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SUBJECT: Criticality in Dump Tanks for HRE-3 Blanket

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CRITICALITY IN DUMP TANKS FOR HRE-3 BLANKET

B. E. Prince and M. W. Rosenthal

The possibility of criticality occurring in the HRE-3 slurry dump tanks has been examined by estimating the critical concentration for an infinite system and comparing it to the concentrations which might conceivably occur with mixing of the core fuel with the blanket. In addition to considering an infinite reactor, the following assumptions were made in obtaining the critical concentration:

1. The fuel is isotopically pure U^{233} .
2. No absorbers are present other than U^{233} and thorium.
3. Nuclear behavior is represented by a Fermi age model with modification to allow for resonance absorptions in fuel (Oracle program of Jaye and Lietzke for bare, one-region reactors). The η of U^{233} is taken to be independent of energy.

Assumptions 1 and 2 are conservative, since an operating reactor would contain protactinium, fission and corrosion products, and higher isotopes of uranium, all of which increase the critical concentration. Assumption 3 should be conservative, particularly since η of U^{233} appears to decrease at epithermal energies. The ratio of U^{233} to thorium required for criticality in an infinite reactor is plotted in Fig. 1 for 20°C and 280°C as a function of thorium concentration.

The maximum concentration of $U^{233} + U^{235} + \text{Pa}^{233}$ in the blanket will be about 3 g/kg Th. This concentration would be increased to 4.2 g/kg Th if the equilibrium core inventory of 17.56 kg were uniformly dispersed in the blanket thorium. The uranium will probably be associated with the

thorium in such a way that this ratio would remain constant, even though the thorium concentration changed. Thus, the value of 4.2 is plotted in Fig. 1 to represent the maximum fuel-to-thorium ratio which would occur in HRE-3 if the mixture were uniform. Under this circumstance, even an infinitely large dump tank at 20°C could not become critical.

Of course, if the core uranium were added to just part of the thorium inventory, higher uranium-to-thorium ratios could occur. However, to attain a ratio of 10 g U^{233} /kg Th in a limited part of the system, all of the core uranium inventory would have to be added to just 1/5 of thorium.

Since the uranium in the blanket dump tank is not likely to attain the concentration required for criticality in a cold, clean, infinite reactor, there should be no criticality problem in the actual dump tanks for the HRE-3 blanket.

gcb

25

20

15

10

5

0

500

1000

1500

Thorium Concentration (g/liter)

Fig. 1

Comparison of Critical Ratio in Infinite
Reactor with Maximum Possible in
HRE-3 (if completely mixed)

$g(U_{235})$
(% of total U)

kg Th

200°C

20°C

Critical ratio for infinite reactor

Equilibrium ratio of total fuel inventory to thorium inventory

Equilibrium blanket concentration