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CFFTP News

More Funding for CFFTP

The Province of Ontario has allocated funding of $9.4 million to the Canadian Fusion Fuels Technology Project, increasing total CFFTP funding to $33 million over five years. The new funds, from the Premier's Technology Fund, will mainly be used to support R&D related to next-step fusion machines, particulary the ITER Collaboration. This work will enhance the spread of fusion capabilities in industry and universities. Base funding for CFFTP is now nearly $7 million per year; Ontario Hydro and NFP are the two other funding partners. Base funding is expanded by contributions from industry and by revenues from contracts for services and equipment supply.

Announcement of the new funding was made jointly by Ontario Minister of Energy Mr. Robert Wong, and Ontario Minister for Industry, Trade and Technology Mr. Monte Kwinter, at a special press conference.In their remarks, the Ministers spoke of the importance of the fusion energy option, and the importance of the ITER Collaboration in progress toward realizing the goal of practical fusion power.

Signing in Brussels of the Canada/Europe Memorandum of Understanding concerning the involvement of Canada in the Euratom contribution to the ITER Conceptual Design activities. Mr. Daniel Molgat (near camera), Ambassador to the Commission of the European Communities, signs for Canada; European Community Vice-President Karl-Heinz Narjes signs for the EC. In his address at the ceremony, Mr. Molgat noted Canada's pleasure in the results of the EC's evaluation of Canada's fusion capabilities, noting also Canada's appreciation of the warm reception of the ITER Council with respect to Canada's involvement.

ITER

ITER Concept Definition Issued

The Concept Definition Report for the International Thermonuclear Experimental Reactor (ITER) has been issued. The report details the conclusions of the ITER Project Team as of October 1, 1988, when the Team's 1988 joint work session ended.

Some of ITER's preliminary reference case design parameters are at present:

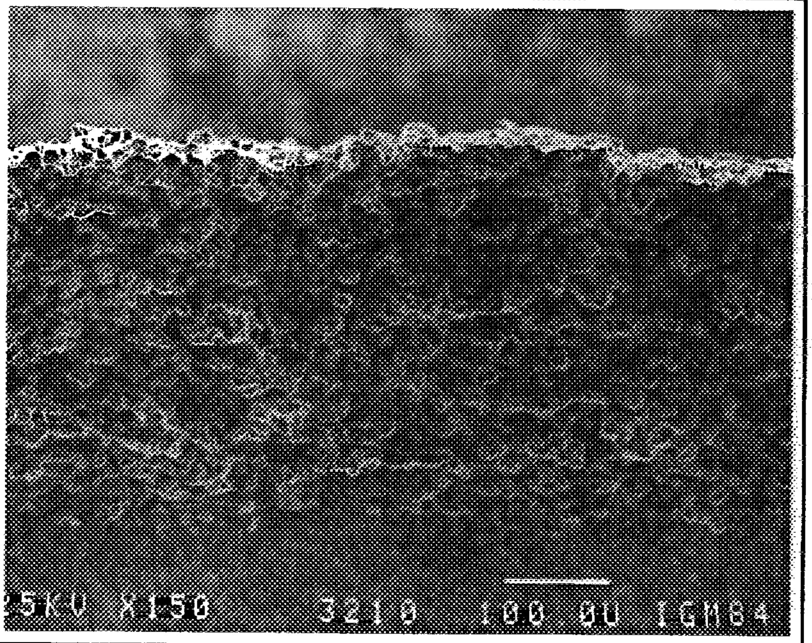
- About 1,000 megawatts of fusion power during operation.
- Major radius: 5.5 metres.
- Plasma current: 22 megamps physics phase; 18 megamps technology phase.
- Superconducting toroidal and poloidal field coils.
- 'D'-shaped plasma cross section with double null divertors.

Continues inside

We regret that some of the pages in this report may not be up to the proper legibility standards, even though the best possible copy was used for scanning

CCFM—Tokamak de Varennes

Tokamak de Varennes was shut down December 12 for modifications and installation of new plasma chamber components. This marks the end of the Tokamak's first experimental cycle, begun in June 1987. In 1988 much interesting work was done, especially after stable high power plasma operation became routine in mid-year. Startup of the modified Tokamak is scheduled for Autumn 1989.



