INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR

ITER EDA NEWSLETTER

VOL. 4, NO. 10 OCTOBER 1995

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, AUSTRIA

ISSN 1024-5642

SUMMARY OF THE FOURTH TECHNICAL MEETING ON SAFETY AND ENVIRONMENT

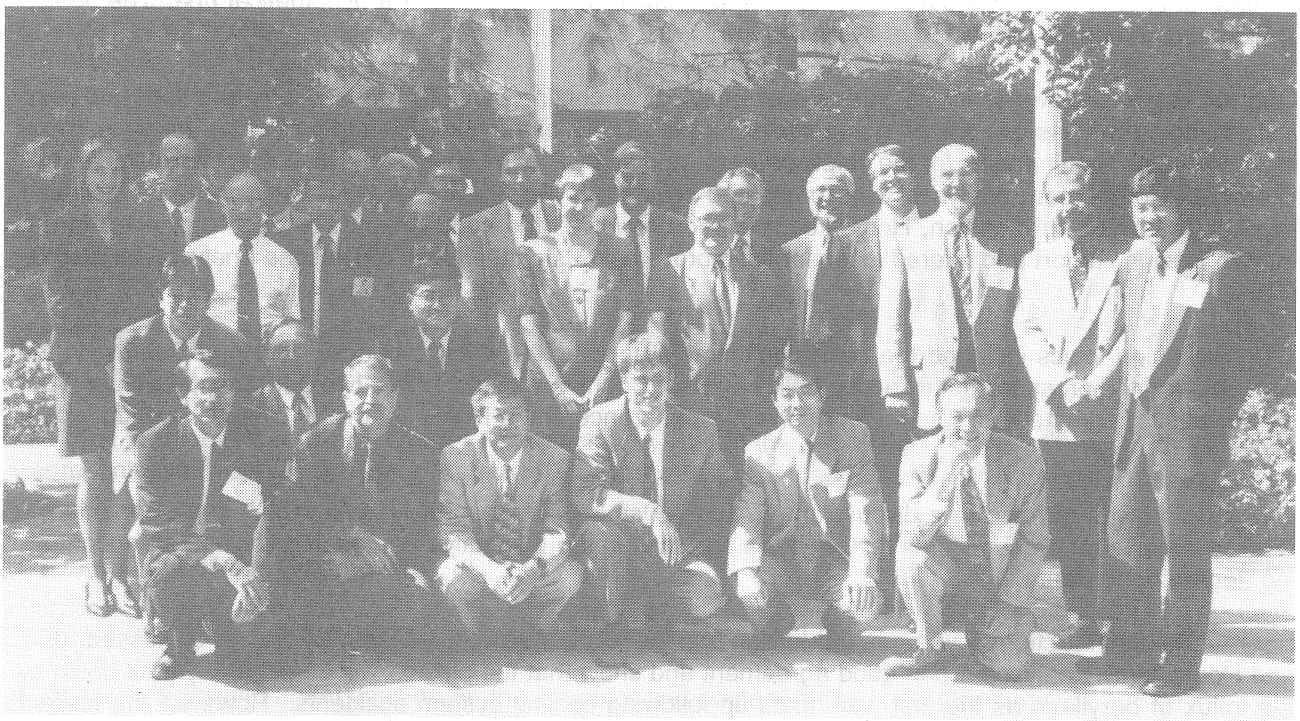
by G. Saji and C. Gordon, Safety, Environment and Health Division, ITER San Diego Joint Work Site

The Fourth Technical Meeting on Safety and Environment was held at the San Diego JWS on October 9–13, 1995. The objectives of this meeting were:

(1) to discuss safety issues at the stage of Interim Design Report (IDR) affecting the Non-Site-Specific-Safety Report (NSSR) including relevant results from current tasks;
(2) to discuss planning and execution of safety assessments for the NSSR-1, and
(3) to review safety area plans and priorities for the post-IDR to support NSSR-1.

