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INSIDE

1990 SUMMER JOINT WORK SESSION

by K. Tomabechi, Chairman, ITER Management Committee

The Joint Work Session of the ITER Conceptual Design Activities (CDA) began on July 2, 1990 at the technical site in Garching, FRG. This session, the final Joint Work Session in the CDA, is designed to meet the following major milestones:

Major milestones

1) by the end of August: i) critical issue assessments and machine design integration will be virtually completed, and ii) draft reports on plans for the long-term Physics and Technology R&D that will be required for the contemplated Engineering Design Activities will be completed,
2) at the IAEA Washington Conference on October 1 - 6, the results of the CDA will be presented,
3) by mid-October, draft documents to support the contents of the conceptual design final report will be completed,
4) at the beginning of November, the conceptual design final report will be completed, and
5) on November 16 the Joint Work Session will end.

50 full-term and over 150 short-term experts contribute to the joint work

The international team, comprising about 50 full-term professionals from the four ITER Parties, started its work by holding a series of Specialists' Meetings and Workshops in order to assess technical issues, to integrate machine design, and to review the long-term R&D plans which were developed during the last Winter Joint Work session and are to be updated during the current session.

More than 150 other experts will come to the joint work site on assignments of varying length to participate in these activities. After the completion of the Joint Work Session, the results will be presented to the ITER Scientific and Technical Advisory Committee and then to the ITER Council at their meetings in late November and mid-December.

ITER SPECIAL GROUP ACTIVITY - SPRING 1990

by C.A. Flanagan and A. Kostenko

Purpose and goals

An ITER Special Group was designated by the ITER Management Committee to be stationed at the Technical Site in Garching, FRG, following the Joint Work Session that ended in March 1990. The period for the performance of this work was from 6 May until 30 June 1990.

The primary roles of the group were to conduct specific technical design and analysis integration work and to assist the remainder of the ITER Design Team, at their home institutions, in the implementation of their work programmes during this interval between Joint Work Sessions.

Organization and operation

Typically, two members from each of the four Parties comprised the Special Group. Dr. A. Kostenko, USSR, was the chairman. The members represented a broad spectrum of disciplines covering the major design areas of the project.

Because of the brief time, a limited number of tasks were identified and responsibility then assigned to individual members. Regular weekly meetings were held to discuss the status of the assigned tasks and to decide upon further action; special meetings were held as needed between cognizant persons. Based on the design and analysis performed on these tasks, letters were prepared documenting the work. The documents were forwarded to the cognizant Project Unit Leaders, Design Unit Leaders, or other ITER members at the home institutions for their consideration.

Task areas

The tasks were in two areas: 1) design and analysis, and 2) documentation and design information.

Several design and analysis tasks were performed. A few of these are briefly described. A perspective view of the present ITER design is on page 8.

Design and analysis

A compilation was prepared of design drawings, design requirements, and the supporting analyses for the design. This compilation should prove to be beneficial to the ITER participants during the final Joint Work Session of the Conceptual Design Activities and in the process of preparing the final technical documentation. For each major system, sub-system, and component, the compilation provides a listing of the current reference, or working drawings, where the design requirements are documented, and where the supporting analyses are found.

Several tasks were completed for the in-vessel active control coils. The in-vessel active control coil requirements were prepared and documented. A proposal was developed for a new configuration for a single-turn loop coil arrangement that satisfies the requirements for both vertical and radial position control, which has been determined to be required. Several calculational models were developed and proposed to provide a promising way to integrate the passive loops, the active control coils, and the basic device while maintaining consistency with the structural and electrical requirements.

