IDM UID
27Y4QC

VERSION CREATED ON / VERSION / STATUS
17 Jul 2017 / 1.20 / Approved

EXTERNAL REFERENCE / VERSION

Guideline (not under Configuration Control)

Appendix 3 Materials

Approval Process			
	Name	*Action*	*Affiliation*
Author	**Vine G.**	**17 Jul 2017:signed**	**IO/DG/COO/PED/FCED/VS**
Co-Authors			
Reviewers	**Pearce R.** **Worth L.**	**31 Aug 2017:recommended** **17 Jul 2017:recommended**	**IO/DG/COO/PED/FCED/VS** **IO/DG/COO/PED/FCED/VS**
Approver	**Lee G.- S.**	**08 Sep 2017:approved**	**IO/DG/COO**
#SecureIDM# *RO: Chiocchio Stefano*			
Read Access	**GG: MAC Members and Experts, GG: STAC Members & Experts, AD: ITER, AD: External Collaborators, AD: IO_Director-General, AD: EMAB, AD: EUROfusion-DEMO, AD: Auditors, AD: ITER Management Assessor, project administrator, RO, LG: [CCS] CCS-All for Ext AM, LG: [CCS] CCS-Section Leaders, LG: [CCS] JACOBS,...**		

Change Log			
Appendix 3 Materials (27Y4QC)			
Version	***Latest Status***	***Issue Date***	***Description of Change***
v1.0	In Work	27 Aug 2008	
v1.1	In Work	29 Aug 2008	
v1.2	In Work	12 Jan 2009	
v1.3	In Work	14 Jan 2009	
v1.4	Signed	26 Jan 2009	
v1.5	Signed	13 May 2009	
v1.6	Signed	18 Jun 2009	Changed approved to accepted throughout document
v1.7	Approved	02 Sep 2009	Minor textual changes for consistency with Vacuum Handbook
v1.8	Approved	26 Sep 2011	Reference to Material Approval Request form added. New materials added. References to requested materials added. Simplification to material groups. Changes agreed with ITER Vacuum RO prior to Up-load.
v1.9	Approved	11 Feb 2014	Added grade and standard for Alumina
v1.10	Approved	11 Feb 2014	Date correction. Affiliation modification.
v1.11	Signed	23 Jan 2015	Changes between v1.10 and v1.11 of 27Y4QC. Links added for, 304 B7 Outgassing data YDH 50 MAR XM-19 MAR Oxygen Free (OF) UNS C10200 Al-15 (Mirrors for EC Equatorial launcher) Tantalum sheet TiN Materials added:- Nitronic-60 (UNS S21800) 431 (UNS S43100) (1.4057) 431 (UNS S43100) (1.4059) Inconel 708 N-type thermocouple STEMET 1301 amorphous brazing alloy Nicuman 23 brazing alloy Nicuman 37 brazing alloy STEMET 1101 microcrystalline brazing alloy STEMET 1108 microcrystalline brazing alloy Aluminium Grade 6061 Tungsten Carbide Mechanical pump (sliding seal) Gold Thin leaf 100 micron (bonding agent) Silver-based braze BAg-8 Titanium ASTM Grade2 T2 & 5 T5 Silicon Mono-crystalline Silicon Poly –crystalline Diamond composite Sckeleton-1 Glass Ceramic MACOR (MGC) Aluminum Oxide (TS-03312) Alumina Filled Cyanate Ester (MC7885-UF) Aluminium Nitride Shapal SH-15) Aluminium Nitride Shapal M-soft Aluminium Nitride (Circuit Board Substrate)

