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Technical Specifications (In-Cash Procurement)

Expert engineer for review and development diagnostic mechanical designs

CFE - Expert engineer for review and development diagnostic mechanical designs

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1 Purpose

The purpose of this Contract is the expert work of an analyst that supports the whole Port Plug and Diagnostic division in the technical check / independent peer review of analysis related technical documents, in the assessment of diagnostic components designs and performance as well as in the execution of analyses of validation of diagnostic design assumptions.

2 Scope

Diagnostics are a critical part of the operation of ITER. They provide the means to observe, control and sustain the plasma performance over long timescales. ITER will operate with a plasma current in the region of 15 MA and toroidal fields of 5 T. The pulse lengths will be in the region of 500s typically and will extend up to several thousand seconds during more advanced operation. A key objective of this device is $Q=10$ operation. This means that a typical fusion power of 500 MW will be provided for 50 MW input.

There are 25 diagnostic ports in ITER Tokamak (Figure 1) hosting diagnostic systems. A large set of plasma diagnostics and other equipment are integrated in the upper (x14), equatorial(x8) and lower (x3) ports, into dedicated housing structures incorporating support equipment.

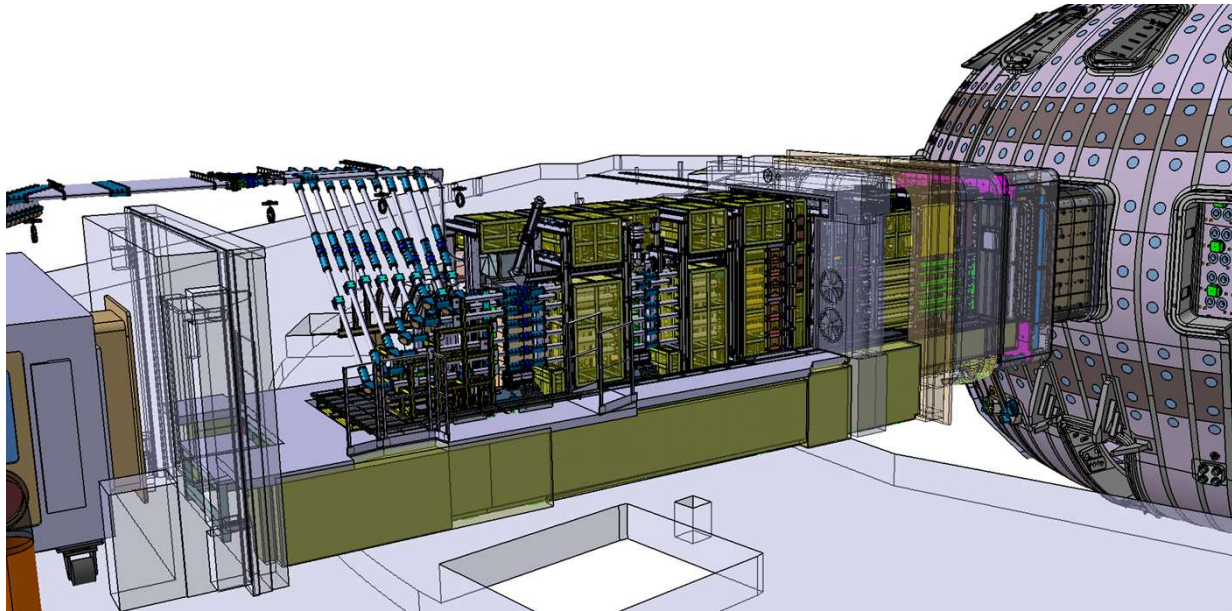


Figure 1: Disposition of an Equatorial Diagnostic Port in the ITER tokamak.

The integrated ports, i.e. the port housing structures assembled with diagnostic systems, are also subject to the harsh ITER environment, must comply with defined (safety) requirements, and must also be installable, operable and maintainable consistent with the ITER facility requirements, i.e. with the highest possible level of standardization and commonality.

