MARKET SURVEY TECHNICAL NOTE

HEATING NEUTRAL BEAM MAGNETIC SHIELDING SUPPLY

Tables

Figures

ABBREVIATIONS AND ACRONYMS

ACCC	Active Correction and Compensation Coil
BtP	Build to Print
DNB	Diagnostic Neutral Beam
HNB	Heating Neutral Beam
HVB	High Voltage Bushing
NA	Not Applicable
NDT	Non Destructive Testing
NB	Neutral Beam
PIA	Protection Important Activity
PIC	Protection Important Component
PMS	Passive Magnetic Shield
QC	Quality Control
RCC-MR	Regles de Conception et de Construction des Materiels Mecaniques des ilots nucleaires réacteur à neutrons rapides
RPOM	Rear PMS Opening Mechanism
RPS	Reference Procurement Specifications

RT	Radiography Testing
SDC-IC	Iter structural design criteria for in-vessel components
SIC	Safety Important Component
SS	Stainless Steel
TC	Thermocouple
VPI	Vacuum Pressure Impregnation

1 SCOPE

Fusion for Energy (F4E) is publishing a Market Survey in preparation of the signature of the Procurement Arrangement (PA) with IO for the supply of the Heating Neutral Beam Magnetic Shielding. This Technical Note provides supporting information so that interested companies can answer to the F4E market survey with a minimum of background. The information on the tender procedure provided with this document is only preliminary and only for the purpose of this Market Survey.

2 INTRODUCTION TO THE HEATING NEUTRAL BEAM INJECTOR

The ITER project aims to build a fusion device, twice the size of the largest current devices, with the goal of demonstrating the scientific and technical feasibility of fusion power. It is a joint project between the European Union, China, India, Japan, South Korea, the Russian Federation and the USA. ITER is currently under construction at Cadarache site, in the south of France. The fusion reactor is expected to be ready for first operation by end of 2025.

Most of the components that make up the ITER project are to be manufactured by each of the participating countries and contributed in kind through so-called Domestic Agencies. Fusion for Energy is the European Domestic Agency (EUDA).

There are two Heating Neutral Beam (HNB) Injectors and one Diagnostic Neutral Beam (DNB) injector inside the ITER Neutral Beam Cell (Figure 1). A third HNB Injector may be added at a later stage.

The ITER Heating Neutral Beam system injects high-energy neutrals into the tokamak plasma. This beam interacts with the tokamak plasma and heats the plasma. The global heating power of Neutral beam heating system of ITER is 33 MW with two NB Injectors (HNB1 and HNB2). A third injector (HNB 3) is optional and may be added in the future in order to provide an additional 16.5MW heating power to the plasma.

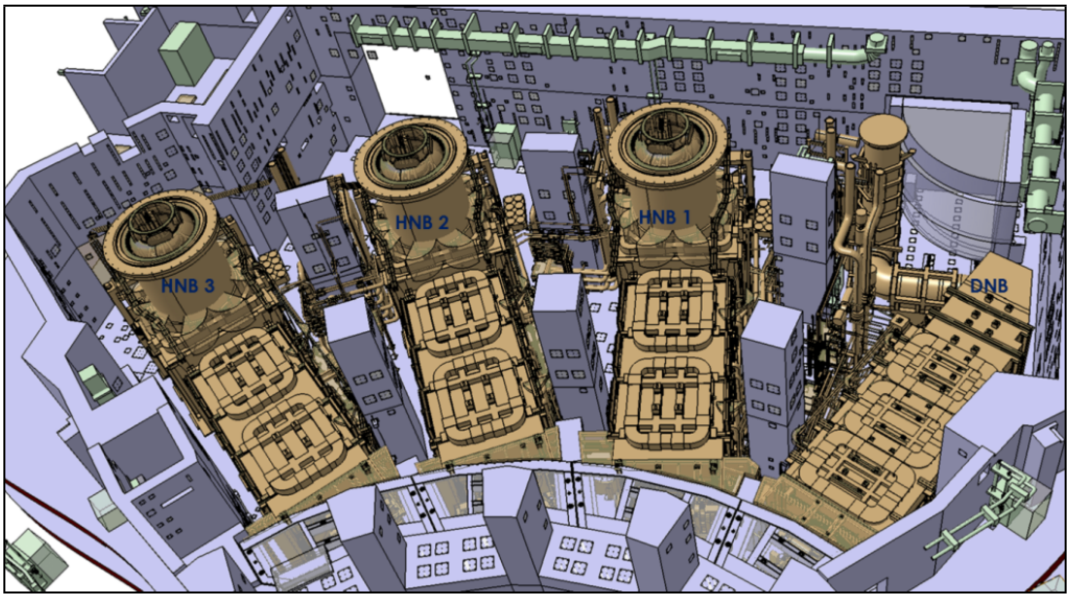

Figure 1: Three HNB injectors and DNB vessels (Diagnostic NB) inside NB cell

The cross section of the NB Injector connected to the ITER Tokamak is represented in Figure 2.

The Magnetic Shielding is composed by PMS (Passive Magnetic Shield) and ACCC (Active Correction and Compensation Coil) surrounding the NB Vessel and the HVB (High Voltage Bushing). It shields the beam from the stray field of the ITER Tokamak, and it is not a vacuum barrier.

One Magnetic Shielding is needed for each of the three HNBs and one DNB.

The HNB1 & 2 Magnetic Shieldings are part of the scope of supply of F4E. The DNB magnetic Shielding is part of the scope of supply of the Indian Domestic Agency.

Part of the Magnetic Shielding for the HNB3 may be in scope of the F4E procurement.

Indicatively each unit of the Magnetic Shielding is 15 meter long, with a weight of 600 tons.

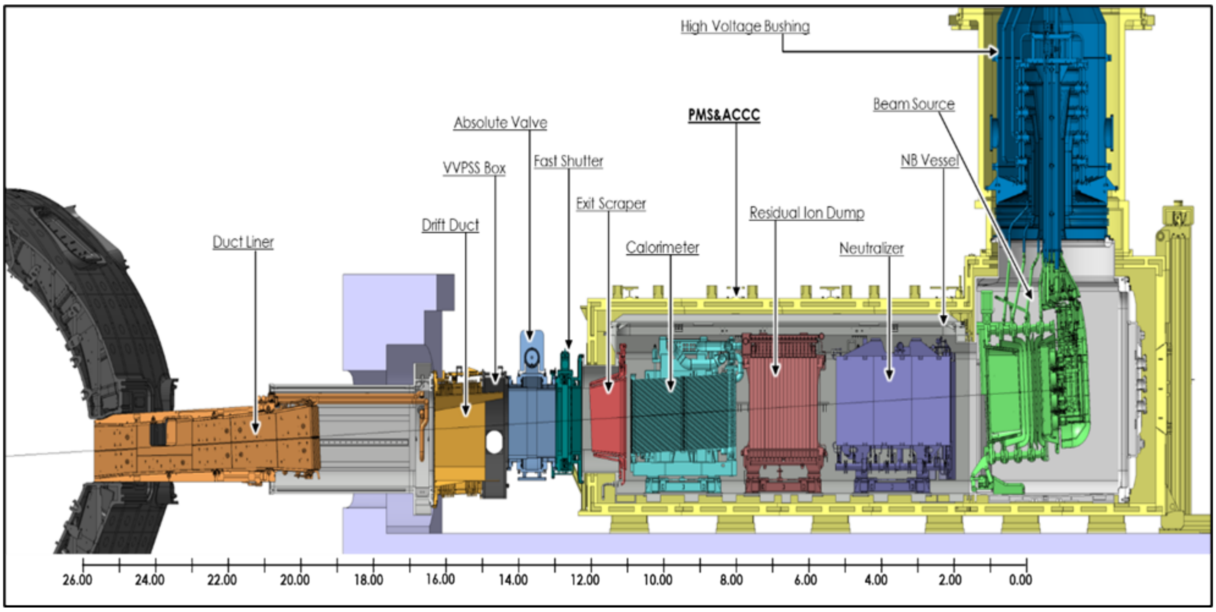

Figure 2: Cross section of the NB Injector

3 Description of the Magnetic Shielding

3.1 Overview

The HNB Magnetic Shielding is made from the following main sub-components:

- Vessel PMS and RPOM (Rear PMS Opening Mechanism) (see Figure 4,Figure 6 and Figure 11)

  It is a box structure made of carbon steel enclosing the NB Vessel (see Figure 6)

  The rear part is a door also made of carbon steel with an opening mechanism (RPOM) (see Figure 12)

- High Voltage Bushing PMS (see Figure 5)

  It is a carbon steel cylinder enclosing the High Voltage Bushing (this latter not part of the supply)

- Active Correction Compensation Coils (ACCC) (see Figure 3)

  It is a set of 8 coils (ACCC1 to ACCC8) located inside the top and bottom Vessel PMS

  Plus a coil (ACCC9) winded around the NB vessel

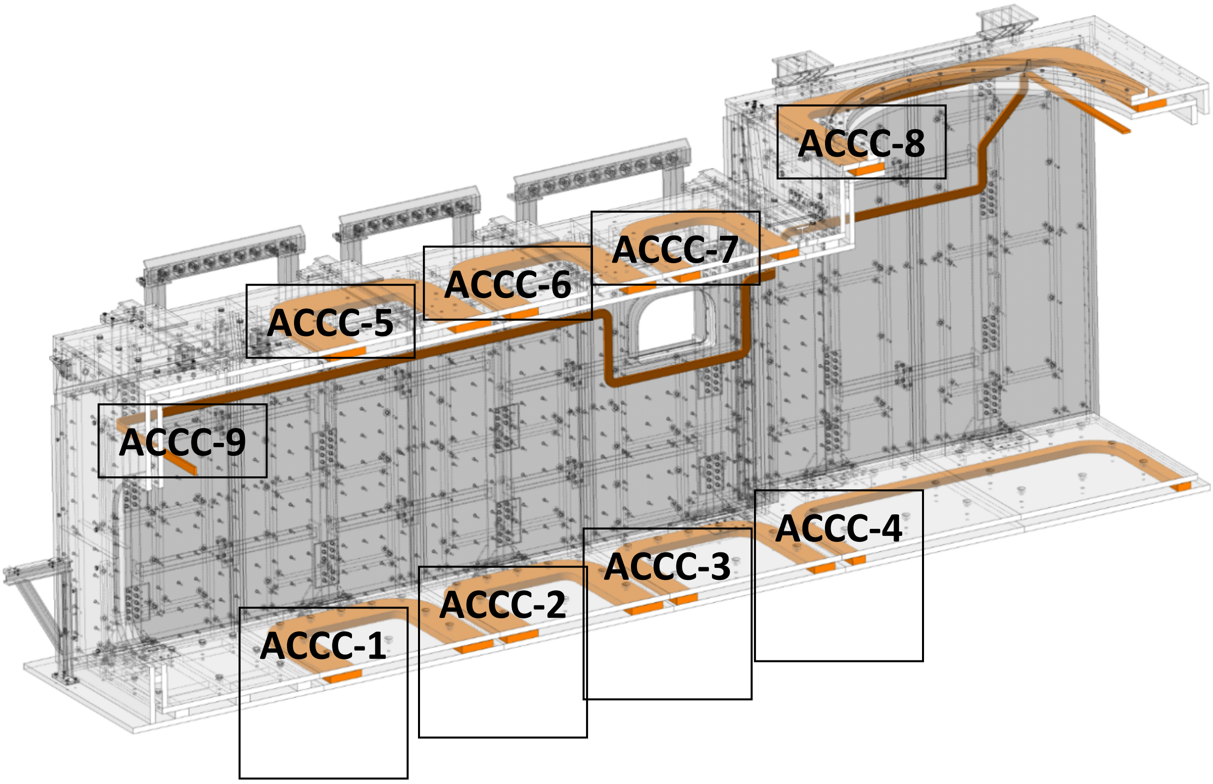

Figure 3 ACCC

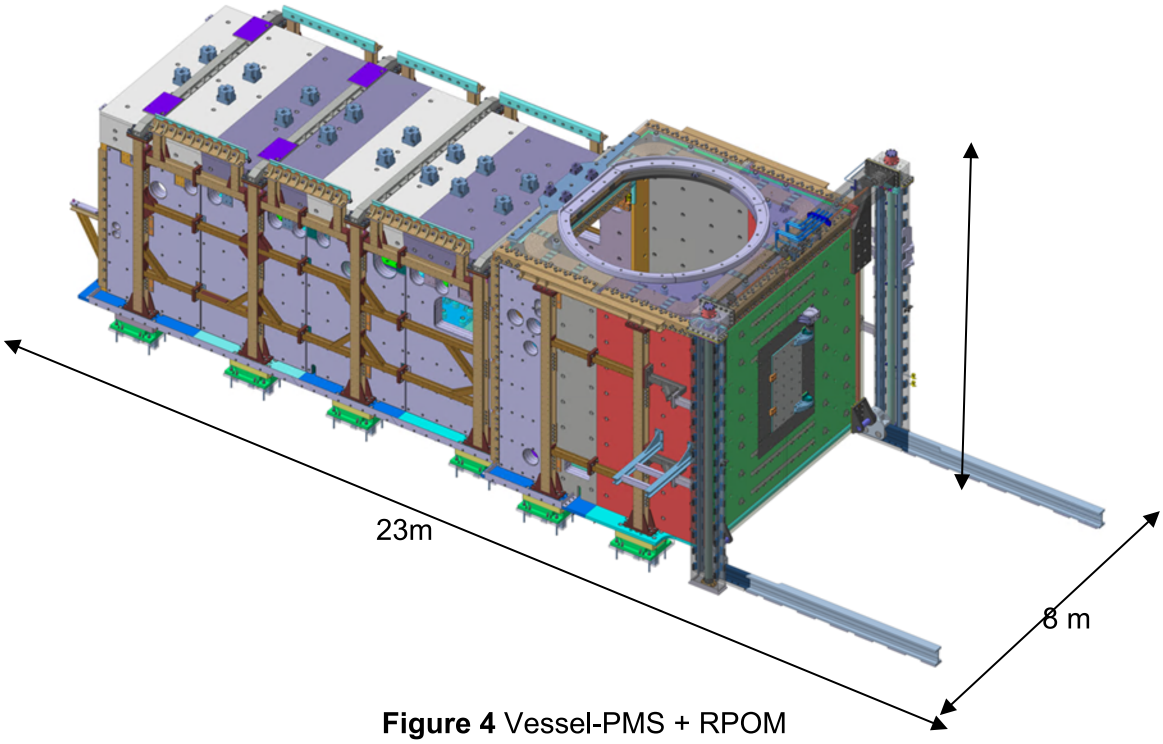

Figure 4 Vessel-PMS + RPOM

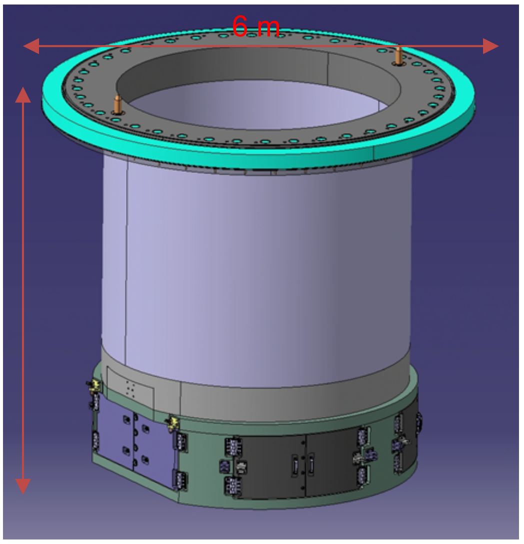

Figure 5 High Voltage Bushing PMS

The main functions of the Magnetic Shielding are:

- Reducing the magnetic field inside the HNB to allow correct operation of the components.

