INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR

ITER EDA NEWSLETTER

VOL. 8, NO. 5 MAY 1999

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, AUSTRIA

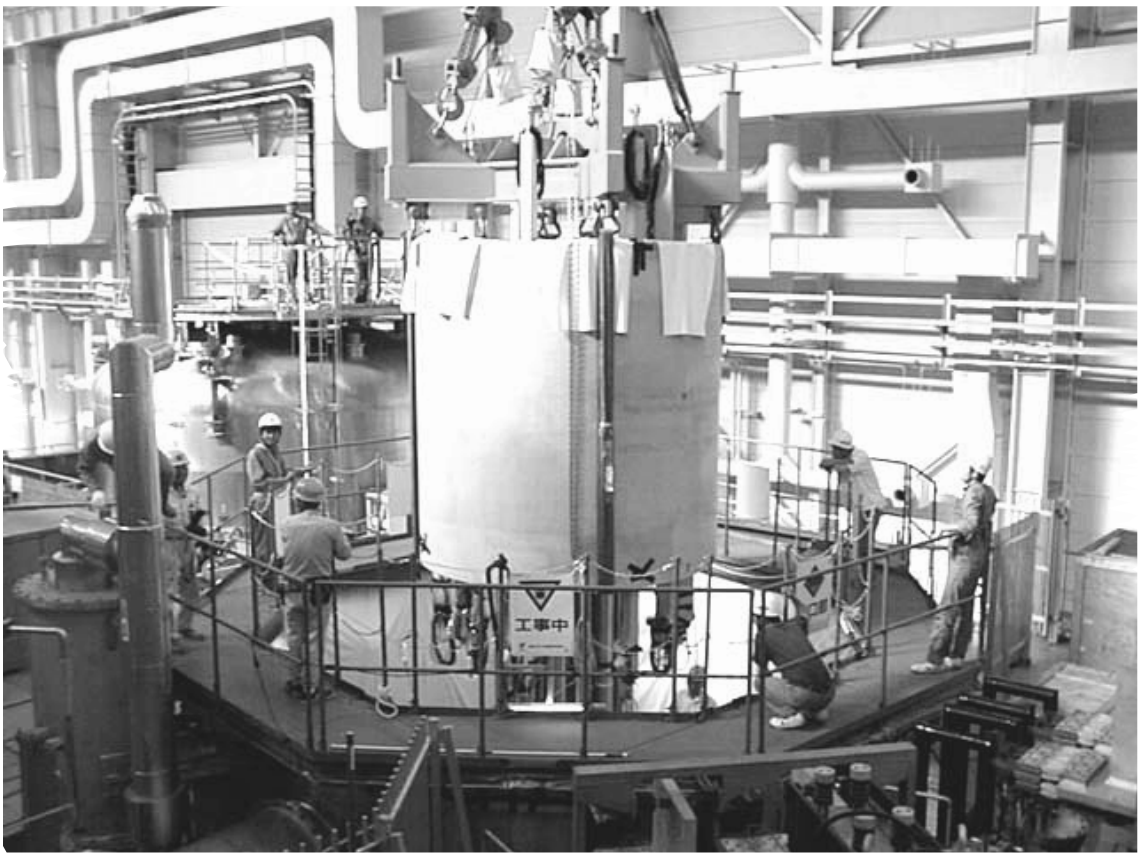
ISSN 1024–5642

INSTALLATION WORK AT JAERI NAKA FUSION RESEARCH ESTABLISHMENT

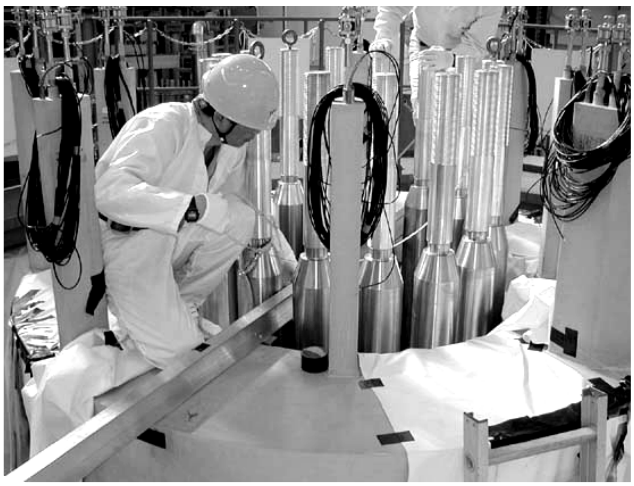
by Dr. H. Tsuji, Head, Superconducting Laboratory, JAERI-Naka

The following brief notes describe the sequence of events related to the installation of the two CS Model Coil Modules and of the CS Insert Coil in the testing vacuum tank at JAERI Naka Fusion Research Establishment.

