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ITER TECHNICAL ADVISORY COMMITTEE MEETING
by Prof. M. Fujiwara, TAC Chair

The ITER Technical Advisory Committee (TAC) was held on June 25-27, 2000 at the Efremov Scientific Research Institute of Electrophysical Apparatus in St. Petersburg, Russian Federation. According to the decision taken at the ITER Meeting held in Tokyo in January 2000, TAC was charged to conduct a review of the converged engineering design and of the possible new R&D needs. The meeting thereby reviewed the progress in the ITER-FEAT design, based on the two documents, "Progress in Resolving Open Design Issues from the ODR" and "ITER Technology R&D Progress Report," issued by the Director on 15 June, considering the key recommendations made at the last TAC at Naka on 20-22 December, 1999. TAC was also intended to provide the ITER Meeting, scheduled for June 30 in Moscow, with a technical assessment and key recommendations of the above mentioned reports.

Thirty-two participants, including ten TAC members, ten invited TAC experts and two Home Team Leaders participated in the review. Prof. P. Komarek was introduced as a new TAC member from the EU; he is the replacement of Prof. F. Troyon. The TAC expressed great thanks to Prof. F. Troyon for his significant contributions to ITER and TAC activities. After the introductory remarks made by the Chairman, the Director summarized major issues of concern, related to the Parties' domestic review, and presented the highlights of activities performed during the first semester of 2000 by JCT and Home Teams as a background. The Director also made an introductory talk, related to the descriptions of the progress report. The Joint Central Team staff then gave a total of fourteen presentations, covering all aspects of the descriptions in the reports. The presentations were made mainly on the first day of the meeting. After detailed discussions on the second day in three consecutive plenary sessions, for the review of progress made in resolving physics issues, converged engineering design options and R&D issues respectively, the preparation of a draft report

Participants in the Meeting

and its review reading were performed on the third day. The following excerpt from the TAC report summarizes the conclusions of the meeting. A discussion also took place on the possibility that a TAC meeting could be organized to review the Draft Final Design Report of ITER-FEAT in January, 2001.

Overall assessment and key recommendations from TAC

(1) TAC appreciates substantial and extended progress made in physics and engineering design activities, in particular, overall analysis of plasma performance and convergence of several engineering options recommended at the last TAC meeting. TAC hereby greatly acknowledges the dedicated effort and the intensive design work made by the Director, JCT and Home Team members.

(2) TAC considers that the final design, which meets ITER objectives, is well underway to resolve remaining issues in physics and technology by using the results of on-going R&D and proposed new R&D in this TAC report.

(3) TAC is pleased to note the continuing activity in physics R&D, making the performance prediction for ITER-FEAT more robust and further reducing physics uncertainties. Progress in resolving physics questions centred on the two priority issues highlighted in the previous TAC of the profile sensitivity of all the scenarios to achieving the objectives and the compatibility of the divertor design with the various operating scenarios.

- Simulations show that the inductive and hybrid scenarios are compatible with the divertor design and there are indications that the steady-state scenario may also be compatible. It is also pleasing to note that the simulations show that sustained ignition may be possible at higher currents (17MA), consistent with the engineering design, for a small (10%) enhancement in confinement, or a reduction in helium accumulation.

- The principal remaining physics uncertainty relates to operation at high normalized densities and the impact of energy loss fraction during an ELM on the divertor targets, emphasizing the need for a reduction in ELM amplitude whilst maintaining good confinement, and a focussed experimental programme of work on this aspect is recommended.

(4) No overall design issue is left open. In the progress report, designs have converged to a reference for all the major aspects.

(5) TAC notes that substantial progress has been made in all the R&D areas, in order to validate the design principles. Thereby, ITER-FEAT can rely on all these R&D issues originally defined for the 1998 ITER design.

- About 75% of the effort is devoted to the Seven Large Projects, which are in most cases coming to completion by 2001.
- R&D on heating systems, particularly gyrotron and high energy ion source, should be continued beyond 2001.
- Eight R&D tasks associated with the ITER-FEAT design and the reduced-cost options, mainly related to the magnet design, have been identified, and detailed task specifications have been developed.

