INIS-mf--12627

ITER

INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1989

ITER DEFINITION PHASE

ITER DOCUMENTATION SERIES, No. 2

ITER DEFINITION PHASE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 1989

ITER DEFINITION PHASE
IAEA, VIENNA, 1989
IAEA/ITER/DS/2

Printed by the IAEA in Austria
July 1989

FOREWORD

Development of nuclear fusion as a practical energy source could provide great benefits for all mankind. This fact has been widely recognized and fusion research has enjoyed a level of international co-operation unusual in other scientific areas. From its inception, the International Atomic Energy Agency has actively promoted the international exchange of fusion information.

In this context, the IAEA responded in 1986 to calls for expansion of international co-operation in fusion energy development expressed at summit meetings of governmental leaders. At the invitation of the Director General there was a series of meetings in Vienna during 1987, at which representatives of the world's four major fusion programmes developed a detailed proposal for a joint venture called International Thermonuclear Experimental Reactor Conceptual Design Activities. The Director General then invited each interested party to co-operate in ITER activities in accordance with the Terms of Reference that had been worked out. All four Parties accepted this invitation.

Joint work on ITER Conceptual Design Activities, under the auspices of the IAEA, began in April 1988 and is scheduled to be completed in December 1990. The plan includes two phases, the Definition Phase and the Design Phase. In 1988 the first phase produced a concept with a consistent set of technical characteristics and preliminary plans for co-ordinated R&D in support of ITER. The Design Phase is producing a conceptual design, a cost estimate and a description of site requirements. All information produced within the Conceptual Design Activities is being made available to each ITER party for use in reaching decisions about its part in further international development of fusion energy.

As part of its support of ITER activities, the IAEA is pleased to publish the documents that summarize the results of the joint work.

INTERNATIONAL ATOMIC ENERGY AGENCY

INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR CONCEPTUAL DESIGN ACTIVITIES

ITER COUNCIL

ADDRESS FOR REPLY: WAGRAMERSTRASSE 5, P.O. BOX 100, A-1400 VIENNA, AUSTRIA
TELEX: 1-12645, CABLE: INATOM VIENNA, FACSIMILE: 43 222 230 184, TELEPHONE: (222) 2360

In May 1988 the European Community, Japan, the Soviet Union and the United States began a collaboration under the auspices of the International Atomic Energy Agency (IAEA) to perform a conceptual design of an International Thermonuclear Experimental Reactor (ITER). This report marks the successful conclusion of the first phase of the activity. The work performed during this phase has defined a single ITER concept which, according to present understanding, should suffice to demonstrate the scientific and technological feasibility of fusion power.

The concept and its supporting research plan have been independently reviewed by the ITER Scientific and Technical Advisory Committee. Based on the favourable outcome of these reviews, the ITER Council has formally approved the Definition Phase Report. This report is based on extensive technical documentation which is available from the IAEA. The ITER concept defined in this report will serve as the focus for the Design Phase which is to be carried out during 1989 and 1990.

Pursuant to the ITER Terms of Reference, the Council has also approved a plan for accomplishing the research and development required to support the design. The required research has been equitably divided among the parties and work has begun on all aspects of the programme.

The remarkable progress achieved in the Definition Phase is the result of the full-time efforts of over two hundred scientists and engineers provided by the four Parties. In addition, the Parties contributed the time of many other professionals for ITER meetings and workshops. It was apparent that very highly qualified technical personnel were made available to the ITER activity for all aspects of the work. The work also benefited greatly from the support of the IAEA and the Federal Republic of Germany, which provided the technical site for joint work on behalf of the European Community.

The ITER Council wishes to express particular appreciation for the strong support received from all Parties during the critical initial phase of the activity.

On behalf of the ITER Council

John Clarke

John F. Clarke
Chairman

CONTENTS

6->8

EXECUTIVE SUMMARY

In April 1988, delegations from the European Community, Japan, the Union of Soviet Socialist Republics and the United States of America met in Vienna under the auspices of the IAEA to initiate a new four party technical endeavour to advance fusion energy research and development. This new endeavour, which came from recent summit level actions, is called the International Thermonuclear Experimental Reactor (ITER) Conceptual Design Activities. The governing ITER Council held its first meeting in April to start the joint work, whose objective is to develop a single conceptual design for a fusion engineering test reactor by the end of 1990. This common conceptual design would then be available for each of the Parties to use in their own domestic programme or in a larger international collaborative venture.

