INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR

ITER NEWSLETTER

Vol.4, No.3 June-July-August 1991

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, AUSTRIA

INSIDE

* Third ITER EDA Negotiating Meeting
* Report on QEN-2 Working Group Activities in Brussels
* Workshop on ITER Driver Blanket Mock-up and Breeder Material Testing
* ITER Workshop on Physics and Design Options

THIRD ITER EDA NEGOTIATING MEETING

Prepared from the Press Guideline from the QEN-3 Meeting

The Third Quadripartite Engineering Design Activities (EDA) Negotiations (QEN) Meeting for the International Thermonuclear Experimental Reactor (ITER) was held on July 8 and 9 in Reston, VA, just outside Washington, D.C. The USDOE was the host.

The four delegations attending the meeting were headed by Dr. James F. Decker, Acting Director, Office of Energy Research, Department of Energy, for the U.S.; Professor Paolo Fasella, Director-General for Science, Research and Development for the European Community (EC); Mr. Hiroto Ishida, Director-General, the Atomic Energy Bureau of the Science and Technology Agency of Japan; and Dr. Boris V. Nikipelov, First Deputy Minister, Ministry of Atomic Power and Industry for the USSR. The deputy delegation heads were N. Anne Davies, Charles Maisonnier, Masaji Yoshikawa, and Nikolai Cheverev, respectivley.

High-level negotiators meet on July 8 and 9 in the USA.

After brief statements from each of the Parties and a presentation and discussion of the Working Group's report on co-center feasibility, the negotiators accepted the comprehensive draft texts for an Agreement establishing the EDA for six years and for a first Protocol covering activities for the first period, expected to be no more than twenty months in duration. The negotiators accepted the text for submission to their authorities for formal approvals by each of the Parties.

Text of the Agreement establishing EDA accepted for submission to Parties for their approval

The draft text states that the EDA will be carried out under the auspices of the International Atomic Energy Agency. The draft text provides that the bulk of the work, i.e., the R&D tasks, will be carried out in the home institutions of the Parties. The design will be carried out by the home teams and by a Joint Central Team located in internationally-staffed co-centers in Garching in the EC, Naka in Japan and San Diego in the U.S. Moscow, USSR, will be the formal seat for ITER Council meetings.

Three internationally staffed EDA co-centers identified

The negotiators identified key positions for the project, which will be apportioned equitably among the Parties. The four delegations intend to hold a last negotiating meeting in Moscow, USSR, on October 2 and 3.

Last negotiating meeting to be held in Moscow, USSR October 2 and 3

In order to continue with preparations for the anticipated start of the EDA, the negotiators asked the Working Group to address a number of matters including suggestions for drafts of specific arrangements with the IAEA, for drafts of secondment agreements, and for drafts of various other procedural arrangements.

REPORT ON QEN-2 WORKING GROUP ACTIVITIES IN BRUSSELS

by M. Roberts, Chair, QEN-2 Working Group

One of the outcomes of the second meeting of the Quadripartite EDA Negotiators (QEN-2) was to ask a working group to address the matter of multiple co-centers for the EDA Joint Central Team

The charter developed by the QEN-2 for the working group is shown in the box.

Charter for Working Group on Multisite Approach to the EDA

EXPLORATION OF A MULTISITE APPROACH TO THE ITER EDA

1. At the 18-19 April negotiation meeting on ITER EDA, it was recognized that the working assumption contained in the final report on ITER CDA of siting the quadripartite Central Team (about 180 professionals) at one center was, for the time being, leading to substantial difficulties: 3 Parties had offered to host the Central Team in sites which have been compared in terms of quantifiable characteristics, none of these Parties wished at the present stage to withdraw its offer.
   It was then agreed to explore whether the new idea of hosting the Central Team in co-centers was technically viable, even if at the expense of some increased complexity in design management and integration.

