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SECOND INTERNATIONAL INDUSTRIES' LIAISON MEETING

by Y. Kaneki, Japan Atomic Industrial Forum, IILM-2 Co-ordinator

The Second International Industrial Liaison Meeting (IILM-2), organized by the industry in order to informally discuss topics related to ITER as a construction project, was held in Tokyo on 2-4 April 1997. Following an initiative of the ITER Council, the first of these meetings was held in San Diego, USA. At this meeting, opinions were exchanged on what role the industries of the ITER Parties might play in the construction of ITER, thus deepening the mutual understanding among the industries of the four Parties.

At their first meeting, the industries decided to meet again on a regular basis, in order to be informed by the ITER management on the progress and on current issues and to provide the ITER management with information and opinions regarding the practical implementation of the ITER project.

At that time, Japan assumed the responsibility to prepare and to host the second Meeting; the author of this article served as co-ordinator. The Meeting was attended by members of industries from Europe, Japan, Russia, and the USA. The number of attendees was restricted in order to ensure good contacts among the participants and to proceed with the discussions in the most efficient manner. The ITER Parties' Fusion Program Directors (or their representatives), the Home Team Leaders of each Party, the ITER Director and staff members of the JCT were invited to attend the meeting as guests. The complete list of the meeting participants and guests is shown at the end of the article.

At the Meeting

The purpose of IILM-2 was to:

- discuss the key issues and topics of highest interest and priority for the construction phase;
- explore the industries' potential roles in the ITER construction;
- exchange views and information between the industry and the ITER management;
- build up relationships for future interactions among the Parties' industries.

The attendees had an open and useful exchange of information and ideas on various issues related to the ITER construction phase and further developed mutual understanding.

Presentations were made by the four ITER Parties' Fusion Program Directors (or their representatives) on the Parties' Fusion Programs and by the ITER Home Team Leaders on the industries' participation in the Parties' ITER Engineering Design Activities.

The ITER Director, Dr. R. Aymar, gave an overview of recent ITER project activities and presented his own ideas on some post-EDA organizational issues.

Open discussions and question and answer periods followed these presentations.

The discussions at the Meeting focused on four pre-selected meeting topics for which the industrial attendees brought previously prepared position papers to the meeting. These topics were:

1. Industrial involvement within the Project structure (architect engineering)
2. Procurement strategy and management
3. Industrial participation of suppliers of equipment/systems and services
4. Expansion on the ideas presented by Japan at IILM-1 to have each Party's industries involved in the development of key technologies.

The results of the meeting discussions are summarized as follows:

Topics 1 and 2: These topics were considered to be closely related since the choice of the project organizational structure, as well as the extent of in-kind contributions, will largely determine the possible procurement strategies available.

Several organizational models were discussed. One possibility would be to have a line management (vertical) structure, namely of owner, prime contractor, major subsystem subcontractors, and industrial suppliers. Another organizational structure relies on "domestic agencies" within the Parties, to be responsible for contracts and procurements involving in-kind contributions. Intermediate organizational models were also discussed. All these models have one feature in common: an owner (ITER Legal Entity) at the top and industrial suppliers at the bottom. The discussions concentrated, therefore, on the central parts of the organizational structures.

As a conclusion, the majority of the attendees was of the opinion that the organizational model must be compatible with the in-kind contributions for the ITER construction phase.

Topic 3: The general feeling after the meeting was that the suppliers of subsystems and components procured under functional specifications should generally be required to be responsible for the performance of their products. For subsystems and components procured under build-to-print or detailed design specifications, the primary responsibility should remain with the organizational entity which accepts the responsibility for the design.

Topic 4: Major attention was paid to the following points:

- the value received by each Party should be related in some way to its level of contribution;
- all Parties of the ITER Construction Phase should have access, at least in principle, to the key technologies;
- access to key technologies, beyond the Party's proportional share of procurement, might have to be at its own (extra) expense;
- the question of access to the key technologies is also related to the use of multi-Party consortia (if formed).

The EU industries will host the third IILM in Europe, hopefully to be held next spring.

LIST OF ATTENDEES

EU

Mr. Feliciano Fuster Jaume, Point of Contact, Honorary Chairman of ENDESA, European CFI Chairman (Spain)

Mr. Sergio Barabaschi, President of ANSALDO RICERCA, Chairman of EIRMA (Italy)

Mr. Adolf Becker, representing AGAN, Senior Marketing Manager for Nuclear and Special Projects, Noell KRC Energie und Umwelttechnik GmbH (Germany)

Mr. Joaquin Calvo, Technical Cabinet Director of ENDESA Group (Spain)

Mr. Alain Vallée, representing EFET, Vice-President Corporate Research and Technology, Framatome (France)

* Dr. Charles Maisonnier, Special Advisor for Thermonuclear Fusion (representing the EU Programme Directorate), European Commission

* Prof. Romano Toschi, EURATOM ITER Home Team Leader

* Mr. M. Bourène, Scientific Advisor to the Delegation of the European Commission in Japan

Japan

Mr. Yuji Kaneki, Point of Contact, General Manager, Department of Development Policy Promotion, Japan Atomic Industrial Forum, Inc.

Dr. Tsutomu Honda, Senior Manager, Nuclear Fusion Development Department, Toshiba Corporation

Dr. Osami Okada, Senior Staff, Nuclear Fusion & Accelerator Project Division, Hitachi, Ltd.

