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1. Scope

- 1) This document defines material properties and materials to be used as wrought material for engineering and production of insulation vacuum vessels and rigid tube-like insulation vacuum shells 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 materials for compensation bellows and vacuum flanges.
- 3) This document is NOT related to any other purpose as aforementioned.

2. Definitions

- 1) A *cryostat vacuum shell material* in terms of this document is the material of the cryostat insulation vacuum shell it self and of each part joined to it by a welding process; except any vacuum flanges and UHV related tubing. This is valid for outside – and inside parts of vacuum shells.

3. Codes and Standards

- 1) The choice of materials shall fulfil all criteria defined in the AD2000 Codes [1].
- 2) Material and testing certificates as defined in the AD2000 Codes shall be prepared as defined in DIN EN 10204 [3].
- 3) Charpy Impact Tests shall be performed as defined in [2] and documented as defined in [3].

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4. Operation Conditions and Special Properties

- 1) Due to failure mode operation a sudden rise of the cryostats inner pressure in parallel with sudden local cooling of the cryostat shell down to 220 K may occur.
- 2) The minimum energy absorption of 21 J/cm² and the average energy absorption of 28 J/cm² over 3 samples during a Charpy impact test at -50°C sample temperature must be demonstrated for each material lot used for production.
- 3) The material must demonstrate the properties of notch impact strength in the base material as well as in heat affected zones and welds.

5. Qualified Materials and Wrought Materials

- 1) Steel pipes from L485 MB defined by [5].
- 2) Certain materials and wrought materials defined by AD2000 / W10 / Table 1:
 - Alloy fine grain steel tubes (see [7]) of the types:
 - P275NL1
 - P355NL1
 - P460NL1
 - P275NL2
 - P355NL2
 - P460NL2
 in conjunction with [8], [9] and [10]
 - Steel, tough at sub-zero temperatures (following [6]):
 - 11MnNi5-3
 - 13MnNi6-3
 - 12Ni14
 - X12Ni5
 - X8Ni9
 - Stainless steel (see [4]) of the types:

1.4301	1.4550	1.4401
1.4404	1.4435	1.4439
1.4580	1.4306	1.4541
1.4571	1.4311	1.4429
- 3) Other materials then listed might be qualified with respect to geometrical restrictions, as long as they fulfil the requirements of [1] and being listed in AD2000 / W10 / Table 1 for a lowest temperature range ≤ -50°C for the application case I.
- 4) Other materials then listed shall be agreed with GSI in writing.

6. Certificates and Documentation

1) Adequate certificates

- stating all relevant material properties as defined by [1],
- stating the properties as defined in chapter 4,
- dated and accredited

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

7. References

- [1] AD 2000 Codes, Verband der TÜV e. V., Beuth Verlag GmbH, Berlin, Germany, 2009
- [2] DIN EN 10045-1, Charpy impact test on metallic materials; part 1: test method; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, 1991
- [3] DIN EN 10204, Metallic products – Types of inspection documents; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2004
- [4] DIN EN 10027-2, Designation systems for steel; numerical system; Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 1992
- [5] DIN EN 10208, Steel pipes for pipelines for combustible fluids – Technical delivery conditions, Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2009
- [6] DIN EN10028-4, Flat products made of steels for pressure purposes – Part 4: Nickel alloy steels with specified low temperature properties, Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2009
- [7] DIN EN 10217-3, Welded steel tubes for pressure purposes – Technical delivery conditions – Part 3: Alloy fine grain steel tubes, Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Berlin, Germany, 2009
- [8] Material Datasheet 352, Verband der TÜV e. V., Berlin, Germany, 2009
- [9] Material Datasheet 354, Verband der TÜV e. V., Berlin, Germany, 2009
- [10] Material Datasheet 357, Verband der TÜV e. V., Berlin, Germany, 2009