Installation work of the CS Model Coil Inner Module was started on 2 June 1999 under the guidance of Dr. Rui Vieira, the US installation team leader. Firstly, the 16 inner tension rods made of stainless steel SS316LN (length 4.5 m, diameter 165 mm) and studs and nuts made of Inconel (M90) were installed in the vacuum tank using stud tensioners from the bottom side of the coil supporting structure. When several technical problems were resolved, all the 16 tension rods were installed on 9 June 1999. Then the CS Model Coil Inner Module, which is a 50-ton Nb3Sn coil, was lifted and carefully taken down towards the coil supporting structure in the tank on the same day.



CS Model Coil Inner Module being taken down towards the coil supporting structure



Quality Assurance inspectors checking the Inner Module position

On the next day, the Inner Module was landed on the supporting structure and Quality Assurance inspectors confirmed that the coil was placed correctly as designed. Therefore, the CS Model Coil Inner Module was successfully placed on the coil supporting structure in the vacuum tank on 10 June.

This day, 10 June, was the last day for Dr. Paul Gertsch of General Atomics to be at the Naka test site. He had been the Principal Engineer for the coil supporting structure for years. Many pieces of equipment and unique coupling tools that Paul designed demonstrated their high performance. All the installation team members at Naka, including myself, would like to express their sincere thanks for the significant contribution made to our joint efforts by Dr. Paul Gertsch, by Dr. John Wohlwend, the manager, and by their colleagues at General Atomics.

On 15 June, the CS Model Coil Outer Module took off the coil stand on which it had been waiting for this lifting day to come for 7 months and landed encircling the CS Model Coil Inner Module. The difference between the outer radius of the Inner Module and the inner radius of the Outer Module is a bit less than 10 mm and the height of the coils is 3 m. Due to this fact, special care was taken so as to position the Outer Module without damaging the insulating surface of both coils. Subsequently, the process of installation kept the team busy for almost 5 hours, but, as a result, the CS Model Coil Outer Module was successfully installed in the testing vacuum tank.

The CS Model Coil Outer Module taking off the stand

Finally, the CS Insert Coil was successfully inserted in the cylindrical narrow gap between the CS Model Coil Inner Module and the Inner Tension rods in the afternoon of 18 June. By this final step, all three model coils, namely the CS Model Coil Outer Module, the CS Model Coil Inner Module and the CS Insert Coil, of a total weight of 109 tons, have been successfully installed on the base supporting structure in the testing vacuum tank at JAERI Naka Fusion Research Establishment. No damage to the people involved or to the property happened in the process of executing this difficult task carried out in close collaboration between the US and the JA Teams.

In the evening of the last installation day, Tadashi Ichihara, the person responsible for the CS Insert Coil fabrication, left JAERI to return to Mitsubishi Electric at Kobe. For more than four years, he and his colleagues at Mitsubishi Electric had devoted their full skills and efforts to the fabrication of this Insert Coil, looking forward to the day to

come when the Insert Coil would be correctly positioned inside the CS Model Coil Inner Module. I assume that the beer he was probably drinking in the Japanese Shinkansen from Tokyo to Kobe had the taste of supreme happiness, combined with a comfortable fatigue. We are all very thankful to Tadashi Ichihara and his colleagues of Mitsubishi, as well as to Makoto Sugimoto, who was responsible for the CS Insert at JAERI, and to all the excellent engineers from Toshiba, MIT, LLNL and JAERI, who participated in the installation work.

From left: Mr. Nakahara, Head, Toshiba Plant Team, Mr. Ikeda, Head, Toshiba Installation Team, and Mr. Kato, JAERI, Leader of Installation, after the long, but happy day of June 15

Taking slowly down the Insert Coil, so as not to damage the insulating surface of the coils

REPORT ON THE COMBINED MEETING OF THE CORE CONFINEMENT & INTERNAL TRANSPORT BARRIER EXPERT GROUP, CONFINEMENT DATABASE & MODELING EXPERT GROUP AND EDGE PEDESTAL EXPERT GROUP, 12-16 APRIL 1999, GARCHING

by G. Janeschitz, J. W. Connor, G. Cordey, O. Kardaun, V. Mukhovatov, R. Stambaugh, F. Ryter, M. Wakatani

