



# Technical Guideline

Number

2.33e

B-MT

## Composite Materials for Cryostat Components

Status

2011-04-04

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### 1. Scope

- 1) This document defines materials to be used for cryostat components with the requirement on low thermal conductivity, high mechanical stability respectively good electrical insulation properties.
- 2) This document defines epoxy fibre materials to be used as wrought material for engineering and production of components in applications like
  - magnet cryostats,
  - cryogenic supply systems,
  - cryogenic transport systems,
  - cryogenic current lead boxes,
  - auxiliary cryogenic systems
 within FAIR accelerators.
- 3) This document does NOT define any material or wrought material for pressure loaded components or components of a magnet cold mass, operated in a cryostat.
- 4) This document is NOT related to any other purpose as aforementioned.

### 2. Definitions

- 1) A *cryostat* in terms of this guideline is a technical system enclosing another technical system to be operated at temperatures far below room temperature, e.g. 4 K.
- 2) A *cryostat component* in terms of this guideline is a single mechanical part at any temperature between RT and the operating temperature of the cold mass which does not belong to the cold mass itself.

### 3. Codes and Standards

- 1) The mechanical properties of the defined material shall be tested and proven following [1], [2], [3] and [4].
- 2) The Izod impact strength shall be proven following [9].
- 3) The water absorption shall be proven following DIN EN ISO 62, method 1 [5].

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- 4) The dielectric constant and dissipation factor shall be proven following [6].
- 5) The dielectric strength shall be proven following [7].
- 6) The arc resistance shall be proven following [8].

### 4. Qualified Materials

- 1) The supplier shall be responsible for the properties fitting the requirements of the relevant application in any case.
- 2) The material shall be applicable at cryogenic temperatures down to 4 K without degradation of properties.

#### 4.1. Materials with requirements on mechanical stability only

- 1) For applications with requirements on mechanical stability only, the glass-epoxy laminate material EP GC 201 as defined in [10] to [13] (NEMA – type: G10) shall be used.
- 2) The physical properties of the base material shall comply with
  - Density  $\approx 1.8 \text{ g/cm}^3$
  - Water absorption  $\leq 0.1\%$
- 3) Values for mechanical properties shall comply with
  - Hardness, Rockwell M 110
  - Tensile Strength @ Break
    - > 240 MPa (crosswise)
    - > 280 MPa (lengthwise)
  - Flexural Modulus
    - > 15 GPa (crosswise)
    - > 17 GPa (lengthwise)
  - Flexural Strength
    - > 405 MPa (crosswise)
    - > 465 MPa (lengthwise)
  - Compressive Strength > 405 MPa
  - Izod Impact, Notched
    - > 6 J/cm (crosswise)
    - > 7 J/cm (lengthwise)
- 4) The defined material must NOT be used for electrical insulation purposes.

#### 4.2. Materials with requirements on electrical insulation only

- 1) For applications with requirements on electrical insulation only, the glass-epoxy laminate materials EP GC 203, EP GC 306 or EP GC 308 as defined in [10] to [13] (NEMA – type: G11) shall be used.
- 2) The physical properties of the base material shall comply with
  - Density  $\approx 1.8 \text{ g/cm}^3$
  - Water absorption  $\leq 0.2\%$

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3) Values for mechanical properties shall comply with

- Hardness, Rockwell M 112
- Tensile Strength @ Break > 230 MPa (crosswise)  
> 270 MPa (lengthwise)
- Flexural Modulus > 17 GPa (crosswise)  
> 19 GPa (lengthwise)
- Flexural Strength > 435 MPa (crosswise)  
> 500 MPa (lengthwise)
- Compressive Strength > 390 MPa
- Izod Impact, Notched > 4.5 J/cm (crosswise)  
> 6 J/cm (lengthwise)

4) Typical values for electrical properties shall comply with

- Dielectric Constant  $\approx 4.50 @ 1 \text{ MHz}$
- Dielectric Strength  $\geq 35.4 \text{ kV/mm}$
- Dissipation Factor  $\approx 0.02 @ 1 \text{ MHz}$
- Arc Resistance  $\geq 120 \text{ s}$

### 4.3. Materials with requirements on electrical insulation and mechanical stability

1) For applications with requirements on mechanical stability AND electrical insulation, a glass-epoxy laminate material G11, as specified in 4.2 shall be used.

## 5. Certificates and Documentation

1) The supplier shall keep a set of corresponding datasheets stating the relevant properties of the materials in use for the application and shall provide them to GSI without reserve in case of a request.

2) Adequate certificates

- stating all values for the defined properties,
- stating the error range within a production lot for the defined properties,
- dated and accredited

shall be delivered with each lot of material in use for production.

## 6. References

- [1] DIN EN ISO 527-1, Plastics- Determination of tensile properties- Part 1: General principles; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 1996
- [2] DIN EN ISO 527-4, Plastics - Determination of tensile properties - Part 4: Test conditions for isotropic and anisotropic fibre-reinforced plastic composites; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 1997
- [3] DIN EN ISO 2039-2, Plastics - Determination of hardness - Part 2: Rockwell hardness, Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2000
- [4] DIN EN ISO 604, Plastics - Determination of compressive properties; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2003
- [5] DIN EN ISO 62, Plastics - Determination of water absorption; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2008
- [6] ASTM D150-98, Standard Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation; ASTM International, West Conshohocken, USA; 1998
- [7] ASTM D149a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; ASTM International, West Conshohocken, USA; 1997
- [8] ASTM D495, Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation; ASTM International, West Conshohocken, USA; 1999
- [9] DIN EN ISO 180, Plastics - Determination of Izod impact strength; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2007
- [10] DIN EN 60893-1, Insulating materials - Industrial rigid laminated sheets based on thermosetting resins for electrical purposes - Part 1: Definitions, designations and general requirements, Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2004
- [11] DIN EN 60893-2, Insulating materials - Industrial laminated sheets based on thermosetting resins for electrical purposes - Part 2: Methods of test, Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2004
- [12] DIN EN 60893-3-1, Insulating materials - Industrial rigid laminated sheets based on thermosetting resins for electrical purposes - Part 3-1: Specifications for individual materials - Requirements for types of industrial rigid laminated sheets, Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2004
- [13] DIN EN 60893-3-2, Insulating materials - Industrial rigid laminated sheets based on thermosetting resins for electrical purposes - Part 3-2: Specifications for individual materials - Requirements for rigid laminated sheets based on epoxy resins, Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2004