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EXTERNAL REFERENCE / VERSION

Call for Expert Documents

Technical Specification for Qualification of magnet assembly procedures

Tech spec for qualification of magnet assembly procedures

Approval Process			
	Name	*Action*	*Affiliation*
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Read Access	**LG: Magnet division's technical assistant, LG: PROCUREMENT, LG: Magnet QA RO, LG: Gennaro Romano, LG: Superconducting Advisor, AD: IO_Director-General, AD: EMAB, AD: OBS - Magnet Division (MAG), AD: Auditors, project administrator, RO**		

Change Log			
Technical Specification for Qualification of magnet assembly procedures (R34F76)			
Version	***Latest Status***	***Issue Date***	***Description of Change***
v1.0	Signed	24 Mar 2015	
v1.1	Approved	25 Mar 2015	Document template updated Requirement to have a car added. Provision to perform specific training needed for the workshop operation added.
v2.0	Signed	03 Jun 2015	Structure revised making the contract deliverable based. TF coil and feeder tasks more detailed.
v2.1	Approved	08 Jun 2015	Comments from Remy implemented.
v2.2	Approved	09 Jul 2015	Minor modifications following PCD comments in sections: -) 1 Purpose (support removed) -) 10 wording on experience modified -) 11 Work conditions and monitoring (first two paragraphs modified)

china eu india japan korea russia usa

CONTRACT TECHNICAL SPECIFICATION

Qualification of Magnet Assembly Procedures

Technical Specification

Table of Contents

1 Purpose

This technical specification describes engineering work for the qualification of assembly procedures for magnet components, in particular for the Feeder System.

2 Scope

ITER superconducting magnet system consists of 18 TF (Toroidal Field) coils, 6 PF (Poloidal Field) coils, a Central Solenoid (CS), 18 Correction Coils (CC) and a Feeder System. All magnet components are complex and many of them unique. Due to limited space availability in the ITER machine the installation and assembly is very demanding, in particular for the feeders which are up to 30 m long with a 3D shape. The assembly procedures are being developed by the IO and DAs with their suppliers but it is essential that all critical procedures have to be tested and qualified before acceptance.

For this purpose, the Magnet workshop (MIFI) has been set up. The workshop is located at CEA Cadarache situated a few km's away from the ITER site. The buildings and infrastructure is provided by CEA as well as the MIFI team consisting of skilled technicians with expertise in the fields of low/high voltage instrumentation, insulation, superconductivity, cryogenics and mechanical assembly [1]. The MIFI area is divided into 2 parts: the main workshop and the storage area. With MIFI the boundary conditions such as equipment, tooling and manpower are provided to perform the qualification and assembly procedures for the components as described below.

3 Definitions

MIFI – Magnet Infrastructure Facilities for ITER

IIS – Inner Intercoil Structure

ILIS – Inner Leg Intercoil Structure

IOIS – Intermediate Outer Intercoil Structure for TF coils

OIS – Outer Intercoil Structure

TC – Technical Coordinator

MWP – Monthly Work Plan

A complete list of ITER Abbreviations can be found under ITER_D_2MU6W5.

4 References

[1] "Magnet Infrastructure Facilities for ITER (MIFI)", Site Support Agreement SSA/IA no 40 – CONV-AIF-2014-4-6, IO ref. IO/AGR/14/4300000999.

5 Estimated Duration

The duration of the contract shall be 24 months. The contract duration may be extended of 12 months only with the express written agreement of the parties.

6 Work Description

The work at MIFI is organised through MWPs where priorities and schedules are defined for single work activities or tasks. The contractor shall provide support in the preparation of the MWPs and coordinate the MIFI technicians among the different activities according to the MWP.

In the paragraphs below the specific work tasks are described. The general implementation process of all of them is as follows:

1) Review of task specification with the corresponding RO from IO.

2) KOM with the IO RO and MIFI Technical Coordinators from CEA and IO and define the requirements needed to perform the task.

3) Follow up and lead the MIFI technicians to ensure proper execution of task.

4) To check the tooling and materials are properly registered in the database.

5) Regular reporting to the IO RO about progress of the task.

6) Review and contribute to the final report of each task.

7) Prepare/update assembly procedures and inspection plans following the outcome of the task.