2. To this effect, a Working Group is set up by the QEN with the charter to:

   a) assess the technical and managerial possibility of dividing between co-centers having a quadripartite staff the responsibilityies and design work foreseen, in the ITER CDA report, for the ITER EDA central team, while maintaining a reasonable balance in the technical relevance of tasks given to each co-center, and ensuring that the Director is in full control of the design integration and of the coherence between design criteria, design specifications and technical objectives;
   b) elaborate at least one example each of tasks and responsibilities sharing among 2 and 3 co-centers, which might include some evolution in time during the period of ITER EDA, keeping in mind that the 4 Parties might wish to agree at some later stage on an enlarged cooperation in fusion;
      More specifically, elements to be analyzed in the example encompass at least the following:
      - o minimization of interfaces within Central Team and between Central Team elements and Home Teams;
      - o evolution of tasks, personnel skills, and team sizes;
      - o relative weighing of R&D and design tasks;
      - o financial and human resource requirements;
      - o incorporation of all ITER elements required for success of project, e.g., coordination of R&D, diagnostics development, testing program;
      - o consideration of broader context of future, ITER-related program elements;
      - o differences with regard to single center mode, e.g., risk, cost, feasibility, recruitment, management;
   c) estimate the relative advantage and drawbacks including the relative overall cost, in money and staff, of co-centers options as compared to a mono-center option.

   The Working Group will be composed of 3 to 4 members per Party who have experience in designing, building or managing large devices. The members will be nominated by the QEN delegations by the end of April. The Working Group will be chaired by Dr. Roberts and formulate its findings in a written report to the QEN at least a week before QEN 3.

3. It is understood that the activities of the Working Group are of an exploratory nature. QEN delegations will check with their authorities whether they will be entitled to consider, during the EDA negotiations, the option of co-centers if:
   - o this option would be recognized technically viable;
   - o the difficulties concerning the mono-center option would remain.

This QEN-2 Working Group was composed of twenty senior participants and observers (see Table below) with a range of experience in project and program management as well as previous Working Group or Working Party activities. This Working Group held a three and one-half day working session in Brussels, hosted by the Commission of the European Communities.

The members of the Working Group agreed at the outset that from the technical point of view the best organization of the Central Team would be as a single team located as a single site. Their efforts in this workshop were devoted to an assessment of a multiple-site co-center organization and a comparison with a single site Central Team.

Three co-center model developed by the Working Group

Co-center models were defined by a general mission statement and associated systems responsibilities. After some exploration of various technically sensible divisions, the Working Group settled on a three co-center model described in the following overall terms. Site A, Project Integration; Site B, Out-of-vessel Components and Related Systems with Reactor Hall and Related Systems; Site C, In-vessel

Components and Related Systems. The two co-center model was derived from the three co-center model by putting the out-of-vessel systems together with project integration, and by putting the reactor hall and related systems with the in-vessel systems. These models were judged to be plausible and useful for analysis.

After having defined these models, the Working Group considered their evolution with some care and then examined the differences between the co-center approach and the single site approach, specifically, the aspects of risk, cost, management and recruitment. The Working Group then considered the various advantages and disadvantages of the co-centers approach.

With this analysis, the Working Group came to the following assessment:

Three co-center organization of ITER EDA Central Team seems feasible.

A multiple-site, co-center organization of the Central Team, although more complex than a single-site organization, seems feasible, provided that:

1. An initial period of joint work is carried out at the integration site to define the project;
2. the design integration and project control function, which would require significant technical resources, remains at the integration site where the Directorate is located;
3. sufficient personnel (about 20% more, relative to a single site) are added to the Central Team to compensate for the impact of added travel time, and the necessity of maintaining sufficient project integration and control; and
4. the authority of the Director is strengthened.

The Working Group reported to the negotiators both in writing and then orally at the third negotiating meeting.

QEN-2 WORKING GROUP MEMBERSHIP

	EC	JAPAN	USSR	USA
Members:	E. Canobbio	A. Kitsunezaki	Yu. Balasanov	E. Brolin
	K. Melchinger	I. Makino	V. Chuyanov	A. Glass
	P. Rebut	S. Matsuda	O. Filatov	B.Montgomery
	R. Toschi	Y. Shimomura	L. Golubchikov	W. Stacey
Observers:	J. Rager	S. Wakimoto		A. Opdenaker
Chair:				M. Roberts

WORKSHOP ON ITER DRIVER BLANKET MOCK-UP AND BREEDER MATERIAL TESTING

by G. Shatalov and V. Chuyanov

The Long-Term ITER R&D Plan prepared by ITER during the CDA called for an extensive R&D program on the ITER driver blanket, including in-pile and out-of-pile blanket mock-ups and scalable models in test facilities.

