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Thu-Af-Po.10-07: Cooling Design and Thermal Analysis for Thermal Shields of a Cryocooler-cooled Superconducting ECR Ion Source MARS-D Magnet

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A demonstrative NbTi based Mixed Axial and Radial field System (MARS-D) is being developed for a next-Generation Electron Cyclotron Resonance Ion Source (ECRIS) at Lawrence Berkeley National Laboratory, which employs a novel closed-loop coil design scheme that more efficiently utilizes conductor fields and extend the application of NbTi for high frequency (up to 45 GHz) ECR operation. The NbTi MARS-D magnet consists of a single hexagonally shaped closed-loop coil and a set of auxiliary solenoids. Nine binary leads made of copper leads with design current ranging from 175 A to 600 A and High Temperature Superconducting leads (HTS) ranging from 250 A to 1000 A will be used for magnet energization. A cryostat for cooling the MARS-D magnet is under design at LBL. The MARS-D magnet working around 4.2 K will be bath-cooled in liquid helium using multiple two-stage cryocoolers. An intermediate temperature thermal radiation shield system is adopted to reduce the heat leakage imposed on 4.2 K coil cold mass assembly from room temperature. The thermal shield system consists of upper neck shield, main shield assembly, flexible cooling connections and its supports. The shield system is conduction-cooled by the first-stage cold heads of the two-stage cryocoolers and the cold head of an additional single-stage cryocooler shared with nine binary leads. The maximum temperature on the shields shall be no higher than 60 K, which is limited by maximum allowable working temperature of warm ends of HTS leads. The paper presents thermal analyses on the thermal radiation shield system including heat loads and effects of eddy current induced during magnet energization on its material selection, as well as optimal design of its cooling structure.

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