Port system conventionally divided into in-vessel (out of scope) and ex-vessel parts. In-vessel part consists of port plug assembly (Figure 2) immersed in vacuum and some air side auxiliary elements (such as water cooling circuit connections, vacuum and gas pipes, mating flanges, etc.) fixed to the port plug closure plate. Port plug is inserted in the vacuum vessel port and bolted to the vacuum vessel flange via a closure plate. Ex-vessel part is composed of Interspace Support Structure (ISS) and Port Cell Support Structure (PCSS).

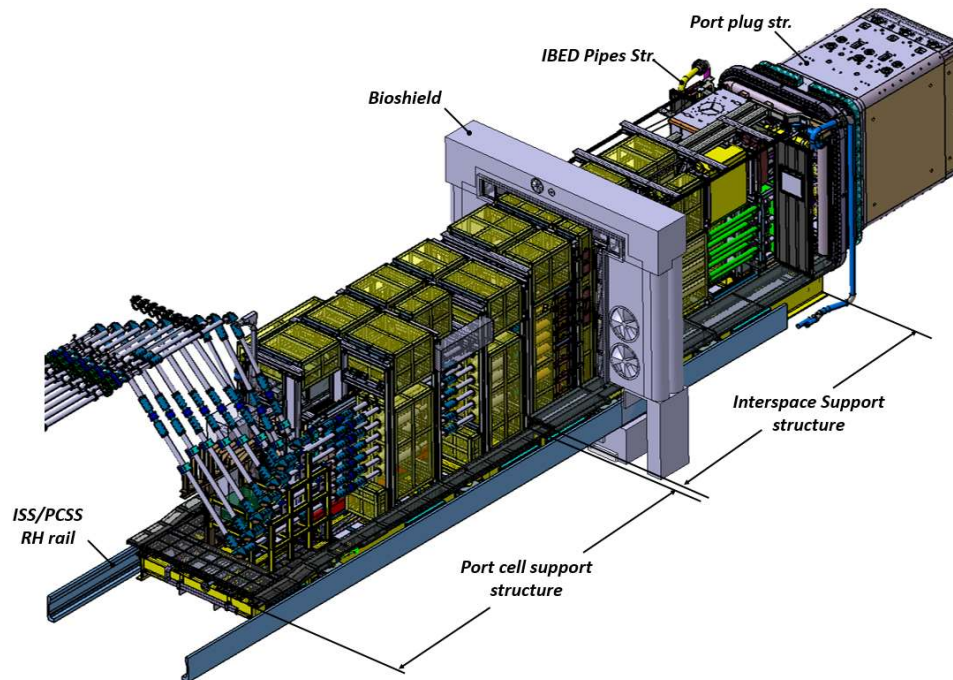


Figure 2: Typical arrangement of a Diagnostic Port in ITER.

To design and build the diagnostic systems, the 7 Domestic Agencies (DAs) are contributing in-kind, under functional specifications Procurement Arrangements (PAs) while IO also undertakes directly parts of the ITER diagnostics and integration scope.

Diagnostic Engineering Section (DES) provides engineering justification and support to diagnostic developers at IO and DAs. Also, DE section supports technical interface development with other PBSs to ensure that diagnostic systems are designed and developed to fulfil their mission.

As part of the support of DES to diagnostic developers, the work of this contract comprises the technical check and independent peer review of analysis related technical documents devoted to justify the integrity and performance in the different design stages as per internal ITER guidelines. It also includes the assessment of diagnostic designs under internal development of IO and other analyses devoted to validate diagnostic design assumptions (for example: thermal distributions in surrounding components, boundary conditions for local analyses, post-processing of analyses of other physics for loads definition, etc...).

