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Technical Specifications (In-Cash Procurement)

Technical specification for Engineering services for PMS-ACCC-DDliner and HVB design-2

Technical specification for Engineering services for PMS-ACCC-DDliner and HVB design second part

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1. Abstract

This document describes technical needs and deliverables of Neutral Beam Heating and Current Drive (NB H&CD) section in engineering services to design the Neutral Beam Injectors (NBI).

2. Background and Objectives

The Neutral Beam (NB) Heating & Current Drive (H&CD) system is designed to:

- Help in accessing the H-mode and heating the ITER plasma at Q>10,
- Provide steady state current drive capability (on-axis, off-axis) for DT, D, H and He plasmas,
- Modify current density and q profile,
- Provide plasma rotation,
- Provide power to sustain the density during shutdown and allow for controlled transition from H to L-mode at the end of burn.

The H&CD NB system consists of two injectors (see below a view of ONE injector). Space is available in the building and on the tokamak for a third system. Each H&CD injector will deliver an atomic deuterium beam of 16.5 MW, with energy of 1 MeV, and will be able to operate for long pulses (up to 3,600 s for "steady state" operation). A system based on negative (D-) ions is used.

In addition to H&CD, plasma rotation is also provided by the NB H&CD injectors.

For the H - He operation phase of ITER, the H&CD injectors can be operated in hydrogen, with beam energy ≤ 0.87 MeV and neutral beam power ≤16.5 MW per injector to the ITER plasma.

		H - He	**D & DT**	**Upgrade** (1)
NB H&CD injection power	MW	≤33	≤33	≤50
Number of heating neutral beam injectors		2	2	3
Injected species		H^0	H^0 or D^0	H^0 or D^0
NBCD beam energy	MeV	0.87	0.87or 1.0	0.87or 1.0
NB H&CD - number of allocated equatorial ports		2	2	3
NB tangency radius(1)	m	5.31	5.31	5.31
NB lowest beam axis level at the tangency poin	mm	417	417	417
NB highest beam axis level at the tangency point(1)	mm	+156	+156	+156
Approximate NB e-folding length of beam profile at the	m	≈0.32	≈0.32	≈0.32
Approximate NB e-folding length of beam profile at the	m	≈0.22	≈0.22	≈0.22

