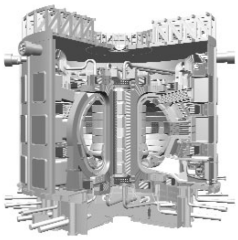

ITER ITA NEWSLETTER

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ITER UPDATE
Information from the Editor

EUROPEAN UNION CHOOSES CADARACHE AS ITS PREFERRED LOCATION FOR ITER

Protracted discussions over the European choice were in danger of placing the complete negotiating schedule of the Parties in jeopardy. However, at a European Council of Ministers meeting on 26 November 2003 agreement was reached on the European preference of Cadarache.

COMMON MESSAGE FROM THE PREPARATORY MEETING FOR THE MINISTERIAL MEETING FOR ITER

Delegations from Canada, China, the European Union, Japan, the Republic of Korea, the Russian Federation and the United States of America met in Vienna on 4–5 December 2003 to advance the ITER Negotiations. The meeting was held at the headquarters of the IAEA and was moderated by IAEA Deputy Director General Werner Burkart.

The delegations have achieved a major milestone in ITER Negotiations, namely, full coverage of cost-sharing for the two candidate sites in the European Union and Japan. The delegations are confident that this achievement provides the basis for reaching consensus on the preferred site at the Ministerial Meeting for ITER. The Ministerial Meeting for ITER will take place on 20 December 2003 in Washington, D.C.

MINISTERIAL MEETING FOR ITER HELD IN WASHINGTON, D.C.

Ministers representing the participants in Negotiations on ITER construction – China, the European Union, Japan, the Republic of Korea, the Russian Federation, and the United States of America – met in Washington on 20 December 2003. Unfortunately, they were unable to reach agreement on the site for ITER, and agreed to meet again after the end of January 2004.

They issued the following joint communique:

“The six Parties have reached a strong consensus on a number of points.
We have two excellent sites for ITER, so excellent in fact that we need further evaluation before making our decisions based on consensus.
We have agreed to provide remaining questions to the candidate host parties by the end of December for their answers by the end of January.
We will ask the ITER Team in conjunction with the ITER Parties to conduct a rapid exploration of the advantages of a broader project approach to fusion power. This work will be done on the same schedule.
With all this information, we plan to hold a follow-up Ministerial meeting to reach consensus as quickly as possible, likely to be in February.”

CANADA ANNOUNCES WITHDRAWAL FROM THE ITER NEGOTIATIONS AND THE ITER TRANSITIONAL ARRANGEMENTS

On 23 December, Canada announced its withdrawal from the ITER Negotiations and the ITER Transitional Arrangements. Writing to the other ministers responsible for ITER, Mr. P. Busquin (for Euratom), Mr. X. Guanhua (China), Mr. T. Kawamura (Japan), Mr. H.K. Park (Republic of Korea), Mr. A. Rumyantsev (Russian Federation), and Mr. S. Abraham (USA), Mr. R.J. Efford (PC, MP) stated:

"I am writing to advise you of the decision by the Government of Canada to withdraw from the ITER negotiations.

As you know, Canada participated in the design phase of the project and has been a party to the subsequent international negotiations. Iter Canada, a private-sector consortium, developed an offer (the Iter Canada Plan to Host ITER) to locate the project at Clarington, Ontario. Based on the excellent attributes of the Clarington site, which include major technical and cost advantages, the offer was presented by Canada to the international Parties at the June 2001 ITER meeting in Moscow. In June 2002, the European Union presented the French site at Cadarache and the Spanish site at Vandellos while Japan tabled its site at Rokkasho-mura. In light of the competitive offers submitted, including significant government financial backing, Canada indicated in December 2002 that it would review the ITER Canada Plan to Host ITER and consider whether to table a revised offer.

