LETTERS TO THE EDITOR

COMMENTS ON "POSSIBLE DESIGN MODIFICATIONS OF THE ITER FUEL CYCLE"

INTRODUCTION

We agree with the general conclusion reached by the authors of Ref. 1 that "the size of the fuel processing cycle, the tritium inventory, and the complexity of the system can... be reduced." However, we believe that their efforts miss the mark for the following reasons:

1. The proposed "modifications" conflict with International Thermonuclear Experimental Reactor (ITER) design goals and advice given to designers.

2. The proposed modifications involve (trivially) the downsizing of components, which leads to loss of operational flexibility.

3. Certain ITER specifications were misunderstood.

4. Safety "improvements" in fuel cycle components are gained at the expense of other systems and overall plant safety.

Let us consider these points further.

CONFLICT WITH ITER DESIGN GOALS AND ADVICE GIVEN TO DESIGNERS

The authors of Ref. 1 set out to "improve" the design by reducing the design margins of the various fuel cycle subsystems described in Ref. 2 and by displacing technical risk from fuel cycle to other reactor systems. This approach contradicts the guidance given to ITER design groups, namely,

1. The objective of the design should be to establish whether necessary functions can be provided by available technology and to identify necessary development where this is not possible.

2. Technical risk should be "shared" between systems in an "equitable" fashion.

Given the early state of fuel cycle design and limited data on interfacing systems, it is inappropriate to "optimize" the fuel cycle design by reducing its performance margins. Rather, it is important to note that in only a few cases (e.g., pellet injection or ceramic breeder tritium recovery) does the reference design depend on major extrapolations of existing technology with incumbent high technical risk. By identifying feasible technologies with acceptable safety and quantifying development targets, the ITER fuel cycle design fully met its (albeit limited) objectives.

Concerning the second point, we took the view that wherever possible, the impact of technical uncertainty in machine design and operation should be accommodated by the fuel cycle because of the following:

1. Most of the large fuel processing components involve straightforward scaleup of existing components, in particular the cryogenic distillation, and certain fuel purification and storage options. Thus, increases in size would not inherently undermine technical feasibility.

2. Increased flow rates and tritium concentrations can be readily accommodated by the fuel cycle to provide operational margins for systems whose performance adequacy is otherwise difficult to ensure.

3. Most tritium processing and storage functions can take place in a separate building or area remote from the torus where space is not at a premium, multiple barriers to release are easily implemented, and any threats from external hazards created by other reactor systems can be ruled out.

DOWNSIZING OF COMPONENTS LEADS TO LOSS OF OPERATIONAL FLEXIBILITY

The modifications to the ITER fuel cycle proposed by the authors involve significant reduction to flows assumed for plasma exhaust, waste water, neutral beam injection (NBI), and pellet injector propellants.

Concerning the degree of tritium enrichment provided for fueling and the protium fraction in the exhaust, the authors state, "Since the plasma operates in 50/50 DT, there is no need to separate D and T. The only function of the CD will be to remove protium generated by the DD Reaction." They proceed to feed only a 10% sidestream of the plasma exhaust to the isotopic separation. This contradicts the ITER plasma exhaust specification (Table III-7 of Ref. 2) in which the protium concentration in plasma exhaust is given as 1%. This relatively high protium concentration is a consequence of water and hydrogen outgassing from graphite, which was assumed to cover most of the plasma-facing components. The potential for water leaks in ITER must be recognized, given the complexity of the in-vessel component cooling. Bakeout efficiency and frequency is also limited by the use of water coolant, which was constrained to <150°C. Therefore, a significant protium source term is to be expected, and processing of only 10% of the exhaust flow under these conditions would be totally inadequate. Regarding the need for tritium-to-deuterium (T/D) ratios of >1, we specified higher purities to permit changeover of the machine from protium or deuterium operation and to permit higher concentrations of tritium to be used in deep fueling, if desired. One advantage of the latter could be to permit gas puffing with deuterium-rich mixtures, which could reduce the tritium holdup on the first wall. Since the tritium retained by graphite is likely to be more vulnerable to release than the inventory in isotopic separation and storage, the *possibility* to produce T/D ratios >1 would seem to offer an overall safety advantage.