The first combined workshop of the Core Confinement & Internal Transport Barrier Expert Group, the Confinement Database & Modeling Expert Group and the Edge Pedestal Expert Group after the re-organization of the Expert Groups took place from April 12 to 16 in Garching. The meeting was started with a 1.5 day plenary session where the main confinement and pedestal physics issues related to their behavior on present day machines and their extrapolation to ITER were presented in the form of overview talks. The rest of the week was spent with more specialized presentations in subgroups of the combined workshop which in some cases consisted of 2 or 1.5 expert groups and in some cases only of a specialized subgroup (i.e. modeling or H-mode threshold subgroup). The contents of the presentations from the plenary session and from the majority of the subgroup meetings are summarized in abstracts which can be found in the minutes of the meeting. Due to the workshop character, 1/3 of the time for each presentation was reserved to discussion, and a more general discussion of 1/2 to 1 hour length took place at the end of each plenary or combined session. Later in the week working meetings (database work) as well as discussion sessions (physics and future program) took place in subgroups. The results of these subgroup meetings are summarized below.

Confinement Database and Modeling Expert Group: Resume of Discussion Sessions

Chairman: G. Cordey

G. Cordey gave a brief summary of the status of the global confinement scalings as documented in the ITER Physics Basis Document and a PPCF article by O. Kardaun. A contribution to the coming H-mode workshop by J. Ongena together with the confinement database group is planned with a paper entitled.: "Density and Shape Dependence of Energy Confinement in Relation to the ITER Physics Basis Scalings". The aim is to better understand the behavior of the confinement versus density, i.e. the discrepancy between a positive density dependence in the existing scalings (positive NEL coefficient) and the degradation seen in most H-mode data from different machines at high density. Besides this specific study a wider investigation of the relation between triangularity / elongation with the energy confinement as well as the effect of density peaking will be performed. Edge data, i.e. data at pedestal top, and their contribution to / impact on confinement should be analyzed for all devices. In terms of improvements to the databases the following is planned:

1. Merging of edge pedestal and global confinement data using SQL server technology. Analysis will be performed with SAS or IDL.
2. Improvement of the density- and magnetic shape parameters (possibly with error estimates)
3. Add new dedicated threshold data (e.g. TCV add lower threshold data; see also below), add AUG hydrogen data, add new scans from C-Mod, JET Gas box data, JT60U, T10 and, if possible, TdeV and START;
4. The effect of different divertors in JET. An update of the database should be available by July 31.

H-Mode Power Threshold Database

Chairman: F. Ryter

A new version of the H-mode power threshold database has been assembled. About 650 time points from 10 tokamaks are now used for the standard analyses with global parameters yielding results similar to the previous ones. The set of local edge data now included in the database is considerably improved. The dependence of the edge electron temperature on the plasma parameters is similar in all the devices, allowing the investigation of its size dependence at the L-H transition. The isotope dependence of both the global and the local analysis was also investigated, yielding results in agreement with JET.

New experimental data soon to be contributed to the database were presented. In Alcator C-Mod, a new scan of the threshold transition yields important edge data. In an extended series of more than 40 discharges performed in JT-60U with the new pumped W-divertor, where the density was scanned to above 50% of the Greenwald density, a reduction of the power threshold was observed, in comparison with the results of the previous campaigns. The density dependence is still being analysed.

The suggestion made at the last meeting to perform regularly a standard H-mode shot in each device in order to investigate threshold data scattering could be partially achieved. In some cases data are already available which will be analysed for the next meeting. In ASDEX Upgrade the standard H-Mode shot performed regularly since the beginning of the present operating period yields interesting results on machine conditioning. The scattering of the power threshold is small (7.5%) after a rather short phase of machine conditioning in which the basic effect was to reduce the hydrogen concentration.

A session was dedicated to the observations made in the different devices which may suggest physics origins of the L-H transition. Interesting new edge potential measurements with the heavy ion beam diagnostic in JFT-2M at the L-H transition were presented. The H-mode power threshold studies with ECRH in TCV confirm those from COMPASS: the power threshold is higher than in the usual case by up to a factor of 5. This may be related to the low density limit of the H-mode power threshold and to the role played by ions and electrons. The importance of the divertor in the L-H transition is not clear: whereas closed divertors are thought to be essential to reduce the

L-H power, "strong enough" pumping is probably also required. The position of the X-point also seems to be an important element. New detailed measurements of edge parameters from DIII-D suggest that the well-known effect of the ion grad B drift on the power threshold may be in contradiction with the hypothesis that only edge data in the main chamber control the L-H transition.

