INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR

ITER EDA NEWSLETTER

VOL. 6, NO. 12 DECEMBER 1997

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, AUSTRIA

ISSN 1024-5642

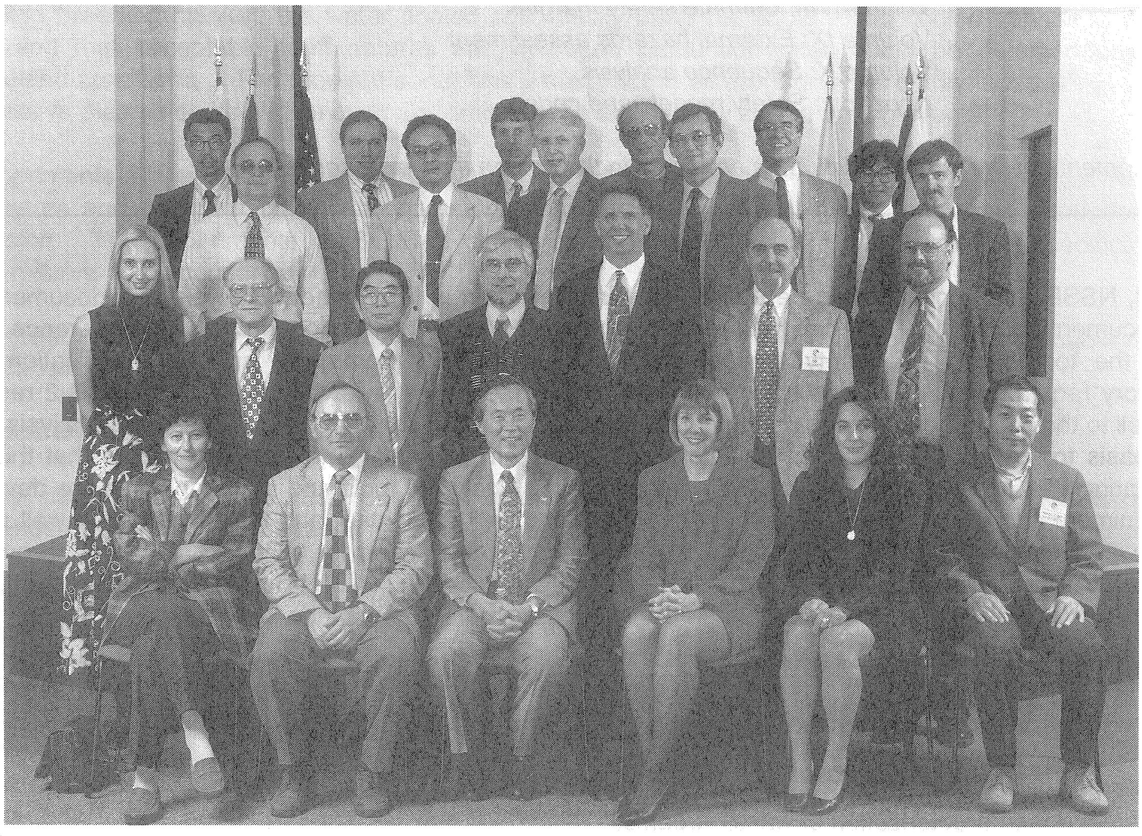
SIXTH ITER TECHNICAL MEETING ON SAFETY AND ENVIRONMENT

by Dr. G. Saji and Dr. D. Baker, ITER Joint Central Team, San Diego Joint Work Site

The ITER Project includes a vigorous design and assessment activity to ensure the safety and environmental attractiveness of ITER. It also ensures that ITER can be sited in any of the sponsoring Parties with a minimum of site-specific redesign. In this activity, detailed safety-related design requirements have been established based on internationally recognized safety criteria and limits, most notably IAEA Safety Criteria. A comprehensive safety and environmental assessment has recently been completed in the Non-Site Specific Safety Report-2 (see boxes).