Further to discussions conducted with the Government of Ontario and Iter Canada, a decision has been made that Canada will not table a revised offer to host the project, nor participate as non-host. Given present priorities and other demands, Canada is not in a position to table a competitive package that would lead to Canada becoming the host to the ITER project. It has been a difficult decision to reach, and it is with regret that Canada is withdrawing from the ongoing negotiations. Canada is also notifying the International Atomic Energy Agency that Canada will be withdrawing from the ITER Transitional Arrangements.

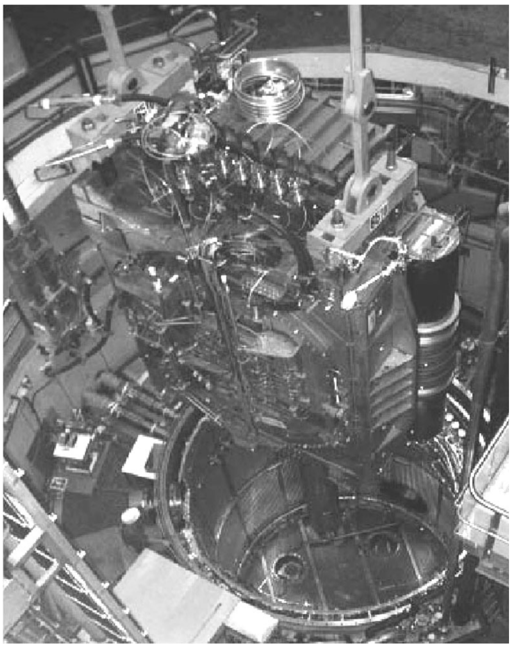
I understand that the international negotiation process is reaching the final stage. I would like to send my strong encouragement and best wishes to you and the other Parties for a successful implementation of the ITER project."

PROGRESS IN ITER MAGNET DESIGN AND PREPARATION OF PROCUREMENT PACKAGES

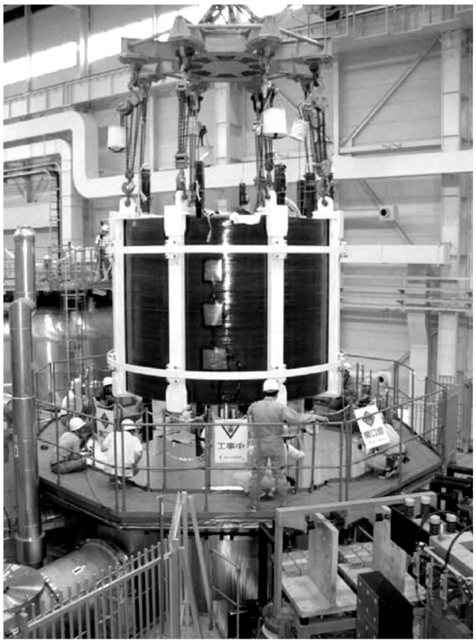
by Dr. N. Mitchell, Acting Division Head, Superconducting Coils and Structure Division, ITER Naka Joint Work Site

The end of the EDA extension in July 2001 saw completion of the ITER magnet design to the extent necessary for a reliable costing. However, options for several critical components remained open and, although all critical areas were analysed to demonstrate that the designs proposed would perform according to requirements, many detailed aspects were not defined (or analysed) to the level required for construction.

Since 2001 the International Team (IT) has concentrated on the preparation of procurement packages for long lead items to be ready for the machine construction. In magnets this has required, in parallel, design development, analysis, and (as a result of R&D) design adjustment. The past two years have been a period of intense development of the magnet design, selection of manufacturing procedures, and reassessment of factors controlling the limiting superconductor conductor performance in the TF and CS coils. Although the effort has been limited by the large reduction in personnel in the magnet division (from 11 in 2001 to its present size of five people), decisions on most design options have now been taken in consensus with the Participant Teams (PTs), analysis is under way and, as a preliminary to completing the procurement packages, the main design definition documentation is being updated.



