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DISRUPTION CHARACTERIZATION AND DATABASE ACTIVITIES FOR ITER

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DISCLAIMER

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Y. GRIBOV,[†] P.C. deVRIES,[*] E.J. FREDRICKSON,[‡] D.A. GATES,[‡] R.S. GRANETZ,[¶] Y. KAWANO,[§]
J. LISTER,[#] R. MARTIN,[*] G. PAUTASSO,[◊] and M. SUGIHARA[†]

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[*]Euratom/UKAEA Fusion Association, Culham Science Centre, Abingdon, United Kingdom.
[†]ITER International Team, Naka, Ibaraki, Japan.
[‡]Princeton Plasma Physics Laboratory, Princeton, New Jersey.
[¶]Massachusetts Institute of Technology, Cambridge Massachusetts.
[§]Japan Atomic Energy Agency, Naka, Ibaraki, Japan.
[#]Association Euratom-Confederation Suisse, Ecole Polytechnique Federale de Laussane, Lausanne, Switzerland.
[◊]Max Planck Institut für Plasmaphysik, Garching, Germany.

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Disruption Characterization and Database Activities for ITER* IT

J.C Wesley[1], A.W. Hyatt[1], E.J. Strait[1], D.P. Schissel[1], S.M. Flanagan[1], T.C. Hender[2], Y. Gribov[3], P.C. deVries[2], E.J. Fredrickson[4], D.A. Gates[4], R.S. Granetz[5], Y. Kawano[6], J. Lister[7], R. Martin[2], G. Pautasso[8] and M. Sugihara[3]

[1]General Atomics, P.O. Box 85608, San Diego, California 92186-5608, USA
e-mail: wesley@fusion.gat.com
[2]Euratom/UKAEA Fusion Association, Culham Science Centre, Abingdon, OX14 3DB, United Kingdom
[3]ITER International Team, Naka, Ibaraki 311-0193, Japan
[4]Princeton Plasma Physics Laboratory, Princeton, New Jersey 08543, USA
[5]Plasma Science Fusion Center, Massachusetts Institute of Technology, Cambridge Massachusetts 02139, USA
[6]Japan Atomic Energy Agency, Fusion Research and Development Directorate, Naka, Ibaraki 311-0193, Japan
[7]Association Euratom-Confederation Suisse, Centre de Recherches en Physique des Plasmas, Ecole Polytechnique Federale de Laussane, CH-1015 Lausanne, Switzerland
[4]Max Planck Institut für Plasmaphysik, Garching, Postfach 1322, D-85741, Garching bei München, Germany

Disruption characterization and database development and analysis activities conducted for ITER under the aegis of the International Tokamak Physics Activity (ITPA) Topical Group on MHD, Control and Disruption are described. Accomplishments during 2005-2006 include: 1) formation of an International Disruption Database (IDDB) Working Group, 2) implementation of an MDSplus-based IDDB infrastructure for collection and retrieval of disruption-relevant tokamak data, and 3) collection of a “version 1” (v.1) data set from seven elongated-plasma tokamaks. Analysis of the current quench data provides a new recommendation to the ITER International Team (IT) about the lower bound on the plasma current decay time in ITER. Plans for further expansion of the scope and content of the IDDB have been identified.

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. The applicable physics bases and samples of the then-available (ca 1996) data are described in [1], and considerations for extrapolation of that data to the then-current ITER design (R = 8.14 m, I = 21 MA) are given therein. Evolution of the ITER design to the present configuration (R = 6.2 m, I = 15 MA) [2] and review of pending disruption-related design issues (e.g., [3]) provide motivation for improvement of the scope and quality of disruption data and for new consideration of the means for extrapolating present data to ITER and beyond.

In 2003, the representatives from the ITER IT and the ITPA identified the need for new and more-comprehensive versions of the databases for plasma current quench rate and for halo current magnitude and toroidal symmetry that were developed during the ITER Engineering Design Activities (EDA). This led to a plan to establish a new, ITPA-sanctioned IDDB, with a structure and implementation and user and public access principles that would parallel those of other existing ITPA databases (see, eg., [4,5]). Key features envisioned for the IDDB included the use of a modern, scalable/expandable data storage means (MDSplus

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[6]) and configuration of the database structure to allow for full traceability of data origins and for significant future growth in data scope, quantity and dimensionality (i.e., profiles, time-sequence data and eventually, simulation/modeling data sets). Contributions to the IDDB and subsequent analysis and publication of data would be effected by an IDDB Working Group, comprising representatives from each contributing device and/or institution, plus additional members interested in using IDDB data. Present membership in the IDDB Working Group comprises 12 individuals representing 8 institutions in the European Union, Japan and the United States.

General Atomics (GA) hosts the IDDB and provides administrative and technical support. An MDSplus "tree-structure" for "version 1" of the IDDB has been established on a password-protected GA server. Data content for the v.1 tree comprises some 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. The v.1 data set now comprises a total of 3535 shots (disruptions), contributed from four devices: C-Mod (2000), DIII-D (1150), JET (185) and NSTX (200). Contributions from ASDEX-Upgrade, JT-60U and MAST are in process and will be incorporated in future analysis. Data submissions for v.1 have identified and resolved issues about how to submit, add, update and retrieve data from the MDSplus "raw data" archive and from the SQL relational database (set up to facilitate IDDB exploration) that is automatically generated on a daily basis from the MDSplus scalar data. Daily back-ups support a unique aspect of the IDDB: users (individual contributors) are directly responsible for the submission, integrity and future modification of the data they contribute.

Provisional evaluation of area-normalized plasma current quench rates for the present v.1 data set have verified the expected toroidal aspect ratio ($A = R/a$) scaling of current quench rates and have established, for plasmas with $2.5 \leq A \leq 3.5$, that the time for full current decay, t_{CQ}, derived on the basis of a linear extrapolation of the average rate of current decay from 80% of initial plasma current to 20% current, is bounded by $t_{CQ}/S \geq 1.67$ ms/m^2. Here S is the before-disruption poloidal cross-section area, derived (for example) from equilibrium reconstruction. This lower bound, when applied to ITER, results in a minimum current quench time that is ~10% smaller than the previous recommendation, established in 2004, detailed in [3].

Near-term future plans for the IDDB call for current-quench data from additional tokamaks and expansion of the v.1 data set to include detailed time-dependent current waveform data, halo current and vertical motion and configuration evolution and/or reconstruction data. On a longer time scale, further expansion of the data set to encompass thermal quench and PFC energy deposition and accountability data, runaway electron formation, in-plasma growth (avalanche gain) and loss to PFC surfaces is anticipated.

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