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In this issue

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INTERNATIONAL

Fusion Materials Research

International Energy Agency (IEA) receives recommendation for wider research in fusion materials.

The five-party IEA collaboration on Radiation Damage in Fusion Materials ends its second five-year term in October 1990.The Executive Committee administering this collaboration, under an IEA Implementing Agreement, has unanimously recommended to the IEA:

- continuation of the Fusion Materials R&D effort for another five-year term under the IEA Implementing Agreement, and
- broadening of the research scope of the Implementing Agreement, which was originally established to conduct research only into fusion-relevant radiation damage on materials.

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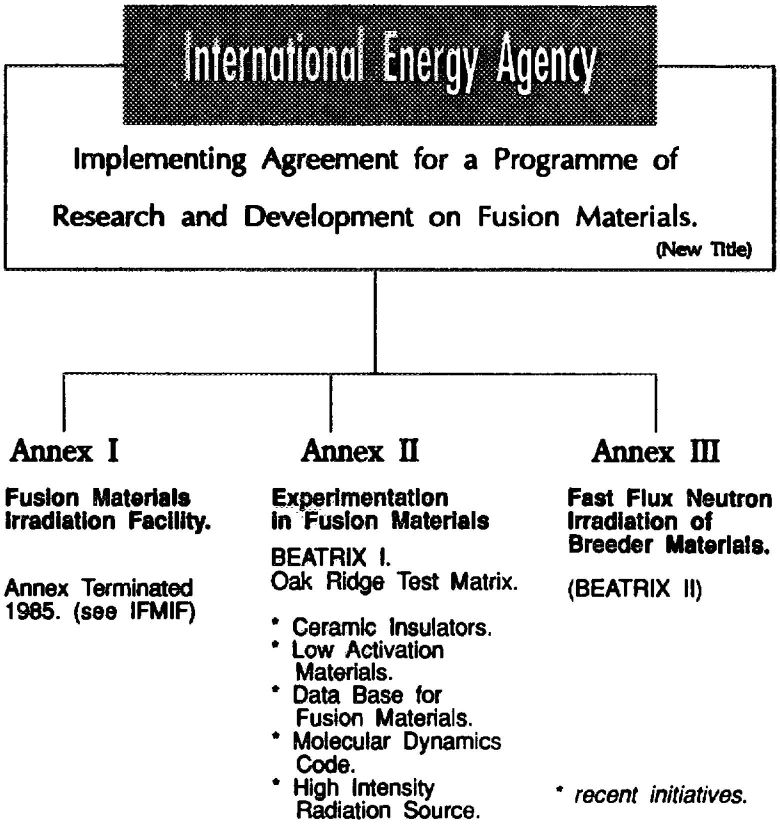

International Energy Agency

Implementing Agreement for a Programme of Research and Development on Fusion Materials.
(New Title)

Annex I

Fusion Materials Irradiation Facility.

Annex Terminated 1985. (see IFMIF)

Annex II

Experimentation in Fusion Materials

BEATRIX I.
Oak Ridge Test Matrix.

- * Ceramic Insulators.
- * Low Activation Materials.
- * Data Base for Fusion Materials.
- * Molecular Dynamics Code.
- * High Intensity Radiation Source.

Annex III

Fast Flux Neutron Irradiation of Breeder Materials.

(BEATRIX II)

* *recent initiatives.*

ITER PHYSICS

CCFM Interested in ITER Physics Effort.

Centre canadien de fusion magnétique (CCFM) is interested in participating in long term ITER physics research, via Canada's fusion collaboration with the European Community. Addressing the recent Euratom meeting (Brussels, January) on Long Term Physics R&D for the Next Step, Richard Bolton, CCFM Director General, made a presentation on the possible contributions of Tokamak de Varennes to the ITER Long Term Physics R&D Plan. CCFM is Canada's main magnetic fusion centre, based on Tokamak de Varennes, which CCFM operates. It was determined by CCFM staff that research directions at CCFM match well with several identified ITER physics R&D needs.

A draft of a Long Term ITER Physics R&D Plan was prepared in 1989 by the ITER physics team.One of the Plan's aims is to produce results which will permit coherent prediction of ITER performance with satisfactory accuracy. Also, an overall optimization of the discharge conditions that can be extrapolated to ITER is required.