The TFMC combined with the European LCT coil being lowered into the TOSKA facility



Inner module of CSMC being lowered into the JAERI test facility

In R&D too, further testing work on the Central Solenoid Model Coil (CSMC) was performed in 2002 and the Toroidal Field Model Coil (TFMC) testing was performed in Nov 2001 and 2002. The analyses of the results of these tests have only just recently been completed and put together into a single coherent view of the conductor performance that can be expected in the ITER magnets. Other major R&D results available after 2001 included the study of the magnet structures fabrication, investigations of options for the NbTi poloidal field (PF) coils, and mechanical tests of shear keys. The test of a PF model coil (as an insert in the CSMC) will only be completed in 2004.

Probably the largest effort has gone into the interpretation of the CSMC and TFMC conductor test results. There was reluctance to agree that performance shortfalls existed and it required considerable perseverance from the IT to initiate proper analysis and objective assessments. At the same time, the IT proposal to reconsider the Nb_3Sn strand requirements in view of progress in industrial production since the model coil strand was ordered (in about 1994) met with general agreement and has shown the way to offset the unexpected results from the model coils. The IT suggestion (after consideration of conductor test results in SULTAN as well as those from the Central Solenoid and TF Coil Insert Coils (CSI, TFI), as well as the CSMC and TFMC themselves) was that the transverse magnetic loads locally on the conductor (as high as 70 tonnes/m in some locations) were causing a performance drop amounting to a reduction of 1.5 K in the maximum allowable operating temperature, compared with about 0.5 K allowed for in the design margins. The most likely reason is strand deformation in the conductor (or, possibly and more seriously, filament breakage).

The results, in terms of the ‘extra’ unexpected strain on the cable that would account for the reduction in temperature margin, are illustrated in Figure 1 (very approximately, the ‘shortfall’ in the expected temperature margin is about 1 K at the TF conductor operating current and 1.5 K for the CSMC). All PTs now agree that there is performance degradation due to transverse load effects and that some conductor optimization is necessary to recover adequate operation margins. The IT believes it is essential to carry out R&D to differentiate between strain degradation due to bending (which is at least in principle reversible) and that due to filament breakage (which is not, and which may be progressive).

Also, the TFI results have been reassessed using thermohydraulic modelling (under transient conditions). The assessment has shown (supporting the results from the CSMC shown in Fig. 1) that the expected benefit from