			Quartz Filled Cyanate Ester (MC7883-UF or MC9883-LPM) Kalrez Non-vacuum application (3rd party pump) Barium Fluoride vacuum windows Molybdenum (Tracks on surface of silicon wafer sensor) ZrO2 with TiN coating Non-vacuum application (3rd party pump) ZrO2 Non-vacuum application (3rd party pump)
v1.12	Approved	23 Jan 2015	Approval corrected to restricted for:- Aluminium Nitride (Shapal SH-15, Shapal M-soft, Circuit Board Substrate) Plus previous:- Links added for, 304 B7 Outgassing data YDH 50 MAR XM-19 MAR Oxygen Free (OF) UNS C10200 Al-15 (Mirrors for EC Equatorial launcher) Tantalum sheet TiN Materials added:- Nitronic-60 (UNS S21800) 431 (UNS S43100) (1.4057) 431 (UNS S43100) (1.4059) Inconel 708 N-type thermocouple STEMET 1301 amorphous brazing alloy Nicuman 23 brazing alloy Nicuman 37 brazing alloy STEMET 1101 microcrystalline brazing alloy STEMET 1108 microcrystalline brazing alloy Aluminium Grade 6061 Tungsten Carbide Mechanical pump (sliding seal) Gold Thin leaf 100 micron (bonding agent) Silver-based braze BAg-8 Titanium ASTM Grade2 T2 & 5 T5 Silicon Mono-crystalline Silicon Poly –crystalline Diamond composite Sckeleton-1 Glass Ceramic MACOR (MGC) Aluminum Oxide (TS-03312) Alumina Filled Cyanate Ester (MC7885-UF) Aluminium Nitride Shapal SH-15) Aluminium Nitride Shapal M-soft Aluminium Nitride (Circuit Board Substrate) Quartz Filled Cyanate Ester (MC7883-UF or MC9883-LPM) Kalrez Non-vacuum application (3rd party pump) Barium Fluoride vacuum windows Molybdenum (Tracks on surface of silicon wafer sensor) ZrO2 with TiN coating Non-vacuum application (3rd party pump) ZrO2 Non-vacuum application (3rd party pump)
v1.13	Signed	23 Feb 2015	MAR ITER_D_9K3J5P for Alumimium 6061 use in VQC 2B and 4B now deleted as request is unnecessary. Use of Aluminium use in all VQC (except VQC 1A-restricted) is already indicated in Appendix 3 Table.
v1.14	Approved	25 Feb 2015	Materials:- -EPDM (Ethylene-propylene), & -Nitrile rubber (Buna – N) Added with use restricted to 2nd, outer, seal gasket only (i.e. between SVS pumped volume/Air) in VQC 2A double sealed flanges (1st, inner seal,

			being metallic) for consistency with materials noted in VH App 8, Flanges, Table 6. Aluminium "and alloys" noted in grades for clarity
v1.15	Approved	20 Aug 2015	Materials added Cu and Cu based alloys:- CuBe1.7 CuBe2 SeCu Ni and Ni based alloys:- Nilo 42 (Nickel Iron Alloy 42 material) Mineral cement:- Thermoguss 2000 Glass / Ceramic:- Zirconia ZrO2
v1.16	Approved	03 Nov 2015	Materials added:- Nicrobraz 10 Alloy BNi6 (Ni / P 11%) Molybdenum solid, pure (not powdered or compound)
v1.17	Approved	06 Jun 2016	Materials added;- PEEK shrink tubing, Brazing Filler Material (Ni 102 / BNi2 / L-Ni2 / B-Ni82CrSiBFE DuPont 951 Green Tape Shapal M-Soft NiP-11% electroless nickel braze Aluminium Nitride (W Coated) G11 / EPGC203 epoxy glass composite Magnesium Oxide, MgO, sintered
v1.18	Approved	12 Dec 2016	Materials added:- Polyimide-cable insulant Zirconia based ceramic paste (Resbond 940) Papyex: N 998 Flexible Graphite Inconel X-750 Aluminium alloy EN AW-6082-T6 Boron Carbide F4C Molybdenum alloy APT-3 TZM SA-240 316Ti Stainless steel Steel 316Ti (1.4571 according to VDEh)
v1.19	Signed	17 Jul 2017	Materials added:- Molybdenum Molykote D-321 R Anti-Friction Coating Sputtered MoS2 Brazing matrial NIORO AuNi 82/18% Araldite Rapid Ticuni Braze BrazeTec_CB10 Copper Alloy (Cu-Sn-Pb) Ertalon 66 SKTN-MED optical glue BPd-2 Braze
v1.20	Approved	17 Jul 2017	Materials added as previous version:-

			Molybdenum Molykote D-321 R Anti-Friction Coating Sputtered MoS2 Brazing matrial NIORO AuNi 82/18% Araldite Rapid Ticuni Braze BrazeTec_CB10 Copper Alloy (Cu-Sn-Pb) Ertalon 66 SKTN-MED optical glue BPd-2 Braze (& 1 correction-Nicrobraz 10 restored)

ITER Vacuum Handbook
Appendix 3

Accepted Materials

	Name	Affiliation
Author/Editor	Liam Worth	IO Vacuum Section
Vacuum Responsible Officer	Robert Pearce	IO Vacuum Section

3 ITER Approved Materials

3.1 Scope

This appendix relates to the materials *accepted* for use in ITER vacuum exposed to the ITER vacuum environments.

