Updates on Technical and Procurement Status in European Contribution to ITER Magnet system

Marcello Losasso - Project Team Manager - F4E
on behalf of Magnet Project Team


ITER Business Forum 2013 - Toulon, France - 21st March 2013
In the Magnet system area F4E is in charge of in kind contributing for ITER project 4 large and integrated Procurement lines:

- Conductors
- Pre-Compression Rings, PRC
- Poloidal Field Coils, PFC
- Toroidal Field Coils, TFC
EU Magnet System – overall F4E activity

Main Activities:
- Planned: 5
- Pre-Tendering: 1
- Tendering: 2
- Contract Execution: 10
- Closed: 3

Total Contractual Activities: 62

F4E - Magnet System Activity Status
Magnets – overall F4E activity

Profile of expenditures by Year %

Payment incr %

Payment cum %

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## Magnets – management level schedule

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**Call For Tenders**

**Data Due**
Conductors:

- More than 80 tons of Nb3Sn strand manufactured in EU and USA; mass production of superconducting strand well established; manufacturing lines and production facilities in operation, the largest Nb3Sn strand production ever – pre-ITER world production was ~15 t/year. EU is doing pretty well, with an estimated end of the production of sc strand within this current year. Also, about 10% of the required CICC already produced and delivered.

- Qualification of PF conductor technically completed and soon starting production phase.

PRC:

- Supply contract for 9 PRC started on last December.

PF Coils:

- Procurement strategy in implementation, the main scope is split into several smaller contracts. Tenders contract for Engineering Integrator and Winding Tools going-on and to be finalized by middle 2013.

TF Coils:

- 2 Full scale prototypes of radial plates successfully manufactured.

- First qualification stage of the WP manufacture on a way to finish, with new facility set-up and tools set-up and final commissioning.

- Winding trials and Heat Treatment tests are on going.

- All major contracts but one have been placed.
EU contribution to ITER: TF Coils

TF COILS: F4E to procure 10 TF coils

- Nb3Sn technology, Cold mass of each TF coil more than 300 ton,
- 12 T on conductors, 6.2 m of toroidal radius

Three main general work packages have been defined in TF area: Radial Plate, Winding Pack and Coil Case Insertion, with main suppliers supported by sub-contractors.

Main scope of the current phase of the TF project is the design and procurement of the tooling for the main constructions, the qualification of the manufacturing processes, tooling and facilities by manufacturing a consistent number of mock-ups, and the identification of the most viable manufacturing routes in order to minimise the cost of the final production.

F4E is presently executing in TF area 11 contracts and the only major one remaining is in an advanced phase of tendering. To implement these contracts, several large, unique and/or special tooling have been designed by industries with F4E and IO support, procured, qualified and commissioned

→ industrial implementation phase
RADIALL PLATES
Main scope of this contract was the manufacture of Two Prototype Radial Plates (one side and one regular) and a number of mock-ups, in order to identify a viable manufacturing route for the radial plate, aimed to minimise the cost of the final production of radial plates. This has been successfully accomplished and the final mass production of 50+20 RP has been launched on Dec 2012 with consortium CNIM-SIMIC. See other presentation at this conference.

WINDING PACK
The main scope of work carried out in the current phase on the winding pack is the design and procurement of the tooling for the construction of the winding pack, qualifying the manufacturing process and tooling by carrying out manufacturing trials and by manufacturing mock-ups and a double pancake prototype, set the adequate facilities and tooling in order to support the series production of the coils within the required schedule. The staged contract has been launched with consortium IBERDROLA-ASG-ELYTT on July 2010. See other presentation at this conference.

THE COIL CASE INSERTION & COLD TEST
This work package is under Negotiated Procurement Procedure. It will not be discussed here.
Schedule of critical components/ TF

ID | Task Name
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1  | Toroidal Field Coils
2  | TF Delivery to ITER
3  | TF11 Delivery to ITER
4  | TF09 Delivery to ITER
5  | TF06 Delivery to ITER
6  | TF04 Delivery to ITER
7  | TF05 Delivery to ITER
8  | TF03 Delivery to ITER
9  | TF01 Delivery to ITER
10 | TF18 Delivery to ITER
11 | TF17 Delivery to ITER
12 | TF14 Delivery to ITER
13 | Contracts
14 | Side Radial Plate prototype
17 | Regular Radial Plate prototype
20 | Radial Plate series production
23 | Winding Pack production
28 | TF Coil Assembly into Coil Cases
EU contribution to ITER: SIMIC and CNIM Radial Plates prototypes, completed in 2012

