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Fri-Af-Po.04-03: Performance of indium wire and indium foil joints between high-temperature superconducting PIT VIPER cables

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High-quality joints are essential for building practical assemblies of fusion-scale magnets, integrating the magnets with bus and leads, and allowing modularity in magnet design. The essential figure of merit for the quality of the joint is its electrical resistance which should be as low as possible. Due to its low bulk resistivity and high ductility, indium is often used to cold-weld the interfaces of a joint. Indium can be applied in different forms, primarily as wire or foil, with wire being preferred because of the resistive indium oxide layer that forms on indium foil. Indium wire has an oxide layer as well, however, it is compromised as the wire experiences significant plastic deformation during joining.

In this paper, we present the results of an experimental series conducted at the MIT Plasma Science and Fusion Center's Liquid Nitrogen Superconducting Magnet Test Facility, aimed at comparing the performance of joints containing either indium wire or indium foil. During a test, a joint between two superconducting PIT VIPER cables joined by a set of five saddles was submerged in liquid nitrogen and energized. In total, nine experiments were run including joint tests with acid-etched foil to remove the oxide layer. Across the experiments, different parameters were varied, such as clamping pressure within the joint, electrical contact area, wire spacing, and foil thickness. Experimental data are compared with results from a COMSOL Multiphysics simulation to develop a model for the total joint resistance. Results demonstrate that the resistance of the indium oxide layer is, in fact, negligible compared to other factors such as contact resistances due to voids and other effects –including but not limited to oxides - at interfaces between different materials and the extent to which the indium undergoes plastic deformation, which allows indium to fill voids and ensure intimate contact between joint components. Nevertheless, it is obtained that joints containing indium foil have approximately 40% higher resistances than those containing indium wire.

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