The ITER Vacuum Handbook (section 5.1) states that

"Only materials *accepted* by ITER for the relevant Vacuum Classification shall be used on ITER vacuum systems. All material for use in vacuum shall be clearly specified at the design stage and certified in accordance with EN 10204 2.2, 3.1 or 3.2, or equivalent, before being used in manufacturing."

Pursuant to this, materials which may be used freely on vacuum systems with the Vacuum Classifications stated are listed in the tables below.

Materials listed in this Appendix and shown as being subject to restricted use for a particular Vacuum Classification are subject to either an overall quota or to particular restrictions on their position of use. *Acceptance* for any particular vacuum application of such a material shall be obtained by submitting the Material Approval Request Form, stored on IDM (ITER_D_2MGWR4), to the ITER Vacuum RO. An example of this form completed is to be found at the end of this Appendix.

3.2 Materials Not on the Approved List

Materials which are not on the *accepted* list may be proposed for use in vacuum. If the vacuum properties of the material are not sufficiently well documented for an assessment to be carried out, a programme of measurement of the relevant properties shall be agreed between the proposer and the designated ITER Vacuum RO.

Details of materials to be considered for *acceptance* shall be submitted to the ITER Vacuum RO using the Material Approval Request Form. The proposer shall agree in advance with the ITER Vacuum RO a plan detailing the type and method of testing to qualify the material for use. The Materials Approval Request Form along with the test data, report and supporting documentation, including any *supplier's* data (Certificates of Conformity, etc.), shall be submitted for consideration.

Materials qualified in this way may be added to the *accepted* list.

3.3 Material Selection / Qualification

The materials listed in the following tables have been considered in terms of usage (vapour pressure, outgassing etc) and in terms of the environment of intended use.

The properties of materials may change either permanently or temporarily when irradiated. Such changes which can affect their suitability for use in vacuum may include -

- Induced radioactivity – which might necessitate the use of remote handling techniques to disassemble or remove a component (e.g. steels may become active). Induced activity may be long-lived or short-lived.
- Mechanical degradation – which might affect the physical integrity of a component or a bond between components or which may generate particulates which could spread through a vacuum system (e.g. PTFE degenerates to a powder). Such changes are permanent.
- Transmutation – where a particular atomic species with good vacuum properties is transformed into one with poor vacuum properties (e.g. silver transmutes to cadmium). The products formed by transmutation can themselves transmute hence such changes can not be considered permanent.
- Chemical change – where the material decomposes under the influence of radiation (e.g. Viton releases hydrochloric acid, and PTFE releases fluorine, both of which are undesirable). Such changes are permanent.
- Desorption – under the influence of radiation, many materials exhibit enhanced outgassing due to induced desorption (e.g. hydrogen from steel when irradiated with X-rays). This stops when the source of radiation is switched off.

The effect of irradiation has been considered for *accepted* materials, and shall be considered in the qualification when materials not on the list are assessed for inclusion on the list.

Table 3-1 *Accepted* Materials

Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Austenitic stainless steels	316L, 316LN 316L(N)-IG + Corresponding EN grades	✓	✓	✓	✓	✓	✓	✓	✓
	316 + Corrsponding EN grades	×	✓	✝	✓	✝	✓	✝	✓
	316Ti SA-240 (NB Bellows Convolutions) MAR: ITER_D_TT37NF			✓					

