

Technical Specifications (In-Cash Procurement)**Technical Specification - Support for Propellant
Modelling of Disruption Mitigation System**

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1 Purpose

The purpose of this call is to provide support for the development of the ITER Disruption Mitigation System (DMS).

2 Scope

The scope of the work will be consulting and providing design solutions for the DMS for fluid studies. This will be predominantly Computational Fluid Dynamics (CFD) but may also include other calculation methods. The main focus of the work will be on modelling the propellant gas that is used to propel pellets of frozen gas towards the ITER Tokamak, please see section 6.1 for an introduction to the ITER DMS and section 6.2 for the Engineering Analysis required for this Call For Expertise (CFE). This contract will provide guidance for future design and experimental work.

3 Definitions

This section is mandatory.

Include here all those relevant to this document.

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

4 References

[1] Template for CFD analysis reports, ITER_D_TL7H73 v1.1

5 Estimated Duration

The overall duration of this work is 12 months.

6 Work Description

The work involves provision of technical expertise and to work together with the IO-TRO and the DMS design team primarily; it may also require working with the DMS Task Force (TF) or contractors supporting the design or related research and development activities.

6.1 Introduction

The purpose of the ITER Disruption Mitigation System (DMS) is to provide machine protection in order to reduce the detrimental effects of plasma disruptions and to ensure the appropriate lifetime of all affected ITER components. It utilises cryogenic hydrogen and neon pellets which are generated inside the injectors which are located in the ISS. These pellets are pneumatically propelled in the time frame of milliseconds towards the plasma and just before entering the plasma are shattered into small fragments to enter the plasma and to reduce damage to the plasma facing components and other structures inside the ITER tokamak. A typical injector design for the equatorial ports can be seen in fig. 1.

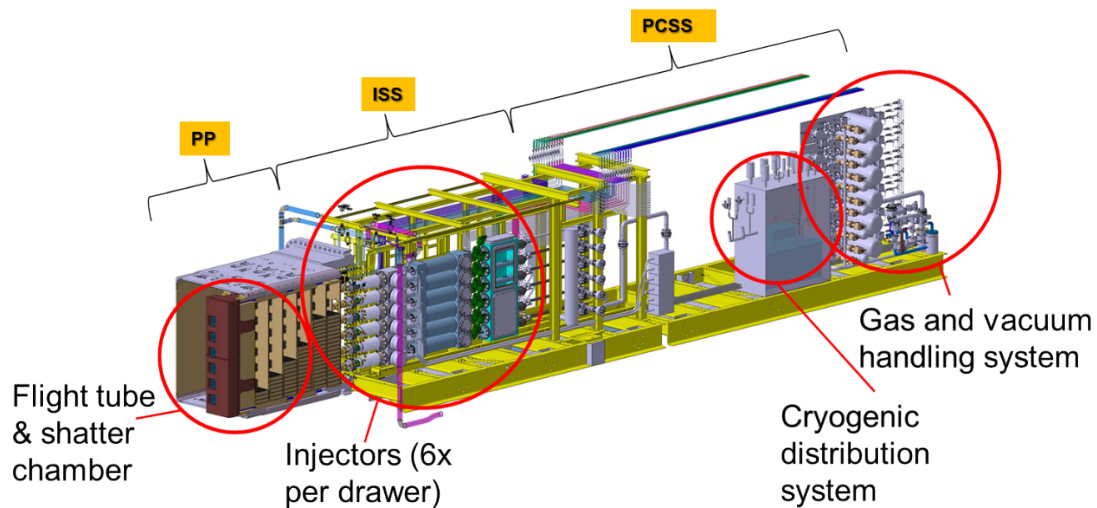


Figure 1: Typical DMS in EP integrated into the ISS and PCSS.

The Disruption Mitigation System (DMS) 18.DM is a rapidly growing system at post-CDR development level.

The DMS uses high pressure gas (as a baseline 100 bar g hydrogen) to pneumatically propel the pellets towards the plasma. An area of concern is that too much propellant gas may reach the plasma before the pellet which would affect the chosen mitigation scheme.

