Experiments on Disruption Runaway Electron Suppression in the DIII-D Tokamak*

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Localized wall damage from runaway electrons formed during tokamak disruptions is a serious concern for future large tokamaks like ITER. In the DIII-D tokamak, a large variety of experiments have been conducted to understand runaway electron formation, amplification, and loss; and to devise methods for avoiding wall damage due to runaway electrons following disruptions. The experiments can be broken into two categories: massive impurity injection experiments and runaway electron studies.

In massive impurity injection experiments, attempts are made to achieve very high total electron density ($n_{crit} \approx 5 \times 10^{16}$ cm^{-3}) during the current quench to collisionally suppress any possible runaway electron seeds. Massive gas injection experiments indicate that the limiting factors in impurity assimilation are found to be the limited mixing efficiency of the plasma (~20% during the thermal quench and 1% during the current quench) as well as the limited rise time of the impurity delivery relative to the thermal quench onset time. Preliminary efforts at improving assimilation over that achieved with massive gas injection have been made using either shattered D_2 pellets or shell pellets made of thin polystyrene shells surrounding boron powder. At present, best results are obtained with either simultaneous five-valve He gas injection or single shattered D_2 pellet, both giving a total electron density of perhaps $0.2n_{crit}$.

In runaway electron studies, high current (0.1–0.5 MA), long-lived (>100 ms) runaway electron populations are intentionally created using small (D = 2.7 mm) cryogenic argon pellet injection. These runaway plateau plasmas consist of two components: a cold ($T \approx 1.6$ eV), dense ($n_e \approx 5-15 \times 10^{13}$ cm^{-3}) background plasma co-existing with a very energetic ($T_e \approx 20$ MeV), tenuous ($n_R \approx 4-18 \times 10^9$ cm^{-3}) electron beam. Preliminary experiments at controlling these runaway electron beams with external coils have shown clear ability to ramp the runaway current up and down and to move the runaway beam vertically. Measurements of the runaway beam composition suggest the presence of an anomalous loss of runaways to the wall at a rate of ≈10/s, possibly due to drift orbit losses. Preliminary experiments at injecting impurities into runaway beams show a clear effect on the runaway current for high-Z (Ne) impurity injection, but no effect for low-Z (He) injection. Possible future directions and plans will be discussed.

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