The Terms of Reference, to which each of the four Parties agreed at the highest levels of government, call for a Definition Phase, to be completed in 1988, and a Design Phase, to be completed by the end of 1990. The requirement for the Definition Phase is that an ITER concept with a single set of technical characteristics be defined within the programmatic guidelines outlined in the Terms of Reference. A preliminary programme of work for the design and R&D activities was to be developed in accordance with the provisions of the Terms of Reference. All these requirements have been met and the work is documented by the Definition Phase Report, which has been approved by the ITER Council.

To accomplish this work, some two hundred individuals were involved on a full-time basis in the four Parties' institutions. Ten persons from each Party worked together in an intensive five-month session at the technical site in Garching, Federal Republic of Germany, to ensure development of the single concept. An equal number of technical experts from the Parties participated in sixteen topical workshops held in support of the Garching work. Meanwhile, Canada became involved with the contribution of the EC Party to ITER, and other countries might also become involved.

In addition to the design characteristics, the R&D plan and the summarizing reports, an important outcome has been the recognition of needs to co-ordinate a broader range of supporting R&D, especially in the underlying fusion physics areas. Furthermore, programme leaders responsible for international fusion collaboration through existing bilateral and multilateral agreements have been orienting their joint work toward ITER support.

The Definition Phase work is briefly summarized in this report. A separate, two volume report, entitled "ITER Concept Definition", presents an extended technical summary and technical details.

INTRODUCTION

Recent years have seen a combination of significant technical progress and successful international collaboration in magnetic fusion research. This has resulted in high-level interest on the part of world leaders in science and government in a multinational effort, aimed at designing and, hopefully, implementing the world's next large step for testing the science and technology of thermonuclear fusion. This interest was reflected in several summit level discussions involving President Mitterrand, General Secretary Gorbachev and President Reagan. These discussions resulted in commitments to co-operate, under the auspices of the International Atomic Energy Agency (IAEA), in the conceptual design and supporting R&D for an International Thermonuclear Experimental Reactor (ITER). This report describes the successful work of the first or definition phase of the ITER activities.

BACKGROUND

In the spring of 1987, the Director General of the IAEA invited representatives of the European Communities (EC), Japan, the Union of Soviet Socialist Republics (USSR) and the United States of America (USA) to meet in Vienna to discuss enhanced international collaboration in fusion. The representatives at this meeting agreed that the most valuable enhancement of fusion collaboration would be the joint design of the next-step experiment in magnetic fusion. They also agreed that an experimental fusion reactor was the correct next step in fusion R&D for each of the world's major programmes. Working groups developed both specific Terms of Reference governing the proposed activities and a set of technical objectives for the experimental fusion reactor. Based on the information generated by the working groups, the representatives recommended participation in four-party activities to their respective political authorities. In the autumn of 1987, the Director General issued an invitation through diplomatic channels to the four Parties to join the activities in accordance with the Terms of Reference, under the auspices of the IAEA. After reviewing the proposed activities and the Terms of Reference at the highest governmental levels, the Parties accepted the Director General's invitation to participate in the three-year conceptual design activities.

The name for the facility being designed, the International Thermonuclear Experimental Reactor (ITER), was chosen for two reasons. First, the words themselves are quite descriptive of the various facilities that the Parties had separately envisioned as the next large step in thermonuclear fusion. Second, the acronym ITER (pronounced "eater") is, itself, meaningful. ITER is the Latin word for "the way". In agreeing upon this activity, all participants expressed their hopes and expectations that the ITER Conceptual Design Activities will open the way to even more effective international co-operation in energy development for the common good of mankind.

OBJECTIVES

The overall objective of ITER is concisely defined in the Terms of Reference as follows: "to demonstrate the scientific and technological feasibility of fusion power." Guidelines for achievement of this objective are then provided.

The Terms of Reference go on to prescribe integrated international activities whose objective is to provide, by December 1990, a conceptual design and supporting R&D that would be available for all Parties to use, either in their own national programme, or as part of a larger international collaborative programme. The ITER Conceptual Design Activities are required:

(a) to define a set of technical characteristics for ITER and, subsequently, to carry out the design work necessary to establish its conceptual design;
(b) to define future research and development needs and to draw up cost, manpower, and schedule estimates for the realization of such a device;
(c) to define the site requirements for ITER, and to perform a safety and environmental analysis; and
(d) to carry out, in a co-ordinated manner, specific validating research and development work supportive of the design activities.