The meeting opened with an update from the JCT on the direction the design evolution is taking following the issue of the Interim Design Report. Deputy to the Director, Y. Shimomura, reviewed the timetable for key decisions, including:

- approval of the Interim Design Reports by IC-9 in December 1995,
- approval by the Director of reference scenarios and analysis specifications for NSSR-1 in early 1996,
- informal review of the Detailed Design key points (including NSSR-1 results) in September/October 1996,
- TAC review of the Detailed Design Report (including NSSR-1) in December 1996, and
- submit Detailed Design Report to IC-11 in December 1996.



Participants in the Meeting

The NSSR-1 must include estimation of radioactive effluents and wastes and define a robust safety envelope as recommended by the ITER Technical Advisory Committee and the Special Review Group. Naka and Garching Safety Liaisons, D. Holland and J. Raeder, provided more information on current design issues at the Naka and Garching sites, including tritium inventories and permeation, heat transport system design options, in-vessel components and the vacuum vessel.

Sessions were held to discuss a range of topics:

- in-vessel dust characterization
- heat transport system events
- confinement approach & implementation
- ALARA implementation
- beryllium-steam/hydrogen/fusion power shutdown
- events to analyze and how to analyze them
- NSSR-1 planning

In-vessel dust is a key safety issue in terms of radioactive source term, beryllium hazard, and potential for hydrogen production. The session included updates from the Home Teams on estimating dust production, possible removal methods, and the unique hazard of tritiated, activated beryllium that must be handled for ITER. During the discussion, the following issues were identified as requiring more attention: methods to monitor and remove dust during the ITER lifetime, characterization of dust in terms of particle size and chemical composition, locations of dust concentration and chemical reaction with steam/water.

Sessions related to heat transport system events addressed three questions:

- Are the tools and methods in place to provide analysis for NSSR-1?
- Is the specification of events understood to permit analysis for NSSR-1?
- What else is needed; what is missing?

The size/basis of in-vessel coolant breaches impacts the design of the vacuum vessel and the vacuum vessel pressure suppression system. The possibilities ranged from small leaks to that if all of the coolant system manifold pipes were sheared. There are uncertainties in interactions between the plasma and the first wall. Thus, a small water leak from the first wall is considered as a relatively frequent possibility. Failure of a large number of coolant pipes should be considered as a low probability event or a hypothetical one. The design should accommodate this range of events.

One full day was devoted to the question of radiological confinement. Three JCT presentations provided insight into current issues: the on-going seismic trade studies of the tokamak and part of the tokamak building; the design requirements for the safety barriers; and an overview of status and issues on radiological confinement. Home Team analyses were presented covering topics such as confinement pressurization and aerosol behaviour. In addition, Home Team experts reviewed the confinement approach described in the Interim Design Report and offered ideas for its improvement using the Lines of Defense analysis adopted by ITER.

The discussion topics included the ITER confinement approach, the judgement of the Home Teams on the concept, and the prospects for its acceptability by Host Country regulators. The two-barrier approach of ITER to radioactivity confinement was supported with a preference of the Home Teams for closed secondary confinement.

One session was devoted to a discussion of ALARA ('as low as reasonably achievable') implementation at ITER. Home Team presentations reviewed the practices in the respective Parties and showed an encouraging degree of similarity.

Beryllium-steam reactions, hydrogen production and the role of fusion power shutdown were discussed. JCT and Home Team analyses are in good agreement and show that the plasma will be passively shut down by the influx of beryllium as the first wall heats up following cooling system accidents. However, the current design and possible design requirements need further assessment to confidently show that hydrogen production would be limited to acceptable values in such postulated accidents.

Safety analysis assumptions can impose restrictions on the design and operation of the machine. The session "Events to Analyze and How to Analyze Them" provided an opportunity to discuss the safety analysis rules that will be used to analyze the reference scenarios in NSSR-1. It was pointed out that the safety analysis events must be identified soon so that NSSR-1 Analysis Specifications can be agreed upon in early 1996.

