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INSIDE

OPTIMIZATION OF ITER DESIGN

by K. Tomabechi, Chairman, ITER Management Committee

In the autumn of 1988, a design concept of ITER was defined after extensive analysis of relevant scientific and technical states of the art. A document describing in detail this concept of ITER was recently published by the IAEA: ITER Concept Definition, Volumes 1 and 2. In 1989 ITER design activities proceeded with evolution of the concept through more detailed analyses and incorporation of the latest data. There was further careful analysis of the data base to be used, taking into account the continuous improvement of our knowledge of plasma physics as well as relevant technologies.

Improvements in ITER performance

As the design work progressed, further optimization of the machine performances became possible with essentially the same overall machine size via a slight readjustment of some machine parameters. These improvements in performance included the following:

(1) Voltseconds built in the machine were increased to assure at least 200 seconds of burn.
(2) Space available for placing radiation shield around the divertor was increased to assure the radiation shield requirement to be met.
(3) Distance of separatrix between null point and strike point on the divertor plate was increased to ease design conditions of the divertor.
(4) Inboard shield/blanket thickness for physics phase was increased so as to leave freedom for strategic choice of whether a breeding blanket be placed in the inboard region at the beginning of the physics phase of operation, thus providing a possibility to proceed to the technology phase without disturbing plasma experiments.

The Design Team investigated the problems and issues thoroughly and tried to optimize the machine design with strong attention to minimize the machine size and cost. The recent outcome of the effort resulted in an optimization of the machine with slight modification of parameters, but with the same overall radial dimensions of the machine, as given below:

Major parameters of the optimized machine

	Old	Present
Plasma current (MA)	22	22
Plasma major radius (m)	5.8	6.0
Plasma minor radius (m)	2.2	2.15
Magnetic field on axis (T)	5.0	4.85
Outer poloidal field coil radius (m)	11.5	11.5

Vertical and horizontal cross sections of the optimized design are given in Fig. 1 and 2. Although in most respects these drawings look almost the same as those in the ITER Concept Definition report, small but significant changes have been made in dimensions and shapes of various components to achieve the improvements indicated above.

Partition of the torus internals has been decided so as to allow maintenance of all the internal components by access from the top of the machine, except the divertors which are designed to be removed through horizontal ports. Active and passive coils of conventional conductors for controlling vertical stability of plasma are placed inside the vacuum vessel.

Selections of breeder concept and current drive and heating techniques for reference design

Concerning the breeding blanket and current drive and heating, three concepts and three scenarios have been studied respectively for application to the ITER design. For the purpose of producing a consistent and integrated machine design, selections of ceramic breeder cooled by water for breeding blanket and neutral beams in conjunction with lower hybrid and electron cyclotron waves for