6.1 Instrumentation cable pulling trials

The objective of this activity is to manufacture an instrumentation cable duct mockup representative of the PF5 feeder and perform cable pulling trials to finalize and qualify the procedure. This task is divided into 3 phases:

Phase 1: First dummy mockup to do pulling trials as fast as possible having only simple 2D bending with representative bends (see Figure 1). The target of this mockup is to determine principle limitations given by the pipe surface conditions. Pipes with 2 different surface finishing conditions are tested.

Phase 2:PF5 ICF ducts (both HV with tightest bends) under representative conditions. PF5 ICF trajectory is one of the most complex ones in the ITER system and therefore, is tested first (see Figure 2).

Phase 3: Cable pulling trial of full PF5 feeder including the ducts of CFT, SBB and CTB (see Figure 3).

Following the outcome of the trials further feeders are selected having been identified with particular difficulties like limited access, high cable filling factor in the ducts, ….

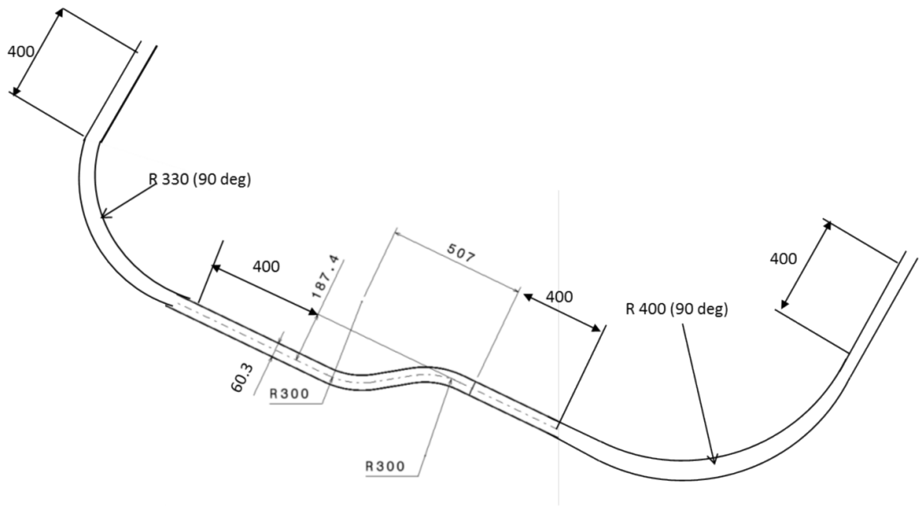

Figure 1. Trajectories of mockup for Phase 1. All dimensions are in mm.

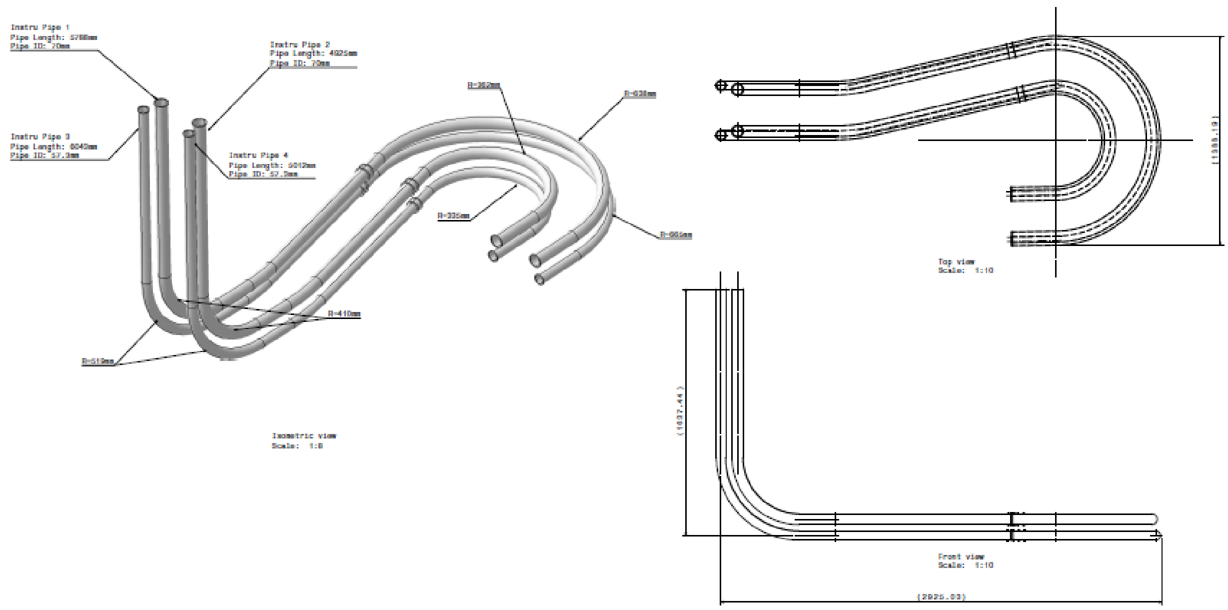

Figure 2. Trajectories of the instrumentation pipes in the PF5 ICF. Note: only the 2 innermost pipes (with the smaller bending radius) will be tested.

