TECHNICAL NOTE RELATED TO THE MARKET SURVEY OF
THE PF COILS COLD TEST FACILITY SUPPLIER

Abstract

The experimental fusion reactor ITER will require the European supply of the Poloidal Field Coils PF2-PF6 of the ITER magnet system using the conductors and clamps supplied by Fusion for Energy (F4E). The outer diameters of the PF2-PF6 Coils are between 10 and 25 metres and their weights range between 208 tons and 399 tons. PF6 Coil will be manufactured elsewhere, but tested under this supply.

This document is the Technical Note related to the Market Survey in preparation of the calls for tender for the Cold Test Facility of the Cold Testing of the ITER Poloidal Field coils PF2 to PF6.

The project is comprised of eight primary work packages, each of which could be carried-out by separate parties drawing upon their specialist strengths. This document provides general information, as well as procurement schedule and strategy, but also details the specific contribution required of each party in carrying out this project. This seeks to enable the individual contributions and responsibilities to be understood and evaluated by all parties.

The related Market Survey covers only the Cold Test facility tasks.
1 INTRODUCTION TO ITER & FUSION FOR ENERGY

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 will be constructed in Europe, at Cadarache in the south of France. The fusion reactor is expected to be ready for operation in 2020.

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 including Fusion for Energy. In many cases the engineering and technologies required to manufacture these components are very advanced.

2 DESIGN OVERVIEW

This document defines the activities to be undertaken, and specifies the production parameters for the supply of Poloidal Field Coils PF2, PF3, PF4, and PF5. In addition, Cold test of PF6 is included in the scope, while its manufacturing is not included as PF6 will be manufactured by ASIPP, China. Moreover, PF1 is not included in this contract as PF1 will be manufactured by the Russian Domestic Agency. PF2-PF5 coils are to be fabricated adjacent to the ITER site in a dedicated PF Coil fabrication building, due to the large coil size, and after cold testing they are handed over to ITER for assembly into the Tokamak machine. The cold testing will be carried out in a dedicated facility in the PF coil fabrication building.

![Figure 1: Schematics of the PF Coils Configuration (for information).](image)

The PF magnet system is composed of six circular coils, the winding packs (WP) consisting of a stack of Double Pancakes (DP). The number of DPs per PF coil varies, as shown in Table 1 below.
Each DP is wound with two-in-hand CICC ("cable-in-conduit-conductor") and consists of an upper and lower pancake.

**Table 1: The Number of DPs per Coil**

<table>
<thead>
<tr>
<th>Coil</th>
<th>Number of DPs</th>
</tr>
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<tbody>
<tr>
<td>PF2</td>
<td>6</td>
</tr>
<tr>
<td>PF3</td>
<td>8</td>
</tr>
<tr>
<td>PF4</td>
<td>8</td>
</tr>
<tr>
<td>PF5</td>
<td>8</td>
</tr>
<tr>
<td>PF6</td>
<td>9</td>
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</table>

**Figure 2. Diagram showing PF6 Coil layout, including pancake joints, terminals, and helium inlet/outlet**

After reception at the PF Coil Fabrication Building, the Conductors are bent to the coil radius, insulated, and impregnated into the final coil dimensions using appropriate tooling to form the double pancakes.

The DPs are then stacked together, impregnated, and the outer joints are completed. The stack is then wrapped in a layer of ground insulation and impregnated in a mould to complete the WP. After completion of the winding pack all support clamps, cover plates, jumpers, cooling pipes and instrumentation systems will be installed and the coil tested and prepared for transport.

