.5	OP	46.7	OP	8	N	S	54.2	54.5	54.7	10	60	10	60
8534	FCV RED	41.6	OP	40.4	OP	40.5	OP	8	N	S	49.6	48.4	48.5	10	60	10	60
8634	FCV RED	47.4	OP	47.3	OP	47.3	OP	8	N	S	55.4	55.3	55.3	10	60	10	60
80029	STR1+X FOOT	1.4	OP	1.4	OP	1.4	OP	0	N	S	1.4	1.4	1.4	-20	40	-30	50
81029	STR2+X FOOT	-4.7	OP	-4.7	OP	-4.7	OP	3.8	N	S	-0.9	-0.9	-0.9	-20	40	-30	50
1501	RCS_INT_CONE	30.6	OP	33.4	OP	33.0	OP	8	N	S	38.6	41.4	41.0	10	50		
1502	RCS_INT_CONE	31.6	OP	34.3	OP	34.0	OP	8	N	S	39.6	42.3	42.0	10	50		
1503	RCS_INT_CONE	34.5	OP	35.9	OP	35.8	OP	8	N	S	42.5	43.9	43.8	10	50		
1504	RCS_INT_CONE	34.9	OP	36.3	OP	36.2	OP	8	N	S	42.9	44.3	44.2	10	50		
1505	RCS_INT_CONE	34.6	OP	35.9	OP	35.8	OP	8	N	S	42.6	43.9	43.8	10	50		
1506	RCS_INT_CONE	34.8	OP	35.4	OP	35.5	OP	8	N	S	42.8	43.4	43.5	10	50		
1507	RCS_INT_CONE	34.9	OP	35.5	OP	35.6	OP	8	N	S	42.9	43.5	43.6	10	50		
1508	RCS_INT_CONE	37.2	OP	38.0	OP	38.0	OP	8	N	S	45.2	46.0	46.0	10	50		
1509	RCS_INT_CONE	36.7	OP	37.5	OP	37.5	OP	8	N	S	44.7	45.5	45.5	10	50		
1510	RCS_INT_CONE	36.6	OP	37.4	OP	37.4	OP	8	N	S	44.6	45.4	45.4	10	50		
1511	RCS_INT_CONE	36.5	OP	37.2	OP	37.3	OP	8	N	S	44.5	45.2	45.3	10	50		
1512	RCS_INT_CONE	29.0	OP	31.4	OP	31.9	OP	8	N	S	37.0	39.4	39.9	10	50		
1513	RCS_INT_CONE	31.1	OP	32.4	OP	32.7	OP	8	N	S	39.1	40.4	40.7	10	50		
1514	RCS_INT_CONE	27.2	OP	31.4	OP	32.1	OP	8	N	S	35.2	39.4	40.1	10	50		
1515	RCS_SHEAR+Z-Y	40.6	OP	41.2	OP	41.3	OP	8	N	S	48.6	49.2	49.3	10	50		
1516	RCS_SHEAR+Z-Y	40.6	OP	41.2	OP	41.3	OP	8	N	S	48.6	49.2	49.3	10	50		
1517	RCS_BOT_FLOOR	28.6	OP	29.5	OP	29.4	OP	8	N	S	36.6	37.5	37.4	10	50		
1518	RCS_BOT_FLOOR	28.6	OP	29.5	OP	29.4	OP	8	N	S	36.6	37.5	37.4	10	50		
1519	RCS_SHEAR+Z+Y	31.1	OP	32.9	OP	32.6	OP	8	N	S	39.1	40.9	40.6	10	50		
1520	RCS_BOT_FLOOR	27.1	OP	28.2	OP	28.0	OP	8	N	S	35.1	36.2	36.0	10	50		
1521	RCS_SHEAR+Z+Y	37.3	OP	38.2	OP	38.1	OP	8	N	S	45.3	46.2	46.1	10	50		
1522	RCS_SHEAR+Z+Y	38.9	OP	39.7	OP	39.7	OP	8	N	S	46.9	47.7	47.7	10	50		
1523	RCS_SHEAR+Z+Y	36.9	OP	37.9	OP	37.8	OP	8	N	S	44.9	45.9	45.8	10	50		
1524	RCS_SHEAR+Z+Y	39.5	OP	40.2	OP	40.2	OP	8	N	S	47.5	48.2	48.2	10	50		
1525	RCS_BOT_FLOOR	28.0	OP	28.9	OP	28.8	OP	8	N	S	36.0	36.9	36.8	10	50		
1526	RCS_BOT_FLOOR	27.1	OP	28.2	OP	28.0	OP	8	N	S	35.1	36.2	36.0	10	50		
1527	RCS_SHEAR-Z+Y	25.1	OP	31.2	OP	29.7	OP	8	N	S	33.1	39.2	37.7	10	50		
1528	RCS_BOT_FLOOR	21.8	OP	29.7	OP	27.6	OP	8	N	S	29.8	37.7	35.6	10	50		
1529	RCS_SHEAR-Y-Z	32.0	OP	32.3	OP	32.5	OP	8	N	S	40.0	40.3	40.5	10	50		
1530	RCS_BOT_FLOOR	30.3	OP	26.3	OP	26.4	OP	8	N	S	38.3	34.3	34.4	10	50		
1531	RCS_SHEAR+Y+Z	30.7	OP	32.6	OP	32.3	OP	8	N	S	38.7	40.6	40.3	10	50		
1532	RCS_SHEAR+Y+Z	26.6	OP	28.6	OP	28.2	OP	8	N	S	34.6	36.6	36.2	10	50		
1533	RCS_SHEAR+Y+Z	26.4	OP	28.4	OP	28.0	OP	8	N	S	34.4	36.4	36.0	10	50		
1534	RCS_BOT_FLOOR	26.7	OP	27.8	OP	27.6	OP	8	N	S	34.7	35.8	35.6	10	50		
1535	RCS_SHEAR-Y+Z	36.9	OP	37.2	OP	37.3	OP	8	N	S	44.9	45.2	45.3	10	50		
1536	RCS_BOT_FLOOR	21.8	OP	29.7	OP	27.6	OP	8	N	S	29.8	37.7	35.6	10	50		
1541	RCS_SHEAR+Y-Z	25.1	OP	31.2	OP	29.7	OP	8	N	S	33.1	39.2	37.7	10	50		
1542	RCS_SHEAR+Y-Z	23.9	OP	31.1	OP	28.2	OP	8	N	S	31.9	39.1	36.2	10	50		
1543	RCS_SHEAR+Y-Z	24.7	OP	31.2	OP	28.9	OP	8	N	S	32.7	39.2	36.9	10	50		
1544	RCS_BOT_FLOOR	21.8	OP	29.7	OP	27.6	OP	8	N	S	29.8	37.7	35.6	10	50		
1550	PT	20.9	OP	24.6	OP	25.8	OP	8	N	S	28.9	32.6	33.8	10	50		
1551	LV1	25.9	OP	29.4	OP	30.5	OP	8	N	S	33.9	37.4	38.5	10	50		
1552	LV2	25.9	OP	29.0	OP	30.2	OP	8	N	S	33.9	37.0	38.2	10	50		
1553	LF	25.5	OP	28.7	OP	29.8	OP	8	N	S	33.5	36.7	37.8	10	50		
1554	RCS_SHEAR-Z+Y	24.9	OP	28.3	OP	29.5	OP	8	N	S	32.9	36.3	37.5	10	50		
1555	RCS_SHEAR-Z+Y	25.3	OP	28.6	OP	29.8	OP	8	N	S	33.3	36.6	37.8	10	50		

NODE	LABEL	A TEMP [°C]	A PW [W]	B TEMP [°C]	B PW [W]	C TEMP [°C]	C PW [W]	UFP [°C]	HTR NOM	HTR SURV	A TEMP +UFP [°C]	B TEMP +UFP [°C]	C TEMP +UFP [°C]	TEMPERATURE LIMIT MIN OPER. [°C]	MAX OPER. [°C]	MIN N.OPER [°C]	MAX N.OPER [°C]
1556	RCS_SHEAR-Z+Y	**25.9**	OP	**29.1**	OP	**30.3**	OP	8	N	S	33.9	37.1	38.3	10	50		
1557	RCS_SHEAR-Z+Y	**25.8**	OP	**29.4**	OP	**30.6**	OP	8	N	S	33.8	37.4	38.6	10	50		
1558	RCS_SHEAR-Z+Y	**26.6**	OP	**30.0**	OP	**31.1**	OP	8	N	S	34.6	38.0	39.1	10	50		
1559	RCS_SHEAR-Z+Y	**26.4**	OP	**29.5**	OP	**30.6**	OP	8	N	S	34.4	37.5	38.6	10	50		
1561	RCS_EXT_CONE	**40.1**	OP	**41.1**	OP	**41.1**	OP	8	N	S	48.1	49.1	49.1	10	50		
1562	RCS_EXT_CONE	**34.2**	OP	**35.4**	OP	**35.3**	OP	8	N	S	42.2	43.4	43.3	10	50		
1563	RCS_EXT_CONE	**30.6**	OP	**33.3**	OP	**32.9**	OP	8	N	S	38.6	41.3	40.9	10	50		
1564	RCS_EXT_CONE	**27.1**	OP	**31.4**	OP	**32.0**	OP	8	N	S	35.1	39.4	40.0	10	50		
1565	RCS_EXT_CONE	**29.0**	OP	**31.3**	OP	**31.9**	OP	8	N	S	37.0	39.3	39.9	10	50		
1566	RCS_EXT_CONE	**31.1**	OP	**32.3**	OP	**32.6**	OP	8	N	S	39.1	40.3	40.6	10	50		
1567	RCS_EXT_CONE	**35.6**	OP	**36.3**	OP	**36.4**	OP	8	N	S	43.6	44.3	44.4	10	50		
1568	RCS_EXT_CONE	**37.2**	OP	**38.0**	OP	**38.0**	OP	8	N	S	45.2	46.0	46.0	10	50		
1571	RCS_SHEAR-Y-Z	**32.0**	OP	**32.3**	OP	**32.5**	OP	8	N	S	40.0	40.3	40.5	10	50		
1572	RCS_SHEAR-Y-Z	**29.8**	OP	**29.2**	OP	**29.4**	OP	8	N	S	37.8	37.2	37.4	10	50		
1573	RCS_SHEAR-Y-Z	**29.5**	OP	**28.5**	OP	**28.7**	OP	8	N	S	37.5	36.5	36.7	10	50		
1574	RCS_BOT_FLOOR	**29.4**	OP	**30.2**	OP	**30.5**	OP	8	N	S	37.4	38.2	38.5	10	50		
1575	RCS_BOT_FLOOR	**31.8**	OP	**32.1**	OP	**32.4**	OP	8	N	S	39.8	40.1	40.4	10	50		
1576	RCS_BOT_FLOOR	**30.3**	OP	**26.3**	OP	**26.4**	OP	8	N	S	38.3	34.3	34.4	10	50		
1581	RCS_SHEAR-Y+Z	**36.9**	OP	**37.2**	OP	**37.3**	OP	8	N	S	44.9	45.2	45.3	10	50		
1582	RCS_SHEAR-Y+Z	**34.0**	OP	**33.9**	OP	**34.0**	OP	8	N	S	42.0	41.9	42.0	10	50		
1583	RCS_SHEAR-Y+Z	**33.0**	OP	**32.5**	OP	**32.6**	OP	8	N	S	41.0	40.5	40.6	10	50		
1584	RCS_BOT_FLOOR	**27.8**	OP	**32.4**	OP	**31.2**	OP	8	N	S	35.8	40.4	39.2	10	50		
1591	RCS_SHEAR+Z-Y	**40.6**	OP	**41.2**	OP	**41.2**	OP	8	N	S	48.6	49.2	49.2	10	50		
1592	RCS_SHEAR+Z-Y	**40.0**	OP	**40.6**	OP	**40.6**	OP	8	N	S	48.0	48.6	48.6	10	50		

Table 5.1.5.1-4 HERSCHEL - Units Temperature results: Sizing Case EOL Nominal D, E and F.

														TEMPERATURE LIMIT			
		D	D	E	E	F	F	UFP	HTR	HTR	D	E	F	MIN	MAX	MIN	MAX
NODE	LABEL	TEMP	PW	TEMP	PW	TEMP	PW		NOM	SURV	TEMP +UFP	TEMP +UFP	TEMP +UFP	OPER.	OPER.	N.OPER	N.OPER
		[°C]	[W]	[°C]	[W]	[°C]	[W]				[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
4	VMC	**41.5**	0.0	**42.1**	0.0	**42.1**	0.0	7.4			48.9	49.5	49.5	-10	50	-20	60
5	SAS +Z	**43.3**	0.0	**44.0**	0.0	**43.9**	0.0	8			51.3	52.0	51.9	-70	80	-80	90
16	MGA+Z	**130.2**	0.6	**130.4**	0.6	**130.4**	0.6	12.4			142.6	142.8	142.8	-150	150	-150	150
21	LGA+Z	**86.7**	0.0	**86.8**	0.0	**86.8**	0.0	8			94.7	94.8	94.8	-150	120	-150	120
41	LGA-Z	**-54.4**	0.0	**-52.7**	0.0	**-52.2**	0.0	8			-46.4	-44.7	-44.2	-150	120	-150	120
45	SAS -Z	**3.0**	0.0	**4.9**	0.0	**5.5**	0.0	8			11.0	12.9	13.5	-70	80	-80	90
49	SREM	**29.6**	2.6	**32.0**	2.6	**32.7**	2.6	8			37.6	40.0	40.7	-10	50	-45	90
56	AAD	**52.6**	0.0	**53.3**	0.0	**53.3**	0.0	8			60.6	61.3	61.3	-70	70	-80	80
70	TANK1	**34.6**	0.0	**35.6**	0.0	**35.8**	0.0	8	N	S	42.6	43.6	43.8	10	45	-20	55
71	TANK2	**32.3**	0.0	**34.5**	0.0	**34.5**	0.0	8	N	S	40.3	42.5	42.5	10	45	-20	55
81	GYRO	**63.3**	0.0	**63.3**	0.0	**63.3**	0.0	0	N	S	63.3	63.3	63.3	-20	55	-30	65
101	RFDN	**32.7**	11.8	**33.5**	11.8	**33.4**	11.8	8			40.7	41.5	41.4	-25	55	-35	65
102	EPC1	**41.1**	9.0	**41.9**	9.0	**41.8**	9.0	8			49.1	49.9	49.8	-20	60	-30	70
103	EPC2	**17.8**	0.0	**18.7**	0.0	**18.6**	0.0	8.2			26.0	26.9	26.8	-20	60	-30	70
104	XPND1	**38.7**	23.0	**39.6**	23.0	**39.5**	23.0	7.6	N	S	46.3	47.2	47.1	-10	45	-20	55
105	XPND2	**23.9**	10.0	**24.9**	10.0	**24.8**	10.0	8	N	S	31.9	32.9	32.8	-10	45	-20	55
106	TWTA1	**51.4**	37.0	**52.0**	37.0	**51.9**	37.0	7.9			59.3	59.9	59.8	-20	60	-30	70
107	TWTA2	**17.2**	0.0	**18.0**	0.0	**17.9**	0.0	8.1			25.3	26.1	26.0	-20	60	-30	70
110	CRS1	**40.5**	8.3	**42.1**	8.3	**41.8**	8.3	7.3			47.8	49.4	49.1	0	50	-10	60
111	CRS2	**41.2**	8.3	**42.9**	8.3	**42.6**	8.3	7.3			48.5	50.2	49.9	0	50	-10	60
201	PCDU	**29.4**	80.0	**31.5**	80.0	**31.1**	80.0	8			37.4	39.5	39.1	-10	47	-20	57
202	CDMU	**29.3**	37.7	**33.1**	37.7	**32.0**	37.7	8			37.3	41.1	40.0	-10	45	-20	55
203	ACC	**30.9**	32.1	**35.0**	32.1	**33.7**	32.1	8			38.9	43.0	41.7	-10	45	-20	55
204	BATT	**17.6**	2.3	**20.1**	2.3	**19.6**	2.3	8	N	S	25.6	28.1	27.6	0	35		
301	FPSPU1_2	**27.8**	30.3	**32.3**	30.3	**34.6**	30.3	8		S	35.8	40.3	42.6	-15	45	-30	60
303	FPDPU	**27.9**	24.0	**32.9**	24.0	**34.5**	24.0	8		S	35.9	40.9	42.5	-15	45	-30	60
304	FPBOLC	**13.3**	6.6	**30.9**	48.6	**20.5**	6.6	8	N	S	21.3	38.9	28.5	-15	45	-30	60
305	FPMECDEC	**16.8**	20.9	**23.6**	21.6	**32.7**	65.0	8		S	24.8	31.6	40.7	-15	45	-30	60
401	CCU	**26.3**	5.4	**27.4**	5.4	**27.8**	5.4	8		S	34.3	35.4	35.8	-10	40	-20	50
404	HSDCU	**31.3**	37.0	**32.3**	37.0	**32.7**	37.0	8			39.3	40.3	40.7	-15	45	-35	60
405	HSDPU	**23.7**	15.3	**27.6**	15.3	**29.9**	15.3	8			31.7	35.6	37.9	-15	45	-35	60
406	HSFCU	**28.4**	42.9	**32.1**	42.9	**33.7**	42.9	8			36.4	40.1	41.7	-15	45	-35	60
501	FHWOV	**9.0**	1.7	**9.1**	1.5	**9.1**	1.5	0	N	S	9.0	9.1	9.1	5	15	-25	55
502	FHHRV	**32.4**	69.7	**26.5**	63.3	**26.5**	63.3	9		S	41.4	35.5	35.5	-10	40	-25	55
503	FHICU	**31.5**	34.5	**23.8**	29.0	**23.9**	29.0	8.3		S	39.8	32.1	32.2	-25	40	-30	60
504	FHFCU	**21.5**	14.3	**16.8**	13.0	**16.9**	13.0	8		S	29.5	24.8	24.9	-10	40	-25	55
506	FHWEV	**23.6**	29.7	**19.4**	27.0	**19.5**	27.0	8		S	31.6	27.4	27.5	0	30	-25	55
507	FHIFV	**7.0**	0.4	**7.0**	0.0	**7.0**	0.0	8		S	15.0	15.0	15.0	-10	40	-25	55
508	IFV-HRV	**25.0**	0.0	**21.1**	0.0	**21.2**	0.0	9			34.0	30.1	30.2	-10	40	-25	55
509	IFV-WEV	**25.1**	0.0	**21.2**	0.0	**21.3**	0.0	9			34.1	30.2	30.3	-10	40	-25	55
510	WOV-WEV	**23.9**	0.0	**20.8**	0.0	**20.9**	0.0	9			32.9	29.8	29.9	-10	40	-25	55
511	HRV-HRH	**28.0**	0.0	**23.9**	0.0	**24.0**	0.0	9			37.0	32.9	33.0	-10	40	-25	55
601	FHWOH	**9.4**	1.7	**9.1**	1.5	**9.1**	1.5	0	N	S	9.4	9.1	9.1	5	15	-25	55
602	FHWEH	**24.4**	29.7	**19.6**	27.0	**19.7**	27.0	7.8		S	32.2	27.4	27.5	0	30	-25	55
603	FHHRH	**30.7**	69.7	**25.2**	63.3	**25.2**	63.3	8.8		S	39.5	34.0	34.0	-10	40	-25	55
604	FHLCU	**30.2**	43.7	**24.2**	37.6	**24.2**	37.6	8		S	38.2	32.2	32.2	-10	40	-25	55
605	FHLSU	**28.3**	49.3	**23.3**	44.7	**23.4**	44.7	8		S	36.3	31.3	31.4	10	40	-25	55
606	FHIFH	**19.2**	0.4	**14.2**	0.0	**14.3**	0.0	8		S	27.2	22.2	22.3	-10	40	-25	55
607	IFH-HRH	**27.3**	0.0	**23.3**	0.0	**23.4**	0.0	9			36.3	32.3	32.4	-10	40	-25	55
608	IFH-WEH	**27.2**	0.0	**23.1**	0.0	**23.2**	0.0	9			36.2	32.1	32.2	-10	40	-25	55
609	WEH-W0H	**25.7**	0.0	**21.3**	0.0	**21.4**	0.0	9			34.7	30.3	30.4	-10	40	-25	55
701	RWL1	**44.0**	16.0	**44.5**	16.0	**44.5**	16.0	8	N	S	52.0	52.5	52.5	0	55	-10	65
702	RWL2	**43.2**	16.0	**43.4**	16.0	**43.5**	16.0	8	N	S	51.2	51.4	51.5	0	55	-10	65
703	RWL3	**44.6**	16.0	**45.0**	16.0	**45.0**	16.0	8	N	S	52.6	53.0	53.0	0	55	-10	65
704	RWL4	**44.6**	16.0	**44.7**	16.0	**44.8**	16.0	8	N	S	52.6	52.7	52.8	0	55	-10	65
8133	FCV MAIN	**41.7**	OP	**42.4**	OP	**42.3**	OP	8	N	S	49.7	50.4	50.3	10	60	10	60
8233	FCV MAIN	**42.4**	OP	**43.6**	OP	**43.4**	OP	8	N	S	50.4	51.6	51.4	10	60	10	60

														TEMPERATURE LIMIT			
NODE	LABEL	D TEMP	D PW	E TEMP	E PW	F TEMP	F PW	UFP	HTR NOM	HTR SURV	D TEMP +UFP	E TEMP +UFP	F TEMP +UFP	MIN OPER.	MAX OPER.	MIN N.OPER	MAX N.OPER
		[°C]	[W]	[°C]	[W]	[°C]	[W]				[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
8333	FCV MAIN	34.6	OP	41.0	OP	38.6	OP	8	N	S	42.6	49.0	46.6	10	60	10	60
8433	FCV MAIN	37.2	OP	37.5	OP	37.7	OP	8	N	S	45.2	45.5	45.7	10	60	10	60
8533	FCV MAIN	42.1	OP	40.8	OP	41.0	OP	8	N	S	50.1	48.8	49.0	10	60	10	60
8633	FCV MAIN	47.3	OP	47.2	OP	47.2	OP	8	N	S	55.3	55.2	55.2	10	60	10	60
8134	FCV RED	41.3	OP	42.0	OP	42.0	OP	8	N	S	49.3	50.0	50.0	10	60	10	60
8234	FCV RED	42.1	OP	43.3	OP	43.1	OP	8	N	S	50.1	51.3	51.1	10	60	10	60
8334	FCV RED	35.0	OP	41.4	OP	39.0	OP	8	N	S	43.0	49.4	47.0	10	60	10	60
8434	FCV RED	46.4	OP	46.7	OP	46.9	OP	8	N	S	54.4	54.7	54.9	10	60	10	60
8534	FCV RED	41.6	OP	40.4	OP	40.5	OP	8	N	S	49.6	48.4	48.5	10	60	10	60
8634	FCV RED	47.6	OP	47.5	OP	47.6	OP	8	N	S	55.6	55.5	55.6	10	60	10	60
80029	STR1+X FOOT	1.4	OP	1.4	OP	1.4	OP	0	N	S	1.4	1.4	1.4	-20	40	-30	50
81029	STR2+X FOOT	-4.7	OP	-4.7	OP	-4.7	OP	3.8	N	S	-0.9	-0.9	-0.9	-20	40	-30	50
1501	RCS_INT_CONE	30.5	OP	33.2	OP	32.8	OP	8	N	S	38.5	41.2	40.8	10	50		
1502	RCS_INT_CONE	31.5	OP	34.2	OP	33.8	OP	8	N	S	39.5	42.2	41.8	10	50		
1503	RCS_INT_CONE	34.3	OP	35.7	OP	35.6	OP	8	N	S	42.3	43.7	43.6	10	50		
1504	RCS_INT_CONE	34.7	OP	36.1	OP	36.0	OP	8	N	S	42.7	44.1	44.0	10	50		
1505	RCS_INT_CONE	34.4	OP	35.7	OP	35.6	OP	8	N	S	42.4	43.7	43.6	10	50		
1506	RCS_INT_CONE	34.9	OP	35.5	OP	35.6	OP	8	N	S	42.9	43.5	43.6	10	50		
1507	RCS_INT_CONE	35.0	OP	35.6	OP	35.7	OP	8	N	S	43.0	43.6	43.7	10	50		
1508	RCS_INT_CONE	37.4	OP	38.1	OP	38.2	OP	8	N	S	45.4	46.1	46.2	10	50		
1509	RCS_INT_CONE	36.9	OP	37.6	OP	37.7	OP	8	N	S	44.9	45.6	45.7	10	50		
1510	RCS_INT_CONE	36.8	OP	37.5	OP	37.6	OP	8	N	S	44.8	45.5	45.6	10	50		
1511	RCS_INT_CONE	36.6	OP	37.4	OP	37.4	OP	8	N	S	44.6	45.4	45.4	10	50		
1512	RCS_INT_CONE	29.0	OP	31.3	OP	31.9	OP	8	N	S	37.0	39.3	39.9	10	50		
1513	RCS_INT_CONE	31.1	OP	32.4	OP	32.7	OP	8	N	S	39.1	40.4	40.7	10	50		
1514	RCS_INT_CONE	27.2	OP	31.4	OP	32.1	OP	8	N	S	35.2	39.4	40.1	10	50		
1515	RCS_SHEAR+Z-Y	40.8	OP	41.4	OP	41.4	OP	8	N	S	48.8	49.4	49.4	10	50		
1516	RCS_SHEAR+Z-Y	40.8	OP	41.4	OP	41.4	OP	8	N	S	48.8	49.4	49.4	10	50		
1517	RCS_BOT_FLOOR	28.1	OP	29.0	OP	28.9	OP	8	N	S	36.1	37.0	36.9	10	50		
1518	RCS_BOT_FLOOR	28.1	OP	29.0	OP	28.9	OP	8	N	S	36.1	37.0	36.9	10	50		
1519	RCS_SHEAR+Z+Y	30.8	OP	32.6	OP	32.3	OP	8	N	S	38.8	40.6	40.3	10	50		
1520	RCS_BOT_FLOOR	26.6	OP	27.6	OP	27.5	OP	8	N	S	34.6	35.6	35.5	10	50		
1521	RCS_SHEAR+Z+Y	37.0	OP	38.0	OP	37.9	OP	8	N	S	45.0	46.0	45.9	10	50		
1522	RCS_SHEAR+Z+Y	38.7	OP	39.5	OP	39.5	OP	8	N	S	46.7	47.5	47.5	10	50		
1523	RCS_SHEAR+Z+Y	36.7	OP	37.7	OP	37.6	OP	8	N	S	44.7	45.7	45.6	10	50		
1524	RCS_SHEAR+Z+Y	39.3	OP	40.0	OP	40.0	OP	8	N	S	47.3	48.0	48.0	10	50		
1525	RCS_BOT_FLOOR	27.5	OP	28.4	OP	28.3	OP	8	N	S	35.5	36.4	36.3	10	50		
1526	RCS_BOT_FLOOR	26.6	OP	27.6	OP	27.5	OP	8	N	S	34.6	35.6	35.5	10	50		
1527	RCS_SHEAR-Z+Y	25.0	OP	31.1	OP	29.6	OP	8	N	S	33.0	39.1	37.6	10	50		
1528	RCS_BOT_FLOOR	21.7	OP	29.7	OP	27.5	OP	8	N	S	29.7	37.7	35.5	10	50		
1529	RCS_SHEAR-Y-Z	32.1	OP	32.4	OP	32.6	OP	8	N	S	40.1	40.4	40.6	10	50		
1530	RCS_BOT_FLOOR	30.3	OP	26.3	OP	26.4	OP	8	N	S	38.3	34.3	34.4	10	50		
1531	RCS_SHEAR+Y+Z	30.4	OP	32.3	OP	32.0	OP	8	N	S	38.4	40.3	40.0	10	50		
1532	RCS_SHEAR+Y+Z	26.3	OP	28.2	OP	27.9	OP	8	N	S	34.3	36.2	35.9	10	50		
1533	RCS_SHEAR+Y+Z	26.1	OP	28.1	OP	27.7	OP	8	N	S	34.1	36.1	35.7	10	50		
1534	RCS_BOT_FLOOR	26.2	OP	27.2	OP	27.1	OP	8	N	S	34.2	35.2	35.1	10	50		
1535	RCS_SHEAR-Y+Z	37.2	OP	37.4	OP	37.5	OP	8	N	S	45.2	45.4	45.5	10	50		
1536	RCS_BOT_FLOOR	21.7	OP	29.7	OP	27.5	OP	8	N	S	29.7	37.7	35.5	10	50		
1541	RCS_SHEAR+Y-Z	24.9	OP	31.1	OP	29.6	OP	8	N	S	32.9	39.1	37.6	10	50		
1542	RCS_SHEAR+Y-Z	23.8	OP	31.0	OP	28.1	OP	8	N	S	31.8	39.0	36.1	10	50		
1543	RCS_SHEAR+Y-Z	24.5	OP	31.1	OP	28.7	OP	8	N	S	32.5	39.1	36.7	10	50		
1544	RCS_BOT_FLOOR	21.7	OP	29.7	OP	27.5	OP	8	N	S	29.7	37.7	35.5	10	50		
1550	PT	20.9	OP	24.6	OP	25.8	OP	8	N	S	28.9	32.6	33.8	10	50		
1551	LV1	25.8	OP	29.4	OP	30.5	OP	8	N	S	33.8	37.4	38.5	10	50		
1552	LV2	25.9	OP	29.0	OP	30.2	OP	8	N	S	33.9	37.0	38.2	10	50		
1553	LF	25.5	OP	28.7	OP	29.8	OP	8	N	S	33.5	36.7	37.8	10	50		
1554	RCS_SHEAR-Z+Y	24.9	OP	28.2	OP	29.4	OP	8	N	S	32.9	36.2	37.4	10	50		
1555	RCS_SHEAR-Z+Y	25.3	OP	28.6	OP	29.8	OP	8	N	S	33.3	36.6	37.8	10	50		

														TEMPERATURE LIMIT			
		D	D	E	E	F	F	UFP	HTR	HTR	D	E	F	MIN	MAX	MIN	MAX
NODE	LABEL	TEMP	PW	TEMP	PW	TEMP	PW		NOM	SURV	TEMP +UFP	TEMP +UFP	TEMP +UFP	OPER.	OPER.	N.OPER	N.OPER
		[°C]	[W]	[°C]	[W]	[°C]	[W]				[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
1556	RCS_SHEAR-Z+Y	**25.8**	OP	**29.0**	OP	**30.3**	OP	8	N	S	33.8	37.0	38.3	10	50		
1557	RCS_SHEAR-Z+Y	**25.8**	OP	**29.4**	OP	**30.6**	OP	8	N	S	33.8	37.4	38.6	10	50		
1558	RCS_SHEAR-Z+Y	**26.6**	OP	**30.0**	OP	**31.0**	OP	8	N	S	34.6	38.0	39.0	10	50		
1559	RCS_SHEAR-Z+Y	**26.4**	OP	**29.5**	OP	**30.6**	OP	8	N	S	34.4	37.5	38.6	10	50		
1561	RCS_EXT_CONE	**40.1**	OP	**41.1**	OP	**41.1**	OP	8	N	S	48.1	49.1	49.1	10	50		
1562	RCS_EXT_CONE	**33.9**	OP	**35.2**	OP	**35.1**	OP	8	N	S	41.9	43.2	43.1	10	50		
1563	RCS_EXT_CONE	**30.4**	OP	**33.2**	OP	**32.7**	OP	8	N	S	38.4	41.2	40.7	10	50		
1564	RCS_EXT_CONE	**27.0**	OP	**31.3**	OP	**32.0**	OP	8	N	S	35.0	39.3	40.0	10	50		
1565	RCS_EXT_CONE	**28.9**	OP	**31.3**	OP	**31.8**	OP	8	N	S	36.9	39.3	39.8	10	50		
1566	RCS_EXT_CONE	**31.1**	OP	**32.3**	OP	**32.6**	OP	8	N	S	39.1	40.3	40.6	10	50		
1567	RCS_EXT_CONE	**35.7**	OP	**36.4**	OP	**36.5**	OP	8	N	S	43.7	44.4	44.5	10	50		
1568	RCS_EXT_CONE	**37.4**	OP	**38.1**	OP	**38.2**	OP	8	N	S	45.4	46.1	46.2	10	50		
1571	RCS_SHEAR-Y-Z	**32.1**	OP	**32.4**	OP	**32.6**	OP	8	N	S	40.1	40.4	40.6	10	50		
1572	RCS_SHEAR-Y-Z	**29.8**	OP	**29.2**	OP	**29.5**	OP	8	N	S	37.8	37.2	37.5	10	50		
1573	RCS_SHEAR-Y-Z	**29.5**	OP	**28.6**	OP	**28.8**	OP	8	N	S	37.5	36.6	36.8	10	50		
1574	RCS_BOT_FLOOR	**29.5**	OP	**30.3**	OP	**30.6**	OP	8	N	S	37.5	38.3	38.6	10	50		
1575	RCS_BOT_FLOOR	**31.8**	OP	**32.1**	OP	**32.4**	OP	8	N	S	39.8	40.1	40.4	10	50		
1576	RCS_BOT_FLOOR	**30.3**	OP	**26.3**	OP	**26.4**	OP	8	N	S	38.3	34.3	34.4	10	50		
1581	RCS_SHEAR-Y+Z	**37.2**	OP	**37.4**	OP	**37.5**	OP	8	N	S	45.2	45.4	45.5	10	50		
1582	RCS_SHEAR-Y+Z	**34.3**	OP	**34.2**	OP	**34.3**	OP	8	N	S	42.3	42.2	42.3	10	50		
1583	RCS_SHEAR-Y+Z	**33.3**	OP	**32.8**	OP	**32.9**	OP	8	N	S	41.3	40.8	40.9	10	50		
1584	RCS_BOT_FLOOR	**27.9**	OP	**32.5**	OP	**31.2**	OP	8	N	S	35.9	40.5	39.2	10	50		
1591	RCS_SHEAR+Z-Y	**40.7**	OP	**41.3**	OP	**41.4**	OP	8	N	S	48.7	49.3	49.4	10	50		
1592	RCS_SHEAR+Z-Y	**40.2**	OP	**40.7**	OP	**40.8**	OP	8	N	S	48.2	48.7	48.8	10	50		

5.1.5.2 Transient Cases with Attitude Change Results

Transient analysis cases were run to assess the thermal behaviour of the SVM when subjected to attitude change (sun from +30 deg to –30 deg on –X side and vice-versa). Main purpose was to verify the capability of the design to meet the stability requirements. Considerations about the stability are reported in AD23. Purpose of this paragraph is to report the temperature level reach from the units during the attitude change in terms of minimum and maximum temperature (table 5.1.5.2). A complete vision of the results is reporetd in AD24.

Table 5.1.5.2-1 HERSCHEL – Transient cases: Min and Max temperatures (without uncertainty)

		P		Q	
NODE	LABEL	T MIN	T MAX	T MIN	T MAX
		[°C]	[°C]	[°C]	[°C]
4	VMC	4.42	26.61	17.97	41.4
5	SAS HOUSING +Z	16.38	33.03	25.08	43.28
16	MGA+Z SEPTUM	61.4	120.99	17.97	41.4
21	LGA+Z	56.48	79.2	63.27	86.68
41	LGA-Z	-64.87	-56.9	-63.58	-54.38
45	SAS HOUSING -Z	-16.23	-1.51	-14.12	2.96
49	SREM	6.8	24.03	9.28	29.53
56	AAD HOUSING	26.91	42.37	35.67	52.59
70	TANK1	11	24.66	11	34.28
71	TANK2	11	23.34	11	31.87
100	GYRO	74.82	79.81	76.8	82.72
101	RFDN	-4.36	20.13	6.98	32.59
102	EPC1	-0.15	28.4	8.48	41.06
103	EPC2	-13.24	2.82	0.71	17.77
104	XPND1	7.05	26.11	16.49	38.62
105	XPND2	-5.6	9.93	6.98	23.88
106	TWTA1	-6.24	38.94	5.12	51.33
107	TWTA2	-15.85	1.97	-1.21	17.18
110	CRS1	14.63	31.21	21.19	40.39
111	CRS2	15.17	32	21.74	41.17
201	PCDU	9.39	22.19	14.02	29.35
202	CDMU	8.87	23.47	11.93	29.17
203	ACC	10.83	24.95	14.12	30.82
204	BATT	1	10.14	1	17.49
301	FPSPU1_2	11.06	23.68	12.71	27.75
303	FPDPU	11.52	23.8	13.1	27.8
304	FPBOLC	-7.87	7.81	-5.45	13.23
305	FPMECDEC	-3.3	11.73	-1.14	16.71
401	CCU	3.41	20.86	5.89	26.29
404	HSDCU	9.91	25.97	12.46	31.26
405	HSDPU	5.73	19.24	7.53	23.65
406	HSFCU	8.7	23.6	10.72	28.31
501	FHWOV	8.98	10.17	8.98	10.13
502	FHHRV	25.49	30.61	26.15	32.33
503	FHICU	25.08	29.95	25.65	31.48
504	FHFCU	14.81	19.74	15.49	21.45
506	FHWEV	16.76	21.81	17.48	23.53
507	FHIFV	6.93	7.37	6.93	7.46

		P		Q	
NODE	LABEL	T MIN	T MAX	T MIN	T MAX
		[°C]	[°C]	[°C]	[°C]
508	IFV-HRV	15.65	22.57	16.67	24.95
509	IFV-WEV	16.1	22.82	17.07	25.11
510	WOV-WEV	13.76	21.36	14.72	23.85
511	HRV-HRH	15.91	24.42	17.94	27.96
601	FHWOH	8.97	10.34	8.97	10.36
602	FHWEH	13.86	20.38	16.78	24.27
603	FHHRH	21.43	27.15	24.02	30.67
604	FHLCU	20.32	27.11	22.14	30.12
605	FHLSU	19.12	25.16	21.07	28.18
606	FHIFH	8.26	16.07	9.94	19.1
607	IFH-HRH	14.64	23.34	17.12	27.22
608	IFH-WEH	14.71	23.2	17.27	27.12
609	WEH-W0H	15.23	22.09	17.58	25.56
701	RWL1	1.13	20.37	25.21	43.98
702	RWL2	1	20.2	23.67	43.17
703	RWL3	1.83	21.03	24.79	44.51
704	RWL4	2.41	21.23	25.71	44.51
8133	FCV BODY MAIN	11.05	31.34	11	41.65
8134	FCV BODY REDUNDANT	11.01	30.99	11	41.28
8233	FCV BODY MAIN	11.48	32.67	15.64	42.38
8234	FCV BODY REDUNDANT	11.03	32.36	15.6	42.06
8333	FCV BODY MAIN	11.14	28.88	11	34.55
8334	FCV BODY REDUNDANT	11.05	29.22	11	34.93
8433	FCV BODY MAIN	11	31.42	11	37.15
8434	FCV BODY REDUNDANT	11.09	39.92	11	46.35
8533	FCV BODY MAIN	13.23	36.82	15.63	42.02
8534	FCV BODY REDUNDANT	15.18	36.38	17.78	41.57
8633	FCV BODY MAIN	11.21	32.18	21.08	47.24
8634	FCV BODY REDUNDANT	11.07	32.5	21.12	47.59
80029	STR1 +X FOOT	1.15	1.41	1.16	1.5
81029	STR2 +X FOOT	-4.91	-4.63	-4.92	-4.57

5.1.5.3 Heater Power Summary

The following tables provide the heater power consumption for the analysis cases performed in transient condition.

Table 5.1.5.3-1 HERSCHEL – Average Heater Power Consumption in Nominal Cases

		Case	Case	Case	Case	Case	Case	Case	Case	Case
TCS ID	INSTALLED	A	B	C	D	E	F	G	H	I
		EOL	EOL	EOL	EOL	EOL	EOL	BOL	BOL	BOL Surv.
	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]
HTR80027NS	21.13	8.83	8.8	8.8	8.84	8.82	8.81	12.47	12.44	19.02
HTR100NS	45.22	10.91	10.2	10.24	11.05	10.35	10.39	37.17	36.99	0
HTR104NS	11.39	0	0	0	0	0	0	0	0	0
HTR105NS	11.39	0	0	0	0	0	0	0	0	0
HTR204NS	14.90	0	0	0	0	0	0	9.16	8.87	10.59
HTR304NS	9.40	0	0	0	0	0	0	0	0	0
HTR501NS	22.80	7.13	9.83	9.75	7.12	9.82	9.74	17.58	14.35	14.32
HTR601NS	32.40	11.19	16.31	16.27	10.94	16.06	16.02	26.03	20.87	16.37
HTR701NS	11.39	0	0	0	0	0	0	0.79	0	1.98
HTR702NS	11.39	0	0	0	0	0	0	2.67	1.68	4.76
HTR703NS	11.39	0	0	0	0	0	0	1.77	1.24	2.81
HTR704NS	11.39	0	0	0	0	0	0	0	0	3.05
HTR70NS	6.17	0	0	0	0	0	0	1.62	1.48	2.63
HTR71NS	6.17	0	0	0	0	0	0	1.49	1.39	2.32
HTR8133NS	2.35	0	0	0	0	0	0	0.7	0.68	0.49
HTR8134NS	2.35	0	0	0	0	0	0	0.71	0.7	0.52
HTR8233NS	2.35	0	0	0	0	0	0	0.18	0.17	0
HTR8234NS	2.35	0	0	0	0	0	0	0.19	0.17	0
HTR8333NS	2.35	0	0	0	0	0	0	0.56	0.54	0.29
HTR8334NS	2.35	0	0	0	0	0	0	0.55	0.54	0.8
HTR8433NS	2.35	0	0	0	0	0	0	0.84	0.76	1.56
HTR8434NS	2.35	0	0	0	0	0	0	0.88	0.8	1.65
HTR8533NS	2.35	0	0	0	0	0	0	0.08	0	0.41
HTR8534NS	2.35	0	0	0	0	0	0	0	0	0.91
HTR8633NS	2.35	0	0	0	0	0	0	0.29	0.25	0
HTR8634NS	2.35	0	0	0	0	0	0	0.29	0.24	0.5
HTR301S	31.00	0	0	0	0	0	0	0	0	23.32
HTR305S	27.48	0	0	0	0	0	0	0	0	9.88
HTR401S	44.50	0	0	0	0	0	0	0	0	38.43
HTR502S	39.00	0	0	0	0	0	0	0	0	30.04
HTR504S	20.79	0	0	0	0	0	0	0	0	0
HTR506S	35.7	0	0	0	0	0	0	0	0	32.12
HTR507S	11.39	4.48	5.93	5.91	4.48	5.92	5.9	8.45	6.8	5.37
HTR602S	32.40	0	0	0	0	0	0	0	0	29.1
HTR603S	39.00	0	0	0	0	0	0	0	0	35.46
HTR604S	20.90	0	0	0	0	0	0	0	0	20.9

TCS ID	INSTALLED	Case A	Case B	Case C	Case D	Case E	Case F	Case G	Case H	Case I
		EOL	EOL	EOL	EOL	EOL	EOL	BOL	BOL	BOL Surv.
	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]	[W]
HTR605S	29.00	0	0	0	0	0	0	0	0	26.46
HTR1523NS	5.82	0	0	0	0	0	0	3.46	3.43	4.79
HTR1562NS	6.35	0	0	0	0	0	0	4.55	4.49	4.92
HTR1544NS	5.23	0	0	0	0	0	0	2.18	2.15	3.82
HTR1550NS	4.90	0	0	0	0	0	0	2.14	2.08	3.7
HTR1554NS	6.04	0	0	0	0	0	0	2.44	2.37	4.59
HTR1513NS	5.75	0	0	0	0	0	0	2.21	2.08	4.4
HTR1506NS	4.16	0	0	0	0	0	0	1.5	1.41	2.35
HTR1535NS	5.66	0	0	0	0	0	0	2.82	2.73	4.24
Total	**629.8**	**42.54**	**51.07**	**50.97**	**42.43**	**50.97**	**50.86**	**145.8**	**131.7**	**368.9**

5.1.5.4 Redundancy Analysis

A series of additional analysis has been performed to verify the temperature behaviour when the redundancy units are activated. In particular the following hot case analyses have been considered:

Transient analysis

- B rid: TT &C activation of line 2 on the hottest case for TT&C and activation of STR2
- C 2 STR ON: two Star Tracker ON on the Hottset case for STR to size the Radiator area

The transient case results obtained are showed in Table

Table 5.1.5.4-1 HERSCHEL – Redundancy analysis temperature results

											TEMPERATURE LIMIT			
		B rid	B rid	C 2STR ON	C 2STR ON	UFP	HTR	HTR	B rid	C 2STR ON	MIN	MAX	MIN	MAX
NODE	LABEL	TEMP	PW	TEMP	PW		NOM	SURV	TEMP+ UFP	TEMP+ UFP	OPER.	OPER.	N.OPER	N.OPER
		[°C]	[W]	[°C]	[W]	[°C]			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
4	VMC	**41.9**	0.0	**41.9**	0.0	7.4			49.3	49.3	-10	50	-20	60
5	SAS +Z	**45.3**	0.0	**44.1**	0.0	8			53.3	52.1	-70	80	-80	90
16	MGA+Z	**129.3**	0.6	**129.9**	0.6	12.4			141.7	142.3	-150	150	-150	150
21	LGA+Z	**86.6**	0.0	**86.6**	0.0	8			94.6	94.6	-150	120	-150	120
41	LGA-Z	**-52.7**	0.0	**-52.2**	0.0	8			-44.7	-44.2	-150	120	-150	120
45	SAS -Z	**4.9**	0.0	**5.5**	0.0	8			12.9	13.5	-70	80	-80	90
49	SREM	**31.9**	2.6	**32.8**	2.6	8			39.9	40.8	-10	50	-45	90
56	AAD	**53.5**	0.0	**53.4**	0.0	8			61.5	61.4	-70	70	-80	80
70	TANK1	**35.6**	0.0	**35.8**	0.0	8	N	S	43.6	43.8	10	45	10	45
71	TANK2	**34.5**	0.0	**34.5**	0.0	8	N	S	42.5	42.5	10	45	10	45
81	GYRO	**63.3**	0.0	**63.3**	0.0	0	N	S	63.3	63.3	-20	55	-30	65
101	RFDN	**33.2**	11.8	**33.9**	11.8	8			41.2	41.9	-25	55	-35	65
102	EPC1	**31.1**	0.0	**42.4**	9.0	8			39.1	50.4	-20	60	-30	70
103	EPC2	**29.9**	9.0	**19.3**	0.0	8.2			38.1	27.5	-20	60	-30	70
104	XPND1	**31.7**	10.0	**40.0**	23.0	7.6	N	S	39.3	47.6	-10	45	-20	55
105	XPND2	**34.3**	23.0	**25.4**	10.0	8	N	S	42.3	33.4	-10	45	-20	55
106	TWTA1	**28.1**	0.0	**52.5**	37.0	7.9			36.0	60.4	-20	60	-30	70

NODE	LABEL	B rid TEMP [°C]	B rid PW [W]	C 2STR ON TEMP [°C]	C 2STR ON PW [W]	UFP [°C]	HTR NOM	HTR SURV	B rid TEMP+UFP [°C]	C 2STR ON TEMP+UFP [°C]	TEMPERATURE LIMIT MIN OPER. [°C]	TEMPERATURE LIMIT MAX OPER. [°C]	TEMPERATURE LIMIT MIN N.OPER [°C]	TEMPERATURE LIMIT MAX N.OPER [°C]
107	TWTA2	**43.8**	37.0	**18.6**	0.0	8.1			51.9	26.7	-20	60	-30	70
110	CRS1	**42.4**	8.3	**42.1**	8.3	7.3			49.7	49.4	0	50	-10	60
111	CRS2	**42.2**	8.3	**42.9**	8.3	7.3			49.5	50.2	0	50	-10	60
201	PCDU	**31.5**	80.0	**31.3**	80.0	8			39.5	39.3	-10	47	-20	57
202	CDMU	**33.2**	37.7	**32.2**	37.7	8			41.2	40.2	-10	45	-20	55
203	ACC	**35.1**	32.1	**33.8**	32.1	8			43.1	41.8	-10	45	-20	55
204	BATT	**20.4**	2.3	**19.8**	2.3	8	N	S	28.4	27.8	0	35		
301	FPSPU1_2	**32.3**	30.3	**34.7**	30.3	8		S	40.3	42.7	-15	45	-30	60
303	FPDPU	**32.9**	24.0	**34.5**	24.0	8		S	40.9	42.5	-15	45	-30	60
304	FPBOLC	**31.0**	48.6	**20.5**	6.6	8	N	S	39.0	28.5	-15	45	-30	60
305	FPMECDEC	**23.7**	21.6	**32.7**	65.0	8		S	31.7	40.7	-15	45	-30	60
401	CCU	**27.4**	5.4	**27.8**	5.4	8		S	35.4	35.8	-10	40	-20	50
404	HSDCU	**32.3**	37.0	**32.7**	37.0	8			40.3	40.7	-15	45	-35	60
405	HSDPU	**27.6**	15.3	**30.0**	15.3	8			35.6	38.0	-15	45	-35	60
406	HSFCU	**32.2**	42.9	**33.7**	42.9	8			40.2	41.7	-15	45	-35	60
501	FHWOV	**9.0**	1.5	**9.1**	1.5	0	N	S	9.0	9.1	5	15	-25	55
502	FHHRV	**26.4**	63.3	**26.5**	63.3	9		S	35.4	35.5	-10	40	-25	55
503	FHICU	**23.8**	29.0	**23.9**	29.0	8.3		S	32.1	32.2	-25	40	-30	60
504	FHFCU	**16.8**	13.0	**16.9**	13.0	8		S	24.8	24.9	-10	40	-25	55
506	FHWEV	**19.4**	27.0	**19.5**	27.0	8		S	27.4	27.5	0	30	-25	55
507	FHIFV	**7.0**	0.0	**7.0**	0.0	8		S	15.0	15.0	-10	40	-25	55
508	IFV-HRV	**21.1**	0.0	**21.2**	0.0	9			30.1	30.2	-10	40	-25	55
509	IFV-WEV	**21.1**	0.0	**21.3**	0.0	9			30.1	30.3	-10	40	-25	55
510	WOV-WEV	**20.7**	0.0	**20.9**	0.0	9			29.7	29.9	-10	40	-25	55
511	HRV-HRH	**23.9**	0.0	**24.0**	0.0	9			32.9	33.0	-10	40	-25	55
601	FHWOH	**9.1**	1.5	**9.1**	1.5	0	N	S	9.1	9.1	5	15	-25	55
602	FHWEH	**19.4**	27.0	**19.5**	27.0	7.8		S	27.2	27.3	0	30	-25	55
603	FHHRH	**25.0**	63.3	**25.1**	63.3	8.8		S	33.8	33.9	-10	40	-25	55
604	FHLCU	**24.1**	37.6	**24.2**	37.6	8		S	32.1	32.2	-10	40	-25	55
605	FHLSU	**23.2**	44.7	**23.2**	44.7	8		S	31.2	31.2	10	40	-25	55
606	FHIFH	**14.1**	0.0	**14.2**	0.0	8		S	22.1	22.2	-10	40	-25	55
607	IFH-HRH	**23.2**	0.0	**23.3**	0.0	9			32.2	32.3	-10	40	-25	55
608	IFH-WEH	**23.0**	0.0	**23.1**	0.0	9			32.0	32.1	-10	40	-25	55
609	WEH-W0H	**21.2**	0.0	**21.3**	0.0	9			30.2	30.3	-10	40	-25	55
701	RWL1	**44.1**	16.0	**44.2**	16.0	8	N	S	52.1	52.2	0	55	-10	65
702	RWL2	**43.1**	16.0	**43.2**	16.0	8	N	S	51.1	51.2	0	55	-10	65
703	RWL3	**44.7**	16.0	**44.7**	16.0	8	N	S	52.7	52.7	0	55	-10	65
704	RWL4	**44.4**	16.0	**44.4**	16.0	8	N	S	52.4	52.4	0	55	-10	65
8133	FCV MAIN	**43.6**	OP	**42.3**	OP	8	N	S	51.6	50.3	10	60	10	60
8233	FCV MAIN	**45.2**	OP	**43.7**	OP	8	N	S	53.2	51.7	10	60	10	60
8333	FCV MAIN	**41.1**	OP	**38.7**	OP	8	N	S	49.1	46.7	10	60	10	60
8433	FCV MAIN	**37.5**	OP	**37.8**	OP	8	N	S	45.5	45.8	10	60	10	60
8533	FCV MAIN	**40.8**	OP	**40.9**	OP	8	N	S	48.8	48.9	10	60	10	60
8633	FCV MAIN	**46.9**	OP	**47.0**	OP	8	N	S	54.9	55.0	10	60	10	60
8134	FCV RED	**43.2**	OP	**41.9**	OP	8	N	S	51.2	49.9	10	60	10	60
8234	FCV RED	**44.9**	OP	**43.4**	OP	8	N	S	52.9	51.4	10	60	10	60
8334	FCV RED	**41.5**	OP	**39.0**	OP	8	N	S	49.5	47.0	10	60	10	60
8434	FCV RED	**46.5**	OP	**46.7**	OP	8	N	S	54.5	54.7	10	60	10	60
8534	FCV RED	**40.3**	OP	**40.5**	OP	8	N	S	48.3	48.5	10	60	10	60
8634	FCV RED	**47.3**	OP	**47.3**	OP	8	N	S	55.3	55.3	10	60	10	60
80029	STR1+X FOOT	**-22.4**	OP	**-0.1**	OP	(*)	N	S	-18.6	7.1	-20	40	-30	50
81029	STR2+X FOOT	**-16.2**	OP	**0.0**	OP	(*)	N	S	-16.2	7.1	-20	40	-30	50
1501	RCS_INT_CONE	**33.4**	OP	**33.0**	OP	8	N	S	41.4	41.0	10	50		
1502	RCS_INT_CONE	**34.2**	OP	**34.0**	OP	8	N	S	42.2	42.0	10	50		
1503	RCS_INT_CONE	**35.4**	OP	**35.8**	OP	8	N	S	43.4	43.8	10	50		
1504	RCS_INT_CONE	**35.7**	OP	**36.2**	OP	8	N	S	43.7	44.2	10	50		
1505	RCS_INT_CONE	**35.7**	OP	**35.8**	OP	8	N	S	43.7	43.8	10	50		
1506	RCS_INT_CONE	**35.4**	OP	**35.5**	OP	8	N	S	43.4	43.5	10	50		

NODE	LABEL	B rid TEMP	B rid PW	C 2STR ON TEMP	C 2STR ON PW	UFP	HTR NOM	HTR SURV	B rid TEMP+ UFP	C 2STR ON TEMP+ UFP	TEMPERATURE LIMIT MIN OPER.	TEMPERATURE LIMIT MAX OPER.	TEMPERATURE LIMIT MIN N.OPER	TEMPERATURE LIMIT MAX N.OPER
		[°C]	[W]	[°C]	[W]	[°C]			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
1507	RCS_INT_CONE	**35.4**	OP	**35.6**	OP	8	N	S	43.4	43.6	10	50		
1508	RCS_INT_CONE	**37.9**	OP	**38.0**	OP	8	N	S	45.9	46.0	10	50		
1509	RCS_INT_CONE	**37.4**	OP	**37.5**	OP	8	N	S	45.4	45.5	10	50		
1510	RCS_INT_CONE	**37.3**	OP	**37.4**	OP	8	N	S	45.3	45.4	10	50		
1511	RCS_INT_CONE	**37.2**	OP	**37.3**	OP	8	N	S	45.2	45.3	10	50		
1512	RCS_INT_CONE	**31.3**	OP	**31.9**	OP	8	N	S	39.3	39.9	10	50		
1513	RCS_INT_CONE	**32.3**	OP	**32.7**	OP	8	N	S	40.3	40.7	10	50		
1514	RCS_INT_CONE	**31.4**	OP	**32.1**	OP	8	N	S	39.4	40.1	10	50		
1515	RCS_SHEAR+Z-Y	**41.2**	OP	**41.3**	OP	8	N	S	49.2	49.3	10	50		
1516	RCS_SHEAR+Z-Y	**41.2**	OP	**41.3**	OP	8	N	S	49.2	49.3	10	50		
1517	RCS_BOT_FLOOR	**36.0**	OP	**29.4**	OP	8	N	S	44.0	37.4	10	50		
1518	RCS_BOT_FLOOR	**36.0**	OP	**29.4**	OP	8	N	S	44.0	37.4	10	50		
1519	RCS_SHEAR+Z+Y	**33.7**	OP	**32.6**	OP	8	N	S	41.7	40.6	10	50		
1520	RCS_BOT_FLOOR	**32.5**	OP	**28.0**	OP	8	N	S	40.5	36.0	10	50		
1521	RCS_SHEAR+Z+Y	**39.3**	OP	**38.1**	OP	8	N	S	47.3	46.1	10	50		
1522	RCS_SHEAR+Z+Y	**41.0**	OP	**39.7**	OP	8	N	S	49.0	47.7	10	50		
1523	RCS_SHEAR+Z+Y	**38.7**	OP	**37.8**	OP	8	N	S	46.7	45.8	10	50		
1524	RCS_SHEAR+Z+Y	**40.8**	OP	**40.2**	OP	8	N	S	48.8	48.2	10	50		
1525	RCS_BOT_FLOOR	**34.2**	OP	**28.8**	OP	8	N	S	42.2	36.8	10	50		
1526	RCS_BOT_FLOOR	**32.5**	OP	**28.0**	OP	8	N	S	40.5	36.0	10	50		
1527	RCS_SHEAR-Z+Y	**31.2**	OP	**29.7**	OP	8	N	S	39.2	37.7	10	50		
1528	RCS_BOT_FLOOR	**29.7**	OP	**27.6**	OP	8	N	S	37.7	35.6	10	50		
1529	RCS_SHEAR-Y-Z	**32.3**	OP	**32.5**	OP	8	N	S	40.3	40.5	10	50		
1530	RCS_BOT_FLOOR	**26.3**	OP	**26.4**	OP	8	N	S	34.3	34.4	10	50		
1531	RCS_SHEAR+Y+Z	**33.3**	OP	**32.3**	OP	8	N	S	41.3	40.3	10	50		
1532	RCS_SHEAR+Y+Z	**29.4**	OP	**28.2**	OP	8	N	S	37.4	36.2	10	50		
1533	RCS_SHEAR+Y+Z	**29.5**	OP	**28.0**	OP	8	N	S	37.5	36.0	10	50		
1534	RCS_BOT_FLOOR	**31.5**	OP	**27.6**	OP	8	N	S	39.5	35.6	10	50		
1535	RCS_SHEAR-Y+Z	**37.2**	OP	**37.3**	OP	8	N	S	45.2	45.3	10	50		
1536	RCS_BOT_FLOOR	**29.7**	OP	**27.6**	OP	8	N	S	37.7	35.6	10	50		
1541	RCS_SHEAR+Y-Z	**31.2**	OP	**29.7**	OP	8	N	S	39.2	37.7	10	50		
1542	RCS_SHEAR+Y-Z	**31.1**	OP	**28.2**	OP	8	N	S	39.1	36.2	10	50		
1543	RCS_SHEAR+Y-Z	**31.2**	OP	**28.9**	OP	8	N	S	39.2	36.9	10	50		
1544	RCS_BOT_FLOOR	**29.7**	OP	**27.6**	OP	8	N	S	37.7	35.6	10	50		
1550	PT	**24.6**	OP	**25.8**	OP	8	N	S	32.6	33.8	10	50		
1551	LV1	**29.4**	OP	**30.5**	OP	8	N	S	37.4	38.5	10	50		
1552	LV2	**29.0**	OP	**30.2**	OP	8	N	S	37.0	38.2	10	50		
1553	LF	**28.7**	OP	**29.8**	OP	8	N	S	36.7	37.8	10	50		
1554	RCS_SHEAR-Z+Y	**28.2**	OP	**29.5**	OP	8	N	S	36.2	37.5	10	50		
1555	RCS_SHEAR-Z+Y	**28.6**	OP	**29.8**	OP	8	N	S	36.6	37.8	10	50		
1556	RCS_SHEAR-Z+Y	**29.0**	OP	**30.3**	OP	8	N	S	37.0	38.3	10	50		
1557	RCS_SHEAR-Z+Y	**29.4**	OP	**30.6**	OP	8	N	S	37.4	38.6	10	50		
1558	RCS_SHEAR-Z+Y	**30.0**	OP	**31.1**	OP	8	N	S	38.0	39.1	10	50		
1559	RCS_SHEAR-Z+Y	**29.5**	OP	**30.6**	OP	8	N	S	37.5	38.6	10	50		
1561	RCS_EXT_CONE	**41.0**	OP	**41.1**	OP	8	N	S	49.0	49.1	10	50		
1562	RCS_EXT_CONE	**35.8**	OP	**35.3**	OP	8	N	S	43.8	43.3	10	50		
1563	RCS_EXT_CONE	**33.3**	OP	**32.9**	OP	8	N	S	41.3	40.9	10	50		
1564	RCS_EXT_CONE	**31.3**	OP	**32.0**	OP	8	N	S	39.3	40.0	10	50		
1565	RCS_EXT_CONE	**31.3**	OP	**31.9**	OP	8	N	S	39.3	39.9	10	50		
1566	RCS_EXT_CONE	**32.3**	OP	**32.6**	OP	8	N	S	40.3	40.6	10	50		
1567	RCS_EXT_CONE	**36.2**	OP	**36.4**	OP	8	N	S	44.2	44.4	10	50		
1568	RCS_EXT_CONE	**37.9**	OP	**38.0**	OP	8	N	S	45.9	46.0	10	50		
1571	RCS_SHEAR-Y-Z	**32.3**	OP	**32.5**	OP	8	N	S	40.3	40.5	10	50		
1572	RCS_SHEAR-Y-Z	**29.1**	OP	**29.4**	OP	8	N	S	37.1	37.4	10	50		
1573	RCS_SHEAR-Y-Z	**28.5**	OP	**28.7**	OP	8	N	S	36.5	36.7	10	50		
1574	RCS_BOT_FLOOR	**30.2**	OP	**30.5**	OP	8	N	S	38.2	38.5	10	50		
1575	RCS_BOT_FLOOR	**32.1**	OP	**32.4**	OP	8	N	S	40.1	40.4	10	50		
1576	RCS_BOT_FLOOR	**26.3**	OP	**26.4**	OP	8	N	S	34.3	34.4	10	50		

											TEMPERATURE LIMIT			
		B rid	B rid	C 2STR ON	C 2STR ON	UFP	HTR	HTR	B rid	C 2STR ON	MIN	MAX	MIN	MAX
NODE	LABEL	TEMP	PW	TEMP	PW		NOM	SURV	TEMP+ UFP	TEMP+ UFP	OPER.	OPER.	N.OPER	N.OPER
		[°C]	[W]	[°C]	[W]	[°C]			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
1581	RCS_SHEAR-Y+Z	**37.2**	OP	**37.3**	OP	8	N	S	45.2	45.3	10	50		
1582	RCS_SHEAR-Y+Z	**33.9**	OP	**34.0**	OP	8	N	S	41.9	42.0	10	50		
1583	RCS_SHEAR-Y+Z	**32.5**	OP	**32.6**	OP	8	N	S	40.5	40.6	10	50		
1584	RCS_BOT_FLOOR	**32.4**	OP	**31.2**	OP	8	N	S	40.4	39.2	10	50		
1591	RCS_SHEAR+Z-Y	**41.1**	OP	**41.2**	OP	8	N	S	49.1	49.2	10	50		
1592	RCS_SHEAR+Z-Y	**40.5**	OP	**40.6**	OP	8	N	S	48.5	48.6	10	50		

(*) the STR uncertainty is: with control law 0°C for STR “on” and 3.8°C for STR “off”; without control law 7.1°C for STR “on”

5.2 PLANCK Thermal analysis

5.2.1 Planck cases

TRANSIENT NOMINAL ANALYSIS

The nominal analysis have been performed considering transient cases with the S/C operating 21 hours in Scientific mode and 3 hrs in Telecom mode. The analysis takes into account also the cyclic variation of SCC power dissipation on each bed (see paragraph 5.2.2.1)
The list of the orbital Transient cases analysed is presented in the following table:

CASE	BOL / EOL	SUN ON PANEL	SAA [deg]	ATTITUDE	SOLAR CONSTANT [W/m²]	Remarks
A1	BOL	+Z	10	Rot X = 0 Rot Y = +10	Summer: 1285	Nominal BOL – Dissipation MODE1
A2	BOL	+Z	10	Rot X = 0 Rot Y = +10	Summer: 1285	Nominal BOL – Dissipation MODE2
A3	BOL	+Z	10	Rot X = 0 Rot Y = +10	Summer: 1285	Nominal BOL – Dissipation MODE3
B1	EOL	+Z	0	Rot X = 0 Rot Y = 0	Winter: 1405	Nominal EOL – SCC1 on
B2	EOL	+Z	0	Rot X = 0 Rot Y = 0	Winter: 1405	Nominal EOL – SCC2 on
C	BOL	+Z	10	Rot X = 0 Rot Y = +10	Summer: 1285	Survival BOL

Table 5.2.1-1- PLANCK Transient nominal analysis cases

The spin of the satellite around its X-axis (1.7 round per minute) has a negligible effect on the amount of solar fluxes on the sun-exposed surfaces, so it is not considered in the current analysis.

CHANGE OF ATTITUDE TRANSIENT ANALYSIS

To verify the thermal stability requirement for the SCC Radiative Panels and the SVM/PLM I/F points transient analysis have been performed taking into account the variation of SCC Power dissipation on each bed; moreover a change of attitude of the satellite from SAA=0° to SAA=10° has been considered at time = 86400 sec.
The analysed cases are the following:

- Cold Transient (**Case P1**):
  Starting from S/S BOL case with Sun on –X and SAA= 0°. Solar constant=1285 W/m^2
  Ending to S/S BOL case with Sun on –X and SAA=+10°. Solar constant=1285 W/m^2
  Duration of change of attitude: 1200s
  Rotation rate: 0.5°/min
  Overall duration of transient case: 348600s (72 hours)
  Dissipation as per nominal case A1 (with SCC1 on and SCC2 off)

- Cold Transient (**Case P2**):
  Starting from S/S BOL case with Sun on –X and SAA= 0°. Solar constant=1285 W/m^2
  Ending to S/S BOL case with Sun on –X and SAA=+10°. Solar constant=1285 W/m^2
  Duration of change of attitude: 1200s
  Rotation rate: 0.5°/min
  Overall duration of transient case: 348600s (72 hours)
  Dissipation as per nominal case A1 (with SCC1 off and SCC2 on)

- Hot Transient (**Case Q1**):
  Starting from S/S EOL case with Sun on –X and SAA=0°. Solar constant=1405 W/m^2
  Ending to S/S EOL case with Sun on –X and SAA= +10°. Solar constant=1405 W/m^2
  Duration of change of attitude: 1200s
  Rotation rate: 0.5°/min
  Overall duration of transient case: 348600s (72 hours)
  Dissipation as per nominal case B1

- Hot Transient (**Case Q2**):
  Starting from S/S EOL case with Sun on –X and SAA=0°. Solar constant=1405 W/m^2
  Ending to S/S EOL case with Sun on –X and SAA= +10°. Solar constant=1405 W/m^2
  Duration of change of attitude: 1200s
  Rotation rate: 0.5°/min
  Overall duration of transient case: 348600s (72 hours)
  Dissipation as per nominal case B2

REDUNDANCY TRANSIENT ANALYSIS

A series of additional analysis have been performed to verify the temperatures behaviour when the redundancy units are activated. The analysis results are reported in paragraph 5.2.5.4

5.2.2 Planck Power Dissipation

The dissipation modes are identified in the following table respect to the status of the HFI and LFI system:

Table 5.2.2-1 PLANCK –Mode Dissipations

MODE	HFI	LFI	COMMENTS
1	Prime	Prime	
2	Prime	Standby	
3	Standby	Prime	

The complete list of the power dissipation in Scientific and Telecom Mode for each case are reported in Table 5.2.2-2.

Table 5.2.2-2 PLANCK – Units Power Dissipations

		Scientific Mode	Scientific Mode	Scientific Mode	Scientific Mode	Scientific Mode	Survival
Sub-System	**Switchable Unit**	**CASE A1**	**CASE A2**	**CASE A3**	**CASE B1**	**CASE B2**	**CASE C**
CDMS							
	CDMU	37.7 W	37.7 W	37.7 W	37.7 W	37.7 W	37.7 W
ACMS							
	AAD	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	ACC	32.1 W	32.1 W	32.1 W	32.1 W	32.1 W	32.1 W
	STR1	10.95 W	10.95 W	10.95 W	10.95 W	10.95 W	OFF
	STR2	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	SAS	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	SAS	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	CRS1	8.3 W	8.3 W	8.3 W	8.3 W	8.3 W	8.3 W
	CRS2	8.3 W	8.3 W	8.3 W	8.3 W	8.3 W	8.3 W
	CRS3	8.3 W	8.3 W	8.3 W	8.3 W	8.3 W	8.3 W
TTC		**duration = 21 hr**	**duration = 21 hr**	**duration = 21 hr**	**duration = 21 hr**	**duration = 21 hr**	
	XPND1	Rx 21 W	Rx 21 W	Rx 21 W	Rx 21 W	Rx 21 W	Rx+Tx 23 W
	XPND2	Rx 10 W	Rx 10 W	Rx 10 W	Rx 10 W	Rx 10 W	Rx 10 W
	EPC1	9.0 W	9.0 W	9.0 W	9.0 W	9.0 W	9.0 W
	EPC2	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	TWT1	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	37 W
	TWT2	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	RFDN	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	11.8 W
	LGA1	Rx2 0.0 W	Rx2 0.0 W	Rx2 0.0 W	Rx2 0.0 W	Rx2 0.0 W	Rx1+Tx2 0.0 W
	LGA2	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	Rx2+Tx1 3.0 W
	LGA3	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	Rx2+Tx1 3.0 W
	MGA	Rx1 0.0 W	Rx1 0.0 W	Rx1 0.0 W	Rx1 0.0 W	Rx1 0.0 W	OFF
Power							
	PCDU	BOL 98.6 W / EOL 102.9 W	BOL 98.6 W / EOL 102.9 W	BOL 98.6 W / EOL 102.9 W	BOL 98.6 W / EOL 102.9 W	BOL 98.6 W / EOL 102.9 W	BOL 81.2 W / EOL 84.1 W
	Battery	2.3 W	2.3 W	2.3 W	2.3 W	2.3 W	6.0 W
Thruster							
	THR D1A	0.71	0.71	0.71	0.71	0.71	3.55
	THR D1B	0.71	0.71	0.71	0.71	0.71	0.71
	THR D2A	0.71	0.71	0.71	0.71	0.71	3.55
	THR D2B	0.71	0.71	0.71	0.71	0.71	0.71
	THR F1A	0.71	0.71	0.71	0.71	0.71	3.55

		Scientific Mode	Scientific Mode	Scientific Mode	Scientific Mode	Scientific Mode	Survival
Sub-System	**Switchable Unit**	**CASE A1**	**CASE A2**	**CASE A3**	**CASE B1**	**CASE B2**	**CASE C**
	THR F1B	0.71	0.71	0.71	0.71	0.71	0.71
	THR F2A	0.71	0.71	0.71	0.71	0.71	3.55
	THR F2B	0.71	0.71	0.71	0.71	0.71	0.71
	THR U1A	2.84	2.84	2.84	2.84	2.84	5.68
	THR U1B	2.84	2.84	2.84	2.84	2.84	2.84
	THR U2A	2.84	2.84	2.84	2.84	2.84	5.68
	THR U2B	2.84	2.84	2.84	2.84	2.84	2.84
	THR A1A	4.56	4.56	4.56	4.56	4.56	0.0
	THR A1B	0.0	0.0	0.0	0.0	0.0	0.0
	THR B1A	4.56	4.56	4.56	4.56	4.56	0.0
	THR B1B	0.0	0.0	0.0	0.0	0.0	0.0
ESA Items							
	SREM	2.6 W	2.6 W	2.6 W	2.6 W	2.6 W	OFF
	FOG	16.5 W	16.5 W	16.5 W	26.8 W	26.8 W	OFF
HFI		**duration = 21 hr**	**duration = 21 hr**	**duration = 21 hr**	**duration = 21 hr**	**duration = 21 hr**	
	DPU N	22 W	22 W	22 W	22 W	22 W	OFF
	DPU R	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	PAU	15 W	15 W	OFF	15 W	15 W	0.0 W
	REU	92 W	92 W	92 W	92 W	92 W	0.0 W
	4K CAU	15 W	15 W	15 W	15 W	15 W	0.0 W
	4K CEU (4KCDE)	42.8 W	42.8 W	42.8 W	42.8 W	42.8 W	0.0 W
	4K PRU (4KCCR)	21 W	21 W	OFF	21 W	21 W	0.0 W
	4K CCU	60 W	60 W	60 W	60 W	60 W	0.0 W
	0.1 K DCCU	16 W	16 W	16 W	16 W	16 W	0.0 W
LFI		**duration = 21 hr**	**duration = 21 hr**	**duration = 21 hr**	**duration = 21 hr**	**Duration = 21 hr**	
	BEU Right -Y	8.77 W	OFF	8.77 W	8.77 W	8.77 W	0.0 W
	BEU Central	12 W	OFF	12 W	12 W	12 W	0.0 W
	BEU Left +Y	11 W	OFF	11 W	11 W	11 W	0.0 W
	DAE	13 W	OFF	13 W	13 W	13 W	0.0 W
	REBA N	41.5 W	41.5 W	41.5 W	41.5 W	41.5 W	0.0 W
	REBA R	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
SCS		**duration = 21 hr**	**Duration = 21 hr**	**duration = 21 hr**	**duration = 21 hr**	**Duration = 21 hr**	
	SCC N	See Array values	See Array values	See Array values	See Array values	0.0 W	0.0 W
	SCC R	0.0 W	0.0 W	0.0 W	0.0 W	See Array values	0.0 W
	SCE N	110 W	110 W	110 W	110 W	0.0 W	0.0 W
	SCE R	0.0 W	0.0 W	0.0 W	0.0 W	110 W	0.0 W

		Telecom	Telecom	Telecom	Telecom	Telecom
Sub-System	**Switchable Unit**	**CASE A1**	**CASE A2**	**CASE A3**	**CASE B1**	**CASE B2**
CDMS						
	CDMU	37.7 W	37.7 W	37.7 W	37.7 W	37.7 W
ACMS						
	AAD	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W

		Telecom	Telecom	Telecom	Telecom	Telecom
Sub-System	Switchable Unit	CASE A1	CASE A2	CASE A3	CASE B1	CASE B2
	ACC	32.1 W	32.1 W	32.1 W	32.1 W	32.1 W
	STR1	10.95 W	10.95 W	10.95 W	10.95 W	10.95 W
	STR2	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	SAS	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	SAS	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	CRS1	8.3 W	8.3 W	8.3 W	8.3 W	8.3 W
	CRS2	8.3 W	8.3 W	8.3 W	8.3 W	8.3 W
	CRS3	8.3 W	8.3 W	8.3 W	8.3 W	8.3 W
TTC		duration = 3 hr	duration = 3 hr	duration = 3 hr	duration = 3 hr	duration = 3 hr
	XPND1	Rx+Tx 23 W	Rx+Tx 23 W	Rx+Tx 23 W	Rx+Tx 23 W	Rx+Tx 23 W
	XPND2	Rx 10 W	Rx 10 W	Rx 10 W	Rx 10 W	Rx 10 W
	EPC1	9.0 W	9.0 W	9.0 W	9.0 W	9.0 W
	EPC2	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	TWT1	37 W	37 W	37 W	37 W	37 W
	TWT2	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	RFDN	11.8 W	11.8 W	11.8 W	11.8 W	11.8 W
	LGA1	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
	LGA2	Rx2+Tx2 0.0 W	Rx2+Tx2 0.0 W	Rx2+Tx2 0.0 W	Rx2+Tx2 0.0 W	Rx2+Tx2 0.0 W
	LGA3	Rx2+Tx2 0.0 W	Rx2+Tx2 0.0 W	Rx2+Tx2 0.0 W	Rx2+Tx2 0.0 W	Rx2+Tx2 0.0 W
	MGA	Rx1+Tx1 3.0 W	Rx1+Tx1 3.0 W	Rx1+Tx1 3.0 W	Rx1+Tx1 3.0 W	Rx1+Tx1 3.0 W
Power						
	PCDU	BOL 99.3 W / EOL 102.9 W	BOL 99.3 W / EOL 102.9 W	BOL 99.3 W / EOL 102.9 W	BOL 99.3 W / EOL 102.9 W	BOL 99.3 W / EOL 102.9 W
	Battery	2.3 W	2.3 W	2.3 W	2.3 W	2.3 W
Thruster						
	THR D1A	0.71	0.71	0.71	0.71	0.71
	THR D1B	0.71	0.71	0.71	0.71	0.71
	THR D2A	0.71	0.71	0.71	0.71	0.71
	THR D2B	0.71	0.71	0.71	0.71	0.71
	THR F1A	0.71	0.71	0.71	0.71	0.71
	THR F1B	0.71	0.71	0.71	0.71	0.71
	THR F2A	0.71	0.71	0.71	0.71	0.71
	THR F2B	0.71	0.71	0.71	0.71	0.71
	THR U1A	2.84	2.84	2.84	2.84	2.84
	THR U1B	2.84	2.84	2.84	2.84	2.84
	THR U2A	2.84	2.84	2.84	2.84	2.84
	THR U2B	2.84	2.84	2.84	2.84	2.84
	THR A1A	4.56	4.56	4.56	4.56	4.56
	THR A1B	0.0	0.0	0.0	0.0	0.0
	THR B1A	4.56	4.56	4.56	4.56	4.56
	THR B1B	0.0	0.0	0.0	0.0	0.0
ESA Items						
	SREM	2.6 W	2.6 W	2.6 W	2.6 W	2.6 W
	FOG	16.5 W	16.5 W	16.5 W	26.8 W	26.8 W
HFI		duration = 3 hr	duration = 3 hr	duration = 3 hr	duration = 3 hr	duration = 3 hr
	DPU N	22 W	22 W	22 W	22 W	22 W
	DPU R	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W

		Telecom	Telecom	Telecom	Telecom	Telecom
Sub-System	**Switchable Unit**	**CASE A1**	**CASE A2**	**CASE A3**	**CASE B1**	**CASE B2**
	PAU	15 W	15 W	OFF	15 W	15 W
	REU	92 W	92 W	92 W	92 W	92 W
	4K CAU	15 W	15 W	15 W	15 W	15 W
	4K CEU (4KCDE)	42.8 W	42.8 W	42.8 W	42.8 W	42.8 W
	4K PRU (4KCCR)	21 W	21 W	OFF	21 W	21 W
	4K CCU	60 W	60 W	60 W	60 W	60 W
	0.1 K DCCU	16 W	16 W	16 W	16 W	16 W
LFI		**duration = 3 hr**	**duration = 3 hr**	**duration = 3 hr**	**duration = 3 hr**	**duration = 3 hr**
	BEU Right -Y	8.77 W	OFF	8.77 W	8.77 W	8.77 W
	BEU Central	12 W	OFF	12 W	12 W	12 W
	BEU Left +Y	11 W	OFF	11 W	11 W	11 W
	DAE	13 W	OFF	13 W	13 W	13 W
	REBA N	41.5 W	41.5 W	41.5 W	41.5 W	41.5 W
	REBA R	0.0 W	0.0 W	0.0 W	0.0 W	0.0 W
SCS		**duration = 3 hr**	**duration = 3 hr**	**duration = 3 hr**	**duration = 3 hr**	**duration = 3 hr**
	SCC N	See Array values	See Array values	See Array values	See Array values	0.0 W
	SCC R	0.0 W	0.0 W	0.0 W	0.0 W	See Array values
	SCE N	110 W	110 W	110 W	110 W	0.0 W
	SCE R	0.0 W	0.0 W	0.0 W	0.0 W	110 W

5.2.2.1 SCC dissipation profile

The working SCC has a dissipation profile of 667s, while the single bed has a whole cycle in 4002 s (6 time 667s). Each SCC is composed of six thermal nodes for the Inner bed and six for the Outer shell, for each thermal node is considered the thermal capacity, the linear conductor and the power dissipation for each phase and has been utilised a simplified BOL and EOL thermal mathematical model reported in Table 5.2.2.1-1/2
In Table 5.2.2.1-3 are reported the value relative to Gas gap conductance for a period time of 1334 sec up to 2000 one .

Highly Simplified BOL Thermal Model of 20 K Sorption Cooler Compressor Assembly

(To be used by Alcatel to simulate compressor interface with radiator)

(Pradeep Bhandari, Mauro Prina, 11-15-2001) (Phone: 818-354-7597) **Modified Model**

Parameter	Location	Units	Phase 1 Heatup 0-667 s	Phase 2 Desorb 667-1334 s	Phase 3 Cool 1334-2000 s	Phase 4 Absorb 2001-2667 s	Phase 5 Absorb 2668-3333 s	Phase 6 Absorb 3335-4000 s	Phase Cycle Time
Therm. Mass	**Inner Bed**	MC_p (J/K)	800	3600	900	670	690	710	
	Outer Shell	MC_p (J/K)	720	720	720	720	720	720	
Conductance	*(Inner Bed to Outer Shell)*	W/K	0.02	0.03	***	6.53	6.53	6.53	
Heat Input	**Inner Bed**	W	201	150	0	36	36	36	
	Outer shell	W	0	0	7	7	7	7	

**** see attached table**

(Gas-Gap Conductance Worksheet)

BOL
Model

Notes:
1) The above values are for beginning of life (excluding margin)
2) The total cycle time is 667*6 = 4000 seconds.
3) There are 6 identical beds which are of phase, by one phase width of 667 sec., with respect to each other.

Table 5.2.2.1-1 PLANCK - Simplified BOL SCC model

Highly Simplified EOL Thermal Model of 20 K Sorption Cooler Compressor Assembly

(To be used by Alcatel to simulate compressor interface with radiator)

(Pradeep Bhandari, Mauro Prina, 11-15-2001) (Phone: 818-354-7597) Modified Model

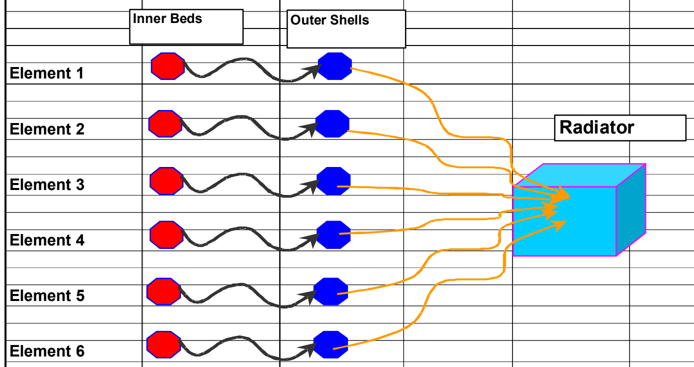
Parameter	Location	Units	Phase 1 Heatup 0-667 s	Phase 2 Desorb 667-1334 s	Phase 3 Cool 1334-2000 s	Phase 4 Absorb 2001-2667 s	Phase 5 Absorb 2668-3333 s	Phase 6 Absorb 3335-4000 s	
									← Phase / ← Cycle Time
Therm. Mass	Inner Bed	MC_p (J/K)	800	3600	930	670	690	710	
	Outer Shell	MC_p (J/K)	720	720	720	720	720	720	
Conductance	(Inner Bed to Outer Shell)	W/K	0.02	0.03	***	6.53	6.53	6.53	
Heat Input	Inner Bed	W	216	183	0	36	36	36	EOL Model
	Outer shell	W	21	21	7	7	7	7	
	Total	W							→ 469 Watts (EOL + Margin)

** see attached table

Use Table in "Gas-Gap Conductance" Workheet for values during Cool phase.

Changed thermal capacitance from last model to get better heat balance

Notes:
1) The above values are for end of life (including margin)
2) The total cycle time is 667*6 = 4000 seconds.
3) There are 6 identical beds which are of phase, by one phase width of 667 sec., with respect to each other.
4) At any time one bed is heating up, one desorbing, one cooling, and three absorbing.
5) Outer shell is thermally and structurally connected to the radiator.
6) Additonal thermal masses for items outside of the compressor elements need to be accounted for to ensure that the radiator thermal oscillations are not excessive.



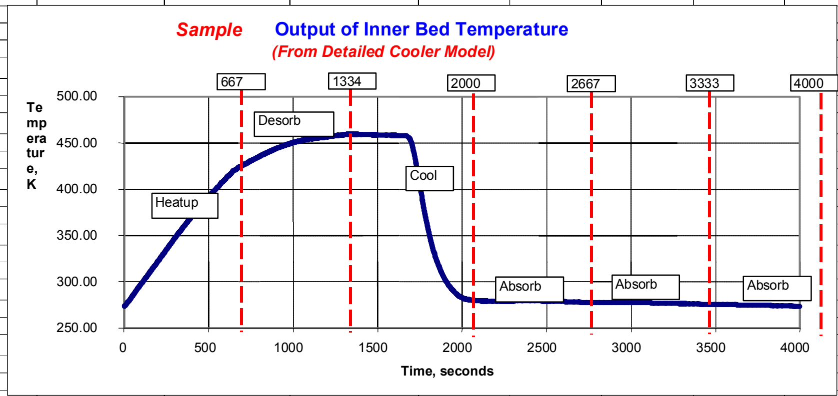


Table 5.2.2.1-2 PLANCK - Simplified EOL SCC model

Time	Gas gap Conductance	Time	Gas gap Conductance	Time	Gas gap Conductance	Time	Gas gap Conductance
[s]	[W/K]	[s]	[W/K]	[s]	[W/K]	[s]	[W/K]
0	0.0313	341	2.3479	394	6.2940	447	6.5519
286	0.0314	342	2.6215	395	6.3069	448	6.5525
289	0.0316	343	2.8875	396	6.3187	449	6.5530
291	0.0318	344	3.1393	397	6.3307	450	6.5534
292	0.0319	345	3.3734	398	6.3420	451	6.5536
293	0.0321	346	3.5880	399	6.3526	452	6.5537
294	0.0325	347	3.7832	400	6.3634	453	6.5539
295	0.0329	348	3.9600	401	6.3728	454	6.5541
296	0.0331	349	4.2804	402	6.3824	455	6.5542
297	0.0337	350	4.4133	403	6.3914	667	6.5543
298	0.0344	351	4.5360	404	6.4003		
299	0.0352	352	4.6454	405	6.4086		
300	0.0359	353	4.7481	406	6.4171		
301	0.0368	354	4.8422	407	6.4247		
302	0.0383	355	4.9295	408	6.4321		
303	0.0397	356	5.0096	409	6.4391		
304	0.0414	357	5.0853	410	6.4456		
305	0.0434	358	5.1568	411	6.4516		
306	0.0459	359	5.2245	412	6.4578		
307	0.0487	360	5.2856	413	6.4636		
308	0.0519	361	5.3454	414	6.4689		
309	0.0558	362	5.4002	415	6.4738		
310	0.0602	363	5.4532	416	6.4793		
311	0.0653	364	5.5034	417	6.4837		
312	0.0709	365	5.5503	418	6.4887		
313	0.0775	366	5.5956	419	6.4932		
314	0.0849	367	5.6379	420	6.4971		
315	0.0934	368	5.6789	421	6.5009		
316	0.1029	369	5.7178	422	6.5049		
317	0.1137	370	5.7541	423	6.5083		
318	0.1258	371	5.7893	424	6.5119		
319	0.1393	372	5.8235	425	6.5151		
320	0.1546	373	5.8553	426	6.5183		
321	0.1716	374	5.8862	427	6.5214		
322	0.1908	375	5.9163	428	6.5242		
323	0.2123	376	5.9436	429	6.5264		
324	0.2366	377	5.9708	430	6.5291		
325	0.2641	378	5.9967	431	6.5315		
326	0.2956	379	6.0219	432	6.5335		
327	0.3317	380	6.0453	433	6.5356		
328	0.3735	381	6.0680	434	6.5373		
329	0.4224	382	6.0902	435	6.5393		
330	0.4799	383	6.1119	436	6.5409		
331	0.5482	384	6.1314	437	6.5423		
332	0.6297	385	6.1514	438	6.5436		
333	0.7276	386	6.1705	439	6.5450		
334	0.8556	387	6.1886	440	6.5463		
335	0.9855	388	6.2058	441	6.5473		
336	1.1518	389	6.2216	442	6.5480		
337	1.3457	390	6.2375	443	6.5488		
338	1.5667	391	6.2526	444	6.5497		
339	1.8118	392	6.2673	445	6.5505		
340	2.0749	393	6.2808	446	6.5512		

Table 5.2.2.1-2 PLANCK - Gas gap conductance

5.2.3 Planck Heater Sizing and Breakdown

The Heater circuit breakdown with the heater power impressed on the TMM nodes is shown in Table 5.2.3-1

Table 5.2.3-1 PLANCK – Heater Circuits Breakdown and Temperature Thresholds

Heater line	TCS ID	HEATER's location	Heaters on Node	Power on node [W]	Power line @27 V [W]	ENABLED in NOMINAL	ENABLED in SURVIVAL	Threshold Nom. [°C]	Threshold Surv. [°C]
TCS Line 01	HTR5427S	close to STR 1	5481	1.175	4.70	NO	YES	N/A	-29/-26
			5482	1.175					
			5483	1.175					
			5484	1.175					
TCS Line 02	HTR5527S	close to STR 2	5581	1.175	4.70	NO	YES	N/A	-29/-26
			5582	1.175					
			5583	1.175					
			5584	1.175					
TCS Line 03	HTR13S	close to DPU1	6026	11.39	22.78	NO	YES	N/A	-19/-16
			6044	11.39					
TCS Line 04	HTR14S	close to DPU2	6047	11.39	22.78	NO	YES	N/A	-19/-16
			6029	11.39					
TCS Line 05	HTR205S	close to REU	6248	15.51	62.00	NO	YES	N/A	-19/-16
			6245	15.51					
			6232	15.51					
			6229	15.51					
TCS Line 06	HTR220S	close to CEU, CCU			51.92	NO	YES	N/A	-18/-15
			6215	15.51					
			6210	15.855					
			6211	15.855					
			6218	2.35					
			6219	2.35					
TCS Line 07		on Heat Pipes	802	26.00	78.00	YES	YES	-13/-12	-13/-12
			805	26.00					
			808	26.00					
TCS Line 08		on Heat Pipes	851	26.00	78.00	YES	YES	-14/-13	-14/-13
			854	26.00					
			857	26.00					
TCS Line 09		on Heat Pipes	801	6.5	91	YES	YES	-15/-14	-15/-14
			803	6.5					
			804	26.00					
			806	26.00					
			807	26.00					
TCS Line 10		on Heat Pipes	852	6.5	91	YES	YES	-16/-15	-16/-15
			853	6.5					
			855	26.00					
			856	26.00					
			858	26.00					
TCS Line 11		on Heat Pipes	802	6.5	91	YES	YES	-17/-16	-17/-16
			852	6.5					
			855	26.00					
			806	26.00					
			808	26.00					

Heater line	TCS ID	HEATER's location	Heaters on Node	Power on node [W]	Power line @27 V [W]	ENABLED in NOMINAL	ENABLED in SURVIVAL	Threshold Nom. [°C]	Threshold Surv. [°C]
TCS Line 12		on Heat Pipes	851	6.5	91	YES	YES	-18/-17	-18/-17
			803	6.5					
			807	26.00					
			857	26.00					
			858	26.00					
TCS Line 13		on Heat Pipes	801	6.5	91	YES	YES	-19/-18	-19/-18
			853	6.5					
			804	26.00					
			854	26.00					
			856	26.00					
TCS Line 14	HTR910 NS	on Helium TANKS	910	1.54	3.08	YES	YES	-9/-6	-19/-16
			900	0.77					
			905	0.77					
TCS Line 15	HTR522S	close to PAU	598	8.1	8.1	NO	YES	N/A	-19/-16
TCS Line 16	HTR203S	close to CRU (4K Pre Reg)	5152	8.1 + 4.7	12.8	NO	YES	N/A	-19/-16
TCS Line 21	HTR920 NS	on TANK +Z+Y	920	6.17	6.17	YES	YES	11/14	14/17
TCS Line 22	HTR925 NS	on TANK +Z-Y	925	6.17	6.17	YES	YES	11/14	14/17
TCS Line 23	HTR930 NS	on TANK -Z	930	6.17	6.17	YES	YES	11/14	14/17
TCS Line 24	HTR8508NS	on FCV A1	8508	2.35	2.35	YES	YES	14/17	14/17
TCS Line 25	HTR8608NS	on FCV A2	8608	2.35	2.35	YES	YES	14/17	14/17
TCS Line 26	HTR1133NS	on FCV D1A	1133	2.35	2.35	YES	YES	14/17	14/17
TCS Line 27	HTR1233NS	on FCV D2A	1233	2.35	2.35	YES	YES	14/17	14/17
TCS Line 28	HTR1333NS	on FCV F1A	1333	2.35	2.35	YES	YES	14/17	14/17
TCS Line 29	HTR1433NS	on FCV F2A	1433	2.35	2.35	YES	YES	14/17	14/17
TCS Line 30	HTR1533NS	on FCV U1A	1533	2.35	2.35	YES	YES	14/17	14/17
TCS Line 31	HTR1733NS	on FCV U2A	1733	2.35	2.35	YES	YES	14/17	14/17
TCS Line 32		RCS Line 1			4.9	YES	YES	19/20	19/20
TCS Line 33		RCS Line 2			3.96	YES	YES	32/33	21/22
TCS Line 34		RCS Line 3			5.27	YES	YES	28/29	20/21
TCS Line 35	HTR202S	close to CAU	6241	8.10	38.98	YES	YES	-9/-6	-19/-16
			6225	11.39					
			6243	8.10					
			6227	11.39					
TCS Line 36	HTR103S	close to REBA1, REBA2	6145	11.39	22.78	NO	YES	N/A	-29/-26
			6133	11.39					
TCS Line 37	HTR703S	inside BATTERY	703	14.90	14.90	NO	YES	1/4	1/4
TCS Line 38	HTR8708NS	on FCV B1	8708	2.35	2.35	YES	YES	14/17	14/17
TCS Line 39	HTR8808NS	on FCV B2	8808	2.35	2.35	YES	YES	14/17	14/17
TCS Line 40	HTR1134NS	on FCV D1B	1134	2.35	2.35	YES	YES	14/17	14/17
TCS Line 41	HTR1234NS	on FCV D2B	1234	2.35	2.35	YES	YES	14/17	14/17
TCS Line 42	HTR1334NS	on FCV F1B	1334	2.35	2.35	YES	YES	14/17	14/17
TCS Line 43	HTR1434NS	on FCV F2B	1434	2.35	2.35	YES	YES	14/17	14/17
TCS Line 44	HTR1534NS	on FCV U1B	1534	2.35	2.35	YES	YES	14/17	14/17
TCS Line 45	HTR1734NS	on FCV U2B	1734	2.35	2.35	YES	YES	14/17	14/17
TCS Line 46		RCS Line 4			4.03	YES	YES	35/36	22/23
TCS Line 47		RCS Line 5			3.78	YES	YES	29/30	20/21
TCS Line 48		RCS Line 6			3.27	YES	YES	19/20	20/21

5.2.4 Thermal stability

The PLANCK thermal stability requirements (ITP-220-P and ITP-230-P) relevant to Spectral Density (SD) and Fourier transform amplitude has been calculated as described below.

The software used is MathCad and the Fourier transform is computed as follow:

$$S_j = \frac{1}{\sqrt{N+1}} \sum_{k=0}^{N} s_K e^{\frac{2\pi ijk}{(N+1)}}$$

(Note: the normalisation

$$\frac{1}{\sqrt{N+1}}$$

is that utilised by MathCad for the computation of the discrete Fourier transform.)

The Power Spectral Density (PSD_{sj}) is computed as follow:

$$PSD_{sj} = 2\frac{\left|S_j\right|^2}{N+1} t_{\max} = 2N\Delta t \frac{\left|S_j\right|^2}{N+1}$$

The measurement unit of the PSD is [K^2/Hz], and consequently the SD_{sj} , to be used for the verification of the ITP-230-P, is:

$$SD_{sj} = \sqrt{PSD_{s,j}} = \sqrt{2N\Delta t} \frac{\left|S_j\right|}{\sqrt{N+1}}$$

with a measurement unit [$K/Hz^{1/2}$].
The temperature time history used to compute the *SD* is 7200 s long with a sampling time of 20 s as specified in the ITP-230-P. The start time of the time history occurs at the beginning of the S/C attitude change.

Concerning the amplitude of the Fourier Transform to be used for the verification of the ITP-220-P, the following applies.
Giving the Fourier transform (S_j) computed as above the amplitude is:

$$\text{amplitude\_S}_j := \frac{\left|S_j\right|}{\sqrt{N+1}} \cdot 2$$

The measurement unit of the Fourier Transform Amplitude is [K].
The temperature time history used to compute the Fourier Transform Amplitude is 16008 s long (4 SCC complete cycle (4002s each one)) with a sampling time of 1 s. The start time of the time history occurs at the beginning of the S/C attitude change.

5.2.5 Planck thermal analysis results

5.2.5.1 Transient nominal results

The temperature results of transient nominal analysis are reported in the table 5.2.5.1-1. The Table contains for the main S/L items, the relevant TMM node, its description, the uncertainty applied, the temperature results in the transient nominal analysis with the minimum values reported for the Cold cases and the maximum values reported for the Hot cases, the temperature with the relative uncertainty applied, the heater enabled according to the case analysed, identified by the "h" reported near the temperature value, the operative and non operative limits. All the temperatures are in degree Celsius.
The temperature uncertainty used is the one evaluated and reported in AD21 except for the following:

- In Cold cases (A1,A2,A3 and C) uncertainty are not applied to the units controlled by heaters
- In Hot cases (B1 and B2) uncertainty on SCC nodes is not applied due to the operating heater control also in these cases.

