INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR

ITER EDA NEWSLETTER

VOL.3, NO. 11 NOVEMBER 1994

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, AUSTRIA

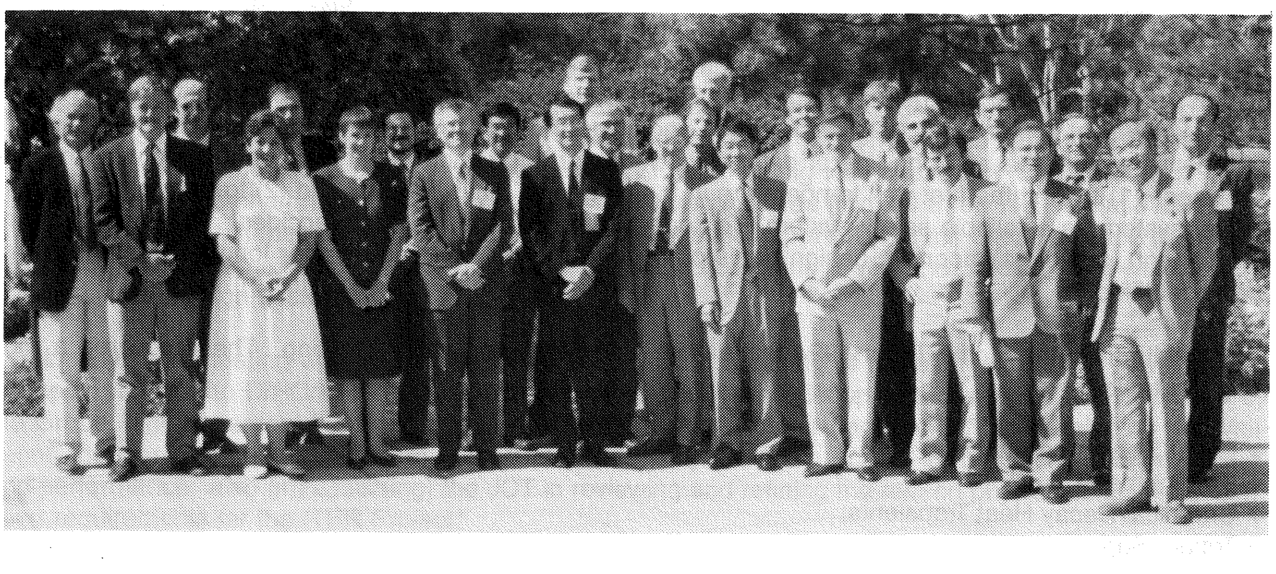
THIRD TECHNICAL MEETING ON SAFETY AND ENVIRONMENT

by Dr. G. Saji, Head, Nuclear Integration Division, San Diego Joint Work Site

The 3rd Technical Meeting on Safety and Environment was held at the San Diego JWS on October 10-14, 1994. The objectives of this meeting were to:

- harvest key results from Home Team safety tasks, especially for "comprehensive safety analyses";
- build consensus for key safety issues to prepare for the Design Assessment Meeting (October 17-28); and
- plan for task agreements for 1995 and beyond.

The meeting was opened by Dr. V. Chuyanov and Dr. R.C. Iotti, who explained the latest ITER developments and the project views on safety. Both stressed the importance of safety in ITER, noting that ITER will set the safety bases for future reactors and the commercialization of fusion technology. ITER must be siteable in any of the four Parties countries and must demonstrate the safety and environmental potential of fusion power. They noted that the safety division has an internal pseudo-regulatory role and an independent safety reviewer role, and must be the developer of safety and environmental design requirements. Safety must work with design integration and divisions responsible for individual systems/components to develop safety and environmental design requirements specific to the system and component. Design groups are then responsible for executing a design which meets these requirements and the safety case must be documented in the ITER Safety Analysis Report.



Participants in the Meeting

It was confirmed that General Safety and Environmental Design Criteria (GSEDC) should be the top level document on the ITER approach to safety. It should start from the objectives set out by the ITER Council and then state the fundamental safety objectives for ITER, fusion safety characteristics, the safety approach (e.g., defense-in-depth, ALARA [as low as reasonably achievable]), and its implementation (i.e., lines of defense, accident categories, safety functions, safety classes, dose targets, etc.). GSEDC should be concise and not overly complicated, with clear and unambiguous terminology.

