JT-60SA Newsletter
No. 76, 29 April 2016

Headline

First TF coil ready for shipment to Japan

Figure 1: Presentation underway in front of the TFCTF cryostat

On 6 April 2016, CEA organized, in Saclay, a friendly and festive ceremony to celebrate that the first toroidal field (TF) coil for the JT-60SA project had completed the final acceptance, validation in the cryogenic testing, and preparation for shipment to Japan.

The ceremony was held under the patronage of Mr. Ichiro Ikeda, Scientific Counsellor of the Japanese Embassy in Paris, Mr. Robert Aymar, the pioneer of superconducting tokamak development at CEA, and Ms. Maria Faury, the French Contact Person to the Broader Approach Steering Committee. A number of main actors in the project were invited, including H. Shirai, the Project Leader, P. Barabaschi, the Project Manager (PM) of EU Home Team, K. Masaki, the representative for the JA PM, A. Pizzuto and R. Gondé, the directors for the contributions from ENEA and CEA (Figure 1). In their respective speeches, each senior representative recalled the exceptional level of cooperation that had been made which, despite the difficulties, allowed the achievement of these important milestones for the JT-60SA project.

A technical and progress review of CEA contributions to the JT-60SA project was then carried out by the CEA Technical Responsible Officers together with their industrial partners. Ms. Suzanne Roy (Air Liquide) reported the design, construction, installation and commissioning of the cryogenic system, which had produced the first litres (2000 l.) of liquid helium in the previous week. P. Decool and Mr. Marc Nusbaum (General Electric Company) presented the design and manufacturing of the TF coils. L. Genini recalled the steps of construction and validation of the TF coil cold test facility (TFCTF) including the Belgian (SCK•CEN) contribution for the procurement of the cryostat and its “accessories”, and the conclusive results of the first TF coil tests. G. Disset and Mr. Olivier Besançon (SDMS technologies) presented the requirements and manufacturing of the outer intercoil structures (OISs). C. Mayri illustrated - on the place of ”enthronement” - the “coronation” procedure (pre-assembly) of TF coils with their OISs. This brief technical tour was concluded by the “christening” ceremony of the first TF coil (Figure 2), which received - as a symbol of successful cooperation between France and Italy developed in the European framework programme - the name ”Annie” after a great French actress who became immensely popular in both countries in the late 1950s.

This celebration was concluded with a moving address by Mr. Robert Aymar who invited the guests to share both the successes so far and the prospect in future of our promising projects (Figure 2).

