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Transport Studies Underway on TFTR

by A.R. DeMeo

The current TFTR experimental run, which began on July 31, is going "exceptionally well" according to Project Head Dale Meade. "When we started in late July, we set a goal of 3,000 shots by the end of December, which would correspond to a typical year. I am extremely pleased that the TFTR has already achieved over 3,000 shots as of October 26. This is a tribute to the excellent work of the TFTR operations staff." TFTR's prolific performance has been a good test of the repairs completed this summer on two toroidal field coils in which small water leaks were discovered last January.

Since the beginning of August, TFTR has been maintaining an ambitious schedule, running 5 weeks instead of the usual 3 between scheduled maintenance weeks. According to Meade, "The TFTR program has been extended to study transport (the loss of particles and energy from the plasma) in order to better understand energy confinement in tokamaks. There is now a 50-50 balance between pushing towards scientific breakeven and plasma understanding. An improved comprehension of transport should lead to improved performance and hence breakeven."

Scientific breakeven will occur when the energy multiplication factor Q equals 1. Q is the ratio of fusion power output to total plasma heating power supplied by ohmic, neutral-beam injection or radiofrequency heating. To date, TFTR has produced world record values of the Lawson factor (1.4×10^{14} sec cm^{-3}) and the temperature (340 million °C) required for breakeven. If tritium were added to TFTR, the Q value for the TFTR's high temperature experiments is projected to be about one-half. This represents a 200-fold improvement over the PLT (Princeton Large Torus) generation of tokamaks and is only a factor of two away from breakeven.

To aid in transport studies, TFTR staff are improving existing diagnostics and developing a number of new measurement techniques. For example, fluctuations in plasma temperature and density will be studied to understand how they affect transport. A beam emission spectroscopy diagnostic is being developed for TFTR in collaboration with the University of Wisconsin. In addition, different techniques will be employed to agitate (perturb) the plasma and study its response.

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Pellet injection is being used on TFTR, both as a means of perturbing the plasma and fueling it. For the past few years, a Deuterium Pellet Injector (DPI), developed by the Oak Ridge National Laboratory (ORNL), has been used on TFTR producing peaked central plasma densities (1.4×10^{14} cm^{-3}) at a plasma temperature of approximately 10 million °C. Over the past year, PPPL collaborated with MIT (Massachusetts Institute of Technology) to

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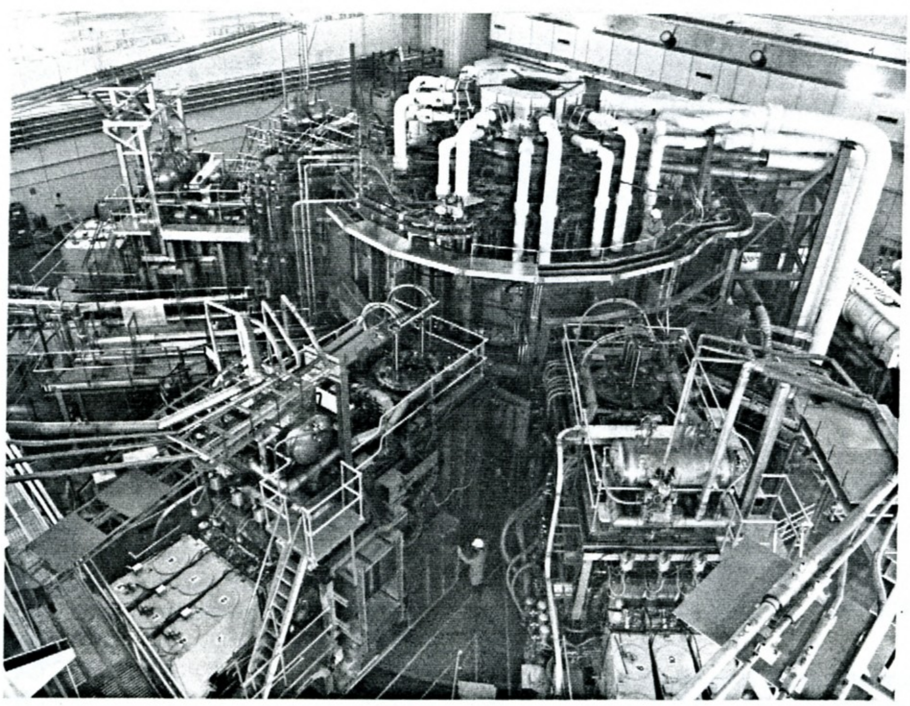
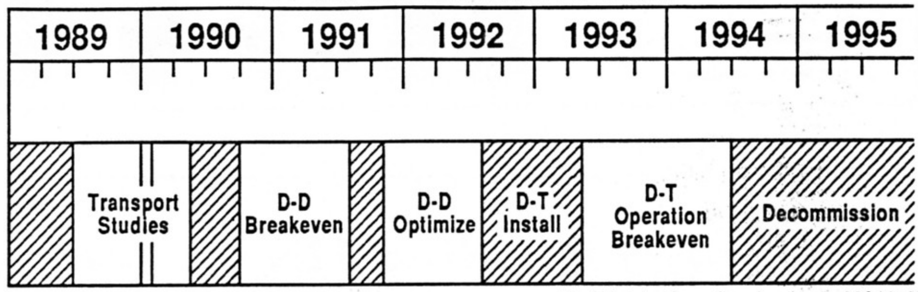