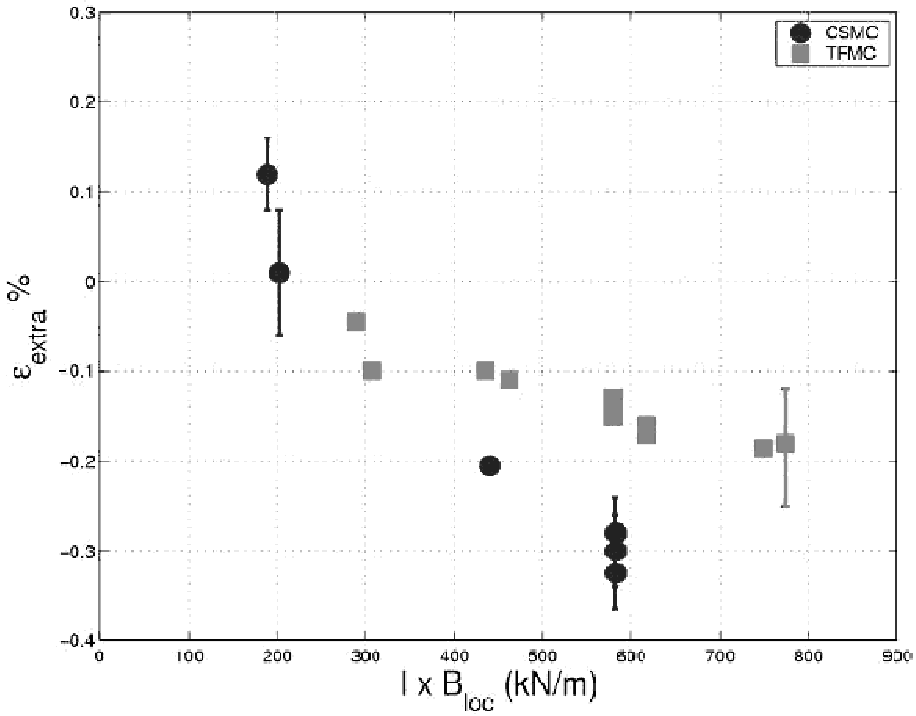


Figure 1. Summary of the Model Coil TCS analysis (I) (R. Zanino)

a low coefficient of expansion (COE) material (titanium) for the jacket is not fully realized. The key action for 2003 was to achieve convergence by all PTs on single reference conductor designs for the ITER TF coils and CS. This objective was met at a meeting organized by the IT at Garching in May 2003. The main decision made at the meeting was that the TF coils and CS conductors will use stainless steel jackets. In the case of the CS, the selected steel is JK2LB, a special alloy developed in Japan, with a low COE between room temperature and 4 K, and good fatigue behaviour. The TF coils and CS conductors will use Nb_3Sn strand with improved critical current performance in order to provide the necessary operation margins.

R&D has been initiated in the EU, JA, RF and US to develop and characterize improved Nb_3Sn strand. The original critical current density targets of 550 and 700 A/mm^2, for bronze route and internal tin wire, respectively, were already exceeded during the model coil fabrication and industrial development (largely driven by the particle accelerator programmes). Now, after discussions with the PTs, targets of 700 and 800 A/mm^2 have been chosen for the procurement.

The detailed design of the structural support concept for the magnets (Figure 2), in particular the TF coils, has received substantial analysis attention. At the end of the EDA, the inner poloidal keys between the TF coils at the top and bottom of the inner straight leg were known to cause unacceptable stress concentrations (with stresses of up to 1000 MPa). It was anticipated that these could be removed by optimizing the positions and lengths of the keys (as well as strengthening the back of the TF coil case). Although the final key configuration has not yet been selected, configurations have been identified with an acceptable fatigue life. Optimization, performed by the IT and RFPT, has taken longer than expected but is now close to a conclusion. Stress analysis of the poloidal key region, with progressively longer keys as one moves from ‘inboard’ to ‘outboard’, has led to a more uniform stress distribution. The peak stress is now close to 500 MPa.

A further critical region in the magnet structures is the design of the intermediate upper and lower outer intercoil structure (OIS) that forms ‘bands’ linking the individual TF coils. These bands function as both shear panels, to provide out-of-plane support, and bands to hold in the TF coils. They have to contain insulating joints

