NUCLEAR CRITICALITY SAFETY

ANALYSIS AND EXPERIMENTS OF ORGANICALLY MODERATED SYSTEMS

Session Organizer: G. R. Smolen (ORNL)

All Papers Invited

1. Experimental Criticality Data Comparing Organic with Water Moderation, *S. R. Bierman (PNL), G. R. Smolen (ORNL), T. Matsumoto (PNC-Japan)*

A joint United States-Japan Criticality Data Development Program was established in 1983 under a Memorandum of Agreement (MOA) between the United States Department of Energy (USDOE) and the Power Reactor and Nuclear Fuel Development Corporation of Japan (PNC). As part of this joint data development program, a criticality experimental program to provide a technological data base on nonreactor systems of plutonium-uranium mixtures was started in the USDOE Critical Mass Laboratory at Hanford, Washington. The results of a series of experiments in this program, designed to provide data for comparing organic with aqueous moderated plutonium-uranium systems, are presented in this paper.

In evaluating nonreactor systems for licensing, operational controls, and similar activities, water moderation is generally assumed to result in conditions for which a system is most reactive. However, some calculational studies[1] have identified various organic media that can result in more reactive conditions than water. One such material is dodecane, a primary component of the organic phase during solvent extraction in reprocessing plutonium-uranium fuels. Thus the organic phase may be a more reactive condition in an extraction column than the aqueous phase. To obtain data on plutonium-uranium in an organic moderator for comparison with aqueous moderation, a series of previously performed criticality experiments[2,3] with fast test reactor (FTR) fuel pins in water were repeated with an organic typical of the solvent extraction process.

The critical size of five lattices of FTR fuel pins, identical to previous water-moderated lattices, was determined using an organic mixture typical of the Purex process. As in the water-moderated measurements, the core boundary was rectangular and the fuel pins were arranged on square lattice pitches of 0.761, 0.968, 1.242, 1.537, and 1.935 cm. These

TABLE I

Experimental Criticality Data—FTR Fuel Pins Moderated and Fully Reflected by Either Water or an Organic Solution of TBP-NPH

Lattice Spacing[a,b] (cm)	Water Moderator[a]			Organic Moderator[a]		
	Experiment Number	Date	Critical Number of Fuel Pins	Experiment Number	Date	Critical Number of Fuel Pins
0.761 ± 0.001	067	7-17-85	1046.9 ± 0.2	065	6-5-85	1054.8 ± 0.2
0.767 ± 0.013	003R	1-24-78	1036.8 ± 0.5	--	--	--
0.968 ± 0.001	021	11-3-78	571.9 ± 0.2	063	5-21-85	599.2 ± 0.8
1.242 ± 0.001	043	1-9-79	293.9 ± 0.1	062	5-15-85	301.8 ± 0.2
1.537 ± 0.001	013	10-9-78	196.7 ± 0.2	--	--	--
1.537 ± 0.001	068R	7-25-85	199.7 ± 0.3	061	5-14-85	199.5 ± 0.3
1.935 ± 0.002	032	12-14-78	165.1 ±0.4	060	5-8-85	165.3 ± 0.1

[a]Error limits are one standard deviation.
[b]Center-to-center spacing between fuel pins in a square pattern.

