Introduction

Data on the expected characteristics of disruptions and on the nature and magnitude of disruption effects are needed for the design and functional validation of ITER components and systems. A new International Disruption Database (IDDB) [1] has been established by the International Tokamak Physics Activity (ITPA) Topical Group on MHD, Disruption and Magnetic Control. Version 1 of the database, hosted by General Atomics, now comprises device attributes and data from a total of 3875 discharges that end in disruption or some similar type of fast plasma-current terminating event (e.g. a vertical displacement event (VDE) or a massive gas injection (MGI) fast plasma shutdown). The present content represents submissions from eight devices: Alcator C-Mod (2167), ASDEX Upgrade (51), DIII-D (1153), JET (200), JT-60U (20), MAST (55), NSTX (200) and TCV (29). The data cover the ranges of major radius \(0.54 \leq R(m) \leq 3.19\) and plasma current \(0.08 \leq I_p(\text{MA}) \leq 3.42\), as shown in figure 1, and an aspect ratio range of \(1.27 \leq R/a \leq 6.62\). The examples with \(R/a > 4.09\) arise from a small number of reduced-minor-radius examples contained within the DIII-D data. With these data excepted, the effective encompassed by the IDDB data.
range of aspect ratio for the collective v.1 data set is $1.27 \leq R/a \leq ~4.1$. Data content of v.1 comprises some 70 scalar variables that quantify the contributing device and device-specific configuration attributes, before-disruption plasma current, shape and other disruption-relevant magnetic and kinetic attributes, plus detailed data on the rate and waveform characteristics of the plasma current decay.

**Current quench rates**

The first application of the database has been in determining the fastest $I_p$ quench rate, which is important in calculating the loading on ITER blanket modules [2]. For this study the current quench (CQ) time is defined as

$$t_{CQ} = \frac{5}{3} \Delta t_{60} = \frac{5}{3} (t_{20} - t_{80})$$

(1)

where $t_{80}$ and $t_{20}$ are respectively the times for the plasma current to decay, after disruption onset, to 80% and 20% of the initial before-disruption plasma current, $I_{p0}$. In contrast to the previous *ad hoc* current quench database content used for [2,3], the v.1 contributed data now uniformly comprise directly-measured $t_{80}$ and $t_{20}$ values. It should be noted that although the current quench time is linearly extrapolated from the 80-20% quench time, there is no presumption the decay is of that form (see [2] for a discussion on this issue). Figure 2 shows the quench times of the v.1 data normalized by the plasma area ($S$) versus the current density, defined as $j_p = I_{p0}/S$. The basis for normalising the current decay time ($t_{CQ}$) by $S$ is discussed in [3] and the data are plotted versus $j_p$ (as in the IPB [3]) as a convenient way to display data from a range of tokamaks and to connect present data to the range of current densities expected in ITER (the pink-shaded domain indicated in figure 2). The NSTX and MAST data clearly have faster $I_p$-quench rates than the conventional $R/a$ tokamaks. The lower bound for the low aspect ratio data is $t_{CQ}/S \geq 0.6$ ms/m$^2$, about 3 times lower than the bound for the standard aspect ratio data. However, figure 3 shows that when the area-normalized CQ times for all of the v.1 tokamaks are further normalized by their respective dimensionless self-inductance factors, $L^* = \ln(8R/a) - 1.75$, the low aspect ratio data now approximately overlays the similar- $j_p$ data from the other standard aspect ratio tokamaks. We caution that the accuracy of our present inductance renormalization procedure is not sufficient to support fine-scale distinctions between the minimum renormalized current quench times for low versus conventional aspect ratio tokamaks.
Neglecting for the moment the NSTX and MAST data, we see from figure 2 that the DIII-D data has the fastest area-normalized CQs of the six standard-aspect-ratio tokamaks represented. In figure 4, we show a high-resolution plot of the fastest $S$-normalized DIII-D current quenches versus $1/q_{cyl} = (I_p(MA) R(m)/(5a^2(m)B_0(T)))$; the nominal ITER value of $1/q_{cyl}=0.88$, which corresponds to $q_{95} = 3$ (ITER scenario 2). Figure 4 shows a reasonably clear division of the data; around, and above the nominal ITER $1/q_{cyl}$-value all data lie at or above $t_{CQ}/S = 1.67$ ms/m$^2$. However, there are twelve data points (out of a total of 1153) with $t_{CQ}/S < 1.67$ ms/m$^2$, at higher $q_{cyl}$ values. The risk the fastest CQs pose to ITER is due to the CQ-induced rapid flux change at the first wall structure. For a given CQ rate, the larger the plasma current, the larger the induced voltage, so risk scales with the plasma current (or as $1/q_{cyl}$) and inversely with the CQ rate. Hence the diagonal line in figure 4 represents a line of equal risk from a disruption at a given toroidal field. Points above the diagonal line represent a reduced risk, compared to a disruption with $t_{CQ}/S = 1.67$ ms/m$^2$ at full nominal current ($I_p = 15$ MA) in ITER. Thus the points with $t_{CQ}/S < 1.67$ ms/m$^2$ do not need to be accounted for in considering the fastest CQ in ITER. This is the basis for choosing $t_{CQ}/S = 1.7$ ms/m$^2$ (to 2 significant figures) as the recommended fastest CQ rate ($t_{min} \approx 36$ ms for $S = 21.3$ m$^2$ in ITER). It should be noted that for the other two large v.1 IDDB datasets, from JET and C-Mod, the area-normalized lower bound is approximately 3.0 ms/m$^2$; whereas the lower
bounds for ASDEX Upgrade and JT-60U are ~2.4 ms/m². We can find no simple explanation internal to the IDDB data as to why the DIII-D lower bound is noticeably lower than that of the other standard aspect ratio tokamaks. Also it should be noted that the database shows a large spread in CQ times, with the majority lying well above the fastest observed value of $t_{CQ}/S$ – for example in DIII-D just 4.9% of the data has a quench time faster than 2 ms/m².

The discussion of CQ rates has been based on a linear extrapolation from 80 to 20% quench times. Extrapolations based on other %-intervals (starting from a maximum of 90% and going to a minimum of 10%) have also been explored and with a very limited number of exceptions the bound $t_{CQ}/S > 1.7$ ms/m² is obeyed. Further an exponential fit to the $I_p$ data (at 8 times during the decay) shows a lower CQ time bound that is very consistent with an exponential fit to the 80 and 20% data points.

**Future Plans**

Near-term future plans for the IDDB call for expansion of the v.1 data set to include detailed time-dependent pre-disruption waveforms to allow pre-disruptive energy loss to be assessed. Also initial data on halo currents will be included. On a longer time scale, we anticipate further expansion of the IDDB data set to encompass thermal quench and plasma-facing-component energy deposition and comprehensive runaway electron related data.

**References**


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