  This is performed by thick carbon steel plates all around the vessel and coils located at the top and bottom part.

- Shielding the Neutral Beam Cell from radiations coming from inside the tokamak.

  This is achieved with polyethylene and lead plates.

- Supporting the NB Vacuum Vessel.

  Performed by the bottom plates and the supports anchored to the floor.

- Providing Secondary confinement barrier from the NB Cell area to the upper floor,

  Performed by the High Voltage Bushing PMS.

3.2 Vessel PMS

The vessel PMS is a modular structure composed by 6 bottom parts (Bottom PMS), 6 top parts (Top PMS), 12 side parts (Side PMS) and 2 front parts (Front PMS), as illustrated in Figure 6.

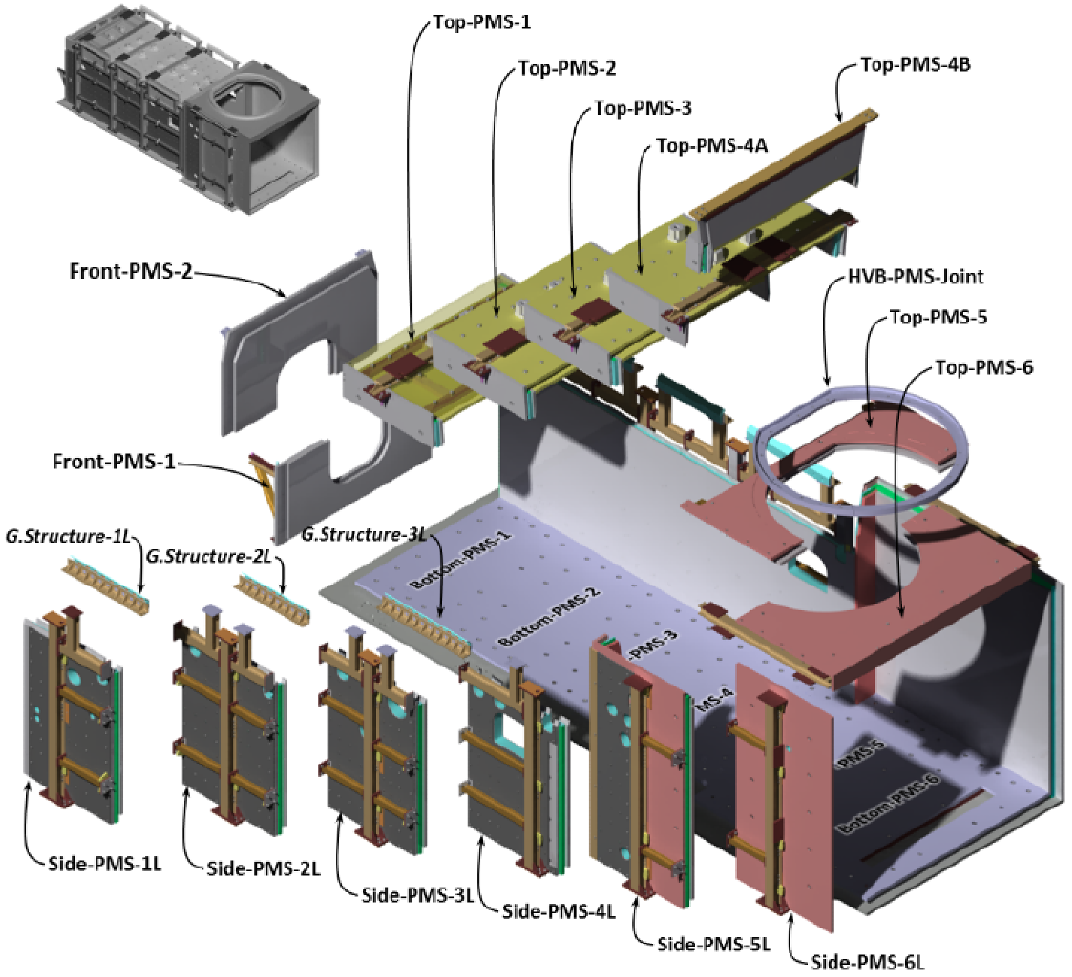

Figure 6 Vessel PMS exploded view

Each part is a sandwich composed by two plates 75mm thick in carbon steel (S235), separated by 100mm long spacers.

The Side PMS contains internally a 100mm thick Polyethylene plate, and externally a 24mm thick lead plate, encapsulated in stainless steel sheet. The H beam structure fixed to the external plate is used for the mechanical connection (see Figure 7).

Bottom and Top PMS contain internally, in sandwich, the coils (see Figure 8 and Figure 9).

Top PMS (with the embedded coils) have been designed to be removed to have maintenance (using Remote Handling) access to the NB Vessel from the top.

Maximum dimension of the plates is 6.4m x 2.7m x 75mm (Side-PMS-6R). The weight of each assembled plate sandwich is approx. 20 tons.

The largest part to be handled (Bottom-PMS 5 + Bottom-PMS 6 + ACCC 4) is 6.4m x 5.3m and weights approx. 42 tons.

The overall assembly weight is around 500 tons, and it is supported by 12 base plates 1m x 0.75m wide (see Figure 10).

