

Guideline (not under Configuration Control)

Appendix 8 Flanges

<i>Approval Process</i>			
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<i>Change Log</i>			
Appendix 8 Flanges (2DJYQA)			
<i>Version</i>	<i>Latest Status</i>	<i>Issue Date</i>	<i>Description of Change</i>
v1.0	In Work	27 Aug 2008	
v1.1	In Work	12 Jan 2009	
v1.2	In Work	18 Jun 2009	New version states development of the appendix is required
v2.0	Approved	03 Apr 2013	Details of demountable vacuum flange sets accepted for use on the ITER project
v2.1	Signed	20 Nov 2013	Added section on demounting flanges in-situ.
v2.2	Revision Required	20 Nov 2013	Updated silver coating to silver jacket for helicoflex class 1 flange set
v2.3	Approved	28 Jan 2014	Revision as requested with expanded table detailing accepted flange/seal combinations
v2.4	Signed	08 Jan 2015	Removed reference to flange class
v2.5	Approved	08 Jan 2015	Header corrected
v2.6	Approved	16 Nov 2022	Updated Drawing numbers for ITER Style Flanges. Added ITER Style Flange seal part number from SA on Spring Energised Metallic Seals. Added ITER Style Flange QSR information. Updated headers and footers. Added section on Flange mounting. Reformatted table colours to improve readability for printed copy. Checked and updated www references. Update other references. Updated approver to be in line with sign off authority
v2.7	Approved	27 Sep 2023	1 - Added rectangular or non circular flanges to scope. 2 - Noted SA on seal was in place. 3 - Added SMDD references for ITER Style Flange seals. 4 - Added ITER Style seal surface requirements for information. 5 - Added requirements for Rectangular or Shaped Seal surfaces and clarified how these should be represented on drawings. 6 - Updated headers and footers to reflect version and date correctly.

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Appendix 8****Demountable Vacuum Flanges for use on the ITER Project**

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8.1 Terms and acronyms

The terms and acronyms detailed in Table 1 are used throughout this document.

Term / Acronym	Contextual meaning
<i>Accepted</i>	Accepted by ITER Vacuum RO through submission for Request for <i>Acceptance</i> [1].
COTS	Commercial Off The Shelf (item listed in a suppliers catalogue)
Flange set	Demountable vacuum joint and gasket seal
Flange	1 half of demountable joint
Gasket or Seal	Replaceable piece which forms the vacuum containment. No distinction of these two terms is made in this appendix.
Mounting	Joining of a flange pair & seal to make the flange set.
Rectangular Type Flange	A generally rectangular or non-circular flange using a shaped seal.
RO	Responsible Officer

Table 1 Terms and acronyms

8.2 Scope

The scope of this appendix is to define the vacuum demountable flange sets *accepted* for use on the ITER Vacuum Systems.

Flange sets (demountable vacuum joint and specified seal arrangements) listed herein may be used, as specified, without further approval.

Demountable vacuum joints not detailed in this appendix shall only be utilised after *acceptance* by the ITER vacuum RO. *Acceptance* of a demountable vacuum joint and seal combination not listed herein will require qualification of the flange set. Qualification of a flange set shall be performed to an *accepted* procedure.

In the case of the ITER style flanges the information included here shall be considered final. The flanges are qualified, see [2] for the Qualification Summary Report. Finalised drawings and seal part numbers are given in Table 9 and Table 4 respectively. The manufacture of these flanges and their primary bolting is to be made in accordance with [3] and [4] taking in to account the design code used for the equipment that they are fitted to.

Non circular or Rectangular flanges are accepted as an alternative to circular flanges in cases where geometric constraints justify their use. These flanges are specific and no standard exists to cover them. In the case of their need the seal manufacture should be consulted early in design process. The strategic agreement [5] provides a route for flange design.

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8.3 Accepted Flange Set Combinations

8.3.1 Standard Flange Set DN (Nominal Diameter)

The flange set DN nominal diameters used shall comply with Table 2.

