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SECOND TECHNICAL MEETING ON QUALITY ASSURANCE

by A. Girard, ITER JCT

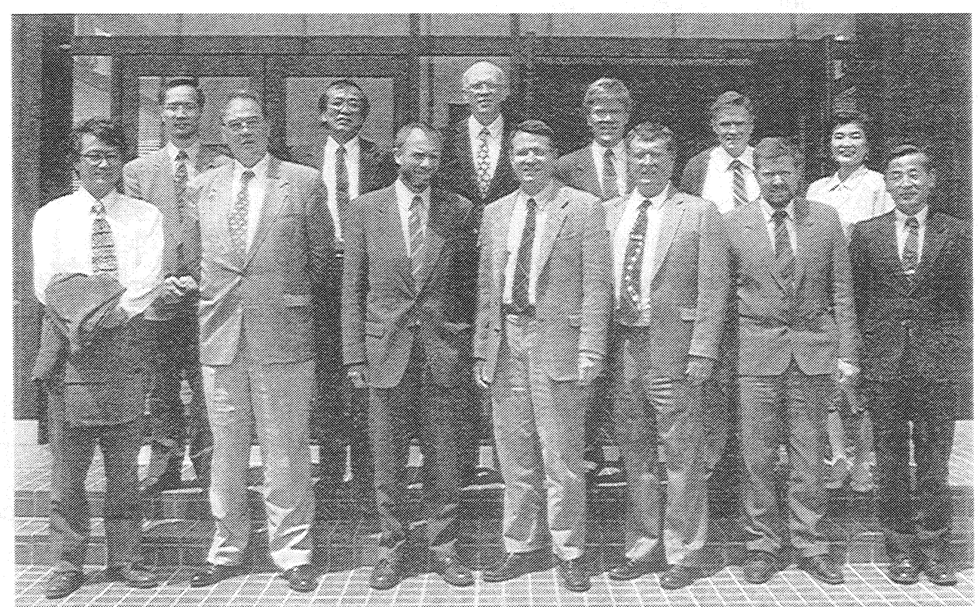
The Second Technical Meeting on Quality Assurance (QA) was held on 23 - 26 April 1996 at the ITER Naka Joint Work Site. The objectives of the meeting were to review the progress made in the implementation of QA, and to identify weak areas which require improvement. Following are a summary and the key recommendations. A list of participants is shown at the end of this article.

Meeting Outline
- Review JCT and HT QA Plans
- Review and approve key QA Guides
- Review progress in implementing QA in the Large R&D Projects
- Discuss future QA effort.

Progress in implementing QA

HT and JCT management support for QA activities has been strengthened. As a result, considerable progress has been made since the first QA technical meeting. There is now good communication on QA concerns among HTs, HT QA co-ordinators, JCT project officers and JCT QA co-ordinators. Additional resources are being made available for QA by the HTs.

In response to the requirements of the "Quality Assurance for Large R&D Projects" (S88PR9), the JCT and the four Parties developed QA Plans. These plans were presented and discussed. Development of these plans



Participants in the Meeting

represents significant progress. The JCT Plan was reviewed with only minor comments. Its draft is now ready for management approval. The US and JA plans were complete, approved by the respective Home Team Leaders, and were being applied to existing contracts. EU and RF plans were not yet finalized.

Quality Assurance Documents

The following QA Documents were reviewed:

- Guideline for Variations and non-Conformities,
- Guideline for Implementations Plans,
- Guidelines for Work Schedule

The documents, with minor revisions, were accepted and signed by the HT QA Co-ordinators and JCT QA Liaison Officers, for early implementation.

Experience in the Large R&D Projects

To assess QA application, the CS Model Coil project was discussed in detail. It is the farthest along and the most complex in terms of interfaces. Technical issues are being successfully resolved by the JCT and HT with "Co-ordination Groups" formed for the purpose of review and problem resolution. This approach should be considered in the other Large R&D Projects. As expected for such a challenging project, a number of problems were encountered and important lessons learned.

