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Technical Specifications (In-Cash Procurement)

Technical Specifications for the Development of a Propellant Valve Prototype

The scope of this contract is to develop a prototype of a propellant valve for the ITER DMS. The work comprises the design, manufacturing and testing of fast eddy current driven valve to deliver high pressure gas upon receipt of a trigger.
This is a contract within the DMS Task Force technology activities.

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1 Preamble

This Technical Specification is to be read in combination with the General Management Specification for Service and Supply (GM3S) [1] that constitutes a full part of the technical requirements.

In case of conflict, the content of the Technical Specification supersedes the content of reference [1].

2 Purpose

Purpose of this document is to give the technical specifications for the development, manufacturing and testing of a propellant valve prototype for the ITER DMS.

3 Acronyms & Definitions

3.1 Acronyms

The following acronyms are the main one relevant to this document.

Abbreviation	Description
MTO	Material Take Off
CRO	Contract Responsible Officer
GM3S	General Management Specification for Service and Supply
IO	ITER Organization
PRO	Procurement Responsible Officer

3.2 Definitions

Term	Definition/Abbreviation
DMS	Disruption Mitigation System
FAT	Factory Acceptance Test
FDR	Final Design Review
MRR	Manufacturing Readiness Review
NDT	Non-Destructive Testing

4 Estimated duration

The estimated duration for the contract is 24 months.

5 Applicable Documents & Codes and standards

5.1 Applicable Documents

It is the responsibility of the Contractor to identify and request for any documents that would not have been transmitted by IO, including the below list of reference documents.

This Technical Specification takes precedence over the referenced documents. In case of conflicting information, it is the responsibility of the Contractor to seek clarification from IO.

Upon notification of any revision of the applicable document transmitted officially to the Contractor, the Contractor shall advise within 4 weeks of any impact on the execution of the contract. Without any response after this period, no impact will be considered.

Ref	Title	IDM Doc ID	Version
1	General Management Specification for Service and Supply (GM3S)	82MXQK	1.4
2	Requirements for Producing a Contractors Release Note	22F52F	5.0
3	Quality Classification Determination	24VQES	5.2
4	ITER Vacuum Handbook	2EZ9UM	2.5
5	ITER Seismic Nuclear Safety Approach	2DRVPE	1.6
6	A. Savtchkov, K.H. Finken, G. Mank, Rev. of Sci. Instr., Vol. 73, Issue 10 (2002), https://doi.org/10.1063/1.1505106.	-	-

5.2 Applicable Codes and Standards

This is the responsibility of the Contractor to procure the relevant Codes and Standards applicable to that scope of work.

Ref	Title	Doc Ref.	Version
CS1	EN 10204:2005 Metallic products. Types of inspection documents	-	-
CS2	2014/68/EU: Pressure Equipment Directive	-	-

6 Background

ITER is a major new device that is under construction at Cadarache, near Marseille, France. This device will study the potential of controlled nuclear fusion to provide safe, clean and virtually limitless energy for humankind. To protect the machine from the consequences of plasma disruptions during high power operations, a DMS is required.

The current DMS is based on the Shattered Pellet Injection technology. This works on the basic principle of a cryogenic pipe gun:

- a pellet consisting of protium or neon is formed inside a cryogenically cooled section of a pipe (the “barrel”),
- the pellet is kept at low temperature (~5K) being ready to be launched,
- high-pressure hydrogen gas shears off the pellet from the barrel walls and propels it down the barrel and the pellet enters a flight line to travel towards the plasma,
- just before the pellet reaches the plasma, it contacts a strike plate or tube bend (the “shatter chamber”) which causes it to shatter.

The high-pressure hydrogen gas is to be delivered by a fast-acting gas valve upon receipt of a trigger request from the central interlock system of ITER. The whole assembly will be installed inside the port cells, where the component will be exposed to ambient magnetic field, radiation and neutron bombardment.

The purpose of this contract is to develop a prototype of an eddy current driven valve and adequate power supply for the ITER DMS. For testing purposes a power supply can be provided by IO if needed.

7 Work description

This section defines the specific scope of work, in addition to the contract execution requirement as defined in [1].