(Photo by John Peoples and Dietmar Krause)

The TFTR is surrounded by a maze of pipes and cables that make up the auxilary heating and cooling systems and the sophisticated diagnostics that are used to measure plasma parameters.

TFTR RESEARCH PLAN



(Art Work by Greg Czechowicz — 89A0079)

The TFTR Project has been extended to mid-1994.

design and construct a Lithium Pellet Injector (LPI), which has been installed on TFTR for use during the current run. For the same pellet size and speed, the lithium will penetrate the plasma more deeply than deuterium. Lithium ions eventually leave the center of the plasma and are replaced by deuterium ions, resulting in higher central deuterium densities.

Radio-frequency heating will become a major part of the TFTR program this year. Experiments have been conducted with 4.5 MW of ion cyclotron radio-frequency (ICRF) heating, delivered to the tokamak by the highest power density antenna in the world. The ICRF heating system was developed in collaboration with ORNL and will be used in conjunction with TFTR's DPI and LPI to fuel and heat high-density plasmas with peaked density profiles. The use of ICRF is expected to result in greater penetration of heating power into the higher-density central region of the plasma, compared to neutral-beam injection. TFTR's longer term plan (early 1992) is to increase the ICRH powers to the neighborhood of 14 MW.

Another important goal for TFTR during the coming year is the reduction of oxygen and carbon impurities in the plasma. These elements enter the plasma when it interacts with internal vacuum vessel components. Impurities soak up energy, radiate it away, rapidly cooling the plasma. During early December, TFTR's internal components will be coated with a thin layer of boron. Based on experience on the TEXTOR and ASDEX tokamaks in Europe, a coating of a relatively light weight element such as boron is expected to reduce substantially the influx of carbon and oxygen resulting in improved energy confinement and therefore higher Q values.

The availability of 25-30 MW of neutral-beam injection and 5-7 MW of ICRF heating, coupled with sophisticated pellet injection and enhanced impurity control, is setting the stage for the most interesting and exciting work yet conducted on TFTR. As Meade noted, "The extension of the TFTR project to 1994 and the emphasis on transport studies are giving us an opportunity to perform experiments aimed at enhancing tokamak performance. With the planned extension of TFTR's capabilities, we are confident that TFTR will continue to make major contributions to the physics data base necessary for the successful operation of the Compact Ignition Tokamak, the International Thermonuclear Experimental Reactor, and eventually a prototype fusion power reactor." The recent changes in leadership in Washington are not expected to change the present TFTR plan significantly.

Republican Staff Director Visits PPPL

(Photo by John Peoples)

David Clement (Left), Republican Staff Director of the U.S. House of Representatives Space, Science and Technology Committee, recently visited PPPL to learn firsthand about magnetic fusion energy. With Mr. Clement in the control room of TFTR are Rich Hawryluk (center), Head of TFTR's Tokamak Operations, and Tip Brolin (right), Deputy Director for Technical Operations.

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