ITER MANAGEMENT ADVISORY COMMITTEE (MAC) MEETING IN NAKA
by Dr. M. Yoshikawa, MAC Chairman

The ITER Management Advisory Committee (MAC) Meeting was held on 28 June 2000 in Moscow, Russia.

The main topics were:
- the consideration of the report by the Director on the ITER EDA Status,
- the review of the Work Program,
- the review of the Joint Fund,
- the review of a schedule of ITER meetings, and
- initial discussion and consideration on the disposition of R&D hardware and facilities and other dispositions relating to the termination of the EDA.

Participants in the Meeting

ITER EDA Status

MAC noted the Status Report presented by the Director in the period between the ITER Meeting in Tokyo (January 2000) and June 2000.

Following in depth discussion on points 7 to 14 of the ITER EDA STATUS, MAC recommended unanimously to delete points 13 and 14, in consideration of the on-going discussions in the “Explorations” framework. In addition, the EU and JA delegations considered it premature, under the present circumstances, to refer in the report to a possible continuous evolution in management structure and configuration from the present EDA status to the possible, and still to be defined joint implementation of ITER construction and operation.

Task Status Summary and Work Program

MAC took note of the Task Agreements Status Summary and compiled list of Task Agreements per Party.

MAC reviewed and supported the two new R&D Task Agreements of which credit is more than 500 IUA. MAC took note of six new R&D Task Agreements of which credit is not more than 500 IUA per task. MAC took note of twenty-four new Design Task Agreements including VHTPs for which credit is not more than 500 IUA or 2.5PPY per task.

MAC reviewed and supported the modifications of Task Agreements since the MAC Meeting at Naka in December 1999 of which credit changes are more than 500 IUA or 2.5PPY, or more than 20%. MAC took note of the modifications of the Task Agreements since the MAC December Meeting, of which credit changes are not more than 500 IUA or 2.5 PPY, or not more than 20%. MAC took note of cancellation of Task. MAC noted the need for resolution of NbTi insert coil issues among the HTLs and the Director.

Joint Fund

MAC reviewed consolidated ITER Joint Fund Accounts for 1999 as presented by the Director with supporting detailed information.

MAC noted each Party’s oversight on the fund provided to the Agent in its territory.

On the basis of the information provided, MAC recommends to the ITER Council to approve the consolidated annual accounts of the ITER Joint Fund for 1999.

MAC recommends the ITER Council to approve the discharge of the US agent from the Joint Fund responsibilities, taking account of US comments on reimbursement of the Agent's close-out costs. MAC recognizes that, following completion of the above procedure, the US involvement in ITER Joint Fund arrangements will be completed.

MAC noted that it is expected to have an adequate balance of 2000 appropriations left at the end of 2000 to cover likely needs for expenditure till the end of the EDA on the assumption that all Parties pay their contributions for 2000 Joint Fund. MAC supported this approach.

MAC requested the Director to indicate, at the next MAC meeting, the status of Joint Fund expenditure in 2000 and the expected patterns of expenditure during 2001.

Schedule of ITER Meetings

MAC reviewed and supported the schedule of Technical Meeting and Workshops shown in the table below. MAC noted that the seven ITER Physics Expert Groups, with their modified titles and charges, are now in full operation and the arrangements for continued interaction with US fusion scientists on generic issues of tokamak physics are now proceeding smoothly.

TECHNICAL MEETING AND WORKSHOPS

Date	Meeting/Activity	Location
18-22 September 2000	13th Diagnostics Physics Expert Group	Naka
11-13 October, 2000	Combined Workshop of the Transport & Internal Barrier Physics, Confinement Database & Modelling, and Energetic Particles, Heating and Steady-State Operation Expert Groups*	Frascati
11-13 October, 2000	Combined Workshop of the Pedestal Physics, Divertor, and MHD, Disruptions and Control physics Expert Groups *	Garching
14 October, 2000	ITER Physics Committee	Garching
13-17 November (tentative)	Technical Meeting on Safety and Environment*	Garching

*Meetings not previously reviewed by MAC

Initial discussion on and consideration of the disposition of R&D hardware and facilities and other dispositions relating to the termination of the EDA

MAC recognized that, in regard to the termination of the EDA, subjects to be discussed include (1) R&D hardware and facilities (items), (2) Joint Fund Assets, (3) Closure of Joint Work Sites and (4) ITER data.