The ITER Council, at its seventh meeting chartered an ad hoc Group of Experts (GOE), chaired by V. Chuyanov, to identify where in the Parties facilities, the critical technology R&D tasks (those that must be initiated at the very outset of the EDA) could be performed efficiently.

Workshop renewed in-pile and out-of-pile testing requirements and existing facility proposals.

One of the GOE's recommendations was to give the task to carry out the design and preparatory work of the in-pile blanket test facility to the USSR.

The ITER Council and QED confirmed the recommendations of the ad hoc GOE. In accordance with these recommendations as the first step the USSR ITER Home Team prepared a special proposal on an in-pile test facility which was sent to all Parties in

March 1991. This workshop, held in Garching on 10-14 June 1991, was then established to renew:
- blanket design and related R&D requirements,
- in-pile testing requirements and existing facility proposals,
- out-of-pile testing requirements and existing facility proposals.

The objectives were to exchange information on recent work, to improve mutual understanding of the issues involved and to make plans for future design and development work on the facilities without trying to make reommendations which would have implications on the task assignment.

All participants agreed that integrated in-pile testing of representative mock-ups are needed before the decision to construct the ITER. To do it in time a vigorous development will confirm the blanket performance and proposed schedule of development. The EC participants expressed some reservations, which reflect the different approach of the EC to the detailed technical objectives of ITER and to the ITER operation scenario, but agreed that the ITER CDA Terms of Reference and the results of the ITER CDA were to be taken as background for the discussion at this meeting.

Types of integrated in-pile mock-up tests

Two types of integrated in-pile mock-up tests were identified:
- Short-term performance tests to establish the main characteristics of mock-ups (some of the tests could be done on different reactors with smaller channels);
- Lifetime tests (to study dependence of the mock-ups performance on the fluence).

Short-term tests will permit to study several (up to 4) different options and will support the decision on common ITER blanket long lifetime tests which can be done only for 1 or 2 selected concepts to confirm the nuclear performance of the chosen common driver blanket.

Most important parameters to be modelled in mock-ups are identified.

The different blanket designs give different priorities to parameters which are to be modelled in mock-ups, but the most important of them are:
1. Correct simulation of nuclear heat deposition in breeder, multiplier and structural materials;
2. ITER-relevant tritium production;
3. Correct simulation of lifetime radiation effects in the integrated mock-ups and in particular He production in Be and Li burn-up in the breeder.

Conditions 1 and 2 are satisfied together but it was recognized that the two conditions 1 (2) and 3 cannot be satisfied in the same reactor and probably two different reactors are needed to achieve both goals.

Range of short-term tests

A very broad range of short-term tests was identified:
- Tritium release tests with different power levels,
- different purge gas flow rate and composition,
- thermal-hydraulic performance tests,
- thermal-mechanics tests with measurements of local strains and deformations,
- thermal cycling tests,
- and others.

To perform the tests, reactor channels of significant size are needed. Different blanket designs demand different space for testing, but participants agreed that a channel 10 cm x 20 cm with an active length > 30 cm will satisfy the needs.

The USSR proposal on a common test facility in SM-3 and RST/IVV reactors was supported.

Proposal on a common test facility in three USSR reactors

SM-3 is a high-flux reactor with mixed spectrum which has been used for materials irradiations and nuclear physics research. RST-6 and IVV-2M are pool-type reactors with relatively easy access to test channels. Especially RST-6 is convenient to be used for short-term performance tests, in combination with the SM-3 reactor for life tests, as they are installed in the same building.

The first estimate of mock-up characteristics have been performed by the USSR team assuming tentative calculation models of blankets which have been proposed by each Party. With these characteristics, the EC, the USA and Japan teams should be able to develop their own designs of mock-ups and supply their design data to the USSR team to check the applicability of their installation in USSR reactors.