(mod. QA-236 F4E_D_22GTTD)
Table 2: Sizes and weights of the DP’s and WP’s

<table>
<thead>
<tr>
<th></th>
<th>Size and Weights of the Double Pancakes</th>
<th>Size and Weights of Finished WP</th>
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<tr>
<td></td>
<td>( R_c (\text{mm}) )</td>
<td>( \text{Height (mm)} )</td>
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<tr>
<td>PF2</td>
<td>8310</td>
<td>962</td>
</tr>
<tr>
<td>PF3</td>
<td>12028</td>
<td>699</td>
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<td>8416</td>
<td>615</td>
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<tr>
<td>PF6</td>
<td>4382</td>
<td>1094</td>
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3 PF COILS FABRICATION BUILDING

The PF building is composed of:

- A workshop area consisting of a single lane with a useful width of 37 m and a useful length of 252 m;
- A building, adjacent to the workshop, hosting locker rooms, offices and services;
- A building, adjacent to the workshop, hosting all the technical services of the PF building.

Outside the PF building there is an area that will be used for different duties:

- entrance of trucks for materials and tools delivery;
- parking place for authorized personnel cars;
- an External (to the PF building) fixed tent to be installed for materials unloading and Storage (ESB), connected to the workshop through the 8 m wide entrance door on the north side of PF building;

Outside area will be fully protected /delimited by a metallic fence, with one entrance door at west side and another one at east side.
Figure 3 and 4 – PF building and surrounding areas.
The main facilities of the PF coils fabrication building are:

- **HVAC:** The PF Coils building is heated/cooled by 13 air condenser rooftop units, each one can provide 109 kW hot power, 205 kW cold power and 43,000 m³/h total air flow. The rooftop units are located on the roof of the building. The rooftop units run with a blend of fresh and recirculated air.

- **Exhaust:** Six exhaust fans (10,000 m³/h).

- **Fluids distribution:** Liquids (cold and hot water) and gases (compressed air, Helium, Nitrogen and Argon).

- **Compressed air:** Two variable speed air compressors. Characteristics:
  - air flow: 5 Nm³/min – oil free each
  - air pressure production: 6 bars

- **Boiler:** Two electrical boilers. Hot power of each boiler reaches 805 kW. Production and distribution temperatures: 80/60°C

- **Chiller:** Two water condenser chillers. Cold power of each chiller reaches 1250 kW. Production and distribution temperatures: 6/12°C

- **Cooling tower:** The two chillers are coupled to two closed-circuit cooling towers, which are located on the roof of the Cooling building.

- **Electrical MV/LV:** Two independent MV switchboards, linked by cables. The MV switchboards supply 5 transformers. Two feeders on 22 kV will supply the MV incoming station. Each transformer supplies one LV switchboard. These 5 LV switchboards supply all the equipment on the PF Coils Building, Electrical Building, Production Building, Offices Building and the Chemical zone.

- **Electrical I&C:**

- **Fire protection system:** Fire hydrants, fire hoses network, sprinkler, pumps and water storage.

- **Crane 25t and main crane 40t:**
Figure 5 – PF building working area internal view

Figure 6 – PF building external view.
4 PROCUREMENT STRATEGY AND SCOPE OF WORK

4.1 THE SCOPE OF PROJECT

The project is split into Work packages, each of which will be subject to a separate Procurement contract (or agreement):

- PF Coils Engineering Integration (EI) (contract placed with ASG Superconductors);
- Tooling / Equipment Provision – Winding (TW) (contract placed with Sea-Alp);
- Tooling / Equipment Provision – Impregnation (TI) (not in the scope of the Market Survey);
- Tooling / Equipment Provision - Additional tooling (TA) (not in the scope of the Market Survey);
- Tooling / Equipment Provision - Cold test facility (CTF);
- Manufacturing and Cold Test (MFR) (not in the scope of the Market Survey);
- Site, Infrastructure and Facilities Management (S&I) (tender on-going);
- PF6 Coil manufacturing (agreement signed with ASIPP – China).