Figure 2: Closing address by Mr. Robert Aymar

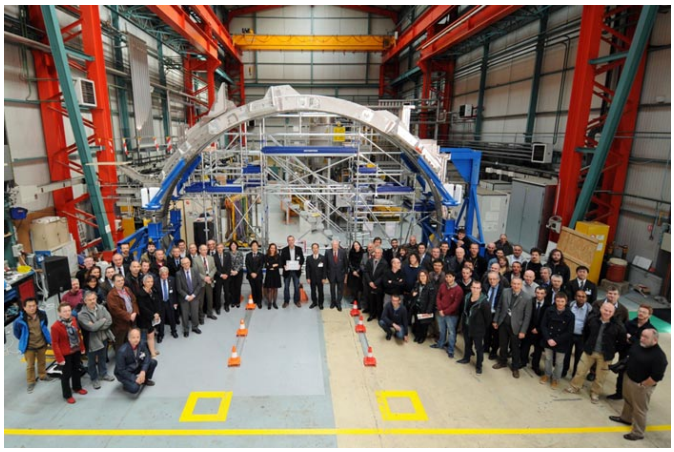
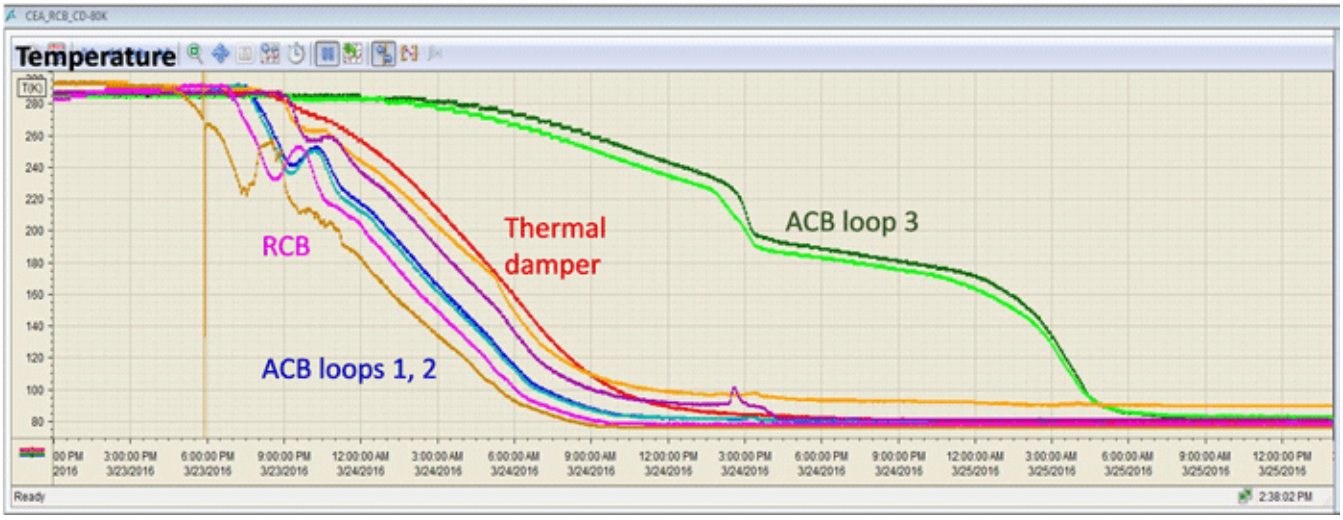


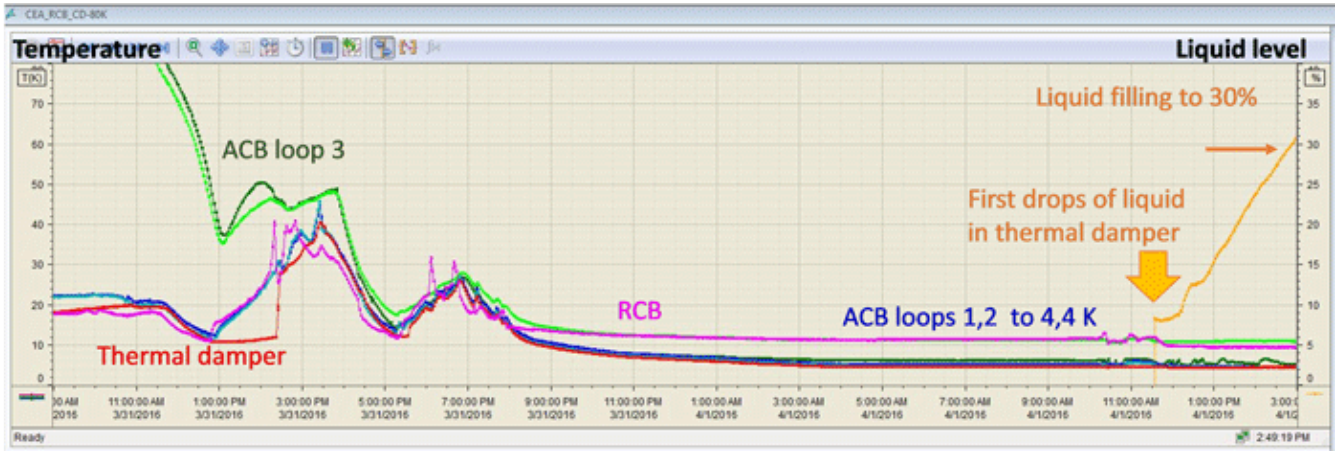
Figure 3: Group photo of participants to the ceremony

News

Cryogenic system starts cool-down



Cool-down from 300 K to 80 K



Cool-down to 4.4 K and first liquefaction

On 16 March 2016, the functional checks on all subsystems of the cryogenic system for the JT-60SA device were successfully finished by Air Liquide Advanced Technologies (ALAT), and the JT-60SA cryogenic system got ready for its first cool-down. The permission for the start of cool-down was given beforehand by CEA, F4E and QST[*] in a dedicated “Pre-Start-up-Safety Review” meeting.