The Sixth Technical Meeting on Safety and Environment was held to review the first draft of NSSR-2 during October 27-November 4, 1997 at the ITER San Diego Joint Work Site. The first draft, distributed to the Home Team safety experts at the beginning of October, is a 1300-page document containing the results of an environmental and safety assessment of the ITER design as of July 1997. The main objectives of the meeting were:

- To hear the Home Teams' safety specialists' informal review of the results of the draft Non-Site Specific Safety Report (NSSR-2) and of the draft ITER Final Design Report Safety Assessment (FDR-Safety);



Participants in the Meeting

- To ensure that the drafts are technically sound and meet the objectives and needs of Home Teams prior to completing the formal draft in mid December 1997 for Technical Advisory Committee (TAC) review;

- To follow progress and present results from longer term R&D supporting NSSR-2;

- To start planning for possible Post July 1998 activities by obtaining input from HTs on regulatory needs for NSSR (the (EDA) "final") and the Site Specific Safety Report (SSSR).

The NSSR-2 is a living document and will continue to evolve until the end of the ITER EDA. It is not part of the FDR Baseline Report of the Final Design Report (FDR) or the Comprehensive Report document set.

The final report, the NSSR, will be completed by further supplementing the NSSR-2. It will be delivered to the Home Teams, by the end of EDA, in July 1998.

Non Site Specific Safety Report-2 (NSSR-2)

The NSSR-2 is an integrated, plant-level safety assessment of the ITER design. It provides site-independent input for an environmental impact assessment and for safety characterization. The main purpose of NSSR-2 is to provide sufficient information to potential host countries so that they can write regulatory submissions for site selection and even beyond. NSSR-2 is approximately 1200 pages in total and is organized as an integrated document in ten volumes plus an appendix, as follows:

Volume I: Safety approach and functions
Volume II: Safety design
Volume III: Radiological and energy source terms
Volume IV: Effluents and emissions
Volume V: Waste management and decommissioning
Volume VI: Occupational safety
Volume VII: Analysis of reference events
Volume VIII: Ultimate safety margins
Volume IX: External hazards assessment
Volume X: Sequence analysis
Appendix: Safety models and codes

The contents of the separate volumes are given in the box on the next page.

Overall, NSSR-2 is considered to be a significant improvement in ITER safety analysis and documentation. The document shows that ITER can be designed, operated, and decommissioned safely: the reference design meets the top level ITER safety requirements and should, with some site specific modification, meet regulatory requirements of any potential host country. Home Team reviews indicate that NSSR-2 responds very well to the Home Teams needs and provides a good basis for further safety research and analysis, and a good basis to start discussion with regulatory authorities. In particular, the reviews indicate that the ITER safety principles and requirements are well presented, the analytical tools and methodologies are developed to a minimum acceptable level, the analysis is logical and well presented, and the document is well written. The reviews also indicated that continued design refinement is needed for occupational safety through the implementation of an iterative As Low As Reasonably Achievable (ALARA) process during the design, maintenance and administrative procedures. Considerable progress was made in the following areas:

- Presentation of safety principles and requirements;
- Quantification of inventories;
- Clearer presentation of methodology and results of effluent analyses;
- Characterization of waste streams;
- Clearance concept with IAEA values as a good common denominator;

- Implementation of ALARA principle in assuring occupational safety;
- Focus on essentials of ultimate safety margin analysis;
- Characterization of the reference computer codes;
- Development of the Radiation Protection Program;
- Combination of top down and bottom up approach in event selection;
- More detailed seismic analysis.

Nevertheless, there remain some considerable challenges. In particular, there remains the difficulty in demonstrating consistency between the safety analysis and the evolving design. The design and safety analysis tasks are parallel and iterative efforts that may be somewhat out of phase at any particular time, with progress in one causing changes in the other. Some aspects of the design are not yet completed so implementation of safety requirements cannot yet be demonstrated. For example, the breeding blanket design for the Extended Performance Phase (EPP) is still fluid while breeding blanket materials and configuration directly impact the safety analysis. In the area of occupational safety, application of the ALARA principle will identify areas for design improvements to reduce occupational exposures during operation, maintenance and decommissioning.

Many comments, dealing with minor restructuring and suggestions for clarification, will be fixed in the final update of NSSR-2 to be released before the end of 1997. More far-reaching comments were made addressing outstanding issues that need further work. These will be considered during the remainder of the EDA. Significant upgrades will be implemented via addenda.

