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SIXTH MEETING OF THE ITER MANAGEMENT ADVISORY COMMITTEE (MAC-6)

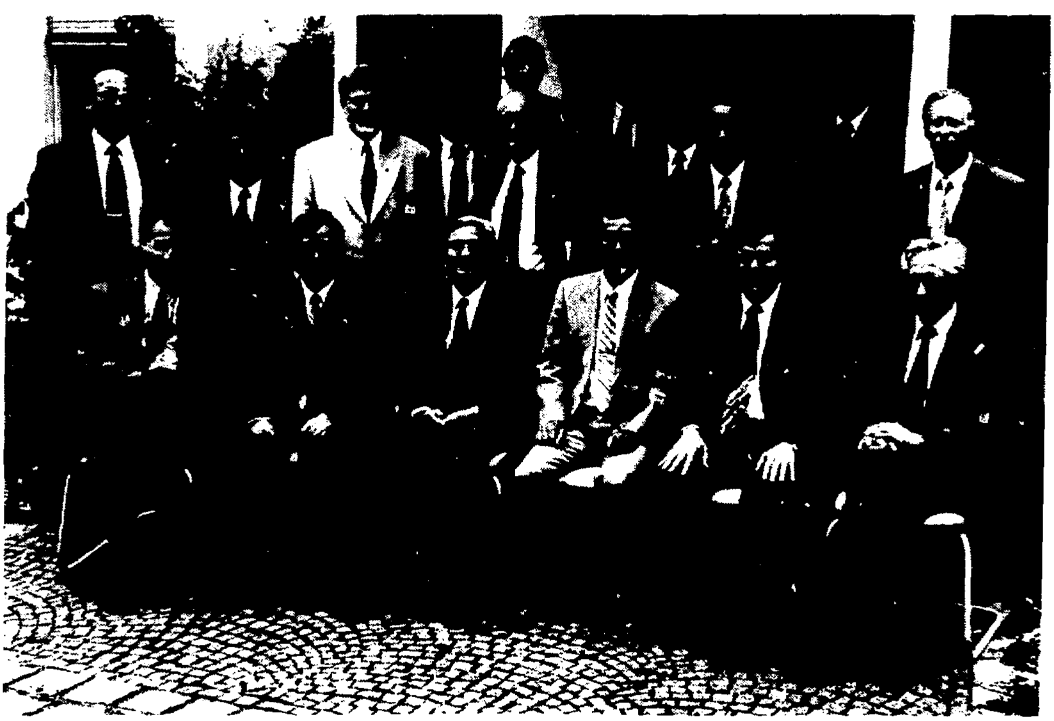
by Dr. M. Yoshikawa, MAC Chair

The sixth meeting of MAC was held at the ITER Garching Joint Work Site on 7 and 8 July 1994. Dr. P.H. Rebut was represented by the Deputy to the Director, Dr. Y. Shimomura. MAC invited the Administrative Officer, Mr. R. Sheldon, and Dr. T. Mizoguti as experts for the JCT. Head of the Garching Joint Work Site, Dr. R. Parker, and Dr. R. Haange were invited as experts for MAC as a whole.

MAC reviewed the condition of the involvement of Kazakhstan, the analysis of ITER EDA Deliverables and Resources, proposals for Task Agreements, the 1995 Joint Fund Budget Allocation and Expenditure Plan, and the proposed schedule of ITER meetings.

Involvement of the Republic of Kazakhstan through the RF contribution to the ITER EDA

MAC recommends to the ITER Council to approve the proposed involvement of Kazakhstan through the Russian Federation contribution to the ITER EDA according to the drafts provided by the RF delegation as revised at this meeting.



Participants in the Meeting

Deliverables and Resources

MAC reviewed and discussed the report by the Director on ITER EDA Resources and Deliverables.

MAC believes that, in order to reach the objectives contained in Article 1 of the ITER EDA Agreement, i.e. to provide enough information and industrial participation to have sufficient confidence in reaching a construction and a site decision in 1998 and to provide adequate guidance to focus the R&D activities, more design resources are required than currently planned in the EDA. An optimization of the mixture of professional staff and support staff in the JCT within the financial resources corresponding to the planned EDA design resources for the JCT as given in Attachment 13, ROD IC-5, should be considered.