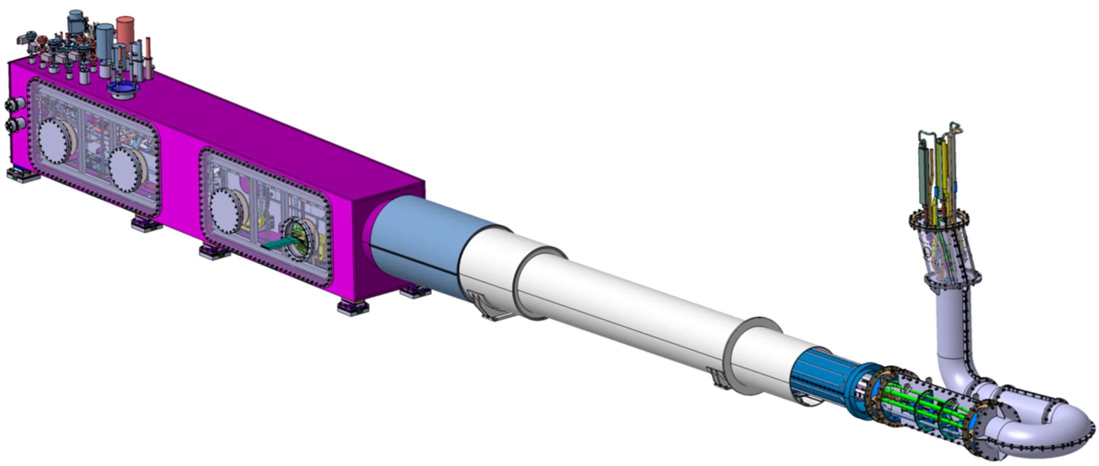

Figure 3. Model of the PF5 feeder. The total length for the instrumentation cables is in the order of 30 m.

6.2 Conductor destructive examination

On regular basis it is required to investigate short pieces of conductor samples to confirm/check quality of conductor subcomponents. The main manufacturing steps are to remove the subcomponents step by step (see Figure 4) and perform visual inspection sometimes complemented with dimensional checks.

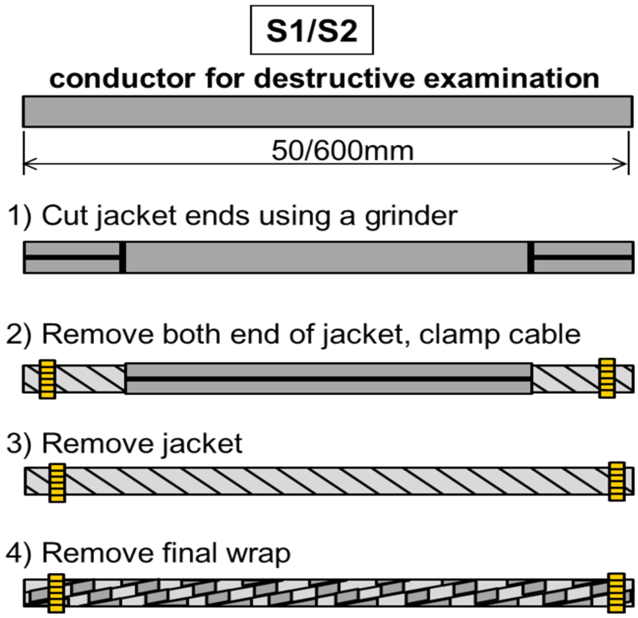

Figure 4. Main steps for a destructive examination of a conductor piece.

6.3 Setting up of vacuum impregnation lab

Many ITER magnet components are using VPI. For the qualification of VPI processes a workspace has to be set up from scratch being able to impregnate small samples by means of VPI. The capacity shall be up to about 5 liters of resin and should foresee the use of either standard epoxy or cyanate ester blend as specified for the ITER TF insulation. This work includes the selection of required material and tooling to be procured by MIFI and to develop/qualify the impregnation procedures.