In the discussions, Home Teams confirmed the need for more detailed sequence analysis and radioactivity release analysis for a limited number of reference events in NSSR-1, based on the scoping systematic analysis of plant sequence assessments. A complete spectrum of event sequences in all modes of facility operation (e.g. maintenance, bakeout) need to be studied to identify the reference events for NSSR-1. All the Home Teams consider it appropriate to plan for physics description in NSSR-1. It was recognized necessary to demonstrate that fusion power can be controlled, the plant can be brought into a safe shutdown condition, and physics uncertainties will be incorporated in the design.

One of the main objectives of the meeting was to further JCT-Home Team planning for NSSR-1. Presentations on the overall master work plan and detailed volume by volume outlines were made. The detailed planning also identified the linkage between current ITER safety tasks and the appropriate volume of NSSR-1. NSSR-1 is planned to be a comprehensive safety assessment that is expected to be used by the Parties as part of their siting and environmental impact studies.

LIST OF PARTICIPANTS

Home Team Participants:

R. Blomquist (EU, NFR/EURATOM)
G. Cambi (EU, ENEA/EURATOM)
J. Crocker (US, Crocker Consulting)
D. Davydov (RF, VNIINM)
W. Gulden (EU, NET)
T. Inabe (JA, JAERI)
F. Kasahara (JA, Toshiba Corp.)
B. Kolbasov (RF, Kurchatov)
M. Krivosheev (RF, Efremov)
G. Marbach (EU, CEA/EURATOM)
K. McCarthy (US, LITCO)
T. Natalizio (EU, CFFTP/EURATOM)
T. Oikawa (JA, JAERI)
Y. Petrov (RF, VNIPIET)
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Y. Seki (JA, JAERI)
R. Stasko (Observer, EU, CFFTP/EURATOM)
Y. Ueda (Observer, JA, Mitsubishi)

JCT Participants:

H.-W. Bartels (San Diego)
D. Dilling (San Diego)
C. Gordon (San Diego)
D. Holland (Naka)
H. Iida (Naka)
A. Kashirski (San Diego)
S. Morozov (San Diego)
S. Piet (San Diego)
A. Poucet (San Diego)
J. Raeder (Garching)
G. Saji (San Diego)
Y. Shimomura (San Diego)
M. Sironi (San Diego)
L. Topilski (San Diego)

FIRST TECHNICAL MEETING ON QUALITY ASSURANCE

by A. Girard, JCT QA Group Leader, San Diego Joint Work Site

The First Technical Meeting on Quality Assurance was held at the San Diego JWS on October 26-28, 1995. Representatives from all the Home Teams (HTs) and the JCT attended; a complete list of participants follows this summary.

1. Objectives of the Meeting

- To initiate the process of combining the views of each HT and of the JCT into a co-ordinated approach to QA for ITER;
- to reach a general understanding on the structure and content of the ITER QA Program;
- to establish the basis of the Quality Assurance to be used for the implementation of Task Agreements, with specific focus on fabrication for R&D.

2. Introduction by the Deputy to the Director

The need to focus on the 7 Large R&D Projects was emphasized, along with the need to develop a common understanding of the nature of the QA Program for ITER EDA.

3. JCT and HT Presentations

The JCT and HTs presented their approach and progress made in the documentation and implementation of a QA system. Some examples of quality assurance, along with areas where quality assurance needs to be strengthened, were given.

4. Meeting Discussion and Conclusions

The meeting participants concurred on the following:

- The product of the EDA is intended for use by all the Parties, individually or jointly, and will form the basis for decisions on further steps in fusion. The Parties (and HTs) have a vested interest in the quality of the work produced and, therefore, have the incentive to put a QA system in place. This QA system should assure that each Party (or HT) can use the results generated by the other Parties (or HTs) within their own systems.
- The primary responsibility for the implementation of QA for Task Agreements resides with the HTs.
- HTs have or are in the process of developing their QA systems.
- The efficient application of QA requires:
  - the use of existing QA systems, while minimizing the creation of new ones, and
  - the careful and complete preparation of technical specifications.
- In response to the technical specification, the HTs should prepare implementation plans.
- QA documents must contribute to the operational lines of communication and interfaces.