R&D hardware and facilities (items)
MAC invites each Party including the US to nominate a person responsible for the disposition of R&D hardware and facilities. MAC requests them to clarify the ownership of the R&D hardware and facilities, and to establish the mode of disposition and associated cost for each item in the light of the MAC-CPs report presented at the MAC Meeting at Garching in July 1999 and that of the ISG at MAC10 by the end of December.

Joint Fund assets
MAC asked the Director, in consultation with MAC-CPs, to propose a uniform procedure for deriving depreciated values of Joint Fund assets in each Party and to report on this matter to the next MAC meeting.

MAC proposes to the ITER Council to ask the Director, in consultation with MAC-CPs, to define ways to deal with the outstanding issues of:
(1) approving the consolidated Annual Accounts of the Joint Fund for the 2000 budget;
(2) discharging the Director for the execution of this budget;
(3) discharging the Agents from their Joint Fund responsibilities, which can only be done after the end of EDA;

Closure of Joint Work Sites
MAC recognized that the obligation to provide host support shown in the compilation list will terminate at the end of the EDA.

ITER data
MAC urges the HTLs and the Director to finalize the work before the end of the EDA with circulating the final task reports after approval, according to agreed procedures.

MAC recommends ITER Council to ask the Director to distribute the documentation shown in point I.1.6 of the Technical Basis for the ITER-FEAT Outline Design to all Parties before the end of the EDA.

MAC recognizes the need to initiate discussions on ways how to handle data produced on facilities constructed during the ITER EDA and that would be operated beyond the end of EDA. MAC asks MAC-CPs to submit a draft principle at the next MAC meeting.

TWENTYSEVENTH EUROPEAN PHYSICAL SOCIETY CONFERENCE ON CONTROLLED FUSION AND PLASMA PHYSICS

by Yuri Igitkhanov, ITER Garching JWS

The 27th European Physical Society Conference on Controlled Fusion and Plasma Physics was held in Budapest, 12-16 June 2000, and was attended by leading fusion physicists from Europe and around the world. Many of the presented papers had direct relevance to ITER or touched on issues related to the physics of reactor plasmas in tokamaks and stellarators. About 10 invited papers were presented, covering a wide range of problems in plasma physics, including confinement and transport issues in fusion devices, astrophysics, and industrial application of plasmas. More than 100 papers were presented on plasma theory and experiments from tolamaks and stellarators. Important, ITER-relevant issues covered will be described below.

Scaling of edge pedestal parameters using the international Pedestal Database was presented (Hatae et al., JAERI). The multi-machine pedestal width scaling shows that the parameter dependence of pedestal width is rather different, e. g. some machines observe an ion poloidal Larmor radius dependence, while, in others, such a dependence is not observed. This scaling study was focused on the type I ELM (edge localised mode) regime, and presents a universal parameter dependence for the pedestal width. Based on this result it becomes apparent that the pedestal width scales with the size of machine. This is favourable for ITER.

The variation of confinement with elongation and triangularity in ELM-y H-mode had been tested on JET (Lomas et al., JET). It was found that the confinement scales strongly with plasma current and elongation, and weakly with the toroidal magnetic field, in a manner similar to the ITER scaling relationships. However, as previously demonstrated on both JET and ASDEX, and in contrast to the ITER scaling, these data show a degradation of confinement as the density is increased by gas fuelling. Both elongation and triangularity increase can counteract the confinement degradation with gas puffing, suggesting that the variation of the edge ballooning limit with shape plays an important role. In addition, vertical stability becomes an important consideration at high elongation, and, empirically, the plasma growth rate in H-mode plasma needs to be reduced by a factor two below that sustainable in L-mode plasmas in order to survive type I ELMs.

The dependence on density of the H-mode power threshold was analysed for different tokamaks. It was found that the L-H transition theory based on the Alfvén-drift turbulence stabilisation by increasing the edge beta can reproduce the power dependence on density in agreement with that seen in experiments (Igitkhanov et al., ITER). The theory gives a strong inverse proportional dependence of threshold power on density at low density in agreement with JT-60 and Compass data and predicts almost linear dependence on density at high densities seen in ASDEX and C-MOD. There is also an intermediate range of density where power is almost independent of density. This case corresponds to JET data.

