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DISRUPTION, HALO CURRENT AND RAPID SHUTDOWN DATABASE ACTIVITIES FOR ITER

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GENERAL ATOMICS

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Disruption characterization and database development and analysis activities conducted in support of ITER under the aegis of the International Tokamak Physics Activity (ITPA) Topical Group on MHD Stability are described. An ITPA International Disruption Database (IDDB) Working Group and a MDSplus-based IDDB infrastructure for collection and retrieval of disruption-relevant tokamak data, first established in 2006, comprises one of several disruption-related "joint activities" being conducted by the ITPA MHD Stability TG. Analysis reported in 2006 [1] of current quench data from eight elongated-plasma tokamaks provided a new "multi-machine-based" recommendation about the lower bound on plasma current decay time expected in ITER. Activities are now in progress to expand the IDDB to encompass halo current data, and new combined current decay and halo current data sets are expected. This data is expected to provide an "integrated" basis for design recommendations to ITER with regard to the rate of plasma current decay and halo current magnitude and toroidal asymmetry. In addition, activities have been initiated to add IDDB data categories for rapid plasma shutdowns effected by massive gas and pellet injection.

Motivation and ITER Design Issues. Data on the expected characteristics of disruptions and on the nature and magnitude of disruption and rapid plasma shutdown consequences are urgently needed for the design and functional validation of ITER components and systems. Key pending design issues related to the torus vacuum vessel and the in-vessel blanket-shield modules include peak vertical forces on the vessel support system, forces and torques owed to halo and induced currents in the in-vessel shield modules and their attachments to the vessel, and halo and eddy current load dynamics for in-vessel components such as radio-frequency launching systems and divertor and first-wall protective surfaces. The focus of IDDB activities has been on developing plasma current decay data and now halo current and rapid shutdown consequence data that can provide guidance for ITER design and systems operation qualification. Data needs and examples of circa 1996 ITER Engineering Design Activity (EDA) disruption data are described in [2]. More recent application of this legacy data to the present ITER design is described in [3] and [4].

Present IDDB activities are focused on developing modern databases that go beyond those developed during the EDA. An ITPA-sanctioned IDDB, with structure and implementation and user and public access principles paralleling those of other existing ITPA databases was established in 2006. Key features include the use of scalable/expandable data storage means (MDSplus [5]) and configuration of the database structure to allow for full traceability of data origins. An IDDB Working Group, comprising representatives from contributing devices, plus additional members interested in using IDDB data, has been established. Content for the 2006 v.1 MDSplus data tree comprises data from some 3500 disruptions and rapid shutdowns, with ca 50 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. Working Group findings from the v.1 data are described in [1]. Key results include verification of the self-inductance scaling of minimum area-normalized current quench times with toroidal aspect ratio ($A = R/a$), and a finding, for plasmas with $2.5 \leq A \leq 3.5$, that the time for current decay, t_{CQ}, is bounded by $t_{CQ}/S \geq 1.7$ ms/m^2. Here S is the before-disruption poloidal cross-section area.

Expansion Activities. Ongoing activities include addition of 7 halo-current and vessel-force data types and solicitations to present and new contributors for revisited or new 'integrated' data examples (shot records) with combined plasma current decay, halo current and [optional] vessel vertical force or impulse (force x time) data. Provisional contributions from three tokamaks have been received. Plans for 2010 encompass revisiting the EDA-era basis for the bound on the product of normalized peak halo current ($I_{h,max}/I_{p0}$) and toroidal peaking factor (TPF), as well as searching for correlations of these and other related halo-current attributes with the parent plasma aspect ratio, elongation, safety factor and rate of initial current decay. In addition, the feasibility of interpreting database composite and device-specific data in terms of a "statistical" load severity spectrum will be explored. Finally, plans for adding massive gas and pellet injection rapid plasma shutdown data are being developed, with the ultimate intent of providing a common disruption/halo current/rapid shutdown design basis for ITER.

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