The first cool-down started with liquid nitrogen pre-cooling. As a special feature, the JT-60SA refrigerator can run in a dedicated purifier mode, where only a part of the refrigerator cold box (RCB) is cooled down to 80 K. Once the cold adsorbers reached 80 K, some 700 m³ of impure helium gas, which had been collected in a storage vessel, were purified to the level of below 1 ppm of nitrogen within a few hours. The purification removes the air impurities, which could damage the turbines and cryomachines.

Next, the 80 K cool-down of the complete cryogenic system was started. The cool-down speed was limited by the aluminium-brazed fin heat exchangers to a maximum speed of about 1 K/min, and a maximum temperature difference between the counter-flows of 40 K, to avoid excessive mechanical stress. Once all of the heat exchangers, interconnecting pipes, cold adsorbers, and cryogenic vessels in the RCB and auxiliary cold box (ACB) had reached 80 K, the dedicated “80 K stand-by mode” was successfully stabilized and validated.

The system was cooled down further to 4.4 K with the expansion turbines started. The first and second turbines (T1 and T2) were operated in series as a Brayton cycle, returning cold helium to the low pressure line and cooling down the RCB counter-flow heat exchangers. Any change in speed, pressure or temperature of one turbine affects the other, therefore continuous control and adjustments are required. The third turbine, T3, distributes supercritical helium to the ACB and allows the liquefaction rate to be increased. First drops of liquid at 4.4 K were successfully produced on 1 April, and the steady state “4.4 K cryo-idle mode”, which will become one of the steady state modes for future JT-60SA operation with the superconducting coils (the toroidal and equilibrium field coils and central solenoid modules), was well validated.

The first refrigeration capacity tests are now being performed. Another cool-down for the second part of the commissioning tests is planned in May.

News

Advancement of ENEA procurements of SCMPS

Figure 1: CS oil transformers at SEA laboratories

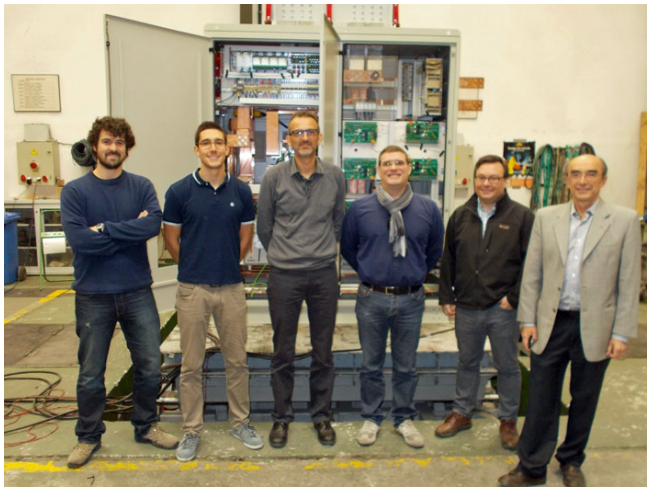


Figure 2: Group photo in the crowbar seismic test at VIRLAB laboratories

The JT-60SA superconducting magnet power supplies (SCMPSs) consist of the toroidal field coil power supply (TFC PS), poloidal field coil power supplies (PFC PSs), and fast plasma position control coil power supplies (FPPC PSs). These systems drive desired currents in the conductors in order to produce a magnetic field to confine and control the plasma inside the vacuum vessel. Part of the PFC PSs (EF2 - 5 PSs) together with the TFC PS will be procured by CEA as a part of the French contribution to JT-60SA, and the rest of the PFC PSs (CS1 – 4, EF1 and 6 PSs) together with the FPPC PSs will be provided by ENEA as part of the Italian contribution.