Mr. Haruhiko Tomita, Manager, Engineering Department, Mitsubishi Fusion Center, Mitsubishi Electric Company

* Dr. Masaji Yoshikawa, Program Director, ITER Council Co-Chair, President, JAERI

* Dr. Shinzaburo Matsuda, Japan Home Team Leader, General Manager, Department of ITER Project, Naka Fusion Research Establishment, JAERI

Russia

Prof. Edouard Kolpishon, Head of Department, JSC "Izhorskie Zavody" Ltd.

Prof. Yuri I. Vishnevski, President, General Director, JSC "High Voltage Apparatus Research Institute"

* Dr. Yuri A. Sokolov, ITER Council Member, Head of Department "R&D on Atomic Science and Technology", Ministry of the Russian Federation for Atomic Energy

* Dr. Oleg G. Filatov, Point of Contact, Russian Federation Home Team Leader, Director, STC "Sintez" Efremov Institute

USA

Dr. William R. Ellis, Point of Contact, Vice President, Advanced Technology, Raytheon Engineers & Constructors, Inc.

Dr. Stephen O. Dean, President, Fusion Power Associates

Dr. Harold Forsen, Senior Vice President, Bechtel (ret.)

Mr. Chris Hamilton, Manager of Technology and Business Development for Fusion, General Atomics

Dr. Samuel Harkness, Director, Research & Development Opeations, Westinghouse Science and Technology Center

* Dr. Milton Johnson, Deputy Associate Director for Fusion Energy Sciences, Office of Energy Research, Department of Energy

* Dr. Charles C. Baker, US Home Team Leader, University of California at San Diego

* Dr. Robert Aymar, ITER Director

* Dr. Yasuo Shimomura, Deputy to the ITER Director

* Dr. Michel Huguet, Deputy Director, Head, ITER Naka Joint Work Site

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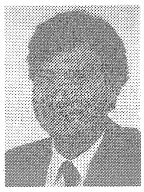
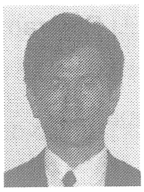
* Invited Attendee

THE ITER BLANKET PROJECT OVERVIEW *

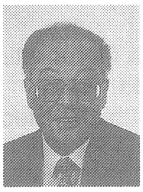
by Drs. A. Cardella, K. Ioki (ITER Joint Central Team), W. Daenner (EU Home Team)



Antonio Cardella (Dr. Ing., nuclear engineering, University of Palermo) joined the JCT at the Garching JWS in September 1993. He is Deputy Project Manager of the Blanket Project and responsible for the limiter and baffle design. Prior to joining ITER he worked from 1978-1982 on the design and manufacturing of components for nuclear reactors. Since 1982 he has been working for the design and R&D of plasma facing components of fusion reactors, firstly at the JRC Ispra and since 1984 at the Max Planck Institut fuer Plasmaphysik, as a member of the NET Team responsible for the development of the divertor system. In 1993, he has been nominated associate professor at the University of Palermo, Italy.



Kimihiro Ioki received his B.Sc. in physics, M.Sc. in nuclear physics, and Ph.D. in nuclear engineering from the University of Tokyo, Japan. He is Head of the Vacuum Vessel and Blanket Division within the ITER Joint Central Team. Dr. Ioki is on secondment from Mitsubishi Heavy Industries to JAERI. He was Deputy General Manager and Group Leader of the Mitsubishi Fusion Center (1992-1993), Deputy Project Leader and Group Leader of Mitsubishi JT-60U Vacuum Vessel Project (1988-1991) and has been working on the design and fabrication of the vacuum vessel, blanket and plasma-facing components for JFT-2M, JT-60, JT-60U, FER and ITER.



Wolfgang Dänner joined the NET Team in 1983 as a member of the Nuclear Engineering Group. In this function, he contributed with his experience in neutronics and blanket design to the ITER CDA. Today he acts as the Field Co-ordinator for Vessel and In-Vessel Components in the ITER EU HT. In July 1995, he was appointed HT Co-manager of the Blanket Project. Prior to his delegation to NET, he worked for 7 years at the Karlsruhe Nuclear Research Center, before joining IPP Garching in 1970 to apply his nuclear technology know-how to the emerging field of fusion technology. Dr. Dänner holds a degree from the Munich Technical University, and was promoted to Dr.-Ing. at Karlsruhe Technical University.

Introduction

The ITER Shield Blanket includes several types of components: the shield modules, with their integrated first wall (FW), filler shields, special port modules, and the backplate (BP) which is the main supporting structure for the modules. The shield modules are subdivided in primary wall, limiter and baffle, according to the function of their FW. Additional essential design elements are the module attachment system, and the electrical and hydraulic connection.

The blanket project (ITER R&D L-4 Project) is organized as a collaborative effort of the four Home Teams (HTs) who involve both research laboratories and industry in the development activities. The project encompasses all relevant R&D activities which should finally lead to the demonstration of the fabricability of the most important components of the ITER device by July 1998. The objectives of the project are:

1. to demonstrate the fabricability of the blanket components,
2. to demonstrate their ability be integrated/assembled,
3. to demonstrate the performance of their key engineering features, and
4. to confirm design choices by results of supporting R&D.

While most of the prototypes are now entering into the construction phase, the supporting R&D in the neutronics, materials and fabrication techniques has already produced important results which are relevant to blanket system and fusion technology in general.