Typical Titanium Carbide Coating on Test Limiter. Electron microscope photograph showing granular TiC coating on head of a test limiter. Solid inconel head substrate is at bottom. White bar shows 100 micrometer scale. To deposit coatings on limiter head, TiC granules 20 micrometers diameter are heated and sprayed onto surface by industrial type plasma torch. Limiter head is hemispherical, radius ≈ 35 mm. Typical titanium-:carbon ratio is 1:0.7.

Work in the last half of 1988 included:

- Demonstration of Tokamak's multi-pulse capability.
- Fast, controlled current ramp-down at up to 7 megamps/second.
- Plasma impact tests on TiC coated limiter.
- Electrical biasing of Tokamak plasma.
- Measurements of carbon impurity species.

With modifications completed, Tokamak de Varennes will be equipped for divertor and limiter operation, with very fast plasma position control, and should have considerably enhanced plasma position stability. This will aid fine measurements of plasma behaviour. Operation with multiple-pulse plasmas is planned, to enhance materials testing, and plasma impurity transport and recycling studies. During the nine-month shutdown, analysis of data from the previous experimental period will be a major preoccupation.

Internal components now being installed include an inconel liner for the plasma chamber, internal coils and divertor plates for the poloidal double-null divertor system, internal coils for the fast horizontal plasma position control system, and 24 metal alloy getters for pumping neutral hydrogen and impurity atoms. Divertor plates will be electrically insulated from the machine structure, so that plasmas can be electrically biased during divertor operation.

Multiple pulse operation was demonstrated shortly before shutdown. Two consecutive controlled plasma pulses were produced, initiated by the machine's solid-state ohmic heating switch. Trains of closely spaced plasma pulses will be used in the next experimental cycle. The Tokamak is purposely designed and built to sustain pulse trains or single pulses 30 seconds long, to study plasma impurity transport and recycling. A lower hybrid radiofrequency plasma heating system is being designed to permit operation with long continuous plasma pulses.

Plasma Biasing. Experiments on the Tokamak illustrated the fact that the electric potential of the plasma can have significant physics effects, as previously demonstrated on PBX (USA). All limiters on Tokamak de Varennes are electrically isolated from the machine structure and can be used to measure plasma potential or to electrically bias the plasma. In a November test, biasing the plasma to -250 volts increased plasma electron density by 25 percent. Plasma density profile was flattened in that test. In a different test, the top and bottom limiters were short-circuited; as Q=2 was approached, average currents of about 60 amps were observed in the circuit, modulated by a 60 amp peak-to-peak sawtooth waveform. Modulation was synchronous with plasma sawtooth oscillations.

The electrically isolated poloidal divertor plates being installed will also be used as electrodes in more extensive plasma biasing experiments. They will permit more thorough investigation of the complex interplay between increased particle confinement time τ_p, plasma impurity production and transport, and energy confinement time τ_e.

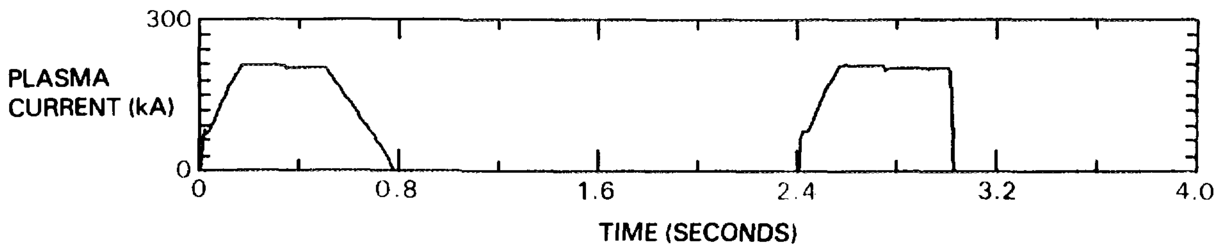
Carbon impurity species. Mass spectrometry measurements showed surprisingly large amounts of carbon monoxide and carbon dioxide; quantitative estimates show that CO production is the main source of plasma impurity, produced by plasma-surface interaction. During plasma plateau, the flux of carbon monoxide molecules at the chamber wall was typically 2-3 x 10^{15} molecules/cm^2. This is about an order of magnitude less than the flux of neutral hydrogen atoms, but about three times the total hydrocarbon flux, which includes non-negligible amounts of higher hydrocarbons such as C_2H_4, C_3H_5 and others. Carbon monoxide levels remained high after the plasma shot ended. Methane levels doubled in a 150 millisecond period following pulse termination. The CO/CO_2 generation is via ionization of water desorbed from chamber walls by plasma-surface interaction. Dissociated oxygen reacts chemically with the graphite limiters and carbon-covered walls to produce CO. Recycling of CO through the plasma provides a constant source of oxygen for further reactions. Reduction of residual water in the chamber could significantly reduce plasma contamination.