For RCS nodes, the uncertainty is always applied (both in hot and cold cases), and a value of 8°C has been assumed.

Table 5.2.5.1 PLANCK – Units Temperature Results

															TEMPERATURE LIMIT			
NODE	LABEL	UFP	CASE A1	CASE A2	CASE A3	CASE C	CASE B1	CASE B2	CASE A1	CASE A2	CASE A3	CASE C	CASE B1	CASE B2	**MIN**	**MAX**	**MIN**	**MAX**
			Min	Min	Min	Min	Max	Max	Tmin - UFP	Tmin - UFP	Tmin - UFP	Tmin - UFP	Tmax +UFP	Tmax +UFP	**OPER.**	**OPER.**	**N.OPER**	**N.OPER**
5427	STR_MY -X FOOT	9.2	17.0	15.6	14.5	-29.0	21.7	21.8	7.8	6.4	5.3	-29.0 h	30.9	31.0	**-20.0**	**40.0**	**-30.0**	**50.0**
5428	STR_MY +Y FOOT	9.2	17.0	15.6	14.5	-29.2	21.8	21.8	7.8	6.4	5.3	-29.2 h	31.0	31.0	**-20.0**	**40.0**	**-30.0**	**50.0**
5429	STR_MY +X FOOT	9.2	16.8	15.4	14.3	-29.1	21.6	21.6	7.6	6.2	5.1	-29.1 h	30.8	30.8	**-20.0**	**40.0**	**-30.0**	**50.0**
5430	STR_MY -Y FOOT	9.2	16.9	15.5	14.4	-29.2	21.7	21.7	7.7	6.3	5.2	-29.2 h	30.9	30.9	**-20.0**	**40.0**	**-30.0**	**50.0**
5527	STR_PY -X FOOT	7.3	-14.4	-15.9	-18.8	-29.0	-9.2	-9.2	-21.7	-23.2	-26.1	-29.0 h	-1.9	-1.9	**-20.0**	**40.0**	**-30.0**	**50.0**
5528	STR_PY +Y FOOT	7.3	-14.4	-16.0	-18.9	-29.0	-9.3	-9.3	-21.7	-23.3	-26.2	-29.0 h	-2.0	-2.0	**-20.0**	**40.0**	**-30.0**	**50.0**
5529	STR_PY +X FOOT	7.3	-14.5	-16.0	-18.9	-29.0	-9.3	-9.3	-21.8	-23.3	-26.2	-29.0 h	-2.0	-2.0	**-20.0**	**40.0**	**-30.0**	**50.0**
5530	STR_PY -Y FOOT	7.2	-14.4	-16.0	-18.9	-29.0	-9.3	-9.3	-21.6	-23.2	-26.1	-29.0 h	-2.1	-2.1	**-20.0**	**40.0**	**-30.0**	**50.0**
13	DPU1	8.1	**6.9**	**5.2**	**2.5**	-19.1	**12.2**	**12.2**	-1.2	-2.9	-5.6	-19.1 h	20.3	20.3	**-10.0**	**40.0**	**-20.0**	**50.0**
14	DPU2	7.6	-4.6	-6.6	-7.8	-19.0	0.9	0.9	-12.2	-14.2	-15.4	-19.0 h	8.5	8.5	**-10.0**	**40.0**	**-20.0**	**50.0**
101	DCCU	8	**13.2**	**11.2**	**9.7**	-16.2	**19.4**	**19.4**	5.2	3.2	1.7	-24.2	27.4	27.4	**-10.0**	**40.0**	**-20.0**	**50.0**

NODE	LABEL	UFP	CASE A1 Min	CASE A2 Min	CASE A3 Min	CASE C Min	CASE B1 Max	CASE B2 Max	CASE A1 Tmin - UFP	CASE A2 Tmin - UFP	CASE A3 Tmin - UFP	CASE C Tmin - UFP	CASE B1 Tmax +UFP	CASE B2 Tmax +UFP	**TEMPERATURE LIMIT** **MIN OPER.**	**MAX OPER.**	**MIN N.OPER**	**MAX N.OPER**
102	REBA1	8.5	**28.3**	**26.8**	**23.5**	-25.3	**33.8**	**33.9**	19.8	18.3	15.0	-25.3 h	42.3	42.4	**-20.0**	**50.0**	**-30.0**	**50.0**
103	REBA2	7.8	-3.9	-5.7	-8.5	-29.0	2.2	2.3	-11.7	-13.5	-16.3	-29.0 h	10.0	10.1	**-20.0**	**50.0**	**-30.0**	**50.0**
104	FOG (GEU)	8.3	**26.3**	**24.5**	**15.4**	-16.2	**37.2**	**37.2**	18.0	16.2	7.1	-24.5	45.5	45.5	**0.0**	**45.0**	**-40.0**	**75.0**
105	FOG (ICU)	8	11.1	9.1	5.1	-17.7	18.6	18.6	3.1	1.1	-2.9 (2)	-25.7	26.6	26.6	**0.0**	**45.0**	**-40.0**	**75.0**
202	4K CAU	8.1	**-2.4**	**-3.4**	**-3.5**	-19.3	**0.7**	**0.7**	-2.4 h	-3.4 h	-3.5 h	-19.3 h	8.8 h	8.8 h	**-10.0**	**40.0**	**-20.0**	**50.0**
203	4K CRU EX 4K PRE-REG	8.7	**28.7**	**27.1**	9.8	-17.5	**36.9**	**36.9**	20.0	18.4	1.1	-17.5 h	45.6	45.6	**-10.0**	**40.0**	**-20.0**	**50.0**
204	CEU	9.3	**27.3**	**26.2**	**25.9**	-17.3	**30.7**	**30.7**	18.0	16.9	16.6	-26.6	40.0	40.0	**-10.0**	**40.0**	**-20.0**	**50.0**
205	REU	9.2	**22.8**	**21.6**	**21.3**	-19.1	**26.2**	**26.2**	13.6	12.4	12.1	-19.1 h	35.4	35.4	**-10.0**	**40.0**	**-20.0**	**50.0**
211	4K CCU Compress.1	11	**44.6**	**43.7**	**43.6**	-10.5	**47.4**	**47.4**	33.6	32.7	32.6	-21.5	58.4	58.4				
212	4K CCU Compress.2	10.5	**39.3**	**38.4**	**38.3**	-10.8	**42.1**	**42.1**	28.8	27.9	27.8	-21.3	52.6	52.6				
219	4K CCU I/F Bracket -X	9.1	9.8	8.9	8.8	-17.5	12.7	12.7	0.7	-0.2	-0.3	-17.5 h	21.8	21.8	**-10.0**	**40.0**	**-20.0**	**40.0**
220	4K CCU I/F Bracket +X	8.6	3.9	3.1	3.0	-18.0	6.7	6.7	-4.7	-5.5	-5.7	-18.0 h	15.3	15.3	**-10.0**	**40.0**	**-20.0**	**40.0**
221	4K CCU I/F Strap -Z	9.9	23.5	22.6	22.5	-13.6	26.2	26.2	13.6	12.7	12.6	-13.6 h	36.1	36.1	**-10.0**	**40.0**	**-20.0**	**40.0**
222	4K CCU I/F Strap +Z	9.8	22.0	21.2	21.1	-14.2	24.8	24.8	12.2	11.4	11.3	-14.2 h	34.6	34.6	**-10.0**	**40.0**	**-20.0**	**40.0**
401	SCE1	9.3	**-9.1**	**-9.1**	**-9.1**	-18.8	**-6.7**	-12.2	-9.1 h	-9.1 h	-9.1 h	-18.8 h	2.6 h	-2.9 h	**-10.0**	**40.0**	**-20.0**	**50.0**
402	SCE2	9.3	-13.9	-14.0	-13.9	-18.4	-11.6	**-7.8**	-13.9 h	-14.0 h	-13.9 h	-18.4 h	-2.3 h	1.5 h	**-10.0**	**40.0**	**-20.0**	**50.0**
519	BEU	9.2	**9.6**	0.4	**3.6**	-12.0	**25.0**	**25.0**	0.4	-8.8	-5.7	-21.2	34.2	34.2	**-20.0**	**40.0**	**-30.0**	**50.0**
520	BEU	9.3	**8.2**	-6.3	**4.2**	-16.9	**20.2**	**20.2**	-1.1	-15.6	-5.1	-26.2	29.5	29.5	**-20.0**	**40.0**	**-30.0**	**50.0**
521	BEU	9.2	**11.3**	0.0	**8.0**	-10.5	**26.7**	**26.7**	2.1	-9.2	-1.3	-19.7	35.9	35.9	**-20.0**	**40.0**	**-30.0**	**50.0**
522	PAU	8.6	**14.6**	**10.2**	-3.3	-13.5	**23.3**	**23.4**	6.0	1.6	-11.9	-13.5 h	31.9	32.0	**-10.0**	**30.0**	**-20.0**	**50.0**
525	DAE POWER BOX	8.1	**24.8**	12.7	**21.9**	1.2	**32.1**	**32.2**	16.7	4.6	13.8	-6.9	40.2	40.3	**-20.0**	**50.0**	**-30.0**	**50.0**
551	CRS3	8.5	**18.6**	**17.0**	**17.0**	**24.9**	**29.7**	**29.9**	10.1	8.5	8.5	16.4	38.2	38.4	**0.0**	**50.0**	**-25.0**	**55.0**
601	XPND_1	8.3	**13.3**	**11.9**	**11.9**	**17.1**	**21.3**	**21.4**	5.0	3.6	3.6	8.8	29.6	29.7	**-10.0**	**50.0**	**-20.0**	**60.0**
602	XPND_2	7.9	**3.9**	**2.4**	**2.4**	**6.5**	**11.6**	**11.7**	-4.0	-5.5	-5.5	-1.4	19.5	19.6	**-10.0**	**50.0**	**-20.0**	**60.0**
603	TWTA_1	8.8	-10.2	-11.8	-11.8	**28.4**	31.6	31.7	-19.0	-20.6	-20.6	19.6	40.4	40.5	**-20.0**	**60.0**	**-30.0**	**70.0**

															TEMPERATURE LIMIT			
NODE	LABEL	UFP	CASE A1	CASE A2	CASE A3	CASE C	CASE B1	CASE B2	CASE A1	CASE A2	CASE A3	CASE C	CASE B1	CASE B2	**MIN**	**MAX**	**MIN**	**MAX**
			Min	Min	Min	Min	Max	Max	Tmin - UFP	Tmin - UFP	Tmin - UFP	Tmin - UFP	Tmax +UFP	Tmax +UFP	**OPER.**	**OPER.**	**N.OPER**	**N.OPER**
604	TWTA_2	7.7	-11.3	-12.9	-12.8	1.0	4.5	4.6	-19.0	(1) -20.6	-20.5	-6.7	12.2	12.3	**-20.0**	**60.0**	**-30.0**	**70.0**
605	RFDN	7.9	-0.2	-2.0	-1.9	**12.6**	17.0	17.2	-8.1	(1) -9.9	-9.8	4.7	24.9	25.1	**-25.0**	**55.0**	**-35.0**	**65.0**
606	EPC1	8.3	**13.0**	**11.5**	**11.5**	**18.4**	**22.6**	**22.7**	4.7	3.2	3.2	10.1	30.9	31.0	**-20.0**	**60.0**	**-30.0**	**70.0**
607	EPC2	7.7	-0.9	-2.4	-2.4	4.5	8.8	8.9	-8.6	-10.1	-10.1	-3.3	16.5	16.6	**-20.0**	**60.0**	**-30.0**	**70.0**
701	CDMU	8.1	**15.8**	**14.2**	**14.0**	**8.3**	**20.6**	**20.6**	7.7	6.1	5.9	0.2	28.7	28.7	**-10.0**	**45.0**	**-20.0**	**55.0**
702	ACC	8	**9.3**	**7.7**	**7.6**	**1.5**	**14.0**	**14.1**	1.3	-0.3	-0.4	-6.5	22.0	22.1	**-10.0**	**45.0**	**-20.0**	**55.0**
703	BATT	8	**12.0**	**10.3**	**10.4**	**9.1**	**17.8**	**17.8**	4.0	2.3	2.4	1.1	25.8	25.8	**0.0**	**35.0**	**N/A**	**N/A**
704	PCDU	8.7	**27.8**	**26.4**	**26.5**	**17.6**	**33.3**	**33.4**	19.1	17.7	17.8	8.9	42.0	42.1	**-10.0**	**45.0**	**-20.0**	**55.0**
705	CRS1	8.6	**29.4**	**27.7**	**27.8**	**24.8**	**35.5**	**35.6**	20.8	19.1	19.2	16.2	44.1	44.2	**0.0**	**50.0**	**-25.0**	**55.0**
706	CRS2	8.7	**32.8**	**31.2**	**31.2**	**28.5**	**38.6**	**38.7**	24.1	22.5	22.5	19.8	47.3	47.4	**0.0**	**50.0**	**-25.0**	**55.0**
900	Helium Tank +Z	7.8	8.5	6.5	4.0	-11.7	14.8	14.9	8.5 h	6.5 h	4.0 h	-11.7 h	22.6 h	22.7 h	**-10.0**	**40.0**	**-20.0**	**50.0**
905	Helium Tank +Y	8.3	11.7	10.3	10.2	-11.9	16.2	16.2	11.7 h	10.3 h	10.2 h	-11.9 h	24.5 h	24.5 h	**-10.0**	**40.0**	**-20.0**	**50.0**
910	Helium Tank -Z	7.9	-9.0	-9.0	-9.0	-15.4	-6.1	-5.7	-9.0 h	-9.0 h	-9.0 h	-15.4 h	1.9 h	2.2 h	**-10.0**	**40.0**	**-20.0**	**50.0**
915	Helium Tank -Y	8	8.9	7.1	7.1	10.9	18.0	18.1	0.9	-1.0	-0.9	2.9	26.0	26.1	**-10.0**	**40.0**	**-20.0**	**50.0**
920	Prop. Tank +Y+Z Lower	8	17.0	14.0	14.0	11.1	24.5	24.5	9.0 h	14.0 h	14.0 h	11.1 h	32.5 h	32.5 h	**10.0**	**50.0**	**10.0**	**50.0**
925	Prop. Tank -Z Lower	8.1	16.2	11.9	12.8	14.0	25.3	25.4	8.1 h	11.9 h	12.8 h	14.0 h	33.4 h	33.5 h	**10.0**	**50.0**	**10.0**	**50.0**
930	Prop. Tank -Y+Z Lower	8	16.3	13.3	13.6	17.5	23.8	23.8	8.3 h	13.3 h	13.6 h	17.5 h	31.8 h	31.8 h	**10.0**	**50.0**	**10.0**	**50.0**
311	SCC1 - Outer shell1	9.9	**-11.1**	**-11.1**	**-11.1**	-18.8	**16.6**	-11.9	-11.1 h	-11.1 h	-11.1 h	-18.8 h	16.6 h	-11.9 h				
312	SCC1 - Outer shell2	9.9	**-11.1**	**-11.1**	**-11.2**	-18.8	**16.7**	-11.9	-11.1 h	-11.1 h	-11.2 h	-18.8 h	16.7 h	-11.9 h				
313	SCC1 - Outer shell3	9.9	**-11.1**	**-11.2**	**-11.1**	-18.8	**16.7**	-11.9	-11.1 h	-11.2 h	-11.1 h	-18.8 h	16.7 h	-11.9 h				
314	SCC1 - Outer shell4	9.9	**-11.1**	**-11.1**	**-11.1**	-18.8	**16.7**	-11.9	-11.1 h	-11.1 h	-11.1 h	-18.8 h	16.7 h	-11.9 h				
315	SCC1 - Outer shell5	9.9	**-11.1**	**-11.2**	**-11.2**	-18.8	**16.7**	-11.9	-11.1 h	-11.2 h	-11.2 h	-18.8 h	16.7 h	-11.9 h				
316	SCC1 - Outer shell6	9.9	**-11.1**	**-11.2**	**-11.1**	-18.8	**16.7**	-11.9	-11.1 h	-11.2 h	-11.1 h	-18.8 h	16.7 h	-11.9 h				
811	HP11 Ver. SCC1	9.7	-11.7	-11.8	-11.8	-18.8	-5.1	-11.8	-11.7 h	-11.8 h	-11.8 h	-18.8 h	-5.1 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
812	HP12 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**

NODE	LABEL	UFP	CASE A1 Min	CASE A2 Min	CASE A3 Min	CASE C Min	CASE B1 Max	CASE B2 Max	CASE A1 Tmin - UFP	CASE A2 Tmin - UFP	CASE A3 Tmin - UFP	CASE C Tmin - UFP	CASE B1 Tmax +UFP	CASE B2 Tmax +UFP	TEMPERATURE LIMIT MIN OPER.	MAX OPER.	MIN N.OPER	MAX N.OPER
813	HP13 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
814	HP14 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
815	HP15 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
816	HP16 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
817	HP17 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
818	HP18 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
819	HP19 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
820	HP20 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
821	HP21 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
822	HP22 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
823	HP23 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
824	HP24 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
825	HP25 Ver. SCC1	9.7	-11.2	-11.2	-11.2	-18.8	-3.5	-11.8	-11.2 h	-11.2 h	-11.2 h	-18.8 h	-3.5 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
826	HP26 Ver. SCC1	9.7	-11.7	-11.8	-11.8	-18.8	-5.1	-11.8	-11.7 h	-11.8 h	-11.8 h	-18.8 h	-5.1 h	-11.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
801	HP1 Hor. SCC1	9.3	-14.2	-14.3	-14.3	-19.1	-10.4	-11.8	-14.2 h	-14.3 h	-14.3 h	-19.1 h	-10.4 h	-11.8 h				
802	HP2 Hor. SCC1	9.3	-12.1	-12.2	-12.2	-18.7	-9.4	-11.7	-12.1 h	-12.2 h	-12.2 h	-18.7 h	-9.4 h	-11.7 h				
803	HP3 Hor. SCC1	9.3	-13.0	-13.1	-13.1	-18.9	-9.7	-12.4	-13.0 h	-13.1 h	-13.1 h	-18.9 h	-9.7 h	-12.4 h				
804	HP4 Hor. SCC1	9.3	-13.1	-13.2	-13.2	-19.2	-9.8	-12.5	-13.1 h	-13.2 h	-13.2 h	-19.2 h	-9.8 h	-12.5 h				
805	HP5 Hor. SCC1	9.3	-14.0	-14.0	-14.0	-19.0	-11.1	-11.9	-14.0 h	-14.0 h	-14.0 h	-19.0 h	-11.1 h	-11.9 h				
806	HP6 Hor. SCC1	9.3	-14.7	-14.8	-14.8	-18.6	-11.4	-11.0	-14.7 h	-14.8 h	-14.8 h	-18.6 h	-11.4 h	-11.0 h				
807	HP7 Hor. SCC1	9.3	-14.7	-14.7	-14.7	-18.8	-11.4	-10.9	-14.7 h	-14.7 h	-14.7 h	-18.8 h	-11.4 h	-10.9 h				
808	HP7 Hor. SCC1	9.3	-14.0	-14.0	-14.0	-18.3	-11.3	-10.5	-14.0 h	-14.0 h	-14.0 h	-18.3 h	-11.3 h	-10.5 h				
511	SCC2 - Outer shell1	9.1	-15.6	-15.6	-15.6	-17.9	-13.8	**18.6**	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	18.6 h				
512	SCC2 - Outer shell2	9.1	-15.6	-15.6	-15.6	-17.9	-13.8	**18.6**	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	18.6 h				
513	SCC2 - Outer shell3	9.1	-15.6	-15.6	-15.6	-17.9	-13.8	**18.6**	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	18.6 h				
514	SCC2 - Outer shell4	9.1	-15.6	-15.6	-15.6	-17.9	-13.8	**18.6**	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	18.6 h				

NODE	LABEL	UFP	CASE A1 Min	CASE A2 Min	CASE A3 Min	CASE C Min	CASE B1 Max	CASE B2 Max	CASE A1 Tmin - UFP	CASE A2 Tmin - UFP	CASE A3 Tmin - UFP	CASE C Tmin - UFP	CASE B1 Tmax +UFP	CASE B2 Tmax +UFP	TEMPERATURE LIMIT MIN OPER.	TEMPERATURE LIMIT MAX OPER.	TEMPERATURE LIMIT MIN N.OPER	TEMPERATURE LIMIT MAX N.OPER
515	SCC2 - Outer shell5	9.1	-15.6	-15.6	-15.6	-17.9	-13.8	**18.6**	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	18.6 h				
516	SCC2 - Outer shell6	9.1	-15.6	-15.6	-15.6	-17.9	-13.8	**18.6**	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	18.6 h				
861	HP61 Ver. SCC2	*9.7*	-15.7	-15.7	-15.7	-17.9	-13.8	-2.8	-15.7 h	-15.7 h	-15.7 h	-17.9 h	-13.8 h	-2.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
862	HP62 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
863	HP63 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
864	HP64 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
865	HP65 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
866	HP66 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
867	HP67 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
868	HP68 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
869	HP69 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
870	HP70 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
871	HP71 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
872	HP72 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
873	HP73 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
874	HP74 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
875	HP75 Ver. SCC2	*9.7*	-15.6	-15.6	-15.6	-17.9	-13.8	-1.2	-15.6 h	-15.6 h	-15.6 h	-17.9 h	-13.8 h	-1.2 h	**-13.0**	**7.0**	**-20.0**	**50.0**
876	HP76 Ver. SCC2	*9.7*	-15.7	-15.7	-15.7	-17.9	-13.8	-2.8	-15.7 h	-15.7 h	-15.7 h	-17.9 h	-13.8 h	-2.8 h	**-13.0**	**7.0**	**-20.0**	**50.0**
851	HP51 Hor. SCC2	9.1	-15.7	-15.7	-15.7	-17.1	-13.3	-7.7	-15.7 h	-15.7 h	-15.7 h	-17.1 h	-13.3 h	-7.7 h				
852	HP52 Hor. SCC2	9.1	-15.1	-15.1	-15.1	-17.8	-13.1	-7.9	-15.1 h	-15.1 h	-15.1 h	-17.8 h	-13.1 h	-7.9 h				
853	HP53 Hor. SCC2	9.1	-15.6	-15.6	-15.6	-18.3	-13.4	-8.2	-15.6 h	-15.6 h	-15.6 h	-18.3 h	-13.4 h	-8.2 h				
854	HP54 Hor. SCC2	9.1	-15.7	-15.7	-15.7	-18.5	-13.5	-8.3	-15.7 h	-15.7 h	-15.7 h	-18.5 h	-13.5 h	-8.3 h				
855	HP55 Hor. SCC2	9.1	-16.0	-16.0	-16.0	-17.5	-14.0	-8.3	-16.0 h	-16.0 h	-16.0 h	-17.5 h	-14.0 h	-8.3 h				
856	HP56 Hor. SCC2	9.1	-16.3	-16.3	-16.3	-18.9	-14.1	-7.8	-16.3 h	-16.3 h	-16.3 h	-18.9 h	-14.1 h	-7.8 h				
857	HP57 Hor. SCC2	9.1	-16.3	-16.3	-16.3	-18.1	-14.1	-7.8	-16.3 h	-16.3 h	-16.3 h	-18.1 h	-14.1 h	-7.8 h				
858	HP57 Hor. SCC2	9.1	-16.0	-16.0	-16.0	-17.9	-14.0	-7.7	-16.0 h	-16.0 h	-16.0 h	-17.9 h	-14.0 h	-7.7 h				

NODE	LABEL	UFP	CASE A1 Min	CASE A2 Min	CASE A3 Min	CASE C Min	CASE B1 Max	CASE B2 Max	CASE A1 Tmin - UFP	CASE A2 Tmin - UFP	CASE A3 Tmin - UFP	CASE C Tmin - UFP	CASE B1 Tmax +UFP	CASE B2 Tmax +UFP	TEMPERATURE LIMIT MIN OPER.	MAX OPER.	MIN N.OPER	MAX N.OPER
3931	SAS1 HOUSING	9.2	8.4	7.4	7.2	-26.7	11.3	11.4	-0.8	-1.8	-2.0	-35.9	20.5	20.6	**-70.0**	**80.0**	**-80.0**	**90.0**
3951	SAS2 HOUSING	7.5	50.0	48.3	47.8	40.6	60.3	60.4	42.5	40.8	40.3	33.1	67.8	67.9	**-70.0**	**80.0**	**-80.0**	**90.0**
3921	LGA+Y HORN	8.3	-45.1	-45.6	-45.8	**-32.4**	-43.3	-43.2	-53.4	-53.9	-54.1	-40.7	-35.0	-34.9	**-150.0**	**120.0**	**-150.0**	**120.0**
3961	LGA-Y HORN	8.2	-60.9	-61.8	-61.7	**-28.9**	-55.2	-55.1	-69.1	-70.0	-69.9	-37.1	-47.0	-46.9	**-150.0**	**120.0**	**-150.0**	**120.0**
3991	LGA-X HORN	7.2	61.3	60.3	60.3	57.7	69.9	69.9	54.1	53.1	53.1	50.5	77.1	77.1	**-150.0**	**120.0**	**-150.0**	**120.0**
3986	MGA-X SEPTUM	8.5	30.7	28.2	28.1	21.3	51.3	51.3	22.2	19.7	19.6	12.8	59.8	59.8	**-150.0**	**150.0**	**-150.0**	**150.0**
3966	SREM	8.2	**16.7**	**14.8**	**13.2**	-17.6	**22.6**	**22.7**	8.5	6.6	5.0	-25.8	30.8	30.9	**-10.0**	**50.0**	**-45.0**	**90.0**
3970	AAD_HOUSING	8.8	40.8	38.9	38.4	30.5	50.3	50.4	32.0	30.1	29.6	21.7	59.1	59.2	**-70.0**	**70.0**	**-80.0**	**80.0**
8508	1FCV BODY	7.9	14.0	14.0	13.9	13.9	15.6	15.6	14.0 h	14.0 h	13.9 h	13.9 h	23.5 h	23.5 h	**10.0**	**60.0**	**10.0**	**70.0**
8608	1FCV BODY	7.8	14.0	13.9	13.9	13.9	17.1	17.1	14.0 h	13.9 h	13.9 h	13.9 h	17.1 h	24.9 h	**10.0**	**60.0**	**10.0**	**70.0**
8708	1FCV BODY	8	14.2	14.1	14.1	14.0	20.0	20.1	14.2 h	14.1 h	14.1 h	14.0 h	28.0 h	28.1 h	**10.0**	**60.0**	**10.0**	**70.0**
8808	1FCV BODY	8	14.0	14.0	14.0	14.0	19.8	19.9	14.0 h	14.0 h	14.0 h	14.0 h	27.8 h	27.9 h	**10.0**	**60.0**	**10.0**	**70.0**
1133	FCV BODY MAIN	7.8	34.2	32.8	32.0	28.5	35.6	35.6	34.2 h	32.8 h	32.0 h	28.5 h	43.4 h	43.4 h	**10.0**	**60.0**	**10.0**	**70.0**
1134	FCV BODY REDUNDANT	7.9	32.6	31.2	30.4	23.3	34.7	34.7	32.6 h	31.2 h	30.4 h	23.3 h	42.6 h	42.6 h	**10.0**	**60.0**	**10.0**	**70.0**
1233	FCV BODY MAIN	7.6	29.8	29.6	29.6	36.4	33.1	32.6	29.8 h	29.6 h	29.6 h	36.4 h	40.7 h	40.2 h	**10.0**	**60.0**	**10.0**	**70.0**
1234	FCV BODY REDUNDANT	7.7	29.3	29.2	29.1	29.9	33.1	32.6	29.3 h	29.2 h	29.1 h	29.9 h	40.8 h	40.3 h	**10.0**	**60.0**	**10.0**	**70.0**
1333	FCV BODY MAIN	7.9	28.2	27.0	27.0	34.8	33.5	33.6	28.2 h	27.0 h	27.0 h	34.8 h	41.4 h	41.5 h	**10.0**	**60.0**	**10.0**	**70.0**
1334	FCV BODY REDUNDANT	8	29.4	28.1	28.2	29.9	33.4	33.5	29.4 h	28.1 h	28.2 h	29.9 h	41.4 h	41.5 h	**10.0**	**60.0**	**10.0**	**70.0**
1433	FCV BODY MAIN	8.1	30.2	28.9	24.9	17.8	34.1	34.1	30.2 h	28.9 h	24.9 h	17.8 h	42.2 h	42.2 h	**10.0**	**60.0**	**10.0**	**70.0**
1434	FCV BODY REDUNDANT	7.9	29.3	28.0	24.0	14.0	34.0	34.0	29.3 h	28.0 h	24.0 h	14.0 h	41.9 h	41.9 h	**10.0**	**60.0**	**10.0**	**70.0**
1533	FCV BODY MAIN	9.2	20.1	19.2	19.2	21.4	22.8	22.8	20.1 h	19.2 h	19.2 h	21.4 h	32.0 h	32.0 h	**10.0**	**60.0**	**10.0**	**70.0**
1534	FCV BODY REDUNDANT	9.3	19.9	19.0	18.9	14.0	22.6	22.6	19.9 h	19.0 h	18.9 h	14.0 h	31.9 h	31.9 h	**10.0**	**60.0**	**10.0**	**70.0**
1733	FCV BODY MAIN	8.8	14.7	14.0	14.0	36.6	20.8	21.0	14.7 h	14.0 h	14.0 h	36.6 h	29.6 h	29.8 h	**10.0**	**60.0**	**10.0**	**70.0**

															TEMPERATURE LIMIT			
NODE	LABEL	UFP	CASE A1	CASE A2	CASE A3	CASE C	CASE B1	CASE B2	CASE A1	CASE A2	CASE A3	CASE C	CASE B1	CASE B2	**MIN**	**MAX**	**MIN**	**MAX**
			Min	Min	Min	Min	Max	Max	Tmin - UFP	Tmin - UFP	Tmin - UFP	Tmin - UFP	Tmax +UFP	Tmax +UFP	**OPER.**	**OPER.**	**N.OPER**	**N.OPER**
1734	FCV BODY REDUNDANT	8.8	14.9	14.0	14.0	24.1	21.0	21.2	14.9 h	14.0 h	14.0 h	24.1 h	29.8 h	30.0 h	**10.0**	**60.0**	**10.0**	**70.0**
8001	Solar Array vs. space -X	8	108.6	108.5	108.5	109.3	118.1	118.1	100.6	100.5	100.5	101.3	126.1	126.1				
8002	Solar Array vs. space-X	7.5	106.6	106.7	106.6	108.2	118.4	118.4	99.1	99.2	99.1	100.7	125.9	125.9				
8003	Solar Array vs. space -X	8.4	107.2	107.0	107.2	108.5	117.7	117.7	98.8	98.6	98.8	100.1	126.1	126.1				
8004	Solar Array vs. space -X	8.1	108.0	108.4	108.0	109.0	117.8	117.8	99.9	100.3	99.9	100.9	125.9	125.9				
8051	Solar Array vs. space -X	8	108.3	108.3	108.3	109.0	117.8	117.8	100.3	100.3	100.3	101.0	125.8	125.8				
8052	Solar Array vs. space +X	7.6	106.4	106.5	106.4	108.0	118.1	118.1	98.8	98.9	98.8	100.4	125.7	125.7				
8053	Solar Array vs. space +X	8.4	107.0	106.7	106.9	108.3	117.5	117.5	98.6	98.3	98.5	99.9	125.9	125.9				
8054	Solar Array vs. space +X	8.1	107.7	108.2	107.7	108.8	117.6	117.6	99.6	100.1	99.6	100.7	125.7	125.7				
8301	Central Solar Array -X	7.9	114.8	114.8	114.8	115.9	121.9	121.9	106.9	106.9	106.9	108.0	129.8	129.8				
8302	Central Solar Array -X	8	114.6	114.5	114.6	115.6	121.4	121.4	106.6	106.5	106.6	107.6	129.4	129.4				
8303	Central Solar Array -X	8.1	114.2	114.6	114.2	115.3	120.8	120.8	106.1	106.5	106.1	107.2	128.9	128.9				
8304	Central Solar Array -X	7.9	114.7	114.9	114.7	115.9	121.5	121.5	106.8	107.0	106.8	108.0	129.4	129.4				
8351	Central Solar Array +X	7.9	114.6	114.6	114.6	115.7	121.7	121.7	106.7	106.7	106.7	107.8	129.6	129.6				
8352	Central Solar Array +X	8	114.4	114.3	114.3	115.4	121.2	121.2	106.4	106.3	106.3	107.4	129.2	129.2				
8353	Central Solar Array +X	8.1	114.0	114.3	114.0	115.0	120.6	120.6	105.9	106.2	105.9	106.9	128.7	128.7				
8354	Central Solar Array +X	7.9	114.5	114.7	114.4	115.7	121.3	121.3	106.6	106.8	106.5	107.8	129.2	129.2				
8101	MLI Solar Array vs. sate	27.7	8.0	7.8	7.6	4.7	11.0	11.0	-19.8	-19.9	-20.1	-23.0	38.7	38.7				
8102	MLI Solar Array vs. sate	26.9	6.0	5.9	5.9	5.7	13.1	13.0	-20.9	-21.0	-21.0	-21.2	40.0	39.9				
8103	MLI Solar Array vs. sate	27.2	5.4	5.3	5.3	6.1	12.1	12.3	-21.8	-21.9	-21.9	-21.1	39.3	39.5				
8104	MLI Solar Array vs. sate	27.3	7.7	7.5	7.5	6.1	11.0	11.0	-19.6	-19.8	-19.8	-21.2	38.3	38.3				
1801	RCS Piping - Line 4	8	30.79	30.71	30.04	19.72	34.47	34.46	22.8 h	22.7 h	22.0 h	11.7 h	42.5 h	42.5 h	**10.0**	**50.0**		
1802	RCS Piping - Line 5	8	35.94	35.51	35.37	19.45	39.88	39.81	27.9 h	27.5 h	27.4 h	11.5 h	47.9 h	47.8 h	**10.0**	**50.0**		
1803	RCS Piping - Line 5	8	30.47	30.54	30.58	21.1	31.21	31.2	22.5 h	22.5 h	22.6 h	13.1 h	39.2 h	39.2 h	**10.0**	**50.0**		
1804	RCS Piping - Line 4	8	35.26	36.2	35.45	23.35	36.54	36.51	27.3 h	28.2 h	27.5 h	15.4 h	44.5 h	44.5 h	**10.0**	**50.0**		
1805	RCS Piping - Line 3	8	27.98	27.97	27.97	19.95	29.04	29.04	20.0 h	20.0 h	20.0 h	12.0 h	37.0 h	37.0 h	**10.0**	**50.0**		

NODE	LABEL	UFP	CASE A1 Min	CASE A2 Min	CASE A3 Min	CASE C Min	CASE B1 Max	CASE B2 Max	CASE A1 Tmin - UFP	CASE A2 Tmin - UFP	CASE A3 Tmin - UFP	CASE C Tmin - UFP	CASE B1 Tmax +UFP	CASE B2 Tmax +UFP	TEMPERATURE LIMIT MIN OPER.	MAX OPER.	MIN N.OPER	MAX N.OPER
1806	RCS Piping - Line 2	8	35.78	36.35	36.2	26.5	36.38	36.37	27.8 h	28.4 h	28.2 h	18.5 h	44.4 h	44.4 h	**10.0**	**50.0**		
1809	RCS Piping - Line 2	8	31.96	31.96	31.95	20.94	33.08	33.08	24.0 h	24.0 h	24.0 h	12.9 h	41.1 h	41.1 h	**10.0**	**50.0**		
1810	RCS Piping - Line 6	8	22.84	20.97	21.69	19.03	28.23	28.28	14.8 h	13.0 h	13.7 h	11.0 h	36.2 h	36.3 h	**10.0**	**50.0**		
1811	RCS Piping - Line 6	8	24.38	22.72	23.41	21.67	30.55	30.59	16.4 h	14.7 h	15.4 h	13.7 h	38.6 h	38.6 h	**10.0**	**50.0**		
1812	RCS Piping - Line 6	8	24.02	22.27	23.18	21.69	28.84	28.89	16.0 h	14.3 h	15.2 h	13.7 h	36.8 h	36.9 h	**10.0**	**50.0**		
1813	RCS Piping - Line 6	8	26.88	25.3	26.53	26.86	30.84	30.88	18.9 h	17.3 h	18.5 h	18.9 h	38.8 h	38.9 h	**10.0**	**50.0**		
1814	RCS Piping - Line 4	8	36.33	35.96	36.78	22.27	36.29	36.28	28.3 h	28.0 h	28.8 h	14.3 h	44.3 h	44.3 h	**10.0**	**50.0**		
1815	RCS Piping - Line 4	8	34.95	34.93	34.93	21.98	36.05	36.05	27.0 h	26.9 h	26.9 h	14.0 h	44.1 h	44.1 h	**10.0**	**50.0**		
1816	RCS Piping - Line 4	8	34.62	35.22	34.47	23.21	36.25	36.23	26.6 h	27.2 h	26.5 h	15.2 h	44.3 h	44.2 h	**10.0**	**50.0**		
1817	RCS Piping - Line 3	8	29.1	29.64	29.63	26.39	30.8	30.79	21.1 h	21.6 h	21.6 h	18.4 h	38.8 h	38.8 h	**10.0**	**50.0**		
1818	RCS Piping - Line 5	8	19.36	20.81	20.82	22.31	22.04	22.18	11.4 h	12.8 h	12.8 h	14.3 h	30.0 h	30.2 h	**10.0**	**50.0**		
1819	RCS Piping - Line 6	8	26.35	25.02	25.34	24.22	31.17	31.2	18.4 h	17.0 h	17.3 h	16.2 h	39.2 h	39.2 h	**10.0**	**50.0**		
1820	RCS Piping - Line 2	8	36.41	37.04	36.95	28.64	38.12	38.1	28.4 h	29.0 h	29.0 h	20.6 h	46.1 h	46.1 h	**10.0**	**50.0**		
1821	RCS Piping - Line 3	8	27.23	29.91	29.69	28.15	23.14	23.07	19.2 h	21.9 h	21.7 h	20.2 h	31.1 h	31.1 h	**10.0**	**50.0**		
1822	RCS Piping - Line 3	8	31.9	34.22	34.01	28.17	27.78	27.73	23.9 h	26.2 h	26.0 h	20.2 h	35.8 h	35.7 h	**10.0**	**50.0**		
1823	RCS Piping - Line 2	8	32.12	32.34	32.12	21.22	36.01	36.02	24.1 h	24.3 h	24.1 h	13.2 h	44.0 h	44.0 h	**10.0**	**50.0**		
1831	RCS Piping - Line 4	8	29.33	37.32	34.41	25.4	19.07	18.54	21.3 h	29.3 h	26.4 h	17.4 h	27.1 h	26.5 h	**10.0**	**50.0**		
1832	RCS Piping - Line 4	8	28	31.65	30.26	26.65	25.58	25.14	20.0 h	23.7 h	22.3 h	18.7 h	33.6 h	33.1 h	**10.0**	**50.0**		
1841	RCS Piping - Line 5	8	22.85	23.2	23.22	23.07	24.76	24.8	14.9 h	15.2 h	15.2 h	15.1 h	32.8 h	32.8 h	**10.0**	**50.0**		
1842	RCS Piping - Line 5	8	24.23	25.27	25.29	26.09	24.43	24.46	16.2 h	17.3 h	17.3 h	18.1 h	32.4 h	32.5 h	**10.0**	**50.0**		
1843	RCS Piping - Line 5	8	19.88	21.44	21.45	22.66	22.36	22.49	11.9 h	13.4 h	13.5 h	14.7 h	30.4 h	30.5 h	**10.0**	**50.0**		
1850	PT - Line 1	8	19	18.99	18.99	18.94	21.35	21.38	11.0 h	11.0 h	11.0 h	10.9 h	29.4 h	29.4 h	**10.0**	**50.0**		
1851	LV1 - Line 1	8	19.92	19.83	20.07	24.23	22.32	22.34	11.9 h	11.8 h	12.1 h	16.2 h	30.3 h	30.3 h	**10.0**	**50.0**		
1852	LV2 - Line 1	8	19.92	19.82	20.05	24.02	22.34	22.37	11.9 h	11.8 h	12.1 h	16.0 h	30.3 h	30.4 h	**10.0**	**50.0**		
1853	LF - Line 1	8	19.85	19.72	19.95	23.04	22.37	22.4	11.9 h	11.7 h	12.0 h	15.0 h	30.4 h	30.4 h	**10.0**	**50.0**		
1854	RCS Piping - Line 3	8	31.8	33.43	32.44	20.32	28.58	28.55	23.8 h	25.4 h	24.4 h	12.3 h	36.6 h	36.6 h	**10.0**	**50.0**		

NODE	LABEL	UFP	CASE A1 Min	CASE A2 Min	CASE A3 Min	CASE C Min	CASE B1 Max	CASE B2 Max	CASE A1 Tmin - UFP	CASE A2 Tmin - UFP	CASE A3 Tmin - UFP	CASE C Tmin - UFP	CASE B1 Tmax +UFP	CASE B2 Tmax +UFP	TEMPERATURE LIMIT MIN OPER.	MAX OPER.	MIN N.OPER	MAX N.OPER
1855	RCS Piping - Line 3	8	31.53	32.89	32.04	22.39	30.15	30.12	23.5 h	24.9 h	24.0 h	14.4 h	38.2 h	38.1 h	**10.0**	**50.0**		
1856	RCS Piping - Line 3	8	31.04	32.59	31.63	19.69	28.34	28.31	23.0 h	24.6 h	23.6 h	11.7 h	36.3 h	36.3 h	**10.0**	**50.0**		
1857	RCS Piping - Line 3	8	29.36	30.97	30.65	21.04	28.82	28.79	21.4 h	23.0 h	22.7 h	13.0 h	36.8 h	36.8 h	**10.0**	**50.0**		
1859	RCS Piping - Line 3	8	30.6	31.85	31.1	22.75	29.33	29.3	22.6 h	23.9 h	23.1 h	14.8 h	37.3 h	37.3 h	**10.0**	**50.0**		
1860	RCS Piping - Line 4	8	41.92	44.54	42.96	31.96	40.99	40.91	33.9 h	36.5 h	35.0 h	24.0 h	49.0 h	48.9 h	**10.0**	**50.0**		
1861	RCS Piping - Line 4	8	39.77	41.8	40.69	28.31	39.17	39.11	31.8 h	33.8 h	32.7 h	20.3 h	47.2 h	47.1 h	**10.0**	**50.0**		
1862	RCS Piping - Line 3	8	31.19	31.78	31.74	26.87	32.87	32.85	23.2 h	23.8 h	23.7 h	18.9 h	40.9 h	40.9 h	**10.0**	**50.0**		
1863	RCS Piping - Line 5	8	36.29	35.88	35.72	19.66	39.68	39.61	28.3 h	27.9 h	27.7 h	11.7 h	47.7 h	47.6 h	**10.0**	**50.0**		
1864	RCS Piping - Line 4	8	28.22	27.83	27.85	20.93	31.6	31.62	20.2 h	19.8 h	19.9 h	12.9 h	39.6 h	39.6 h	**10.0**	**50.0**		
1865	RCS Piping - Line 6	8	25.22	23.46	23.62	19.52	29.94	29.96	17.2 h	15.5 h	15.6 h	11.5 h	37.9 h	38.0 h	**10.0**	**50.0**		
1866	RCS Piping - Line 6	8	23.88	22.14	22.93	21.07	28.8	28.85	15.9 h	14.1 h	14.9 h	13.1 h	36.8 h	36.9 h	**10.0**	**50.0**		
1867	RCS Piping - Line 5	8	28.96	28.62	28.65	19.98	30.02	30.02	21.0 h	20.6 h	20.7 h	12.0 h	38.0 h	38.0 h	**10.0**	**50.0**		
1868	RCS Piping - Line 2	8	32.26	32.24	31.89	20.45	33.82	33.82	24.3 h	24.2 h	23.9 h	12.5 h	41.8 h	41.8 h	**10.0**	**50.0**		
1869	RCS Piping - Line 3	8	29.43	29.76	29.74	22.97	29.72	29.72	21.4 h	21.8 h	21.7 h	15.0 h	37.7 h	37.7 h	**10.0**	**50.0**		
1870	RCS Piping - Line 5	8	28.78	29.17	29.2	22.12	28.07	28.04	20.8 h	21.2 h	21.2 h	14.1 h	36.1 h	36.0 h	**10.0**	**50.0**		
1871	RCS Piping - Line 5	8	29.97	30.74	30.75	23.16	30.07	30.03	22.0 h	22.7 h	22.8 h	15.2 h	38.1 h	38.0 h	**10.0**	**50.0**		
1872	RCS Piping - Line 5	8	28.42	29.35	29.35	22.29	28.72	28.68	20.4 h	21.4 h	21.4 h	14.3 h	36.7 h	36.7 h	**10.0**	**50.0**		
1873	RCS Piping - Line 5	8	28.59	28.91	28.93	22.29	29.87	29.86	20.6 h	20.9 h	20.9 h	14.3 h	37.9 h	37.9 h	**10.0**	**50.0**		
1874	RCS Piping - Line 5	8	30.97	31.54	31.57	24.58	32.05	32.03	23.0 h	23.5 h	23.6 h	16.6 h	40.1 h	40.0 h	**10.0**	**50.0**		
1875	RCS Piping - Line 5	8	29.42	30.3	30.31	26.52	29.69	29.67	21.4 h	22.3 h	22.3 h	18.5 h	37.7 h	37.7 h	**10.0**	**50.0**		
1876	RCS Piping - Line 5	8	28.13	28.89	28.89	25.71	30.01	30	20.1 h	20.9 h	20.9 h	17.7 h	38.0 h	38.0 h	**10.0**	**50.0**		
1877	RCS Piping - Line 5	8	28.13	28.89	28.89	25.71	30.01	30	20.1 h	20.9 h	20.9 h	17.7 h	38.0 h	38.0 h	**10.0**	**50.0**		
1878	RCS Piping - Line 5	8	26.93	27.5	27.49	24.7	29.09	29.08	18.9 h	19.5 h	19.5 h	16.7 h	37.1 h	37.1 h	**10.0**	**50.0**		
1879	RCS Piping - Line 5	8	26.93	27.5	27.49	24.7	29.09	29.08	18.9 h	19.5 h	19.5 h	16.7 h	37.1 h	37.1 h	**10.0**	**50.0**		
1881	RCS Piping - Line 6	8	24.21	23.45	23.62	23.64	27.05	27.09	16.2 h	15.5 h	15.6 h	15.6 h	35.1 h	35.1 h	**10.0**	**50.0**		
1882	RCS Piping - Line 6	8	20.68	20.04	20.32	20.85	23.14	23.17	12.7 h	12.0 h	12.3 h	12.9 h	31.1 h	31.2 h	**10.0**	**50.0**		

NODE	LABEL	UFP	CASE A1 Min	CASE A2 Min	CASE A3 Min	CASE C Min	CASE B1 Max	CASE B2 Max	CASE A1 Tmin - UFP	CASE A2 Tmin - UFP	CASE A3 Tmin - UFP	CASE C Tmin - UFP	CASE B1 Tmax +UFP	CASE B2 Tmax +UFP	TEMPERATURE LIMIT MIN OPER.	MAX OPER.	MIN N.OPER	MAX N.OPER
1883	RCS Piping - Line 6	8	22.11	21.69	22.21	24.71	23.65	23.67	14.1 h	13.7 h	14.2 h	16.7 h	31.7 h	31.7 h	**10.0**	**50.0**		
1884	RCS Piping - Line 6	8	18.96	18.95	18.95	19.94	20.05	20.05	11.0 h	11.0 h	11.0 h	11.9 h	28.1 h	28.1 h	**10.0**	**50.0**		
1891	RCS Piping - Line 2	8	31.35	32.33	30.28	19.59	32.06	32.04	23.4 h	24.3 h	22.3 h	11.6 h	40.1 h	40.0 h	**10.0**	**50.0**		
1892	RCS Piping - Line 2	8	30.97	32.72	31.29	27.5	29.69	29.66	23.0 h	24.7 h	23.3 h	19.5 h	37.7 h	37.7 h	**10.0**	**50.0**		
1893	RCS Piping - Line 2	8	26.51	29.27	27.01	24.01	22.88	22.83	18.5 h	21.3 h	19.0 h	16.0 h	30.9 h	30.8 h	**10.0**	**50.0**		

Note :

(1) The temperature (including uncertainty) reached by TWTA in nominal Cold Case B & C is –20.6 °C. The temperature value is obtained at the end of the 21 hours of Scientific mode (unit non operative) and it is above the switch-on temperature limit of the unit (–30°C).

(2) The temperature (including uncertainty) reached by FOG (ICU) in Cold case A3 is –2.9 °C vs a minimum operative limit of 0.°C. In this case it is possible raise the temperature above 0°C switching on at 100% the 4K CRU's heaters mounted on the same shear panel.

In Hot cases B1 and B2, the maximum temperatures reached by the HP vertical nodes 811-826 and 861-876 are higher respect to the previous analysis results. The increase of the temperature is mainly due to the increase of the Heat pipes heater thresholds in Hot cases (2°C higher), in order to have only one set of heater settings, all along the satellite lifetime and avoid different settings between BOL and EOL conditions.

Since the heaters are enabled also in hot cases (HP heater consumption in case B1 = 12.5W and in case B2 = 25.7W), the temperatures of SCC nodes (unit and HP network) are presented without uncertainty.

5.2.5.2 Change of attitude transient case results

Transient analysis cases were run to assess the thermal behaviour of the SVM when subjected to attitude change (sun from 0 deg to +10 deg on –X side). Main purpose was to verify the capability of the design to meet the stability requirements. In paragraphs 8.4 / 8.5 / 8.6 / 8.7 the temperature plots of the main units during the change of attitude transient cases P1 and Q2 are shown, with change of attittude occurring at Time =86400s. The complete temperature data are reported in AD25.

5.2.5.3 Heater Power Summary

The following table reports the heater power consumption for the transient nominal analysis cases.

Table 5.2.5.3-1 PLANCK - Heater power need

Line	NODE	Description	Installed power	A1 BOL Mode1	A2 BOL Mode2	A3 BOL Mode3	C BOL Surv	B1 EOL SCC1 on	B2 EOL8 SCC2 on
			[W]						
	TOTAL		961.88	92.43	97.98	97.66	741.32	19.14	32.23
24	8508	1FCV BODY	2.35	0.61	0.8	0.86	2.05	0	0
38	8608	1FCV BODY	2.35	0.82	1	1.07	2.07	0.35	0.33
25	8708	1FCV BODY	2.35	0	0	0	0.66	0	0
39	8808	1FCV BODY	2.35	0.23	0.58	0.57	0.66	0	0
26	1133	FCV BODY	2.35	0	0	0	0	0	0
40	1134	FCV BODY	2.35	0	0	0	0	0	0
27	1233	FCV BODY	2.35	0	0	0	0	0	0
41	1234	FCV BODY	2.35	0	0	0	0	0	0
28	1333	FCV BODY	2.35	0	0	0	0	0	0
42	1334	FCV BODY	2.35	0	0	0	0	0	0
29	1433	FCV BODY	2.35	0	0	0	0	0	0
43	1434	FCV BODY	2.35	0	0	0	0.38	0	0
30	1533	FCV BODY	2.35	0	0	0	0	0	0
44	1534	FCV BODY	2.35	0	0	0	0.33	0	0
31	1733	FCV BODY	2.35	0	0.01	0.01	0	0	0
45	1734	FCV BODY	2.35	0	0	0	0	0	0
1	5427	STR_MY -X	4.7	0	0	0	0.49	0	0
2	5527	STR_PY -X	4.7	0	0	0	0.49	0	0
3	13	DPU1	22.78	0	0	0	15.71	0	0
4	14	DPU2	22.78	0	0	0	3.02	0	0
36	103	REBA2	22.78	0	0	0	12.28	0	0
35	202	4K CAU	38.98	0	0	0	33.56	0	0
16	203	4K CRU EX 4K	12.8	0	0	0	0	0	0
6	220	4K CCU I/F	51.92	0	0	0	46.86	0	0
5	205	REU	62.04	0	0	0	40.58	0	0
15	522	PAU	8.1	0	0	0	0	0	0
37	703	BATTERY	14.9	0	0	0	0	0	0
14	910	Helium Tank	3.08	0	0.57	0.35	0	0	0
21	920	Prop. Tank	6.17	0	0	0	2.8	0	0
22	925	Prop. Tank -Z	6.17	0	0	0	2.8	0	0
23	930	Prop. Tank -Y+Z	6.17	0	0	0	2.8	0	0
7	HP7	SCC / SCE Heat	78	78	78	78	78	12.54	25.7
8	HP8	SCC / SCE Heat	78	1.71	3.97	3.75	78	0	0
9	HP9	SCC / SCE Heat	91	0	0	0	91	0	0
10	HP10	SCC / SCE Heat	91	0	0	0	91	0	0
11	HP11	SCC / SCE Heat	91	0	0	0	91	0	0
12	HP12	SCC / SCE Heat	91	0	0	0	91	0	0
13	HP13	SCC / SCE Heat	91	0	0	0	36.5	0	0
32	LINE 1	RCS LINE 1	4.9	0.26	0.4	0.48	2.78	0	0
33	LINE 2	RCS LINE 2	3.96	1.42	1.65	1.71	2.33	0.85	0.85
34	LINE 3	RCS LINE 3	5.27	2.11	2.54	2.53	4.36	0.95	0.94
46	LINE 4	RCS LINE 4	4.03	2.69	3.35	3.12	2.97	1.55	1.54
47	LINE 5	RCS LINE 5	3.78	3.32	3.73	3.73	2.44	2	1.97
48	LINE 6	RCS LINE 6	3.27	1.26	1.38	1.48	2.4	0.9	0.9

5.2.5.4 Redundancy Analysis

A series of additional analysis has been performed to verify the temperatures behaviour when the redundancy units are activated. In particular the following hot case analysis have been considered (SAA=0 deg):

Transient nominal analysis

- TT &C activation of line 2 (with – SCC2 on)
- DPU2 and REBA2 On (with – SCC2 on)
- In addition a case with both Star Tracker activated has been also performed. (with – SCC2 on)

In redundant case with both STR on, the **4K CEU** reach a temperature of 40.2°C (uncertainty included) vs 40.0° of maximum operative limit.

Table 5.2.5.4-1 PLANCK - Redundancy analysis temperature results

										TEMPERATURE LIMIT			
NODE	LABEL	UFP	STR1-2 on	TTC2 on	REBA2-DPU2 on	STR1-2 on	TTC2 on	REBA2-DPU2 on		**MIN**	**MAX**	**MIN**	**MAX**
			Max	Max	Max	Tmax+UFP	Tmax+UFP	Tmax+UFP		**OPER.**	**OPER.**	**N.OPER**	**N.OPER**
			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]		[°C]	[°C]	[°C]	[°C]
5427	STR_MY -X FOOT	9.2	24.64	21.27	22.34	33.8	30.5	31.5		**-20.0**	**40.0**	**-30.0**	**50.0**
5428	STR_MY +Y FOOT	9.2	24.80	21.3	22.35	34.0	30.5	31.6		**-20.0**	**40.0**	**-30.0**	**50.0**
5429	STR_MY +X FOOT	9.2	24.51	21.1	22.17	33.7	30.3	31.4		**-20.0**	**40.0**	**-30.0**	**50.0**
5430	STR_MY -Y FOOT	9.2	24.67	21.17	22.22	33.9	30.4	31.4		**-20.0**	**40.0**	**-30.0**	**50.0**
5414	<14> CCD HOUSING	9.2	20.21	21.67	22.71	29.4	30.9	31.9		**-20.0**	**40.0**	**-30.0**	**50.0**
5527	STR_PY -X FOOT	7.3	26.39	-9.24	-11.03	33.7	-1.9	-3.7		**-20.0**	**40.0**	**-30.0**	**50.0**
5528	STR_PY +Y FOOT	7.3	26.46	-9.3	-11.14	33.8	-2.0	-3.8		**-20.0**	**40.0**	**-30.0**	**50.0**
5529	STR_PY +X FOOT	7.3	26.23	-9.34	-11.14	33.5	-2.0	-3.8		**-20.0**	**40.0**	**-30.0**	**50.0**
5530	STR_PY -Y FOOT	7.2	26.33	-9.31	-11.14	33.5	-2.1	-3.9		**-20.0**	**40.0**	**-30.0**	**50.0**
5514	<14> CCD HOUSING	7.3	20.23	-9.39	-11.22	27.5	-2.1	-3.9		**-20.0**	**40.0**	**-30.0**	**50.0**
13	DPU1	8.1	14.17	12.21	-1.34	22.3	20.3	6.8		**-10.0**	**40.0**	**-20.0**	**50.0**
14	DPU2	7.6	2.31	0.85	13.92	9.9	8.5	21.5		**-10.0**	**40.0**	**-20.0**	**50.0**
101	DCCU	8	20.02	19.4	18.67	28.0	27.4	26.7		**-10.0**	**40.0**	**-20.0**	**50.0**
102	REBA1	8.5	34.60	33.83	7.03	43.1	42.3	15.5		**-20.0**	**50.0**	**-30.0**	**50.0**
103	REBA2	7.8	3.06	2.24	27.33	10.9	10.0	35.1		**-20.0**	**50.0**	**-30.0**	**50.0**
104	FOG (GEU)	8.3	38.32	37.18	35.28	46.6	45.5	43.6		**0.0**	**45.0**	**-40.0**	**75.0**
105	FOG (ICU)	8	19.61	18.56	20.83	27.6	26.6	28.8		**0.0**	**45.0**	**-40.0**	**75.0**
202	4K CAU	8.1	0.86	0.66	0.55	9.0	8.8	8.7		**-10.0**	**40.0**	**-20.0**	**50.0**
203	4K CRU EX 4K PRE-REG	8.7	38.22	36.86	33.88	46.9	45.6	42.6		**-10.0**	**40.0**	**-20.0**	**50.0**
204	CEU	9.3	30.94	30.7	30.52	40.2	40.0	39.8		**-10.0**	**40.0**	**-20.0**	**50.0**

NODE	LABEL	UFP	STR1-2 on	TTC2 on	REBA2-DPU2 on	STR1-2 on	TTC2 on	REBA2-DPU2 on		TEMPERATURE LIMIT MIN	MAX	MIN	MAX
			Max	Max	Max	Tmax+UFP	Tmax+UFP	Tmax+UFP		**OPER.**	**OPER.**	**N.OPER**	**N.OPER**
			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]		[°C]	[°C]	[°C]	[°C]
205	REU	9.2	26.49	26.24	26.07	35.7	35.4	35.3		**-10.0**	**40.0**	**-20.0**	**50.0**
211	4K CCU Compress.1	11	47.56	47.39	47.29	58.6	58.4	58.3					
212	4K CCU Compress.2	10.5	42.29	42.11	42.01	52.8	52.6	52.5					
219	4K CCU I/F Bracket -X	9.1	12.85	12.68	12.57	22.0	21.8	21.7		**-10.0**	**40.0**	**-20.0**	**40.0**
220	4K CCU I/F Bracket +X	8.6	6.87	6.7	6.6	15.5	15.3	15.2		**-10.0**	**40.0**	**-20.0**	**40.0**
221	4K CCU I/F Strap -Z	9.9	26.39	26.22	26.13	36.3	36.1	36.0		**-10.0**	**40.0**	**-20.0**	**40.0**
222	4K CCU I/F Strap +Z	9.8	24.98	24.81	24.71	34.8	34.6	34.5		**-10.0**	**40.0**	**-20.0**	**40.0**
401	SCE1	9.3	-12.23	-12.25	-12.24	-12.2	-12.3	-12.2		**-10.0**	**40.0**	**-20.0**	**50.0**
402	SCE2	9.3	-7.76	-7.77	-7.77	-7.8	-7.8	-7.8		**-10.0**	**40.0**	**-20.0**	**50.0**
519	BEU	9.2	25.35	25	25	34.6	34.2	34.2		**-20.0**	**40.0**	**-30.0**	**50.0**
520	BEU	9.3	20.56	20.22	20.21	29.9	29.5	29.5		**-20.0**	**40.0**	**-30.0**	**50.0**
521	BEU	9.2	27.06	26.71	26.69	36.3	35.9	35.9		**-20.0**	**40.0**	**-30.0**	**50.0**
522	PAU	8.6	23.69	23.34	23.35	32.3	31.9	32.0		**-10.0**	**30.0**	**-20.0**	**50.0**
525	DAE POWER BOX	8.1	32.68	32.13	32.2	40.8	40.2	40.3		**-20.0**	**50.0**	**-30.0**	**50.0**
551	CRS3	8.5	30.14	28.66	29.94	38.6	37.2	38.4		**0.0**	**50.0**	**-25.0**	**55.0**
601	XPND_1	8.3	21.60	10.89	21.43	29.9	19.2	29.7		**-10.0**	**45.0**	**-20.0**	**60.0**
602	XPND_2	7.9	11.99	21.72	11.81	19.9	29.6	19.7		**-10.0**	**45.0**	**-20.0**	**60.0**
603	TWTA_1	8.8	31.95	5.59	31.78	40.8	14.4	40.6		**-20.0**	**60.0**	**-30.0**	**70.0**
604	TWTA_2	7.7	4.86	29.03	4.67	12.6	36.7	12.4		**-20.0**	**60.0**	**-30.0**	**70.0**
605	RFDN	7.9	17.44	16.25	17.24	25.3	24.2	25.1		**-25.0**	**55.0**	**-35.0**	**65.0**
606	EPC1	8.3	22.94	8.71	22.76	31.2	17.0	31.1		**-20.0**	**60.0**	**-30.0**	**70.0**
607	EPC2	7.7	9.17	22.14	8.98	16.9	29.8	16.7		**-20.0**	**60.0**	**-30.0**	**70.0**
701	CDMU	8.1	21.09	20.59	21.02	29.2	28.7	29.1		**-10.0**	**45.0**	**-20.0**	**55.0**
702	ACC	8	14.53	14.01	14.54	22.5	22.0	22.5		**-10.0**	**45.0**	**-20.0**	**55.0**

NODE	LABEL	UFP	STR1-2 on	TTC2 on	REBA2-DPU2 on	STR1-2 on	TTC2 on	REBA2-DPU2 on	TEMPERATURE LIMIT MIN	MAX	MIN	MAX
			Max	Max	Max	Tmax+UFP	Tmax+UFP	Tmax+UFP	OPER.	OPER.	N.OPER	N.OPER
			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
703	BATT	8	18.18	18	18.01	26.2	26.0	26.0	**0.0**	**35.0**	**N/A**	**N/A**
704	PCDU	8.7	33.65	33.2	33.53	42.4	41.9	42.2	**-10.0**	**45.0**	**-20.0**	**55.0**
705	CRS1	8.6	35.88	35.25	35.7	44.5	43.9	44.3	**0.0**	**50.0**	**-25.0**	**55.0**
706	CRS2	8.7	39.03	38.95	38.86	47.7	47.7	47.6	**0.0**	**50.0**	**-25.0**	**55.0**
900	Helium Tank +Z	7.8	16.38	14.83	13.89	24.2	22.6	21.7	**-10.0**	**40.0**	**-20.0**	**50.0**
905	Helium Tank +Y	8.3	16.49	16.2	16.06	24.8	24.5	24.4	**-10.0**	**40.0**	**-20.0**	**50.0**
910	Helium Tank -Z	7.9	-5.67	-5.76	-5.75	2.2	2.1	2.2	**-10.0**	**40.0**	**-20.0**	**50.0**
915	Helium Tank -Y	8	18.41	17.17	18.19	26.4	25.2	26.2	**-10.0**	**40.0**	**-20.0**	**50.0**
920	Prop. Tank +Y+Z Lower	8	25.02	24.51	24.37	33.0	32.5	32.4	**10.0**	**50.0**	**10.0**	**50.0**
925	Prop. Tank -Z Lower	8.1	25.77	25.37	25.35	33.9	33.5	33.5	**10.0**	**50.0**	**10.0**	**50.0**
930	Prop. Tank -Y+Z Lower	8	24.26	23.79	23.89	32.3	31.8	31.9	**10.0**	**50.0**	**10.0**	**50.0**
311	SCC1 - Outer shell1	9.9	-11.85	-11.86	-11.85	-11.9	-11.9	-11.9				
312	SCC1 - Outer shell2	9.9	-11.85	-11.86	-11.85	-11.9	-11.9	-11.9				
313	SCC1 - Outer shell3	9.9	-11.85	-11.86	-11.85	-11.9	-11.9	-11.9				
314	SCC1 - Outer shell4	9.9	-11.85	-11.86	-11.85	-11.9	-11.9	-11.9				
315	SCC1 - Outer shell5	9.9	-11.85	-11.86	-11.85	-11.9	-11.9	-11.9				
316	SCC1 - Outer shell6	9.9	-11.85	-11.86	-11.85	-11.9	-11.9	-11.9				
811	HP11 Ver. SCC1	9.7	-11.82	-11.83	-11.83	-11.8	-11.8	-11.8	**-13.0**	**7.0**	**-20.0**	**50.0**
812	HP12 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8	**-13.0**	**7.0**	**-20.0**	**50.0**
813	HP13 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8	**-13.0**	**7.0**	**-20.0**	**50.0**
814	HP14 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8	**-13.0**	**7.0**	**-20.0**	**50.0**
815	HP15 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8	**-13.0**	**7.0**	**-20.0**	**50.0**
816	HP16 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8	**-13.0**	**7.0**	**-20.0**	**50.0**
817	HP17 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8	**-13.0**	**7.0**	**-20.0**	**50.0**

										TEMPERATURE LIMIT			
NODE	LABEL	UFP	STR1-2 on	TTC2 on	REBA2-DPU2 on	STR1-2 on	TTC2 on	REBA2-DPU2 on		**MIN**	**MAX**	**MIN**	**MAX**
			Max	Max	Max	Tmax+UFP	Tmax+UFP	Tmax+UFP		**OPER.**	**OPER.**	**N.OPER**	**N.OPER**
			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]		[°C]	[°C]	[°C]	[°C]
818	HP18 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8		**-13.0**	**7.0**	**-20.0**	**50.0**
819	HP19 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8		**-13.0**	**7.0**	**-20.0**	**50.0**
820	HP20 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8		**-13.0**	**7.0**	**-20.0**	**50.0**
821	HP21 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8		**-13.0**	**7.0**	**-20.0**	**50.0**
822	HP22 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8		**-13.0**	**7.0**	**-20.0**	**50.0**
823	HP23 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8		**-13.0**	**7.0**	**-20.0**	**50.0**
824	HP24 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8		**-13.0**	**7.0**	**-20.0**	**50.0**
825	HP25 Ver. SCC1	9.7	-11.84	-11.85	-11.84	-11.8	-11.9	-11.8		**-13.0**	**7.0**	**-20.0**	**50.0**
826	HP26 Ver. SCC1	9.7	-11.82	-11.83	-11.83	-11.8	-11.8	-11.8		**-13.0**	**7.0**	**-20.0**	**50.0**
801	HP1 Hor. SCC1	9.3	-11.78	-11.8	-11.79	-11.8	-11.8	-11.8					
802	HP2 Hor. SCC1	9.3	-11.73	-11.73	-11.73	-11.7	-11.7	-11.7					
803	HP3 Hor. SCC1	9.3	-12.36	-12.37	-12.37	-12.4	-12.4	-12.4					
804	HP4 Hor. SCC1	9.3	-12.44	-12.45	-12.45	-12.4	-12.5	-12.5					
805	HP5 Hor. SCC1	9.3	-11.94	-11.94	-11.94	-11.9	-11.9	-11.9					
806	HP6 Hor. SCC1	9.3	-11.00	-11.02	-11.01	-11.0	-11.0	-11.0					
807	HP7 Hor. SCC1	9.3	-10.91	-10.92	-10.92	-10.9	-10.9	-10.9					
808	HP7 Hor. SCC1	9.3	-10.52	-10.52	-10.52	-10.5	-10.5	-10.5					
511	SCC2 - Outer shell1	9.1	18.57	18.57	18.57	18.6	18.6	18.6					
512	SCC2 - Outer shell2	9.1	18.58	18.58	18.58	18.6	18.6	18.6					
513	SCC2 - Outer shell3	9.1	18.59	18.58	18.59	18.6	18.6	18.6					
514	SCC2 - Outer shell4	9.1	18.59	18.58	18.58	18.6	18.6	18.6					
515	SCC2 - Outer shell5	9.1	18.61	18.61	18.62	18.6	18.6	18.6					
516	SCC2 - Outer shell6	9.1	18.63	18.62	18.62	18.6	18.6	18.6					
861	HP61 Ver. SCC2	*9.7*	-2.79	-2.8	-2.8	-2.8	-2.8	-2.8		**-13.0**	**7.0**	**-20.0**	**50.0**

NODE	LABEL	UFP	STR1-2 on	TTC2 on	REBA2-DPU2 on	STR1-2 on	TTC2 on	REBA2-DPU2 on		TEMPERATURE LIMIT MIN	MAX	MIN	MAX
			Max	Max	Max	Tmax+UFP	Tmax+UFP	Tmax+UFP		OPER.	OPER.	N.OPER	N.OPER
			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]		[°C]	[°C]	[°C]	[°C]
862	HP62 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
863	HP63 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
864	HP64 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
865	HP65 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
866	HP66 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
867	HP67 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
868	HP68 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
869	HP69 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
870	HP70 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
871	HP71 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
872	HP72 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
873	HP73 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
874	HP74 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
875	HP75 Ver. SCC2	*9.7*	-1.23	-1.24	-1.24	-1.2	-1.2	-1.2		**-13.0**	**7.0**	**-20.0**	**50.0**
876	HP76 Ver. SCC2	*9.7*	-2.79	-2.8	-2.8	-2.8	-2.8	-2.8		**-13.0**	**7.0**	**-20.0**	**50.0**
851	HP51 Hor. SCC2	9.1	-7.70	-7.72	-7.72	-7.7	-7.7	-7.7					
852	HP52 Hor. SCC2	9.1	-7.90	-7.91	-7.91	-7.9	-7.9	-7.9					
853	HP53 Hor. SCC2	9.1	-8.23	-8.25	-8.24	-8.2	-8.3	-8.2					
854	HP54 Hor. SCC2	9.1	-8.33	-8.34	-8.34	-8.3	-8.3	-8.3					
855	HP55 Hor. SCC2	9.1	-8.24	-8.25	-8.25	-8.2	-8.3	-8.3					
856	HP56 Hor. SCC2	9.1	-7.80	-7.81	-7.81	-7.8	-7.8	-7.8					
857	HP57 Hor. SCC2	9.1	-7.75	-7.77	-7.76	-7.8	-7.8	-7.8					
858	HP57 Hor. SCC2	9.1	-7.65	-7.66	-7.66	-7.7	-7.7	-7.7					
3931	SAS1 HOUSING	9.2	11.56	11.34	11.2	20.8	20.5	20.4		**-70.0**	**80.0**	**-80.0**	**90.0**

NODE	LABEL	UFP	STR1-2 on	TTC2 on	REBA2-DPU2 on	STR1-2 on	TTC2 on	REBA2-DPU2 on		**TEMPERATURE LIMIT** **MIN**	**MAX**	**MIN**	**MAX**
			Max	Max	Max	Tmax+UFP	Tmax+UFP	Tmax+UFP		**OPER.**	**OPER.**	**N.OPER**	**N.OPER**
			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]		[°C]	[°C]	[°C]	[°C]
3951	SAS2 HOUSING	7.5	61.06	60.35	60.32	68.6	67.9	67.8		**-70.0**	**80.0**	**-80.0**	**90.0**
3921	LGA+Y HORN	8.3	-43.13	-43.25	-43.32	-34.8	-35.0	-35.0		**-150.0**	**120.0**	**-150.0**	**120.0**
3961	LGA-Y HORN	8.2	-55.01	-49.62	-55.1	-46.8	-41.4	-46.9		**-150.0**	**120.0**	**-150.0**	**120.0**
3991	LGA-X HORN	7.2	70.05	69.93	69.92	77.3	77.1	77.1		**-150.0**	**120.0**	**-150.0**	**120.0**
3986	MGA-X SEPTUM	8.5	51.59	51.31	51.29	60.1	59.8	59.8		**-150.0**	**150.0**	**-150.0**	**150.0**
3966	SREM	8.2	23.25	22.65	21.81	31.5	30.9	30.0		**-10.0**	**50.0**	**-45.0**	**90.0**
3970	AAD_HOUSING	8.8	51.12	50.35	50.31	59.9	59.2	59.1		**-70.0**	**70.0**	**-80.0**	**80.0**
8508	1FCV BODY	7.9	15.63	15.55	15.63	23.5	23.5	23.5		**10.0**	**60.0**	**10.0**	**70.0**
8608	1FCV BODY	7.8	17.05	17.08	17.04	24.9	24.9	24.8		**10.0**	**60.0**	**10.0**	**70.0**
8708	1FCV BODY	8	20.41	19.52	20.22	28.4	27.5	28.2		**10.0**	**60.0**	**10.0**	**70.0**
8808	1FCV BODY	8	20.23	19.35	20.04	28.2	27.4	28.0		**10.0**	**60.0**	**10.0**	**70.0**
1133	FCV BODY MAIN	7.8	36.51	35.55	36.67	44.3	43.4	44.5		**10.0**	**60.0**	**10.0**	**70.0**
1134	FCV BODY REDUNDANT	7.9	35.63	34.68	35.8	43.5	42.6	43.7		**10.0**	**60.0**	**10.0**	**70.0**
1233	FCV BODY MAIN	7.6	32.66	32.63	32.63	40.3	40.2	40.2		**10.0**	**60.0**	**10.0**	**70.0**
1234	FCV BODY REDUNDANT	7.7	32.58	32.55	32.55	40.3	40.3	40.3		**10.0**	**60.0**	**10.0**	**70.0**
1333	FCV BODY MAIN	7.9	33.85	35.57	33.71	41.8	43.5	41.6		**10.0**	**60.0**	**10.0**	**70.0**
1334	FCV BODY REDUNDANT	8	33.68	35.41	33.54	41.7	43.4	41.5		**10.0**	**60.0**	**10.0**	**70.0**
1433	FCV BODY MAIN	8.1	35.84	34.08	31.22	43.9	42.2	39.3		**10.0**	**60.0**	**10.0**	**70.0**
1434	FCV BODY REDUNDANT	7.9	35.72	33.97	31.13	43.6	41.9	39.0		**10.0**	**60.0**	**10.0**	**70.0**
1533	FCV BODY MAIN	9.2	22.94	22.78	22.7	32.1	32.0	31.9		**10.0**	**60.0**	**10.0**	**70.0**
1534	FCV BODY	9.3	22.72	22.56	22.48	32.0	31.9	31.8		**10.0**	**60.0**	**10.0**	**70.0**

									TEMPERATURE LIMIT			
NODE	LABEL	UFP	STR1-2 on	TTC2 on	REBA2-DPU2 on	STR1-2 on	TTC2 on	REBA2-DPU2 on	MIN	MAX	MIN	MAX
			Max	Max	Max	Tmax+UFP	Tmax+UFP	Tmax+UFP	OPER.	OPER.	N.OPER	N.OPER
			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]
	REDUNDANT											
1733	FCV BODY MAIN	8.8	21.16	20.96	21.02	30.0	29.8	29.8	**10.0**	**60.0**	**10.0**	**70.0**
1734	FCV BODY REDUNDANT	8.8	21.32	21.13	21.19	30.1	29.9	30.0	**10.0**	**60.0**	**10.0**	**70.0**
1801	RCS Piping - Line 4	8	34.40	34.45	34.44	42.4	42.5	42.4	**10.0**	**50.0**		
1802	RCS Piping - Line 5	8	37.46	39.45	39.74	45.5	47.5	47.7	**10.0**	**50.0**		
1803	RCS Piping - Line 5	8	30.91	31.16	31.2	38.9	39.2	39.2	**10.0**	**50.0**		
1804	RCS Piping - Line 4	8	36.46	36.51	36.49	44.5	44.5	44.5	**10.0**	**50.0**		
1805	RCS Piping - Line 3	8	28.82	29.04	29.04	36.8	37.0	37.0	**10.0**	**50.0**		
1806	RCS Piping - Line 2	8	35.08	36.38	35.62	43.1	44.4	43.6	**10.0**	**50.0**		
1809	RCS Piping - Line 2	8	31.98	33.08	33.08	40.0	41.1	41.1	**10.0**	**50.0**		
1810	RCS Piping - Line 6	8	27.31	28.29	28.17	35.3	36.3	36.2	**10.0**	**50.0**		
1811	RCS Piping - Line 6	8	29.67	30.64	30.45	37.7	38.6	38.5	**10.0**	**50.0**		
1812	RCS Piping - Line 6	8	27.68	28.86	28.73	35.7	36.9	36.7	**10.0**	**50.0**		
1813	RCS Piping - Line 6	8	29.36	30.81	30.61	37.4	38.8	38.6	**10.0**	**50.0**		
1814	RCS Piping - Line 4	8	36.12	36.28	36.28	44.1	44.3	44.3	**10.0**	**50.0**		
1815	RCS Piping - Line 4	8	35.97	36.05	36.05	44.0	44.1	44.1	**10.0**	**50.0**		
1816	RCS Piping - Line 4	8	36.17	36.23	36.24	44.2	44.2	44.2	**10.0**	**50.0**		
1817	RCS Piping - Line 3	8	30.11	30.79	30.81	38.1	38.8	38.8	**10.0**	**50.0**		
1818	RCS Piping - Line 5	8	22.15	21.81	22.21	30.2	29.8	30.2	**10.0**	**50.0**		
1819	RCS Piping - Line 6	8	29.39	31.21	30.83	37.4	39.2	38.8	**10.0**	**50.0**		
1820	RCS Piping - Line 2	8	37.04	38.11	37.13	45.0	46.1	45.1	**10.0**	**50.0**		
1821	RCS Piping - Line 3	8	22.29	23.09	23.18	30.3	31.1	31.2	**10.0**	**50.0**		
1822	RCS Piping - Line 3	8	27.27	27.74	27.81	35.3	35.7	35.8	**10.0**	**50.0**		

										TEMPERATURE LIMIT			
NODE	LABEL	UFP	STR1-2 on	TTC2 on	REBA2-DPU2 on	STR1-2 on	TTC2 on	REBA2-DPU2 on		**MIN**	**MAX**	**MIN**	**MAX**
			Max	Max	Max	Tmax+UFP	Tmax+UFP	Tmax+UFP		**OPER.**	**OPER.**	**N.OPER**	**N.OPER**
			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]		[°C]	[°C]	[°C]	[°C]
1823	RCS Piping - Line 2	8	32.03	36.02	35.69	40.0	44.0	43.7		**10.0**	**50.0**		
1831	RCS Piping - Line 4	8	18.14	18.57	18.57	26.1	26.6	26.6		**10.0**	**50.0**		
1832	RCS Piping - Line 4	8	25.06	25.15	25.15	33.1	33.2	33.2		**10.0**	**50.0**		
1841	RCS Piping - Line 5	8	24.80	24.78	24.83	32.8	32.8	32.8		**10.0**	**50.0**		
1842	RCS Piping - Line 5	8	24.45	23.99	24.48	32.4	32.0	32.5		**10.0**	**50.0**		
1843	RCS Piping - Line 5	8	22.46	22.11	22.52	30.5	30.1	30.5		**10.0**	**50.0**		
1850	PT - Line 1	8	20.67	21.36	20.92	28.7	29.4	28.9		**10.0**	**50.0**		
1851	LV1 - Line 1	8	21.88	22.33	21.96	29.9	30.3	30.0		**10.0**	**50.0**		
1852	LV2 - Line 1	8	21.91	22.35	21.99	29.9	30.4	30.0		**10.0**	**50.0**		
1853	LF - Line 1	8	21.94	22.38	22.03	29.9	30.4	30.0		**10.0**	**50.0**		
1854	RCS Piping - Line 3	8	27.89	28.55	28.24	35.9	36.6	36.2		**10.0**	**50.0**		
1855	RCS Piping - Line 3	8	29.44	30.12	29.85	37.4	38.1	37.9		**10.0**	**50.0**		
1856	RCS Piping - Line 3	8	27.55	28.31	28.02	35.5	36.3	36.0		**10.0**	**50.0**		
1857	RCS Piping - Line 3	8	27.68	28.79	28.76	35.7	36.8	36.8		**10.0**	**50.0**		
1859	RCS Piping - Line 3	8	28.64	29.31	29.08	36.6	37.3	37.1		**10.0**	**50.0**		
1860	RCS Piping - Line 4	8	40.87	40.93	40.95	48.9	48.9	49.0		**10.0**	**50.0**		
1861	RCS Piping - Line 4	8	39.07	39.12	39.13	47.1	47.1	47.1		**10.0**	**50.0**		
1862	RCS Piping - Line 3	8	32.52	32.86	32.88	40.5	40.9	40.9		**10.0**	**50.0**		
1863	RCS Piping - Line 5	8	37.49	39.25	39.54	45.5	47.3	47.5		**10.0**	**50.0**		
1864	RCS Piping - Line 4	8	31.55	31.8	31.61	39.6	39.8	39.6		**10.0**	**50.0**		
1865	RCS Piping - Line 6	8	29.12	29.97	29.62	37.1	38.0	37.6		**10.0**	**50.0**		
1866	RCS Piping - Line 6	8	27.86	28.86	28.7	35.9	36.9	36.7		**10.0**	**50.0**		
1867	RCS Piping - Line 5	8	29.98	30.02	30.02	38.0	38.0	38.0		**10.0**	**50.0**		
1868	RCS Piping - Line 2	8	32.96	33.83	33.05	41.0	41.8	41.1		**10.0**	**50.0**		

										TEMPERATURE LIMIT			
NODE	LABEL	UFP	STR1-2 on	TTC2 on	REBA2-DPU2 on	STR1-2 on	TTC2 on	REBA2-DPU2 on		MIN	MAX	MIN	MAX
			Max	Max	Max	Tmax+UFP	Tmax+UFP	Tmax+UFP		OPER.	OPER.	N.OPER	N.OPER
			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]		[°C]	[°C]	[°C]	[°C]
1869	RCS Piping - Line 3	8	29.48	29.72	29.73	37.5	37.7	37.7		**10.0**	**50.0**		
1870	RCS Piping - Line 5	8	27.67	28.66	28.17	35.7	36.7	36.2		**10.0**	**50.0**		
1871	RCS Piping - Line 5	8	29.46	30.48	30.14	37.5	38.5	38.1		**10.0**	**50.0**		
1872	RCS Piping - Line 5	8	27.46	29.81	28.8	35.5	37.8	36.8		**10.0**	**50.0**		
1873	RCS Piping - Line 5	8	29.18	29.46	29.98	37.2	37.5	38.0		**10.0**	**50.0**		
1874	RCS Piping - Line 5	8	31.26	30.81	32.13	39.3	38.8	40.1		**10.0**	**50.0**		
1875	RCS Piping - Line 5	8	28.35	31.56	29.74	36.3	39.6	37.7		**10.0**	**50.0**		
1876	RCS Piping - Line 5	8	28.69	31.71	30.06	36.7	39.7	38.1		**10.0**	**50.0**		
1877	RCS Piping - Line 5	8	28.69	31.71	30.06	36.7	39.7	38.1		**10.0**	**50.0**		
1878	RCS Piping - Line 5	8	27.91	30.86	29.15	35.9	38.9	37.2		**10.0**	**50.0**		
1879	RCS Piping - Line 5	8	27.91	30.86	29.15	35.9	38.9	37.2		**10.0**	**50.0**		
1881	RCS Piping - Line 6	8	26.00	27.09	27.13	34.0	35.1	35.1		**10.0**	**50.0**		
1882	RCS Piping - Line 6	8	21.95	23.17	24.03	29.9	31.2	32.0		**10.0**	**50.0**		
1883	RCS Piping - Line 6	8	22.33	23.67	24.74	30.3	31.7	32.7		**10.0**	**50.0**		
1884	RCS Piping - Line 6	8	19.08	20.05	20.07	27.1	28.1	28.1		**10.0**	**50.0**		
1891	RCS Piping - Line 2	8	31.97	32.04	29.88	40.0	40.0	37.9		**10.0**	**50.0**		
1892	RCS Piping - Line 2	8	30.18	29.66	29.18	38.2	37.7	37.2		**10.0**	**50.0**		
1893	RCS Piping - Line 2	8	25.11	22.84	21.27	33.1	30.8	29.3		**10.0**	**50.0**		
8001	Solar Array vs. space -X	8	118.07	118.06	118.06	126.1	126.1	126.1					
8002	Solar Array vs. space-X	7.5	118.35	118.35	118.35	125.9	125.9	125.9					
8003	Solar Array vs. space -X	8.4	117.71	117.72	117.71	126.1	126.1	126.1					
8004	Solar Array vs. space -X	8.1	117.84	117.84	117.83	125.9	125.9	125.9					
8051	Solar Array vs. space -X	8	117.82	117.81	117.8	125.8	125.8	125.8					
8052	Solar Array vs. space +X	7.6	118.09	118.08	118.08	125.7	125.7	125.7					

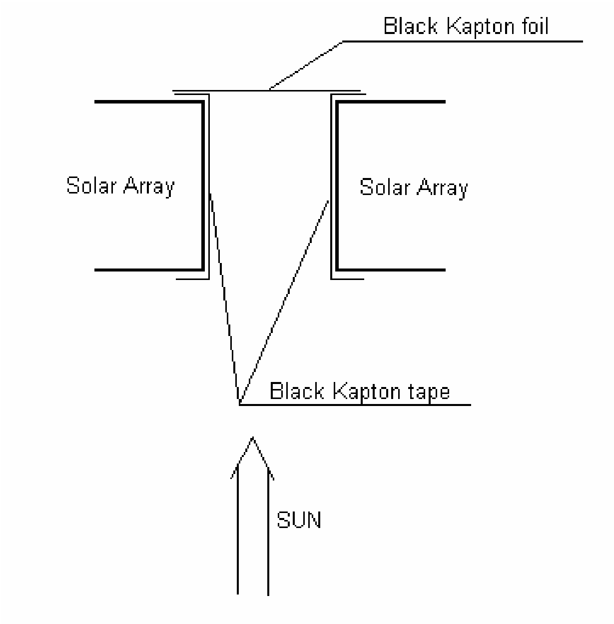
										TEMPERATURE LIMIT			
NODE	LABEL	UFP	STR1-2 on	TTC2 on	REBA2-DPU2 on	STR1-2 on	TTC2 on	REBA2-DPU2 on		MIN	MAX	MIN	MAX
			Max	Max	Max	Tmax+UFP	Tmax+UFP	Tmax+UFP		OPER.	OPER.	N.OPER	N.OPER
			[°C]	[°C]	[°C]	[°C]	[°C]	[°C]		[°C]	[°C]	[°C]	[°C]
8053	Solar Array vs. space +X	8.4	117.45	117.46	117.45	125.9	125.9	125.9					
8054	Solar Array vs. space +X	8.1	117.58	117.59	117.58	125.7	125.7	125.7					
8301	Central Solar Array -X	7.9	121.90	121.9	121.9	129.8	129.8	129.8					
8302	Central Solar Array -X	8	121.39	121.39	121.39	129.4	129.4	129.4					
8303	Central Solar Array -X	8.1	120.78	120.77	120.77	128.9	128.9	128.9					
8304	Central Solar Array -X	7.9	121.54	121.54	121.54	129.4	129.4	129.4					
8351	Central Solar Array +X	7.9	121.70	121.69	121.69	129.6	129.6	129.6					
8352	Central Solar Array +X	8	121.19	121.18	121.18	129.2	129.2	129.2					
8353	Central Solar Array +X	8.1	120.58	120.57	120.57	128.7	128.7	128.7					
8354	Central Solar Array +X	7.9	121.34	121.33	121.33	129.2	129.2	129.2					
8101	MLI Solar Array vs. sate	27.7	11.10	10.99	10.85	38.8	38.7	38.6					
8102	MLI Solar Array vs. sate	26.9	13.03	13.01	13	39.9	39.9	39.9					
8103	MLI Solar Array vs. sate	27.2	12.30	12.4	12.28	39.5	39.6	39.5					
8104	MLI Solar Array vs. sate	27.3	11.09	11.08	11.02	38.4	38.4	38.3					

5.2.5.5 Sun trapping on Solar Array

The effect of the sun trapping into the gap among the solar array panels of PLANCK, has been analyzed using a dedicated reduced model and considering the gap as a cavity.
The lateral sides of the cavity (solar array edge) have been assumed covered by black kapton tape, and the bottom of the cavity is a black kapton foil (see figure).
In this condition, considering the sun perpendicular to the cavity (SAA=0°) and in winter solstice (solar constant of 1405 W/m^2) and assuming adiabatic condition (i.e. no flux exchange to the other surfaces), the following temperature are obtained:

- Lateral sides: 106 °C
- Bottom side: 181 °C

The 181 °C maximum temperature is reached only by the bottom kapton foil and it has to be considered as a hot spot. While on the solar array lateral side the 106 °C of temperature will not be exceeded.



6. CONCLUSIONS

6.1 HERSCHEL

The following thermal interface requirements are not compliant (NC) or partially compliant (PC) with respect to the applicable requirements and are treated by dedicated RFD:

- **ITP-100-H : NC**
  For details see applicable RFD (H-P-300000-ALS-RD-0009, Issue 2) issued by ALS and approved by ASP (see CCB#72, H-P-ASP-LT-5490) with no design modification.

- **ITP-120-H : PC and ITP-130-H : PC**
  For details see applicable RFD (H-P-300000-ALS-RD-0029, Issue 1) issued by ALS and approved by ASP (see CCB#69, H-P-ASP-MN-5329) with no design modification.
  After the TMM updating, the radiative area has been optimised with the objective to decrease the overall heater power consumption. As a consequence the satellite average temperature is increased and the requirement on the truss and shield attachment points can not completely met. This requirement could be satisfied decreasing again the average temperature of satellite, but with an important impact on power budget
  Due to the limited average out of specification (25.7 °C vs 20°C and 22.8 °C vs 20°C) it is suggested to maintain the current design to avoid impact on the power budget.

- **ACP-060-H about variation around setpoint of STR : PC**
  Variation around set-point of the Herschel STR feet during the HOT CASE (EOL) is not met (0.54 vs 0.5). This out of requirement takes a time of about 4 hours after a S/C change of attitude. This remains to be addressed to OG for approval, but it is considered as a minor issue since the requirement is 0.5.

All the units are maintained within their temperature limits with the exclusion of the following:

HOT CASES (Uncertainty included)

❑ **GYRO:**	set point	63.0°C vs 55.0°C
❑ **CRS:**	case B	50.5°C vs 50.0°C
❑ **XPND:**	case B	47.8°C vs 45.0°C
❑ **TWT:**	case B	60.5°C vs 60.0°C
❑ **FHHRV**:**	case D	41.4°C vs 40.0°C
❑ **FHWEV**:**	case D	31.6°C vs 30.0°C
❑ **FHWEH**:**	case D	32.2°C vs 30.0°C
❑ **FHIFV**:** (**ITI-020-H** Temp. stability req.)		0.000861 K/s vs 0.0003 K/s (Cold case) 0.000827 K/s vs 0.0003 K/s (Hot case)

*****: Temperatures obtained using the HIFI IIDB issue 3.2. Applicability of this issue is still under discussion between ESA/ASP/ALS***

RECOVERY ACTIONS:

GYRO:

For details see RFD (H-P-300000-ALS-RD-0011, Issue 3) issued by ALS and approved by ASP (see CCB#74, H-P-ASP-MN-5553) with no design modification.

CRS:

For details see RFD (H-P-300000-ALS-RD-0014, Issue 2) issued by ALS with letter HP-ALS-04-0426 dated 17/09/04. ASP answer is still waiting. No design modifications are envisaged.

XPND:

For details see RFD (H-P-300000-ALS-RD-0015, Issue 1) issued and approved by ALS. This RFD has been also provided to ASP for information on 06/07/04 (ref. H-P-ALS-04-0322).
No design modifications are envisaged.

TWT:

For details see RFD (H-P-300000-ALS-RD-0014, Issue 2) issued with letter HP-ALS-04-0426 dated 17/09/04. No design modifications are envisaged.

Remark:

VMC unit the thermal design has been conceived considering this unit switched-on only up to the end of transfer orbit. In this condition the unit works correctly within the requested limits.
If the unit will be requested to be operative during the rest of the mission the hot case temperature reaches about 57°C (in EOL cases) vs 50°C of maximum operative limit.

6.2 PLANCK

The following thermal interface requirements are not compliant (NC) or partially compliant (PC) with respect to the applicable requirements and are treated by dedicated RFD:

- **ITP-150-P: NC**
  For details see RFD (H-P-300000-ALS-RD-0009, Issue 2) issued by ALS and approved by ASP (see CCB#72, H-P-ASP-LT-5490) with no design modification.

- **ITP-170-P: NC**
  The radiative flux between BEU/PAU radiators and PLM shield is 2.109 W if calculated without the uncertainty temperature. Considering the uncertainty temperature, as requested by ASP, the radiative flux is of 2.45W vs maximum radiative load of 2.3W.
  Based on this last analysis result a RFD (H-P-300000-ALS-RD-0010, Issue 3) has been issued by ALS and approved by ASP (see CCB#72, H-P-ASP-LT-5490) with no design modification.

- **ITP-180-P and ITP-200-P: NC**
  For details see RFD (H-P-300000-ALS-RD-0009, Issue 2) issued by ALS and approved by ASP (see CCB#72, H-P-ASP-LT-5490) with no design modification.

- **ITP-PROPELLANT TANK STABILITY: PC**
  The requirement relative to the gradient over the life of the satellite between each Propellant Tank is 1.809°C vs a maximum requested value of 1.5°C.
  No recovery actions are foreseen and w.r.t. previous value (2.08°C) a RFD (H-P-300000-ALS-RD-0030, Issue 1 has been issued and approved by ALS.
  This RFD has been also provided for info to ASP on 26/07/04 (ref. H-P-ALS-04-0370)

- **SCC Stability (Absorbing beds stability): NC**
  NC is due to the SCC High Amplitude Peak Power Dissipation and no recovery actions are envisaged.
  Request for Deviation (H-P-300000-ALS-RD-0013, Issue 4) has been issued and approved by ASP (see CCB#74, H-P-ASP-MN-5553).

All the units are maintained within their temperature limits with the exclusion of the following:

HOT CASES (Uncertainty included)

- **PAU:** case B1&B2 32.0°C vs 30.0°C

RFD to cover an out of specification equal to 1°C (T unit ≈ 31°C) has been issued and approved by ASP (see CCB#72, H-P-ASP-LT-5490) with no design modification.

- **CRU**:** case B1&B2 45.6°C vs 40.0°C
  (46.9°C when both STRs are on)

- **FOG (GEU)**:** case B1&B2 45.5°C vs 45.0°C
  (46.6°C when both STRs are on)

Remarks:** Results are obtained using new inputs provided by ESA (SCI-PT/33615, dated 02/02/05) that foreseen 4 channels switched-ON (26.8 watts dissipated).

In case only 3 channels (20.1 watts dissipated) have to be considered ON the temperatures are:

- **CRU:** 42.8°C (including 8.7°C of uncertainty). For a value equal to 41.8°C a RFD (H-P-300000-ALS-RD-0014, Issue 2) has been issued to ASP with letter HP-ALS-04-0426 dated 17/09/04.

