VOLUME 21
TANSAO 21 1-552 (1975)

1975 ANNUAL MEETING

NEW ORLEANS, LOUISIANA

JUNE 8-13, 1975

AMERICAN NUCLEAR SOCIETY

TRANSACTIONS

NUCLEAR CRITICALITY SAFETY

CRITICALITY SAFETY PARAMETERS FOR ADVANCED LMFBR FUELS

1. Criticality of Pu-U Nitrate Solution Containing Glass Raschig Rings, *R. C. Lloyd, E. D. Clayton (BNW)*

Criticality data on the effect of Raschig rings is needed to more accurately establish nuclear criticality safety limits in storing and processing fissile solutions. Experiments being performed provide data on Pu-U systems typical of the LMFBR fuels. These experiments make use of Raschig rings in Pu-U nitrate solutions. The data help establish the effectiveness of the fixed neutron poison as a method of criticality control. The use of Raschig rings permits handling larger quantities of material both safely and economically. These experiments also provide experimental benchmarks for validating calculational techniques and cross-section sets.

The experiments were performed utilizing a 61.03-cm-i.d. cylindrical vessel which was fully reflected with water on the sides and bottom. The wall thickness of the stainless-steel cylinder was 0.079 cm. (A diagram of the experimental setup is shown in Fig. 1.)

The Pu-U nitrate solutions contained between 30 to 38 wt% Pu in the Pu+U (^{240}Pu content of ~5.7 wt% and ^{235}U content of U, 0.66 wt%). The Pu concentrations in the nitrate solutions ranged between 83 to 92 g/liter. The glass Raschig rings were 1.5-in. o.d., 1.25-in. i.d., and 1.7 in. long. The glass contained boron in the form of B_2O_3 (1.5 wt%). This is equivalent to a nominal $\frac{1}{2}$wt% boron loading in the rings. This concentration was chosen for the experimental program instead of the more commonly used 4 wt% boron glass so that criticality could be achieved with vessel sizes compatible with available system equipment; i.e., 61.03-cm-diam cylinder. The volume displacement of these rings in the vessel was 19.3%.

The criticality data are summarized in Table I where the critical solution height is given for the various solutions used. The isotopic analyses for the fissionable

TABLE I

Criticality of U-Pu Solutions in Raschig Ring-Filled Tank*

Experiment No.	wt% Pu in U+Pu	Pu Conc[a,b] (g/liter)	U Conc[c] (g/liter)	Acid Molarity	Total NO_3 (g/liter)	Specific Gravity	Critical Height (cm)
106	38.6	92.3	147	4.2	433	1.4691	57.56
107	36.4	89.9	157	4.1	425	1.4778	63.98
108	33.2	86.1	173	3.9	418	1.4820	70.46
109	31.6	83.7	181	3.8	414	1.4850	76.07
110	30.1	82.4	191	3.6	409	1.4995	79.78
111	30.5	81.7	186	3.5	394	1.4856	79.93
112	30.4	80.8	185	3.5	391	1.4812	81.51
113	30.4	79.4	182	3.4	384	1.4731	85.70

*Description of glass Raschig rings:

Boron Nominal (wt%)	Dimensions, in.			Density (g/cm^3)	Chemical Composition, wt%						Ring Displacement
	i.d.	o.d.	Length		SiO_2	B_2O_3	Al_2O_3	Fe_2O_3	Na_2O_3	K_2O	
0.5	1.25	1.50	1.70	2.51	91.55	1.5	2.25	0.05	3.50	1.15	19.3%

[a] $\frac{Gd}{Pu} = 2.4 \times 10^{-4}$ by wt, $\frac{Fe}{Pu} = 1.66 \times 10^{-2}$ by wt.

[b] Isotopic analysis of plutonium in the fissile solution (wt% of Pu):

	Sample 692 (Exp. 106-109)	Sample 694 (Exp. 110)	Sample 697 (Exp. 111-114)
^{239}Pu	93.951	93.901	93.840
^{240}Pu	5.621	5.663	5.710
^{241}Pu	0.348	0.362	0.376
^{242}Pu	0.061	0.059	0.058
^{238}Pu	0.019	0.015	0.016

[c] Isotopic analysis of uranium in the fissile solution (wt% of U):

^{238}U	99.317
^{236}U	0.012
^{235}U	0.665
^{234}U	0.006

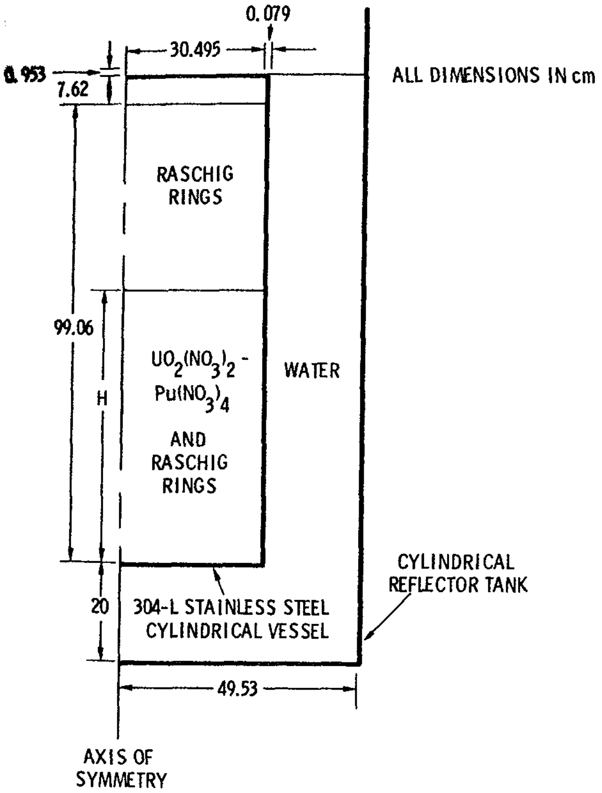

Fig. 1.