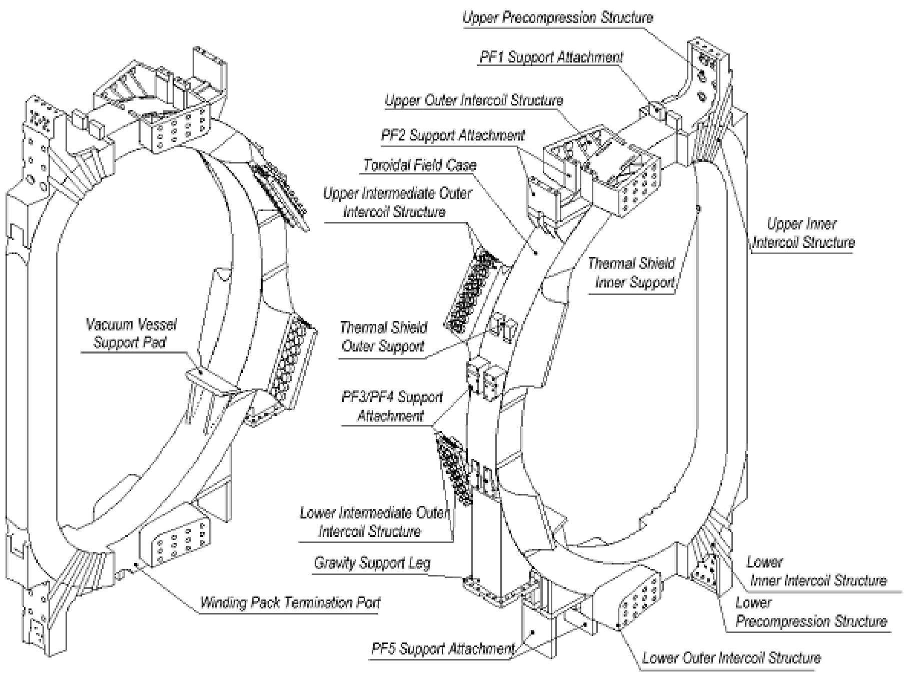


Figure 2. TF Coil structural support (in July 2003)

which can transmit both tension and shear. Two concepts were developed at the end of the EDA, a 'box' type of panel and a 'friction' type, as shown in Figure 3. To complicate the issue, two fabrication methods were proposed for the outer TF coil legs and the OIS, one involving casting of the thick sections and one involving welding of plates. As is usual in such situations, the design has to be optimized around the fabrication method and it is not possible to maintain one design and two fabrication methods.

The assessment of both OIS designs has been completed with a finite element stress analysis. Problems were found with the box design due to fatigue in the bolts and opening of the flanges connecting adjacent boxes, which creates overloading of the shear keys. These issues have been among the considerations which led to the selection of the friction joint design. This design decision makes the use of castings for the TF coil cases much less cost-effective (even if the problems of quality control could be solved) and has led to the selection of the welded plate route.

Further decisions have also been taken on the performance requirements of the individual regions of the TF coil cases. Three grades of steel have now been introduced (previously there were two), which allows a significant reduction in the quantity of the highest strength (electro-slag refined) material. This brings the total TF coil structure supply comfortably within the capabilities of a single supplier and means that, although individual structure subsections can come from different suppliers, each TF coil structure segment has identical mechanical properties and there is no need for expensive duplication of forging shapes with multiple suppliers. Of course, the ITER Construction Parties have to agree a suitable procurement strategy to permit this.

Design work on the CS was restarted early in 2003 and, following the decisions of the May magnet meeting (steel jacket and use of butt joints), a new reference design has been prepared. This design incorporates a new design of the CS coolant inlets (placed in the highest stress region, these have to have a carefully controlled geometry to avoid stress concentrations), butt joints between pancakes, and a dummy turn at each of the individual module winding ends to transmit the tensile load on the conductor around the terminal joints. The CS stack is precompressed vertically by a set of nine inboard and outboard steel tie-plates. The CS con-

