

## MASSIVE GAS INJECTION SYSTEM FOR DISRUPTION MITIGATION ON THE DIII-D TOKAMAK\*

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Injection of massive quantities of deuterium or noble gases ( $>10^{22}$  molecules) has proven to be very effective at mitigating the deleterious effects of disruptions in the DIII-D tokamak<sup>1,2</sup>. Both the heat load to the divertor and the forces to the first wall were reduced by more than a factor of four. Total electron densities (free and bound) of  $\sim 10^{21} \text{ m}^{-3}$  have been achieved, close to that required to prevent avalanche multiplication of runaway electron currents during the current rampdown.

Two tested configurations will be described. These configurations use a fast operating solenoid valve with an orifice diameter of 4 mm with a maximum flow rate in helium of  $5 \times 10^4 \text{ Pa m}^3/\text{s}$  at a reservoir pressure of 7 MPa. A new valve with an orifice diameter of 20 mm will be tested when DIII-D resumes operation in 2006. The new valve, with a theoretical flow of 25 times the original valve, is actually close to that required for ITER. Calculations show that a set of four such valves can reach the no-avalanche density in ITER in  $\sim 0.25 t_{\text{CQ}}$  where  $t_{\text{CQ}}$  is the plasma current quench time.

It is clear that massive gas injection can provide sufficient mass flow to minimize disruption damage in large tokamaks. The long current decay times in such devices probably make valves like this suitable for mounting exterior to the blanket modules in low magnetic field regions. Trade offs of many factors including rise time, neutron damage, neutron streaming, and reliability will have to determine the most suitable configuration. The last remaining physics question is what is the mixing mechanism which transports the impurities to the plasma interior and how fast is it.

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<sup>1</sup> Taylor, P.L., *et al.*, Phys. Plasmas, **6**, 1872 (1999)

<sup>2</sup> Whyte, D.G., *et al.*, Phys. Rev. Lett., **89**, 55001 (2001).