3 Definitions

DA: Domestic Agency

DES: Diagnostic Engineering Section

DSM: Diagnostic Shield Module

EM: Electro-Magnetic

PP: Port Plug

FDR: Final Design Review

IO: ITER Organization

IO-TRO: ITER Organization technical Responsible Officer

ISS: Interspace Support Structure
PA: Procurement Arrangement
PIA: Protection Important Activity
PBS: Project Breakdown Structure
PDR: Preliminary Design Review
PCSS: Port Cell Support Structure
SLS: System Load Specifications
StIR: Structural Integrity Report
VV: Vacuum Vessel

For a complete list of ITER abbreviations see: [ITER Abbreviations \(ITER_D_2MU6W5\)](#).

4 References

N/A.

5 Estimated Duration

The duration shall be for 1 year from the starting date of the task order. Services are to be provided mostly off the IO-CT work site (but some days of visit to IO site are envisaged).

6 Work Description

The work will be for the independent review and execution of integrated and distributed diagnostic systems engineering justification by analysis, loads definition and reporting following ITER rules and guidelines. Below, a few typical examples of such diagnostic systems and areas where they have to be integrated and analysed, are given.

An example of a typical integrated diagnostic port and port plug can be seen below. Figure 2 illustrates the integrated diagnostic equatorial port in ITER. It spans from the in-vacuum part called Port Plug to the building area called Port Cell. Several diagnostic systems and service are to be integrated. They have to be supported by the port infrastructure (PP, ISS and PCSS) and buildings and have to survive typical ITER loads (EM, thermal, seismic, maintenance, accidental etc).

The deliverables are arranged by Tasks. Each task contains deliverables' type (marked as "x") description which could be assigned to the Contractor's team for completion.

Note that, depending on the needs, several deliverables of the same type can be assigned for one Task. The due date is defined in the table in Section 8.

6.1 Task 1 – Assessment and independent review of Load Specifications and Analysis Reports for diagnostic systems (port-integrated or distributed)

Deliverable type 1.1.x – Assess/ review available input files for load definitions (Seismic, Electromagnetic, Neutronic, Thermal-Hydraulics), as well as mechanical models, relevant to a given integrated diagnostic port or a given distributed diagnostic. Identify necessary analysis to complement/ update the loads on the system (in particular, interface loads) for the newest available mechanical design of the diagnostic and the port plug infrastructure following the various ITER guidelines and safety procedures for monitoring checking and verification. Document assessment in the technical report), discuss with IO analysis experts and ROs and

upload in the IDM in order to improve analyses. For Protection Important Activities and SIC components, provide inputs for the independent verification.

Deliverable type 1.2.x – Assess/ analyze available System Load Specifications for a given integrated diagnostic port or a given distributed diagnostic. Document assessment in the technical report, discuss with IO analysis experts and ROs and upload comments/ suggestions in the IDM in order to improve SLSs and analyses. For Protection Important Activities and SIC components, provide inputs for the independent verification.

Deliverable type 1.3.x – Assess/ analyze available Structural Integrity Report for a given integrated diagnostic port or a given distributed diagnostic. Document assessment in the technical report, discuss with IO analysis experts and ROs and upload comments/ suggestions in the IDM in order to improve StIR and analyses. For Protection Important Activities and SIC components, provide inputs for the independent verification.

Review and check comments to the PDR/ FDR System Load Specifications and Structural Integrity Reports for each tenant system where available. Identify and launch necessary analysis to complement/ update the loads on the system (in particular, interface loads) for the newest available mechanical design of the diagnostic and the port plug infrastructure following the various ITER guidelines and safety procedures for monitoring checking and verification. Put reports in the IDM for review by experts. For Protection Important Activities and SIC components in the integrated port, provide inputs, analysis DBs and reviews and technical check lists as per IO MQP.

6.2 Task 2 – Production of supportive analysis for diagnostic systems (port-integrated or distributed) integrity / performance justification and loads definition.