	DN10 DN16	DN25	DN40	DN50	DN63	DN100	DN160	DN200	DN250	DN300
CF*	✓	✓	✓	✓	✓	✓	✓	✓	✓	
ISO-KF	✓	✓	✓	✓	✓					
ISO-K					✓	✓	✓	✓	✓	✓
VCR ¹	✓	✓								
ITER Style					✓(DN65)	✓	✓(DN150)	✓	✓	✓

✓ *Accepted for use*

* CF sizes shall be in accordance with ISO 3669-2:2007 [6], ¹ VCR from 6 to 25 mm (1/4 to 1 inch)

Table 2 Flange Size

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8.3.2 Type of Flange Set

The type of flange set and seal combinations shall comply with Table 3.

Vacuum Classification [7] (VQC)	Behind an Accepted Isolating Valve (Y/N) ¹	Flange Set	Double Seal Required?	Range of size (DN)	1 st (Vacuum) Seal Material	2 nd (Atmosphere) Seal Material
1	No	ITER Style	Yes	63 - 300	Metallic – Silver jacketed Helicoflex Table 4 [5]	
	Yes	ITER Style	Recommended	63 - 300	Metallic – Silver jacketed Helicoflex Table 4 [5]	
	Yes	ISO-CF	No	16 - 250 ²	Silver coated copper gasket	N/A
	Yes	ISO-K	No	63 – 100	Aluminium edge type Table 6 [8]	N/A
	Yes	ISO-KF	No	16 - 63	Aluminium edge type Table 6 [8]	N/A
	Yes	VCR	No	¼ -1 inch	Silver coated gasket in carrier Table 5 [9]	N/A
2	N/A	ITER Style	Yes	63 - 300	Metallic – Silver jacketed Helicoflex Table 4 [5]	
	N/A	ITER Style	Yes	63 - 300	Metallic – Silver jacketed Helicoflex [10]	Seal material from Table 7
	N/A	ISO-CF	No	16 - 250 ²	Silver coated copper gasket	N/A
	N/A	ISO-K	No	63 – 100	Aluminium edge type Table 6 [8]	N/A
	N/A	ISO-KF	No	16 - 63	Aluminium edge type Table 6 [8]	N/A
	N/A	VCR	No	¼ -1 inch	Silver coated gasket in carrier Table 5 [9]	N/A

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Vacuum Classification [7] (VQC)	Behind an Accepted Isolating Valve (Y/N) ¹	Flange Set	Double Seal Required?	Range of size (DN)	1 st (Vacuum) Seal Material	2 nd (Atmosphere) Seal Material
3	N/A	ITER Style	Yes	63 - 300	Metallic – Silver jacketed Helicoflex [10]	N/A
	N/A	ITER Style	Yes	63 - 300	Metallic – Silver jacketed Helicoflex [10]	N/A
	N/A	ISO-CF	No	16 - 250 ²	Silver coated copper gasket	N/A
	N/A	ISO-K	No	63 – 100	Aluminium edge type Table 6	N/A
	N/A	ISO-KF	No	16 - 63	Aluminium edge type Table 6	N/A
	N/A	VCR	No	¼ -1 inch	Silver coated gasket in carrier Table 5 [9]	N/A
4	Yes	ISO-CF	No	16 - 250 ²	Silver coated copper gasket	N/A
	Yes	ISO-K	No	63 – 100	Aluminium edge type Table 6	N/A
	Yes	ISO-KF	No	16 - 63	Aluminium edge type Table 6	N/A
	Yes	VCR	No	¼ -1 inch	Silver coated gasket in carrier Table 5 [9]	N/A
	N/A	ISO-K	No	63 - 400	Table 7	N/A
	N/A	ISO-KF	No	16 - 63	Table 7	N/A
¹ Isolates system from main VV ² See section 8.4.1 for CF flange restrictions						

Table 3 Accepted flange set and seal combination

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8.3.3 Flange Mounting / Demounting

8.3.3.1 Design of Vacuum Flanged Systems

The design of VQC 1 systems utilizing flanges shall be such that the system, or components of the system, can be removed from the area of service through the demounting of ITER style flange set, see Table 3.

8.3.3.2 Flange Mounting

Flange shall be mounted and tested according to the procedures given in [11] .

8.3.3.3 Vacuum Testing

100 % of vacuum flange sets shall be helium leak tested to ensure the vacuum performance of the flange set is compliant with its VQC.

Where a system or component of a system has been removed from the area of service VQC 1 flange other than ITER style shall be helium leak tested prior to the system or component installation in the area of service.

ITER style flange sets shall be helium leak tested on mounting.