- **FOG (GEU):** 41.1°C

As a recovery actions for both units, , ALS suggest to use FOG only with 3 channels ON

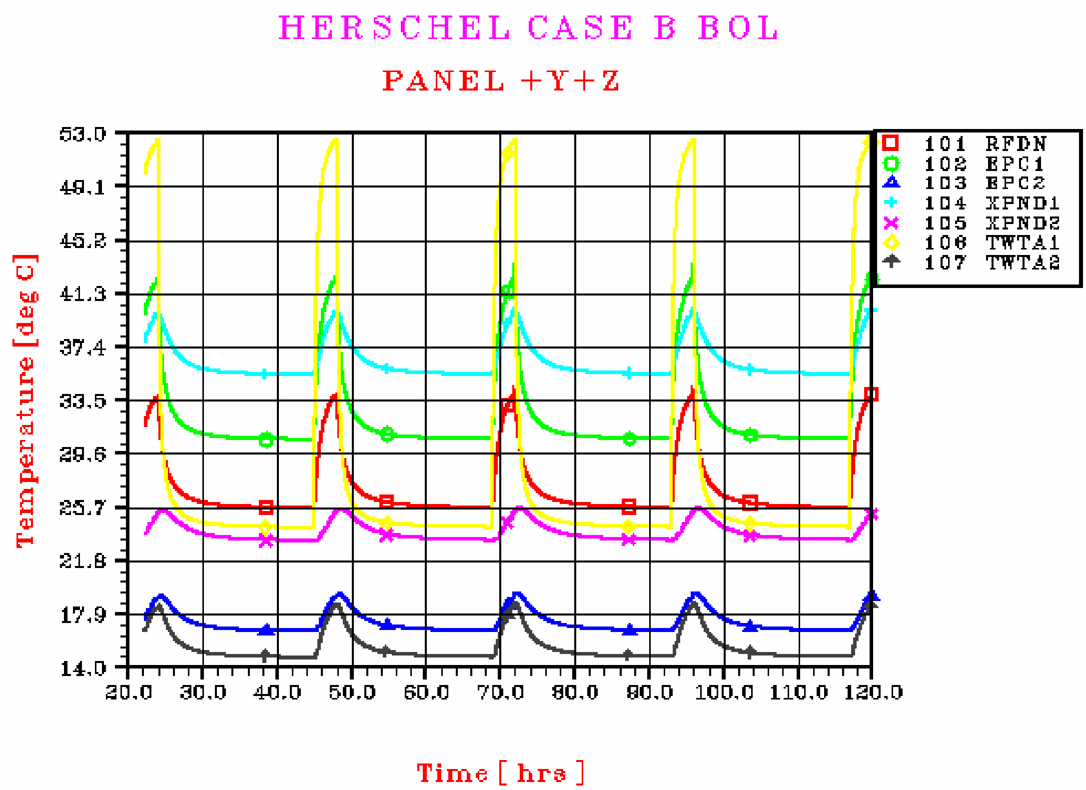
COLD CASES (Uncertainty included)

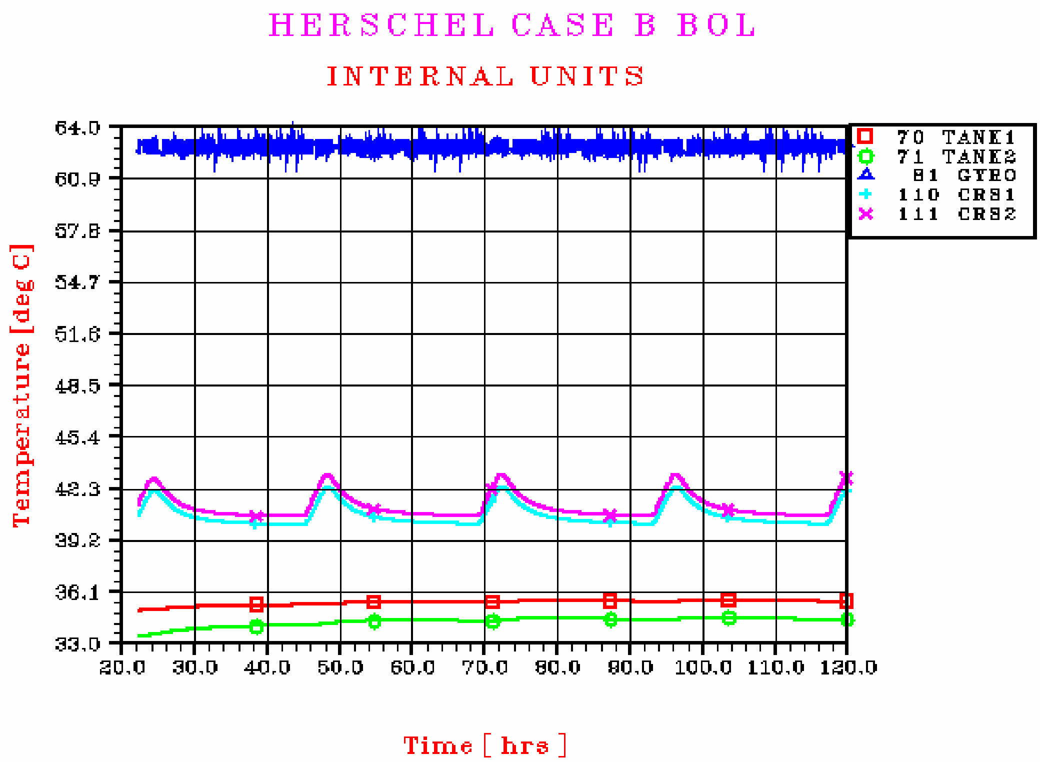
- **FOG (ICU)**** case A3 -2.9°C vs 0.0°C

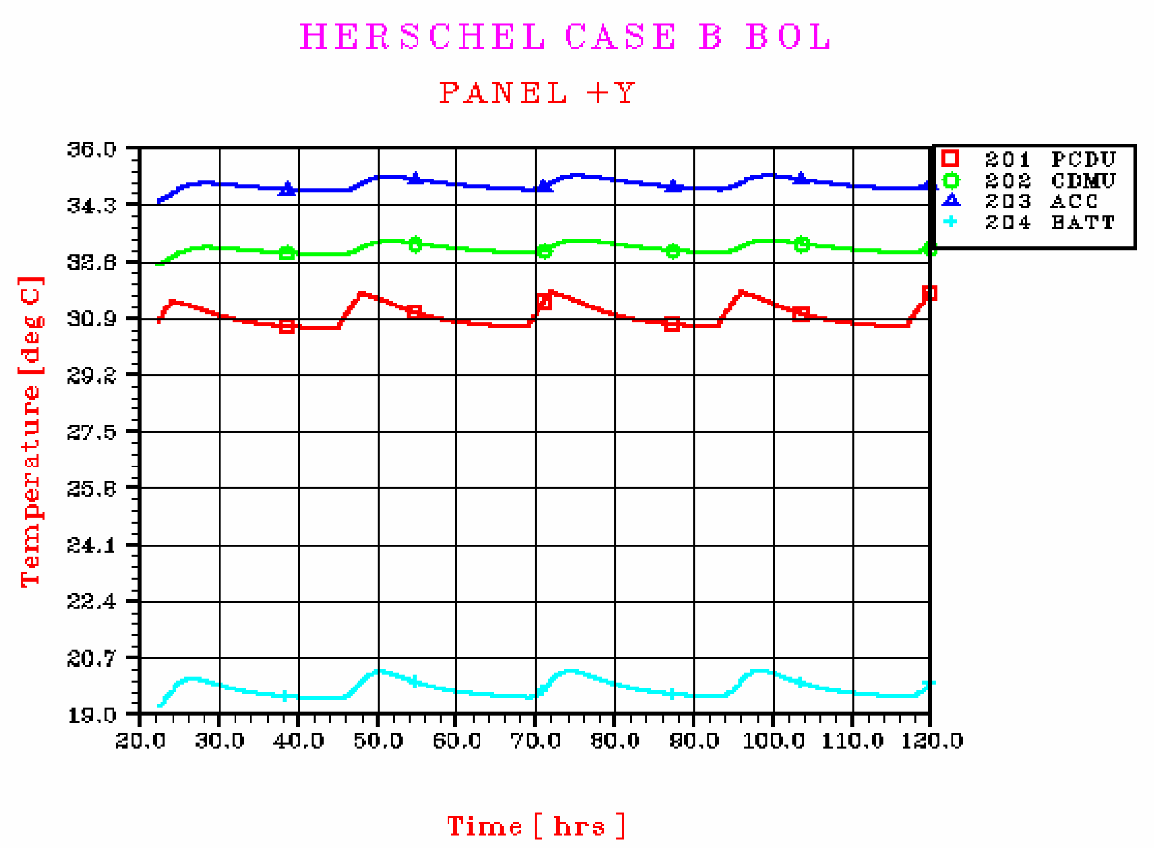
Remarks:**
These results are obtained using new inputs provided by ESA (SCI-PT/33615, dated 02/02/05) that foreseen 3 channels switched-ON (16.5 watts dissipated).
The temperature (including uncertainty) reached by FOG (ICU) in Cold case A3 is –2.9 °C vs a minimum operative limit of 0.°C. In this case it is possible raise the temperature above 0°C switching on at 100% the 4K CRU's heaters (12.8 W) mounted on the same shear panel.

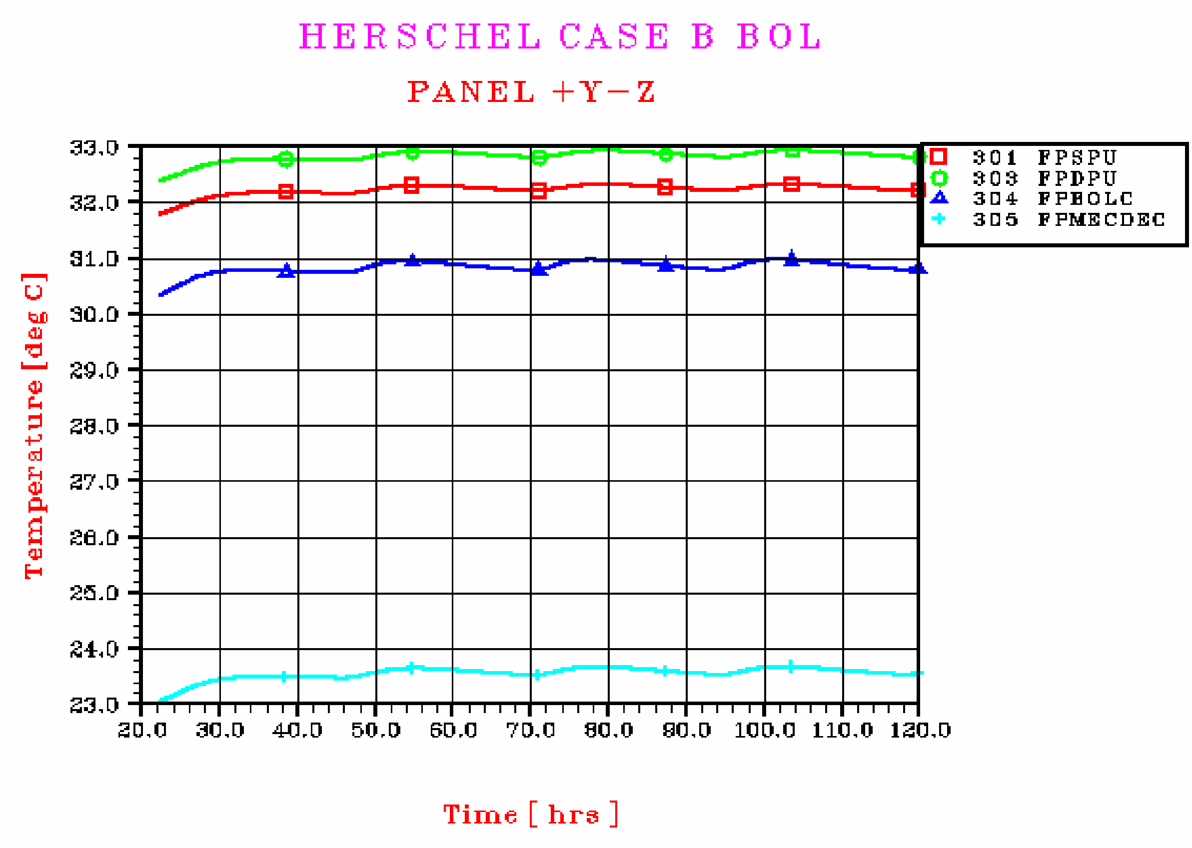
7. HERSCHEL: TEMPERATURE PLOTS

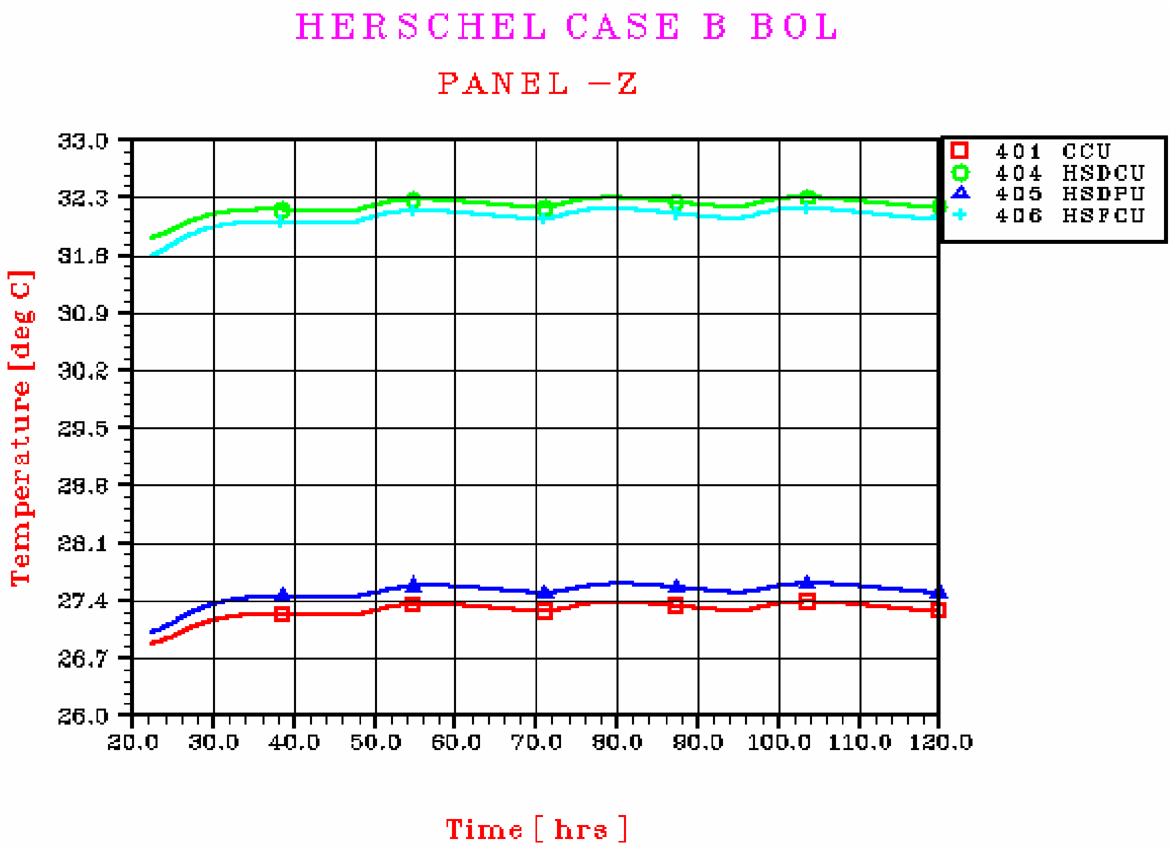
7.1 HERSCHEL RESULTS OF CASE B

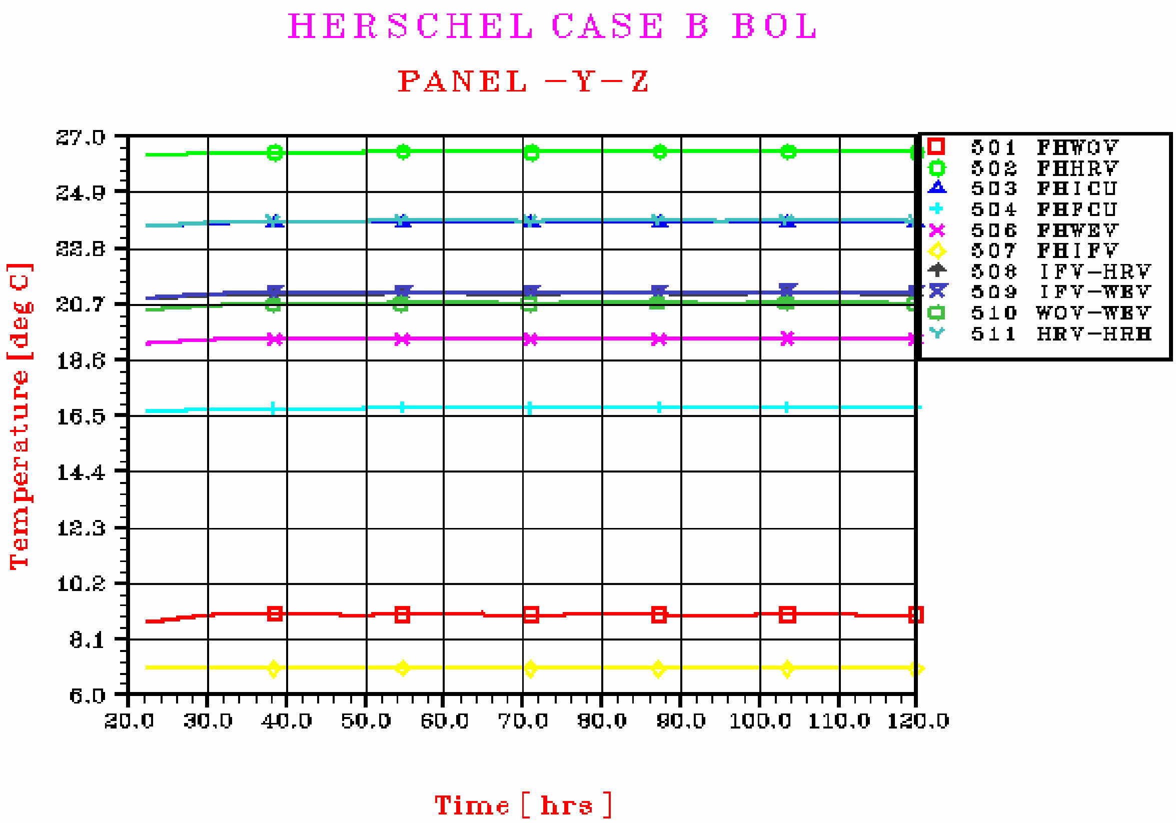


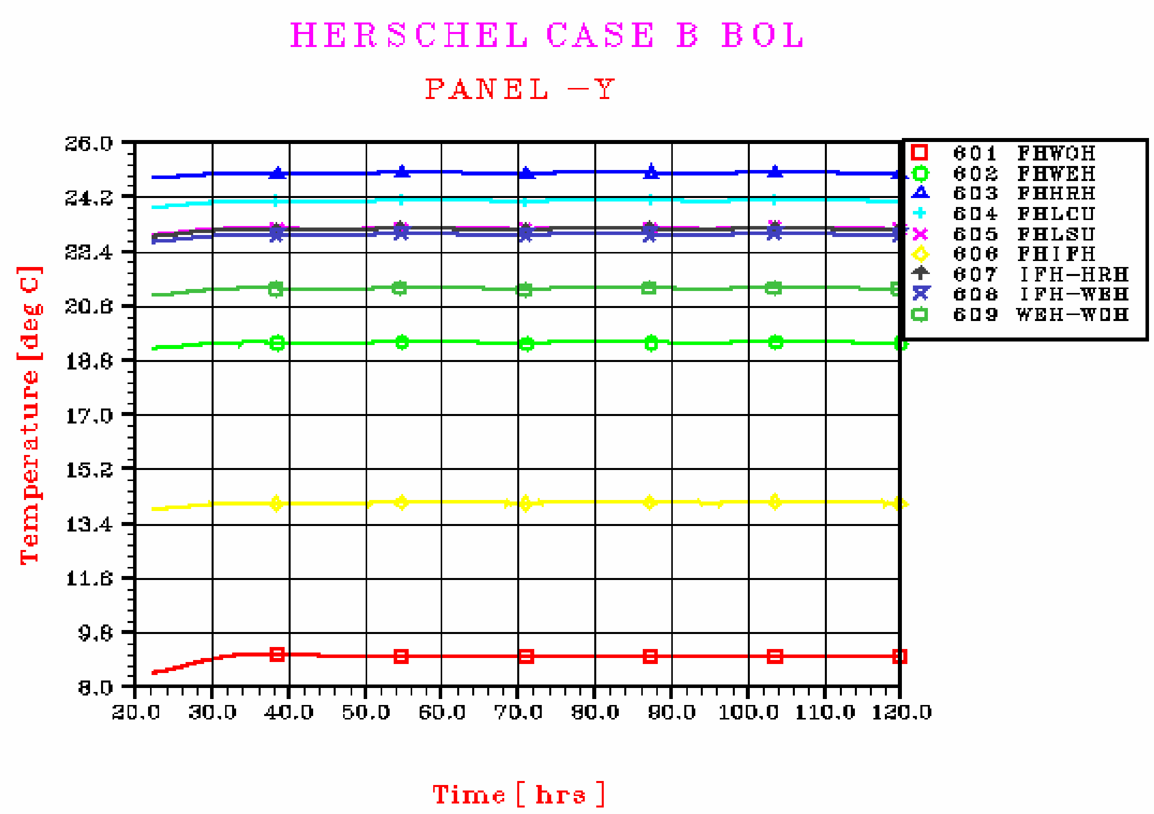


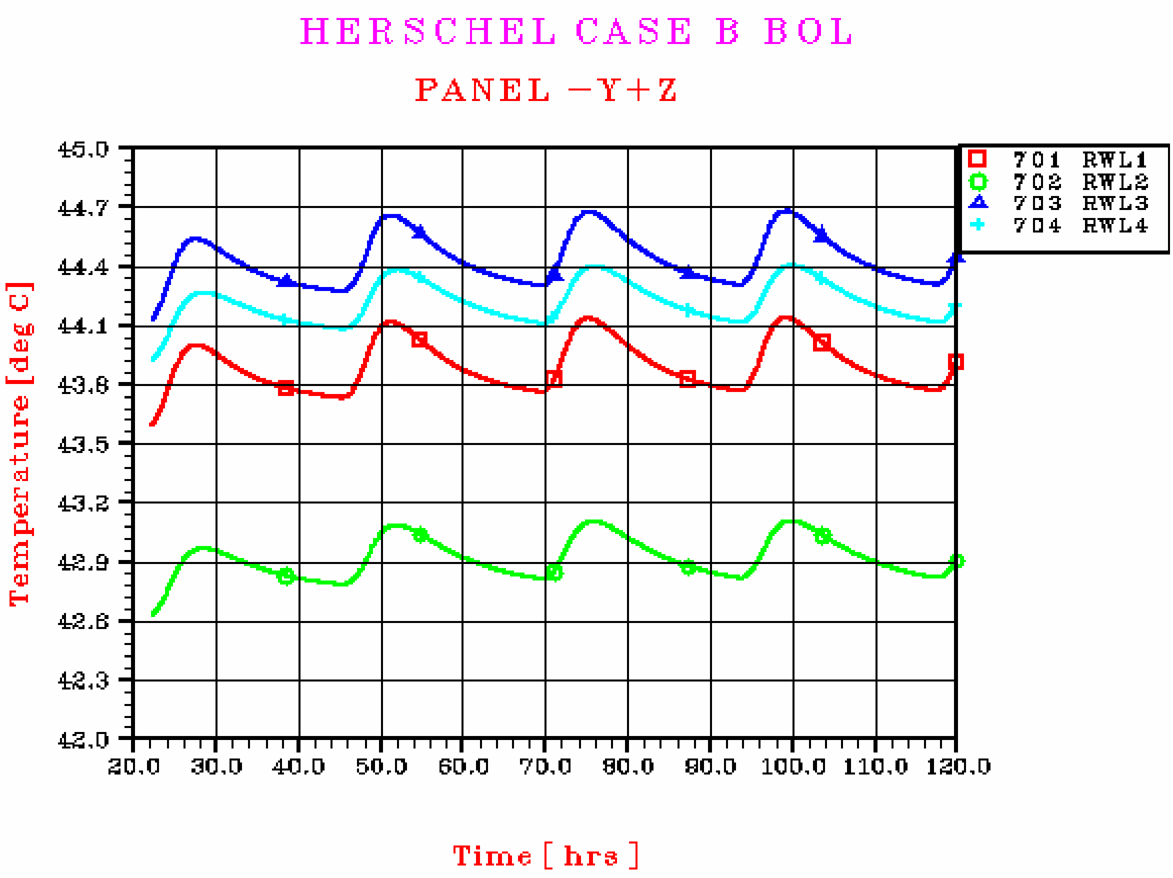

HERSCHEL CASE B BOL
PANEL +Y
Temperature [deg C]
36.0
34.3
32.6
30.9
29.2
27.5
25.8
24.1
22.4
20.7
19.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]
201 PCDU
202 CDMU
203 ACC
204 BATT

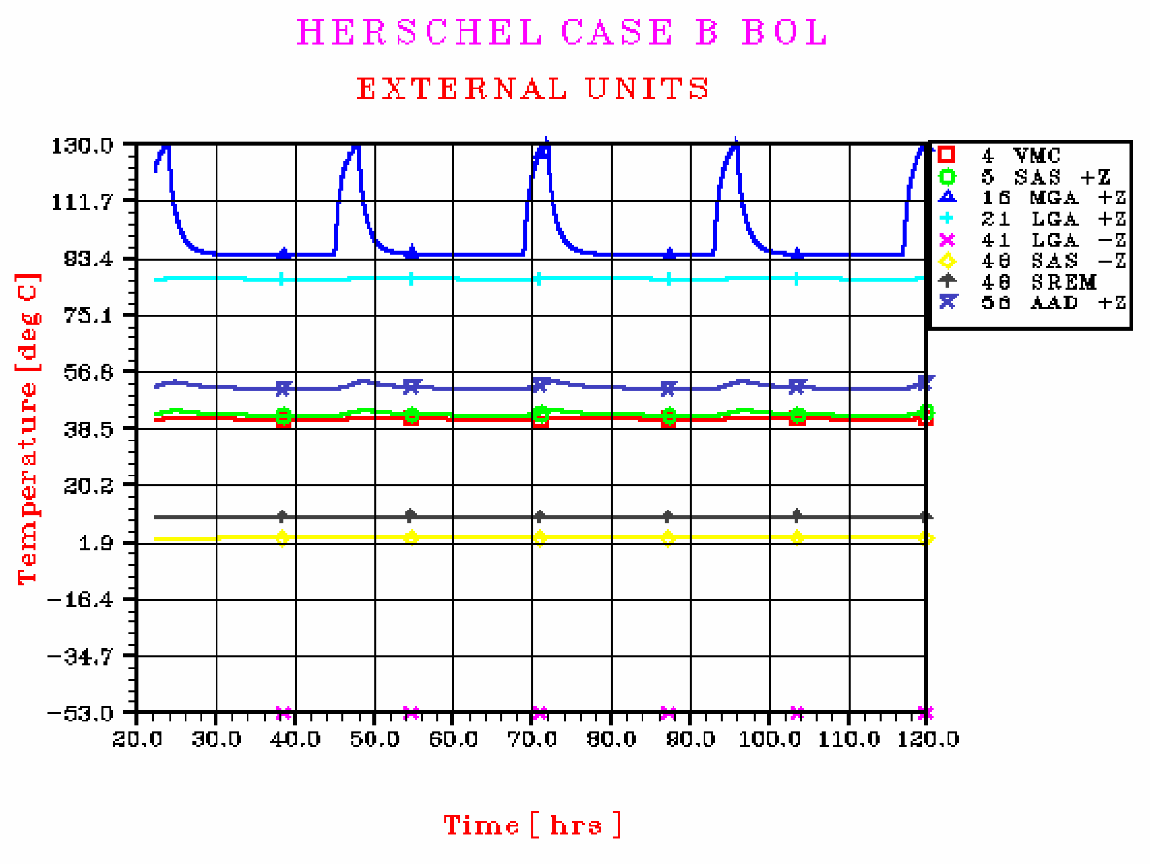

HERSCHEL CASE B BOL
PANEL +Y-Z
Temperature [deg C]
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]
301 FPSPU
303 FPDPU
304 FPBOLC
305 FPMECDEC

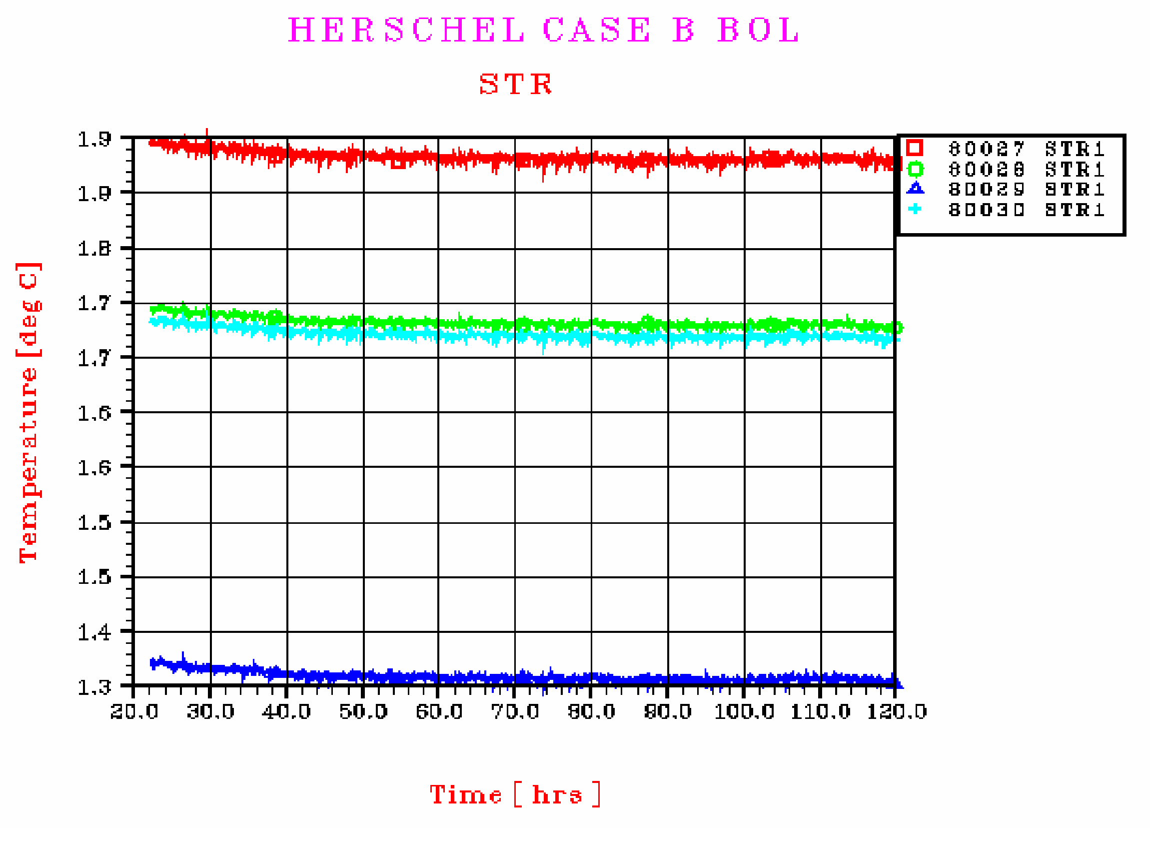

HERSCHEL CASE B BOL
PANEL -Z
Temperature [deg C]
33.0
32.3
31.6
30.9
30.2
29.5
28.8
28.1
27.4
26.7
26.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]
401 CCU
404 HSDCU
405 HSDPU
406 HSFCU

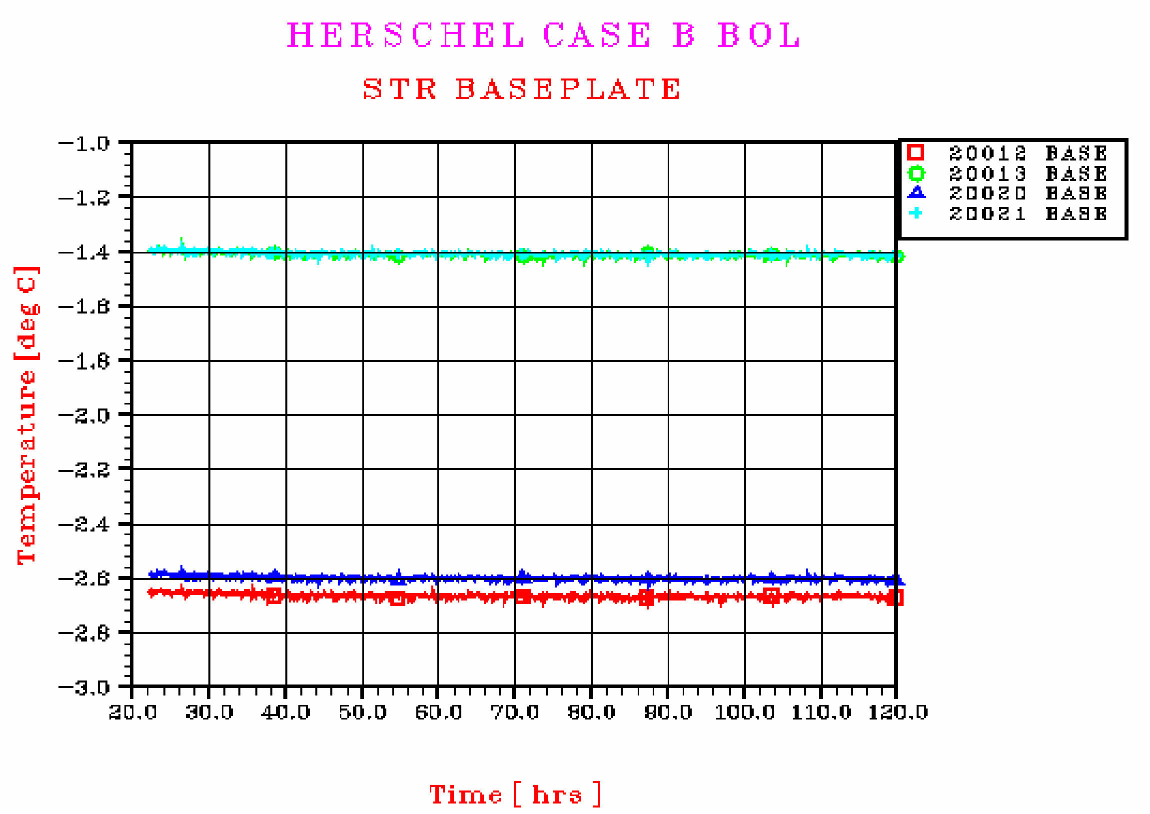

HERSCHEL CASE B BOL
PANEL -Y-Z
Temperature [deg C]
27.0
24.9
22.8
20.7
18.6
16.5
14.4
12.3
10.2
8.1
6.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]
501 FHWOV
502 FHHRV
503 FHICU
504 FHFCU
506 FHWEV
507 FHIFV
508 IFV-HRV
509 IFV-WEV
510 WOV-WEV
511 HRV-HRH

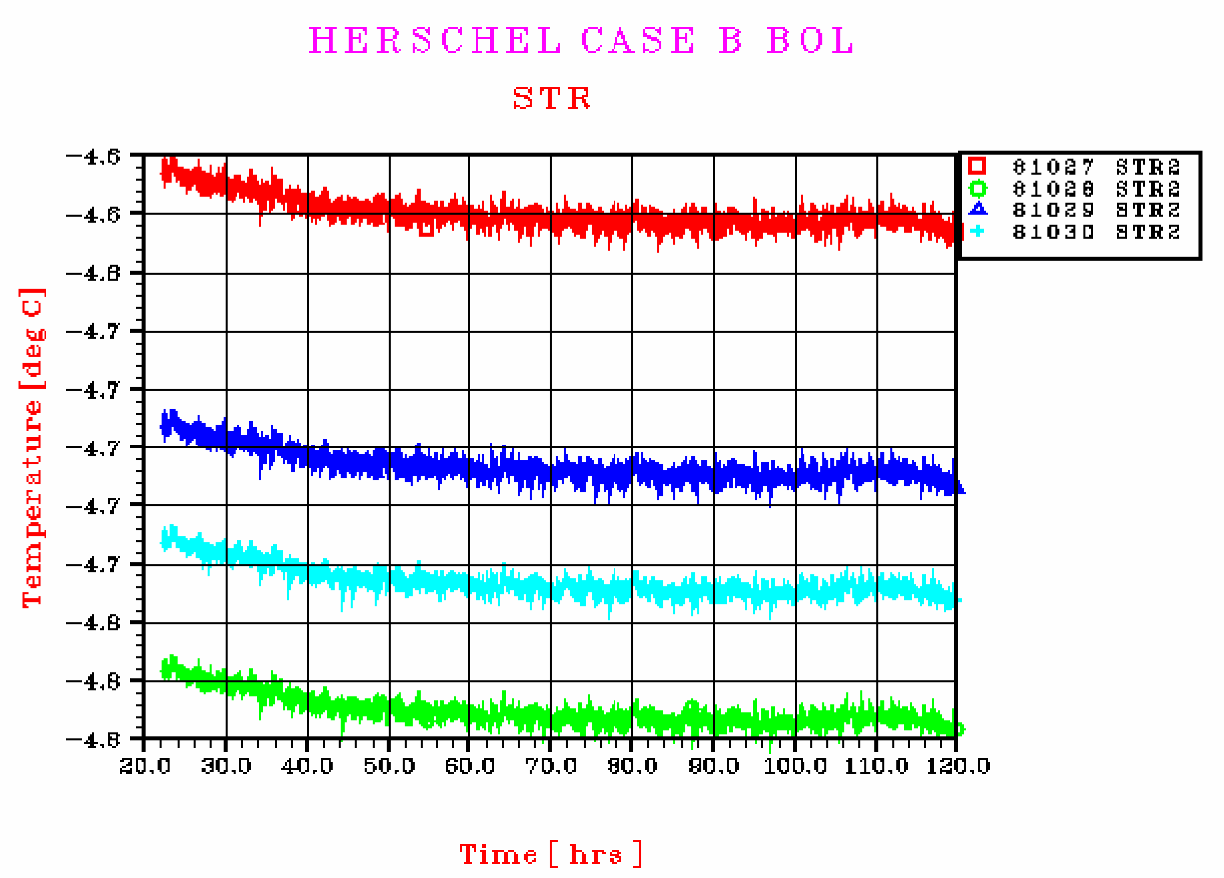

HERSCHEL CASE B BOL
PANEL -Y
Temperature [deg C]
26.0
24.2
22.4
20.6
18.8
17.0
15.2
13.4
11.6
9.8
8.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]
601 FHWOH
602 FHWEH
603 FHHRH
604 FHLCU
605 FHLSU
606 FHIFH
607 IFH-HRH
608 IFH-WEH
609 WEH-WOH


HERSCHEL CASE B BOL
PANEL -Y+Z
Temperature [deg C]
45.0
44.7
44.4
44.1
43.8
43.5
43.2
42.9
42.6
42.3
42.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]
701 RWL1
702 RWL2
703 RWL3
704 RWL4


HERSCHEL CASE B BOL
EXTERNAL UNITS
Temperature [deg C]
130.0
111.7
93.4
75.1
56.8
38.5
20.2
1.9
-16.4
-34.7
-53.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]
4 VMC
5 SAS +Z
16 MGA +Z
21 LGA +Z
41 LGA -Z
48 SAS -Z
49 SREM
56 AAD +Z

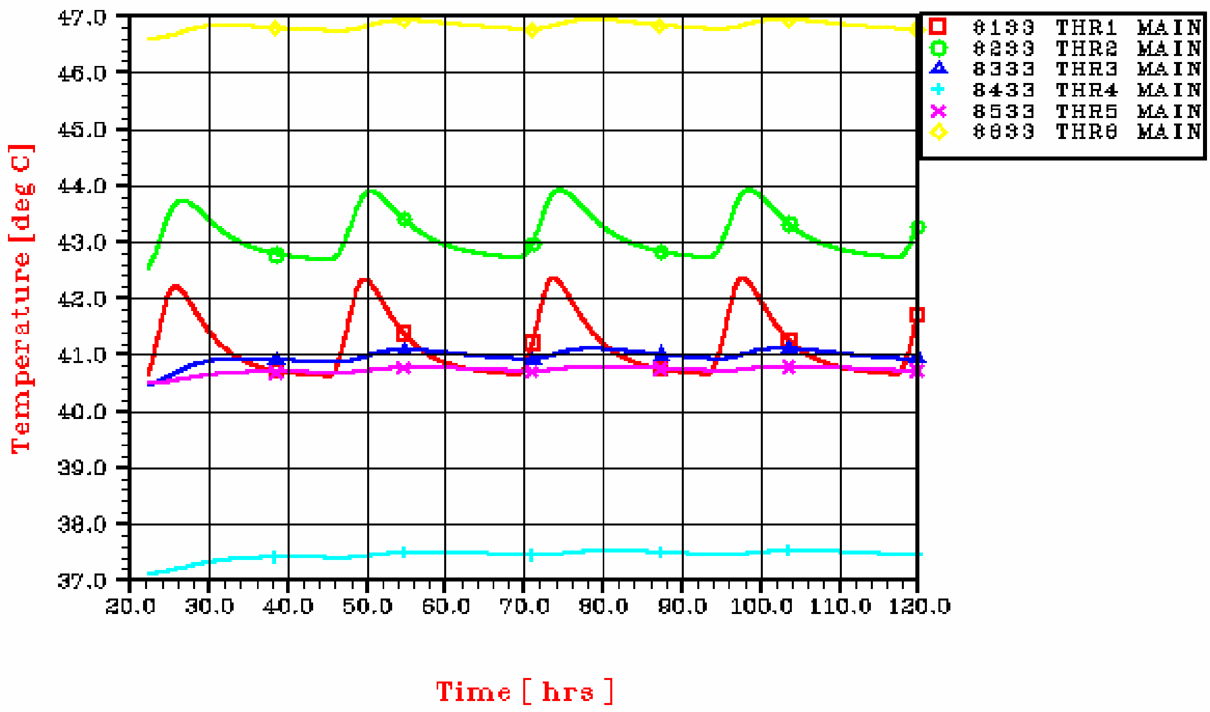

HERSCHEL CASE B BOL
STR
Temperature [deg C]
1.9
1.9
1.8
1.7
1.7
1.6
1.6
1.5
1.5
1.4
1.3
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]
80027 STR1
80028 STR1
80029 STR1
80030 STR1


HERSCHEL CASE B BOL
STR BASEPLATE
20012 BASE
20013 BASE
20020 BASE
20021 BASE
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4
-2.6
-2.8
-3.0
Temperature [deg C]
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]


HERSCHEL CASE B BOL
STR
81027 STR2
81028 STR2
81029 STR2
81030 STR2
Temperature [deg C]
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]

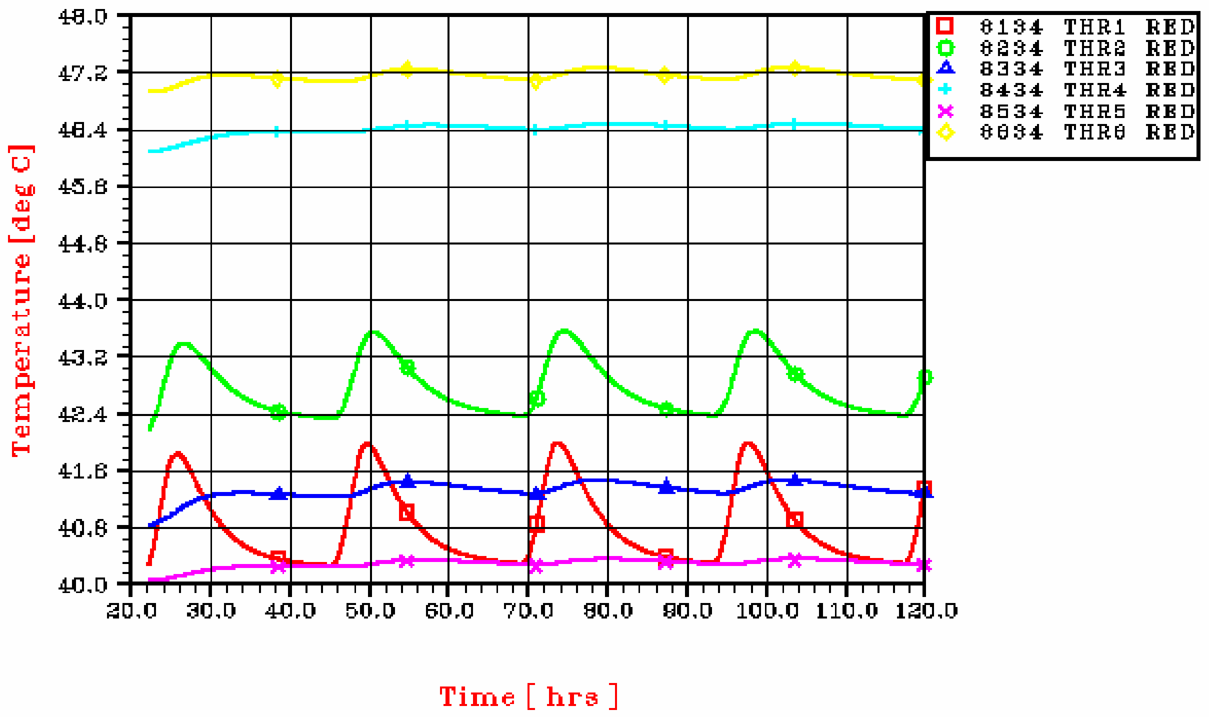
HERSCHEL CASE B BOL

THRUSTERS MAIN

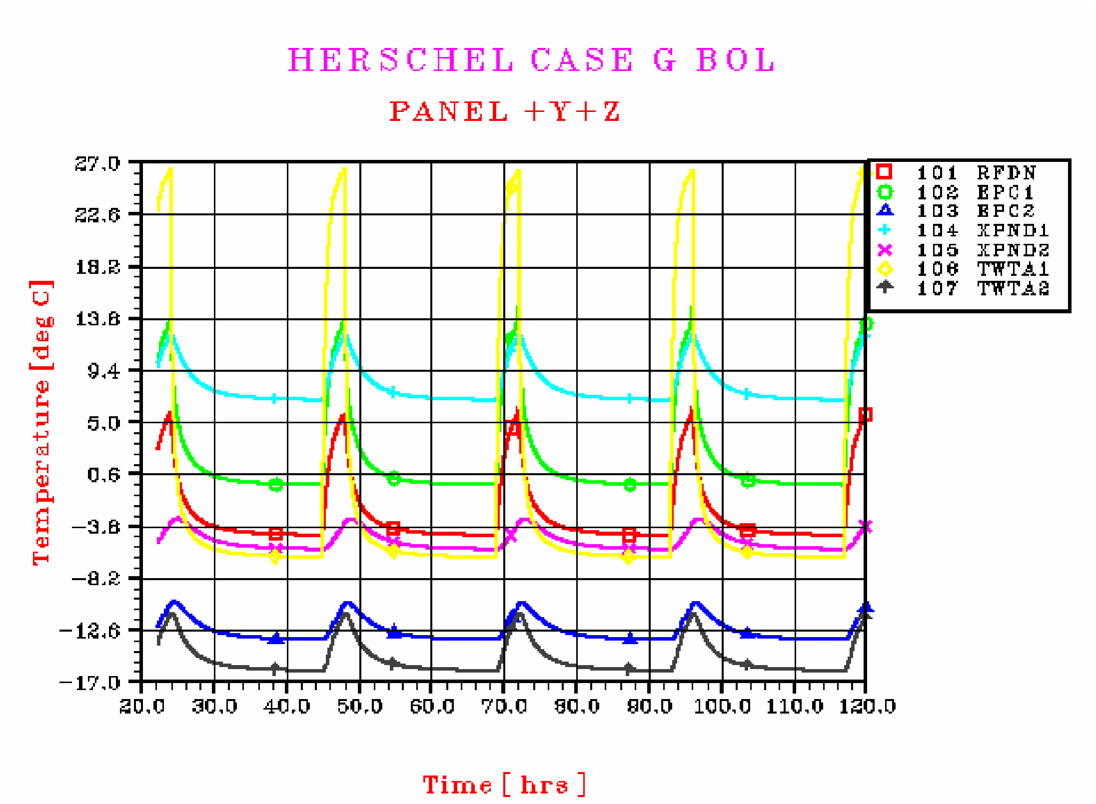


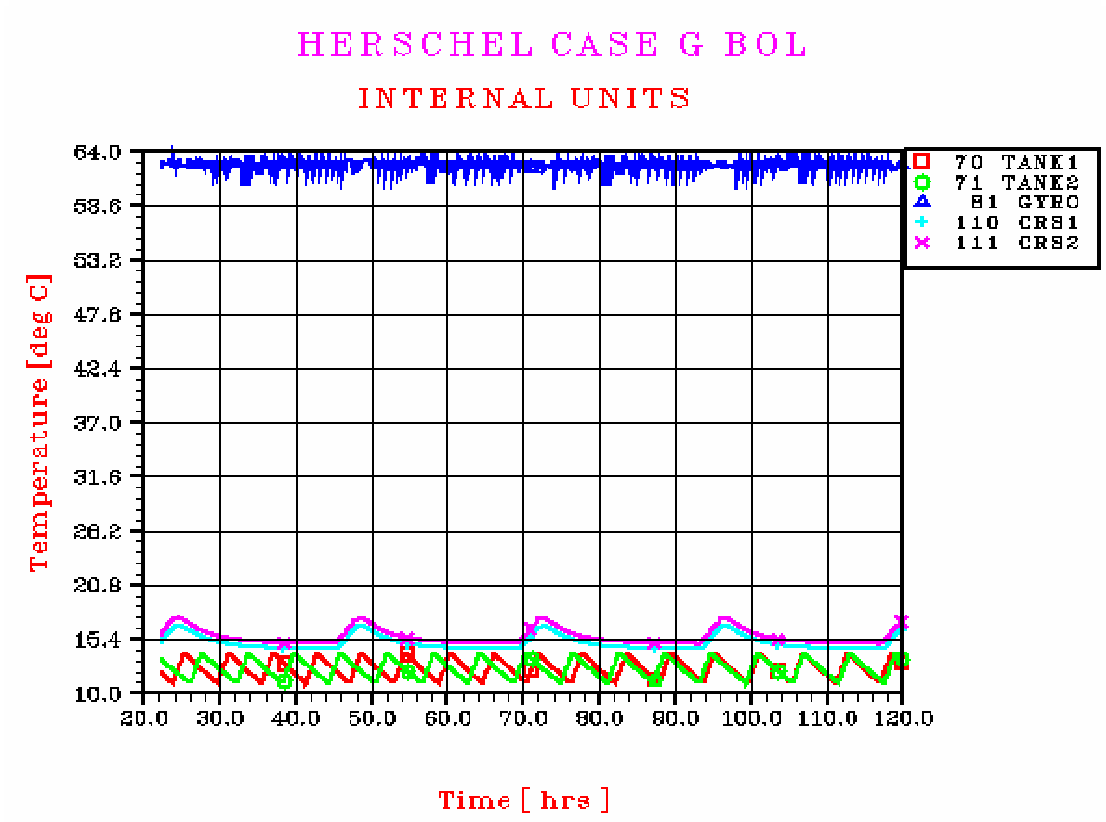
HERSCHEL CASE B BOL

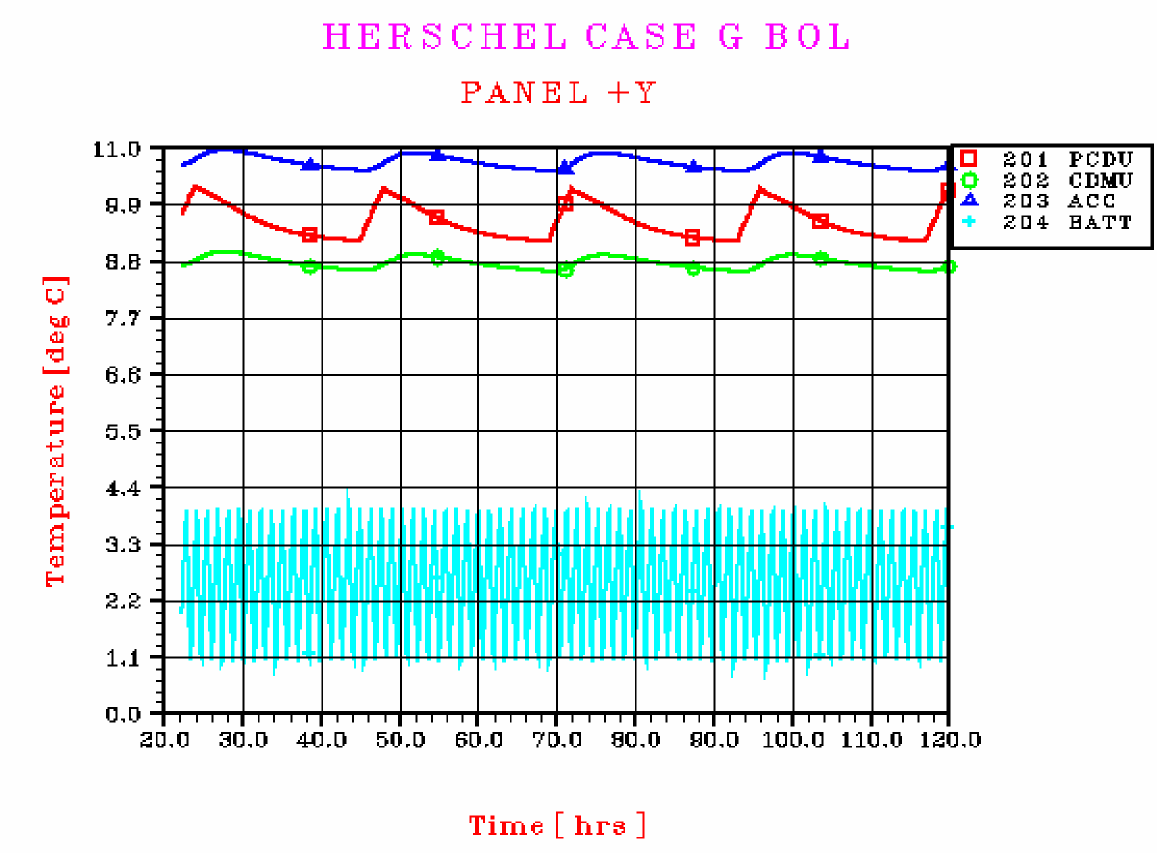
THRUSTERS REDUNDANT

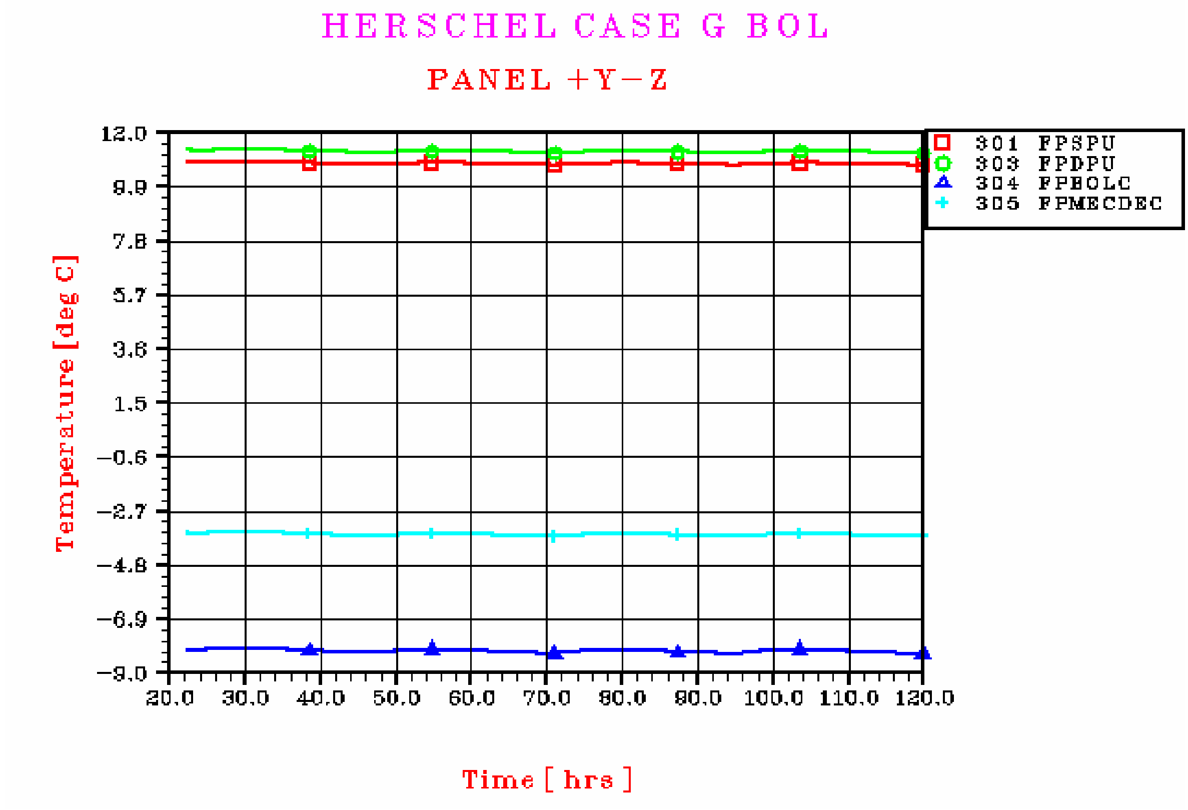


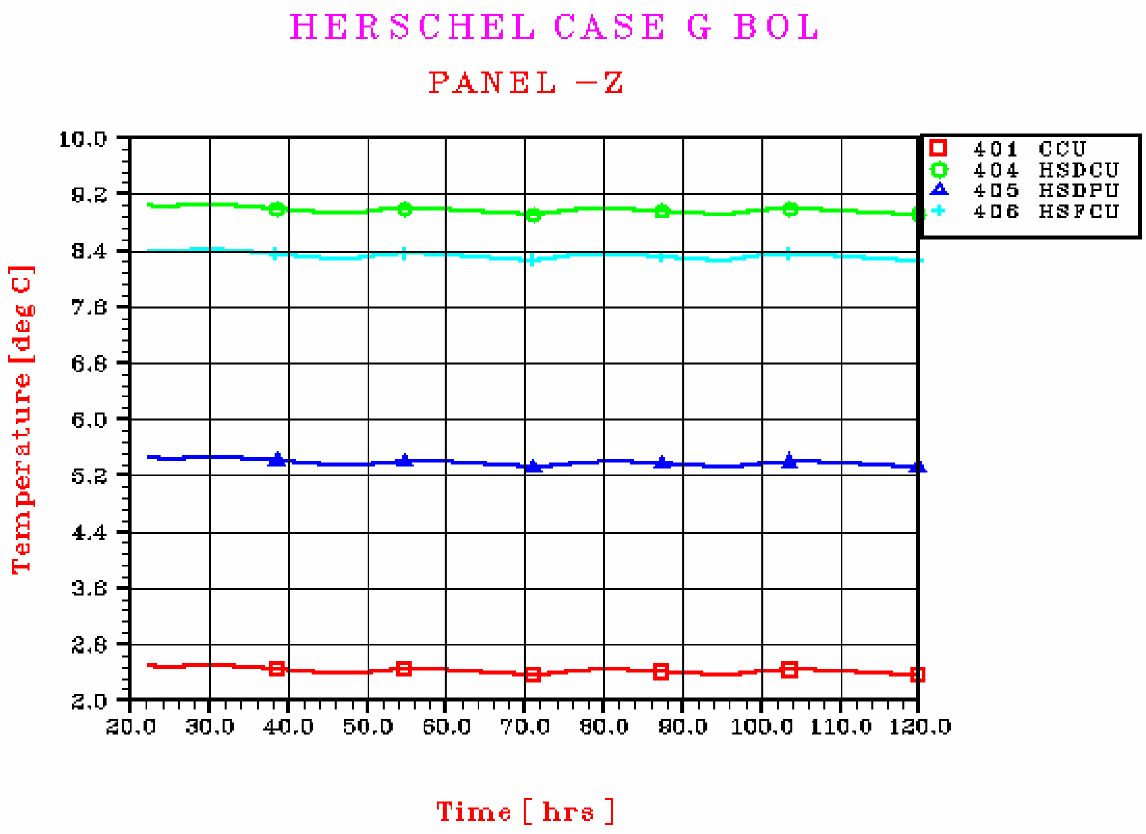
7.2 HERSCHEL RESULTS OF CASE G

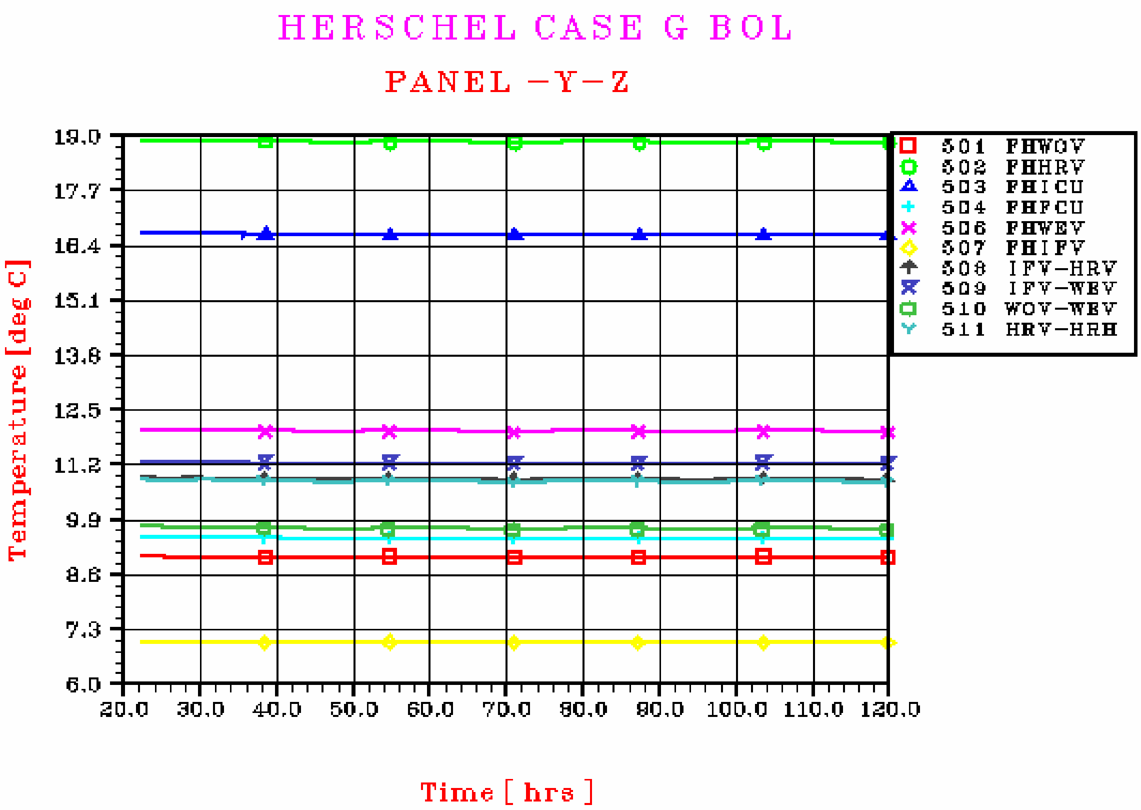


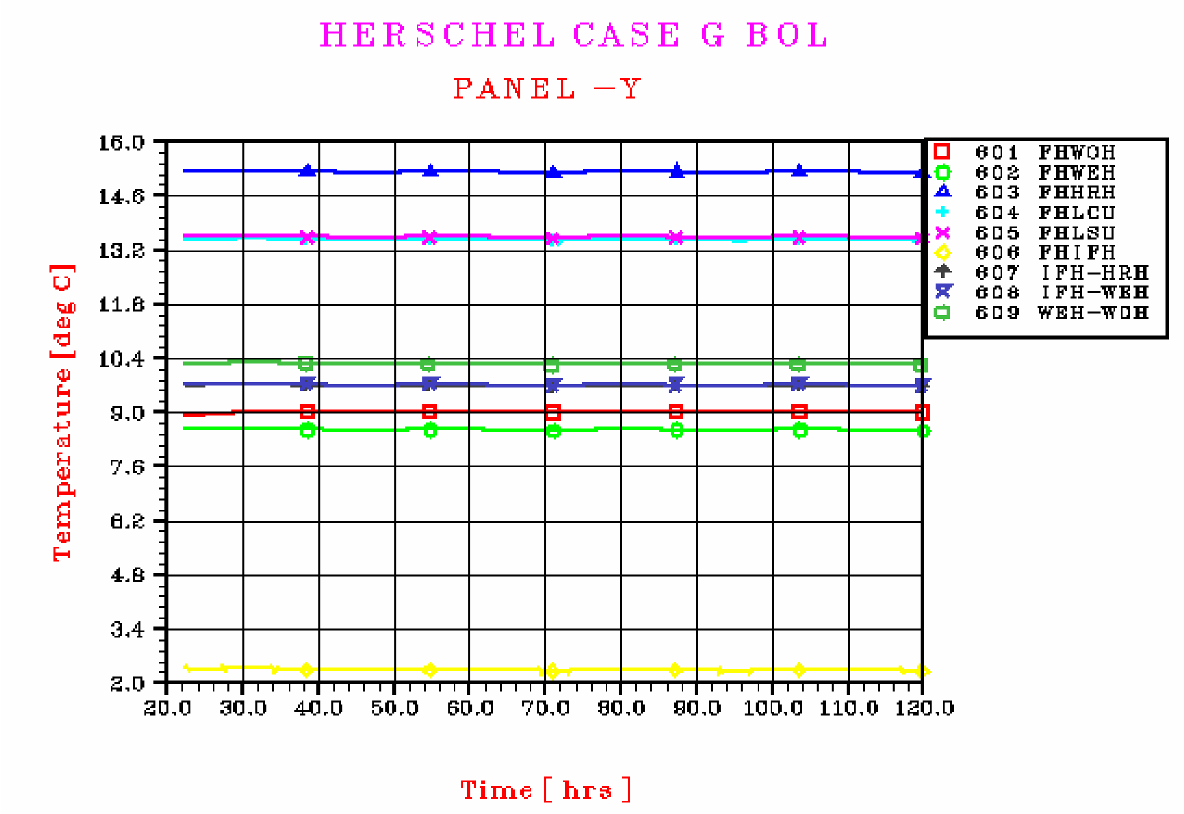


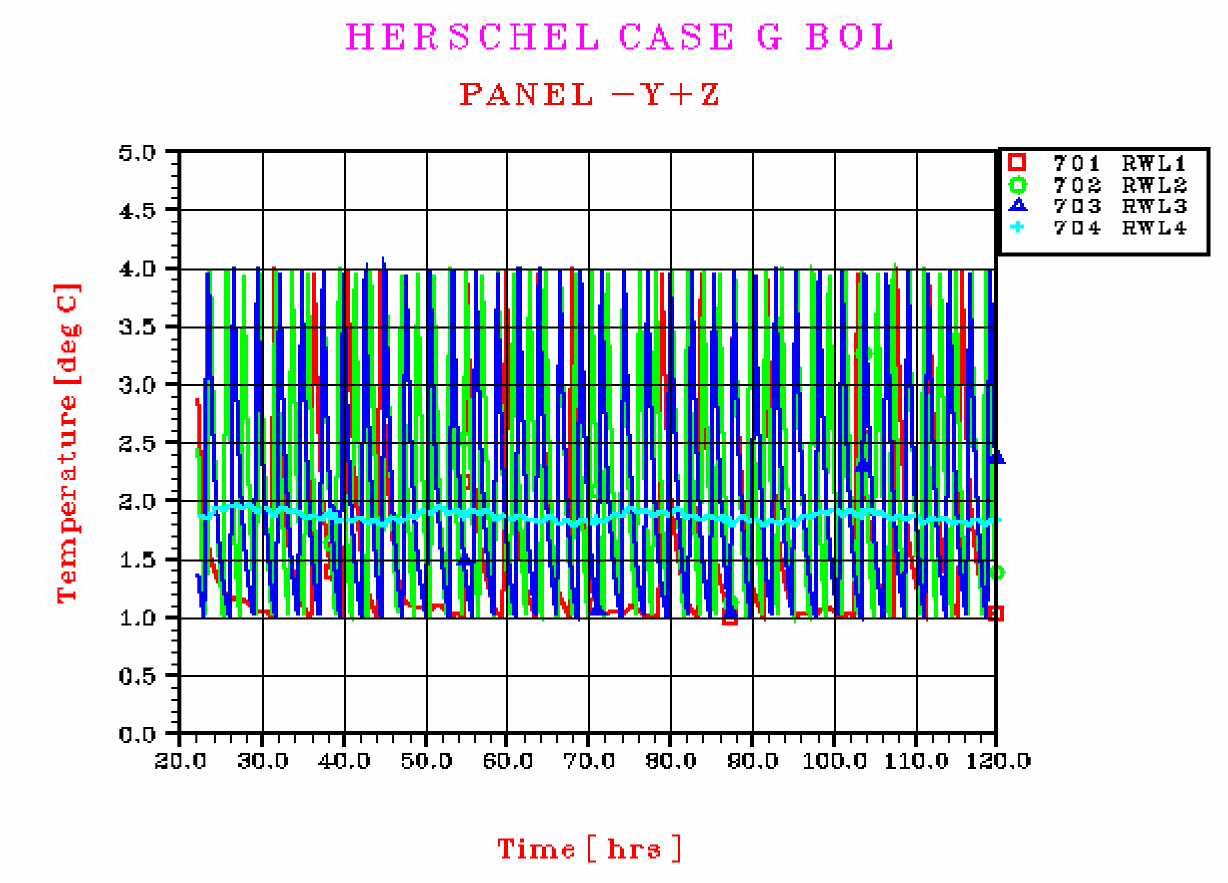

HERSCHEL CASE G BOL
PANEL +Y
201 PCDU
202 CDMU
203 ACC
204 BATT
Temperature [deg C]
11.0
9.9
8.8
7.7
6.6
5.5
4.4
3.3
2.2
1.1
0.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]

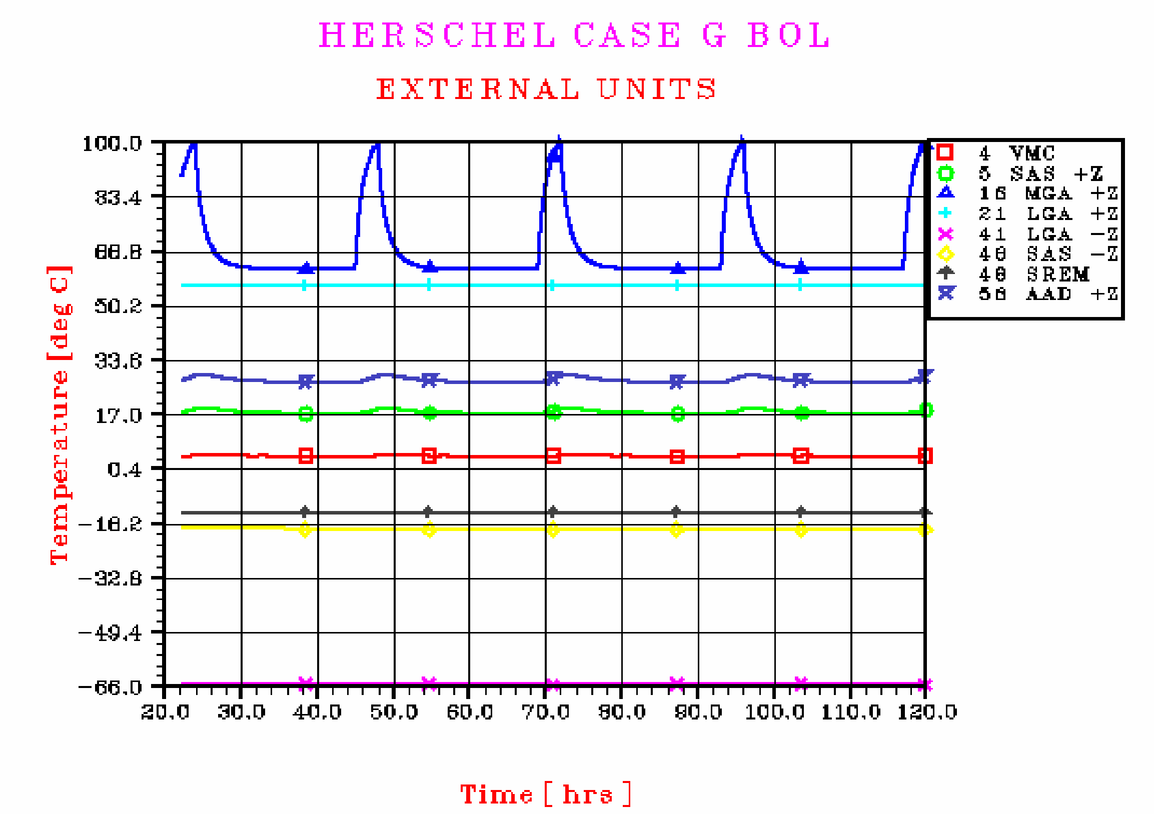

HERSCHEL CASE G BOL
PANEL +Y-Z
301 FPSPU
303 FPDPU
304 FPBOLC
305 FPMECDEC
Temperature [deg C]
12.0
9.9
7.8
5.7
3.6
1.5
-0.6
-2.7
-4.8
-6.9
-9.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]

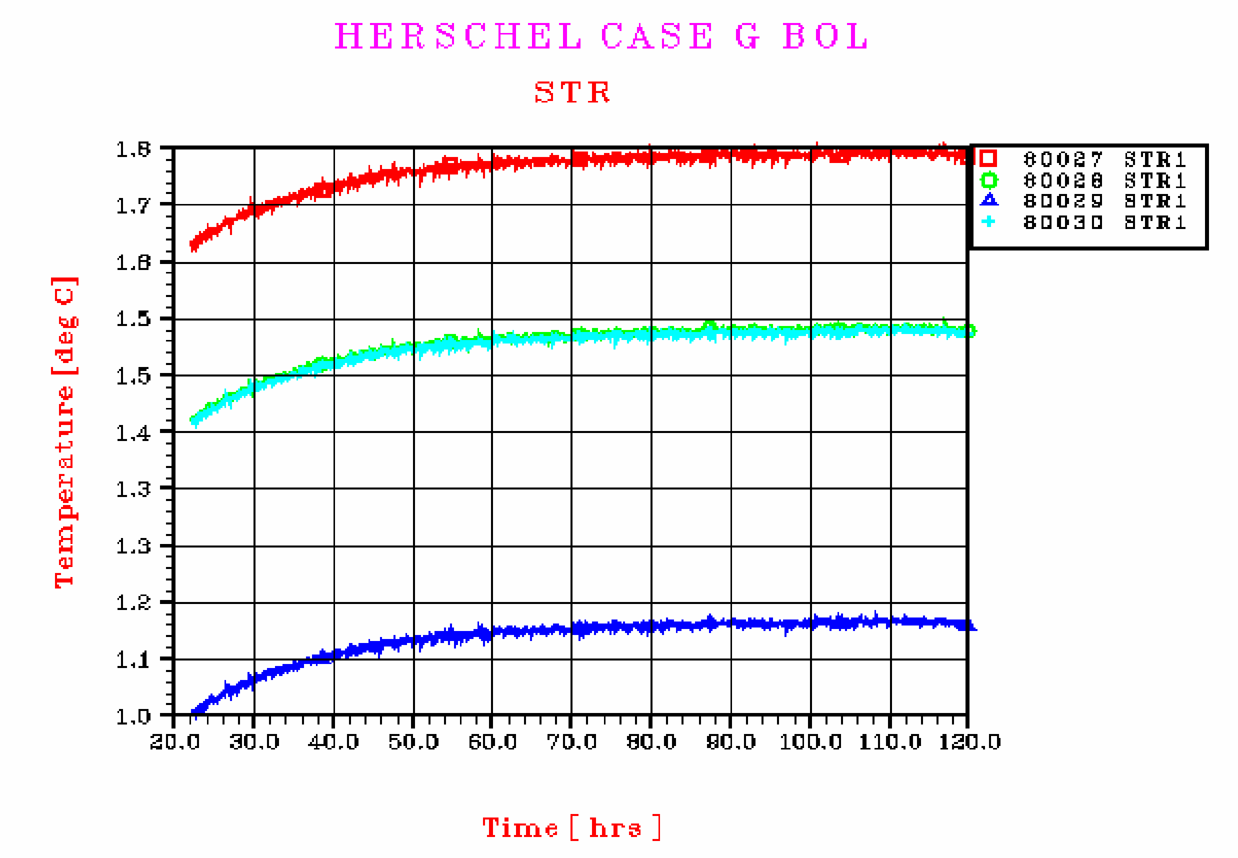

HERSCHEL CASE G BOL
PANEL -Z
Temperature [deg C]
10.0
9.2
8.4
7.6
6.8
6.0
5.2
4.4
3.6
2.8
2.0
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]
401 CCU
404 HSDCU
405 HSDPU
406 HSFCU

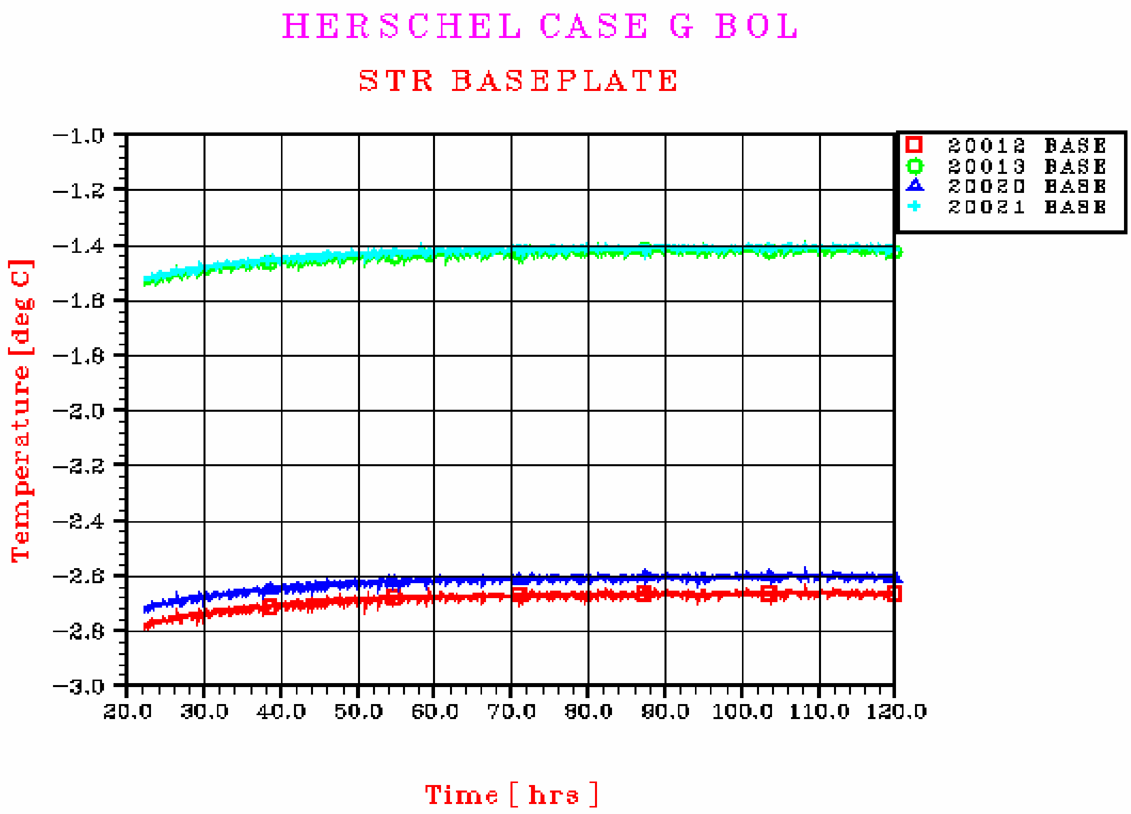

HERSCHEL CASE G BOL
PANEL -Y-Z
Temperature [deg C]
19.0
17.7
16.4
15.1
13.8
12.5
11.2
9.9
8.6
7.3
6.0
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]
501 FHWOV
502 FHHRV
503 FHICU
504 FHFCU
506 FHWEV
507 FHIFV
508 IFV-HRV
509 IFV-WEV
510 WOV-WEV
511 HRV-HRH

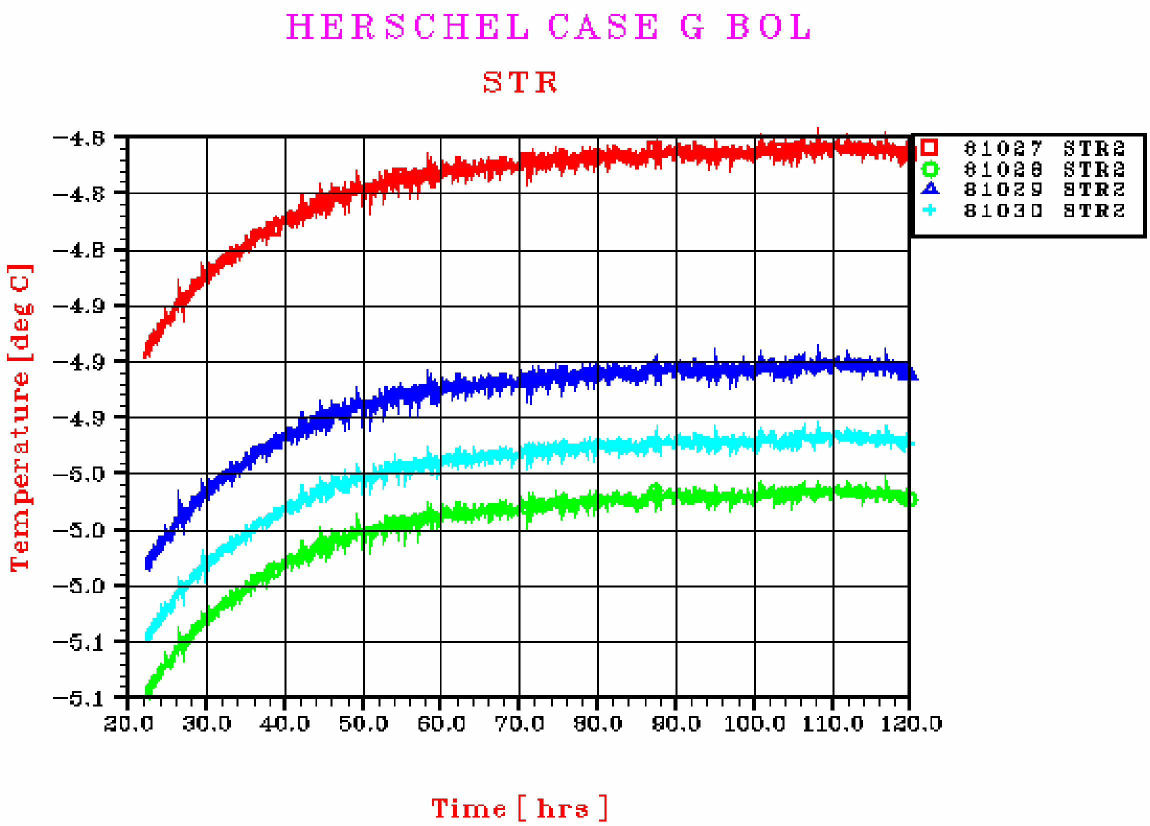

HERSCHEL CASE G BOL
PANEL -Y
Temperature [deg C]
Time [hrs]
601 FHWOH
602 FHWEH
603 FHHRH
604 FHLCU
605 FHLSU
606 FHIFH
607 IFH-HRH
608 IFH-WEH
609 WEH-WOH
16.0
14.6
13.2
11.8
10.4
9.0
7.6
6.2
4.8
3.4
2.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0

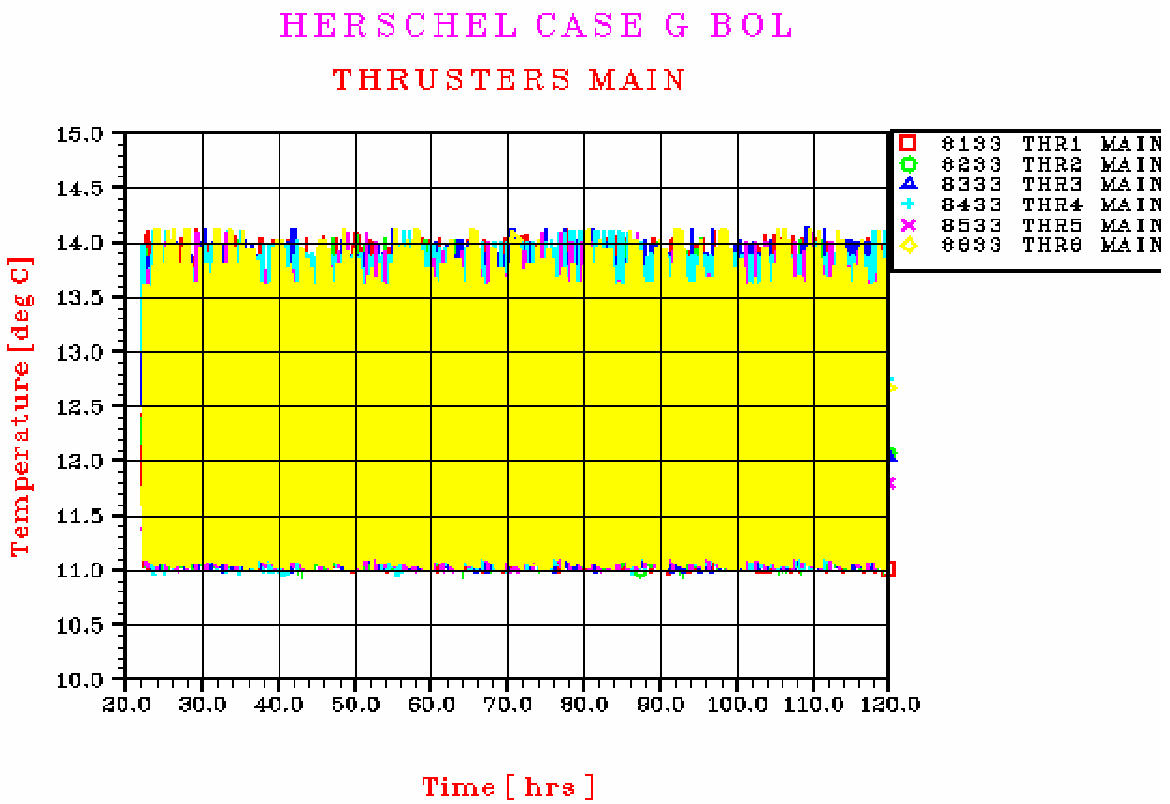

HERSCHEL CASE G BOL
PANEL -Y+Z
Temperature [deg C]
Time [hrs]
701 RWL1
702 RWL2
703 RWL3
704 RWL4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0

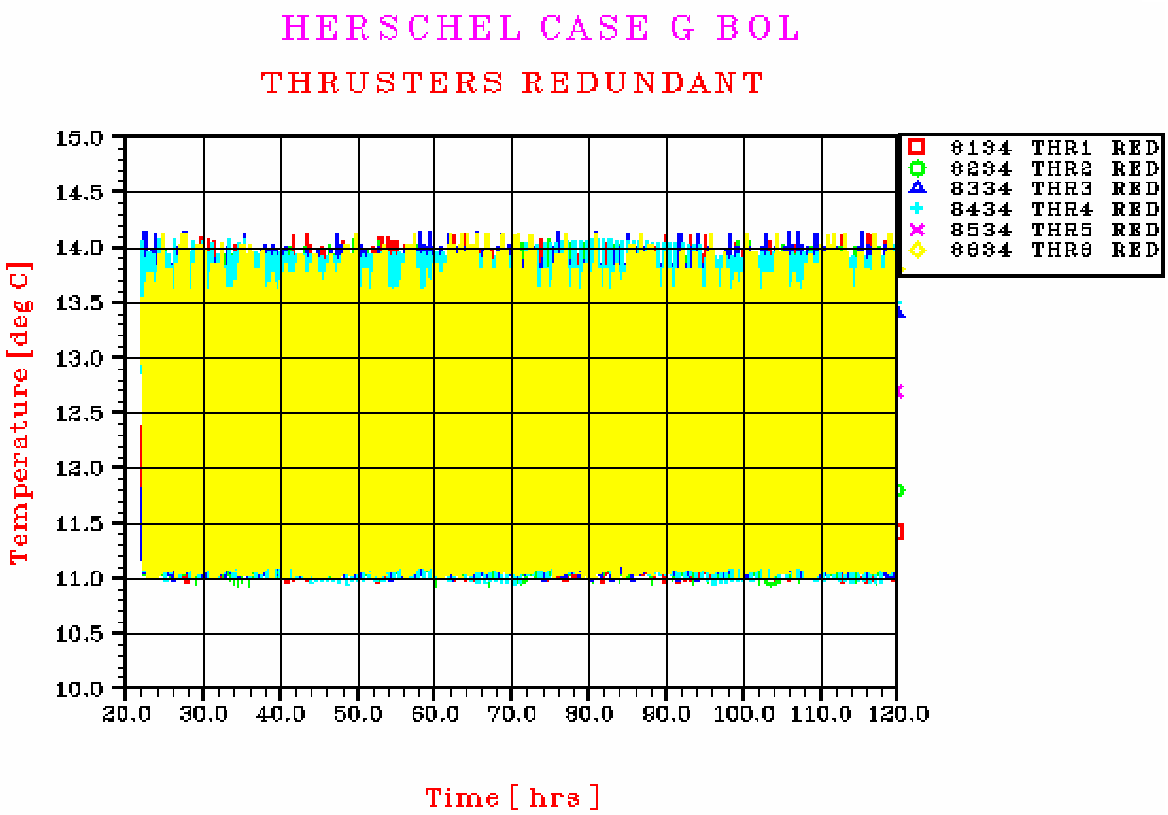

HERSCHEL CASE G BOL
EXTERNAL UNITS
Temperature [deg C]
Time [hrs]
4 VMC
5 SAS +Z
16 MGA +Z
21 LGA +Z
41 LGA -Z
48 SAS -Z
49 SREM
56 AAD +Z


HERSCHEL CASE G BOL
STR
Temperature [deg C]
Time [hrs]
80027 STR1
80028 STR1
80029 STR1
80030 STR1

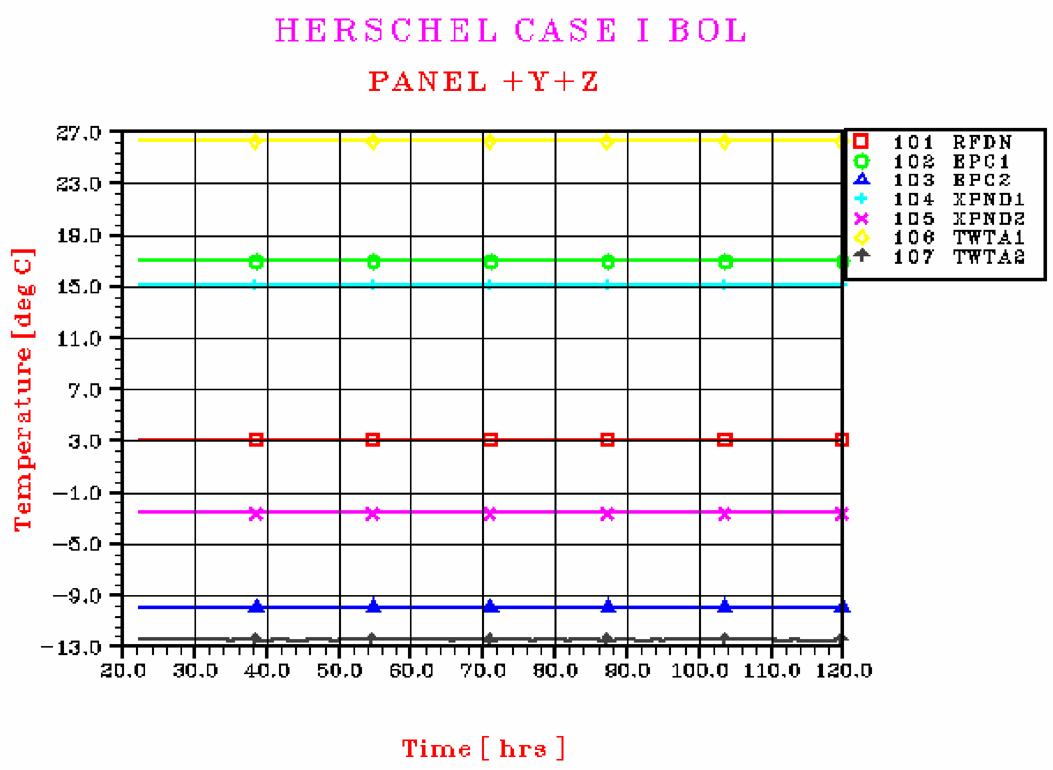

HERSCHEL CASE G BOL
STR BASEPLATE
Temperature [deg C]
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4
-2.6
-2.8
-3.0
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]
20012 BASE
20013 BASE
20020 BASE
20021 BASE

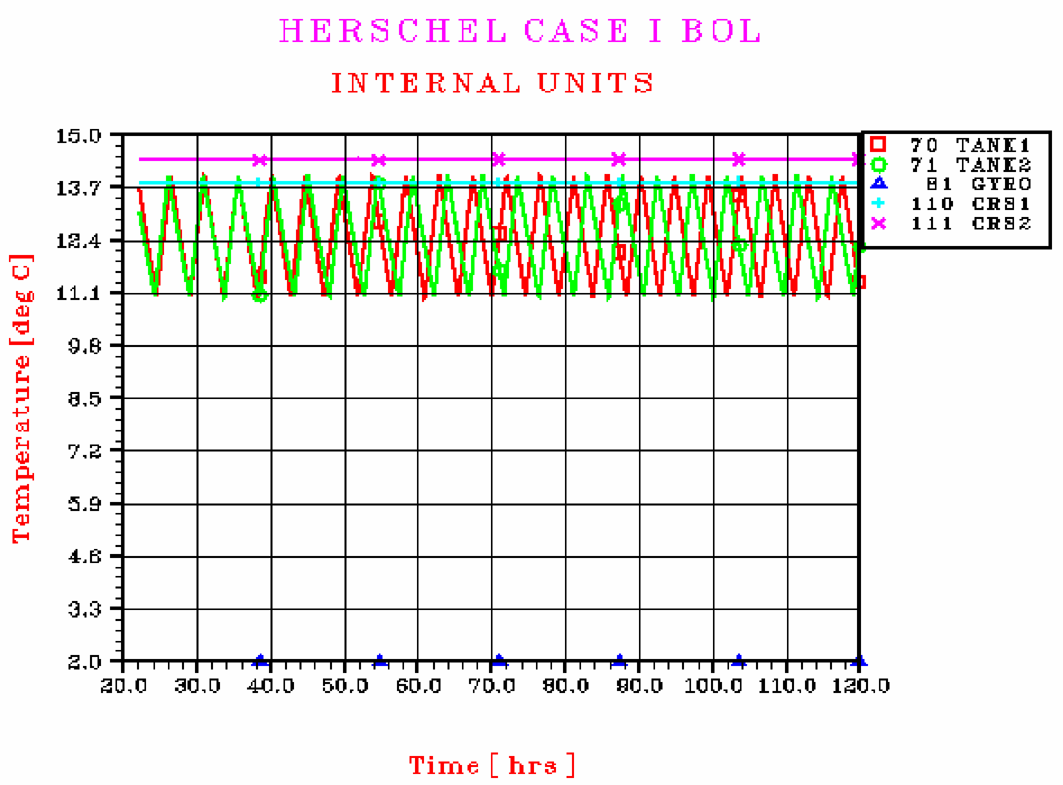

HERSCHEL CASE G BOL
STR
Temperature [deg C]
-4.8
-4.8
-4.8
-4.9
-4.9
-4.9
-5.0
-5.0
-5.0
-5.1
-5.1
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]
81027 STR2
81028 STR2
81029 STR2
81030 STR2

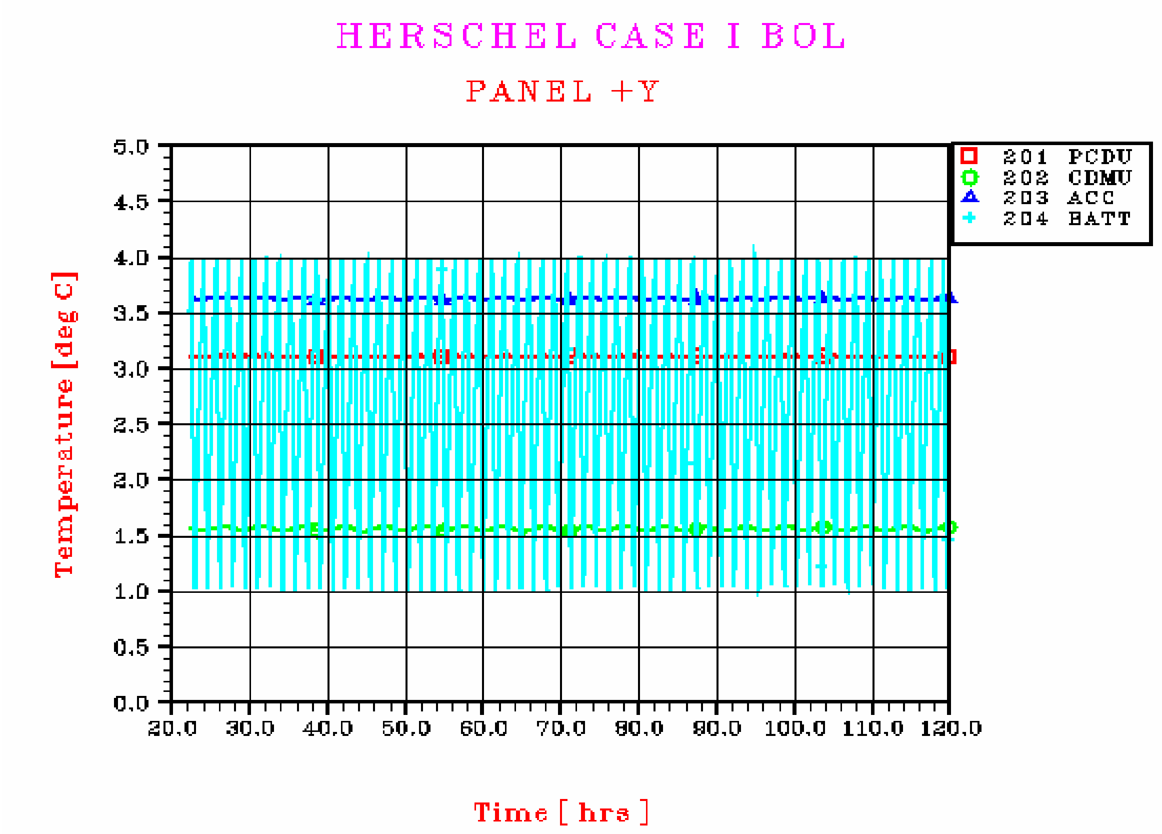

HERSCHEL CASE G BOL
THRUSTERS MAIN
Temperature [deg C]
Time [hrs]
8133 THR1 MAIN
8233 THR2 MAIN
8333 THR3 MAIN
8433 THR4 MAIN
8533 THR5 MAIN
8633 THR6 MAIN