Out-of-reactor testing of blanket modules

All Parties presented reports on the status and plans of out-of-reactor testing of blanket modules. It was clear from presentations and group discussions that all Parties would perform small-scale and medium-scale tests using their own facilities and that multiple designs would be examined during the early stage of testing. The large-scale tests would be performed on the selected ITER driver blanket design at a common out-of-pile test facility.

In the USA recently a formal request was made for expressions of interest from industry to construct and operate such a large out-of-reactor test facility, and 15 companies have responded. Among the companies are several aerospace and nuclear corporations. It is presently planned that a formal request for proposals will be sent out to interested companies in late summer or early fall 1991. Information from interested companies indicates that existing test facilities can be modified at a reasonable cost within the ITER time schedule to perform the 1/2-scale tests.

Japan proposed to conduct full-scale mock-up tests with the HENDEL facility which can be used for development of high-temperatue engineering test reactors (gas-cooled) and can supply ~16 MW heating power to the test stand, which will satisfy the heating conditions for the thermal loading tests of one blanket module.

All four Parties reported design works and optimization studies performed after completion of the CDA. In all cases the blanket design is mainly unchanged but work was concentrated on critical issues and on enhanced performance such as increase of the tritium breeding ratio and decrease in the blanket tritium inventory.

The presentations made during this workshop on material testing gave strong consensus for the need for continuation of base material and irradiation properties studies of the candidate blanket materials to assure that all options can be evaluated on an equal database. Several critical areas were identified.

The workshop has shown that in spite of delay of the EDA Agreement the ITER community continues to work and significant progress has been reported.

ITER WORKSHOP ON PHYSICS AND DESIGN OPTIONS JULY 10-18, 1991, AT GENERAL ATOMICS, SAN DIEGO

by D. Post, Chairman

The Workshop was organized at the request of the acting ITER home team leaders Drs. V. Chuyanov, A. Glass, Y. Shimomura, and R. Toschi. The charter specified for the meeting was:

"The primary topic of the meeting should be to review the ITER performance, parameters and operation scenarios. The objectives are to exchange information on recent work, to improve mutual understanding of the issues involved and to make plans for new work without trying to draw conclusions/consensus on ITER parameters. The latter will be the responsibility of a future Working Group."

The meeting had four components:

Components of the Workshop

1. Comparison of the views of each Party on the capability of the CDA design to fulfil the CDA objectives;
2. Exchange of views on potential design options;
3. Exchange of information about the ongoing work on the critical physics of ITER;
4. Exchange of information about the development of methods and techniques for systems analysis.

There was a frank and open exchange of views on all topics which will serve to set the stage for the upcoming Special Working Group discussions on the ITER Terms of Reference.

ITER Capability

The views of everyone on the capability of the CDA design point to meet the CDA objectives were reasonably close with only relatively minor, but important, points of divergence. These views were generally consistent with the recommendations of the CDA design team on the areas needing attention. Everyone agreed that ignited and long-pulse operation could be accomplished with, at most, only relatively minor adjustments in the design parameters. The energy confinement capability was generally felt to be adequate, but the group from the EC felt that some enhancement was needed to provide additional margin. Everyone judged that the problem of achieving acceptable divertor performance was very severe, even for ignited operation, and recommended that the divertor be the highest priority item (technology and physics) in the R&D program. In addition, everyone agreed on the severity of the disruption problem. Finally, there was general agreement that control of the current profile with non-inductive current drive was important for extended burn pulses and to minimize disruption effects. The groups from the EC, USSR, and USA agreed that steady-state operation of the CDA ITER was not feasible based on our present understanding of divertor physics because adequate power and particle exhaust cannot be provided for steady-state conditions. The group from Japan recognized the same problem but stated that steady-state operation with a neutron wall loading of 1 MW/m^2 should be included in the reference ITER operational scenarios but that further effort is needed to identify a satisfactory operational scheme.

Design Adjustments and Improvements

Each group recommended that some modifications to the CDA design point be considered.

