U.S. PARTICIPATION IN THE ITER TEST BLANKET MODULE (TBM) PROGRAM

M. Abdou (UCLA), C. Wong (GA), D. Sze (UCSD), A. Ying (UCLA),
M. Sawan (UW), N. Morley (UCLA), S. Willms (LANL),
R. Nygren (SNL), B. Merrill (INEEL), B. Nelson(ORNL)

A critical element in the ITER mission since its inception has been testing integrated blanket modules in special ports. Among the principal objectives of the ITER Test Blanket Module (TBM) Program are:

1) demonstrate the principles of tritium self-sufficiency in practical systems,

2) develop the technology necessary to install breeding capabilities to supply ITER with the tritium necessary for operation in its extended phase of operation, and

3) provide experimental data vital to evaluating the feasibility, constraints, and potential of the DT cycle for fusion systems (including limitations on options for improving plasma physics performance, e.g. conducting shells, passive coils, thick armors/first wall)

Adequate tritium supply is a central issue for the operation of ITER and the development of fusion energy. TBMs will be inserted in ITER from "Day 1" of its operation and will provide the first EXPERIMENTAL data on the feasibility of the DT cycle for fusion. A decision on the types of TBMs allowed in ITER is scheduled in 2005. The US has been a leader in the science and engineering of technology testing on ITER and other fusion devices and has many unique capabilities to contribute to the ITER TBM program. But owing to the time lost following the US withdrawal from ITER, it is critical that the US immediately re-initiate participation in the ITER TBM program to ensure that the US-favored concepts and interests are included and that the US has access to R&D information from the much larger blanket programs of Europe and Japan and other international partners.

Is there enough tritium supply for fusion development?

The availability of tritium supply has been a central issue for the development of fusion energy. DT plasmas consume HUGE amounts of tritium, unprecedented in the history of mankind. This tritium cannot be provided for long from non-fusion tritium production sources. Tritium consumption in DT devices is 55.8 Kg per 1000 MW of fusion power per year. In contrast, the tritium supply available for fusion accumulated over 40 years of CANDU reactors operation will peak at 27 kg in the year 2027 and, if not consumed sooner, will decay at a rate of 5.47% per year. Typical tritium production capacity from fission reactors specially designed for tritium production is only a few kg per year, and at the prohibitive cost of about $200 million dollars per kg. The CANDU tritium supply will be available for use in ITER in its initial phase of operation, but will not enable ITER to run its extended phase of operation at reasonable device availability. Successful tests of breeding blankets in ITER's early phase are essential to develop the tritium-

breeding blanket modules that will replace the outboard shielding blanket modules in ITER's extend phase of operation.

It must be also clearly recognized that all DT experimental devices, and, of course, the DEMO and power plants, will have to breed their own tritium. This puts a premium on integrated testing of tritium breeding blanket concepts in ITER. Without a successful TBM in ITER, the world will not have an adequate tritium supply for fusion energy development – an ironic consequence considering the fundamental promise of fusion as an "inexhaustible energy source". Therefore, it is of critical importance that the fusion program accelerates the development of breeding blankets now, including a serious TBM program on ITER, to ensure that tritium is available for fusion development and to ensure that the premise of the fusion energy development program is credible and attainable.

What is the ITER Test Blanket Module (TBM) Program?

The TBM program is not included as an item in the ITER procurement packages because each ITER Party has its own favored blanket concepts (2 allowed per party) for testing in ITER and use in DEMO. The participating parties will design and build their own modules to be tested in ITER. However, the effort is managed by a joint committee called the Test Blanket Working Group, or TBWG, constituted from members of the ITER Central Team and representatives of the parties. The TBWG is approved by and reports to the ITER Director. Test Blankets and Test Plans are evaluated as to impact on ITER operations and safety as well as requirements on ITER design and construction (e.g. providing access ports, remote maintenance equipment, accommodation of piping, ancillary equipment, etc.).

Breeding Blankets will be tested in ITER by inserting Test Blanket Modules (TBM) in specially designed ports. It should be noted that the ITER Basic Device does not have any breeding capability. It has only a non-breeding, shielding blanket. Each TBM will have its own integrated loops and systems for tritium breeding, tritium processing, heat extraction, etc. Ancillary equipment to support the TBMs (e.g. heat exchangers, tritium processing subsystems) will be located outside the cryostat. Each TBM will also be heavily instrumented requiring new diagnostics for the nuclear-electromagnetic environment.

Why should the U.S. participate in the ITER TBM program?

The specific reasons are many, but the flavor is this: The US needs to test technologies that the US wants to develop, and must have, for any further development of fusion; other DT devices, CTF, DEMO, and power plants. Without participation we will not be able to create the necessary environment and programs for the US to build knowledge, experience, and competence in fusion Nuclear and Tritium technologies that are so vital to the practicality and safety of DT fusion devices. Additionally the US will lose access to the R&D information from the much larger blanket programs of Europe and Japan and other international partners. Building competence takes decades – not participating in ITER TBM will jeopardize the US ability to build future DT devices.

The benefit-to-cost-ratio for the TBM program is very high. For a few million dollar expenditure on test blanket modules, we will acquire vital data and develop critical technologies as an excellent return on the billions of dollars investment in ITER. Data on a myriad of subjects like plasma-blanket interactions constraints and benefits, viability of material combinations, functional configurations, allowable thicknesses and types of structural materials, limitations on high temperature heat extraction, etc. will be critical in guiding US Fusion R&D in both plasma physics, plasma configurations, and fusion technology.

What unique capabilities does the US bring to the program?

The US has been a leader in the science and engineering of technology testing on ITER and other fusion devices and has many unique capabilities to contribute to the ITER TBM program. In the last 30 years the U.S. has been assessing and advancing both evolutionary and revolutionary first wall and blanket design options and their application to fusion power plant systems, resulting in direct impact on plasma physics and fusion technology development. We have continued to maintain a mature tritium breeding blanket assessment and design team that covers all necessary disciplines, including areas of fusion materials, nuclear technology, up-to-date capability in thermal and structural analysis, thermo-fluid physics, engineering design codes, neutronics and activation predictive capabilities, systems analysis, safety design and assessment and waste disposal. Team members are from national laboratories, universities, and industry. In the last five years under the APEX program the U.S. team has developed the unique appreciation of the interaction of the first wall/blanket with the plasma performance. Physicists studying plasma surface interactions, disruptions, type-I ELMs, and plasma stabilization have been working closely with first wall and blanket design engineers. This experience places the U.S. team in a unique position to develop a robust and high performance TBM to be tested in ITER.

What must the US do NOW in the TBM Program?

- Join ITER TBWG and ensure ITER plans do not exclude US-favored TBM concepts.

- The US must begin to evaluate US-favored blanket concepts and select TWO Blanket Concepts (for testing in ITER) by 2005. The Evaluation and selection team will involve experts from Blanket/FW, Tritium, Safety, Materials, PFC, and Plasma Physics Programs. This effort will involve a number of universities, national laboratories, and industry.

- Perform concurrent R&D on a small number of critical issues necessary to make prudent selection decisions. Examples include MHD insulators, tritium permeation barriers, material interactions and thermomechanics.

- Establish interactions on ITER TBM with international partners. Refocus some of the existing international collaborations to emphasize ITER TBM.