6.4 TF coil assembly tasks

The objective is to support procedures related to TF coil assembly like the IOIS fitting test, ILIS attachment, winding pack feedthrough assembly or casing cooling. The TF coil structural parts are shown in Figure 5. Further details of the tasks are given in the paragraphs below.

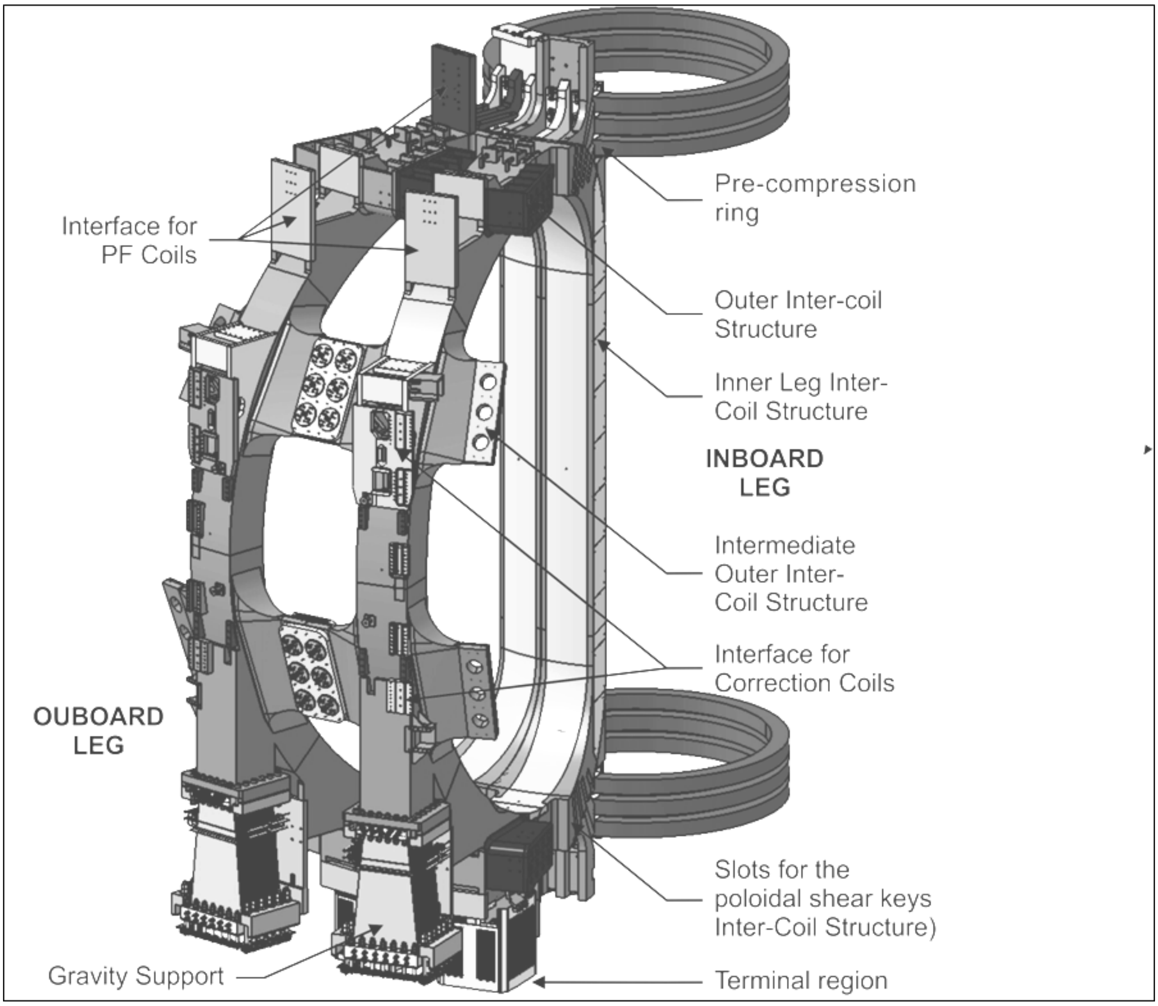

Figure 5. Structural parts of the TF coils.