Titanium carbide (TiC) limiter coatings. Plasma impact tests on TiC-coated test limiters have been performed. In tests at 200 kiloamp plasma current, TiC coated hemispherical limiter heads absorbed 30 kilowatt on a 10-20 cm^2 area, a power density exceeding 15 megawatts/m^2. There was no measurable titanium contamination of the plasma. One test limiter, with a 200 micrometer-thick TiC coating, withstood 17 plasma shots at these power levels. When the limiter was inserted further, however, flaking of the TiC coating occurred, probably due to thermal stress. While tests at the 30 kilowatt absorbed power level appear encouraging, improvement of coating design to increase thermal stress tolerance is envisaged. Coatings are deposited by plasma torch, at thicknesses up to 400 micrometers.

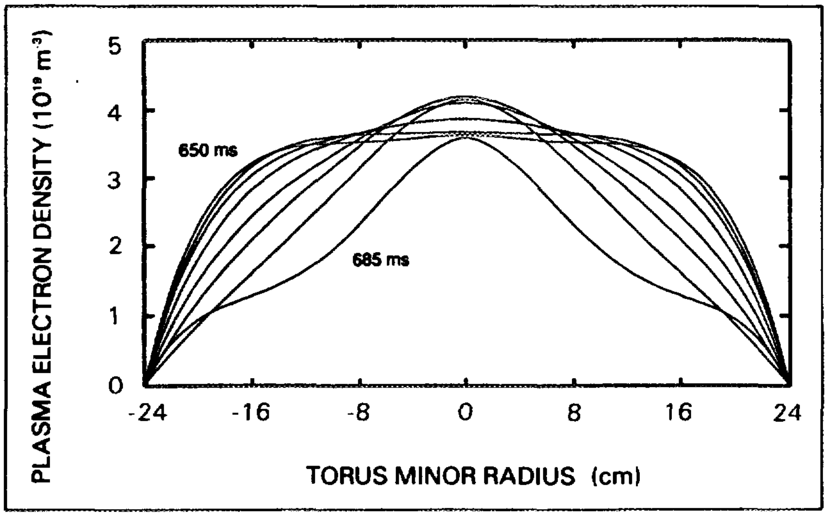
Plasma current rampdown tests. These have been very satisfying; controlled rampdown at rates up to 7 megamps/second have been achieved (250 kiloamps to zero in 37 milliseconds). Plasma remains stable throughout rampdown, until plasma current vanishes. Peaking of the electron density profile (see curves) and soft X ray profiles is observed, consistent with expectations resulting from modelling of current density profile during rampdown.

Research results have been presented at an American Physical Society (Plasma Physics Division) conference (Florida, November, 1988) and the IAEA's 12th International Conference on Plasma Physics and Controlled Nuclear Fusion Research (Nice, October 1988). In January, results of plasma biasing experiments were presented by Dr. Pierre Couture at the US-Japan Workshop on Tokamak Physics in San Diego.

