

Technical Specifications (In-Cash Procurement)

**Technical Specification for Disruption Mitigation System
Radiation and Stray Magnetic Field Resilient Turbo
Molecular Pumps**

Technical Specification for Disruption Mitigation System Radiation and Stray Magnetic Field Resilient Turbo Molecular Pumps that will allow stray magnetic field Qualification testing and subsequent supply

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1 Purpose of document

To define the requirements for the supply of a radiation hard TMP for qualification testing. On successful completion of magnetic field resilience qualification testing, subsequent supply is then possible.

2 Definitions

Where the following terms appear in bold type, they have the following meanings:

Shall: Mandatory requirement or rigid constraint

Should: Optional requirement or flexible constraint

May: Not a requirement or constraint, included as a suggestion or recommendation to the implementing contractor

Abbreviation/term	Contextual Meaning
TMP	Turbo Molecular Pump
DMS	Disruption Mitigation System
CF	Conflat Flange [3]
KF	Klein Flange [4]
ASN	French Nuclear Safety Authority (from French “Autorité de Sûreté Nucléaire”)
IDM	ITER Document Management
IO	ITER Organization
ISO	International Organization for Standardization
MIP	Manufacturing and Inspection Plan
PIC	Protection Important Component
QA	Quality Assurance
QP	Quality Assurance
RO	Responsible Officer

Table 1 : Definitions

3 Scope

- The scope of this document is to define the requirements that pertain to the initial supply of a single pump for some magnetic qualification testing. Subsequent to successful magnetic qualification and if the pump meets all the all other requirement the supply of further pumps is then allowed

4 Extent of Supply

- The SPI design requires two TMPs per port location; one guard vacuum TMP and one process vacuum TMP
- The supply will initially be a single pump for magnetic field qualification testing to be completed by the IO. Successful qualification will allow for future supply of pumps which is currently 14 pumps plus spares

5 System Technical Requirements

5.1 Vacuum Quality Classification

[TMP001] DMS TMPs **shall** comply with the requirements of VQC 3 [1]

5.2 Confinement Boundary

[TMP002] TMP vacuum containment boundary sealing **shall** comply with Table 2.

Boundary Seal	Containment boundary seal
Electrical feed-through demountable joint	Single, metal
Electrical feed-through	Single,
Case Seal(s)	Single, metal

Table 2 TMP Confinement boundary

[TMP003] The DMS TMP **shall** be from a manufacturer who demonstrates, by actual tests or historical reference data for model relevant pumps that in the event of pump rotor crashes there **shall** be no loss of confinement for the TMP.

[TMP004] The DMS TMP model selected **shall** be from a manufacturer who confirms from, actual tests or historical reference data for model relevant pumps that in the event of pump rotor crash, the torque exerted from the TMP to the local connections **shall** be below $3 \times 10^4 \text{Nm}$.

5.3 Pump Type

[TMP005] The DMS TMPs **shall** be compatible with the operating pressure ranges defined in table 3.

DMS TMP Type	Vacuum Requirement (Operating Pressure Range)
Guard vacuum TMP	10Pa - 1×10^{-6} Pa
Process vacuum TMP	10Pa - 1×10^{-6} Pa

Table 3 Operating pressure ranges

[TMP006] DMS TMPs **shall** utilise a drag stage.

[TMP007] There **shall** be one common TMP standard for all DMS applications

[TMP008] The pumps bearings **shall** be magnetically levitated

[TMP009] DMS TMPs **shall** be fitted with manufacturer's standard inlet mesh splinter shield.

5.4 TMP Performance

[TMP012] DMS TMPs **shall** meet the requirements for pumping performance as specified in Table 4.

Measurement		Requirement (measured at TMP inlet without splinter shield)	Condition
Ultimate pressure		$\leq 10^{-6}$ Pa	Backing pressure ≤ 5 Pa.
Pumping speed	He	$\geq 250 \text{ l.s}^{-1}$	With a backing pressure ≤ 100 Pa and an inlet pressure $\leq 1 \times 10^{-1}$ Pa.
	H ₂	$\geq 200 \text{ l.s}^{-1}$	
	N ₂	$\geq 300 \text{ l.s}^{-1}$	
TMP Minimum Compression ratio	Nitrogen $\geq 1 \times 10^7$ Hydrogen $\geq 1 \times 10^3$		

Table 4 Required TMP performance

[TMP013] DMS TMPs pumping speed performance **shall** not be degraded by more than 30% when an inlet mesh splinter shield is utilised.

