# Structural Upgrade of In-Vessel Control Coil on DIII D*

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For most of 2003, DIII-D operated 12 new in-vessel outer wall mounted control coils. The single turn, rectangular coils are mounted in 2 levels of 6 coils each. The coils were used for many experiments such as suppression of the resistive wall mode, for correction of magnetic field imperfections and for creation of an ergodic edge magnetic field for the suppression of edge localized modes. During operation with a maximum current of 4.5 kA at 100 Hz, one coil developed a leak through the stainless barrier that separates the nitrogen blanketed insulated conductor from vessel vacuum. A pair of coils was taken out of operation for the last month of the year. This paper describes the failure investigation, design, analysis, component testing, repair, system testing and new interlocks for the system that will see significant use in 2004.

The crack in the stainless barrier was attributed to low cyclic fatigue related to operation of the coil at 100 Hz, a frequency near the vertical natural frequency of the coaxial lead. Finite element analysis (FEA) after the failure showed that electromagnetic forces on the single conductor section were sufficient to excite the coaxial lead in a vertical mode. The crack likely developed in less than a second.

Repair options were limited. The coils are mounted to the walls and removal of PF tiles was discouraged in order to minimize the repair time. Welding on the coil was limited in order to protect the internal polyamide insulator from overheating. Repairs included: 1) seal the leak in the faulted coil, 2) increase the stiffness of the single conductors near the coaxial transition and 3) significantly increase the first natural frequency of the coaxial leads to allow operation to 1000 Hz. In-vessel vibration testing was done at each stage of repair to compare the natural frequency of the three types of leads with that determined by FEA models. Verification testing was done prior to vessel closure. The test included temporary installation of field tolerant strain gages to monitor strain in the stainless for comparison with model results. Permanent vacuum vessel port deflection monitors were added with the hope that excessive lead vibrations could be detected by port deflections for interlock purposes. All 12 coils were successfully repaired, upgraded and test results are encouraging.

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