Accomplishment of ITER's objectives will require operations that release a great deal of fusion energy. ITER is not intended to be a power reactor, however. Rather it is to be an experimental engineering device, the operation of which is essential in learning how to build a practical fusion reactor. As such, ITER represents a stage in the development of fusion rather than a finished product. It also follows that the ITER design will reflect the uncertainties that still remain in both the science and engineering of fusion. Experimental operation of ITER will, therefore, be planned to validate engineering design concepts and to qualify engineering components for a fusion reactor. It should, in addition, demonstrate the reliability of ITER engineering systems and the potential for maintainability of a reactor. Finally, it must do the above in a way that serves to enhance the potential for safe and environmentally acceptable operation of a power producing fusion reactor.

The objective of the first phase of the ITER Conceptual Design Activities, the Definition Phase, was to accomplish the following by November 1988:

(a) definition of an ITER concept with a coherent set of technical characteristics in accordance with the guidelines of the Terms of Reference, and
(b) development of a preliminary programme of work for the design and R&D activities during the subsequent Design Phase in 1989 and 1990.

ORGANIZATION

The ITER Conceptual Design Activities constitute the largest worldwide fusion collaboration ever attempted. The design work requires:

- joint work (by about 40 scientists and engineers) at one technical site in sessions of several months duration each year,
- workshops on specific technical issues, involving other specialists, and
- work conducted at each Party's home sites both between and during sessions of joint work.

Each Party makes equal contributions to both joint and domestic design work, equivalent to about 80-100 person-years from each Party over the three-year course of the activities. The R&D activities, performed in the laboratories of the Parties, are divided equitably among the Parties. The level of effort on technology R&D tasks specific to the ITER design is approximately $ 10 million per year for each Party. Comparable levels of effort are applied to physics R&D.

The technical site for the joint work, at the Max-Planck-Institut für Plasmaphysik at Garching, was provided by the Federal Republic of Germany on behalf of the EC. The accompanying photograph (Fig. 1) shows many of the participants, gathered under the flags of the EC, Japan, the USSR and the USA for the dedication of the site, where joint design activities began on May 2, 1988.

The organization for direction and management of the highly integrated joint activities is indicated by Fig. 2. All ITER Conceptual Design Activities are governed by the ITER Council (IC), which is composed of two representatives from each Party and is responsible for the overall direction of the activities. The ITER Management Committee (IMC), composed of the Managing Director of each Party, is responsible for the direct management of the activities. All major technical decisions are reached in unanimity by the Managing Directors. An ITER Scientific and Technical Advisory Committee (ISTAC), composed of 12 members (three members per Party) chosen so as to ensure that all areas of expertise required for the execution of the Conceptual Design Activities are represented, advises the IC on scientific and technical matters. The names and affiliations of the persons who served during the Definition Phase in the various management positions are listed in Attachment 1.

In the accomplishment of the Definition Phase tasks, about 40 professionals (10 from each Party) worked closely together from May through September, 1988 at the technical site at Garching. Under the ITER Management Committee, these full-time workers were organized in four project groups - Physics, Basic Device Engineering, Nuclear Engineering, and Systems Analysis - each fully integrated. During this five-month session of joint