5.5 TMP Interface Connections

[TMP014] The DMS TMP **shall** be demountable from the inlet utilising CF sealing.

[TMP015] The DMS TMP foreline flanges **shall** be CF.

[TMP016] The interface inlet connection to the DMS TMP **shall** be DN 160 demountable joint.

[TMP017] The interface exhaust connection to the DMS TMP **shall** be a DN 40 demountable joint.

5.6 Orientation

[TMP018] TMPs shall be capable of operation in compliance with the requirements of this Technical Specification in either vertical or horizontal orientations.

5.7 Pump Isolation

[TMP019] TMP fore-line isolation valves **shall** be minimum DN 40.

[TMP020] The pumps **shall** be compatible with the use of valves shall be chosen from the ITER standard list [4]

5.8 Mechanical Shock

[TMP021] The TMP model selected **shall** be from a manufacturer who demonstrates, by actual tests or historical reference data for model relevant pumps that the TMP is able to withstand an inlet vent to atmosphere without damage to the pump resulting in loss of vacuum containment for the TMP.

[TMP022] The TMP model selected **shall** be from a manufacturer who demonstrates, by actual tests or historical reference data for model relevant pumps that in the event of fore-line vent there **shall** be no loss of vacuum containment for the TMP.

5.9 Environmental

[TMP023] Components of the DMS TMP **shall** be capable of operation under the environmental conditions as specified in Table 5.

Condition	Operating range
Radiation	Total integrated dose up to 5×10^6 Gy (gamma equivalent)
Magnetic field	≤ 150 mT in any direction
Temperature	5-35Celcius (It is acceptable to reduce inlet pressure range and duration of load in order to meet this requirement)

Table 5 Environmental Conditions

5.10 Materials

[TMP025] A full Bill of Materials with detailed material information **shall** be provided for discussion review and approval prior to contract for supply being placed.

[TMP026] The pump **should** be compatible with Chemical composition and impurity requirements for materials [12]

[TMP027] The pumps **shall** not contains oils or greases within the vacuum envelope

5.11 Vacuum Flanges

[TMP028] Demountable vacuum flanges **shall** utilise metallic gaskets.

[TMP029] All demountable vacuum flanges **shall** be supplied with required gasket seals.

5.12 Cables

[TMP030] Cables **shall** utilise non halogen materials

[TMP031] Cables **shall** be capable of allowing a pump controller separation of up to 200m

[TMP032] Cables **shall** be radiation resilient up to 5×10^6 Gy

[TMP033] Cables **should** be flame retardant (According to IEC 60332-1- flame propagation on single cables-)

[TMP034] Cables **shall** be compatible with the use of passive fire protection

[TMP035] Cables **should** be low smoke (according to IEC 61034)

[TMP036] The cables **should** possess non toxicity (according to IEC 60754-2)

[TMP037] The cables **shall** be compatible with disconnection points and transition between cables type over their length.

