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B-MT	Design of Cryostat Flanges	Status	2011-05-31

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1. Scope

1) This document defines the design of flanges joined to cryostat 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 beam pipe respectively beam vacuum related flanges and flanges at cryogenic temperatures.
3) This document is NOT a replacement for any specifications in terms of [2].
4) This document is NOT related to any other purpose as aforementioned.

2. Definitions

1) A *cryostat* in terms of this document is a technical system enclosing another technical system to be operated at temperatures far below room temperature (e.g. 4.5K).
2) A *cryostat insulation vacuum shell* in terms of this document is the outermost cryostat shell which is keeping the insulation vacuum of a cryostat.
3) A *cryostat flange* in terms of this document is any flange, permanently joined to a cryostat insulation vacuum shell.
4) A *main flange* in terms of this document is any flange; joined to a cryostat insulation vacuum shell; which is providing an opening to fulfil the functionality the cryogenic module is mainly dedicated to.
5) An *auxiliary flange* in terms of this document is any cryostat flange directly facing the insulation vacuum of a cryostat and not being a main flange.

3. Codes and Standards

1) The European pressure equipment directive 97/23/EC [1] defines the legal basics for the documentation of pressure equipment.

2) The AD 2000 Code [2] is defining all engineering and documentation requirements related to pressure equipment.
3) ISO 1609 [3] and DIN 28404 [4] are defining flange design and dimensions for applications in Vacuum technology.
4) DIN EN ISO 4287 [13] specifies parameters and properties of technical surfaces.

4. Design Guidelines

1) In case of pressure equipment in terms of [1] all requirements and specifications as defined by [2] must be fulfilled.
2) Any O-Ring groove of a flange must be designed and manufactured as defined by [8].
3) All surfaces as counter part of elastomer based gaskets must provide an adequate quality to reach a single He - leak rate of $\leq 1*10^{-9}$ mbar*L/s as (defined by [11]) with applying elastomer based vacuum gaskets as defined by [12]. A surface quality of $R_a \leq 1{,}6$ is at least required. For surface quality definitions see [13].
4) All surfaces as counter part of elastic metal based gaskets as defined by [12] must show a surface quality of $0{,}8 \leq R_a \leq 1{,}6$ all over the full sealing area. For surface quality definitions see [13].
5) Circular flanges must show circular and concentric toolmarks only.
6) The welding of cryostat flanges must fulfil the specifications of [9].

4.1. Flange Materials

1) The choice of material for any cryostat flange must fulfil the specifications as defined by [7].

4.2. Main Flange Design

1) As long as not specified different within a superordinated specification document, ISO-K flanges, as defined by [3] and [4], must be applied as main flanges for a cryostat.
2) The preference series of nominal diameters for ISO-K flanges is DN 63, 100, 160, 250, 320, 400 and 500. For the use of different nominal diameters for ISO-K flanges no other then technical reasons shall be accepted as justification. In case, no other dimensions as defined by [3] and [4] are permitted.
3) In case of nominal diameters larger then DN 500, the flange design must be similar to the ISO-K design wherever possible. Dimensions must be fit to the mechanical requirements such, that sufficient structural stability of the flange is guarantied providing an adequate safety factor depending on the application.
4) A main flange must be designed such, that the use of elastomer- and metal based gaskets (e.g. Helicoflex®) is possible without any change or rework of the flange construction is getting necessary. Especially planarity and surface quality of sealing surfaces must be carefully designed for the use of metal based gaskets to achieve lowest leak rates.

5) For closure of ISO-K and ISO-K like flanges only purchase parts conform to the ISO-K standard, respectively similar to the ISO-K standard for nominal diameters of greater then DN500, must be applied.

4.3. Auxiliary Flange Design

1) As long as not specified different within a superordinated specification document, CF flanges, as defined by [5] and [6], shall be applied as auxiliary flanges for a cryostat.
2) The preference series of nominal diameters for CF flanges is DN 16, 40, 63, 100, 160, 200, 250, 300 and 400. For the use of different nominal diameters for CF flanges no other then technical reasons shall be accepted as justification. In case, no other dimensions as defined by [5] and [6] are allowed.
3) In case of CF flanges of the sizes DN 300 and 400 are planned for application, the detailed design must be agreed with the contraction entity in writing. For this purpose, the contractor shall deliver a detailed technical Drawing in due time prior to production of the component.
4) For closure of CF - flanges a solution applying through holes only must be preferred. In case any thread hole is required, only metric threads are permitted.
5) For bolted connections only components as defined by [10] are permitted.

5. References

[1] Directive 97/23/EC, European parliament and the council of the European Union, http://eur-lex.europa.eu, 1997
[2] AD 2000 Codes, Verband der TÜV e. V., Beuth Verlag GmbH, Berlin, Germany, 2009
[3] ISO 1609, Vacuum technology; Flanges dimensions, Beuth Verlag GmbH, Berlin, Germany, 1986
[4] DIN 28404: Vacuum technology; flanges; dimensions, Beuth Verlag GmbH, Berlin, Germany, 1986
[5] ISO 3669: Vacuum technology, Bakable flanges, Dimensions; Beuth Verlag GmbH, Berlin, Germany, 1986
[6] Technical Guideline F-TG-V-3.4e: Manufacturing of CF-Knife Edge Flanges
[7] Technical Guideline F-TG-K-2.3e: Cryostat Flange Materials
[8] Technical Guideline F-TG-V-3.3e: Design of O-Ring Grooves
[9] Technical Guideline F-TG-V-3.1e: Constructive Design of Welding Seams for Vacuum Chambers
[10] Technical Guideline F-TG-V-2.36e: Specification of Bolts, Studs, Nuts and Washers for non-bakeable UHV Components
[11] Technical Guideline F-TG-K-7.19e: Vacuum Testing of Cryostat Vacuum Vessels
[12] Technical Guideline F-TG-K-3.66e: Gaskets for Cryostat Insulation Vacuum Vessels
[13] DIN EN ISO 4287: Geometrical Product Specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters, Beuth Verlag GmbH, Berlin, Germany, 2010