The Group from the EC recommended increasing the major radius by 15% without increasing the aspect ratio significantly to satisfy requirements for engineering margins, to enhance the confinement capability, and to provide more inductive flux.

The Japanese view was that the CDA design requires a number of small adjustments to provide for adequate engineering margin. They suggested the use of additional in-vessel coils to enhance the capability for sweeping the divertor strike point.

The group from the USSR recommended that the major radius should be increased slightly to enhance the inductive capability and that the elongation should be reduced.

The US group recommended that a number of small adjustments be made to provide adequate engineering margin. Their conclusion was that ITER was marginal for technology testing, and they suggest that a design with a higher aspect ratio may offer the possibility of improving the performance, particularly for technology testing. They would also recommend that the physics operation phase be shortened so that the machine will not reach the end of its operating life before the technology phase operation can be completed.

Design Options

Each group presented and discussed the status of their design option studies, which chiefly emphasized the impact of increasing the aspect ratio. Increasing the aspect ratio while maintaining physics requirements constant lead to an increase of B_{tor}, decreases in I_p, R, a (minor radius) and to variation of the fusion power (a decrease for constant average neutron wall load and possibly an increase for constant peak neutron wall load). Most of the studies indicated that, for fixed engineering constraints, the divertor heat loads were unchanged.

The results presented by each party (some were ongoing and therefore incomplete) indicate that a design with an aspect ratio of 4 is possible, but has not significant advantages for ignited operation (particularly if the vertical stability of the higher aspect ratio design appears more robust. Since most of the high performance energy confinement data has been obtained with low aspect ratio plasmas, the accuracy of extrapolating confinement properties is greater for lower aspect ratio designs.

Higher aspect ratio designs, however, appear to offer the potential that static divertor conditions for long-pulse and steady-state may be mitigated although they remain severe and the problems of vertical stability and confinement uncertainties remain. This is related to the fact that one may operate at higher density (therefore improved divertor performance) since a lower current has to be driven non-inductively (both the total plasma current is lower and the bootstrap current fraction increases somewhat for increased aspect ratio). In addition, the divertor load can be decreased in a high aspect ratio machine, as in the CDA ITER, if seeding with impurities can be used because at higher density a lower seeding concentration is needed to produce a given radiative loss.

As for the ignited mode, vertical stability and the poloidal field energy are critical issues, but driving the full or a large part of the plasma current non-inductively allows better control of the internal inductance. Also the plasma current for higher aspect ratio designs is lower and therefore the problem of the poloidal field energy is somewhat less important.

Physics Issues

The ongoing work in the critical physics was discussed during the second half of the meeting.

In terms of preparing for the EDA, it was generally felt that the ongoing physics work should emphasize continued work on the critical physics issues identified during the CDA (the divertor, disruptions, confinement databases, etc.) and on the preparation of analysis tools for the EDA rather than trying to anticipate design specific work before the start of the EDA.

The major activity in energy confinement was the continuing work on the ITER H-mode database, including the establishment of an H-mode threshold database, and updates of the ITER L-Mode database. Evidence of a new confinement regime (VH) with energy confinement substantially above H-mode was reported for DIII-D.

The importance of profile effects (especially j(r)) is becoming increasingly apparent in experiments, increasing the importance of current profile control by non-inductive current drive.

Assessments of the H-mode density limit showed that JET limiter data (EC) agreed with the Borrass scaling, and preliminary D-IIID H-mode data did not (US). Work on the effects of runaway electrons is continuing (EC, USSR). In particular, results from JET indicate the Be limiters substantially reduce the runaway production following disruptions.

For alpha particles, there is continuing work on the assessment of alpha losses due to toroidal field ripple and to collective modes (especially TAE mode).