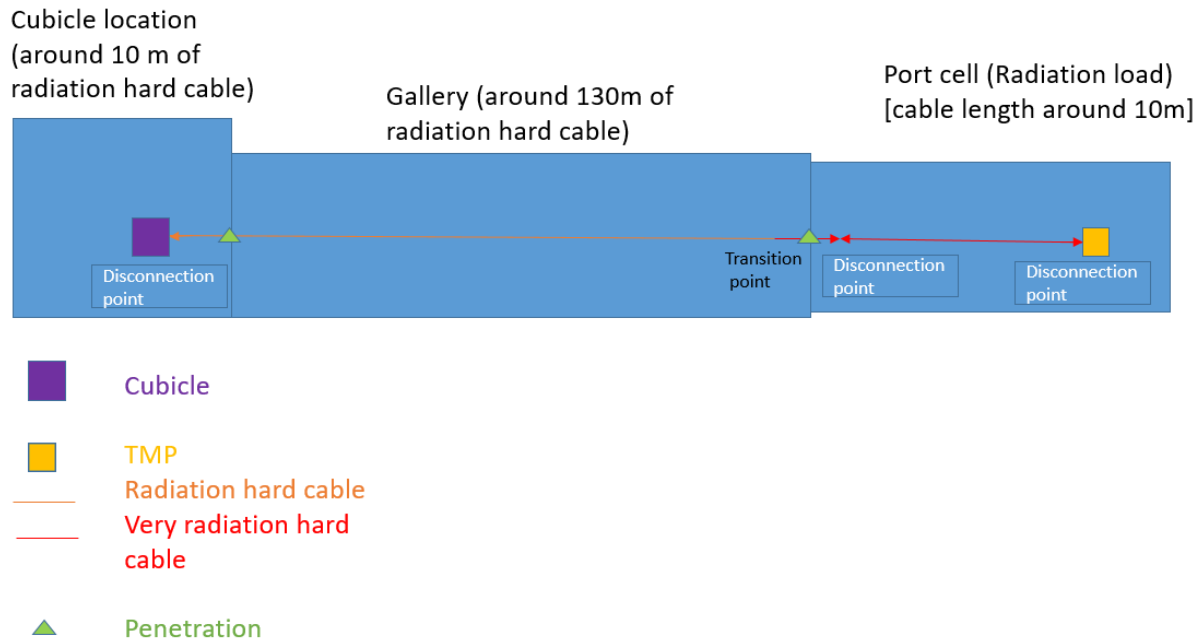


Image 1 Example of cable disconnection points, lengths and transitions

5.13 Seismic

The TMPs shall be demonstrably seismically robust to the following Floor Response Spectra envelope which covers the Port Cells at Iter

Input data

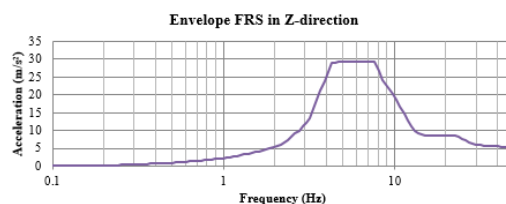
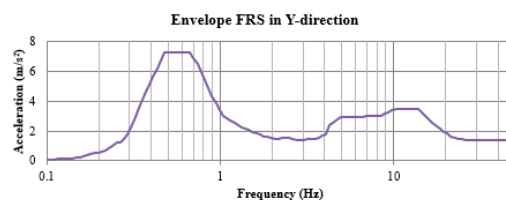
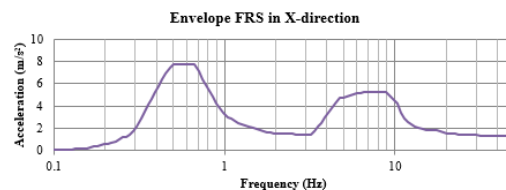
Damping ratio → **4.0%**

. node numbers starts →

[illegible]

Output data

Frequency [Hz]	SL2 Design FRS		
	K-direction [m/s ²]	direction-2 [m/s ²]	direction-3 [m/s ²]
0.1	0.0309658	0.0887427	0.0235084
0.105	0.0398351	0.0371765	0.0330865
0.10205	0.1069107	0.1046686	0.0363444
0.15763	0.1148343	0.1465621	0.0394685
0.121551	0.126131	0.1265062	0.0407016
0.127628	0.1439762	0.1615317	0.0670575
0.13401	0.162891	0.1533853	0.0646412
0.16071	0.0787062	0.1634382	0.0740663
0.147746	0.2165358	0.245167	0.0945408
0.155133	0.2485706	0.2459369	0.0332444
0.162689	0.3038244	0.2468719	0.1067147
0.175384	0.337162	0.2827767	0.1186365
0.176594	0.4305713	0.4328844	0.141311
0.186585	0.5078428	0.5048767	0.1688927
0.197393	0.5759031	0.5714721	0.1778822
0.207893	0.6247241	0.6202101	0.2027637
0.223202	0.8238027	0.8214615	0.253466
0.240662	1.0024009	0.9984309	0.2341558
0.256235	1.1967024	1.1960307	0.3177625
0.265393	1.2665894	1.2621498	0.3282255
0.278536	1.4649176	1.4678314	0.3667867
0.292526	1.7352515	1.7421942	0.4040898
0.307152	2.1971752	2.2096374	0.4194549
0.32251	2.9158649	2.9063549	0.4502639
0.338635	3.562332	3.5599373	0.536696
0.355657	4.1237894	4.0946313	0.5660026
0.373346	4.6852546	4.6903253	0.6300029
0.392013	5.246721	5.1340192	0.6740033
0.411614	5.8018674	5.6587132	0.7180036
0.431294	6.3636537	6.1834072	0.7706058
0.453804	6.931201	6.7308102	0.8241238
0.476434	7.49425865	7.2327951	0.8771901
0.500319	7.7465315	7.295832	0.9387035
0.525335	7.7465315	7.295832	1.0082013
0.551602	7.7465315	7.295832	1.0776391
0.579182	7.7465315	7.295832	1.1471968
0.608141	7.7465315	7.295832	1.2167874
0.638545	7.7465315	7.295832	1.3065052