Table 1: NB Heating and Current Drive Parameters

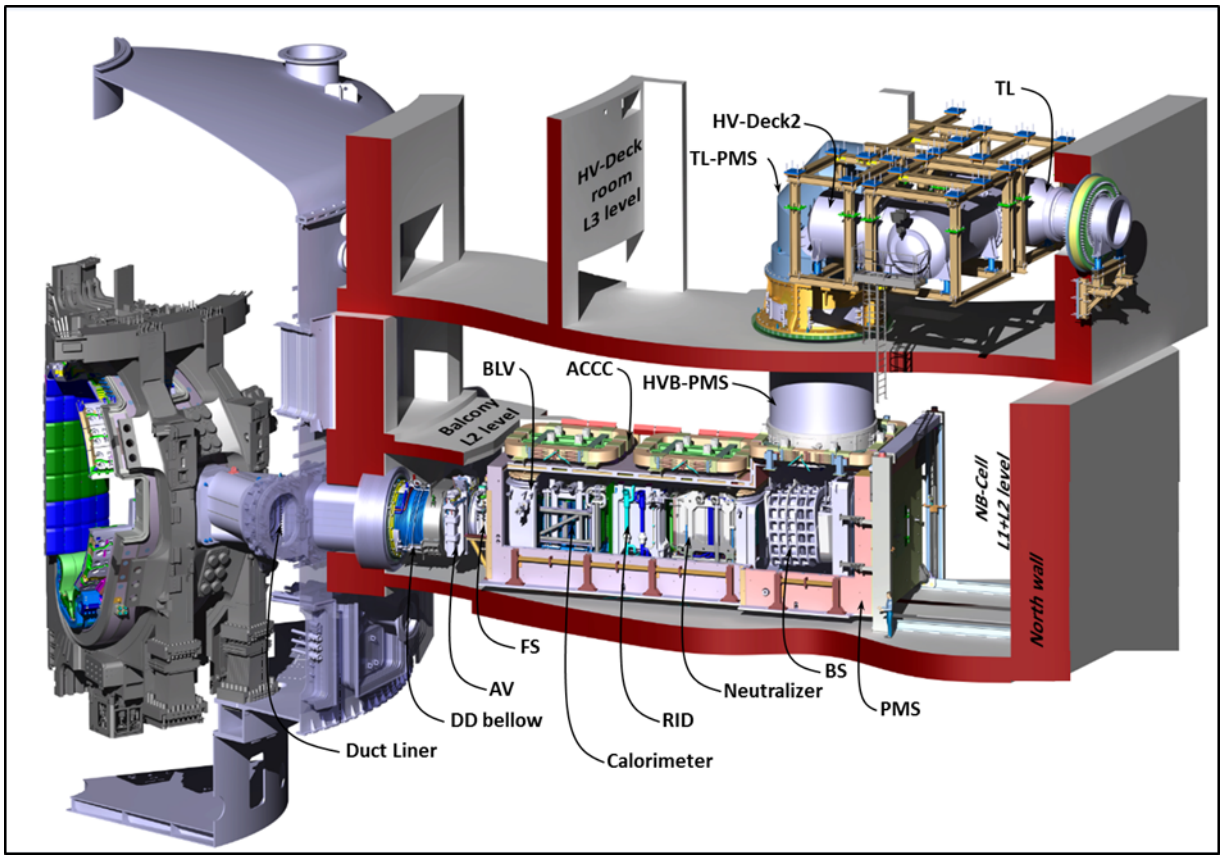

Figure 1: 3D view of Heating Neutral Beam injector

3. Definitions

ACCC	Active Correction/Compensation Coil
CAD	Computer-Aided Design
FMECA	Failure Mode, Effects and Criticality Analysis
H&CD	Heating & Current Drive
IS	Interface Sheet
HNB	Heating Neutral Beam
PA	Procurement Arrangement
PDF	Plant Definition Form
PMS	Passive Magnetic Shield
RAMI	Reliability, Availability, Maintainability & Inspectability
RH	Remote Handling
RID	Residual Ion Dump
TDF	Task description Form
TRO	Technical responsible Officer

For a complete list of ITER abbreviations see: ITER Abbreviations (ITER_D_2MU6W5)

4. Scope of Work

The beam-line components, vessels passive magnetic shield and coils of the ITER heating neutral beam injectors (HNB) are to be supplied by the EU Domestic Agency (EU-DA) as well as the drawings. See Figure 1.
The objective of this engineering contract is to perform the following tasks:

- Following-up the design activities related to the following HNB components:
  - the Passive Magnetic Shield (PMS),
  - the Active Correction Compensation Coils (ACCC),
  - the Fast Shutter (FS),

  to bring their maturity design from the preliminary design to the final design and to start preparing the call for tender for the manufacturing phase; this covers preparation of all documents necessary for the PA signature.
- To review the HVB seismic analysis including the modification of the associated report and documents.

5. Estimated Duration

The duration shall be 24 month from the starting date of the contract. Up to 8 trips are foreseen during this contract.

The work will be fully based at the ITER Organization Worksite.

6. Work Description

6.1 Activities related to the PMS

6.1.1 PMS description

6.1.1.1 The PMS is an assembly of the following parts:

The PMS is making up of different parts and materials its total mass is around 730tons. It is constituted of:

- Low carbon steel plates,
- Polyethylene plates located on the side, the top and the rear of the HNB injector
- Lead plates located on the side, and the rear of the HNB injector.
- The PMS includes the magnetic shielding of: BLV and BSV; HVB and TL elbow.

