Contents

1. Scope

1) This document defines design principles for engineering and production of Multi Layer Insulation (MLI) blankets to be applied to thermal shields and cold masses in applications like
   - magnet cryostats
   - cryogenic supply systems
   - cryogenic transport systems
   - cryogenic current lead boxes
   - auxiliary cryogenic systems

   within FAIR accelerators.
2) This document is NOT related to any other purpose as aforementioned.

2. Definitions

1) A *cold mass* means an active cooled object being cryostated at temperatures far below 50 K.
2) A *thermal shield* means an active (by cooling tubes) or passive cooled (50 K ≤ T ≤ 80K) construction of sheet metal, shielding a cold mass from exceeding radiation heat load.
3) A *MLI blanket* means a package of stacked layers of superinsulation foil interleaved by spacer fabric in which n layers superinsulation alternate with n-1 layers of spacer fabric.
4) An *external shield blanket* means a MLI blanket on the side of a thermal shield directing to a radiation source, warmer then the thermal shield itself when operated.
5) An *internal shield blanket* means a MLI blanket on the side of the thermal shield directing to a cold surrounding, colder then the thermal shield it self when operated.
6) A *cold mass blanket* means a MLI blanket directly applied to a cold mass surface.
7) A *composite layer* is a stack of one superinsulation foil and one spacer layer.
8) The *packing factor* of MLI blankets is defined as ratio of the number of composite layers to the total thickness of a blanket, measured on a horizontal plane surface with no tension and force applied.

3. Codes and Standards

1) Materials to be used for engineering and production of MLI blankets are defined in [1].
2) Handling guidelines for MLI blankets and materials are defined in [2].

4. Thermal Properties and Requirements

1) The average heat load remaining from an external shield blanket shall be ≤ 1 W/m² (unless defined other then this within a detailed specification) for one blanket fully applied to the correlating object.
2) The average heat load remaining from an internal-, respectively a cold mass blanket shall be ≤ 0.1 W/m² (unless defined in detailed specification other then the given values) for one blanket fully applied to the correlating object.
3) To reduce the average heat load of any blanket, gaps and holes, working as thermal radiation windows, shall be strictly reduced to an unavoidable minimum.
4) To prevent radiation windows, no perforation holes of two back-to-back composite layers shall superimpose.

5. Mechanical Properties and Requirements

1) A full coverage with the MLI blanket of the object to be insulated is indispensable.
2) The cutting tolerances shall be better then ± 1 mm for all stacked composite layers belonging together in one MLI blanket while all layers shall have congruent and smooth edges.
3) The packing factor (see chapter 2.) of MLI blankets shall be ≤ 5 composite layers / mm.
4) The compression at a sewed seam must not increase the packing factor by more then 50%.
5) The number of composite layers shall not exceed n = 30.

6. Thermo-Mechanical Properties and Requirements

1) The theoretical minimum dimensions (under low temperature operation conditions) of the innermost layer of an external blanket facing the outer surface of a cold object shall be derived from the technical drawings of the object to cover. At this, occurring production tolerances and thermal contraction of the blanket materials as well as of the object to cover, shall be respected.
2) The minimum dimensions of a blanket shall be designed such, that no tension forces appear due to thermal contraction of the blanket relative to the cold object at operation temperature.
3) A lowest possible packing factor at operating temperature is of prime importance for the thermal performance of MLI blankets.

7. Production and Assembly

1) As long as not stated within a detailed specification other than this, plastic based materials shall be used for MLI production.
2) In case non organic materials are required, find material specifications in [1].
3) The outermost (directing to warm temperature) layer of a plastic based MLI blanket shall be of a reinforced super-insulation type as defined in [1].
4) The innermost (directing to cold surface) layer shall be of the relevant superinsulation foil material.
5) No Spacer fabric shall be exposed to any edges or surfaces to avoid its catching.
6) For any layer interconnection sewing shall be applied. The use of adhesives or adhesive tape will not be accepted.
7) Where ever possible blankets shall be produced from stacks of continuous layers.
8) When joining non continuous layers is unavoidable, sewed seams shall be distributed on an outer and a inner stack of layers, while single layers of all hems shall interleave with an offset of ≥ 50 cm (see figure 1).

