

## Report

# ITER Vacuum Handbook Attachment 2 - Cleanliness Requirements Relating to the Assembly of Vacuum Equipment

This Attachment sets out the requirements which must be satisfied when performing assembly work on, or in, the ITER vacuum systems. It covers preliminary assembly work in assembly areas final assembly and integration work inside and outside the vacuum vessels

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Document Security: level 1 (IO unclassified) RO: Pearce Robert			
Read Access	RO, project administrator, AD: ITER, AD: External Collaborators, AD: IO_Director-General, AD: IC_OMPE_WG, AD: Section - Vacuum - EXT, AD: Section - Vacuum, AD: Auditors, AD: ITER Management Assessor		

Change Log				
<i>Title (Uid)</i>	<i>Version</i>	<i>Latest Status</i>	<i>Issue Date</i>	<i>Description of Change</i>
ITER Vacuum Handbook Attachment 2 - Cleanliness Requirements Relating to the Assembly of Vacuum Equipment (MBXPP3_v1_7)	v1.7	Approved	13 Mar 2014	Construction Volume 13: Health, Safety and Environmental Management Plan (ITER_D_EC8ALD) removed and replaced with "ITER Health & Safety & Environment management plan" with out reference.  Updated version numbers and date.
ITER Vacuum Handbook Attachment 2 - Cleanliness Requirements Relating to the Assembly of Vacuum Equipment (MBXPP3_v1_6)	v1.6	Signed	13 Mar 2014	version number!
ITER Vacuum Handbook Attachment 2 - Cleanliness Requirements Relating to the Assembly of Vacuum Equipment (MBXPP3_v1_5)	v1.5	Signed	13 Mar 2014	Reference list update
ITER Vacuum Handbook Attachment 2 - Cleanliness Requirements Relating to the Assembly of Vacuum Equipment (MBXPP3_v1_4)	v1.4	Signed	13 Mar 2014	Corrected the version number.  All comments from reviews of the document have been taken into account in this final version. This version is ready for final review by the ITER Vacuum RO and subsequent approval.
ITER Vacuum Handbook Attachment 2 - Cleanliness Requirements Relating to the Assembly of Vacuum Equipment (MBXPP3_v1_3)	v1.3	Signed	13 Mar 2014	Removed reference to "Construction Volume 13: Health, Safety and Environmental Management Plan "
ITER Vacuum Handbook Attachment 2 - Cleanliness Requirements Relating to the Assembly of Vacuum Equipment (MBXPP3_v1_2)	v1.2	Signed	06 Feb 2014	All comments from all reviewers addressed.
ITER Vacuum Handbook Attachment 2 - Cleanliness Requirements Relating to	v1.1	Signed	04 Feb 2014	All comments received addressed. Track changes included in attachment.

the Assembly of Vacuum Equipment (MBXPP3_v1_1)				Requirements for atmospheric air included.
ITER Vacuum Handbook Attachment 2 - Cleanliness Requirements Relating to the Assembly of Vacuum Equipment (MBXPP3_v1_0)	v1.0	Signed	20 Dec 2013	Version 1.0
ITER Vacuum Handbook Attachment 2 - Cleanliness Requirements Relating to the Assembly of Vacuum Equipment (MBXPP3_v0_0)	v0.0	In Work	20 Dec 2013	



# **ITER Vacuum Handbook**

## **Attachment 2**

### **Cleanliness Requirements Relating to the Assembly of Vacuum Equipment**

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# 1 Terminology

The following terms and acronyms listed in are used throughout this Attachment.

Term/acronym	Contextual meaning
<i>Accepted</i>	Accepted for use by the ITER Vacuum Responsible Officer
ALARA	As Low As Reasonably Achievable
Ex-vessel work	Work for which the operator(s) remains physically outside the vacuum system (e.g. assembly of a vacuum pipework run)
In-vessel work	Work for which the operator(s) must enter the vacuum system to perform (e.g. assembly in the main VV or cryostat)
Operator(s)	Person(s) performing the work
RA	Risk Assessment
UT	Ultrasonic Testing
VV	ITER main Vacuum Vessel
VQC	Vacuum Classification
WRO	Work Responsible Officer – Responsible for preparation of the RA and WI. The WRO is also responsible for ensuring that the work is performed to the WI and any safety requirements are satisfied
WI	Work Instruction – as part of the documentation package includes written procedures such as method statements

**Table 1 Terms and acronyms with meaning in context of this document**

## 2 Scope

This Attachment sets out the requirements which must be satisfied when performing assembly work on, or in, the ITER systems which have been assigned a VQC [1]. This document is applicable for work performed at the ITER site.