In August 2013, ENEA awarded the joint venture POSEICO - JEMA a procurement contract starting with design activities. It foresaw the realization of 8 PSs and 6 transformers covering part of the JT-60SA PFC PSs (including the CS1, CS2, CS3, CS4, EF1 and EF6 PSs) and FPPC PSs.

In April 2015, the First Design Report on the SCMPSs was completed by POSEICO - JEMA and it was officially approved by ENEA, F4E and QST (formerly JAEA[*]).

The transformer manufacturer chosen by POSEICO - JEMA was Società Elettromeccanica Arzignanese S.p.A (SEA) with extensive experience over more than 50 years in the design and construction of special power transformers. According to SEA’s advice, POSEICO - JEMA proposed, instead of the electro-dynamic stress evaluation and thermal analyses of SCMPS transformers (as initially foreseen in the first design), to perform:

- a short-circuit type test on one of the transformers;
- a thermal type test based on the temperature measurement in the secondary windings of one dry FPPC and oil CS transformer, through a temperature probe in each secondary winding placing its tip at the upper hottest point.

In addition, the temperature distribution on the 4 vertical sides was monitored with a thermo-graphic camera. These alternative solutions assured the quality of the transformer design and improved its reliability, eliminating any possible doubts on the results of the electro-dynamic and thermal analyses, since such analyses take a long time, but produce only approximate results which are not really reliable enough. This proposal was accepted by all project partners (ENEA, F4E and QST[*]). Prior to the short-circuit tests, the FPPC transformer was subjected to acceptance routine tests as specified in IEC 60076-1. The short-circuit type test was carried out in accordance with IEC 60076-5 at CESI laboratories in Milan in July 2014. The same procedure was adopted for the CS transformer, except for the short-circuit type test which was carried out at SVEPPI laboratories near Venice (Italy) in October 2015 (Figure 1).

Then, all of the transformers were transferred to the SEA laboratories for final acceptance tests of the FPPC transformers in July 2014 and of the CS transformers in November 2015, respectively.

All of the tests gave positive results, moreover the hot-spot temperature-rise measurements by thermal probes and thermo-graphic camera did not highlight any critical hot spots. In order to improve the heat exchange between air and oil, an air fan was added for each of the 4 CS transformers. The oil transformers for CS2 and CS3 converters are currently stored at the SEA laboratories.

Next, 2 FPPC transformers were transferred from POSEICO to the JEMA laboratories (San Sebastian, Spain) in order to test the FPPC converters. The manufacturing process of the FPPC converters was completed in November 2014 and, in the meantime, the characterisation process of the FPPC converters, focussed on demonstrating the correctness of the choices made during the design phase, started at the JEMA laboratories.

The acceptance tests were performed in accordance with IEC 60146 standard at the JEMA laboratories from 17 - 20 February 2015. According to the test procedure approved, and the IEC 60146 standard, the acceptance tests were split into type and routine tests.

All of the tests gave a positive result, and again the thermo-graphic camera did not highlight any critical hot spots. An additional type test was performed considering a step voltage signal reference at variable frequency from 1 Hz up to 50 Hz, in order to characterize the dynamic behaviour of the output voltage of the FPPC converter and its ability to follow fast transitions of the plasma position.

In May 2015, seismic tests of the crowbar (being a safety relevant component) were performed according to the IEC 60068-3-3 60068-2-47 standard at VIRLAB laboratories, and confirmed their very good construction (Figure 2).

The realisation of the CS1 and CS4 converters at JEMA laboratories was completed in September 2015 (Figure 3).

Finally, the crowbar system for the CS/EF PSs was successfully tested at JEMA laboratories in collaboration with CEA in November 2015. The current capability type test was performed at ±23 kA and 2 GA^2s.

CS1 and CS4 converters will be tested in May 2016, whereas those for CS2 and CS3 are currently under construction.

All power supplies will be delivered to the QST[*] Naka site (Japan) within 2017.