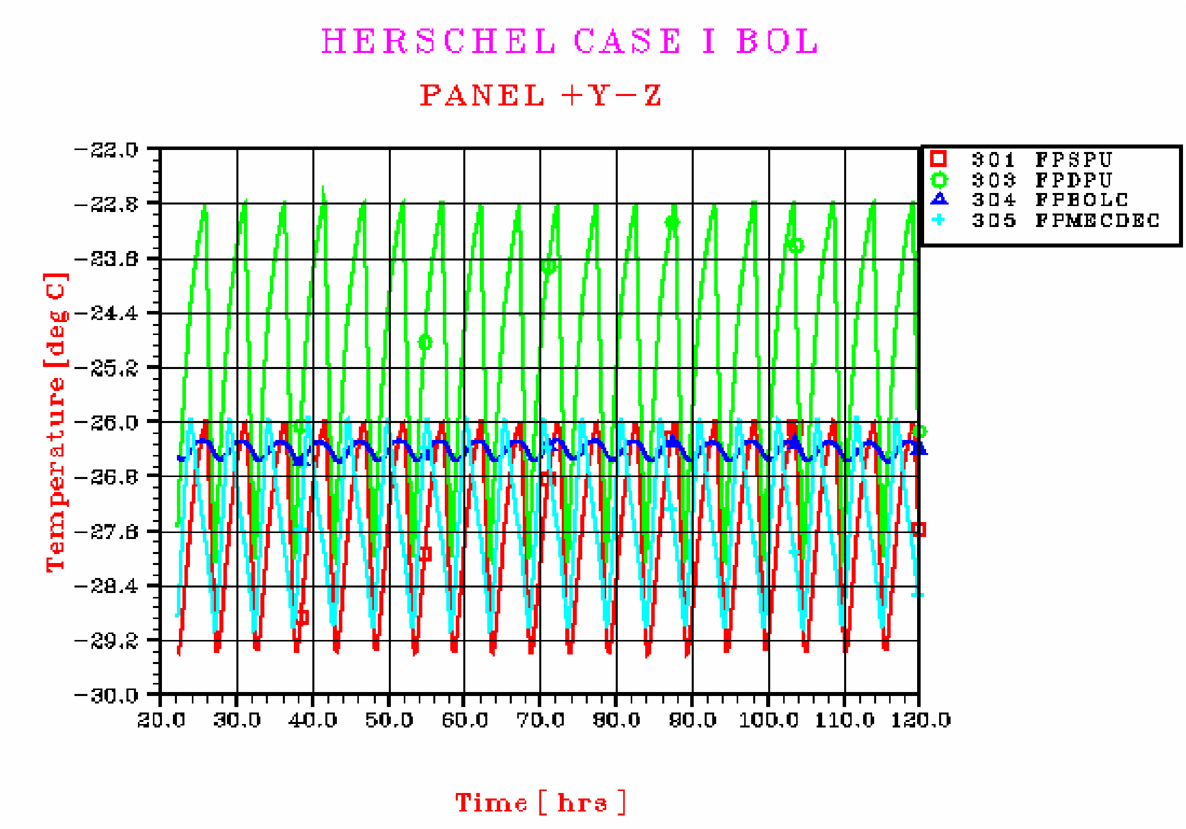

HERSCHEL CASE G BOL
THRUSTERS REDUNDANT
Temperature [deg C]
Time [hrs]
8134 THR1 RED
8234 THR2 RED
8334 THR3 RED
8434 THR4 RED
8534 THR5 RED
8634 THR6 RED

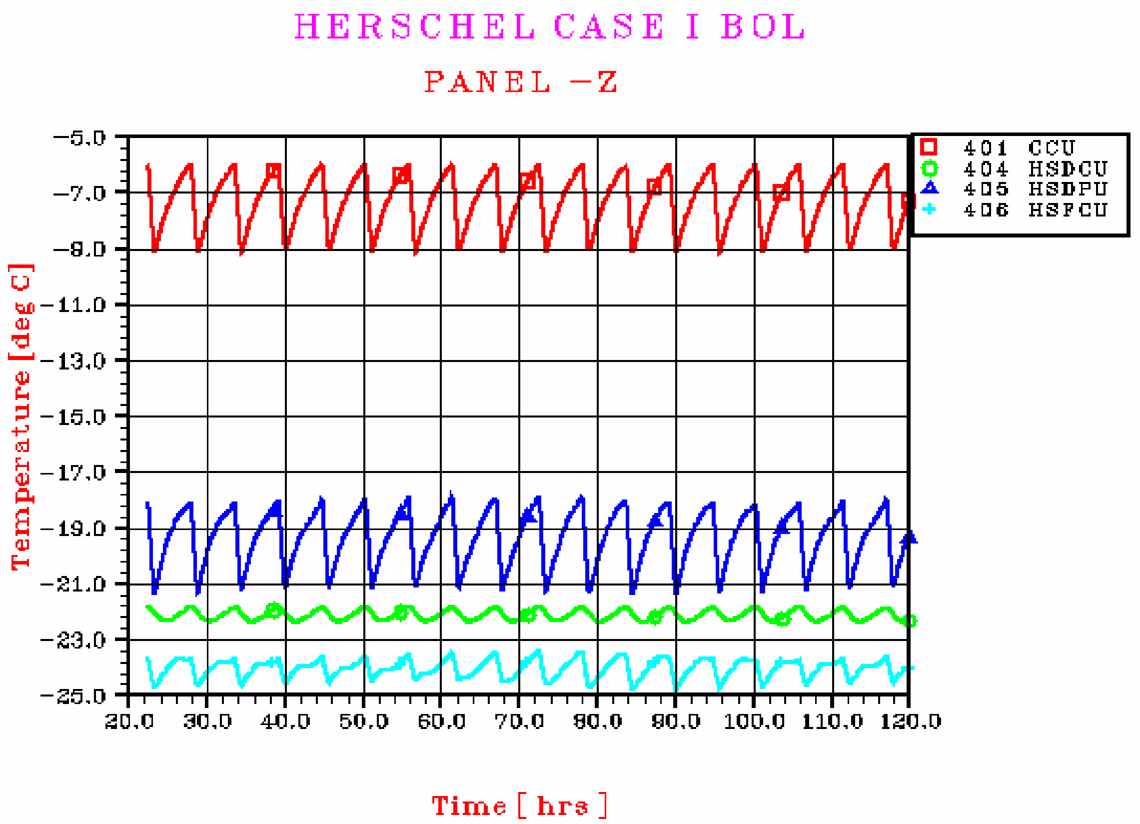
7.3 HERSCHEL RESULTS OF CASE I

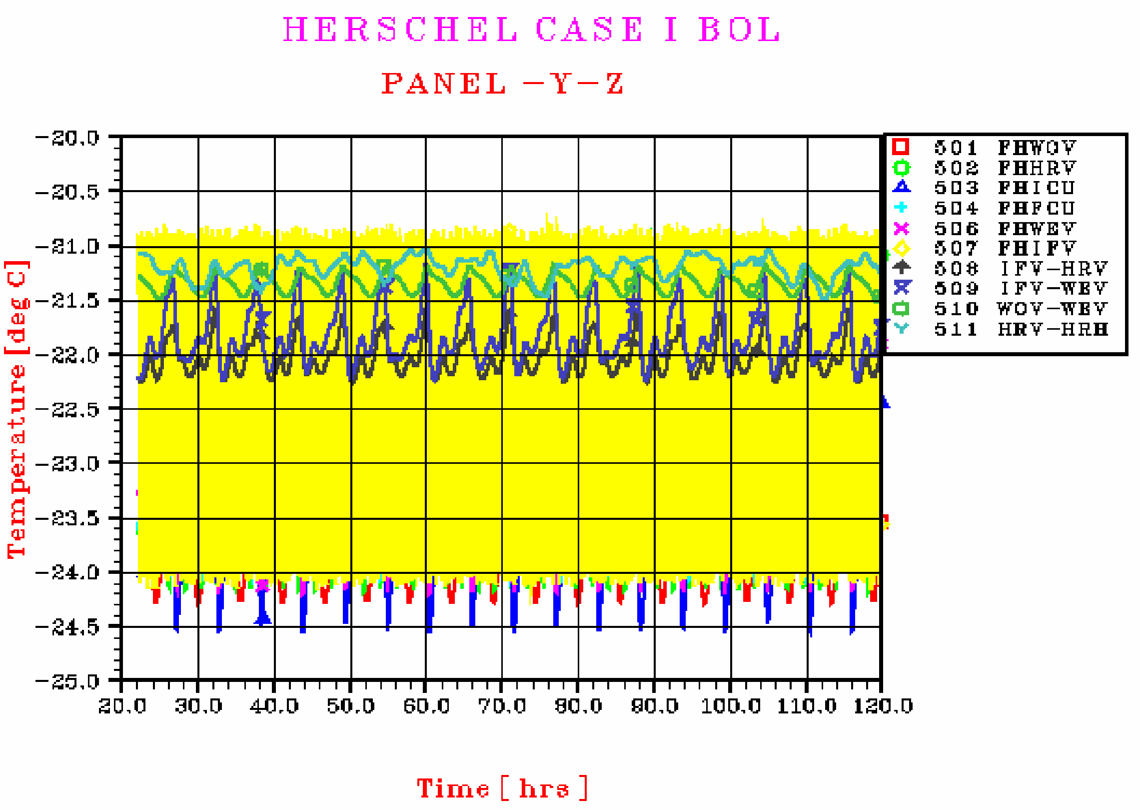


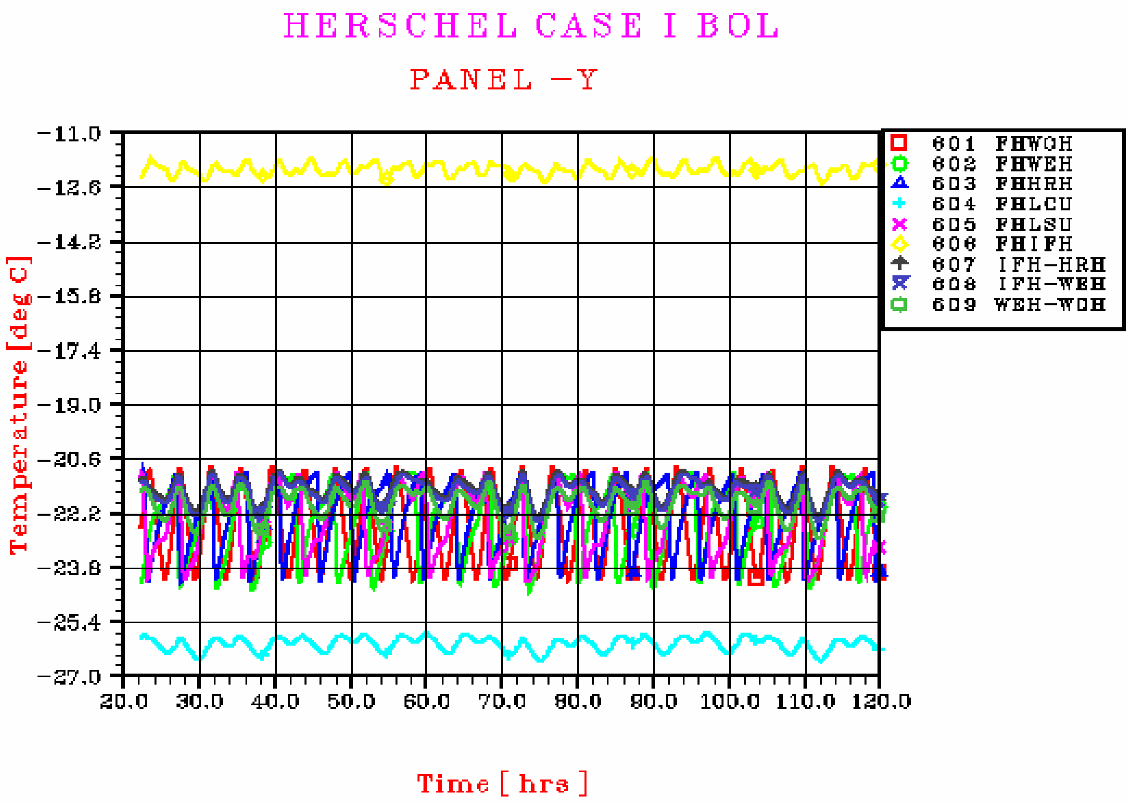


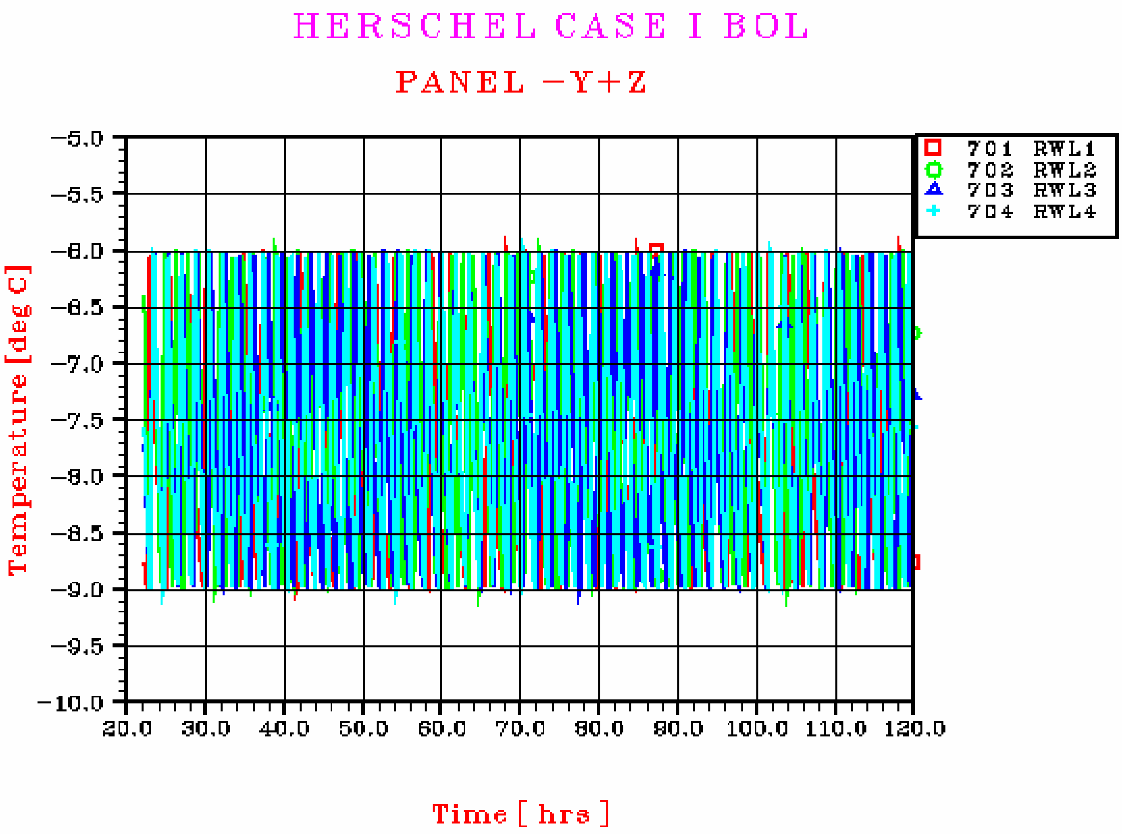

HERSCHEL CASE I BOL
PANEL +Y
Temperature [deg C]
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]
201 PCDU
202 CDMU
203 ACC
204 BATT

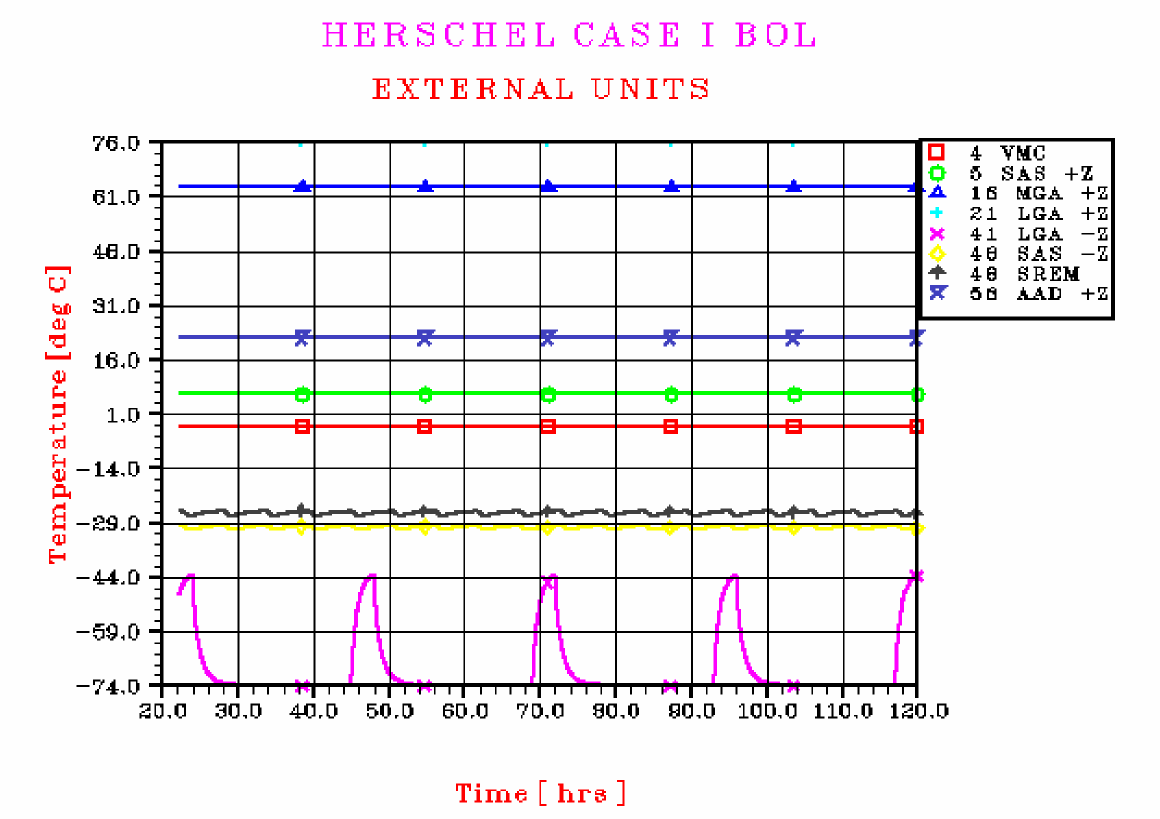

HERSCHEL CASE I BOL
PANEL +Y-Z
Temperature [deg C]
-22.0
-22.8
-23.6
-24.4
-25.2
-26.0
-26.8
-27.6
-28.4
-29.2
-30.0
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]
301 FPSPU
303 FPDPU
304 FPBOLC
305 FPMECDEC

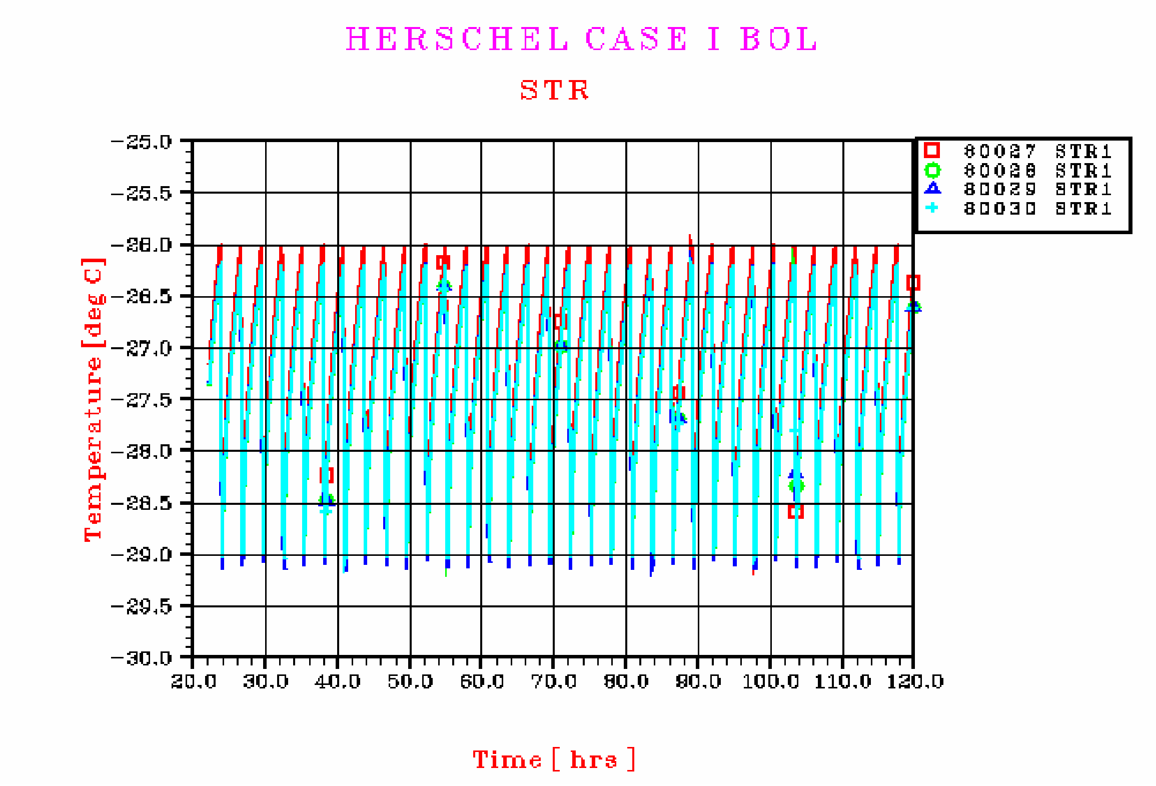

HERSCHEL CASE I BOL
PANEL -Z
401 CCU
404 HSDCU
405 HSDPU
406 HSFCU
Temperature [deg C]
Time [hrs]

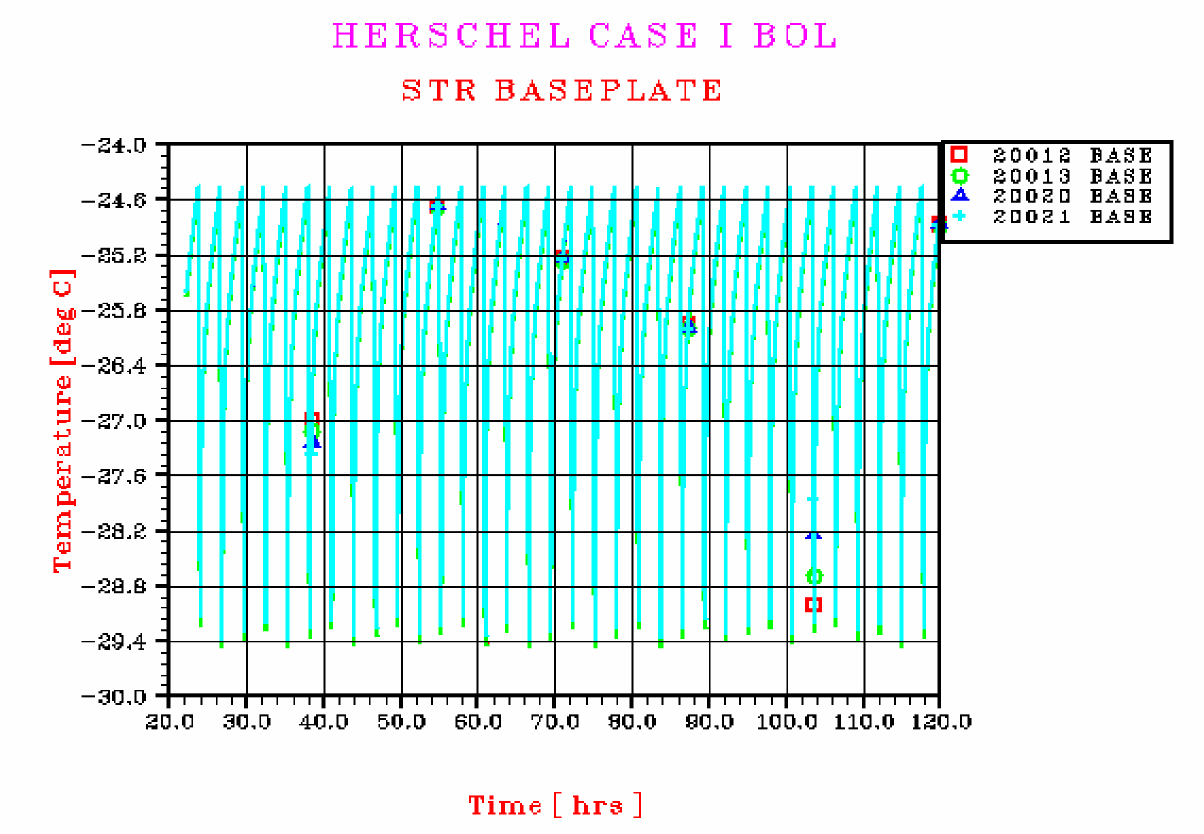

HERSCHEL CASE I BOL
PANEL -Y-Z
501 FHWOV
502 FHHRV
503 FHICU
504 FHFCU
506 FHWEV
507 FHIFV
508 IFV-HRV
509 IFV-WEV
510 WOV-WEV
511 HRV-HRH
Temperature [deg C]
Time [hrs]

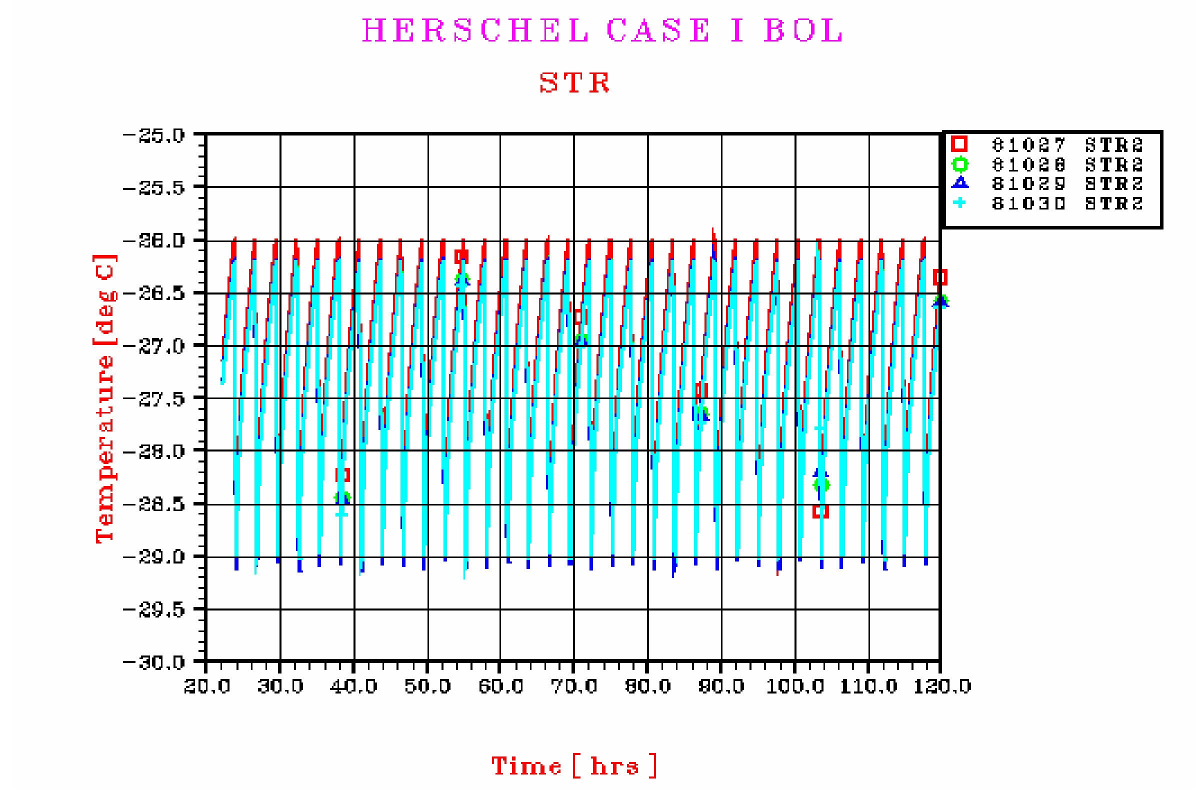

HERSCHEL CASE I BOL
PANEL -Y
-11.0
-12.6
-14.2
-15.8
-17.4
-19.0
-20.6
-22.2
-23.8
-25.4
-27.0
Temperature [deg C]
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]
601 FHWOH
602 FHWEH
603 FHHRH
604 FHLCU
605 FHLSU
606 FHIFH
607 IFH-HRH
608 IFH-WEH
609 WEH-WOH

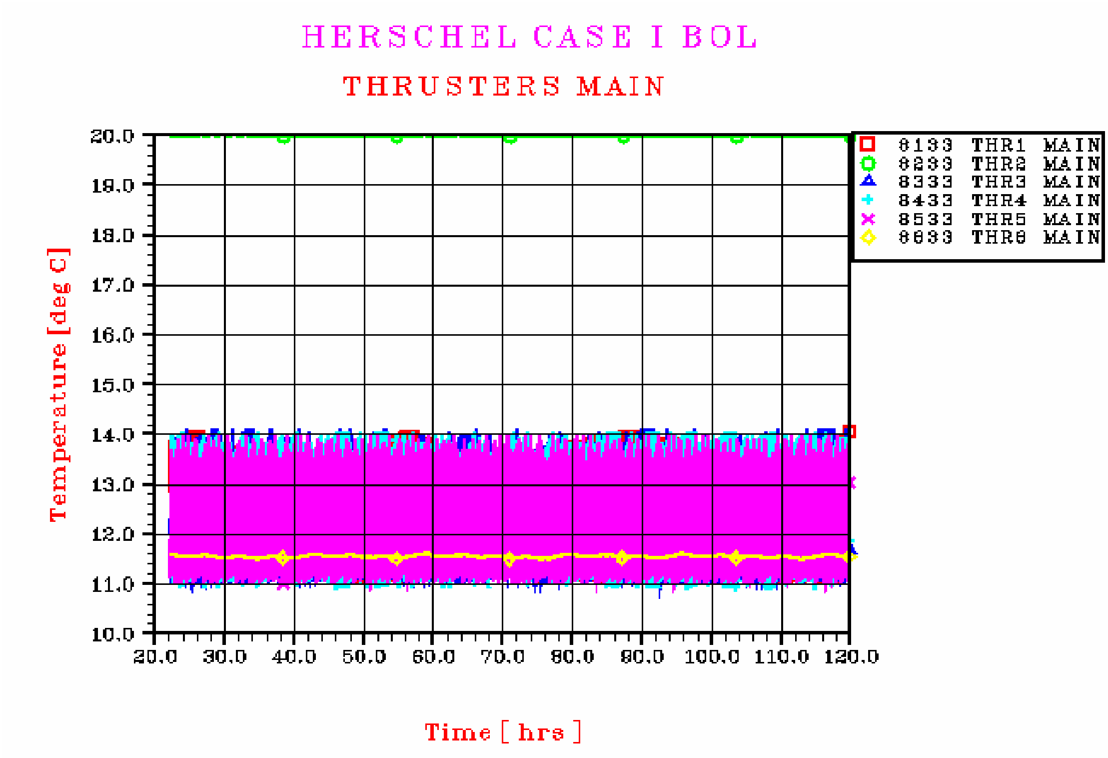

HERSCHEL CASE I BOL
PANEL -Y+Z
-5.0
-5.5
-6.0
-6.5
-7.0
-7.5
-8.0
-8.5
-9.0
-9.5
-10.0
Temperature [deg C]
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
Time [hrs]
701 RWL1
702 RWL2
703 RWL3
704 RWL4

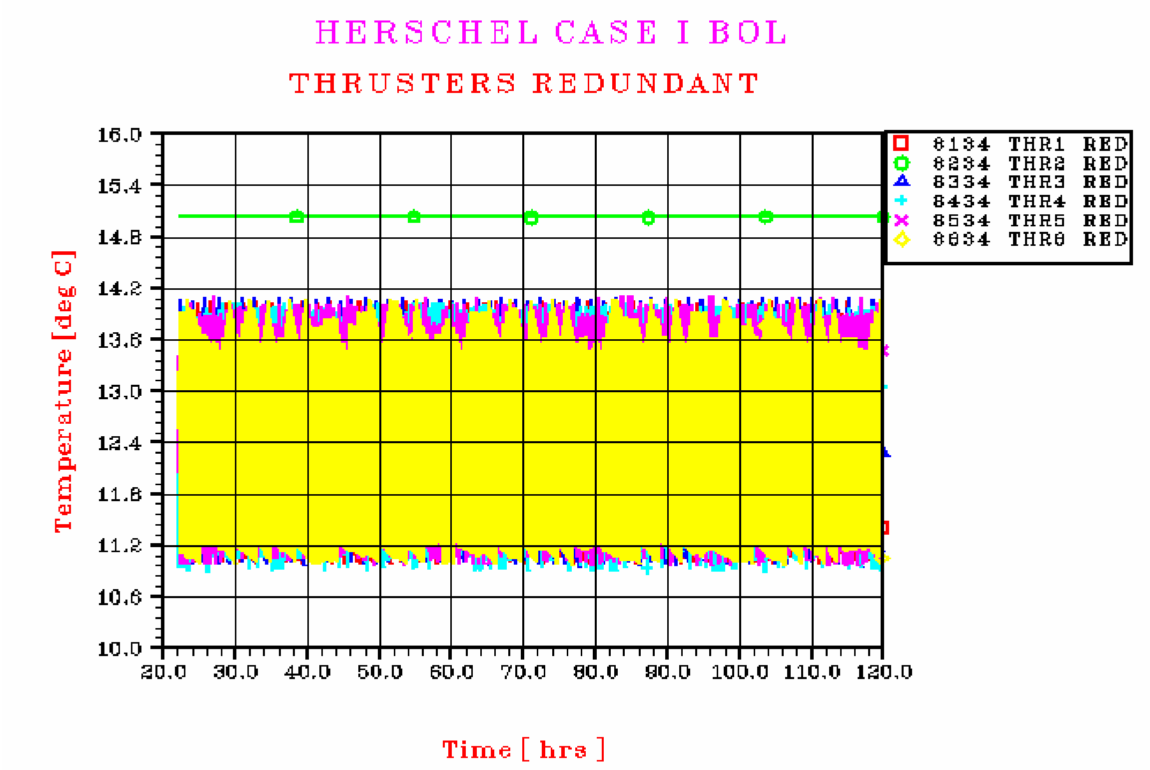

HERSCHEL CASE I BOL
EXTERNAL UNITS
Temperature [deg C]
76.0
61.0
46.0
31.0
16.0
1.0
-14.0
-29.0
-44.0
-59.0
-74.0
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]
4 VMC
5 SAS +Z
16 MGA +Z
21 LGA +Z
41 LGA -Z
48 SAS -Z
49 SREM
58 AAD +Z


HERSCHEL CASE I BOL
STR
Temperature [deg C]
-25.0
-25.5
-26.0
-26.5
-27.0
-27.5
-28.0
-28.5
-29.0
-29.5
-30.0
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]
80027 STR1
80028 STR1
80029 STR1
80030 STR1

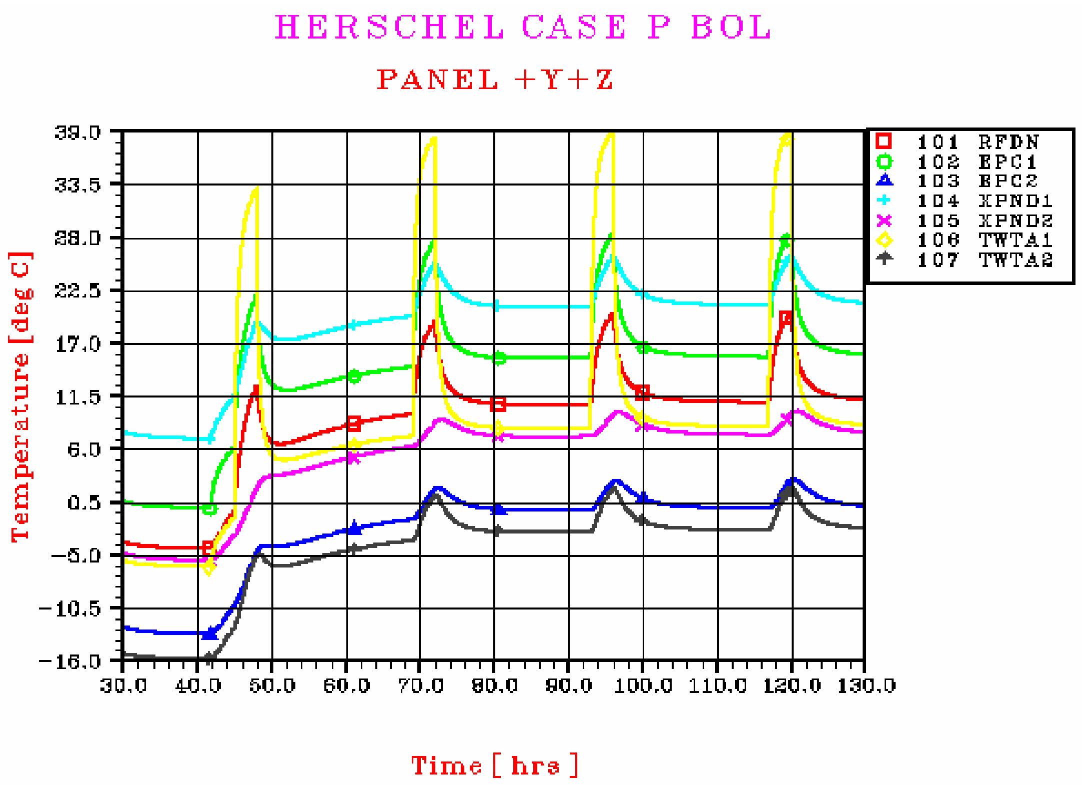

HERSCHEL CASE I BOL
STR BASEPLATE
20012 BASE
20013 BASE
20020 BASE
20021 BASE
Temperature [deg C]
Time [hrs]

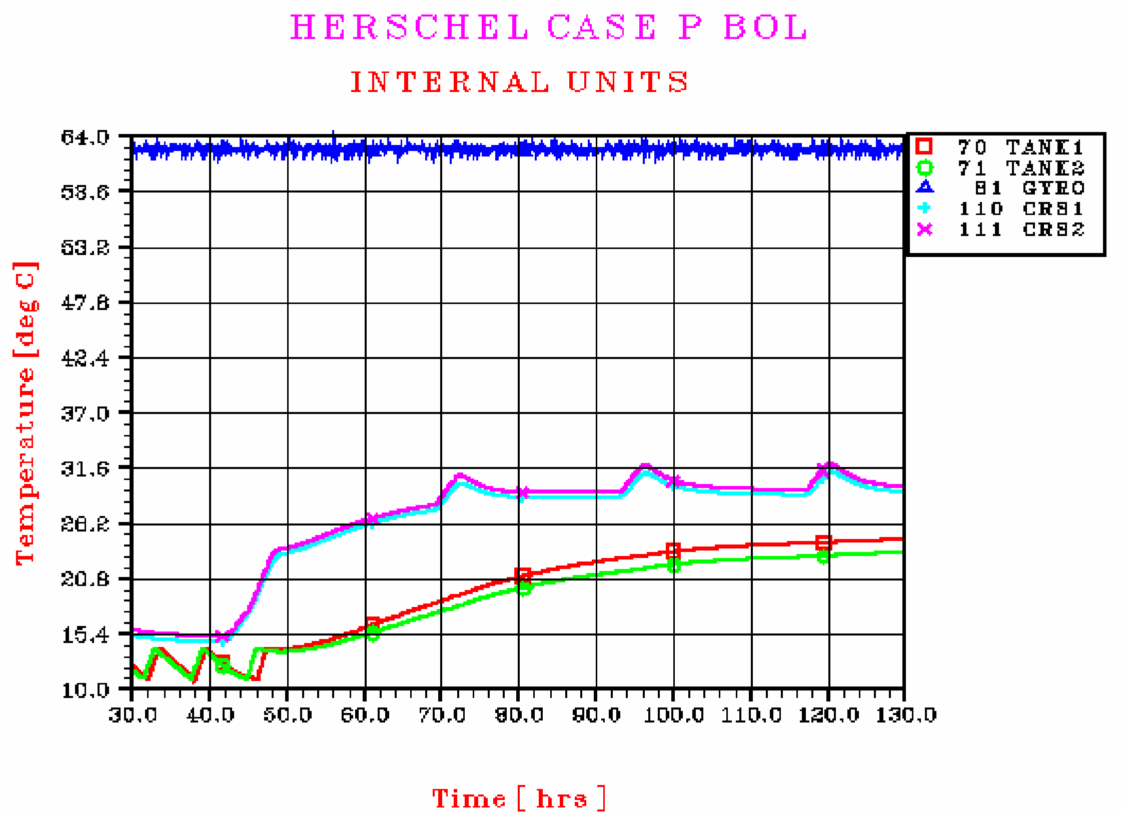

HERSCHEL CASE I BOL
STR
81027 STR2
81028 STR2
81029 STR2
81030 STR2
Temperature [deg C]
Time [hrs]

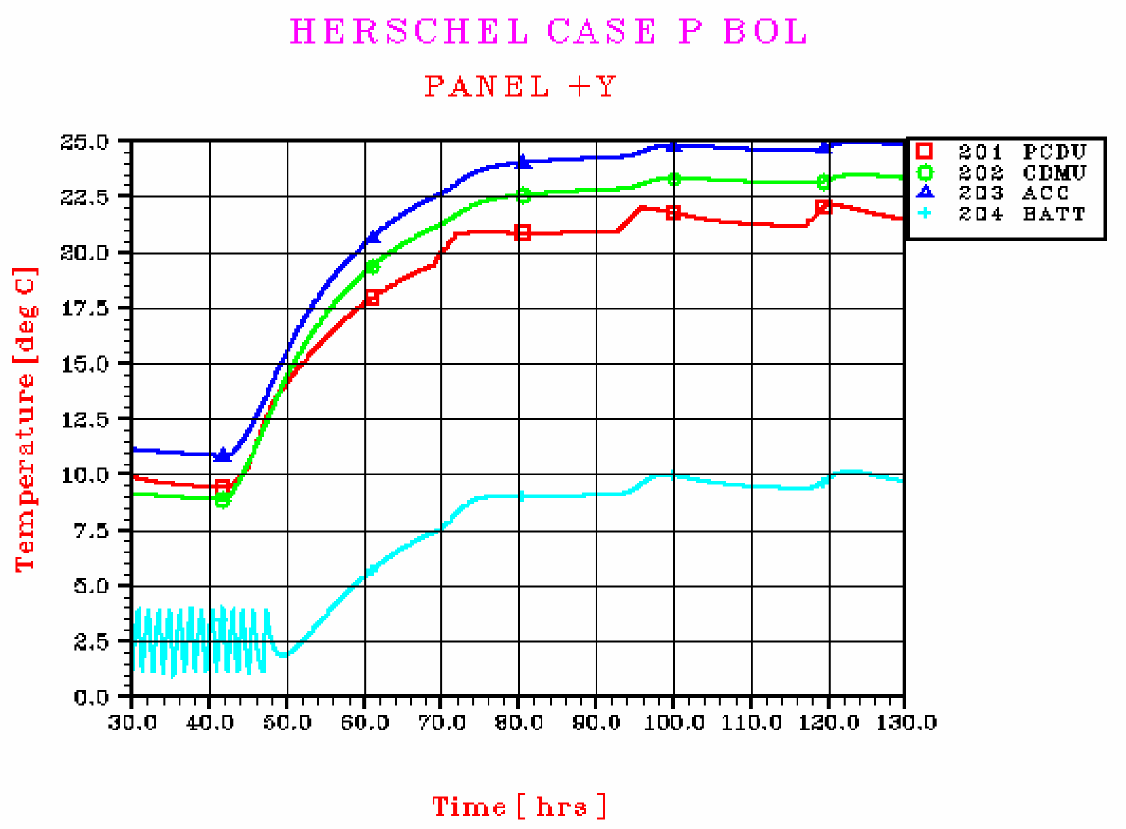

HERSCHEL CASE I BOL
THRUSTERS MAIN
Temperature [deg C]
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]
8133 THR1 MAIN
8233 THR2 MAIN
8333 THR3 MAIN
8433 THR4 MAIN
8533 THR5 MAIN
8633 THR6 MAIN

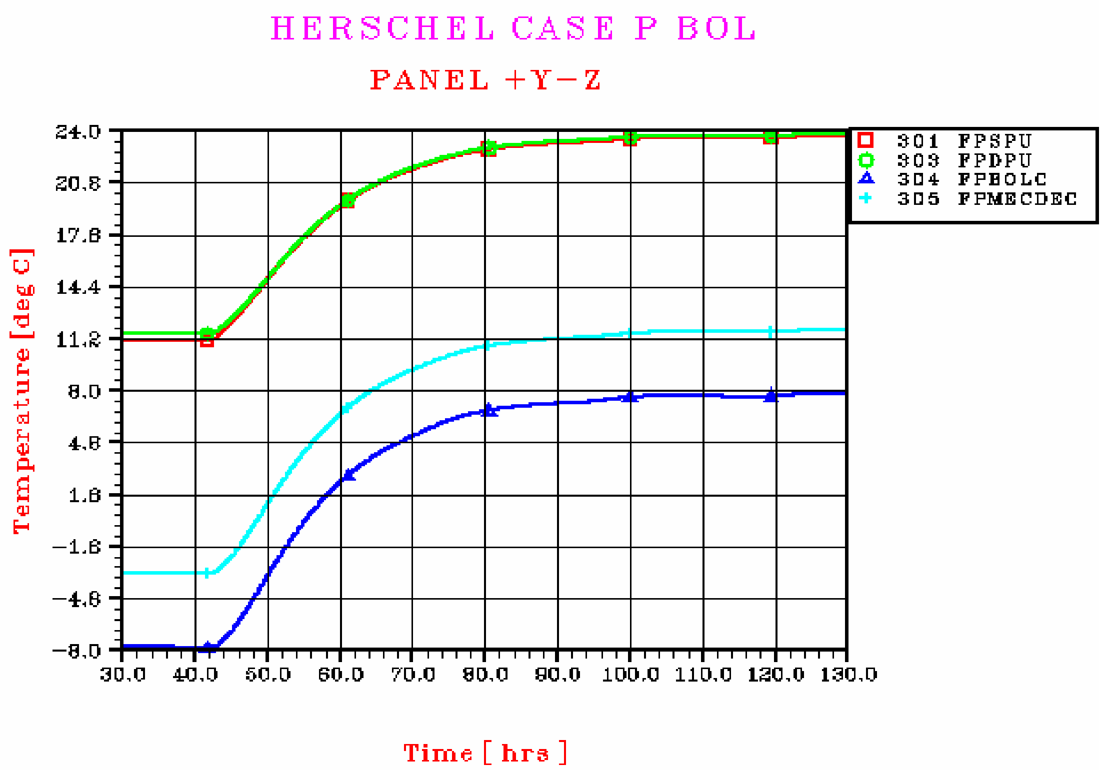

HERSCHEL CASE I BOL
THRUSTERS REDUNDANT
Temperature [deg C]
16.0
15.4
14.8
14.2
13.6
13.0
12.4
11.8
11.2
10.6
10.0
20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0
Time [hrs]
8134 THR1 RED
8234 THR2 RED
8334 THR3 RED
8434 THR4 RED
8534 THR5 RED
8634 THR6 RED

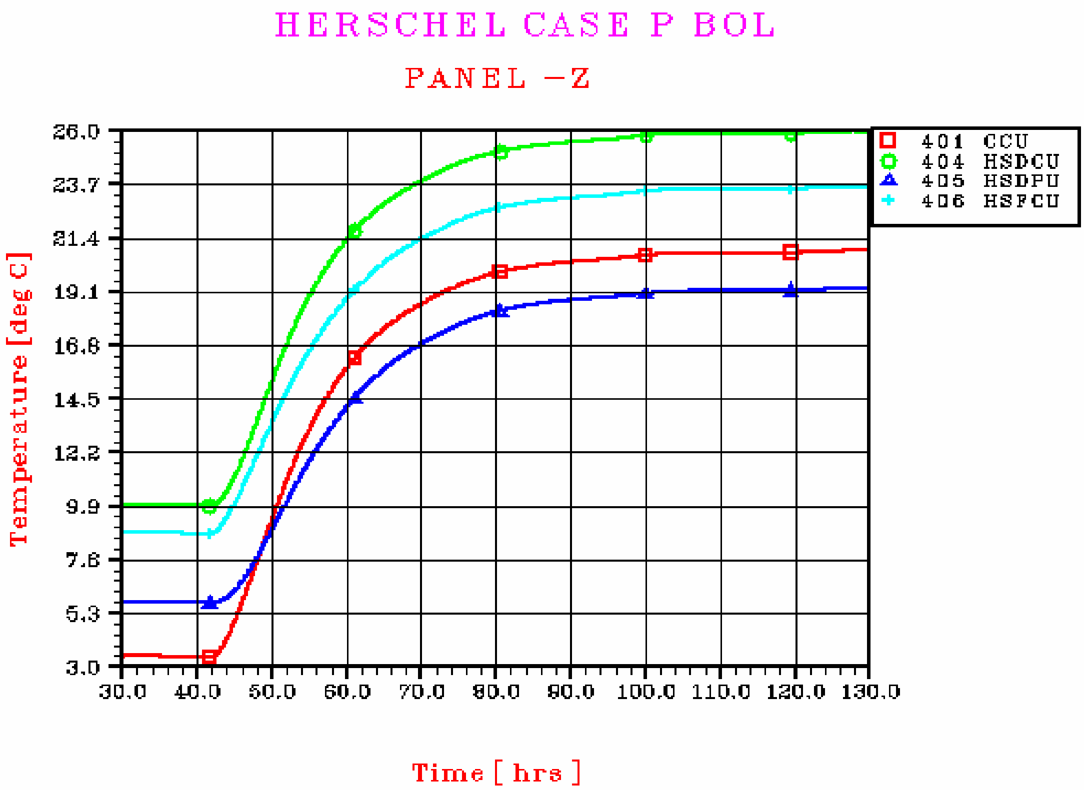
7.4 HERSCHEL RESULTS OF CASE P

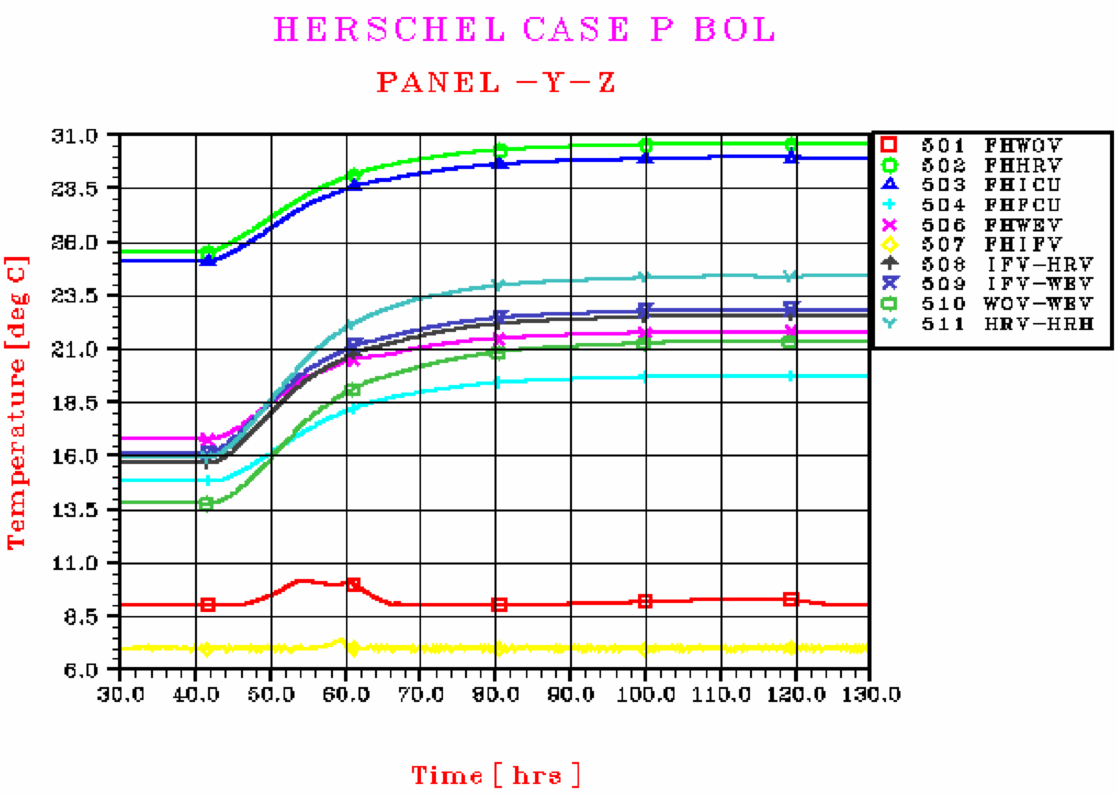


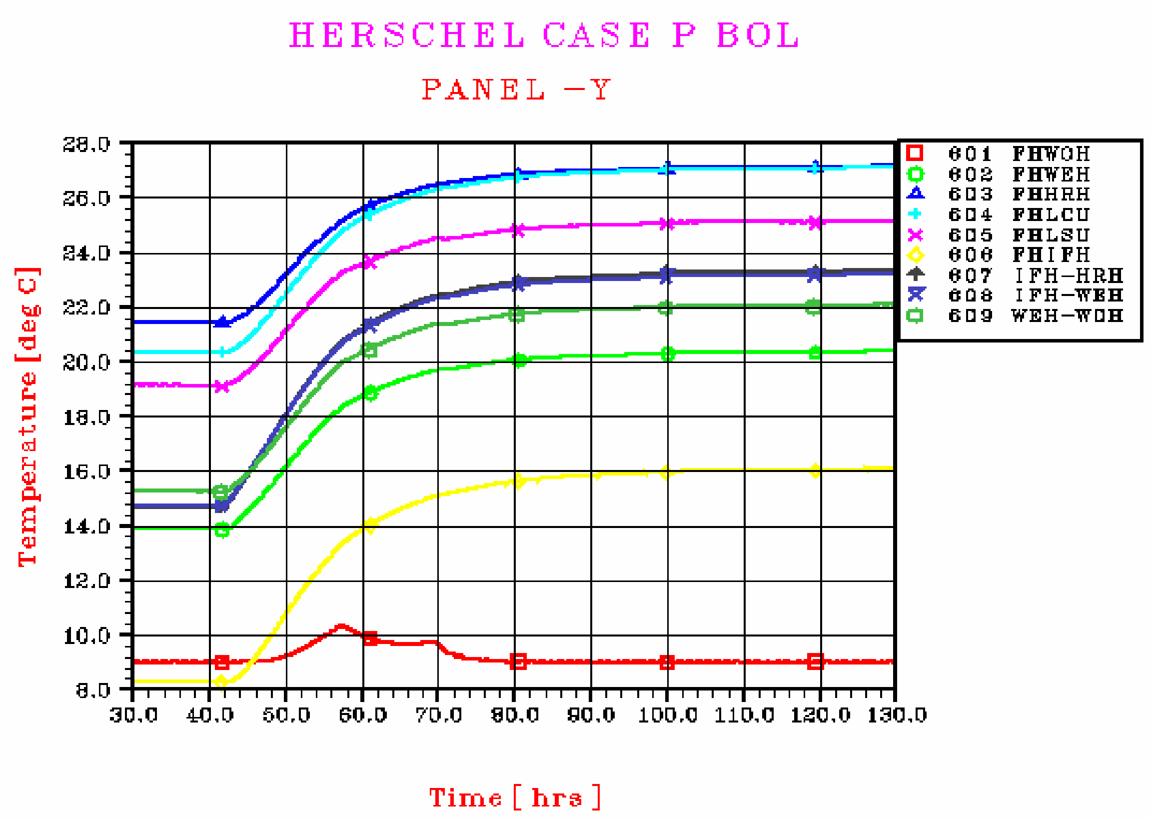


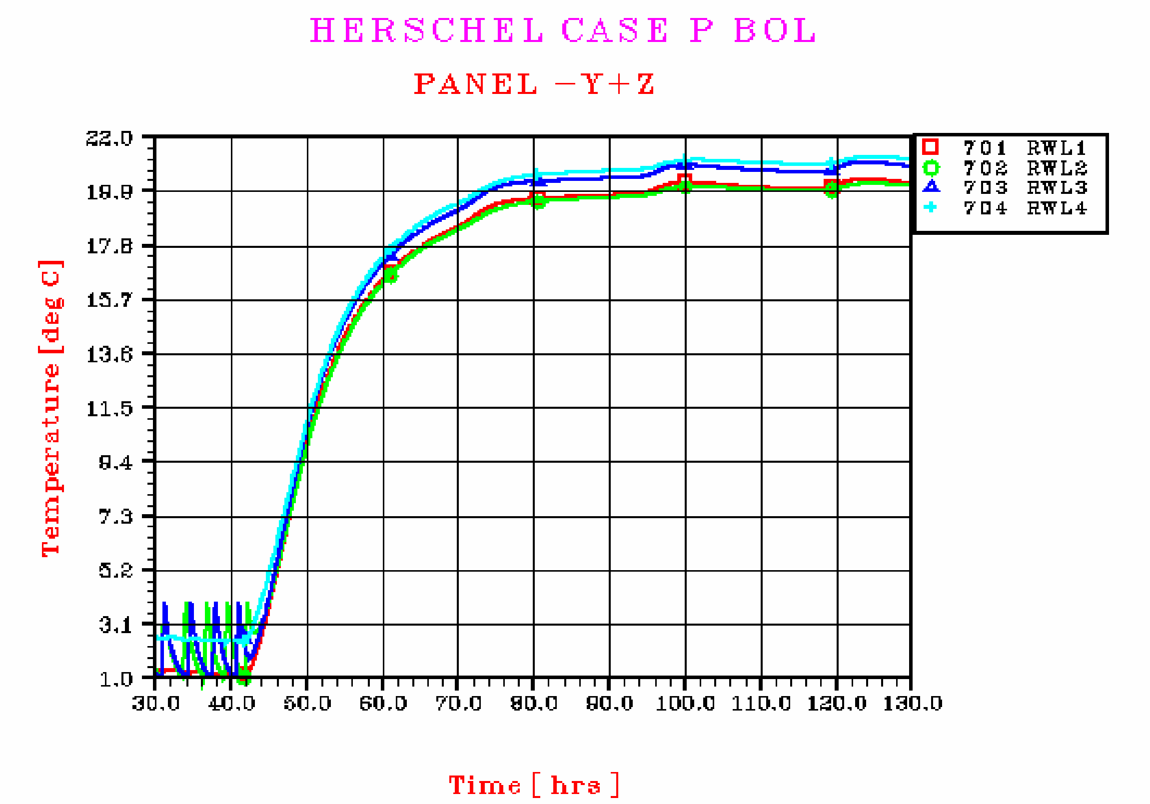

HERSCHEL CASE P BOL
PANEL +Y
Temperature [deg C]
Time [hrs]
201 PCDU
202 CDMU
203 ACC
204 BATT
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0


HERSCHEL CASE P BOL
PANEL +Y−Z
Temperature [deg C]
Time [hrs]
301 FPSPU
303 FPDPU
304 FPBOLC
305 FPMECDEC
24.0
20.8
17.6
14.4
11.2
8.0
4.8
1.6
−1.6
−4.8
−8.0
30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0


HERSCHEL CASE P BOL
PANEL -Z
Temperature [deg C]
Time [hrs]
401 CCU
404 HSDCU
405 HSDPU
406 HSFCU
26.0
23.7
21.4
19.1
16.8
14.5
12.2
9.9
7.6
5.3
3.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0

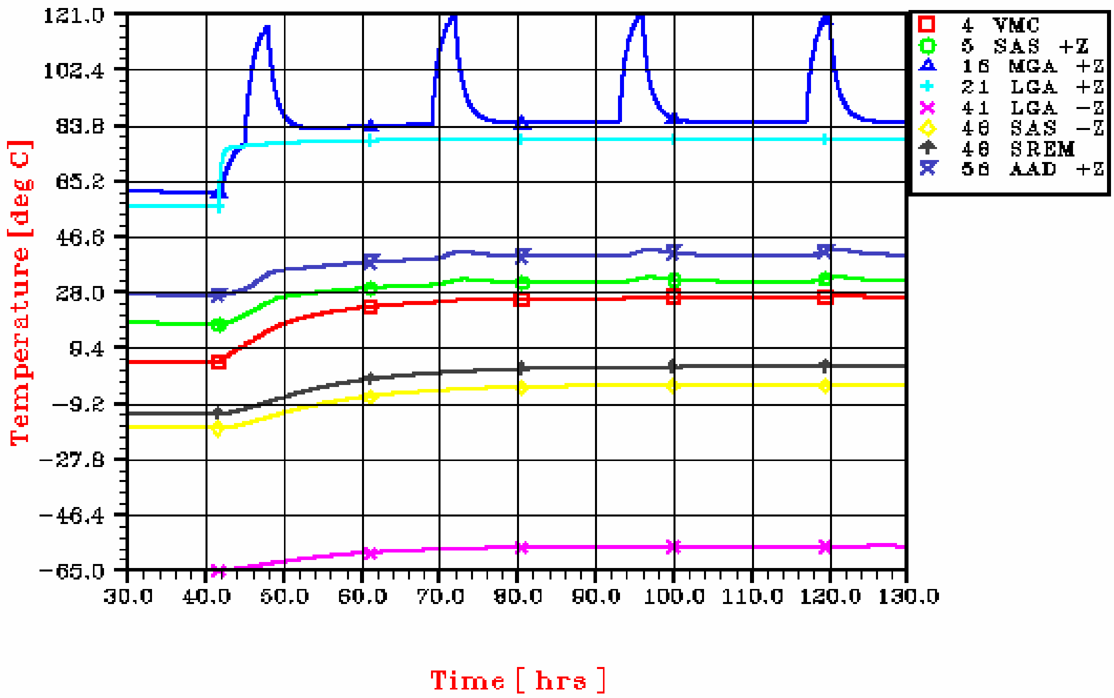

HERSCHEL CASE P BOL
PANEL -Y-Z
Temperature [deg C]
Time [hrs]
501 FHWOV
502 FHHRV
503 FHICU
504 FHFCU
506 FHWEV
507 FHIFV
508 IFV-HRV
509 IFV-WEV
510 WOV-WEV
511 HRV-HRH
31.0
28.5
26.0
23.5
21.0
18.5
16.0
13.5
11.0
8.5
6.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0


HERSCHEL CASE P BOL
PANEL -Y
Temperature [deg C]
Time [hrs]
601 FHWOH
602 FHWEH
603 FHHRH
604 FHLCU
605 FHLSU
606 FHIFH
607 IFH-HRH
608 IFH-WEH
609 WEH-WOH


HERSCHEL CASE P BOL
PANEL -Y+Z
Temperature [deg C]
Time [hrs]
701 RWL1
702 RWL2
703 RWL3
704 RWL4

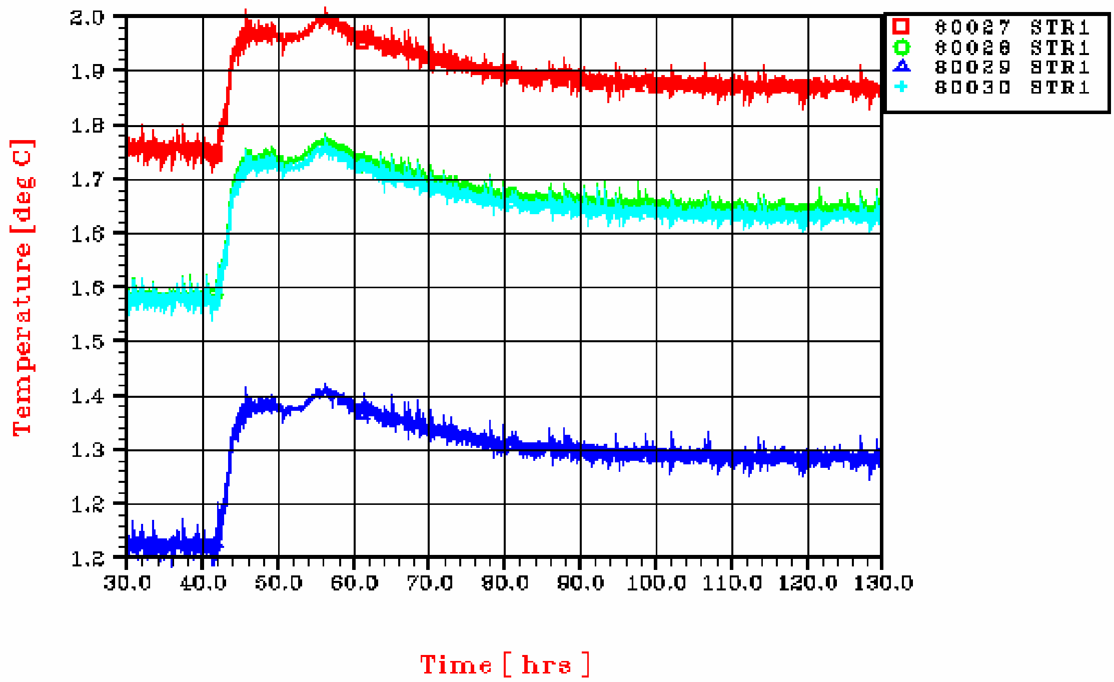
HERSCHEL CASE P BOL

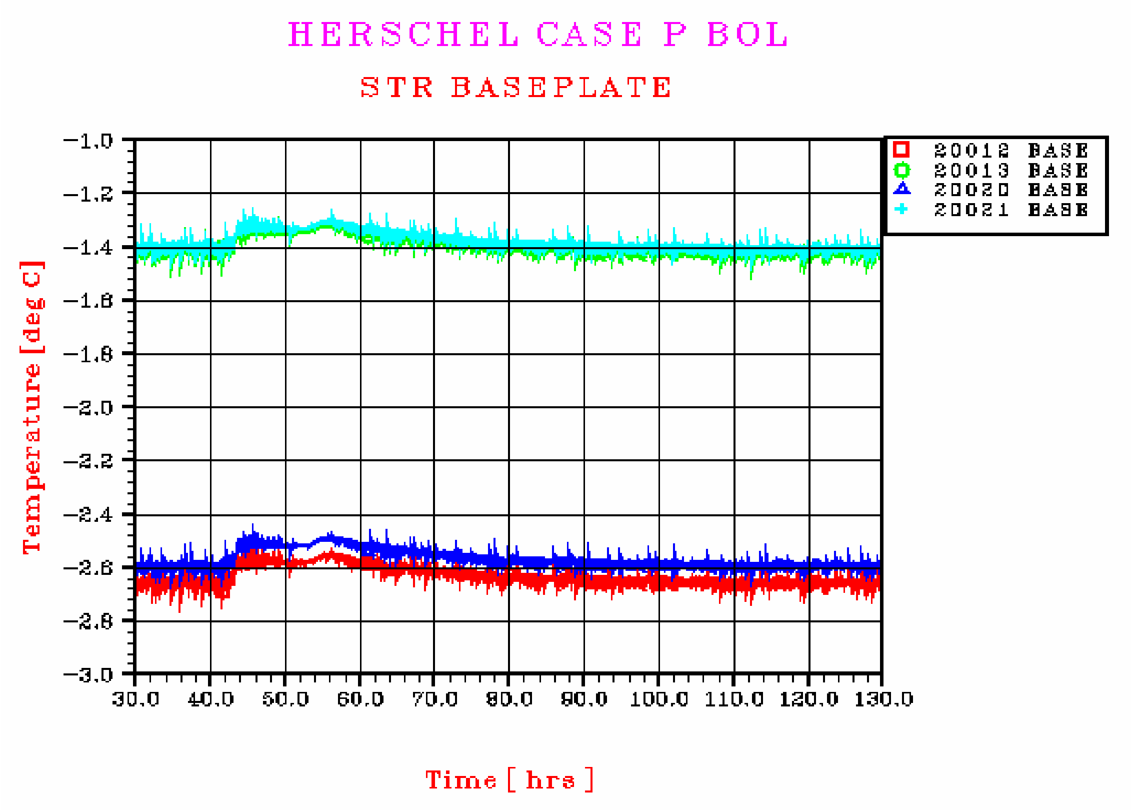
EXTERNAL UNITS

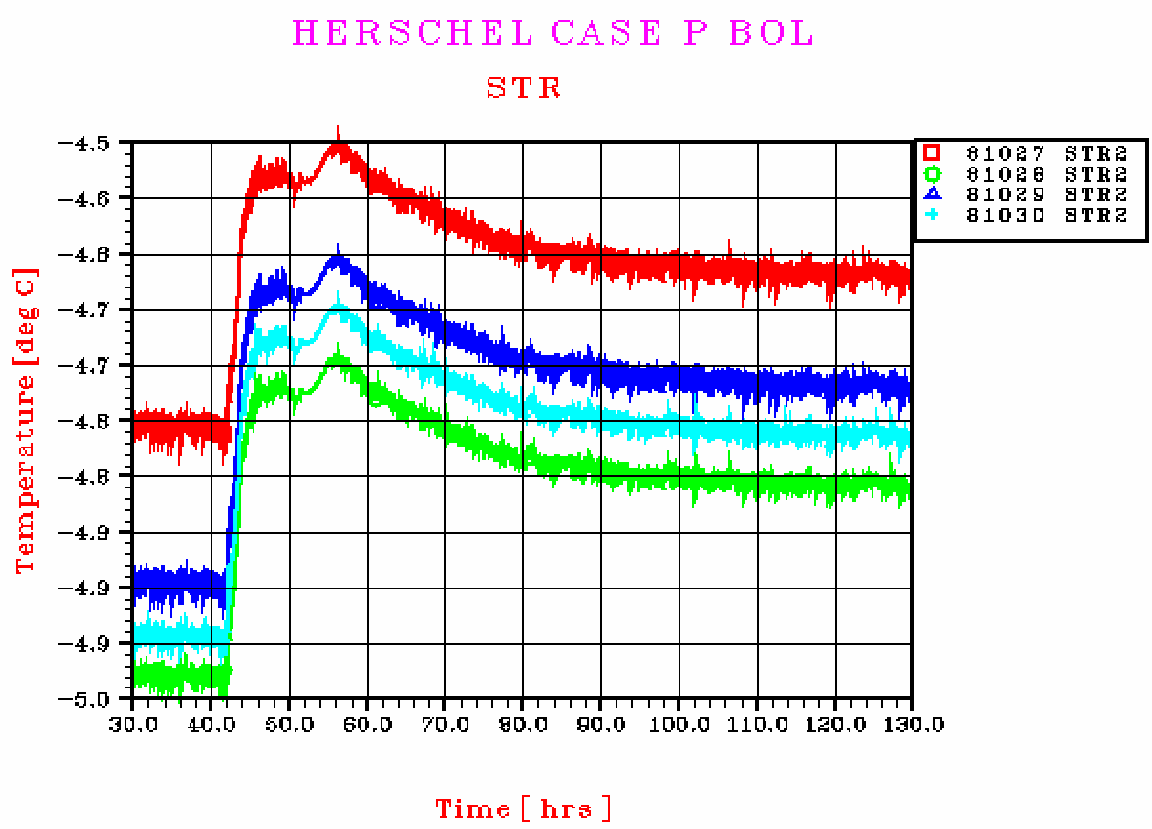


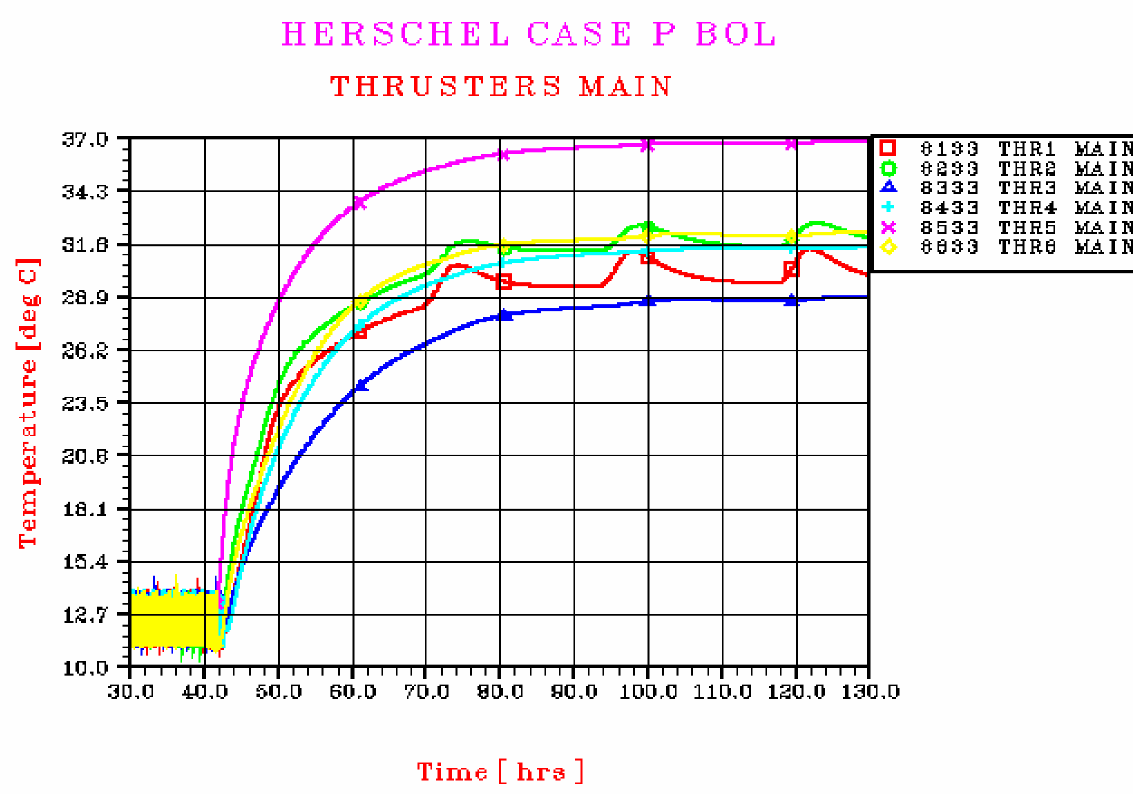
HERSCHEL CASE P BOL

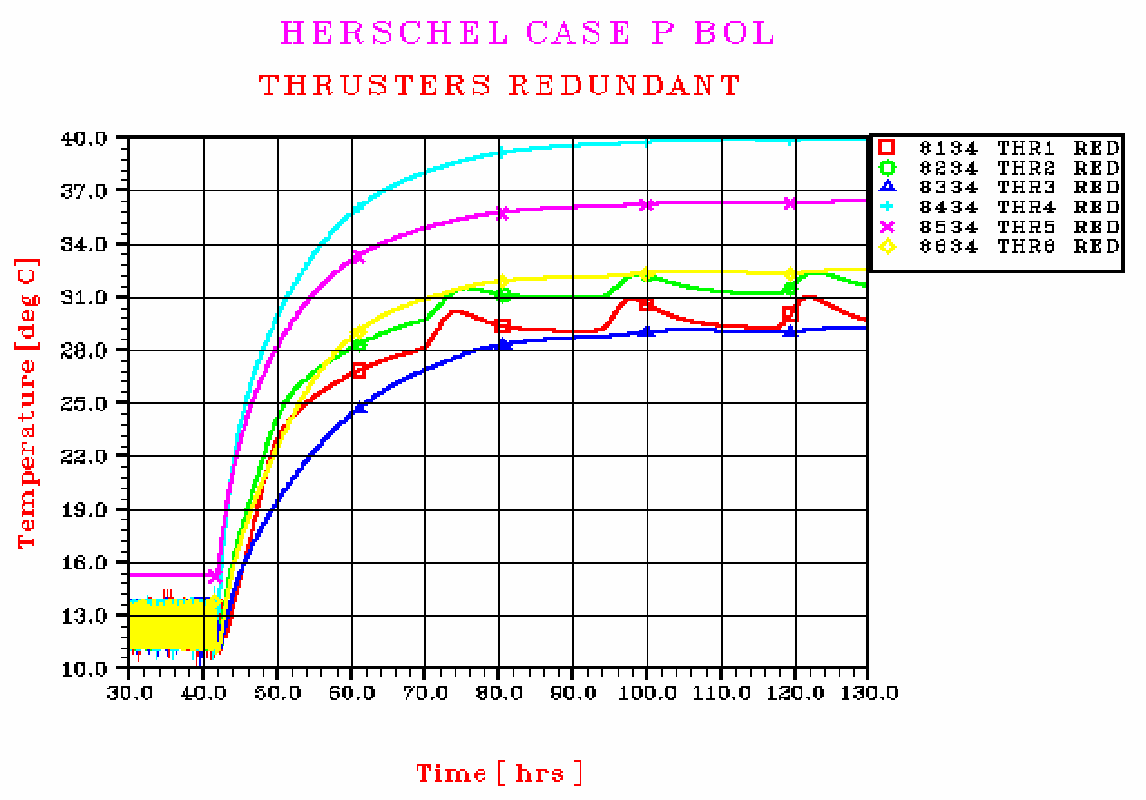
STR



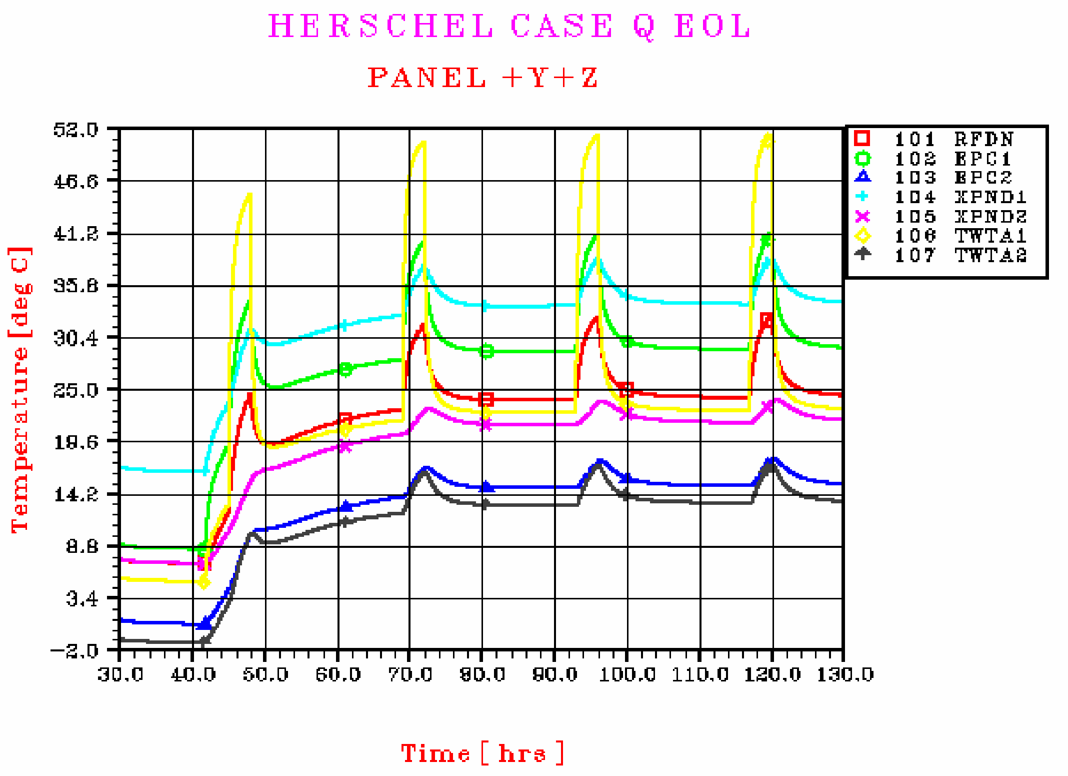

HERSCHEL CASE P BOL
STR BASEPLATE
20012 BASE
20013 BASE
20020 BASE
20021 BASE
Temperature [deg C]
Time [hrs]
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4
-2.6
-2.8
-3.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0

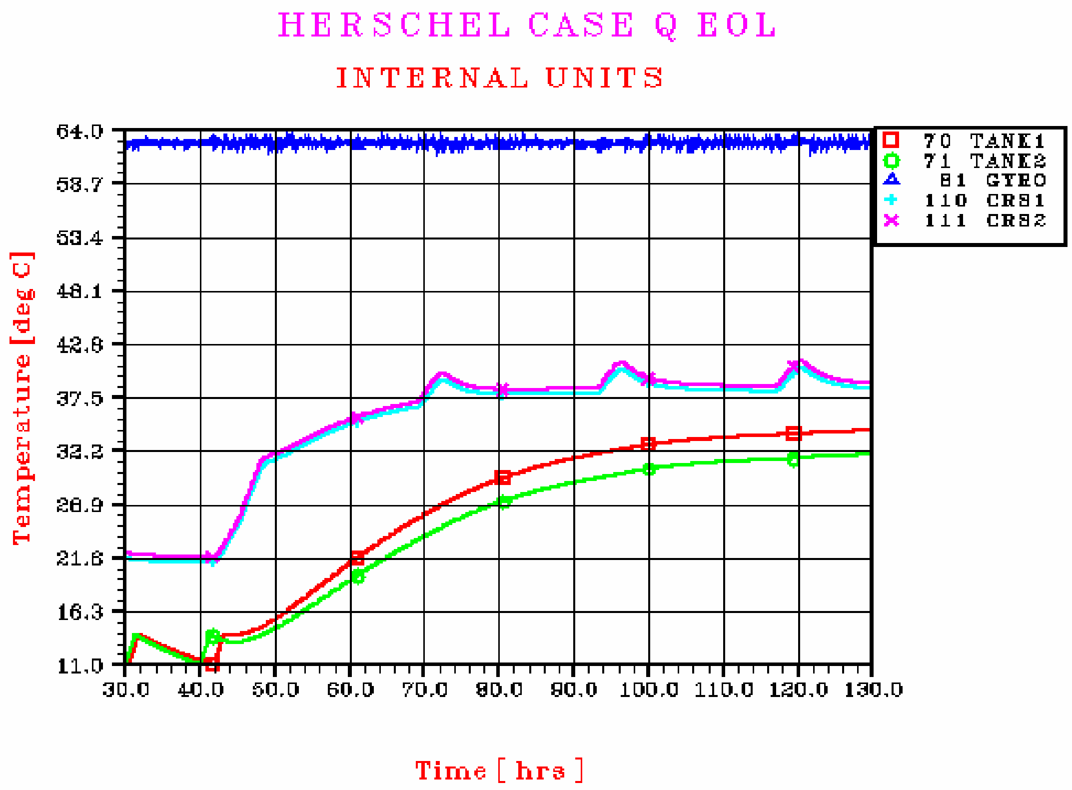

HERSCHEL CASE P BOL
STR
81027 STR2
81028 STR2
81029 STR2
81030 STR2
Temperature [deg C]
Time [hrs]
-4.5
-4.6
-4.6
-4.7
-4.7
-4.8
-4.8
-4.9
-4.9
-4.9
-5.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0

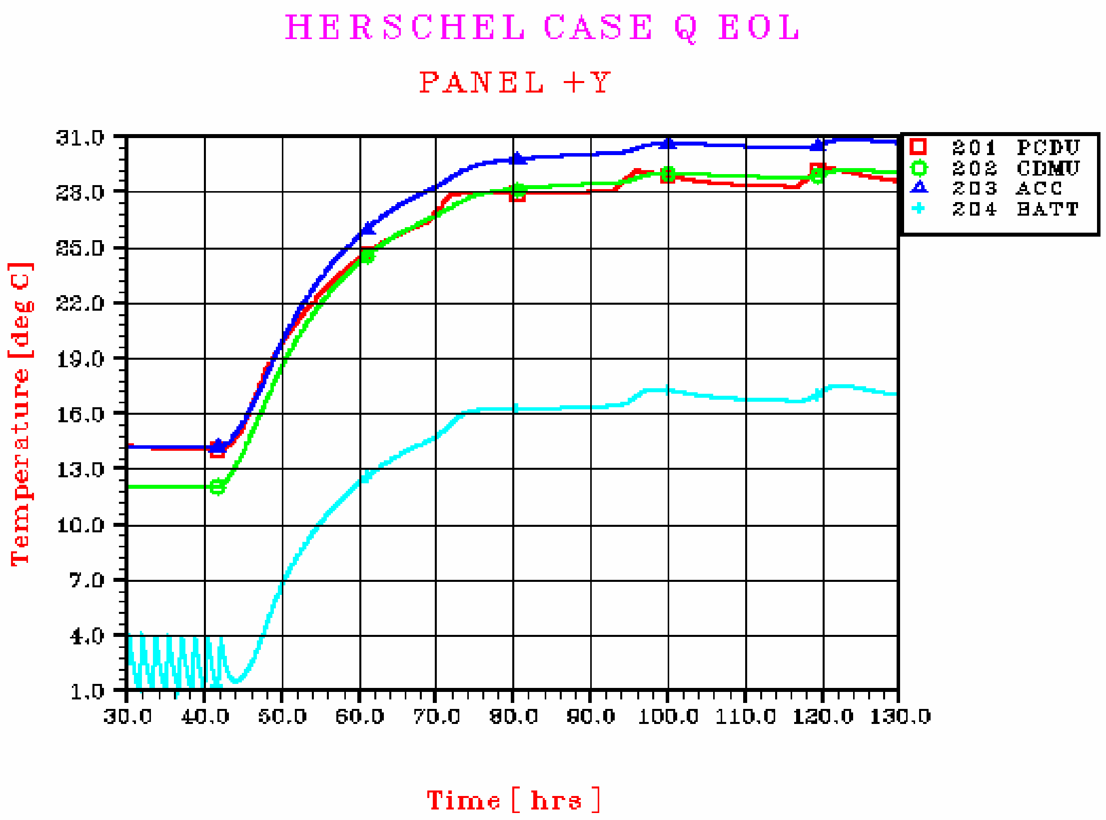

HERSCHEL CASE P BOL
THRUSTERS MAIN
37.0
34.3
31.6
28.9
26.2
23.5
20.8
18.1
15.4
12.7
10.0
Temperature [deg C]
30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0
Time [hrs]
8133 THR1 MAIN
8233 THR2 MAIN
8333 THR3 MAIN
8433 THR4 MAIN
8533 THR5 MAIN
8633 THR6 MAIN

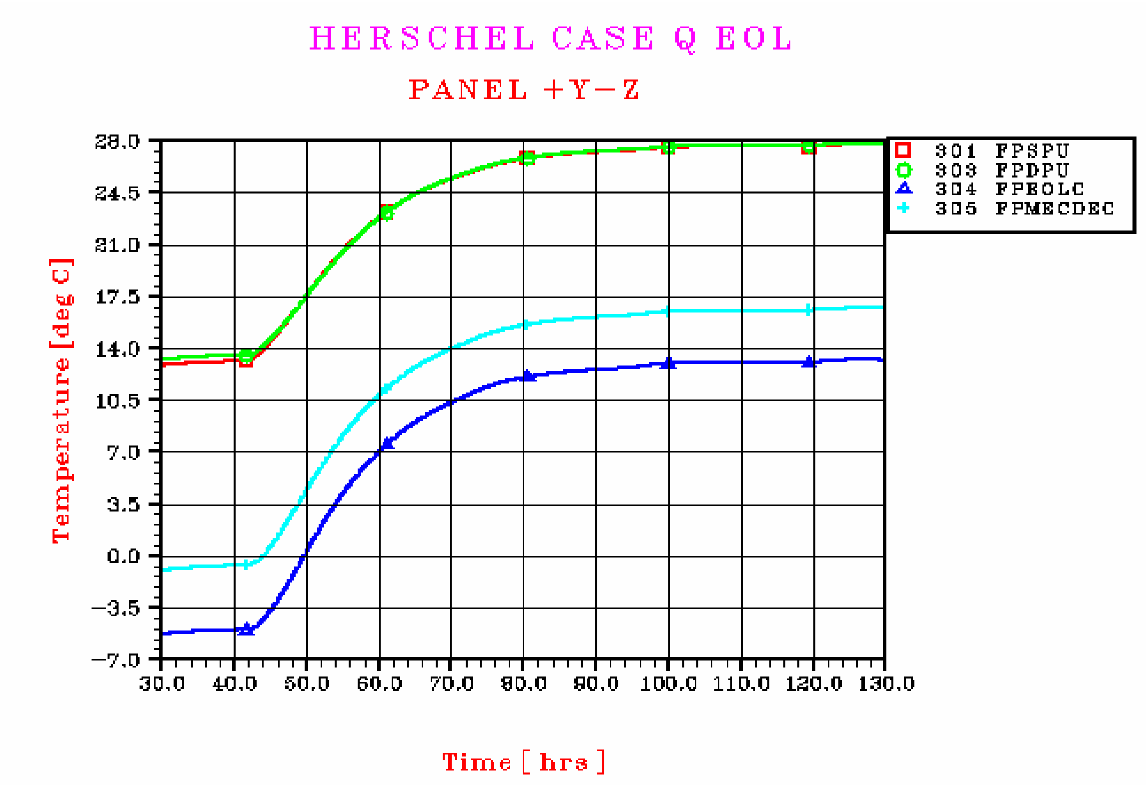

HERSCHEL CASE P BOL
THRUSTERS REDUNDANT
40.0
37.0
34.0
31.0
28.0
25.0
22.0
19.0
16.0
13.0
10.0
Temperature [deg C]
30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0
Time [hrs]
8134 THR1 RED
8234 THR2 RED
8334 THR3 RED
8434 THR4 RED
8534 THR5 RED
8634 THR6 RED

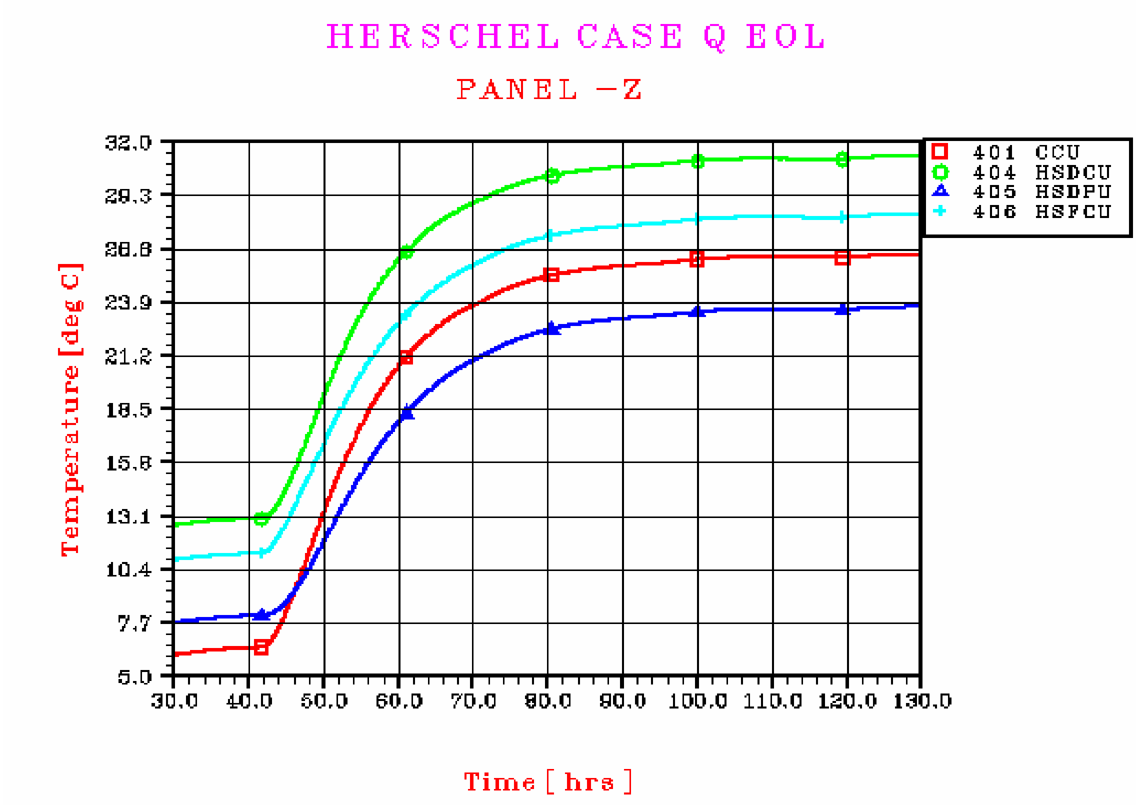
7.5 HERSCHEL RESULTS OF CASE Q

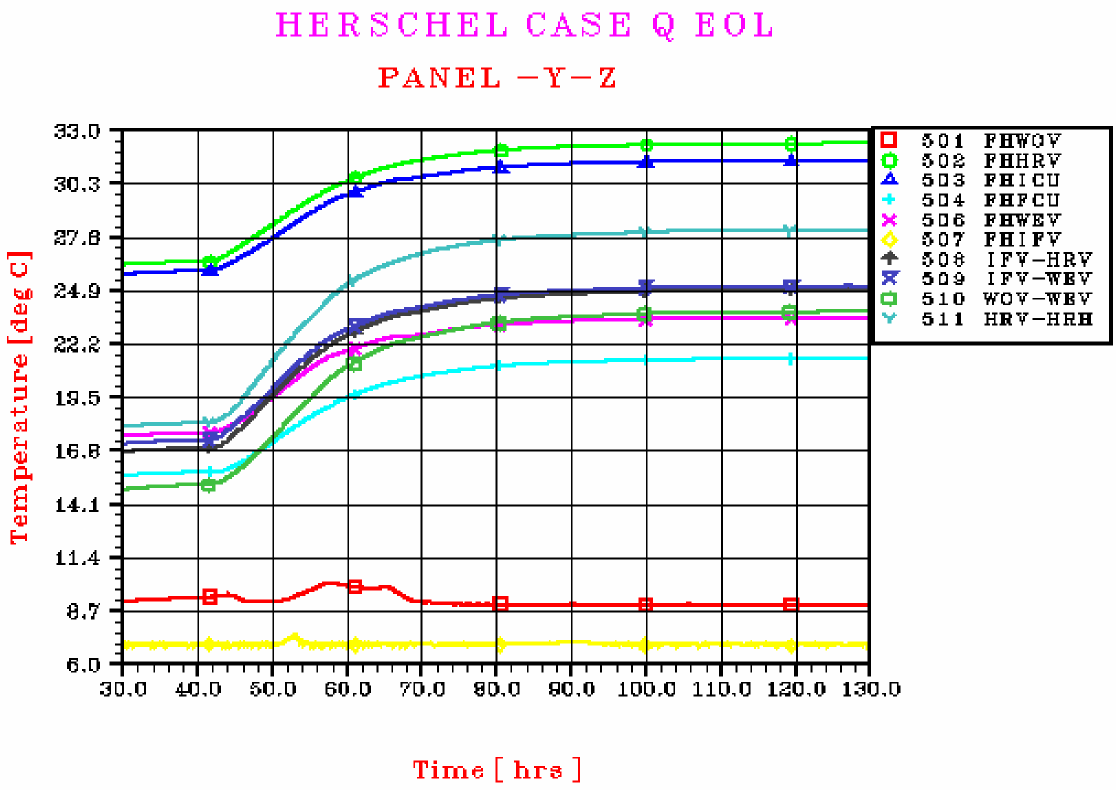


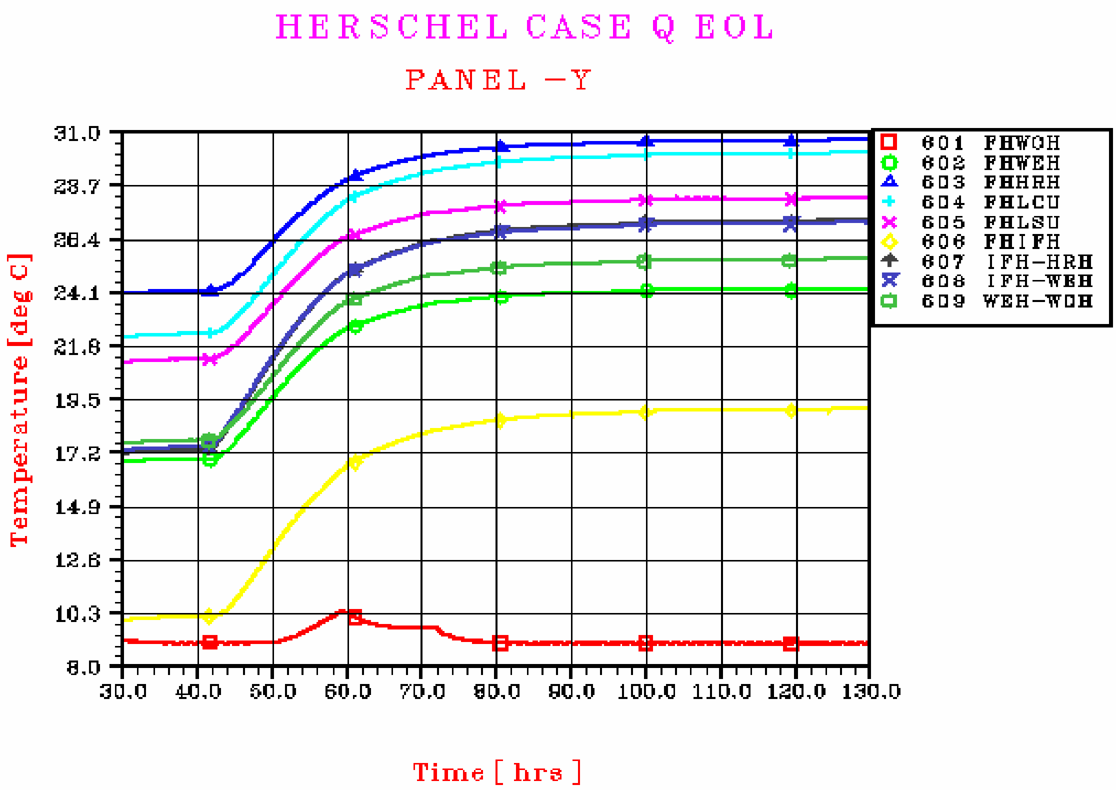

HERSCHEL CASE Q EOL
INTERNAL UNITS
Temperature [deg C]
64.0
58.7
53.4
48.1
42.8
37.5
32.2
26.9
21.6
16.3
11.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
Time [hrs]
70 TANK1
71 TANK2
81 GYRO
110 CRS1
111 CRS2