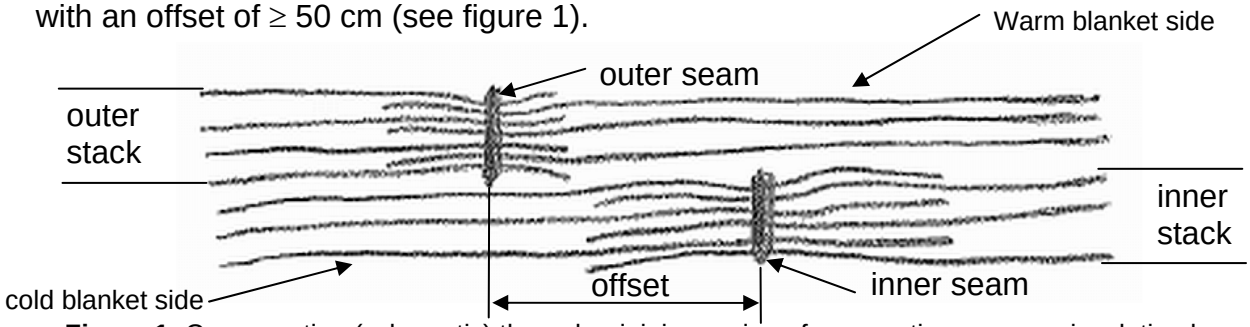

Figure 1: Cross section (schematic) through a joining region of non continuous superinsulation layers.

9) The number and length of applied closures shall be reduced to a minimum by optimising the blanket layout.
10) Hook and Loop strips shall be used as closures. The strips shall be sewed to the blankets as shown in figure 2.

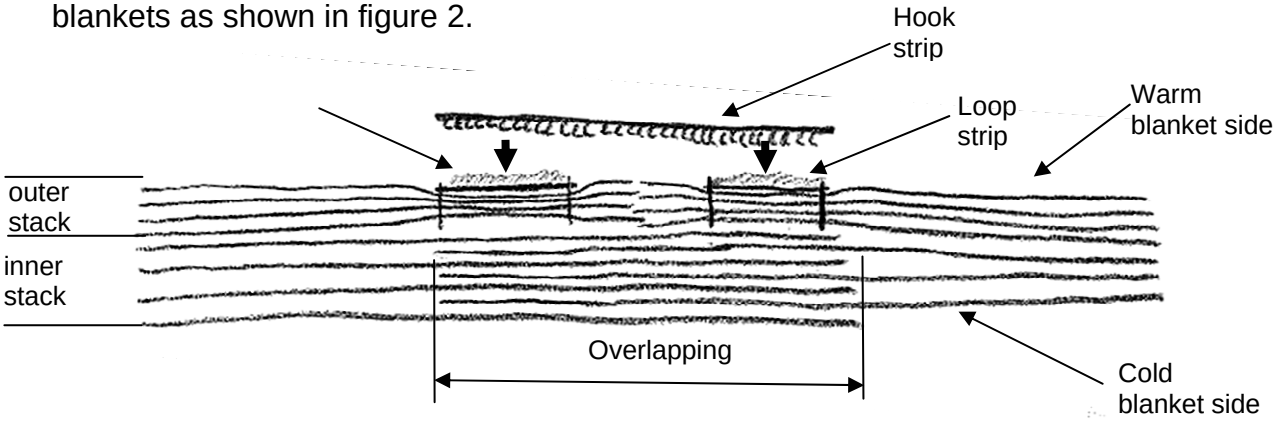

Figure 2: Cross section (schematic) through a closure region of a MLI blanket.

11) Within a closure region the blanket shall be separated into an outer and an inner stack. Parallel loop strips shall be applied by sewing to the warm side of the outer stack. The outer stacks, equipped with loop strips are forming hems. The inner stack is built from overlapping layers with an overlap of ≥ 10 cm.
12) In mounted position, the forces and tensions acting onto a closure shall be minimised. Thus all closures shall be positioned always at the lower side of a MLI blanket mounted.
13) In case of opening of any closure, the MLI blanket shall remain on the object applied to by it self.
14) The relative slip between composite layers shall be impeded by adequate methods.

8. Production of Wound MLI

1) Where ever possible, the use of MLI blankets shall be preferred.
2) Wound MLI is only admitted, whenever the use of MLI blankets are of disadvantage for the production process AND installation process AND the corresponding heat load.
3) In cases where wound MLI is required, the motivation shall be documented in detail.
4) For the winding scheme the heat load has always to be considered. Minimising the heat load is of highest priority.

9. Documentation

1) All cutting and sewing patterns shall be documented within technical drawings, provided to GSI.
2) In case of wound MLI the winding procedure shall be documented in detail by
   - the number of layers
   - the winding tension
   - detailed winding schemes

   for each object to be insulated.

10. References

[1] GSI-FAIR Technical Guideline: Number TR2.34e, Materials for Multi Layer Insulation Blankets, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany, 2009
[2] GSI-FAIR Technical Guideline: Number TR13.2e, Handling of Multi Layer Insulation Blankets and Materials, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany, 2009