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P4.071 Thermal loads and cooling design for ITER in-port low field side reflectometer diagnostic system

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The current design for the ITER Low Field Side Reflectometer (LFSR) diagnostic system contains six circular waveguides that function as both launch and receive antennas. The waveguides run from the diagnostic first wall (DFW) to the source/detector with the total length of approximate 40 meters. The front end of LFSR, interfacing with the plasma facing DFW and its supporting diagnostic shielding Modules (DSM), is integrated into equatorial port plug 11 (EPP #11) by the Russian Federal Domestic Agency (RFDA). It is required to function in high temperature, high magnetic field, high nuclear radiation, and high vacuum environment in the port zone.

High thermal loads drive the design of the front end waveguides of LFSR system. During plasma operation, the 14 MeV neutrons from DT fusion reactions penetrate into the port plug and in-port diagnostic components. Diagnostic viewing apertures will result in heat loads penetrating deep into the supporting structures. Meanwhile, the surface heat flux of 0.35 MW/m2 has to be applied on those surfaces affected by a viewing factor consistent with the aperture surface position and orientation. The results indicate that the in-port LFSR structure and components receive about 80% of the total heat loading onto the diagnostic shield module in which it resides.

Due to the specific viewing aperture layout at the front-end of LFSR, the cooling channel design is challenging. The thermal-hydraulic design iterations are performed using ANSYS CFX, which allows the solution of conjugated heat transfer in solid and liquid parts. The ITER Structural Design Criteria for In-Vessel components (SDC-IC) guides the detailed structural aspects of cooling channels, such as the plasma facing wall thickness, thermal ratcheting damage as well as mitigating the high thermal-induced stress to ensure the structural integrity.

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