The plan will be discussed and refined during 1990 by ITER Partners. As of January, the main technical topics identified in the draft Plan are:

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ITER PHYSICS

CCFM Interested in ITER Physics Effort.

- Power and Particle Physics. This refers to integration of three knowledge areas; plasma edge physics, plasma-wall interaction and impurity control.
- Plasma disruption control and operational limits.
- Enhanced confinement.
- Long pulse operation, including non-inductive current drive.
- Physics of a burning plasma.

The established scientific program of CCFM has these main topics:

- Impurity behaviour and control, and plasma-wall interaction.
- Divertor plate and limiter biasing, current and helicity injection.
- Fast plasma current ramp up and ramp down, and multi-pulse operation.
- Long pulse operation for 30 seconds, using lower hybrid plasma current drive at a high power density and ohmic heating transformer recharging during lower hybrid current drive.

Therefore, CCFM believes that its current program, and comprehensive set of diagnostic equipment would enable it to contribute to ITER physics R&D in the Draft Plan areas of Power and Particle physics and Long Pulse operation. Also, since the Japanese tokamak JT-60 has demonstrated that the high confinement H-mode can be sustained during lower hybrid operation, CCFM staff suspect that Tokamak de Varennes will in future contribute work toward the Enhanced Confinement topic identified in the Long Term Plan.

On Tokamak de Varennes, steady progress is being made in fitting internal coils for the two triplet divertors and the fast horizontal plasma position control systems. First plasma with the modified machine is now expected in May.

It is believed that divertor operation will contribute to understanding of the physics of edge plasmas, particularly in energy and particle transport at the plasma edge. Electrical biasing of fusion plasmas is currently of great interest to fusion workers, and Tokamak de Varennes is the only machine with electrically isolated divertor plates capable of biasing the plasma through the divertors. Biasing experiments will begin this summer.

In December 1989, a favourable review was given by an international panel to the design of the lower hybrid current drive which CCFM plans to fit to Tokamak de Varennes. A radiofrequency power density of 1 megawatt/m^{3} is targeted at the lower hybrid injection frequency of 3.7 GHz.

More information from Brian Gregory (514) 652-8729 or Réal Décoste (514) 652 8715 at CCFM.

INTERNATIONAL

Fusion Performance Record Achieved at JET

Canada congratulates workers at the Joint European Torus (JET) project in England on the fusion performance records achieved in late 1989.

The JET machine results indicate that fusion 'breakeven', the generation of fusion power equal to the power used to maintain the plasma, is within reach for fusion workers. The work at JET highlights the great progress toward building a working fusion test reactor that has occurred in the last decade.

The JET machine held for one second plasmas that would, with deuterium-tritium fuel, generate fusion power of 10 megawatts, or 60% of the power used in maintaining the plasma. In the accepted notation, Q_{DT} = 0.6 was achieved. In one machine run on JET, $Q_{D\text{-}T}$ = 0.8 was achieved for about 0.1 seconds.

Dr Paul Rebut, Director of JET, expressed in November the view that JET had basically achieved its objective of establishing the scientific feasibility of fusion as an energy source. He went on to say that he considers the problems of heating and confining a fusion plasma to be solved. "We now have to concentrate on reducing (plasma) impurities and controlling the plasma fuelling for long enough for a reactor", he also said.

The JET machine has, at different times, exceeded the threshold values in three important parameters required in a fusion power reactor; temperature, plasma density and energy confinement time.

	Fusion Power Reactor needs (Typical)	Best at JET (1989)
Temperature T (millions °C)	200	280
Density n (particles m^{3})	2×10^{20}	4×10^{20}
Confinement time τ (seconds)	1.5	1.8

The product of these three parameters, $Tn\tau$, sometimes called the fusion product, is an important index of the approach to ignition of a fusion power reactor. Reactor ignition requires a $Tn\tau$ value of about 5×10^{22}; JET approached within a factor of eight of that value late last year, with a $Tn\tau$ of 6×10^{21} (M°C. m^{3}s).