5. Working Session

The following documents were reviewed and modified, accordingly, during this session:

- ITER QA Program (S 88 PR1 W1.4)
- QA for Large R&D Projects (S 88 PR9 W1.7)

6. Recommendations

- Continue the implementation of QA by the HTs to the on-going tasks;
- Approve the QA documents as revised at the meeting;
- Recommend that the JCT and HTs QA Plans focus on the 7 Large R&D Projects and that they be completed by the end of 1995;
- A 2nd Technical Meeting to be held in April 1996 to:
  - review the progress made in the implementation of QA,
  - identify any weak areas which require improvement.

LIST OF PARTICIPANTS

EC:	JA:	RF:	US:
L. Baker	M. Araki	P. Chaika	T. James
	Y. Ozawa		K. Sowder

JCT Members: W. Gauster (Garching), R. Coombes (Naka), A. Girard, Y. Shimomura, R. Swift (San Diego)

THIRD WORKSHOP OF THE CONFINEMENT MODELING AND DATABASE EXPERT GROUP

by Dr. D. Boucher, ITER JCT, and Dr. J.G. Cordey, JET Joint Undertaking

The Third Workshop of the Confinement Modeling and Database Expert Group was held on October 16–19, 1995 at the Naka JAERI site in Japan. A list of participants follows at the end of the article.
The opening session was chaired by the Chairman of the Group, J.G. Cordey, who presented a list of scientific issues on which progress needed to be made; these were a clarification of the ITER ignition margin, a clear statement of the status of the 1-D model testing, and suggestions for reducing the confidence interval of the H-mode threshold. This was followed by a short presentation by the Head of the JCT Physics Team (F. Perkins), who re-emphasized the importance of the size scaling of the H-mode threshold for ITER; this issue had also been singled out by TAC as one of the most urgent issues. Other issues raised by TAC that should be addressed by the group were the isotope scaling of both the confinement and the threshold and the scaling of the H-L transition.

An account of the status and operation of the profile database was given by D. Boucher. At present, it contained some 32 pulses from eight different machines (ASDEX, DIII-D, JET, JT-60U, T10, TFTR and TEXTOR). The database was performing well and being routinely accessed by the whole 1-D modeling team. Further steady state ELMy pulses which are more relevant to the operational mode of ITER would be provided by DIII-D, JET and ASDEX-U. Comparative D and D-T pulses from TFTR would also be added so that the isotope scaling could be studied. The results of the four technical sessions are summarized in the following boxes:

1-D Modeling and Error Tests Analysis Session (Chairman J. Connor)

O. Kardaun described various statistical measures of "goodness of fit" for 1-D modeling and an approach to collapsing them onto figures of merit. D. Boucher then described a procedure and software for presenting the results of 1-D modeling using such tests, illustrating this with preliminary examples. He also enumerated a sequence of steps in developing a description of modeling for ITER from 0-D to full physics based 1-D. This was followed by seven presentations by participants in the 1-D modeling activity. M. Turner described results from the Culham model, the IFS/PPPL model and a combination of the two. A. Fukuyama described results with the Current Diffusive Ballooning Mode (CDBM) model, followed by M. Kotschenreuther with those from the IFS/PPPL model. A. Taroni discussed a set of empirical models: Bohm, gyro-Bohm and a combination (with reduced coefficients for the Bohm contribution to H-mode) and the results of testing them. R. Waltz described his fast code which he had used for testing six models; he also discussed a physics basis form Bohm-like scaling and a new compact model incorporating drift wave physics. D. Mikkelsen presented work from PPPL, namely Multi-Mode modeling of the ITER database and testing a number of other models against a TFTR L-mode in the ITER database. (The Weiland model in the multi-mode model showed sensitivity to the impurity profiles.) Finally, W. Houlberg described comparisons of seven models against the ITER database.

The 1-D modeling group then discussed the content of Section 7 of Chapter 2 of the ITER Physics Basis document, considering how to provide prescriptions for the temperature profile for ITER modeling. The role of sawteeth, edge pedestals and a confinement region were considered and ideas on how to use 1-D modeling to guide this were proposed.

