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Paschen testing of ITER Central Solenoid qualification module

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General Atomics is currently fabricating superconducting magnet modules for ITER Central Solenoid in its Poway, CA facility. A critical step during final testing of the modules is high voltage checks of the insulation in Paschen conditions. A qualification coil was fabricated using the same techniques and equipment as the CS Modules. The qualification coil insulation was tested at voltages up to 30kV at pressures from 10-3 mbar to atmosphere to validate the CS Module insulation design and Paschen testing equipment.

Using the same vacuum chamber for cooling the coil to 4.5K, Paschen testing was performed utilizing a system to localize discharges without venting the vacuum chamber. Discharge events were detected using a high voltage tester and specially designed in-chamber multi-camera system.

The initial protection of the ends of the instrumentation wires failed and modifications were made to prevent Paschen discharges at the coil instrumentation wire ends.

Further testing revealed breakdown in the hand-wrapped area of the piping over the helium pipe weld where the instrumentation wires exited the ground insulation. Two modes of failure were identified: failure of the wire insulation (cracking) and failure of the ground insulation. The insulation scheme was redesigned and requalified. The final liquid helium pipe joint insulation scheme consisted of Glass-Kapton® (GK) tape wrapped with epoxy resin. Methodologies were developed to fill “cusps” between round wires and round pipes and to eliminate a problem of wire insulation cracking after resin curing. This insulation scheme was implemented on the qualification coil, which then passed 30kV in all prescribed Paschen conditions.

This paper describes the qualification coil Paschen test results, development of Paschenization techniques to be used on ITER CS Modules, development of the insulation joints, and method of extracting instrumentation wires on the helium supply and return pipes while maintaining high voltage standoff in Paschen conditions.

Co-authors: Dr SMITH, John (General Atomics); Dr KHUMTHONG, Kenneth (ITER Projects / Energy & Advanced Concepts, General Atomics); Dr SCHAUBEL, Kurt (General Atomics); Mr NORAUSKY, Nikolai (General Atomics); Dr LLOYD@GA.COM, Samuel (ITER Projects / Energy & Advanced Concepts, General Atomics); Dr PIEC, Zbigniew (ITER Projects / Energy & Advanced Concepts, General Atomics)

Presenter: Dr KHUMTHONG, Kenneth (ITER Projects / Energy & Advanced Concepts, General Atomics)

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