ITER 1-D Modelling Workshop: Resume of Transport Modelling Session

Chairman: J.W.Connor

D.Mikkelsen presented his work on comparing critical temperature gradient lengths from ITG linear stability theory with data from C-MOD. In C-MOD the plasma is expected to be close to marginal stability, but it appears to greatly exceed the theoretical predictions of the Ti gradient. Several issues must be clarified before a firm conclusion can be made. R.Waltz described perturbative tests of transport models. Investigations of TEXT cold pulse reversal experiments in ohmic discharges led to the conclusion that non-local transport models are not necessary to explain the rapid propagation. Temperature coupling (in those models that depend on Ti /Te) is essential to explain pulse reversals. The DIII-D ECH pulse modulation experiments did not see pulse reversal in the electron channel but did see reversal in the ion channel. Considering five transport models it was found that no single model could explain the amplitude and phase reversal in all experiments. X.Garbet presented work on transport close to stability thresholds. It has been shown recently that turbulence simulations at fixed flux exhibit large scale transport events. This behaviour has been studied with a low dimensional model for the evolution of the turbulence level and the profiles. This model shows that the transport is diffusive over large spatial and time scales. However, it also shows that a perturbation may propagate ballistically, with a velocity proportional to the square root of the flux. Driving this system with a stochastic source shows transport events similar to those in the simulation. W.Houlberg described evidence for ion temperature gradient screening of impurities in DIII-D VH-mode plasmas obtained with the aid of the NCLASS code and charge exchange spectroscopy. The rapid change of impurity profile shapes after the V-H transition allows determination of diffusive and convective properties of both intrinsic and injected impurities, and the reduced level of turbulence allows comparison with neoclassical theory. Substantial agreement is found in analysis of He +2 to Ne+10, which exhibit the neoclassically predicted temperature screening. Even modest levels of the ratio of neoclassical to turbulent diffusivities should lead to hollow ITER impurity profiles.

ITER 1-D Modelling Workshop: Resume of Working Sessions

Chairman: J.W.Connor

The group discussed how the ITER profile database work would be carried forward following the reorganisation of the JCT. The database and associated software had been installed at Garching and would be installed at Naka in the coming two weeks. Naka would be the main centre for management of the database. The group agreed to frame a proposal to detail the work that was required for management of the database and the role to be played by members of the group. This would give some idea of the effort that could be required from technical support at Naka. It was agreed that it would be the responsibility of the group to maintain contact with data providers to get experimental data in to the database.

The group agreed to proceed with the preparation of a paper on the profile database for submitting to Nuclear Fusion. The contents and outline arrangement of the paper as well as the responsibility for sections assigned to group members were discussed. The group also discussed ideas for the content of a Nuclear Fusion paper on their modelling work. The paper will contain a study of how the goodness of fit for model predictions is correlated with various physics parameters in order to shed light on the causes of inaccurate predictions.

Other topics discussed included: benchmarking issues; improvements to model discrimination and the need for an ITER-RC target discharge on the profile database server.

Pedestal Expert Group: Resume of Discussion Sessions

Chairman: R. Stambaugh

The Pedestal Group is a new expert group formed to focus on the issues of the H-mode shear layer at the plasma edge.

The Pedestal region is the region between the core and the divertor regions, receiving from and supplying to boundary conditions from both. The main issues in the Pedestal region are L-H transition physics, H-L transition physics in connection with the density limits, the limiting pressure gradient in the Pedestal, the width of the Pedestal, and the Edge Localized Modes (ELMs). The physics in the Pedestal region is necessarily a mixture of plasma, neutral and impurity effects. The physics studies necessarily involve mainly details of strongly varying edge profiles.

The Pedestal Group sees its principal areas of study as:

1) L-H transition physics
2) H-L transition physics (connection to density limits)
3) Type III ELM boundaries
4) Type I ELM boundaries
5) The stability physics setting the maximum pressure gradient
6) The physics setting the width of the Pedestal.
7) The MARFE boundary
8) ELM Physics generally
9) Guidance to the Confinement Groups on which Pedestal regimes lead to stiff or not stiff core transport behavior.
10) Guidance to the divertor group on plasma parameter compatibility with Pedestal physics allowing good confinement (e.g. minimum ratio of line average to separatrix density).