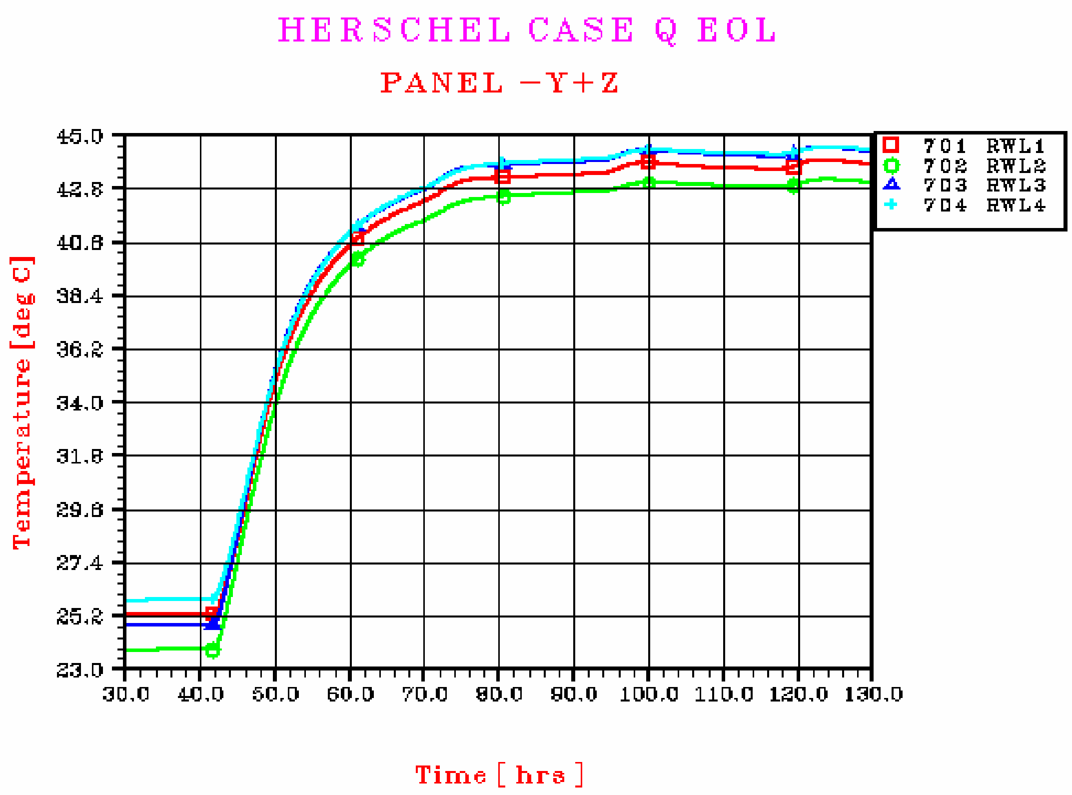

HERSCHEL CASE Q EOL
PANEL +Y
Temperature [deg C]
31.0
28.0
25.0
22.0
19.0
16.0
13.0
10.0
7.0
4.0
1.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
Time [hrs]
201 PCDU
202 CDMU
203 ACC
204 BATT

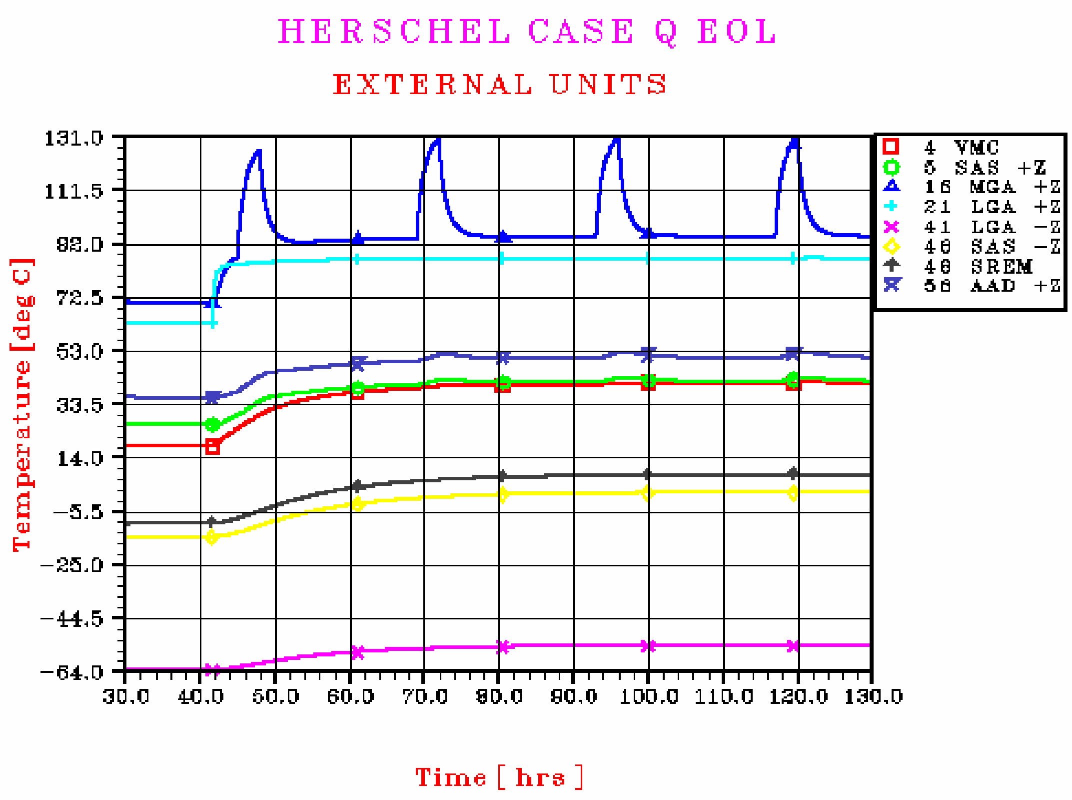

HERSCHEL CASE Q EOL
PANEL +Y-Z
301 FPSPU
303 FPDPU
304 FPEOLC
305 FPMECDEC
Temperature [deg C]
Time [hrs]


HERSCHEL CASE Q EOL
PANEL -Z
401 CCU
404 HSDCU
405 HSDPU
406 HSFCU
Temperature [deg C]
Time [hrs]


HERSCHEL CASE Q EOL
PANEL -Y-Z
Temperature [deg C]
33.0
30.3
27.6
24.9
22.2
19.5
16.8
14.1
11.4
8.7
6.0
30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0
Time [hrs]
501 FHWOV
502 FHHRV
503 FHICU
504 FHFCU
506 FHWEV
507 FHIFV
508 IFV-HRV
509 IFV-WEV
510 WOV-WEV
511 HRV-HRH

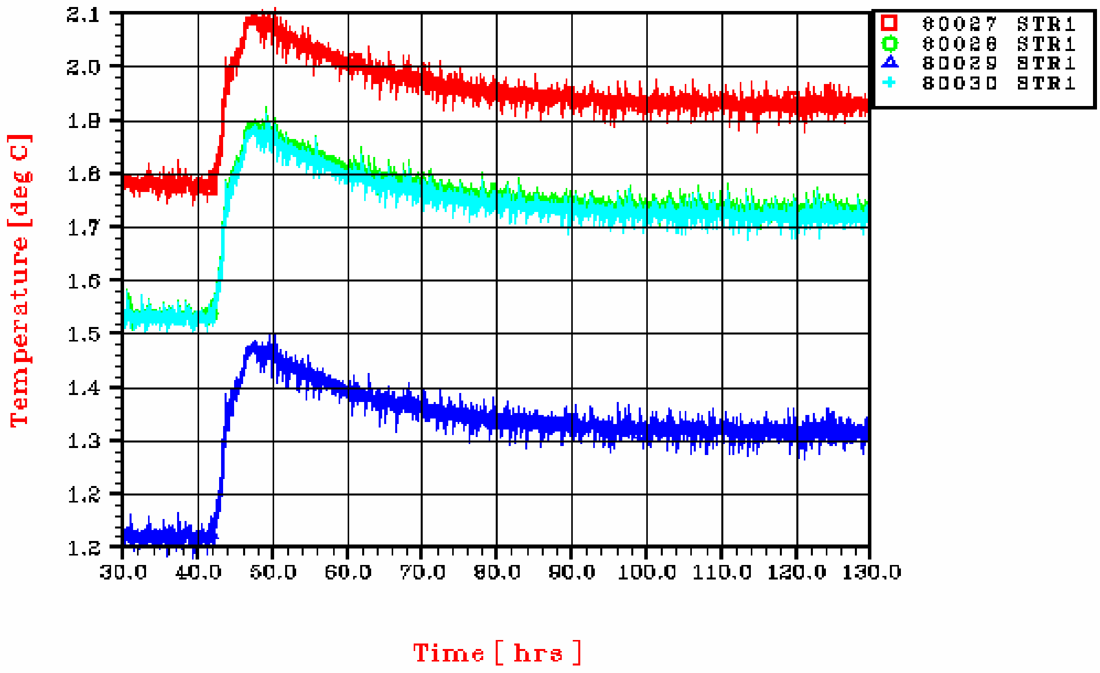

HERSCHEL CASE Q EOL
PANEL -Y
Temperature [deg C]
31.0
28.7
26.4
24.1
21.8
19.5
17.2
14.9
12.6
10.3
8.0
30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0
Time [hrs]
601 FHWOH
602 FHWEH
603 FHHRH
604 FHLCU
605 FHLSU
606 FHIFH
607 IFH-HRH
608 IFH-WEH
609 WEH-WOH


HERSCHEL CASE Q EOL
PANEL -Y+Z
Temperature [deg C]
Time [hrs]
701 RWL1
702 RWL2
703 RWL3
704 RWL4


HERSCHEL CASE Q EOL
EXTERNAL UNITS
Temperature [deg C]
Time [hrs]
4 VMC
5 SAS +Z
16 MGA +Z
21 LGA +Z
41 LGA -Z
46 SAS -Z
48 SREM
56 AAD +Z

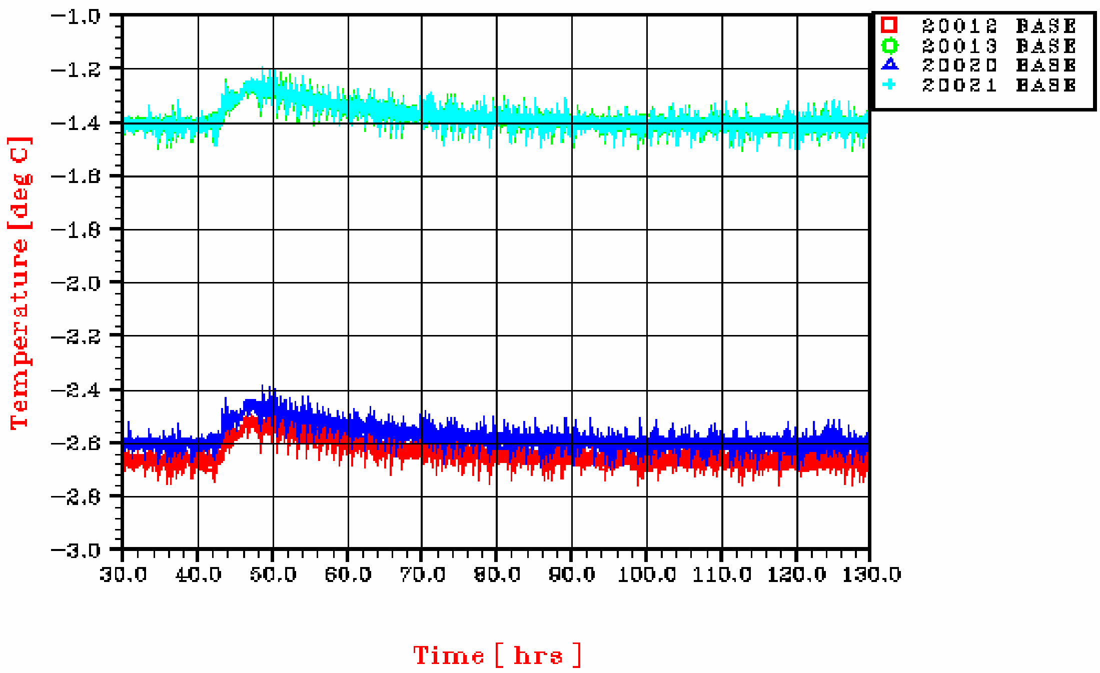
HERSCHEL CASE Q EOL

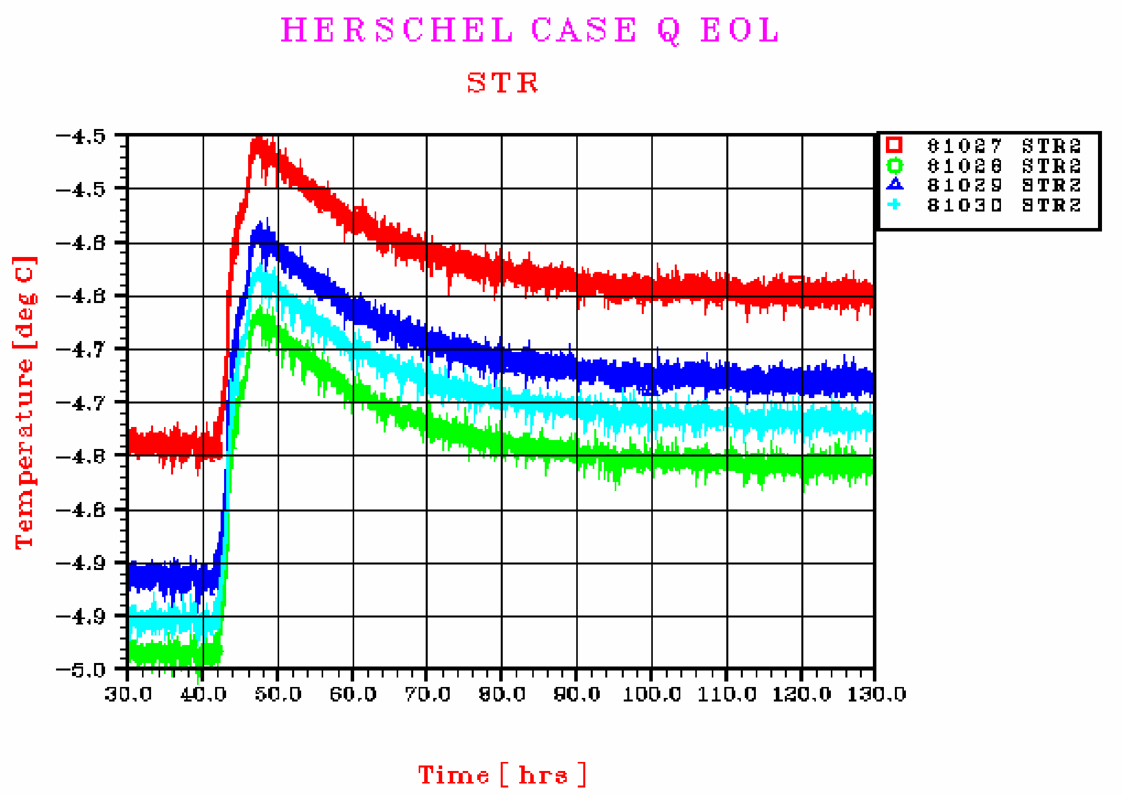
STR

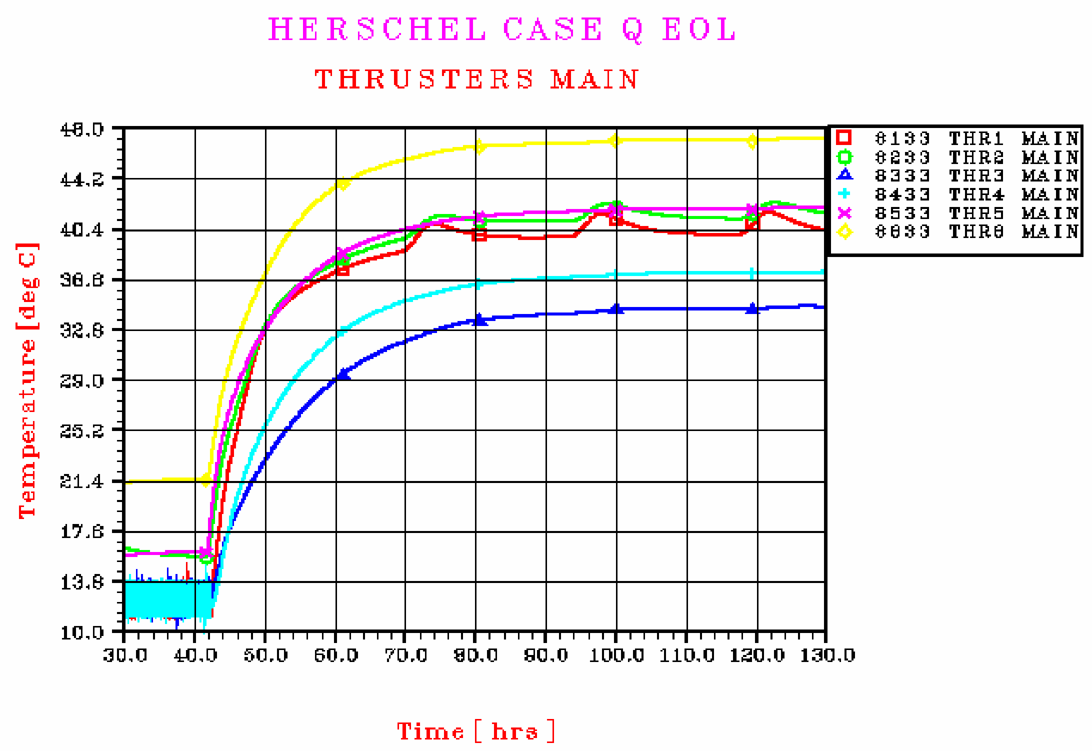


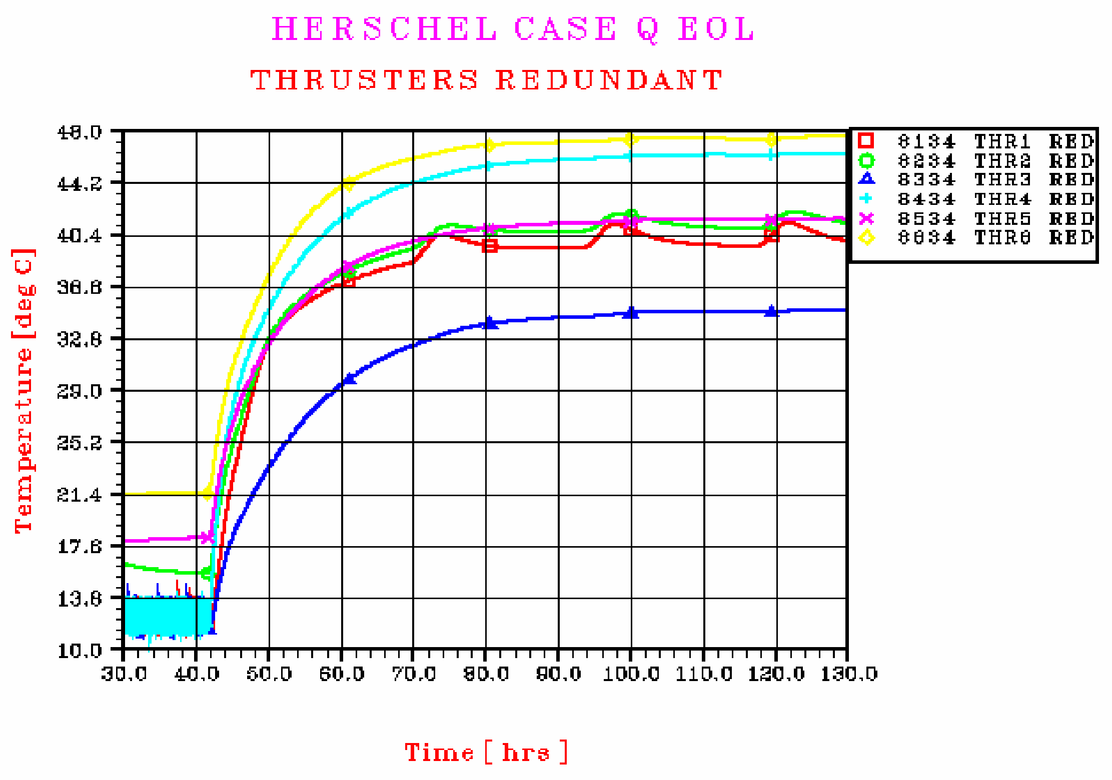
HERSCHEL CASE Q EOL

STR BASEPLATE




HERSCHEL CASE Q EOL
STR
81027 STR2
81028 STR2
81029 STR2
81030 STR2
Temperature [deg C]
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
Time [hrs]

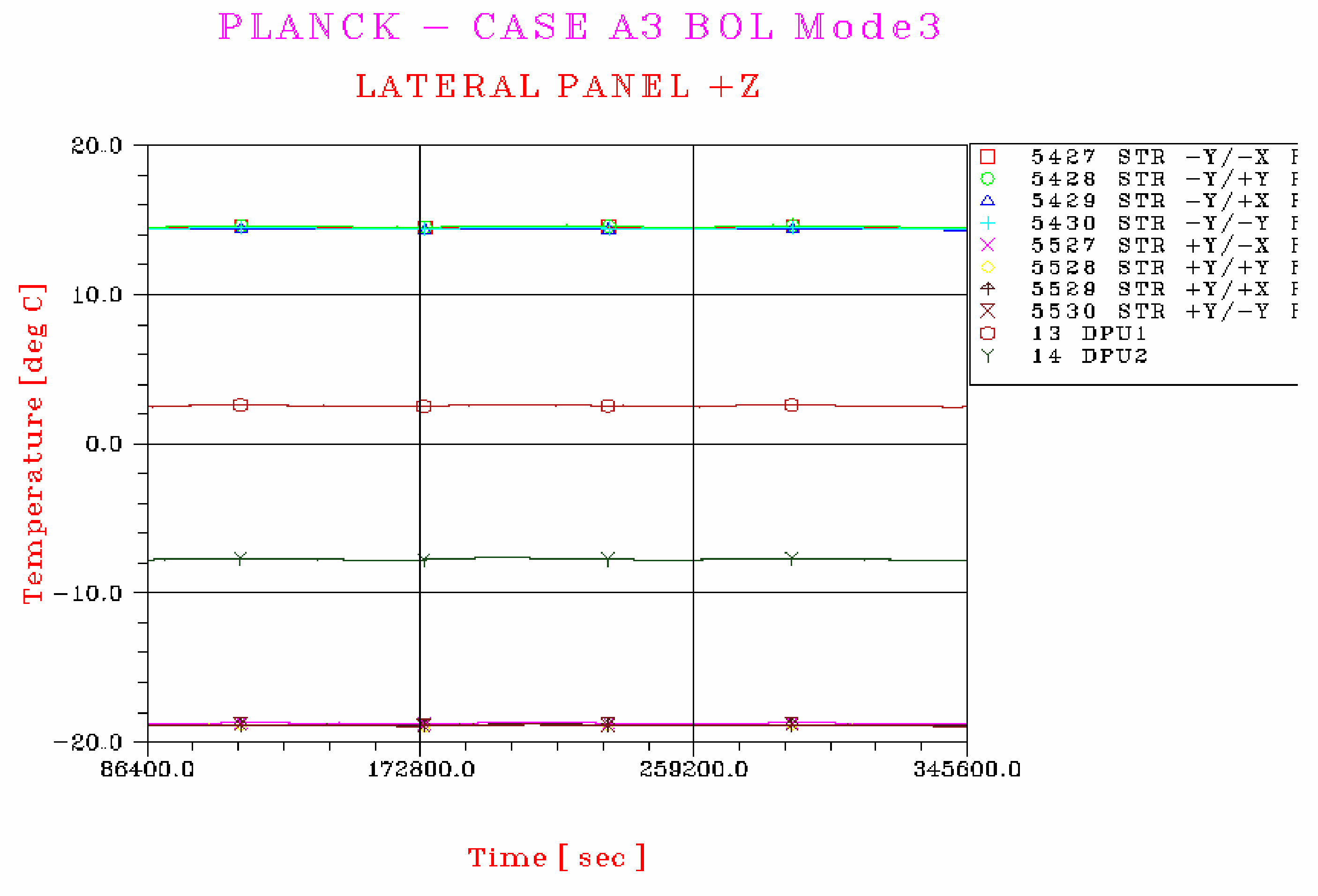

HERSCHEL CASE Q EOL
THRUSTERS MAIN
8133 THR1 MAIN
8233 THR2 MAIN
8333 THR3 MAIN
8433 THR4 MAIN
8533 THR5 MAIN
8633 THR6 MAIN
48.0
44.2
40.4
36.6
32.8
29.0
25.2
21.4
17.6
13.8
10.0
Temperature [deg C]
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
Time [hrs]


HERSCHEL CASE Q EOL
THRUSTERS REDUNDANT
8134 THR1 RED
8234 THR2 RED
8334 THR3 RED
8434 THR4 RED
8534 THR5 RED
8834 THR6 RED
Temperature [deg C]
Time [hrs]
48.0
44.2
40.4
36.6
32.8
29.0
25.2
21.4
17.6
13.8
10.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0

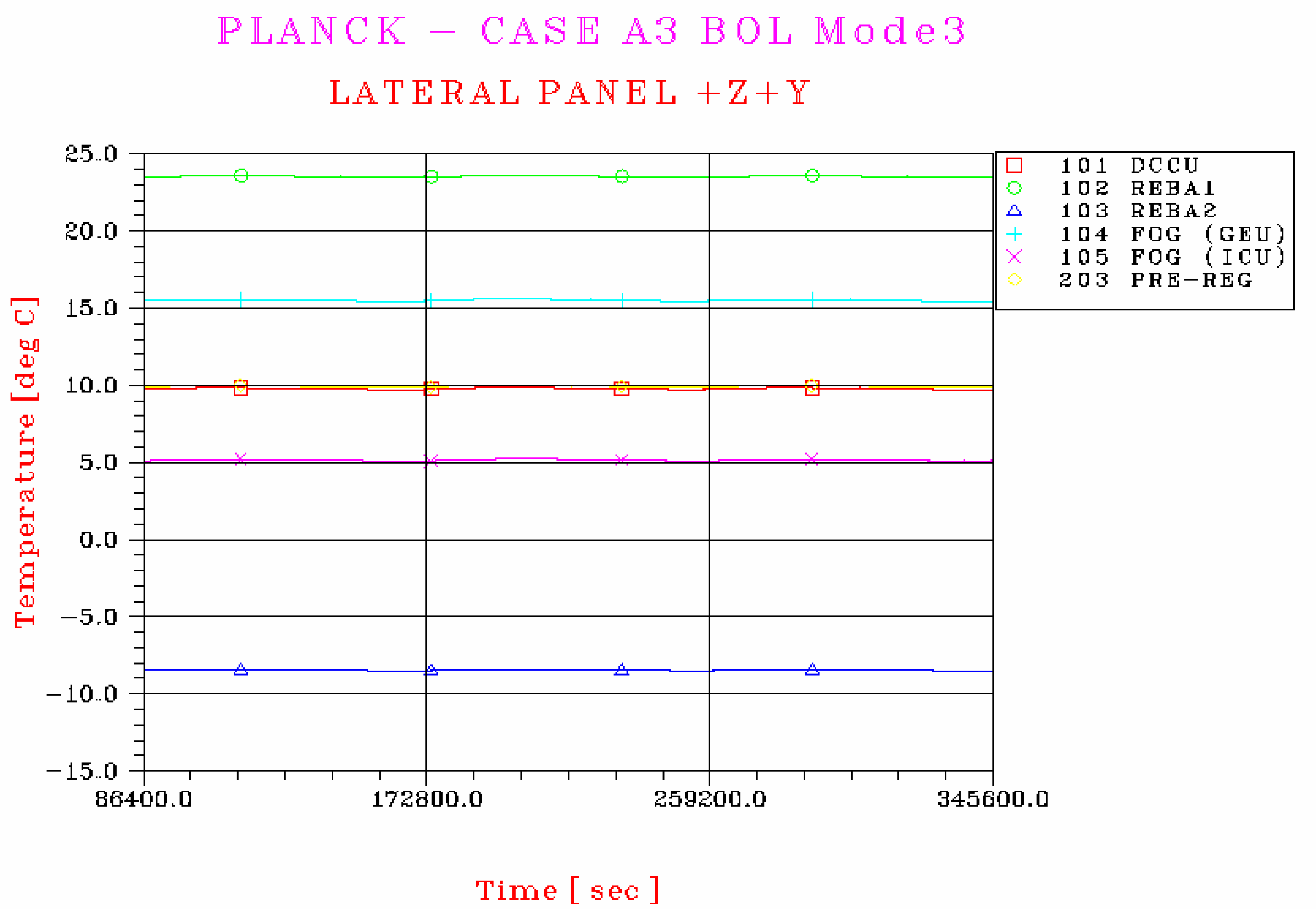
8. PLANCK: TEMPERATURE PLOTS

8.1 PLANCK: PLOTS OF TRANSIENT NOMINAL ANALYSIS CASE A3

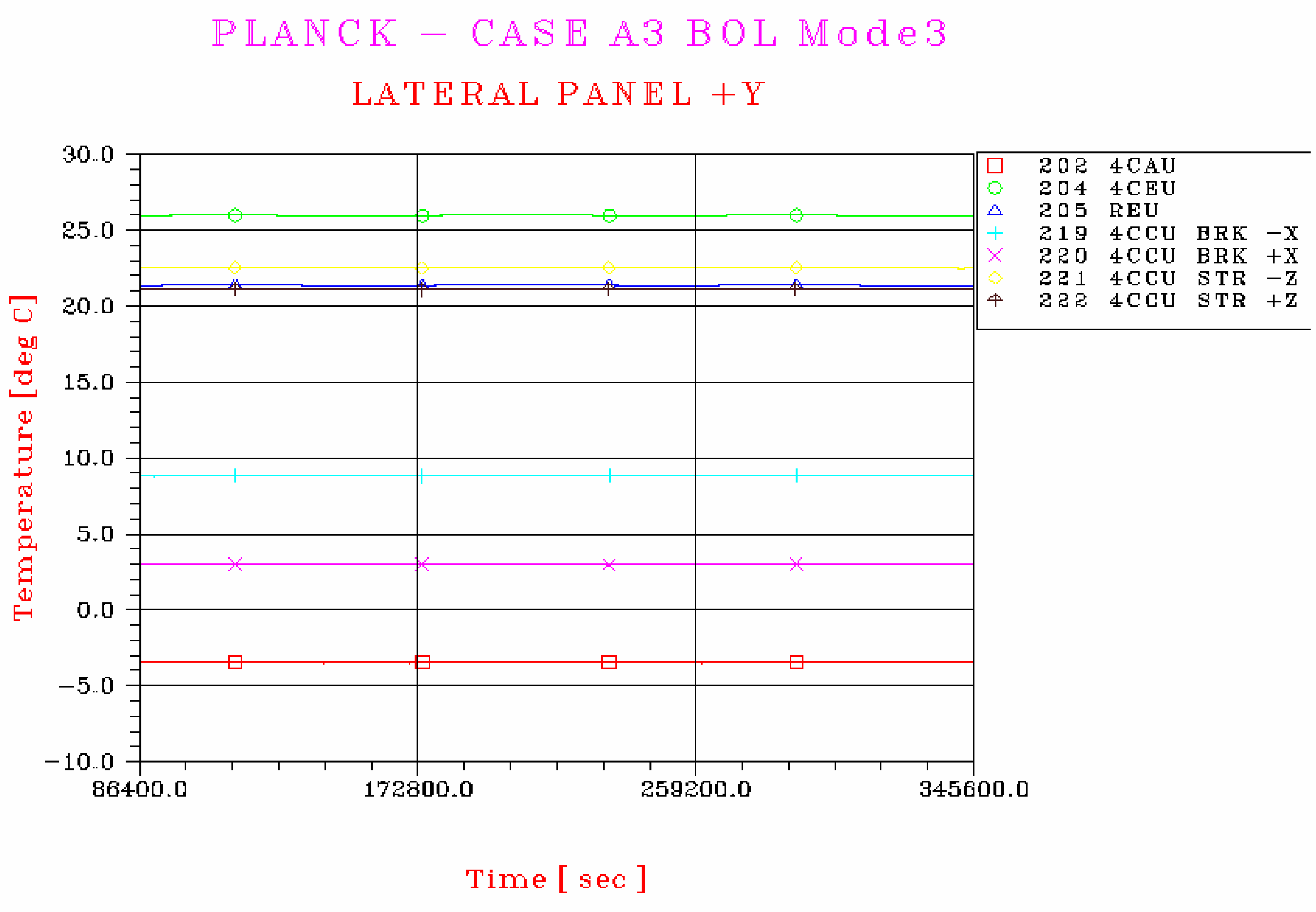
In the following figures, the temperature plots of the transient nominal analysis concerning the satellite in BOLcondition and in configuration Mode 3 (Case A3).



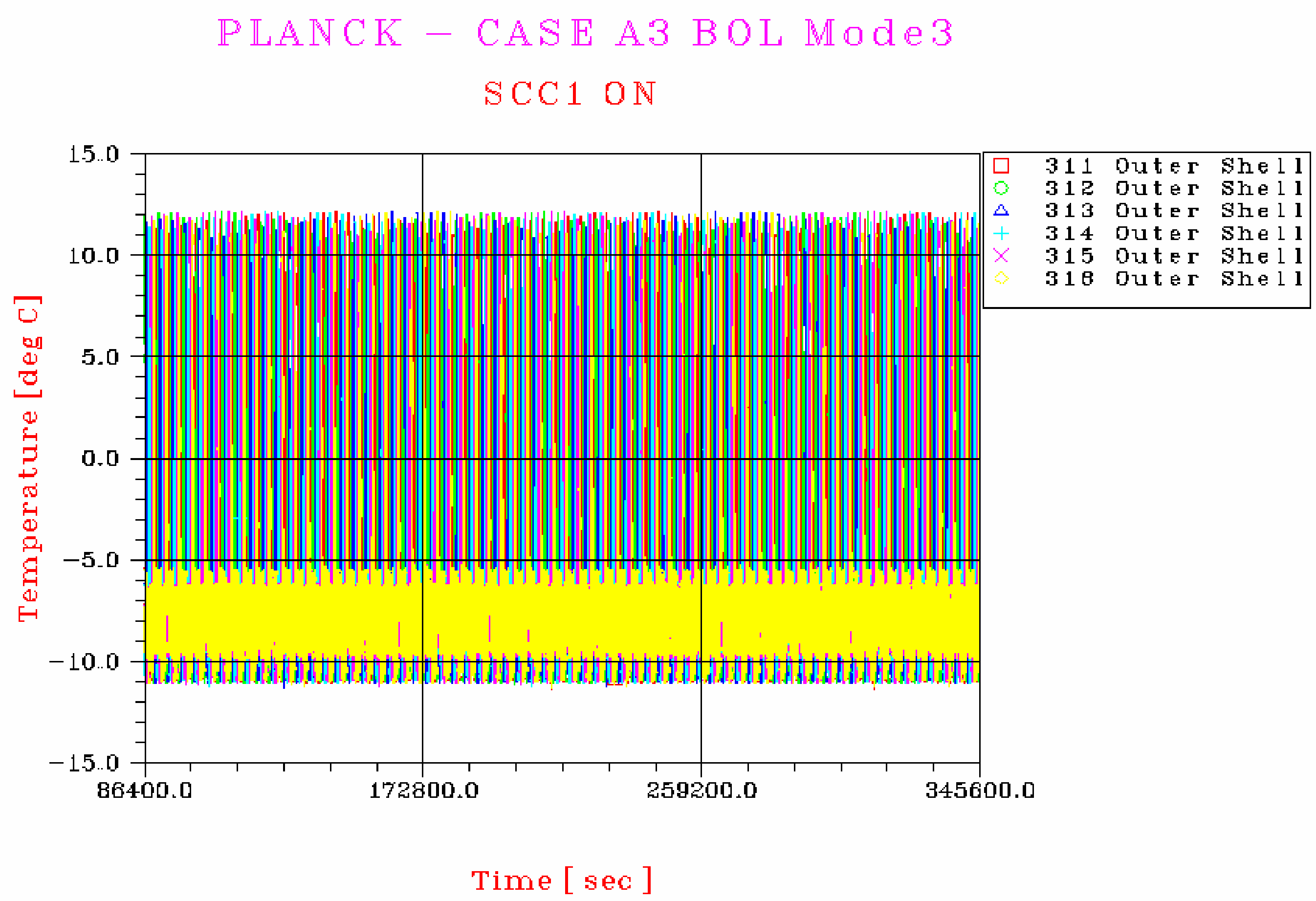
Figures 8.1-1 BOL Case A3 +Z panel



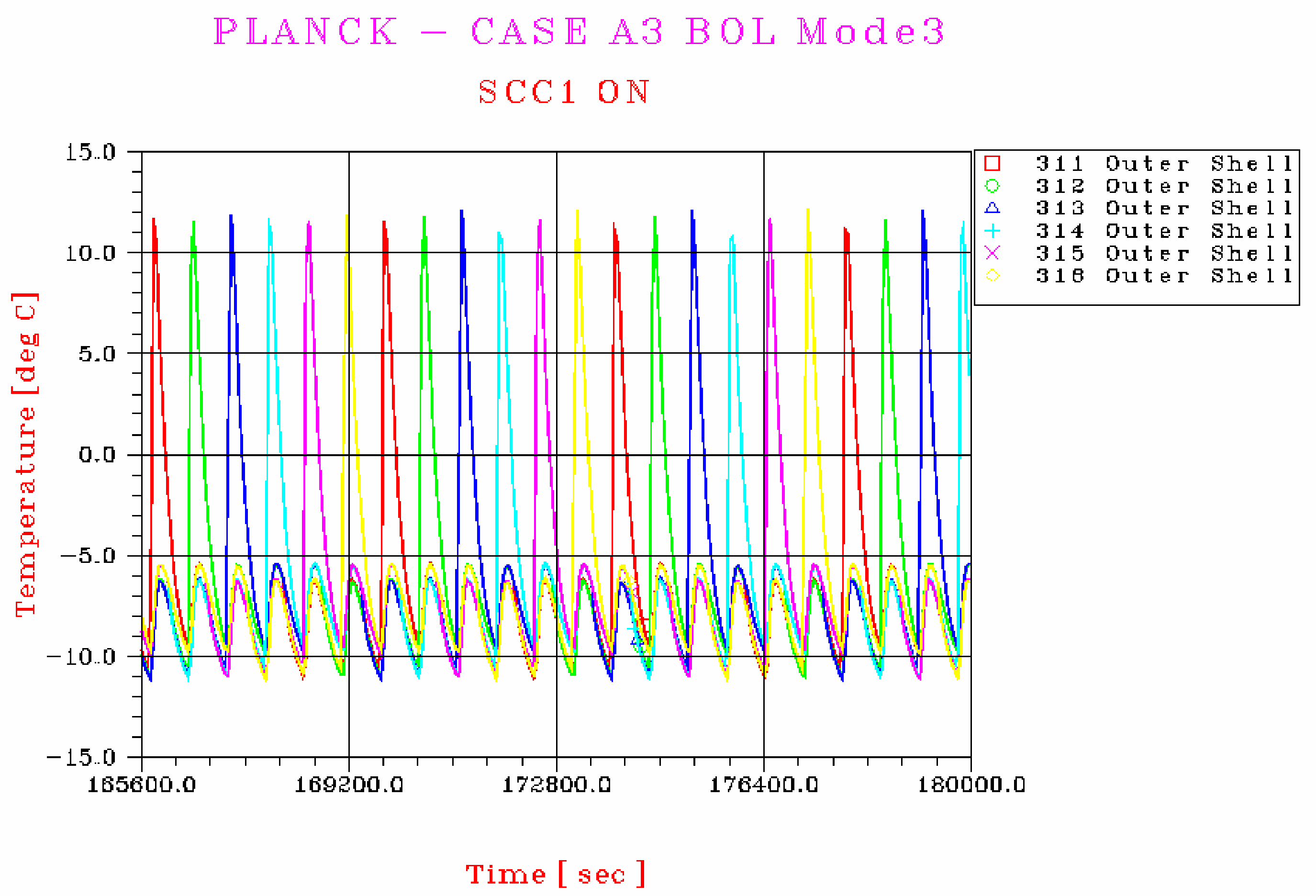
Figures 8.1-2 BOL CASE A3 +Y+Z panel



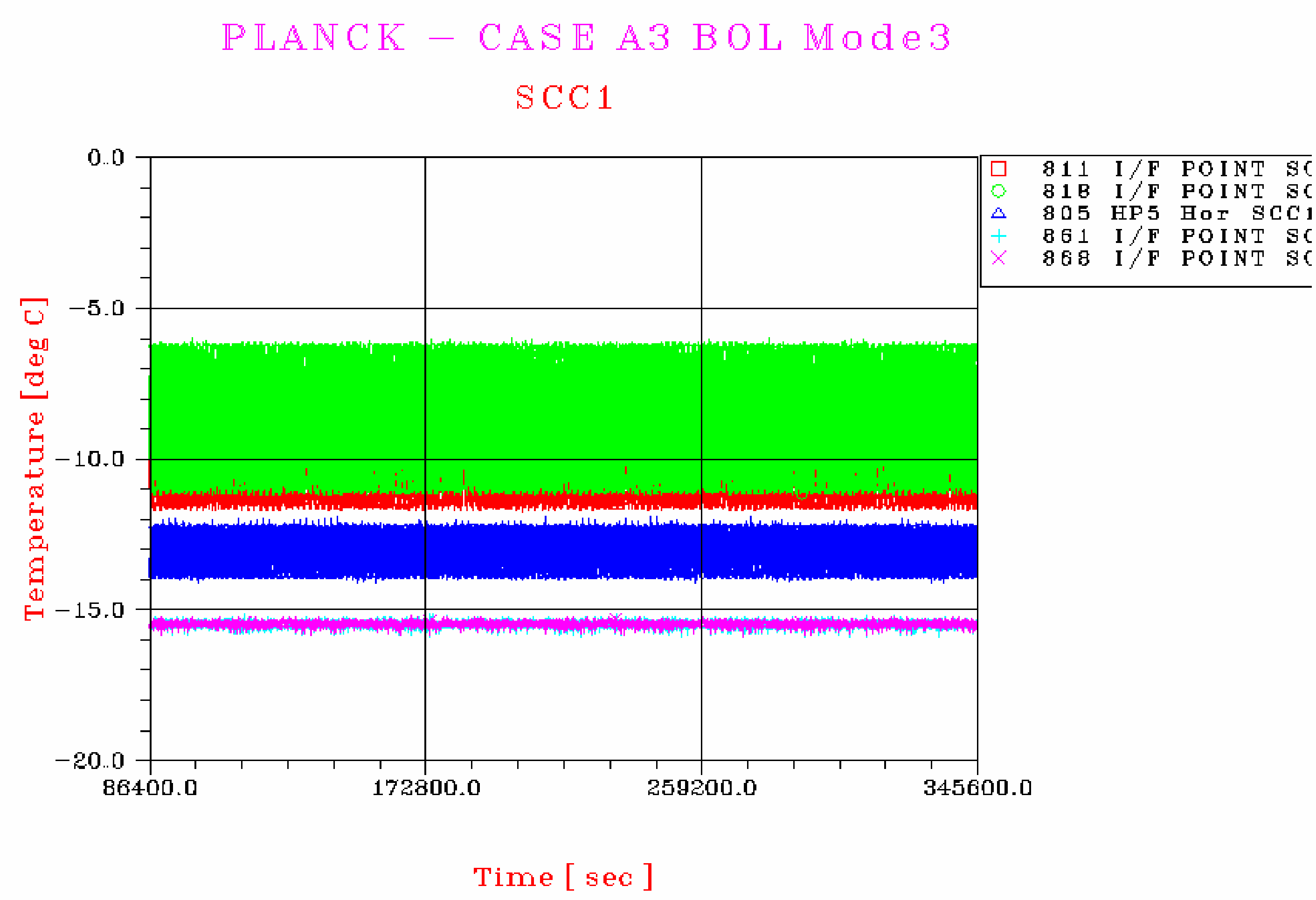
Figures 8.1-3 BOL CASE A3 +Y panel



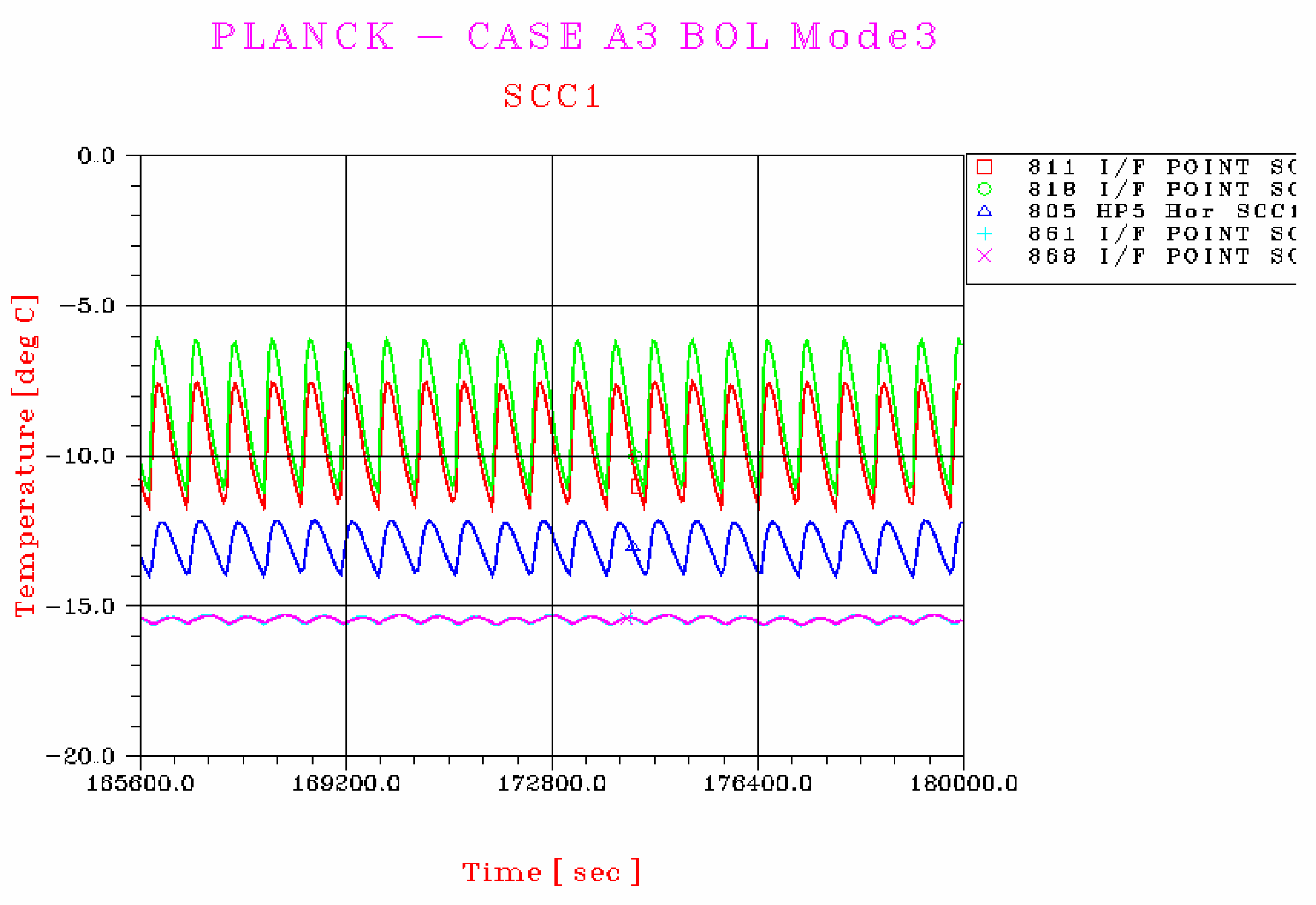
Figures 8.1-4 BOL CASE A3 +Y-Z panel



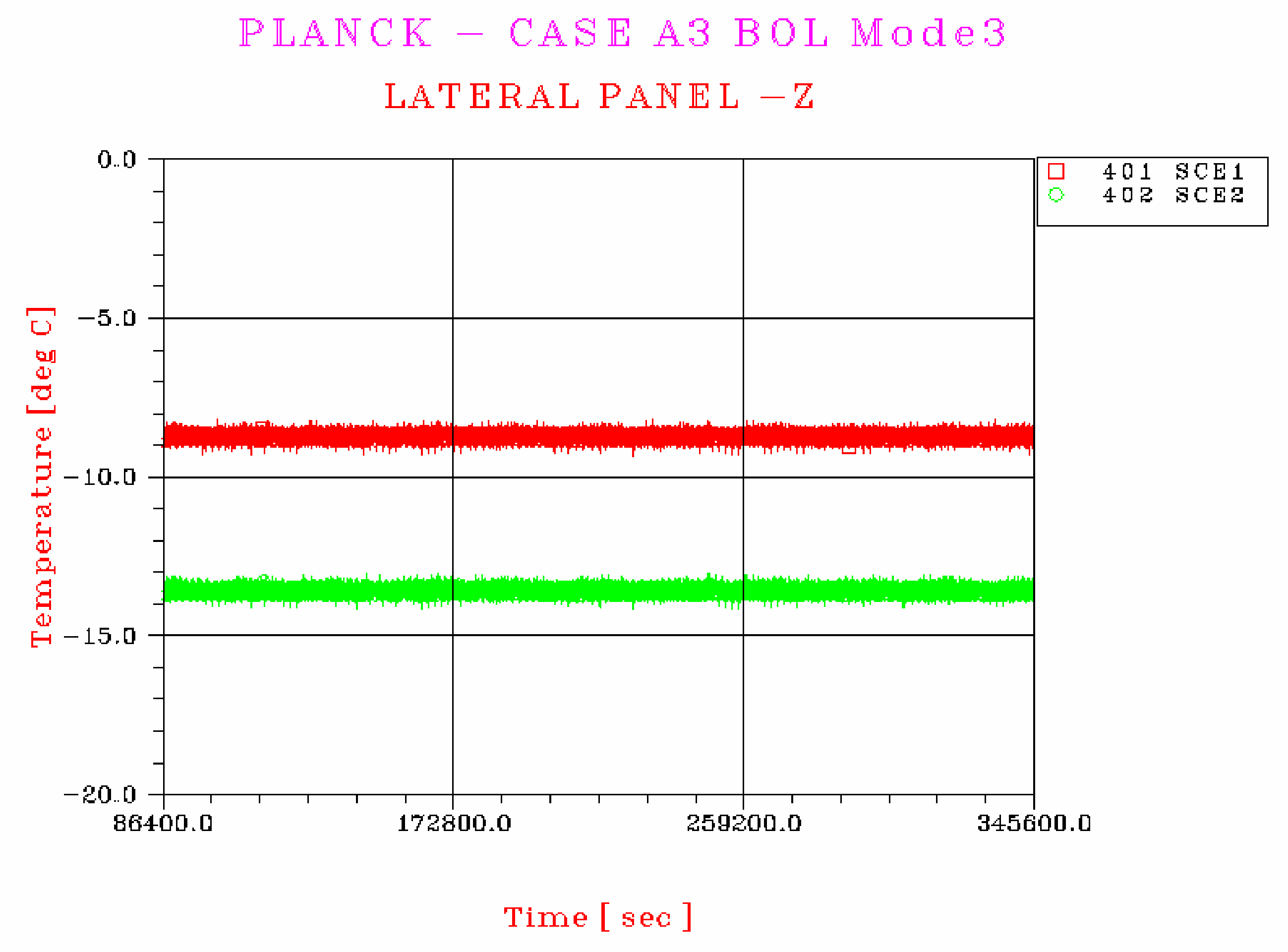
Figures 8.1-5 BOL CASE A3 +Y-Z panel



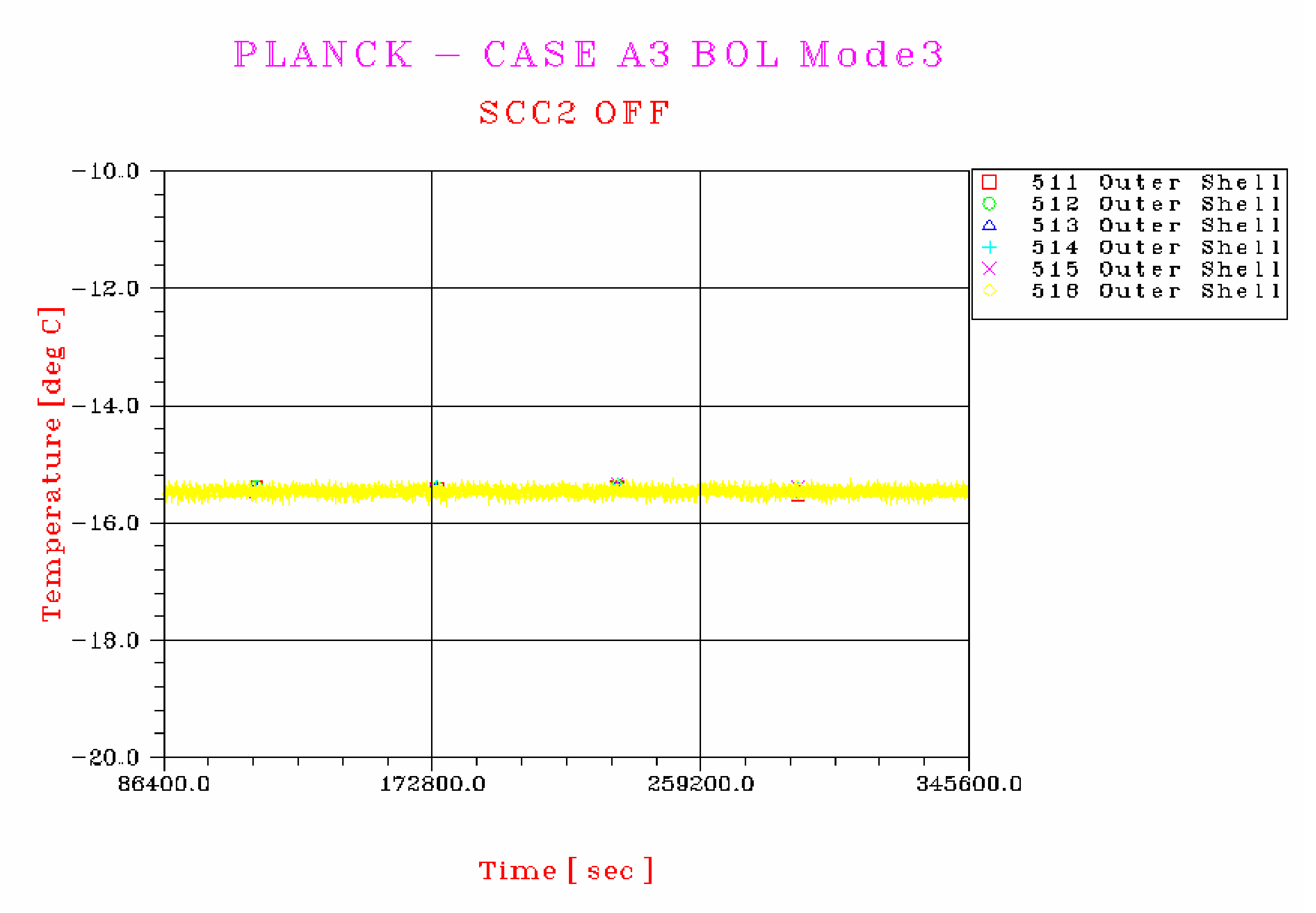
Figures 8.1-6 BOL CASE A3 SCC I/F temperatures



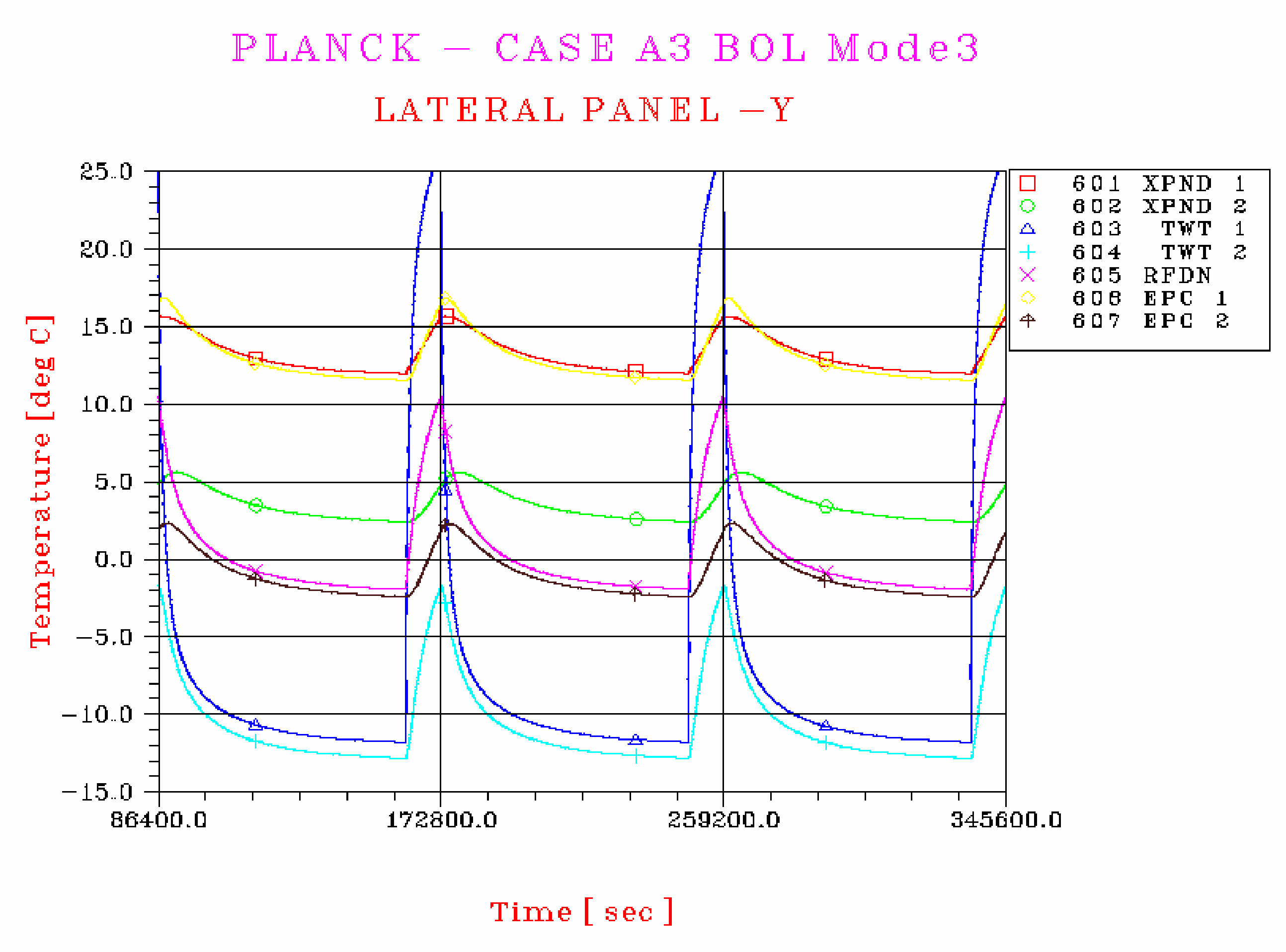
Figures 8.1-7 BOL CASE A3 SCC I/F temperatures



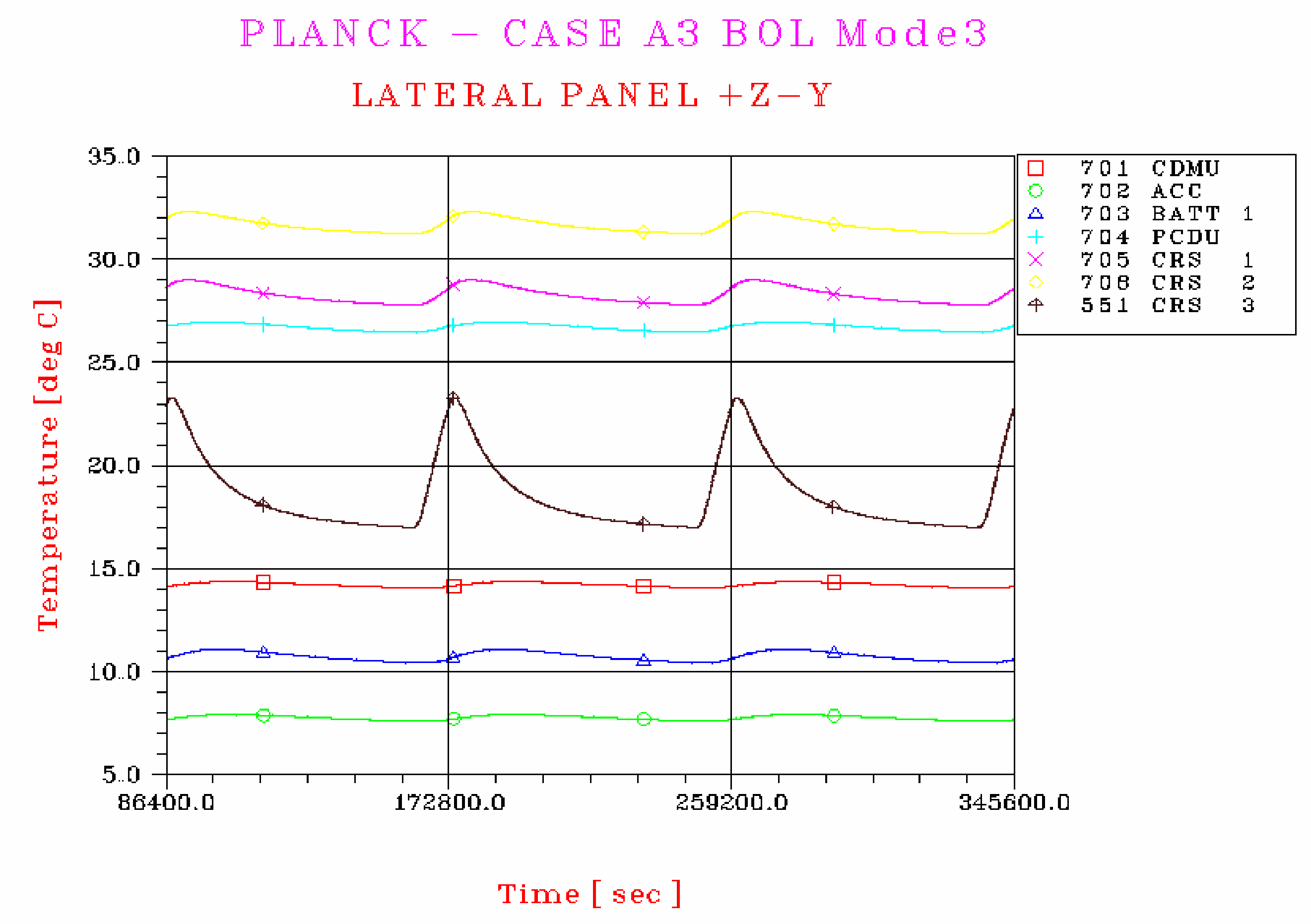
Figures 8.1-8 BOL CASE A3 -Z panel



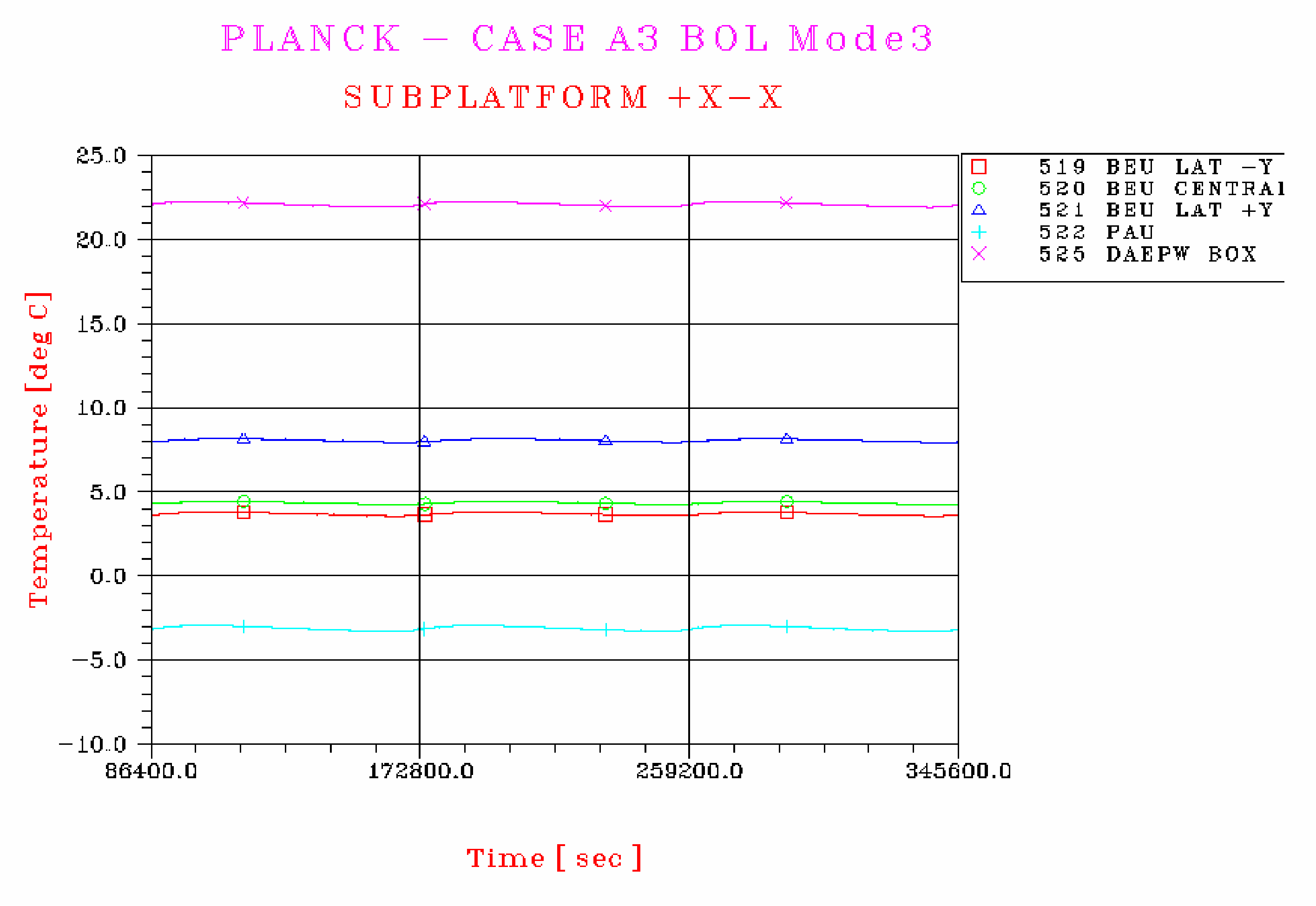
Figures 8.1-9 BOL CASE A3 –Y-Z panel



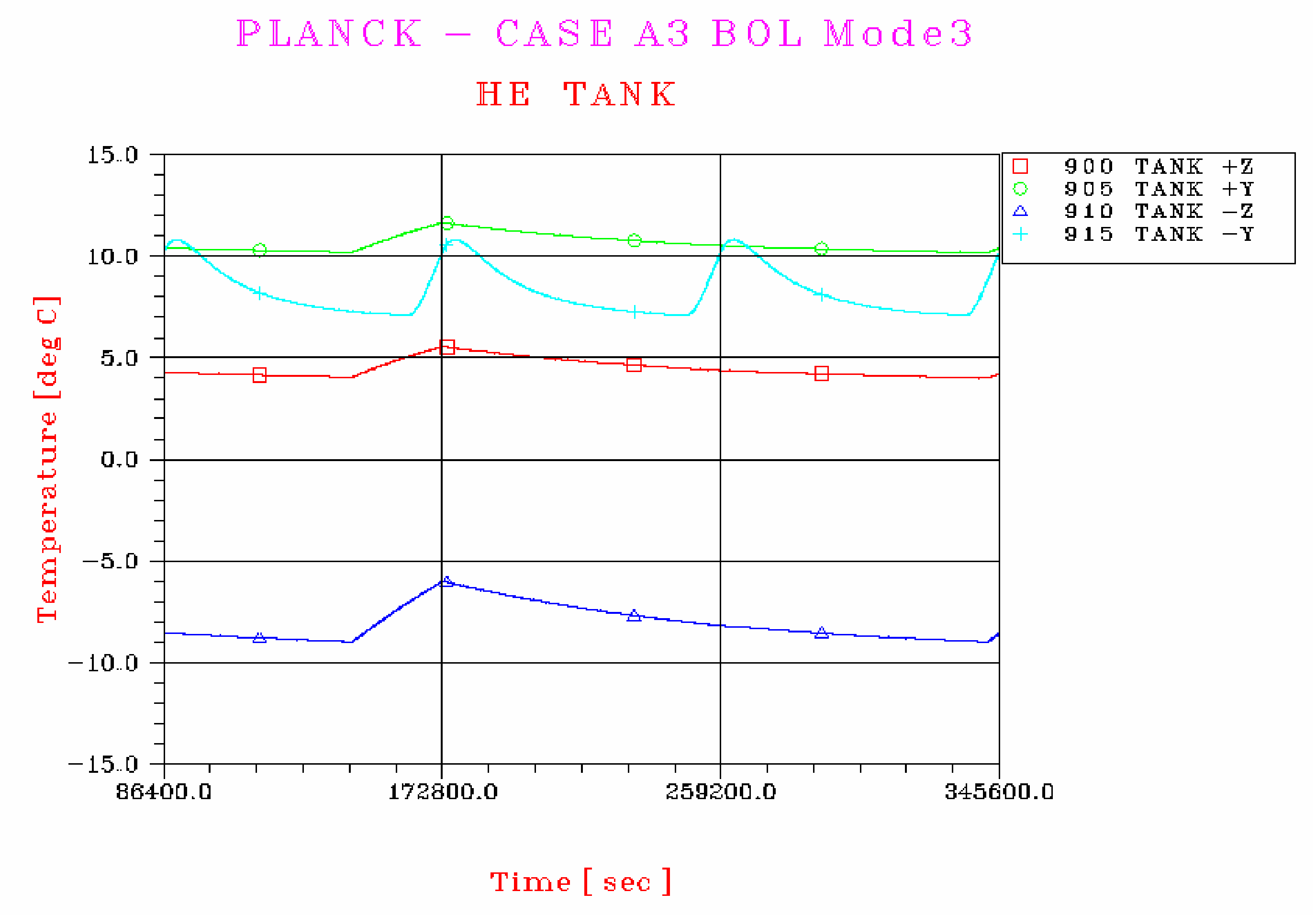
Figures 8.1-10 BOL CASE A3 -Y panel



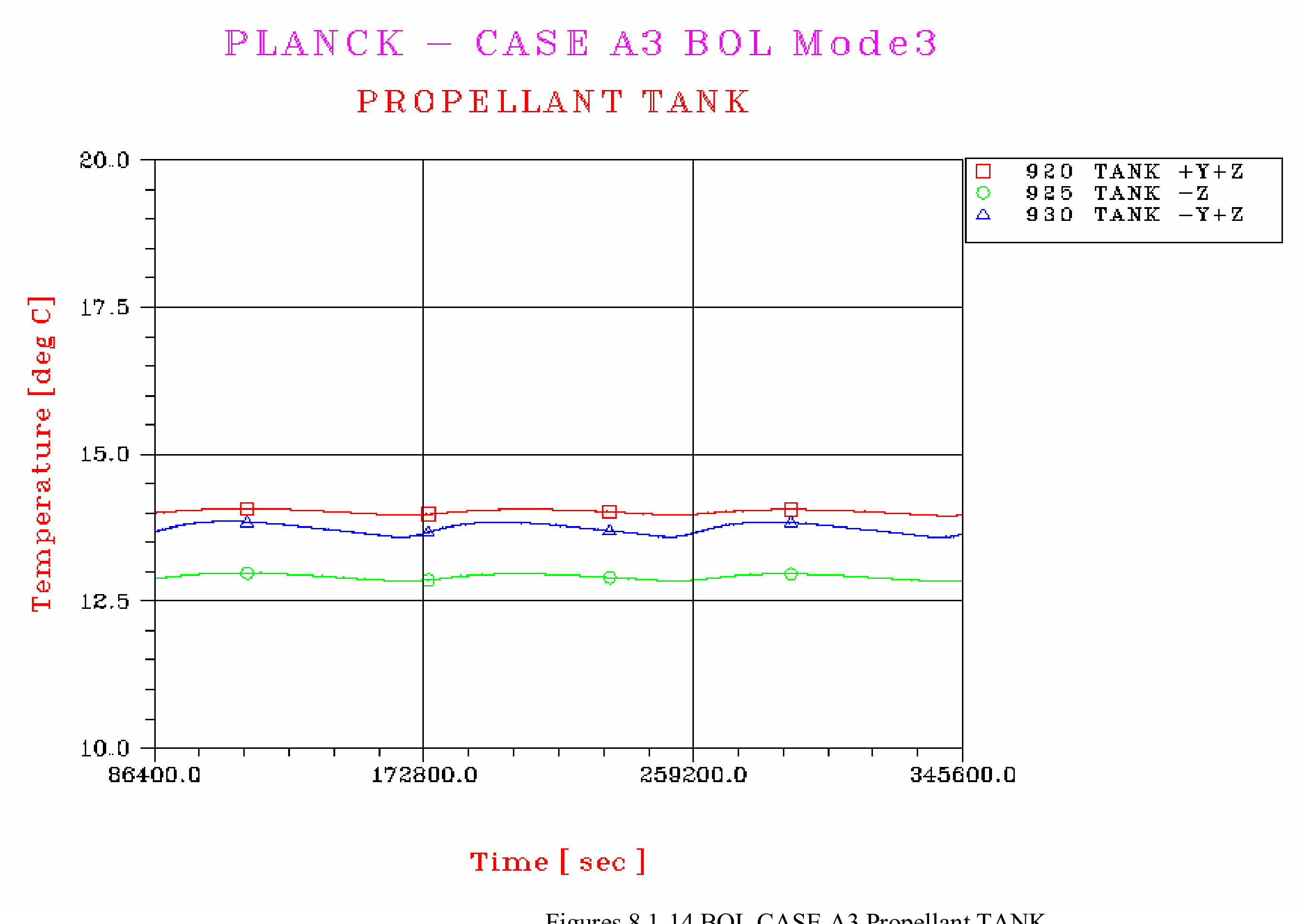
Figures 8.1-11 BOL CASE A3 -Y+Z panel



Figures 8.1-12 BOL CASE A3 subplatform panel



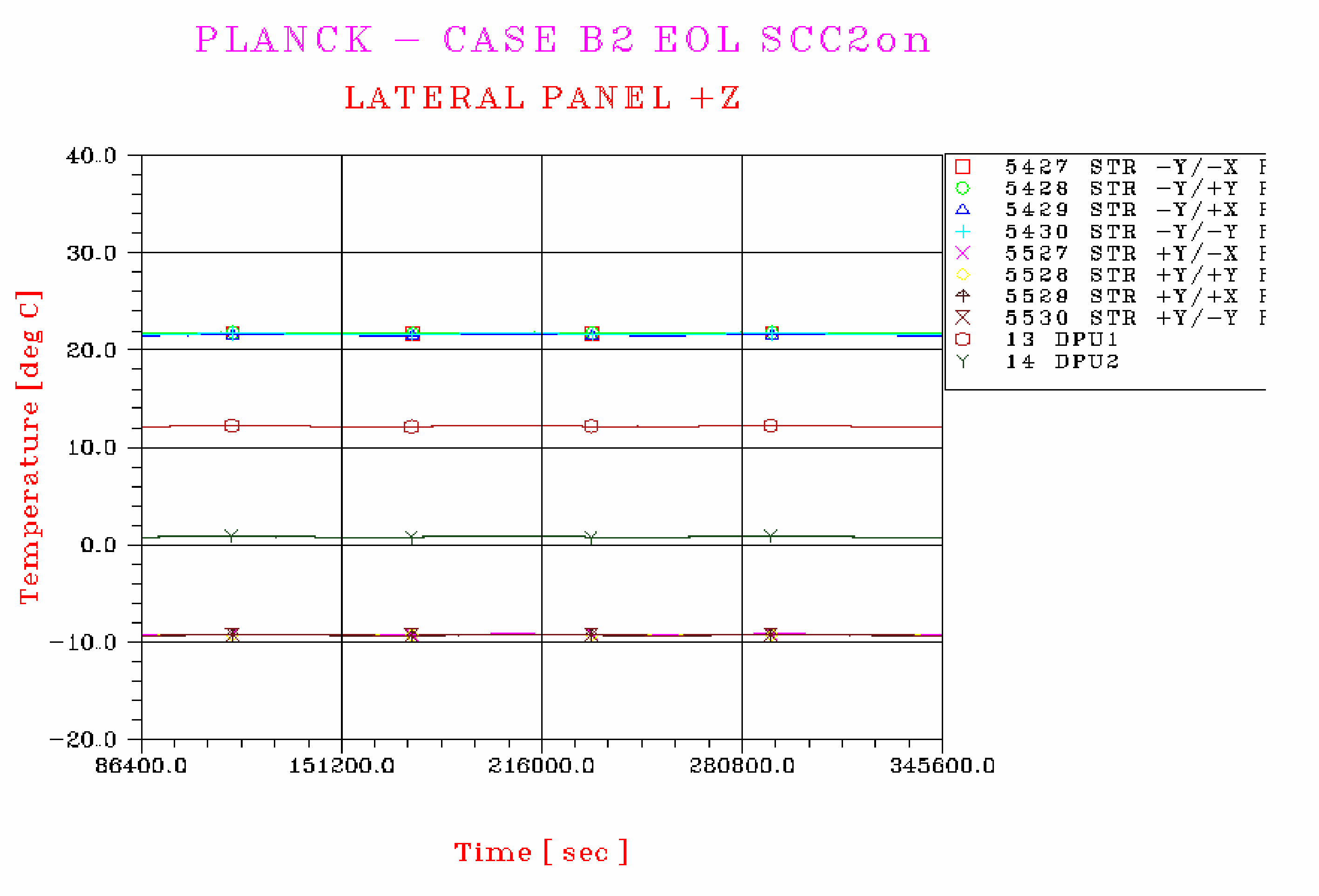
Figures 8.1-13 BOL CASE A3 Helium TANK



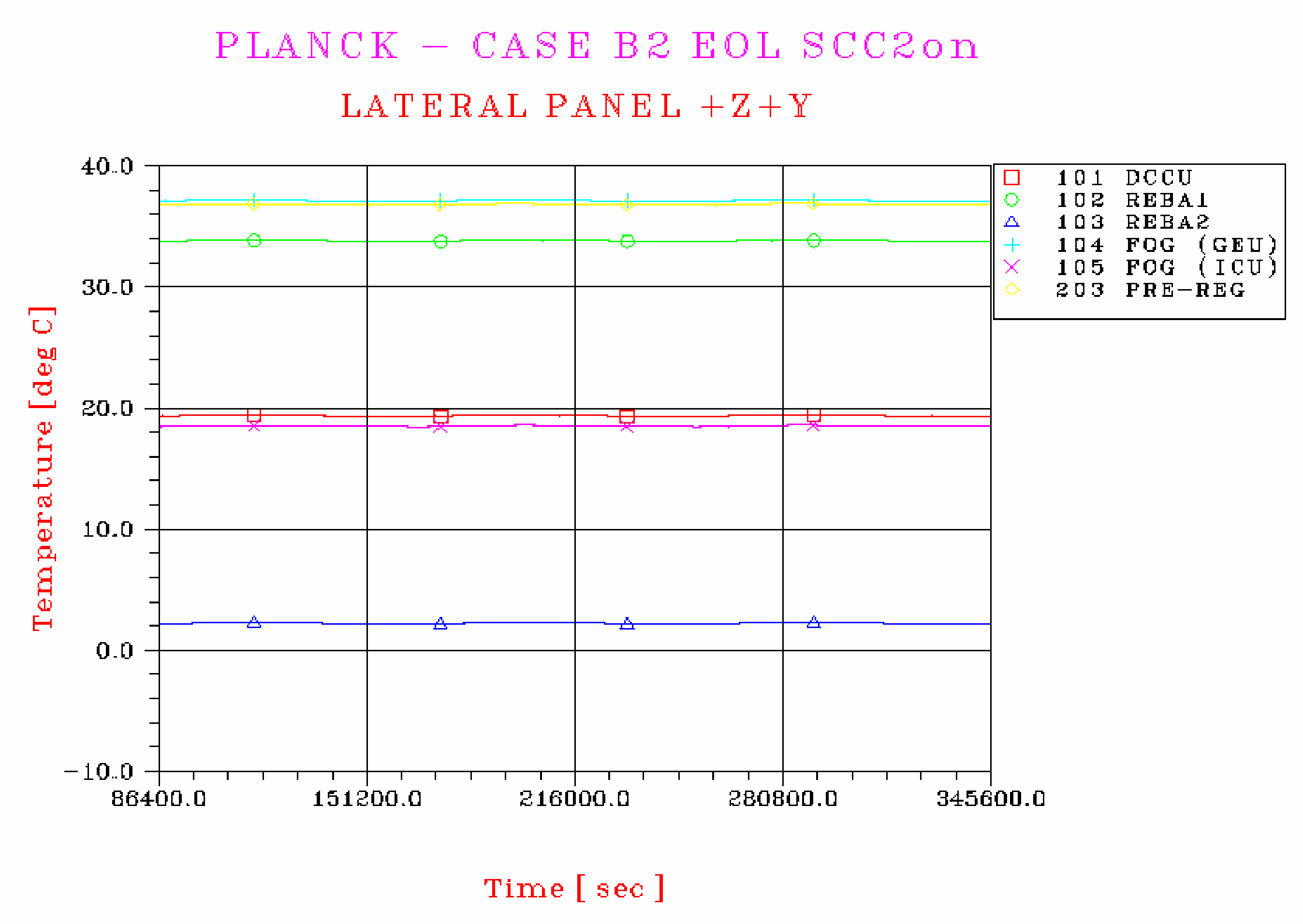
Figures 8.1-14 BOL CASE A3 Propellant TANK

8.2 PLANCK: PLOTS OF TRANSIENT NOMINAL ANALYSIS CASE B2

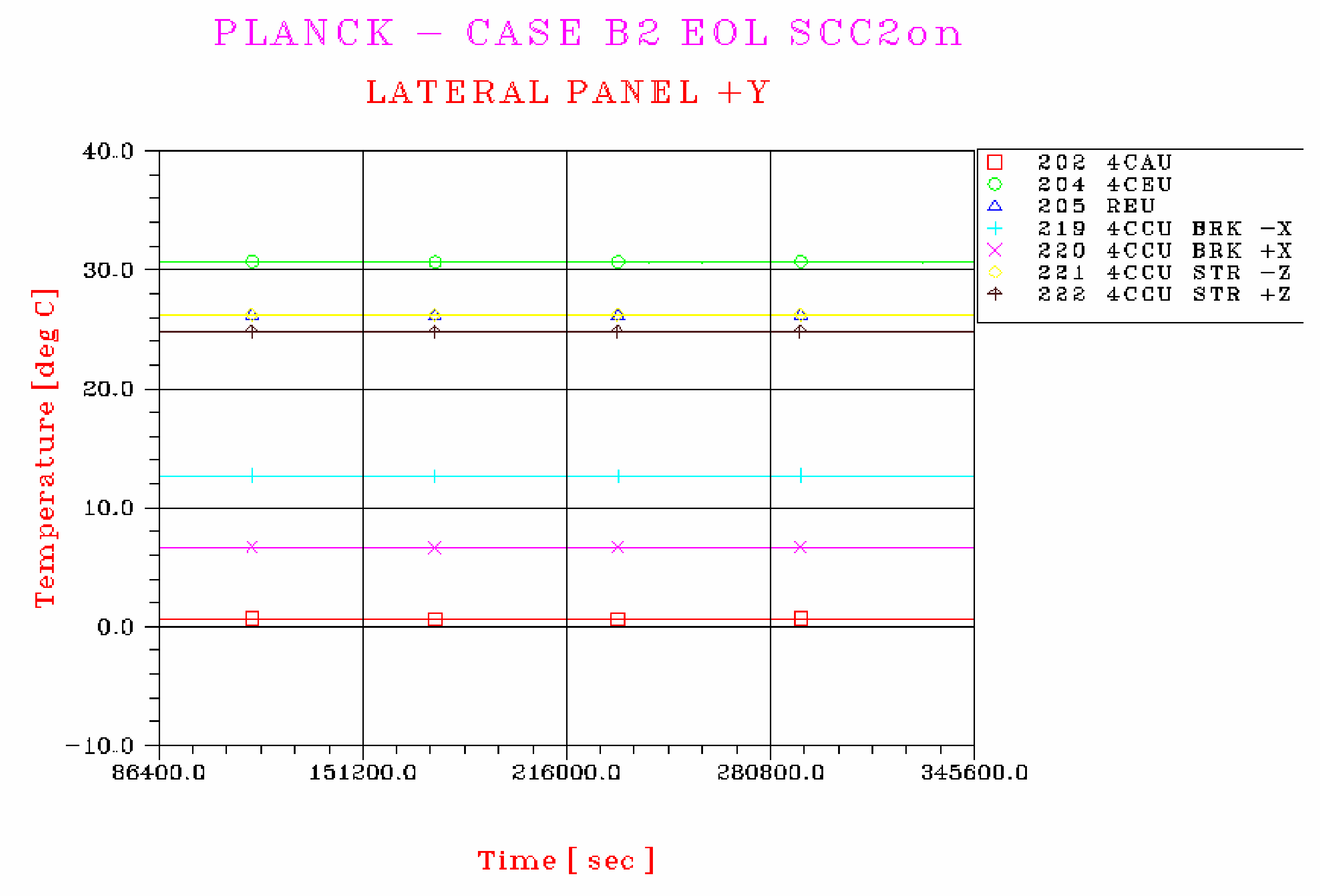
In the following figures, the temperature plots of the transient analysis concerning the satellite in EOL condition and with the SCC2 operating are presented.