Status and Recent R&D Results supporting NSSR-2

Research and development efforts throughout the international fusion community have strengthened the ITER safety analysis presented in NSSR-2. Many of the R&D efforts are continuing and will further improve the ITER design and safety analysis over the coming months. Recent R&D results were discussed and are presented below.

- Assessments involving three different breeding blanket and test module designs (the EPP reference design breeding blanket, the water cooled solid design, and the liquid metal cooled vanadium design), showed that acceptable temperatures and hydrogen production rates could be obtained under the modeled conditions . The required conditions varied for the different designs but included items such as an active plasma shutdown function and limits on the Li inventory spilled during events.

- Experiments at the SIRENS, MAGRAS, MKT and PLAST facilities demonstrated the effects of materials, pressure and particle flux on the characteristics and deposition of tokamak dust from disruptions and erosion. The experiments at SIRENS confirmed the NSSR-2 dust size distribution specification of 0.5 microns to be conservative.

- Progress in design and performance of dust removal systems showed the potential applicability of the electrostatic dust removal technique to ITER .

- Research in chemical reactivity revealed several interesting results:

  - For Be-steam reactions at temperatures below about 450°C, a protective oxide layer is formed. This results in the maximum reaction rate near the start of the steam exposure and a decrease to small or negligible hydrogen generation after the oxide layer is formed. At temperatures above 600°C, the hydrogen generation behavior remains linear in time.
  - Experiments indicate that irradiated Be cooled from 700°C to 150°C undergoes more severe degradation with increasing fluence after 100 thermal cycles. Further experiments are needed to better characterize this phenomenon in the relevant ITER regime.
  - LiPb-water interaction experiments (termed LIFUS) are planned at a facility at ENEA Brasimone.

- New measurement tools, the "Whole Energy Absorption Spectrometer" and a "Calorimetric Apparatus", have been developed and applied for thirty-two materials to benchmark decay heat calculations. Experiments showed that results calculated with FENDL/A-2.0 agree with the associated decay data libraries within +/- 10 % for stainless steel and copper. Uncertainties were much larger for tungsten (see Newsletter Vol.6, No 10, October 1997).

Contents of the separate volumes of NSSR-2

Volume I presents the general safety design approach, safety during normal operation, defense in depth, safety functions, lines of defense, the graded approach for implementation, and safety management. The logical deployment of chapters starting with hazard identification is improved from the NSSR-1 version.

Volume II provides a comprehensive and condensed description of the current ITER design from a safety point of view. In this volume, together with Volume X, ITER General Safety and Environmental Design Criteria, the structures, systems and components important to safety are evaluated. Refinements are made to distinguish safety requirements and requirements for good design practice.

Volume III characterizes radioactive source terms, chemically hazardous materials, and hazardous energy sources. This version incorporates the technical basis of the most recent source term data obtained by recent R&D supporting NSSR-2.

Volume IV addresses effluents such as tritium, activation products, direct radiation, and non-nuclear radiation during normal operation and maintenance. Efforts were made for completeness with respect to hazardous materials, systems and activities (including waste handling and change over to the Extended Performance Phase - EPP).

Volume V addresses radioactive waste, non-radioactive hazardous waste streams, and waste management at the ITER site. Results of an in-depth feasibility study on decommissioning are included in this version. The results of numerical analyses of waste stream dynamics versus level of contact dose and versus several sets of exemption criteria ('clearance level' analysis per 'de minimis' principle) are also added.

Volume VI shows that ITER shall be designed to protect site personnel and exposures shall be maintained As Low As Reasonably Achievable (ALARA). This version includes a comprehensive qualitative occupational safety assessment for ITER based on a series of health physicists review and occupational safety assessment meetings on site.

Volume VII addresses the results of analyses of accidents that are representative and encompass the entire spectrum of plausible accidents. The safety analyses presented in this volume form the focal point of the Safety Analysis Report. The effects of anticipated process disturbances, postulated component failures, and human errors (postulated initiating events- PIEs) are described, including their consequences, to evaluate the capability of the ITER design to control or accommodate such situations and failures. The events cover loss of plasma control events and coolant leakage accidents as well as large tritium leakage accidents from the tritium plant outside the tokamak basic machine.

