

Overview of disruptions with JET-ILW

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This paper presents an analysis of disruptions occurring during JET-ILW plasma operations covering the period from #80128 up to #92504. The total number of disruptions was 1951 including 466 MGI (massive gas injection), VDE (vertical displacement event) and Error Field Correction Coil experiments, which led to intentional disruptions; hence the average disruption rate is 16.1%. MGI has been routinely used in protection mode both to terminate pulses when the plasma is at risk of disruption, and to mitigate against disruptions, in total 896 shots were ended by MGI. The subset of 913 natural disruptions, which were not affected by special dedicated experiments or MGI protection, was used for analysis of pre-disruptive plasma behaviour. The pre-disruptive plasma parameters of the natural disruptions are $I_p=(0.82-3.14)\text{MA}$, toroidal field $B_t=(0.98-3.36)\text{T}$, $q_{95}=(1.52-9.05)$, $l_i=(0.58-1.86)$, $\beta_{\text{ap}}=(0-1.1)$, volume average plasma density $n_e=(0.2-8.5)10^{19}\text{m}^{-3}$, X-point (317 shots) and limiter (596 shots) configurations. Apart from 21 exceptional cases, the MGI was triggered by $n=1$ locked mode (523 shots) or by the disruption itself, specifically by dI_p/dt (207 shots) or by toroidal loop voltage (145 shots). On JET only the locked mode was treated as either a precursor or the cause of disruptions. However, long lasting locked modes ($\geq 100\text{ms}$) do exist prior to disruption in 75% of cases. Though, 10% of non-disruptive pulses have a locked mode which eventually vanished without disruption. The plasma current quench (CQ) may result in 3D equilibria, termed as asymmetrical disruptions, which are accompanied by sideways forces. Unmitigated VDEs generally have significant plasma current toroidal asymmetries. The unmitigated disruptions also have large plasma current asymmetries presumably because there is no plasma vertical position control during CQ. However, MGI is a reliable tool to mitigate 3D effects and accordingly sideways forces. The vessel structure loads depend on the force impulse and force time behaviour or rotation. The toroidal rotation of 3D equilibria is of particular concern because of potential resonance with the natural frequencies of the vessel components in large tokamaks such as ITER. The amplitude-frequency interdependence is important, since a simultaneous increase of amplitude and frequency would potentially create the most challenging load conditions.

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Primary author: Dr GERASIMOV, Sergei (CCFE)

Co-authors: Dr RIMINI, Fernanda (UkCCFE); Dr SZEPESI, Gabor (UkCCFE); Dr ARTASERSE, Giovanni (ItENE); Dr CARVALHO, Ivo (PtIST); Dr ZAKHAROV, Leonid (LiWFusion); Dr BARUZZO, Matteo (ItRFX); Dr TSALAS, Maximos (ITERFr); Dr MASLOV, Mikhail (UkCCFE); Mr MCCULLEN, Paul (UkCCFE); Dr ABREU, Paulo (PtIST); Dr LOMAS, Peter (UkCCFE); Dr HENRIQUES, Rafael (PtIST); Mr FELTON, Robert (UkCCFE); Dr MORADI, Sara (BeLPP); Dr HENDER, Tim (CCFE); Dr KRUEZI, Uron (ITERFr); Mr SCHIPPERS, William (UkCCFE)

Presenter: Dr GERASIMOV, Sergei (CCFE)

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