Deliverable type 2.1x – Prepare System Load Specifications for the integrated port or a given distributed diagnostic at the PDR or FDR level, following ITER guidelines: [ITER_D_33TTPJ - Guideline for ITER System Load Specifications](#). These load specifications shall be separate documents to cover in-VV, PP, Port Interspace and Port Cell Areas, respectively, and where applicable. Identify and launch necessary analysis to complement/ update the loads on the system (in particular, interface loads) for the newest available mechanical design of the diagnostic and the port plug infrastructure following the various ITER guidelines and safety procedures for monitoring checking and verification. SLS shall be discussed with expert and ROs and approved in the IDM.

The Port Plug area System Load Specifications shall contain:

- Mechanical Loads applicable;
- Electromagnetic loads due to EM transient events;
- Relevant Thermal-Hydraulic loads;
- Loads in Incident and Accident Events;
- Interface loads.

An example is given in the System Load Specifications for Diagnostic Shield Module in Equatorial Port #12 (PDR version): <https://user.iter.org/default.aspx?uid=URA3GV>.

The Port Interspace area System Load Specifications shall contain:

- Mechanical Loads applicable;
- Relevant Electromagnetic loads;
- Relevant thermal loads during normal operation and baking;
- Loads in Incident and Accident Events: fire loads included;
- Loads due to maintenance operations;
- Interface loads.

The Port Cell area System Load Specifications shall contain:

- Mechanical Loads applicable;
- Relevant thermal loads;
- Loads in Incident and Accident Events: fire loads included;
- Loads due to maintenance operations;
- Interface loads.

Deliverable type 2.2x – Development mechanical design of a dedicated diagnostic or its components from the sketch concept to the detailed model level which is implemented into CATIA/Enovia, including necessary analyses to justify fitness to purpose, performance and integrity. The final deliverable will be a descriptive document (DDD like).

Put reports and models in the IDM (engineering data base) for review by experts (example of contents of the report is given here: <https://user.iter.org/default.aspx?uid=VYTX3Y>). For Protection Important Activities and SIC components in the integrated port, provide inputs, analysis DBs and reviews and technical check lists as per IO MQP. All inputs and models, including FEA models and their descriptions, used for the supporting analyses and creation of the PDR-level Load Specifications, shall be provided to IO. The reports shall be written in clear English and all supporting reports shall be made available in the IDM for the expert review. The FE models, macros, excel files and any necessary documents to reproduce these analyses (re-run and post process) must be included in a data package.

Deliverable type 2.3x – Prepare Structural Assessment Report for the integrated diagnostic port or a given distributed diagnostic at the PDR or FDR level for up to three areas (PP/ in-VV, ISS and PCSS, attachments to the building's embedded plates), were applicable, following the [Procedure for Analyses and Calculations \(22MAL7 v6.6\)\(current\)](#) and other applicable ITER documents and guidelines.

The assessment shall be focused on principal infrastructures and shall follow the graded approach and its outputs will be used for further (local) analysis of tenant systems (where applicable) without a need for them to run the full-scale assessment.

Run and finalize all supportive analyses required for the proper definition of loads of integrated items as well as those required to characterize the interface loads of on-board systems and components.

Generation of all routines and procedures required for the correct interpolation of loads from supporting analyses to the mechanical model in which the structural assessment is based.

Discuss reports with experts and provide inputs for independent verification, if necessary. Upload the reports in the IDM for review.

Answer comments (if any) and update if necessary.

All or part of the subtask of this Task may be Protection Important Activity.

Deliverable type 2.4x – Prepare specifications documents including all particular requirements and constraints (vacuum related, material strength, material compatibility, room constraints, thermal performance...) derived from the mechanical designs developed in deliverables type 2.2x in support of manufacturing technical specifications.

7 Responsibilities

7.1 Contractor's Responsibilities

In order to successfully perform the tasks in these Technical Specifications, the Contractor shall:

- Strictly implement the IO procedures, instructions and use templates;
- Provide experienced and trained resources to perform the tasks;
- Contractor's personnel shall possess the qualifications, professional competence and experience to carry out services in accordance with IO rules and procedures;
- Contractor's personnel shall be bound by the rules and regulations governing the IO ethics, safety and security IO rules.