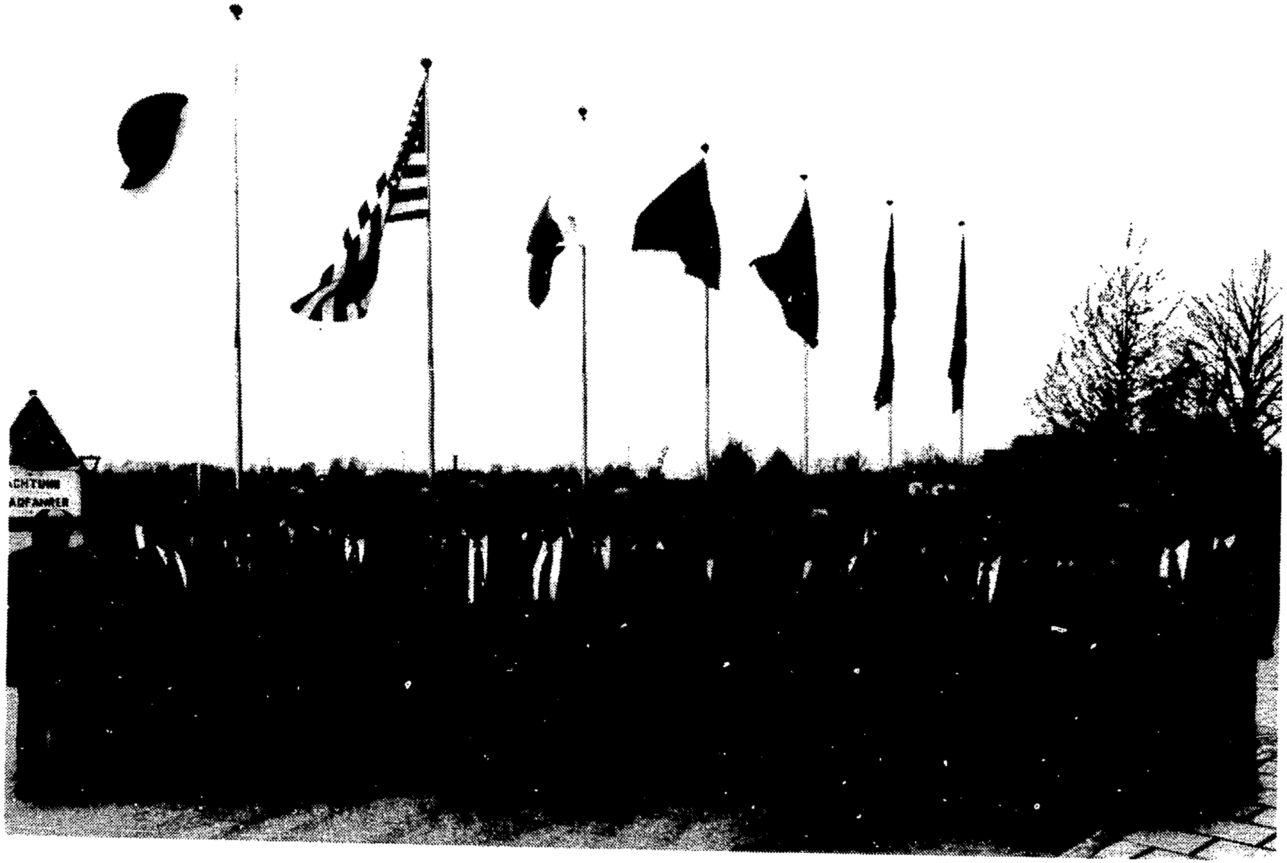

FIG. 1. ITER participants at inauguration of joint work.