It covers

- preliminary assembly work in assembly areas
- final assembly and integration work inside and outside the vacuum equipment.

## 3 Purpose

The purpose of the requirements described herein are to ensure that the overall contamination levels in the various vacuum equipment of the ITER machine when it is brought into operation are commensurate with the Vacuum Classification (VQC) of the pertinent vacuum equipment.

All procedures and processes used during assembly and testing work of ITER vacuum systems equipment shall comply with the requirements of the ITER Vacuum Handbook [1].

## 4 General Requirements

These requirements are applicable to all assembly work for all items with a VQC. Subsequent sections detail VQC specific requirements.

## **4.1 Management of Work**

All work shall be performed in compliance with the ITER Health & Safety & Environment management plan which concerns the safety of work on the IO site. The basic requirements of the referenced document which must be satisfied are outlined below.

### **4.1.1 Risk Assessment**

The risks associated with assembly and test of vacuum equipment shall be assessed prior to work commencing. The risk assessment shall be performed by a competent person and approved by the IO. Prior to work commencing all controls identified to lower the risks to a level commensurate with the principles of ALARA shall be in place.

### **4.1.2 Work Instruction**

All assembly and test operations shall be performed to a Work Instruction (WI). The WI may take the form of, for example, a written procedure or method statement. The WI shall be approved by the IO and supported by a relevant Risk Assessment (RA).

The requirements for cleanliness and cleanliness control as described in this Attachment shall be stated in the WI as shall the processes to achieve the requirements as stated herein.

#### **4.1.2.1 Deviations from the WI**

During the execution of the tasks as defined in the WI it may be necessary to deviate from the WI. All deviations from the WI shall be agreed with the WRO prior to execution. The WRO shall update the WI accordingly to account for the deviation. Any unauthorised deviation from the WI shall be reported to the WRO.

### **4.1.3 Personnel**

No work shall be performed except by competent personnel trained to perform the work to be carried out.

## **4.2 Area Designation**

The area in which the work shall be performed shall be designated according to the VQC of the system being worked upon. All general and any specific requirements pertaining to the work being performed in the area shall be clearly displayed in the working area preferably with the WI and RA.

## **4.3 Operator Attire**

All operators performing work on vacuum equipment with any VQC where there is a risk of the operator coming into physical contact with the vacuum facing surfaces shall wear suitable attire. The exact nature of the attire to be adorned shall be specified in the WI and displayed on the area designation (section 4.2).

### **4.3.1 Personnel Protective Equipment**

The operators shall adorn PPE as defined as a result of the Risk Assessment. All PPE shall be clean and free from surface contamination such as grease and oil.

### **4.3.2 Ex-vessel work**

As a minimum and in addition to the requirements of 4.3.1 the operator shall wear the following when assembling vacuum equipment ex-vessel;

- Clean powder free latex or nitrile outer gloves
- Clean lint free overalls

### **4.3.3 In-vessel work**

In addition to the requirements of 4.3.2 the operator shall also adorn the following



garments when performing work in-vessel;

- Clean plastic overshoes
- Hair nets or caps and beard covers where appropriate
- Clean plastic helmet cover

## **4.4 Tools**

### **4.4.1 General**

All tools shall be fit for purpose and shall be specified in the WI.

Prior to use all tools shall be cleaned by wiping with a clean lint free cloth dampened with isopropyl alcohol (IPA) or laboratory grade ethanol.

### **4.4.2 Tools for use in-vessel**

All tools for use in-vessel shall come from a dedicated set of tools which are new or have only been used for in-vessel work.

Tools shall be logged into and out of the working area.

After each assembly stage a check shall be made to ensure all tools have been removed from the work area.