More information from Prof. Horst Pacher, Scientific Coordinator (514) 652-8726. Contacts for individual topics:
Plasma biasing—*Dr. Pierre Couture (514) 652-8716*
Carbon Impurities—*Prof. Bernard Terreault (514) 468-7711*
Coated limiters—*Prof. Barry Stansfield (514) 652-8735 or Prof. Robert Saint-Jacques (514) 468-7709*



Two consecutive tokamak pulses on Tokamak de Varennes, in shot no. 6218. This plasma current trace shows repeatability of pulse rise and plateau. Preset termination of shot at t 3.0 seconds curtails second pulse. Pulse spacing of 2.4 seconds is not a limit; when tokamak resumes operation, close spaced multiple pulse operation will be a normal operating option.



Evolution of electron density profile during a disruption-free plasma current rampdown at 6 megamps/second (tokamak shot no. 5,027). Density profile traces are 5 milliseconds apart. Initial current was 250 kiloamps. Rampdown begins 650 milliseconds into the shot; plasma is extinguished at 690 milliseconds. Note that profile begins changing towards a more peaked distribution almost as soon as rampdown starts.

Canatom Design Award

In a national competition, Canatom Inc. received an Award of Merit for its design of Tokamak de Varennes from the Association of Consulting Engineers of Canada. Canatom designed the Tokamak proper, including its jointed vacuum vessel, its coil systems, and the civil works and power systems. Philip Cumyn, Project Engineer on the Tokamak since 1978, received the award at the 1988 ACEC awards ceremony.

Universities

University Fusion Network Proposed

On behalf of a group of seven Canadian universities, the National Fusion Program has proposed to set up and administer an $11 million university fusion research network, under the federal government's Networks of Centres of Excellence Program. The network's aims are to perform significant basic research in areas identified as lacking by the world fusion community, and to train more fusion engineers and researchers. Under the proposal submitted November 30, 1988, three major topics would be investigated by the network:

- Materials studies related to ITER priorities.
- Magnetic confinement studies related to ITER priorities.
- Inertial confinement (ICF) studies with Krypton Fluoride lasers.

The seven universities involved are:

University of British Columbia, University of Alberta, University of Saskatchewan, McMaster University, University of Toronto Institute for Aerospace Studies, INRS-Énergie (part of Université du Québec), and Acadia University.

The materials studies objective is to develop and test new erosion-resistant first wall materials, for lining plasma chambers of next-step fusion machines such as ITER. The magnetic confinement program would explore the physics of high-confinement fusion plasma modes which commercial fusion power will require, and which ITER will explore in ignition plasmas. The proposed ICF studies would study plasma instabilities in ICF targets irradiated by a KrF laser beam smoothed by induced spatial incoherence.

In the proposal, the university network would have access to the resources of the National Fusion Program and its key project centres to further the research objectives, to expedite the transfer of new expertise to industry, and aid communications with world fusion centres.

The proposal was submitted by Atomic Energy of Canada Limited, which operates the National Fusion Program. Macphee Technical Corporation, as consultant to NFP, planned and wrote the proposal and coordinated university input.

The resolution by the universities to collaborate formally in the special-purpose network, and to ask NFP to submit the network proposal, was made at a Chalk River conference concerning the network, attended by university representatives and delegates from CCFM and CFFTP, in September 1988.

ITER

Continued from front page

- About 100 megawatts injected neutral beam power.
- In-vessel components fully replaceable.
- Divertor plates replaced insitu.
- Vertical and horizontal maintenance, fully remote but hands-on where feasible.

Among the technical objectives for ITER machine are:

- Demonstrate controlled ignition, with D-T burn periods up to 2 weeks.
- Steady state burning as ultimate objective.
- Neutron wall loading (average) of 1.0 megawatts/m^2 to support engineering test objectives.

Three breeder blanket options are being examined; aqueous lithium salt blanket (ALSB), solid breeder, and lithium-lead eutectic. A tritium breeding ratio of about one is targeted.

The 40 member ITER Project Team reconvenes for a February/March joint work session at the ITER Technical Site (Max Planck Institute for Plasma Physics, Garching, W. Germany).