5.14 Component Quality classifications

The supply of the TMP **shall** be according to the Classification Quality Class 2 [14]

5.15 Safety Classification

The highest safety classification of the TMPs for the possible applications is PIC SIC-2

6 Contract Management

6.1 Control Points

The IO shall ensure a close oversight of the production of its main Suppliers and Subcontractors in accordance with approved Manufacturing and Inspection Plans (MIP) [7], as detailed in Section 7. This monitoring shall include Control Points at critical steps in the Suppliers' plans. The control points shall be integrated into the agreed schedule.

A Notification Point (NP) is a milestone where the Supplier is required to notify the IO, that it has completed a specific task or a specific deliverable and is proceeding to the next task or to the next action on the specific deliverable. A NP is meant to enable the IO personnel to follow the progress of the Contract and possibly to witness a critical manufacturing step at the Supplier's premises. The Notification shall be sent by the Supplier to the IO at least 10 working days prior to the scheduled manufacturing step. The IO shall decide whether or not they want to attend. A NP shall not affect the production flow of the Supplier that shall continue the work even without a reply from the IO.

A Hold Point (HP) is a milestone where the Supplier is required to notify the IO, that it has completed a specific task or a specific deliverable and must stop the associated processes until a HP Clearance is issued. The HP Clearance shall be issued on the basis of clearly identified Quality Control and data and Acceptance test results to be provided to the IO at the time of the request. The IO shall have a maximum of 5 working days to review the Suppliers data and to notify the Supplier of its decision. In case of clearance the Supplier shall resume its activity. In case of rejection, the Supplier shall develop a recovery plan that shall be submitted and reviewed by the IO within 10 working days of submission.

A Witness Point (W) is a milestone which identifies an operation to be witnessed. Adequate notice shall be given to the IO, in order to allow the IO to participate to the operation.

A Surveillance Point (S1) identifies an operation that requires 100% inspection.

A Surveillance Point (S2) identifies an operation that requires random inspection or spot checks.

Review (R) identifies a document or report to be reviewed.

The preliminary list of Control Points shall be defined by the supplier in their Quality Plan. Additional Control Points may be identified following review of the MIPs.

6.2 Data Management

The data generated during the execution of the present Contract shall be supplied electronically and entered by IO into the ITER IDM.

6.3 Monitoring and Access Rights

The Supplier shall submit periodic reports to the IO, with a frequency depending on the progress of the works. Progress meetings shall be conducted at the IO or Supplier premises, or via teleconference, as required by the IO.

The Supplier shall ensure that access rights are granted to IO personnel at all locations where ITER work is being performed.

In case of concerns regarding the quality of production, the IO reserves the right to perform unscheduled inspections in accordance with Par. 3.10 of the ITER Procurement Quality Requirements [9]. Planned and documented audits will be performed by the IO, and regulatory body representatives in France, to verify compliance with the technical and quality requirements of the Contract.

Moreover the IO reserves the right to take photographs of the ITER equipment during the contract life.