#### **4.4.2.1 Hand Tools**

Hand tools shall be stored in a clean tool container which may be transported into the working area. The tool container shall also include an inventory list of tools contained therein. Prior to removal from the work area the inventory of tools shall be checked against the inventory list. Any discrepancy between the tools in the container and the inventory list shall be reported to the Work Responsible Officer (WRO).

#### **4.4.2.2 Power Tools**

The use of power tools in-vessel shall be specified in the WI.

Prior to the use of power tools adjacent parts of the work area shall be screened off by the use of clean polyethylene sheeting, aluminium foil or the like to catch swarf, debris, etc. and to minimise its spread to other parts of the job.

Following each stage of such work, swarf, debris, etc., shall be cleaned up by vacuuming and surfaces wiped down with clean lint-free rags dampened with IPA or laboratory grade ethanol.

#### **4.4.2.3 Welding/ Brazing Equipment**

Welding and/ or brazing equipment shall be used only as specified in the WI. All operations of this type shall be supported by the relevant paper work (such as hot work permit) which shall be attached to the WI.

Prior to starting any such operation, surfaces to be worked on shall be cleaned by swabbing with an IPA or laboratory grade ethanol on clean lint-free rags.

Adjacent parts of the work piece shall be screened off by the use of clean polyethylene sheeting, aluminium foil or the like to catch weld spatter etc.

PPE such as welding screens shall be clean and new, or clean and dedicated for in-vessel work.

#### **4.4.2.4 Tools Containing Fluids**

The use of tools containing fluids, such as hydraulic jacks, shall be avoided where possible. Where the use of a tool containing fluid cannot be avoided then the following requirements must be satisfied.

The working fluid shall normally be air or glycol based.

The use of hydraulic tools containing oils as the working fluid is prohibited unless *accepted* by the ITER Vacuum Responsible Officer.

The area surrounding to tool shall be protected, with plastic sheeting, from the possible release of the fluid.

As far as is practical the tool shall be wrapped in plastic sheet to prevent the possible spread of contamination from leaking fluid.

The WI shall include measures which must be taken in the event of loss of fluid from the tool into the work area.

#### 4.4.2.5 Equipment, trolleys, jigs, slings, etc.

All such equipment, etc., shall be maintained in a fully serviceable manner.

All such items shall be operated in a manner such that no oils, greases, etc., can be transferred to surfaces in the clean area or that debris including particulates can be shed from the items.

#### 4.4.2.6 Vacuum Pumps

All vacuum pumps for use in-vessel shall be dry (oil free) type.

#### 4.4.2.7 Specialised Tools

The use of specialised equipment shall be by prior agreement with the WRO and only to the procedures as specified in the WI.

### 4.5 Materials

#### 4.5.1 Marking

Indelible inks and paint used for temporary mark shall only be *accepted* for use under the following conditions:

The marking can be completely removed without residue

All markers shall **not** contain any contaminants as described below:

- Ferrite steel
- Chlorine content greater 0,25%
- Sulphur and sulphur compounds
- Products which may release elements: Pb, Hg, P, Zn, Cd, Sn, Sb, Bi, As, Cu, rare earth elements.

#### 4.5.2 Adhesive Tape and plastic coverings

Adhesive tapes, peel-off preservative varnishes and temporary plastic coverings, used for austenitic stainless steels shall meet the following requirements:

- halogen or sulphur content shall be less than 0,10% in weight
- less than 15 ppm of chloride and 10 ppm of fluoride shall be released through lixiviation.

#### 4.5.3 Grinding and Cutting Wheels

Grinding and cutting wheels for use on vacuum equipment shall be alumina based and only used for austenitic stainless steel. Cutting wheels for use in vessel shall be *accepted* for use by the IO.

#### 4.5.4 Products for Ultrasonic Testing (UT)

Only ITER approved [2] coupling fluids required for UT are accepted for use on vacuum

equipment. Requirements pertaining to coupling fluids are detailed in the ITER Vacuum Handbook [1].

#### 4.5.5 Products for Liquid Penetrant Examination

Only ITER approved liquid penetrant product families are *accepted* for use on vacuum equipment [2].

#### 4.5.6 Machining Fluids

Only machining fluids *accepted* by the IO are acceptable for use on vacuum equipment [2].

