critical heights within a minimally reflected 106.6-cm-i.d. tank heterogeneously poisoned with vertical, parallel, evenly spaced stainless-steel plates containing 1 wt% natural boron. The system resembled Lloyd's except for size, details of the heterogeneous poison, and the use of uranium solution instead of plutonium solution. Qualitatively, the latter two differences are unimportant to this discussion, so an evaluation on the basis of size may be made. The specific example selected for comparison in the same fashion used in Ref. 1 was 450.8-g U/liter solution poisoned with 0.259-cm-thick plates spaced 1.46 cm. The calculated neutron reproduction factors for 60-cm solution height with boron stainless-steel material present and with the plate material replaced by a void are 1.004 ± 0.006 and 1.556 ± 0.005, respectively. (These values were calculated using Hansen-Roach[7] cross sections.) The plates occupied 17.78% of the critical volume—comparable to their 19.27%. The conclusion here is that the reactivity effect of neutron poisoning in a large tank is indeed very important for high concentration fissile solution. This is also consistent with one limiting case: A three-dimensionally infinite critical region of poisoned fissile solution would have a neutron reproduction factor equal to k_∞ for the fissile solution alone if all poison regions were replaced by voids. For both 391-g Pu/liter and 450.8-g U/liter solutions, k_∞ is something greater than 1.5.

To test further the contention that their conclusion depends upon tank size, a sequence of calculations in decreasingly smaller, unreflected, cuboidal tanks was performed. In each case, k_{eff} was calculated with the boron stainless-steel material present and with it replaced by a void. The number of plates was selected so that a reproduction factor near unity was obtained when the poison material was included. Table I shows the result of this program.

The diminishing influence of the poison material as the vessel decreases in size seems to support the present contention. A second limiting case lends further support: When the tank volume is so small that solution alone is critical, then k_{eff} will certainly remain unchanged if the poison material is replaced by a void for there is none.

TABLE I

KENO Calculated k_{eff} for 450.8-g U/liter Solution in Various Sized Cuboidal Tanks

Tank Dimensions L × W × H (cm)	Plate Spacing (cm)	k_{eff}	
		Plate Material Included	Plate Material Replaced by Void
106.6 × 106.6 × 130.7[a]	0.953	1.003 ± 0.006	1.621 ± 0.010
50.0 × 50.0 × 100.0	1.852	1.002 ± 0.006	1.395 ± 0.010
30.0 × 30.0 × 60.0	5.0	1.007 ± 0.010	1.092 ± 0.012
26.0 × 26.0 × 52.0	13.0	0.990 ± 0.013	1.028 ± 0.013
24.0 × 24.0 × 50.0	24.0	subcritical	

[a] Plates spanned only 119.7 cm of this height. Also, this calculation included some distant room reflection.

Two factors influence the *magnitude* of the difference in reproduction factors calculated for poisons and voids as seen in Table I. The difference depends upon size for a given type of poison, because less is required in a smaller tank to achieve $k_{\text{eff}} = 1.0$ and its absence would be less important. In a given tank, however, the difference would be greater for poison elements having a high-boron content than for those of low-boron concentration. The authors of Ref. 1 hint at this in their final full paragraph on p. 133 when they give $k_{\text{eff}} = 0.819 \pm 0.005$ for 4 wt% boron-loaded rings in place of the 0.5 wt% rings (1.012 ± 0.006).

Robert E. Rothe

Dow Chemical Company
Rocky Flats Division
P. O. Box 888
Golden, Colorado 80401

August 9, 1974

---

[4] C. L. SCHUSKE, *Chem. Eng. Prog. Symp. Ser.*, **61**, *60*, 18 (1965).

[5] R. E. ROTHE, *Nucl. Sci. Eng.*, **35**, 267 (1969).

[6] R. E. ROTHE, D. L. ALVAREZ, and H. E. CLARK, "The Criticality of Periodically Boron-Poisoned Enriched Uranium Solution Systems," submitted to *Nuclear Technology*.

[7] GORDON E. HANSEN and WILLIAM H. ROACH, "Six and Sixteen Group Cross Sections for Fast and Intermediate Critical Assemblies," LAMS-2543, Los Alamos Scientific Laboratory (1960).

Response to "The Influence of Neutron Poisons on High-Concentration Plutonium Solutions"

We are pleased to comment on the Letter of R. E. Rothe, entitled, "The Influence of Neutron Poisons on High-Concentration Plutonium Solutions."[1] We wish to emphasize that the experimental data and our conclusions as given in Ref. 2 are correct as they stand for the *systems measured.* It is always possible for someone to misuse any data, but we would hope any such person applying these data to criticality problems would be sufficiently aware of the factors affecting criticality to understand that insertion of voids in an infinite system (a system with no neutron leakage) would affect neither neutron leakage nor k_∞ but that the neutron absorbing boron-containing glass raschig rings would, in any event, act to reduce k_∞.

The calculational comparisons shown in Table V, Ref. 2, were given to make the criticality safety engineer aware of the magnitude of the change in the effect of raschig rings with concentration. These data are for use in establishing criticality safety guidelines and for checking calculational models. Conclusions from finite systems should not be extrapolated to infinite systems (from small to large vessels, etc.) without consideration of the different conditions encountered, and of how these may affect criticality.

The vessel size used in the experiment was chosen not only from the practical view of the experiment, but to be of equivalent size to many process vessels and also to the common 55-gal drum. In any event, the final paragraph of Ref. 2, in the section entitled "Theory and Correlation," should clarify any misconceptions on the part of any reader:

> "As the boron content of the rings is increased, neutron absorption becomes the predominant mechanism by which the reactivity is decreased over the entire solution concentration range. This is illustrated in Table I where it is shown that the geometric buckling for the critical 391-g Pu/liter solution increases from 0.002 cm^{-2} to about 0.011 cm^{-2} when the boron content of the rings is decreased from 4 to 0.5 wt%. Although some variation in the volume of solution displaced by the two different rings was

---

[1] ROBERT E. ROTHE, *Nucl. Sci. Eng.*, **55**, 482 (1974).

[2] R. C. LLOYD, S. R. BIERMAN, and E. D. CLAYTON, *Nucl. Sci. Eng.*, **50**, 127 (1973).

unavoidable in the respective experimental assemblies (18.78 and 19.27 vol%), this reduction in reactivity is also indicated by the calculations. For the 391-g Pu/liter solution, a KENO-calculated k_{eff} value of 0.819 ± 0.005 was obtained with 4 wt% boron in the rings as compared to the 1.012 ± 0.007 value obtained with 0.5 wt% boron. This 19% reduction in k_{eff} is due to the added neutron absorption in boron."

It may be worth restating from the conclusion in Ref. 2 that, for unpoisoned material, the minimum critical volume occurs at 175- to 200-g Pu/liter and that on addition of poison, the minimum critical concentration is shifted upward.

R. C. Lloyd

Battelle Memorial Institute
Pacific Northwest Laboratories
P. O. Box 999
Richland, Washington 99352

August 30, 1974