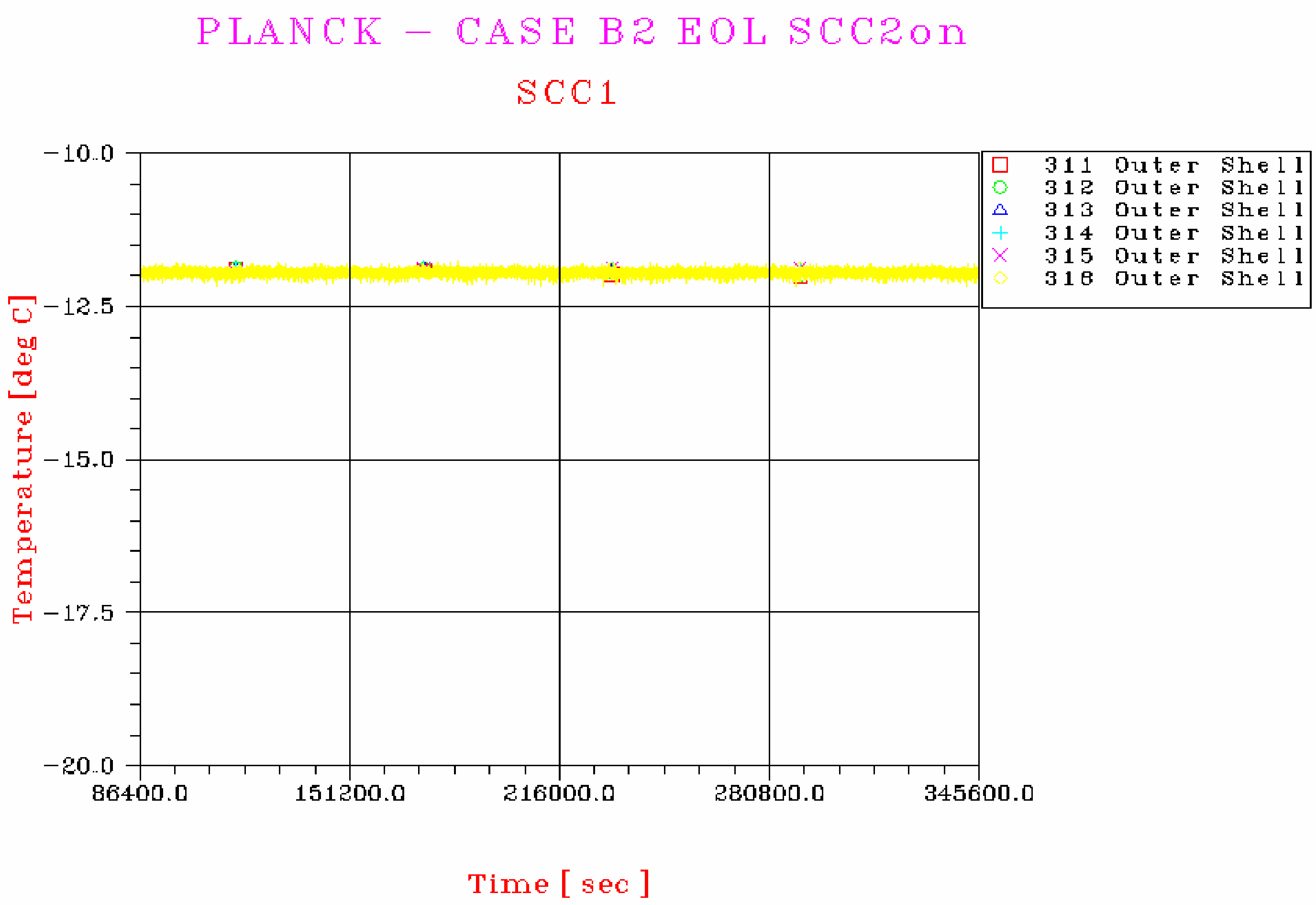
Figures 8.2-1 EOL CASE B2 +Z panel



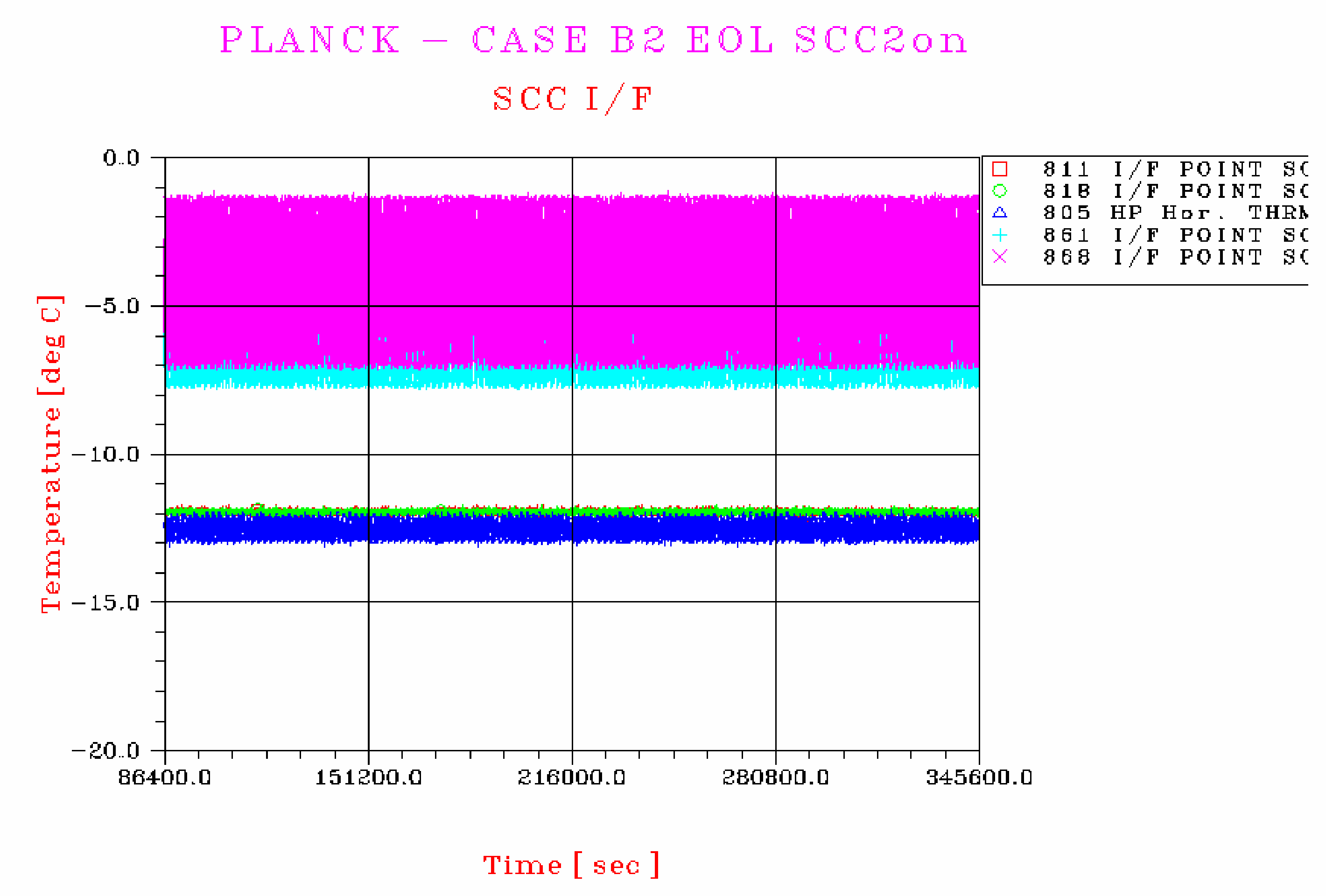
Figures 8.2-2 EOL CASE B2 +Y+Z panel



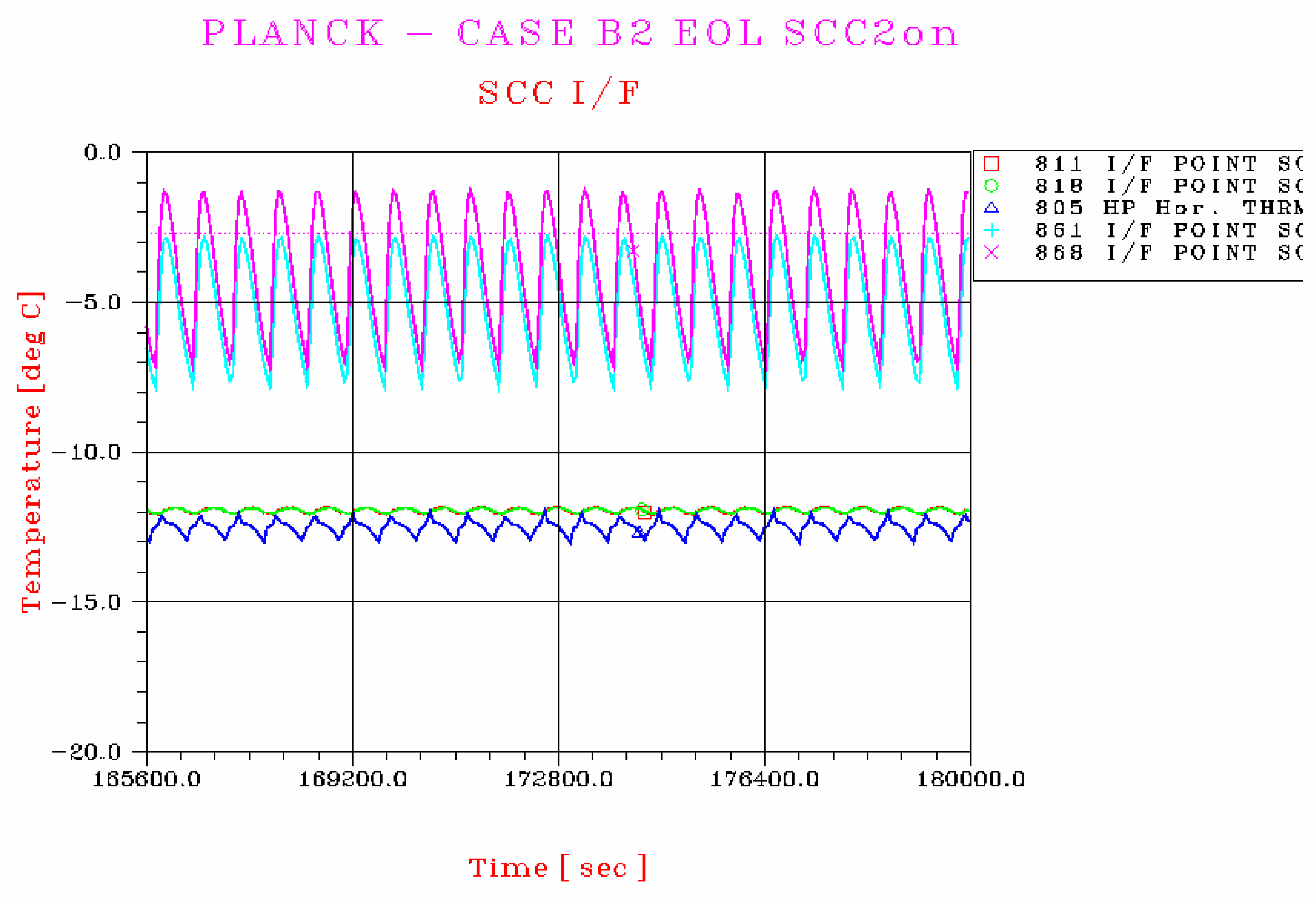
Figures 8.2-3 EOL CASE B2 +Y panel



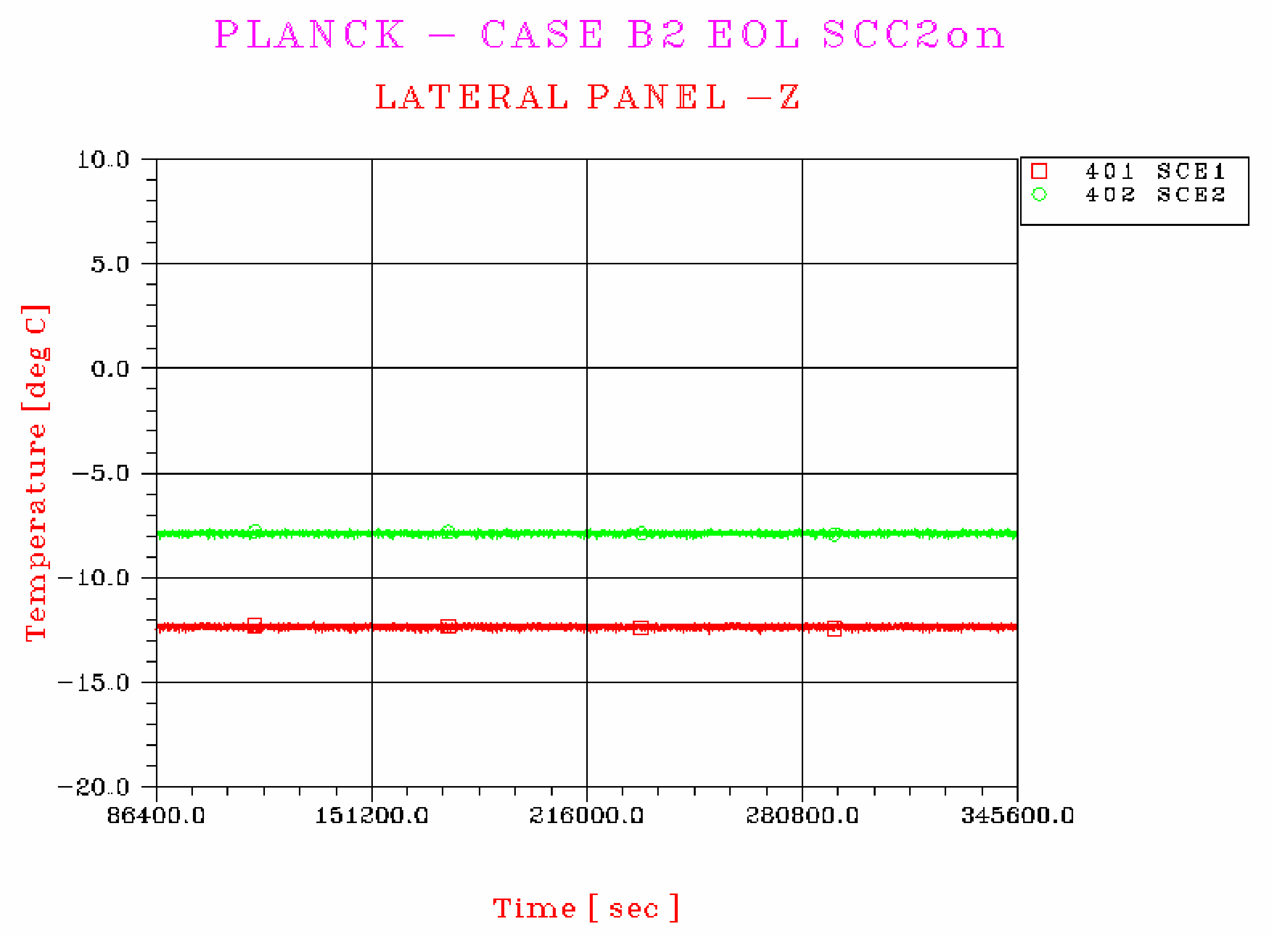
Figures 8.2-4 EOL CASE B2 +Y-Z panel



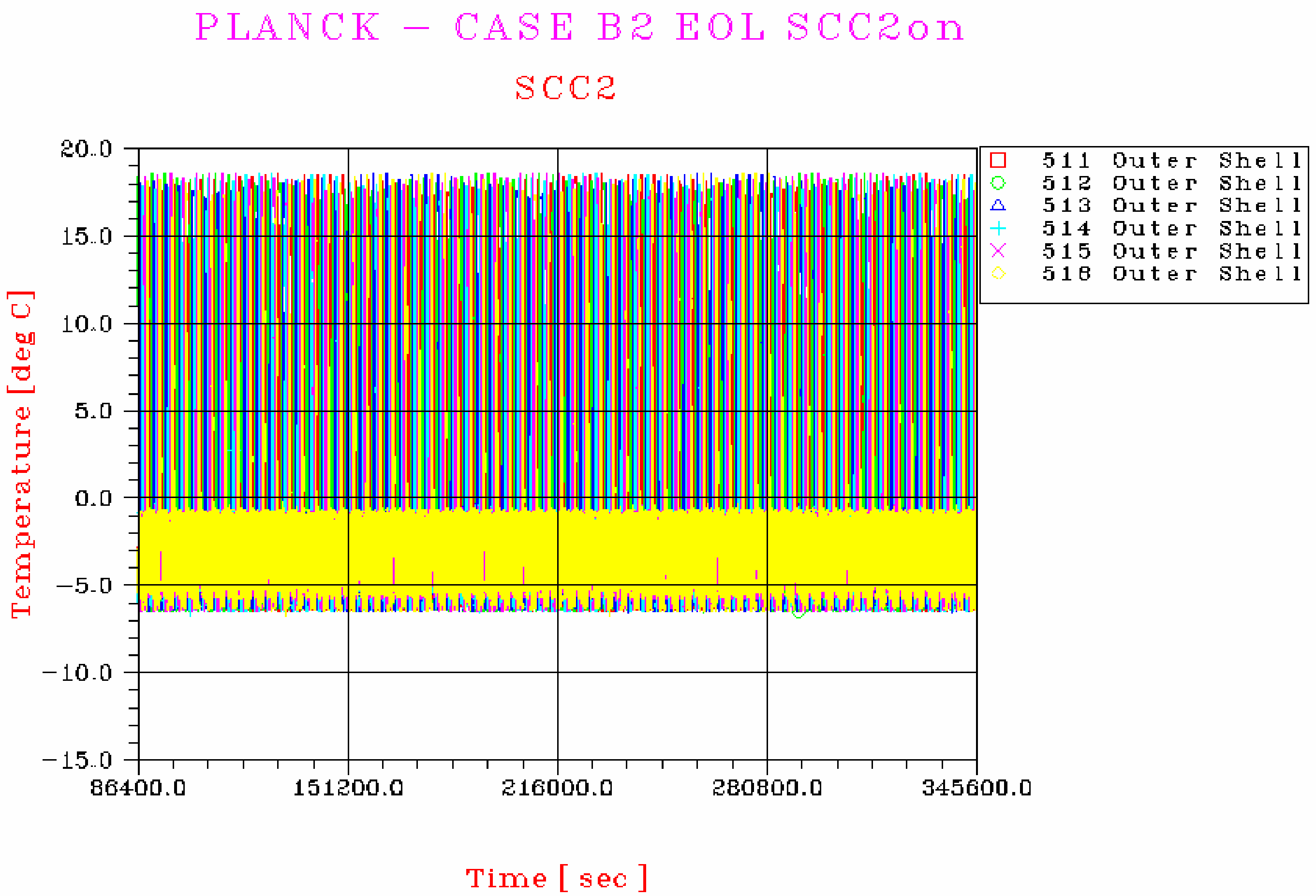
Figures 8.2-5 EOL CASE B2 SCC I/F temperatures



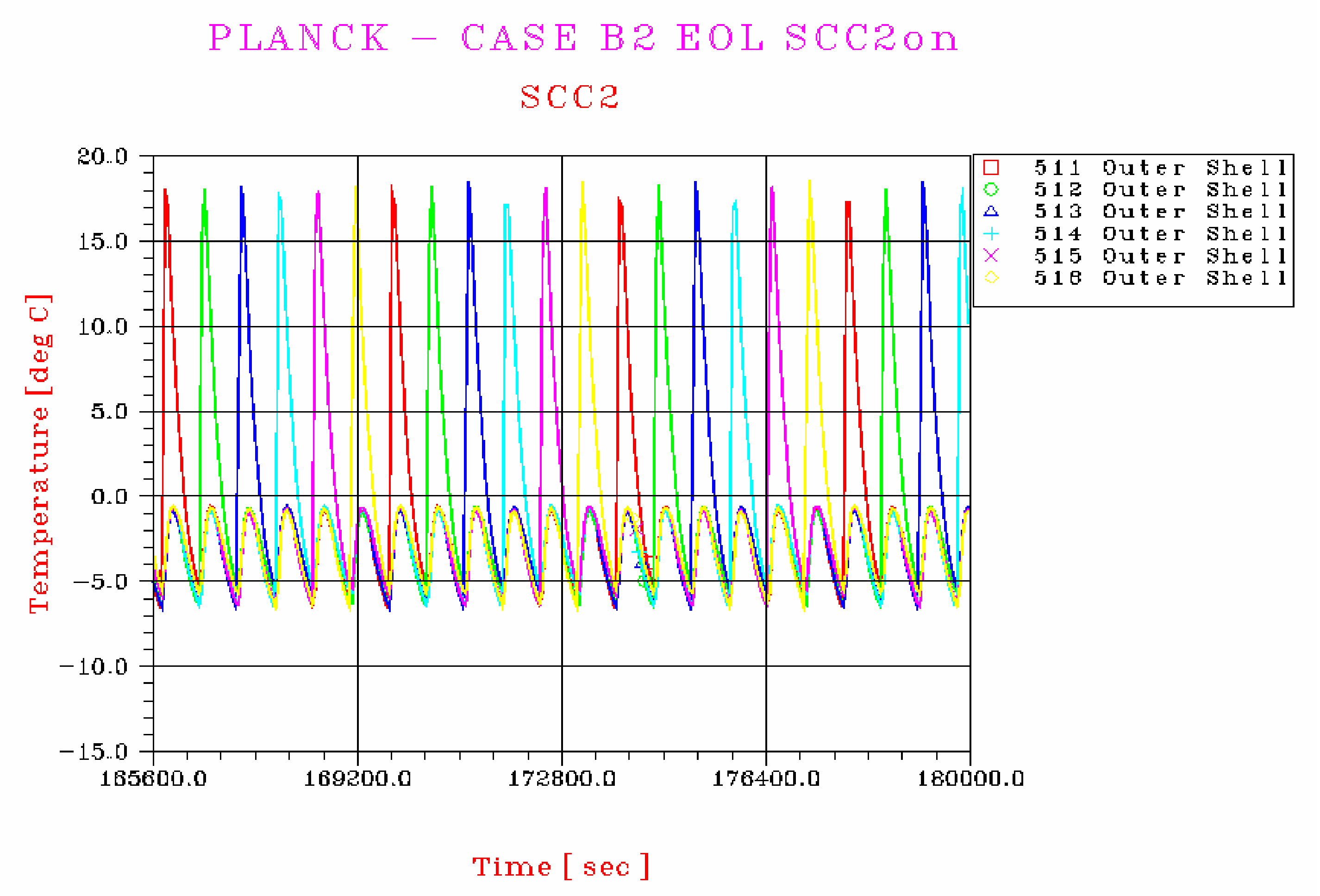
Figures 8.2-6 EOL CASE B2 SCC I/F temperatures



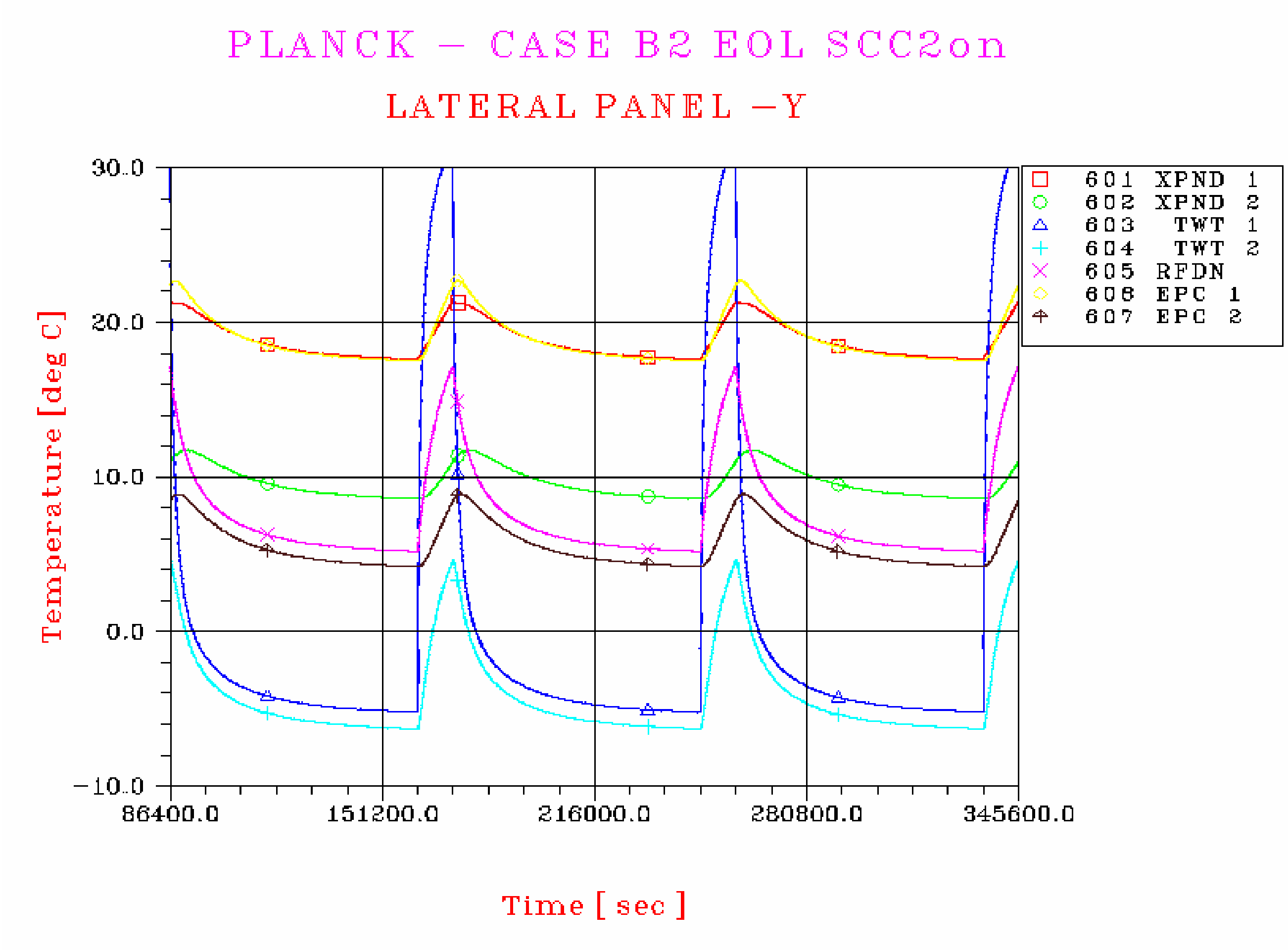
Figures 8.2-7 EOL CASE B2 -Z panel



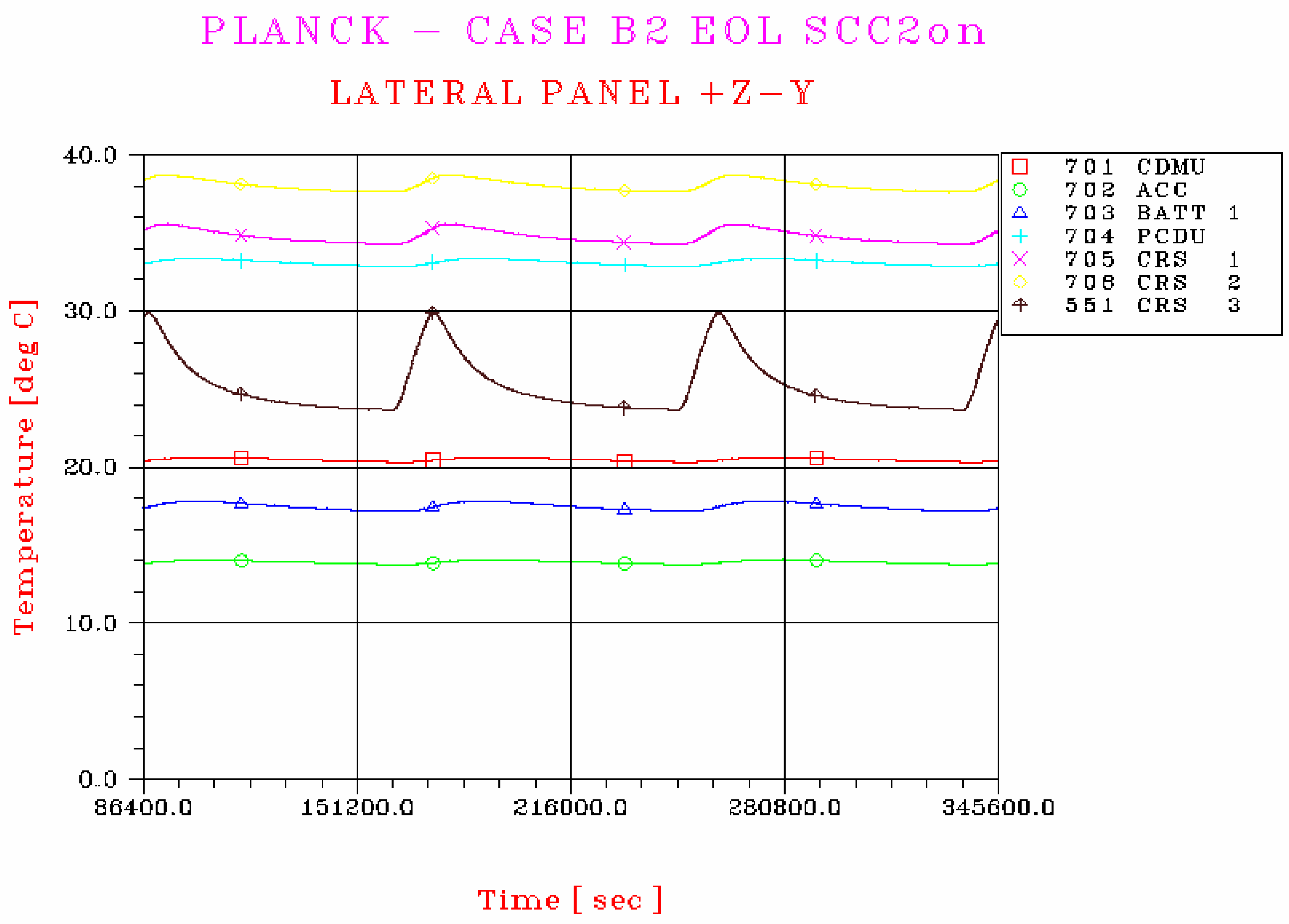
Figures 8.2-8 EOL CASE B2 –Y-Z panel



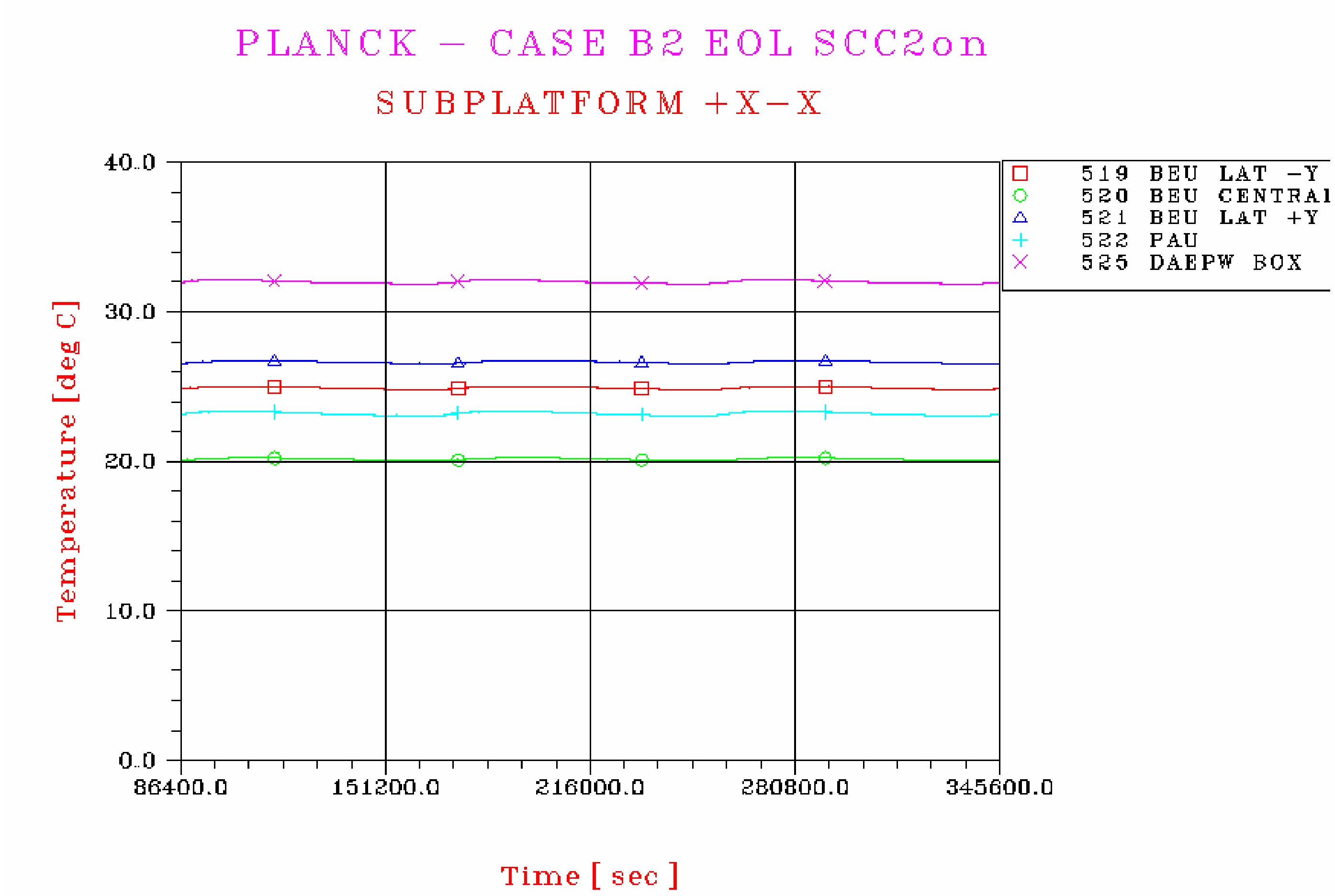
Figures 8.2-9 EOL CASE B2 –Y-Z panel



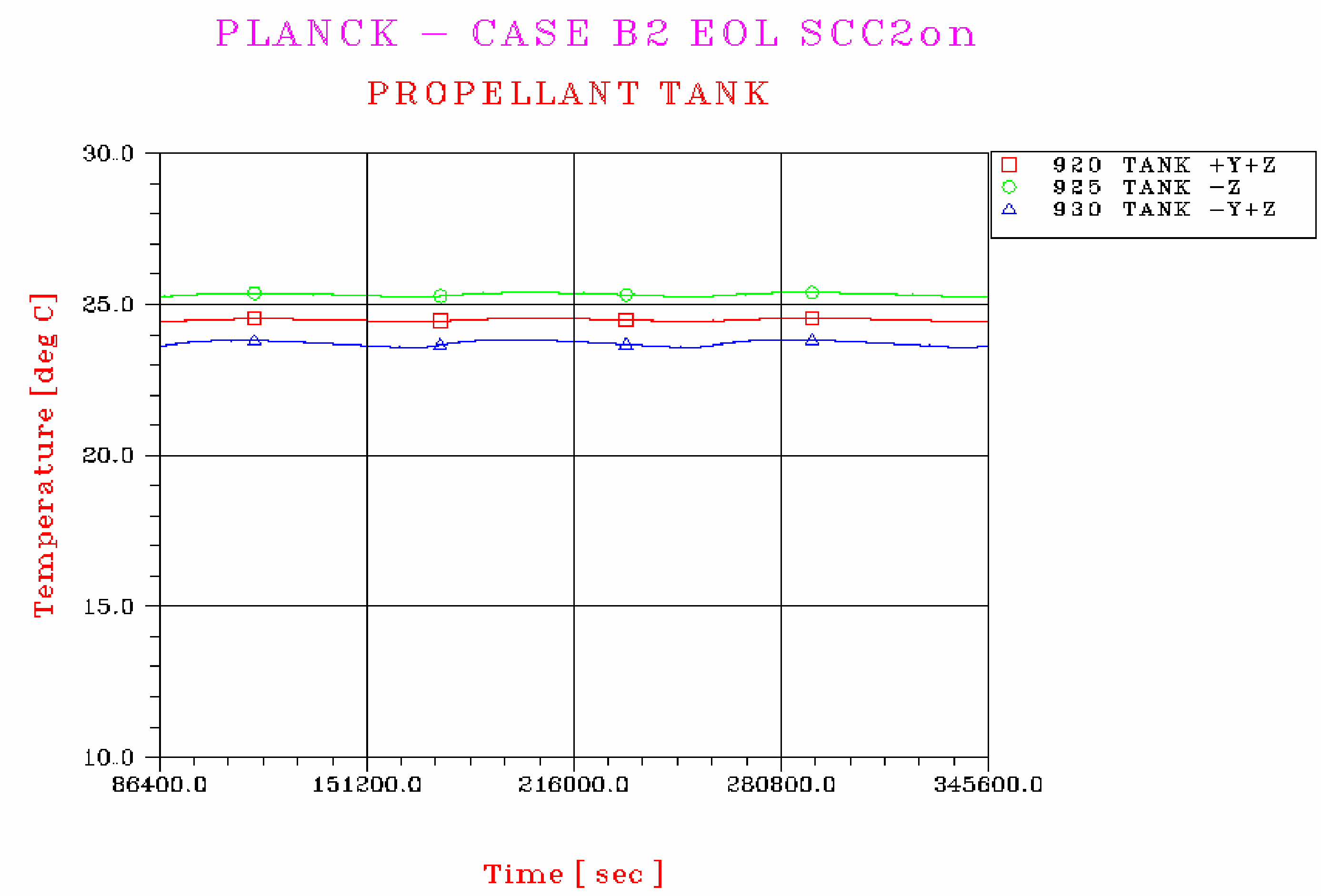
Figures 8.2-10 EOL CASE B2 -Y panel



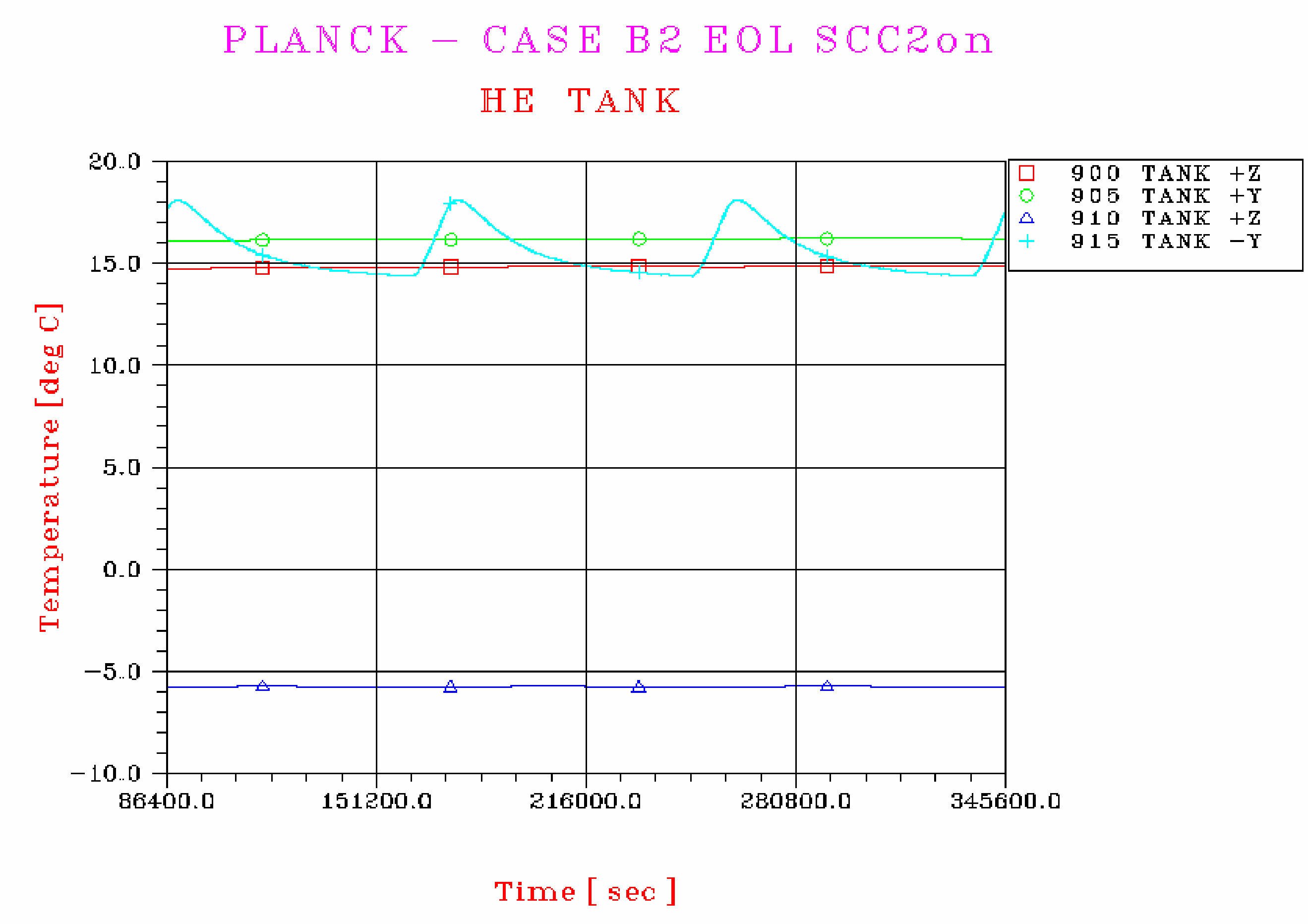
Figures 8.2-11 EOL CASE B2 -Y+Z panel



Figures 8.2-12 EOL CASE B2 subplatform panel



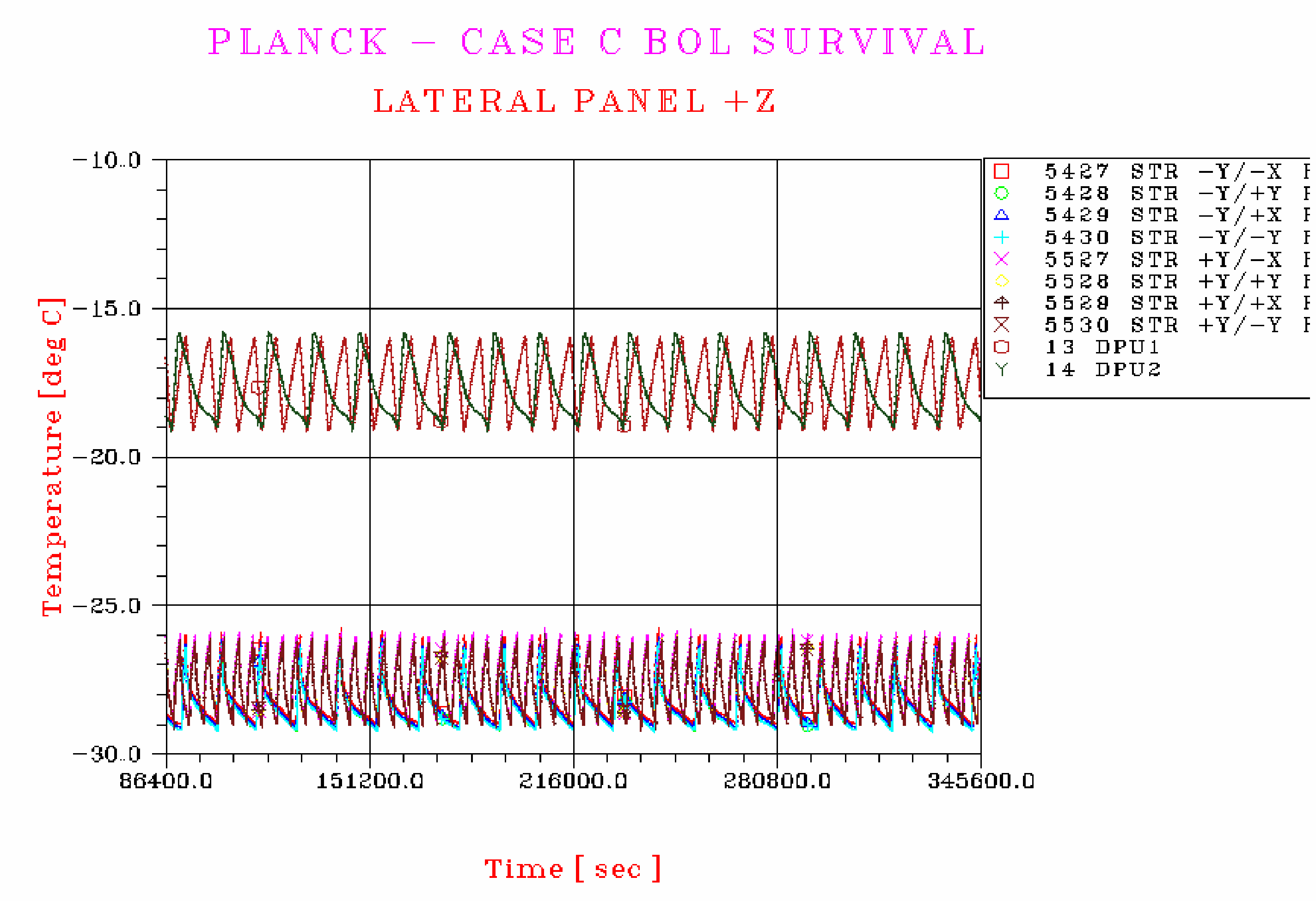
Figures 8.2-13 EOL CASE B2 propellant Tank



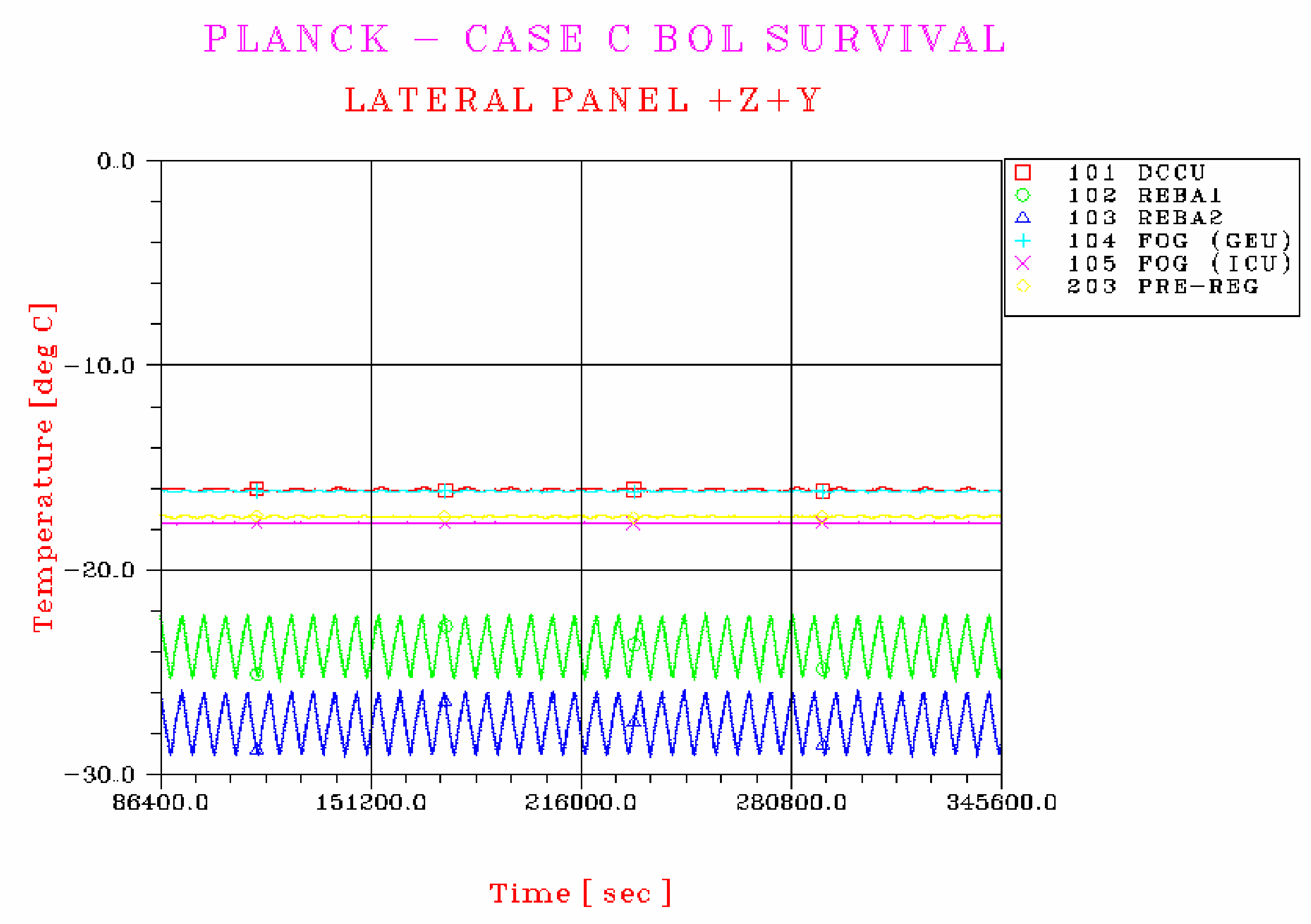
Figures 8.2-14 EOL CASE B2 He Tank

8.3 PLANCK: PLOTS OF TRANSIENT NOMINAL ANALYSIS CASE C

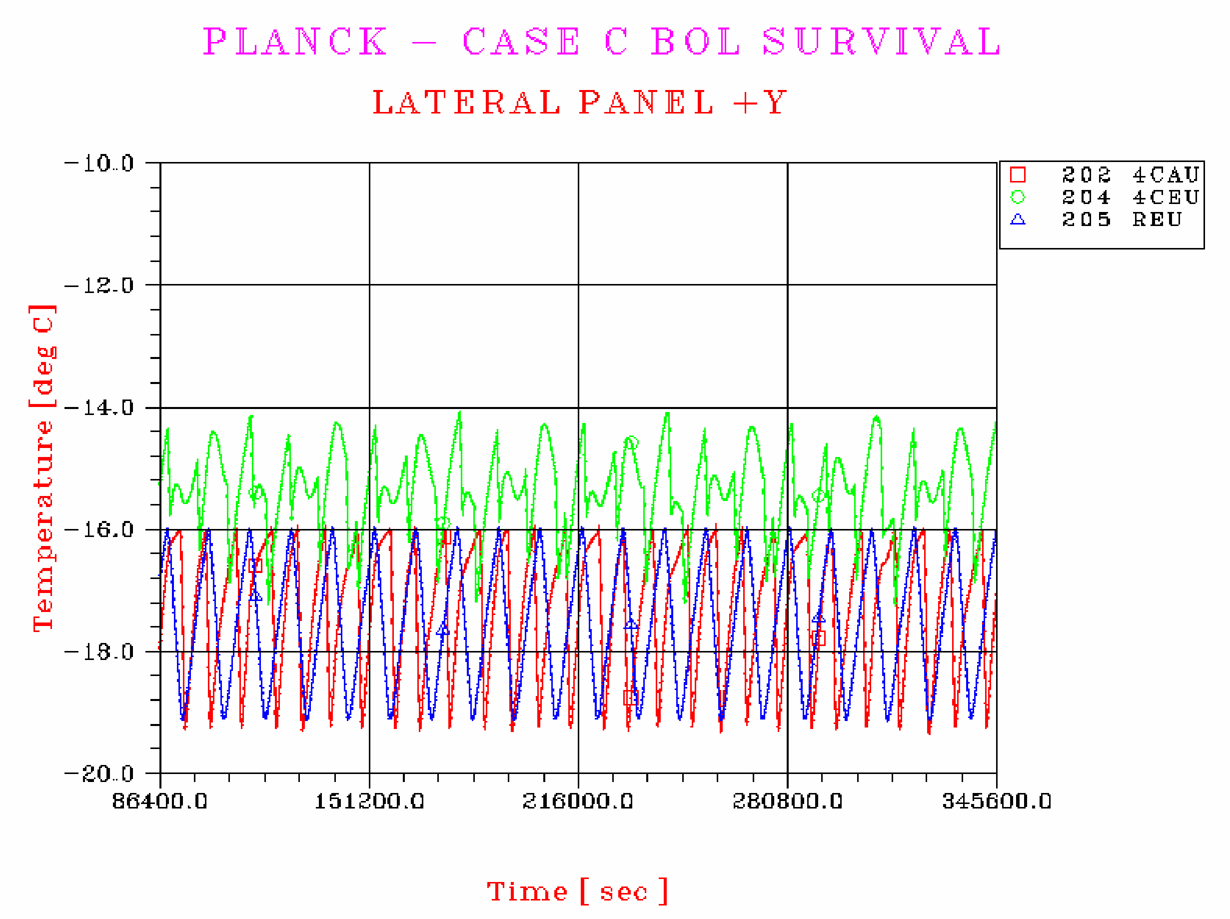
In the following figures, the temperature plots of the transient nominal analysis concerning the satellite in BOL condition and Survival mode are presented.



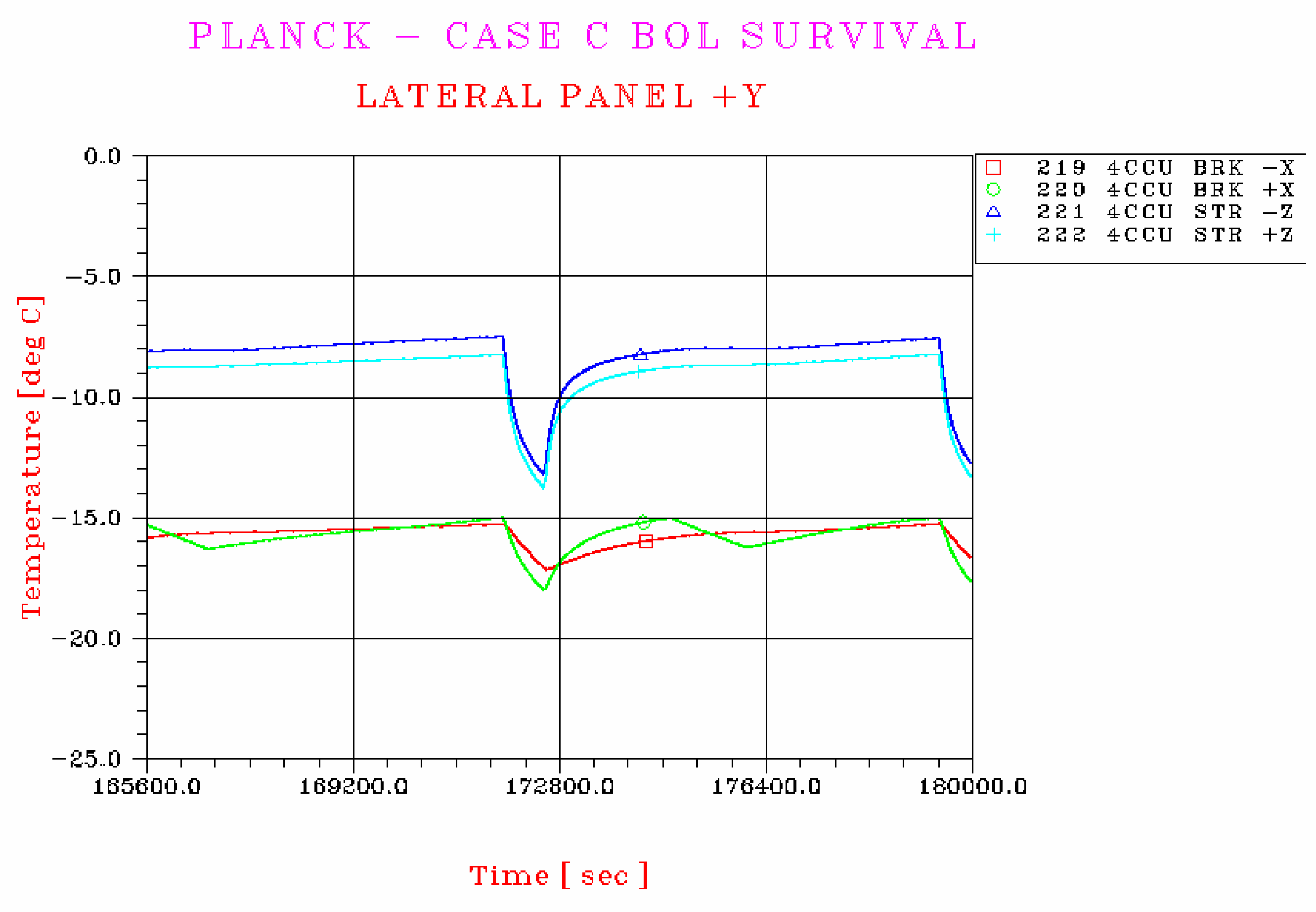
Figures 8.3-1 BOL CASE C +Z panel



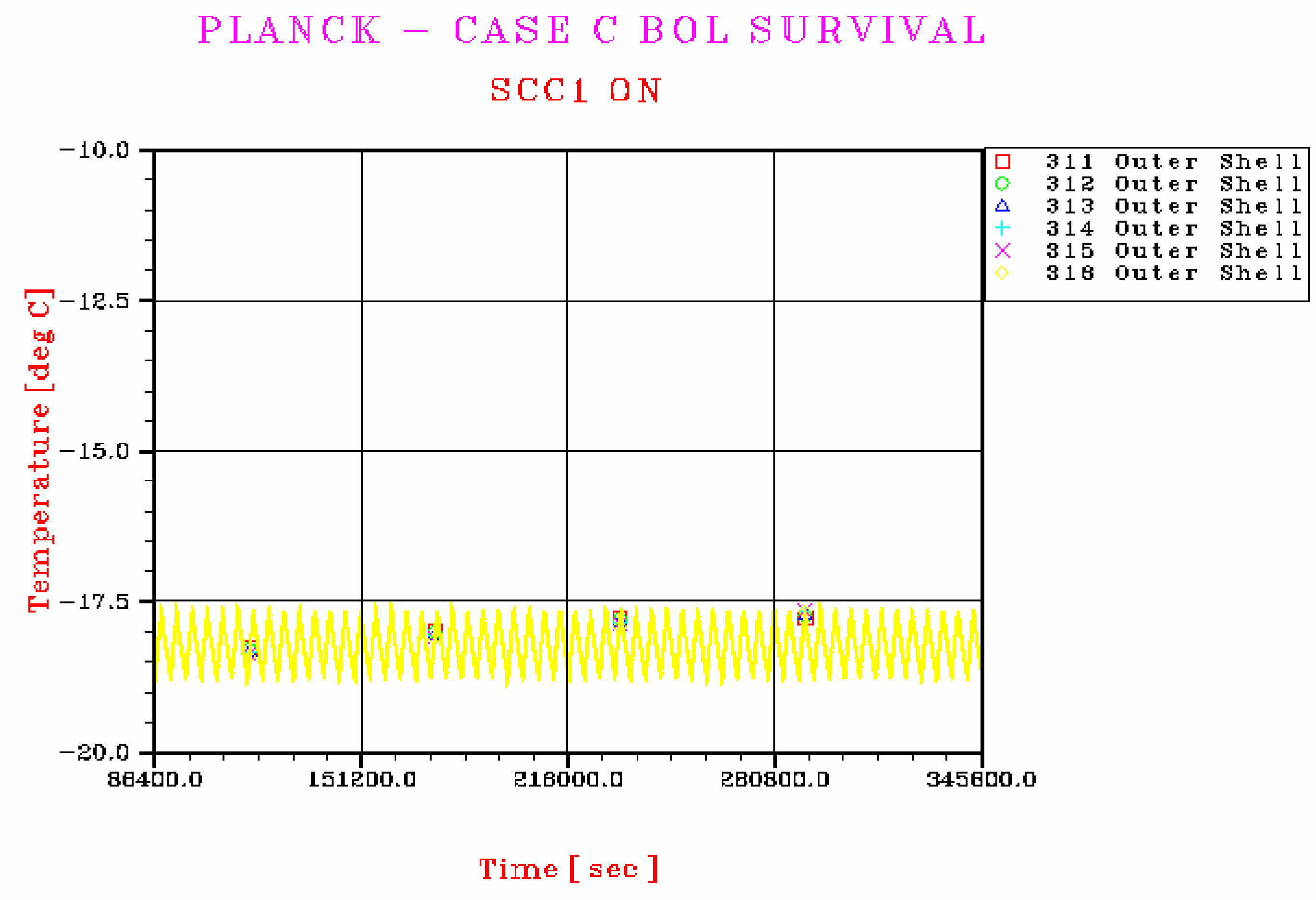
Figures 8.3-2 BOL CASE C +Y+Z panel



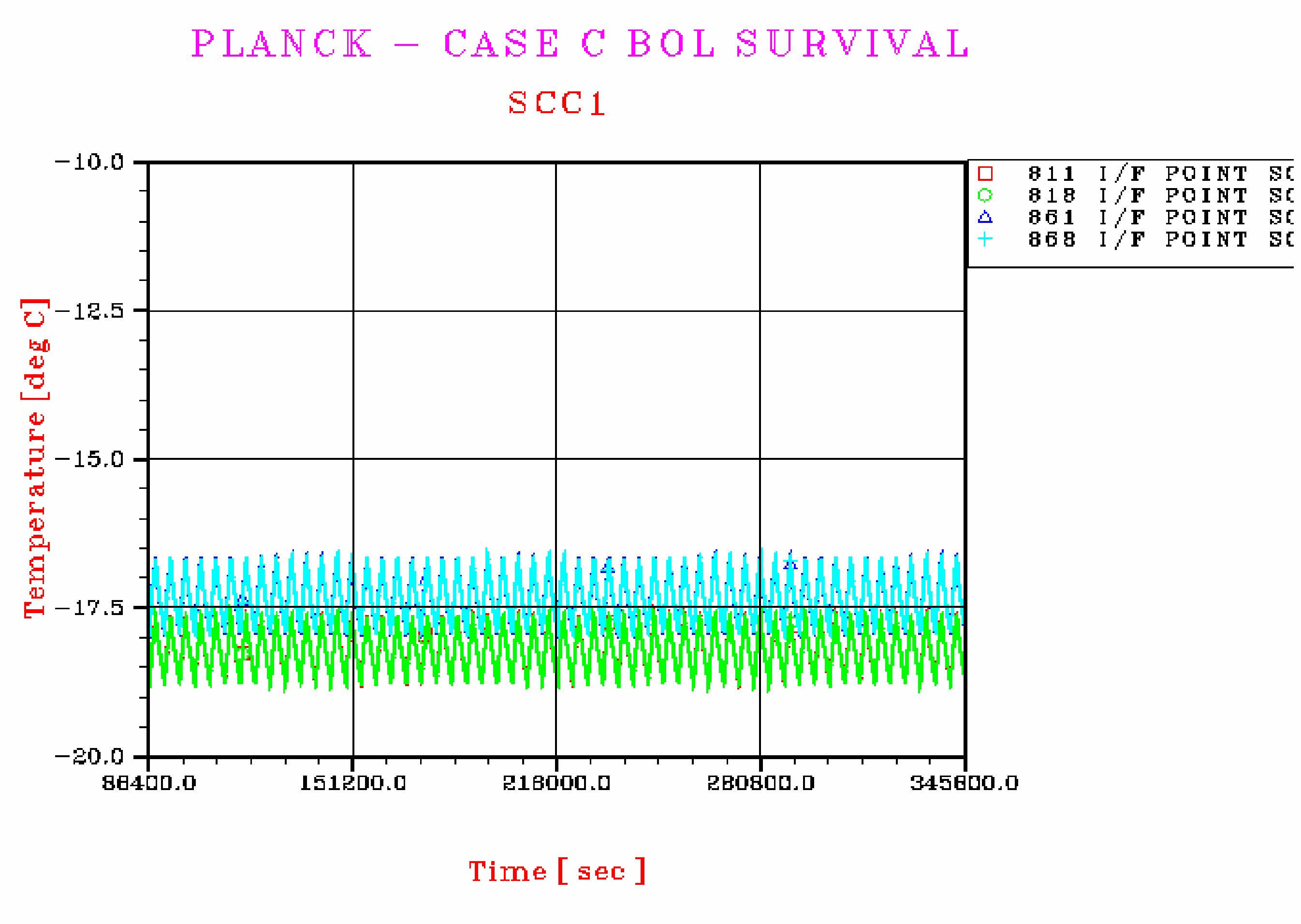
Figures 8.3-3 BOL CASE C +Y panel



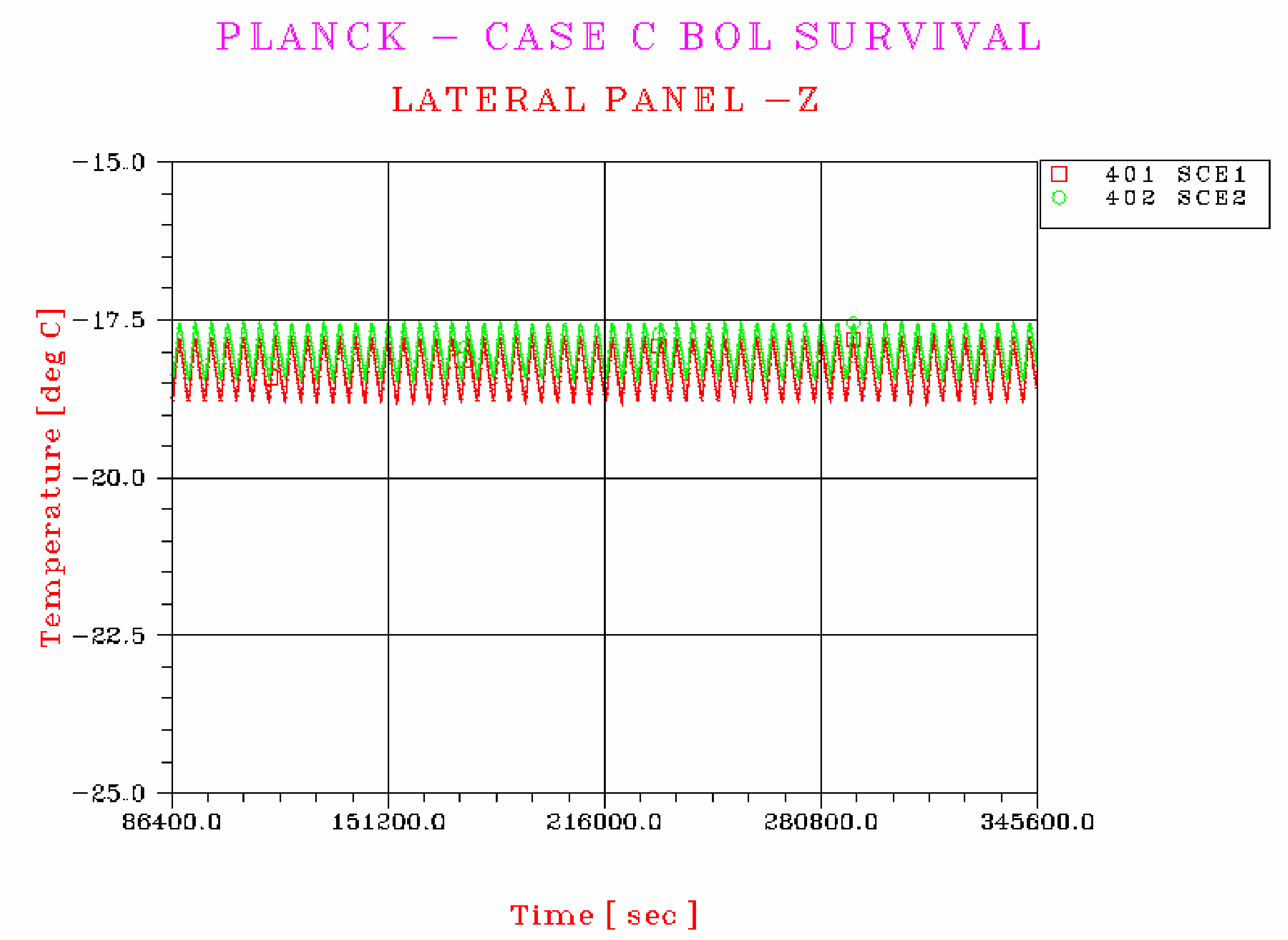
Figures 8.3-4 BOL CASE C - 4K CCU temperature



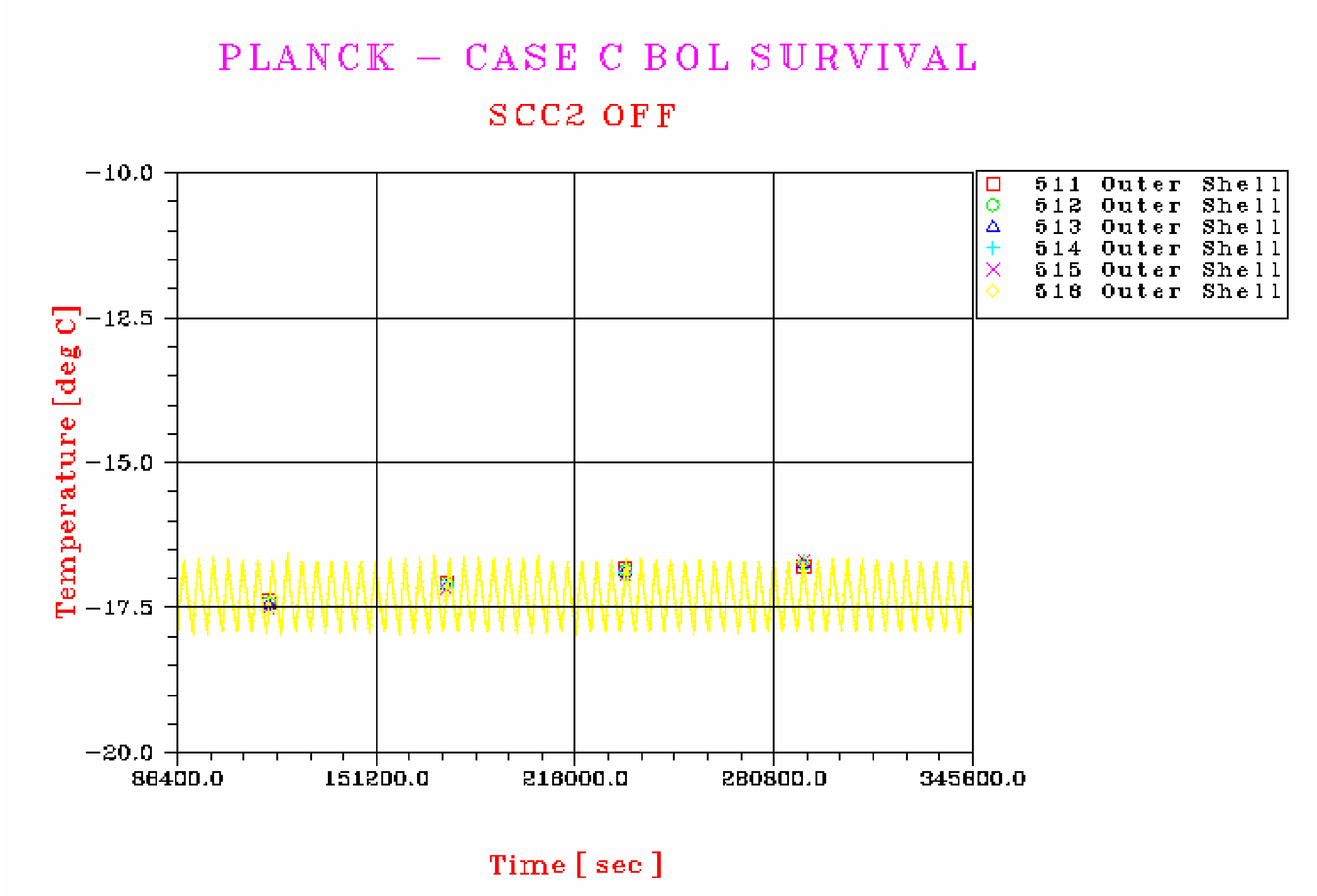
Figures 8.3-5 BOL CASE C +Y-Z panel



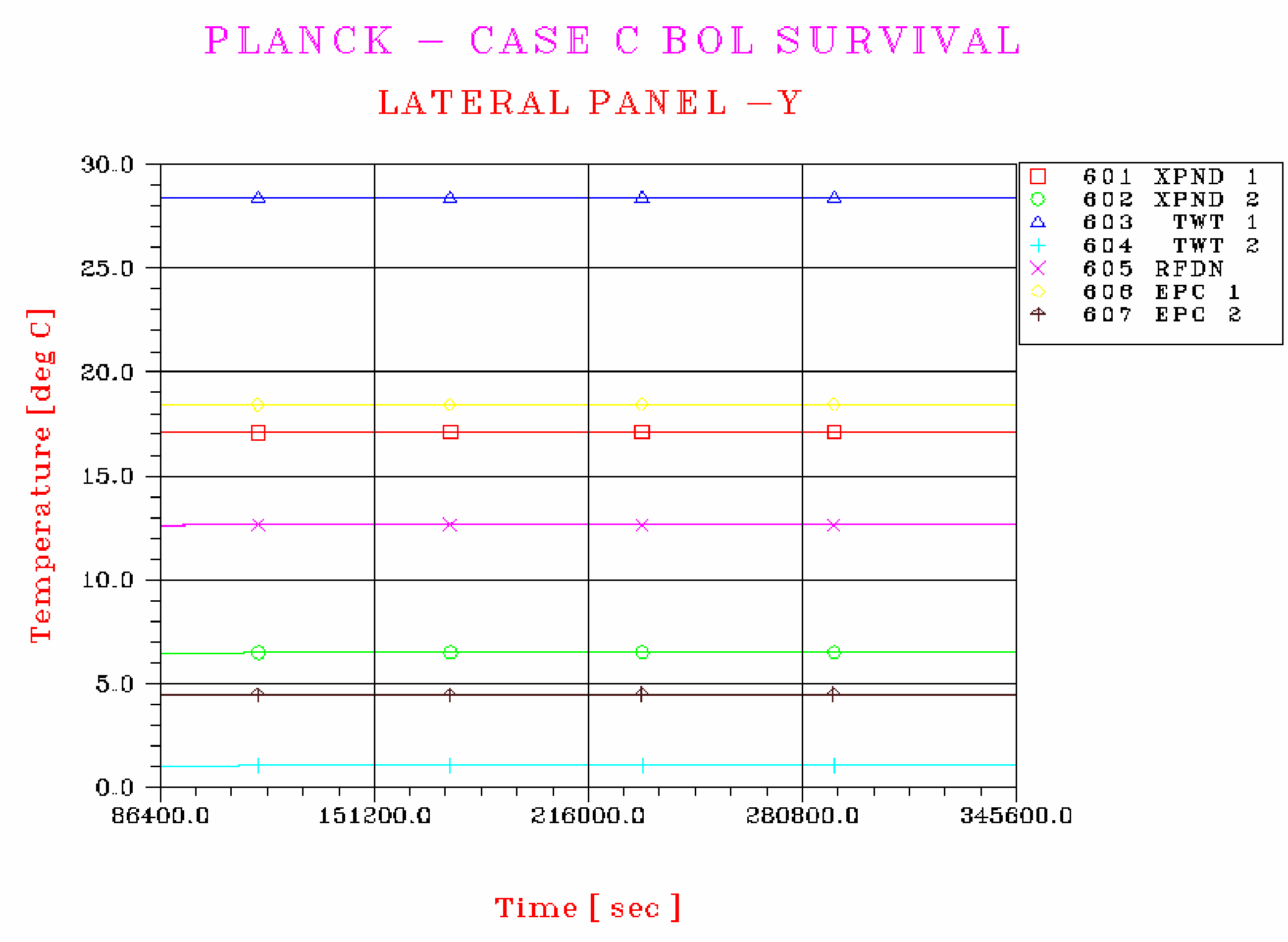
Figures 8.3-6 BOL CASE C SCC I/F temperature



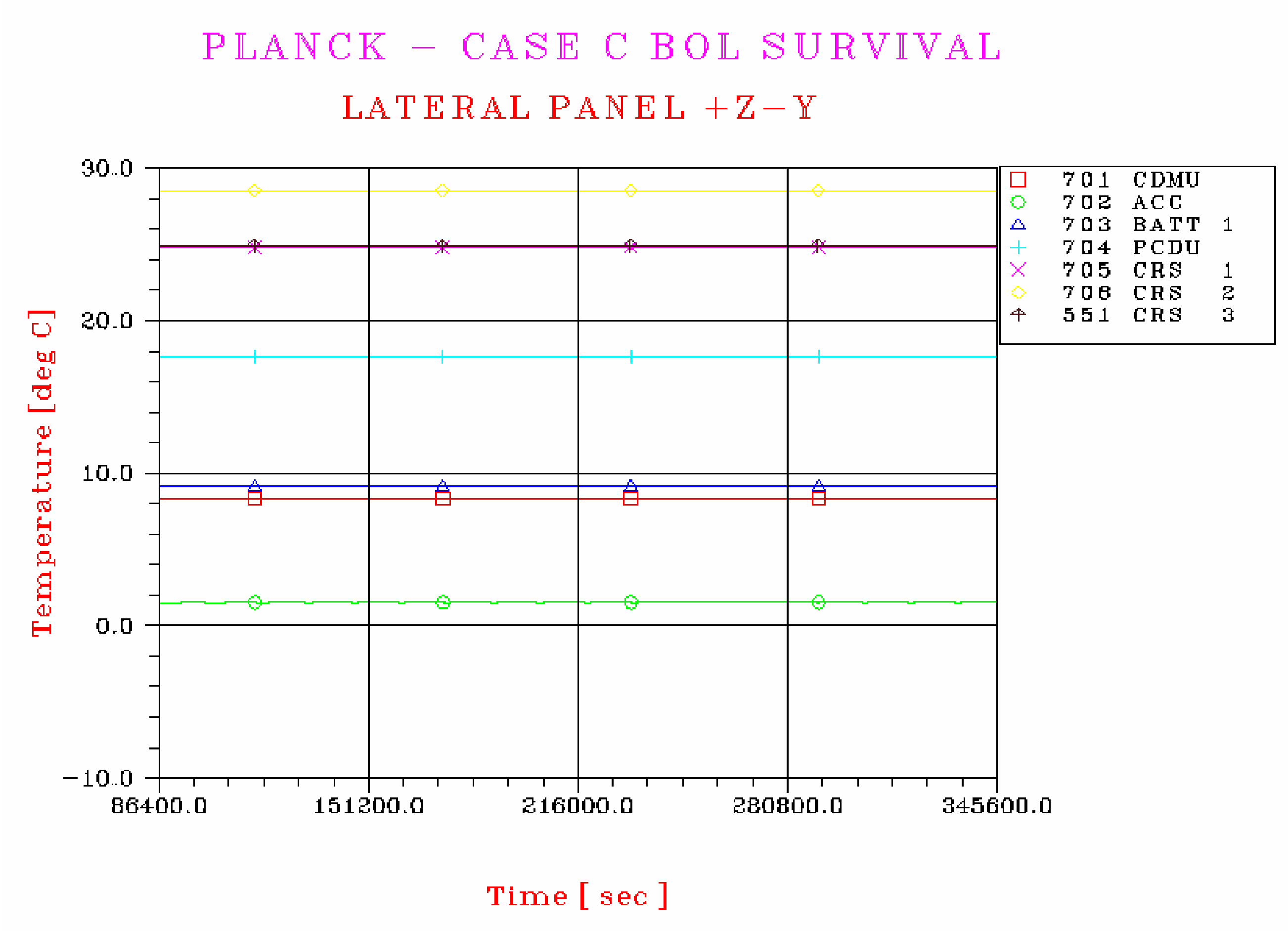
Figures 8.3-7 BOL CASE C -Z panel



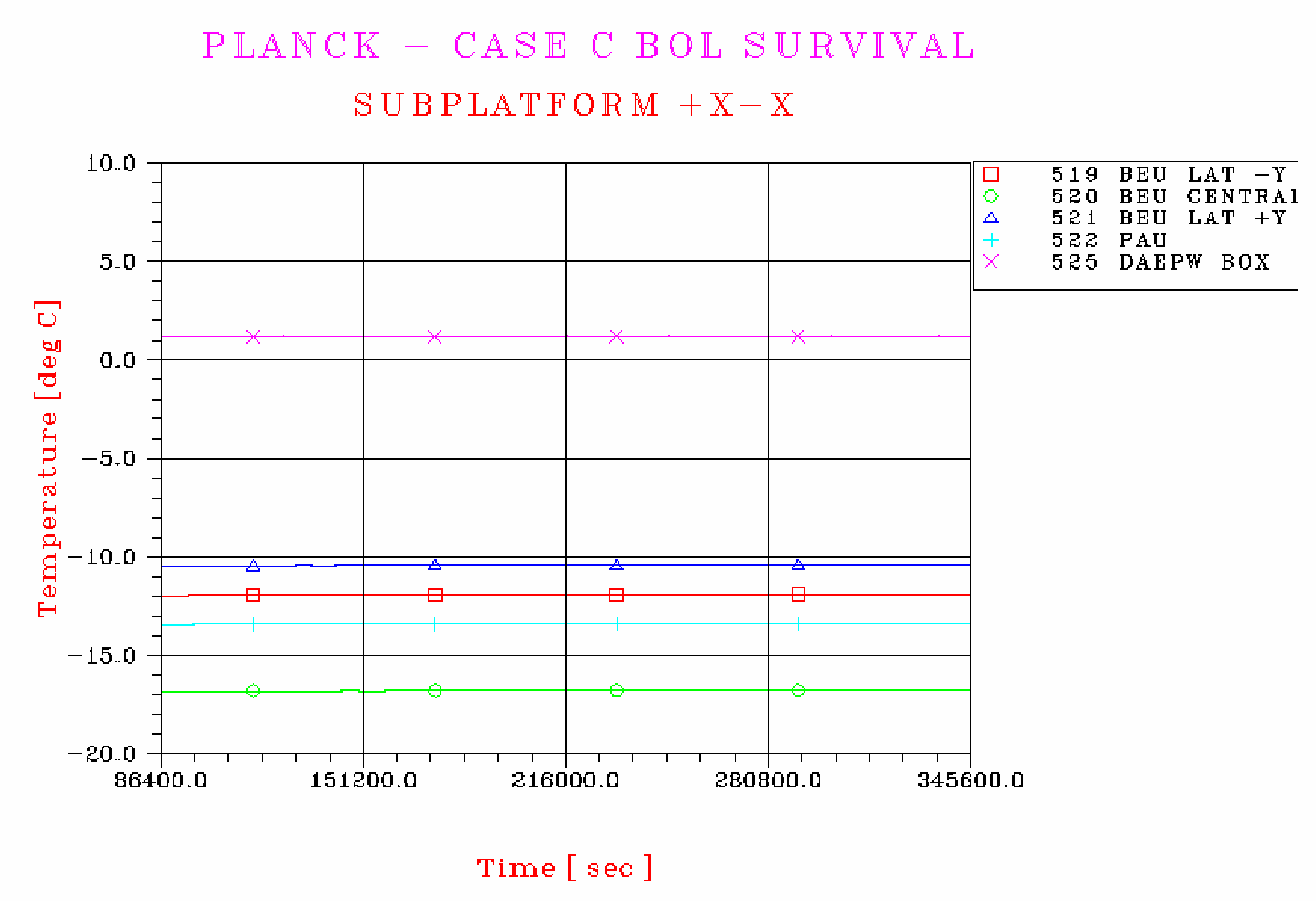
Figures 8.3-8 BOL CASE C –Y-Z panel



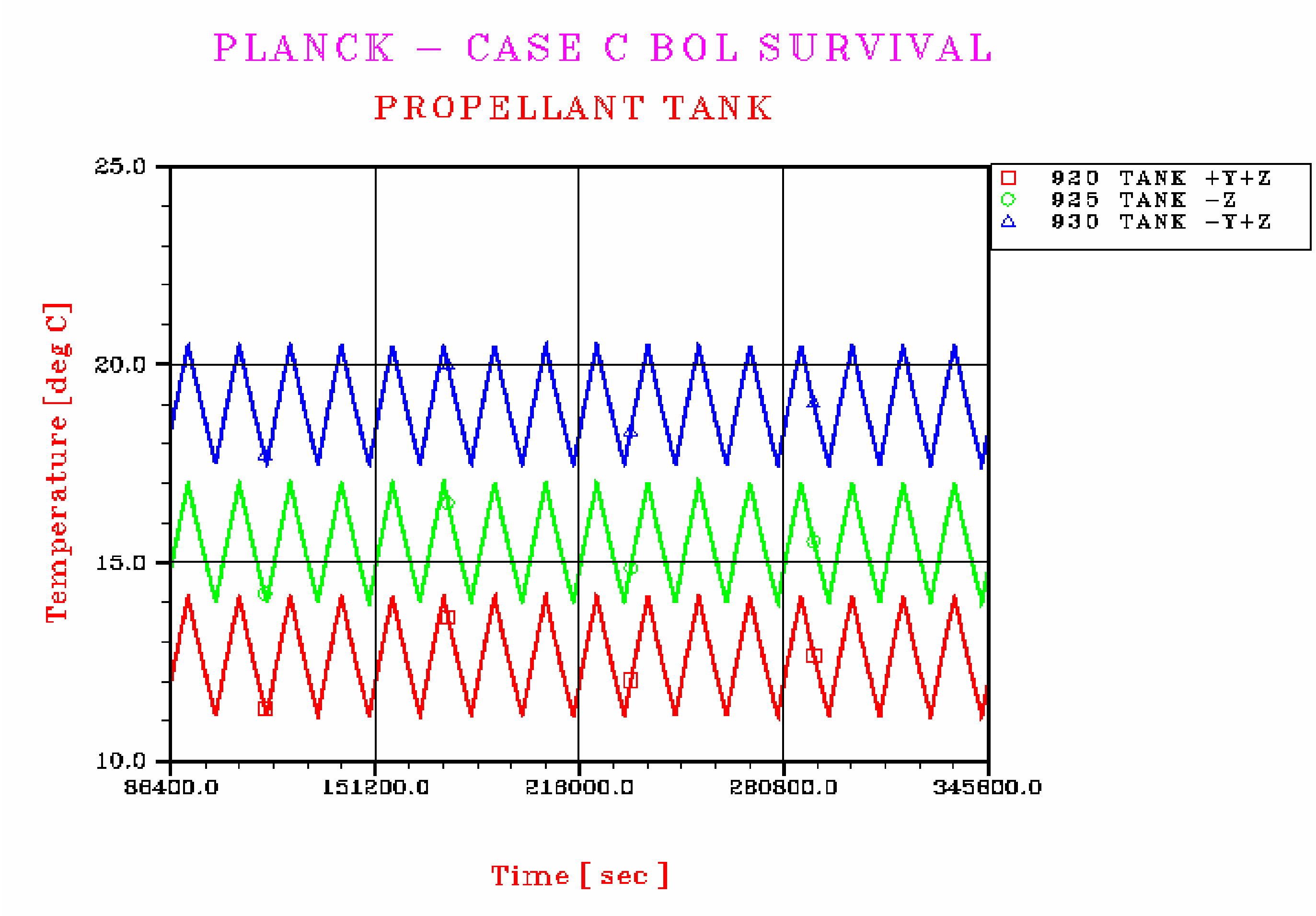
Figures 8.3-9 BOL CASE C -Y panel



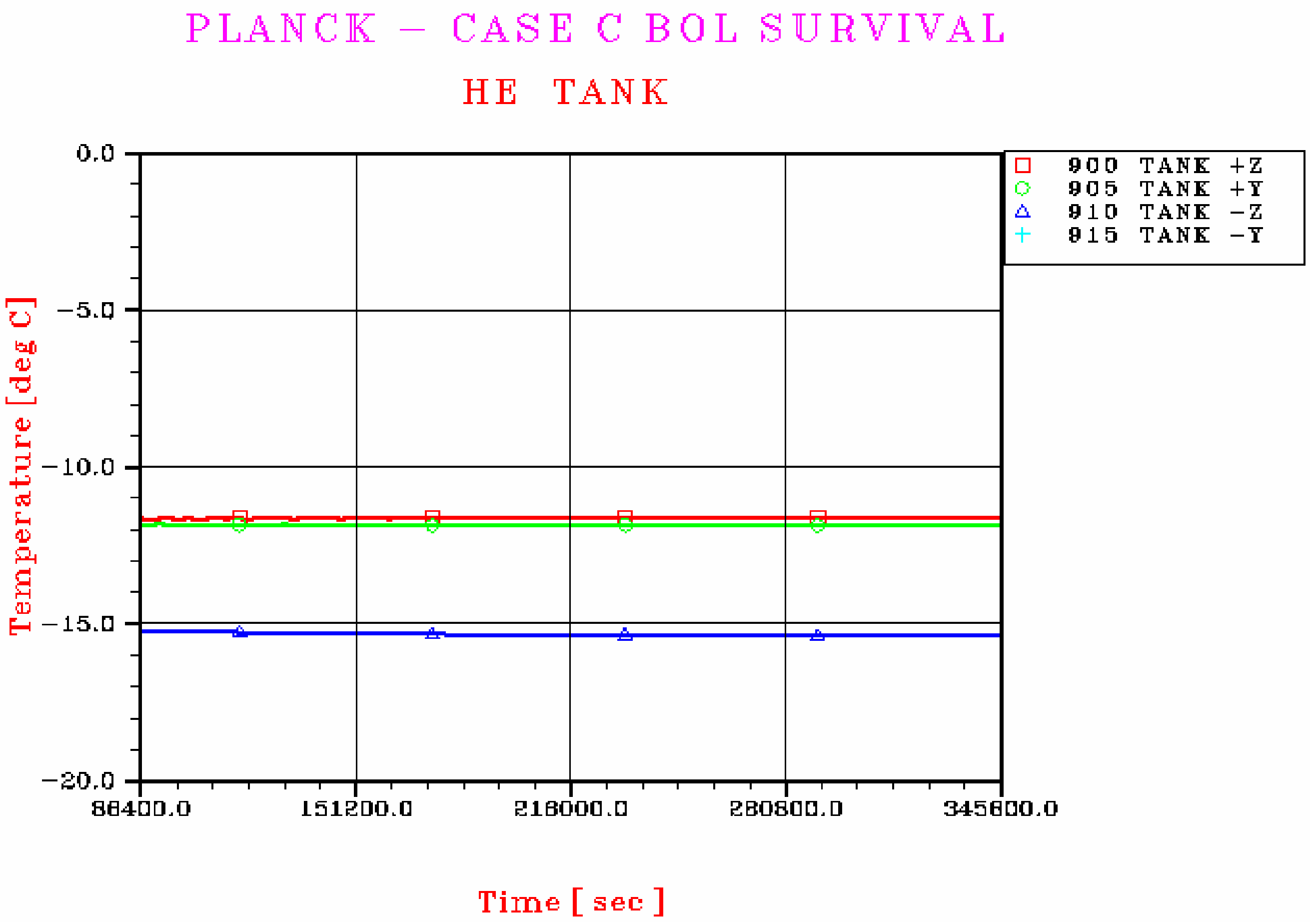
Figures 8.3-10 BOL CASE C -Y+Z panel



Figures 8.3-11 BOL CASE C subplatform panel



Figures 8.3-12 BOL CASE C propellant Tank

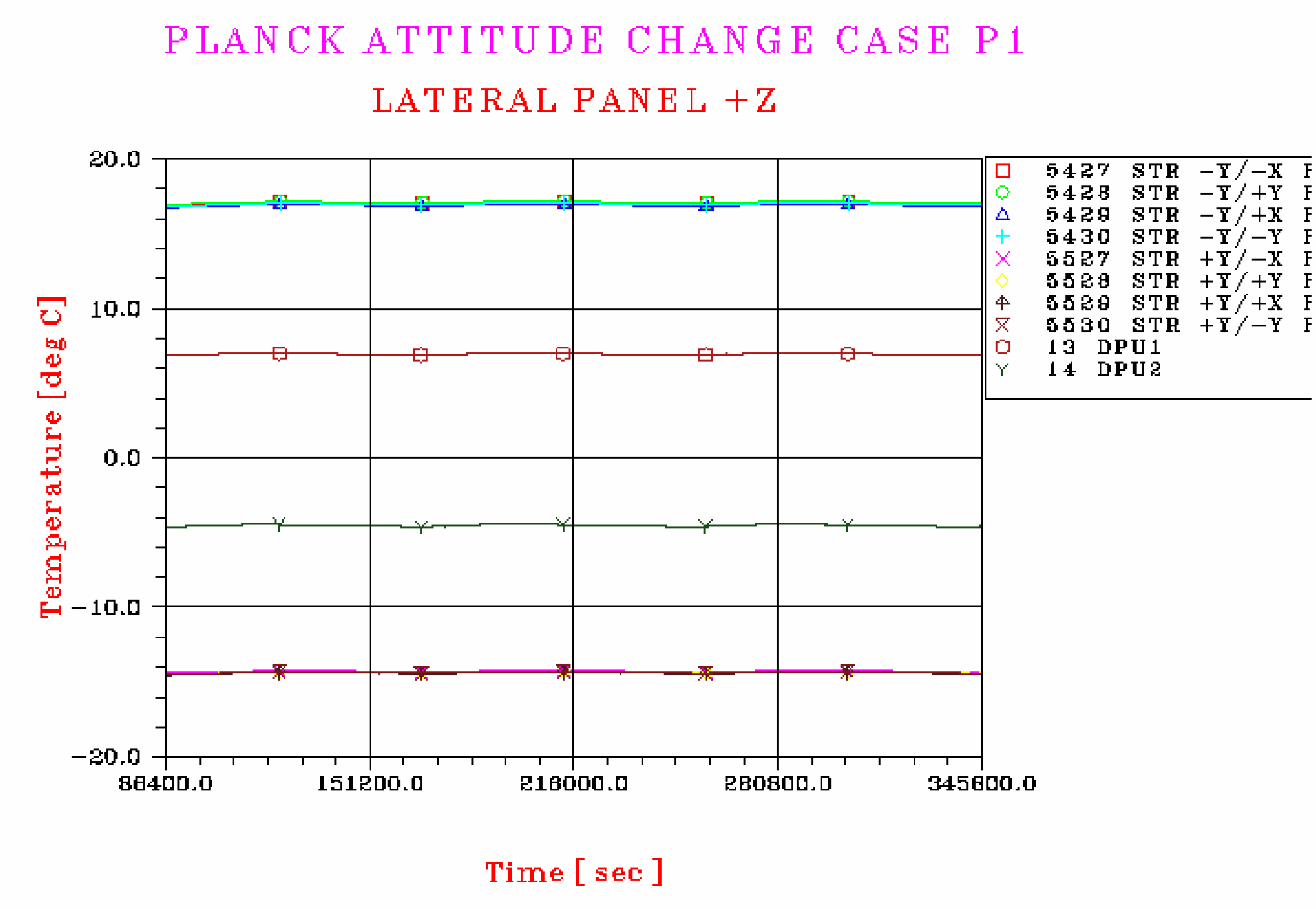


Figures 8.3-13 BOL CASE C He Tank

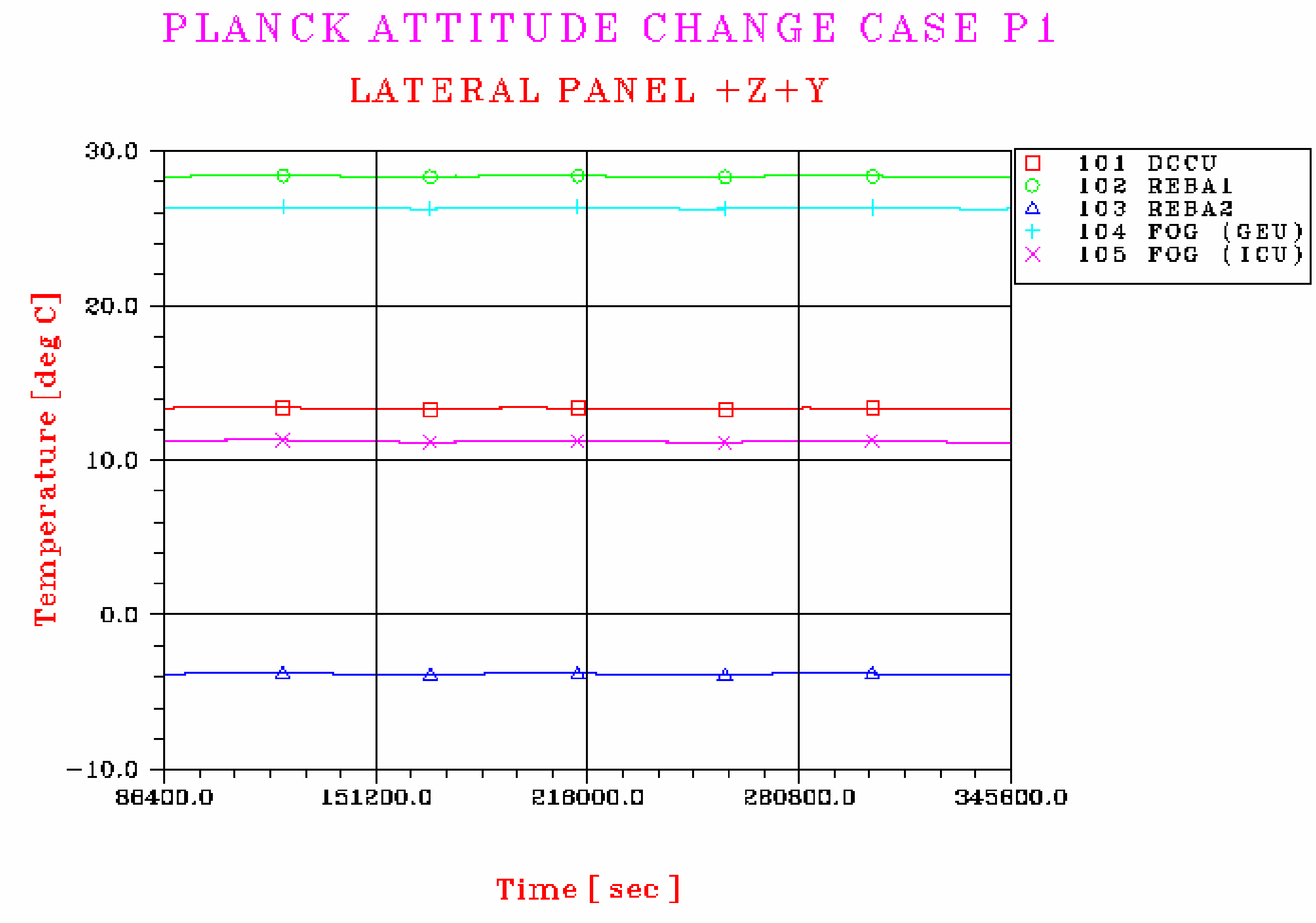
8.4 PLANCK: PLOTS OF TRANSIENT CASE P1

In the following figures, the temperature plots of the transient analysis concerning the attitude change of the satellite in BOL condition and unit SCC1 operative are presented.