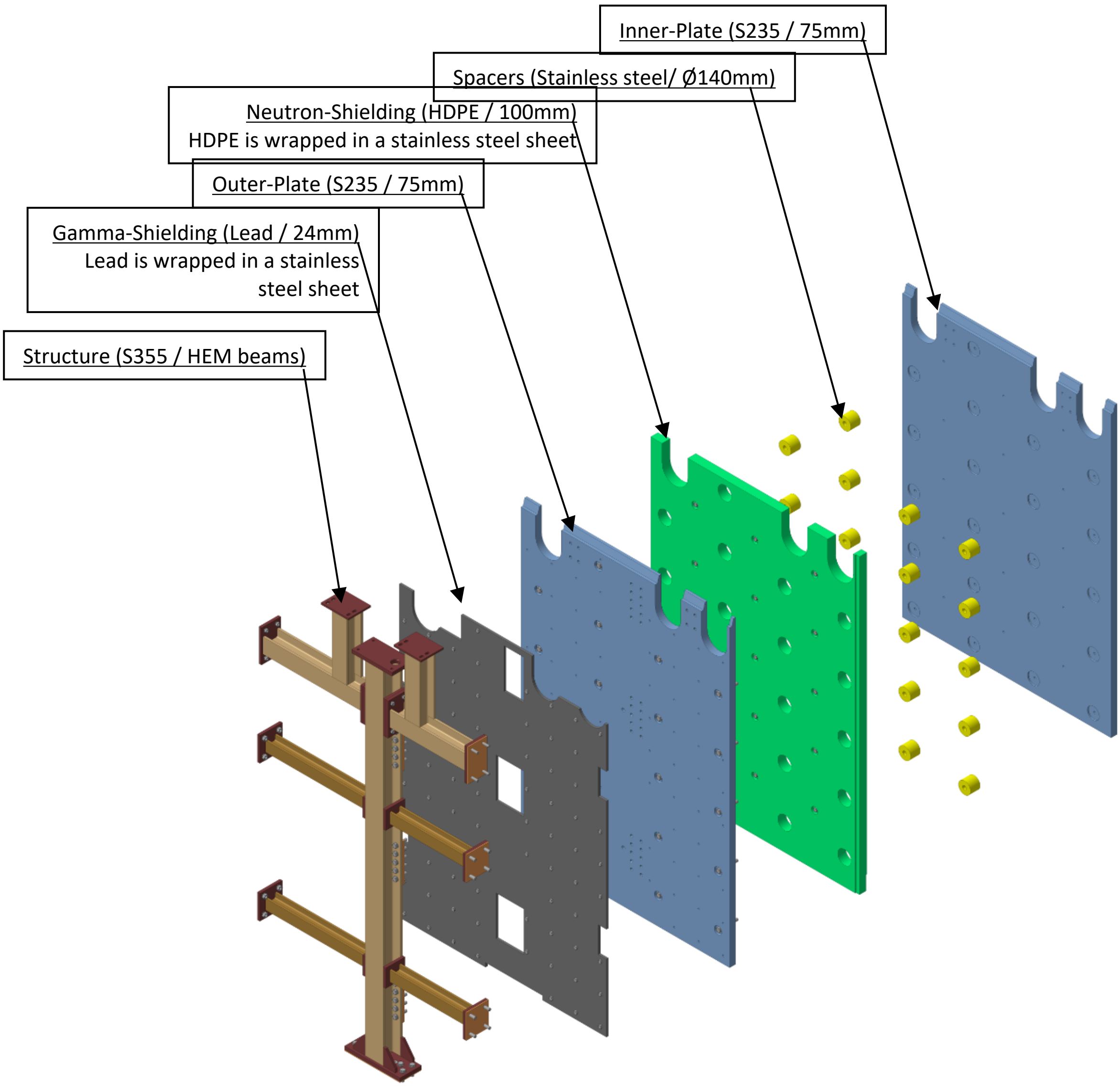

Figure 7 Side PMS exploded view

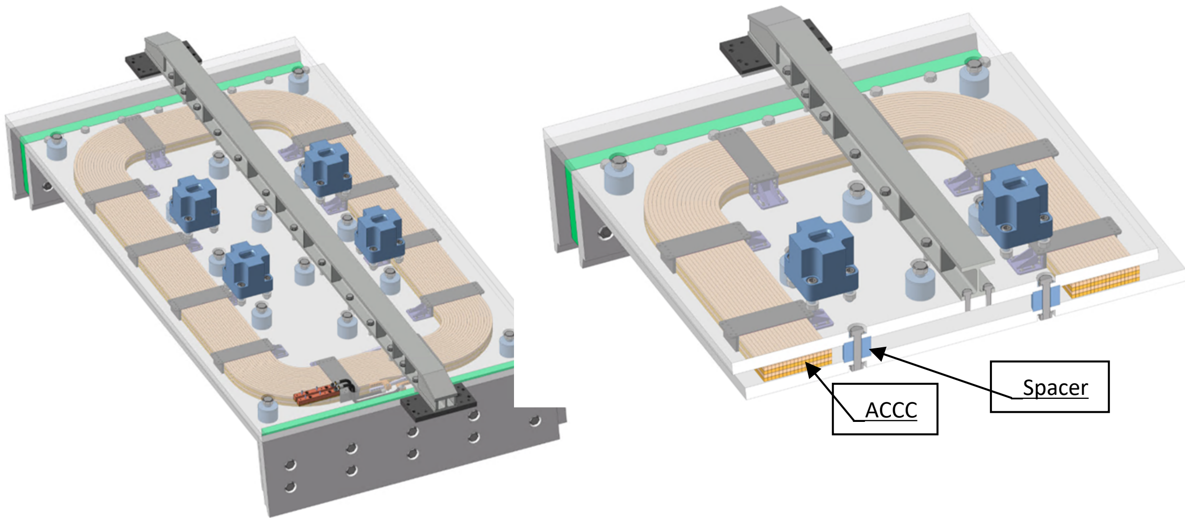

Figure 8 Top PMS

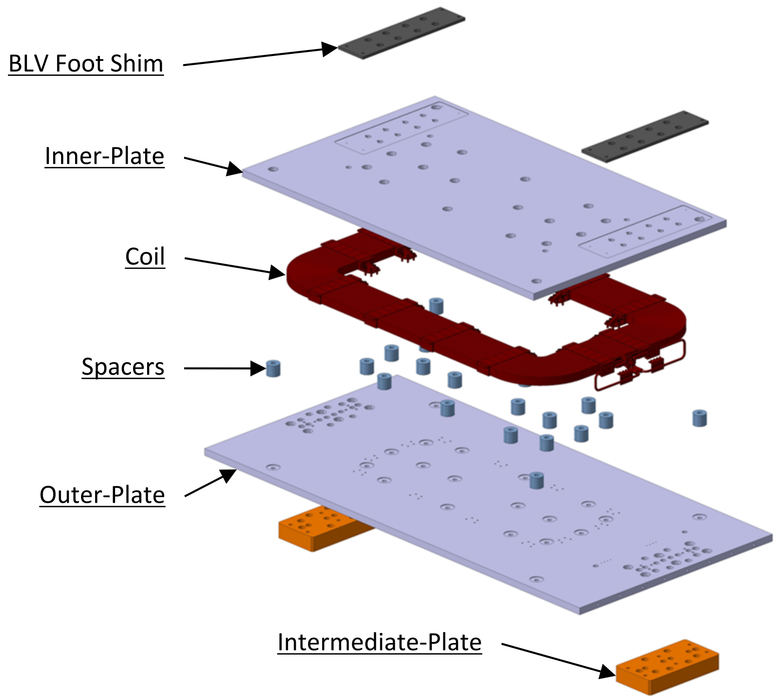

Figure 9 Bottom PMS

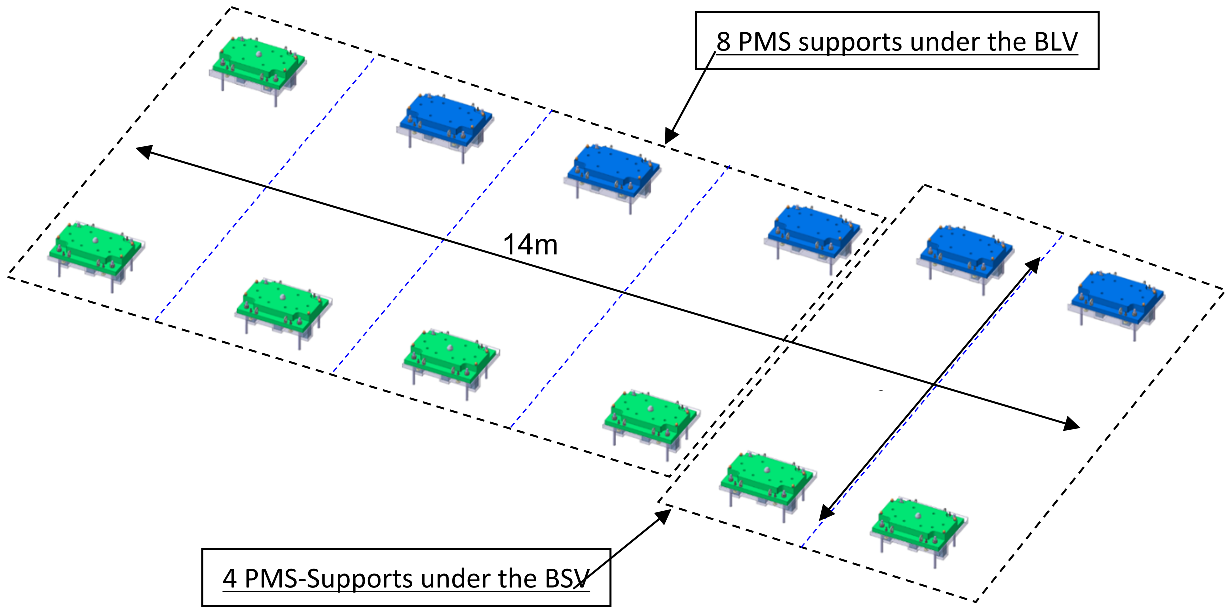

Figure 10 Vessel PMS base plates

3.3 RPOM

The rear part has the same sandwich construction than the side panels. It is composed of 2 sandwich panels joined by internal beams. It can be opened to have maintenance access to the NB vessel.

Trapezoidal screw actuated by water hydraulic motors and a rail system allow to open it (see Figure 11 and Figure 12). The hydraulic power pack is also included in the scope.

It has a weight of 55 tons and a dimension approx. 7m x 7m.

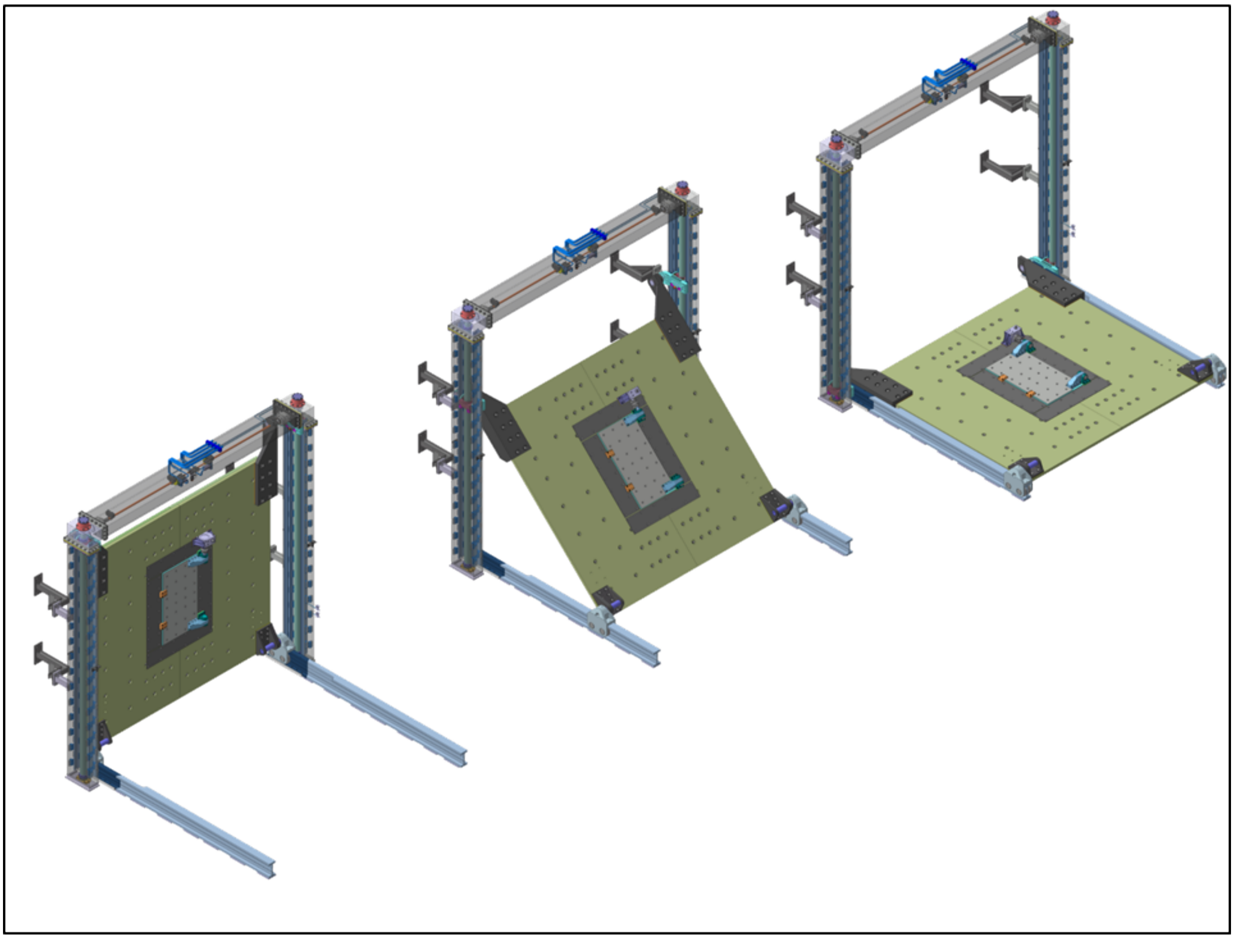

Figure 11 RPOM opening

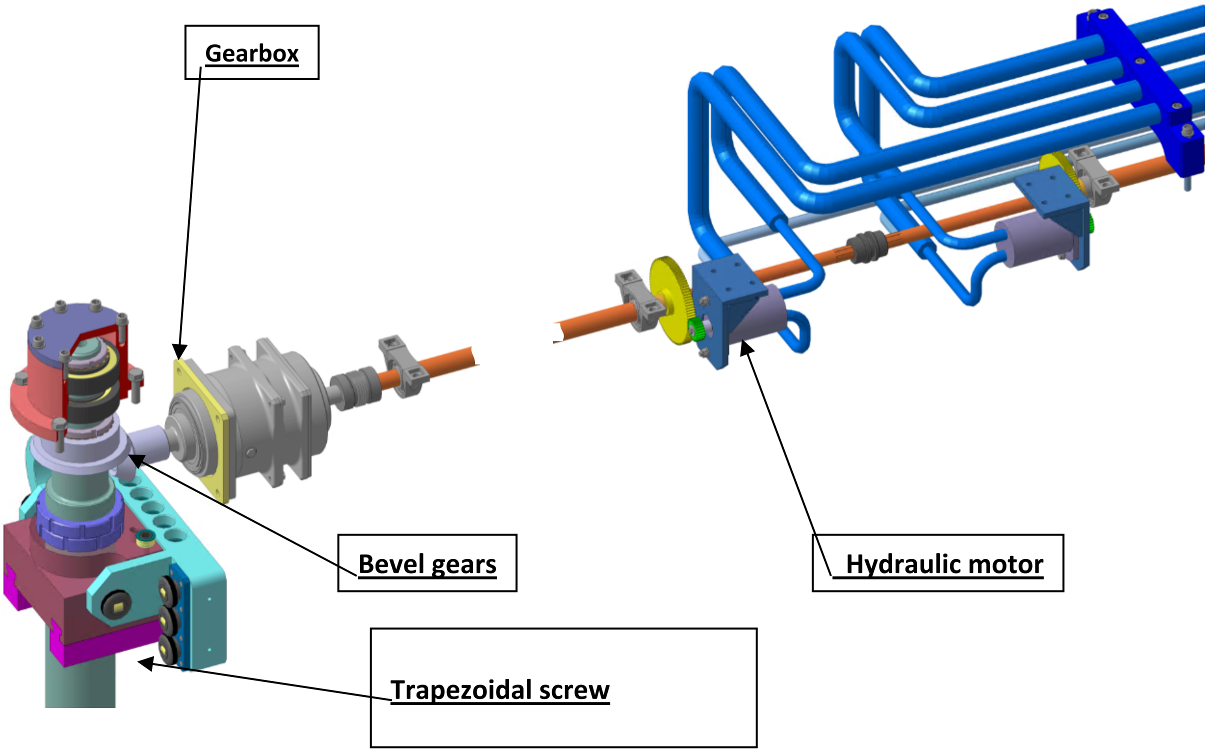

Figure 12 RPOM mechanism

3.4 HVB PMS

It is composed of a carbon steel (S235) cylinder, 150 mm thick, 4m diameter and 5m height, overall weight approx. 70 tons. When installed it is supported from the ceiling, not in contact with the Vessel PMS.

The lower part, demountable, has ports and doors to access the HVB that will be hosted inside.

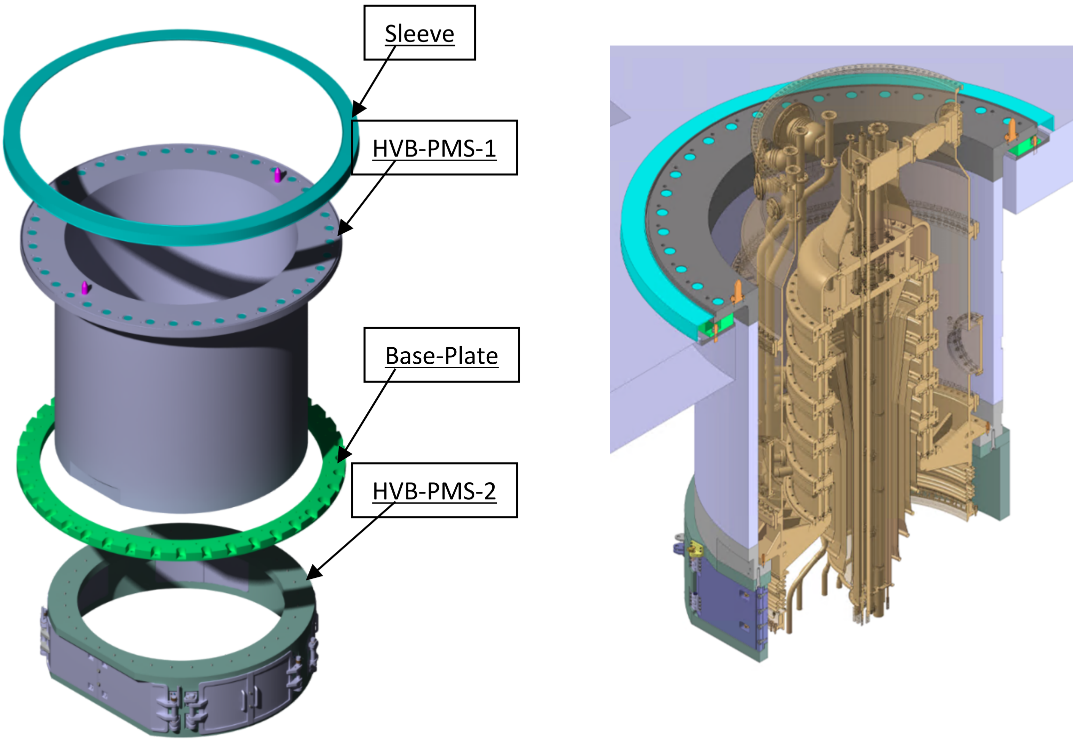

Figure 13 HVB PMS

3.5 Main PMS requirements

Requirements are driven by the magnetic shielding functions, by the support function and by the radiological protection. They have impact on the material characteristics, on the manufacturing and on the assembly.