7.2 IO's Responsibilities

The IO shall:

- Nominate the Responsible Officer to manage the Contract;
- Organise a monthly meeting(s) on work performed;
- Provide offices at IO premises if necessary.

8 List of Deliverables and due dates

The main deliverables are provided in the table below.

T#	D #	Description	Deliverable numbers (estimated from Design Review Plan)	Due Dates
1	D1.1.x	Assess/ review available input files for load definitions (Seismic, Electromagnetic, Neutronic, Thermal-Hydraulics), as well as mechanical models, relevant to a given integrated diagnostic port or a given distributed diagnostic.	D1.1.1	T0 + 2 months
			D1.1.2	T0 + 4 months
			D1.1.3	T0 + 6 months
			D1.1.4	T0 + 8 months
			D1.1.5	T0 + 10 months

2	D1.2.x	Assess/ analyse available System Load Specifications for a given integrated diagnostic port or a given distributed diagnostic.	D1.1.6	T0 + 12 months
			D1.2.1	T0 + 3 months
			D1.2.2	T0 + 6 months
			D1.2.3	T0 + 9 months
			D1.2.4	T0 + 12 months
	D1.3.x	Assess/ analyse available Structural Integrity Report for a given integrated diagnostic port or a given distributed diagnostic.	D1.3.1	T0 + 3 months
			D1.3.2	T0 + 6 months
			D1.3.3	T0 + 9 months
			D1.2.4	T0 + 12 months
	D2.1.x	Prepare System Load Specifications for the integrated port or a given distributed diagnostic at the PDR or FDR level, following ITER guidelines	D2.1.1	T0 + 6 month
			D2.1.2	T0 + 12 months
	D2.2.x	Develop mechanical model of integrated system or its components	D2.2.1	T0 + 4 months
			D2.2.2	T0 + 8 months
			D2.2.3	T0 + 12 months
	D2.3.x	Prepare Structural Integrity Report for the integrated diagnostic port or a given distributed diagnostic at the PDR or FDR level	D2.3.1	T0 + 4 months
			D2.3.2	T0 + 8 months
			D2.3.3	T0 + 12 months
	D2.4.x	Prepare specifications documents including all particular requirements and constraints in deliverables type 2.2x in support of manufacturing technical specifications.	D2.4.1	T0 + 6 month
			D2.4.2	T0 + 12 months

9 Acceptance Criteria

The deliverables will be posted in the Contractor's dedicated folder in IDM, and the acceptance by the IO will be recorded by their approval by the designated IO TRO. These criteria shall be the basis of acceptance by IO following the successful completion of the services. These will be in the form of reports as indicated in section 8, Table of deliverables.

10 Specific requirements and conditions

Experience in FEA analysis applied to diagnostic for fusion plasma.

Experience in developing plasma diagnostic mechanical designs.

Experience in using ANSYS Classic & workbench v.15 or higher analysis and pre-processing models from CAD (Catia/ SpaceClaim / DesignSpace).

Experience in FEA pre-processing, mesh generation and model's quality assessment;

Experience in Mechanical (linear/non-linear/static/dynamic);

Experience in thermal-hydraulic analysis (single and coupled);

Experience in ParaView and post-processing tool (interface with ANSYS to be developed);

Experience in advanced Finite Element Analysis techniques (sub-modelling, interpolation, contact technologies, programming (APDL) and coupled field analysis);

Experience in structural assessment Code post-processing techniques (linearization and categorization of stresses, fatigue, limit analysis, non-linear analyses);

Experience in structural assessments using ITER-relevant nuclear Codes and Standards (RCC-MR ed. 2007);

Experience in creation of Load Specifications for ITER complex integrated systems and management of interface loads between upper level components and tenant systems following an integrated analysis approach;

Monitoring and reporting of status of projects;

Communication with international local and remote teams in context of nuclear fusion research or similarly complex research and engineering environment;

Organization, taking minutes and action tracking of international meetings;

Understanding of schematics and 3D models.