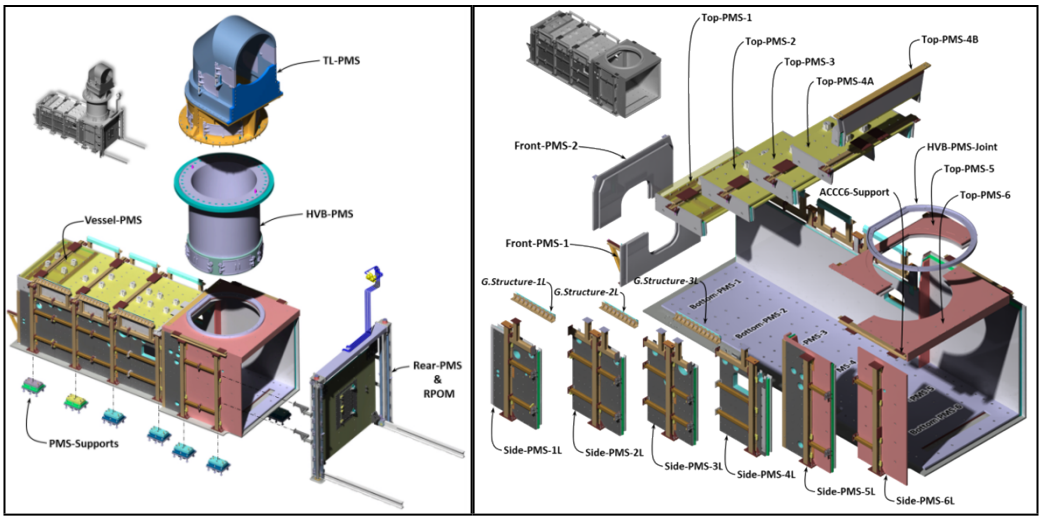

Figure 2: Different parts of the PMS and the vessel-PMS

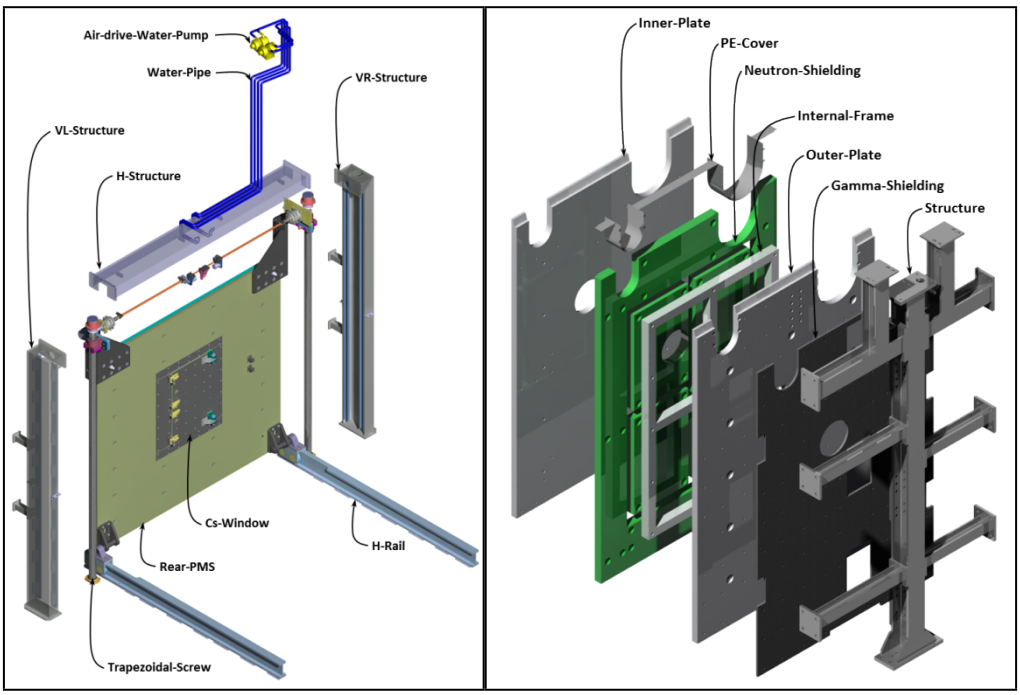

Figure 2: Different parts of the RPOM and a side-PMS

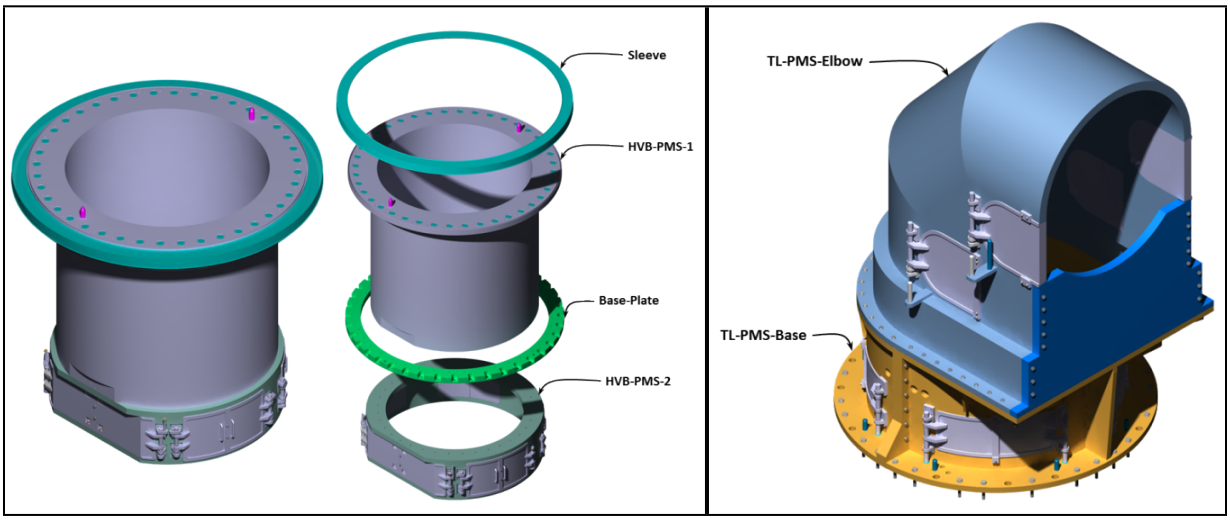

Figure 2: Different parts of the HVB-PMS and the TL-PMS

6.1.1.2 The PMS has 4 major functions:

- **Magnetic function:**

The PMS works in conjunction with the active compensation/correction coils to limit the magnetic field inside the Beam Line Vessel (BLV) and Beam Source Vessel (BSV) to acceptable levels that do not interfere with the operation of the HNB components. Thanks to the two layers of the carbon steel.

- **Nuclear function:**

The PMS shields the HNB injector to reduce the dose rate in the NB-Cell during the shutdowns and operations. This function is fulfilled by using a layer of polyethylene and 2 layers of carbon steel to reduce the operation dose rate, and a layer of lead to shield the NB-Cell from Gamma ray coming from the activated material.

- **Support function:**

The PMS is supporting lot of equipment such as: BLV, BSV, HVB, ACCC-, pipes supports, platforms etc.

- **Air sealing:**

The HVB-PMS needs to prevent the flow of air between the NB-Cell and the HV-Deck room. Even in case of unlikely loading or extremely unlikely loading.

6.1.2 Needs of the PMS-PA

To prepare the PMS PA (53.P4.EU.01) signature and to follow up the start of manufacturing activities, several tasks are required.

Before the signature of the PA, all the IO documents describing design, loading conditions and interfaces related to this component shall be prepared and approved.

After the signature and during the PA, following up the engineering activity is needed to check the progress of the different task that will be done by F4E, among others:

- optimization design of the PMS internal frame linking the 2 layers
- optimization design of the TL-PMS windows