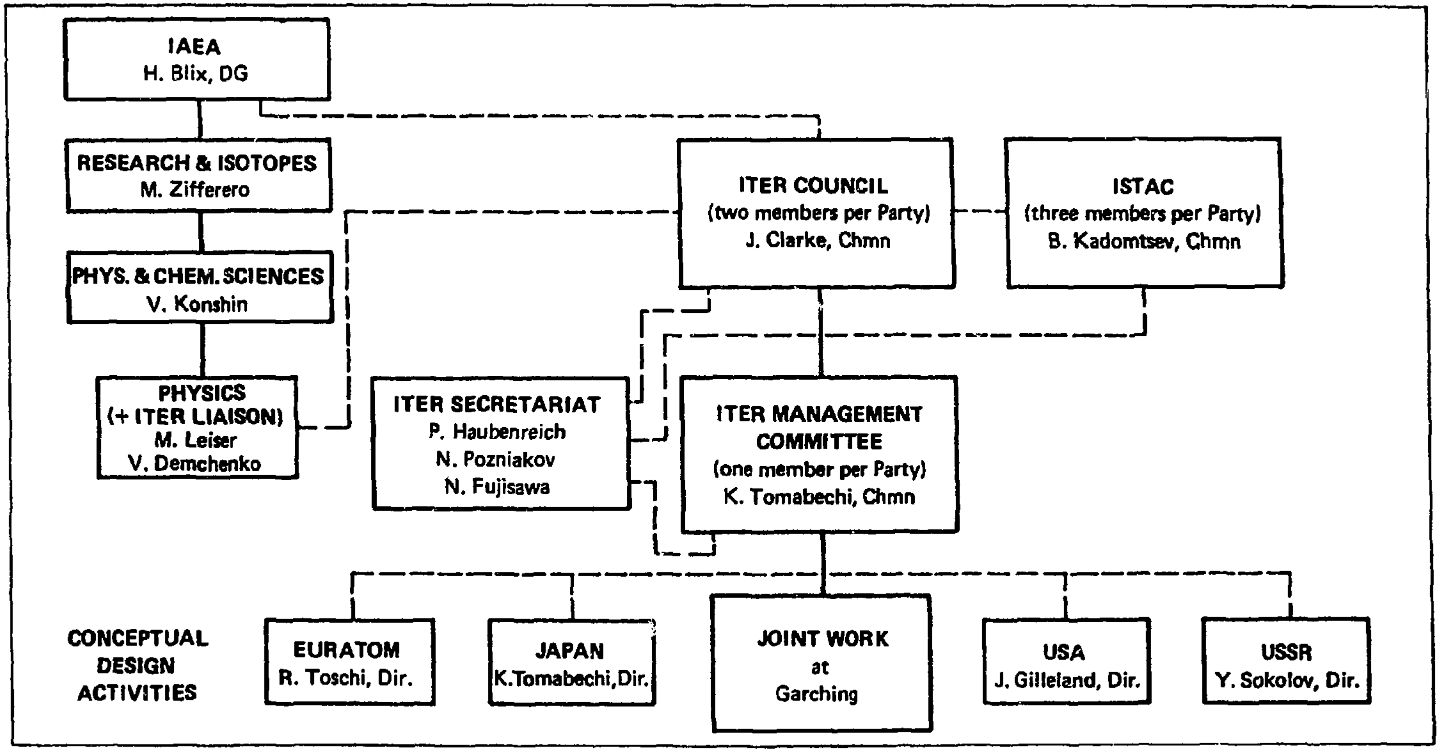

FIG. 2. Organizational structure of quadripartite co-operation in ITER Conceptual Design Activities.

work, similar numbers of professionals were working on ITER at home sites of each Party. In order to assure the best assessment of the state of the art in specific areas of physics and technology relevant to ITER, sixteen meetings of specialists were held in Garching during the joint work session. In addition, short-term visits by experts provided additional valuable contributions to the ITER activities.

DEFINITION PHASE ACTIVITIES

Guidelines

The Terms of Reference required a concept to be defined in accordance with the following general guidelines. ITER is to accomplish its overall objective of demonstrating feasibility of fusion power:

- "by demonstrating controlled ignition and extended burn of deuterium-tritium plasmas, with steady-state as an ultimate goal,
- by demonstrating technologies essential to a reactor in an integrated system, and
- by performing integrated testing of the high-heat-flux and nuclear components required to utilize fusion power for practical purposes."

The Terms of Reference also provided more detailed objectives and technical characteristics to guide the design activities.

The ITER device is to be a tokamak, based on the scientific and technological database expected to be available to support a decision, at the end of 1990, to proceed to engineering design and constructions. However, to the extent possible, the design should provide access for the introduction of advanced features and new capabilities and to allow for optimizing plasma performance during operation. ITER should be designed to meet its objectives with reasonable cost.

The operation of ITER, after commissioning, is to be carried out in two phases: a physics phase devoted mainly to plasma physics objectives (notably controlled ignition) and a technology phase devoted to engineering objectives, which entail extended burn of deuterium-tritium plasmas. Between operational phases, some machine modifications may be made.

ITER is to be designed to have a confinement capability sufficient for reaching ignition, implying a plasma current more than twice the maximum achievable in present-day large tokamaks. The design has to be compatible with the requirements of steady-state operation, with a ratio of fusion power to power injected to drive the burn (the Q value) about 5.

Other technical guidelines include:

- pulse length at least a few hundred seconds,
- average neutron wall loading about 1 MW/m^2,
- useful lifetime neutron fluence 1 MW a/m^2 or more,
- during the technology phase, a tritium-breeding blanket with a breeding ratio as close to unity as practicable.

Physics basis

Specification of the size and other characteristics of the plasmas required to achieve ITER objectives depends primarily on plasma physics considerations. The crucial physics areas for the ITER design are shown in Table 1. For each of these areas, an assessment of the present state of the physics knowledge and of the improvements potentially possible was performed by the participants, with contributions by the home teams and experts at design workshops. From these preliminary assessments, some initial conclusions were drawn and key issues identified.

TABLE 1. CRUCIAL PHYSICS AREAS FOR THE ITER DESIGN

* Plasma performance and operational limits (energy confinement, fast ion confinement, density limits, MHD limits, etc.)
* Plasma equilibrium and control (including poloidal field configuration)
* Plasma heating and current drive
* Particle and power exhaust
* Disruptions

In the H-mode, the global energy confinement time is roughly twice the "normal" L-mode value. Some enhancement of the energy confinement over L-mode values is achievable by centrally peaked heating, divertor operation, or some degree of profile control. In scoping studies for ITER, the required enhancement factor was generally treated as a parameter to be determined.

