Optimizing stability, transport, and divertor operation through plasma shaping for steady-state scenario development in DIII-D

C.T. Holcomb[1], J.R. Ferron[2], T.C. Luce[2], T.W. Petrie[2], P.A. Politzer[2], C. Challis[3], J.C. DeBoo[2], E.J. Doyle[4], C.M. Greenfield[2], R.J. Groebner[2], M. Groth[1], A.W. Hyatt[2], G.L. Jackson[2], C. Kessel[5], R.J. La Haye[2], M.A. Makowski[1], G.R. McKee[6], M. Murakami[7], T.H. Osborne[2], J.-M. Park[7], R. Prater[2], G.D. Porter[1], H. Reimerdes[8], T.L. Rhodes[4], M.W. Shafer[6], P.B. Snyder[2], A.D. Turnbull[2], and W.P. West[2]

[1]Lawrence Livermore National Laboratory, Livermore, California, USA
[2]General Atomics, San Diego, California, USA
[3]Euratom/UKAEA Fusion Association, Culham Science Centre, Abingdon, UK
[4]University of California, Los Angeles, California, USA
[5]Princeton Plasma Physics Laboratory, Princeton, New Jersey, USA
[6]University of Wisconsin, Madison, Wisconsin, USA
[7]Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA
[8]Columbia University, New York, New York, USA

Abstract. Recent studies on the DIII-D tokamak [J.L Luxon, Nucl. Fusion **42**, 614 (2002)] have elucidated key aspects of the dependence of stability, confinement, and density control on the plasma magnetic configuration, leading to the demonstration of nearly noninductive operation for >1 s with pressure 30% above the ideal no-wall stability limit. Achieving fully noninductive tokamak operation requires high pressure, good confinement, and density control through divertor pumping. Plasma geometry affects all of these. Ideal MHD modeling of external kink stability suggests it may be optimized by adjusting the shape parameter known as squareness (ζ). Optimizing kink stability leads to an increase in the maximum stable pressure. Experiments confirm stability varies strongly with ζ, in agreement with the modeling. Optimization of kink stability via ζ is concurrent with an increase in the H-mode edge pressure pedestal stability. Global energy confinement is optimized at the lowest ζ tested, with increased pedestal pressure and lower core transport. Adjusting the magnetic divertor balance about a double-null (DN) configuration optimizes density control for improved noninductive auxiliary current drive. The best density control is obtained with a slight imbalance toward the divertor opposite the ion grad(B) drift direction, consistent with modeling of these effects. These optimizations have been combined to achieve noninductive current fractions near unity for over 1 s with normalized pressure $3.5 < \beta_N < 3.9$, bootstrap current fraction >65%, and a normalized confinement factor $H_{98(y,2)} \approx 1.5$.

PAC Nos: 52.55.Fa, 52.55.Dy, 52.55.Tn