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5. Critical Experiments Using High-Enriched Uranyl Nitrate with Cadmium Absorber, *W. E. Converse, R. C. Lloyd, E. D. Clayton (BNWL), W. A. Yuill (Allied Chem)*

The need for experimental criticality data on high-enriched uranium solution systems containing soluble neutron poisons has been indicated.[1] Data have been presented previously on soluble poisons in plutonium systems[2-4] and in low-enriched uranium systems.[5] To supply data required on high-enriched uranium, a series of experiments was performed at the Pacific Northwest Laboratory (Critical Mass Laboratory) using high-enriched (~85 wt% ^{235}U) uranyl nitrate solution with cadmium nitrate as a soluble neutron poison. These experiments were specifically undertaken to support the design of the dissolvers to be used in the Flourinel Dissolver Process and Fuels Storage (FAST) Facility at the Idaho Chemical Programs Plant (ICPP). The ICPP is operated by the Allied Chemical Corporation, Idaho Chemical Programs, for the U.S. Department of Energy. The experiments supply data for use in criticality safety and as benchmarks to test calculational techniques.

This series of experiments was performed using a 241.8-mm-i.d. stainless-steel (Type 304) cylindrical vessel reflected on the sides and bottom with at least 200 mm of water or water plus cadmium nitrate. The experimental vessel thickness was 0.79 mm on the sides and 6.35 mm on the top and bottom. The cylindrical reflector tank was made of carbon steel with a 1016-mm o.d. and 2.77-mm-thick walls on the sides and bottom. For all experiments, the reflector solution height was maintained at the top of the experimental vessel. A detailed description of the experimental assembly is shown in Fig. 1.

The uranyl nitrate used in these experiments contained ~500.0 g U/litre with 0.1 *M* excess nitric acid. The average enrichment was ~85 wt% ^{235}U.

Each experiment was performed by incrementally increasing the uranium solution level in the experimental vessel until the critical level was determined. A safety and control rod (positioned external to the experimental tank) were used. At each solution level, the safety rod was fully withdrawn and the control rod was withdrawn until it no longer influenced the reactivity of the experiment. The first two experiments were done with no cadmium added to the uranyl nitrate. The first experiment had water only in the reflector tank and the second had water plus cadmium nitrate (at ~15 g Cd/litre) in the reflector tank. For the remaining experiments, water alone was used in the reflector tank and the cadmium concentration in the uranyl nitrate to the experimental vessel was varied. The results of the experiments including details of solution concentrations and critical solution heights are presented in Table I.

Calculations were performed for each experiment by modeling the system using the KENO-IV[6] computer code. Cross sections for KENO were generated using the EGGNIT[7] computer code. Seventeen epithermal- and one thermal-group cross sections were used.[8] Input data for EGGNIT was FLANGE[9]-ETOG[10]-processed ENDF/B-IV data. The calculated k_{eff}'s are also shown on Table I. For unpoisoned cases the codes are calculating about 3% high in k_{eff}. For poisoned cases the codes calculate k_{eff} about 2% low.

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DIMENSIONS OF EXPERIMENTAL VESSEL:

Inside Radius, mm	120.9
Inside Height, mm	1066.8
Side Wall Thickness, mm	0.79
End Thicknesses, mm	6.35

EXPERIMENTAL DIAGRAM:

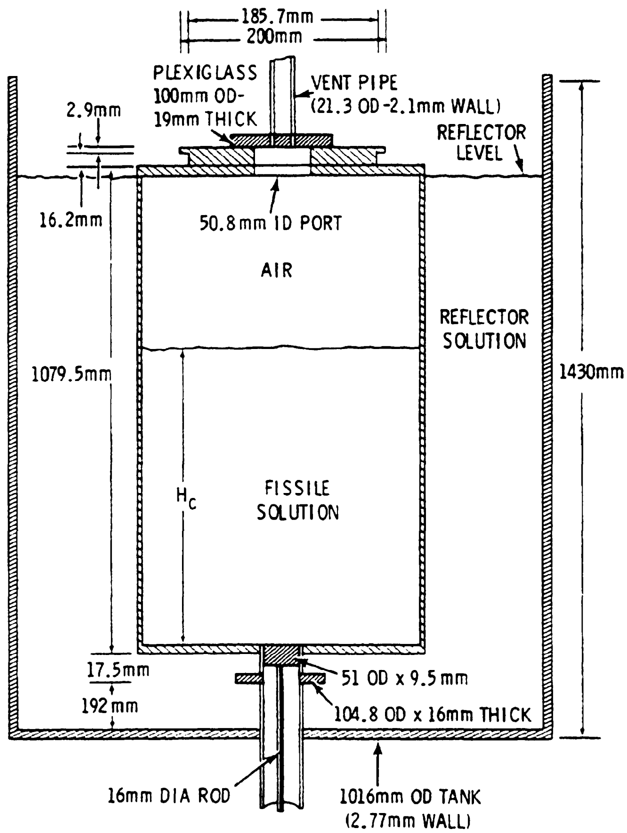

Fig. 1. Description of experiment.

TABLE I

Results of Experiments on the 241.8-mm-i.d. Cylindrical Vessel Containing Highly Enriched Uranyl Nitrate* and Cadmium Nitrate

Solution Cd[a] Concentration (g Cd/litre)	Reflector Cd[a] Concentration (g Cd/litre)	Critical Height (cm)	Calculations KENO/EGGNIT[b] $k_{eff} \pm 1\sigma$
0	0	22.33	1.024 ± 0.008
0	15	30.58	1.040 ± 0.010
1.98	0	28.20	0.971 ± 0.010
3.98	0	37.75	0.998 ± 0.012
6.35	0	76.05	0.985 ± 0.007

*As uranyl nitrate, $UO_2(NO_3)_2$, 478.7 g U/litre, S.G. = 1.6592, 0.194 *M* excess nitrate. Isotopics: (wt%) = ^{234}U = 0.94, ^{235}U = 85.02, ^{236}U = 3.46, ^{238}U = 10.58.

[a]As cadmium nitrate, $Cd(NO_3)_4 \cdot 4H_2O$.

[b]KENO-IV calculations using 18-group-averaged cross sections from EGGNIT. One sigma (1σ) values are derived from KENO code statistics.