The analyses of fast alpha particle confinement indicate that the ripple in the plasma edge should be below 1.5 % to limit the ripple losses to acceptable levels. The initial conclusion for the density limit in present experiments is that it appears to be due primarily to disruptions following modifications of the current profile caused by excessive radiation losses. The Troyon scaling for the beta limit is a reasonable characterization of the beta limit that can be expected in ITER.

On the basis of assessments of the performance of candidate systems for heating and current drive, three major current drive options for the central plasma were identified: high-energy neutral beams (E about 1 MeV), electron-cyclotron waves, and ion-cyclotron fast waves, all supplemented by lower-hybrid current drive in the outer portions of the discharge. The power required for current drive systems for steady-state operation was anticipated to be of the order of 100 MW.

The recommended configuration for power and particle control is a poloidal divertor. However, the development of a credible concept for long operating lifetime will require substantially more physics and engineering work.

Disruption data from the present generation of tokamaks was assessed and characterized. The initial conclusions were that the thermal quench time can be as short as hundreds of microseconds and the maximum current decay rate can be assumed to be about 1 MA per millisecond. The minimization and accommodation of disruption effects are a key design issue.

Scoping studies

The desirable device parameters for ITER were surveyed using four different overall system codes as well as more simplified analyses. ITER reference parameters needed to be chosen such that the device would be capable of achieving the joint objectives of ignition and steady-state performance. Since typical scalings for energy confinement time depend in differing degrees on plasma current (I) and aspect ratio (A), an investigation was undertaken to explore the scope of device parameter choices in I-A space, with fixed assumptions on peak fields, plasma safety factor, and distance between plasma and toroidal field coil on the inboard side, amongst others.

The variation over I-A space of the enhancement factors for energy confinement time needed for ignition differs according to the various scaling laws, which have different dependence on plasma current and size. The best compromise position, from the point of view of attaining the ignition goal at a reasonable cost and power level in a technically feasible device, was determined to be a device with a plasma current of 20 MA and an aspect ratio of 3. It appeared that the compromise region of design space for ignition performance would result in a basic device with sufficient flexibility for long-burn, current-driven operation in the technology phase. Therefore, the region around the stated parameters was studied in further detail to reduce device size and cost, while optimizing the performances in both phases of operation. Recognizing the different goals, a different set of plasma parameters was chosen for each phase. The change between the phases might require replacement of in-vessel components. These parameters were chosen to balance the demands on confinement for the two phases and to alleviate the problems associated with energy removal by reducing fusion power generation in the technology phase when ignition would not be a requirement.

ITER concept

Based on the results of the assessment of the relevant scientific and technical databases, and of the investigation of possible configurations and performances of ITER machines, an ITER concept was defined for a machine that would have the ability to operate with a variety of plasmas, in order to meet both technology and physics objectives assigned to ITER. The major parameters of the basic ITER device are shown in Table 2.

For technology experiments and tests, the machine can be operated typically with a plasma of 18 MA at a major radius of 5.5 m with the full tritium breeding blanket installed. For the plasma physics experiments, the same machine, but with a thinner shield blanket instead of the breeding blanket, can produce a plasma current of 22 MA by fully inductive operation or a larger plasma current under some technical conditions.

The toroidally and poloidally segmented in-vessel components (tritium breeding blanket, first wall and divertor) are contained and supported within a combined vacuum vessel and outer shield. There are large penetrations at the top of the vessel for removal of major in-vessel components, with subsidiary access or additional heating ports on, above, and below the equator.

The 16 toroidal field coils use $(NbTi)_3Sn$ type superconductor with liquid helium cooling. The centering forces are taken by a vault structure formed from the noses of the coil cases. The superconductor uses forced flow cooled conductors with glassfibre reinforced epoxy resin insulation and bonding. The poloidal field coils, apart from the vertical stability control coils that are normal conducting and situated within the vacuum vessel, are superconducting and lie outside the TF coils. The central solenoid is self-supporting and contains three up-down-symmetric coil sets. There is an upper and lower "divertor" coil and two pairs of outer equilibrium coils.

Maintenance of all basic device components is designed to be fully remote. Provisions for hands-on maintenance will be made wherever possible. The main biological shielding for the machine lies outside the PF coils, within the vacuum vessel shielding providing the minimum shield necessary for the coils.