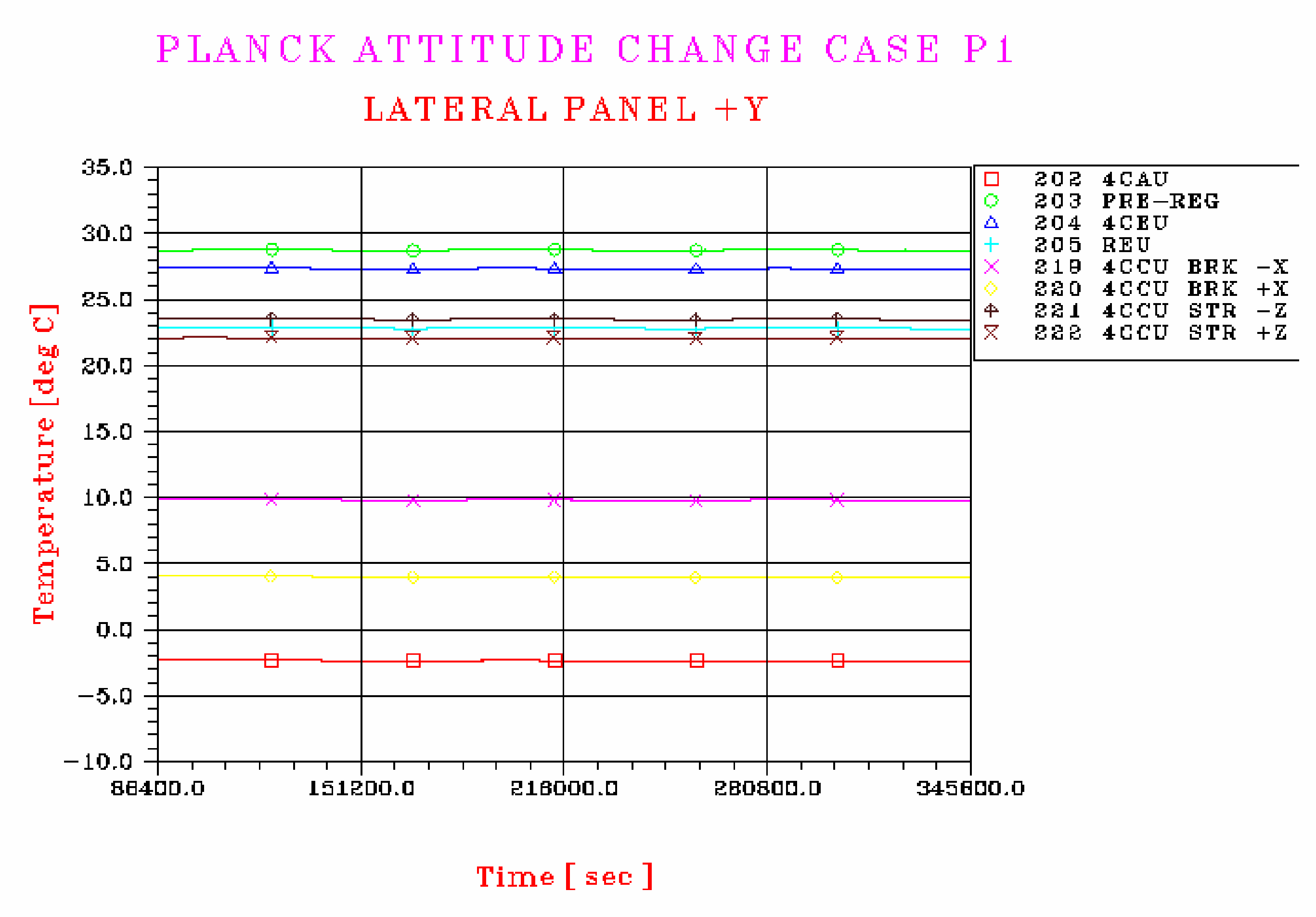
Change of attititude at time=86400s



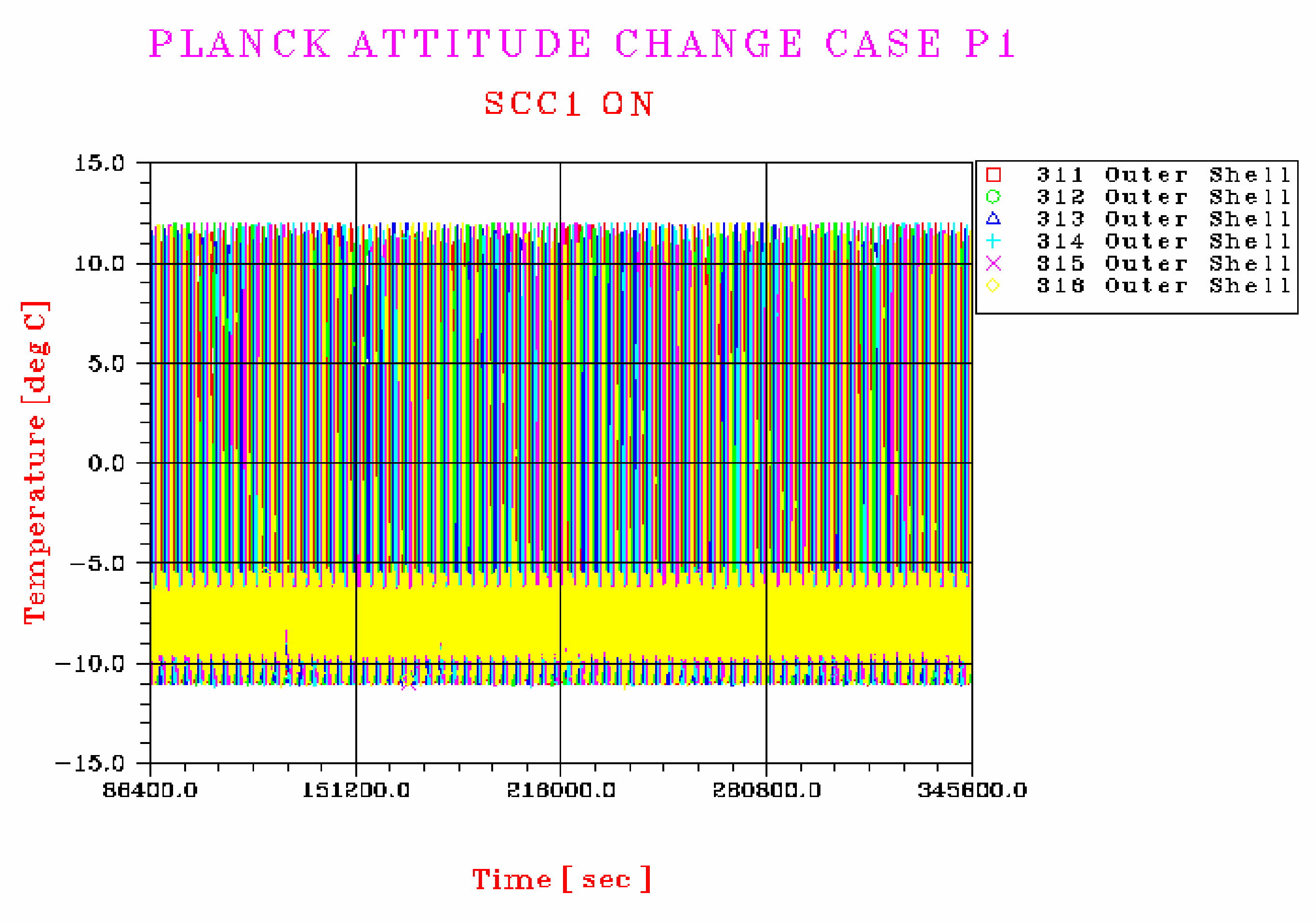
Figures 8.4-1 BOL attitude change +Z panel



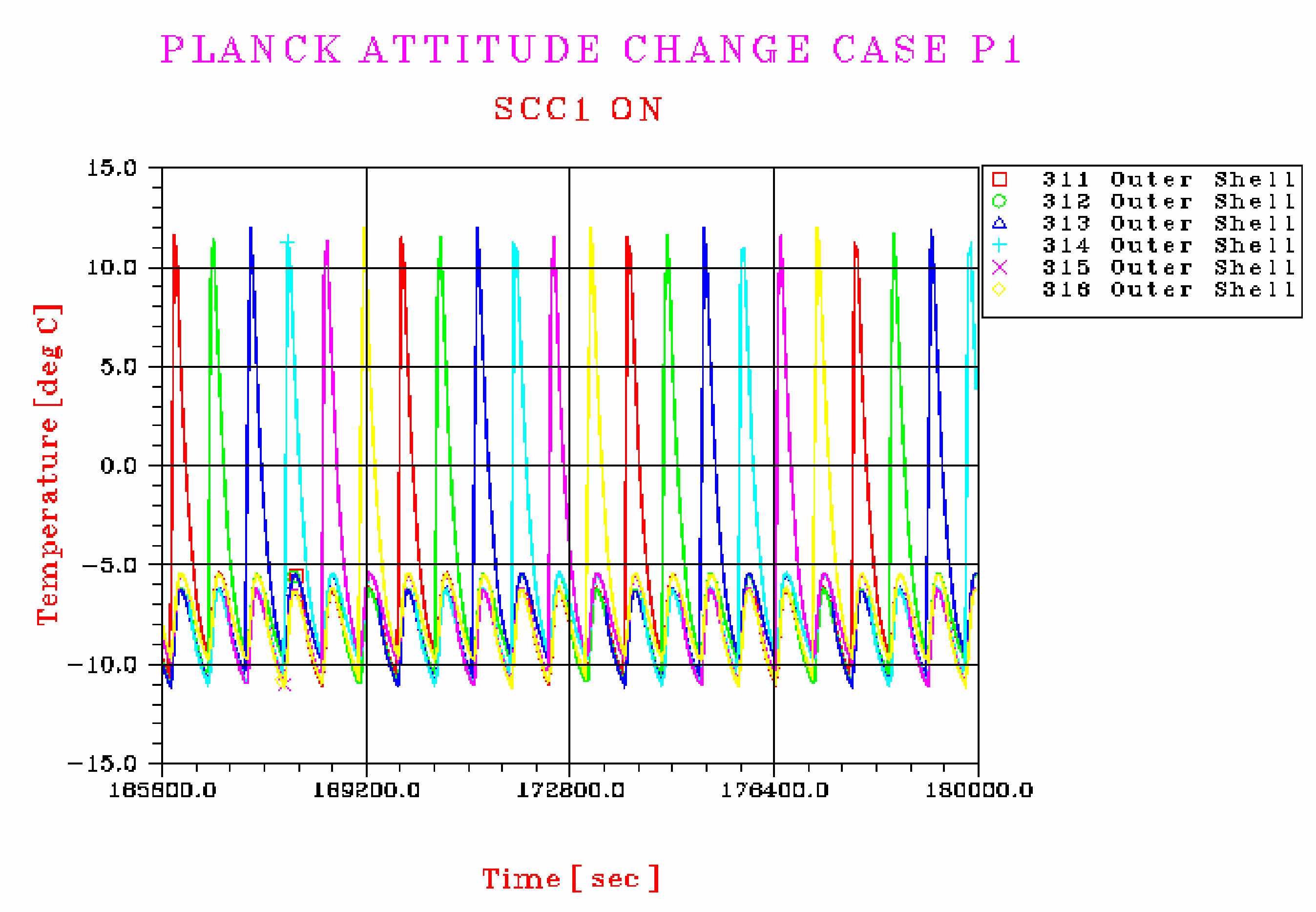
Figures 8.4-2 BOL attitude change +Y+Z panel



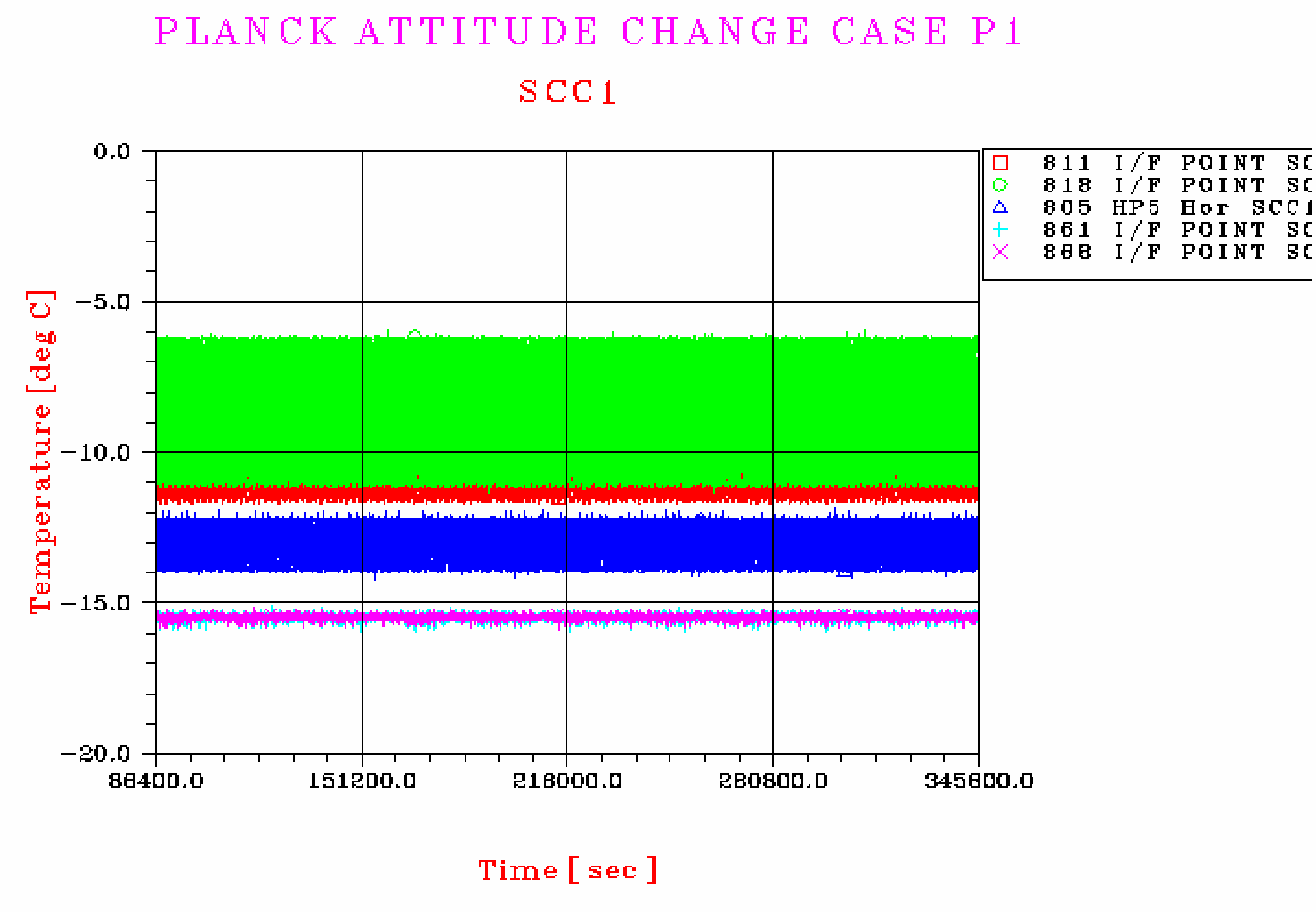
Figures 8.4-3 BOL attitude change +Y panel



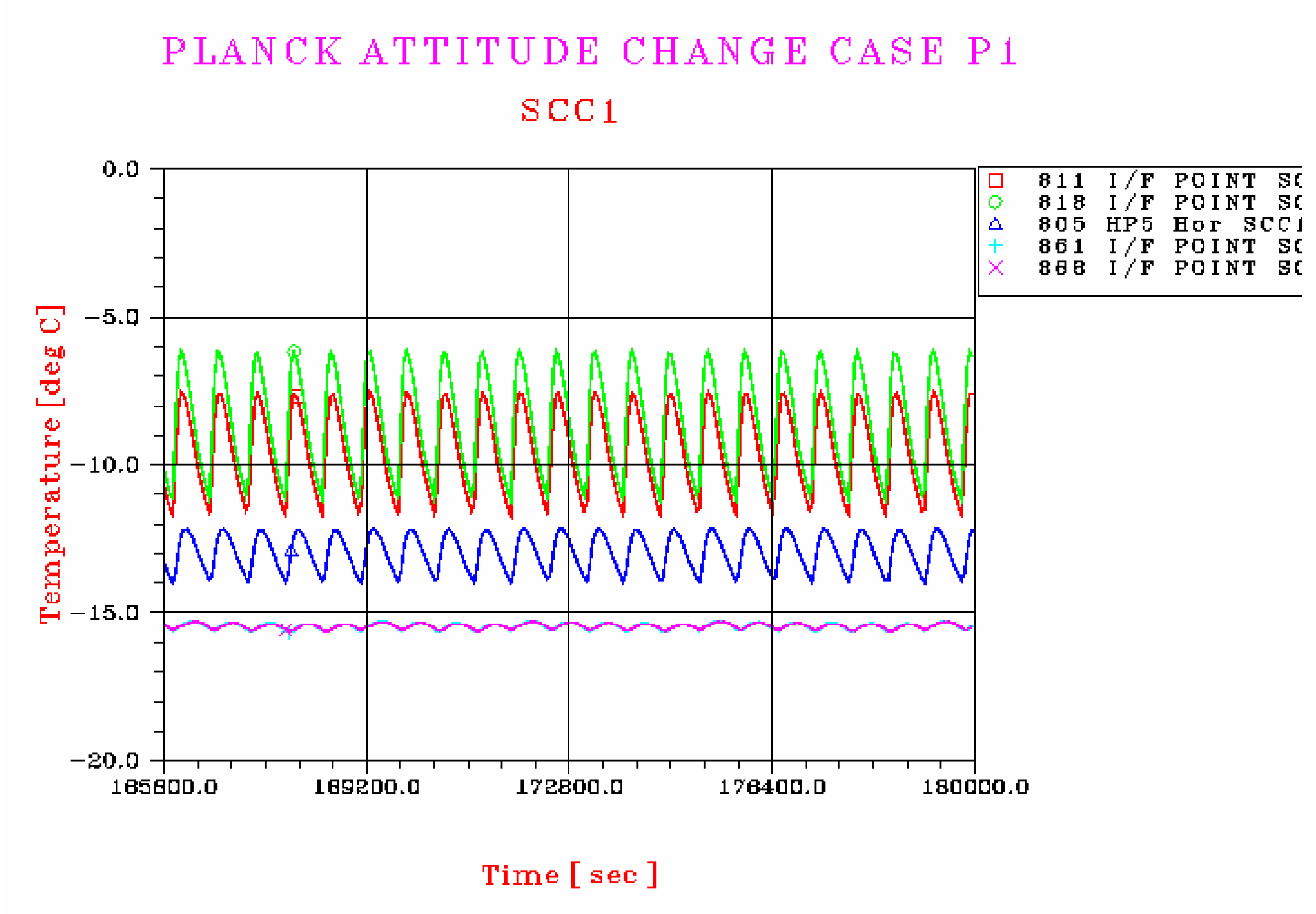
Figures 8.4-4 BOL attitude change +Y-Z panel



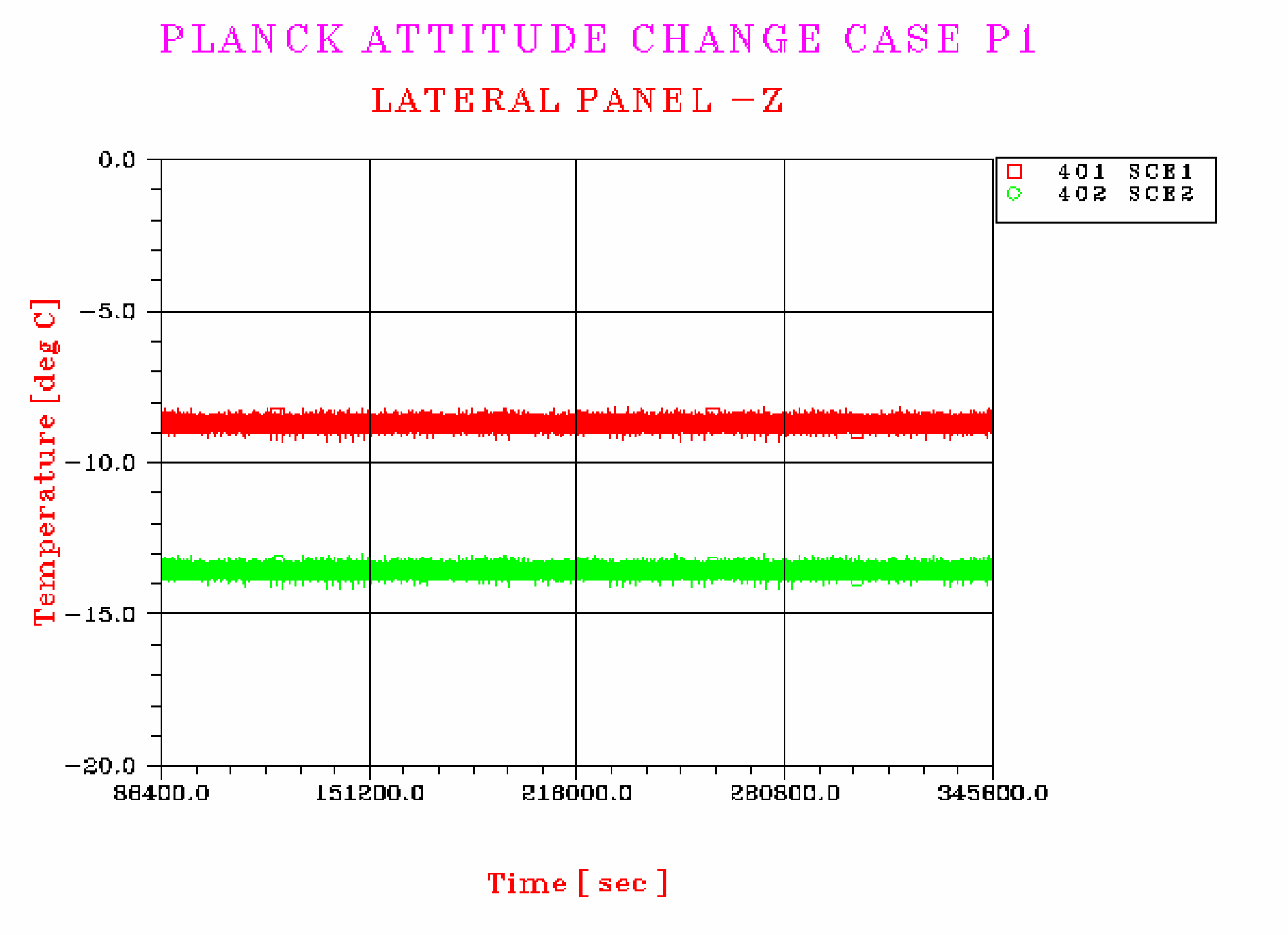
Figures 8.4-5 BOL attitude change +Y-Z panel



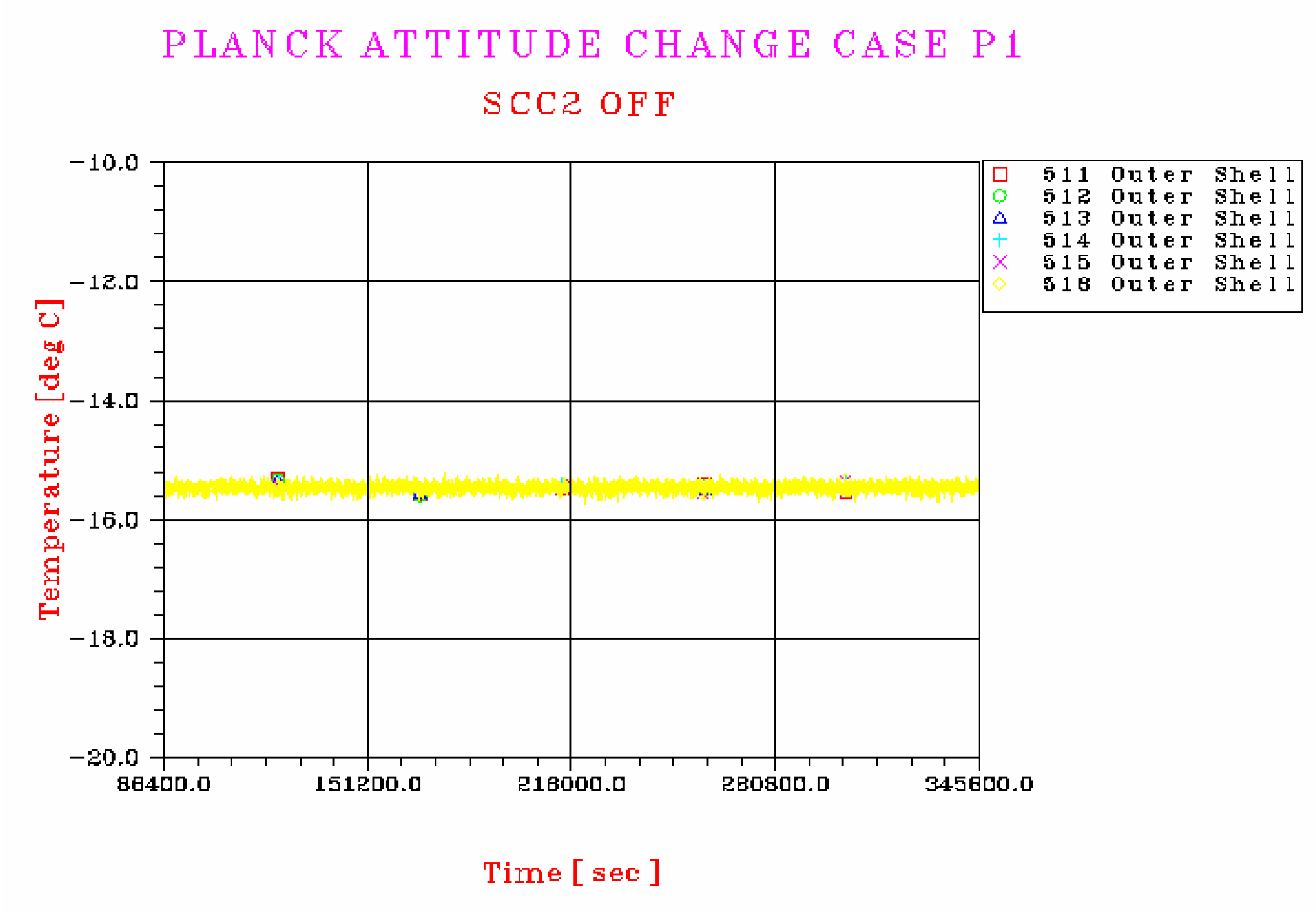
Figures 8.4-6 BOL attitude change SCC I/F temperatures



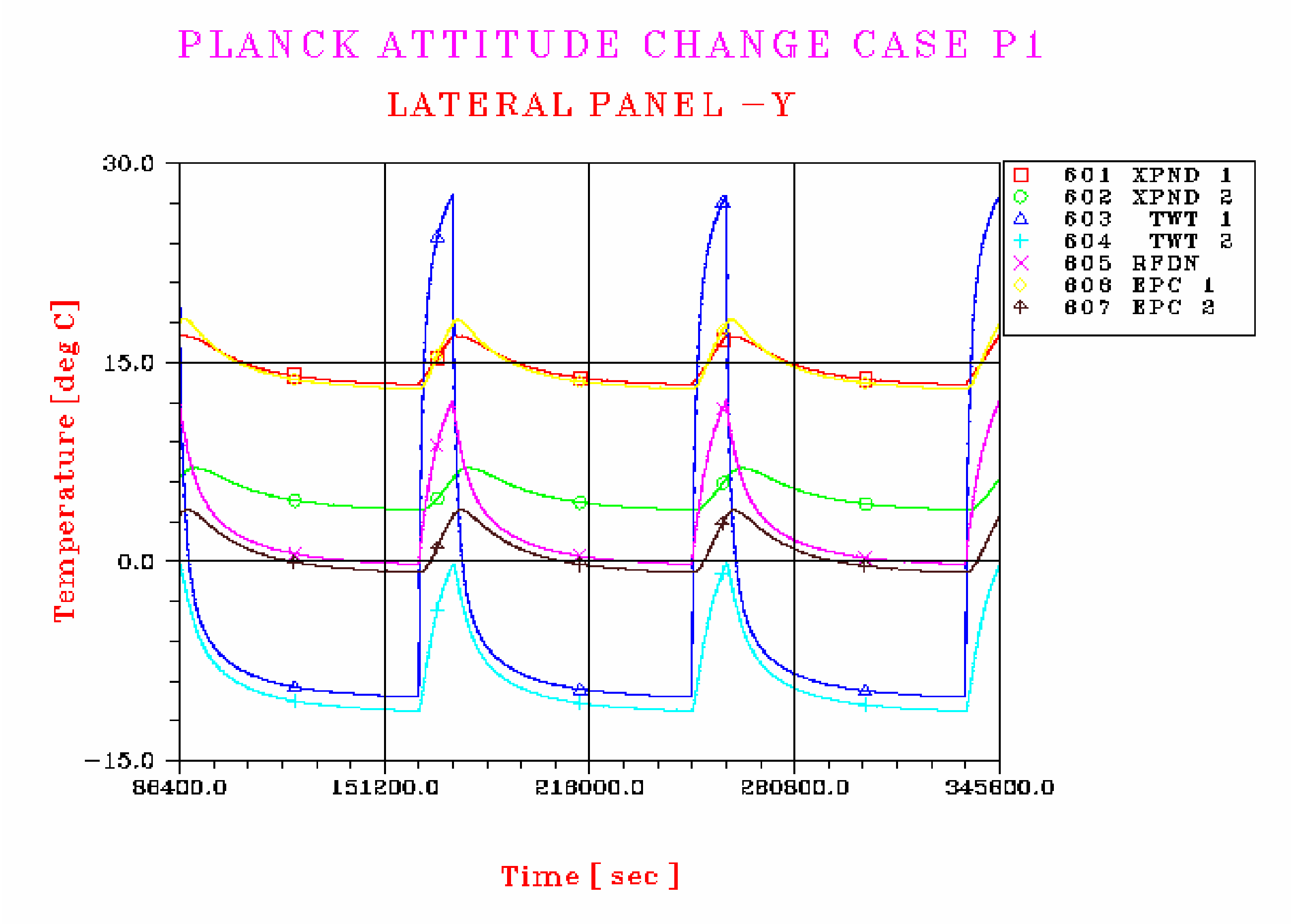
Figures 8.4-7 BOL attitude change SCC I/F temperatures



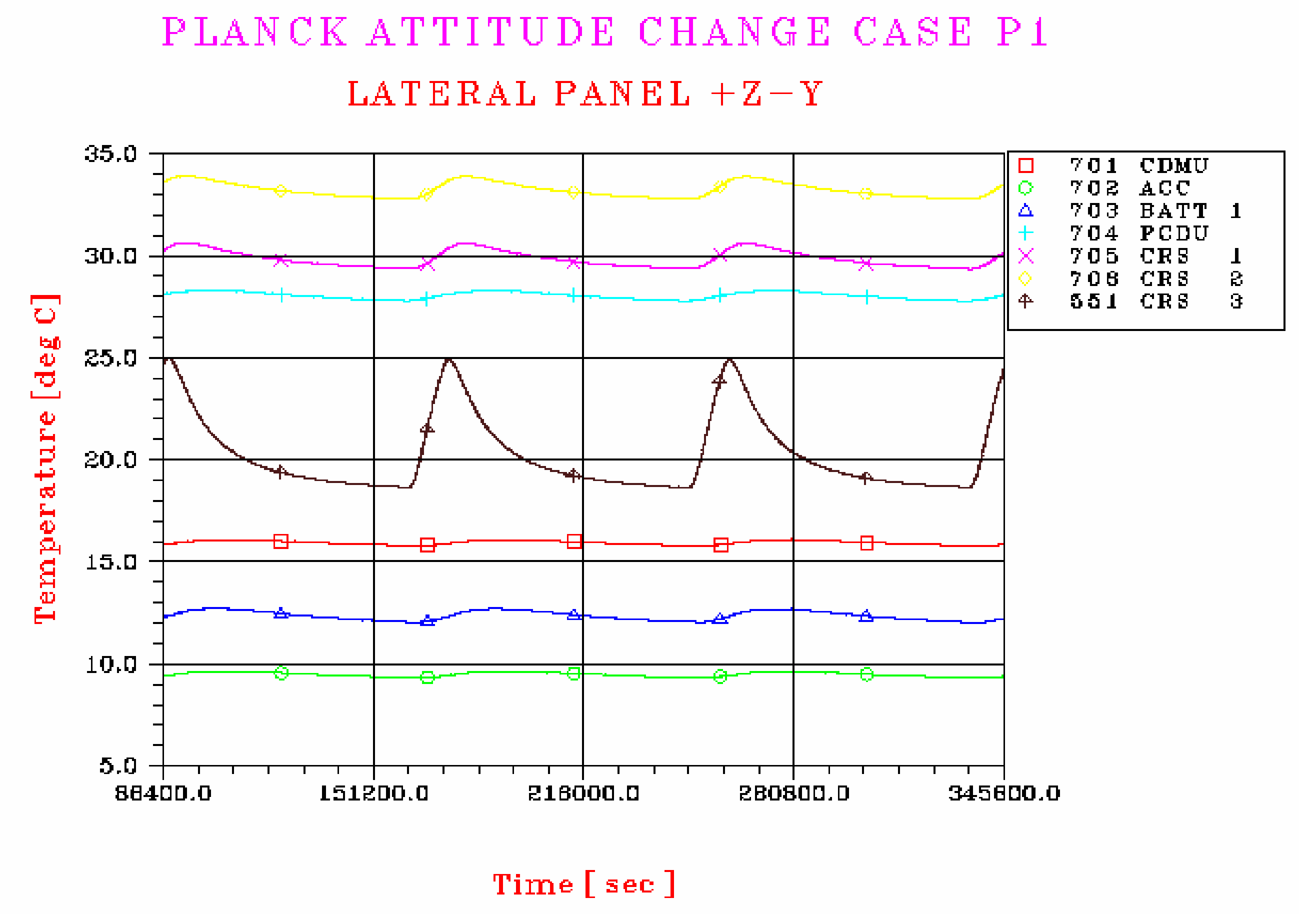
Figures 8.4-8 BOL attitude change -Z panel



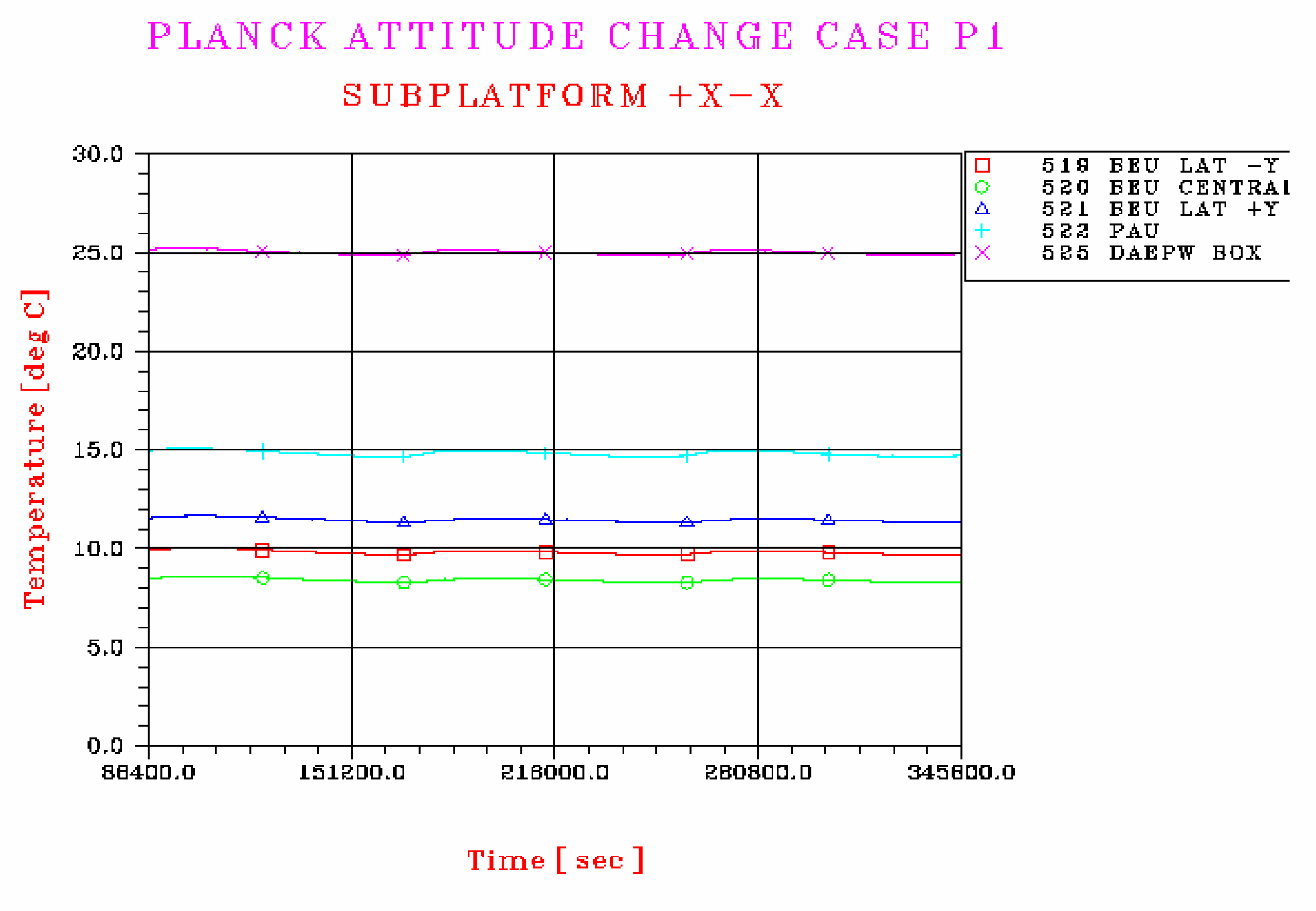
Figures 8.4-9 BOL attitude change –Y-Z panel



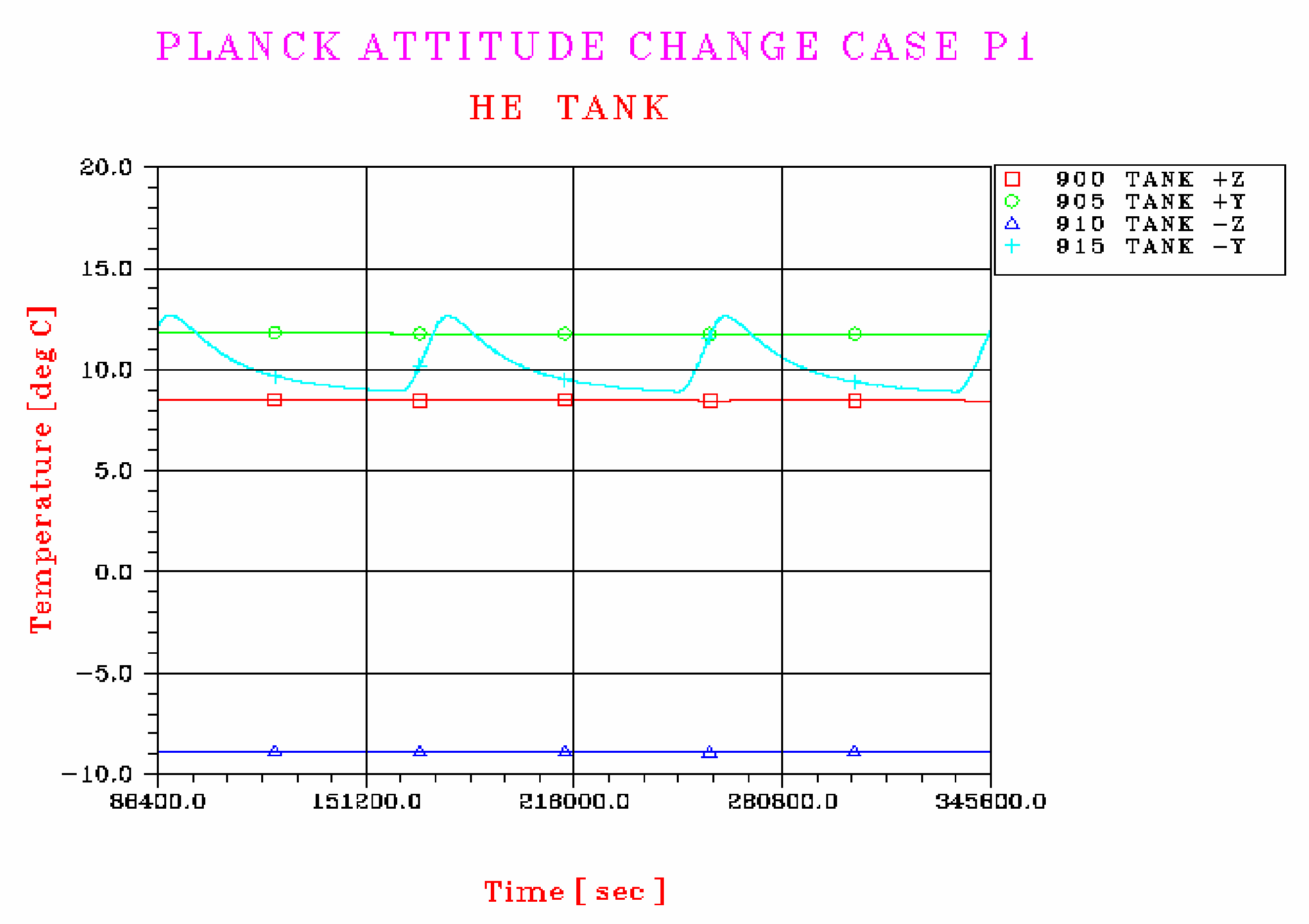
Figures 8.4-10 BOL attitude change -Y panel



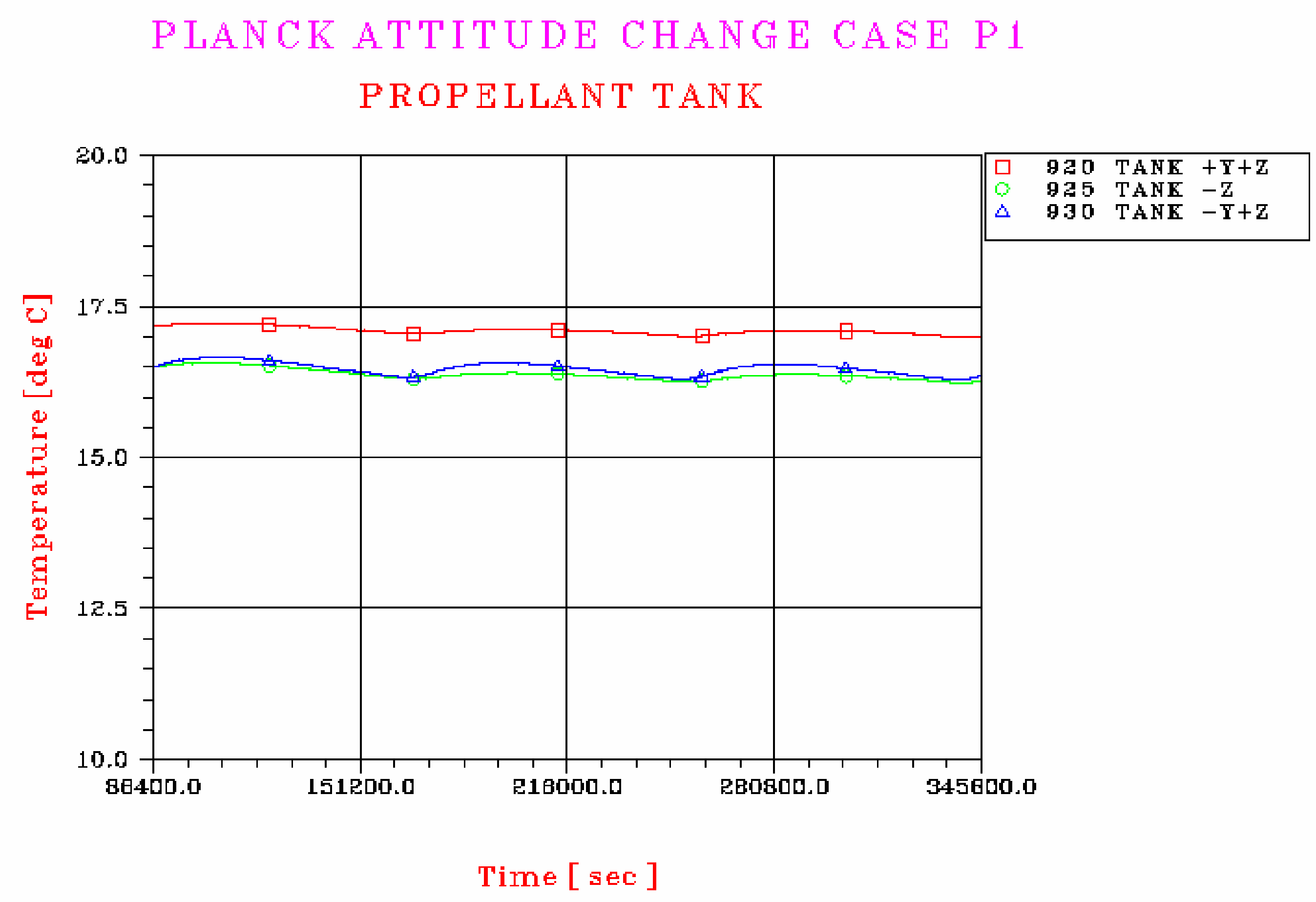
Figures 8.4-11 BOL attitude change -Y+Z panel



Figures 8.4-12 BOL attitude change subplatform panel



Figures 8.4-13 BOL attitude change Helium TANK

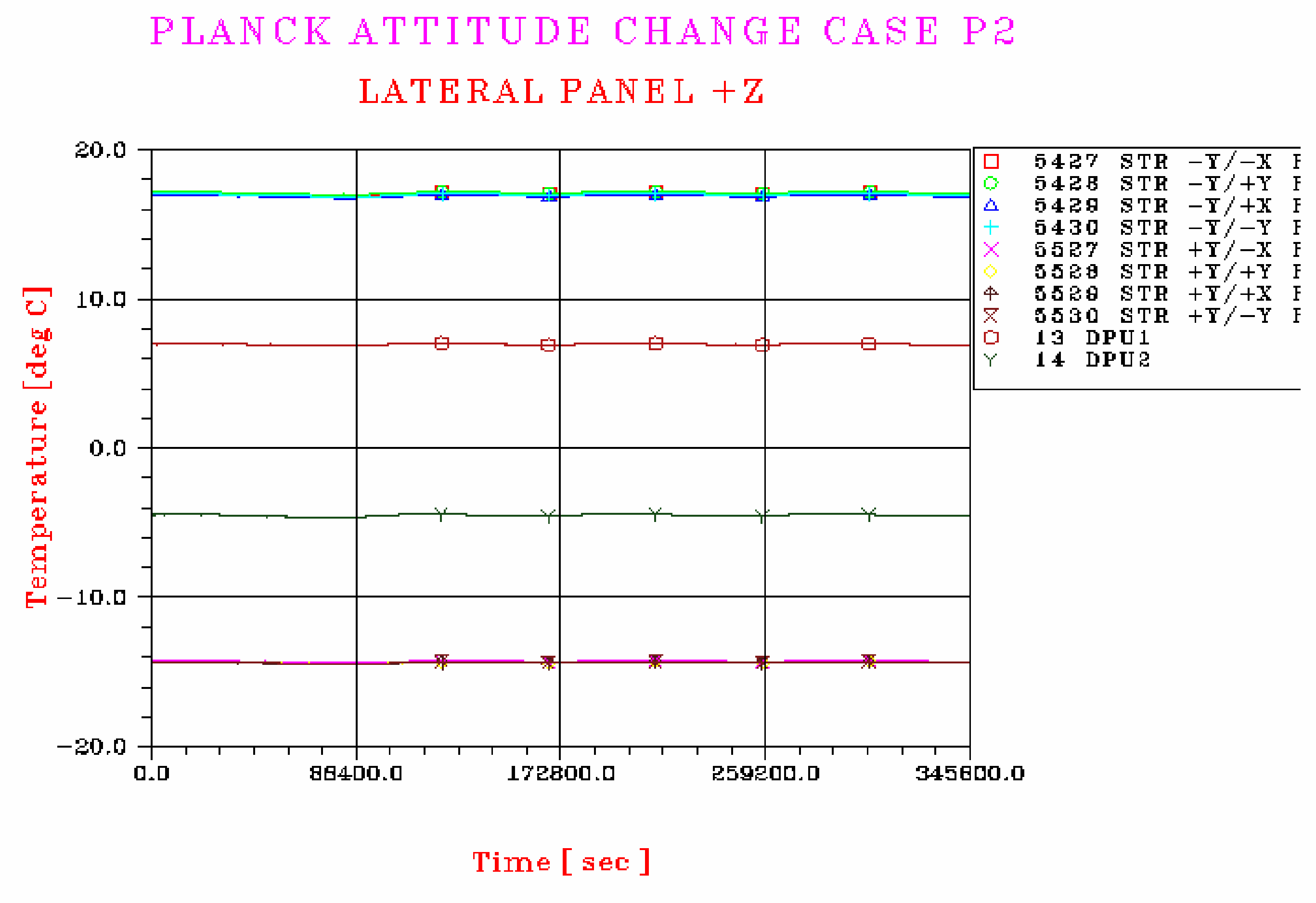


Figures 8.4-14 BOL attitude change Propellant TANK

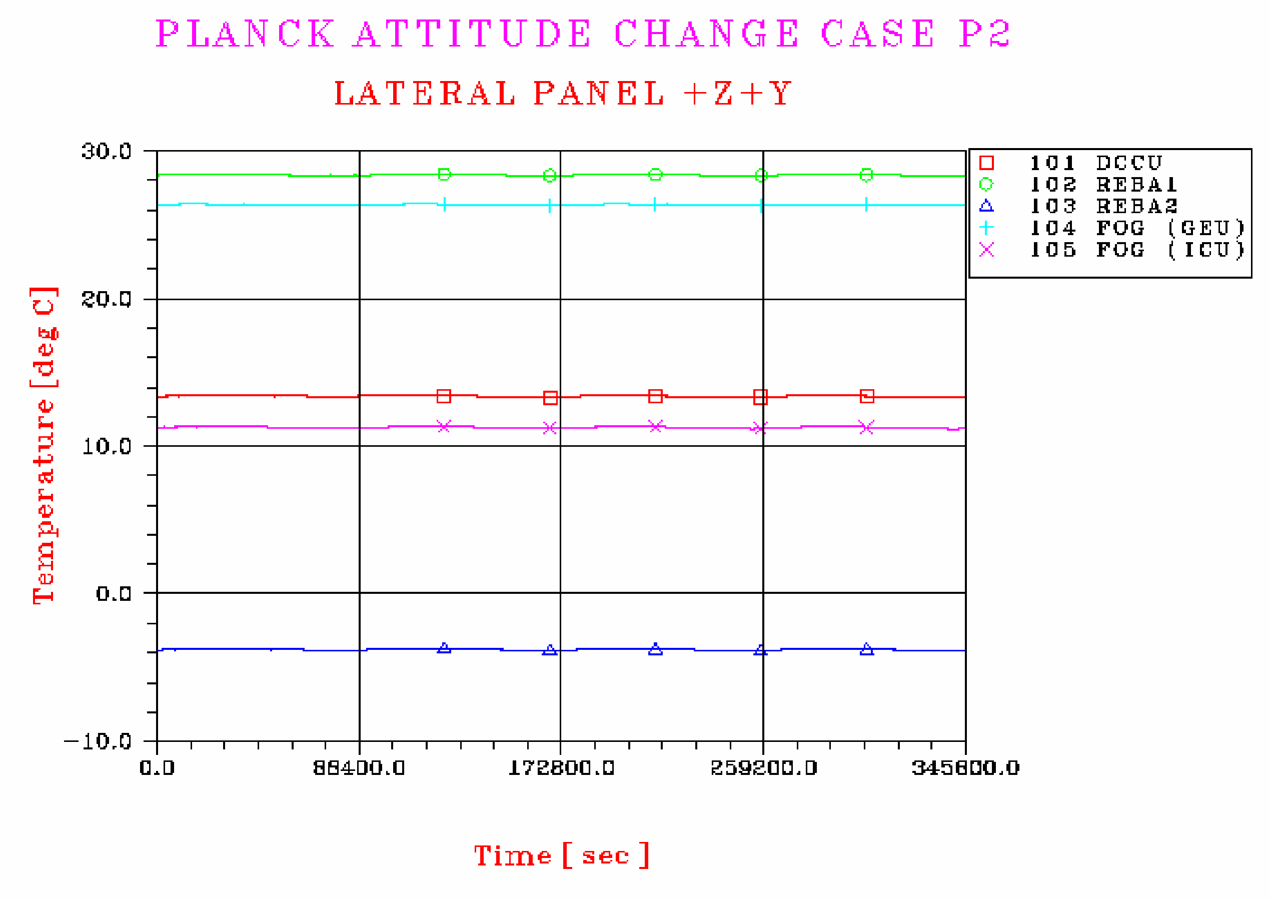
8.5 PLANCK: PLOTS OF TRANSIENT CASE P2

In the following figures, the temperature plots of the transient analysis concerning the attitude change of the satellite in BOL condition and unit SCC2 operative are presented.

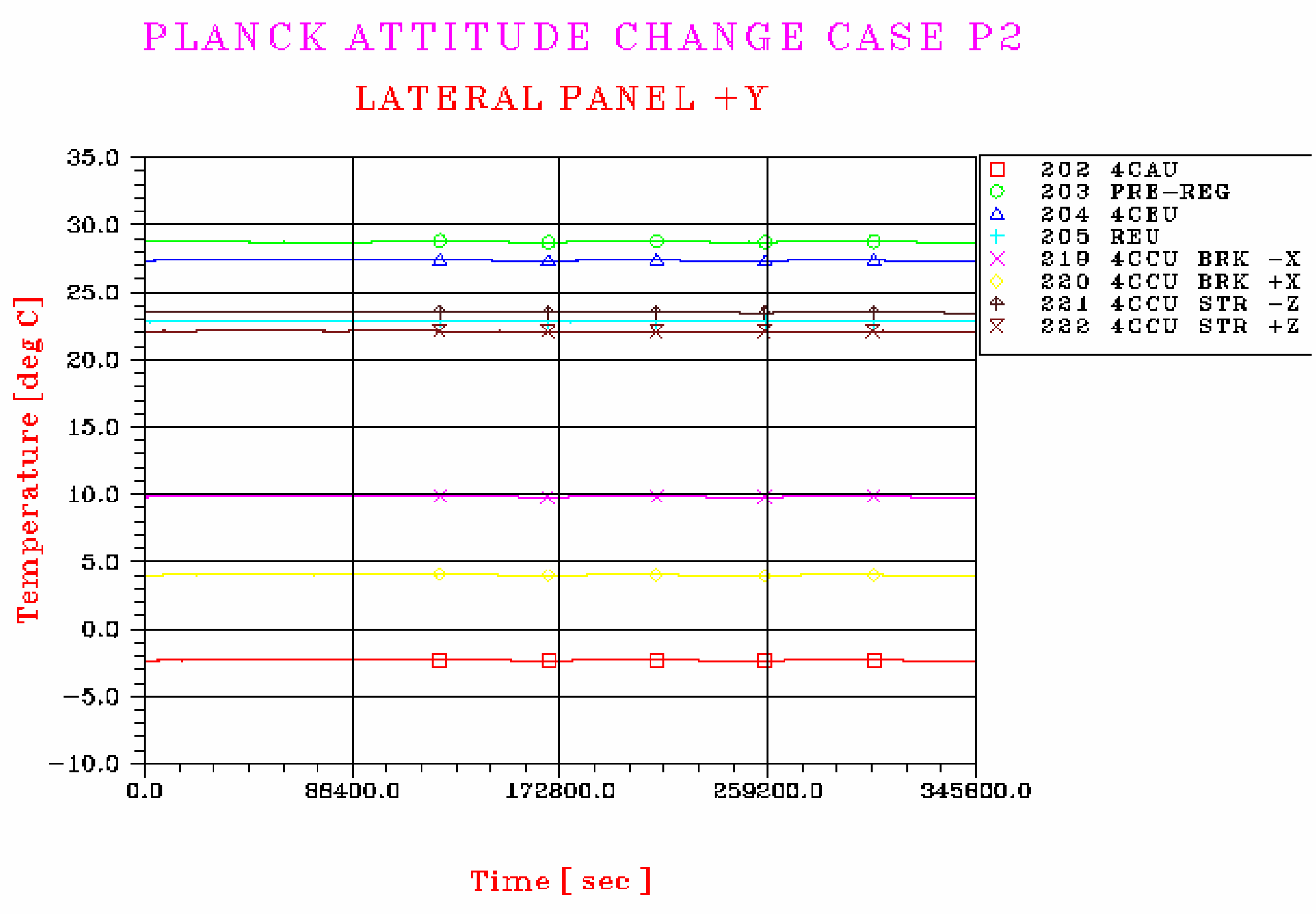
Change of attititude at time=86400s



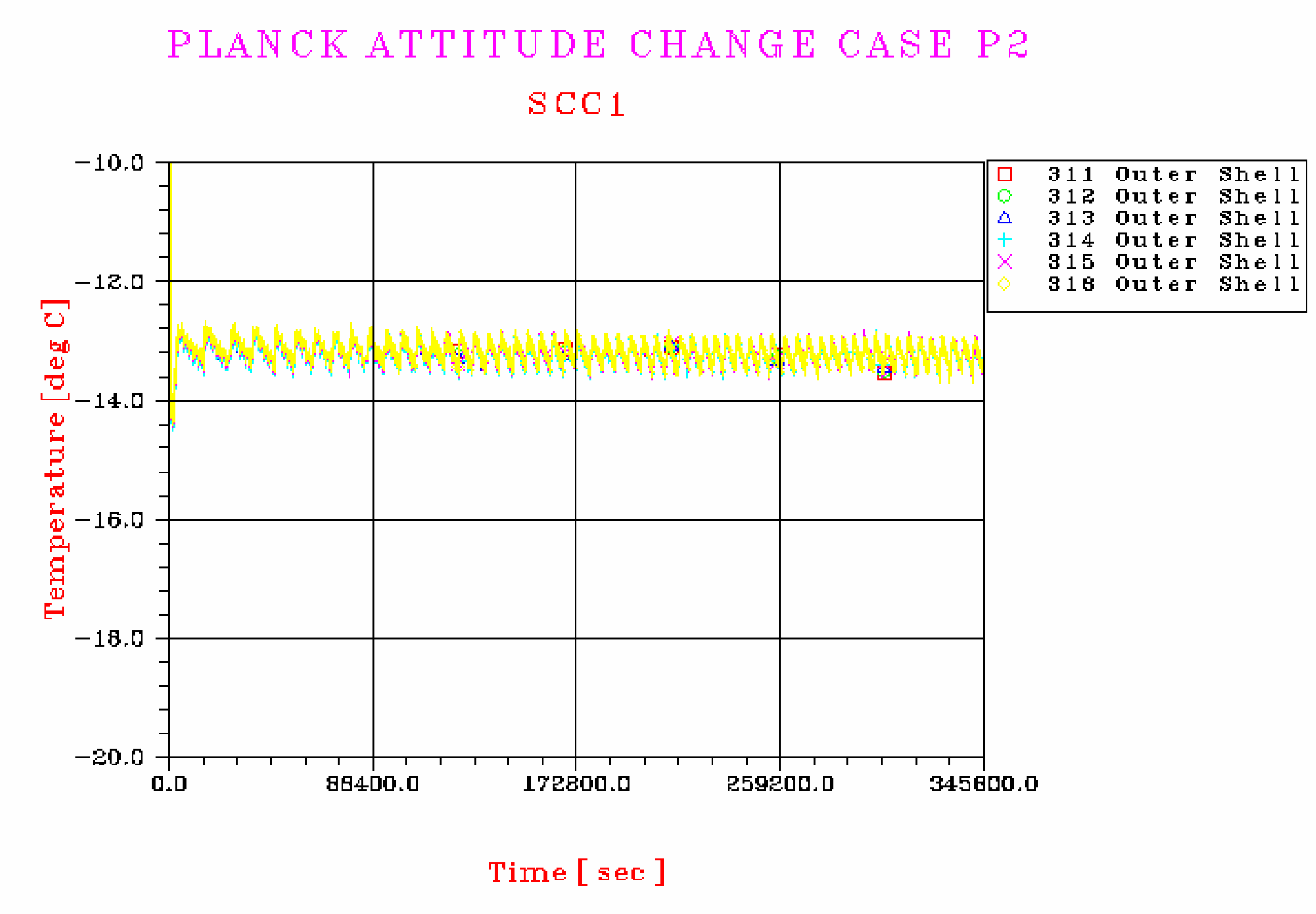
Figures 8.5-1 BOL attitude change +Z panel



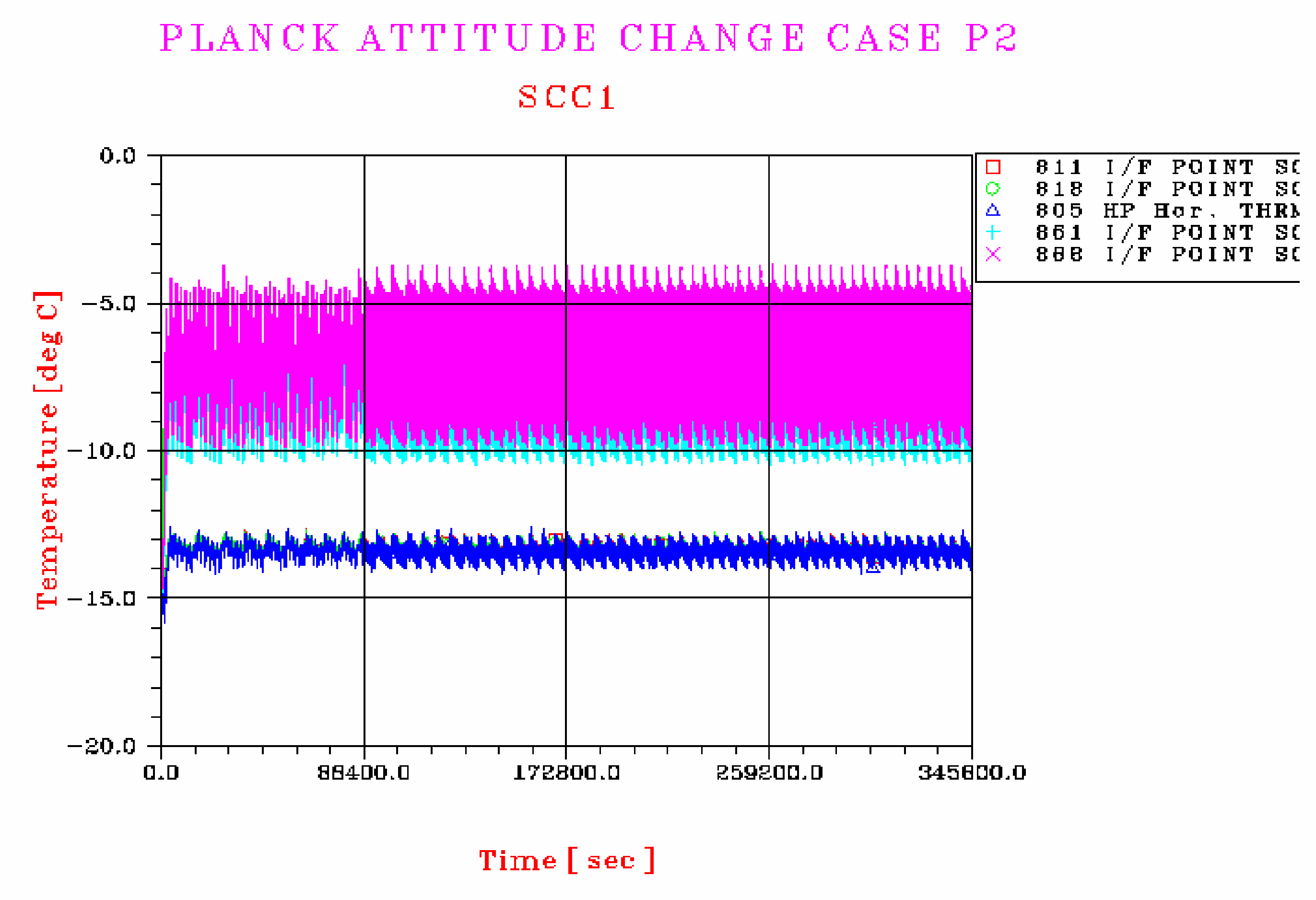
Figures 8.5-2 BOL attitude change +Y+Z panel



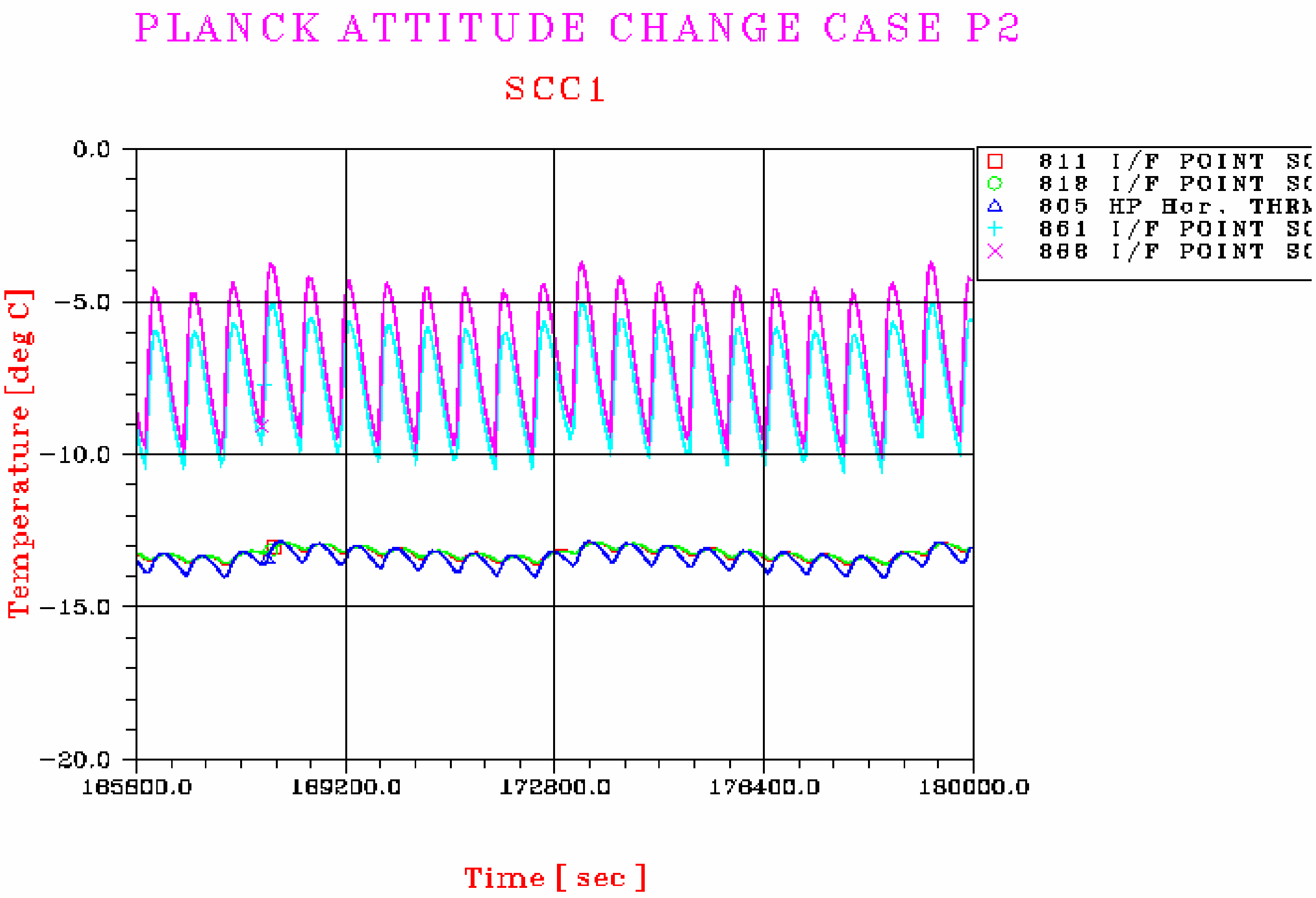
Figures 8.5-3 BOL attitude change +Y panel



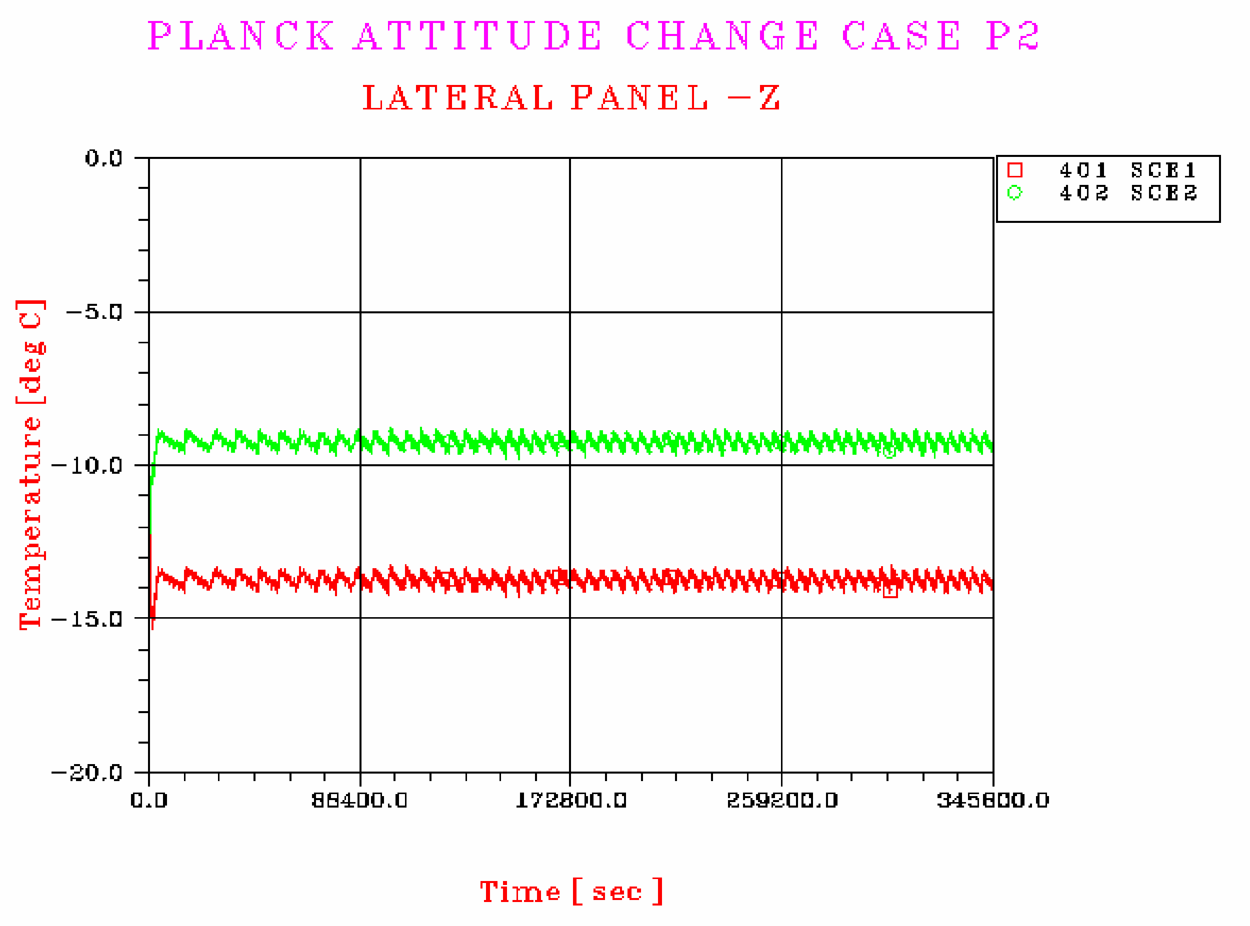
Figures 8.5-4 BOL attitude change +Y-Z panel



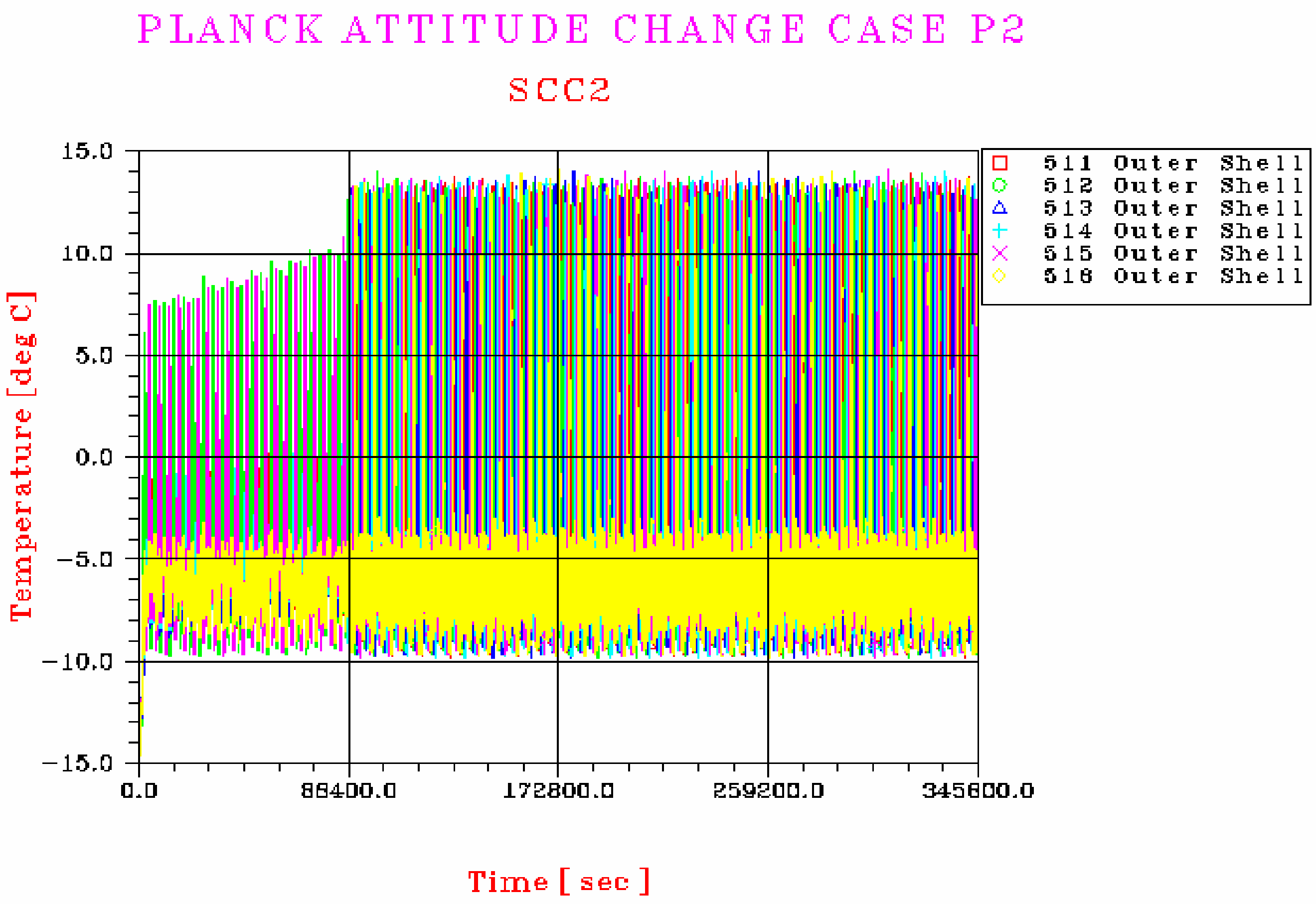
Figures 8.5-5 BOL attitude change SCC I/F temperatures



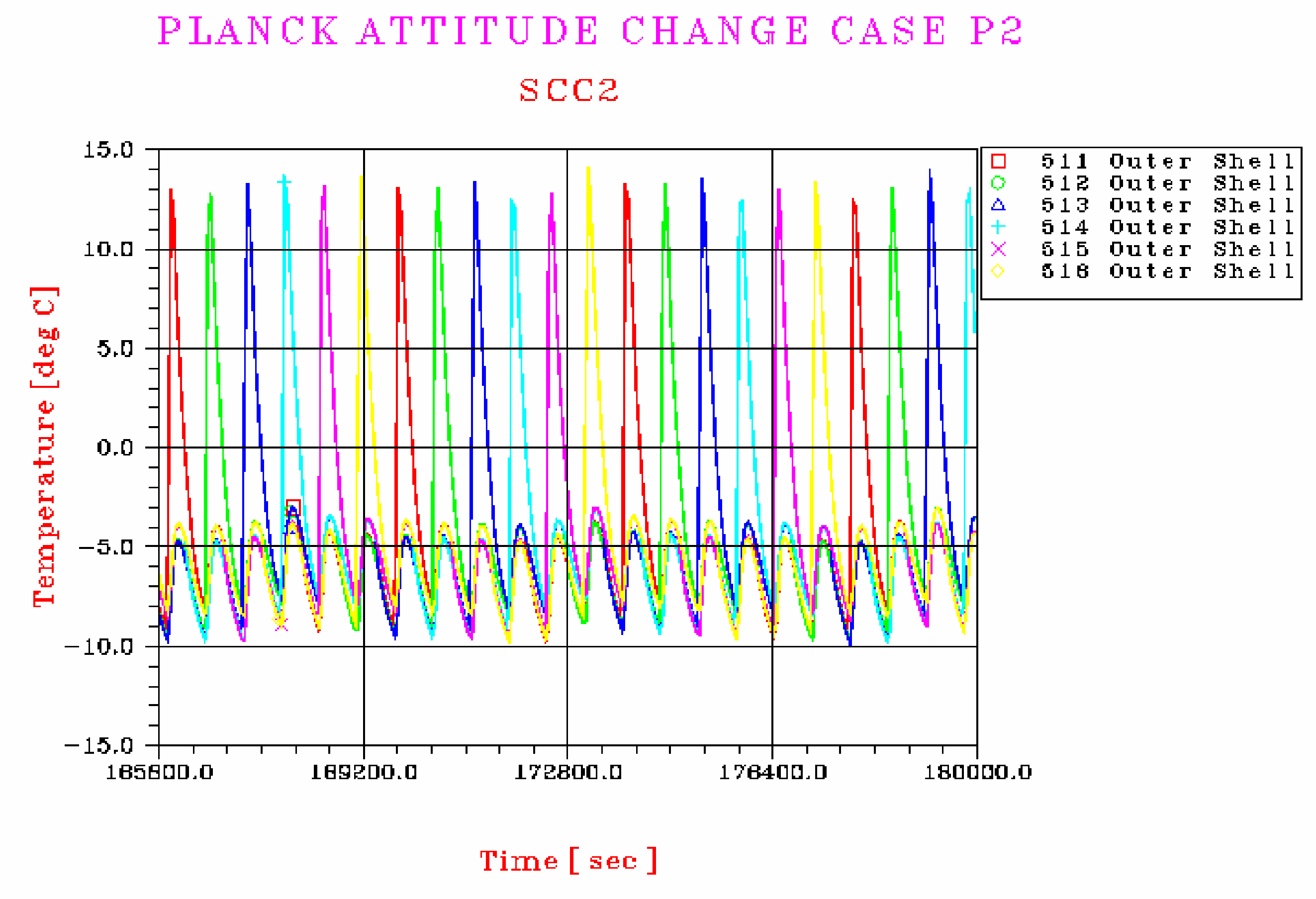
Figures 8.5-6 BOL attitude change SCC I/F temperatures



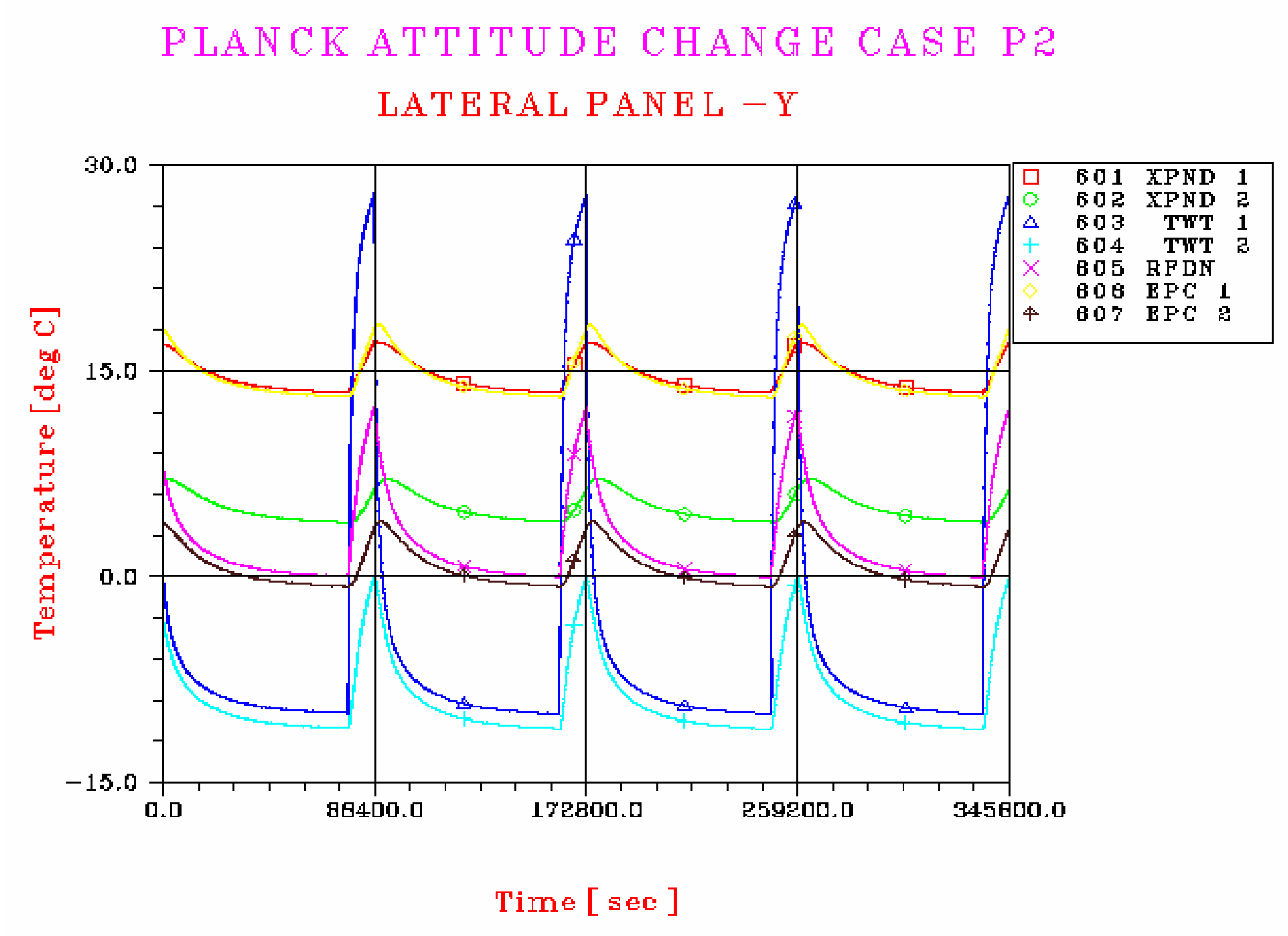
Figures 8.5-7 BOL attitude change -Z panel



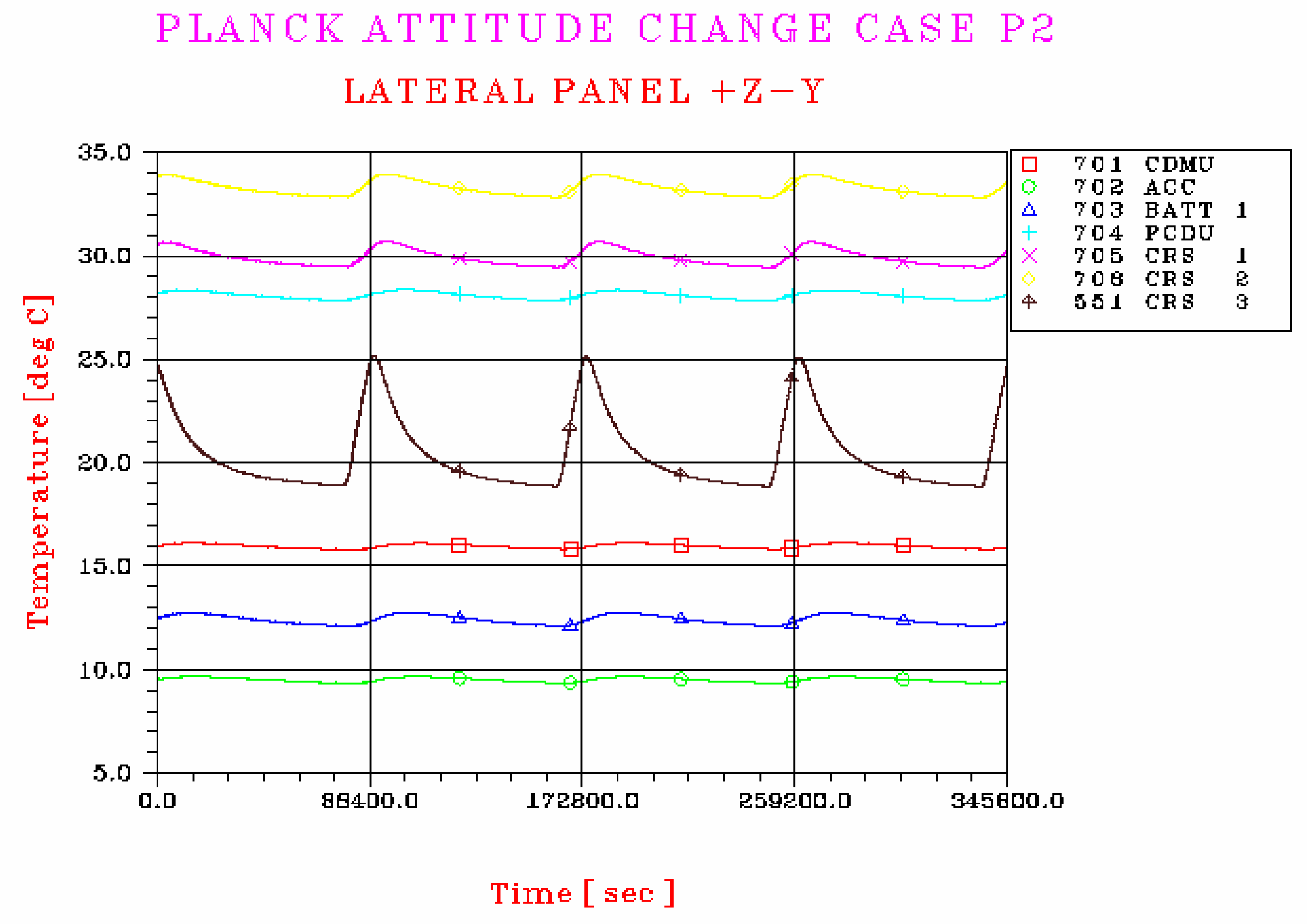
Figures 8.5-8 BOL attitude change -Y-Z panel



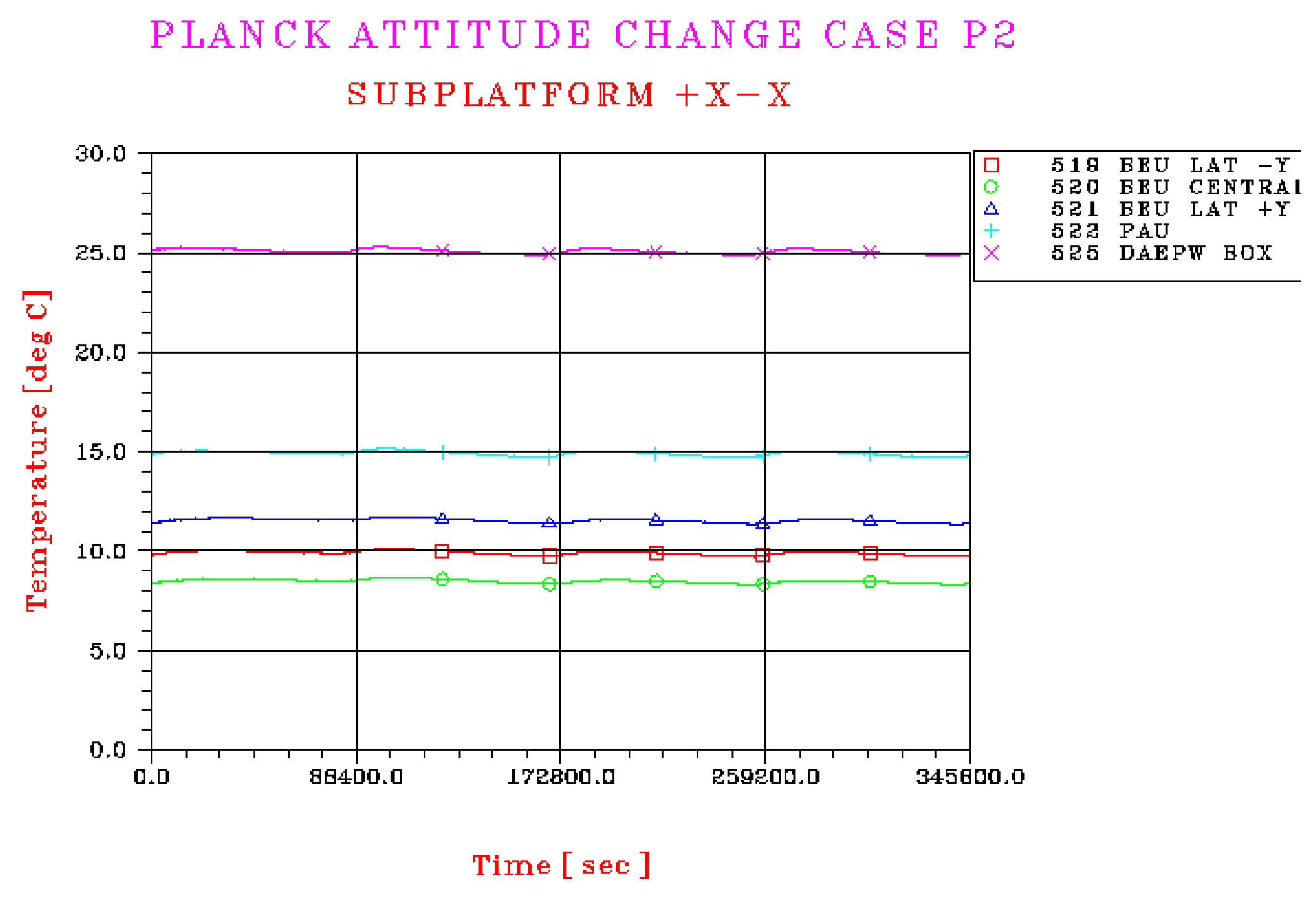
Figures 8.5-9 BOL attitude change –Y-Z panel



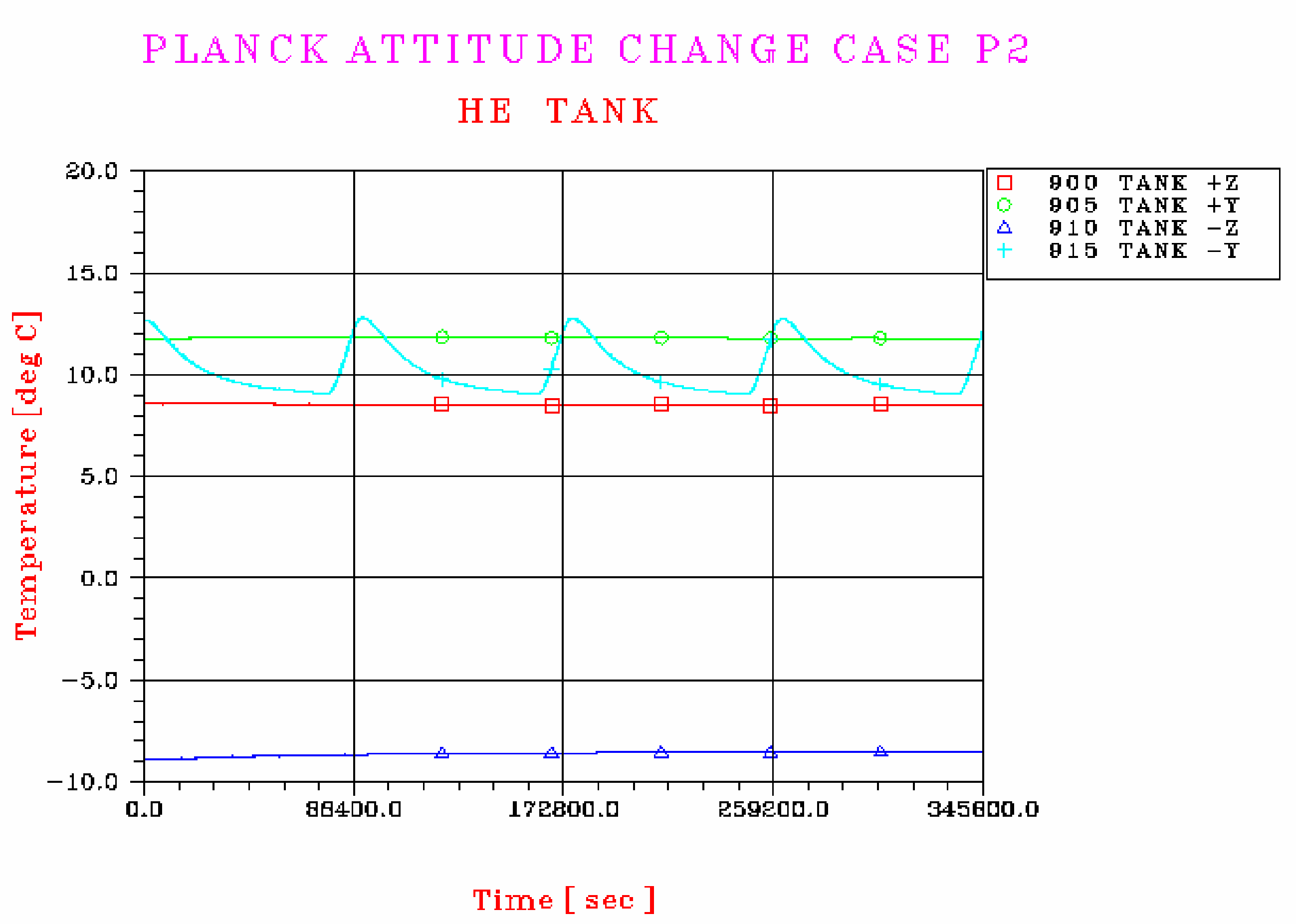
Figures 8.5-10 BOL attitude change -Y panel



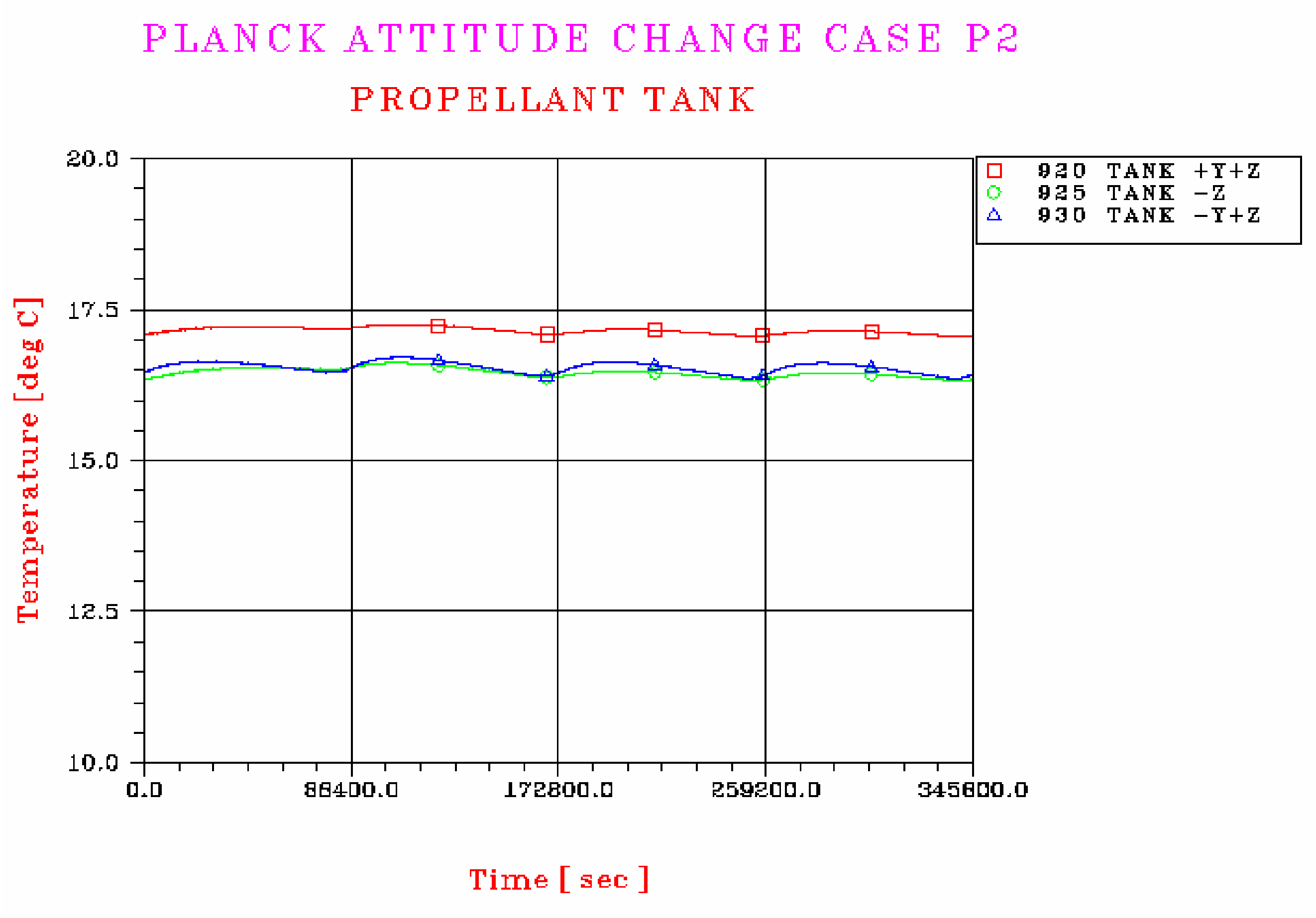
Figures 8.5-11 BOL attitude change -Y+Z panel



Figures 8.5-12 BOL attitude change subplatform panel



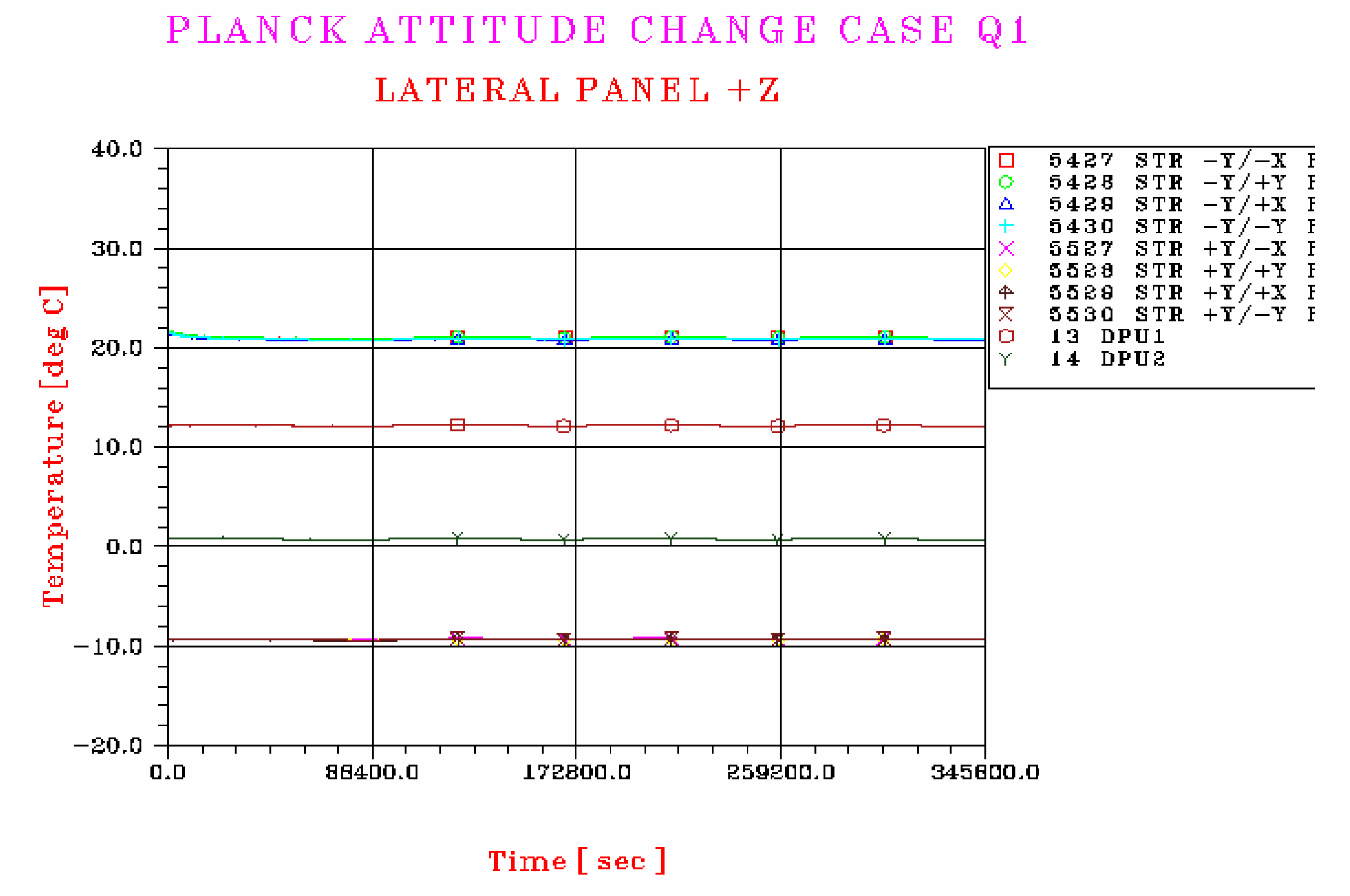
Figures 8.5-13 BOL attitude change Helium TANK



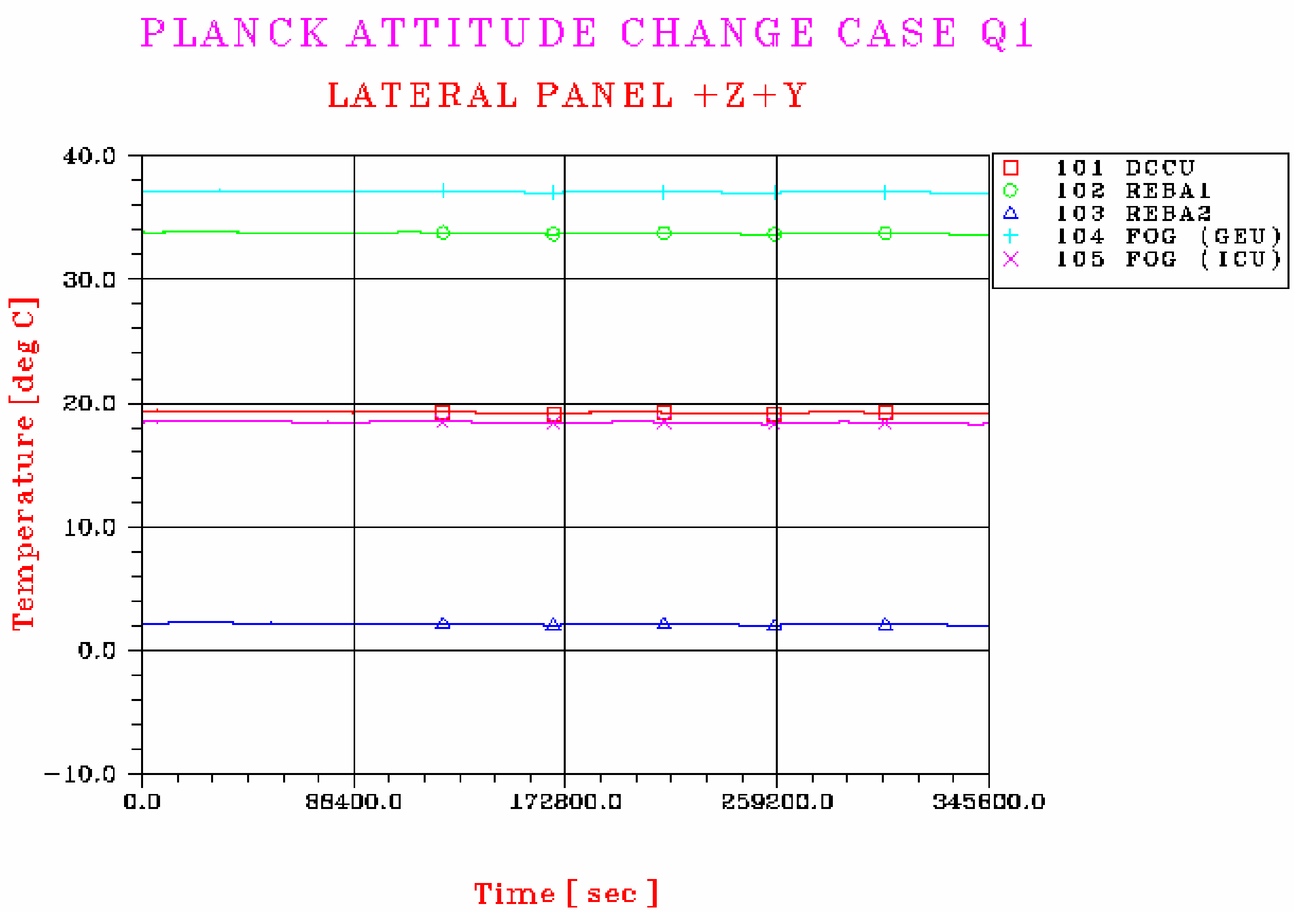
Figures 8.5-14 BOL attitude change Propellant TANK