Volume VIII discusses the ultimate safety margins for hypothetical situations or events that are beyond the PIEs discussed in the preceding volume. The objectives of this volume are not only connected with the future regulatory process but also with the need to show the safety and environmental potential of fusion and compliance with the no-evacuation goal. In this version, the results are organized by safety function to help show completeness.

Volume IX discusses site hazards for the reference site and the plant protection against these hazards. The seismic safety approach and assessment, and protection against airplane crashes, tornadoes, and extreme cold temperatures are included. This version includes the results of a detailed three dimensional seismic response spectrum analysis of a full tokamak configuration, as well as load combination issues in connection with earthquake and vertical displacement episodes.

Volume X summarizes the initiating event and accident sequence identification process, and provides a catalog of all identified initiators and the most important accident sequences. This is presented by a master logic diagram, together with event trees and tables of postulated initiating events. For each initiating event, an assessment is provided that shows the link with the accident analysis in Volume VII justifying the selection of the set of reference events.

The Appendix summarizes information about the computer codes used in the ITER accident analysis and on the key models developed for each code used in NSSR-2 Volumes VII and VIII. This information is expected to be necessary for future regulatory processes.

- To date, six Ingress of Coolant (ICE) experiments and eight Loss of Vacuum (LOVA) experiments were performed and used as benchmark tests for code validation. Comparison of code calculations and ICE experimental results showed that there is a significant effect of the impinging jet heat transfer on the vessel pressurization. Further work is planned.

- The calculational models and results of several engineering safety studies were reviewed, including: seismic analysis, radiolysis, and safety of the tritium plant. The seismic analysis reported in NSSR-2 shows that the natural frequencies of the building at soil elasticity are very close to the tokamak natural frequencies. The radiolysis study showed several interesting results including the indication that radiolysis decreases as temperature increases. The discussion of the tritium plant safety focused on the systems analyzed and the peak pressures during deflagration.

- The PACTITER code, used to calculate corrosion product behavior in the Primary Heat Transport System (PHTS) loops, has been verified under PWR conditions based on thirty years of experience from French nuclear reactors. There is on-going work to evaluate PACTITER predictions under more ITER-relevant conditions (e.g., lower temperature and the ITER water chemistry environment). Studies and data that may prove useful in benchmarking the application of PACTITER to ITER conditions were discussed.

Conclusions

It is recognized that component and system R&D projects that contain safety-related investigations have yet to be completed. However, NSSR-2 has shown that the basic design could meet specific regulatory requirements of any of the potential host countries. It is further concluded that the facility could be constructed and operated with a high level of protection of the health and safety of the occupational work force and the general public, and with minimal environmental impact.

NSSR-2 demonstrates that, with appropriate design and operation, there is no significant safety issue with respect to public safety. It also indicates that continued design refinement is needed for occupational safety by positive application of the ALARA principle. The process is now developed and extensive activities are in progress.

NSSR-2 has shown that a minimum level of analysis tools and methodologies has now been developed, although further verification and validation of computer codes are still needed to demonstrate that they adequately simulate postulated accidental situations. Further work will be needed in running codes to compare with existing experimental results and to the results of new experiments that will be needed beyond the EDA.

NSSR-2 has demonstrated that there are areas where safety assessment can be successfully conducted by an international collaboration. However, it was also recognized that there remain some site specific issues, such as wastes and decommissioning, which may be better done by the potential host countries in line with their regulatory practice.

The meeting ended with all participants agreeing that NSSR-2, its production, and its review during the 6th Technical Meeting on Safety and Environment were great successes and together were an excellent demonstration of international cooperation.

List of Participants

EU: W. Gulden (EU Task Area Leader [TAL], NET), G. Marbach (EURATOM-CEA), R. Matsugu (CFFTP), K. Moshonas (CFFTP), M.-T. Porfiri (EURATOM-ENEA)
JA: T. Inabe (JA TAL,JAERI), M. Hashimoto (JAERI), T. Maruo (JAERI), T. Tsunematsu (JAERI)
RF: B. N. Kolbasov (RF TAL, Kurchatov), M. Krivosheev (Efremov), Y. Petrov (VNIPIET)
US: D. A. Petti (US TAL, INEL), J. Crocker (Crocker Consulting), K. A. McCarthy (INEL)