Low-temperature, low-pressure water coolant and 316L austenitic stainless steel structural material were selected for first wall and blanket designs. The first wall being considered for the early phase of operation is a protected wall of carbon-based tiles, mechanically attached or bonded to the heat sink.

Divertor plates with carbon-based protection and copper, molybdenum, or vanadium heat sink material are predicted to be satisfactory at the heat fluxes expected during physics experiments. Plates with high-Z material

TABLE 2. ITER OPERATING PARAMETERS

Parameter	Physics Phase[a] Inductive Operation	Physics Phase[a] Extended Operation	Technology Phase[b] Inductive Operation	Technology Phase[b] Steady-state Operation
Major radius, R (m)	5.8	5.8	5.5	5.5
Minor radius, a (m)	2.20	2.25	1.8	1.8
Elongation, 95% flux surface	1.9	2.0	2.0	2.0
Toroidal field on axis, B (T)	5.0	5.0	5.3	5.3
Current, I_p (MA)	22	25	18	18
Ion temperature, T_i (keV)	10	10	10	18
Confinement time, τ_E (s)	3.1	3.3	2.7	1.8
Fusion power, P_{fus} (MW)	1000	1000	880	820
Neutron wall load (MW/m^2)	1.0	1.0	1.0	0.9

[a] *Initial configuration, without tritium-breeding blanket*

[b] *Modified configuration, with tritium-breeding blanket*

protection could operate for technology testing with longer lifetime if low-temperature, high-density plasma edge conditions could be realized. Sweeping of the separatrix may ease, to some extent, the technical problems in designing the divertor plates.

For supplying tritium to the ITER machine itself, three options of blanket design are under consideration; i.e., solid breeders, LiPb eutectic breeders, and lithium salt solution breeder.

An important objective of the testing phase is an extraction of high grade heat from reactor-relevant modules and sectors. Testing space will include 4-8 modules with a volume of approximately 1 m^3 each, and two full outboard blanket sectors.

The basic fuelling mechanism will be gas puffing. Pellet injection is planned for density ramp-up and profile control. Torus exhaust pumping may require compound cryopumps.

Performance flexibility

The ITER design should be, to the greatest extent possible, flexible to provide access for the introduction of advanced features and new capabilities. During an early phase of physics experiments of ITER operations, an ignition mode with pure inductive drive and steady-state burn mode with non-inductive current drive will be studied. In this D-T physics phase, a relatively small number of ignition mode and steady-state mode operations with intense neutron production is envisaged, and neutron fluence is expected to be low. After installation of breeding blankets, the ITER should be reliably operated in a steady-state and/or a long-pulse mode, devoted to engineering objectives and testing programme.

Therefore, the machine should have flexible and extended capabilities, especially with regard to plasma size, plasma current, configuration (elongation, triangularity, different divertor configuration, etc.) and operation range (beta, safety factor, etc.). In order to achieve these capabilities, plasma surrounding structures should be replaceable and performance of the poloidal field system should be flexible. Extended operations with a larger plasma size and higher plasma current are especially important to enhance the confinement capability of ITER in the physics phase.

The device is also suitable for the steady-state mode of operation and in that case, the plasma current should be around 15-18 MA with reasonable Q value (≥ 5), current drive power (approximately 100 MW), neutron wall loading (approximately 1 MW/m^2) capability.

RESEARCH AND DEVELOPMENT PLAN

Extensive fusion R&D activities are being carried out in the national programmes of various countries. A great deal of information essential to ITER will be generated from these R&D activities and such information will be made available for the ITER design activities. During the Definition Phase, it soon became clear that all the tasks needed for ITER could not be supported within the budget of $10 million per year per Party over the three years. Therefore, only technology tasks specific to ITER design were presumed to be included in the supporting R&D budget category. For the physics tasks, the ITER activities would be based on voluntary sharing of the efforts among the four Parties.

A plan for ITER technology R&D was developed. In the plan, the R&D tasks are divided into six areas: Blanket, Plasma Facing Components, Magnets, Fuel Cycle, Heating and Current Drive, and Maintenance. The list of tasks and the work proposed by the ITER participating parties for each task are summarized in Attachment 2.

A list of specific physics R&D needs for ITER design was produced. The tasks cover a number of crucial design related physics R&D issues on which information is required to enable, in 1990, the confirmation of the technical working assumptions on which the ITER concept is based. Work has now begun to meet the required physics R&D needs from the programmes of the four Parties.

It should be noted that the R&D plan for ITER was produced based on the information available at a preliminary stage of the ITER design activity so that it will be reviewed and modified as the need arises.