CFFTP
Canadian Fusion Fuels Technology Project

Ceramic Breeder Temperature Profiles

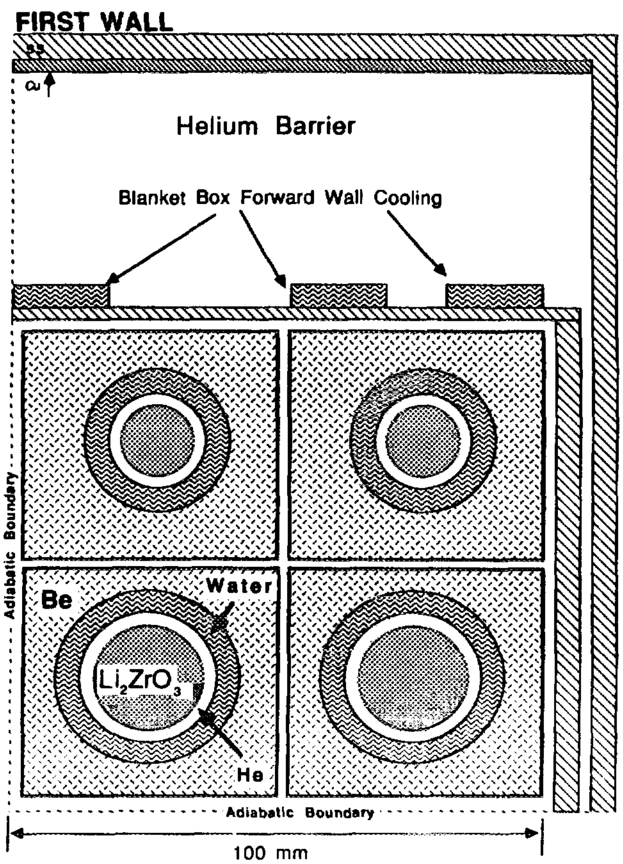
CFFTP is studying a variety of breeder blanket concepts to estimate blanket temperature profiles under similar operating conditions. Two-dimensional temperature profiles are calculated, and parametric analyses performed to estimate effects of design variations on the temperature profiles.

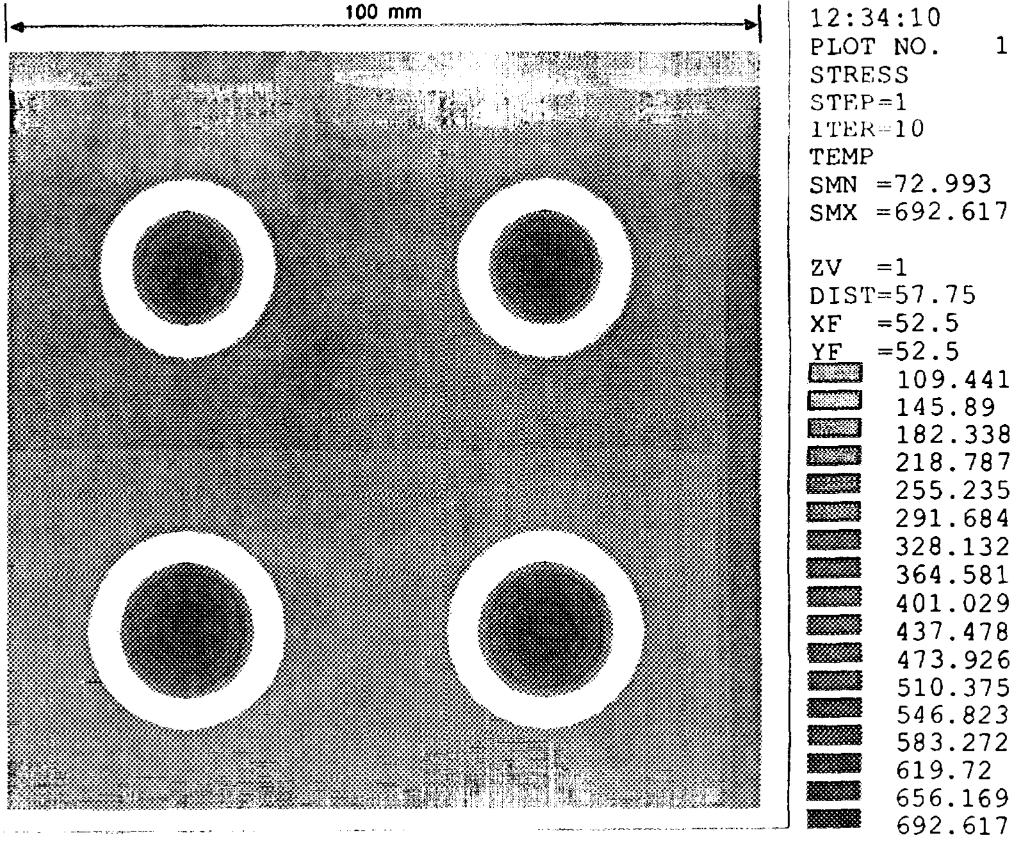
The European Community's ITER reference blanket design is a solid ceramic breeder-in-tube blanket with a sintered beryllium neutron multiplier. CFFTP recently analyzed a Canadian variant of the EC-ITER concept, using lithium zirconate microspheres as the breeder material, with square-section sintered beryllium components.

