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1. Scope

- 1) This document defines materials to be used for engineering and production of Multi Layer Insulation (MLI) blankets to be applied to thermal shields 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 *thermal shield* is an actively (by cooling tubes) or passively (by thermalisation straps) cooled ($50\text{ K} \leq T \leq 80\text{K}$) construction of sheet metal, shielding a cold mass from exceeding radiation heat load.
- 2) A *MLI blanket* is 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.

3. Codes and Standards

- 1) Outgassing and water content shall be measured following [1].
- 2) The Al film thickness of a superinsulation foil shall be measured following [2].
- 3) Yarn properties shall be measured following [7] and [8].
- 4) The wrought materials for Aluminium foils shall follow the definitions in [6].
- 5) Aluminium foil properties shall follow the definitions in [3], [4] and [5].

4. General Properties

- 1) All superinsulation foil material shall be perforated, typically by applying
 - random distributed
 - round holes of \varnothing 4 mm (approximately)
 - with a minimum pitch of 120 mm x 165 mm (approximately)
 - to reach open areas of min. 0.05 % to max. 0.1 % of its total area.
- 2) Different characteristics might be applied but shall be agreed with GSI in writing.

5. Organic Materials

- 1) The application of organic superinsulation materials is indicated within detailed specifications of the relevant application.

5.1. Superinsulation Foil Material

5.1.1. Base Material Properties

- 1) The base material of the superinsulation foil shall be made from a polyester foil (boPET) of
 - Material Polyethylene Terephthalate
 - Thickness min. 5.5 μ m, max. 7.0 μ m
 - corona- or plasma discharge treated
 - bi-axially oriented and thermally stabilised
- 2) The physical properties of the base material shall comply with
 - Outgassing rate TML \leq 0.24%
RML = 0.00%
CVCM \leq 0.04%
 - Tensile strength min. 190 MPa.
- 3) The physical and mechanical properties as specified shall remain unchanged after the Aluminium coating (as follows) has been applied.

5.1.2. Metal Coating Properties

- 1) The base material shall be coated on both sides with an Aluminium thin film of a
 - Thickness $t_c = 40$ nm (typical value)
 - Surface resistivity $R_{\square} \leq 0.8 \Omega$.

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5.2. Spacer Material Properties

- 1) The material of the spacer layers shall be
 - knit woven fabric
 - Material 100% Polyester yarn
 - Mesh size 1.7 mm x 1.7 mm (typical value)
 - Thickness min. 0.05 mm, max. 0.1 mm
 - washed and thermally stabilised
- 2) The physical properties of the base material shall comply with
 - Mass per unit area min. 5 g/m², max. 8 g/m²
 - Outgassing rate
 - TML ≤ 0.17%
 - RML ≤ 0.08%
 - CVCM ≤ 0.04%
 - Tensile strength min. 80 MPa

5.3. Reinforced Superinsulation Foil Material

- 1) The reinforced superinsulation foil material films shall have either an integrated net, made of either polyester or polyamide fabric.
- 2) Reinforced superinsulation foil materials shall show the same properties as defined in chapter 4, 5.1.1 and 5.1.2. but having a
 - thickness min. 12 µm to max. 25 µm.

6. Closure Material

- 1) All closures shall be designed as hook-and-loop fasteners while the hook strap of the closures shall be of a "hook" – type only.
- 2) The material of the closures shall be of the
 - Basic construction woven
 - Material 100% Polyester
- 3) The physical properties of the base material shall comply with
 - Overall thickness 2.35 ± 0.25 mm
 - Weight 300 g/m² ± 10 %
 - Peel Strength with Hook
 - average 2.0 N/cm
 - min. 1.3 N/cm
 - Shear Strength with Hook
 - average 10.3 N/cm²
 - min. 7.3 N/cm²
 - Breaking Strength min. 210 N/cm
- 4) All closures shall withstand at least 100 opening cycles without any change of peel and shear strength.
- 5) All closures shall withstand at least 10000 opening cycles with a maximum loss of peel and shear strength of max. 50%.

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7. Thread Material

- 1) Any yarn shall be of the
- Material Polyester
 - Construction core-spun thread
 - Linear density approx. Nm 44 / 3 (dtex 227 * 3)
 - Tensile strength approx. 3.03 cN
 - Elongation at break approx. 20%

8. Inorganic Materials

- 1) The application of inorganic materials for Super insulation is indicated within the correlated detailed specifications.

8.1. Base Material Properties

- 1) The base material of inorganic superinsulation shall be made from a foil of
- Material rolled Aluminium foil, Al alloy, Al content $\geq 99.0\%$
 - Surface one side bright-, one side matt finished
 - Thickness $20 \mu\text{m} \pm 8\%$
 - Temper annealed
 - Cleaning corona- or plasma discharge cleaned, free of any organic residues
 - Wettability index A with distilled water
- 2) The physical properties of the material shall comply with
- Mass per unit area $54.2 \text{ g/m}^2 \pm 8\%$
 - Tensile strength min. 80 MPa
 - Elongation $>1.0 \%$

8.2. Spacer Material Properties

- 1) The material of the spacer layers shall be
- micro fibre glass fabric
 - Thickness min. 0.05 mm, max. 0.1 mm
- 2) The physical properties of the base material shall comply with
- Mass per unit area max. 16 g/m^2
 - Water absorption max. 7 % by weight after 24 h, 100 % relative humidity at STP
 - Outgassing rate max. $10^{-7} \text{ Pa} \cdot \text{m}^3/\text{s}$ (after 100 h)
 - Tensile strength min. 1 MPa



Technical Guideline

Number

2.34e

B-MT

Materials for Multi Layer Insulation Blankets

Status

2011-04-04

9. Quality Testing and Assurance

- 1) All defined characteristics shall be certified for each lot of material in use for production of MLI blankets by applying adequate testing methods following the relevant standards.
- 2) All defined characteristics shall be guaranteed for all material within each lot in use for production of MLI blankets.

9.1. Quality Testing

- 1) All quality testing methods shall follow relevant standards and shall be performed by the material providers to proof the required material properties.

9.2. Quality Documentation

- 1) Adequate certificates
 - stating the conformity with the defined properties
 - stating all measured values for the defined properties
 - stating the error range for measured properties within a production lot
 - dated and accreditedmust be delivered with each lot of material.

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10. References

- [1] ECSS-Q-70-02A, Space product assurance: Thermal vacuum outgassing test for the screening of space materials; European Cooperation For Space Standardization, Noordwijk, Netherlands, 2000
- [2] ASTM F390-98 Standard Test Method for Sheet Resistance of Thin Metallic Films With a Collinear Four-Probe Array; ASTM International, West Conshohocken, USA; 2003
- [3] DIN EN 546-2, Aluminium and aluminium alloys – Foil – Part 2: Mechanical properties; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2007
- [4] DIN EN 546-3, Aluminium and aluminium alloys – Foil – Part 3: Tolerances on dimensions; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2007
- [5] DIN EN 546-4, Aluminium and aluminium alloys - Foil - Part 4: Special property requirements; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2007
- [6] DIN EN 573-3, Aluminium and aluminium alloys - Chemical composition and form of wrought products – Part 3: Chemical composition and form of products; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2009
- [7] DIN EN ISO 2060, Textiles - Yarn from packages - Determination of linear density (mass per unit length) by the skein method; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 1995
- [8] DIN EN ISO 2062, Textiles - Yarns from packages - Determination of single-end breaking force and elongation at break; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 1995