Project Management

The Deputy Director, Head of the ITER Garching Joint Work Site, and the EU HT Leader share the project responsibility. The project is also jointly managed by the ITER JCT and the EU HT. The project management scheme is shown on the following page.

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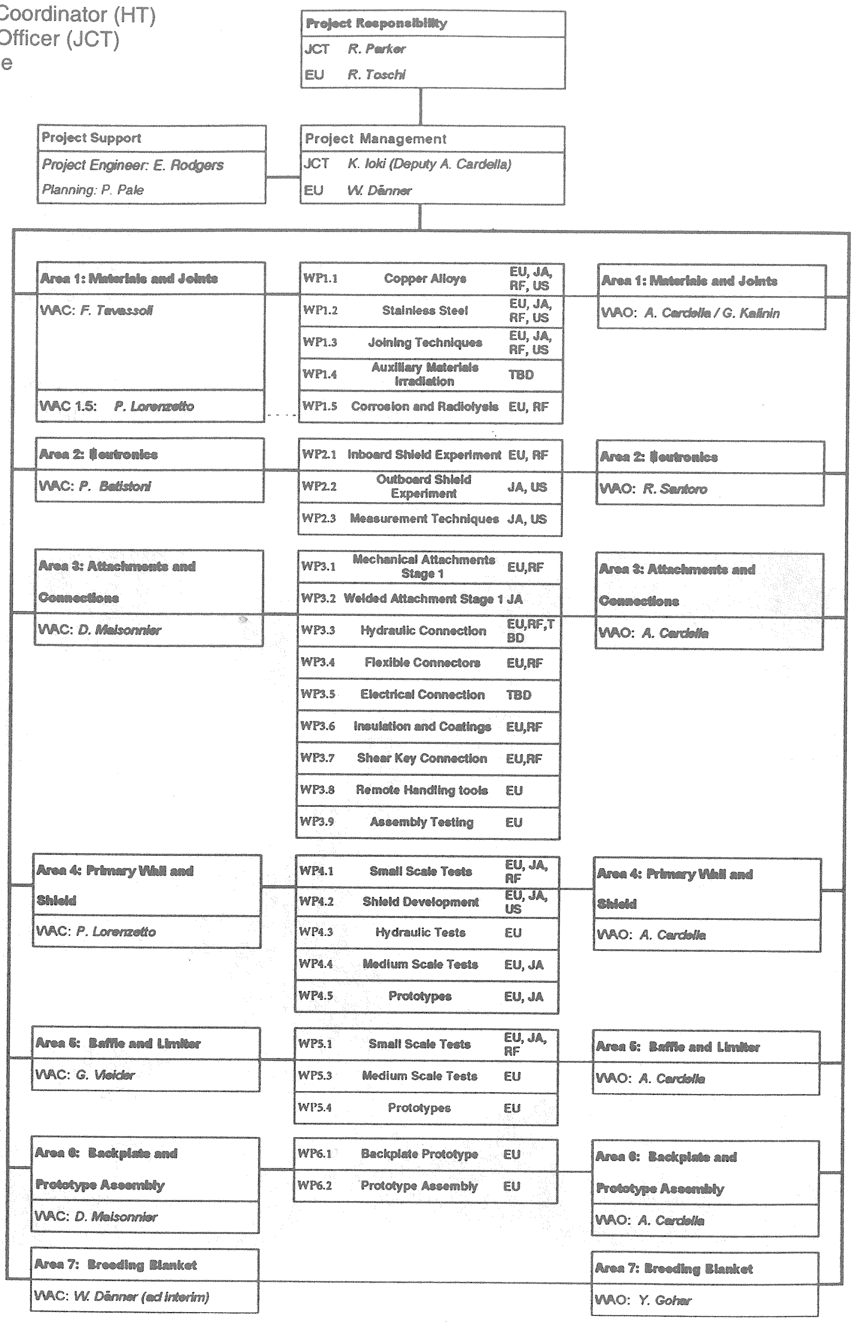
* This is the sixth article in a series describing the Seven Large ITER R&D Projects. For the previous articles in the series see Newsletter, Vol. 5, Nos. 8 and 9, and Vol. 6, Nos. 2, 3 and 4.

WAC=Work Area Coordinator (HT)
WAO=Work Area Officer (JCT)
WP=Word Package



BLANKET PROJECT MANAGEMENT SCHEME

Materials R&D

The following main materials are being selected and characterized:

- Stainless steel (SS) 316 LN which has been selected as the reference structural material for the blanket system because of its extended database.
- Dispersion strengthened copper (DS-Cu) Glidcop Al25-IG and, alternatively, precipitation hardened CuCrZr IG which have been selected as heat sink materials for the FW in order to increase its thermomechanical and thermohydraulic performances.
- Beryllium (S65C) as armour material for most of the first wall (carbon fibre composite is also under consideration as a back-up solution for limiters).
- Tungsten alloy as armour for the lower baffle modules.
- Special fitting materials (Inconel 718 and 615, Titanium) and coatings for the mechanical attachment system.

Screening experiments among various candidate alloys have been performed before selecting these reference materials. The characteristics of some of these materials have been improved through a close collaboration with the supplier. Special ITER grades have been defined and characterized.