This document provides common information and contributions required from CTF in carrying out this project. An Interface Agreement will define the individual contributions, duties and responsibilities of each party, which will also be represented in an Interface Committee. This execution of the main stages of the project (where Cold Test Facility contributions are in bold) shall be carried out as follows:

- Takeover of the PF coil fabrication building;
- Furnish the PF coil fabrication building;
- Manufacturing planning;
- Design;
- Procurement, and installation of the main tooling for the manufacture of PF5 and PF2;
- Completion of manufacturing drawings and preparation of QA documentation and manufacturing procedures for all PF coils;
- Component fabrication qualification;
- Day by day maintenance of equipment for manufacturing;
- Day by day maintenance and operation of the PF coil fabrication building;
- Fabrication of mock-ups for PF5 and PF4, and dummy double pancake for PF5;
- Installation of the Cold Test Facility;
- Maintenance of the Cold Test Facility;
- Fabrication of PF5 and PF2 and cold tests of PF6, PF5 and PF2 (CTF partially involved);
- Procurement and installation of the tooling for PF3 and PF4;
- Fabrication of 5-turns dummy double pancake for PF4;
- Fabrication and cold tests of PF4 and PF3 (CTF partially involved);
• Disassembly and storage of the special purpose tooling;
• Clearance and handover of the PF Coil fabrication building.

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<th>Contract Sign.(Jan 14)</th>
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<td>PF6 - ASIPP</td>
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<td></td>
<td></td>
<td></td>
<td>3 years</td>
</tr>
</tbody>
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Figure 7. The Staged Manufacturing Planning

4.2 CALL FOR TENDER TENTATIVE SCHEDULE AND CONTRACT DURATION

The launching of the call for tender for the CTF is planned for third quarter of 2014 and the contract will last approximately 4.5 years.

4.3 COLD TEST FACILITY

The coils will be cooled in 3 different cryostats, one cryostat for PF6, one cryostat for PF5 and PF2, one cryostat for PF3 and PF4. The cryostats shall reach an insulation vacuum less than 10⁻⁴ mbar. The cryostats will be delivered in several pieces and will be assembled and welded in place.

The radiation losses on the 77K coil can be considered at the level of 1 W/m² using a proper superinsulation shield.

The weight of the coil will be supported with tie rods or better with supports. Losses due to the weight could be considered at the level of 0.5 W/Ton at 77K.
During the cool-down a maximum difference between the input gas and the maximum coil temperature will be maintained below 50K.

The inlet pressure is considered to be 11 bar abs. A higher pressure will help to reduce the cool down time. Max duration of each test = 90 days.

The cryogenic plant shall use helium gas due to pressure drop and thermal capacity to cold test the PF coils in a close circuit.

The cryogenic plant will consist of:

- A refrigeration system will guarantee the needed cold power of around 20 kW at 77K;
- 3 cryostats;
- Transfer lines;
- Cold box and valves;
- Heat exchangers;
- Sensors and instrumentation;
- Plant System/tooling I&Cs.

Figure 8: Cold Test Facility Area configuration for PF5-2 and PF6
Figure 9: Cold Test Facility Area configuration for PF4-3 and comparison between the 3 cryostats
4.4 COLD TEST FACILITY (CTF) RESPONSIBILITIES

In accordance with the Technical Specification provided by the EI, the contractor shall:

- Provide a Detailed Technical Specification of the test facility needed to perform the cold test at 77 K in the site dedicated to it, according to time schedule foreseen by the EI.
• Provide Manufacturing Design of cryogenics tooling and test cryostat(s).

• Preliminary acceptance tests will be made at CTF provider premises under supervision of the EI.

• Build, install and commissioning the cold test facility (including all the auxiliary equipment, infrastructures and plant as indicated by the EI technical specifications).

• Provide, transport to site, installation and commisioning of the cryostat(s) as defined by the EI necessary to perform the cold test of the PF Coils;

• Provide, transport to site, installation and commissioning of the cooling plant required plus cryo-cold boxes, distribution lines, cooling tower, buffer and compressor;

• Provide, transport to site, installation and commissioning of instrumentation, safety devices, control and supervision system;

• Ensure that every new Plant System/tooling I&Cs installed in the Cold Test Facility shall contain provisions to allow interfacing to CODAC supervision system;

• Provision of all documentation relating to the equipment under their supply for compliance with regulations, and operation / instruction manuals relating to said equipment;

• Training of the MFR, S&I (for safety issues), EI and F4E personnel in all aspects of the use of the cold test equipment and other tooling provided; and advice / participation in the test operations conducted by them;

• On-site maintenance and repair of all cold test facility equipment and tooling throughout the duration of the test phase;

• On completion of the project, the CTF provider will deliver Manuals for partial and/or full dismantling and for efficient / safe on-site storage.