The electrical design of the in-magnet and ex-vessel components was examined relative to electrical resistance requirements. Three areas were examined and preliminary conclusions made. The layout of the main vacuum pumps to the torus results in an evacuation header connecting the main vacuum pump to the forepump; this header generates a toroidal loop without any insulation or resistive elements and therefore an insulation joint between the pumps appears to be the most desirable electrical solution. There is also a toroidal header in the cryogenic supply in which insulation breaks appear desirable also. Finally, an electrical path exists between the thin-walled cryostat vessel and the vacuum vessel along the main vacuum ducts to the pumps. Therefore, it has been concluded that an insulation or resistive element should be installed between the cryostat vessel and the vacuum pumps to assure acceptable electrical properties.

Promising design approach developed

A promising design approach was developed for the upper vertical port region of the design. This region is comprised of several different vacuum zones and topologies. In addition, the interior components require the routing of numerous inlet and outlet coolant pipes into this region. As a result, the design of these different vacuum zones and the routing of all of the piping is a critical issue, especially with respect to assembly and maintenance. The proposed design solution satisfies the functional and assembly/maintenance demands. The approach will now be subjected to comprehensive review by the cognizant project design personnel.

A preliminary assessment was completed of the forces and stresses on the vertical preloading structure of the central solenoid for the various operating scenarios under consideration. Calculations were performed to identify the limiting value of the retractive forces on the coil of the solenoid taking into account cyclic fatigue conditions. The preliminary conclusions are that the retractive forces in the central solenoid will likely be within the allowable values and that the fatigue lifetime can be satisfied. These preliminary conclusions must be confirmed by more detailed analyses.

Documentation and design information

Several tasks were completed in the documentation and design information areas. An updated version of the Physics section of the Design Information Document, developed earlier within the Physics Group, was issued during this period. This included Version 2 of the ITER Physics Design Guidelines to be used by all designers where appropriate. Corrections were made to a number of design drawings and these updated drawings were issued.

Finally, housing and office assignments were arranged, hotel accommodations were planned, and participant information was developed in preparation for the Summer Joint Work Session that began on 2 July 1990.

The Special Group was successful in addressing its goals and tasks during this brief period between Joint Work Sessions. The functions of the group were performed smoothly and the group benefitted from its small size and from having worked closely together during the previous year. Several design integration tasks and design tasks were able to be addressed and preliminary conclusions reached. All of the work was thoroughly documented in internal letters and memos. The preliminary conclusions will be re-visited by the cognizant design personnel during the first weeks of the Summer 1990 Joint Work Session.

D.V. EFREMOV SCIENTIFIC RESEARCH INSTITUTE OF ELECTROPHYSICAL APPARATUS AND ITS PARTICIPATION IN ITER-RELATED ACTIVITIES

by O.G. Filatov

45 years of experience

The D.V. Efremov Scientific Research Institute of Electrophysical Apparatus (NIIEFA*) was founded in 1945 in Leningrad. Recently, a new science and industry corporation "Elektrofizika" was established on the basis of the institute and the Leningrad Experimental Electrical Machinery Building Plant (LOEZ*). The corporation has now substantially increased industrial capacity. The total number of employees is 11,000, of which 5,000 (including 2,000 scientists and engineers) belong to NIIEFA and 6,000 to LOEZ.

Science, technology and industrial applications

The main areas of science and technology activities at NIIEFA are the research and development aiming at creation of equipment for high energy physics, nuclear physics, controlled fusion, accelerators for industry and

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* NIIEFA and LOEZ are the respective abbreviations of Russian names of the institute and the plant mentioned.

Fig. 1. Winding of superconducting coils for T-15 at NIIEFA

medicine and lasers for technological applications. The plants of "Elektrofizika" produce electrophysics equipment for all types of charged particle accelerators, fusion devices and laser technology. Also produced are turbogenerators up to 200 MW, turbogenerators for autonomous electrical stations, electrical machines for industrial users within the capacity range from 100 KW up to several MW, various electrotechnical apparatus, equipment for the nuclear power industry and household electrical devices.