The other L-7 projects are not as far along and differ in that they have less complex interfaces among the HTs. However, discussion of these projects indicated that similar problems could occur.

The problems and potential problems could be grouped into the following categories:

Work specifications in contracts differ from JCT requirements:
- ♦ Difficulty in specifying requirements in advance for R&D projects;
- ♦ Problems in communicating technical specifications, etc. at the JCT/Home Team interface;
- ♦ HTs' attempt to contain costs results in changes.

Work processes not adequate:
- ♦ Difficulty in specifying work processes in advance;
- ♦ Lack of time to perform necessary R&D on processes.

Non-conformities developed:
- ♦ Technical problems in achieving specifications force deviations;
- ♦ Lack of agreement on deviations between performer and JCT;
- ♦ Processes and quality procedures not properly applied.

Other problems:
- ♦ Process for meeting the national standards for other parties is not adequately understood or resolved.

Recommendations

- ♦ Need to continue to improve communications between HT and JCT. All documents related to technical specifications, work processes, quality procedures, and testing and inspections should be made available to the JCT.

- ♦ Project-wide QA plans and implementation rules need to be developed and accepted by all Parties to avoid unnecessary friction. An example is a standard way to handle deviations and non-conformance.

- ♦ Agreement on technical specifications, work processes and quality procedures should be completed early to avoid problems later in production.

- ♦ Key acceptance tests and independent checks should be specified and arrangements made for witnessing selected tests by the JCT.

- HTs and the JCT should now perform assessments of the implementation of their own QA plans.

- Before preparation of long-term procurement documents for items important to nuclear safety, a substantially enhanced QA program with additional resources is needed.

- Production experience and application of QA to the Large R&D projects should be documented so lessons learned can be applied to ITER construction.

The next QA Meeting should focus on the impact of QA implementation on the Large R&D Projects and on the development of a QA framework for ITER long-term procurement items. The meeting should be held at the Garching JWS in about the 18-22 November 1996 time period.

All the participants wish to express their appreciation for the opportunity to informally discuss QA issues with management at the fine reception and also for the support provided for this meeting.

LIST OF PARTICIPANTS

EU HT: L. Baker
JA HT: M. Araki, Y. Ozawa
RF HT: P. Chaika
US HT: K. Sowder

JCT: R. Coombes, J. Dietz, A. Girard, D. Holland, M. Huguet (Deputy Director), N. Mitchell, K. Okuno, Y. Shimomura (Deputy to the Director), B. Spears, D. Thome

JA industry experts: A. Ozaki (Toshiba), S. Kajiura (Hitachi Ltd.)

SUMMARY OF ITER DIAGNOSTIC MEETINGS

by Dr. A. Costley, ITER JCT, and Dr. K. Young, PPPL

The 4th Meeting of the Diagnostic Expert Group was held in Moscow, RF, on 1 - 2 March 1996. The meeting was held jointly with a Technical Meeting on Diagnostics. The meeting followed Progress Meetings on the design of a) Visible, Infrared, Thomson Scattering and Neutral Particle Analysis Systems and b) Neutron Systems. The meetings were hosted by the Kurchatov Institute, Moscow. The principal conclusions of the meetings were:

- At the ITER Point Design Review held late January, the interfaces of Diagnostics with other systems received considerable attention. While pleased that design integration had advanced significantly, the Expert Group expressed concerns about the small number of ports presently allocated to diagnostics and the present very limited access for diagnostics on the top of the machine. They also identified an urgent need for design definition for the diagnostic neutral beam and for the related diagnostic systems.

- At the series of Progress Meetings, good progress was shown in the design of the radial neutron camera, the interferometer and the divertor impurity monitoring system. Most other tasks are likely to be completed by the end of the Task Agreement Period in May. This was the first time that design analysis of systems had been done to the level where the capability for meeting the measurement requirements was tested, and it is probable that some compromises will be necessary.