KEY: ✓ = approved for use. × = not approved for use. ✝ = restricted use

Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
	316Ti (Elektical and optical patch boxes) MAR: ITER_D_TLM3YP				✓				
	304L 304LN 304B4 + Corresponding EN grades	✓	✓	✓	✓	✓	✓	✓	✓
	304 304 B7 Outgassing data:- ITER_D_EMZ98G + Corresponding EN grades	×	✓	✝	✓	✝	✓	✝	✓
Austenitic stainless steels	YDH 50 MAR:- ITER_D_4CRYM8	✓	✓	✓	✓	✓	✓	✓	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Austenitic Chromium-Manganese-Nickel stainless steels	XM-19 (UNS S20910), MAR:- ITER_D_DG7SKX JJ1	✓	✓	✓	✓	✓	✓	✓	✓
Austenitic Chromium-Manganese-Nickel stainless steels	Nitronic-60 (UNS S21800) MAR:- ITER_D_CA3TB6 Material data sheet ITER_D_CX9QCX Material information ITER_D_DCEREP	✓	✓	✓	✓	✓	✓	✓	✓
Precipitation Hardening Iron Base Super-alloy	Grade 660 (UNS S66286), another name A286 + Corresponding EN grades	✓	✓	✓	✓	✓	✓	✓	✓
Ferritic (martensitic) stainless steel	430 (UNS S43000) Eurofer, F82H, Rusfer,	✓	✓	✓	✓	✓	✓	✓	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Ferritic (martensitic) stainless steel	431 (UNS S43100) (1.4057) ITER roughing pump shaft MAR:- ITER_D_DCCQYE Materials cert ITER_D_DBY4WW	×	×	×	×	✝	✝	×	×
Ferritic (martensitic) stainless steel	431 (UNS S43100) (1.4059) ITER roughing pump rotor and case MAR:- ITER_D_DCHJDM Materials cert ITER_D_DCEQ7B	×	×	×	×	✝	✝	×	×
Kovar	ASTM F15 KV-1~9	✓	✓	✓	✓	✓	✓	✓	✓
Nickel		✓	✓	✓	✓	✓	✓	✓	✓
Nickel based Alloys	Nimonic 80A(UNS N070080)	✓	✓	✓	✓	✓	✓	✓	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
	Monel 400	✓	✓	✓	✓	✓	✓	✓	✓
	Alumel (95% Ni, 2% Mn, 2%Al, 1%Si)	×	✝	×	✓	×	✓	×	✓
	Chromel (90%-10% Ni – Cr)	✓	✓	✓	✓	✓	✓	✓	✓
	Alloy 718 (UNS N07718) Alloy 625 (UNS N06625)	✓	✓	✓	✓	✓	✓	✓	✓
	Inconel 708 Bellows seal MAR:- ITER_D_KTP2JW	✓	✓	✓	✓	✓	✓	✓	✓
	N-type thermocouple MAR :- ITER_D_64J7S9	×	×	×	✓	×	×	×	×
	Nilo 42 (Nickel Iron Alloy 42 material) MAR:- ITER_D_QTVQ7F	×	✓	×	✓	×	✓	×	×

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
	Inconel X-750 (UNS N07750, DIN W.-Nr. 2.4669) MAR: ITER_D_S98EXM Material datasheet ITER_D_SM54DQ	✓	✓	✓	✓	✓	✓	✓	✓
Nickel based Braze	STEMET 1301 amorphous brazing alloy Vacuum brazing of W-Cu joint in the Divertor Dome PFUs armour (only PRPs) MAR:- ITER_D_7NTH2J Outgassing data:- ITER_D_7NSWW8 Mat Cert ITER_D_7NTH2J	×	✓	×	✓	×	✓	×	✓
	Nicrobraz 10 Alloy BNi6 (Ni / P 11%) Brazing of stainless steel cable sheaths into stainless steel bulkheads. MAR:- ITER_D_QZW8DY	✓	✓	✓	✓	✓	×	×	×

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
	Ni 102 Nickel-based high temp brazing paste For Brazing of non-vacuum boundary components DNB Beam (AKA:-Ni 102, BNi2 , L-Ni2, B-Ni82CrSiBFE-970/1000, 4777F, 9500/97) MAR ITER_D_S43LCB	×	✓	×	✓	×	✓	×	✓
Nickel based Braze	Nickel - Phosphorus 11% vacuum braze for the 6x diamagnetic coils (55.AG) under Triangular Support MAR ITER_D_S5EHB2	×	✓	×	✓	×	✓	×	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Pure Copper	Oxygen Free (OF) UNS C10200 Oxygen Free electronic (OFE) UNS C10100 EU grades: Cu-ETP (CW004A), Cu-FRTP, (CW006A), Cu-OF (CW008A), Cu-OFE (CW009A), Cu-PHCE (CW022A)	✝	✓	✓	✓	✓	✓	✓	✓
Pure Copper	Oxygen Free (OF) UNS C10200 OF (CW008A) MAR:- ITER_D_NT9JT5	✝	✓	✓	✓	✓	✓	✓	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Copper alloys	CuCrZr-IG: Cr (0.6 – 0.9 %), Zr (0.07 – 0.15 %) CuCr1Zr (CW 106C) CuCrZr (UNS C18150) БрХЦр (RF grade) YZC (JA grade)	✓	✓	✓	✓	✓	✓	✓	✓
	CuBe1.7 MAR:- ITER_D_RBENAP	×	✓	×	×	×	×	×	×
	CuBe2 MAR:- ITER_D_RB34RC	×	✓	×	×	×	×	×	×
	SeCu MAR:- ITER_D_R7NEZM	×	✓	×	×	×	×	×	×