3.5.1 Nuclear Safety classification

ITER components are classified according to their contribution to the nuclear safety functions. Components classified SIC-1 and SIC-2 are considered Safety Important and follows strict quality and technical requirement. For the case of the PMS they are designed and shall be manufactured according to RCC-MR code. Components classified Safety Relevant or Non-SIC follows more conventional requirements.

Figure 14 shows the classification of the PMS components:

- Red parts are SIC-1
- Orange Parts are SIC-2
- Yellow parts are SR (Safety Relevant)
- Grey parts are Non-SIC

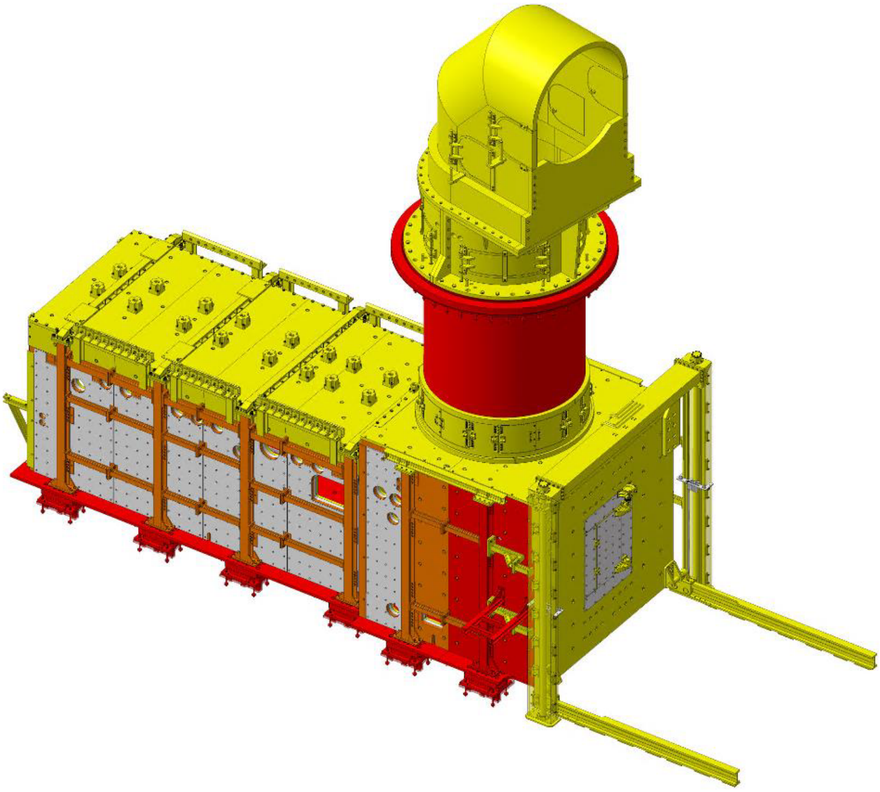

Figure 14 SIC Classification

3.5.2 Material requirements

3.5.2.1 Plate and HVB material

Material of the plate is low carbon steel type S235 according to EN 10025-2. The material needs to fulfil the additional requirement, listed in RPS RM 1135 of the RCC-MR-2007 code, like additional inspections (e.g. ultrasound).

For radioprotection reason the material shall satisfy the limits in Table 1 for the impurities.

Component	Max content (% in weight)
Co	0.01
Nb	0.01
Ta	0.01
Ni	0.05

Table 1 Impurities requirement S235

To perform the foreseen magnetic shielding function the steel magnetic properties need to be guaranteed. Figure 15 and Table 2 show the reference magnetic characteristics. F4E is currently performing measurements on a series of S235 samples with different chemistry and thermal treatments to establish the minimum acceptable characteristics.

H (A/m)	B (T)
1.41891	0.00024
2.83173	0.00049
7.10892	0.00134
14.1789	0.00307
70.8513	0.03264
141.724	0.12741
207.593	0.3
283.428	0.55911
337.601	0.7
940.461	1.30001
1417.08	1.45629
2834.13	1.6397
5669.49	1.7683
7085.68	1.81111

Table 2 S235 magnetic characteristics

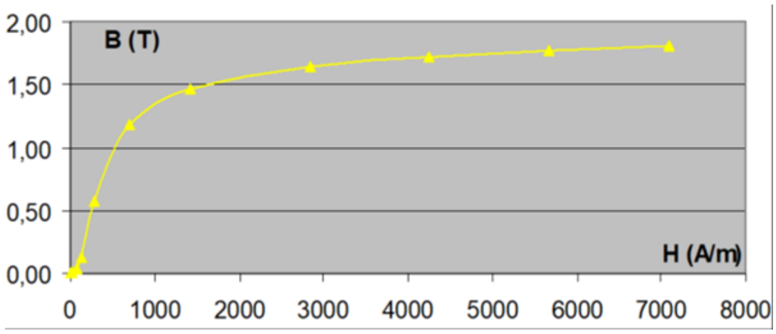

Figure 15 S235 magnetic characteristics

3.5.2.2 Other structural material

Material for components classified SIC shall follow applicable RPS. Those are listed in Table 3:

RPS	EN	Application
RM1135	EN 10025 S235/S355	Beams / structural parts
RM 5151	EN 10269 42CrMo4	Bolts and nuts
RM 3335	EN 10088-2 X2CrNiMo17-12-2 (1.4404) (316L)	Spacers between plates
Special	EN 10269 NiCr19Fe19Nb5Mo3 (Alloy 718)	Bolt between plates

Table 3 RPS

Material for SR or non-SIC component and standard parts like bolts follows EN standards.

Material used in very large quantity shall respect ITER impurities requirements listed in Table 4

Material	Co %	Ni %	Nb %	Ta %
Carbon steel	0.010	0.050	-	-
Stainless steel	0.050	-	0.100	0.050
Inconel Alloy 718	0.100	-	-	0.010

Table 4 Impurities requirements other materials

Material procured in significant quantity do not have impurities requirement but a chemical analysis is requested.

Material procured in small quantities will not have impurities requirement nor a chemical analysis.

3.5.2.3 Polyethylene

Polyethylene shall have a minimum density of 0.95 g/cm³ at 35°C and halogen-free. No special shielding characteristics (Boron additive) or fire reaction is prescribed.

3.5.2.4 Lead

The Lead shall have a minimum density of 11.34 g/cm³ at 35°C, and incapsulated in a stainless-steel case.

3.5.3 Manufacturing requirements

Manufacturing of SIC component shall follow RCC-MR, and activities are classified as PIA, requesting technical supervision. Anyhow there are not pressure equipments, so the supervision by a notified body is not needed. Most components are classified Support Class S1 (for the SIC-1) / Class S2 (for the SIC-2), HVB PMS is Box Structure Class 2.

RCC-MR prescription according to the selected class applies mainly to fabrication (welding and its examination, forming).

Manufacturing of non-SIC components follows applicable EN/ASME standards.

3.5.4 Carbon steel corrosion protection

Due to the radiation dose (1MGy) and RCC-MR prescription the following surface treatment are allowed:

- Paint according to RF 5300, class PIG, resistant to 1MGy and halogen-free. Surface of the bolted joints shall not be painted
- Manganese Phosphate Coating following section RF 5200

3.5.5 Factory assembly requirements

A factory assembly of the Vessel PMS plus RPOM and of the HVB PMS is required (separately).

Components shall be cleaned before factory assembly according to Class B from RF 6000. After cleaning they will be assembled in a clean area according to RF 6242 (Level II).

A typical assembly sequence of a subassembly (bottom PMS containing an ACCC) is represented in Figure 16.

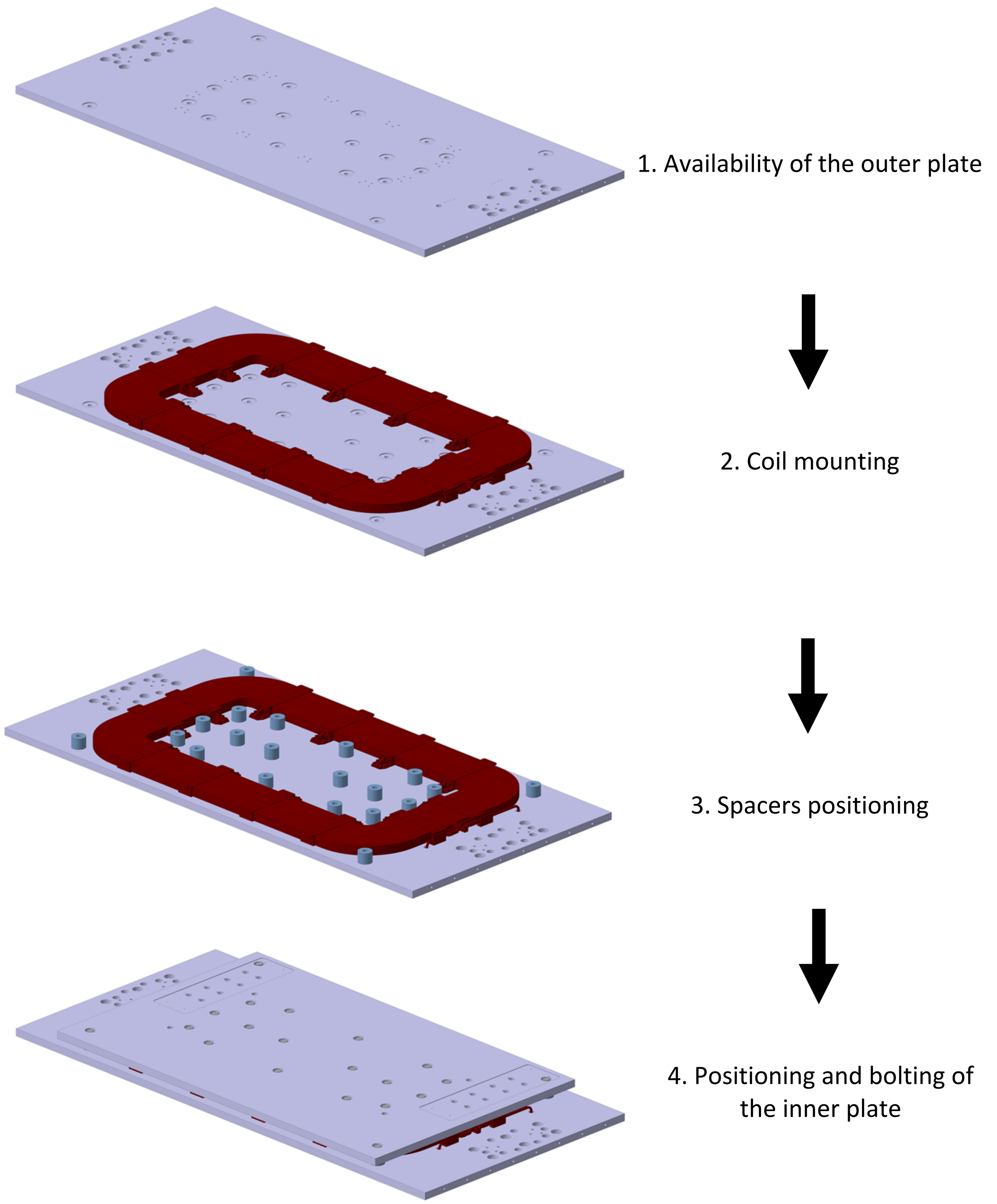

Figure 16 Typical assembly sequence (PMS with coil)

During the final assembly the gap between subassemblies (e.g. see Figure 17) need to be controlled to assure mechanical contact and good magnetic performance. Maximum gap shall be 1 mm.

Custom machining of plates to adapt the interfaces with the adjacent ones is allowed, if deemed necessary due to the machining tolerances of the plates and the assembly tolerances of the subassembly.

After custom machining the related surfaces will be corrosion protested by Manganese Phosphate Coating or painting at the choice of the supplier.

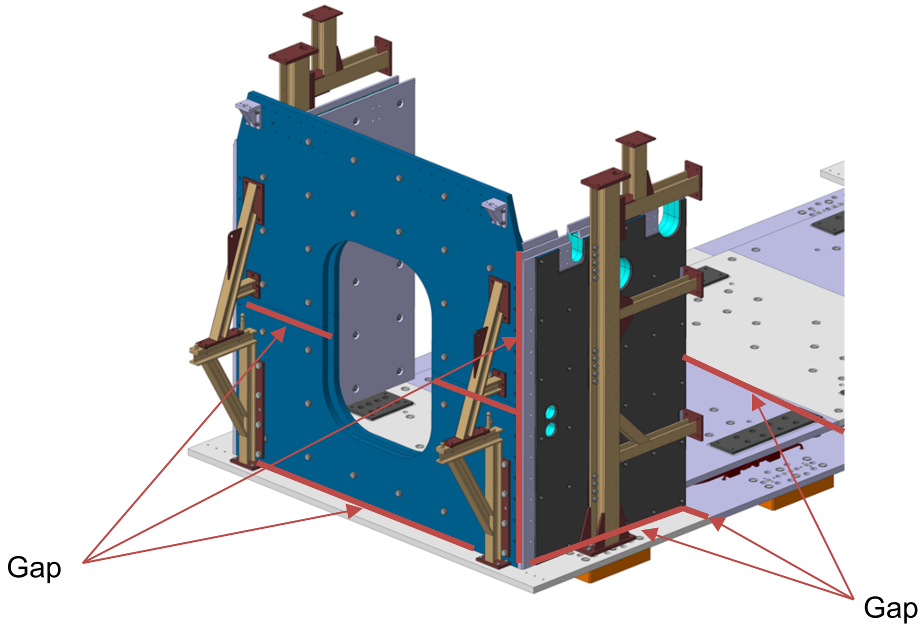

Figure 17 Assembly gaps

Shims are foreseen at the connection of the H structures. Once the correct alignment is reached the structures will be counter drilled and pinned before disassembly to create references to be used at on-site assembly in ITER site.