The first implementation of SPI technology on DIII-D suffered due to failure to recover a significant proportion of the propellant gas. The JET DMS used an extensive vacuum system for propellant recovery that recovered a much greater proportion of the propellant gas. However, space and other constraints at ITER will prevent installation of a similar propellant recovery system. The ITER system will investigate the use of a smaller vacuum system that includes a number of structures designed to delay the propellant gas. The port plug structure will also be able to contribute towards delaying the propellant gas.

A second but related part of this call for expertise will be the modelling of the migration of activated dust. This may collect with the port plug or DMS equipment and lead to an increased hazard during maintenance.

6.2 Engineering Analysis

Prepare a CFD based methodology to simulate pellet injection into the propellant suppression volume and port plug in order to quantify the related exhaust of the propellant gas. Figure 2 is a cross section image showing the major components.

The aim is to quantify the amount of propellant gas that enters the torus ahead of the pellet. For reference the pellet should reach the torus in ~25ms-50ms but this is dependent on numerous factors but a time of 50ms should be used for estimations. The geometry of the DMS and the port plug will be supplied by IO. For costing purposes typical geometry will be supplied at the time of bid submission. The propellant gas profile will either be given by IO to the contractor or IO will give the contractor the information required to calculate the propellant gas profile.

Provide a conceptual design solutions for structures that can be used to delay the propellant gas and quantify their performance.

Provide recommendations for further improvement of the system design and operational performance.

Investigate and quantify the migration of activated dust into the DMS locations. It is assumed that firing the propellant gas may remove some of the activated dust, this will also be investigated and quantified. This task will require quantifying the amount of dust that accumulates within the port plug structure and quantifying how much of this dust can be removed by firing the propellant valve.

The software used for this contract can either be commercial, open source or developed in house. The contractor will need to provide verification that the software used is suitable for this contract with their bid submission. Copies of all subroutines, input files, source codes, and compiled executables shall be supplied to IO so that the analysis can be repeated at the IO site.

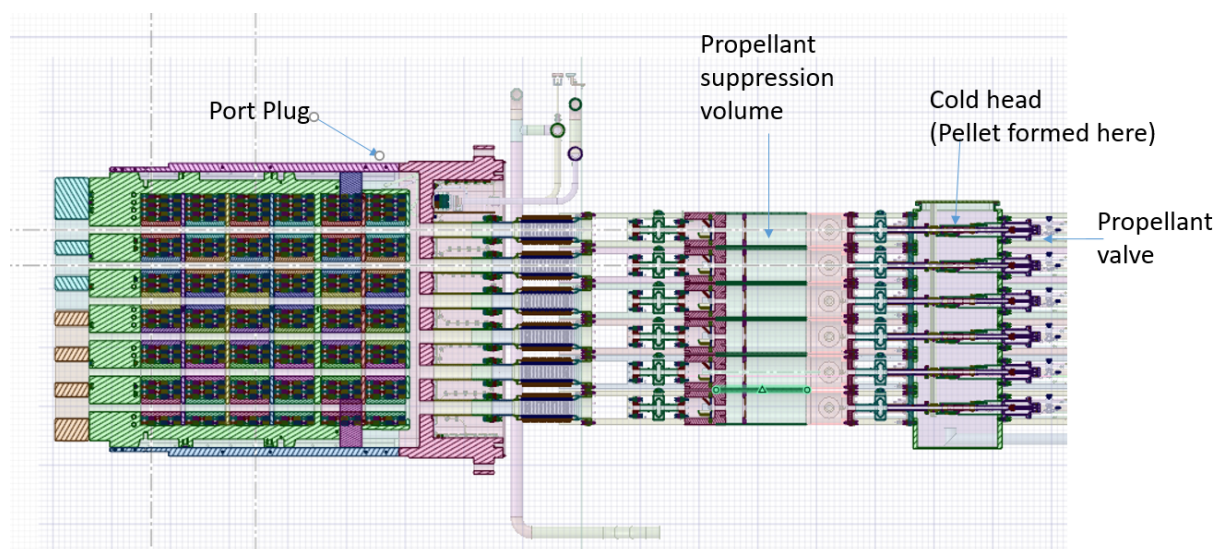


Figure 2: Cross section image showing propellant valve, cold head, propellant suppression volume, and port plug