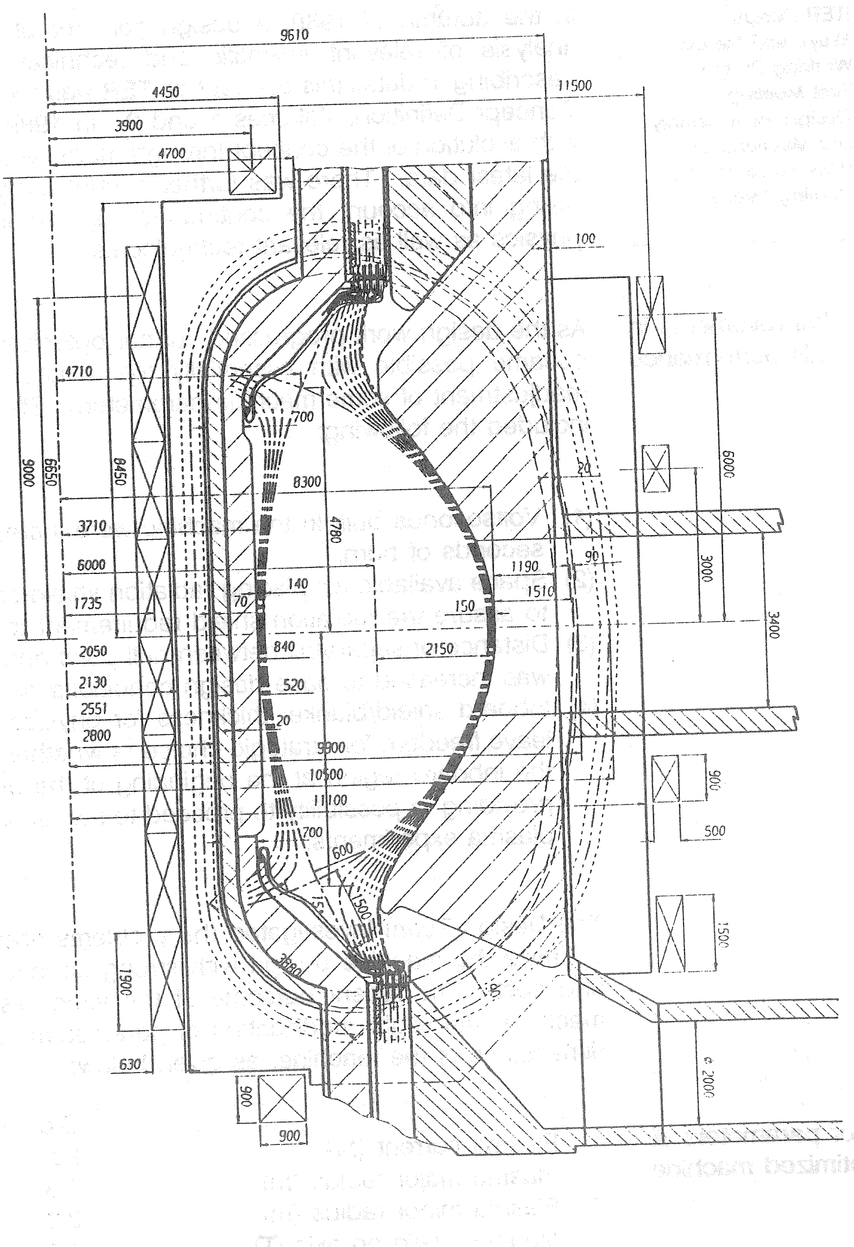

Fig. 1. Vertical cross section of ITER

current drive and heating have been respectively made tentatively, although all concepts and scenarios should remain for further detailed study by the Design Team. In other words, it should be noted that all the concepts and scenarios under investigation have their own technical advantages and disadvantages in different aspects to each other so that it is not possible to conclude at this stage of the design, whether one solution is definitely superior over the others and the others be discarded. Therefore, the designers believe that studies should be continued on all the concepts and scenarios currently being investigated for ITER.

Work is on schedule.

The optimized design gives improved performances and the exploration is now under way to further enhance the performances to the extent possible. Thus the ITER design is progressing well, aiming at a consistent and workable machine design. In general, the work is on schedule and an ITER Interim Report has been written as the result of the Summer Joint Work Session which ended on October 20, 1989.