CONCLUSION

During the Definition Phase, the ITER organization functioned efficiently and effectively, with strong support given by the four Parties and the IAEA, so that the required work was completed on schedule.

The ITER Definition Phase work identified a machine concept that would enable flexible and extended operation, satisfying the objectives assigned to ITER. Crucial design related R&D issues were identified both in physics and technology areas, on which additional information was urgently needed. An R&D plan was prepared for the four Parties to perform the necessary work on these near-term issues. A number of technical problems were also identified which need to be resolved on a longer time scale. A mechanism was agreed upon that will aid in the co-ordination of longer term activities in the fusion programmes of the Parties to resolve these problems.

The activities in the Design Phase are aiming at producing both an integrated ITER design and performing the research needed to reduce the present technical uncertainties. The present design guidelines, both for physics and engineering, will continue to be refined during the course of the ITER Conceptual Design Activities in the light of the new information that is being obtained concurrently in the fusion programmes of the four ITER Parties.

Attachment 1

MEMBERSHIP OF ITER COUNCIL, ADVISORY AND MANAGEMENT COMMITTEES 1988

ITER COUNCIL

EURATOM	Prof. Paolo Fasella	CEC, Brussels
	Dr. Charles Maisonnier	CEC, Brussels
Japan	Dr. Katsuhisa Ida	STA, Tokyo
	Dr. Sigeru Mori	JAERI, Tokyo
USA	*Dr. John F. Clarke	DOE, Washington
	Dr. James F. Decker	DOE, Washington
USSR	Acad. Evgenij P. Velikhov	Kurchatov, Moscow
	Dr. Nikolai Cheverev	SCUAE, Moscow

ITER SCIENTIFIC AND TECHNICAL ADVISORY COMMITTEE

EURATOM	Dr. Paul-Henri Rebut	JET, Abingdon
	Dr. Donald R. Sweetman	UKAEA, Abingdon
	Prof. Francis Troyon	CRPP, Lausanne
Japan	Prof. Nobuyuki Inoue	Univ. Tokyo, Tokyo
	Prof. Tadashi Sekiguchi	Yokohama Natl.Univ., Yokohama
	Dr. Masatoshi Tanaka	JAERI, Naka
USA	Prof. Robert W. Conn	UCLA, Los Angeles
	Prof. T. Kenneth Fowler	UC, Berkeley
	Prof. Paul H. Rutherford	PPPL, Princeton
USSR	Dr. Valerij A. Chuyanov	Kurchatov, Moscow
	*Acad. Boris B. Kadomtsev	Kurchatov, Moscow
	Dr. Vyacheslav A. Krylov	Efremov, Leningrad

ITER MANAGEMENT COMMITTEE

EURATOM	Prof. Romano Toschi	NET, Garching
Japan	*Dr. Ken Tomabechi	JAERI, Naka
USA	Dr. John R. Gilleland	LLNL, Livermore
USSR	Dr. Yurij A. Sokolov	Kurchatov, Moscow

*Chairman

Attachment 2

ITER TECHNOLOGY R&D
TASKS AND CONTRIBUTIONS FROM THE PARTIES

	EC	J	USSR	USA
Area: Blanket				
Ceramic breeder	+	+	-	+
LiPb breeder	+	-	+	-
H_2O/Li solution breeder	+	-	-	+
Beryllium	-	-	-	+
Structure material	+	-	+	+
Area: Plasma Facing Components				
Low-Z material	+	+	+	+
High-Z material	-	+	+	-
First wall test	+	+	-	+
Divertor test	+	+	+	+
Area: Magnet				
Toroidal coil	+	+	+	-
Poloidal coil	+	+	-	+
Insulation material	+	+	+	+
Structural material	+	-	+	-
Radiation tolerant magnet	-	-	-	+
Cryogenics	-	+	+	-
Area: Fuel Cycle				
Fuelling	+	+	+	+
Pumping	+	+	-	-
Fuel purification	+	-	-	-
Area: Heating/Current Drive				
Source: EC: 150-250 GHz	+	-	+	+
Source: LH: 6-8 GHz	+	-	-	-
Source: NB: negative ions	+	+	+	+
Area: Maintenance				
Components qualification	+	-	-	-
In-vessel operations demonstration	+	+	-	-

89-03051

INTERNATIONAL
ATOMIC ENERGY AGENCY
VIENNA, 1989

SUBJECT GROUP: III
Physics/
Plasma Physics, Fusion