In summary, the profile database is progressing well, software for comparing the fits of models against the data is being developed and a determined effort to submit models to the validation process is underway. The next step is to try to reconcile discrepancies in the modeling, remove problems in the various procedures and in the database and to ensure that the modeling continues to be carried forward in the four ITER Parties.

H-Mode Database Session (Chairman J. DeBoo)

The discussion of H-mode database work centered in two main areas: dimensionless scaling studies and discussions of the uncertainty in the confinement prediction for ITER. Preliminary, global analysis of dimensionally identical comparisons of JET and DIII-D discharges and DIII-D and C-Mod discharges indicates that B remains constant, suggesting that the concept of ρ^* scaling experiments is valid. Detailed profile analysis is required to validate this global result. ρ^* scaling studies performed in the ITER shape were reported from DIII-D, JET and JT-60U. For low q H-mode discharges with applied power well above the H-mode threshold power, ρ^* scaling studies indicated gyro-Bohm-like scaling on JET and DIII-D. For powers closer to the L-H transition power, within factor 1.5–2.0, Bohm-like scaling was observed on JT-60U and JET. The Bohm-like scaling on JT-60U was attributed to an increase in ELM frequency with toroidal field. It was pointed out that the current ITER design point – as determined by using the 0.85 ITER93H scaling – cannot be achieved by directly extrapolating the recent JET and DIII-D dimensionally similar experiments along a pure gyro-Bohm scaling path at β_N=2. This is because the H-mode power threshold scaling is worse than gyro-Bohm and this less favourable scaling is encountered before achieving the ITER design point. However, the ITER design point could be achieved along such a gyro-Bohm scaling path at larger β_N.

Detailed discussions were held on the uncertainty of the confinement time predicted for ITER. The root mean square error (RMSE) value of a given regression fit does not include uncertainties associated with systematic, Tokamak-to-Tokamak variations in the data or variations in predictions due to adopting different functional forms with similar statistical validity and thus does not reflect a true uncertainty estimate. Non-linear functional forms for fitting the H-mode data using the same number of fitting parameters as the ITER93H scaling expression were reported which gave a 40% lower prediction for ITER than ITER93H. Additional data from ELM-free JT-60U and DIII-D discharges may help constrain allowed functional forms for fitting. Also additional ELMy data from JT-60U, ASDEX-Upgrade and new JET ELMy data may improve the ELMy dataset.

H-Mode Threshold Session (Chairman F. Ryter)

During the sessions on the H-mode threshold the following topics were addressed: status of the ITER threshold database, new experimental data on power threshold results from several devices, discussion of threshold issues relevant for ITER.

The threshold database contains about 3000 observations from nine divertor tokamaks. The database is described in a paper submitted to Nuclear Fusion, now available as an IPP-Garching report and the database is now available to the public. For the analyses, a subset of data which is believed to be coherent, has been identified. The analyses, existence diagrams, linear regressions and discriminant analyses yield threshold size dependencies varying between $R^{1.5}$ and $R^{2.5}$ (R: major radius). Expressions providing better descriptions for the smaller device (COMPASS-D) have weaker size dependencies but larger RMSE. The power threshold predictions for ITER at a density of 5×10^{19} m^{-3} vary between 70 and 150 MW for the weaker and stronger R dependencies, respectively.

New data from Alcator C-Mod, ASDEX Upgrade, COMPASS-D, JET, and JT-60U were described. This data, mostly obtained in systematic scans, is now included in the database. This will extend the parameters range to higher values (up to 8T and 3×10^{20} m^{-3} and is expected to improve the conditioning of the database. Moreover, during these recent experimental campaigns, attention was paid to collecting neutral pressure and plasma edge measurements, believed to be important for transition studies.

