REFERENCE 144

E. B. JOHNSON AND C. E. NEWLON, "THE EFFECT OF STEEL-WATER REFLECTORS ON THE CRITICALITY OF LOW-ENRICHED URANYL FLUORIDE SOLUTION," TRANS. AM. NUCL. SOC. 11: 383-384 (1968).

VOLUME 11 NUMBER 1

1968 ANNUAL MEETING

TORONTO, CANADA

JUNE 10-13, 1968

AMERICAN NUCLEAR SOCIETY

and

CANADIAN NUCLEAR ASSOCIATION

TRANSACTIONS

TRANSACTIONS

OF THE
AMERICAN NUCLEAR SOCIETY
FOURTEENTH ANNUAL MEETING
JUNE 10-13, 1968
ROYAL YORK HOTEL
TORONTO, CANADA

Technical Program Chairman
D. G. Hurst (AECL)

Editor
Ruth Farmakes (ANS)

Reviewers

W. Howard Arnold (W-Astro), *Aerospace Division*
Albert L. Babb (U of Wash)
J. R. Beyster (GGA), *Shielding Division*
Leslie Burris, Jr. (ANL)
H. C. Claiborne (ORNL)
E. Duane Clayton (BNW), *Technical Group, Nuclear Criticality Safety*
John E. Cunningham (ORNL), *Materials Science and Technology Division*
J. A. DeMastry (BMI)
F. Feiner (Cornell), *Reactor Physics Division*
M. J. Feldman (ANL-Idaho)
Frank Foote (ANL)
D. D. Glower (Ohio St U)
Jules Godel (BNL), *Remote Systems Technology Division*
Paul Greebler (GE-San Jose)
D. H. Gurinsky (BNL)
D. F. Hang (U of Ill), *Education Division*
A. F. Henry (W-BAPL), *Board Representative*
David L. Hetrick (U of Ariz)
Henry C. Honeck (duPont-SRL), *Mathematics and Computation Division*
R. W. Houston (Columbia), *Reactor Operations Division*
D. G. Hurst (AECL), *Technical Program Chairman*
R. E. Jervis (U of Toronto), *Isotopes and Radiation Division*
J. H. Kittel (ANL)
S. S. Krishnan (Forensic Sciences)
Jay Kunze (GE-Idaho)
J. E. LeSurf (AECL)
Milton Lewis (Douglas United Nucl)
Robert L. Long (UKAEA)
Edward A. Mason (MIT)
A. R. Matheson (GGA)
Harry Pearlman (AI)
A. K. Perkons (Crime Lab-Toronto)
Andrew Robeson (VPI)
Sol Sandhaus (NUS)
Frank Schroeder, Jr. (USAEC), *Chairman, Program Committee*
A. Einar Swanson (Black & Veatch), *Power Division*
J. Ernest Wilkins (GGA), *Board Representative*

NUCLEAR CRITICALITY SAFETY—II

2. The Effect of Steel-Water Reflectors on the Criticality of Low-Enriched Uranyl Fluoride Solution, *E. B. Johnson, C. E. Newlon (ORNL)*

The effect of composite reflectors of steel and water on the reactivity of single cylinders of aqueous solution of low-enriched uranium has been studied. The results are applicable in the evaluation of the nuclear criticality safety of shipping containers and provide bases for the verification of calculational models.

The solution was contained in each of two stainless-steel cylinders having 0.079-cm-thick walls; the solution diameters were 33.02 and 39.09 cm. The thickness of lateral steel reflectors adjacent to the solution ranged up to 5.08 cm and was surrounded by an infinitely thick water reflector. There was no top or bottom reflector. Similar experiments using $U(93.3)O_2(NO_3)_2$ have been reported.[1] Table I summarizes the data.

It was found that the presence of 1.27-cm-thick steel outside either container resulted in the maximum decrease in reactivity from that with water alone; this reactivity change was approximately $2.8 and $1.8 for the 33.02- and 39.09-cm-diam cylinders, respectively. Further increase in steel thickness up to 5.08 cm increased the reactivity, but not to that existing with water alone. Interposition of 0.081-cm-thick cadmium between the 39.09-cm-diam solution cylinder and the steel decreased the reactivity of the cylindrical volume from that without the cadmium; however, the presence of cadmium between the 5.08-cm-thick steel reflector and the water resulted in no reactivity change. These latter measurements emphasize the importance of the relative locations of neutron-absorbing materials in the evaluation of the nuclear criticality safety of water-reflected containers.

A one-dimensional transport theory code ANISN[2] with the Hansen-Roach cross-section set[3] and a buckling approximation of the form $DB^2\phi$ for the finite longitudinal cylinder dimension, were used for the analysis of the experimental data. The largest difference between computed and experimental values of k_{eff} was 0.016, as shown in the table. The code also permits calculation of the neutron current densities at the fuel-reflector interface and, therefore, provides an indication of the number and energy of the neutrons that are returned to the fuel region. The computations thus indicate that the changes in reactivity of the solution cylinders induced by the steel reflector are primarily the result of the competition between the effective decrease in the reflection of the thermal component and the effective increase in the reflection of the epithermal component of the neutron flux at the fuel-reflector interface with increasing thicknesses of steel.

1. DIXON CALLIHAN et al., "Critical Mass Studies, Part V," K-643, Oak Ridge Gaseous Diffusion Plant (1950).
2. WARD W. ENGLE, JR., "A User's Manual for ANISN," K-1693, Oak Ridge Gaseous Diffusion Plant (1967).
3. G. E. HANSEN and W. H. ROACH, "Six and Sixteen Group Cross Sections for Fast and Intermediate Critical Assemblies," LAMS-2543, Los Alamos Scientific Laboratory (1961).

TABLE I

Experimental Critical Heights and Computed k_{eff} of Cylinders of $U(4.98)O_2F_2$ Solution with Lateral Composite Steel-Water Reflectors*

	Reflector Steel Thickness, cm						
	0	0.64	1.27	1.90	2.54	3.81	5.08
33.02-cm-diam Cylinder							
Composite steel-water reflector[a,b]							
Critical height, cm	84.60	158.85	201.60	172.80	143.00	109.10	91.95
k_{eff}[c]	1.009	0.999	0.995	0.998	0.998	1.001	1.003
39.09-cm-diam Cylinder							
Steel reflector (no water)[d]							
Critical height, cm	98.80	74.65	64.75	59.30	55.70	50.90	48.20
k_{eff}[c]	1.000	1.003	1.007	1.009	1.011	1.013	1.016
Composite steel-water reflector[a,d]							
Critical height, cm	44.70	48.70	49.40	48.95	48.20	46.50	45.10
k_{eff}[c]	1.012	1.004	1.003	1.004	1.005	1.006	1.006
Composite 0.081-cm-thick cadmium-steel-water reflector[d,e]							
Critical height, cm	64.90				54.45		50.80
k_{eff}[c]	1.002				1.011		1.008

*The solution concentration was 909.1 g U/liter ($H:^{235}U$ = 488). The cylindrical container was 0.079-cm-thick type-304 stainless steel with no top or bottom reflector.

[a]The steel was adjacent to the solution cylinder; the thickness of the water was effectively infinite.

[b]The steel reflector and the water had a common height of 243.9 cm measured from the same reference as the solution height.

[c]Values computed by ANISN Code.

[d]The steel reflector and the water had a common height of 106.2 cm measured from the same reference as the solution height.

[e]The cadmium was between the solution container and the steel.