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R&D for reliable disruption mitigation in ITER

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The disruption mitigation system (DMS) is a key plant system to ensure the reliable and successful operation of ITER from the first experimental campaign onwards. The DMS baseline concept and design is based on present knowledge on disruption mitigation, which, nevertheless, remains subject to significant gaps in understanding, especially as concerns runaway electron (RE) formation and mitigation. This paper outlines the challenges of implementing a highly reliable DMS for ITER, presents recent progress towards the consolidation of the baseline system and develops a strategy and plan for achieving the required level of disruption mitigation to satisfy ITER's operational needs.

The baseline DMS is based on shattered pellet injection (SPI) technology. This technology delivers the material to the tokamak vessel by accelerating large cryogenic pellets that are broken into smaller fragments at the end of the delivery tube. A total of 25 pellets of different sizes can be injected to mitigate the thermal and electro-magnetic loads while preventing the formation of runaway electrons. Additionally, as a second layer of defense, the DMS is supposed to provide sufficiently fast energy dissipation should a runaway beam form accidentally.

The most important challenge for disruption mitigation in ITER will be to ensure that runaway electron formation is excluded during the mitigation action up to the nominal plasma current. Designing a DMS that fulfils this essential requirement requires much better understanding of the generation of runaway electron seed populations during the MHD driven thermal quench. Another constraint is the need to ensure that the line radiation is homogenous enough to prevent first wall melting during the mitigated thermal quench. The required R&D work on the technology side comprises the integration of the baseline DMS into the ITER physical environment, the optimization of the pellet injection and shattering processes with special focus on the fragment ablation and penetration process and the optimum fragment size distribution, the assessment of the requirements for material injection for optimized effectiveness and operability in the ITER environment and the plasma parameter range. The latter will have a strong focus on the efficiency of multiple pellet injection and their relative timing and jitter.

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