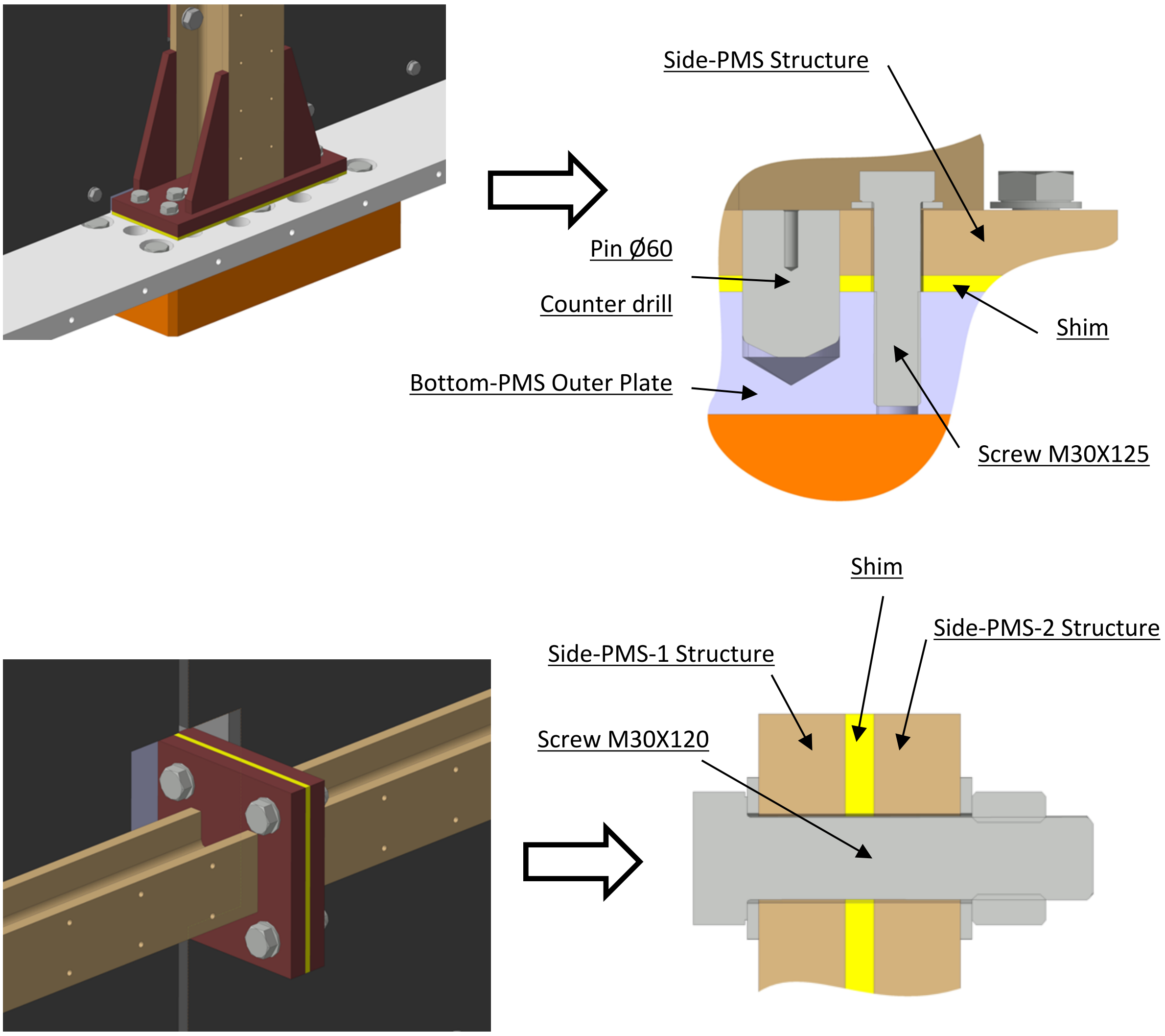

Figure 18 Shims and pin

The rails and the structure of the RPOM (see Figure 19) will be installed on temporary supports simulating the real position of the embedded plates installed in ITER. Also for this structure the shims will be adjusted and parts pinned for reference.

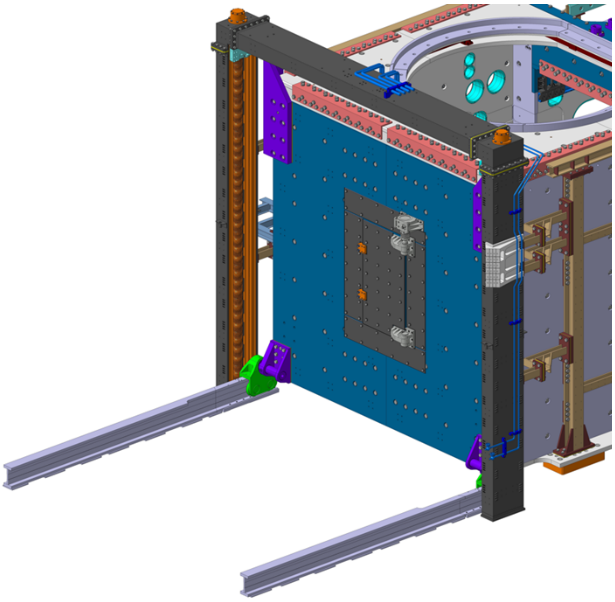

Figure 19 RPOM assembly

After the complete assembly, in addition to the metrology survey on gaps and other external interfaces (e.g. the NB Vessel interfaces), some functional tests will be required, the main are:

- Electrical measurements of the coil, to check that they did not suffer any damage
- Opening and closing of the rear door, to check correct operation
- Dismounting and re-assembly of the Top-PMS plates
- Opening and closing of the maintenance windows in the RPOM and HVB-PMS

3.5.6 Disassembly and shipping

After successful completion of the Factory Acceptance Tests the PMS shall be disassembled in individual sandwich panes (see Figure 6).

The biggest components will be the HVB–PMS1, the Rear Door, the Top PMS-5/6 and the Bottom PMS-5/6. These two last components need temporary supports and stiffeners for handling to avoid damages to the coils, see Figure 20 and Figure 21.

The maximum size of packaged items that can be transported on normal French roads to the ITER Site is;

- for HEL - Highly Exceptional Load: (9m wide × 9.1m high and 19m long with a weight limit of 600 tonnes)
- for CEL - Conventional Exceptional Load: (5m wide × 5m high and 19m long with a weight limit of 60 tonnes).

Except for the biggest components listed above, for which the supplier should assess the applicable category, the rest of the components can be shipped as CEL.

Delivery of first and second unit may be done in two different period, in some months' time.

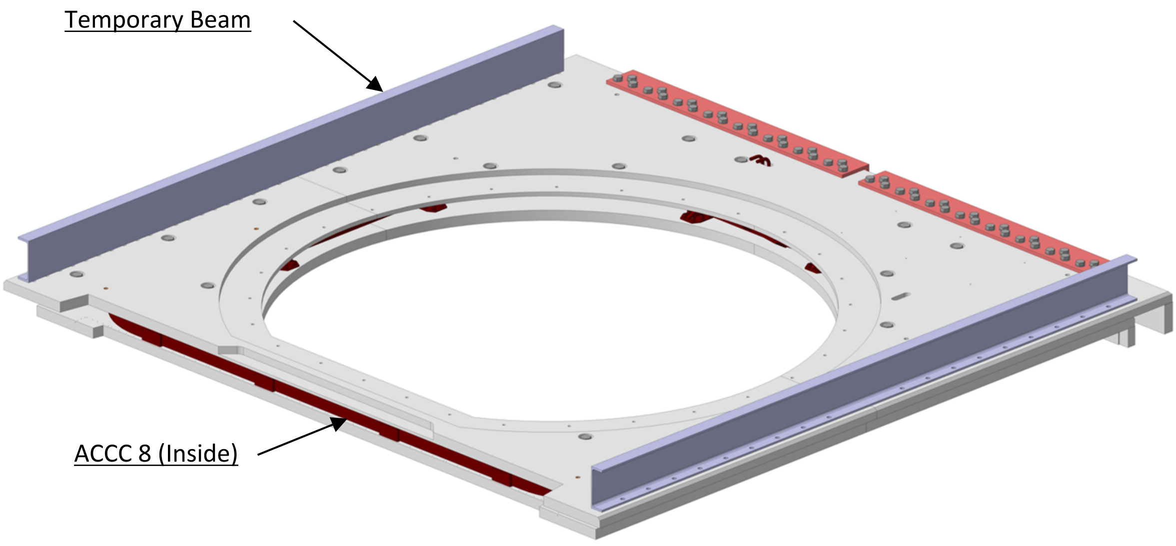

Figure 20 Top PMS 5/6 with temporary supports

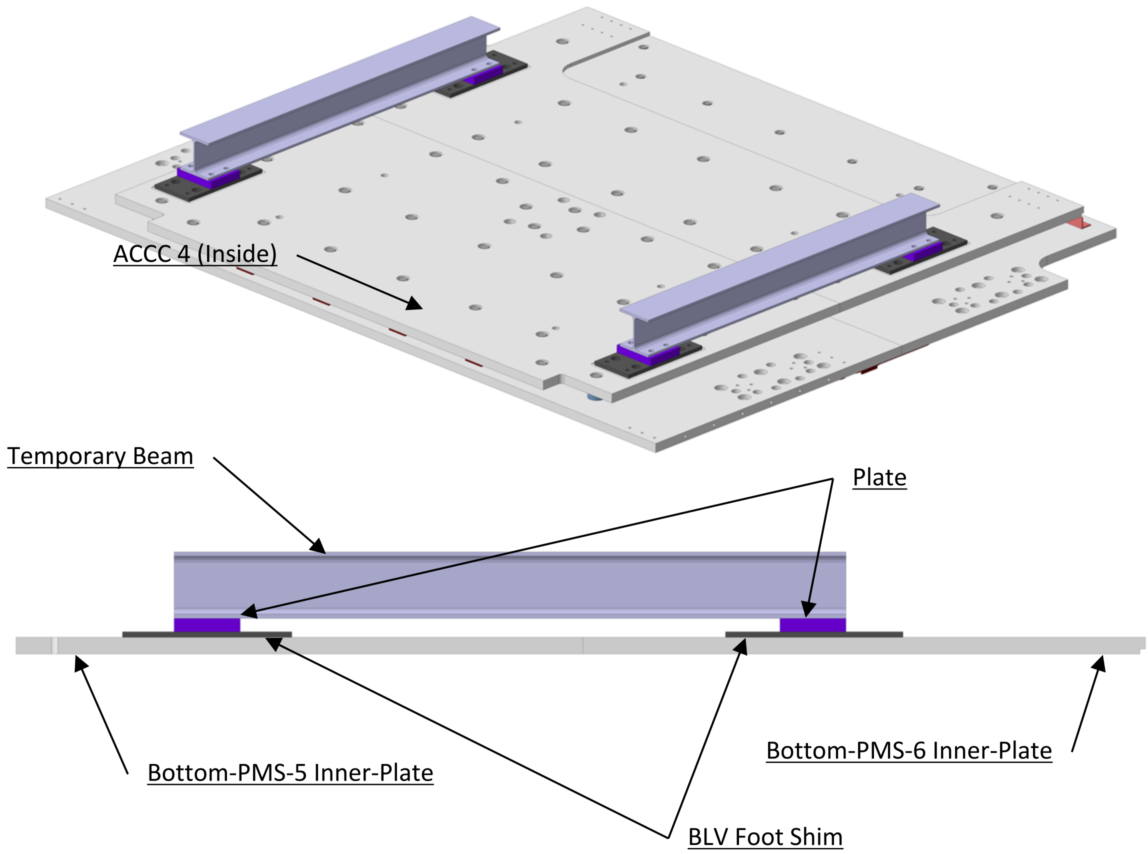

Figure 21 Bottom PMS 5/6 with temporary supports

3.5.7 Site Acceptance Test

The site acceptance tests will be limited to check that no component has been damaged during the shipping.

It will consist in check of the package, of the cleanliness condition and electrical tests of the ACCC insulation.

3.6 ACC Coils

The coil conductor material is copper. They are cooled by natural convection, and through (thermal) contact with the PMS plates. Main characteristics and dimensions are listed in Table 5.

		ACCC1	ACCC2	ACCC3	ACCC4	ACCC5	ACCC6	ACCC7	ACCC8	ACCC9
Geometry / Coil construction	**Nb of turn**	92	92	92	64	96	72	52	72	24
	Nb of pancake	4	4	4	4	4	4	4	4	12
	Nbturn/pancake	23	23	23	16	24	18	13	18	2
	Conductor total length (m)	~816	~800	~547	~513	~921	~687	~473	~1174	~1081
	Conductor size (mm)	□20	□20	□20	□20	□20	□20	□20	□20	Ø15*
	Coil Mass (kg)	~3029	~2970	~2031	~1904	~3419	~2550	~1756	~4358	~1702

Table 5 ACCC Characteristics

ACCC 1 to 8 insulation is made with vacuum-pressure impregnation, while ACCC 9 is made by a standard cable winded around the NB Vessel.

3.6.1 ACCC 1 to 8

Overall and cross section dimension of ACCC1 to 8 are listed in Figure 22 and Figure 23.