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Copper alloys-Bronze	Aluminum bronze: UNS C63200,(82Cu-9Al-5Ni4Fe), CuAl10Ni5Fe4 (CW307G) CW301G (CuAl6Si2Fe)	✝	✓	✓	✓	✓	✓	✓	✓
Copper alloys-Bronze	Aluminium Bronze Casting (SO-5) (oilless bearing for in -vessel mirror motors. MAR:- ITER_D_4CT93S	×	✓	×	✝	×	✝	×	✝
Copper alloys-Bronze	Bronze (Cu-Sn-Pb) Application is VQC N/A (approved for installation use only) MAR: ITER_D_UG2K5V								
Copper alloys-Alumina Dispersion Strengthened	Glidcop Al60 Glidcop Al25-IG Al-15	✓	✓	✓	✓	✓	✓	✓	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Copper alloys-Alumina Dispersion Strengthened	Al-15 (Mirrors for EC Equatorial launcher) MAR:-ITER_D_4CQPLA	×	✓	×	✓	×	✓	×	✓
Copper-based braze	Nicuman 23 brazing alloy as a brazing alloy for use in the divertor MAR:- ITER_D_9K83MF Outgassing data:- ITER_D_6XLFJQ	×	✓	×	×	×	×	×	×
Copper-based braze	Nicuman 37 brazing alloy for use in VQC 1B as a brazing alloy for use in the divertor. MAR :- ITER_D_9K6V2C Outgassing data:- ITER_D_6XLFJQ Materials cert ITER_D_9K6V2C	×	✓	×	×	×	×	×	×

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Copper-based braze	STEMET 1101 microcrystalline brazing alloy Vacuum brazing of Cu-CuCrZr joint in the Dome PFUs armour MAR:- ITER_D_7NXAUN Outgassing data:- ITER_D_7NSWW8 Materials certificate ITER_D_7NSWW8	×	✓	×	✓	×	✓	×	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Copper-based braze	STEMET 1108 microcrystalline brazing alloy Vacuum brazing of Cu-CuCrZr joint in the Dome PFUs armour MAR:- ITER_D_7NSWW8 Outgassing data:- ITER_D_7NSWW8 Materials certificate ITER_D_7NSWW8	×	✓	×	✓	×	✓	×	✓
Beryllium	S – 65C VHP, DShG-200, TGP-56FW, CN-G01	✓	✓	✓	✓	✓	✓	×	×
Aluminium	Pure or alloys	✝	✓	✓	✓	✓	✓	✓	✓
	Aluminium alloy EN AW-6082-T6 MAR : ITER_D_S97FXR Deviation request also required for this VQC 1A application	✝							

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Tungsten	Pure sintered W and rolled, cast W alloy, W-1%La_2O_3 CVD	×	✓	×	✓	×	✓	×	✓
Tungsten Carbide	WC Cemented Carbide (Bearing Ring). MAR:-ITER_D_4CSC86 Mechanical pump (sliding seal) MAR :- ITER_D_L25NLL	×	✓	×	✓	×	✓	×	✓
Caesium		×	✓	×	✓	×	✓	×	✓
Gold		✝	✝	✝	✓	✓	✓	✓	✓
Gold	Thin leaf 100 micron (bonding agent) MAR:- ITER_D_QDASPX	×	✝	×	×	×	×	×	×

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Gold based braze	Nioro brazing materials (AuNi 82/18%) MAR: ITER_D_TVU72E	✓	✓	✓	✓	✓	✓	✓	✓
Silver		✝	✝	✝	✓	✓	✓	✓	✓
Silver-based braze	BAg-8 (Japanese Industrial Standard; JIS Z3261) Ag as filler material for brazing on the DNB bushing MAR :- ITER_D_AJL8YX Deviation request ITER_D_4AHGK6 Transmutation data ITER_D_4FJRHJ, ITER_D_7PGX7C	×	✝	×	×	×	×	×	×
Silver-based braze	BrazeTec_CB10 MAR: ITER_D_UMF87D		✝						