7 Quality Assurance

Quality Requirements shall be in accordance with the "ITER Procurement Quality Requirements" [9]. The ITER Quality Assurance Program shall be applied to all the work under this Contract. The ITER QA Program is based on IAEA Safety Standard GS-R-3 and on conventional QA principles and integrates the requirements of the INB Order dated 7 February 2012 on the quality of design, construction and operation in Basic Nuclear Installation. For this purpose, the Supplier and Subcontractors carrying out contracts placed under this Contract shall be in compliance with the QA requirements under the relevant ITER QA classifications, the requirements of the INB Order and shall have an IO approved QA Program or an ISO 9001 accredited quality system, complemented with the above mentioned requirements.

Prior to commencement of any work under this Contract, a “Quality Plan” (QP) [10] shall be produced by the Supplier and Subcontractors and submitted to the IO for approval, describing how they will implement the ITER Procurement Quality Requirements.

Prior to commencement of any manufacturing, a “Manufacturing and Inspection Plan” (MIP) [7] shall be produced by the Supplier and Subcontractors and approved by the IO, who will mark up any intended intervention point. MIPs are used to monitor Quality Control and acceptance tests during the execution of the Contract. It should be noted that interventions additional to those required in this Technical Specification may be included on the MIP by the IO. The right of the IO listed above shall apply in relation to any Subcontractor and in this case the IO will operate through the Supplier. The overseeing of the quality control operation by the IO shall not release the Supplier from his responsibility in meeting any aspect of this Technical Specification.

Subcontractors not performing Critical Quality Activities (i.e. activities that if not performed correctly may affect safety, functionality or reliability) may be exempted from the requirement to supply Quality Plans and Manufacturing & Inspection Plans, subject to agreement by the IO.

All requirements of this Technical Specification and subsequent changes proposed by the Supplier during the course of execution of this Contract are subject to the Deviation Request process described in “Contractors Deviations and Non-conformities Procedure” [11].

In case of Contracts concerning SIC components and/or a Safety Related Activity, or PIC and/or Protection Related Activities, the Quality Assurance Programme of the Supplier shall comply with the requirements of the INB Order dated 7 February 2012 and the subsequent ASN decisions linked to this Order. For this purpose, the Supplier and Subcontractors carrying out contracts placed under the Contract shall be in compliance with the QA requirements under the relevant QA classifications as defined in “Quality Classification Determination” and additional requirements of the INB Order dated 7 February 2012 and the subsequent ASN decisions linked to this Order.

In particular for SIC, the IO, as the Nuclear Operator, will supervise the whole production cycle of the Supplier and Subcontractors in accordance with the document “Overall supervision plan of the chain of Suppliers for Safety Important Components, Structures and Systems and Systems and Safety Related Activities” , which shall be identified in the MIP [7].

8 Applicable and Reference Documents

8.1 Applicable Documents

This list contains applicable documents:

- [1] ITER Vacuum Handbook (IVH) (ITER_D_29DFGH)
- [2] ISO 3669:2020(en) Vacuum technology — Dimensions of knife-edge flanges
- [3] KF Flange DIN 28403 / ISO 2861
- [4] <http://www.vatvalve.com/business/valves/catalog/X>
- [5] ITER Requirements Regarding Contractors Release Note (22F52F)
- [6] ITER On-Site Testing Strategy (44U2Y4)
- [7] Requirements for Preparing and Implementing a Manufacturing and Inspection Plan (22MDZD)
- [8] Procedure on procurement documentation exchange between IO, DAs and contractors (35BVQR)
- [9] ITER Procurement Quality Requirements (ITER_D_22MFG4)
- [10] Procurement Requirements for Producing a Quality Plan (22MFMW)
- [11] Requirements for DA / Supplier / Subcontractors Deviations & Nonconformities (22F53X)
- [12] Chemical composition and impurity requirements for materials (REYV5V)
- [13] Safety requirement Roombook (KF63PB)
- [14] Quality Classification Determination (24VQES)

8.2 Reference Documents

This list contains documents for information:

- 1. Electrical Design Handbook (EDH Part 1: Introduction (ITER_D_2F7HD2)
- 2. Radiation Hardness Manual (RAD), Volume II Gamma Radiation (ITER_D_222RR8)
- 3. Order dated 7 February 2012 relating to the general technical regulations applicable to INB (7M2YKF v1.7)

Appendix 1: List of Deliverables

The Supplier shall produce a Manufacturing Dossier describing the System and its constituent components as designed and manufactured. This shall be supplied at the latest with delivery of the System. The Manufacturing Dossier shall include the following:

- Signed As-Built Drawings, Documents, and Data following manufacture and FAT
- Contractor Release Note
- Quality Plan
- Testing Procedures, Specifications and Reports
- Material Control Reports, incl. Certificates, Inspections, Concessions etc.,
- Manufacturing Documentation, incl. Manufacturing procedures, Non-Destructive Testing (NDT) Procedures, Process specifications etc.,
- Records of approved Non-Conformances (NCR) and Deviation Requests (DR)
- Certificates of conformance
- Control Reports from Factory Acceptance Tests (Visual Examination, Non-Destructive Tests, Leak Tests, Certificates of Cleanliness, Pressure Test, Geometric measurements, etc.)
- Codes and Standards conformity certificates
- Completed Manufacturing & Inspection Plans
- Manuals and Instructions for the handling, assembly, operation and maintenance of all SSCs, Tools and Equipment within the supply

The Supplier shall provide a Delivery Report together with the System, stating as a minimum:

- The packing date;
- The full address of the place of delivery and the name of the person responsible to receive the package, as well as of the Supplier's name and full address;
- Bill of Materials
- Release Note;
- Packing List;
- Material Safety Sheet;
- The declaration of integrity of the package;
- The declaration of integrity of the components;
- Any additional relevant information on the status of the components.

Prior to Final Acceptance, the Supplier shall provide an update to the Manufacturing Dossier, consisting of the following:

- Control Reports from On-Site Testing
- Signed As-built Drawings, Documents and Data following installation and On-Site Testing

Delivery

Requirements for Labelling, Cleaning, Packaging, Handling, Shipment and Storage

Scope of application

The following generic requirements apply both for the shipment of equipment, etc. from the manufacture/assembly site to the ITER Site or to any intermediate site.

Suitable precautions shall be taken to avoid damage to the equipment. The components shall be fitted with the required accelerometers or other sensors and shall be packed as defined below.

The equipment shall be subject to control and inspection, as defined below.

Labelling and Traceability

All components and the main subcomponents shall be clearly marked in a permanent way and in a visible place with the IO official numbering system according to the document “ITER Numbering System for Components and Parts” [24]. A detailed ‘IO component identification standard’ together with printed label (QR-code) templates will be provided by IO.

Cleaning

During cleaning, particular attention shall be given to the removal of weld spatter, debris and other foreign matter, particularly from the coolant passages and sealing surfaces. Final cleaning shall ensure effective cleaning without damage to the surface finish, material properties or metallurgical structure of the materials. The Supplier shall submit to the IO the proposed cleaning procedure for approval/acceptance.

The demonstration of meeting the above cleaning requirements represents a Hold Point (HP).

Packaging and Handling

Any special IO or regulatory transportation requirements shall be documented and provided to the Supplier prior to shipment.

Subsequent to the Factory Acceptance Test, the components shall be partially disassembled to the maximum size that can be shipped. All components requiring re-assembly at the ITER Site shall be clearly labelled and tagged.

The supplier shall design and supply appropriate packaging, adequate to prevent damage during shipping lifting and handling operations. Where appropriate, accelerometers or other sensors shall be fitted to ensure that limits have not been exceeded. When accelerometers are used, they shall be fixed onto each box and shall be capable of recording the acceleration along three perpendicular directions.

Shock absorbing material shall be used.

Each shipment shall be accompanied by a Delivery Report shall be prepared by the Supplier, stating as a minimum:

- The packing date;
- The full address of the place of delivery and the name of the person responsible to receive the package, as well as of the Supplier's name and full address;
- Bill of Materials
- Security Measures
- Release Note [25];
- Packing List;
- Material Safety Sheet;
- The declaration of integrity of the package;
- The declaration of integrity of the components;
- Any additional relevant information on the status of the components.