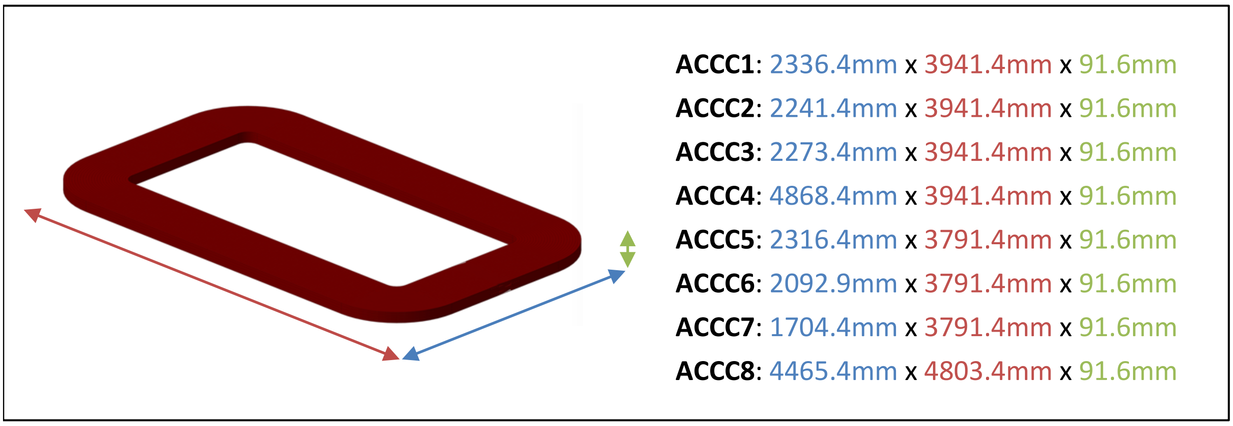

Figure 22 Coil 1-8 overall dimensions

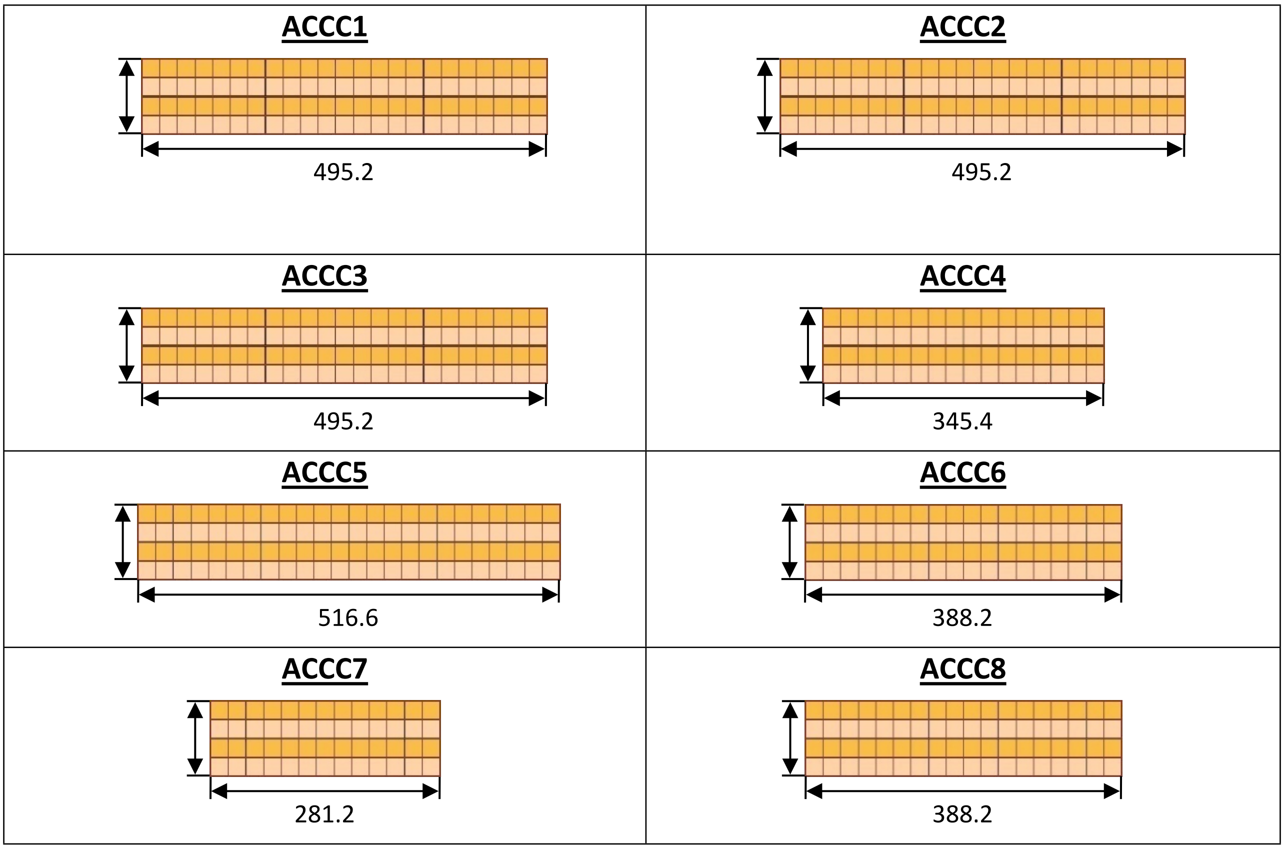

Figure 23 Coil 1-8 cross sections

The conductor is square, 20mm x 20mm, with rounded edges. Indicative dimensions for the insulation are shown in Figure 24.

It is the manufacturer responsibility to choose the final composition and thickness of the insulation layers, and to respect the insulation voltage requirement listed in 3.7. Indicative dimensions are shown in Figure 24.

The coil is provided with three insulations: conductor insulation (inter-turn), pancake insulation (inter-layer) and overall coil insulation (to earth insulation) (see Figure 25). The insulation shall provide also for the required coil mechanical stiffness before impregnation and mechanical strength after the impregnation.

The external surface shall be painted with a conductive varnish.

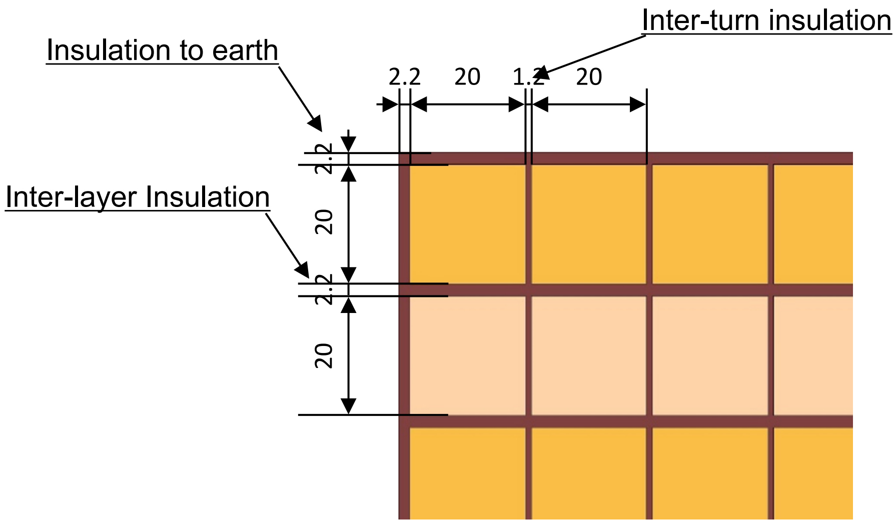

Figure 24 Indicative insulation dimensions

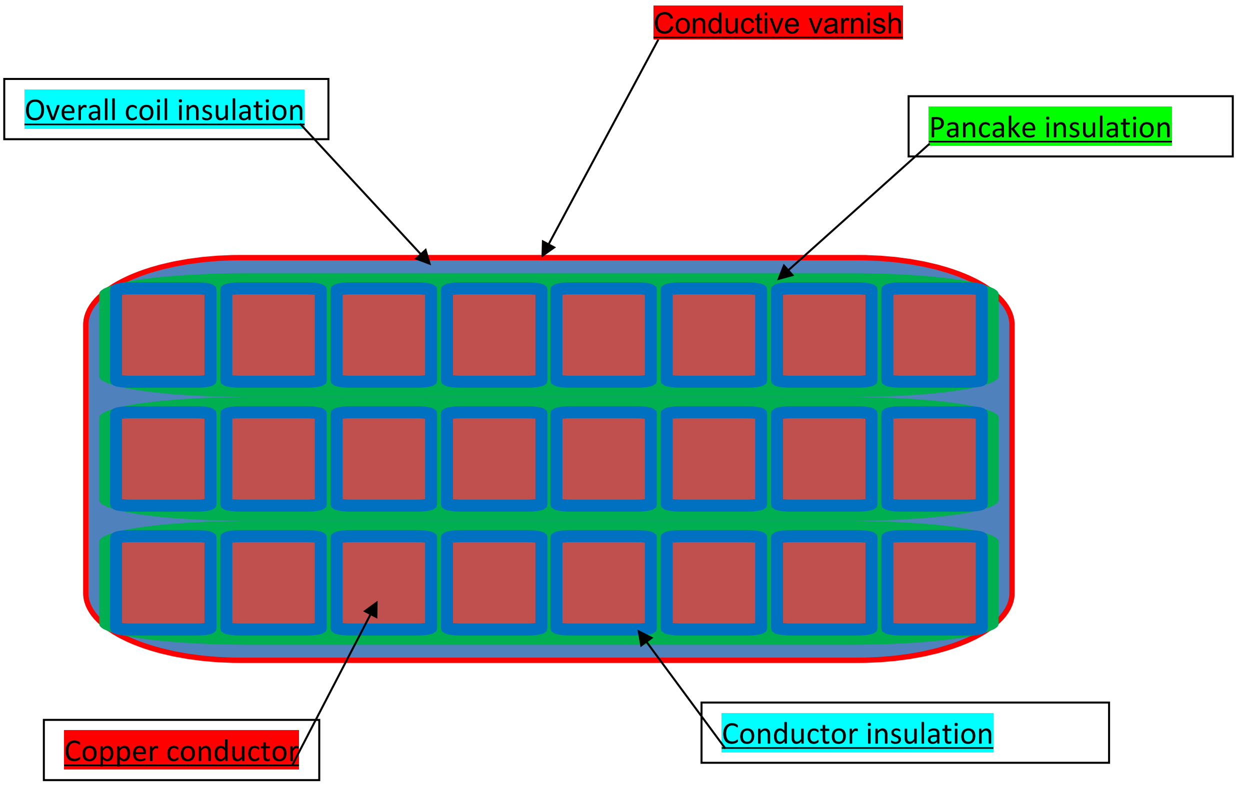

Figure 25 Coil insulation structure

Figure 26 shows a coil installed over a PMS plate before the closure of the sandwich with the top plate. The design foresees an electrical connection between pancakes made with bolted busbars.

F4E will evaluate alternative design that can improve the reliability and/or the easiness of manufacturing, reducing the number of joints (e.g. double pancakes).

After its impregnation and before being painted with the conductive varnish, each coil shall be equipped with four thermocouples that shall be placed in a good thermal contact with the coil insulation surface.

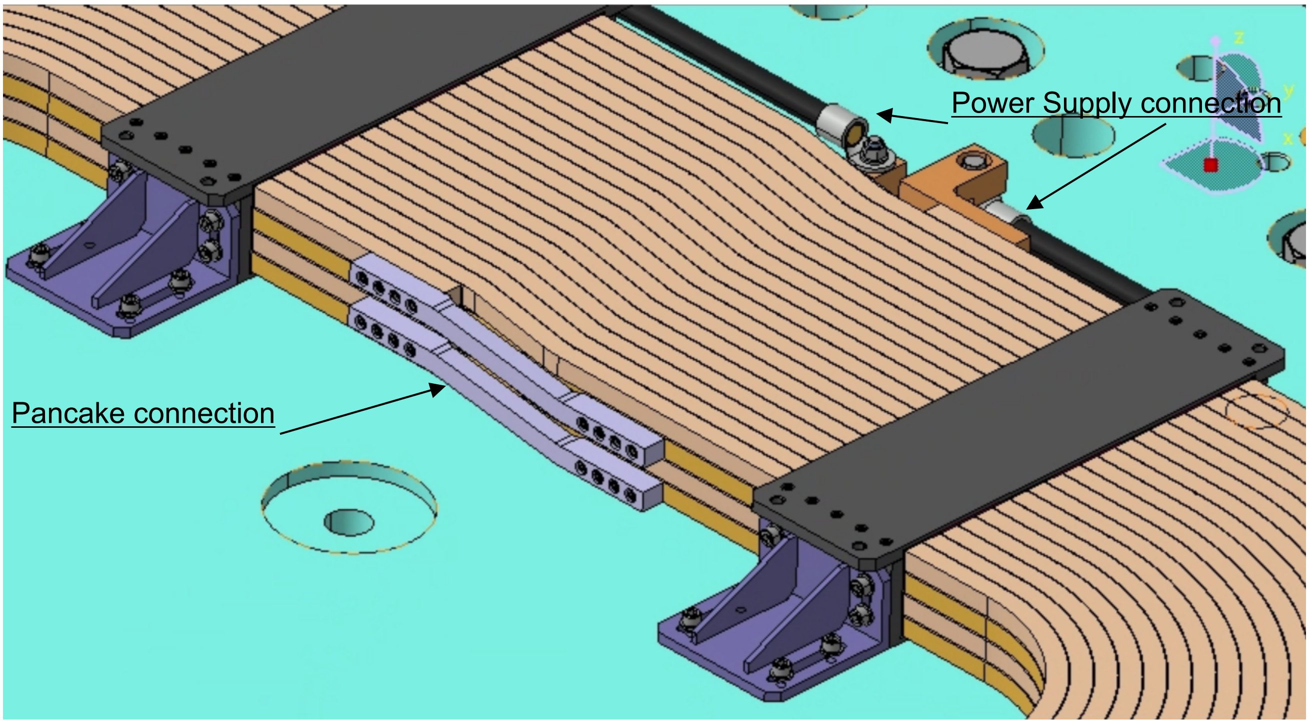

Figure 26 Coil electrical connections

3.6.2 Integration of the ACCC 1-8 with the PMS

Figure 26, Figure 28 and Figure 28 show the electrical connections to the power supply with a flexible cable arriving inside the PMS sandwich. This connection is part of the scope of the supply.