#### 4.5.7 Unacceptable Materials

It is prohibited for the materials listed in Table 2 to become in contact with the surface of vacuum equipment.

Metals	Plastics
Carbon steel	PVC
Zinc	
Lead	

Table 2 Prohibited materials

## 5 Performance of Work

### 5.1 In-Vessel Dressing Working Procedures

The following general clean area procedures shall be followed and combined with good judgment in order to produce and maintain vacuum.

1. Controlled clean dressing area at entrance and exit of vacuum vessel will be set up with appropriate notices posted.
2. No food, drink, chewing gum or ablutions allowed within the vacuum vessel.
3. Clean protective clothing must be worn when working in-vessel. Clean overalls/coats, gloves and overshoes will be put on when entering the vacuum vessel and taken off upon exit.
4. Hands should be washed before wearing clean gloves. This must be done especially if any lotions or creams have been used.
5. Change clean gloves if contamination is suspected.
6. Cover hair and arms if there is any possibility of them contacting a clean vacuum surface.
7. Equipment brought into the clean dressing area for entry into vacuum vessel must be clean. Carts, stands, tools and other equipment must not be oily or greasy and must be wiped down with appropriate cleaning solutions immediately prior to entering the clean area. Note that wheels on carts must also be cleaned.
8. Tools that are cleaned for in-vessel use must not leave the clean area until end of job.
9. Expendable tools (saw blades, files, cutters, stainless steel wire brushes, grinding wheels, etc.) used shall be new and cleaned to minimize the potential for contamination.

### 5.2 Cutting, Drilling, Grinding, Filing and Polishing

Such operations shall only be carried out when specified in the work instructions.

Cutting fluids, lubricants, polishing materials, etc., may only be selected from those which have been *accepted* by IO for the relevant VQC.

Prior to starting any such operation, surfaces to be worked on shall be cleaned by swabbing with IPA or laboratory grade ethanol on lint-free rags.

Adjacent parts of the work piece shall be screened off by the use of clean polyethylene sheeting, aluminium foil or the like to catch swarf, debris, etc. and minimise its spread to other parts of the job.

Following each stage of such work, swarf, debris, etc., shall be cleaned up with a vacuum cleaner and surfaces wiped down with an IPA or laboratory grade ethanol using clean lint free rags.

If grinding is essential, the grinding wheel shall be free of organic components and shall have been manufactured in an oil-free, clean environment. Grinding wheels shall be *accepted* by IO prior to use.

### **5.3 Welding, Brazing & Soldering**

All welding shall be to the requirements of the ITER Vacuum Handbook Attachment 1 [3].

Such operations shall only be carried out when specified in the WI.

Only *accepted* weld fillers, brazing materials, solders and fluxes may be used.

Following each stage of such work, surfaces once cooled shall be wiped down with IPA or ethanol using clean lint-free rags and all traces of flux, etc., removed.

### **5.4 Mechanical Joining**

Surfaces to be joined shall be cleaned by swabbing with IPA or laboratory grade ethanol on lint-free rags.

Only fasteners of the type specified in the WI and fabricated from *accepted* materials shall be used.

Unless specified in the WI, no lubricants, greases, thermal compounds, etc., shall be used on joints or fasteners.

### **5.5 Marking**

Marking of any surface shall normally be carried out by scribing. The use of marker pens, ink, dyes, paint, etc., shall only be as specified in the WI. Only IO *accepted* marker pens, ink, dyes, paint, etc. shall be used.

## **6 Specific Requirements**

To preserve cleanliness of the components and the area in which the components are assembled and/or integrated the requirements as specified in the following sections shall be satisfied. The requirements pertain to vacuum equipment after final cleaning.

### **6.1 Assembly and Integration**

#### **6.1.1 VQC 1 and 2 Demountable Joints**

The making of demountable joints of flange class 1 [4] for use on VQC 1 equipment shall be under the supervision of the IO Vacuum Section. This requirement shall be stated in the WI. The ITER Vacuum Responsible Officer will nominate a representative of the IO Vacuum Section to supervise this activity.

#### **6.1.2 Ex-Vessel**

In the case where assembly operations are to be performed on a piece of vacuum equipment with exposed surfaces of different VQC (for e.g. VV sector) the more stringent

requirements for cleanliness shall apply to the whole piece.