- providing the DJD for all the analysis run including the justification of all the fasteners
- providing an analysis report detailing the electromagnetic analyses performed for the PMS and the ACCC and including the coils current optimization
- providing the updated 3D model
- providing an updated DDD of the PMS according to the latest design that will be delivered for the FDR
- review of the 2D manufacturing drawings;
- preparation of the technical specifications for tests and inspections;
- reporting to manufacturing progress to the NB section;

6.1.3 Task description

The tasks that shall be done for the PMS are described here below:

- finalization and modification of the Annex-B according to the reviewer comments
- update of internal PAs ISs
- Follow up and manage amendments and deviations of the PA (engineering & manufacturing report) to be issued each month after start of the manufacturing contract.
- review of the 2D manufacturing drawings produced by the supplier
- preparation the FDR documentation (compliance matrix, ISs, RH documentation...)

- Update of the RPOM seismic analysis according to the new Floor Response Spectra (FRS) of the tokamak building. The goal is to check that the current design is also compliant with the new seismic behaviour of the building.

6.2 Activities related to the ACCCs

6.2.1 ACCC description

The primary function of the Active compensation/Correction Coils (ACCC) and the PMS is to limit the magnetic field inside the BLV and BSV to acceptable levels by producing magnetic fields which counter the ITER stray fields especially where the beam is not neutralized.

The ACCC are made of copper and a thin layer made of epoxy implemented between the pancake and the turns to guaranty an electrical insulation. The ACCCs component are cooled by water and supplied by 800A of current at 110V potential.

The ACCC are making up of different parts and materials their total mass is around 85tons.