4.5 MANUFACTURING OPERATOR – RESPONSIBILITIES (NOT IN THE SCOPE OF THE MARKET SURVEY, ONLY FOR INFORMATION)

The MFR is responsible for the manufacturing and cold test activities, and shall work under the supervision of the PF Coil Engineering Integrator to accomplish his tasks:

• To procure consumable materials, components and standard tooling defined by EI;

• To perform all Manufacturing activities respecting Production schedules, Manufacturing, Qualification and Test Procedures given by the EI;

• To perform Cold Testing activities respecting Production schedules and test procedures given by the EI;

• To carry out the Incoming inspection tests with the supervision of the EI;

• To be responsible for the storage of materials/components/ tooling;
To prepare the working areas, including handling of material/components/tooling with the supervision of the EI;

To witness the installation, commissioning and decommissioning of the tooling in the PF building;

To be trained in all aspects of the manufacturing and cold test, including the use of the winding and impregnation equipment, cold test facility and other tooling;

To operate functionally the PF Building working areas (i.e. setting of climate conditions);

To address and implement all the requirements regarding access, health, safety, security, environmental and coordination;

Component Fabrication Qualification;

Dummy DP manufacture and Report;

Series Production of PF Coils;

Acceptance test of PF Coils at Room Temperature;

Cold Tests of the PF Coils.

After final acceptance of the last PF coil the MFR shall clear the PF fabrication building for handover back to F4E. The supplied tooling shall be dismantled by S&I according to the manuals provided by Tooling Providers. Manufacturing tooling owned by the MFR, if any, shall be disassembled and removed.

4.6 PF COIL ENGINEERING INTEGRATOR RESPONSIBILITIES (NOT IN THE SCOPE OF THE MARKET SURVEY, ONLY FOR INFORMATION)

The EI has a role to provide the technical expertise and to supervise and monitor the fabrication of the PF Coils, under the approval of F4E. (This party manages the project and provides direction to the other parties contributing to the project);

The EI shall provide activity of Project Management including supervising the manufacturing and cold test progress, commissioning, and on-site installation of the equipment with the Tooling Suppliers, the project time schedules and risk plans, also integrating the information from the other contract suppliers and keeping them up-to-date;

The EI shall prepare manufacturing drawings for all PF coils components, according to the Contract models and drawings to be supplied;

The EI shall define the PF Coil Manufacturing and the Cold Test Plan, which shall include the manufacturing and inspection steps and Requirement Specifications for all tooling / equipment (both custom and off-the-shelf) needed to accomplish the manufacture and the Cold Tests of PF2, PF3, PF4, PF5 and PF6;

The EI shall supervise the MFR during the Component Fabrication Qualification for all components to be fabricated. The EI duties on this activity are the same as for the production;
• Following F4E & IO approval of Qualification, the EI shall supervise the MFR during the PF Coil Manufacture and Cold Tests, and will be responsible for providing the Acceptance Documents at completion of each manufacturing process for all PF Coils and the Final Acceptance Documents after the Cold Tests;

• The EI shall define the manufacturing processes and work instructions and get them approved by F4E. In case of modification with respect to the reference process, the EI will provide the updated information to F4E and to the S&I, who will keep the ICPE file updated.

• EI will provide all documentation and drawing only in English language

4.7  F4E MARKET SURVEY

In order to establish its strategy for the procurement of the Poloidal Field Coils (PF2-PF6 Coils) and enhance its understanding of the market situation, F4E submits the hereunder Market Survey to the interested suppliers. By participating in this market survey, your company will enhance visibility towards F4E and may also be contacted for additional exchanges.

You can answer directly to the Market survey by clicking HERE.

Thank you for your interest.