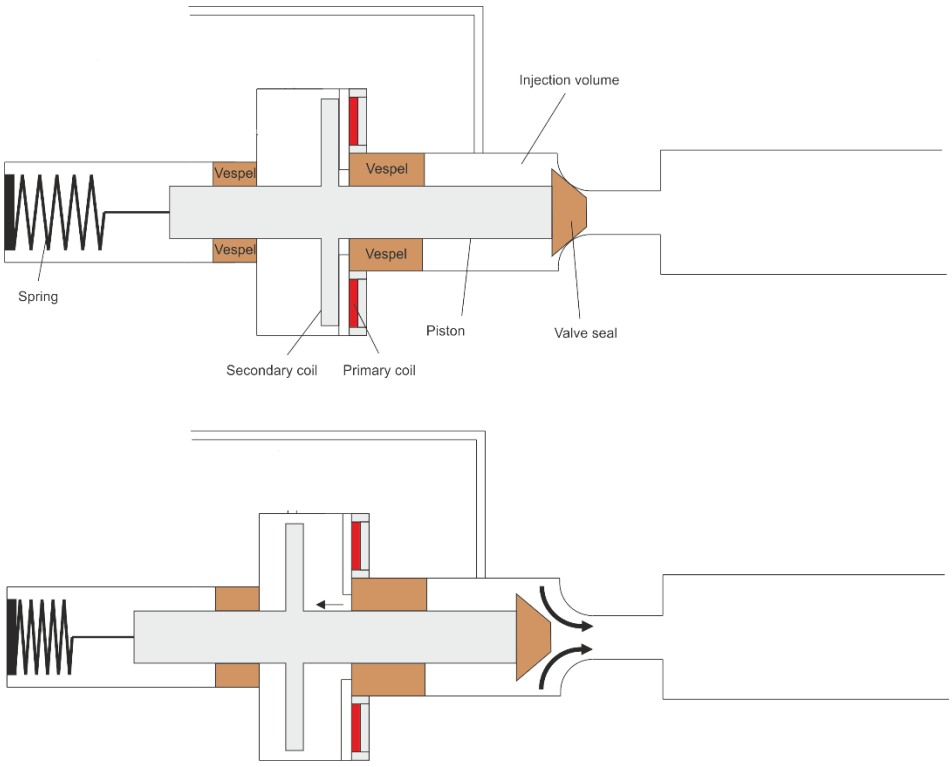
The scope of the service contract is the design, the manufacturing and the testing of the propellant gas valve as detailed in the following sections.

7.1 Task #1

7.1.1 Description

The task #1 is the detailed design of the propellant valve, including a CAD model and a Design Description Document containing the calculations and reasoning behind the design.

The propellant valve shall be an eddy current valve similar to the valves developed at the Forschungszentrum Jülich [6]. These valves have been operated successfully in magnetic fields without shielding and were therefore chosen as propellant valves for the ITER DMS in the port cell environment. The valve must open within 1 ms with a minimal time jitter and must deliver up to 6 barL Hydrogen. The injected amount shall be controllable through the coil voltage and propellant valve pressure.



For task #1, the Contractor shall deliver the following:

1. Detailed CAD model of the valve
2. Design Description Document of the valve
3. FDR

7.1.2 Design Requirements

The valve shall fulfil the following requirements:

- Opening time ≤ 1 ms
- Delivered gas amount ≤ 6 barL (adjustable through coil voltage)
- Operating pressure ≤ 60 bara [CS2]
- Valve plenum size 250 cm³
- Leak rate over valve seal (at all times) ≤ 1*10^-6 mbarL/s
- Leak rate to atmosphere (at all times) ≤ 1*10^-8 mbarL/s
- Operating voltage 800 V – 1200 V
- Vacuum class VQC-1A [4]
- Quality class QC-4 [3]
- Seismic class SC2 [5]
- Mean cycles between failures ≥ 10,000

7.1.3 Environmental requirements

The valve shall be able to operate in these ambient conditions without additional shielding:

- Operating temperature ≤ 50°C
- Radiation level 10^6 Gy

- Ambient magnetic field 400 mT

7.1.4 Interface requirements

The valve shall have the following interfaces:

- Nozzle diameter 8 mm
- Barrel interface do = 15 mm, s = 1.5 mm
- Cryostat interface KF flange with do = 190 mm
- Propellant gas inlet ¼" female VCR
- Pellet gas inlets 2x ¼" male VCR on KF
- Cold cell electric feed throughs 3x 25pin Sub-D female on KF
- Valve size D = 130 mm, L = 180 mm

7.1.5 CAD requirements

The CAD model shall fulfil the following requirements:

- The CAD model shall contain all components that will be present in the actual valve with correct dimensions and materials.
- The CAD model shall be submitted in CATIA or .stp format.

7.1.6 Delivery Time

The maximum expected duration for this task is 4 months, including a simple FDR.

7.2 Task #2

7.2.1 Description

The task #2 is the manufacturing of the propellant valve, including the MRR, the manufacturing drawings and the FAT results.

After successful FDR, the manufacturing drawings have to be prepared and the Factory Acceptance Tests have to be specified. This is then reviewed in the MRR. After successful MRR, the Contractor shall manufacture the valve and perform the FAT.