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Silver-based braze	BPd-2 MAR: ITER_D_UXN7AY				✝				
Tantalum	Sheet MAR:-ITER_D_2LN64R	✓	✓	✓	✓	✓	✓	✓	✓
Germanium		✝	✓	✝	✓	✝	✓	✝	✓
Samarium Cobalt (Sm_2Co^{17})	R26HS	×	✓	×	✓	×	✓	×	✓
Zinc		×	×	×	×	×	×	×	×
Cadmium		×	×	×	×	×	×	×	×
Titanium	Pure or alloys	✝	✝	✝	✓	✝	✓	✝	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Titanium	Titanium ASTM Grade2 T2 & 5 T5 ICH & CD antenna: Removable vacuum transmission lines MAR:- ITER_D_6R2ZJW Related attachments ITER_D_6R2ZJW, ITER_D_6R2ZJW, ITER_D_6R2ZJW	✝	×	×	×	✝	×	×	×
Titanium based braze	Ticuni Braze MAR: ITER_D_UMFFFP		✝						
Quartz		✓	✓	✓	✓	✓	✓	✓	✓
Silicon	Mono-crystalline, 380 µm thick board Ex-vessel magnetic sensor (55.A5/A6 MEMS) Total mass ~2.5g for all sensors MAR:- ITER_D_DFVQ4C	×	×	×	✝	×	×	×	×

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Silicon	Poly-crystalline 40 µm diameter plugs through 380 µm thick mono-Si circuit board Ex-vessel magnetic sensor (55.A5/A6 MEMS) Total mass ~0.001g (1mg) for all sensors MAR ITER_D_DG5JJR	×	×	×	✝	×	×	×	×
Silica,	Fused SiO2	✓	✓	✓	✓	✓	✓	✓	✓
Composite (diamond, silicon carbine, silicon)	Sckeleton-1 MAR:- ITER_D_64NG84	×	✓	×	×	×	×	×	×
Diamond	Pure and DLC, CVD	✓	✓	✓	✓	✓	✓	✓	✓
Graphite	Pyrolytic (Langmuir Probe) MAR:- ITER_D_2LUWMJ	×	✝	×	✝	×	×	×	×

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
(see note 1)	GR-1 (restricted to allow tracking). MAR:- ITER_D_4CRPVS	×	✝	×	✝	×	×	×	×
	Papyex: N 998 Flexible Graphite MAR: ITER_D_KZWER7 Technical guide ITER_D_RZM4SU	×	✝	×	×	×	×	×	×
Composite (Carbon Fibre Composite CFC, see note 1)	SNECMA and Dunlop: various grades Supercarb NB 31 (3D), NIC-01 Toyo Tanso:CX2002U (2D)	×	✓	×	✓	×	✓	×	✓
Porcelain	C221	✓	✓	✓	✓	✓	✓	✓	✓
Ceramic	Kyocera A479	✓	✓	✓	✓	✓	✓	✓	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Glass Ceramic	DuPont 951 Green Tape For Low-Temperature Co-fired Ceramics sensor applied to PBS 55.AA/AB/AC MAR ITER_D_S22ME4 Outgassing test reports ITER_D_QYRA8N ITER_D_QYM8ZD	×	✓	×	✓	×	✓	×	✓
	MACOR (MGC) Small machined parts MAR:-ITER_D_LF5RDE Vac data:- ITER_D_LEYH7S	×	✓	×	✓	×	✓	×	✓
	Shapal Hi-M SOFT (machinable AlN) In-vessel Magnetic Sensors (55.AA/AB/AC/AJ) applications Outgassing data ITER_D_C9TP4H Material datasheet ITER_D_C9XYVT	×	✓	×	✓	×	✓	×	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
$MgAl_2O_4$		✓	✓	✓	✓	✓	✓	✓	✓
MgO	Magnesium oxide as base insulation material for the In-Vessel Coils conductor. Powder glued and sintered in blocks, confined in the conductor jacket MAR ITER_D_STESWL	×	✓	×	✓	×	✓	×	✓
Titanium dioxide TiO_2		×	✓	×	✓	×	✓	×	✓
Alumina Al_2O_3	Grade IV to ASTM D2442	✓	✓	✓	✓	✓	✓	✓	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Alumina (Al_2O_3)	Aluminum Oxide (TS-03312) Surface coating for slid pin, internal shield etc MAR:- ITER_D_4CQG7F	×	✓	×	×	×	×	×	×
Alumina cyanate ester	Alumina Filled Cyanate Ester (MC7885-UF) Ex-vessel Magnetic Sensors (55.A5/A6 MEMS), Qty ~30g for all sensors MAR:- ITER_D_DFZ4YK	×	×	×	✓	×	×	×	×
Aluminium Nitride	Shapal SH-15 (Small moulded/machined parts) MAR:- ITER_D_EH72BL	×	✝	×	✝	×	×	×	×