The next level of detail should be covered by documents which are 'intermediate' in the sense that they expand on the requirements for the designers. Examples include criteria for confinement and decay heat removal. This work should eventually lead to formulating safety design requirements at component/systems level from the designers' point of view which interpret the GSEDC and the intermediate documents. These system level safety design requirements should be developed further in an evolutionary way by both the safety group and the designers.

The JCT informed the meeting participants on the status of the Early Safety and Environmental Characterization Study (ESECS). The original scope of the ESECS was to provide a site independent safety and environmental assessment of the ITER EDA design, including: an outline of the safety and environmental principles and safety implementation strategy used in the project; a characterization of hazards (inventories of radioactive and toxic materials and energy sources); an assessment of effluents, doses to the public and doses to workers from normal operation of the installation; a comprehensive safety analysis assessing the frequency range and consequences of a wide range of postulated accident scenarios; and an assessment of the waste generated over the life-cycle, including the waste from decommissioning the installation. The Home Teams believe that ESECS is needed for June 1995 and should contain the best information available by that time in accordance with the original objectives.

JCT also presented the confinement strategy as it was outlined in the TAC-4 report and suggested modifications to that strategy that will be presented at the design assessment meeting. The proposed confinement strategy would have two 'strong' boundaries surrounding the large radioactive inventories in the tokamak. The first boundary is the vacuum vessel with a pressure suppression tank to keep pressures between 0.2 and 0.5 MPa during design basis accidents. The second boundary are the heat transport system vaults, ducts surrounding heat transport system piping, and the cryostat. The third boundary are the building (including the pit) and the stack. It was recognized that the ITER confinement boundaries will be complex because of the geometry of the tokamak, and it may be difficult to demonstrate the independence and strength of the cryostat as the second boundary, given the large number of common penetrations with the first boundary.

An ITER decay heat removal strategy was also presented by the JCT to the Home Teams which emphasized the importance of the decay heat removal as one of the fundamental safety functions. To cope with the ITER safety objective "to show the safety and environmental safety potentials of fusion", a look is also taken beyond design basis scenarios. The general approach of taking little credit from uncertain plasma physics and experimental in-vessel components (such as first wall and divertor) leads to the requirement that the vacuum vessel cooling system be a strong line of defense. Two important design recommendations evolved from the analyses: (1) to limit the first wall temperature in the long term (days, weeks) and (2) to design the vacuum vessel system as a reliable safety system. To cope with beyond design basis accidents (no cooling of any component), the most important design goals of limiting the first wall and divertor long-term temperatures were identified.

The results from the Home Team 1994 tasks were also presented at the meeting. These covered a wide range of topics:

- Event Sequence Analysis;
- Confinement;
- Chemical/Decay Heat Transients;
- Tritium Safety;
- Activation Product Source Term;
- Occupational Exposure and Waste Management; and
- Structural and Seismic Safety.

In summary, agreement was reached on:

- the future direction of FSEDC as a high-level document with more detailed plant and system level requirements to be developed by JCT designers and safety experts in intermediate level documents;
- ESECS is needed for June 1995 and should be based on the best information available to that time to meet the original objectives;
- the general confinement and decay heat removal strategies presented by the JCT; and
- safety assessments should not credit in-vessel components as a safety barrier due to plasma uncertainty.

The meeting participants acknowledged and supported the project's safety management approach, in particular, the integration of safety and designers, the need for a positive safety culture, and the management's recognition of the need for consistent design information.

There were no major disagreements between the JCT safety group and the Home Teams, but areas where more work is needed were identified. The JCT has seen an improvement in Home Team task results, in particular, their applicability to ITER. The proposed revised Safety Importance Classification was viewed by the Home Teams as a good step forward, although it needs some improvement to obtain consensus.

Finally, concerns were expressed about:

- second confinement barrier independence;
- the need for one more strong, independent line of defense for decay heat removal; and
- the need for Be-steam data, in particular, for irradiated Be, and the need for more sophisticated analysis.

Overall, it was agreed that the results and discussions at this meeting represented real progress.

