



Technical Guideline

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B-MT

Gaskets for Cryostat Insulation Vacuum Vessels

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1. Scope

- 1) This document defines requirements, materials and gasket types for gaskets to be applied to cryostat flange at high vacuum 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 ultra high vacuum- or beam vacuum chamber application.
- 3) This document is NOT related to gasket applications in cryogenic tubing or any inter-connection at cryogenic temperatures.
- 4) This document does NOT represent a replacement for any relevant technical standards in terms of 97/23/EC [1] or the AD2000 Code [2].
- 5) This document is NOT related to any other purpose as aforementioned.



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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.

3. Codes and Standards

- 1) The European pressure equipment directive 97/23/EC [1] defines the legal standards for components and assemblies being identified as pressure equipment.
- 2) The AD 2000 Code [2] defines the engineering, production and documentation standards in terms of pressure equipment.
- 3) Dimensions for ISO-K and CF gaskets are defined by ISO 1609, ISO 3669 and DIN 28404 [11], [12], [13].
- 4) Dimensions and quality acceptance criteria for O-Ring gaskets are defined by DIN ISO 3601 [8], [9].

4. General requirements

- 1) As long as not defined different within a dedicated specification, elastomer based gaskets must not be applied in equipment, exposed to radiation.
- 2) As long as not directly installed within position of application, gaskets must be packed safely within an adequate, clean and dust-free packaging.
- 3) Only virgin and undamaged gaskets must be used for sealing purposes.
- 4) Any gasket must be suitable for He – leak rates of $\leq 10^{-9}$ mbar*L/s when installed in between adequate sealing surfaces. For detailed requirements on sealing surfaces and He – leak testing see [3] and [6].
- 5) Only standardised components following DIN, EN and ISO standards or industrial components, techniques and processes being available on the European market must be applied as gaskets or for gasket manufacturing.
- 6) In case any solution or material fitting the requirements of the dedicated application better then the solutions provided herein, such solution shall be introduced in writing, listing all requirements, advantages, risks, processes, sources of supply and costs. The application of such solution must be agreed with the contractor in writing.
- 7) For gaskets, applied to pressure equipment in terms of [1] all relevant standards in terms of [1] and [2] must be adhered.



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5. Elastomer Based Gaskets

- 1) In case of doubt, the usability of an elastomer based material must be agreed with the contracting entity in writing.
- 2) Foamed materials must not be used for vacuum gaskets in general.

5.1. Qualified Elastomer Materials

- 1) Materials applied in equipment, being exposed to radiation, shall show improved properties to withstand radiation exposure. The supplier shall prove the radiation resistance properties by providing adequate data sheets or certificates together with the products.
- 2) As long as no better solution can be found for equipment being exposed to radiation, or is specified within a dedicated specification, only
 - Nitrile-Butadiene-Rubber (NBR)
 - Ethylen-Propylen-Dien-Monomer (EPDM)based materials are qualified.
- 3) For equipment NOT being exposed to radiation also FPM (e.g. Viton[®] or equivalent in chemical composition and Quality) based materials are qualified.

5.2. O-Ring Gaskets

- 1) O-Ring gaskets must be delivered as specified by [8] and [9].

5.2.1. Back-Up Rings

- 1) For assembly situations of elastomer based O-Ring gaskets, where component overstraining; due to exceeding compression or extrusion; or lacking position stability of the gasket; must be expected, the application of back-up rings must be considered.
- 2) In case of back-up rings for ISO-K standard parts are applied, back-up rings must fit the specifications of [11] and [13].
- 3) In case of none ISO-K standards are applied, back-up rings must fulfil the specifications of [10].
- 4) Back-up rings must be manufactured from aluminium materials or stainless steel materials. The choice of materials must fit the requirements of the adjacent components to prevent any damage of flanges.