Figure 3: CS1 converter at JEMA laboratories

News

M200 thread cutting for VVGSs successfully completed

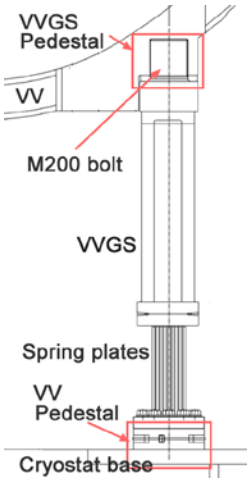


Figure 1: VVGS side view

Figure 2: VVGS pedestal and thread cutter


Figure 3: M200 bolt thread on the VVGS pedestal

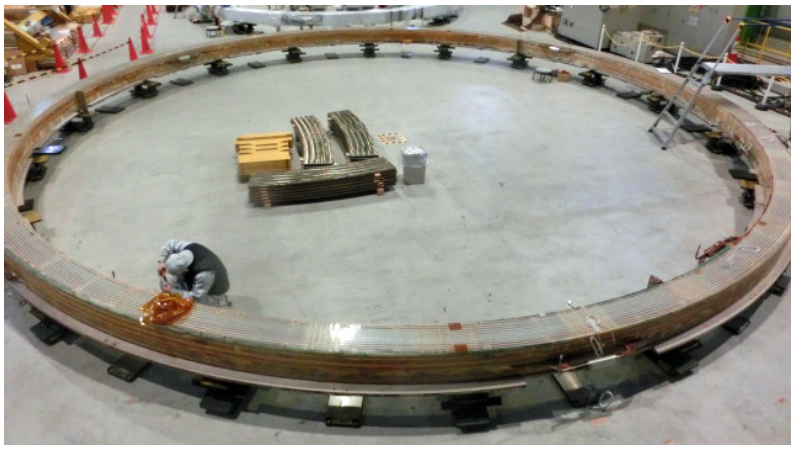
Each of 9 vacuum vessel gravity supports (VVGSs) will be joined with an M200 bolt to the VVGS pedestal at the bottom of each odd-numbered vacuum vessel (VV) sector (Figure 1). The thread milling of the pedestals with a special thread cutter (Figure 2), except for that of the final 20° sector which has not been installed yet, started in January, 2016.

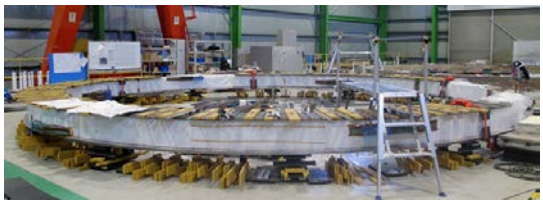
The spring plates (lower part of the VVGSs) must be installed square with the machine centre with the tolerance of 1 mm. The heat contraction after the final VV sector welding is foreseen to cause each pedestal to shift in the toroidal direction. Therefore, firstly, the amount of contraction at each end of the final sector was calculated and estimated to be 6 mm. Then, the current positions of the VVGS pedestals and VV pedestals on the cryostat base were precisely measured by a laser marker and tracker. Finally, the M200 threading of the VVGS pedestals (Figure 3) was performed taking account of the estimated drifts.

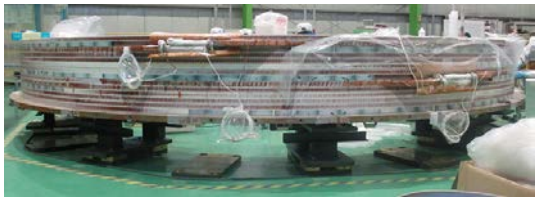
The M200 thread cutting for all of 8 VVGSs was completed at the end of April 2016.

News

Status of EF1 - 3 manufacturing


EF1 coil in preparation for ground insulation


EF2 coil in preparation for ground insulation


EF3 coil in DP stacking

A total of 6 equilibrium field (EF) coils are to be located outside the toroidal field (TF) coils in JT-60SA. The conductor is a circular NbTi cable in square conduit cooled by supercritical helium. The coils are clamped to the TF coil cases. The EF3 and EF4 coils are mounted on the odd-numbered TF coils, whereas coils EF1, EF5 and EF6 are mounted on each TF coil, and coil EF2 is mounted on the outer intercoil structures. Each coil is self-supporting with regard to radial (in-plane) loads.