#### **6.1.2.1 VQC 1**

Areas for the assembly of VQC 1 equipment shall be physically segregated from other work areas in the vicinity unless those work areas are of the same cleanliness (i.e. the room in which the clean area is to be established meets the cleanliness requirements *per se*).

The suitability of the clean area shall be checked on a regular basis (daily) by monitoring the airborne particulate count, which should not exceed  $5 \times 10^6$  Particles of size  $> 0.5 \mu\text{m}$  per  $\text{m}^3$ . Should the daily air check return a particle count not in compliance with these limits specified herein the WRO shall be informed as soon as possible.

#### **6.1.2.2 VQC 2**

Areas for the assembly of VQC 2 equipment shall be maintained clean by daily cleaning of the working areas, including the floors and surfaces.

#### **6.1.2.3 VQC 3 and 4**

Areas for the assembly of VQC 3 and 4 equipment shall be kept clean by daily cleaning of the general area.

### **6.2 In-vessel**

#### **6.2.1 General**

Personnel entering the inner area shall wear clean room clothing, comprising clean white overalls; overshoes or clean job specific footwear; protective hair nets or caps and beard covers where appropriate; powder free latex or nitrile outer gloves as specified in Section 4.3.

Personnel entry shall be through a controlled temporary vestibule with curtains screening the vessel entry aperture and the outer access from general areas. This vestibule shall be constructed so that it can be maintained in a clean and controlled manner. The vestibule shall be divided into two areas with a step over barrier between them. Each area will have sticky mats on the floor. The outer area will be for changing into clean room clothing.

Dedicated clean tools and equipment shall be stored in the inner area. Positive air flow shall be maintained from the inner to the outer area.

Only authorised personnel shall be permitted to enter the inner area.

No work shall be carried out by personnel who have not been trained for such work.

Where possible when working in the vessel, personnel shall stand on suitably supported temporary flooring manufactured from stainless steel or aluminium sheet covered with clean aluminium foil. Such foil shall be replaced at frequent intervals.

#### **6.2.2 VQC 1**

The requirements for cleanliness pertaining to in-vessel VQC 1 work areas shall be compliant with section 6.1.2 of this Attachment with the exception that the vacuum containment boundary may be considered a barrier for work area segregation.

#### **6.2.3 Ventilation**

##### **6.2.3.1 VQC 1 & 2 ventilation air flow rate**

Vacuum enclosures shall be ventilated with atmospheric air at a flow rate sufficient to provide at least 10 air changes per hour. The flow rate shall be determined on a case by case basis depending on the volume to be ventilated.

##### **6.2.3.2 VQC 1 and 2 ventilation air humidity**

Air for the ventilation of VQC 1 and vacuum enclosures shall have a relative humidity not exceeding 70%

#### **6.2.3.3 Particulate count**

Air for ventilation of VQC 1 enclosures shall have a maximum particulate count which shall not exceed  $5 \times 10^6$  Particles of size  $> 0.5 \mu\text{m}$  per  $\text{m}^3$  measured at the vessel air inlet.

### **6.3 Work Areas in the Vicinity of VQC 1 and 2 Systems**

All vessel apertures open to VQC 1 and / or 2 vacuum areas which are not directly involved in the work being undertaken shall where practical be covered by clean polyethylene sheeting or clean aluminium foil.

The region of the machine being worked on shall be screened by a polythene tent or similar. All surfaces inside this area shall be cleaned off before and after the process by vacuuming and swabbing with IPA or laboratory grade ethanol using clean lint-free rags.

All equipment shall be protected in such a way that no contamination can be transferred to vacuum surfaces.

Care shall be taken to ensure that no oils or greases (including finger grease) are rubbed into any surface which forms a vacuum boundary.

## **7 References**

- [1] ITER Vacuum Handbook (ITER\_D\_2EZ9UM).
- [2] Appendix 4 Accepted Fluids (ITER\_D\_2ELN8N).
- [3] Attachment 1. Inspection and Qualification of Welded Joints (ITER\_D\_2FMM4B).
- [4] ITER Vacuum Handbook Appendix 8 Flanges (ITER\_D\_2DJYQA).