6.4.1 IOIS fitting test

The purpose is to verify the IOIS assembly procedure. For this purpose, an IOIS mock-up with 4 shear pins (see Figures 6 and 7) is used. The main activities to be done at MIFI and to be followed up by the contractor are:

The main activities are:

- Manufacture the chassis to install the IOIS mock-up
- Manufacture the centering tools and insertion tools
- Assist the IO surveyor and review the applicable survey procedures
- Coordinate the IOIS pins fitting test for two different IOIS mock-ups with inclination configuration to simulate the approved assembly baseline procedure
- Perform the upper and the lower insertion configuration with and without the shear pin cool down

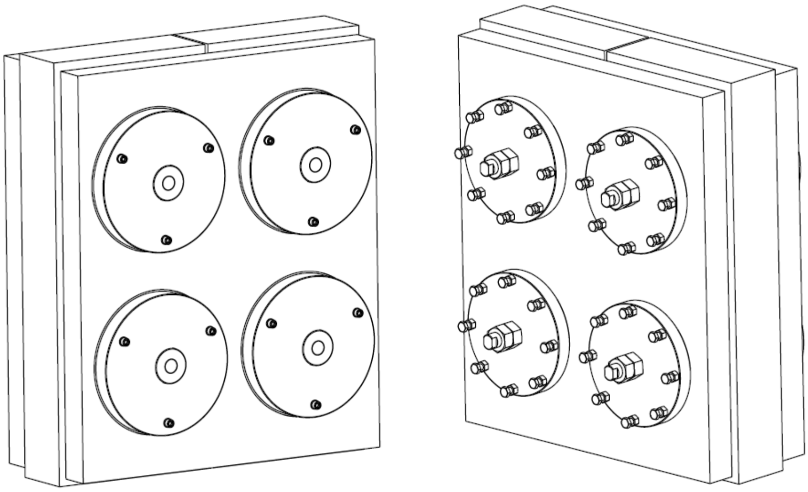

Figure 6. Isometric view of the IOIS mock-up. The dimensions are about 1.3 x 1.1 x 0.69 m (max. dimensions in assembled stage).

6.4.2 ILIS attachment

Based on the submission of a pre-qualification report, the detailed procedure of the selected attachment technique of customized ILIS panel based on flat metallic sheets shall be developed on real scale panel dimension sample (see Figures 7 and 8). This work task will include the collaboration with TF Magnet division member to finalize conceptual tooling design drawing adapted to the real TF inboard environment. The technique of spot welding positioning, fixation by gluing, clamping of panel through uniform applied pressure shall be implemented and a corresponding inspection report shall be written with main acceptance criteria cross checked and records:

- Spot welding control points
- Glue appliance methology
- Pressurisation bladder technique main acceptance parameters checked
- Panel Planarity inspection

Deliverables shall include the built to print Design drawing agreed with magnet division and assembly division, the inspection report and the detailed procedure establishment.

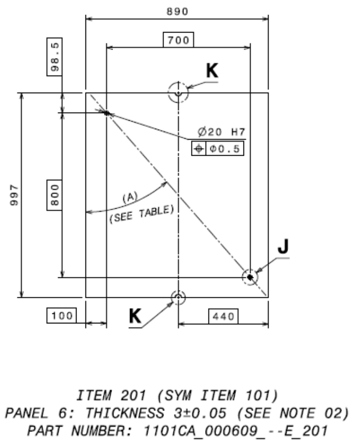

Figure 7. Typical ILIS panel size (all dimensions are in mm).

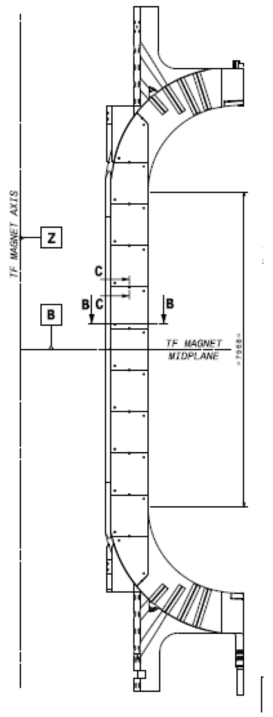

Figure 8. ILIS panels assembly layout (all dimensions are in mm).

6.4.3 Casing cooling mockup

The objective of this activity is to confirm the cooling efficiency of the cooling pipe in the TF coil structure is sufficient to avoid heating of the conductor by the nuclear heating. For this purpose, a mockup is to be built according to the developed design to verify experimentally the predictions derived from models. In order to get an idea of the scope the specification of a mockup produced end of 2014 can be found in Figure 9.

