ITER Ion Cyclotron Heating and Current Drive System Gas Barrier

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Two ion cyclotron antennas are being utilized to heat and drive the current of the ITER plasma. These two antennas are capable of injecting 24 MW of rf power into the plasma and are powered by eight transmitters. To transmit the power from the transmitters to the two antennas, water and gas cooled 12 in. (50 Ω) coaxial transmission lines, rf switches, and Hybrid Power Splitters are required to tune and match the RF power to the plasma. The transmission lines originate from the RF Building (Building 15) where the transmitters are located, route through the Assembly Building (Building 13) and enter into the Tokomak Building (Building 12) on the south side. In anticipation of the heating of the inner and outer conductors, the transmission lines are cooled by water cooled jackets on the outside of the outer conductor and the flow of inert gas in the interstitial space between the inner and outer conductors. The flow of cooling gas requires that each of the sixteen coax lines, each approximately 150 meters in length, be separated into four discrete sections to allow for efficient cooling of the inner conductor. This necessitates the use of gas barriers that are compatible with the operation of rf transmission lines. One of the four gas barriers in each line may also serve as a secondary Tritium barrier as well.

The gas barriers as well as the transmission line are to operate at rf power levels up to 6 MW in the frequency range of 40 to 55 MHz. The maximum voltage standing wave ratio (VSWR) allowed is 1.05. With a 6 MW power level, the materials of all the components of the transmission line require high voltage standoff capabilities which necessitates the use of ceramics or quartz for inner to outer conductor standoffs and supports as well as the gas barrier itself. The anticipated temperature range of the 300 mm diameter outer conductor of the coax is 20°C to 70°C while the 130 mm diameter inner conductor is expected to be 20°C to 155°C. The cooling gas for the inner conductor, either clean dry air or nitrogen, is to have a velocity of 3 to 7 m/s with a pressure head of 0.3 MPa absolute. These velocity and pressure parameters as well as the gas type were selected for the voltage standoff capabilities.

The qualification testing scenario for the gas barrier is 35 kV at 47.5 MHz for 3600 s. The voltage in the area of the gas barrier will be increased to 40 kV for 0.1 s at a 10% duty cycle for 60 s at the beginning, middle, and end of the 3600 s duration. The cooling gas velocity will vary between 3 to 7 m/s to determine the optimal velocity for heat removal from the inner conductor.

General Atomics is pursuing the development of an ion cyclotron heating and current drive (ICH&CD) gas barrier for the ITER transmission line system. GA has generated a design, performed electric field analysis, structural pressure analysis and gas flow analysis on the design model. A prototype device is in fabrication and will be delivered to Oak Ridge National Laboratory for testing. Testing is anticipated to be completed by the summer of 2012. The design features and all analyses of the gas barrier will be described and the test results will be presented.

[1] R. Rathi, et al., IEEE/NPSS 24th Symposium on Fusion Engineering (2011).

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