8.3.3.4 Flange Demounting

Where there is a requirement to breach a VQC 1 boundary through the demounting of an accepted vacuum flange, Table 3, the breach shall only be made at an ITER style flange set.

It is prohibited to demount VQC 1 flange sets other than ITER style in the area of service (e.g. in the port cell). The system, or components of the system, shall be transported to a suitably contamination controlled area (e.g. the hot cell) prior to the demounting of a VQC 1 flange set other than ITER style.

8.3.4 Seal Material Type

8.3.4.1 Metallic Seal Combinations

8.3.4.1.1 ITER Style Flanges

ITER style flanges have been qualified with specific seals. The manufacturer's part number of seals to be used with ITER style flanges is given in Table 4. These shall be ordered to the requirements of technical specification [5] to ensure their qualification.

The use of seals other than those with part numbers compliant with the manufacturing drawings is prohibited unless *accepted* by the ITER Vacuum RO.

Seal Description & Flange Size	Manufacture's Drawing (SMDD Reference)	TECHNETICS Part number Reference
HELICOFLEX HND 229 - DN65	111-0081957 REP 01 https://user.iter.org/?uid=4JDTQJ	211439
HELICOFLEX HND 229 - DN100	111-0081957 REP 02 https://user.iter.org/?uid=4JDTQJ	224803
HELICOFLEX HND 229 - DN150	111-0081957 REP 03 https://user.iter.org/?uid=4JDTQJ	211440
HELICOFLEX HND 229 - DN200	111-0081957 REP 04 https://user.iter.org/?uid=4JDTQJ	224804
HELICOFLEX HND 229 - DN250	111-0081957 REP 05 https://user.iter.org/?uid=4JDTQJ	224805
HELICOFLEX HND 229 - DN300	111-0081957 REP 06 https://user.iter.org/?uid=4JDTQJ	224806
HELICOFLEX HND 229 – DN500	111-0168156 https://user.iter.org/?uid=8SXRNW	234614

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Table 4 Authorised ITER Style Flange Seals

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8.3.4.1.2 VCR

VCR® is a registered trademark of Swagelok. VCR flange sets shall utilise silver coated stainless steel gaskets with the Swagelok part numbers as listed in Table 5.

VCR (inch)	Product description (part number) [9]
1/4	316 SS VCR Face Seal Fitting, 1/4 in. Silver-Plated Gasket Retainer (SS-4-VCR-2-GR)
1/2	316 SS VCR Face Seal Fitting, 1/2 in. Silver-Plated Gasket Retainer Assembly (SS-8-VCR-2-GR)
3/4	316 SS VCR Face Seal Fitting, 3/4 in. Silver-Plated Gasket Retainer (SS-12-VCR-2-GR)
1	316 SS VCR Face Seal Fitting, 1 in. Silver-Plated Gasket Retainer (SS-16-VCR-2-GR)

Table 5 VCR gasket product description and manufacturer's part number

8.3.4.1.3 CF

CF type flange sets shall utilise silver coated high-purity, oxygen-free (OFHC) copper gaskets.

8.3.4.1.4 Aluminium Edge Type

Aluminium edge type seals shall be utilised for ISO – K and ISO - KF flange sets.

For reference a manufacturer's part number of aluminium edge type gasket seals are provided in Table 6.

Nominal Diameter (DN)	Manufacturer's Part Number [8]	
	ISO - K	ISO - KF
16		34.016001.142.116-iz1
25		34.016001.142.125-iz1
40		34.040001.142.140-iz1
50		34.050001.142.150-iz1
63	34.063001.342.106	34.063001.142.163-iz1
80	34.080001.342.108	
100	34.100001.342.110	

Table 6 EVAC Al edge type gasket seal part numbers

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8.3.4.2 Non-metallic Seals

Non-metal seal gasket material shall be chosen from Table 7. The seal gasket material chosen shall be compatible with the area of service. The radiation environment that the seal shall operate is defined in the ITER Nuclear Safety Room Book [12].

Material	Temperature limit (°C)	Maximum allowable accumulated lifetime dose 1 MeV equivalent (Gray)
Viton	150	1 x 10 ³
EPDM (Ethylene-propylene)	120	5 x 10 ⁵
Nitrile rubber (Buna – N)	80	1 x 10 ⁴

Table 7 Seal material temperature and radiation limits

8.3.5 Clamping Arrangement

The flange set clamping arrangement utilised shall comply with Table 8.