5.3. Cord Gaskets

- 1) When ever the application of endless o-rings is not possible, the application of bonded cord gaskets must be preferentially considered. For manufacturing of bonded cord gaskets, the techniques of gluing or vulcanisation can be applied, whereat gluing shall be preferred.
- 2) For the process of cord gasket gluing, an adequate one-component cyanoacrylate adhesive type is recommended for use. The adhesive DELO-CA[®] 2725 or equivalent in

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composition and quality is recommended. For detailed product data and instruction sheet see [16] and [17].

- 3) For the production of glued cord gaskets, at least following requirements must be fulfilled
 - Use of undecayed and unspoiled chemicals and wrought materials only
 - Correct dimensioning of cord length in correlation to the gasket groove dimensions
 - Optimal dimensioning of glue amount to be applied
 - Adherence of application instructions and all parameters defined herein
 - Reproducible, clean and controllable cutting of the elastomer cord
 - Careful cleaning of adherend surfaces without any residuals
 - Controllable and reproducible application of glue
 - Controllable and reproducible splicing process
 - Careful removal of all residuals after gluing
 - Avoiding damages of sealing surfaces
- 4) The production of glued cord gaskets must be carefully planned, optimised and prepared before being applied to production.
- 5) In case the application of glued or vulcanised cord gaskets is required by any reason, the supplier must assure that the joining technology is applicable on site of operation of the device being concerned. The applicability must be clarified in agreement with the contracting entity.

6. Metal Based Gaskets

- 1) The application of individually crafted metal based sealing techniques (e.g. cold welded gaskets of Copper, Silver, Gold or Indium gaskets) must be avoided. In case such gaskets are expected to be required, the necessity must be justified in writing and resolved in mutual agreement together with the contracting entity.

6.1. CF Gaskets

- 1) Only copper CF gaskets as defined by [12] and [4] are qualified for application in CF flanges (see [5]).
- 2) For assembly instructions for CF flanges see [7].

6.2. ISO-K Metal Gaskets

- 1) For nominal diameters \leq DN250 Aluminium knife edge gaskets are available. The applicability of such gaskets must be checked.

6.3. Elastic Metal Gaskets

- 1) In case of sealing purposes where neither CF nor ISO-K metal gaskets can be applied, the applicability of elastic metal gaskets showing a ductile metal jacket around a close wound helical spring (e.g. Helicoflex[®] or equivalent in design, function and quality) must be checked.

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- 2) Due to elastic metal gaskets are customised components, the application must be agreed with the contracting entity in writing.

6.4. In Situ Welded Gaskets

- 1) In case the application of in situ welded elastic metal gaskets is required by any reason, the contractor must assure that the joining technology is applicable on site of operation of the device being concerned. The applicability must proven by the contractor and its application must be agreed in writing with the contracting entity.
- 2) For manufacturing of in situ welded gaskets, only approved and reliable technologies must be applied. The reliability must be proven by the contractor.

7. Documentation, Labelling and Certificates

7.1. Documentation

- 1) All specification- and ordering data of any standard or customised gasket must be supplied to the contractor latest 20 working days prior to the planned date of delivery for the device.
- 2) In case of in situ manufacturing of gaskets (cord gaskets, in situ welded gaskets), special documentation as follows must be delivered latest 20 working days prior to the planned date of delivery for the device.
- 3) In case of elastomer based gaskets being applied in radiation exposed areas, if known, the maximum tolerable radiation dose shall be documented for the material in use. In case no other definition for the tolerable radiation dose exists (e.g. from the material manufacturer) the tolerable radiation dose shall be defined as the induced radiation dose, at which the material
 - increases its rubber hardness by 20% or exceeds a hardness of 82 Shore-A [14]
 - decreases its compression set [15] by a factor of 0.5 or falls below 5% compression setrelative to the non irradiated material.

