Simulation of ITER Operational and Startup Scenarios in the DIII-D Tokamak*

T.C. Luce,[1] E.J. Doyle,[2] J.C. DeBoo,[1] G.L. Jackson,[1] T.A. Casper,[3] J.R. Ferron,[1] P.A. Politzer,[1] M.R. Wade,[1] R.J. Groebner,[1] C.T. Holcomb,[3] D.A. Humphreys, A.W. Hyatt,[1] M. Murakami,[4] T.W. Petrie,[1] C.C. Petty,[1] and W.P. West[1]

[1]General Atomics, P.O. Box 85608, San Diego, California 92186-5608, USA
[2]University of California, Los Angeles, California 90095, USA
[3]Lawrence Livermore National Laboratory, Livermore, California 94550, USA
[4]Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA

Operational scenarios designed for use in ITER to achieve its physics and technology goals have been explored in a shape close to that proposed for ITER. The scenarios studied include the baseline ELMing H mode, steady-state, and hybrid scenarios. Discharges with parameters matching the baseline (q_{95}=3, β_N=1.8) and steady-state (q_{95}=5, β_N=2.8) scenarios have been obtained. The performance is slightly below that needed in ITER for Q=10 and Q=5, respectively. In the baseline scenario, the presence of an n=2 tearing mode degrades confinement slightly. Performance at the Q=10 level can be recovered by a 10% increase in β_N, but higher performance is limited by the appearance of an n=1 tearing mode. In the steady-state scenario, higher β_N can be obtained for shorter duration, but β is limited by fast-growing MHD. In addition, all scenarios come into current equilibrium with ℓ_i below the range used to design the poloidal field coil set.

The original startup scenario for ITER starts from a small outboard limited plasma. The cross-section expands to keep the limiter q constant as the current increases, with diverted plasma from 7.5 MA. Scaled to DIII-D, this scenario resulted in rapid current penetration (as planned), but ℓ_i during the limiter phase exceeded the design window for ITER. Sawteeth appeared already during the limiter phase, making access to advanced scenarios that require $q > 1$ difficult. These and other issues led to a proposed alternative ITER startup scenario with larger plasma from breakdown and divertor formation as early as 3.5 MA. With this new startup, it was possible to reach current flattop without sawteeth in DIII-D for reduced current discharges as in the steady-state scenario for ITER. Hybrid scenario performance approaching that needed for Q=10 in ITER has been accessed in DIII-D with this startup, with small sawteeth appearing only at the end of the current rise. Feedback control of ℓ_i was developed in the divertor phase of the current rise, using the current ramp rate as the means of changing ℓ_i. Work on the operational and startup scenarios have been carried out separately up to now; complete ITER simulation discharges will be carried out in the future.

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