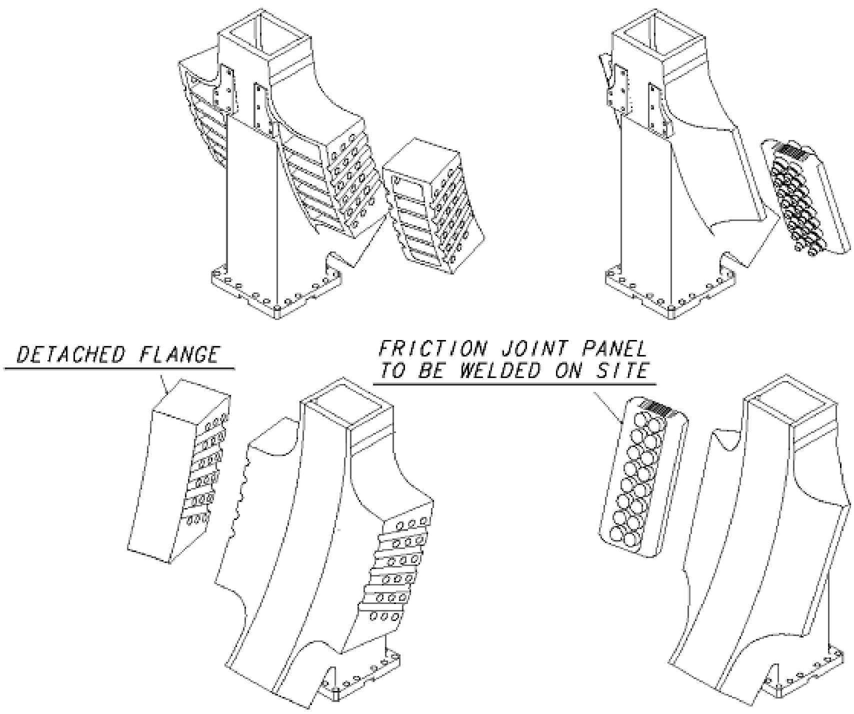


Figure 3. Box and friction type OIS designs

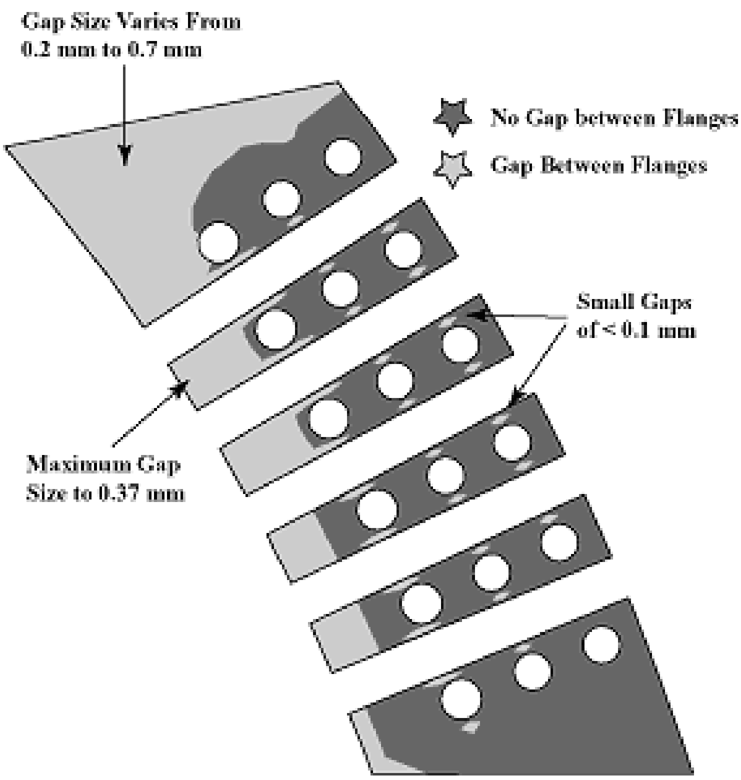


Figure 4. Finite element analysis of box type OIS showing gaps opening on the shear keys of the upper segment [C.Jong]

ductor and CS design have been reoptimized to maximize the flux generation. Structural analysis of the conductors and insulation (local detailed models) and of the whole stack (axisymmetrical model) is being repeated for this new CS design. It has been confirmed that the plasma flux can be maintained (or slightly improved) while reducing the peak field on the solenoid to 12.8T from the previous 13.5T. This allows some reduction in the steel jacket thickness for the conductor, simplifying the fabrication.

The correction coils have been another area that has received design and analysis attention. These coils, shown in Figure 5, consist of 18 individual coils arranged outside the TF coils. They are to provide correction of non-axisymmetric error fields arising from the main coil manufacture and installation as well as dynamic stabilization (using feedback control) of plasma resistive wall mode instabilities. As part of a general re-assessment of the conductor AC losses with the new strand types, for the first time a proper cooling assessment has been performed for the correction coils. Recent (2003) increases in the control requirements for these coils (especially as regards ELMs and their effect on the sensors used for wall mode control) have meant that losses have exceeded the cooling capability, and a redesign of the conductor cooling circuits is now underway.

