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Sat-Mo-Or4-03: STEP TF cable and remountable joint prototype testing

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The Spherical Tokamak for Energy Production (STEP) is a prototype fusion power plant, planned to be operational in the 2040s. STEP TF coils consist of cables operating at 90kA of current with a peak-field on coil of 16T. These cables are jointed together through a remountable interface at multiple locations in the coil pack which allow for remote maintenance. The joints are intended to operate at 1 nΩ with a background field of 5T on average. Over the course of the last year, the STEP program has worked with Advanced Conductor Technologies (ACT) to develop the STEP TF cable by developing a vacuum pressure impregnation (VPI) manufacturing process for the cable. Two sub-scale cable legs with a re-mountable joint have been tested at SULTAN.

Mechanical and electrical model verification was conducted using shorter cables of length 0.5m –1m with an assortment of tape level tests. Tape critical current degradation under axial strain, transverse compression and transverse tension were measured, feeding into a mechanical model that was used to predict cable level behaviour. Several 0.5m length cables were manufactured using VPI and attested to failure in a 5-point bend test. Critical current degradation of the cable was captured using an ANSYS model, which was used to design the SULTAN legs. A series of electrical tests have been conducted to understand the performance of the joint and Multiphysics models have been built to enable model verification that is fed back into the concept design.

This paper outlines the advances made in manufacturing process, quality inspection of solder impregnation through CT, microscopy, inter-tape resistance at various cable lengths (0.5m, 1m, 3.5m) and the results of the test campaign at SULTAN. The SULTAN campaign consists of measurements of the critical current, temperature and joint resistance. Mechanical cycling has been conducted to check for the robustness of the cable. A series of temperature, voltage and hall measurements have been compared to multiphysics models of the test article developed in H4C, Ansys CFX and ANSYS mechanical to predict cable and joint performance. This activity is a major de-risking exercise with learnings fed back into the design of the jointed TF coils.

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