The manufacturing of the EF4, EF5 and EF6 coils has already been completed and they were temporarily installed on the cryostat base in the torus hall in 2014, ready for later mounting to the lower section of the TF coils.

The latest progress of the EF1, EF2 and EF3 coil production, to be mounted on the upper section of the TF coils, can be summarised as follows (see figures):

- EF1 coil:
  After all the 12 single pancake coils were stacked last November, the first curing was finished at the end of 2015. Taping of ground insulation film is now in progress.
- EF2 coil:
  Curing of the ground insulation was finished in April 2016.
- EF3 coil:
  Winding of the final double pancake (DP) for EF3, which was also the last pancake coil fabricated for the EF coil system of the JT-60SA device, was completed in November 2015. DP stacking was started in January 2016, and completed at the end of February.

News

First quench detector and current lead heater PS delivered

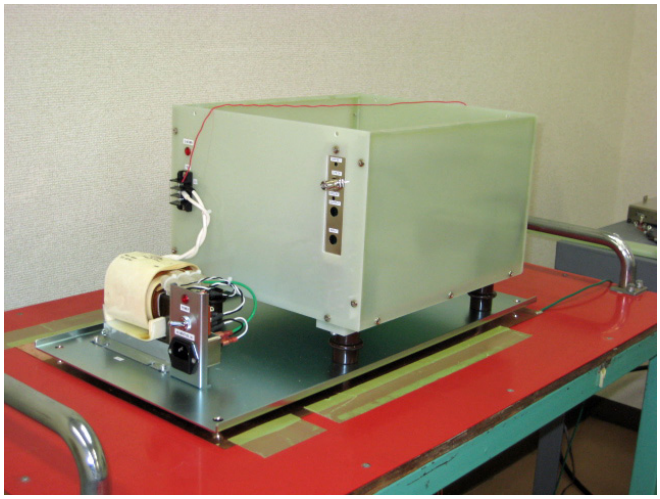


Figure 1: Quench detector (high voltage section)

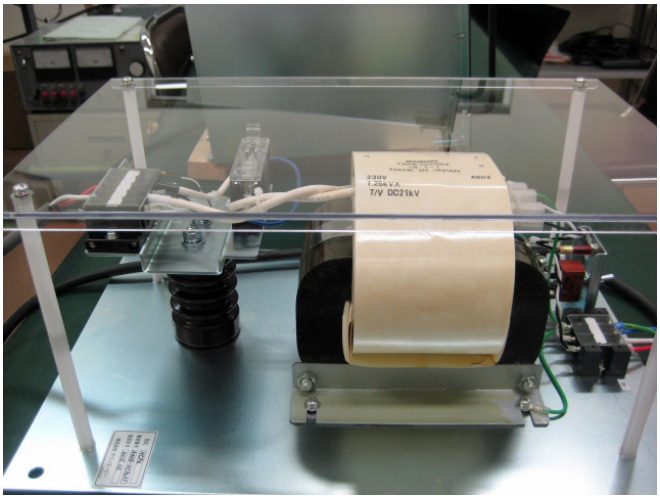


Figure 2: Current lead heater PS (high voltage section)

The first units of the quench detector (Figure 1) and the current lead heater power supply (PS) (Figure 2), which will be provided by Techno AP Ltd. as a part of the Japanese contribution to JT-60SA, passed acceptance tests and were delivered to the QST[*] Naka site at the end of February, 2016.

The quench detector detects and triggers conductor protection devices as soon as part of a coil stops being superconducting and reverts to a normal conductive state for any reason (Figure 3).

The current lead heater PS controls and maintains the temperature of the current lead terminal (room temperature side) at the target temperature of 293 K to prevent its insulation performance being degraded by dew.

A total of 90 quench detectors for the toroidal and poloidal field coils, and 26 current lead heater PSs, will be delivered to the QST[*] Naka site by 2018.

