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Progress of Procurements by EU & JA Cooperation

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After a complex start-up phase due to the necessity to carry out a re-baselining effort with the purpose to fit in the original budget while aiming to retain the machine mission, performance, and experimental flexibility, in 2009 detailed design could start. With the majority of time-critical industrial contracts in place, in 2012, it was possible to establish a credible time plan, and now, the project is progressing on schedule towards the first plasma in March 2019. After careful and focused R&D and qualification tests, the procurement of the major components and plant are now well advanced in manufacturing design and/or fabrication. In the meantime the disassembly of the JT-60U machine has been completed and the engineering of the JT-60SA assembly process has been developed. The actual assembly of JT-60SA started in January 2013 with the installation of the cryostat base.

CEA through Alstom (Belfort, France) and ENEA trough ASG (Genoa, Italy) are presently manufacturing the 18 TF coils including one spare coil. All the strand has been fabricated by Furukawa Electric (Japan) and the conductor cabling and jacketing has already reached half-production stage at ICAS (Italy). Winding of the double pancakes started in July 2013. The winding pack is wrapped in a layer of ground insulation and vacuum-impregnated with epoxy resin. The TF winding pack is enclosed in an austenitic stainless steel FM316LNL case assembled from segments using EB or TIG welding. The casing for both coils is being made by Walter Tosto (Chieti, Italy) and shipped to both TF coil manufacturers. Plates and forgings for 18 coil casings are now available and the first casings are being manufactured. The outer inter-coil structure (OIS) consists of 18 sections connected by electrically insulted friction joints designed to resist the out-of-plane loads from overturning moments on the TF coils and the hoop tension in the toroidal direction from the in-plane expansion of the TF coils. The OIS is being manufactured by SDMS (Isére, France) and the gravity support by Alstom (France). Once encased and impregnated, the coils will be cold- tested at full current before shipment to Japan. A cold test facility for the TF coils is being installed at the CEA Centre in Saclay (France). The cryostat (length 11.5 m, width 6.5 m, height 5m) with integrated LN2 thermal shield, test frames for the TFC, associated valve box vessel and vacuum pumping units has been already manufactured and installed. The helium refrigerator (500 W at 4.5 K) and DC power supply (26 kA, ± 10V) with a coil protection system has also already been installed. The first TF coil will start tests in July 2014. Testing will continue with the 19th coil planned to be tested in October 2016. JT-60SA uses 6 equilibrium field (EF) coils and a central solenoid (CS) split into four modules, each with separate power supplies. Manufacture of all the EF/CS coil conductor is taking place on the Naka site, in a purpose-built 600 m long jacketing line and building (based on the design of the ITER conductor facility), and using strand manufactured by Furukawa Electric. The first conductor with superconducting cable (450m length) for EF-H (High Field) conductors was fabricated in March 2010. Seven CS conductor and 35 EF conductor lengths have been manufactured by March 2013. The two smallest EF coils can be manufactured in the factory and shipped to the site. The winding of the EF4 coil was completed by Mitsubishi Electric (Japan) and shipped to Naka in April 2012 and the coil was completed by January 2013. A building and winding line has been purpose-built at the Naka site for the larger coils (as well as for the wind-and-react process of the CS module manufacture). The double pancakes (or equivalent) of EF5 and EF6 were wound from May 2012 at the JAEA Naka site. The manufacture of the EF5 and EF6 coils will be completed by December 2013 so that they can be installed temporally on the cryostat base before the assembly of the plasma vacuum vessel. The detailed design of the magnet thermal shield has been completed in November 2012. The polished stainless steel plates and pipes have been already procured. The VVTS will be manufactured from the end of 2013 in Japan. JT-60SA will use High Temperature Ssueprconducting current leads, made by Karlsruhe Institute of Technology (KIT). The HTS material is Bi2223 (bismuth strontium calcium copper oxide) with Ag-Au stabilizer. Manufacturing of HTS leads started in 2012 and the first pressure test of the heat exchanger was performed in August 2013. The first delivery of the current leads (for the TF coils) will take place in 2014, with those for the PF coils being delivered in 2015 and in early 2017.

The vacuum vessel sectors are being manufactured by Toshiba Corporation as separate inboard and outboard segments to ease transportation. These are then brought together in the purpose-built Vacuum Vessel Sector Assembly Building at Naka. The dimensional tolerances of this process are well within the ±5mm allowed. Currently six 40º sectors have been completed, and all remaining sectors (one 40º, two 30º and one 20º) will be ready by February 2014. The plasma Facing Components (PFC) material necessary for the initial divertor assembly were completed by Kawasaki Plant Systems Ltd. and delivered to Naka by April 2013. In addition, for the initial divertor, all 36 cassette bodies have now been completed by Kinzoku Giken Co Ltd and are now being fitted with the PFCs.

The machine cryostat base, the first major item of EU hardware, fabricated by IDESA/Asturfeito (Spain) was delivered to Naka at the end of January 2013, and installed in the torus hall by March 2013. The material for the cylindrical shell, purchased by Japan and supplied by Outokumpu (Finland), has been already delivered to Spain. The manufacturing of the vessel body is expected to begin during 2014 for final delivery in 2017. The lid manufacture (by Japan) will also commence in 2014. Both these components are first needed towards the end of the machine assembly.

The JT-60SA magnet power supplies are almost entirely made up of new components, based on existing motor-generator sets and main transformers. The QPCs are being manufactured for Consorzio RFX by Nidec-Ansaldo Sistemi Industriali. Type-testing was completed in 2012, and manufacturing began on the 13 units in February 2013, with delivery planned by March 2015. The SNU's are being manufactured for ENEA by OCEM Energy Technology. The contract was signed in October 2012, and detailed design is underway, with delivery of final components due by September 2017. Main magnet power supply units manufacture is being undertaken (for TF/EF) by JEMA of Spain for France (CEA), and (for CS/EF/FPCC) by Poseico-JEMA for Italy (ENEA), with delivery due between mid-2015 and end 2017.

The Cryogenic system consists of a helium refrigerator (warm compressors, oil/water removal, refrigerator cold box, heat exchangers, low temperature adsorbers, and expansion turbines), and an auxiliary cold box (heat exchangers, helium baths, cryogenic circulators, and cold compressor). The cryogenic system must cope with large pulsed heat loads at 4.4 K twice as high the average plant power. The system is presently being designed and built by Air Liquide Advanced Technologies (France).On-site installation will be complete in 2015, and it will be operational late in 2016.

The paper gives an overview of the present status of the engineering design, manufacturing and assembly of the JT-60SA machine. The paper will also highlight the important achievement attained in establishing very quickly as early as 2008 an efficient management system and collaborative environment amongst Japanese and European engineers and scientists.