LIST OF PARTICIPANTS

EC: S. Ciattaglia, W. Gulden, G. Marbach, F. Mazille, A. Natalizio, J. Raeder
JA: T. Inabe, F. Kasahara, Y. Seki
RF: B.N. Kolbasov, V.M. Korzhavin, M.V. Krivosheev
US: L. Cadwallader, J. Crocker, G. Longhurst, K. McCarthy, B. Merrill, G. Nardella, D. Petti, N. Uckan
JCT: H.-W. Bartels, V. Chuyanov, C. Gordon, D. Holland, A. Kashirski, S. Morozov, S. Piet, A. Poucet, G. Saji, L. Topilski

ITER EXPERT GROUP MEETING ON DISRUPTIONS, PLASMA CONTROL AND MHD

by Dr. S. Mirnov, Chair, TRINITI (Troitsk Institute) and Dr. S. Wesley, Co-Chair, ITER San Diego JWS

The first meeting of the ITER Expert Group on Disruptions, Plasma Control and MHD Stability (D/PC/MHD) was held on September 29 and 30, 1994 in Seville, Spain. The meeting was well attended by the Group membership and other interested Joint Central Team (JCT) members; all of the objectives set for the first meeting were completed during two day-long working sessions. The meeting was chaired by Sergei Mirnov; John Wesley acted as co-chairman on behalf of the JCT. Representatives from all three ITER Joint Work Sites (JWSs) participated in the meeting: this participation reflects the importance of the Group's scope to physics integration (San Diego JWS), in-vessel component design (Garching JWS) and poloidal field magnet and plasma control design (Naka JWS).

The focus of the meeting was on organizational matters and updating of the elements of the Physics R&D Workplan relevant to D/PC/MHD. A statement of objectives for the Group was discussed and approved by the Group. The statement highlights the Expert Group's role in "Assist(ing) the JCT in developing and validating the disruption, plasma control and MHD stability physics-related basis for predicting ITER capability and performance; also (in) assist(ing) the JCT in reviewing and refining the related physics design and operation requirements for the ITER Project."

The Group also established the dates and format for the next meeting, which will be a Workshop focused on disruption and vertical displacement event characterization and physics specifications, to be held at the Garching JWS. The five day meeting has been tentatively scheduled for February 13-17, 1995.

Specialists from the four ITER Parties (delegations of two to four people from each Party) are expected to participate in the meeting.

Discussion and revision of the Physics R&D Workplan consumed a majority of the two-day meeting. A revised Workplan was prepared and subsequently approved by the Group after final editing. Elements in the Workplan largely follow the original draft, but with a more logical organization and more explicit specification of near-term experiment and theoretical tasks. A condensed version of the revised Workplan is presented in Tables 1 and 2. A new priority level X(= extra-urgent) was also added; this priority level reflects the need indicated to the Group by Ron Parker (Deputy Director for the Garching JWS) for near-term input - in time for preparation of the Interim Design Report - on design requirements for plasma-facing in-vessel components. The scheduling and topic of the February Workshop will address this need.

TABLE 1. SUMMARY OF PHYSICS R&D WORKPLAN FOR DISRUPTIONS

R&D Area or Task	Description	Key Issues or Impact on ITER Design
1.0	Disruptions and Vertical Displacement Events (VDEs)	
1.1	Disruption characterization	Interim data for in-vessel components by early 1995 (X-priority). Follow-up data for model validdation (Task 1.5) and to support construction decision (1996, H-priority)
1.1.1	Probability and severity	Frequency and severity spectrum
1.1.2	Thermal quench and scrape-off layer	Time-scale and distribution of in-vessel energy loading
1.1.3	Current quench rates in impurity-influx-dominated plasmas	Effect of impurity influx from thermal quench on I_p quench. Radiation transport effects in high-opacity regime
1.1.4	Runaway production and deposition	Runaway e^- current and energy; where will electrons strike material walls?
1.2	Characterization of halo current from VDEs	Halo current scaling with plasma size, thermal and magnetic energy and vertical instability growth rate; toroidal and poloidal peaking; arcing and other surface interaction effects
1.3	Pre-emptive disruption	Use of impurity injection to initiate 'controlled' disruption with benign thermal and current quench rate
1.4	Disruption avoidance	Precursor identification and detection; use of other signals and/or "artificial intelligence"; role of plasma rotation and error field amplitude; feedback control; intervention with localized heating or current drive
1.5	Integrated disruption model	Integrated effects model to predict characteristics of ITER disruptions after onset of the thermal quench at W_{th}~1 GJ

