DESIGN AND ANALYSIS OF THE CRYOPUMP FOR THE DIII–D UPPER DIVERTOR*

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A cryocondensation pump for the upper inboard divertor on DIII–D is to be installed in the vacuum vessel in the fall of 1999. The cryopump removes neutral gas particles from the divertor and prevents recycling to the plasma. The pump is design for a pumping speed of 30,000 l/s at 0.4 mTorr. The cryopump is toroidally continuous to minimize inductive voltages and avoid electrical breakdown during disruptions. The cryopump consists of a 25 mm Inconel tube cooled by liquid helium and is surrounded by nitrogen cooled shields. A segmented ambient temperature radiation/particle shield protects the nitrogen shields.

The pump is subjected to a steady state heat load of less than 10 W due to conduction and radiation heat transfer. The helium tube will be subjected to Joule heating of less than 300 J due to induced current and a particle load of less than 12 W during plasma operation. The thermal design of the cryopump requires that it be cooled by 5 g/s liquid helium at an inlet pressure of 115 kPa and a temperature of 4.35 K. Thermal analysis and tests show that the helium tube can absorb a transient heat load of up to 100 W for 10 s and still pump deuterium at 6.3 K.

Disruptions induce toroidal currents in the helium line and nitrogen shields. These currents cross the rapidly changing magnetic fields, applying complex dynamic loads on the cryopump. The forces on the pump are extrapolated from magnetic measurements from DIII–D plasma disruptions and scaled to a 3 MA disruption. The supports for the nitrogen shield consist of a racetrack design, which are stiff for reacting the disruption loads, but are radially flexible to allow differential thermal displacements with the vacuum vessel. Static and dynamic finite element analyses of the cryopump show that the stresses and displacements over a range of disruption and thermal loadings are acceptable. The results of the thermal and stress analysis for the upper divertor cryopump are presented in this paper.

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