An extensive R&D has also been devoted to the joining techniques. After trials on several technologies, the preferred technology for joining SS to SS and Cu alloys to SS is the solid to solid HIP (hot isostatic pressing). The R&D on the beryllium, tungsten and carbon fibre composites joints to the Cu alloy heat sink has been performed in conjunction with the divertor program. Silver-free brazing, HIP and active metal casting are the best choices. Characterization and tests on these joints have been performed. As a result of the R&D remarkable improvements in the joint technologies have been achieved. These technologies could be also applied in fields other than fusion.

Irradiation experiments have been initiated to study and characterize the effects of neutrons on the materials and their joints. These experiments will be extended up to the end of the EDA.

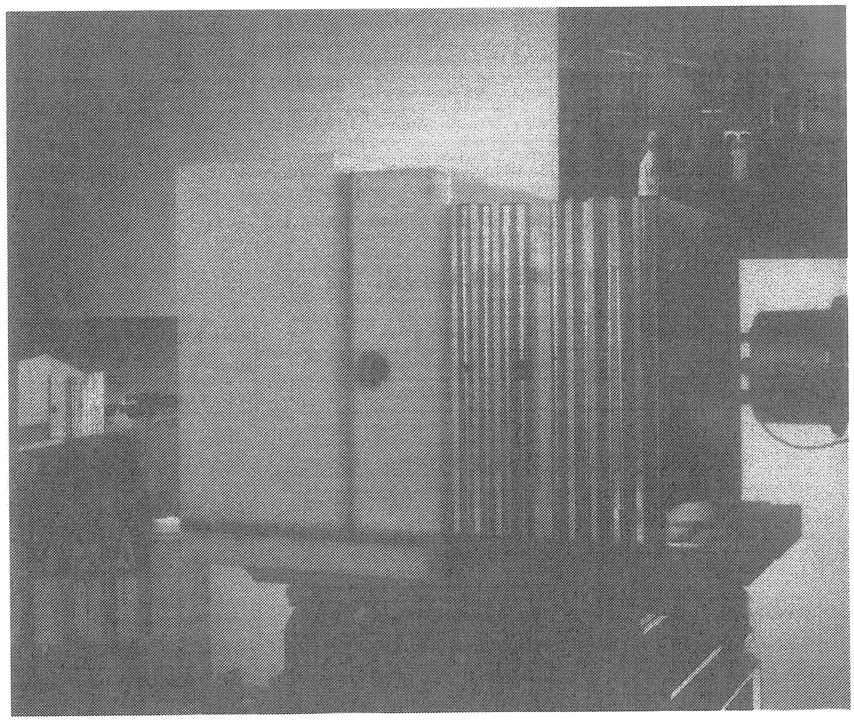


Figure 1. Neutronic Shield Experiment (EU HT)

Corrosion and Water Chemistry

Aqueous corrosion of 316 LN stainless steel is being investigated with special emphasis on stress corrosion cracking (SCC) phenomena, irradiation-assisted stress corrosion cracking (IASCC), and corrosion fatigue, in particular for HIPed materials. The results are expected to confirm, by the end of the EDA, the suitability of 316 LN IG stainless steel for the specific ITER operation conditions. Water radiolysis and its prevention by dissolved hydrogen is being studied by means of irradiation simulating the proper range of linear energy transfer. The results will be used as benchmark for computer codes and for the specification of the proper water chemistry for the coolant.

Neutronics Experiments

The neutronics performance of the shield blanket has been validated by experiments undertaken by EU, JA, RF and US on mock-ups of bulk shield and toroidal field coils and of shield with gaps. The experiments have recently been completed. The planned measurements (nuclear heating, neutron and gamma spectra, thermal and fast neutron reaction rates) and the associated analyses have been carried of according to the task workplan.

One of the main achievements of the task has been the assessment of the reliability of MCNP computer code predictions, and the adequacy of FENDL-1 nuclear data, which are the reference tools for the ITER design. Precision was found within +/-30% for relevant nuclear responses up to 1 m of penetration depth.

Ad hoc experiments were carried out on nuclear heating and on induced radioactivity in samples of relevant structural materials for data validation. The measured data showed a good agreement with calculated data in general; the materials showing discrepancies were identified. Furthermore, improved techniques for measuring nuclear heating and radioactivity are being developed and applied to extend the experimental range to the low levels expected at the superconducting toroidal field coils. One of the experiment assemblies is shown in Figure 1 on the previous page.

Blanket Modules R&D

At present, two main fabrication routes are under consideration and testing for the shield modules: solid HIP of plates with tubes accommodated inside premachined grooves and powder HIP with metal powder consolidated around a prefabricated tube gallery. They are expected to differ in the achievable tolerances, in the degree of controllability and in specific cost.

The development of the shield blanket component is performed in two main stages. In the first, small-scale mock-ups have been manufactured using the technologies developed in the materials and joint work area. These mock-ups have been tested in order to assess their performances. Additional FW mock-ups are being manufactured to perform long-term tests (up to the full nominal number of cycles foreseen for ITER) in order to assess the fatigue lifetime of the FW. The two HIP options have already been successfully demonstrated (with the copper first wall included). A major subject of optimization is the number of HIP steps which need to be performed to manufacture the module with its integrated FW.