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Aluminium Nitride	Shapal M-soft (sintered composite of Al nitrate and B nitrate) MAR:- ITER_D_C9TCXH Outgassing data:- ITER_D_C9TP4H	×	✝	×	✝	×	×	×	×
Aluminium Nitride	Aluminium Nitride (Circuit Board Substrate) Ex-vessel sensor, total quantity 1.3kg maximum MAR:- ITER_D_DG7QJY Outgassing Data :- ITER_D_DG46FA	×	×	×	✝	×	×	×	×
Aluminium Nitride	AlN (high purity sintered for IVS RF shield) MAR ITER_D_SMX5GR Outgassing data ITER_D_DG46FA Chemical analysis ITER_D_SLZRLQ	×	✓	×	✓	×	✓	×	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Silicon Nitride (SiN_4)	TSN-03 (in vacuum ball brearing) MAR:- ITER_D_4C5QZJ	×	✓	×	×	×	×	×	×
Caesium Iodide CsI	Ti activated	×	✓	×	✓	×	✓	×	✓
Resin -Epoxy	TGDDM	×	×	✝	✓	✝	✓	×	✓
Resin -Epoxy	Araldite rapid MAR: ITER_D_UELUT4								✓
Resin -Cyanate Ester	Quartz Filled Cyanate Ester (MC7883-UF or MC9883-LPM) Bonding agent in sensor silicon wafer Ex-vessel Magnetic Sensors (55.A5/A6 MEMS), Qty ~30g for all sensors MAR:- ITER_D_DG4HDK	×	×	×	✝	×	×	×	×

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Optical glue	SKTN-MED optical glue MAR: ITER_D_76JZCP		✝						
Composite (Epoxy / (glass fibre)	G10. Electrical insulator MAR:- ITER_D_4E9Q2M	×	×	×	✓	×	×	×	✓
	G11 / EPGC203. Electrical insulator MAR ITER_D_SRSGTV	×	×	×	×	×	×	×	✓
Inorganic adhesive	Thermoguss 2000	×	✓	✝	✓	✝	✓	×	✓
	Thermoguss 2000 MAR:- ITER_D_R69NWA Performance as a seal on MI cable must be demonstrated by qualification tests on actual cables	×	×	×	×	✓	×	×	×
Glass	S 2, R- and T	×	✝	×	✓	×	✓	×	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Polyimide	Vespel	×	✓	×	✓	×	✓	×	✓
Polyimide	ERTALON 66 Application is VQC N/A (approved for installation use only) MAR: ITER_D_UG2BMP								
Polyimide	Thermopastic Polyimide (TPI), Axon Cable MAR: ITER_D_RTNM3U This sample accepted by outgassing test in MAR				✝				
PEEK (Polyether ether ketone)	As shrink tubing for steady-state sensors 55.A5/A6 MAR ITER_D_RT2T5V Product datasheet ITER_D_RMLNSM	×	×	×	✓	×	✓	×	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
EPDM (Ethylene-propylene)	Use restricted to 2nd , outer, seal gasket only (i.e. between SVS pumped volume/Air) in VQC 2A double sealed flanges (1st, inner seal, being metallic)	×	×	✝	×	×	×	×	×
Nitrile rubber (Buna – N)	Use restricted to 2nd , outer, seal gasket only (i.e. between SVS pumped volume/Air) in VQC 2A double sealed flanges (1st, inner seal, being metallic)	×	×	✝	×	×	×	×	×
Superinsulation	Aluminium deposited Kapton, Mylar. Aluminium foil	×	×	×	✝	×	×	×	✓
	Aluminium deposited Polyester	×	×	×	×	×	×	×	✝
Halogenated materials	PTFE, Fibreslip (Teflon fibre-glass weave)‡ ‡ PTFE bearings are approved for positions where the predicted radiation fluence over the full operational life of ITER is less than 103 Gray (Gamma or Neutron dose equivalents)	×	×	×	✓	×	×	✓	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
	Viton	×	×	✝	✝	✝	✓	✓	✓
	Kalrez Non-vacuum application (3rd party pump) VQC=N/A MAR:- ITER_D_L5MK2Q								
	Bromine (In Halogen lamp for CXRS Diagnostic in-situ calibration. MAR:- ITER_D_48D5EX	×	✝	×	×	×	×	×	×
Barium Fluoride	Barium Fluoride vacuum windows MAR:- ITER_D_P8Q4NT ITER_D_32KTBX	✓	×	×	×	✓	×	×	×
Molybdenum	Molybdenum as solid pure form (i.e. not powdered or compound form)	✓	✓	✓	✓	✓	✓	✓	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Molybdenum	Tracks on surface of silicon wafer sensor Ex-vessel Magnetic Sensors Qty ~0.001g (1mg) total for all sensors MAR:- ITER_D_DG5ZG5	×	×	×	✝	×	×	×	×
Molybdenum alloy	Mo alloy (Titanium(0.5)-Zirconium(0.08)-Molybdenum, TZM) MAR: ITER_D_TRZ5LS Outgassing data ITER_D_TR7YZC	✓	✓	✓	✓	✓	✓	✓	✓
MoS_2	Molykote D-321 R Anti-Friction Coating MAR: ITER_D_U3HP3S								✝
MoS_2	Molykote D-321 R Anti-Friction Coating MAR: ITER_D_UAT6CB				✝				