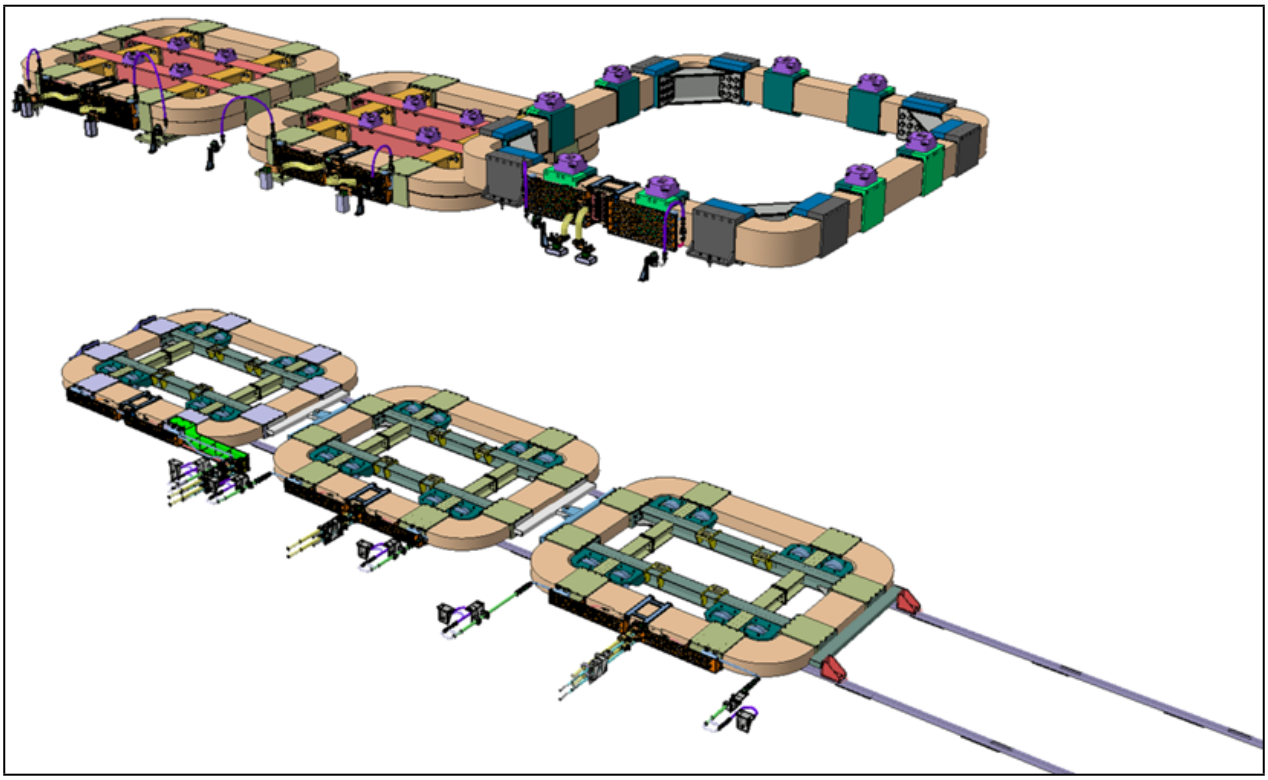

Figure 2: Active Correction Compensation Coils

6.2.2 Needs of the ACCC-PA

To prepare the ACCC PA (53.P4.EU.01) signature and to follow up the start of manufacturing activities, several tasks are required.

Before the signature of the PA, all the IO documents describing design, loading conditions and interfaces related to this component shall be prepared and approved.

After the signature and during the PA, following up the engineering activity is needed to check the progress of the different task that will be done by F4E, among others:

- Follow up and manage amendments and deviations of the PA (engineering & manufacturing report) to be issued each month after start of the manufacturing contract.
- optimization design of the power supply and cooling water terminals;
- justifying all the Load Cases analysis listed in the ACCC Load Specification

- providing the DJD for all the analysis run including the justification of all the fasteners
- providing the updated 3D model
- providing an updated DDD of the ACCC according to the latest design that will be delivered for the FDR
- preparation of the tender specifications and the execution of the tender phase;
- preparation of the 2D manufacturing drawings;
- preparation of the technical specifications for tests and inspections;
- Reporting to manufacturing progress to the NB section;

6.2.3 Task description

The tasks that shall be done for the ACCCs are described here below:

- finalization and modification of the annex-b according to the reviewer comments
- update of internal PAs ISs
- follow up and manage amendments and deviations of the pa (engineering & manufacturing report) to be issued each month after start of the manufacturing contract.
- review of the 2d manufacturing drawings produced by the supplier
- preparation the FDR documentation (compliance matrix, ISS, RH documentation)

6.3 Activities related to the Fast Shutter

6.3.1 Fast Shutter description

The Fast Shutter (FS) is located downstream of the calorimeter, at the exit of the BLV (See Figure 1). The design involves the movement of a door perpendicular to the horizontal axis of the BLV. Sealing is provided via a flexible metallic seal.

