CRITICALITY OF HETEROGENEOUS SYSTEMS - UO_2-PuO_2 SOLIDS IN FISSILE SOLUTION CONTAINING GADOLINIUM NITRATE

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DISCLAIMER

SUMMARY

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The application of neutron absorbers for criticality prevention in fuel cycle operations can permit the safe handling of large quantities of material with reduced probability of criticality. If, however, soluble poisons are to be considered as either a primary or secondary means of criticality control, their use must be based on a firm knowledge of the effects of the absorber.

To provide confirmatory data, a series of criticality experiments was performed to determine the effectiveness of soluble poison (gadolinium nitrate) on criticality of a heterogeneous assembly of FFTF-type fuel pins in Pu-U nitrate solution. The arrangement simulates the simplest approach to a possible dissolver configuration, wherein during the dissolution process, a heterogeneous system of solids in fissile solution (the partly dissolved fuel) would prevail.

The fuel assembly was composed of a lattice of 301 fuel pins positioned in a 55.5 cm ID stainless steel vessel, as shown schematically in Figure 1. This vessel was in turn contained within a larger cylindrical vessel providing for water reflection as shown. The U-Pu nitrate solution, containing varying amounts of gadolinium, was added to the loaded lattice assembly to obtain criticality through variation on solution height.

The experimental data, together with the fuel pin description and chemical makeup of the solutions are included in Table 1. The gadolinium proved to be very effective in this system. In the absence of the gadolinium poison the lattice-solution assembly became critical at a solution height of only 19.2 cm, whereas, with 1.3 g Gd/ℓ the critical solution height was increased to 68.9 cm. The H/Pu ratio for the fuel pin solution combination was $\sim$ 86.

The results of theory-experiment comparisons utilizing ENDF/B cross sections and the KENO Monte Carlo Code will be presented and discussed.

TABLE 1

Preliminary

CRITICALITY OF PINS IN GADOLINIUM-POISONED FISSILE SOLUTION

Experiment Number	Critical Height (cm)	Gadolinium (g/ℓ)
115	19.205	0.0
116	23.066	0.25
117	28.227	0.5
119	45.753	1.0
120	64.506	1.25
123	68.862	1.3

Chemical Composition of Solution

Pu	∿ 77.6 g/ℓ
U	∿ 181.4
Sp. gr.	1.4685
H^+	3.25
NO_3	374.00

Isotopic Composition of Pu and U in Solution (wt%)

Plutonium		Uranium	
239	93.840	235	0.659
240	5.710	236	0.012
241	0.376	238	99.329
242	0.058		
238	0.016		

Fuel Pin Description

Fuel Pin Dimensions

	OD (cm)	Length (cm)
Fuel Column	0.495	69.22
Cladding (316-SS)	0.584	72.90

Fuel Per Pin

PuO_2-U(NAT)O_2: 138.4 ± 1.3 g

Pu: 30.75 ± 0.03 g
U: 91.16 ± 1.03 g
O: 16.49 ± 0.17 g

Fuel Enrichment

25.2 wt% Pu

Fuel Density

10.35 ± 0.09 g/cm^3
(93.34 ± 0.79% theoretical)

Isotopic Composition of Pu in Pins

^{238}Pu: 0.04 ± 0.01 at%
^{239}Pu: 86.19 ± 0.06 at%
^{240}Pu: 11.88 ± 0.06 at%
^{241}Pu: 1.73 ± 0.01 at%
^{242}Pu: 0.16 ± 0.01 at%

UO_2-PuO_2 SOLIDS IN FISSILE SOLUTION CONTAINING GADOLINIUM

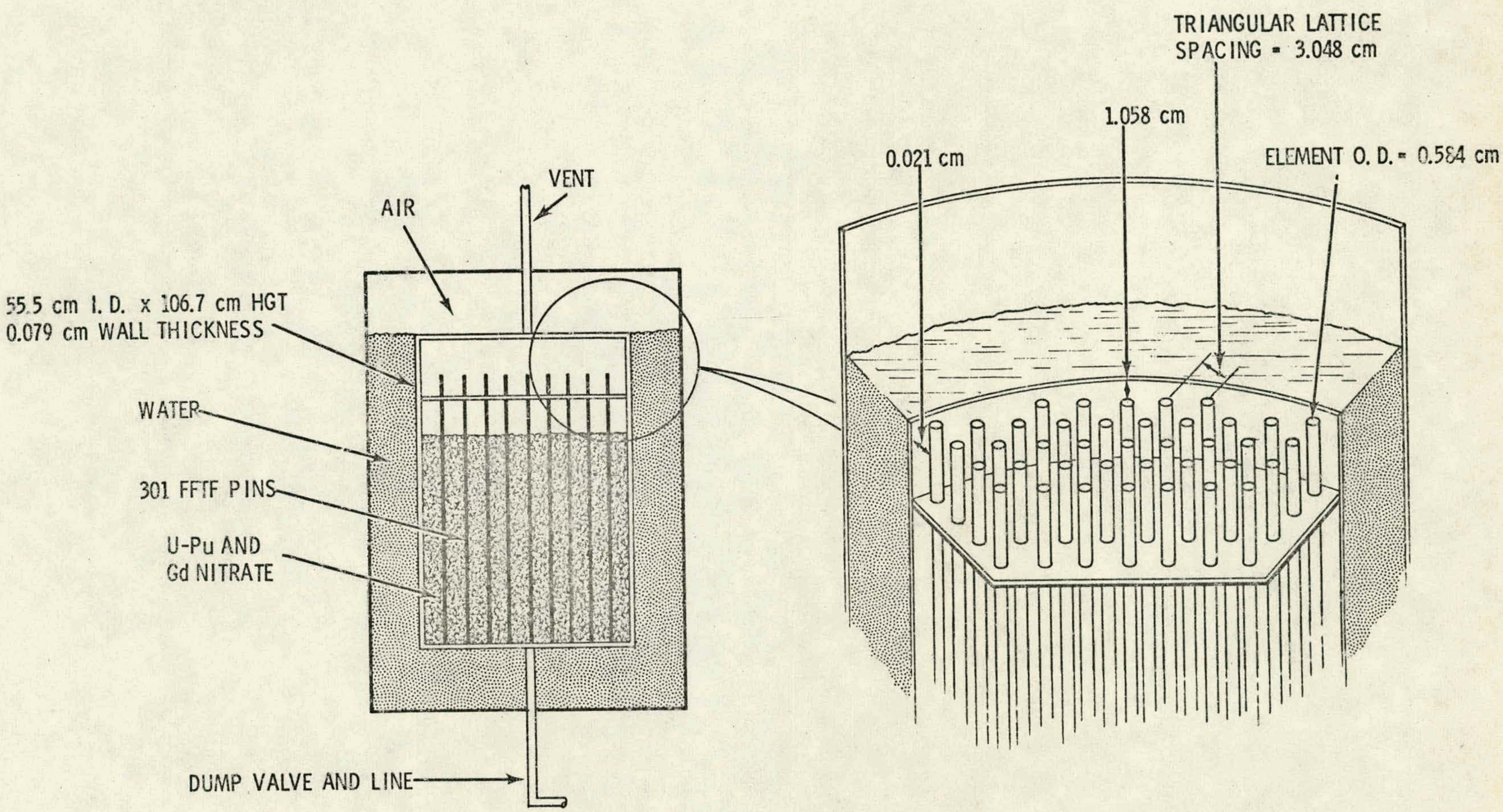

FIGURE 1