ITER SPECIFICATIONS MISUNDERSTOOD

The water detritiation source term for ITER is admittedly unclear in the ITER fuel cycle report. The authors confused the ITER aquatic source term (3480 kg/day or 145 kg/h shown in Table 2 of Ref. 1) with the hydrogen isotopic flow rate to the cryodistillation from vapor-phase catalytic exchange (4000 mol/h in Table 1 of Ref. 1). The 145 kg/h source term we assumed for ITER is dominated by water recovered from atmospheric driers and drains, especially following spills. The design value of 200 kg/h would also permit detritiation of coolant. However, for a permeation rate of 1000 Ci/day (Table III-21 of Ref. 2), this might be required only late in the operational life of ITER, if at all. The extent to which the plant must cope with postaccident spill cleanup is a difficult judgment. We felt it prudent to assume that a significant fraction of the water contents of a coolant loop could be released to containment, collected, stored in tanks, and detritiated based on available capacity. We assumed that the plant would be allowed to operate during this cleanup period, so that the water collected would have to be decontaminated to a level suitable for environmental discharge in a reasonable time. The 200 kg/h capacity we provided would permit water recovered from a major spill to be processed in 3 to 6 months, while simultaneously processing chronic source terms. (A recovery period of 1 yr could be argued to be acceptable—an assumption that would permit a significant reduction in column diameter but not column height.) We chose to use a 3- to 6-month period, since it could be accommodated with a water distillation column of a diameter for which there exists an extensive operational data base, an assumption consistent with the design objectives. Column height is determined by detritiation factor. Since there was no consensus that routine coolant detritiation would be necessary, we did not configure the water distillation columns specifically for this. However, the water distillation column is divided into three sections, so that coolant detritiation could be provided by the first two sections, returning the detritiated coolant to the coolant supply tank. We would like to add a practical note concerning the determination of water detritiation requirements: Coolant water leakages and spills have been routinely underestimated in heavy water reactor designs. Potential sources are easily overlooked at the concept stage, and water collected due to leakage, decontamination, and maintenance generally exceed the designers' expectations. Allowing an operational margin that contributes to the regulatory acceptability of the plant and can be accommodated without excessive cost or technological risk should be viewed as a virtue in design.

SAFETY IMPROVEMENTS?

Flow rates for the neutral beam gas and pellet injector propellant gases are based on the judgment that concentrations on the gas-feed side of these systems should be kept quite low to facilitate maintenance and to minimize the consequences of accidental releases. Both of these systems are located adjacent to the torus and are quite large and complex. The decision to minimize the tritium content in NBI and pellet injector working gases and reduce the gas processing in the harsh, limited access environment close to the torus seems quite defensible.

CONCLUSION

In conclusion, we agree completely with the authors' sentiments: Reducing the flows will have a distinct benefit on fuel cycle inventory (safety) and cost. However, this must be done using valid assumptions and without compromising the operational flexibility or the safety of other systems. The ITER CDA fuel cycle study achieved its aim of demonstrating the availability of most of the required technology, and a credible route for the development of remaining items. The EDA will involve confirming design choices and optimizing the design. In the course of this optimization, many of the "conservatisms" in the design can be eliminated in a systematic, logical manner through consultation with those responsible for interfacing systems including safety and physics.

Finally, it should be noted that the fuel cycle CDA design evolved through consensus gained in numerous workshops. The authors of Ref. 1 were invited to all of these workshops and participated in the preparation and review of the final report, which they criticize in their paper. Since their paper was presented *before* the ITER report was finalized, it seems odd that these issues could not have been clarified prior to publication of the ITER fuel cycle report.

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REFERENCES

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