- The priorities for R&D activities need to be determined and the potential tasks specified. The Expert Group Members agreed to assist in this process. It was agreed that key topics are:

Component Developments:

Windows to meet vacuum and safety requirements,
Radiation-resistant magnetic coils,
Long-pulse integrator,
Radiation-resistant bolometers,
Plasma-facing mirrors,
Lost-alpha detectors,
Diamond detectors,
Calibration and alignment identification.

New Diagnostic Technique Developments:

Tangential polarimetric technique,
Collective scattering,
Fast-wave reflectometry,
Erosion measurement of tiles.

Assessment: Feasibility of short-pulse, high-intensity diagnostic neutral beam

- Before the Expert Group meeting comments had been requested from all the other ITER Physics Expert Groups on the diagnostic measurement requirements tables and at this meeting there was a thorough reassessment of these tables taking into account the comments received. Revised tables were prepared.

- The proposed list of diagnostics that will be available for initial plasma operation, that is the diagnostic Start-Up Set, was reviewed. The Expert Group decided not to advise any changes at this time beyond adding "halo" current monitors as a definitive requirement. A tabular set of relationships between the requirements and the Start-Up Set is to be prepared.

- It was recommended that the measurement specifications should be reviewed to ensure that they achieve the requirements for control capability.

- The Progress Meeting on Collective Scattering held at Kyushu University last December produced clear recommendations. The low frequency (60-80 GHz) and CO_2 wavelength ranges were selected as the most promising ranges. The CO_2 option needs to be taken to the same theoretical analysis level as the low frequency option before a choice between these two options can be made.

- Potential program elements from the four Parties in voluntary activity in studying the effects of neutral particle fluxes on mirrors were discussed. Progress has been made in calculating erosion levels and some effects on aluminum and copper mirrors at relevant particle fluences have been observed in Europe. It was agreed that this work would be continued as joint work for members of the Expert Group and JCT.

- A Sub-Group on Reflectometry has been established. The Group will work largely by electronic means and will advise the JCT on the many choices and options for the application of this technique to ITER and review the system designs. Similar specialist sub-groups in other areas are under consideration.

- Publication of "ITER Diagnostics". It is proposed that people involved in design of diagnostics should be encouraged to publish their work in Plasma Physics and Controlled Fusion as soon as their work merits it. A final journal issue of a special reprint volume with additional new work and overviews would be produced towards the end of the EDA.

- It was felt that communication still needs to be improved. Much better methods of communicating reports and drawings are in preparation and will be available very shortly.

- It is proposed to hold the next Expert Group Meeting in October, and the next set of Design Progress Meetings will be probably in November.

Participants in the Meeting

All the participants thought that the meetings were productive and useful. The preparation and organization of the meetings were excellent and the participants would like to thank Drs. Strelkov and Orlinsky for their careful arrangements and the Kurchatov Institute for its hospitality.

LIST OF PARTICIPANTS IN THE EXPERT GROUP MEETING

EU: P. Stott

JA: S. Kasai
O. Mitarai
K. Muraoka
A. Nagashima
T. Nishitani
H. Ogawa

US: R. Snider
K. Young (Chair)