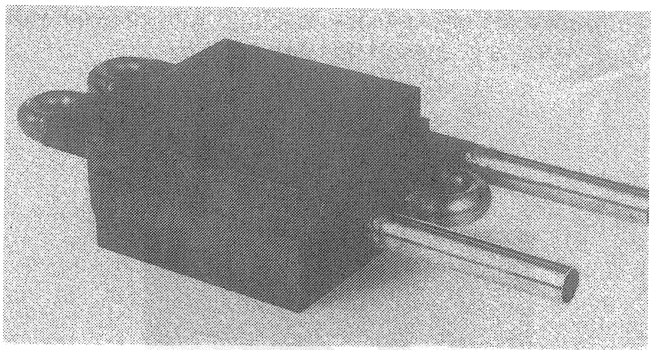


Figure 2. First Wall Mock-up with Be Armour (EU HT)

Figure 2 shows an EU primary FW mock-up which includes 316 LN, DS-Cu and beryllium and which was successfully tested for 1000 cycles under four times the nominal heat load. In Figure 3 (overleaf) baffle mock-ups with the armour in tungsten and carbon fibre composites are shown. Figures 4 and 5 show JA FW and shield mock-ups and Figure 6 shows an EU solid HIP shield mock-up.

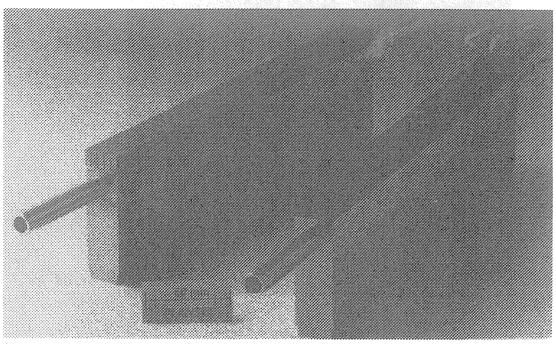


Figure 3. Baffle Small-Scale Mock-Ups with CFC and Tungsten Armour (EU HT)

JA HT low cycle fatigue tests of small-scale FW mock-ups fabricated by HIP bonding have confirmed that they have sufficient fatigue lifetime against repeated mechanical and thermal cycles, much longer than the design fatigue curve or even longer than the raw fatigue data obtained by the material tests.

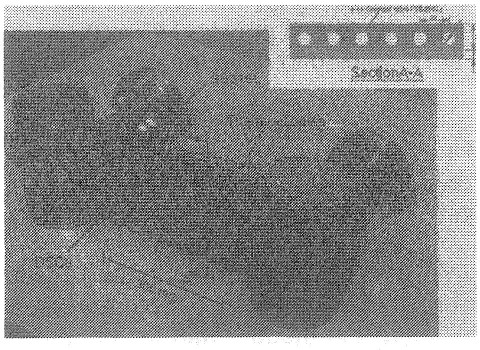


Figure 4. FW Mock-Up (JA HT)

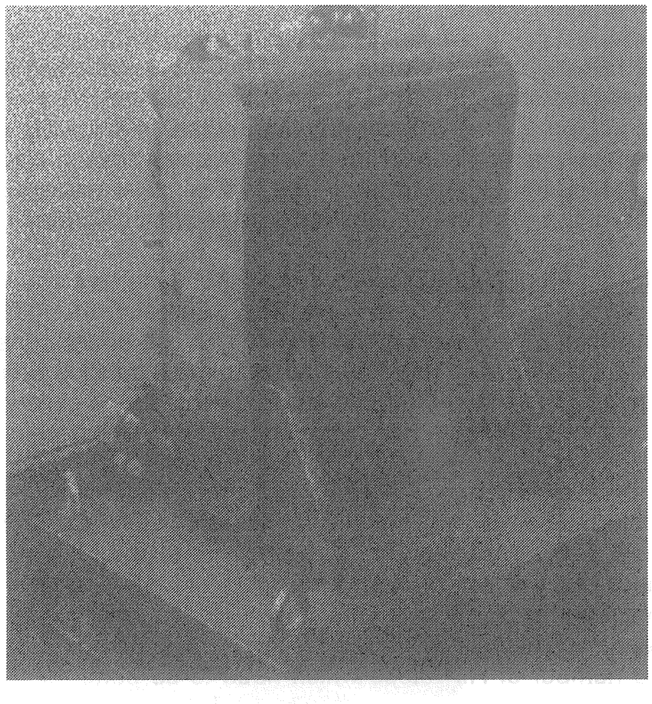


Figure 5. Solid HIP Blanket Module (JA HT)

The JA HT has successfully completed fabrication of medium-scale mock-up with solid HIP technology and the EU HT has just completed fabrication of large-scale shield block mock-up with powder HIP technology. The applicability of fabrication route and methods proposed has been cofirmed.

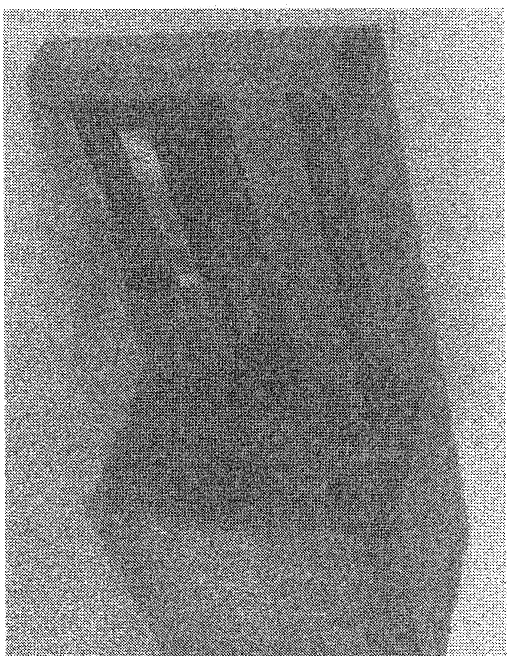


Figure 6. Solid Hip Blanket Module (EU HT)