The following ITER-relevant issues were discussed: improvement of the projections to ITER, role of the neutrals, the H-L transition. To improve the threshold power extrapolation to ITER analyses will be made with a dataset restricted to powers close to the threshold, as provided by the recent scans. The role of neutrals will be documented by including the pressures measured in main chamber and divertor when possible. The experimental study of the H-L transition will be addressed, in agreement with the operational programs of the devices, in experiments with powers just exceeding the threshold to study the effect of the density increase on H-L transitions.

New Data, L- Mode Database and Edge Modeling (Chairman T. Takizuka)

Recent results of JT-60U contributing to ITER physics were presented by S, Ishida. $H/q \approx 1$, $P_{thr} \approx n^{0.5}B$, ρ^* scaling, high triangularity, Internal Transport Barrier and reversed shear were highlighted. Higher triangularity improved the edge confinement and stability of ELM. Reversed shear enhanced the electron confinement as well as ion and particle confinement. The present status of the L-mode database by S. Kaye has been submitted and was introduced by J.G. Cordey and thermal confinement scaling was presented. Rather stronger density dependence ~ $n^{0.5}$ and power degradation ~ $\rho^{0.75}$ in τ_{th} were shown. Discussion was held on the paper of L-mode database to be submitted. J. Ongena reported the improved confinement in TEXTOR with high density and edge radiation. The enhancement factor increased up to 1.7 with density increase. It still remained about 1.5 near or slightly above the Greenwald density limit. JET Ohmic data were presented by K. Thomsen in which both the linear regime and the saturated regime were clearly seen. A. Taroni then presented a model of transport including a new edge boundary condition for the simulation of the H-mode. A mixed type model was employed, in which Bohm and gyro-Bohm diffusivities were used to describe L-modes whilst only gyro-Bohm diffusivities were used for the H-modes. A model of critical pressure gradient at the H-mode pedestal was presented by K. Itoh.

Long-term issues were considered at a special session, chaired by F. Perkins. This session consisted of four talks:

A. Fukuyama presented a set of equations that were able to replicate experimentally observed evolution of particle density profiles.

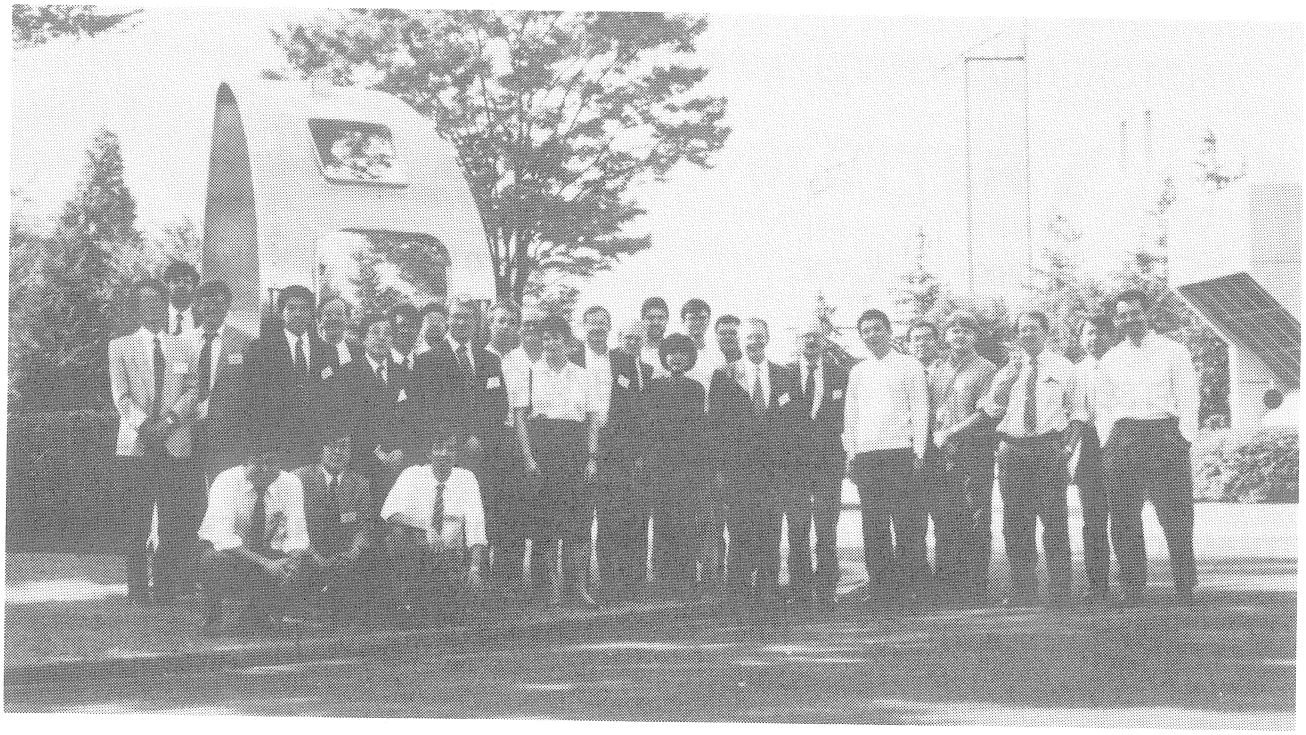
W. Houlberg summarized the discussions of the Helium Transport Conference in Charleston, SC, USA. Core transport is sufficiently rapid that the relative helium concentration in the core plasma is uniform and thus the overall concentration will be determined by pumping and recycling.