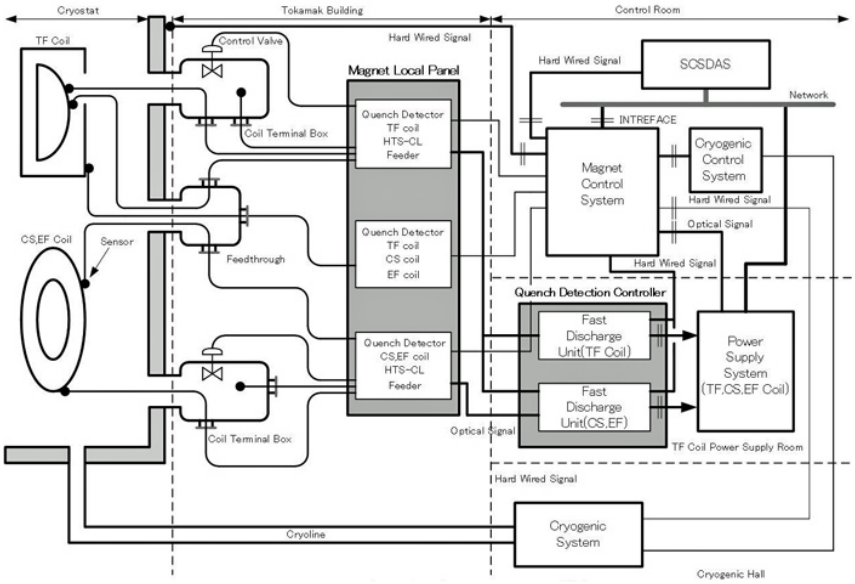


Figure 3: Configuration of measurement control for the JT-60SA superconducting magnet

Meeting

18th STP Project Committee Meeting

On 16 March 2016, the 18th Meeting of the Satellite Tokamak Programme Project Committee (STP-PC) was held at the QST[*] Naka site between Europe and Japan. A total of 37 participants joined the meeting also by videoconference. There were 6 members from the STP-PC, the Project Leader (PL), 4 experts from the Project Team, and 26 experts from the EU and JA Home Teams.

At the meeting, the PL overviewed the project status and presented the “Annual Report 2015” and “Project Plan”, subsequently submitted to the 18th Broader Approach Steering Committee on 22 April 2016. The latest status of procurement and assembly was also reported in detail by the Project Managers of the EU and JA Home Teams.

The STP-PC expressed satisfaction with the achievements and the progress in both EU and JA procurements as well as the assembly since the last PC. The progress included fabrication of the equilibrium field coils (EF1, EF2 and EF3), central solenoid modules (CS1, CS2 and CS4), high temperature superconductor current leads for the poloidal field coils, power supply systems, and cryostat vessel body cylindrical section, start of vacuum vessel (VV) thermal shield assembly around the 340° VV torus, and commissioning of the cryogenic system. In particular, the STP-PC commended the Integrated Project Team for the delivery of the first toroidal field (TF) coil to the cold test facility and the positive test results, recognising this achievement as a major project milestone. The STP-PC further encouraged the EU Implementing Agency and Voluntary Contributors to find reasonable ways to minimize the procurement delay based on the experience acquired from the initial few TF coils production, and so forth.

The STP-PC decided that the next STP-PC meeting (PC-19) would be held on 11 October 2016.

Note

[*] The Fusion Research and Development Division (of the Naka and Rokkasho Fusion Institutes) of the Japan Atomic Energy Agency (JAEA) has been separated and integrated as a part of the newly established National Institutes for Quantum and Radiological Science and Technology (QST) since 1 April 2016. QST has superseded JAEA as the Implementing Agency of the Broader Approach for Japan.

Calendar

30 May – 3 June 2016
22nd International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 2016)
Rome, Italy

4 – 8 July 2016
43rd European Physics Society Conference on Plasma Physics (EPS 2016)
Leuven, Belgium

6 – 7 July 2016
25th Technical Coordination Meeting (TCM-25)
Avilés, Spain

5 – 9 September 2016
29th Symposium on Fusion Technology (SOFT 2016)
Prague, Czech Republic

11 October 2016
19th Meeting of the STP Project Committee (PC-19)
Naka, Japan

Contact Us

The JT-60 Newsletter is released monthly by the JT-60SA Project Team.
Suggestions and comments are welcome and can be sent to newsletter@jt60sa.org.

For more information, please visit the website: http://www.jt60sa.org/.