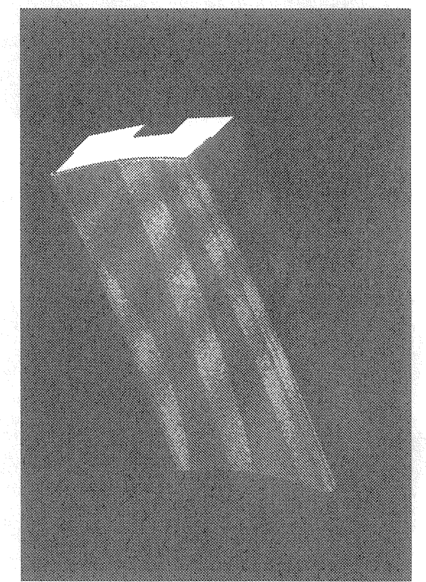


Figure 7. Model of the Blanket Module Prototype (EU HT)

In the second stage medium scale mock-ups and prototypes are being manufactured. Fig. 7 shows one of the primary module prototypes. the medium scale mock-ups due to their limited size will be tested in thermomechanical test facilities. The prototypes will be assembled on the backplate prototype in order to demonstrate the component integration. Destructive tests will follow in order to have a final assessment of their fabricability and collect data on tolerances.

Attachments and Connections

To decide between mechanical and welded attachment of the modules onto the backplate, initial R&D on both options has been completed last year. For a mechanical system basic qualification tests have successfully been conducted to find the optimum coatings for seizing prevention. The welded attachment was investigated with respect to shrinkage and distortion effects during narrow gap tig welding. Plasma cutting tests have been performed as well and the possibility to collect the cutting debris has been demonstrated with a device integrated into the module. At the end of this development phase, the mechanical attachment system has been selected, and now the project is focused on its development by manufacturing and testing parts of it.

Backplate Prototype

The backplate is a key part of the blanket system. It is a large double walled shell structure. Its realization is a major technological challenge because of its size and complexity. The manufacturing feasibility will be achieved by manufacturing a large-scale prototype of one BP sector (see Figure 8). The development of suitable techniques to minimize the welding distortions and collection of relevant data on the manufacturing tolerances are the main goals of the prototype.

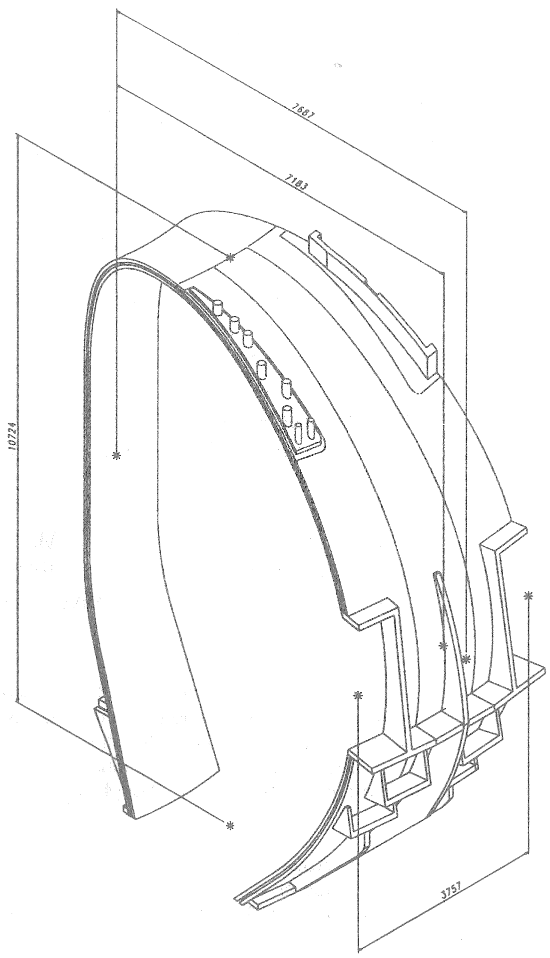


Figure 8. Backplate Sector

Conclusions

The execution of the project is a challenging task requiring close co-operation between the JCT and the Home Teams because of the component complexity and the interrelationship between the R&D tasks and component design with its evolutions. The blanket project has already achieved significant technological results and has completed its basic R&D plan to a large extent. It is now entering into the manufacturing phase of its prototypes. The results achieved so far give confidence that the goals of the project will be reached successfully.

PROGRESS ON MICROWAVE REFLECTOMETRY

by Dr. J. Sánchez, Asociación EURATOM-CIEMAT, Madrid, Spain

Reflectometry is a diagnostic based on the reflection of a millimeter wave beam at the plasma critical layer. In a simplified interpretation which needs some refinements, the evolution of the phase delay is related to the movements of the critical layer (density fluctuations) and the magnitude of the time delay can be used to reconstruct the electron density profile.

The access needed to the plasma is moderate (the density profile is obtained from a single sightline) and the only plasma-facing components are metallic elements without high optical quality requirements. Due to these facts, reflectometry is a strong candidate for the diagnosis of the electron density in ITER: position control, density profile in the main and divertor plasma, control of ELM's and other macroscopic perturbations (TAE's, MHD modes...) are measurements assigned to reflectometry.

