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The ITER Disruption Mitigation Strategy

Although the thermomechanical loads generated by plasma disruptions in ITER require operations to strongly focus on disruption avoidance, these cannot be ruled out, especially during the early phases of the ITER Research Plan (IRP) [1] when scenarios are established and the operational space is extended. Even at relatively low plasma performance, these disruption loads can be severe on ITER, particularly with regard to damage of plasma-facing components. Disruption mitigation is therefore critical, not just for the achievement of the ultimate goal of high current (15 MA), burning plasma operation (Q = 10), but also for the timely execution of the IRP to reach this goal. ITER's disruption mitigation strategy relies on the injection of multiple cryogenic pellets that are disintegrated into small fragments before entering the plasma, a technique called shattered pellet injection (SPI). The Disruption Mitigation System (DMS) is at the conceptual design level and consists of a total of 24 injectors distributed over 3 equatorial ports as well as 3 additional injectors in 3 upper port plugs.

The design work is progressing on the basis of a set of requirements that were derived from present limited knowledge on disruption mitigation using SPI. However, there are major uncertainties in these requirements that need to be urgently addressed to increase the confidence level in the DMS design. An international Task Force has been established which drives an extensive programme to assess the requirements and to validate the design choices for the ITER DMS. The Task Force experimental and modelling programme is primarily focused on answering fundamental questions key to the ITER mitigation strategy: Can the density be raised efficiently by superimposing multiple pellets? Can runaway electron formation be avoided through massive injection of hydrogen? Can the required radiation levels be reached uniformly enough to avoid melting of the first wall? What is the optimum fragment size and velocity for maximum material assimilation?

With its injection capabilities, the requirements on reliability and availability, and the demanding constraints imposed by the limited physical space and very harsh environment, the ITER DMS is a first-of-a-kind system. The technology programme of the task force is dedicated to the optimisation and testing of key components, covering issues such as: a) systematic tests and optimisation of the pellet formation and release process; b) the creation of a support laboratory, providing a test bed to assess the performance of key components; c) the development and testing of shattering units to deliver the required fragment sizes; d) the development of a pellet launching unit consisting of optimised fast valve and punch mechanisms; e) the development of optical pellet diagnostics to diagnose pellet alignment, pellet integrity and pellet parameters.

[1] ITER Research Plan, ITR-18-03, ITER Organization, 2018 (https://www.iter.org/technical-reports).

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