In addition to the design and analysis, the magnet procurement packages have been under preparation since July 2001. These procurements cover approximately 25% of the ITER hardware cost. The procurement is divided into six main units (conductor, TF coil, PF coils, CS coils, structures and busbars/current leads). Drafting groups were set up in 2001 for each package (except for the CS coils, which started only in 2003), although some PTs were slow to provide representatives and to submit contributions. Of these six packages, none are fully complete but all except the CS coils and busbars/current leads are available in draft form. Details of items such as quality assurance and qualification testing also remain to be finalized. The completion of these packages is being affected by the long timescale of negotiations which will eventually fix the procurement sharing and will thus have a strong impact on the viable procurement strategy. The intention is that the IT will have the complete packages, including annexes ready in 2004.

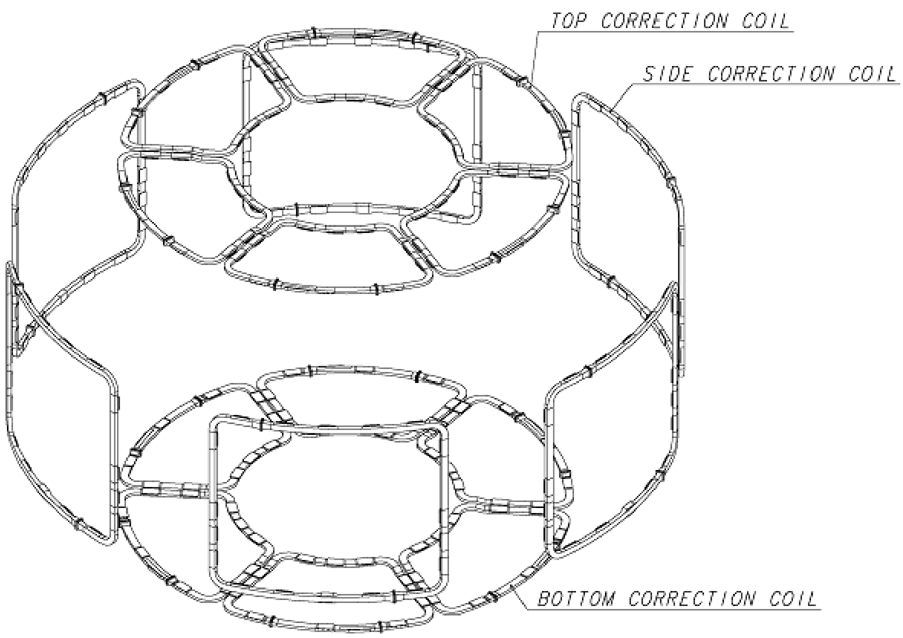


Figure 5. Correction coils

25 YEARS AGO

by Dr. V. Vlasenkov, RF Preparatory Committee Contact Person

On 20–23 November 1978 the First Steering Committee Meeting of the International Tokamak Reactor (INTOR) Workshop, organized under the auspices of the IAEA, took place at the IAEA headquarters in Vienna. Senior participants from each participating country – G. Grieger (CEC), B. Kadomtsev (USSR), S. Mori (Chairman, Japan) and W. Stacey (USA) – attended the meeting. J. Phillips, H. Seligman and V. Vlasenkov represented the IAEA.

The INTOR activities were the starting point of the international collaboration in practical demonstration of fusion power. One could say that INTOR was the predecessor of ITER. In developing a model for the administration and technical structure for an international fusion project, INTOR created the basis for the success of ITER, which is at the stage of finalization of the construction agreement between the six ITER Parties.

Items to be considered for inclusion in the ITER ITA Newsletter should be submitted to C. Basaldella, ITER Office, IAEA, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: +43 1 2633832, or e-mail: c.basaldella@iaea.org (phone +43 1 260026392).

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