MAC also believes that, in order to reach the objectives contained in Articles 1 and 2, i.e. to start construction at the end of the EDA, would require a site selection in 1996 and an increase of the design resources over those necessary to reach Article 1 objectives of approximately 350 PMY and associated support staff.

The MAC-6 views on Resources and Deliverables were subsequently noted by IC-6. The Council agreed that the Parties should initiate steps to increase substantially the Home Team design resources along the lines suggested by MAC, and the Director may optimize the balance of the JCT professionals and support staff resources within the overall envelope of resources set out in IC-5 ROD Attachment 13. The Council encouraged the Parties to use their best efforts to respond constructively to the needs of the project.

Proposals for Task Agreements

MAC reviewed and supported the Director's proposals for Task Agreements for:

- ITER ECH Window Development with the EC and US Parties
- ITER Gyrotron Development with the JA, RF and US Parties
- Plasma Exhaust Processing Technology Development with the EC and the US Parties
- ITER Tritium Plant Safety Enhancement with the EC and JA Parties
- Supply of Nb_2Sn Strand for the ITER TF Model Coil with the EC Party.

MAC requests the Director to provide: preparation of framework for the above tasks to show the overall strategy, the rationale of the Task Splitting aiming at avoiding unnecessary duplications and the correlations with the main ITER milestones. MAC notes the importance that implementing institutions are made fully aware of ITER Agreement provisions related to the intellectual property rights.

The January-December 1995 Joint Fund Budget Allocation and Expenditure Plan

The Director provided MAC with the January-December 1995 Joint Fund budget allocation and expenditure plan. Regarding the limited resources that can be made available by the Parties for the Joint Fund, MAC recommends to the ITER Council that the JCT should propose a revised budget on the basis of the 1994 allocation.

With regard to the breakdown of the cost, MAC understands that a reasonable increase of travel money would be appropriate. MAC also feels reluctant to accept the cost for the IPMS systems (hardware and services) and asks for a review of the management tools.

Proposed Schedule of ITER Meetings

The Director provided to the MAC the schedule of proposed ITER Meetings. MAC reviewed the schedule and recommended to the Council to endorse the schedule of Meetings with some modifications.

MAC considers it important to expedite the activities of the physics expert groups to enable co-ordination on the input of the Parties' physics programs into the ITER EDA.

SIXTH MEETING OF THE ITER TECHNICAL ADVISORY COMMITTEE (TAC-6)

by Prof. Paul H. Rutherford, TAC Chair

The TAC-6 Meeting was held at St. Petersburg, Russian Federation, on 12-14 July 1994. Thirteen TAC Members attended the meeting, as well as seven experts nominated by the ITER Parties: Dr. J.-M. Ané and Dr. F. Engelmann (EC), Dr. M. Nagami and Dr. T. Tsunematsu (JA), Dr. O. Filatov and Dr. Yu. Sokolov (RF), and Dr. J. Galambos (US). Presentations to the TAC were given by ten members of the Joint Central Team (JCT) and the four Home Teams (HTs).

Participants in the Meeting

The TAC-6 meeting was called to address the following charge from the ITER Council, formulated at the IC-5 Meeting on 27-28 January 1994:

The ITER Council requests TAC to assess the results of the sensitivity analysis to be carried out by the Director and JCT to determine the optimum way to achieve a reduction in the estimated construction cost while minimizing the impact on the performance margin. This assessment should be carried out as soon as the sensitivity study is completed, which is expected to be in about six months.

In the record of the IC-5 Meeting, the scope and objectives of this 'Sensitivity Study' were described as follows:

The purpose of this study will be to determine the relative importance of different design parameters, within small ranges of variation, in determining the overall cost. The study will identify the modest further optimization of the major machine parameters which would be needed to provide a reserve against the possibility of future cost increases. The impact on plasma performance should be quantified.