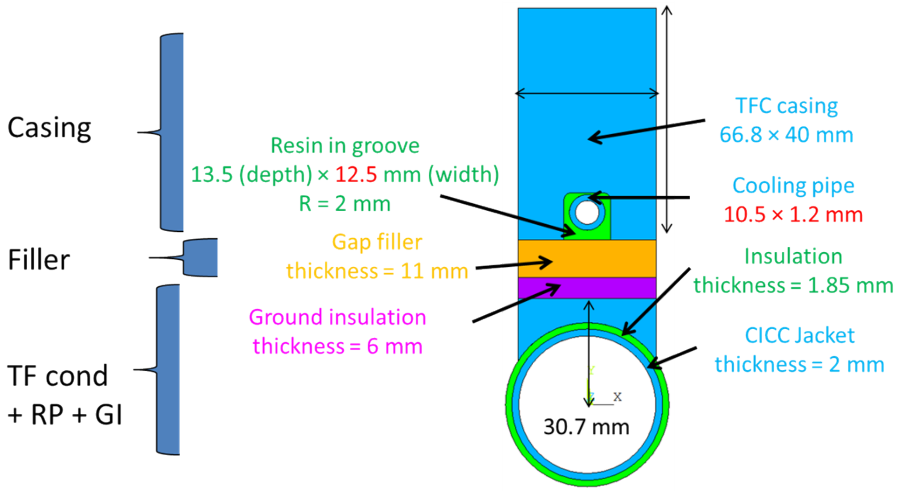

Figure 9. Cross section of the STR mock-up. The length of the casing/conductor assembly is 1 m.

6.5 Low voltage instrumentation measurement chain

The purpose is to support the qualification of procedures related to all components of the measurement chains: sensors, cables, feedthroughs, connectors, patch-panels, signal conditioners and controllers for checking the measurement chain as a chain not as components considered individually. The aspects to be addressed are:

-) functionality (example of a patch panel shown in Figure 10)

-) physical attachment (example of temperature sensor attachment on a pipe is given in Figure 11)

-) wiring and wire clamping

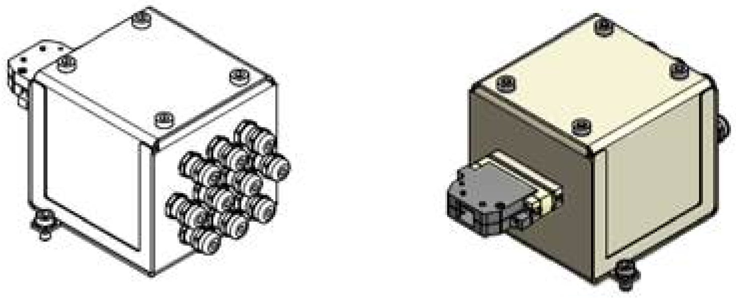

Figure 10. Patch panel example (the dimensions are roughly 100x100x100 m).

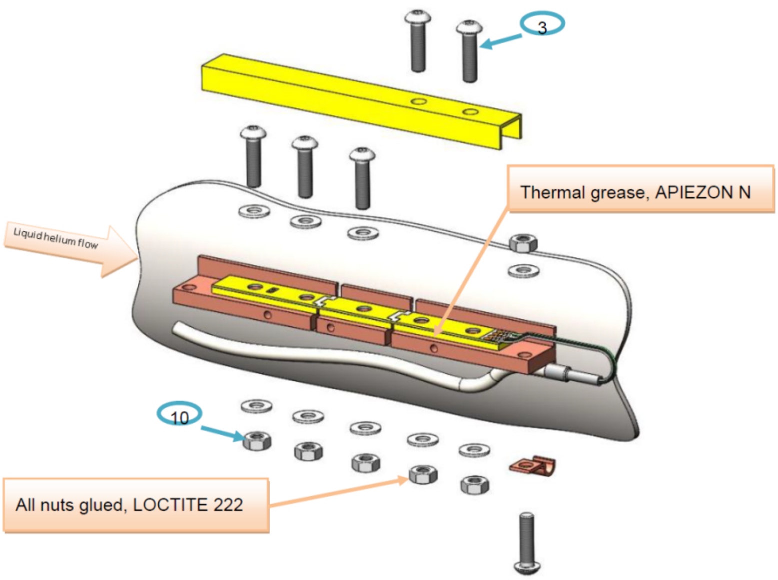

Figure 11. T-shape copper support for a temperature sensor brazed on a pipe.