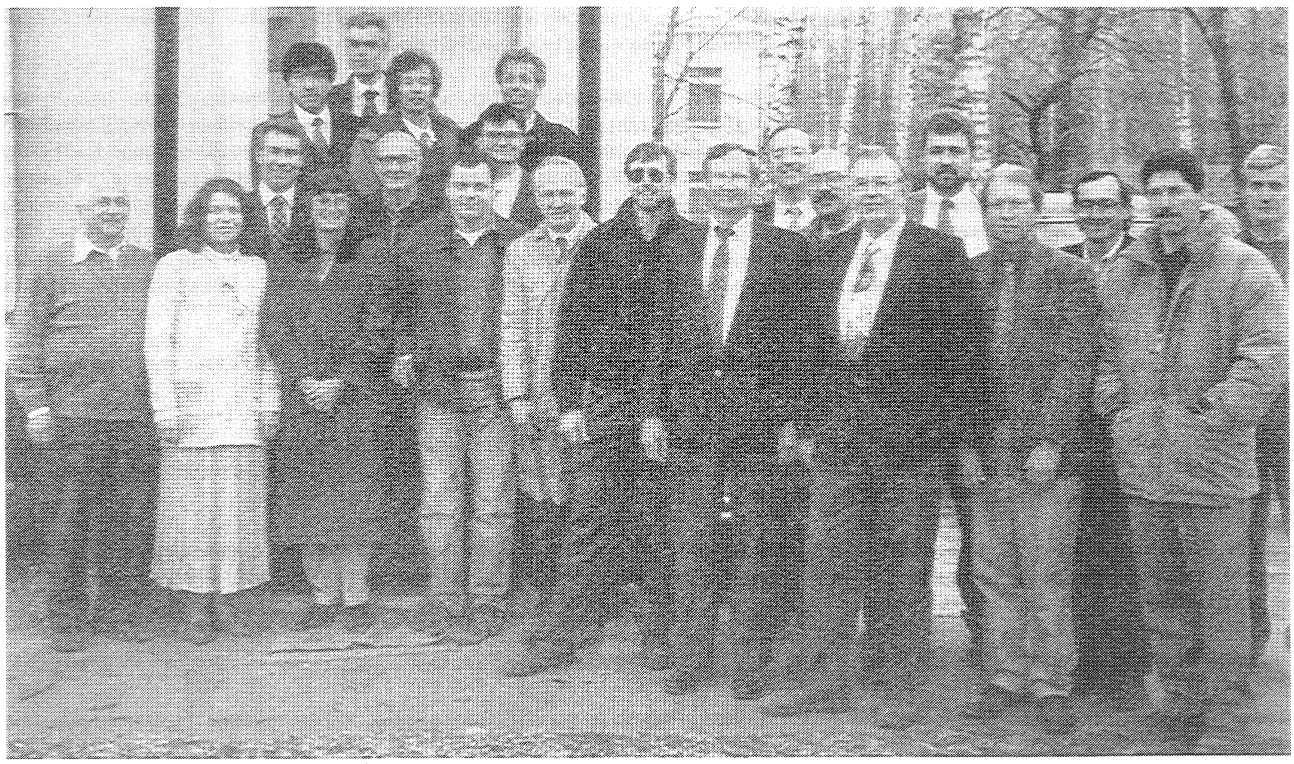
RF: A. Kislyakov
S. Lebedev
D. Orlinsky
K. Razumova
V. Strelkov

JCT: A. Costley (Co-Chair)
L. Johnson
L. deKock
V. Mukhovatov
T. Sugie (JA attached to JCT)
C. Walker
S. Yamamoto

FOURTH WORKSHOP OF THE CONFINEMENT MODELLING AND DATABASE EXPERT GROUP

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

Academician B. Kadomtsev greeted the participants in the Fourth Workshop of the Confinement Modelling and Database Expert Group, which was held at the Kurchatov Institute in Moscow, RF. J. Cordey, Chair of the Expert Group, outlined the objectives of the Workshop, namely to make substantial progress in the two urgent tasks: H-mode confinement scaling and H-mode power threshold, by the end of 1996, and in the high priority task, testing of transport models, by the end of 1997. In addition, the Group prepared action lists for the next six months in all areas covered by the Expert Group. The agenda items were discussed in sessions designated thereto. A brief summary of these discussions is given overleaf.