Chief Designer of fusion installations in the USSR

In the area of controlled fusion, NIIEFA is the Chief Designer of fusion installations in the USSR. The Director of the institute, Acad. Glukhikh, who, at the same time, is the Director General of "Elektrofizika", supervises science and engineering developments at NIIEFA which are carried out in co-operation with other research centres and industrial establishments.

At NIIEFA, the well known tokamaks, T-3 and T-4, were designed. These machines demonstrated outstanding results which were followed then by expansion of tokamak experiments all over the world. The institute designed tokamaks T-10, T-15 with superconducting toroidal field (TF) system, TSP with strong field and adiabatic plasma compression, several mirror machines, stellarators, an installation for inertial fusion based on electron beams ANGARA-5, and others. All main non-standard components of these machines were manufactured at the plants belonging to "Elektrofizika". Fig.1 shows winding of superconducting coils for T-15 at NIIEFA. Photos of assembled T-15 and main parameters of tokamaks T-10, T-15 and TSP were published in ITER Newsletter, Vol. 3, No. 3. Starting from the mid-seventies, the institute has been participating in fusion reactor projects, both on national (OTR) and international level (INTOR).

Organization and co-ordination of ITER-related works

NIIEFA has been involved in ITER-related activities since 1988. All main departments of the institute contribute in ITER-related design work and supporting R&D. Overall co-ordination of these activities is the responsibility of the Department of Magnetic Confinement Installations, Electromagnetic Systems and Power Supply Systems. Department Head is O.G. Filatov, Deputy Head is V.P. Muratov, Leading Scientist is Prof. N.A. Monoszon and Leading Engineer is V.A. Beljakov. The Department itself carries out

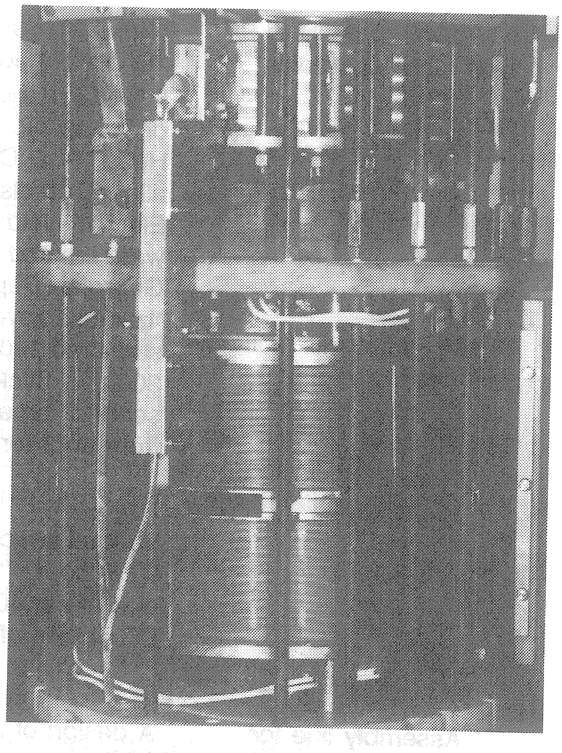


Fig. 2. 12-T solenoid for superconductor short sample testing in the framework of ITER-related R&D programme

important ITER-related design and R&D activities, as follows:

- design of toroidal and poloidal field coils (Division Head, G.F. Churakov),
- computational analysis of electromagnetic systems (Laboratory Head, N.I. Doinikov),
- development of plasma operation scenarios and algorithms for control of plasma parameters (Laboratory Head: V.A. Beljakov), and
- design of electric power supply systems (Division Head, V.G. Kuchinskij).

Scientists and engineers of NIIEFA provide substantial direct contribution to the ITER conceptual design. The Deputy Director, V.A. Krylov, is a member of the ISTAC. A.I. Kostenko heads the Special Integration Group at Garching. S.N. Sadakov is Head of the Containment Structure Design Unit. Since the winter 1990 joint work session, A.M. Astapkovich works for the Poloidal Field Design Unit.