Initial results from the Pedestal database analysis (assembled by the divertor expert groups during EDA) were presented in the plenary session by G. Janeschitz and M. Sugihara on the impact of the Pedestal temperature on the core confinement behavior and on a physics based pedestal width scaling, respectively.

The Pedestal Group agreed on developing measures and on creating a more flexible database that can be readily used to relate developments in theory to experimental data.

Looking to the forward program on possible experiments on various machines, it was decided that a list of people to be agreed, by e-mail, each responsible for a specific issue to be investigated, will be developed. This lead person is then required to discuss experiments and analysis to be performed on each machine with the other members of the pedestal group by e-mail. Progress on this and adjustments to this type of organization will be discussed at the next meeting.

ITB Issues and Forward Programme: Executive Summary of Working Session
Chairman: M.Wakatani

Tokamak regimes with weak or negative central magnetic shear (NCS) and internal transport barriers (ITBs) demonstrating improved confinement relative to the ELMy H-mode are considered as likely candidates for steady-state high-Q operation of RTO/RC ITER. These regimes are, however, significantly less developed than the H-mode. In particular, high performance regimes are often transient, and there is no scaling for the threshold power extrapolable to reactor grade plasmas. At these Sessions, the present status of experimental studies of ITBs was reviewed by P.Gohil. Recent data on ITB formation were presented by T.Fukuda (JT-60U), X.Garbet (Tore Supra), G.Sips (JET) and E.Barbato (FTU). Results of theoretical analysis of stability of NCS configurations were presented by M.Wakatani. The summary of a recent USA Workshop on the Physics Requirements for Advanced Tokamaks was presented by P.Gohil.

The "ITB properties" have been identified by the ITER Physics Committee Meeting (Naka, Oct. 1998) as one of the 1999 urgent research areas which includes prediction of the threshold heating power for ITB formation in RTO/RC ITER as a near-term task. Although a number of important experimental and theoretical results have been obtained in this area, prospects for accessibility of ITBs in the RTO/RC ITER remain unclear. Systematic studies of ITB formation in individual tokamaks have just begun, and initial results are not always consistent with each other (e.g. BT dependence of the threshold power in JT-60U and JET).

It has been agreed that a parameter space of plasmas with ITBs in each machine will be defined and presented at the next Workshop of the Core Confinement and ITB Expert Group as a first step in assembling the ITB Threshold Database. Prospects for non-dimensionally identical experiments, addressed the ITB formation conditions were discussed in brief; they were considered premature.

Concluding remarks

The new scheme of Expert Group meetings agreed at the last physics committee meeting, namely to permit more interaction between expert groups with strong interfaces, by arranging the meetings at the same time and the same location turned out to be very successful. The mixture of plenary and subgroup sessions allowed information and ideas to be exchanged between the different expert groups and subgroups (topic groups), at the same time permitting detailed and specialized discussions within each expert group or topic group. The feedback we received from the different members and additional experts who participated in the meeting was generally very positive and in some cases even enthusiastic.

The next combined meeting of these three expert groups will take place during the last week of September, adjacent to the H-mode workshop. However, the first meetings in spring 2000 are planned to be a combined meeting of the Pedestal Expert Group with the Divertor Expert Group and of the Confinement Database and Modelling Expert Group with the Core Confinement & Internal Transport Barrier Expert Group, respectively.

List of Participants

EU: T. Aniel, E. Barbato, G. Becker, D. Campbell, J. Connor, G. Cordey, X. Garbet, L. Horton, O. Kardaun, Y. Martin, J. Neuhauser, J. Ongena, H. Pacher, C. Roach, E. Righi-Steele, F. Ryter, A. Sips, J. Snipes, J. Stober, W. Suttrop, K. Thomsen, M. Tokar, M. Turner, M. Vaovic, J. Weiland, H. Weisen, H. Wobig, R. Wolf

JA: T. Fukuda, T. Hatae, Y. Miura, N. Ohyabu, T. Takizuka, K. Toi, M. Wakatani

US: T. Carlstrom, C. Chang, J. DeBoo, P. Gohil, W. Houlberg, A. Hubbard, D. Mikkelsen, T. Osborne, F. Perkins, R. Stambaugh, R. Waltz

RF: V. Vershkov, A. Chudnovski

JCT: Y. Igitkhanov, G. Janeschitz, H. Matsumoto, V. Mukhovatov, M. Shimada, M. Sugihara

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).

Printed by the IAEA in Austria
July 1999

99-02142