The main functions of the FS are:

- to provide part of the primary vacuum confinement of the NB system (FS casing only);
- to guarantee the confinement of radioactive materials in case of accidental over pressurization (FS casing only);
- to guarantee, when closed, a low conductance ($<10^{-4}$ m^3/s for D_2) between the volume of the injectors and the neutral beam duct;

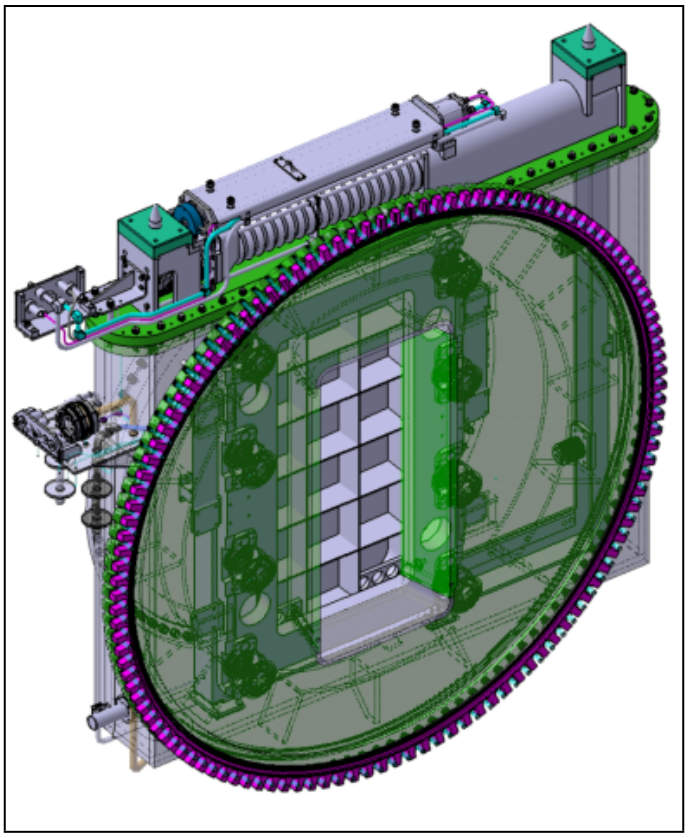

Figure 3: Fast Shutter

6.3.2 Needs for the FS PA

The FS mechanism has a novel and untested configuration and includes an aggressive requirement for the leak rate of gas past the shutter during regeneration of the Neutral Beam cryo-pumps, when the pressure increased on one side of the shutter. During this process the level of gas leaking into the main vacuum vessel must be kept below a defined rate to prevent contamination of the main vessel cryo-pumps with the gas and the resulting need to regenerate these main cryo-pumps at more frequent intervals.
A R&D of the shutter shall be done to confirm this requirement.

IO needs to follow the progress of the R&D and inform F4E about the engineering solution that shall be implemented and included in the PA. This task includes preparation of the FDR and PA signature by writing the required documentation.

6.3.3 Task description

The tasks that shall be done for the FS are described here below:

- preparation of the Technical Specification regarding the R&D
- review of technical offers regarding the R&D of the fast shutter
- final report of R&D result

6.4 Activities related to the NB cell lead wall

6.4.1 Lead wall description

The Lead wall is a shield installed in the NB Cell to protect the room from gamma. The lead wall is composed of a several panel of lead and a steel structure to support it. The wall is attached to the building. (Interfaces with the building are already defined: Embedded plates).