TABLE 2. SUMMARY OF PHYSICS R&D WORKPLAN FOR PLASMA CONTROL AND MHD

R&D Area or Task	Description	Key Issues or Impact on ITER Design
6.0	MHD stability and plasma equilibrium/shape control	
6.1	Beta-limit demonstration discharges	β-limit for ITER-like plasma configurations (SN, κ_{95} ~1.5, δ_{95} ~ 0.25, quasi-equilibrated profiles)? Is the β-limit hard (disruptive) or soft (decreased confinement)?
6.2	Effect of q(0)<1 on β-limit	β-limit vs. q(0), q=1 radius, q_{95}, pressure profiles; MHD activity and disruptive characteristics. Relate data to ideal and resistive MHD
6.3	Effect of shape on β-limit	To support ITER design justification
6.4	Theoretical prediction of β-limit	Validated predictive β-limit model; application in predicting onset of disruptions
6.5	Error-field locked mode and plasma rotation effects	Does ITER need error field compensation and/or NBI (or another rotation drive)?
6.6	Wall stabilization by plasma rotation	Will wall stabilization obtained with rotating plasmas improve the β-limit?
6.7	Shape control disturbances	Disturbances in l_i and β_p, effects of ELMS and/or giant sawteeth, equilibrium effects of non-zero current density at the separatrix
6.8	Effect of halo currents on large-amplitude vertical control	Vertical control characteristics for large-amplitude excursions with plasma-wall contact and halo-current interaction; prospects for recovery from large-amplitude disturbances (e.g., mild VDEs)

The status and results of the on-going ITER MHD stability modeling benchmarking activity were presented by John Hogan. The benchmarking effort has been carried out on a voluntary basis by MHD modeling specialists in the ITER Parties during the past six months and has resulted in an initial assessment of the MHD stability properties of candidate ITER plasma cases with pressure and current profiles derived from transport code simulations supplied by the JCT. Comparisons of results among various codes show good agreement in stability estimates for ITER cases with $q(0) \geq 1$ and L-mode profiles; these cases all have MHD stability at normalized betas well above the values needed for 1.5 GW ITER operation. Stability estimates for simulated H-mode profiles (with edge confinement barriers) show similar optimism about 1.5 GW operation, albeit with more sensitivity to details of the edge profiles and evaluation of the stability properties out to the plasma edge. Here there is some difference among various models depending on the edge stability treatment. Further study will be needed to resolve these differences.

Evaluation of stability for both the L- and H-mode cases with *ad hoc* profile modifications to produce $q(0) \leq 1$ shows deterioration of MHD stability (Troyon factor) as q(0) falls below unity. However, conclusions are clearly dependent on both modeling basis and assumptions about the internal q-profile. Group members identified this sensitivity as an important ITER MHD issue; better experimental data for both low- and high-beta plasmas (especially, q-profile measurements) and careful validation of ideal and resistive stability models for the q(0)<1 regime are needed. These needs are incorporated in the revised Workplan.

Nikolai Ivanov presented results of a preliminary analysis of recent T-10 experiments on locked mode suppression with electron cyclotron radiofrequency heating (ECRH). In some cases, suppression of the locked-mode-related disruption with application of electron cyclotron heating at the plasma center was observed. Moderate quantities of EC power ($\leq$ 800 kW) were effective in the suppression of mode-locking and the onset of locked-mode-related disruptions. The method could be applied to ITER after verification on ITER-like experiments.

John Wesley also noted that comprehensive presentations on vertical displacement events in ASDEX-U and disruption characteristics and mitigation in JT-60U and JET were, respectively, made by Otto Gruber and Ryuji Yoshino during the IAEA Conference. In Wesley's opinion, these and many other MHD stability and disruption-related papers presented at the IAEA's 15th International Conference on Plasma Physics and Controlled Nuclear Fusion Research reflected an increased recognition of the importance of disruptions and MHD stability limits for ITER and tokamak reactor design.

Group members also made informal presentations on the status of D/PC/MHD work in the national programs and/or Home Teams. The presentations showed that elements of the original Workplan were generally well-covered, both among the Parties and within the various tokamaks or theoretical groups in a given Party. Each Party has significant on-going efforts in the areas of D/PC/MHD.

