THE ITER CENTRAL SOLENOID

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The United States proposes to build the Central Solenoid for the International Thermonuclear Experimental Reactor (ITER), a fusion tokamak experiment with the goal of generating 500 MW of fusion power with high gain (Q>10). The Central Solenoid must provide most of the volt-seconds needed to induce and sustain a 15 MA plasma for burn times of > 400 s. The 6.4 GJ Central Solenoid design requires a 45 kA conductor and has a peak field of 13 T. The Central Solenoid consists of six pancake-wound modules, stacked vertically, and held in axial compression by an external structure. The five-stage cable has 1/3 copper and 2/3 advanced Nb3Sn strands in a thick superalloy conduit and is cooled by the forced-flow of supercritical helium through the cable space. Key design issues include the qualification of a conduit with adequate fatigue strength, avoiding filament damage from transverse Lorentz loads, managing local axial tension in the winding insulation, qualifying compact intramodule butt joints, and providing sufficiently rapid quench detection.

In 2003, Incoloy 908 was replaced by JK2LB as the reference conduit material. However, recent work at M.I.T. has discovered brittle equilibrium phases in JK2LB. 3D transient simulations, including transverse load effects, indicate a 1 K improvement in temperature margin, using Incoloy 908. Three vendors are developing advanced internal tin Nb3Sn strands with 4.2 K, 12 T critical currents > 1,000 A/mm^2 and +/- 3 T hysteresis losses < 600 mJ/cc. A full-scale hairpin conductor will be tested in SULTAN to prove adequate cable performance under full transverse cyclic loads before solenoid testing.