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Experimental Measurements of Cryogenic Heat Loads on SST-1 Helium Cryogenic Plant

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The SST-1 cryostat houses 130 thermal shields cooled using liquid nitrogen, 16 toroidal field (TF) coils, 9 poloidal field (PF) coils and their associated support structures. Superconducting Magnets System (SCMS) of the SST-1 consisting of TF and PF coils is designed to cool with forced flow supercritical helium (SHe) at 4 bar (a), 4.5 K and a mass flow rate of 300 g/s using helium refrigerator-cum-liquefier (HRL) of 1.3 kW equivalent cold power at 4.5 K.
Last several campaigns, we have observed that the TF and PF coils could not be simultaneously cooled to 4.5 K due to heat loads from SCMS exceeding the installed cryogenic capacity of HRL. In order to cool the TF coils system at desired conditions of 4.5 K, we had to isolate PF coils as well as TF Case hydraulics from HRL at intermediate temperatures of ~ 20 K. In this specific case, the PF coils and TF Case surfaces would be at elevated temperatures in the range of 40 K – 50 K.
To ascertain overall heat loads from SCMS, its associated supports structure along with the cryogenic distribution system under different cooling scenarios on SST-1 helium cryogenic plant, we have recently conducted a dedicated campaign. In this experiment, we demonstrate cool down of TF magnets in single phase supercritical helium mode to ~ 5 K for the first time. Helium supply pressure, temperature and mass flow rate are measured at the outlet of HRL before it is fed to SCMS while helium return temperature and pressure from SCMS are recorded at return line of HRL. This gives a clear picture of equivalent heat loads on HRL system. The cryogenic heat load is found to be ~ 1286 - 1350 W (+/-3%) at 5.5 K under single phase flow conditions. In the same campaign we have succeeded to cool all the nine PF coils to ~ 5 K by isolating TF coils from HRL for the first time. In this work, we report the experimental measurement procedure, instrumentation details and heat load data analysis. These results serve useful purpose in assessing the net cooling power requirement for the simultaneous cooling of the TF and PF coils and facilitate long duration plasma experiments in future.

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