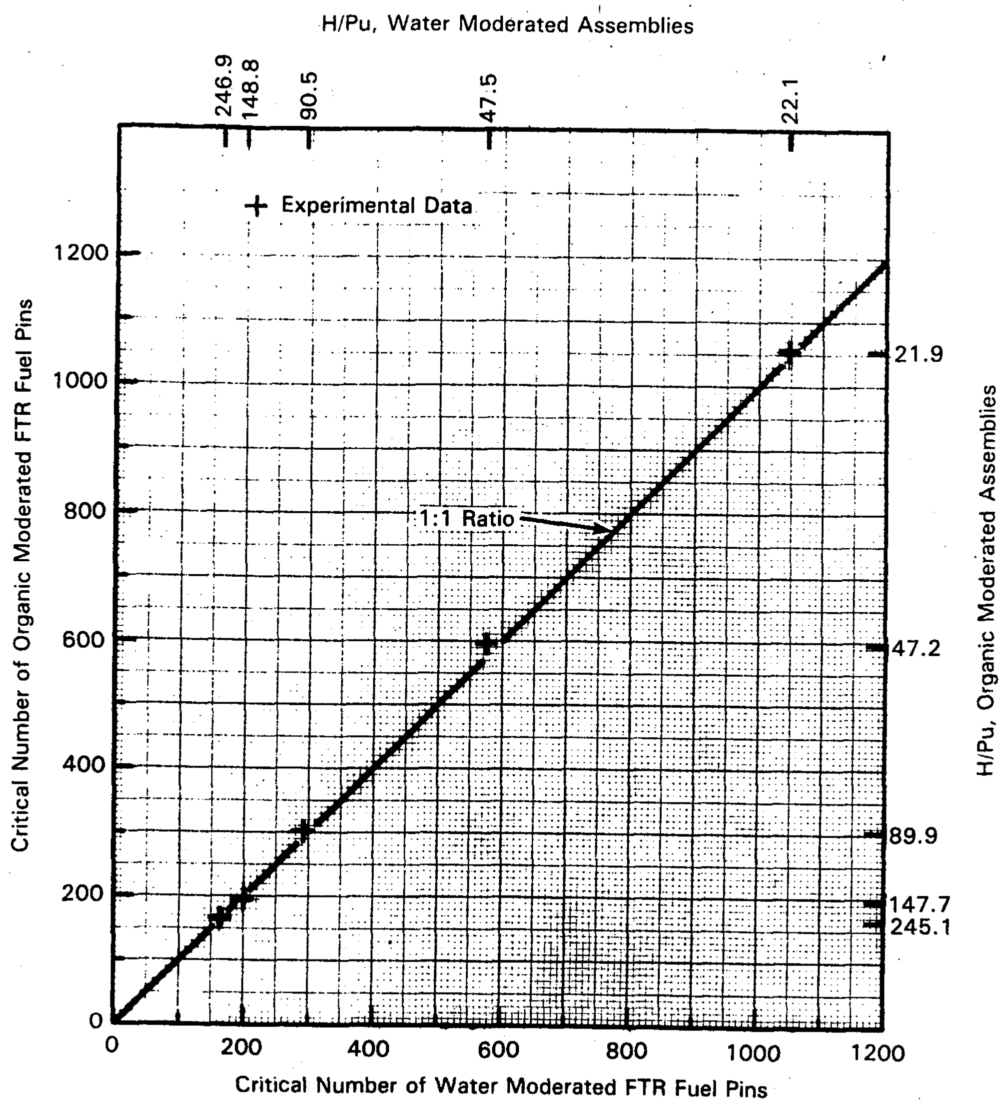

Fig. 1. Critical size comparison of organically and water-moderated FTR fuel pin lattices.

selected center-to-center fuel spacings result in neutron moderation varying from near optimum to very undermoderated.

The experimental results for the five organic moderated lattices are presented in Table I along with the results previously obtained on the five identical water-moderated lattices. The experimental assemblies were fully reflected on all sides by at least 15 cm of the moderator, except for the top surface. The top reflector region of each experimental assembly consisted of at least 15 cm of moderator perforated by fuel pin hardware. The critical size of each assembly identified in Table I was determined by incrementally adding neutronically symmetrical fuel pins in an approach to the critical condition. Consequently, the critical sizes reported in Table I are not dependent on perturbations, such as differences in moderator levels, control blade worths, or control blade locations. Thus, respective water and organically moderated assemblies are directly comparable with one another.

The experimental results are graphically compared in Fig. 1, in which the critical sizes of the organically moderated assemblies are plotted against the critical size of the water-moderated assemblies. As can be seen in Fig. 1, the organically moderated assemblies tend to become slightly less reactive than the water-moderated assemblies as moderation decreases. The differences between aqueous and organic moderation are essentially negligible, however, except for the 0.968-cm lattice spacing. Water-moderated experiments, repeated for other reasons, at lattice spacings of 0.761 and 1.537 cm indicate that the difference observed at 0.968 cm is greater than would be expected. It should be noted, however, that the 0.761-cm lattice configuration is not directly comparable with the other lattices. This and other aspects of the experimental results will be addressed in a calculational study to be presented later.

1. L. C. DAVENPORT, J. K. THOMPSON, "A Survey of Criticality Parameters for ^{239}Pu in Organic Media," *Trans. Am. Nucl. Soc.*, **27**, 419 (1977).

2. S. R. BIERMAN, B. M. DURST, E. D. CLAYTON, R. I. SCHERPELZ, "Critical Experiments with Fast Test Reactor Fuel Pins in Water," *Nucl. Technol.*, **44**, 141 (1978).

3. B. M. DURST, S. R. BIERMAN, E. D. CLAYTON, "Critical Experiments with Solid Neutron Absorbers and Water-Moderated Fast Test Reactor Fuel Pins," *Nucl. Technol.*, **48**, 128 (1979).