Sawtooth models were presented by J. Connor. It was agreed that ITER needs a sawtooth model and the Porcelli, Boucher, Rosenbluth model was provisionally adequate, but individual research to improve sawtooth models is both necessary and to be encouraged.

JT-60U High-Ti ELM-free data were summarized by T. Takizuka. In this data set, the H-mode multiplier decreases with increasing plasma current.

In the final session of the Workshop the group reviewed and revised the 1995 ITER Physics R&D Needs table and agreed on a list of Action Items to perform before the next meeting of the Group. The Group proposed to meet next in mid-March 1996, either in Garching or Moscow, and planned on having a joint meeting with the Confinement and Transport Expert Group in October, attached to the 16th IAEA Conference on Plasma Physics and Nuclear Fusion Research in Montreal, Canada.

The Group thanked the host organization (JAERI) and the local organizer T. Takizuka for organizing this workshop.



Participants in the Meeting

LIST OF EXPERT GROUP MEMBERS AND INVITED EXPERTS

EU:
M. Alexander, Garching
J.W. Connor, Culham
J.G. Cordey, JET
O. Kardaun, Garching
J. Ongena, Juelich
F. Ryter, Garching
A. Taroni, JET
K. Thomsen, JET
M. Turner, Culham

JA:
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A. Fukuyama,
Okayama Univ.

JA (cont'd.):
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K. Itoh, NIFS
S.-I. Itoh, Kyusyu Univ.
Y. Kamada, JAERI
Y. Miura, JAERI
M. Mori, JAERI
Y. Ogawa, Tokyo Univ.
H. Shirai, JAERI
T. Takizuka, JAERI
K. Toi, NIFS
M. Wakatani, Kyoto Univ.

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W. Dorland, IFS
W.A. Houlberg, ORNL
S. Kaye, PPPL*)
M. Kotschenreuther, IFS
D. Mikkelsen, PPPL
R.E. Waltz, GA

JCT:
D. Boucher
F. Perkins

*) was unable to attend the meeting

ITER EVENTS *)

MAC-9, St. Petersburg, RF, 3 November
TAC-9, Garching, EU, 27–29 November
ITER Physics Committee Meeting, Garching, EU, 30 November–1 December
Tritium Plant Technical Meeting combined with Fuelling & Pumping Meeting, Naka, Japan, 4–8 December
IC-9, Garching, EU, 12–13 December

*) Attendance at all ITER Meetings by invitation only.

Items to be considered for inclusion in the ITER Newsletter should be submitted to B. Kouvchinnikov, ITER Office, IAEA, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: (+43 1) 237762; phone (+43 1) 2060 26392.

Printed by the IAEA in Austria
December 1995

95-03898