7.1.1. Special Documentation for Cord Gaskets

- 1) In case of cord gaskets being applied, the production process must be documented in detail with at least the following information:
 - Materials and chemicals in use for production
 - Technical drawings of special tooling in use for production
 - Cord cutting process
 - Cleaning processes
 - Glue application process
 - Curing process
 - Finishing process (e.g. removal of residuals)

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- All parameters, relevant for production (e.g. temperatures, humidity, mating forces, curing time, wearout parameters of the cutting tool etc.)
- 2) All required tests prior to, during and after manufacturing of cord gaskets must be documented within adequate testing descriptions.

7.1.2. Special documentation for In Situ Welded Gaskets

- 1) In case of in situ welded metal gaskets being applied, the production process must be documented in detail with at least the following information:
- Materials and chemicals in use for production
 - Technical drawings of special tooling in use for production
 - Complete and detailed process description
 - All parameters, relevant for manufacturing (e.g. temperatures, electrical current and voltages, cooling time, wearout parameters of tools etc.)
- 2) All required tests prior to, during and after manufacturing of in situ welded gaskets must be documented within adequate testing descriptions.

7.2. Labelling

- 1) Gaskets must be clearly labelled on their packaging with at least
- Supplier
 - Ordering number
 - Main Dimensions
 - Material
 - Date of production
 - Lot number resp. serial number

7.3. Certification

- 1) The He – leak rate of a gasket type must be certified by the supplier by providing adequate quality documentation.
- 2) In case of customised components, an adequate certificate for He – leak tightness based on control sample tests must be delivered for each type of gasket.

8. References

- [1] Directive 97/23/EC, European parliament and the council of the European Union, <http://eur-lex.europa.eu>, 1997
- [2] AD 2000-Code; Verband der TÜV e. V.; Beuth Verlag GmbH; Berlin; Germany; 2009
- [3] Technical Guideline F-TG-V-3.3e: Design of O-Ring Grooves
- [4] Technical Guideline F-TG-V-3.42e: Copper Gaskets for ConFlat® Flanges
- [5] Technical Guideline F-TG-K-3.64e: Design of Cryostat Flanges
- [6] Technical Guideline F-TG-K-7.19e: Vacuum Testing of Cryostat Vacuum Vessels
- [7] Technical Guideline F-TG-V-13.1e: Assembly Instructions for knife-edge UHV flanges
- [8] DIN ISO 3601-1: Fluid power systems - O-rings - Part 1: Inside diameters, cross-sections, tolerances and designation codes, Beuth Verlag GmbH; Berlin; Germany; 2010
- [9] DIN ISO 3601-3: Fluid power systems - O-Rings – Part 3: Quality acceptance criteria, Beuth Verlag GmbH; Berlin; Germany; 2010
- [10] DIN ISO 3601-4: Fluid power systems - O-rings - Part 4: Anti-extrusion rings (back-up rings), Beuth Verlag GmbH; Berlin; Germany; 2010
- [11] ISO 1609, Vacuum technology; Flanges dimensions, Beuth Verlag GmbH, Berlin, Germany, 1986
- [12] ISO 3669: Vacuum technology; Bakable flanges; Dimensions, Beuth Verlag GmbH, Berlin, Germany, 1986
- [13] DIN 28404: Vacuum technology; flanges; dimensions, Beuth Verlag GmbH, Berlin, Germany, 1986
- [14] DIN 53505: Testing of rubber - Shore A and Shore D hardness test, Beuth Verlag GmbH, Berlin, Germany, 2000
- [15] ISO 815-1: Rubber, vulcanized or thermoplastic - Determination of compression set - Part 1: At ambient or elevated temperatures, Beuth Verlag GmbH, Berlin, Germany, 2008
- [16] DELO technical Information, DELO-CA 2725, DELO Industrial Adhesives, Windach, Germany, 2010, <http://www.delo.de>
- [17] Instructions for use & General information on the product group, DELO-CA, DELO Industrial Adhesives, Windach, Germany, 2007, <http://www.delo.de>