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SOME PROBLEMS ASSOCIATED WITH TRITIUM IN FUSION REACTORS

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ABSTRACT

A number of problems associated with the use of tritium in fusion reactors are yet to be addressed. Some are peculiar to mirror machines and attempts at direct conversion of plasma energy to electricity, while others are of general concern. Several of these are considered from the point of view of one who has worked with tritium for several years. Specific areas mentioned include liquid phase mass transfer of tritium in liquid lithium, isotopic separation, preliminary calculations on permeation barriers, isotopic swamping, and some thoughts on maintainance.

* Work performed under the auspices of the U.S. Atomic Energy Commission.

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While total tritium inventories and average tritium release rates for fusion reactors have been predicted, the range of estimates of those factors vary by at least a factor of 100. It is a fact that the basic physical-chemical data required to make more reliable estimates are not available. Because of the concomitant implications for nuclear safety that this variation implies, we would do well to acquire the requisite information demonstrating that total inventories and release rates can be, in fact, very low. The present estimates amount to little more than educated guesses. Such conclusive information might provide a major impetus for additional CTR funding, particularly when scientific feasibility becomes more imminent.

If we assume that the tritium breeder material is continuously circulated to keep the tritium inventory to a minimum, one is necessarily interested in the rate at which tritium can be extracted from the breeder blanket material. In the case of lithium, one competing approach is to extract tritium by permeating it through a "tritium window" which is a permselective membrane, probably of a niobium-1% zirconium alloy. Simple calculations are presented to show that the rate limiting step of such an extraction scheme is probably not in the liquid phase, but rather in permeation through the window itself. This is true whether or not the liquid lithium is flowing in the presence of a strong magnetic field. This calculation, however, is based on estimates that may be unreliable. A technique for providing the appropriate information is suggested.

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Along the same lines, it has been suggested that tritium inventories can be reduced by the technique of isotopic swamping. In this approach, a large excess of another hydrogen isotope is deliberately added to the flowing breeder material, and the combined tritium-protium (for example) is extracted. Calculations are presented which indicate that an increase in tritium extraction efficiency is unlikely, unless a slow kinetic surface process dominates the permeation phenomenon. This results not only from prohibitive pumping requirements, but also from chemical interactions of the hydrogen isotopes with the host lattice.

Unwanted permeation of tritium through metal walls operating at elevated temperature has been a continuing concern. The reactor proper with its associated heat transfer equipment are obvious places where it is important to restrict the rate of tritium permeation. Such permeation would result in increased release rates to the outside environment, either through cooling water loops, or to the atmosphere from the contaminated equipment during maintenance operations. Estimates of permeability are presented which might be achieved by the application of barrier materials to hot walls. These barrier materials generally fall into the class of inorganic nonmetallic solids. Further areas of research are suggested. In addition to the parts of the system that might be described as the reactor proper, these same techniques may be applied with even greater success to auxiliary equipment involved in the isotopic separation of the hydrogen isotopes recycled to the reactor.

An initial calculation on electromagnetic separation of hydrogen isotopes is presented, in which it is assumed that the separation process could be incorporated into the neutral beam injection cycle required for D-T mirror machines. Serious difficulties seem apparent, but they are perhaps no greater than perfecting high intensity neutral beams themselves.

Finally, some comments are made on the other isotopic separation techniques available, the costs of existing isotopic separation plants involving tritium, and some personal observations on the relative release rates and personnel safety precautions associated with routine major maintenance on tritium-contaminated equipment.