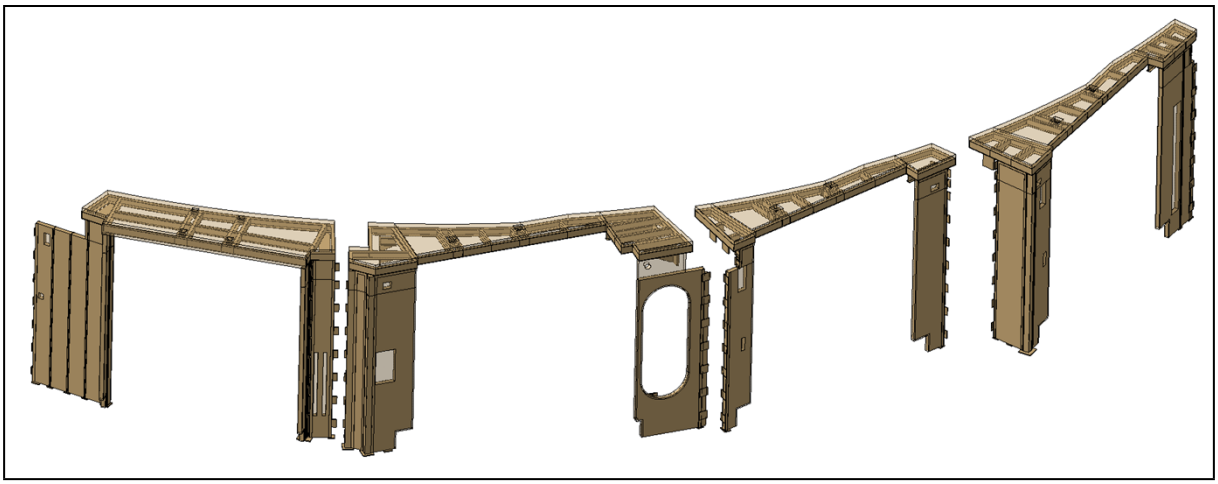

Figure 4: lead wall

For the maintenance of the NB Front End Components, the balcony (yellow) and a part of the lead wall (red) are removed to get access to the manipulator. These Parts of the Lead wall are classified RH class2.

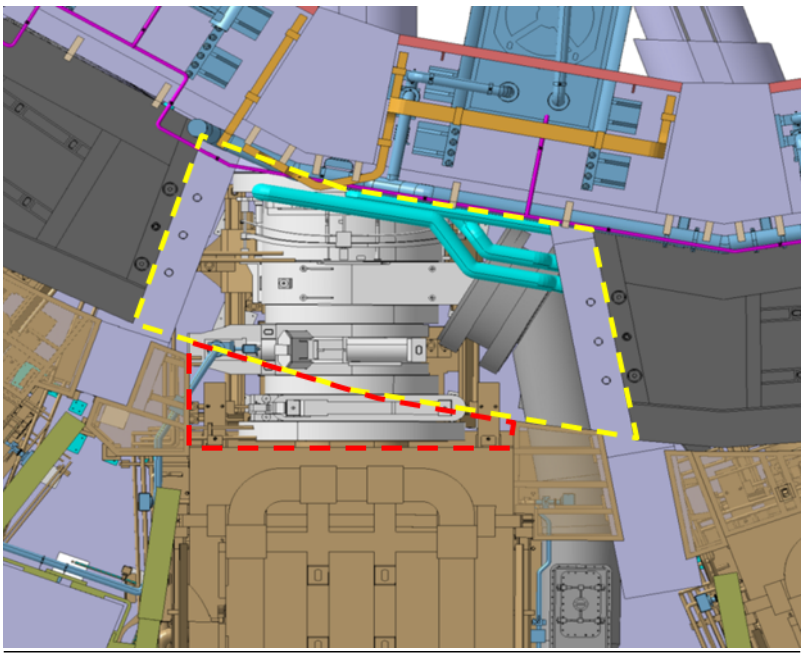

Figure 5: RH interfaces

The purpose of the task is to prepare:

- the Design requirement Document,
- the load specification,
- Perform associated mechanical analysis.

6.4.2 Task description

The purpose of the task is to prepare:

- the Design requirement Document,
- the load specification,
- Perform associated mechanical analysis.

7. List of the deliverables

In order to ensure proper reporting to the IO NB section management, 'the engineering and manufacturing report' related to the PA shall contain the following points:

- technical discussion describing the proposed modification if any and the decisions taken related to each component
- status of the 2D manufacturing drawing to be approved or to be modified
- status of the manufacturing components including schedule, on hold, delay, and description of the manufacturing issues if any
- status of non-conformity
- status of deviation request

The Table 3 describes all the deliverables related to this contract.