R&D on magnet systems

According to on-going R&D programme, a special stand (LIS-12) was built for superconductor short sample tests. It consists of a split superconducting solenoid producing a maximum field of 12 T in a 150-mm diameter bore (Fig.2) and a device for AC loss measurements in conductor samples based on a superconducting dipole magnet. A superconducting DC transformer is used to generate a 30-kA current in the tested samples. The LIS-12 equipment has successfully passed through tests. Now, testing of candidate conductors for toroidal field coils is being carried out. The tested conductors are designed for both "react and wind" and "wind and react" manufacturing technologies. This work is led by Laboratory Head, G.V. Trokhachev.

Various types of electrical insulations, compatible with both types of manufacturing technologies are being developed and tested. For the first technology, fibreglass materials impregnated with various polyimides are studied; and, for the second one, epoxy impregnated fibreglass materials as well as materials based on micaplastics are tested. Research reactor IRT-5000 of the Physics Institute in Riga is used to irradiate samples at low temperature (~10 K) up to a dose of $5x10^9$ rad.

Stress analysis and material studies

Stress analyses of electromagnetic system, divertor plates and vacuum vessel are performed in the Mechanics Division (Division Head, Yu.V. Spirchenko). Experts of this division also carry out R&D on development and qualification of cryogenic steels for TF coil cases and conductor conduits (Laboratory Head, R.V. Chvartatskij). Mainly, two types of high strength austentic N-alloyed steels are under study. One of them was developed at E.O. Paton Electric Welding Institute (δ_y= 1240 MPa, δ_u = 1640 MPa) and the other one was created at the Institute of Metals of the Academy of Sciences of Georgian Republic (δ_y = 1360 MPa, δ_u = 1840 MPa). Industrial corporation "Izhorskii zavod" manufactures high quality 12-ton ingots of the first type of steel and 190-mm rolled plates. Preparations are in progress to manufacture 300-mm thick plates which are needed for coil cases of ITER. As to the second type of steel, two plates of 40 and 70-mm thickness were made from an 8-ton ingot.

Various switching devices are being developed for electric power supplies of ITER coils. Among them are DC breakers, reverse switches, etc. able to operate at 40 to 50 kA and 30 kV. Industry now produces such devices for DC values of 5 to 10 kA.

Assembly line for manufacturing long conductors designed

A design of a special assembly line for manufacturing conductors of lengths of more than 200 m was made at NIIEFA. The Head of the Technology Division is V.I. Peregud. The line will be put into operation in 1992.

Laser welding is being studied as one of the options for welding of conductor conduits. Laser welding technology center is being established at the institute under the leadership of Prof. G.A. Baranov. It is planned to manufacture double pancakes with a diameter of 2 m and test them under conditions close to those foreseen for ITER. For this purpose, modification of test stand SIMS, at I.V. Kurchatov Institute has already begun (SIMS - Upgrade-1). This stand was formerly used for testing of superconducting coils of tokamak T-15. This work is carried out in close co-operation with I.V. Kurchatov Institute. A possibility of testing of large circular-shape coils is considered as well.

Vacuum systems and divertor

The Department of Vacuum Systems (Department Head, Yu.G. Prokofjev) carries out design of vacuum vessel, divertor plates and pumping systems. A broad R&D programme on material studies and technologies for manufacturing of divertor plates is on-going in the division, which is led by G.L. Saksaganskij. Both low-Z materials (graphite, pyrographite and c/c composites) and high-Z materials such as W-, Ta- and Mo-based alloys as well as Cu- and Mo-alloys for cooling system elements are being studied. For this purpose, several electron and ion accelerators are used which are able to imitate ITER-like operation conditions of divertor including disruption. To test full-scale divertor sections, it is planned to modify and subsequently use an industrial EB-welding installation ESP-30 equipped with five 30-keV electron guns. Each gun has a power of 1,2 MW.