The diagram shows calculated temperature profiles for the Canadian variant of the EC-ITER reference blanket concept. Reference condition for this plot is a first wall neutron load of 1 MW/m². The analyses indicate that a viable blanket design could be achieved using the lithium zirconate spheres as the breeder, as well as the reference lithium aluminate material.

For a practical blanket, a reasonable operating temperature range for the ceramic breeder is 450-700 °C. Blanket temperature profile is found to be sensitive to the width of the helium gas annulus gap separating the breeder tube and the tube for the water cooling jacket; in the plot shown, gas gap width is 1.0 mm for the small tube arrays and 1.2 mm for the larger tube arrays.

More information: Paul Gierszewski, CFFTP (see Contact data).





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Temperature profile of variant of European Community ceramic breeder-in-tube blanket, using lithium zirconate microspheres as the breeder. Temperature range is 73 °C to 692 °C, plotted in profile intervals of 36.5 °C. Lightest shading is 109.5 °C max., darkest shading is 692.6 °C max. Conditions: reference neutron load = 1 MW/m².

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INTERNATIONAL

Fusion Materials Research

The recommendations were accepted in Paris (January 1990) at the 19th meeting of the IEA's Fusion Power Coordinating Committee (FPCC), which coordinates six international fusion research collaborations, with three more in the formative process.

Activities in progress under the Fusion Materials Implementing Agreement are shown in the diagram. The recent initiatives shown are advancing well. In the Materials Data Base activity, for example, some data on stainless steels and ceramics are in the review stage, and an electronic version of the handbook is being tested.

New Scope in Fusion Materials R&D

At its tenth annual meeting (Tokyo, December 1989) the Fusion Materials R&D Executive Committee agreed unanimously that instead of being limited to radiation damage in materials, the Implementing Agreement be considerably broadened. The broadened scope recommended to the IEA includes:

(1) Research on the effects of the expected environment of fusion reactors, including the nuclear, plasma, chemical, physical, mechanical and thermal aspects of that environment on the properties and behaviour of materials.

(2) Research to develop new and improved materials resistant to the effects of that environment.

(3) Research, development, design, construction and operation of special test facilities that may be required to carry out such research.

(4) Establishment of a common data base on materials for use in the design of fusion facilities.

Dr Gil Phillips, of the Canadian National Fusion Program, completed his two-year term as Chairman of this Executive Committee at the Tokyo meeting. The new chairman is Dr Max Victoria (Switzerland).

IFMIF–International Fusion Materials Irradiation Facility

There is wide agreement that a new high intensity fusion materials irradiation source is needed for materials tests. The original effort to build such a source, under Annex I (see diagram) expired in 1985 for lack of funding. A working group is being formed to define the characteristics and experimental program for such a source.

Summary of Implementing Agreements.

Under formal Implementing Agreements, the IEA currently coordinates international fusion research collaborations in six areas:

- Superconducting Magnets R&D: (EC, Japan, Switzerland, USA.)
- TEXTOR Exploitation: (Canada, EC, Japan, Switzerland, Turkey, USA.)
- Fusion Materials R&D: (Canada, EC, Japan, Switzerland, USA.)
- ASDEX/ASDEX Upgrade Exploitation: (EC, USA.)
- Stellarator R&D: (EC, USA.)
- Large Tokamaks R&D: (EC, Japan, USA.)