No	Name	Deliverables	Estimated due date
1	Technical specifications for PMS, ACCCs and R&D for FS	Preparation of Technical Specification regarding R&D. The technical specification shall address all details related to engineering tasks to be performed, all technical details related to prototyping, manufacturing, testing, shipping and storage for the components. It shall also address clear boundary of supply and responsibilities. Documentation to be provided by supplier at each stage must also be detailed. Design and manufacturing codes must also be indicated in this document.	T0+3 months
		Finalization and modification of Annex-B according to reviewers' comments. The annex B is a technical specification. It shall address all details related to engineering tasks to be performed, all technical details related to prototyping, manufacturing, testing, shipping and storage for the components. It shall also address clear boundary of supply and responsibilities. Documentation to be provided by supplier at each stage must also be detailed. Design and manufacturing codes must also be indicated in this document.	
2	Mechanical analysis	RPOM mechanical analysis according to latest Floor response spectra. The aim of this task is to update the RPOM analysis according to new seismic spectrum for the tokamak building and to implement reviewers' comments raised on the previous version of the analysis report	T0+6 months
3	Update of internal ISs for the PMS and ACCC	Update of internal PAs ISs. The IS are necessary to describe the mechanical interfaces between two components/system.	TO+9 months
4	Lead wall	Writing of the DRD and load specifications, and perform all the calculation related to the lead wall in the NB cell and prepared the associated analysis report. Analyses models are also part of the deliverables	T0+14 months
5	Final report of FS R&D activities	Final report of R&D result. The aim of this task is to report about all the work done and results obtained regarding the R&D activities of the fast shutter. This document will also be used in order to demonstrate that the future component build	T0+18 months

		based on the result of this task will ensure it safety function and will be reliable.	
6	Review of 2D manufacturing drawings proposed by manufacturer	Review of PMS 2D manufacturing drawings produced by supplier. The review is necessary to ensure manufacturability of the components and that they will match during assembly.	T0+21 months
		Review of ACCCs 2D manufacturing drawings produced by supplier. The review is necessary to ensure manufacturability of the components and that they will match during assembly.	
7	Report of manufacturing progress and issues for the PMS and ACCCs	Follow up and manage amendments and deviations of PA (Engineering & manufacture report). The content of this report is described here above. Several update are necessary in order to ensure traceability and reporting to the IO section leader and TRO about the progress of the manufacturing activities.	T0+24
	FDR documentation for PMS and ACCCs	Preparation of FDR documentation (compliance matrix, ISs, RH documentation...). This task is necessary to control that all documents required by QA procedure are ready and compliant for the FDR. It is critical here because components are part of the ITER hard core components.	T0+24

Table 3: List of deliverables

8. Specific requirements and conditions

The required resource is a mechanical engineer at least 5 years of working experience in mechanical design.

The engineer shall have:

- Experience on mechanical design activities follow up
- Knowledge of electromagnetic design components and magnetic parameters (field, hysteresis, permeability, ect..)
- Experience on hydraulic analysis (calculation of the pressure drop, definition of the cooling water parameters)
- Experience on international and French codes and standards : RCC-MR, SDC-IC, ASMEE 8
- Experience on written technical specification and documentation
- Experience in manufacturing processes (welding, machining, forging, ect..)
- Experience on Catia V5 (mechanical design software used in ITER)
- Experience on Enovia V5 (PLM software used in ITER)
- Experience on finite element mechanical and seismic analysis using Ansys-15 (knowledge of the modules: static analysis, modals analysis, transient analysis, response spectrum
- English fluent (written and spoken)
- Knowledge of Neutral Beam system is an advantage

9. Work Monitoring / Meeting Schedule

Final Reports should be self-contained, and relevant documentation, such as drawings should be supplied together with it electronic form. Deviations from the Task Order Specifications, approved by the ITER Organization, shall be recorded in a specific chapter of the relevant final report.

10. Quality Assurance (QA) requirements

The organisation conducting these activities should have an ITER approved QA Program 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).

Prior to commencement of any manufacturing, a Manufacturing & Inspection Plan Manufacturing and Inspection Plan (22MDZD) must be approved by ITER who will mark up any planned interventions.

Deviations and Non-conformities will follow the procedure detailed in IO document MQP Deviations and Non Conformities (22F53X).

Prior to delivery of any manufactured items to the IO Site, a Release Note must be signed MQP Contractors Release Note (22F52F).

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).

11. 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 [20].