## Thermal Interfaces and Design Requirements

### Definitions

The baseline assumptions for the MEPS unit thermal design are the followings:

(a): MEPS is an insulated unit: A unit with a weak thermal link to the spacecraft. A unit that is attached to the S/C via a bracket and wrapped in MLI is an insulated unit.

(b): MEPS is externally mounted unit: A unit located outside the S/C main body and radiatively coupled to deep space and the S/C external elements.

(c): MEPS uses S/C controlled survival heaters: MEPS will require a separate control line (harness) in order to control the temperature of the unit based on the unit survival compartment temperature sensors output and the unit survival heaters. These are designed as part of the unit thermal control subsystem and will be monitored and controlled by the S/C thermal control system.

Please note that if the abovementioned assumptions are not applicable, the unit thermal design concept may change. This can be limited to the passive thermal control design or may result to a change from passive to an active thermal control design.

The operational temperature limits for the MEPS interface with the S/C, i.e. the mounting bracket temperature are indicated in the following table:

Table xx: Temperature limits for MEPS interface with S/C

|  |  |  |  |
| --- | --- | --- | --- |
| Non-op (min), deg C | Non-op (max), deg C | Operational (min), deg C | Operational (max), deg C |
| -40 | 50 | -40 | 50 |

In addition, for the better performance, it is required that MEPS does not receive direct solar illumination, especially on its telescopes. Therefore, it is highly recommended that S/C guarantee shadow at the location of MEPS. This can be done either by using a global heat shield like what is done in Solar Orbiter or by using local sunshades on the S/C structure.

### Thermal Control

A passive thermal control design is foreseen for MEPS instrument. For the passive thermal design, external radiators or radiative surfaces are considered for dissipating the internal power of the instrument to space. Independent power budgets for the operational and non-operational (survival) heaters are required. The required power depends on the S/C and mission environmental conditions in different mission phases. An estimation of the necessary operational and survival heater power budgets are given in the following table:

Table xx: Operational and survival heaters power budget estimation for MEPS.

|  |  |
| --- | --- |
| Survival, W | Operationalm |
| 3 W (average) or 6W (max with 50% duty cycle) | 2 W |

The unit thermal design main objective is to keep all of the unit parts inside their operational temperature limits. In addition, it is important to keep the detectors as cold as possible for the better performance. Therefore, as a general approach the unit thermal design architecture is based on dissipating the electronics power via radiators to the deep space. At the same time, the MLI will be used to keep the unit insulated from the radiative environment.

### Thermal Interface Design

The main interfaces for the unit thermal design with the S/C can be defined as following:

* Conductive interfaces:

All of the interfaces with the mechanical joints between the unit and the S/C or S/C mounting bracket. The unit thermal design itself includes low conductive materials such as Titanium or composites like ULTEM between the unit and the unit mounting bracket. The main sources of the conductive heat transfer between the unit and the S/C are the interface bolts, grounding strap and the harnesses. The effect of all of these will be considered in the thermal design process in order to keep them minimum.

* Radiative interface:

In addition to the deep space itself, all of the S/C elements which have a view factor with the unit can be considered as the radiative interfaces. Depending on the temperature, location, area and the thermos-optical properties of these elements the radiative coupling between the unit and the S/C will be calculated. A rough estimation of this coupling is important at early stages of the design, especially for deciding about the unit faces, which accommodate the radiators.

* Survival heaters control interface:

As mentioned before in Sec. 5.4.1, we assume that there will be a “S/C controlled” line to operate the survival heaters when the unit is switched OFF. The definition of the interface regarding the available budget and the type of the temperature sensors are important to be agreed between the unit and the S/C.

### Thermal Hardware Interfaces

The foreseen thermal hardware for the passive thermal design, consist of radiators with OSR (Optical Solar Reflector), SSM tapes (Second Surface Mirrors), MLI (Multi-layer Insulation), optical paintings, insulating material etc.

Depending on the decision of the mounting bracket, there will be also HW interface between the unit and the S/C mounting bracket in terms of the MLI. It is important to define which parts need to be covered with MLI, e.g. harnesses, mounting bracket, purge pipe (if any), Grounding strap(s) etc., except the unit itself.

## Instrument Handling

### Cleanliness

Because of the silicon detectors as well as the sensitive thermal hardware, the cleanliness of the unit is quite important. The unit shall always be handles in an ISO 8 cleanroom or better. The Unit will be assembled in ISO 8 clean room environment and ISO class 6 clean benches before the delivery.

### Physical Handling Requirements

MEPS has sensitive detectors (20um and 300 um thick), sensitive thermal hardware like OSR, SSM and MLI, magnetic sensitive and ESD parts. Hence, the physical handling shall be done by the personnel from the MEPS team or by other personnel but according to the unit provided handling procedure.

The following general precautions shall be respected:

* To apply ESD precautions.
* To apply as minimum ISO 8 cleanliness requirements.
* To use non-magnetic tools if working close to MEPS unit. Note that MEPS contains very strong permanent magnets!
* Do NOT remove unit red-tag covers until integration is finished.
* Do NOT touch SSMs (second surface mirrors).
* Do NOT load MLI standoffs.
* Do NOT load unit purge adaptor unnecessarily.

### Instrument Purging and Contamination Requirements

Depending on the AIT activities, active purging may be required. In addition, BOL (Beginning of Life) and EOL (End of Life) limits will be defined for the unit sensitive surfaces and parts and for the both particular and molecular contaminations.

# INSTRUMENT ASSEMBLY, INTEGRATION AND VERIFICATION

## Verification Concept and Methods (at S/C)

**Verification Concept:**

The strategy adopted for verification constitutes a best-possible compromise between schedule, risk, and cost considerations. Noteworthy guiding principles for the approach include:

* The preferred method of verification is test, preferably within the environment under which the article being verified will operate, when feasible. Testing is preferable because:

a) It is a quantitative demonstration of the item being verified.

b) It is insensitive to modeling assumptions.

c) It has the benefit of providing operator experience and testing of adjacent systems.

d) It adds to system reliability by providing hours of operation.

e) It acts as a method of discovery. In other words, one can discover properties about the test item that are beyond the context of the test being conducted.

* Where possible, system requirements verification activities should be conducted and tracked at the highest–possible level of assembly. Testing of top-level performance requirements at the highest level possible brings adjacent systems into play, and thereby more fully addresses and characterizes system-level interactions and behaviors.
* Requirements to be verified via inspection should be closed as late in the process as possible.
* All functional and performance as well as environmental requirements designated for formal verification and closure shall be verified prior to the launch and applicable to the relevant model philosophy.

**Verification Methods:**

The MEPS instrument will employ four primary verification methods to assess functionality and compliance with the requirements:

* Test (including demonstration):

Verification by test involves the direct measurement of performance to show system compliance with a specified requirement.

* Analysis:

Due to cost or physical limitations, some requirements cannot be verified by test, or may not be fully verifiable by testing alone. In such cases, analysis is performed to ensure that the unit will meet its requirements. To the extent practicable, analysis should be validated by correlation to test data.

* Review of design:

Verification by review of design (ROD) consists of using approved records and evidence that shows a requirement is met. For example design documents and reports and engineering drawings can be used in this method of verification.

* Inspection:

This approach applies to requirements that do not describe the performance of the system but instead describe a design characteristic or method. Inspection may also apply to situations where a requirement may be satisfied solely by the review of available documentation or records.

## The detailed process of the requirements verification process definition and control will be done based on the multi-lateral agreements between the involved parties. Afterwards, these steps will be defined in the unit engineering plan document or a dedicated AIVT plan document.