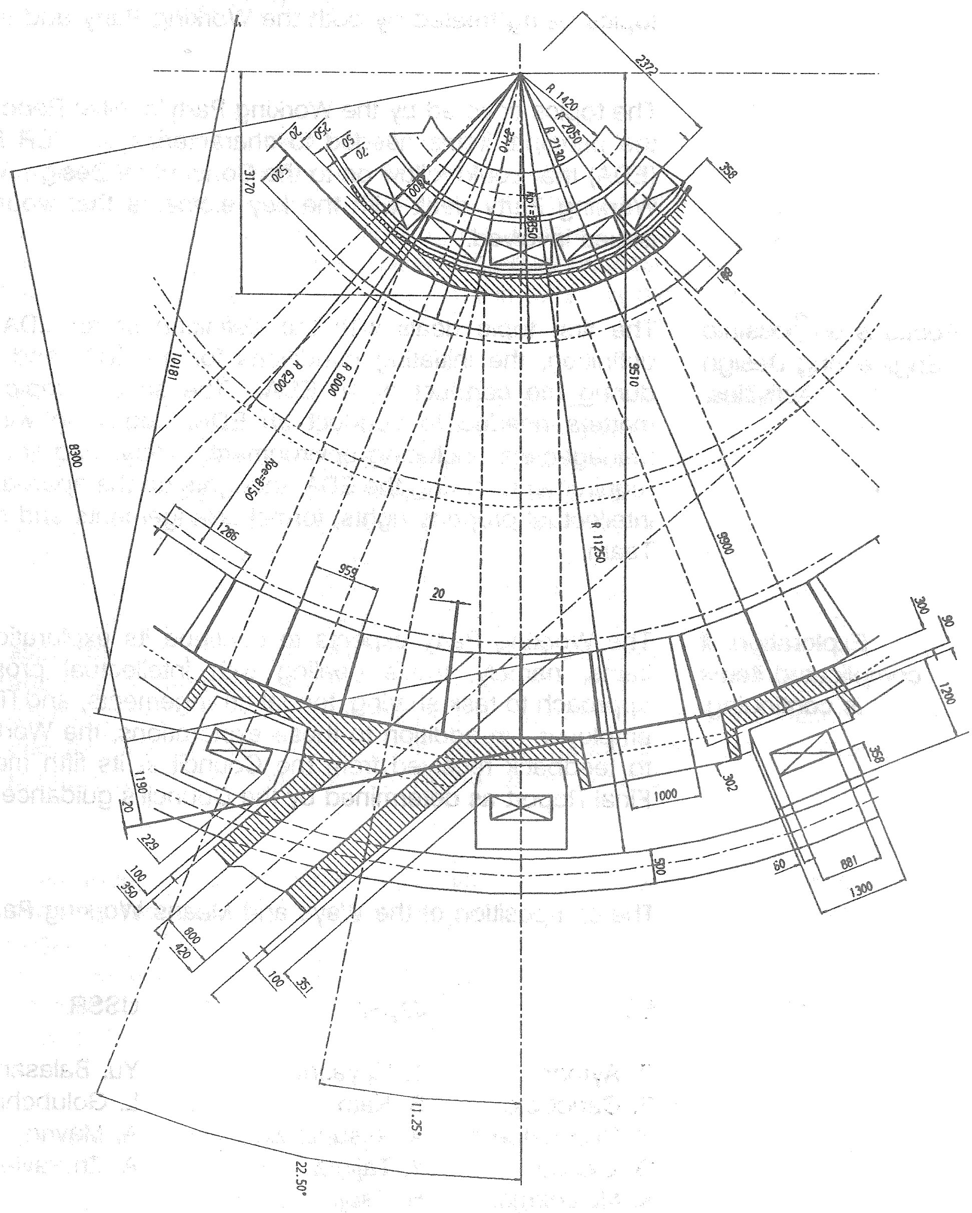

Fig. 2. Horizontal cross section of ITER

WAYS AND MEANS WORKING PARTY HOLDS ITS FIRST MEETING

by M. Roberts, Chairman, Council W&M Working Party

Working Party was chartered to assist ITER Council explore.

At its meeting in July the ITER Council agreed that, in view of the encouraging progress in the Conceptual Design Activities, the Council should proceed, as required by the Terms of Reference, to formulate "suggestions on how the Parties may explore ways and means to comply with the objective of the co-operation." To assist the Council in this function, a Working Party was chartered. Its mission was stated as follows. "The Working Party is charged with the task of proposing those supporting elements needed for the possible conduct of the Engineering Design of ITER. The Working Party should report on its first findings at the November 1989 meeting of the ITER Council for use with the Interim Conceptual Design Report and present its final report to the Council in April 1990."

The Working Party, composed of four or five members from each Party, held its first meeting at the technical site for joint work in Garching on October 9 through 11. The Deputy Director General of the IAEA, M. Zifferero, participated in the meeting on behalf of the Agency. The principal reason for meeting in Garching was to facilitate discussions with the ITER Management Committee (IMC) on those topics being treated by both the Working Party and the IMC.

The topics covered by the Working Party's Initial Report are intended to represent the principal items needed to characterize an ITER Engineering Design Activity (EDA) that could follow on to the Conceptual Design Activities. For each item, the Working Party dealt with the key elements that would convey the sense of the issues involved.

Focus is on possible Engineering Design Activities.

The first topic deals with the definition of an EDA, starting with the general definition, the initiating conditions for an EDA, and a tentative plan of actions during the conduct of an EDA. The second topic deals with those practical matters needed to conduct an EDA, beginning with project organization and management, including environment, safety, and licensing, the construction site requirements during the EDA, thoughts on the approach to task sharing, handling intellectual property rights, formal arrangements and housing for the EDA Central Team.

Exploration of complicated items is continuing.