The study should begin with the present outline design as the reference point. A small number of alternate design points should be identified and studied, including cases in which the plasma major radius is reduced by up to about 10%, and cases in which the plasma elongation is increased up to the limits set by a single-null divertor configuration and by the ability to control the plasma vertical position without internal coils. Variations of up to about 10% should be allowed in other parameters, such as q-value, aspect ratio, toroidal field strength and plasma current. The alternate design points to be considered should all lie within the constraints imposed by the present magnet design concept and magnet structural approach. However, the number of toroidal field coils should be varied in the range of 2-24.

The Sensitivity Study

The Sensitivity Study was carried out over a period of approximately five months and involved participants from the JCT and from all HTs.

The report, *Findings of the ITER Sensitivity Study (Volumes I and II)*, was prepared jointly by the JCT and HT participants and was submitted by the Director for consideration at TAC-6. Volume I of this report presents the findings of the Sensitivity Study. Volume II provides all of the material presented at three meetings of the JCT/HT study participants, which were held at the ITER Joint Work Site in San Diego in March, May and June 1994.

To examine the sensitivity of plasma performance and machine cost to variations of the major machine parameters, the JCT/HT participants selected six 'common study points' to be compared with the reference outline design parameters. Table 1 provides a listing of the common design variants which were studied in comparison with the present reference outline design (OD).

Variants (a), (b) and (g) maintain the same plasma elongation as the reference outline design. However, variant (a) illustrates the effect of reducing the magnetic field, by removing two layers of the toroidal field (TF) coils and of the central solenoid (CS) in the reference outline design, which results in smaller values of major radius, plasma current and magnetic field on axis. Variant (b) represents the effects of a reduction of the minor and major radii without reducing the field strength, leading to an increased aspect ratio and a reduction in plasma current. Variant (g) represents the effects of a reduction in major radius accompanied by a reduction in the plasma current. Variants (d), (e) and (f) examine variations at increased plasma elongation [1.65 for (d), and 1.7 for (e) and (f)]. The increased elongation minimizes the reduction of plasma performance, by maintaining a higher plasma current at a reduced minor radius. Variant (d) provides for a higher magnetic field at larger aspect ratio than the reference outline design, while variants (e) and (f) maintain the same aspect ratio as in the reference outline design, but at a lower magnetic field on axis. Variant (e) has almost the same plasma current as the reference outline design. In the performance/cost assessment, all these alternate design points were studied for the case of 24 TF coils, the same as in the reference outline design studied for the case of 24 TF coils, the same as in the reference outline design. All the design points were chosen so as to satisfy the requirements of the detailed technical objectives, e.g., ignition and at least 1,000 seconds burn at a neutron wall load of about 1 MW/m^2. Moreover, all the design points were required to satisfy the same physics and engineering constraints, e.g., similar dimensions for the single-null divertor and scrape-off layer, similar shield/blanket thickness and separatrix/wall distance, similar free-bending TF-coil shape, similar maximum fields at the TF and CS conductors and similar maximum magnet stress levels.

TABLE 1. COMMON STUDY POINTS

	Reference OD	(a)	(b)	(d)	(e)	(f)	(g)
R(m)	8.1	7.89	7.67	7.65	7.5	7.1	7.5
a(m)	3.0	3.0	2.67	2.64	2.78	2.63	2.78
A	2.7	2.63	2.87	2.9	2.7	2.7	2.7
B(T)	5.72	5.23	5.88	5.92	5.2	4.54	5.34
I(MA)	24	22.8	20.3	21.9	23.3	20.5	21
K(95%)	1.55	1.55	1.55	1.65	1.7	1.7	1.54

The higher elongation cases are more demanding than the reference outline design in regard to control of the plasma shape and stabilization of vertical plasma motion. For this reason, the power-supply requirements for the poloidal field (PF) system and the associated issues of AC losses in the PF and TF systems were a major focus of the study. As for the reference outline design, shape control and vertical stabilization were provided by six external PF coils: no in-vessel control coils were allowed. The requirements for vertical stabilization were addressed for variant (e) compared with the outline design for two representative destabilizing perturbations:

a fast drop in beta-poloidal, and a small vertical displacement of specified magnitude either toward or away from the divertor. The controllability of larger, abnormal (disruptive) plasma motions was also addressed.