The ITER diagnostics organization has defined three reflectometers: the Main Plasma Reflectometer which is being designed in collaboration by the EU and Russian teams, the Position Control reflectometer , under the responsibility of the US team and the Divertor Plasma reflectometer, being designed by the EU team with strong involvement of the ITER JCT, which also interacts with the other reflectometers.

Given the broad interest that teams from the four ITER Parties showed in the reflectometer systems the ITER Diagnostics Expert Group established the Reflectometry Working Group fifteen months ago. The RWG includes about 20 specialists from the 4 Parties and the JCT under the Chairmanship of J. Sanchez from the EU team and the Vice-Chairmanship of G. Vayakis, from the ITER JCT. The role of the RWG is not directly to lead the design of the reflectometers but to be a discussion forum where the specialists can get the information on the running designs and present their suggestions. It works mainly by remote communication and uses major general meetings (ITER diagnostics, IAEA, APS-EPS...) to provide contact between the members. An Internet www server with the relevant information is maintained by G. Vayakis at the ITER San Diego JWS. In addition, the role of the RWG is to identify areas of R&D which are necessary for several of the systems (one of them is profile initialization, which is being studied by the IST in Lisbon with the 1-D WKB approximation and by MIT, Boston, applying a 2-D full wave formalism to the lowest frequency range) and to coordinate common efforts in fields such as waveguide and antenna design, wave propagation studies, turbulence effects, emitter-receiver technology, data analysis...etc.

Somehow triggered by the RWG activity, the Workshop held at CIEMAT (Madrid) last May 5-7 was organized as the third of a series, which had started with the meeting in JET (Abingdon, 1992) and was followed by a second meeting in PPPL (Princeton, 1994). The results of the first two days' discussions at the Workshop are briefly summarized below.

Density fluctuations studies were discussed on the first day. The interest in density fluctuation studies related to the understanding of transport was described by C. Hidalgo, who indicated that many of the possible instabilities have specific signatures in the density fluctuations that could be observed with reflectometry: correlation lengths, density gradient fluctuations, intermittence in the fluctuation levels, relative amplitude of density and temperature fluctuations (the latter involving additional diagnostics). In many of these measurements related to the plasma core, reflectometry (though suffering limitations in the signal interpretation) is one of the few techniques available.

Fluctuation studies were reported from JET, DIII-D, CCT, Gamma 10, W7AS and ASDEX Upgrade (transition L-H). G. Conway presented the results of correlation studies in JET, T. Rhodes, from UCLA, presented an extensive comparison of reflectometry (homodyne, phase and amplitude signals) and Langmuir probe measurements both in CCT and DIII-D. Fluctuation spectra, time behaviour of the fluctuation level and correlation lengths were in good agreement for a broad range of experiments. This agreement was better for the homodyne signal than for the pure phase measurement, in accordance with some other experiments and simulations. The role of the homodyne ($A.\cos\Phi$) vs the phase (Φ) signals was also discussed in the simulations and discussion session. Most of detailed results were shown from simplified 2- dim.models which can afford enough statistics with moderate computing requirements: G. Conway was using the physical optics model to show how the phase and amplitude signals depart from the original density fluctuation as the parameters (wavelength and level) of the fluctuation evolve. T. Estrada was using a 2- dim. WKB model to analyze reflectometry correlation lengths vs turbulence poloidal wavelength . As discusses earlier, the homodyne signal was in most cases a better indicator than the phase (though with significant error for the shorter turbulence wavelengths). Different interpretations were given during the discussion session: vector average (strong amplitude is always related to meaningful phase, whereas the strong interference instants show low amplitude and meaningless phase, thus giving a higher statistical weight to the "good" data), higher non-linearity of the phase signal due to the 2π ambiguity, phase runaway... On the other hand, there were also elements acting against the homodyne signal: spectral broadening due to the amplitude- frequency conversion for large phase excursions. Phase runaway studies were discussed together with the data from W7AS (B. Brañas, M. Hirsch). The existence of rotating structures together with some antenna misalignment was highlighted as the possible explanation. Comparison with models, showing good agreement, was also presented. Full wave 2-dim. models (F. Serra, G. Leclert) have been developed to a substantial level but comprehensive studies still require very long computational times.

Finally, some open questions remained about the possible discrepancy between full wave models and the experiments (mainly related to the "scattering picture" given by the full wave theories as opposed to the "corrugated mirror" with strong localization of the measurements which seems more in accordance with the experiments). Ideas looking towards stronger localization, such as "resonant absorption", were launched (T. Rhodes).

The second day of the workshop was devoted to **density profile studies**. Data from different machines using a broad range of techniques were presented: ASDEX Upgrade (J. Santos, M. Manso, using fast swept FM with time-frequency distribution analysis: TDF); DIII-D (contribution by T. Rhodes using fast swept FM with complex demodulation and FFT analysis); Tore Supra (P. Moreau and F. Clairet , using fast swept FM with FFT analysis); RTP (P. de Vries , pulse radar technique); Gamma 10 (A. Mase, fast swept FM with Maximum Entropy Method analysis, MEM) and TdeV (D. Pinsonneault, Amplitude Modulation). Most systems are approaching "standalone" profile inversion from the raw data with a very low level of failed profiles (which usually can be determined a priori by observing the noisy raw data). In general, agreement with additional diagnostics (Thomson scattering, Multichannel interferometry, Lithium beam) was excellent. Experiments were showing detailed physics features with high time and space resolution: profile evolution during L-H transition, observation of ELM's and macroscopic modes.