The Working Party expects to continue its exploration of the most complicated items, namely, those dealing with intellectual property rights treatment, the approach to task sharing, formal arrangements, and ITER as a potential personnel employer. In addition to these explorations, the Working Party plans to respond to feedback received from the Council at its fifth meeting and work toward the Final Report as determined by the Council's guidance at that meeting.

The composition of the Ways and Means Working Party is shown below:

EC	Japan	USSR	US
R. Aymar	T. Hayashi	Yu. Balasanov	J. Gavin, Jr.
E. Canobbio	S. Kato	L. Golubchikov	M. Gottlieb
H. Donoghue *	A. Kitsunezaki	A. Mavrin	C. Newstead
G. Grieger	Y. Tajima	A. Zhuravlev	A. Opdenaker
K. Melchinger	H. Tsuji		M. Roberts **

* Secretary
** Chair

ASSEMBLY AND MAINTENANCE DESIGN ACTIVITIES

by T. Honda, Leader, Assembly and Maintenance Design Unit

The ITER Assembly and Maintenance Systems consist of the complete set of equipment and procedures required to successfully assemble and maintain the tokamak components into a reactor configuration capable of operation in the prescribed manner. Consequently, the Assembly and Maintenance Design Unit has three main functions:

Main functions of the Assembly and Maintenance Design Unit

(1) Establishment of the scenario and procedures for initial assembly of ITER,
(2) identification of baseline procedures for the maintenance of in-vessel components (i.e. divertors, first wall, blankets, etc.) as well as ex-vessel components (i.e. heating and current drive systems, vacuum pumping systems, fuelling, diagnostics, etc.), and
(3) design of special purpose equipment required to perform the tasks.

Several types of equipment will be required to perform the third task, including manipulator systems, material handling systems, and general and specific purpose tools.

Remote maintenance as design criterion

The design criterion, established at the beginning of the project, is that ITER must be designed for complete remote maintenance. This means that the components themselves, their required connections, and access to them must be designed to be compatible with remote handling equipment. However, provisions for hands-on maintenance will be incorporated wherever possible outside the cryostat vessel (which forms the exterior boundary of the tokamak assembly).

Two categories of the machine components

For maintenance planning, the components inside the cryostat have been divided into two categories: lifetime and requiring scheduled replacement. The main in-vessel components such as the divertor plates and blankets are expected to be replaced periodically and therefore require simple procedures which can be executed as rapidly as possible. All other basic device components in the cryostat such as the toroidal and poloidal field (TF and PF) coils will be replaced only in case of an accident or failure. Minimizing the replacement time is not a major design requirement for these components. In addition to the basic tokamak assembly, auxiliary systems located outside the cryostat will also become activated and require remote maintenance. These systems include the heating and current drive systems, components of the vacuum pumping system, the fueling system and plasma diagnostics. Finally, the remote handling equipment itself must be maintained as much as possible by hands-on access.

Stage of initial assembly

Even though it is possible to initially assemble ITER using complete remote handling techniques and equipment, it would be unreasonably costly and time consuming. Consequently, the main lifetime components will be assembled by use of conventional techniques. The initial assembly could be used, however, as a demonstration of the remote handling equipment required for change-out of the limited lifetime items.

During the first assembly, and in all subsequent replacement operations, the main crane will be used extensively for handling the heavy payloads. Utilizing different lifting rigs attached to the crane, the TF Coils, PF Coils, intercoil structure, vacuum vessel sectors, and blanket/shield modules will be installed from the top. Establishing a complete definition of the requirements on the main bridge crane is a critical issue.

Remote replacement of the blanket segments will be carried out by dedicated devices operating from above the reactor. The inboard segments and the outboard segments can be independently removed with simple translations in all three planes, i.e. no rotating of the heavy pieces will be required. The sequence of operations is as follows:

(1) Remove the biological shield and cryostat upper access port.
(2) Install blanket handling device on the top of the vacuum vessel port.
(3) Open the top of the vacuum vessel.
(4) Cut the cooling lines.
(5) Remove the shield plug.
(6) Remove the failed blanket segment to a containment structure.
(7) Transport it to a hot cell.
(8) Install a new segment by following the above steps in reverse order.

