A SYSTEMATIC APPROACH TO ERROR FIELD ANALYSIS IN ITER*

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Experiments in existing tokamaks have demonstrated that small non-axisymmetric magnetic fields (asymmetric error fields), can severely degrade plasma performance.[1–4] Low order harmonic error fields larger than a critical size are capable of exerting drag on rational *q* surfaces which is sufficient to stop the natural plasma rotation; a phenomena known as "mode locking."[1] Once mode locking occurs the self-healing properties of rotation are lost and magnetic islands grow causing a degradation of plasma performance and potential loss of the plasma column (disruption). Scaling of the locked mode threshold in present machines indicates that the ITER limit will be 5 to 10 times more restrictive than on existing tokamaks. Fortunately, ITER will be the first major machine built with a priori knowledge of the error field problem. In this paper we describe the methodology being used in the design of ITER to reduce the asymmetric error fields to below the expected locked mode threshold.[5]

The asymmetric error field limits imposed on ITER and the definition of helical harmonics are reviewed. Error fields generated by individual poloidal field (PF) and toroidal field (TF) coils based on expected misalignment errors are presented. Other sources of error fields are explored and found to be much less severe than those associated with the PF and TF coils. A statistical method is developed based on random number theory which allows individual error field sources to be combined to estimate the total error field level. This total level becomes the design specification for the correction coil (CC) system, which is designed to reduce the remnant error fields to below the expected locked mode threshold. The CC system consists of three poloidally distributed picture frame coils, with each set containing two independent currents. A methodology is developed to determine the currents in each CC required to mitigate the error field from individual sources and from the statistically combined error field from all sources. A non-linear constrained minimization algorithm is used to determine the optimum CC currents.

The correction coil system is shown to reduce the statistically expected asymmetric error field level to below the projected locked mode threshold. The results indicated that the "worst case" error fields expected in the machine, which are primarily caused by misalignment of the PF and TF coils, will be approximately eight times larger than the projected locked mode threshold for the device. The CC system is shown to be capable of reducing remnant error fields typical of individual coil misalignment errors by a factor of 4 to 12 times, depending on the source. The CC is capable of reducing the statistically expected worst case error field to below the locked mode threshold which represents a factor of eight correction. The correction coil system being designed into ITER, with its three poloidal distributed coil sets, is a factor of 2 to 4 times more effective than other CC systems which have been retrofitted on most large scale tokamak devices.

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