JCT: R. Aymar, ITER Director (via telecon); Y. Shimomura, Deputy to the Director; V. Chuyanov, Deputy Director; D.J. Baker, H.W. Bartels, Y. Hoshi, A. V. Kashirski, H. Matsumoto, S. I. Morozov, S. Sadakov, G. Saji, V. Tanchuk, N.P. Taylor, L. N. Topilski (all San Diego JWS); C. W. Gordon, Safety Liaison (Naka JWS); H. Iida, Safety Liaison (Garching JWS)

JAERI'S ANNUAL PUBLIC SEMINAR ON FUSION RESEARCH AND DEVELOPMENT

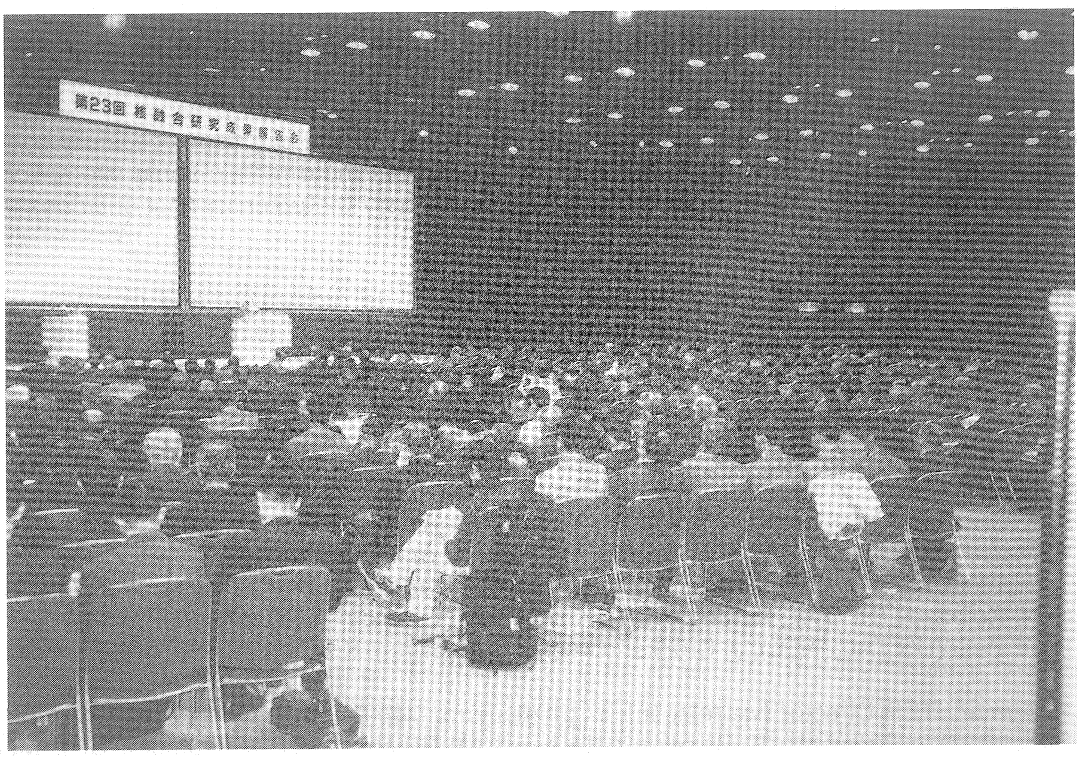
by Dr. M. Azumi, Head of the Department of Fusion Plasma Research, Naka, JAERI

The Japan Atomic Energy Research Institute (JAERI) held the 23rd Annual Public Seminar on Fusion Research and Development on December 3, 1997 at the Tokyo International Forum. This is a seminar at which the progress of nuclear fusion research at JAERI is presented. It is open to the public. Nearly 700 people from various sectors participated in the seminar. Among the attendees were 6 Diet members and a number of secretaries of Diet members, many high level officers of the government as well as of several local governments, about 500 participants from the nuclear industries including prominent members of the Keidanren (the largest and most powerful organization of major industries), and people from the press. It should be emphasized that among the participants were not only people from organizations or foundations related to the atomic industries and energy development. Also many young university students of other faculties and people not at all connected with science, such as an instructor of Ikebana (traditional flower arrangement ceremony in Japan), were interested in the energy problem and energy science and enjoyed the seminar. Members of the ITER JCT, including Dr.M.Huguet, Head of the ITER Naka Joint Work Site, were also there.