The predictive modelling of JET shows that accumulation of fast particles near the separatrix could increase the pedestal width and explain experimentally observed differences between type I ELMs, induced by NBI and ICRH in JET (Parail et al., JET). Strong gas puffing in NB-heated plasmas could effectively reduce the fast particle population near the separatrix which brings ELM frequency to that of ICRF heated plasmas.

The edge electric field structure and the magnetic drift effect on the L-H transition was analysed in DIII-D (Carlstrom et al.,) It was shown that changing the direction of magnetic field causes up to a five-fold increase in the L-H power threshold but does not significantly alter the edge profiles of density and temperature near the plasma edge. This result indicates that additional physics, other than that involving the local edge profiles of density and temperature near the plasma mid-plane, is needed to describe the L-H transition. The plasma transition near the X-point shows substantial changes when the direction of magnetic field is changed, suggesting that physics associated with the X-point region may play a key role in determining the H mode power threshold.

Plasma contamination due to impurity release from divertor plates during ITER type I ELMs had been numerically investigated (Landman, Wuerz). Subsequent ELMs depositing their energy onto divertor plate might result in enhanced impurity production. First numerical estimations show that the maximum tolerable ELM energy is about 0.5 MJ/m^2, which is considerably lower for redeposited layers, occurring after disruption at the divertor plate, than for the virgin vertical target. It was also shown that released impurities between ELMs can contaminate the upstream SOL (scrape-off layer) region and concentrate near the X-point. Lateral deflection of the hot evaporated plasma due to the current flow in the vapour has been also found by numerical calculation.

Many papers were devoted to the physics of the internal transport barrier (ITB) and their role in advanced scenarios with enhanced core confinement. To be relevant for a reactor, these favourable confinement properties have to persist under conditions of predominant electron heating, and of close thermal coupling between electrons and ions. Thus the ion-electron energy exchange time/energy confinement time under nominal ITER conditions would have to be about ten times lower than in typical ASDEX ITB discharges. The reactor-relevant conditions were closely reproduced on JET where electron-ion thermalised plasma was obtained by ICRH heating following the production of strongly peaked density profiles by pellet injection (PEP mode). This observation was compared with theoretical predictions of transport models and stability analyses in a review talk (Lackner, IPP).

High density H-mode disharges with good confinement and small ELMs have been reported from DIII-D (Leonard, DIII-D). These discharges were made possible by a combination of gas puffing with divertor pumping. The gas puffing increases the pedestal density close to the Greenwald limit with little or no change in the pedestal pressure. At pedestal densities above this level the pedestal pressure begins to degrade as the pedestal temperature drops below about 200 eV. Initially, this results in a drop in the main plasma confinement due to stiffness in the electron temperature and flattening of the density profile. However, at higher densities the density profile spontaneously re-peaks to the pre-gas puff shape on an energy confinement timescale, compensating for the reduction in pedestal pressure and re-establishing good confinement. This density profile peaking occurs under conditions which enhance the neoclassical Ware pinch. These regimes, if sustained at high power, are promising for reactor conditions.

Projecting to ITER, it seems now that the difficulty to operate in type I-ELMy H-mode regime can be overcome by reducing the ELM energy and at the same time keeping good confinement by using pellets. A key point is to decrease the pedestal pressure by increasing ELM frequency by gas-puffing and to recover the associated reduction of H-factor by density profile peaking by pellet injection. Another possibility for reduced ELM energy with good confinement is alternative ELM regimes, i.e., Type II ELMy discharges. So far, all divertor tokamaks reported this regime. Most consistently, important parameters are high triangularity and high safety factor. This alternative regime can be employed as the reference operation for ITER (Sugihara, ITER).

Items to be considered for inclusion in the ITER Newsletter should be submitted to B. Kuvshinnikov, ITER Office, IAEA, Wagramer .Strasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: +43 1 2633832, or e-mail: c.basaldella@iaea.org (phone +43 1 260026392).
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