F4E will evaluate alternative design that can improve the reliability and/or the easiness of manufacturing (e.g. extending the coil conductor outside the plate to connect it externally).

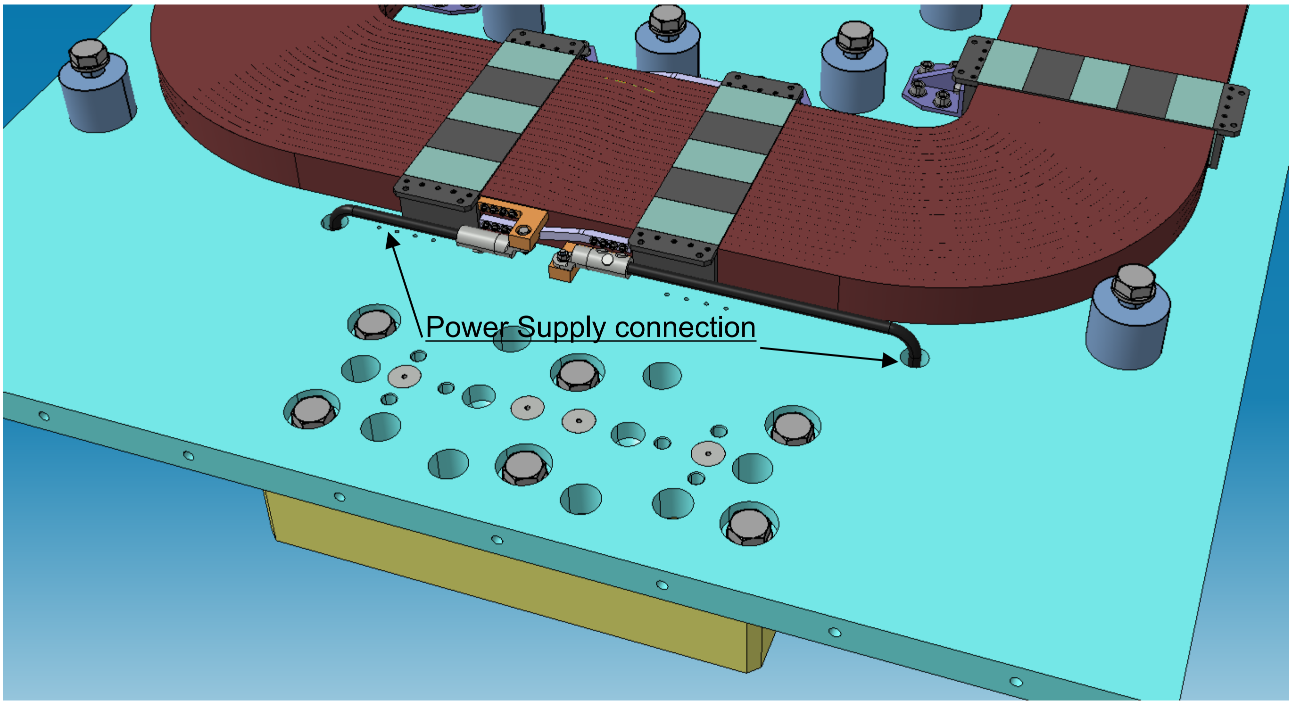

Figure 27 Power supply connection (above Bottom PMS plate)

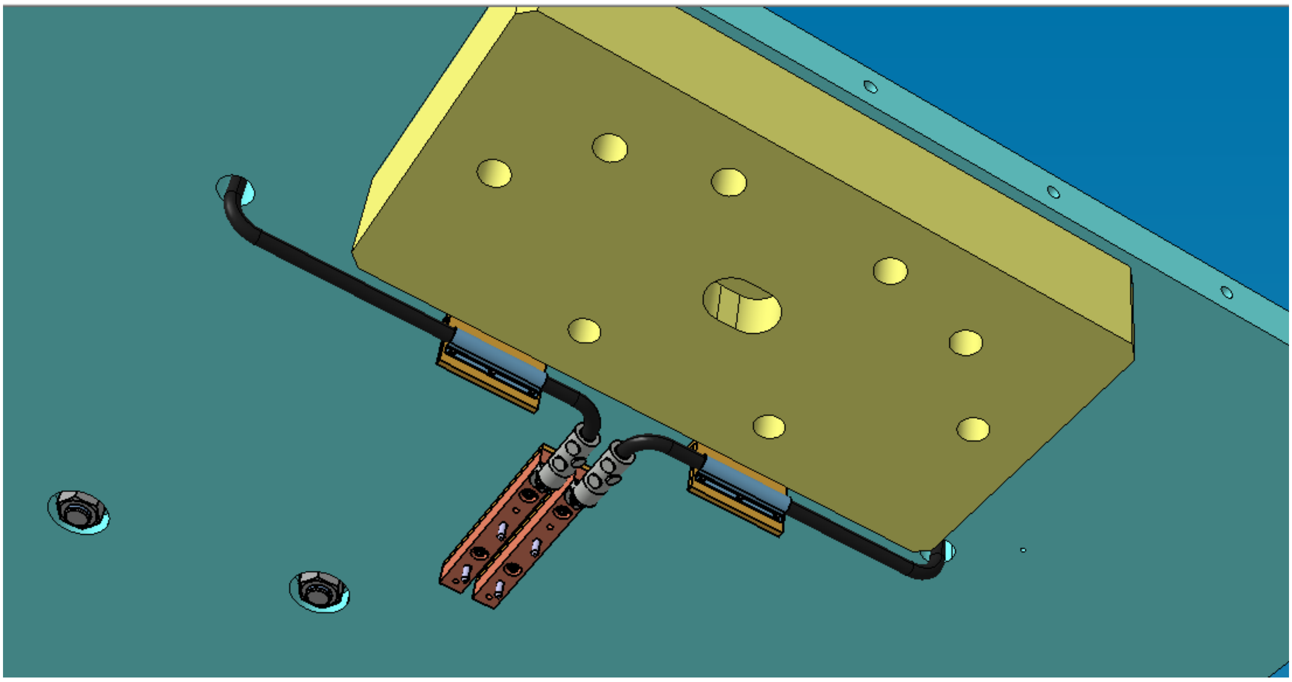

Figure 28 Power supply connection (below Bottom PMS)

The coils are mechanically and thermically connected to the PMS plate with the supports shown in Figure 29 and Figure 30. They are made of two parts clamped around the coils. Supports have elastic shims (radiation resistant rubber) to accommodate coil thermal expansion and manufacturing tolerances.

It is foreseen that supports are installed on the coils during their manufacturing and their planarity are checked to guarantee uniform contact between PMS and ACCC. They can be custom machined, or epoxy grouting can be used to compensate coil tolerances.

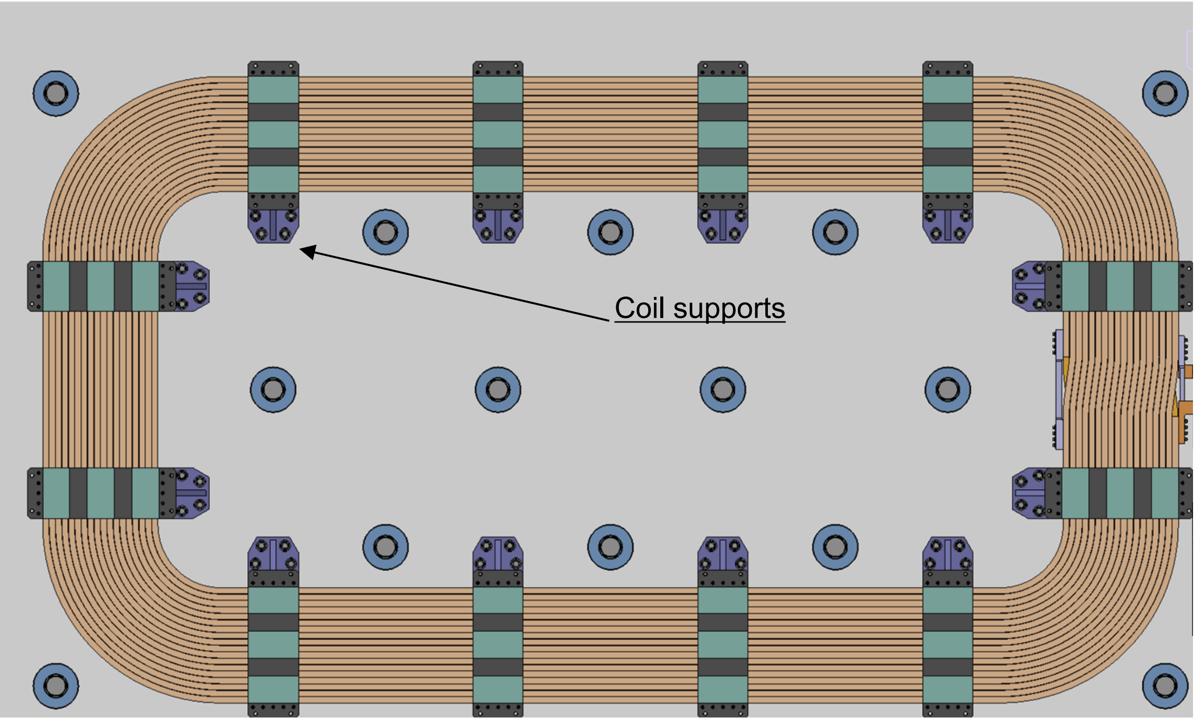

Figure 29 Coil installed over PMS Plate

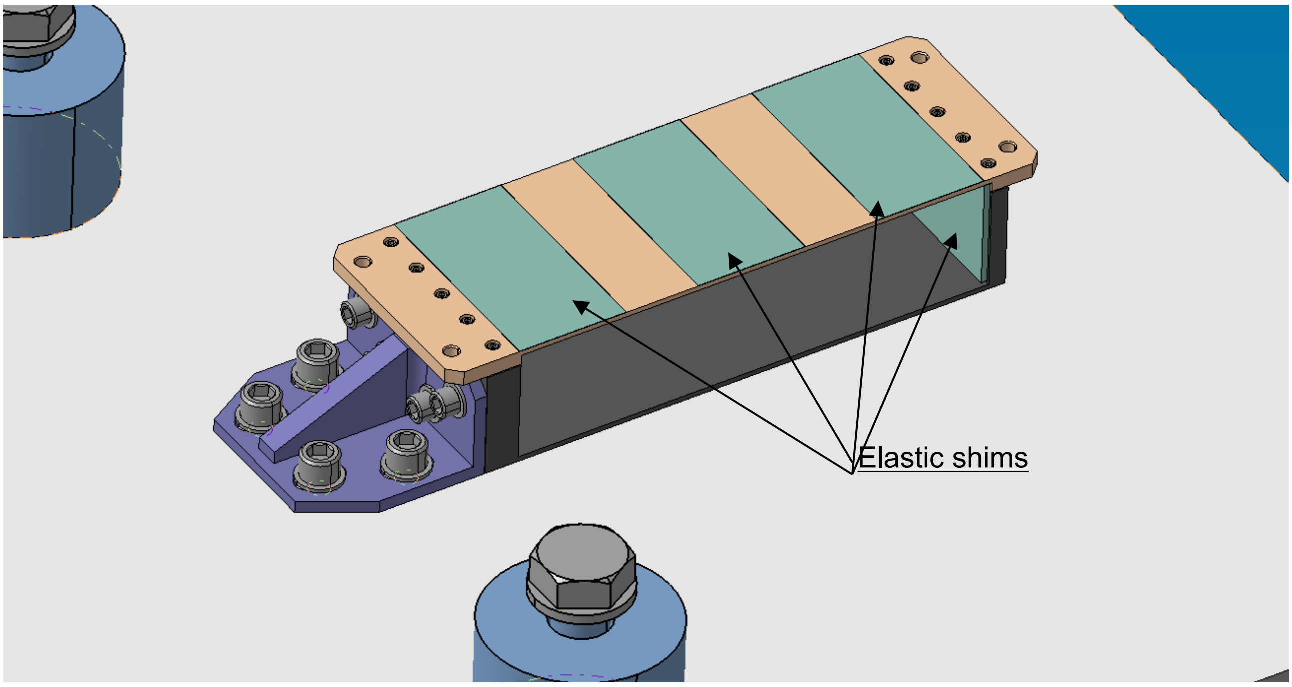

Figure 30 Coil support

3.6.3 ACCC 9

ACCC9 is an insulated conductor that will be wound around the HNB Vessel (see Figure 31).

The scope of supply consists of the cable and of the supports that hold it on the vessel.