In the area of vacuum pumping systems, development of a crysorption pump is in progress. Cryocondensation of deuterium and tritium has been studied and data obtained on cryosorption of helium by activated charcoal. Technology for covering a plate with granules of activated coal and for regeneration of sorption elements have been developed. Now, a large-scale model of this type of a pump is under development. Also, a turbomolecular pump (10 m^3 of nitrogen per second) has been experimentally investigated. A larger one (20 m^3 s^{-1}) is in process of fabrication now, being close to completion.

Alternate divertor and blanket

NIIEFA is conducting research on Ga-based liquid metal divertor (both droplet and film options) and on liquid metal lithium blanket with slot channels (Laboratory Head I.R. Kirillov). Experiments are being performed on MHD stands and on tokamak T-3M (B = 3.5 T, R = 1 m, a = 0.2 m and Ga circuit with flow rate of 5 l per second) which is located at science and industry corporation "Energija". The work is being carried out in co-operation with Physics Institute of Latvian Academy of Sciences and with Leningrad Polytechnical Institute.

Fuel injection

In co-operation with the Leningrad Polytechnical Institute, NIIEFA is conducting research on fuel pellet injectors. In the frame of this programme, the experimental study of the following options are carried out:

- light gas injector modules (v=1.5-2 km per second; frequency range, 1-3 Hz; pellet size, d=h=4-10 mm; long operation),
- electromagnetic technique for pellet acceleration (v=2-10 km per second) and
- beam ablation technique for pellet acceleration (v$\sim$ 10 km per second; laser; electron beam).

30 YEARS "NUCLEAR FUSION"

by C. Bobeldijk, Head, Scientific Journals Section, IAEA

Broad spectrum of fusion-related information published monthly

The IAEA journal "Nuclear Fusion" started as a quarterly journal, publishing its first issue in September 1960. During the past 30 years the journal has matured into a prestigious international monthly journal publishing, on average, 15 peer-reviewed articles per issue (full papers, letters and reviews) as well as conference reviews, books reviews and a fusion calendar. In addition, the journal has traditionally published the summary papers of the IAEA fusion conferences, reports of IAEA Technical Committee meetings, the executive summaries of INTOR and ITER, and status reports on fusion compiled or written by the International Fusion Research Council (IFRC), the advisory body on fusion matters to the IAEA.

Content of Anniversary Issue

The Anniversary Issue of "Nuclear Fusion", Vol. 30, issue 9, will contain the most recent IFRC status report comprising 13 technical papers detailing all aspects of the status of controlled thermonuclear fusion research. The papers, written by an expert subcommittee of the IFRC, deal with both the physics and the technology of fusion research. The issue opens with an introductory note from Dr. Hans Blix, Director General of the IAEA, followed by an executive summary and a general overview of the technical papers. This part appeared as a separate booklet in June 1990 entitled "Status Report on Controlled Thermonuclear Fusion".