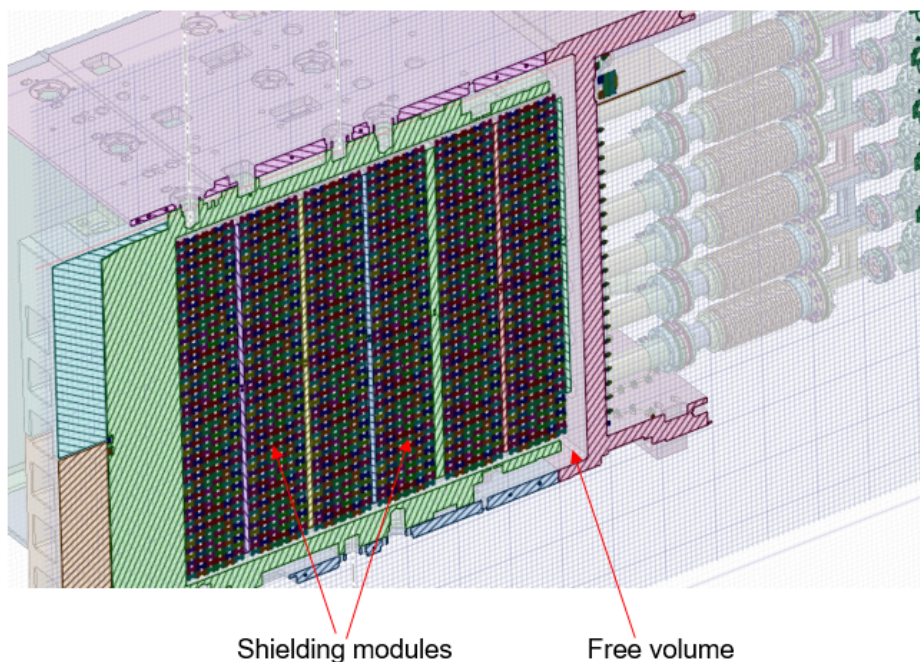


Figure 3: Cross section of port plug showing shielding modules and free volume

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 template *template for CFD analysis* [1] when creating analysis reports;
- 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.
- Provide copies all subroutines, input files, source codes, and compiled executables

The official language of the ITER project is English. Therefore, all input and output documentation relevant to this Contract shall be in English. The Contractor shall ensure that all the professionals in charge of the Contract have an adequate knowledge of English, to allow easy communication and adequate drafting of technical documentation. This requirement also applies to the Contractor's staff working at the ITER site or participating in meetings with the ITER Organization.

7.2 IO's responsibilities

The ITER Organization shall

- Nominate the Responsible Officer to manage the Contract;
- Organise regular meeting(s) on work performed;
- Provide CAD designs of DMS and port plug by using the IO Data Exchange procedure

The ITER Organization shall in addition give the possibility to the contractor to review documents on the ITER documents database (IDM). Furthermore the IO shall make all technical data and documents available to the Contractor which will be required to carry out its obligations in a timely manner.

8 List of deliverables and due dates

D#	Description	Due Date*
D1	Report 1 on DMS Fluid Studies	T0 + 2 months
D2	Report 2 on DMS Fluid Studies	T0 + 4 months
D3	Report 3 on DMS Fluid Studies	T0 + 9 months
D4	Report 4 on DMS Fluid Studies	T0 + 12 months

*T0 corresponds to the date of the signature of the contract.

8.1 Report 1

The first report will find and detail the fundamental science and equations that describe this problem, from pellet propulsion to the propellant gas entering the torus. In addition this report will also detail how each type of problem will be solved, be it hand calculation, CFD etc. and show how the results are validated.

