ANALYSIS OF DIII-D UPGRADED NEUTRAL BEAMLINE BENDING MAGNET THERMAL SHIELDS

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The ion bending magnets in the DIII-D neutral beamlines are protected by 12.7 mm thick copper thermal shields that are inertially cooled by single pass water lines. As beam pulse lengths have been extended to 3–4 seconds, these shields have suffered from thermal cracking, which once initiated, often propagates through a water cooling line causing leaks. Recent modeling of the beam ions distribution across the thermal shields shows very uneven heating due to overlapping ion trajectories throughout the bending magnet region. This modeling shows peak heat fluxes (on the order of 6 MW/m^2) near the failure locations.

A second possible factor affecting bending magnet thermal shield failure is beam power modulation. In recent years the beam source power has been rapidly turned on and off to enable feedback regulation of beam injection power at less than full power operation. Beam divergence is largest at startup, and with modulation's frequent startups, the heat flux to the bending magnet thermal shields may be increased. Test results of rapid beam modulation impact on heat flux to the shield will be presented.

To repair the damaged pole shields and to increase the allowable high power pulse duration, the bending magnet thermal shields are being replaced with an upgraded design. The improved design is centered on improved cooling in the peak heat flux region. A small panel insert in the larger shield plate is considered with numerous small water channels using cooling technology from the laser diode industry. The insert panel is designed to maintain low surface temperature (less than 200˚C) and to keep the temperature rise of the cooling water under 40˚C. The remainder of the thermal shield is inertially cooled with water lines spaced to return the shield to initial temperature during the 600 second cool-down period.

Details of the bending magnet thermal shield heat flux modeling, the effect of beam modulation and the new long pulse shield design are presented.

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