Cost comparisons were carried out for the variant design points using the same costing date as for the reference outline design. The costs for the major systems including magnets, structures, power supplies, vacuum vessel, shield/blanket and other in-vessel components, auxiliary plant systems, and buildings were estimated on the basis of agreed algorithms which, for small variations around the reference outline design, relate these costs to the variations in parameters such as conductor length (magnets), volume (structures), stored energy (power supplies), surface area (vacuum vessel, shield/blanket and in-vessel components), heat capacity (auxiliary plant), etc. The costs for certain systems remained fixed for all design variants. In addition, each Home Team provided cost variations, which were used to evaluate the dispersion among the different costing codes and methodologies.

A second part of the Sensitivity Study focused on the issues associated with the choice of the number of TF coils, examining in particular the effects of having only 20 coils in ITER, compared with the reference outline design which has 24 TF coils. The issues examined included (a) the adverse effects of different levels of magnetic field ripply and the design options for reducing the ripple in the 20 TF coil case to the level in the reference outline design (maximum edge ripple of about 2%), (b) the neutral beam injection geometry and current drive performance (for negative-ion-based neutral beams with energies in the 1 MeV range, or possibly higher), and (c) the requirements for access to, and remote maintenance of, in-vessel components, especially the divertor cassettes and the shield/blanket modules.

TAC Response to the IC Charge

The TAC commended the Director and the Sensitivity Study participants from the JCT and the four HTs for carrying out a comprehensive analysis in a relatively short time.

The TAC considered the Sensitivity Study to provide a valid description of the relative importance of different design parameters, within small ranges of variation, in determining both the projected plasma performance and the overall cost estimate. The TAC noted that the variations considered were constrained by the present engineering design concept, especially the magnet design and structural concept and the poloidal field and divertor configurations.

The TAC noted that there is a satisfactory level of agreement between the JCT's costing algorithms and the costing codes used by the HTs in regard to the cost variations among the different design points studied.

The TAC found that the present outline design has been successful in its attempt to maximize physics and engineering performance while minimizing cost and complexity. However, the uncertainties in the models used to project plasma performance exceed the differences in performance projected for the various alternate design points considered in the Sensitivity Study. Thus, by using the results of the Sensitivity Study, it may be possible to realize small reductions (<10%) in the cost estimate either because of an improved database in key areas (helium transport and exhaust, size-scaling of H-mode confinement) or because of an explicit decision to increase the risk of insufficient confinement margin. At this time, the TAC considered that it would be prudent to retain the present major machine parameters.

In regard to a possible change in the number of TF coils from 24 to 20, the TAC found that such a change would have modest advantages for neutral beta current drive flexibility and for remote maintenance. However, because of the requirement to maintain the field ripple at no higher than its present value, such a change would have a major impact on the entire magnet configuration and should be considered only in the context of a modification of the overall design concept. For the outline design as constrained at present, the choice of 24 coils appeared to be appropriate to the TAC.

The TAC's findings and conclusions/recommendations are contained in the TAC's report "Minutes and Report (TAC-6)", which was presented to the ITER Council at its meeting in Moscow on 27-28 July 1994.

SUMMARY OF MAGNET TECHNICAL MEETING

by R.J. Thome, Head, Superconducting Coils and Structures Division, ITER Naka Joint Work Site (JWS)

A Magnet Technical Meeting was held at Naka JWS on 27-30 June 1994. Representatives from all four Parties attended. A list of participants is provided overleaf.

The meeting began with a plenary session in which the Joint Central Team (JCT) presented the status of activities by the Conductor Subgroups on AC Losses, Stability/Quench Analyses, and the QUELL Experiment. Activities have begun in all areas as part of '93 and '94 Task Agreements. There has been considerable preparation for experiments, but there is little data to date. A status report on the activities will be prepared by the end of 1994 by the subgroups to summarize progress and relate the data taken and experiments to the ITER conductor designs and/or design criteria. A Table of Contents for this report will be prepared by the JCT and supplied to the Parties by 31 July.