Regular replacement of in-vessel components

Regular replacement of the smaller components, mainly the plasma facing components such as the divertor plates or armour tiles will require frequent intervention into the tokamak's central, i.e. plasma, volume. In-vessel manipulators and transporters outfitted with special purpose tools will be inserted into the vacuum vessel through large centerline ports for access to these components. These operations will be performed after back-filling the vacuum vessel with an inert gas to avoid contamination of the first wall armour tiles by oxygen.

The maintenance sequence for a divertor plate maintenance operation is as follows:

(1) Open the vacuum vessel port.
(2) Insert the manipulator and transporter.
(3) Grip the divertor plate by use of end effector on end of manipulator.
(4) Cut the cooling pipes.
(5) Disconnect the mechanical mountings.
(6) Move the divertor inside and the transporter outside of the vacuum vessel.
(7) Install the new divertor by using above sequence in reverse order.

Ex-vessel components maintenance requires further detail design.

Equipment for maintenance of ex-vessel components (the NBI, RF, Nuclear Test modules, vacuum pumps, etc.) has not been studied to the same level as that of the in-vessel due to a different degree of design detail. However, it is anticipated that the crane will be used along with floor mounted mobile transporters to obtain top, bottom, and side access to them. Other special equipment, such as a double door cask containing the required handling tools, will be installed.

Concept optimization and preliminary design is on-going for all in-vessel remote handling equipment. Divertor handling equipment, effectors, cutters/welders for piping and blanket handling equipment are examples of the efforts. The design analysis concentrates, in the meanwhile, on feasibility studies, reduction of intervention times, interfaces with machine components design, access requirements, and recovery modes for failure during maintenance operations. Conceptual analysis for ex-vessel equipment is being carried out in parallel with the definition of the auxiliary systems.

ITER PROGRESS PRESENTED

Symposium on Fusion Engineering in the United States

The status of the ITER conceptual design at the end of the 1989 summer session was recently described to a large audience of fusion engineers and technologists in the USA. An audience of more than 400 at a plenary session of the 13th Symposium on Fusion Engineering (SOFE) heard C.D. Henning's presentation entitled "ITER in Perspective." In it he first showed how ITER had become a key element of the world's four major fusion programmes. He then described the design, including the recent adjustments of parameters, and explained how it is based upon information from a wide variety of experiments and supporting R&D. This paper and others, which dealt with ITER physics guidelines and various engineering aspects of the conceptual design, led to numerous informal discussions and wider recognition of the significant progress being made in the ITER activities.

The SOFE series of biannual meetings, of which this was the 13th, is sponsored by the Institute of Electrical and Electronic Engineers (IEEE). As usual with SOFE, attendees came from all sectors of the U.S. fusion programme and several other countries.

TV presentation in the Soviet Union

At the ITER Council meeting in July 1989, Dr. J. Gilleland introduced a video tape illustrating the ITER design process. The facility and the machine, including assembly procedures, are depicted by computer-generated, perspective drawings. This film was initially produced for the United States fusion programme with support from Bechtel, Inc. Council members were appreciative and suggested that the tape be adapted for international audiences. For this purpose, they offered several suggestions for possible modifications, including the language of the soundtrack. The film resulting from the follow-up actions was recently shown by the Central Television of the USSR. It was presented in a popular TV programme discussing fundamental problems of science and technology. The ITER Conceptual Design Activities were introduced to millions of TV spectators in the country as an encouraging international venture.

General Assembly of the United Nations

In his statement to the 44th Session of the United Nations General Assembly in New York on 25 October 1989, the Director General of the IAEA, Dr. H. Blix, characterized the ITER Conceptual Design Activities as an example of a successful international approach in solving problems of a new technology development for the generation of energy. Pointing out that commercial use of fusion energy is not a matter of the near future, he stated at the same time that "in the work toward a fusion reactor, internationalization has been highly successful in the first conceptual design phase of the International Thermonuclear Experimental Reactor or ITER project carried out under IAEA auspices."

COMING EVENTS

The following major ITER events will take place in the near future:

ITER Council Meeting	Vienna	30 Nov - 1 Dec 1989
Joint Work Session	Garching	22 Jan - 23 March 1990
Meeting of Working Party on Ways and Means	Vienna	29 - 31 Jan 1990

The detailed ITER Events Calendar for 1990 will be published in the December issue of the ITER Newsletter.

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