8.2 Report 2

Analysis and report using the current ITER port plug design and DMS design. The aim is to quantify the amount of propellant gas that enters the torus ahead of the pellet

The geometry will be supplied prior to the start of deliverable 2. Please note that geometry may change from that given in at bid submission but will be of similar level of detail.

The geometry can be de-featured for ease of analysis but it must be demonstrated that it is still representative. The propellant gas profile will either be given by IO to the contractor or IO will give the contractor the information required to calculate the propellant gas profile.

An essential part of this task is the verification of the results from CFD analysis.

8.3 Progress report 3

Investigate changes to the design to reduce the amount of gas that arrives ahead of the pellet. The main variables to be investigated are:

Geometry Changes

- Structures placed within the propellant suppression volume
- Rearrangement or even removal of parts the shielding within the port plug itself.
 - Within reason it may be possible to rearrange or even remove some of the shielding, illustrated in Figure 3, within the port plug if it can be demonstrated that this will reduce the amount of propellant gas arriving ahead of the pellet to an acceptable level.
- Use of a fast shutter downstream of the propellant suppression volume.

Fluid changes

- Propellant gas profile
 - A totally separate contract is investigate the pellet launcher unit which may result in a significantly different propellant gas profile.

For costing purposes it should be assumed that that 12 sub-models should be run testing aspects of the changes in isolation. In addition five runs of the entire ITER DMS and port plug geometry will be required. The exact details of each analysis model will be discussed and agreed throughout the duration of the contract.

12 Sub-models investigating:

- Propellant Suppression Volume geometry variations
- Port plug volume/shielding module rearrangement variations
- Fast Shutter timing
- Propellant gas profile

The five full models will be agreed during the project. But they will include aspects of the sub-models listed above and will be used to confirm the overall performance gain.

8.4 Report 4

This report will investigate dust migration from the torus into the port plug structure and/or the DMS components. The Tungsten and Beryllium dust will be generated from plasma surface interactions with the divertor and the first wall, this dust may become activated or contaminated with tritium during ITER operations. If sufficient quantities are present in DMS components this could cause a hazard for maintenance activities.

This report will calculate the type and quantity of dust that settles within the port plug and DMS equipment over time.

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 the approval of 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

The person proposed shall have at least 15 years of proven experience in the following areas:

- Degree in engineering, doctorate preferred.
- Experience in rarefied gas dynamics; fundamentals and simulations.
- Experience in CFD, specifically simulation of high pressure gas discharges in vacuum.
- Knowledge of dust migration studies and analysis.
- Previous experience of engineering analysis at fusion facilities.
- Experience of validation of complex fluid problems.
- Experience with creating technical documents and presentations.

11 Work Monitoring / Meeting Schedule

The work will be managed by means of Progress Meetings and through the formal exchange of documents and transmitted by emails which provide detailed progress.

Progress Meetings will be called by the ITER Organization or the C-TRO. They will be held as needed and at least bi-monthly, either on the IO site or via videoconference. Progress meetings will involve C-TRO(s) and the IO-TRO. External experts will be invited – if needed – to discuss technical matters. The C-RO and IO-RO will be invited in case of contractual discussions.

For all Progress Meetings, minutes, including action items, shall be written by the C-TRO and be stored in the ITER IDM in order to ensure traceability (see also Deliverable D7 in section

12 Delivery time breakdown

T0 is the date of the contract signature. 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 [Quality Assurance for ITER Safety Codes \(ITER_D_258LKL\)](#).

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](#)).

Drawing Registration in the IO system shall be performed according to the Procedure for the Management of Diagrams and Drawings in pdf Format Using the SMDD Application ([KFMK2B](#)).

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 [P7Q3J7](#) - Specification for CAD data Production in ITER direct 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 (PIC) 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 (as per *ITER D PSTTZL*) 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 ITER D 45P8YK Defined requirements PBS 18 DMS is mandatory.