The Conductor Group status report included benchmark testing activities on superconducting strand and a review of the strand, cabling, and jacketing activities by the Parties, including:

- A second round of benchmark testing shall be done to resolve questions generated in the first round.
- In strand production, all Parties have completed State 1 of their Task Agreements (submission of QA Manuals) and Stage 2 (trials on 0.5 tons of strand in multiple billets of material to optimize process variables and meet the strand specification). Some Parties are well into Stage 3 (production of 0.5 tons of material to the ITER specification to demonstrate process control and repeatability).
- In Central Solenoid (CS) conductor jacketing, the equipment installed in the EC is undergoing trials with full size cross-section stainless steel and short lengths of Incoloy. A 12 m length of steel with butt welds has been successfully prepared and formed onto a final radius for conductor shipment.
- In Toroidal Field (TF) conductor jacketing, the Russian Federation has made a full size section of dummy copper TF cable and successfully jacketed it with titanium while waiting for Incoloy samples. The trial length is 35 m and has been wound onto a shipping spool.
- A review of the conductor production schedule shows that, initially, the delivery of the Incoloy for jacketing is critical, but eventually the schedule is governed by strand delivery by the EC and US. The EC and US will be requested to review the situation and try to improve the anticipated schedule.

The status of the Model Coil activities was also summarized by the JCT in the opening plenary session. The US/Japan Team has been corresponding regularly and is well along in the preliminary design of the CS Model Coil. Progress in the design of the TF Model Coil, on the other hand, has been slower because of the decision to consider a configuration that was not included in the December 1993 specification by the JCT. In the near term, the selection of a configuration is essential if the milestone for having TF Model Coil construction complete by mid-1994 is to be maintained. Discussions on this topic are continuing between the JCT and the EC.

The plenary session then proceeded with a representative from each Party presenting a joint design for the TF and CS coil systems as required by existing Task Agreements on Joint Development. Each Party then summarized the homework done by Group 3 (Full Scale Coil Analyses) since the February 1994 meeting.

After the plenary sessions, the attendees were divided into two groups for parallel working sessions: (1) oriented toward structural analyses of the full scale coil systems and components, and (2) oriented toward conductor issues.

Several potential reference design modifications were presented by the JCT and are included in a draft "Task Specification for Cost Estimates" distributed at the end of the meeting. Comments on this draft have been requested, and a final version will be distributed to the Home Teams on 29 July. The major modifications currently being considered are related to the design of the TF coil conductors and cross section, the outer Poloidal Field coils and support structures, and the Mechanical Structure design. These areas were discussed in the parallel sessions.

Representatives from all Parties presented results on full-scale coils (Group 3) design and structural analyses based on the homework list from the February 1994 meeting. Discussions were held to compare the results and review the design modifications.

A tentative homework list was prepared by the group, listing the issues to be solved and assigning to each Party specific tasks (subject to comment and approval). Priorities are indicated on selected issues, for which results are desired by 1 August. Intermediate results were also requested for the interim deadlines of 1 August and 15 September. The JCT will communicate with the Home Teams in order to evaluate the shorter term results and request further analyses or specify modifications to the tasks.

The meeting closed with a plenary session in which the parallel session chairmen summarized the group conclusions and the proposed homework tasks. The JCT will review the proposed homework and come to a mutual agreement with the Home Teams on assignments.

The next Magnet Technical Meeting has been scheduled for 8-11 November 1994 and will be held at Naka.