Participants in the Workshop

Profile Database session

D. Boucher, caretaker of the ITER profile database, presented the latest status of the database. The database is progressing well with new discharges from TFTR, DIII-D and JT-60U and two new discharges submitted by ASDEX-U. As agreed during the previous workshop, new measures were implemented to improve communication between data providers and modellers using the data. These proved quite useful to record and solve the difficulties modellers encountered in the use of the data. The profile database now contains shots from JET, TFTR, JT-60U, DIII-D, ASDEX-U, TEXTOR and T-10. However, information for some of these discharges is still incomplete and these need to be attended to. Modellers also expressed the need to add rotation, momentum sources and fast ion pressure profiles as new signals to the database. These new signals are to be added to the profile database manual and supplied in future by data providers.

Global Confinement Databases session

Essentially, all of the action items from the last Expert Meeting for the L- and H-database work were completed by the time of the Moscow meeting. Work on the L-mode database is progressing nicely with a paper to be submitted to Nuclear Fusion in its draft stages, and the database release is imminent. New data that were submitted to the H-mode database were discussed. COMPASS-D, with a shape similar to that of ITER, submitted 14 ELMy discharges, which have confinement times close to the values given by 0.85* ITERH93-P. 35 ITER-like ELMy discharges from ASDEX-U were submitted; these also agreed well with 0.85* ITERH93-P. Future contributions from ASDEX-U will include better estimates for the fast ion stored energy, ρ^*-scan data from ITER demonstration discharges, and H^0-> H^+ data. Alcator C-Mod data which were submitted had confinement times that are systematically higher than those given by the H-mode scaling expressions. These discharges were boronized, underscoring the importance of taking wall conditions into account in some explicit fashion in improved confinement modes. New data from DIII-D were added to see if the curvature in the non-linear fits could be reduced; however, the new non-linear fit was essentially the same as before. Finally, a presentation on measures of goodness of fits was made. A statistical technique presented by O. Kardaun resulted in a 95% confidence interval of the predicted 6s ITER design point confinement time of between 3.5s and 9s. It was also shown that the ITER92H scaling expression appears to be a better fit to the ELMy data than 0.85* ITERH93-P, in that the latter gives a spurious dependence of ratio of measured to fit stored energy on q_{cyl}.

H-Mode Power Threshold session

The session on the H-mode power threshold was opened by F. Ryter, who presented the status of the threshold database work. The action list for the past 6 months was almost completed. In particular, the JT-60U data were given to the database. The first contribution from TCV (Lausanne) was sent to the database recently, which now includes 10 divertor tokamaks. The threshold expressions at present favoured are: 1) $P_{thres} = 0.3\ \bar{n}_e B_T\ R^{2.5}$, which gives the dimensionally correct fit, under the assumption that $\bar{n}_e B_T$ is the correct dependence; 2) the free linear regression $P_{thres} = 0.3\bar{n}_e^{0.77}\ B_T^{0.71} R^{1.0} \alpha^{0.98} K^{-0.05}$. Expression 1) yields 140 MW and 2) 65 MW for ITER at $\bar{n}_e = 5 \times 10^{19}\ m^{-3}$. A comparison of the power threshold with and without boronization in Alcator C-Mod was presented by J. Snipes. The effect of boronization on power threshold results in only a small reduction of the power necessary to reach the H-mode. This data which is well-documented with radiation power and neutral gas values was given to the database. The new DIII-D contribution to the database was presented by D. Schissel. It includes the recent scans made in this device and includes radiation and neutral gas data. Experiments with intense gas puffing after which the H-mode occurs at powers lower than in the H-mode threshold in JFT-2M, were analyzed by Y. Miura. These results are interpreted with a model based on ion losses in the divertor region. It is, however, not clear whether such a mechanism could be used in a larger device to decrease the threshold power.