materials, and the chemical composition of the glass Raschig rings, also, are included in the table.

There are currently few data for the effectiveness of Raschig rings on the criticality of Pu-bearing solution systems. The measurements reported herein provide the only available data for code validation on Pu-U nitrate solutions with Raschig rings.

2. The Criticality Implications of Pu-U Carbide and Pu-U Nitride Fuel Mixtures, *S. R. Bierman, B. W. Howes, E. D. Clayton (BNW)*

To date, the principal emphasis has been on the development of mixed-oxide fuels for LMFBRs, and the criticality safety efforts have been directed toward providing data for criticality control on mixed oxides in the fuel cycle. However, other types of fuels that may prove to have advantages over the oxides are currently being considered. Two of these consist of mixtures of either plutonium-uranium monocarbides or plutonium-uranium mononitrides.

Although there are some limited calculational results available[1] for plutonium carbide and for plutonium nitride in the undermoderated range (0 to 20 H/Pu), there is no information for plutonium-uranium carbide or nitride mixtures. No experimental criticality data that are appropriate to fuel cycle operations outside reactors exist as yet for either fuel. To provide the necessary insight for selecting and planning experiments, and to provide the interim guidance needed in development of the carbide and nitride fuels, a series of survey calculations was initiated. The results of these calculations are described and com-

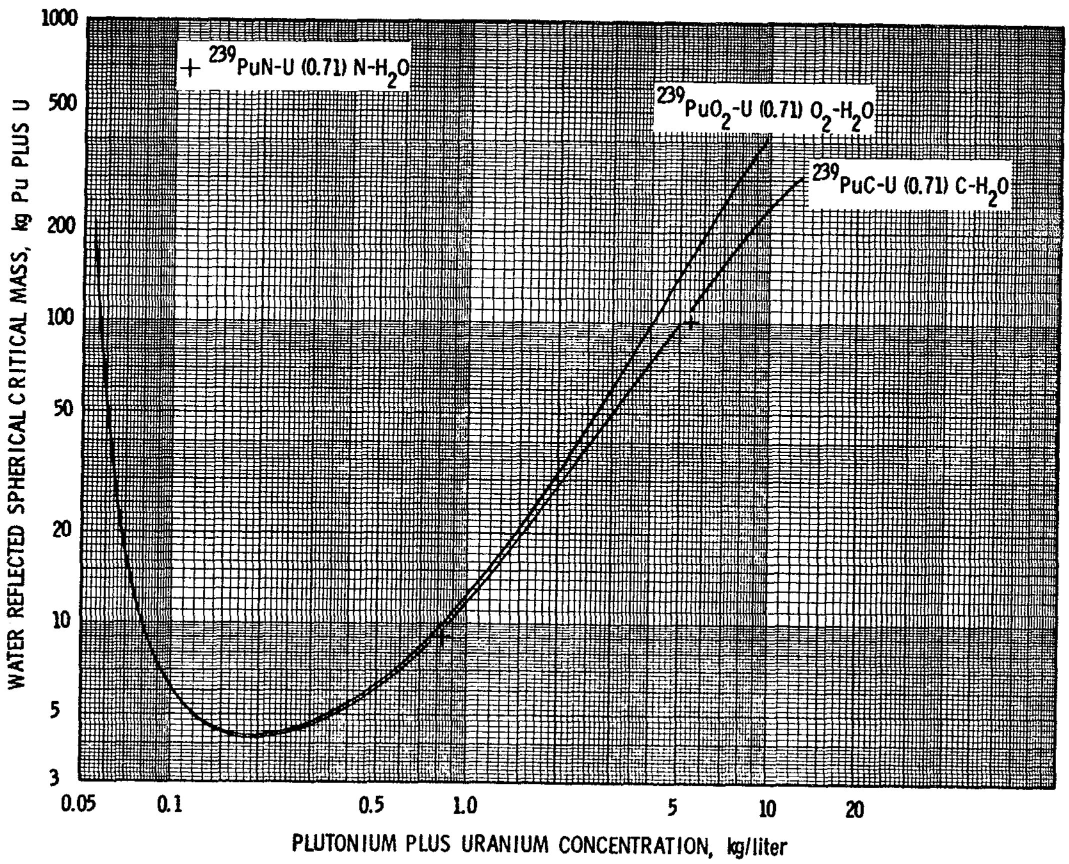

Fig. 1. Spherical critical mass 15 wt% Pu + U.