After reviewing the status presentations, the consensus of the Group was that coverage of D/PC/MHD issues among the on-going experimental and theoretical programs of the ITER Parties was generally adequate, but that there is still need for (1) more dedicated machine time and staffing for experimental disruption studies (including 'disruption demonstration discharges' with comprehensive diagnostics data and high-resolution profile measurements during the disruption); and (2) explicit statement of higher priority for development of the 'integrated disruption model' that will be required to predict ITER disruption characteristics in the impurity-influx-dominated regime. At the same time, the Group confirmed the importance of early discussion and input to in-vessel component physics design requirements, with the planned Workshop/Technical Meeting being the best means to do this in a timely manner.

A third meeting of the Expert Group was proposed to be held in September 1995 that would focus on ITER MHD stability and beta-limits with $q(0)<1$ (including supporting experimental data). The Group agreed that this timing would be appropriate for new experimental and theoretical work to be done. Review of progress towards this goal and final scheduling of the third meeting will take place in a meeting of the Group members to be held during the February Workshop.

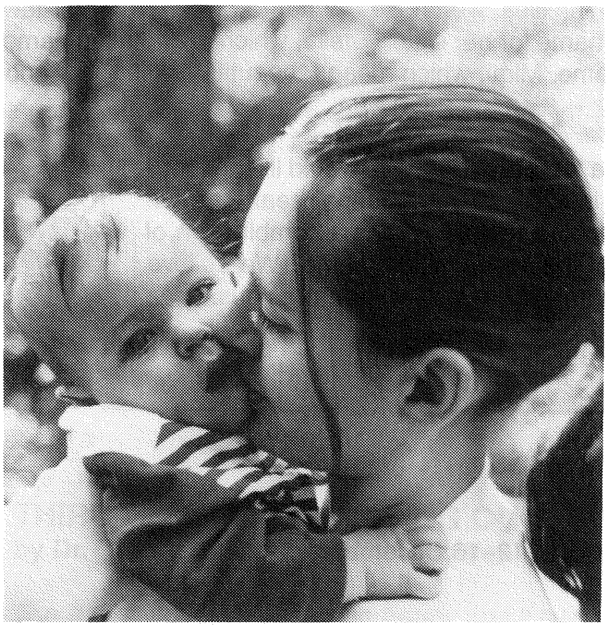
LIST OF PARTICIPANTS

EC:	JA:	RF:	US:
O. Gruber	K. Yamazaki	N. Ivanov	S. Jardin
T. Hender	R. Yoshino	S. Mirnov (Chairman)	T. Taylor
F. Hofmann			N. Sauthoff
F. Engelmann (ex-officio)			

JCT: N. Fujisawa, K. Ioki, P.-L. Mondino, S. Ortolani, R. Parker, F. Perkins, J. Wesley (Co-Chairman)

TO BE PARENTS OF NEWBORN BABIES IN NAKA
by C. Boschi, A. Portone, E. Rigoni, I. Benfatto

To be parents of newborn babies in Japan is sometimes very nice and sometimes very hard. It is nice because in Japan, wherever you are, for example in the supermarket, walking in town, or travelling by train, you will see many Japanese to stop what they are doing and to look at your baby saying: "Kawaii desu ne" (beautiful and pretty baby). They come near you to see your baby better and to know his/her age, name, etc. Moreover, kidnapping and child violence do not exist in Japan and this is very reassuring for us. On the opposite, for foreigners to deal with medical care can sometimes be a hard job in Naka, where English speaking doctors are not as largely available as in Tokyo. We have to say thank you to the ITER local staff that gave (and is giving) us good support in solving this kind of problem. Up to the childbirth the personal experiences for the two newborn babies have been quite different and, for this reason, they are separately described in the following.



