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Disruption Mitigation Studies in DIII–D[1]

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Critical to the viability of the tokamak concept along with the operation and survivability of future devices is the development of techniques to terminate the discharge safely and mitigate the destructive effects of disruptions: high thermal and electromagnetic loads as well as intense high energy runaway electron beams. A series of dedicated disruption experiments on DIII–D have provided further data on the discharge behavior, thermal loads, halo currents, and runaway electrons and have evaluated techniques to mitigate the disruptions while minimizing runaway electron production. Non-axisymmetric halo currents occur with currents up to 30% of the plasma current and with toroidal peaking factors of 2 at the time of peak halo current. Large heat fluxes are also measured with up to 100% of the pre-disruption thermal energy deposited on the divertor floor. Fundamental questions on the halo current generation, scaling, and mitigation are being addressed by comparisons of DIII–D plasmas during disruptions with the DINA time-dependent resistive MHD code and with semi-analytic halo current evolution models. Experiments injecting cryogenic impurity "killer" pellets of neon, argon, and methane have successfully mitigated these disruption effects; reducing the halo currents by 30%–50%, lowering the halo current asymmetry to near unity, reducing the vertical force on the vessel, and enhancing the power loss through the radiation channel to $\sim$ 90%. Often runaway electrons are generated following the pellet injection and results of recent experiments using pre-emptive "killer" pellets help benchmark theoretical models of the pellet ablation and plasma energy loss (KPRAD and TSC codes), and of the runaway electron generation (CQL3D Fokker-Planck code). Use of the models has led to two new runaway generation mechanisms; both a modification of the standard Dreicer process and arising out of instability induced transport or time dependent effects. Experiments with a massive helium gas puff (3000 T-l in 7 ms) have also effectively mitigated disruptions but without the formation of runaway electrons that can occur with "killer" pellets. The massive gas puff results provide encouragement for longer term approaches to disruption mitigation which are focusing on liquid jets. focusing on liquid jets.

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[2]In collaboration with the DIII–D National Team.