Multi-mode error field correction on the DIII-D tokamak

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Abstract. Error field optimization on DIII-D tokamak [Luxon, J.L., Nucl. Fusion **42** (2002) 814] plasma discharges has routinely been done for the last ten years with the use of the external "$n=1$ coil" or the "C-coil". The optimum level of correction coil current is determined by the ability to avoid the locked mode instability and access previously unstable parameter space at low densities. The locked mode typically has toroidal and poloidal mode numbers $n=1$ and $m=2$, respectively, and it is this component that initially determined the correction coil current and phase. Realization of the importance of nearby $n=1$ mode components $m=1$ and $m=3$ has led to a revision of the error field correction algorithm. Viscous and toroidal mode coupling effects suggested the need for additional terms in the expression for the radial "penetration" field B_{pen} that can induce a locked mode. To incorporate these effects, the low density locked mode threshold database was expanded. A database of discharges at various toroidal fields, plasma currents, and safety factors was supplemented with data from an experiment in which the fields of the $n=1$ coil and C-coil were combined, allowing the poloidal mode spectrum of the error field to be varied. A multivariate regression analysis of this new low density locked mode database was done to determine the low density locked mode threshold scaling relationship $n_{\mathrm{e}} \propto B_{\mathrm{T}}^{-0.01} q_{95}^{-0.79} B_{\mathrm{pen}}$ and the coefficients of the poloidal mode components in the expression for B_{pen}. Improved plasma performance is achieved by optimizing B_{pen} by varying the applied correction coil currents.

Keywords: error field, tokamak, mode-coupling, DIII-D, locked mode