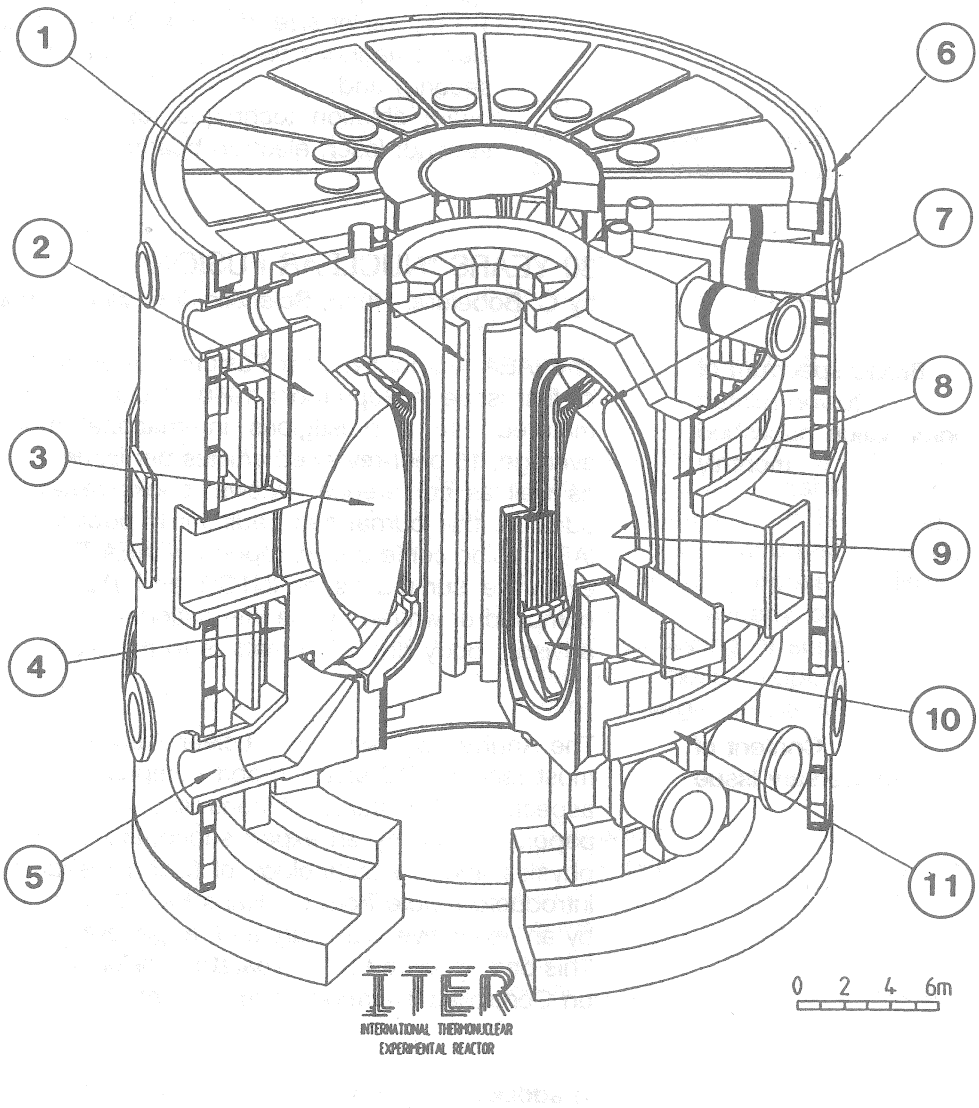
In addition, the Anniversary Issue will include a comprehensive database of tokamak confinement data from several major tokamak experiments. This database is the first in a series of articles meant to provide the fusion community with confinement relevant data from all the major tokamaks in a unified format.

ITER MAJOR EVENTS - 1990

Joint Work Session	Garching	2 July - 16 Nov
ITER Council Meeting	Vienna	26 - 27 July
ISTAC Meeting	Vienna	12 - 14 Sep
ITER Council Meeting	Washington	8 - 9 Oct
ISTAC Meeting	Vienna	28 - 30 Nov
ITER Council Meeting	Vienna	13 - 14 Dec

ITER REFERENCE PARAMETERS

Plasma major radius, R (m)	6.0
Plasma half-width at midplane, a (m)	2.15
Elongation, 95% flux surface	1.98
Toroidal field on axis, B_o (T)	4.85
Nominal maximum plasma current, I_p (MA)	22
Nominal fusion power, P_f (MW)	1000



1- CENTRAL SOLENOID
2- SHIELD/BLANKET
3- PLASMA
4- VACUUM VESSEL-SHIELD
5- PLASMA EXHAUST
6- CRYOSTAT
7- ACTIVE CONTROL COILS
8- TOROIDAL FIELD COILS
9- FIRST WALL
10- DIVERTOR PLATES
11- POLOIDAL FIELD COILS

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