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Insulation Systems for the ITER Central Solenoid Modules

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General Atomics is currently fabricating seven (six plus one spare) modules for the ITER Central Solenoid in its Poway, CA facility. One of the critical steps in developing the fabrication process for the modules was to develop the insulation system providing the electrical isolation between turns and to grounded components. The insulation system for a module was required to withstand a maximum test voltage of 30kV, with a design goal of 150kV to ground for all penetrations and leads. The complex geometries of the coil, the helium penetrations, leads, and helium piping required the use of novel materials and approaches for the insulation.

Materials were developed to improve the handling of large sheets of fiberglass and Kapton® polyimide of the ground insulation. On the vertical surfaces and around the corners of the CSM, sheets of lightly-bonded Glass-Kapton®-Glass (GKG) and Glass-Kapton® (GK) were used. These sheets were developed and tested for electrical strength and resin permeability in comparison to glass and Kapton® sheets.

Around the leads and helium penetrations, electrical strength and tracking distance were obtained using built-up layers of a thermoplastic polyimide (TPI). Sheets of DuPont Mitsui AURUM® TPI were thermoformed and interlaced with other sheet materials to obtain the required tracking distance.

The liquid helium supply and return pipes were insulated with 20 layers of Kapton® coated on one side with a B-stage epoxy resin that was dry to the touch. These Kapton® tapes were wrapped around the pipes (without interstitial layers of glass), with a ground mesh and a final outer layer of prepreg glass for durability, and then cured. The insulation was tested for electrical strength in air and in Paschen conditions.

Instrumentation wires attached to the conductor exited the ground insulation along the helium pipes. The sealing of the “cusps” between the round wires and the round pipes was accomplished with high resin content prepreg glass. A methodology was developed to eliminate a problem of wire insulation cracking after curing the epoxy. These wire exits were tested in Paschen conditions.

A ground screen was installed around the entire coil, its penetrations, and the helium pipes. The ground screen consisted of stainless steel mesh sheets spot-welded together with a single-point ground. The ground screen for the leads and helium penetrations was made by forming the screen pieces and connected to the pipe ground mesh with spot welds.

A qualification coil was insulated and tested to 10kV prior to resin injection. A vacuum pressure impregnation of the resin was completed after which the coil passed a 30kV hipot. This qualification coil serves as a final test article to validate the design and fabrication of the insulation system.

This paper describes the insulation system and the development and testing of the novel insulation materials used in the ITER CSM.

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Eligible for student paper award?

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