As part of task #2, the Contractor shall deliver the following:

1. Manufacturing Drawings
2. FAT specifications
3. MRR
4. FAT results

7.2.2 FAT Requirements

The FAT shall contain at least the following tests:

- Dimensional Test
- PT of pressurized welds

- Volumetric NDT of pressurized welds
- He Leak test against atmosphere
- Pressure test with pressure ≥ 90 bara

7.2.3 FAT result Requirements

The FAT results shall contain at least the following tests:

- Dimensional Drawing with "As manufactured" values
- PT report of pressurized welds
- Volumetric NDT report of pressurized welds
- He Leak test report
- Pressure test report

7.2.4 Delivery Time

The maximum expected duration for this task is 11 months, including a simple MRR.

7.3 Task #3

7.3.1 Description

The task #3 is the testing of the propellant valve, including functional test, test in magnetic field and cycle test.

Under the scope of the task #3, the Contractor shall deliver the following:

1. Test report of the functional test (opening time, valve plate movement, gas release)
2. Test report of the magnetic field test (test setup, gas release at different B-fields)
3. Test report on the cycle test (1000 cycles, gas release over time, inspection for wear)
4. Pellet release test

7.3.2 Functional test Requirements

The functional test shall at least cover the following items

- Opening time of the valve
- Leak rate over the valve seal
- Movement profile of the valve plate
- The amount gas released
- Gas release and supply voltage relation

7.3.3 Magnetic field test Requirements

The magnetic field test shall at least cover the following items

- The amount gas released at different magnetic field strengths
- 100 valve cycles at 400 mT and observation of gas release

7.3.4 Cycle test Requirements

The cycle test shall at least cover the following items

- 1,000 cycles at 60 bar filling pressure without magnetic field
- Leak test over valve seal after cycle test
- Inspection for wear

7.3.5 Pellet release tests

The propellant valve and its power supply shall be shipped to one of the ITER DMS test laboratories (Budapest/Hungary or Grenoble/France). The choice will depend on the actual operation schedule at the time the propellant valve is available for pellet release tests. In the offer the maximum shipping costs shall be included.

The release of protium (H) pellets and neon (Ne) with H shell pellets shall be tested. As target, the H pellet shall achieve velocities of ~500 m/s. In addition, the lower range, i.e. gas amount is just enough to release the pellet, and upper range (max operational pressure and opening duration) shall be explored for H and Ne with H-shell pellets.

7.3.6 Delivery Time

The maximum expected duration for this task is 9 months.

7.4 Optional Task #4

7.4.1 Description

A power supply, currently being manufactured for the ITER DMS, for providing a fast voltage discharge to energize the primary coil of the eddy current valve can be provided by IO. In case the power supply is not suitable for the design as proposed by the Contractor, an adequate power supply should be specified and built by the Contractor. The additional costs will be covered by releasing the optional task 4.

8 Location for Scope of Work Execution

The Contractor shall perform the work at their own location.

9 IO Documents & IO Free issue items

No input nor free issue item is expected from IO.

10 List of deliverables

The Contractor shall provide IO with the documents and data required in the application of this technical specification, the GM3S [1] and any other requirement derived from the application of the contract.

You can find here below a minimum list of documents, but not limited to, that are required within the expected timing:

#	Task	Deliverable / Technical Design Family	Detailed description	Due date in months (T0+x)*
D1	T1	Design Description Document	Propellant valve Design Description Document	T0+3
D2		Report	FDR Report	T0+4
D3	T2	Drawings	Manufacturing drawings	T0+6
D4		Report	FAT specifications	T0+6
D5		Report	MRR Report	T0+8
D6		Report	FAT results	T0+15
D7	T3	Report	Functional test results	T0+18
D8		Report	Magnetic field test results	T0+21
D9		Report	Cycle test results	T0+24

(*) T0 = Commencement date of the contract; X in months.

Contractor shall prepare their document schedule based on the above and using the template available in the GM3S [1] appendix II (click here to download).

11 Quality Assurance requirements

The Quality class under this contract is QC-4 and the GM3S section 7 [1] applies in line with the defined Quality Class.

12 Safety requirements

No specific safety requirement related to PIC components apply.

12.1 Pressure Equipment

The propellant valve is pressure equipment under [CS2]. The design has to be made accordingly, the necessary NDT and marking has to be done and the testing at pressure has to be performed with the necessary safety precautions in place.

12.2 Seismic class

The valve is seismic class SC2. The design must show through analysis that it can withstand the accelerations (X = 62.8 m/s², Y = 141.6 m/s², Z = 178 m/s²).

13 Specific General Management requirements

Requirement for GM3S section 6 [1] applies completed/amended with the below specific requirements:

13.1 Contract Gates

In addition to the contract gates as defined in [1] section 6.1.5, the scope of work call for Contract gates (FDR, MRR) as defined in section 7 of this document.

13.2 Meeting Schedule

The Contractor shall organize regular videoconferences in agreement with IO to present the progress.

13.3 CAD design requirements

This contract requires for CAD activities and GM3S section 6.2.2.2 [1] applies.