LIST OF PARTICIPANTS

EC:	JA:	RF:	US:
L. Bottura, NET	M. Nishi, JAERI	A. Alexeev, Efremov	M. Chaniotakis, MIT
C. Jong, ECN	M. Sugimoto, JAERI	M. Zhelamskij, Efremov	B. Smith, MIT
A. Torossian, CEA	Y. Takahashi, JAERI		P. Titus, MIT
M. Perella*), Ansaldo	N. Koizumi*), JAERI		
G. Vecsey*), PSI	H. Ogata*), JAERI		

JCT:

P. Barabaschi, San Diego	F. Iida, Naka	M. Shimada, Naka
D. Bessette, CEA**)	A.I. Kostenko, Naka	B. Stepanov, Naka
P.L. Bruzzone, NET**)	Y. Krivchenkov, Naka	J. Stoner, Naka
C.W. Bushnell, Naka	N. Mitchell, Naka	R.J. Thome, Naka
B. Green, Naka	K. Okuno, Naka	R. Vieira, Naka
M. Huguet, Naka	Z. Piec, Naka	F.M.G. Wong, Naka
	C. Sborchia, Naka	K. Yoshida, JAERI**)
		E. Zapretilina, Naka

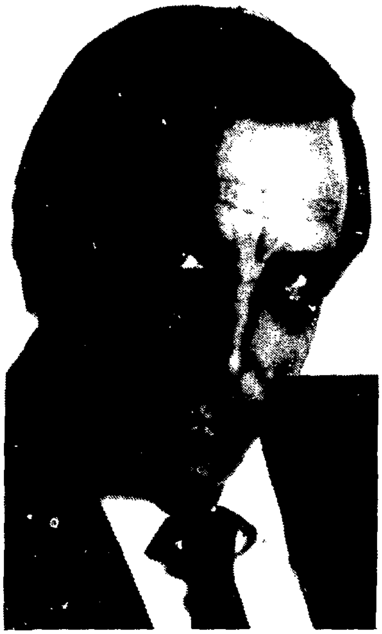
*) Observer, **) VHTP

NEWS IN BRIEF

At the national meeting of the US Home Team for the International Thermonuclear Experimental Reactor (ITER) held on May 10-11,1994, at the John Hancock Conference Center in Boston, Massachusetts, Chuck Flanagan received a Certificate of Appreciation from the US Department of Energy. The certificate was in recognition of Chuck's work on behalf of his contributions to the fusion program, and in particular for his efforts as US ITER Deputy Home Team Leader. The certificate was signed by Martha Krebs, Director of the Office of Energy Research and was presented by Charles C. Baker, US Home Team Leader, Oak Ridge National Laboratory, and by Thomas R. James, Director, ITER and Technology Division of the Office of Fusion Energy, Department of Energy. Mr. James also presented Chuck with a certificate of appreciation from the Office of Fusion Energy, signed by all staff members employed by the office. Recently, Chuck shifted from full-time employment with the US ITER Home Team to part-time employment. He has given up the day-to-day responsibilities with the US Home Team as Deputy Home Team Leader, but will remain with us as the Secretary of the ITER Technical Advisory Committee.

DR. ALEXANDRE I. KOSTENKO

in memoriam



Alexandre Ivanovich Kostenko, a member of the ITER Naka Team and Group Leader for the Full Scale Coils Group, passed away the morning of July 8, 1994, at the age of 56.

He received the Engineering Degree in Electrical Machines and Apparatus in 1963 and began his career at the D.V. Efremov Scientific Research Institute of Electrophysical Apparatus, St. Petersburg. He participated in the design and commissioning of the Electron Synchrotron at the EFTI in Erevan, Armenia, and later contributed to the design of superconducting storage magnets and switches for pulsed power applications. He became manager of the T-15 project in 1976 and while working on T-15 participated in the INTOR project. He received his Doctor's Degree in 1980 and in 1983 became Head of the Superconducting Magnet Laboratory at the Efremov Institute.

In 1989, Alexandre joined the ITER activities and contributed to the CDA Superconducting Magnet design. He continued to work for ITER and joined the Naka team in the fall of 1993. Alexander published more than 20 articles and books and received 10 USSR Certifications of Authorship, all relating to superconducting apparatus.

Alexandre was friendly, robust, outgoing, and a joy to be with. He was full of life and gave energy to those around him. He made many friends around the world and will often be remembered. Alexandre is succeeded by his wife Lilia, his daughter Yulia and his grandson Oleg, who reside in St. Petersburg, Russia.

The very supportive response provided by the JAERI and the Japanese hosts in Naka during this tragedy was greatly appreciated by the JCT and all others involved.

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).

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