R. Ryter reported on the H-L studies in ASDEX-U. The H-L transitions caused by a reduction of the heating power show a clear hysteresis, whereas H-L transitions obtained by increasing density with gas puffing occurred at the same power level as the L-H transition so that the hysteresis disappears, possibly due to the high neutral density. More experiments on this essential question for ITER are foreseen in several devices. J. Cordey presented the new JET contribution to the threshold database. This data set includes the recent ITER-dedicated threshold experiments. Attention was paid to radiation, neutral gas and edge measurement. Several H-L transitions were also included. The threshold contribution from TCV prepared by Y. Martin and the TCV group was presented by F. Ryter. This, the first contribution from this device, includes 35 discharges reaching the H-mode under ohmic heating, due to either shaping or density increase. The experiments were completed in an ITER-like configuration. The threshold power of these discharges lies somewhat above the usual scalings.

Finally, J. Connor mentioned that new significant threshold results will only be available from COMPASS-D when the tokamak can be operated at $B_T \geq 1.9T$.

Common threshold experiments between Alcator C-Mod, ASDEX-U, DIII-D, JET, JT-60U were proposed by J. Snipes, to fill the lack of data between the high field density points of Alcator C-Mod and the other contributors. This proposal was discussed and the decision was made to perform some experiments along this line.

Finally, F.W. Perkins showed that inclusion of finite beta physics is required to recover expression 1) for the threshold power. Depending on the assumed physics phenomenon determining the L-H transition, different scalings can be derived which could be tested experimentally.

Model Testing Session

The session was opened by J. Connor who reviewed the Action Plan from the previous workshop, concluding that it had been essentially completed.

Presentations were made of a series of updates on the development and testing against the profile database of a number of transport models, with some simulations of projected ITER fusion performance. These models included a number of semi-empirical ones, with contributions from the Kurchatov Institute, JET, Culham Laboratory and JCT while theory based ones were provided from Japan and the U.S. groups at General Atomics, PPPL, the Institute of Fusion Studies and ORNL. An important aspect of the work reported was the willingness of different modellers to use and test each others' models and to evaluate their performance against agreed criteria. While some problems regarding the implementation of the models in different transport codes remain, exemplified by occasional discrepancies between the results of various modellers, most models are achieving 10-30% accuracy in reproducing the data. D. Boucher reported progress with the provision of software on the Database Server for analysis of the results against the agreed criteria and presented some preliminary findings. Agreement was reached on how the results should be used to compare models.

Issues that arose included the potential for gyro-Bohm models to apparently show Bohm scaling due to different density profiles associated with neutral particle sources and the sensitivity of some models to the assumed edge boundary conditions. When the models were used to predict ITER performance a wide variation was found.

During a working session the 1-D modelling group decided how to organize its work in order to be able tc present a paper at the next IAEA Conference in Montreal and to determine a course of action for modelling activity in the near future. In particular, plans to understand and eradicate discrepancies between modellers and to ensure that each model was tested by more than one modeller were made and a common set of physics guidelines for ITER projections were identified. When these steps are in place it is planned to make predictions for ITER including sensitivity studies using these well defined reference criteria.

Session covering other issues and topics of interest

At the beginning of the session, high-density H-modes in DIII-D (DeBoo), ASDEX-U (Ryter), JFT-2M (Miura) and JT-60U (Takizuka) were reported.

Preliminary experiments in DIII-D showed a degraded confinement, but still achieving an H factor ~1.4, for a density of 1.5* nGr (nGr is the Greenwald density limit). One explanation for the degradation of the H-mode confinement involves the 2/1 and 3/2 tearing modes. In order to clarify such hypotheses, high density H-mode experiments ($n > nGr$) are planned in the near future.

H-modes at a density beyond the Greenwald limit were also obtained by simultaneous gas puffing and pellet injection (30 Hz, 1.2 km/s) in ASDEX-U. Density feedback control proved to work well. At $n = nGr$ after the pellet injections, the H-factor was about 1.5, while during pellet injections it dropped to about 1.2

In JFT-2M, the range of H-mode density in the H-mode database is $0.2 < n/nGr < 0.8$ with an average of $n/nGr = 0.5$. At the high density $n/nGr > 0.6$, pellet-injected H-modes showed good confinement ($H > 2$). On the contrary, high-density H-modes with intense gas puff had poor confinement.