The cable shall comply with the following requirements:

- Radiation resistance 1MGy as per: IEEE 383 (radiation resistance only) or IEC 60544-2;
- Fire retardancy as per: NFC 32070 C1, IEC 60332-1 and/or IEC 60332-3;
- Low Smoke as per: IEC 61034;
- Zero Halogen as per: IEC 60754-1;
- Non Toxicity as per: IEC 60754-2;

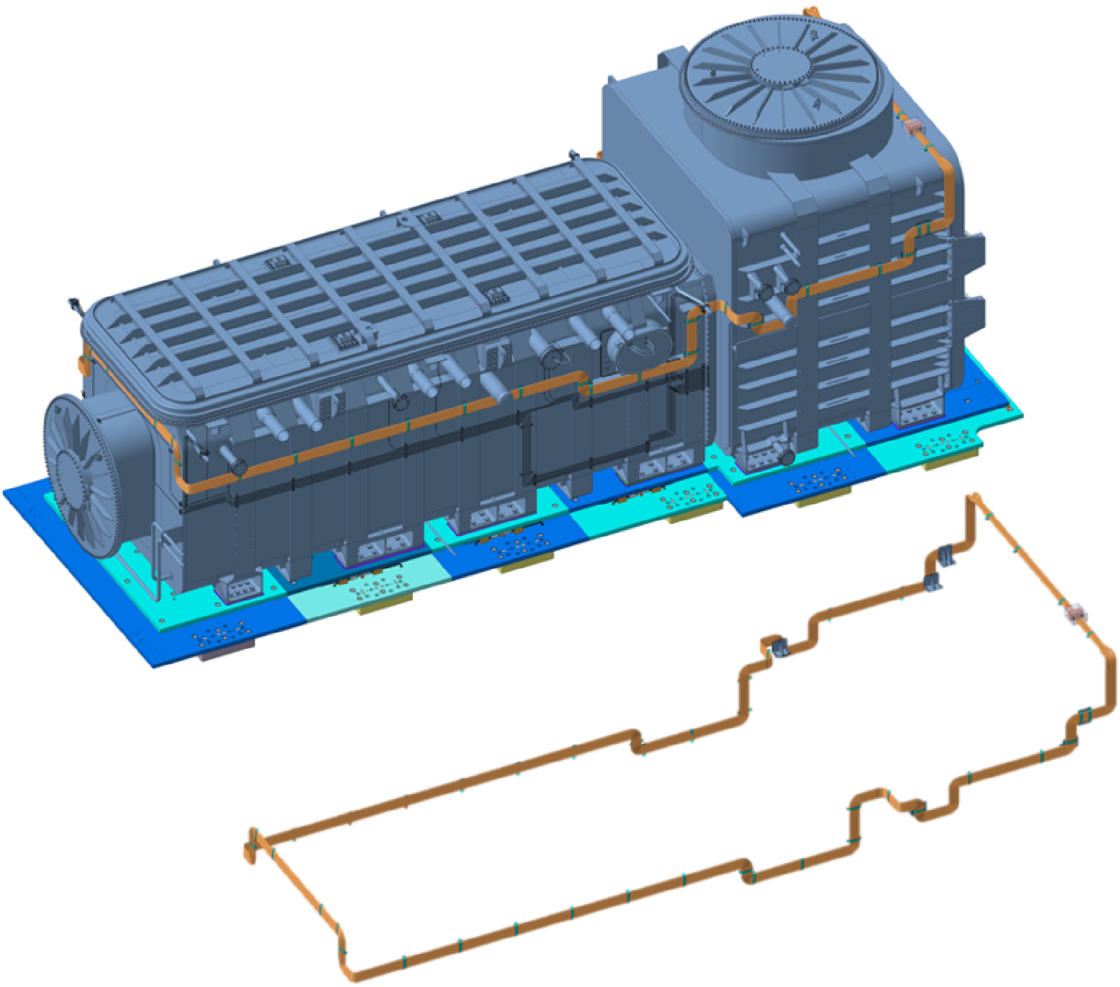

Figure 31 ACCC 9

3.7 ACCC main requirements

The inter-turn coil nominal voltage is 40 V, the inter-layer nominal voltage is 1.8 kV and the voltage to ground is 3.6 kV. It is manufacturer responsibility to choose the final composition and thickness of the insulation layers.

3.7.1 Material requirements

For the conductor the material shall be Copper OFXLP UNS C10300 or C10200 in half-hard conditions and in compliance with the requirements listed in Table 6.

Copper Chemical composition				
Copper + silver %	min.	99.95		
Silver %	min	0.08	max	0.12
Oxigen %	max	0.001		
Phosporous %	max	0.004		
Cobalt %	Max	0.05		
Niobium %	Max	0.01		
Tantalum %	Max	0.01		
Other characteristics				
Electrical resistivity at 20 Deg (Ω·m).	max	1.76E-08 (98% IACS)		
Yield strength 0.2% (MPa	min	200	max	290
Elongation at fracture [%]			max	14%
Ultimate tensile stress (MPa)	min	250		
Hardness (VHN)	min	70	max	90

Table 6 Copper requirements

DGEBA or DGEBF resin according to Table 7 are proposed as the impregnation resin for the ACCC, since already qualified for ITER application.

If alternative resins than DGEBA or DGEBF are to be used, the resin shall be qualified, and its mechanical and electrical performance after irradiation at 1MGy shall be at least as good as the one proposed.

Type	Epoxy Resin	Hardener (all anhydride)	Additives
DGEBF	Ciba Geigy GY282 (100pbw)	Ciba Geigy HY918 (MTHPA)	Ciba Geigy DY073 (0.25pbw)
DGEBA	MY745	HY905	DY072 DY073
DGEBA	LY1025/CH	HY905	Orlitherm44

Table 7 Resin types

3.7.2 Manufacturing requirements

The insulation system and the Vacuum Pressure Impregnation (VPI) shall be qualified with a linear model of the coil structure.

All parameters of the process (pressures and temperature curves, characteristics of the resin) shall be controlled.

The following tests are foreseen on the linear model:

- Inter-turn insulation (250 V).
- Inter-layer insulation (12 kV).
- Insulation to earth (15 kV).
- Breakdown voltage measurement (no superficial flashover).
- Insulation glass content (> 75%).
- Insulation visual inspection and dimensional check.
- Insulation tensile and shear strength on samples extracted from the model (40 & 20 MPa).

The joint method between turns (bolting or brazing) shall be qualified with mechanical and electrical tests.

Before proceeding with the series production the first coil needs to complete the full dimensional and electrical tests.

3.7.3 Testing requirements

For each coil the following series of tests (for acceptance) and measurement (for information) are foreseen after manufacturing:

- Dimensional tests and visual inspection (compliance with drawings).
- Insulation to earth test (10 kV).
- Insulation loss factor measurement.
- Temperature rise measurement (and thermocouple test).
- Inter-turn insulation test (transformer or capacitor method).
- Insulation to earth test (10 kV AC, 20kV impulse).
- Insulation resistance to earth test (100 MΩ).
- Insulation loss factor measurement.
- Capacitance to earth measurement.
- Electrical resistance measurement.
- Impedance with frequency measurement.

After installation inside the PMS the following tests will be repeated:

- Insulation resistance to ground test (100 MΩ).
- Insulation resistance to earth test (10 kV).
- Insulation resistance to ground test (100 MΩ).
- Impedance with frequency measurement.

3.7.4 Assembly and shipping

ACCC-1 to 8 shall be installed inside the Top and Bottom PMS plates. Supplier shall be responsible for the transportation to the factory where the PMS will be assembled. Design and manufacturing of lifting and transportation are also included in the scope.

Transportation of the coils to ITER site will be done together with the PMS, without disassembling.

4 SCOPE OF SUPPLY

The expected scope of Supply is based on Build-to-Print (B-t-P) specification provided by F4E to the Supplier(s)*.

The scope of the contract is expected to include

- Production of manufacturing drawings and plans,
- Execution of the Manufacturing Readiness Review (MRR) with the participation of experts from F4E, ITER Organization and external experts.
- Manufacturing.
- Factory testing
- Disassembly and shipping
- Delivery to ITER at Cadarache and SAT (no reassembly on site).

On the basis of the B-t-P design provided by F4E, the supplier shall produce the manufacturing drawings and consequently shall procure materials, and shall manufacture and deliver the components in line with the required delivery schedule for installation in Cadarache.

Build-to-Print Specification means that F4E provides the final specification from IO to the Supplier(s), namely:

- Bill of Materials
- 2D Drawings (Build-to-Print) including the contractual dimensions and tolerances;
- CATIA 3D model;
- Equipment specification including:
    - Reference Procurement specifications for material procurement;
    - B-t-P Welds tables with proposed welds configuration compliant (including NDT control) with the applicable manufacturing codes (RCC-MR) and requirements and in accordance with the Build-To-Print drawings;
    - Factory testing and delivery requirements.

2D Drawings are provided for the single parts, with tolerances that will guarantee correct operation. Some of the surfaces will be identified as "custom machined surfaces after metrology survey during factory assembly).
It is the responsibility of the supplier to guarantee the factory assembly and to pass the factory tests. Tolerances affecting the assembly can be adjusted, in agreement with F4E, according to the chosen manufacturing and assembly route.
It is expected that during the manufacturing design minor adaptation will be needed (e.g. on the final geometry of the ACCC). Those adaptations are part of the scope but will need F4E/IO authorization.

Based on this Build-to-Print specification, the scope of work of the Supplier includes, mainly:

1. Manufacturing Engineering:
    - ✓ Manufacturing plan;
    - ✓ Material procurement specification;
    - ✓ 2D drawings for manufacturing and testing;
    - ✓ Procedural baselines for manufacturing sequence, welding, NDE, and factory assembly;
    - ✓ A Manufacturing Readiness Review (MMR) that authorizes start of procurement and manufacturing activities after successful demonstration by the Supplier. Earlier procurement of raw materials is accepted but subjected to the approval by F4E/IO of the material technical specification.
2. Procurement:
    - ✓ Base Materials;
    - ✓ Bolts;
    - ✓ Off-the-shelf products.
3. Manufacturing:
    - ✓ Machining;
    - ✓ Forming;
    - ✓ Metrology;
    - ✓ Welding;
    - ✓ NDT of the welded joints such as VT, PT, RT, UT;
    - ✓ Marking and identification of components;
    - ✓ Final cleaning.
4. Factory testing:
    - ✓ Factory assembly;
    - ✓ Metrology and gap inspection;
    - ✓ Functional tests as described in 3.5.5;
5. Packaging and shipment to ITER Cadarache:
    - ✓ The PMS will be disassembled in individual subassemblies.
6. Documentation:
    - ✓ Quality documentation;
    - ✓ Manufacturing documentation;

✓ End of Manufacturing Report (EMR) dossier.

In addition, the Supplier will design and procure the specific jigs, fixtures and frames that are needed for the construction and testing of the equipment. These items are not specified by F4E.

* The procurement strategy is not yet defined; the possible options are described in section 6.

5 Technical and Industrial Capacity

The potential Supplier(s) is expected to be experienced in the following fields:

Table 8: Expected industrial capacity (*)

	Vessel PMS	RPOM	HVB PMS	ACCC
Manufacturing of large component	No	Yes	Yes	Yes
Precise assembly of large components (at factory)	Yes	Yes	No	No
Manufacturing according to RCCM or similar codes	Yes	No	Yes	No
Quality system suitable for management of safety relevant activities	Yes	No	Yes	No
Manufacturing of large parts in plastic material	Yes	No	Yes	No
Lead shields fabrication	Yes	No	No	No
Manufacturing engineering	Yes	Yes	Yes	Yes
Copper magnet manufacturing	No	No	No	Yes
Magnetic tests of carbon steel	Yes	No	No	No
Non-destructive examination such as RT and UT	Yes	No	Yes	No
Machinery manufacturing	No	Yes	No	No
Water hydraulics	No	Yes	No	No
High Vacuum component manufacturing	No	No	No	No
Clean environment manufacturing	Yes	No	Yes	Yes

* The procurement strategy is not yet defined; the possible options are described in section 6.

One of the main challenges will be to fabricate SIC parts compliant with the French nuclear code: RCC-MR 2007 especially for what concern material procurement, welding and the Non Destructive Testing, even though the components are not pressure bearing nor primary confinement.

The second main challenge concerns the precision of the overall assembly, that consists of individual elements up to 6 m long and 20 tons weight, with tolerance of the order of 1 mm in some interfaces.

The potential Supplier(s) is expected to have the industrial capacity for procuring and manufacturing up to two magnetic shielding to the requested schedule, in particular:

- Manufacturing engineering;

- Management team for the engineering, procurement and construction contract as well as effective activity execution management;
- Quality assurance and quality control activities;
- Machining, dimensional inspection, and non-destructive examination for large components;
- Manufacturing documentation management;
- Factory with suitable capacity (floor space and load capacity, cranes, cleanliness) for assembly of equipment suitable for the manufacturing scope execution;
- Adequate management system for Safety Relevant Activities to be performed.

With this market survey, the Supplier(s) is invited to provide information on the parts of the contract which are intended to be subcontracted. Among the activities which may be considered subcontracted or insourced, where applicable, are:

- cutting and machining activities;
- forming;
- surface treatments (painting, phosphate coating);
- welding, NDT;
- dimensional inspection;
- lead and polyethylene shields;
- machinery (RPOM) manufacturing and water hydraulics;
- factory assembly.

6 PROCUREMENT STRATEGY

The procurement strategy has not yet been defined by F4E and will depend also on the outcomes of this Markey survey. Two possible scenarios are being considered:

- Scenario 1: F4E will procure the Magnetic Shielding in one single contract; the contractor is responsible for the manufacturing of all the parts included in the scope (PMS, ACCC) as well as the integration, acceptance tests and delivery operations; the contractor may subcontract or rely on industrial partners to complete the scope of work;

- Scenario 2: the scope of work is divided in 2 lots that can be awarded to 2 different suppliers:
    - Lot 1: manufacturing, testing, and delivery of the ACCC (*);
    - Lot 2: manufacturing of the PMS (Vessel PMS, HVB PMS and RPOM), assembly of the ACCC inside the Vessel PMS, complete factory assembly, testing, and delivery to ITER site;

  The suppliers for Lot 1 and Lot 2 may rely on industrial partners or subcontractors.

  (*) the ACCC will be delivered by the supplier of lot 1 to F4E; F4E will deliver this component to Lot 2 supplier as free issued item

An option for the installation at ITER site may be included

7 SCHEDULE

The main tentative dates of the current planning are indicated below:

- F4E plans to publish a Call for Tender (CFT) in Quarter 4 of 2024. The contract is planned to be signed within 1 year from the CFT publication.

- The current estimated duration of the contract until delivery is 4 to 4.5 years.

8 Market Survey

Please answer to the F4E Market Survey by clicking on this link:

https://ec.europa.eu/eusurvey/runner/NB_MAGNETIC_SHIELDING