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
MoS_2	Sputtered MoS_2 MAR: ITER_D_TL5DS8		✝						
MoS_2		×	✝	×		×	✝	×	✝
$MoSe_2$		×	✝	×	✝	×	✝	×	✝
WS_2		×	✝	×	✝	×	✝	×	✝
WSe_2		×	✝	×	✝	×	✝	×	✝
Boron Nitride		×	✓	×	✓	×	✓	×	✓
Titanium Nitride (TiN)	PVD hard coating (anti-seizing of bolt threads, used generally) MAR:- ITER_D_2LPCE9	×	✓	×	✓	×	✓	×	✓

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Boron Carbide		×	✝	×	✝	×	✝	×	✝
	Boron Carbide, Hot pressed sintered MAR: ITER_D_T7DB99		✝						
Zirconium Nitride	Chemical Vapour Deposition Coating	×	✝	×	✝	×	✝	×	✝
Zirconia	ZrO_2 with TiN coating Non-vacuum application (3rd party pump) VQC=N/A MAR:- ITER_D_L239S5								

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Material / Material Class	Grades, (or composition applicable to ITER)	Vacuum Quality Classification							
		1A	1B	2A	2B	3A	3B	4A	4B
Zirconia	ZrO_2 ceramic can in a mechanical vacuum pump Non-vacuum application (3rd party pump) VQC=N/A MAR :- ITER_D_KZAGJN								
	ZrO_2 sintered or plasma sprayed MAR:- ITER_D_R64Q62	×	✓	×	×	×	×	×	×
	Zirconia based adhesive RESBOND 940. MAR & Outgassing data ITER_D_RUDVER:				✝				

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3.4 Example Material Request Form

Material Approval Request *(v1.0)*										Ref No: Mat-Cha-1 *(Assigned by Vacuum RO)*
Material submitted for approval:	Ceramic TRADE Name xxx									
Proposed form:	Solid									
Proposed Use:	HV Bushing									
VQC of proposed use:	1A	1B	2A	2B	3A	3B	4A	4B	N/A	
	☒	☒	☒	☒	☒	☒	☒	☒	☐	
If restricted give details of coverage (e.g. amount, surface area etc)										
Chemical Analysis / Material Safety Data Sheet available:	YES	*Attached Copy document ref. (electronic if available)*								
Agreed test plan:	NO	*Attached Copy document ref. (electronic if available)*								
Vacuum Test data Available:	YES	*Attached Copy document ref. (electronic if available)*								
Outgassing rate (at 100 °C)	N/A									
Vapour pressure (at 100 °C)	N/A									
Max temperature:	1000			Operating temperature:	240					
Pre installation treatment *(baking, electropolishing etc)*	Baked clean									
Requested by:	A.N.Other			Date Submitted:	25/03/09					
Affiliation :	USA			E-Mail	A.Other@USA.org					
Vacuum Material Approval Status: ***(To be completed by ITER Vacuum Group RO)***										
Approved for VQC:	1A	1B	2A	2B	3A	3B	4A	4B	N/A	
	☒	☒	☒	☒	☒	☒	☒	☒	☐	
Limits / Restrictions (Attached Doc.)†										
ITER Vacuum RO	Approver:	L.Pressure								
	Date:30/03/09									

Grey boxes to be completed by requesting officer. Boxes in Red to be completed by ITER Vacuum RO.

† Reasons for material rejections shall be supplied with the notification of material refusal.

3.5 Notes:-

1. Carbon and carbon composites shall be conditioned for (vacuum) use in accordance with the ITER Vacuum Handbook. ITER vacuum handbook ITER_D_29DFGH