Flange set	Clamping Arrangement	Flange Option
ITER Style	Bolt ring	Fixed, rotatable
ConFlat	Bolt arrangement	Fixed, rotatable
ISO - KF	Chain clamp, ISO-K cold steel double clamp.	N/A
ISO - K		

Table 8 Flange clamping arrangement

8.4 Flange Set Manufacture

8.4.1 COTS Flange Sets

CF, VCR ISO-K and ISO-KF flange sets are commercially available items readily available in all parties' countries. It is recommended that these items be purchased from companies supplying vacuum equipment as part of their core business. The use of flange sets which are not purchased from a company supplying vacuum equipment as part of its core business shall only be by prior *Acceptance*.

To ensure compatibility between flanges (knife edge dimensions, bolt circle and number, etc.) manufacturers of CF larger than DN160 in size shall be *accepted* by the ITER Vacuum RO.

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8.4.2 ITER Style Flange Set

ITER style flanges shall be manufactured according to the requirements of this Appendix and following the requirements of the ITER Vacuum Handbook [7] and the respective technical specifications [3] & [4].

8.4.2.1 Manufacturing Drawings

ITER Style flanges shall be manufactured in accordance with the drawings listed in Table 9.

Nominal Diameter	SMDD Drawing Folder ¹
DN65	https://user.iter.org/?uid=2C5DKZ
DN100	https://user.iter.org/?uid=2JGYRT
DN150	https://user.iter.org/?uid=24S93M
DN200	https://user.iter.org/?uid=2JH5JK
DN250	https://user.iter.org/?uid=2JHULA
DN300	https://user.iter.org/?uid=2JHVRV
DN500	https://user.iter.org/?uid=2ASVVP
¹ The parent folder for all ITER style flange assembly drawings are found this SMDD folder https://user.iter.org/?uid=YUR2QY .	

Table 9 ITER Style flange drawing reference

8.4.2.2 ITER Style Flange Circular Seal Surface Requirements

The manufacturing drawings detail the surface finish requirement. For the avoidance of any doubt these are:

1. The direction of the surface finish lay shall be circular and have a turned finish.
2. The surface roughness of the seal surface shall be between 1.6µm Ra and 3.2µm Ra.
3. The spacing parameter of the seal surface shall have a value of RSm ≤ 0.15mm Maximum.
4. The seal surface shall be free of any cross scratches.
5. The surface finish shall be specified on drawings using the symbols from ISO 1302.
6. After finishing the seal surface shall be protected in all further operations.
7. In the case that there are holes to be made in the sealing surface either for attachment or venting ports these shall be made before the final finishing of the seal surface to prevent any subsequent damage.

8.4.3 Rectangular or Shaped Type Flange sets

These special flange sets are commonly known either as Shaped, Rectangular or Race Track types and need particular attention to their design to ensure that they can meet the leak rate requirements of the VQC specified. The detail of their design is bespoke as no standard covers them.

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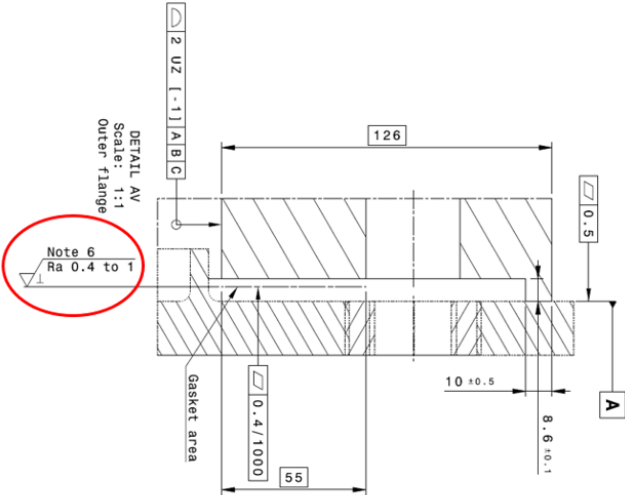
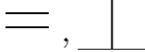
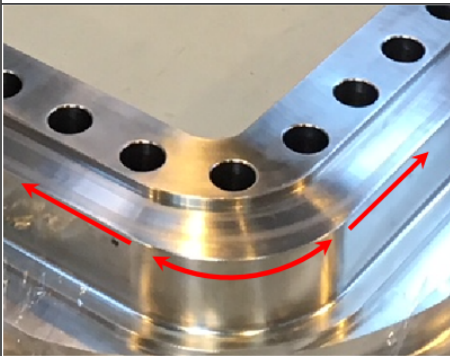
8.4.3.1 Rectangular or Shaped Seal Surface Requirements - Metallic Seals