New techniques and future reflectometers were also shown for Tore Supra (P. Moreau: dual frequency system and C. Laviron: automatic linearisation of sweepers), Textor (A. Hugenholtz: multichannel pulse radar system), Asdex Upgrade (A. Silva: new channels plus fast swept heterodyne detection), TJ-II (A. Silva: combined AM-FM system) and JET (N. Deliyanakis: fast short range FM, to be applied to the existing multichannel system). The comparison of "hardware based" techniques such as AM and Pulse Radar (which directly obtain the time delay characteristic by performing some of the processing at the detection level) with the swept FM technique (the homodyne signal is processed by software in order to obtain the time delay characteristic) leaded to some agreement: basically all techniques converge and the decision to use one of them in a given experiment will depend on the technology development at the given moment. In particular for ITER the idea is to concentrate in transmission lines and front ends and to leave the emitter-receiver issues to a later stage. The effect of fluctuations in profile measurements was discussed by J. Sanchez by using the WKB 2-dim. model: the determination of the average density seems to be possible by averaging in time or space the reflectometer signals, despite the nonlinear relation between both magnitudes. Rotation of structures could lead to systematic errors in swept FM systems (these errors can be minimized by fast sweeping). Anyway, further analysis is required on the effects of phase runaway in FM profile measurements, which seem to be absent from the experiments.

The third day was devoted to **reflectometry for ITER**. G. Vayakis (ITER Joint Central Team) made a very comprehensive presentation of the status of the systems design, including the position control system (O mode 10-60 GHz), the main plasma system (O, X-l, X-u modes 10-225 GHz) and the divertor reflectometer (O, X-u modes 20-960! GHz). The access difficulties for the systems out of midplane and mainly for the high field side (main plasma + plasma position) and divertor systems are significant. A deep study of the possible waveguide routings and front ends has been done but further analysis of the behaviour of bends, sensitivity to waveguide misalignment and antennas is needed. In the discussion session, an important point (which is matter of one of the RWG allocated tasks) was the issue of profile initialization: a deep analysis presented by M. Manso was showing that the density profile can be located with high accuracy (typ. 2-3mm for the ASDEX Up system) within a broad range of density profiles. A report with the results of this work will be available soon. Also A. Mase presented some preliminary 1-dim. results with the analysis of the effect coming from reflection with wavelengths which violate the WKB assumption. The results show that the measurement is quite tolerant and the errors are small. A 2-D full wave study of the same effect is being performed at MIT.

Finally, specific problems of the divertor reflectometer were discussed: T. Estrada introduced a correlation-based method for the determination of the density profile in turbulent plasmas with difficult access. L. Cupido was showing the results from the JET comb reflectometer, a solution which could be applied to determine the peak density in the ITER divertor. Concerning technology, L. Cupido presented a comprehensive view of the present day availability of microwave sources. This is a serious problem for the divertor system which would require a huge frequency coverage (up to 960 GHz). In principle, broadband swept sources with acceptable performance are available up to 170-200 GHz and above that only narrow band sources exist.

As a conclusion of the meeting, the three reflectometers for ITER seem feasible, with still many difficulties to solve. Fortunately, there is a broad international interest in the field and many groups are directly contributing to the system design, together with the ITER-JCT. This international collaboration will be strengthened from the RWG by creating a network of specialists in the different fields: antenna and waveguide design, propagation theory, data processing, source technology. Concerning a forthcoming workshop, the idea was to establish a more formal organisation in order to keep the two year pace. For the moment the exact date and place for the next workshop are open.

LIST OF PARTICIPANTS

Canada: G. Conway, University of Saskatchewan; D. Pinsonneault, Centre Canadien de Fusion Magnétique,Varennes, Quebec

France: F. Clairet, C. Laviron, and P. Moreau, all Association EURATOM-CEA, Cadarache; G. Leclert, LPMI, Univ. Henri Poincare Nancy I

Germany: M. Hirsch, Max-Planck-Institut fuer Plasmaphysik, Garching; D. Wagner, Institut fuer Plasmaforschung, Universitaet Stuttgart

Japan: A. Mase, Plasma Research Center, University of Tsukuba

Portugal: L. Cupido, M. E. Manso, J. Santos, F. Serra, A. Silva, and P. Varela, all Centro de Fusão Nuclear, Instituto Superior Tecnico, Lisbon

Spain: B. Brañas, T. Estrada, C. Hidalgo, E. de la Luna, and J. Sánchez, all Asociación EURATOM-CIEMAT, Madrid

The Netherlands: A. J. H. Donne, A. Hugenholtz, P. de Vries, all FOM Instituut voor Plasmafysica, Rijnhuizen, Nieuwegein

USA: T. L. Rhodes, UCLA, General Atomics, San Diego

ITER: G.Vayakis, ITER-JCT, San Diego JWS

JET Joint Undertaking: N. Deliyanakis, JET, Abingdon, UK

Items to be considered for inclusion in the ITER Newsletter should be submitted to B. Kouvchinnikov, ITER Office, IAEA, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: +43 1 237762, or e-mail: basaldel@ripo1.iaea.or.at (phone +43 1 206026392).

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