The President of JAERI, Dr. M. Yoshikawa, made a greeting remark, in which he mentioned that controlled thermonuclear fusion, having an inherent capability of utilizing the literally limitless source of energy, will also promote development of new technologies applicable to other areas. The introductory talk was given by Dr. H. Kishimoto, a member of JAERI's Executive Board and the Director-General of the Naka Fusion Research Establishment. He presented an overview of the progress of nuclear fusion research made by JAERI during the last year.

Six topics were presented at the seminar addressing the following areas: the recent progress of the ITER program, materials development for a fusion reactor, and experimental research on JT-60. Professor Sergio Barabaschi, Chairman of the Fusion Program Evaluation Board of the EU, was invited to give a special lecture on the European Union Fusion Program.

Dr. S. Matsuda, the ITER Home Team Leader of Japan, reported on the present status of the ITER EDA activities. In addition to reporting on the basic Tokamak machine design, he also presented the results from a couple of design studies, such as the Tokamak assembly in the cryostat scenario and the seismic design concept. The progress of the Central Solenoid Model Coil Project was shown as an example of the progress made in the past year.



Participants in the Seminar

Dr. E. Tada reported on the advanced technology for producing parts of the reactor structure and for remote handling supporting the ITER design. The latest development and achievements of the fabrication of the 1/20 torus section of the vacuum vessel as well as those of the blanket remote handling system have been introduced as eminent results of the major part (Seven Large Projects) of the ITER R&D Program.

Recent progress and future prospects of the advanced materials studies for fusion reactor applications were reported by Dr.H. Nakajima. The development of low activation materials to be used as the first wall and blanket structures for the DEMO reactor is a long-term endeavor and a critical issue on the path to the fusion energy development. The effort to explore the structural materials at JAERI is currently focused on two candidate materials: reduced activation ferritic-martensitic steel and SiC composites.

Dr.T. Hirayama reported that a world record of ion temperature and of fusion triple product has been achieved in JT-60U in 1997. Also, the quasi-steady-state operation of H-mode plasmas was successfully extended to about nine seconds under the closed divertor configuration. The non-inductive current was 70 to 80% of the total current. Furthermore, efficient helium removal was demonstrated in the quasi-steady-state phase using a pumped divertor. The ratio of effective particle confinement time of helium to the energy confinement time was about four, which satisfies the ITER requirement being less than ten.These new results contribute to the development of a steady-state operation scenaio for fusion reactors.

Professor S. Barabaschi reported that the European Union is recognizing fusion as an area of common European interest and made itself an attractive partner for an international collaboration on the design work of the first experimental reactor, ITER. The European fusion program involves, in an integrated effort, around 2,000 professional staff from basic and applied research centres as well as from industrial companies. The EFET (an industrial consortium formed in Europe in 1990) is supporting the objectives of the European fusion program and considers ITER as the necessary next step towards a power reactor. The ITER EDA Agreement is also a path-finder for future world-scale research initiatives, and this should not be overlooked in the future political design of the initiative, he added.

Contributing to the purpose of the seminar and to the review talks were exhibitions at 41 booths in the foyer. These exhibitions impressed the participants with the most recent achievements in the ITER R&D, in particular, with models such as the 'mice' robot which walks inside tubes to weld and cut them. One of the other highlights was the demonstration of the remote experiment. The JT-60 control room at Naka and the remote handling laboratory at Tokai, both located little more than 100 km from Tokyo, were connected to the terminal in the seminar room via computer network. Very unusual, but seemingly successful, was an experiment when Ms. J. Nagaya, not a scientist, presented the fusion basics with plain words as an instructor. The participants were enjoying this presentation.

At one of the Seminar's Exhibition Booths

Dr. H. Kishimoto concluded the seminar thanking the participants for their continuous support of fusion research, and emphasizing that JAERI would do its best to continue its enhanced efforts towards fusion energy.

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, or e-mail: c.basaldella@iaea.org (phone +43 1 206026392).

Printed by the IAEA in Austria
February 1998

98-00380