Three new Implementing Agreements are being forged: Blanket R&D and Tritium Recovery; Environment, Safety and Economics; Reversed Field Pinches.

Blanket R&D and Tritium Recovery.

An Ad-Hoc Committee recommended in January that the FPCC support and coordinate a program on Breeder Blanket R&D and Tritium Recovery, under a new IEA Implementing Agreement. Work envisaged includes building and testing of breeder blanket modules and sub-modules. A number of IEA member countries have Blanket programs. There is enough complementarity, the Committee felt, that a cooperative international program might allow broader coverage of the field and better use of existing facilities in different countries. The Ad Hoc Committee is now dissolved. Its members were J. Darvas (EC), R. Dowling (USA), T. Iijima (Japan) and G. Phillips (Canada).

Environmental, Safety and Economic Aspects.

This collaboration is intended to improve understanding of economic and environmental aspects of fusion energy, and to develop safety and environmental assessment methodologies. Eight Tasks have been agreed by all parties so far:

- Tritium Safety and Environmental Effects
- Activation Product Codes
- Mobilization of Activation Products
- (First Wall) Erosion Dust Generation
- (Public) Dose Calculations for Activation Products
- System Safety Study Methodology
- Failure Rate Data Base
- Superconducting Magnet Safety

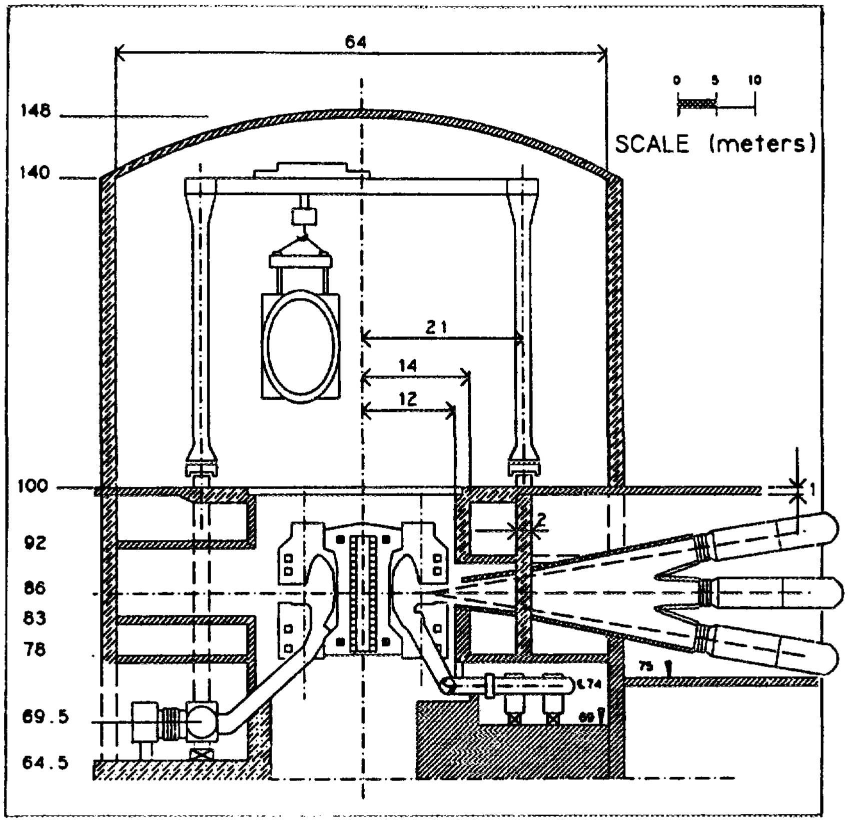
Gary Vivian of CFFTP is Task Leader for work on Tritium Safety and Environmental Aspects. A draft Implementing Agreement has been prepared, and should be available for signing this year.

More information: Gil Phillips or Bill Holtslander, National Fusion Program, or Gary Vivian, CFFTP.