Power and particle control remains the most critical issue. There were several studies (EC, US, Japan) which indicated that higher sweep frequencies were needed to sweep the divertor strikepoint. The Japanese group presented a study that indicated that internal coils would allow an increase in the sweep frequency to 2 Hz at full current (6 Hz at reduced current), reducing the divertor plate temperature excursion and thermal fatigue effects. EC 2-D simulations showed that the divertor parameters scaled strongly with density and power, yielding a narrow operational window in density for acceptable plasma temperatures at the divertor plate. In addition, there was continued work by all groups on code development and validation. Calculations by several groups (Japan, USSR, and US) indicated that impurity radiation in the diverted plasma could reduce the peak divertor heat loads by as much as 50% or more in the CDA design. Up to a factor 5 reduction was reported, for a high aspect ratio design calculation (US), but no corresponding ITER CDA calculation was performed. Disruption simulation experiments in the USSR indicated that the energy deposited during disruptions may be reduced substantially by vapor shielding and that the net erosion due to disruption could be substantially lower than previously estimated.

Vertical stability analyses (rigid modes-Japan, USSR; non-rigid modes-US, Japan) showed differences between the two models at low l_i and reduced stability at high aspect ratio.

Results were also presented on the continued assessment of the performance of Neutral Beam, Lower Hybrid and Fast Wave Current Drive, and the potential contributions of the bootstrap current.

A workshop on Diagnostics R&D was planned for October in Leningrad.

The status of the ITER Physics R&D Program was also discussed. The status of assessments of the R&D program was reported by the partners and a detailed report was presented by the US. The conclusions of the studies are that the most critical problems remain the divertor and disruptions, and that increased emphasis is needed on these problems. The Japanese group also emphasized the need for attention to vertical stability questions. Information was exchanged on the implementation of the ITER Physics R&D Program. A reporting date for the next series of contributions to the ITER Physics R&D Program was tentatively established for Nov. 30, 1991.

Systems Issues

The systems group addressed both the prospects and status of a single, international systems and operational code for the EDA and the methods used in the recent systems studies and operational performance analyses carried out during the last year for ITER.

Several code efforts were discussed. These included TOKDES code in the EC that has been used primarily for magnet design work, the Japanese system code, the ALICE code in the USSR, and the US SUPERCODE. The systems group agreed to proceed with the development of improved modules for the codes, including 1 and 1 1/2 D effects and other physics and engineering improvements as necessary. Improvements in analysis and presentation methods were also discussed.

LIST OF PARTICIPANTS

EC:
F. Engelmann (NET)
N. Mitchell (NET)
G. Pacher (NET)
E. Salpietro (NET)
W. Spears (NET)
R. Toschi (NET)

US:
D. Baldwin (LLNL)
S.A. Cohen (PPPL)
J.N. Doggett (LLNL)
J. Galambos (ORNL)
A. Glass (LLNL)
S. Haney (LLNL)
J. Hogan (LLNL)
A. Kellman (GA)
D. Lousteau (ORNL)
J. Luxon (GA)
W. Nevins (LLNL)
E. Oktay (DOE)
R.R. Parker (MIT)
L. Pearlstein (LLNL)
J. Perkins (LLNL)
N. Pomphrey (PPPL)
D.E. Post (PPPL)

US (cont.):
P. Rutherford (PPPL)
D. Sigmar (MIT)
K. Thomassen (LLNL)
N. Uckan (ORNL)
J. Wesley (GA)
K. Young (PPPL)

Japan:
N. Fujisawa (JARI)
H. Matsumoto (JAERI)
Y. Murakami (JAERI)
Y. Kishimoto (JAERI)
Y. Shimomura (JAERI)
M. Sugihara (JAERI)
E. Tada (JAERI)
H. Tamai (JAERI)
T. Tsunematsu (JAERI)

USSR:
V.A. Chuyanov (Kurchatov)
V.V. Deriglasov (Kurchatov)
A.B. Mineev (Kurchatov)
V.S. Mukhovatov (Kurchatov)
V.A. Parail (Kurchatov)
V.I. Pistunovich (Kurchatov)
P.N. Yushmanov (Kurchatov)

The ITER NEWSLETTER is prepared and published by the International Atomic Energy Agency, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria. Telex: 1–12645, Cable: INATOM VIENNA, Facsimile: 43 1 234 564, Tel.: 43 1 2360–6393/6394. Items to be considered for inclusion in the ITER Newsletter should be submitted to B. Kouvchinnikov, ITER Secretariat.

Printed by the IAEA in Austria
September 1991

91-03655