The degradation of the H-factor with increasing electron density was seen in JT-60U. The H-factor, which was about 2 to 2.5 at $ne/nGr < 0.5$, decreased to nearly unity at $ne/nGr = 0.8$ to 1. Simultaneous neon and D_2 injection slightly improves the confinement factor at $ne/nGr \sim 1$ from $H = 1$ to $H = 1.2$.

High-density plasmas, not of the H-mode, but of the high-confinement L-mode, were found in TEXTOR. J. Ongena showed that these stationary plasmas with strong edge radiation were obtained by the feedback control of neon puffing. The confinement time increased with density in the range of $0.5 < ne/nGr < 1.2$; the confinement time τ_E normalized to the ITERH93-P scaling reaches 1.2. The density profile was rather peaked with no evidence of impurity accumulation.

The confinement characteristics of Supershots in TFTR were reported by S. Kaye. Peakedness of density and beam deposition profiles is important for good confinement. Li pellet injection reduced the particle recycling drastically and led to an improvement in confinement.

Results from sawtooth modelling were reported by Dr. Boucher, S. Kaye and J. Connor, respectively. Various trigger models for the sawtooth instability were shown. Detailed validation of these models against experimental data (sawtooth period, etc.) will be the subject of future work.

During the second part of this session various contributions were presented. Dimensional considerations for heat transport models in turbulent magnetized plasmas were presented by Y. Gott.

The status of JT-60U experiments and future plans were reported by T. Takizuka. High triangularity was effective in increasing the edge pressure gradient without giant ELMs. The ρ^* scaling experiment showed that ELMy confinement was like Weak-Gyro-Bohm or Gyro-Bohm, unlike the previous Bohm-type confinement in the low triangularity configuration. Good confinement in reversed shear plasma was shown, in which high density did not degrade the confinement.

S. Neudatchin presented the L-H-L transitions in JET and JT-60U. Rapid, non local change of the transport coefficients over a wide plasma region appeared to be an important feature of the transport in improved confinement modes.

A. Kukushkin presented his work on Electron Cyclotron Radiation transport and proposed a non-local transport model, which is described by spatial-integral equations.

In the **Final Session**, the Group agreed on a List of Action Items to be completed before the next meeting. It also proposed that the item 4.5 in the ITER Physics R&D Needs table on the creation of a hot ion database should be made a long-term task.

The Group recommended to meet next in Montreal on 14-16 October 1996, immediately after the IAEA Conference. This workshop would then be followed by a meeting next year in Garching, Germany, with a tentative date of March 1997. The group also asked the Chair and Deputy to ensure that in future meetings more time be devoted to data analysis, and they agreed to this request.

The group finally thanked the host organization, Kurchatov Institute, and the local organizer, M. Ossipenko, for ensuring the success of this workshop.

LIST OF PARTICIPANTS

EU:

J. Cordey	JET
M. Alexander	EURATOM-IPP
J. Connor	EURATOM-Culham
O. Kardaun	EURATOM-IPP
J. Ongena	EURATOM-TEXTOR
F. Ryter	EURATOM-IPP
A. Taroni	JET
M. Turner	EURATOM-Culham

JA:

Y. Miura	JAERI
T. Takizuka	JAERI

RF:

A. Chudnovskii	KIAE
Yu. Dnestrovskii	KIAE

RF (cont'd.):

A. Kukushkin	KIAE
S. Lysenko	KIAE
S. Neudatchin	KIAE
M. Ossipenko	KIAE
A. Polevoi	KIAE
Y. Gott	KIAE

US:

J. DeBoo	GA
W. Houlberg	ORNL
D. Schissel	GA
J. Snipes	MIT
R. Waltz	GA
S. Kaye	PPPL

JCT: D. Boucher, F. Perkins

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 206026392).

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