More on this, presented later at this IBF

CNIM side RP during transportation at WP manufacturing site

SIMIC regular RP during manufacturing
TF activities status in EU: Tools Commissioning

• **Facility preparation complete** with a 6000M² equipped brand new workshop
• **winding line** manufacturing, installation and qualification has been completed in recent months by performing several winding trials:
  - ✓ 2 of single turn with EU dummy conductor
  - ✓ 1 of 3 turns in single length with EU dummy conductor
  - ✓ 1 of single turn with EU OST s.c., 1 of single turn of EU EAS s.c.
  - ✓ Bending trials on RF dummy conductor to define bending parameters for all DP turns;
• **T-scan dimensional** check procedure, in order to measure the real length of each turn, in different production phase, successfully qualified.
• **electric Termination** tooling completed
• **FSJS completed**, Testing foreseen in April in Sultan.
• **Helium Inlet** Mock ups for design qualification, after re-design finalized by IO on Dec 2012, ready for test in KIT during spring.
TF activities status in EU: qualification and tools

- **Heat Treatment**
  Furnace installed and commissioned in ASG La Spezia, with Heat treatment of 1 full size DP turn made with EU OST conductor completed.

- **Transfer of DP into radial plate**
  Tooling completed, installed and successfully commissioned in La Spezia.

- **Turn Insulation**
  Insulation tooling under final assembly at Elytt (Bilbao), and final commissioning in La Spezia foreseen before summer for complete tooling, including co-wound tape wrapping head.

- **Cover plate laser welding**
  Laser welding tooling assembled and commissioned in La Spezia.

- **Impregnation Tooling**
  Resin Mixer procured, Mold for 3 m beam procured. Commissioning of impregnation tooling/equipment and pre-qualification of impregnation process with 3-m beam.
Winding line qualification

Winding line (TPA): single turn.

Winding line: 3 turns in a single length.
Commissioning of the Ferruzzi oven for the conductor heat treatment conducted during September/October 2012. Tests performed with three turns of dummy conductor

Heat Treatment full cycle tests performed

- Flow Measurements
- Impurities Measurement
- Simulations of faults
- Vacuum after HT: \(7.3 \cdot 10^{-4}\) mbar

Biggest RHT furnace ever deployed: 30m by 5m by 14m
Capability of the machine demonstrated. Transfer process successful - Accuracy/resolution of machine movements acceptable
- Potential for automation of movements
- Potential to reverse operations if required
- Minor improvements to be implemented (e.g. support for joggle during DP separation).

Video clips of TF construction available at this link:

http://f4enet.f4e.org/News/Archive2013/Pages/DiscoverhowEuropewillmanufacturetheITERTFcoils.aspx
F4E has to procure 5 Poloidal Field Coils (PF2 to PF6).

- NbTi technology, Cold mass of PF coil more than 300 ton
- 24 m dimension → built on site, 6 T on conductors
- Major issues are winding and impregnation of large double pancakes with heavy-wall square conductor → this will be verified with the manufacture of prototype dummy double pancakes during the first stage of the manufacturing contract.

The PF coils procurement strategy foresees a major split in Engineering Integration, manufacturing in Cadarache, tooling and infrastructure, facility, cold test.

7 major contracts are necessary.
2 of the major contracts are in tendering phase.

→ in procurement phase
EU contribution to ITER: PF Coils work Packages

PF Coils Engineering

Engineering and Integration ("Holistic" vision)

Manufacturing

Coils fabrication / test
Cold test

Cold Test Facility

Cold Test Facility

Site, Infrastructure and safety

Infrastructure / Building Ops

Winding Tooling & Equipment

Impregnation Tooling & Equipment

Tooling - impregnation

Tooling - Additional

Additional Tooling & Equipment
The Overall Procurement Strategy for the PF Coils has been presented to ExCo on September 25th 2012, and positively received.

The Individual Procurement Strategy for the Engineering Integrator has been approved by the Committee, in that same meeting.

Negotiated Procedure for Engineering Integrator on going

Negotiated Procedure for Tooling for Winding is being implemented.

The first offers for EI have been already submitted to F4E, selection of the candidates on going.

