Realizing Steady-State Tokamak Operation for Fusion Energy

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Abstract. Continuous operation of a tokamak for fusion energy has clear engineering advantages, but requires conditions beyond those sufficient for a burning plasma. The fusion reactions and external sources must support both the pressure and the current equilibrium without inductive current drive, leading to demands on stability, confinement, current drive, and plasma-wall interactions that exceed those for pulsed tokamaks. These conditions have been met individually, and significant progress has been made in the last decade to realize scenarios where the required conditions are obtained simultaneously. Tokamaks are operated routinely without disruptions near pressure limits, as needed for steady-state operation. Fully noninductive sustainment with more than half of the current from intrinsic currents has been obtained for a resistive time with normalized pressure and confinement approaching those needed for steady-state conditions. One challenge remaining is handling the heat and particle fluxes expected in a steady-state tokamak without compromising the core plasma performance.

PACS Nos.: 89.30.Jj, 28.52.Av, 52.55.Fa, 52.25.Xz, 52.55.Wq