6.6 Feeder joint assembly procedures

Feeder assembly tasks include activities like In-joining trials, feeder joint assembly and insulation.

6.6.1 <u>In-joints</u>

The objective is to finalize the specification for the In-joints and identify the optimum parameters like Ag layer thickness, In wire diameter and spacing, clamping pressure to ensure low resistance joint. The main steps are:

- -) Ag plating of Cu blocks (different layer thicknesses and surface preparation procedures)
- -) Joining with In wires: measurement of the In intermediate layer thickness as a function of pressure
- -) Destructive examination of the surfaces by means of visual inspection and SEM. Some examples are given in the Figures below.

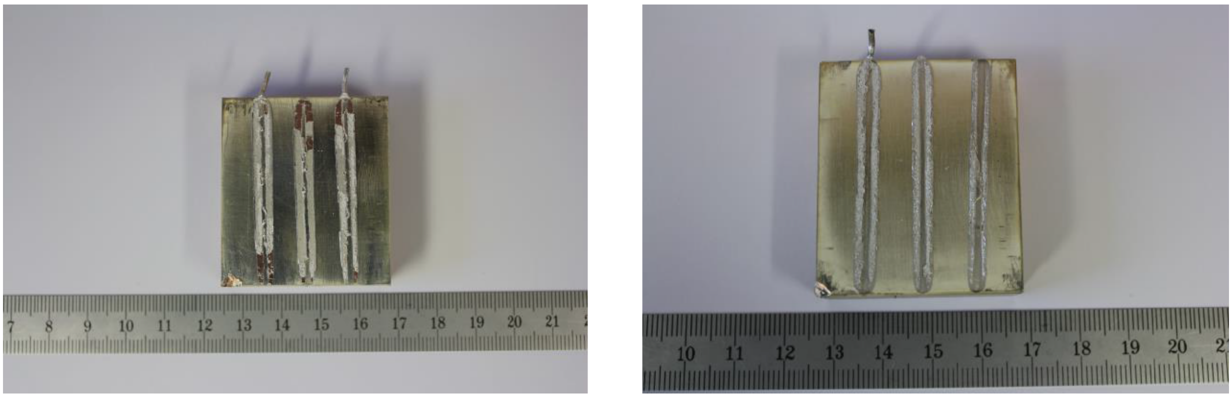

Figure 12. Copper blocks with Ag layer and In wires after pressing and opening the joint by removing the counterpart.

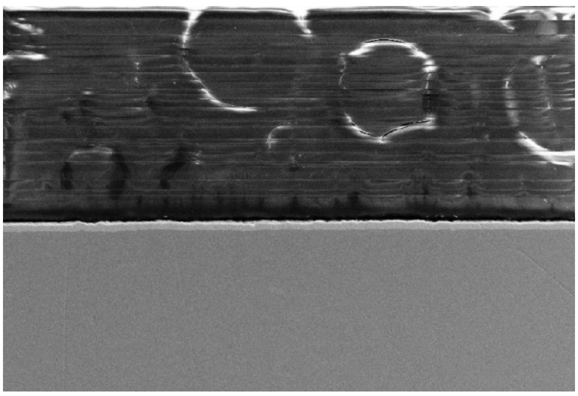

Figure 13. SEM of the Cu-Ag layer where no In was present after removal of counterpart.

6.6.2 Joint assembly

The main manufacturing steps are:

- -) Cable preparation (Ni removal, wrap removal, silver plating)
- -) Joint box preparation (machining of explosion bonded plates, tinning of copper sole)
- -) Half joint assembly (compaction of prepared cable and tin alloy foil into joint box, closure welding, heating for completing the soldering process)
- -) Joint assembly (soldering of 2 half joints)
- -) Clamping (welding of joint clamps and stiffing blocks)
- -) Adding G10 side filler pieces

-) Cooling pipe assembly (welding of He pipes, fixing in G11 blocks)

-) Final assembly (G10 filler pieces and half clamps at the joint ends)

-) Outer insulation (wet winding to apply the outer insulation of the complete joint)

The assembly sequence starting from the half joint is given in Figure 14.

