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SUBJECT: Reactivity Changes Associated with Slurry Settling
in Small Slurry Reactors

TO: DISTRIBUTION

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SUMMARY

The reactivity changes resulting from slurry settling have been computed for a number of small one-region slurry reactors using an IBM-704 routine.¹ Calculations were performed for three temperatures, two sizes, and five initial thorium concentrations.

In general, reactivity additions on settling were observed which decreased with increasing thorium inventory, increasing temperature, and decreasing diameter. For example, at 100°C a 2.5-ft diameter "square" cylinder (height equal to diameter) showed a maximum reactivity introduction of 4% $\delta k/k$ with an initial concentration of 100 g Th/l and a moderator composition of 75% D₂O, 25% H₂O; at 200°C the maximum reactivity introduction was 3.6%. With the same conditions, a 2-ft diameter "square" cylinder was subcritical on settling. For an initial thorium concentration of 400 g Th/l the 2.5-ft reactor showed a reactivity introduction of 1.4% at 100°C and 0.7% at 200°C.

¹ C. W. Nestor, Rapid Transit - Reactivity Survey Code for the IBM-704, (CF memo in preparation.)

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REACTIVITY CHANGES ASSOCIATED WITH SLURRY SETTLING IN SMALL SLURRY REACTORS

C. W. Nestor and M. W. Rosenthal

The change in reactivity, Δk_e , which occurs on settling of $\text{ThO}_2\text{-U}^{235}\text{O}_3$ slurry in a small one-region reactor has been investigated using an IBM-704 routine. In the model used the core was represented by a "square" cylinder having the same buckling as the sphere size of interest. The settled slurry was assumed to be uniformly dispersed in the bottom region of the reactor, with a region of pure moderator in the upper region (note illustration in Fig. I). The inventory of fertile and fissile materials in the vessel remained constant.

Calculations were performed for equivalent vessel diameters of 2 and $2\frac{1}{2}$ ft, temperatures of 20, 100, and 200°C, initial slurry concentrations ranging from 100 to 500 g Th/liter, and moderators ($\text{D}_2\text{O-H}_2\text{O}$ mixtures) containing 25, 50, and 75% D_2O . In all cases the reactor was made critical on the basis of a uniform slurry concentration throughout the entire vessel.

The results obtained for temperatures of 20 and 100°C are presented in Figs. II and III; maximum reactivities obtained from quadratic fits to curves similar to those in Figs. II and III are given in Figs. IV, V, and VI. As shown, the peak value of reactivity encountered as the slurry settles decreases as the size is decreased, the temperature increased, or the mole fraction of D_2O increased.

As settling occurs, there is an increase in neutron resonance captures and in fast neutron leakage; however, thermal leakage decreases and thermal utilization becomes larger. The first two changes tend to remove reactivity, whereas the last two add reactivity. Increasing the reactor size, decreasing

the temperature and increasing the H_2O mole fraction all have the effect of decreasing the importance of those terms which remove reactivity and thus lead to the higher reactivity peaks obtained. Making changes in the design and operating conditions other than the thorium inventory which reduce or eliminate the reactivity peaks generally have the effect of increasing the ratio of uranium to thorium required for criticality.

If the critical ratio of uranium concentration to thorium concentration is plotted for a given reactor as a function of thorium concentration, the curve shows a minimum.¹ The reactors considered in this study have initial conditions which lie to the left of this minimum; reactors to the right of the minimum are always subcritical on settling.

¹ B. E. Prince and M. W. Rosenthal, Survey of the Static Nuclear Characteristics of Small, One-Region Slurry Reactors, ORNL CF-58-7-76.

Figure 1 Reactor Configuration

Fig. 2 - Reactivity vs. Settled Region
Thorium Concentration

TEMPERATURE : 20°C, 100°C

REACTOR DIAMETER : 2.5 FT.

25% D₂O, 75% H₂O

Fig. 3 - Reactivity vs. Settled Region
Thorium Concentration

TEMPERATURE: 100°C

REACTOR DIAMETER: 2 FT, 2.5 FT

75% D₂O, 25% H₂O

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FIGURE III

25% D₂O, 75% H₂O

x: 20°C
o: 100°C
□: 200°C

Fig. 4 - Maximum Reactivity vs. Initial Thorium Concentration

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50% D₂O, 50% H₂O

x — x: 20°C
o — o: 100°C
□ — □: 200°C

Figure 5 - Maximum Reactivity vs.
Initial Thorium Concentration

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75% D₂O, 25% H₂O

* — * : 20°C
○ — ○ : 100°C
□ — □ : 200°C

Figure 6 - Maximum Reactivity vs. Initial Thorium Concentration

MAXIMUM REACTIVITY, PER CENT

10

8

6

4

2

0

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