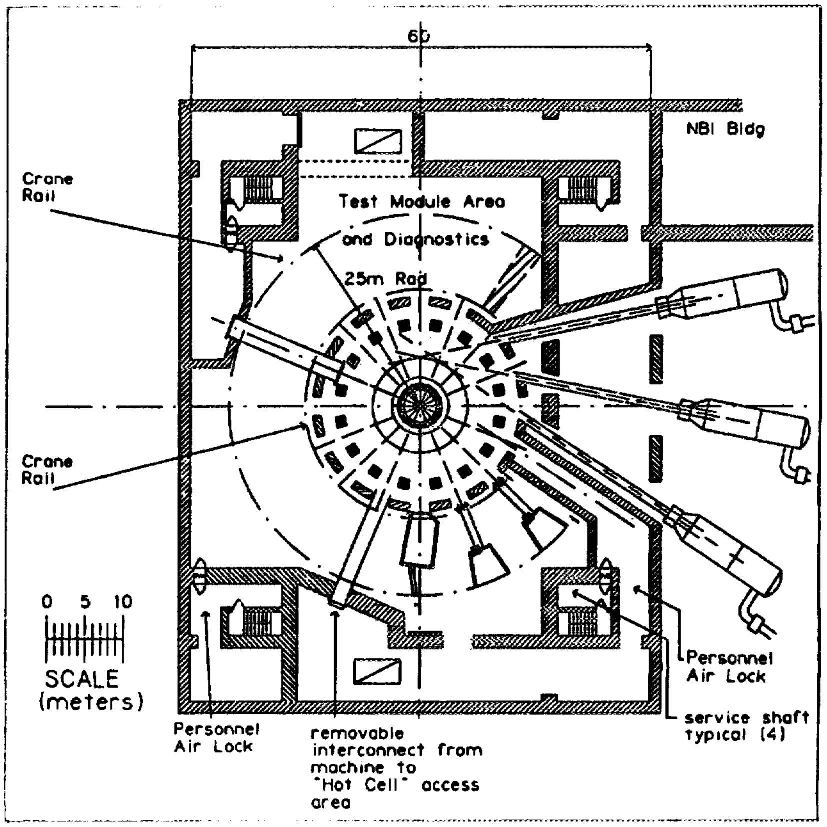
ITER DESIGN

Two views of an ITER reactor building design option, produced in a CFFTP design exercise. See back page.

Tokamak Building Vertical Section
Split section showing two vacuum pumping arrangements.



Tokamak Mid Plane
Port Room



ITER DESIGN

Reactor Building Options

Canadian designers at CFFTP* have been exploring various reactor building design options, based on information generated by ITER conceptual design work in Garching, West Germany.

We reproduce in this issue two views from one such design exercise, to indicate to readers the possible scale of the ITER reactor building in relation to the reactor itself.

Reactor building requirements are developed from component designs and a preliminary safety analysis. Arrangement of equipment in the reactor building is based first on operating and maintenance requirements for reactor systems. The greatest space is required by in-vessel maintenance and neutral beam injectors. Specific equipment placed in a building design concept includes:

- neutral beam injectors.
- primary heat transfer circuits.
- radiofrequency plasma current drive and heating.
- torus vacuum pumps.
- reactor maintenance equipment.
- fuelling equipment.
- diagnostics.
- blanket tritium extraction systems.

John Blevins is the CFFTP design engineer specialist in reactor building design; he has worked on a number of fusion reactor designs including ITER. The drawings are from his paper "ITER Reactor Building Design Study" presented at IEEE 13th Symposium on Fusion Engineering", Knoxville, Tenn, USA October 1989.

* Canadian Fusion Fuels Technology Project.

More information from John Blevins, CFFTP.

National Fusion Program

Director, *Dr. David P. Jackson*

The National Fusion Program (NFP) coordinates and supports fusion development in Canada. NFP was established to develop Canadian fusion capability, in industry and in research and development centres. NFP develops international collaboration agreements, and assists Canadian fusion centres to participate in foreign and international projects.

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Contact Data Update:

Error correction:

Please note that the correct FAX number for the National Fusion Program Office is (613) 584-4243.

In the last issue of FusionCanada, the area code was wrongly given as (514) instead of (613).