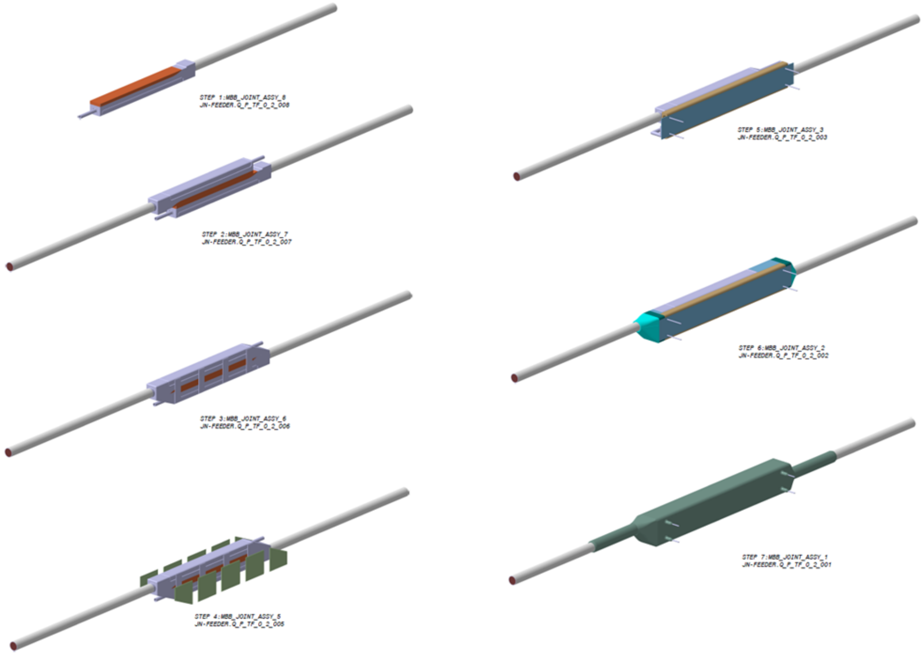

Figure 14. Assembly sequence of MB joint.

6.6.3 Feeder insulation

The objective is to qualify the draft procedure in preparation by ASIPP by making adequate mockups and test them under Paschen conditions to verify the insulation meets the requirements.

7 Responsibilities

7.1 IO Responsibilities

- To provide the technical specifications for the tasks to be followed up.
- To ensure resources available at MIFI to perform the tasks in the given timeframe as described below.

7.2 Contractor Responsibilities

- To ensure the task due dates can be met as described.

8 Deliverables and Due Dates

Del	Title	Due Date*
8.1	Instrumentation cable pulling trials	3
8.2	Destructive examinations of conductor samples	6
8.3	Setting up of vacuum impregnation lab	9
8.4	IOIS fitting test	12
8.5	Low voltage instrumentation measurement chain	15
8.6	Feeder joint assembly procedure	18
8.7	Feeder insulation	21
8.8	TF coil assembly procedures	24

*Months after signature of the contract

9 Acceptance Criteria

The outcome of the tasks is to obtain procedures for the assembly of magnet components. The acceptance is having procedures whose feasibility is demonstrated and confirmed by corresponding tests.

10 Specific Requirements and Conditions

The contractor shall provide proven expertise in the following areas:

- At least 3 years-experience in the engineering of components of the same category as described above
- At least 5 years-experience in the field of monitoring and supervising a workshop performing activities related to qualification and installation of components
- Involvement in commissioning and control systems of cryogenic components
- Experience in Non-destructive examination
- Good knowledge in factory acceptance tests
- Ability to work effectively in a multi-cultural environment
- Good knowledge of factory acceptance tests
- Ability to communicate fluently and write reports in English
- Driving license valid in Europe. A personal or company car has to be available for commuting between IO and MIFI site.
- Knowledge in high voltage insulation using glass fiber reinforced composite material for cryogenic application is advantageous.
- Ability to communicate in the French is advantageous.

The Contractor may be required to be certified in performing specific tests according to relevant standards; in this case the IO will bear the relative costs.

11 Work Conditions and Monitoring

- The contractor shall assign the required resources for executing the abovementioned services efficiently;
- Given the frequent interactions between IO ROs and the MIFI team the resource working on this contract shall be available full time and deployed to the IO site in St Paul-lez-Durance, France and at CEA Cadarache (in St. Paul-lez-Durance), where the MIFI workshop is located;
- Given the fact suppliers hold trade secrets in the manufacture of ITER Magnet and Feeder System and some of their components, and that competitive considerations are at play, the expert is expected to disclose any and all conflicts of interest in the conduct of this contract, and sign non-disclosure agreements as directed by the IO.

12 Timetable

The tentative timetable is as follows:

Call for Expertise	July 2015
Contract award	August 2015

13 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.