Canadian Participation

Canada participates in the European Community contribution to ITER. As part of it's participation, Canada is contributing to the design effort of the ITER Project Team. In the 1988 joint summer work session of the Team, Mr. Robert Stasko of CFFTP worked at the ITER Technical Site to contribute to the design effort. His work included coordination of reactor building layout, and contributions to biological shield design and methodologies for replacing major reactor components, including control of radioactive contamination. Mr. Stasko joins the ITER Project team for the February/March design review workshop and will attend the 1989 joint summer work session in Garching.

Canada is also committed to contributing R&D effort to ITER. Among present R&D efforts are solid breeder and aqueous lithium salt blanket research, as well as contributions to ALSB design.

INTERNATIONAL

The International Atomic Energy Agency has appointed Dr. David Jackson as a member of its International Fusion Research Council (IFRC). This Council advises the IAEA Director General, Dr. Hans Blix, on the Agency's fusion programs. IFRC members represent the leaders of major national fusion programs.

Dr. C. Richard Neufeld of CCFM is in Japan working at the JFT2-M tokamak at the Tokai Research establishment of JAERI. JFT2-M emphasizes auxiliary plasma heating research. Dr. Neufeld, a Hydro-Québec physicist, is on a one year attachment working on radiofrequency heating experiments.

A Workshop on Aqueous Lithium Salt Blankets was held February 7-9 in Toronto, attended by US and Canadian blanket workers. Presentations and discussions at the joint meeting covered water chemistry, hardware and systems design, safety and environmental topics and consideration of R&D requirements for an engineering test reactor ALSB. CFFTP was Toronto host for the Workshop, attended also by invited guests from Europe and Japan.

Industry in Fusion

This item continues coverage of corporations in the Canadian fusion infrastructure.

HVSI—High Vacuum Systems Inc.

Mississauga, Ontario

HVSI makes high- and ultrahigh-vacuum components and systems to order for research establishments and industry. They have supplied assemblies for fusion and tritium research in Canada and overseas. In these areas, experience includes tokamak components and tritium systems and gloveboxes. The company meets Quality Assurance standards applicable for tritium and fusion systems.

The company made all four movable limiter assemblies for Tokamak de Varennes, including the linear hydraulic actuators, limiter mountings and vacuum seals. In 1983 HVSI fabricated the welded stainless steel vacuum chamber for the STOR-M tokamak at University of Saskatchewan (see FusionCanada Issue 5). This vessel incorporates large vacuum-tight bellows forming part of the toroidal chamber ring.

HVSI has begun fabrication of the tritium microballoon filling station for University of Rochester, under a CFFTP contract. In the past, they constructed controlled atmosphere gloveboxes for ENEA Frascati, Italy, for containing tritium systems.

More information; David Chato, HVSI Marketing Manager, or Alan Meikle of CFFTP (see Contact Data).

CFFTP News

Advisory Committee Review

CFFTP calls each year upon its Advisory Committee of senior fusion researchers to review its programs and their relevance to world fusion activity. The Committee met again in November 1988 to evaluate presentations on Project programs and goals.

Among the newer programs reviewed, formation of the CFFTP Industrial Advisory Committee (IAC) drew particular interest and a strong endorsement. The IAC, now being established, is charged with the specific task of expediting the systematic transfer to industry of CFFTP-developed technology. The Committee also strongly endorsed a proposal for a new CFFTP Tritium Technology Facility, a laboratory to expand present tritium experimental facilities, to be located at Chalk River Nuclear Laboratories.

CFFTP Advisory Committee members were:

International Members:
Dr. J.L. Anderson; *Los Alamos National Laboratory, USA.*
Dr. Y. Naruse; *Tokai Research Establishment, Japan.*
Dr. J. Nihoul; *The NET team, Garching, W. Germany.*

Canadian Members:
Dr. R. Morrison; *Energy, Mines and Resources Canada (Committee Chairman).*
Dr. R.A. Bolton; *CCFM, Québec.*
Dr. A.A. Harms; *McMaster University (Physics Dept.).*
Dr. G.J. Phillips; *National Fusion Program (Committee Secretary).*

The Committee endorsed the continuing relevance of the CFFTP's work, and made valuable recommendations for enhancing future work. Recommendations were presented to CFFTP's Steering Committee. (A reference overview of CFFTP programs and directions appeared in issue 5 of FusionCanada.)

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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