8.6 PLANCK: PLOTS OF TRANSIENT CASE Q1

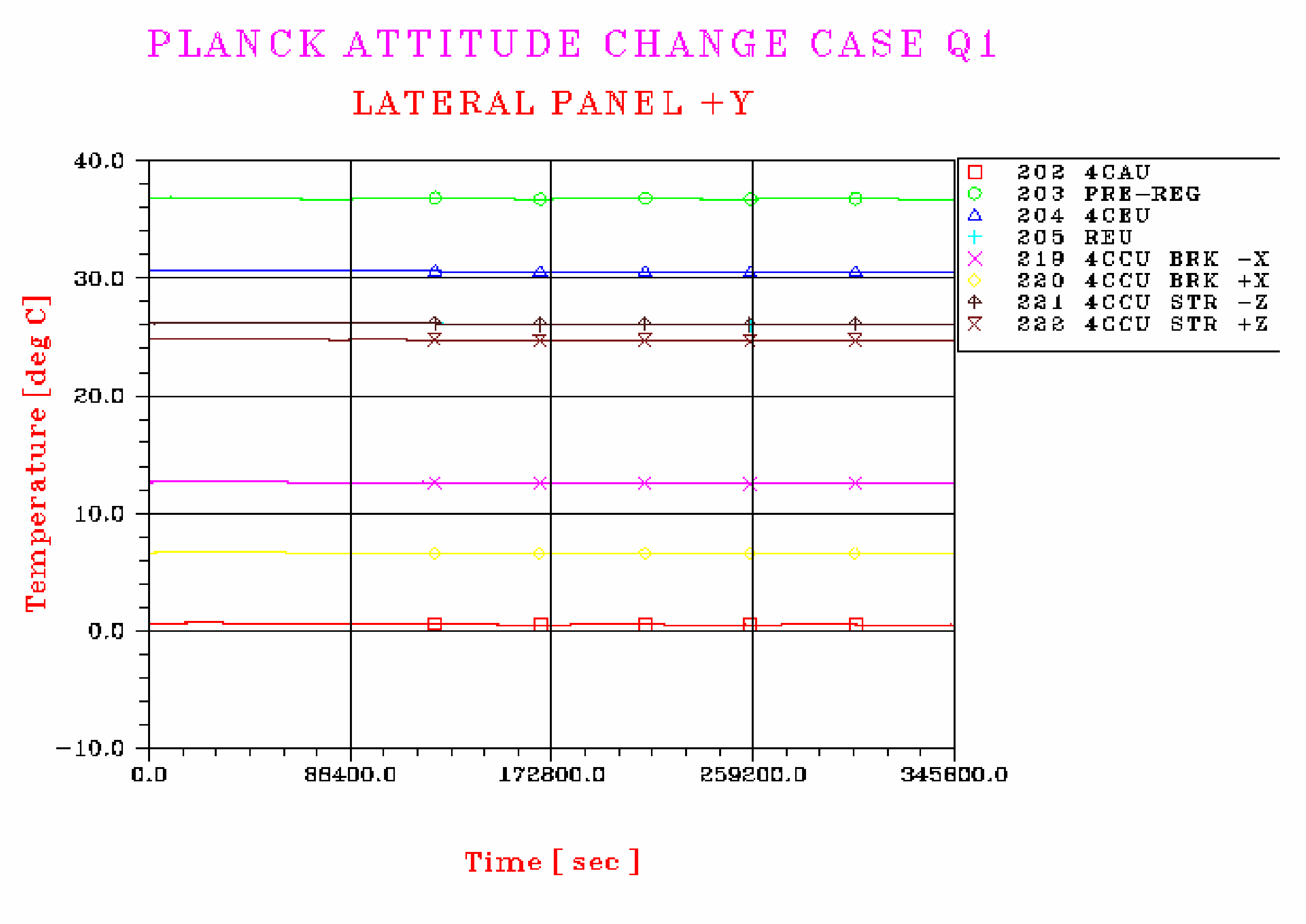
In the following figures, the temperature plots of the transient analysis concerning the attitude change of the satellite in EOL condition and with the SCC1 operating are presented.
Change of attitude at time=86400s



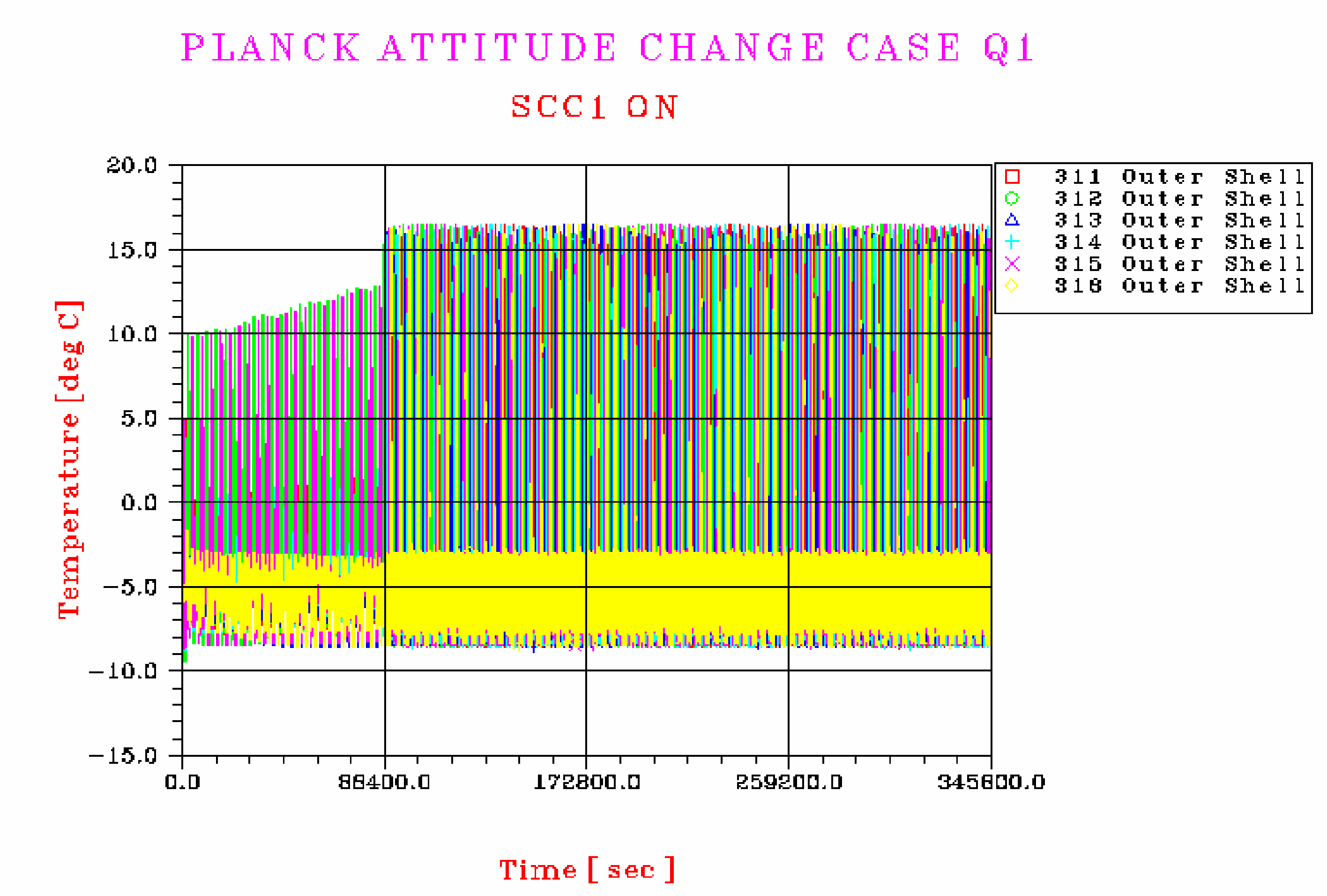
Figures 8.6-1 EOL attitude change +Z panel



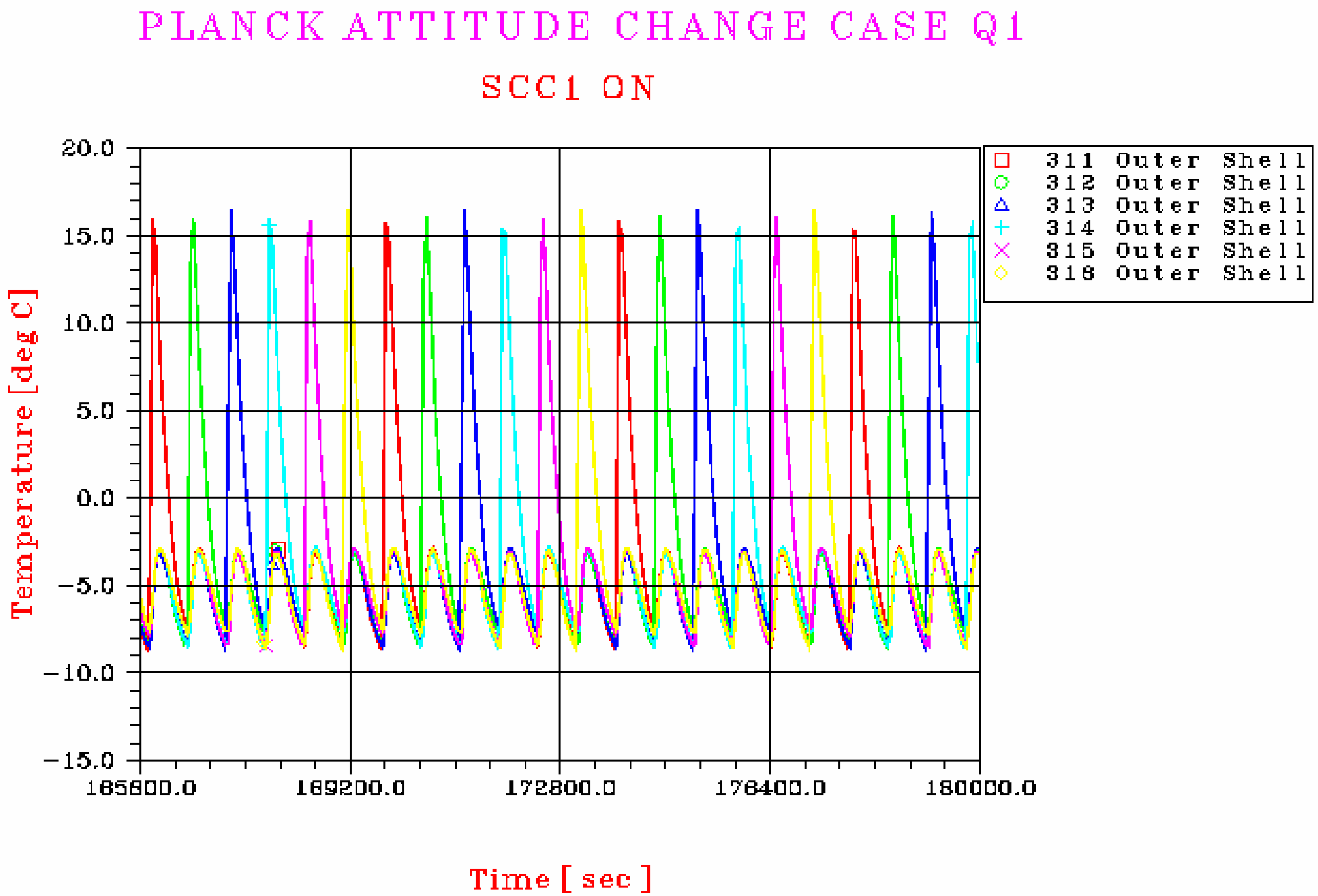
Figures 8.6-2 EOL attitude change +Y+Z panel



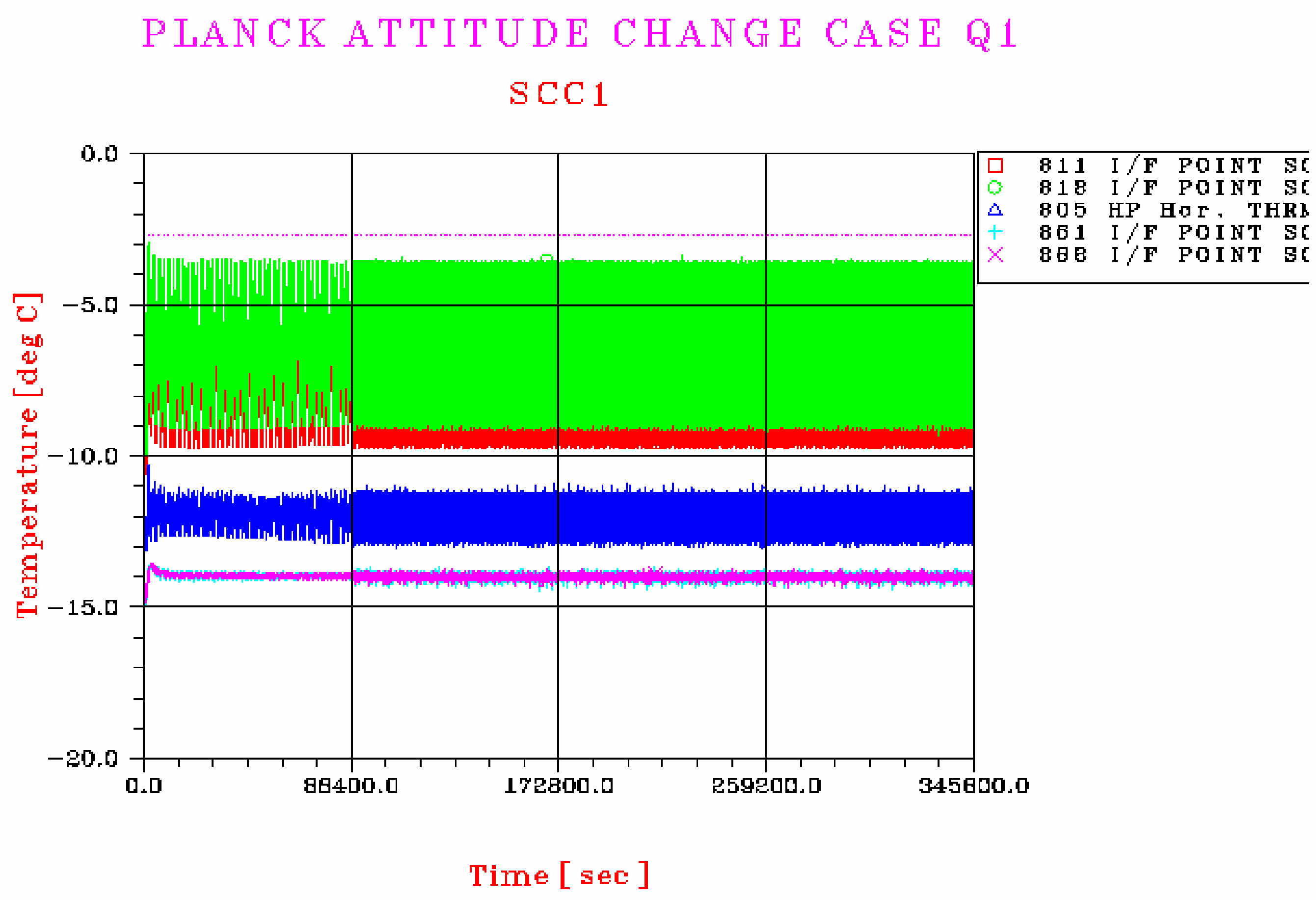
Figures 8.6-3 EOL attitude change +Y panel



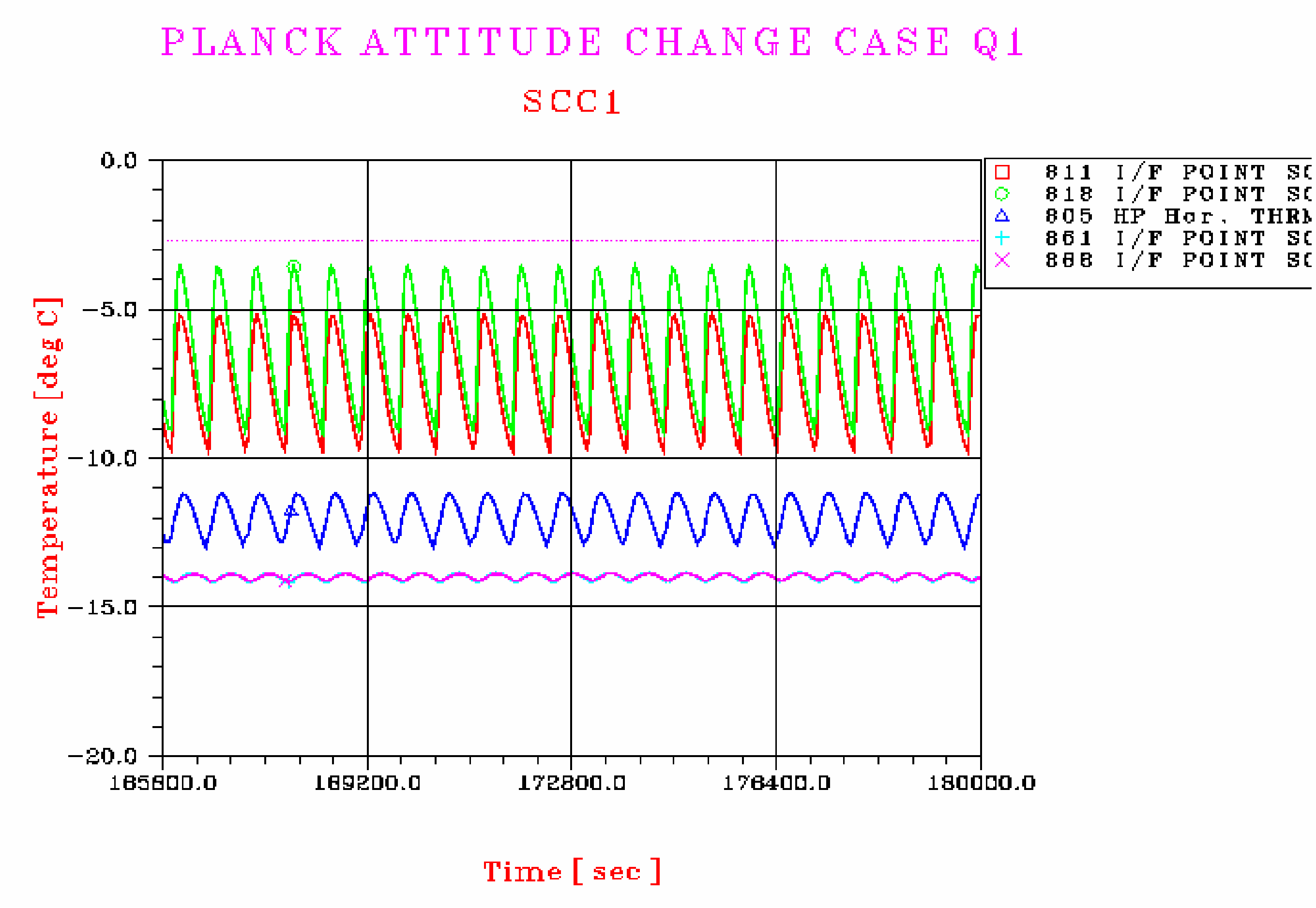
Figures 8.6-4 EOL attitude change +Y-Z panel



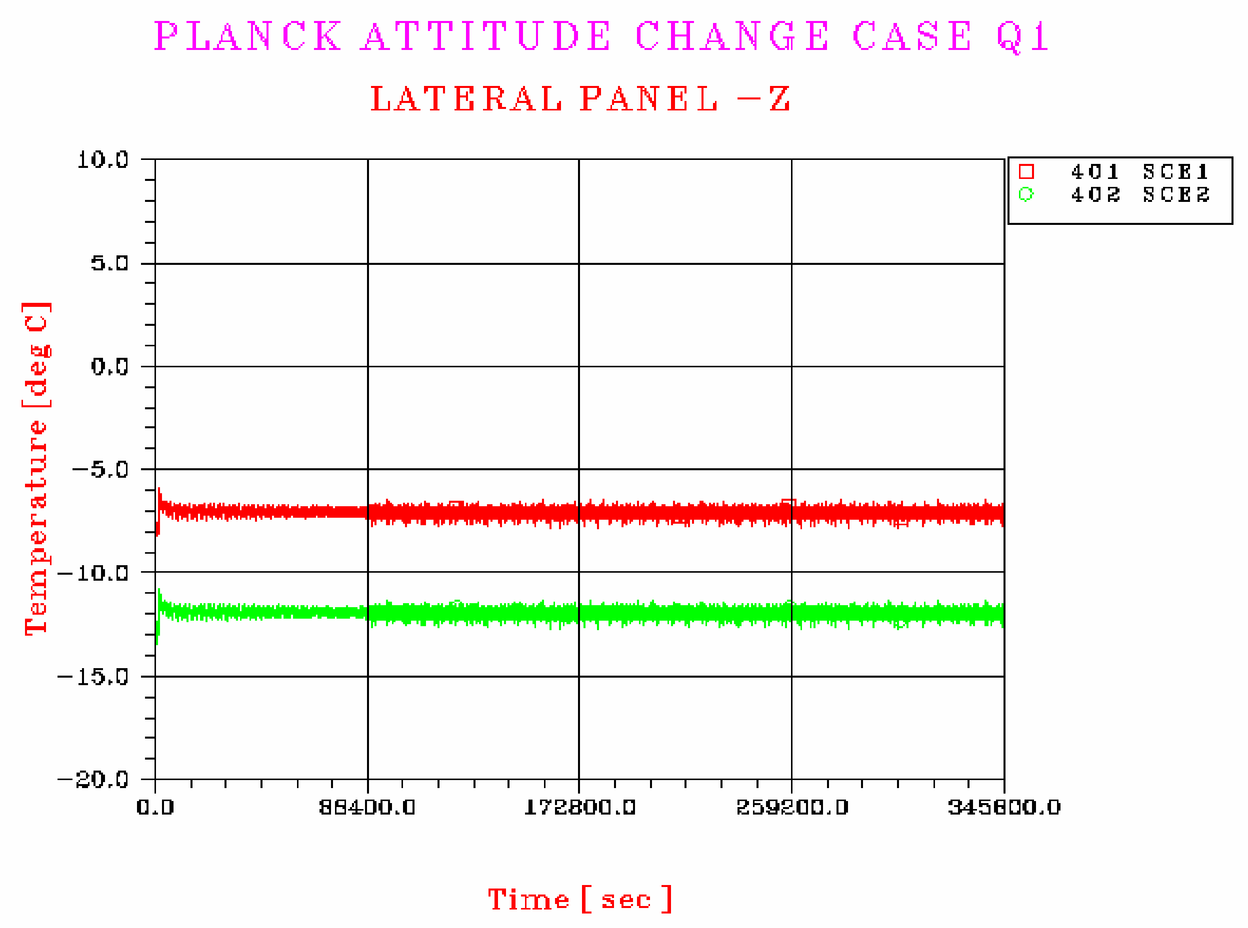
Figures 8.6-5 EOL attitude change +Y-Z panel



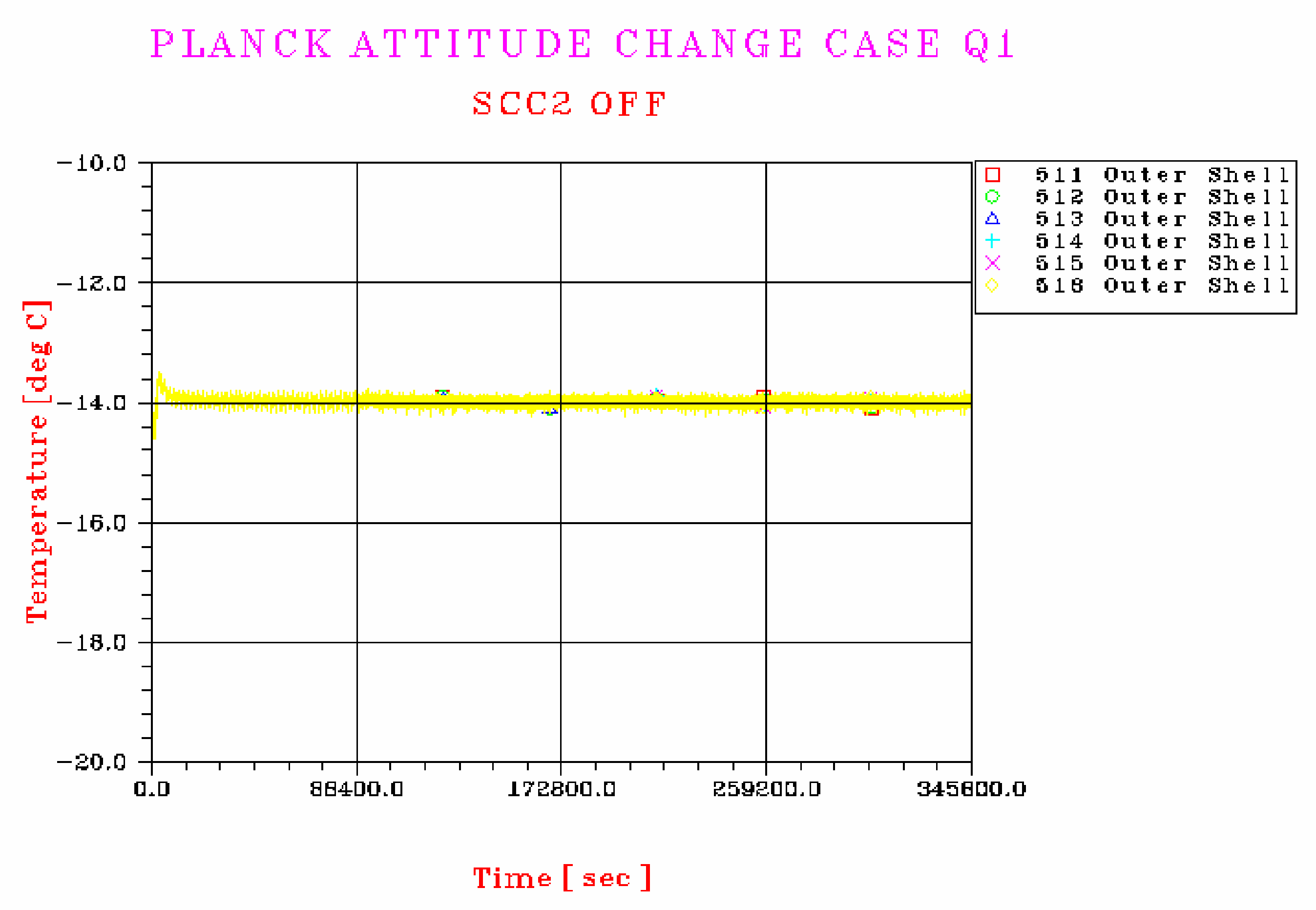
Figures 8.6-6 EOL attitude change SCC I/F temperatures



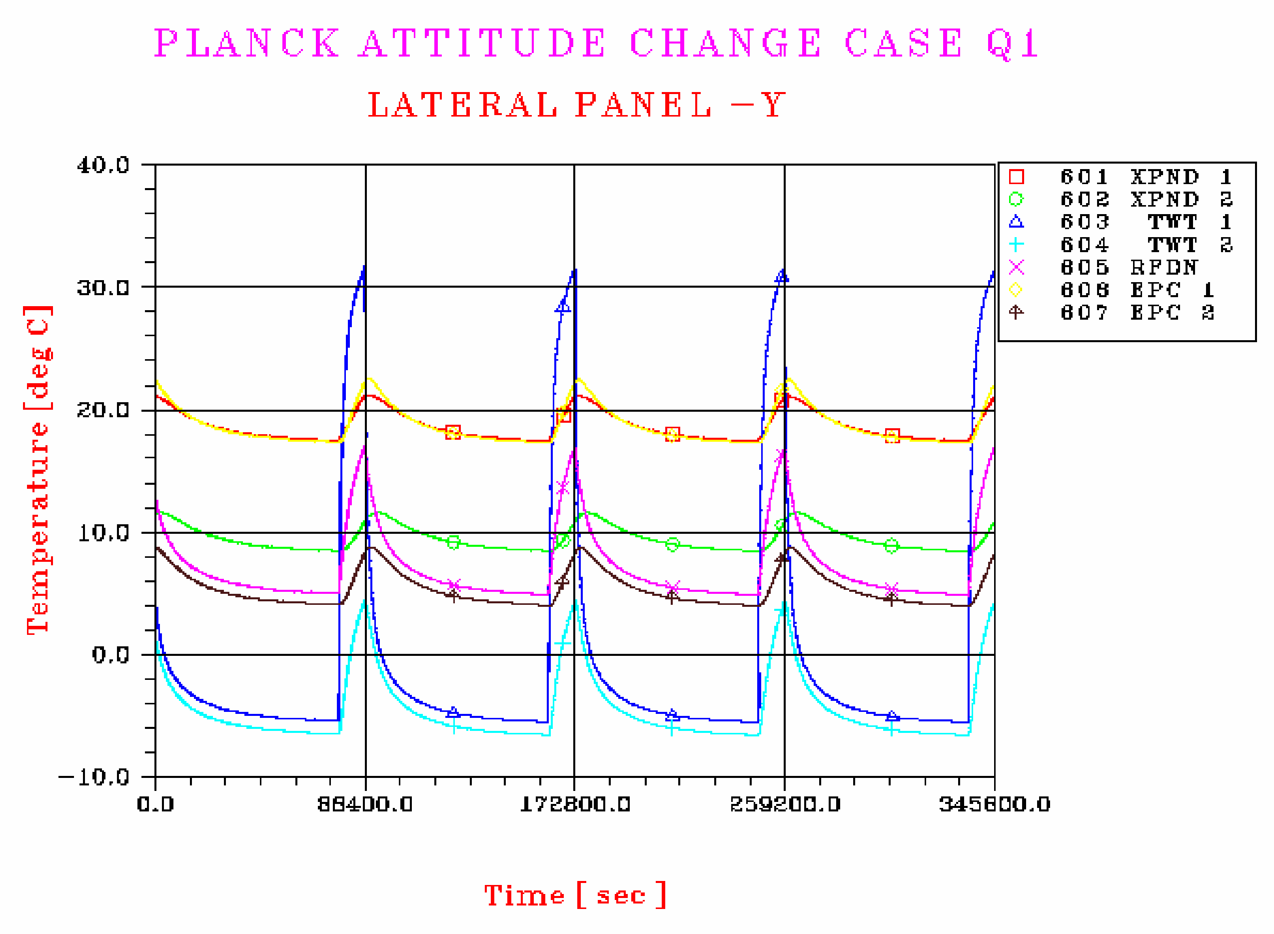
Figures 8.6-7 EOL attitude change SCC I/F temperatures



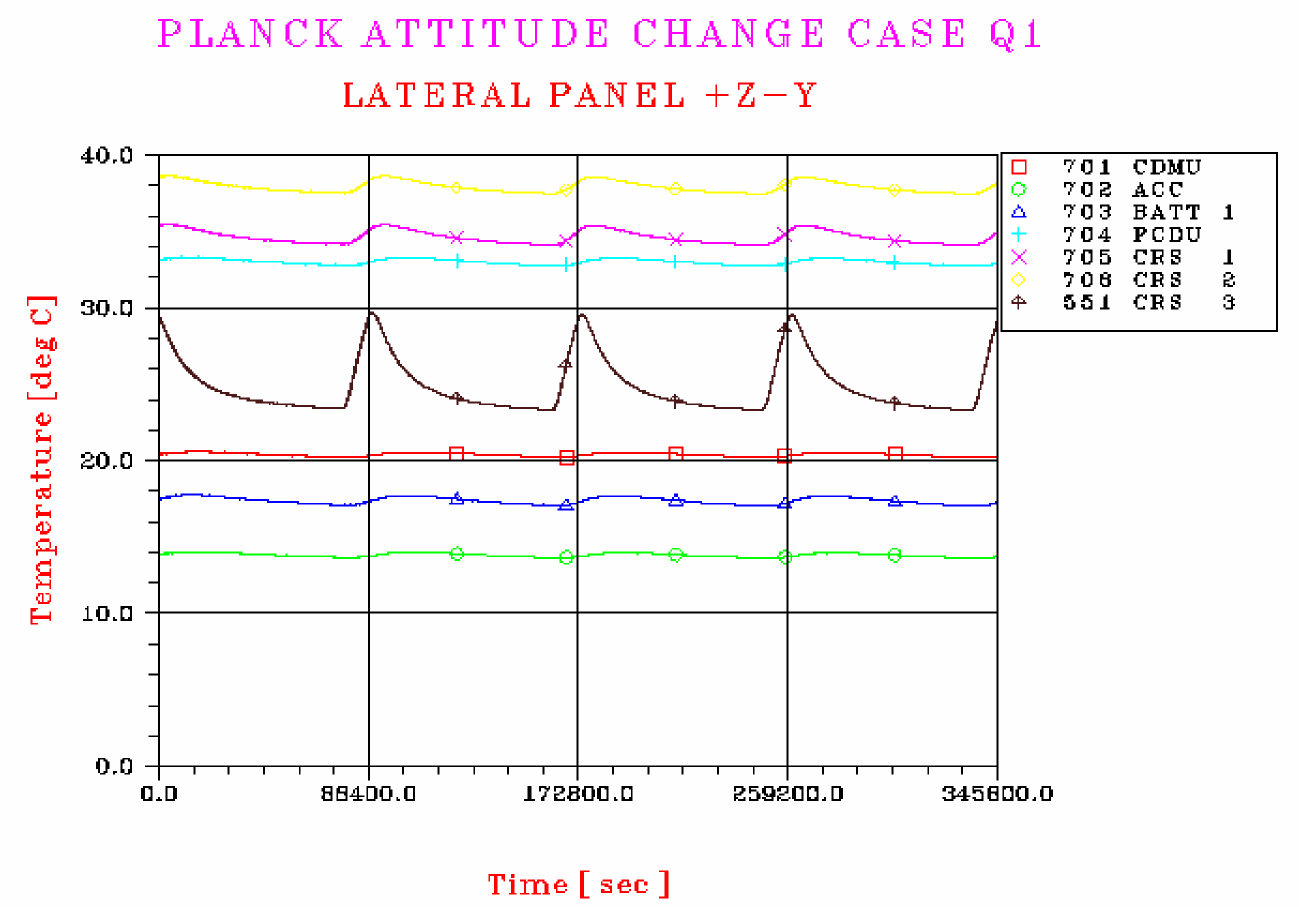
Figures 8.6-8 EOL attitude change -Z panel



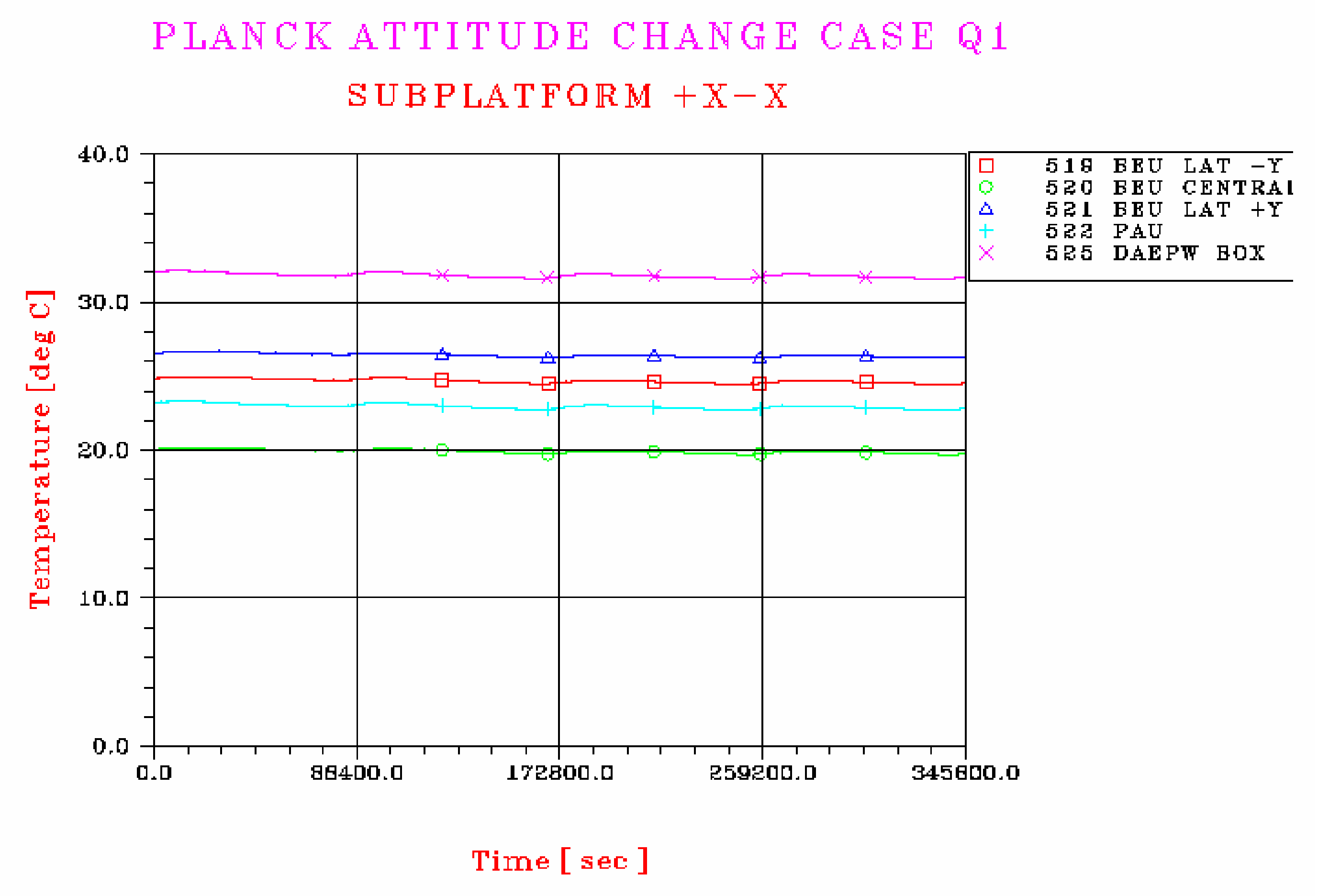
Figures 8.6-9 EOL attitude change –Y-Z panel



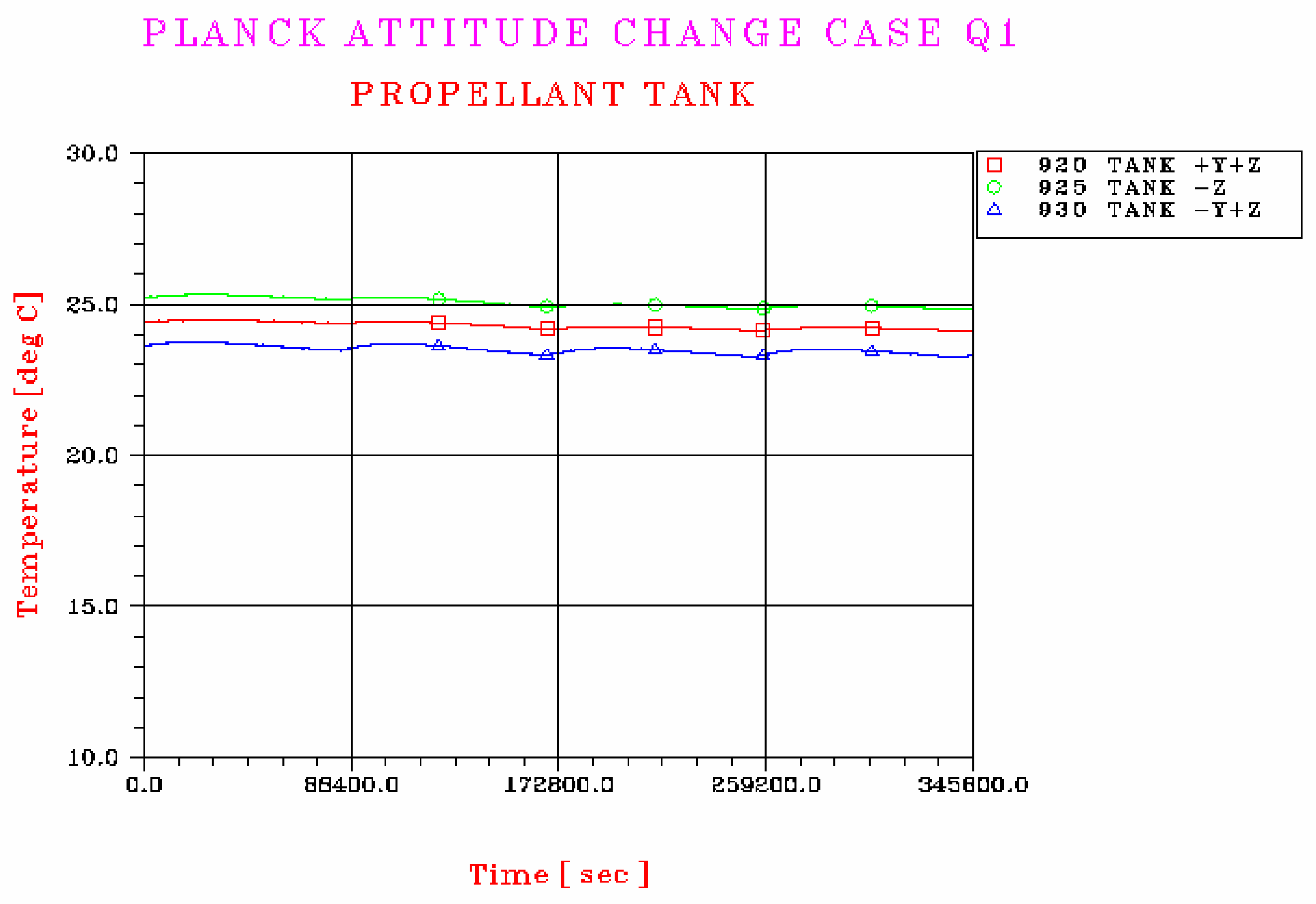
Figures 8.6-10 EOL attitude change -Y panel



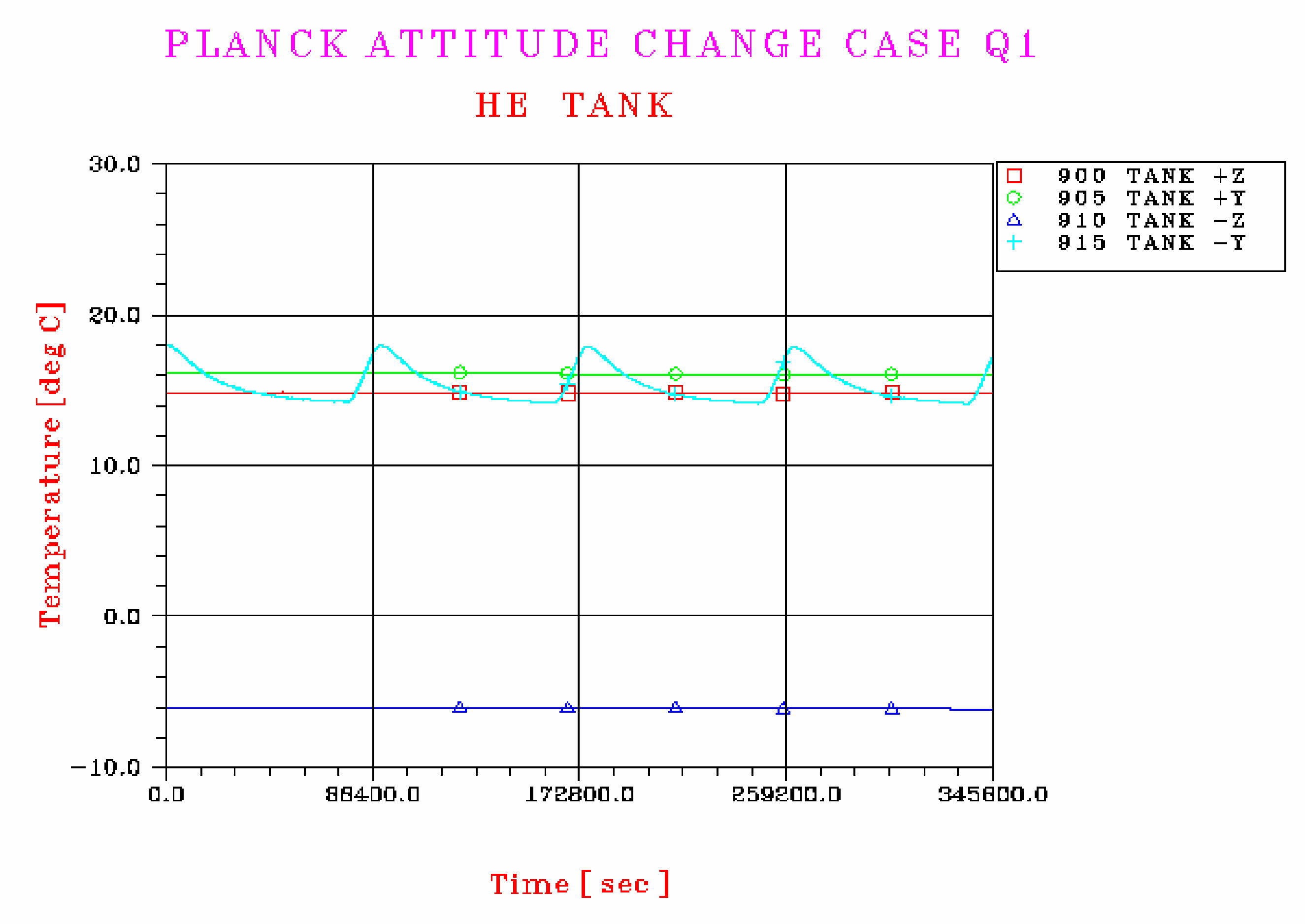
Figures 8.6-11 EOL attitude change -Y+Z panel



Figures 8.6-12 EOL attitude change subplatform panel



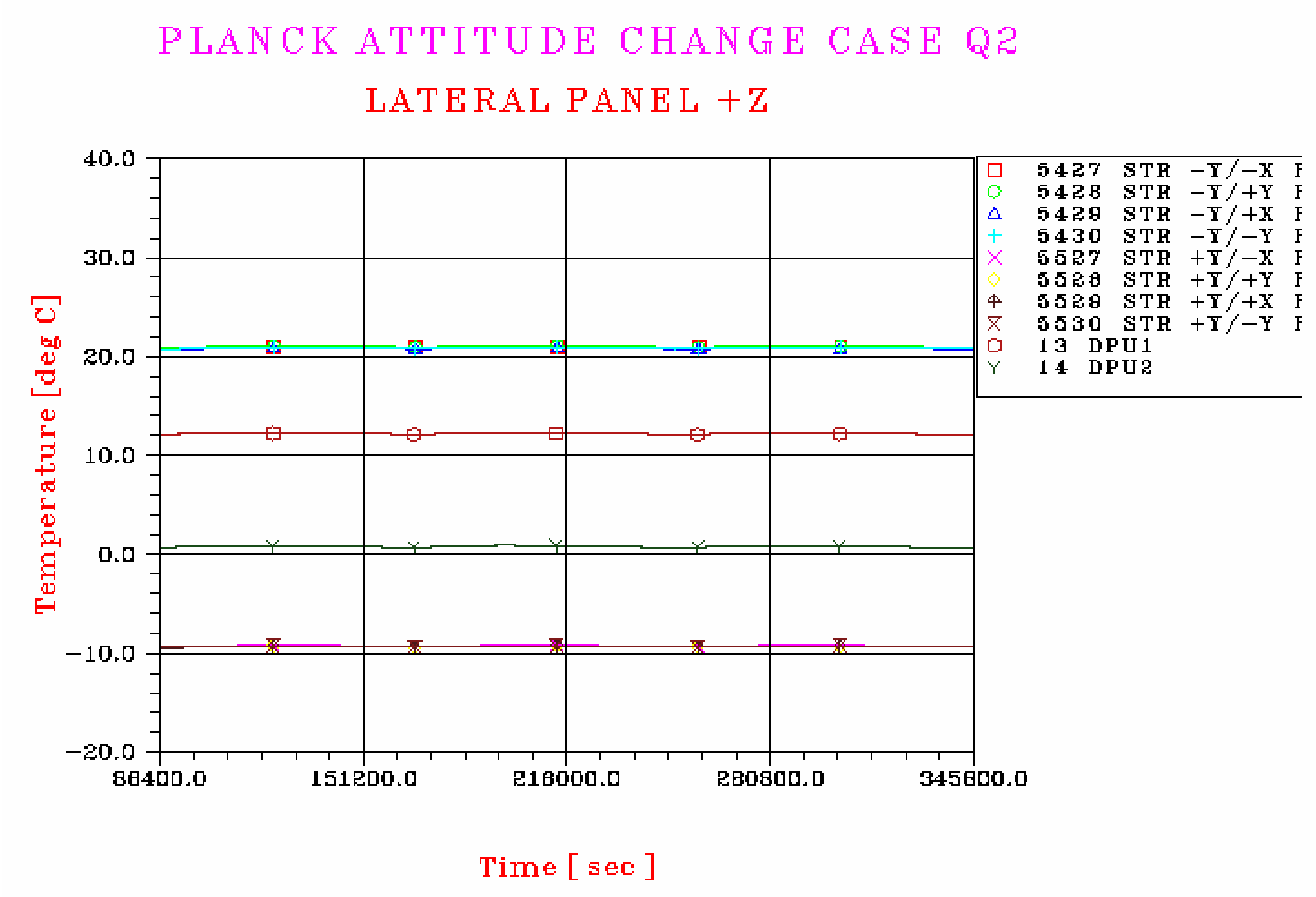
Figures 8.6-13 EOL attitude change propellant Tank



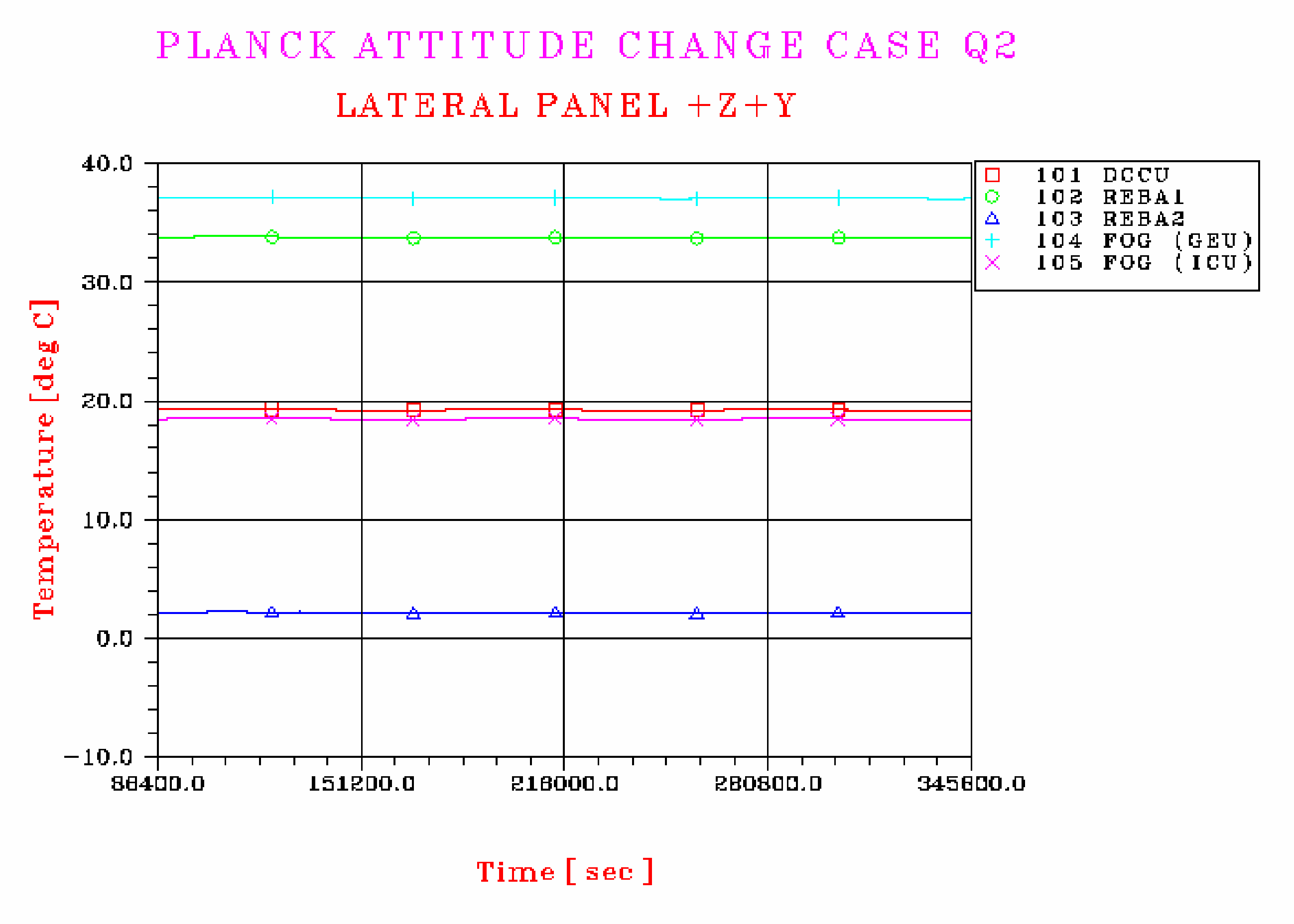
Figures 8.6-14 EOL attitude change He Tank

8.7 PLANCK: PLOTS OF TRANSIENT CASE Q2

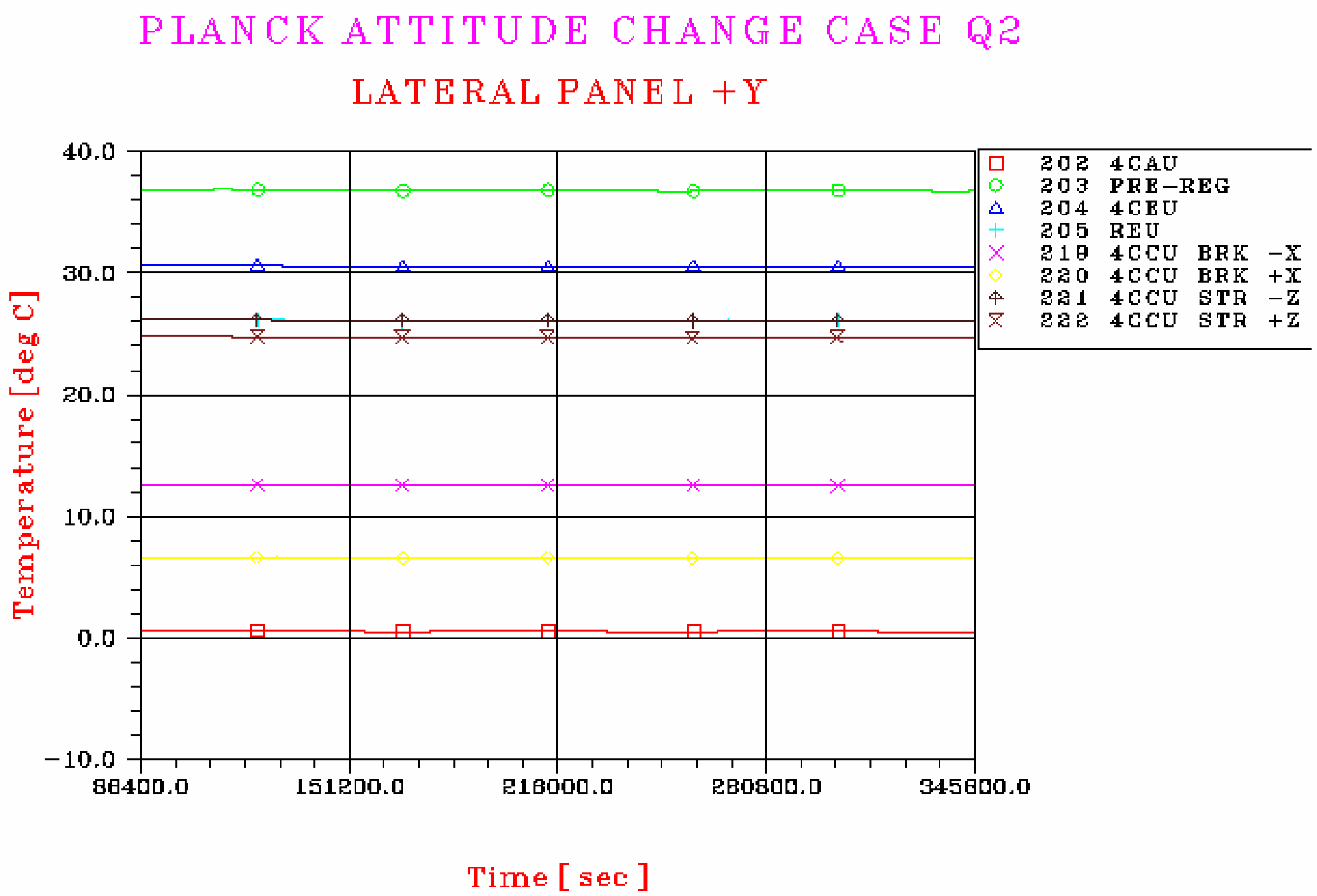
In the following figures, the temperature plots of the transient analysis concerning the attitude change of the satellite in EOL condition and with the SCC2 operating are presented.
Change of attittude at time=86400s



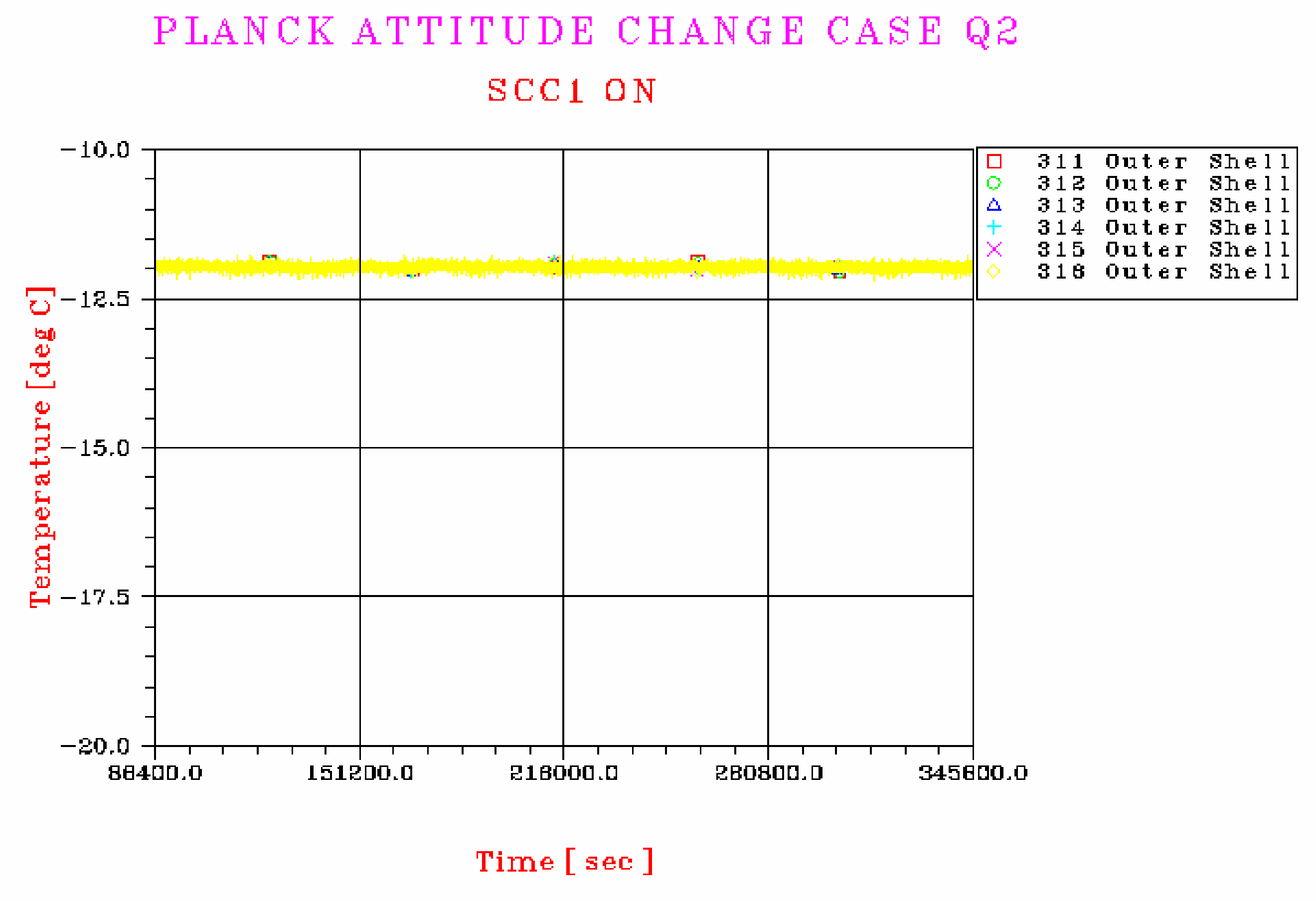
Figures 8.7-1 EOL attitude change +Z panel



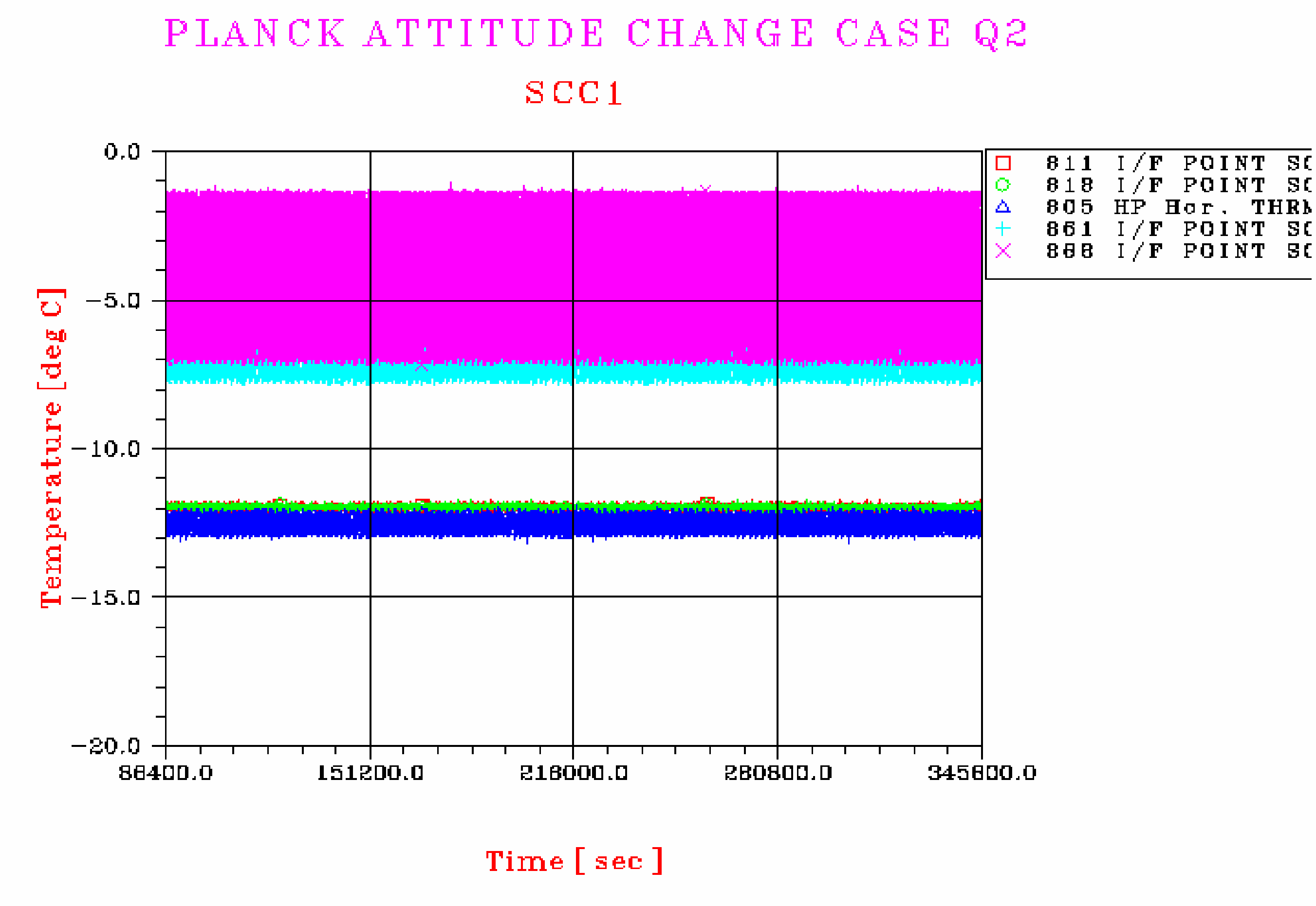
Figures 8.7-2 EOL attitude change +Y+Z panel



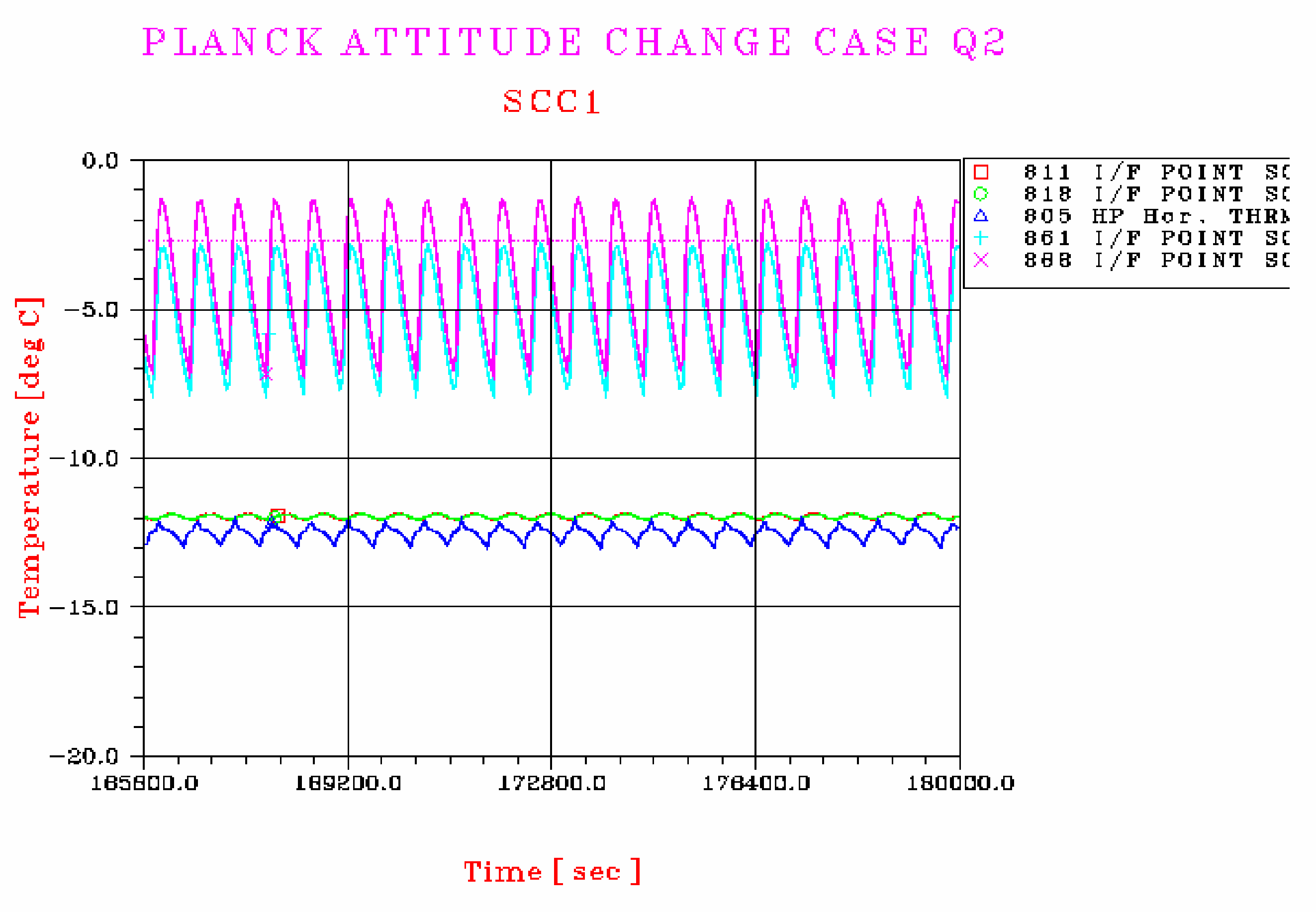
Figures 8.7-3 EOL attitude change +Y panel



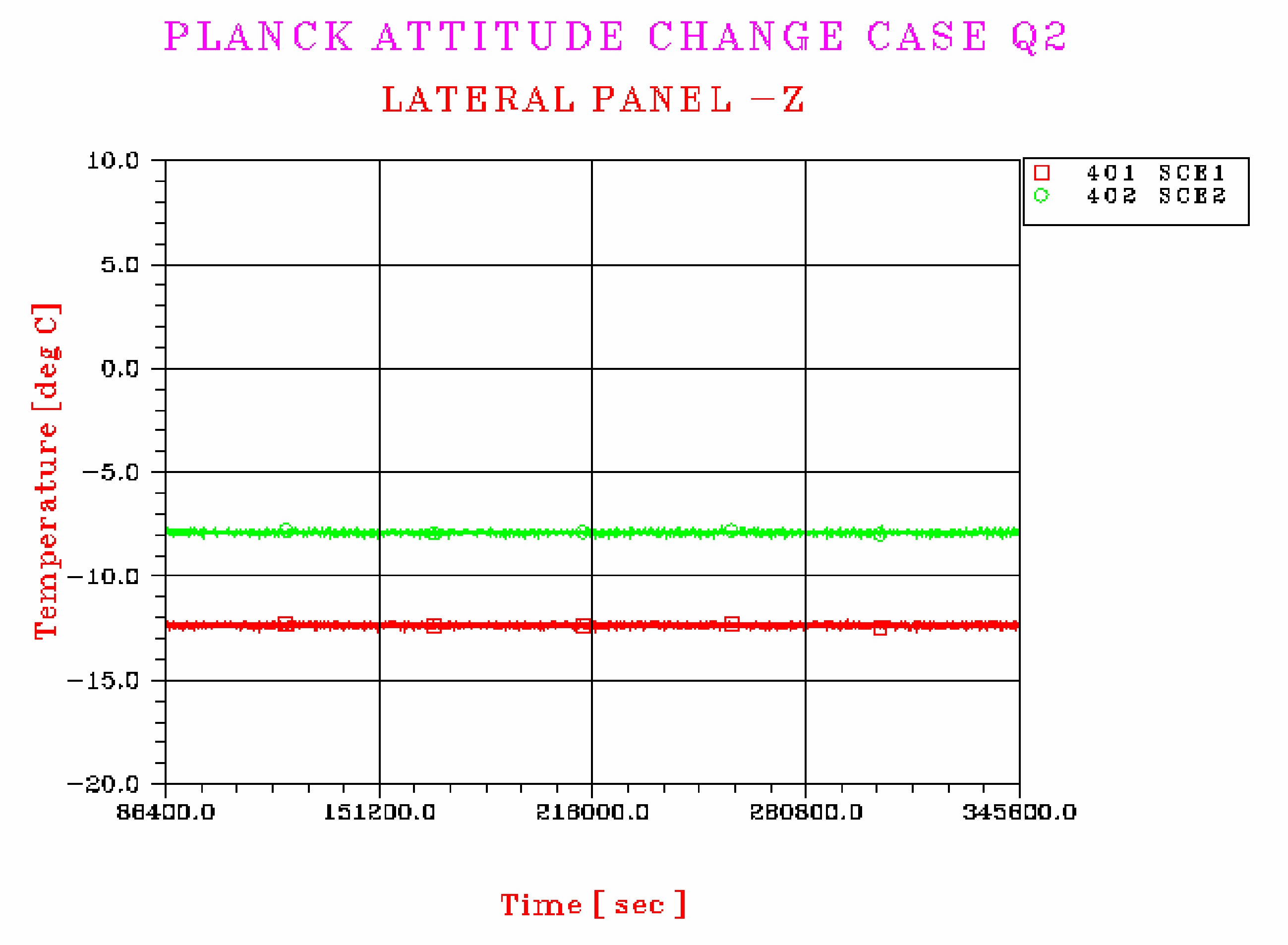
Figures 8.7-4 EOL attitude change +Y-Z panel



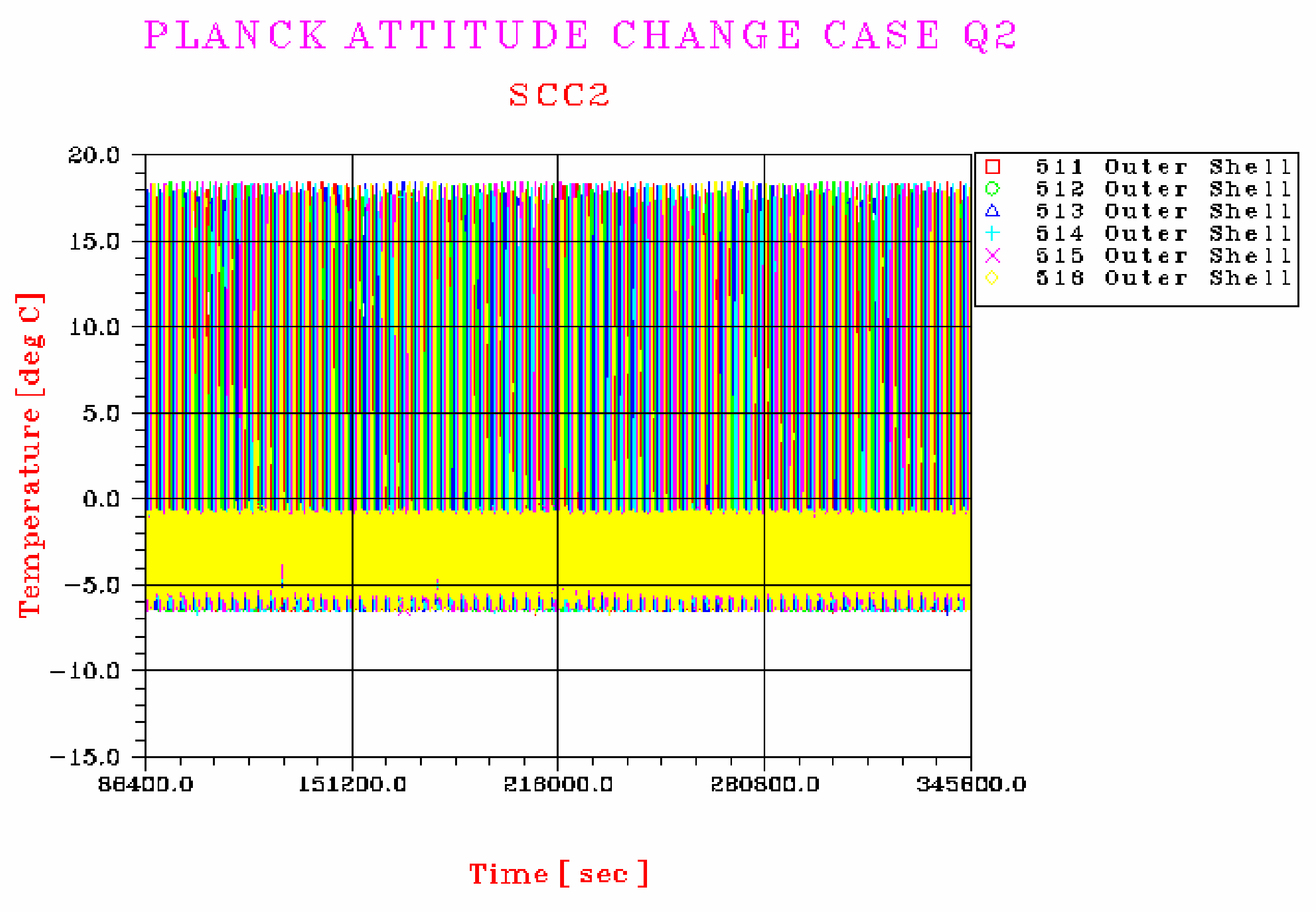
Figures 8.7-5 EOL attitude change SCC I/F temperatures



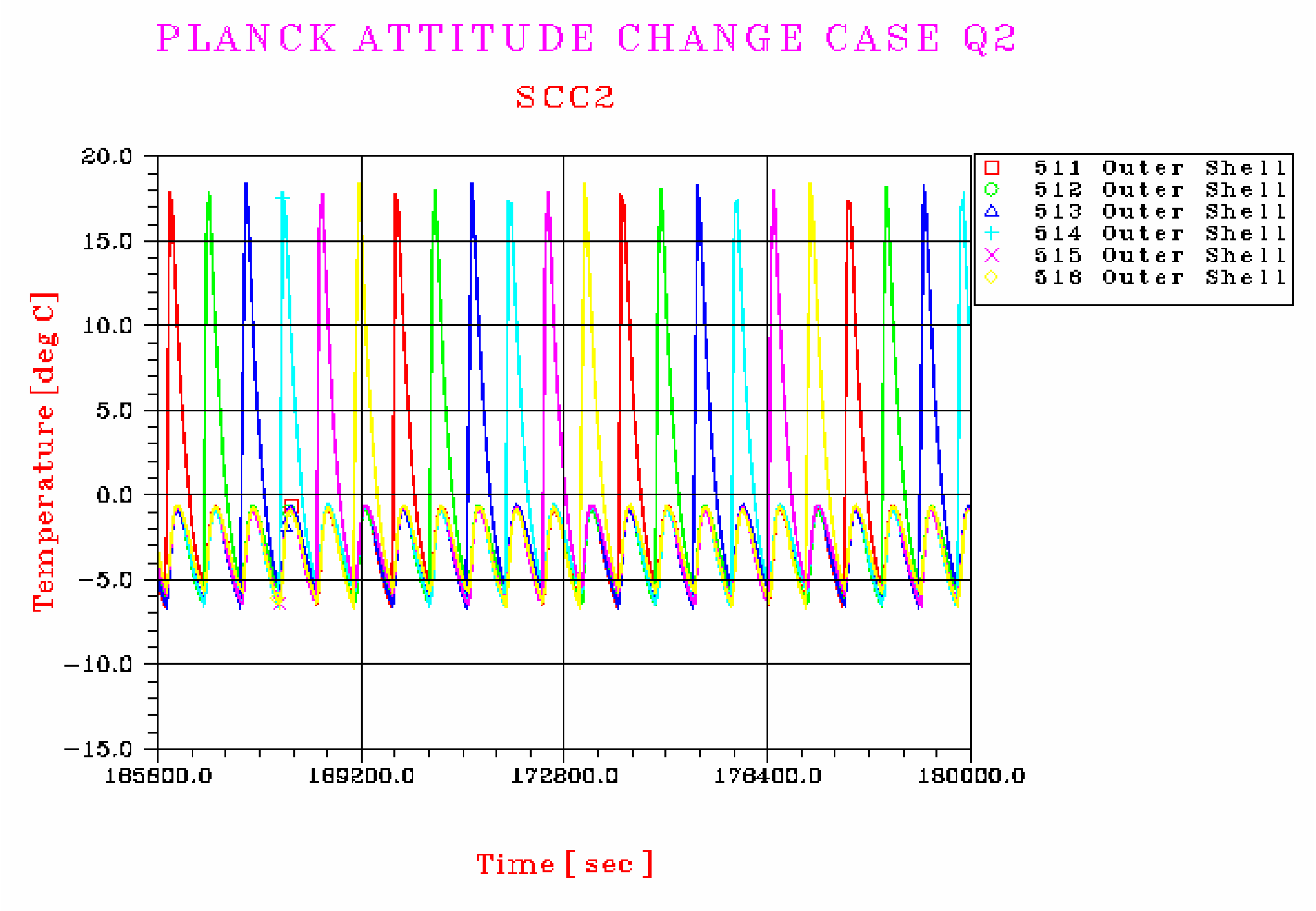
Figures 8.7-6 EOL attitude change SCC I/F temperatures



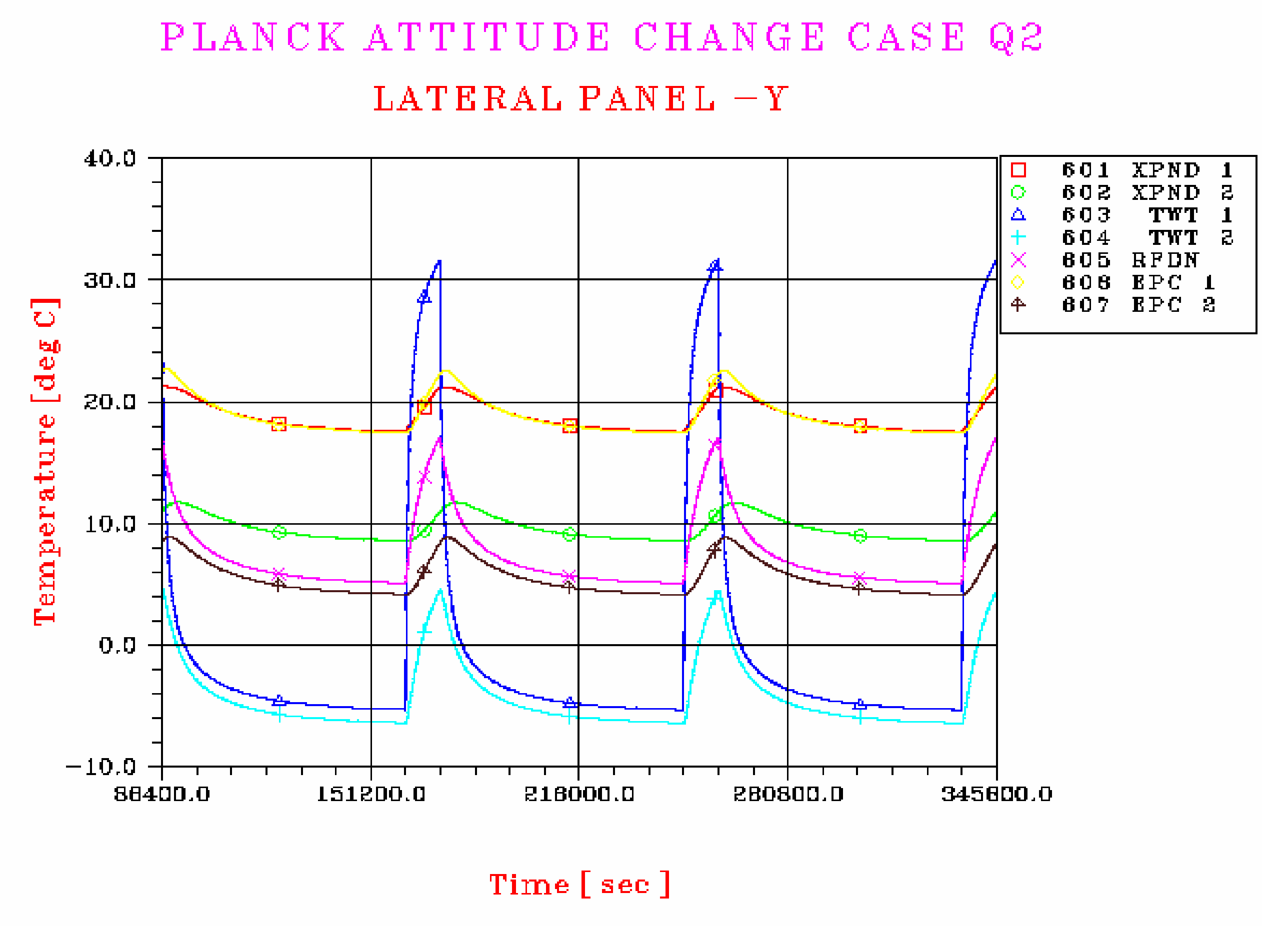
Figures 8.7-7 EOL attitude change -Z panel



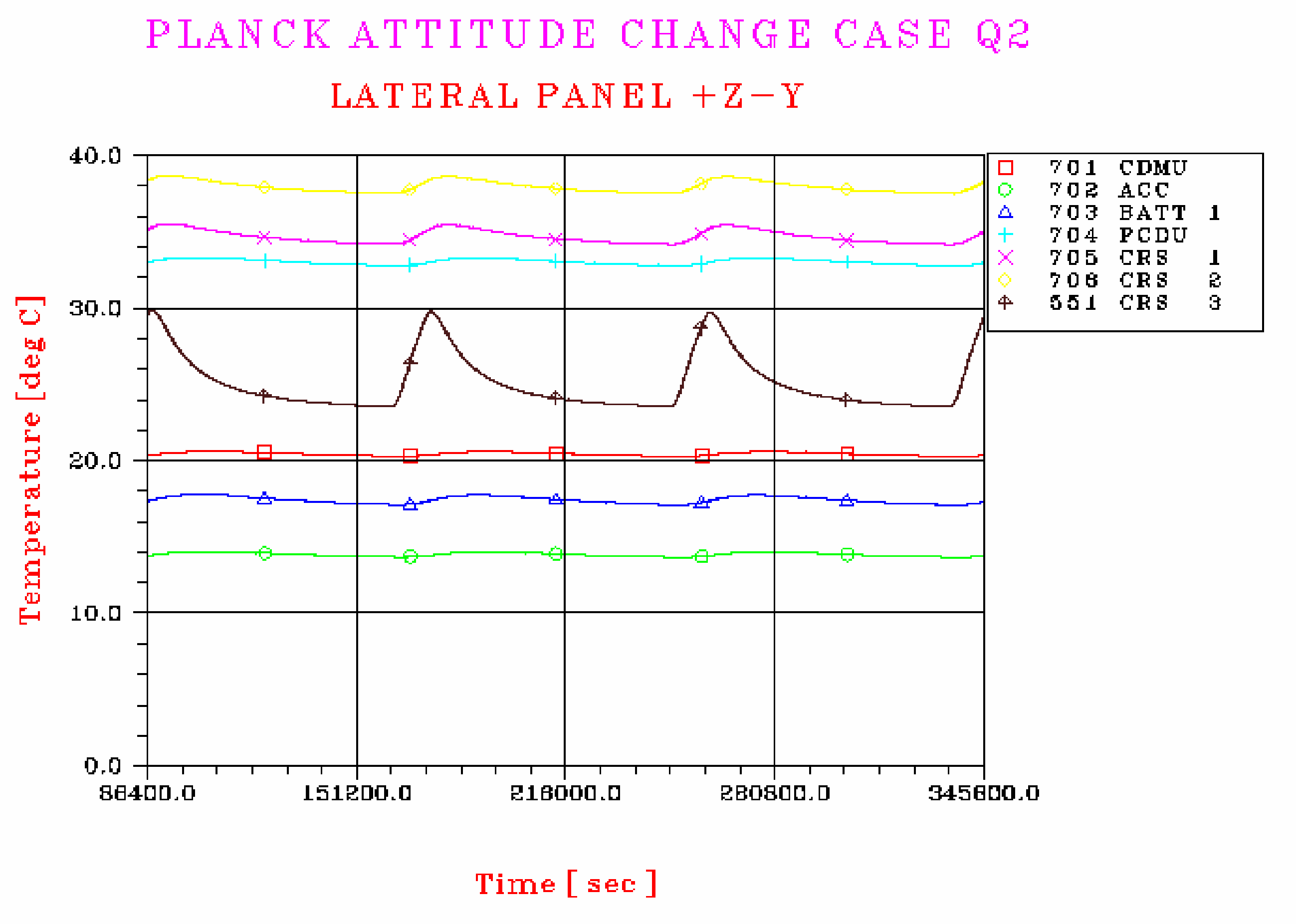
Figures 8.7-8 EOL attitude change -Y-Z panel



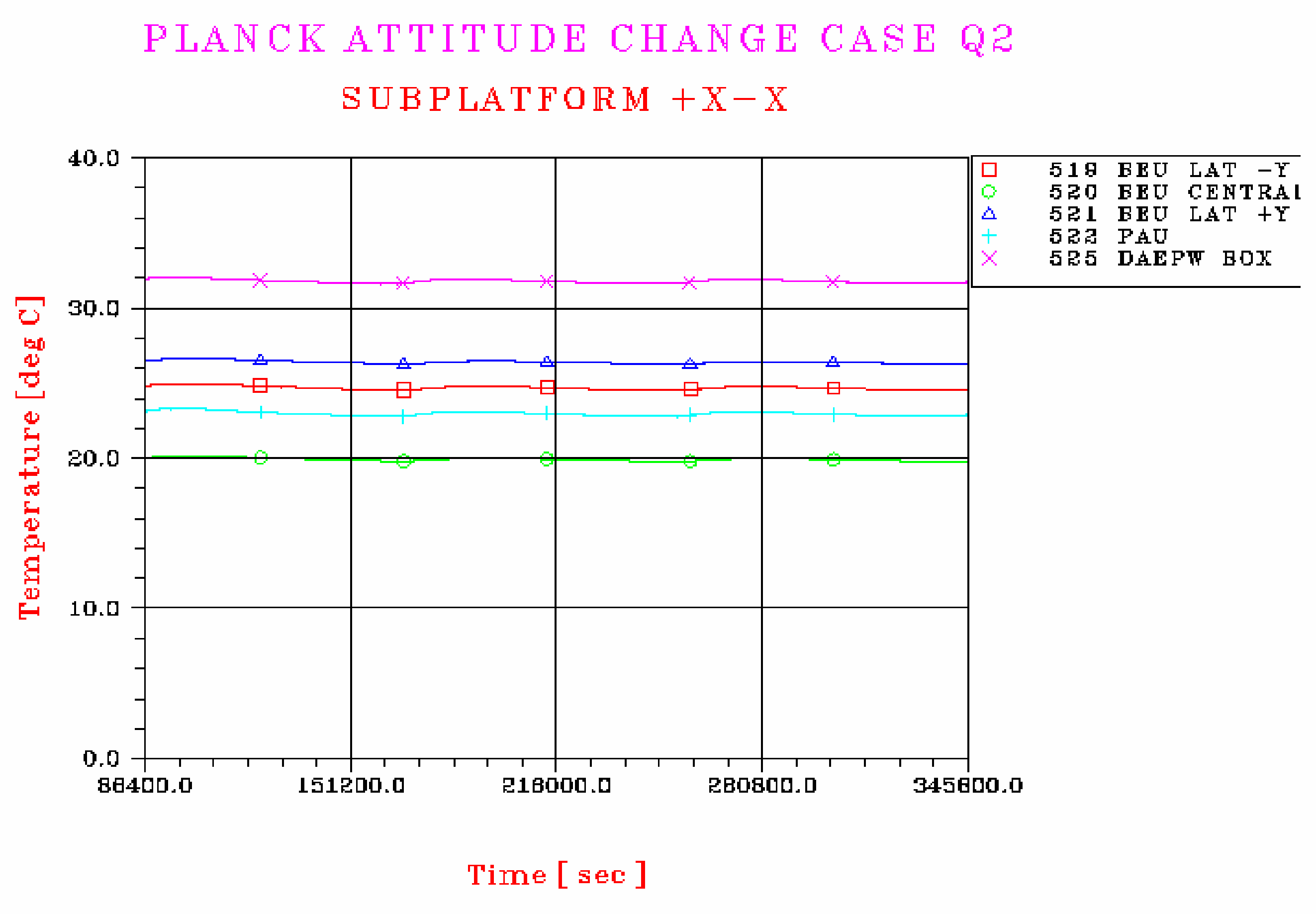
Figures 8.7-9 EOL attitude change –Y-Z panel



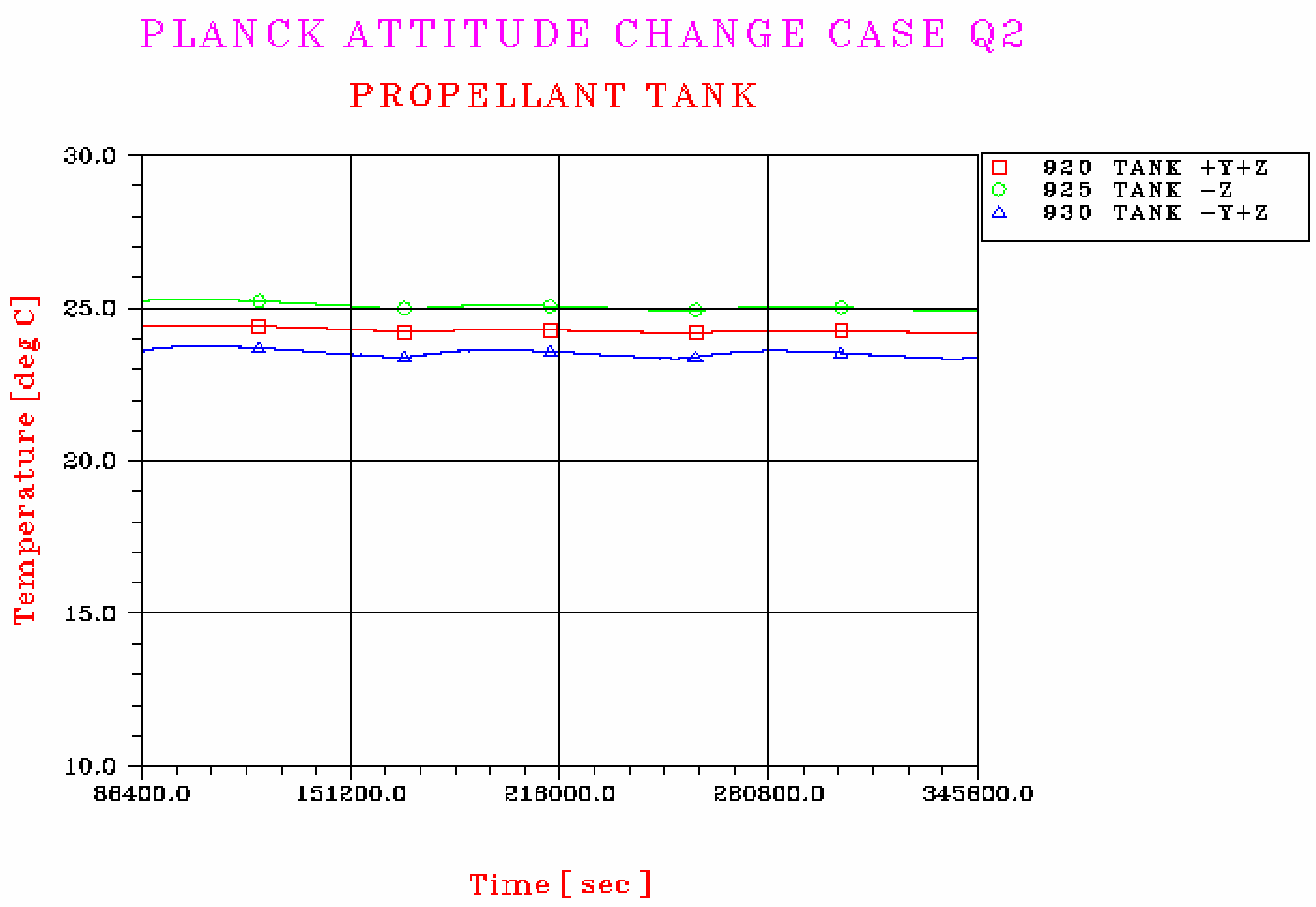
Figures 8.7-10 EOL attitude change -Y panel



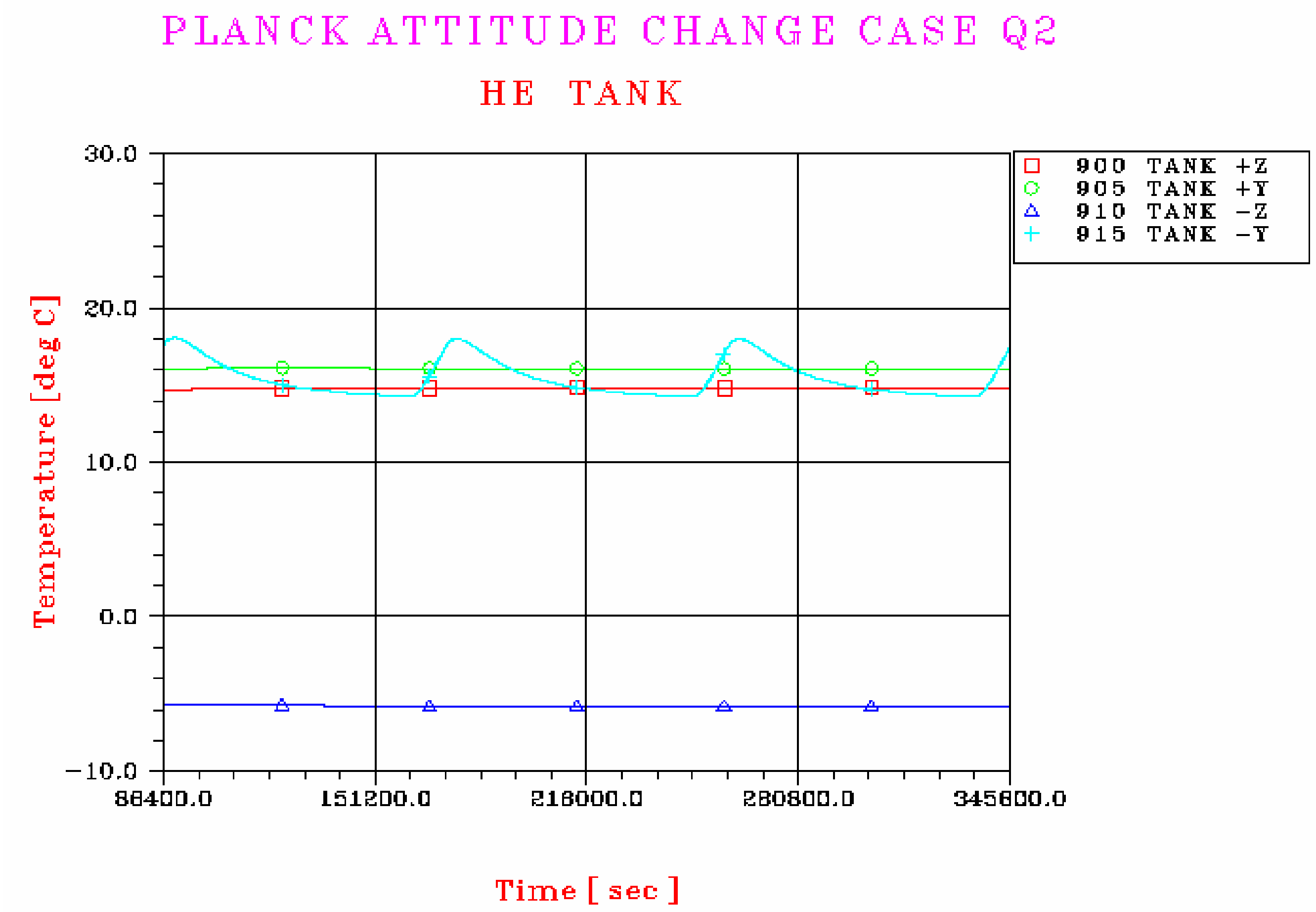
Figures 8.7-11 EOL attitude change -Y+Z panel



Figures 8.7-12 EOL attitude change subplatform panel



Figures 8.7-13 EOL attitude change propellant Tank



Figures 8.7-14 EOL attitude change He Tank

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