In the case that a metallic sealing of the spring energized type is used on a Shaped, Rectangular or Race Track flange then the Surface finishing requirements shall be:

1. The direction of the surface finish lay shall be parallel at all times to the axis of the seal torus.
2. The surface roughness of the seal surface shall be greater than 0.4µm Ra and less than 1µm Ra. The target value shall be 0.8µm Ra.
3. The seal surface shall be free of any cross scratches.
4. The flatness tolerance of the seal surface along the torus axis shall be < 0.4/1000.
5. The flatness tolerance of the seal surface across the torus axis shall be < 0.5/100.
6. The surface finish shall extend up to an additional 5mm each side of the nominal seal torus location to allow for correct landing of the seal on the required surface.
7. The surface finish shall be specified on drawings using the symbols from ISO 1302.
8. After finishing the seal surface shall be protected in all further operations.
9. In the case that there are holes in the sealing surface either for attachment or venting ports these shall be made before the final finishing of the seal surface to prevent any subsequent damage.

These are to be expressed on all drawings thus.

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Requirement	Clarifying notes
<p>5. The surface finish lay, as defined by ISO 1302:2002, shall be parallel to the axis of the seal</p> <p>Note 6 : The target value is Ra 0.8 µm</p>  <p>Adapted from Sheet 15 of IO Drawing 050687 ---</p>	<p>ISO 1302</p> <p>Particular attention shall be made to the use of these symbols,</p> <p></p> <p>when defining the lay of the surface finish to ensure the surface finish lay is correctly oriented to the surface and direction of the seal torus.</p> <p>Whenever possible the appropriate symbol shall be applied in two complementary section views to remove any ambiguity on the requirement in the corners of the flange, i.e. the need is for a continuous and smooth radial transition from one straight side to the next straight side, lay direction is show in red in this example.</p> 
<p>c 0.4/1000</p>	Flatness Tolerance of the sealing surface along the torus axis
<p>c 0.5/100</p>	Flatness Tolerance of the sealing surface across the torus axis.
Tolerance of the seal rebate depth - this is specific to the seal torus diameter and required VQC needed	

8.4.3.2 Rectangular or Shaped Seal Surface Requirements - Elastomer Seals

When using elastomer sealing in place of metallic sealing the same parameters shall be used.

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References

- [1] Request for Acceptance (ITER_D_9AY4HD).
- [2] Qualification Synthesis Report PBS-31 ITER Style Flanges (ITER_D_YPSRU8).
- [3] ITER Style Flange Manufacturing Technical Specification (ITER_D_RSL7WD).
- [4] ITER Style Flange Primary Bolts Manufacturing Technical Specification (ITER_D_RT8BGK).
- [5] Technical Specification strategic agreement of the supply of Spring Energised Metallic Seals for ITER vacuum systems (ITER_D_2LKJ2E).
- [6] ISO/TS 3669-2 Vacuum technology — Bakable flanges: 2007.
- [7] ITER Vacuum Handbook (ITER_D_2EZ9UM v2.5).
- [8] “EVAC,” [Online]. Available: <https://evacvacuum.com/>. [Accessed 14 Nov 2022].
- [9] “VCR® Metal Gasket Face Seal Fittings — Nuts, Gaskets, and Accessories,” [Online]. Available: <https://products.swagelok.com/en/all-products/fittings/vcr-metal-gasket-face-seal-fittings/nuts-gaskets-accessories/c/120?clp=true>. [Accessed 14 Nov 2022].
- [10] “HELICOFLEX® RESILIENT METAL SEAL,” [Online]. Available: <https://technetics.com/products/helicoflex-metal-resilient-seal/>. [Accessed 14 Nov 2022].
- [11] Technical Specification Vacuum Flange Make-up (ITER_D_T6V3EJ).
- [12] Nuclear Safety Roombook, (ITER_D_KF63PB).