11 Work Monitoring / Work Monitoring / Meeting Schedule

Work is monitored through reports (see List of Deliverables section).

12 Delivery time breakdown

See Section 8 "List Deliverables section and due dates".

13 Quality Assurance (QA) requirements

The organisation conducting these activities should have an ITER approved QA Program or an ISO 9001 accredited quality system.

The general requirements are detailed in [ITER Procurement Quality Requirements \(ITER_D_22MFG4\)](#).

Prior to commencement of the task, a Quality Plan must be submitted for IO approval giving evidence of the above and describing the organisation for this task; the skill of workers involved in the study; any anticipated sub-contractors; and giving details of who will be the independent checker of the activities (see [Procurement Requirements for Producing a Quality Plan \(ITER_D_22MFMW\)](#)).

Documentation developed as the result of this task shall be retained by the performer of the task or the DA organization for a minimum of 5 years and then may be discarded at the direction of the IO. The use of computer software to perform a safety basis task activity such as

analysis and/or modelling, etc. shall be reviewed and approved by the IO prior to its use, in accordance with IO Software Policy.

14 CAD Design Requirements (if applicable)

For the contracts where CAD design tasks are involved, the following shall apply:

The Supplier shall provide a Design Plan to be approved by the IO. Such plan shall identify all design activities and design deliverables to be provided by the Contractor as part of the contract.

The Supplier shall ensure that all designs, CAD data and drawings delivered to IO comply with the Procedure for the Usage of the ITER CAD Manual ([2F6FTX](#)), and with the Procedure for the Management of CAD Work & CAD Data (Models and Drawings [2DWU2M](#)).

The reference scheme is for the Supplier to work in a fully synchronous manner on the ITER CAD platform (see detailed information about synchronous collaboration in the ITER [GNJX6A](#) - Specification for CAD data production in ITER Contracts.). This implies the usage of the CAD software versions as indicated in CAD Manual 07 - CAD Fact Sheet ([249WUL](#)) and the connection to one of the ITER project CAD data-bases. Any deviation against this requirement shall be defined in a Design Collaboration Implementation Form (DCIF) prepared and approved by DO and included in the call-for-tender package. Any cost or labour resulting from a deviation or non-conformance of the Supplier with regards to the CAD collaboration requirement shall be incurred by the Supplier.

15 Safety requirements

ITER is a Nuclear Facility identified in France by the number-INB-174 ("Installation Nucléaire de Base").

For Protection Important Components and in particular Safety Important Class components (SIC), the French Nuclear Regulation must be observed, in application of the Article 14 of the ITER Agreement.

In such case the Suppliers and Subcontractors must be informed that:

- The Order 7th February 2012 applies to all the components important for the protection (PIC) and the activities important for the protection (PIA).
- The compliance with the INB-order must be demonstrated in the chain of external contractors.
- In application of article II.2.5.4 of the Order 7th February 2012, contracted activities for supervision purposes are also subject to a supervision done by the Nuclear Operator.

For the Protection Important Components, structures and systems of the nuclear facility, and Protection Important Activities the contractor shall ensure that a specific management system is implemented for his own activities and for the activities done by any Supplier and Subcontractor following the requirements of the Order 7th February 2012 ([PRELIMINARY ANALYSIS OF THE IMPACT OF THE INB ORDER - 7TH FEBRUARY 2012 \(AW6JSB v1.0\)](#)).

Compliance with [Defined requirements for PBS 55 - Diagnostics \(NPEVB6 v1.3\)](#) or its flowed down requirements in [SRD-55 \(Diagnostics\) from DOORS \(28B39L v5.2\)](#) is mandatory.