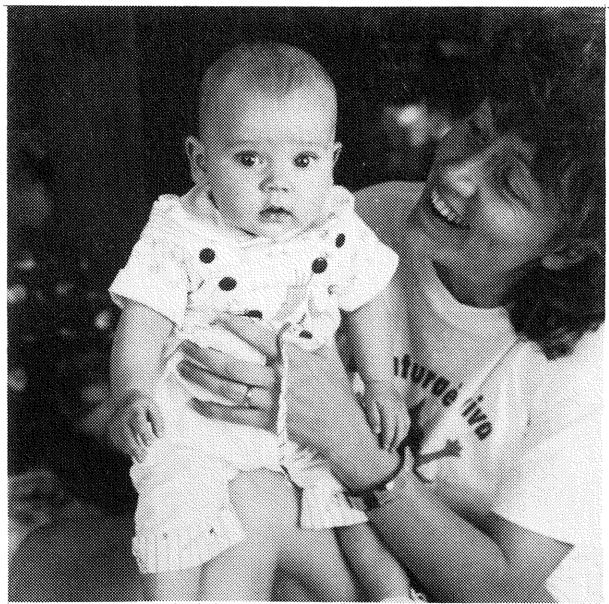
Claudia Boschi and Alfredo Portone, parents of Riccardo

Riccardo was born in Bologna on April 21, 1994, as his parents were about 30 years before. After he had moved to Japan last August, he soon became Riccardo-chan and he is now a formally registered "alien" citizen of our little Naka town.

Living in Japan with a newborn baby is a beautiful experience, and we wish to thank all people that were (and still are) helping us in different ways. Our little community of ITER gaijin (foreigners) and friendly Japanese neighbours is more and more becoming a large family, and we do feel at home when being here. Moreover, Japan is a fascinating country and very safe to live in. We believe that Riccardo-chan will enjoy these first years of his life here, and we all will miss Japan when we will leave.

Of course, there are drawbacks and the major one, we feel, is the large distance separating us from our families in Italy. In particular, Riccardo's grandfathers and grandmother miss him so much that they never called us so often before.

We feel very lucky to have the opportunity to join the ITER project, come to Japan and have such a beautiful baby boy. As a matter of fact, Riccardo is encouraging us to continue in the successful experiment of being "parents in Japan" and we hope to make our ITER family even larger.



Enrica Rigoni and Ivone Benfatto, parents of Stella Mirai

To join the ITER team in Japan and to give birth to our second daughter were two choices which came simultaneously into our life, and in the end they were a single, not easy, decision.

Being both curious and optimistic, we were exited by the possibility of spending several years in Japan, discovering this country so far from Europe.

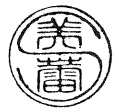
Moreover, we were encouraged by Sheila Kitzinger, who is a worldwide expert on pregnancy and childbirth. We asked her about childbirth in Japan and we still remember her answer: "Japan is a society where children are precious, and I am sure you will have a happy experience." She also gave us the name of a Japanese childbirth teacher who helped us to find the maternity clinic.

We arrived in Naka one year ago. The pregnancy had already started, and our first action was to look for English speaking doctors. This was not an easy job, and a few times we were afraid, for example on discovering that to call an ambulance or the emergency hospital it is necessary to speak Japanese. However, from the beginning our neighbours were very kind and when they knew about the pregnancy, some who speak English told us: "If you need help, do not hesitate to call us any time, even at night."

As for the place of birth, there are several options for a pregnant woman in Japan. We chose a small clinic run by Mrs. Fusako Sei. She is a midwife with much experience, and at her clinic it was possible to choose an under-water delivery in a cozy environment.

Stella was born on 12 June 1994. As in many Japanese families, we chose the name of our daughter few days after her birth. Our first daughter suggested the first name for her sister, Stella, which is an Italian name meaning "star". Mrs. Sei suggested a Japanese middle name, Mirai, which means "beautiful flower bud" and it is the name of Mrs. Sei's clinic.

From our neighbourhood and friends Stella Mirai received a lot of presents. We would like to mention the one she received from the Naka ITER staff. It is a Japanese personal seal that, we believe, is unique in Japan (and in the rest of the world, too) because it has a combination of the Western character "S" and the two Kanji characters of the Mi-rai middle name. We believe that for our daughter it will be a precious thing from a country where children are precious.



FORTHCOMING EVENTS *)

- MAC-7, Tokyo, Japan, 30 Nov.–1 Dec.
- TAC-7, Naka, Japan, 5–7 Dec.
- Technical Meeting on Irradiation Testing, Garching, Germany, 12–16 December
- IC-7, Naka, Japan, 14–15 Dec.

*) 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 23606392).

Printed by the IAEA in Austria
January 1995

95-00171