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ITR/P5-23: Development and Testing of Plasma Disruption Mitigation Systems Applicable for ITER

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Disruptions on large tokamaks present challenges to handle the intense heat flux, the large forces from halo currents, and the potential first wall damage from multi-MeV runaway electrons. Injecting large quantities of material into the plasma during the disruption can reduce the plasma energy and increase its resistivity and electron density to mitigate these effects. Developing the technology to inject sufficient material deeply into the plasma for a rapid shutdown and runaway electron collisional suppression is an important capability needed for maintaining successful operation of ITER and future reactors. The initial system developed for this application at Oak Ridge National Laboratory (ORNL) made use of a fast acting solenoid valve designed and routinely used for pneumatic pellet injection systems. The prototype valve equipped with a relatively large supply cylinder (0.3 L) was tested in the lab with various gases (Ar, Ne, He, and hydrogen) at pressures up to 70 bar and then used in experiments on DIII-D to inject gases to mitigate some of the deleterious effects of disruptions on the tokamak [1]. The prototype was later replaced with a multi-valve system that can accommodate up to six valves. This system allowed experiments with much higher gas injection rates. The prototype was provided to C-Mod and used for successful disruption mitigation experiments [2]. A second ORNL system was recently provided to C-Mod, and initial experiments have been carried out. An alternative technique, injection of a relatively large (~16 mm diameter) shattered pellet, for rapidly getting sufficient material into the plasma was more recently developed at ORNL and successfully tested in plasma disruption experiments on DIII-D [3]. With the large pellets proving to be very effective, we are evaluating different techniques to shatter the pellet and direct the debris stream. Here we present the status/progress on the development of these systems and the potential of these techniques to provide reliable disruption mitigation on ITER.

[1] D.G Whyte et al., Phys. Rev. Lett. 89 (2002) 055001-1.
[2] R. Granetz et al., Nucl. Fusion 46 (2006) 1001.
[3] N. Commaux et al., Nucl. Fusion 51 (2011) 103001.

Country or International Organization of Primary Author

U.S.A.

Primary author: Mr COMBS, Stephen (USA)

Co-authors: Mr FOUST, Charles (Oak Ridge National Laboratory, Oak Ridge, TN, USA); Dr RASMUSSEN, David (Oak Ridge National Laboratory, Oak Ridge, TN, USA); Dr BAYLOR, Larry (Oak Ridge National Laboratory, Oak Ridge, TN, USA); Dr COMMAUX, Nicolas (Oak Ridge National Laboratory, Oak Ridge, TN, USA); Dr PARKS, Paul (General Atomics, San Diego, CA, USA); Dr MARUYAMA, So (ITER Organization, Route de Vinon sur Verdon, 13115 Saint Paul Lez Durance, France); Mr MEITNER, Steven (Oak Ridge National Laboratory, Oak Ridge, TN, USA); Dr JERNIGAN, Thomas (Oak Ridge National Laboratory, Oak Ridge, TN, USA)

Presenter: Mr COMBS, Stephen (USA)

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