U. S. BACKGOUND IN ITER FUELING SYSTEMS AND FUTURE CONTRIBUTIONS

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Fueling systems are essential components for fusion energy research, including standard gas fueling and pellet fueling. Gas fueling systems are relatively straightforward and have always been included in the initial construction and operations of fusion experiments. In contrast, the pellet fueling systems have typically been added to the experiments later to extend the plasma density limit and provide a perturbative tool for particle transport studies. With pellet fueling systems now available, practically every fusion experiment is now equipped with a pellet injector (e. g., DIII-D, Alcator C-Mod, and MST in the U. S. and JET, Tore Supra, JT-60U, LHD, and ASDEX-U abroad). With the larger plasma volume of ITER, pellet fueling will be more important than ever to achieve deeper core fueling and high fueling efficiency, especially for tritium.

The US Fusion Science and Technology Program has sponsored a Plasma Fueling Research and Development Program (with participation led by ORNL) for over 25 years; it is generally recognized as the preeminent such program in the world. It carries out R&D in direct support of present US experiments (DIII-D, MST, NSTX, and ET) as well as doing research on advanced concepts for future experiments both nationally and internationally. For example, the US program has provided pellet fueling systems for JET, TFTR, DIII-D, Tore Supra, PLT, PDX, ISX, ATF, MST, and Gamma-10. During the ITER CDA and EDA (1989 – 1998), the U. S. was responsible for ITER fueling system design and R&D. During that period, some key accomplishments included (1) tritium injector design and testing with ITER-size (up to 8 mm) DT and T pellets and cumulative T amounts of a few 10s of grams, (2) development of innovative high-field-side launch technology and experiments, and (3) demonstration of high-throughput/steady-state hydrogen ice supply approaching the full ITER pellet fueling design value. More recently, a massive gas puff system for disruption mitigation studies has been developed and successfully tested on DIII-D, and this technique may be scalable to ITER.

A significant amount of fueling R&D still needs to be completed before commencing on the final design and construction of the ITER pellet fueling system. The fueling system must operate in a nuclear environment and be maintained remotely. The mass throughput requirement of the ITER pellet fueling system is significantly greater than that achieved to date with a screw extruder, which is assumed in present baseline design. The pellet injector must operate for long pulse lengths and be highly reliable, delivering ≈100% intact pellets to the plasma through curved guide tubes that exit from the inner wall. While the pneumatic injectors have demonstrated the required reliability, long-pulse centrifuges (which do not need propellant gas) included in the baseline ITER design have not achieved the overall reliability objective to date. A development and testing program will be required to validate the proposed ITER fueling system design and to modify it as needed.

The U. S. is in good position to take the lead in the R&D, design, construction and testing of the ITER fueling systems, particularly the pellet injection system. This will enable the U. S. to maintain a strong presence in this unique and innovative fusion technology, extending the present operational capabilities to those required for fueling fusion reactors. The resulting development will be available for implementation on present and planned U. S. experiments, thereby providing direct benefits to the U. S. program. For example, a small ITER prototype pellet fueling system operating with D_2 is ideally suited for edge fueling on DIII-D and is included in their present 5-yr plan. A white paper on U. S. participation in ITER fueling systems will be prepared for the U. S. ITER forum scheduled for May 8-9, 2003, at the University of Maryland University College.