

Runaway Electrons in JET - Status of RE Data after End of JET Operations in 2023

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Plasma major disruptions pose severe threats to the device integrity in future operations of International Thermonuclear Experimental Reactor (ITER). They can cause dangerous excessive electromagnetic forces, heat loads and generation of the intense beams of relativistic runaway electrons (RE). Localized interaction of intense RE beams with surrounding plasma facing components (PFC) inevitably will result in unacceptable PFC damage. To avoid/suppress RE generation and mitigation of other disruption detrimental consequences the Disruption Mitigation System (DMS) is under design for ITER. It will be based on injection of impurities in the form of solid shattered pellets (SPI). Despite significant progress in studies relevant to the ITER DMS design, the set of physical and technology problems remains un-resolved. Development of DMS requires further advances in understanding of the physics of RE and their interaction with plasma, solid pellets and neutral gases (fuel and injected impurities). For this purpose the comprehensive database on RE generation at disruptions in JET has been elaborated recently including the data obtained just before the end of JET operations in 2023.

This report presents the first summary and current status of the JET RE database analysis. The first events of the RE generation have been detected in spontaneous disruptions in JET from the early experiments. A series of dedicated experiments on RE generation have been carried out during whole period of JET operations with divertor (at carbon fiber composite (CFC) tiles till to 2009) and with ITER-like Wall (from 2011)). From the beginning of JET operations there were several attempts to review the data on RE generation events. However, these attempts are still waiting for a compiling into joint database. RE generation in spontaneous disruptions, during those triggered by constant gas puff, at Massive Gas Injection (MGI) and SPI, including latest experiments on benign RE termination, provided the data for JET database. An analysis of this database should stimulate further advances in understanding of the physics of RE and to serve as the basis for possible numerical simulations. The mapping of RE parameters enabled establishing links of pre-disruption and post-disruption parameters. Despite the plasma parameters are poorly known during and after disruptions, this approach enables establishing links between plasma parameters before thermal quench and during current decay (Te and ne, li, and current quench (CQ) rates, data from EFIT, etc.). Obtained data was used to study the trends in RE parameters for a wide range of disrupted JET currents (up to 6.25 MA). Note, that at certain combinations of plasma pre-disruption parameters data analysis yielded the trends, which are in contrary to that obtained early on limited number of points. CQ studies revealed different, accelerating and constraining effects of initial plasma configurations (circular (limiter) or X-point) on RE generation and value of current conversion ratio (I_{pl}/I_{RE}). One of the important results from the data-base analysis is observation of lower threshold in generation and a decreasing trend in conversion ratio I_{RE}/I_{pl} depending on CQ rates.

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