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C2Or3D-01: Design considerations of the SPARC cryogenic system

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The SPARC project at Commonwealth Fusion Systems (CFS) is a tokamak system designed to demonstrate commercially relevant fusion energy and achieve net fusion power output during the first operating campaign, with eventual pulse energies exceeding 1 GJ. The SPARC tokamak includes eight magnet systems, three of which utilize high temperature superconducting (HTS) tapes, cooled by the SPARC cryogenic system (CRYO) via three supercritical cryogenic loops at temperatures: {8 K, 15 K, 80 K}. CRYO 8 K and 15 K loops cool the HTS magnets to maintain thermal stability and prevent quench, while magnets cooled to 80 K are normally conductive. CRYO provides helium refrigeration from a hybrid cryogenic system including a steady-state cryoplant supporting all CRYO temperature loops, and a fixed volume 8 K blowdown system to remove heat and maintain temperature stability from the toroidal field (TF) magnets during and after fusion pulses. CRYO 4.5 K equivalent peak cooling power is 17 kW for the cryoplant and 2.9 MW for the blowdown system during a 10 second fusion pulse. Primary cryoplant mechanical equipment includes screw compressors, turboexpanders, heat exchangers, and circulation pumps while the blowdown system consists of a series of helium storage tanks operating at independent temperatures and pressures, with make up compressors to reset the blowdown system between pulses. CRYO also includes a distribution valve box and multiple vacuum jacketed process lines ranging in nominal diameter from 20 - 600 mm. This paper investigates the various sub-elements which in combination represent SPARC CRYO and attempts to address some of the technical challenges identified by the team.

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