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C3Or4B-04: Performances of the JT-60SA cryogenic system in the integrated commissioning test

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Toward an early realization of fusion energy, a Broader Approach (BA) Agreement between Japan and the European Union was established in 2007. As part of this agreement, a tokamak-type fusion experimental device, JT-60SA, was constructed in Japan as a collaboration between Fusion for Energy and the National Institutes for Quantum and Radiological Science and Technology (QST). The JT-60SA uses a superconducting magnet system involving 18 Toroidal Field (TF) coils, 4 Central Solenoid (CS) modules, 6 Equilibrium Field (EF) coils, superconducting feeders, and 26 high-temperature superconductor current leads. The total cold weight is around 766 tons. A helium cryogenic system with an equivalent refrigeration capacity of 9.5 kW at 4.5 K cools the magnet system, the thermal shield, the current leads and provides refrigeration for the Divertor Cryopumps. CS and EF coils are operated with changing currents during plasma experiments to initiate and control the plasma inducing strongly variable heat loads by AC losses and eddy currents. To mitigate the impact of transient heat fluctuations and ensure stable operation of compressors, turbine expanders and cryogenic circulators the cryogenic system uses a thermal damper system with 7-m3 of liquid helium. The assembly of JT-60SA was completed in March 2020, and the cool-down of the magnet system for the integrated commissioning of the entire system started in October 2020. However, the test was interrupted due to an electrical short at the electrical terminals of the EF1 coil. From 2021 to 2023, repair of terminals, insulation reinforcement, and high voltage tests were conducted. From May 2023, the integrated commissioning test was resumed. It took 41 days to cool the magnet system from room temperature to reach the transition to the superconducting state. At steady state condition, the cryogenic system provided 2 kg/s of supercritical helium for magnet and feeders, 0.04 kg/s of helium gas at 50 K to the HTS current leads, and 0.4 kg/s of helium gas at 80 K to the thermal shield. The cryogenic system operated continuously for 7 months, and JT-60SA successfully achieved the first plasma and a maximum plasma current of 1.2 MA.

In this presentation, we report the outline of the cryogenic system, heat load profiles, and the behavior of the cryogenic system during cool-down and plasma experiments.

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