EI contract will not be discussed here
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The schedule includes tasks such as delivery of various PF coils, contracts, and key milestones for the development and construction phases. Each task is associated with specific dates indicating its start and end, ensuring a well-planned timeline for the project.
PF Coil Manufacture on Site

A large facility has been prepared at Cadarache for the manufacture of PF2 to PF6 coils on site. Cold testing area for these coils has to be added to this facility.
PF Coils activities in EU: site preparation completed on Feb 2012.

PF Coils Manufacturing Building

- Length: 257 m
- Width: 49 m
- Height: 17 m
PF Coils Winding Tools

- Winding Tooling for all coils have many similarity but different diameter tables
- The coils will be wound sequentially (PF 5 followed by PF2) and for this reason is envisaged to have adaptable common tooling between them in order to re-utilizing most of the winding tooling components.
- Winding tools includes subcomponents (Intra-connections station)

The contractor will:

• Perform the design, manufacture, installation on site and commissioning of the tooling
• Train the manufacturing personnel in its use
• Support and maintain the equipment throughout the course of the PF Coil Project
• Decommission the equipment for storage or eventual disposal on completion of their use.
F4E has to procure 6 + 3 Pre-compression-rings

- Large composite linear dimension, never checked the 1-to-1 mechanical properties
- Contract has been signed on October 2012 with EADS CASA ESPACIO.
- Contract duration: 51 months.
Process qualification phase during ~2 years necessary for the manufacturer to prepare required analysis, is underway. The scope is to study possible fabrication processes, qualify processes, fully mechanically characterize the prototype ring (testing extracted specimens), NDE,…

Qualification process with subscale ring to achieve x 4 the membrane stress.

Fabrication of 9 rings following exactly the same fabrication process of the one qualified by prototype ring.
EU contribution to ITER: Conductors

F4E has to in-kind procure:

20 km of ITER Toroidal Field conductor, 22 km of ITER Poloidal Field conductor, 28 km of JT-60SA Toroidal Field conductors, including dummy and production lengths.

About 15 activities in this area are in advanced execution phase.

- Very high production rate and volume (almost 100 ton of Nb3Sn strand)
- Very demanding qualification procedure
- Very demanding supply chain, including Cabling & Jacketing, testing, characterization, qualification
- Very demanding raw material and logistic schedule
- Strand/conductor combination qualified after successful test in Sultan facility

→ industrialization phase
F4E has to provide 27 superconducting unit lengths of conductor for the TF Coils

**EAS Nb₃Sn Strand (Bronze Route)**

50% of EAS production is successfully completed

**OST Nb₃Sn Strand (Internal Tin)**

91% of OST production is successfully completed

**Strand (material)**

**Cable (work)**

**Conductor (jacket material + jacketing work)**

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IBF/13 March 21st, 2013 - M.Losasso - F4E
EU contribution to ITER: Conductor for PF

EU qualification process finished. Production in ICAS has started beginning of 2013 for PF conductor
Completed UL TF conductor on the Spooler ready to pass the leak test in Cryotec

Compaction machine in Tratos & 900 m Jacketing Line for PF and TF conductors, Cryotec
Conductor lengths at the test benches and at WP production site

TF UL insertion into the Vacuum tank for global leak test
Demanding quality control for thousand of welds: NDT, leak test, visual inspection, dye penetrant, RX...
The EU contribution to ITER project in the Magnet area is in advanced phase of industrial contracts implementation: more than 10 relevant contracts currently progressing in sparse geographical area.

Magnet area has already tested the full life-cycle of contracts: the first ever contract in F4E was signed in this area, and important contracts are already closed or near completion.

We think crucial to act as partner of industries contracted to whom we provide added value by steering them toward more viable design options and manufacturing routes, by acting as active link between final customer (IO) and them, and by helping them into solving technical and administrative issues. Helping our suppliers in defining and maintaining a systematic and tight quality control during production is added value we provide for risk reduction and final quality.

There are unprecedented requirements for quality control, logistics, delivery schedules, information flow among different parties, change design management. This calls for timely upstream delivery of design data and technical input. Tight coordination with all involved parties is needed in order to manage the final quality of results and to maintain the cost under control.

**Fast decision process, technical skilled resources in industries and DAs, strong cooperation and partnership of F4E staff with industries and IO are a must.**
Thank you for your attention

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