Overview of disruptions with JET-ILW

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Abstract:
The paper presents an analysis of disruptions occurring during JET-ILW plasma operations covering the period from the start of ILW (ITER-like wall) operation up to completion of JET operation in 2016. The total number of disruptions was 1951 including 466 with deliberately induced disruptions. The average rate of unintended disruptions was 16.1 %, which is significantly above the ITER target at 15 MA. The pre-disruptive plasma parameters are: plasma current Ip = (0.82–3.38) MA, toroidal field BT = (0.98–3.4) T, safety factor q95 = (1.52–9.05), plasma internal inductance li = (0.58–1.86), Greenwald density limit fraction FGWL = (0.04–1.61), with 720 X-point plasma pulses from a subset of 1420 unintended disruption shots. Massive gas injection (MGI) has been routinely used in protection mode both to terminate pulses when the plasma is at risk of disruption and to mitigate against disruption effects. The MGI was mainly triggered by the n = 1 locked mode (LM) amplitude exceeding a threshold or by the disruption itself, namely, either dIp/dt (specifically, a fast drop in Ip) or the toroidal loop voltage exceeding threshold values. For mitigation purposes, only the LM was used as a physics precursor and threshold on the LM signal was used to trigger the MGI prior to disruption. Long lasting LM ($\geqslant$ 100 ms) do exist prior to disruption in 75% of cases. However, 10% of non-disruptive pulses have a LM which eventually vanished without disruption. The plasma current quench (CQ) may result in 3D configurations, termed as asymmetrical disruptions, which are accompanied by sideways forces. Unmitigated vertical displacement events (VDEs) generally have significant plasma current toroidal asymmetries. Unmitigated non-VDE disruptions also have large plasma current asymmetries presumably because there is no plasma vertical position control during the CQ and so they too are subject to large vertical displacements. MGI is a reliable tool to mitigate 3D effects and correspondingly sideways forces during the CQ. The vessel structure loads depend on the force impulse and force time behaviour, including their rotation. The toroidal rotation of 3D configuration may cause resonance with the natural frequencies of the vessel components in large tokamaks such as ITER. The JET-ILW amplitude-frequency interdependence of toroidal rotation of 3D configurations is presented.