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TRANSACTIONS

3. KAYE D. LATHROP, "DTF-IV—A Fortran-IV Program for Solving the Multigroup Transport Equation with Anistropic Scattering," LA-3373, Los Alamos Scientific Lab. (1965).
4. J. S. PHILBIN, "Description and Analysis of the ACPR Fuel Storage Container," Triga Owners Conference, Feb. 24-26, 1974, Albuquerque, N.M., Proceedings to be published by General Atomic Co. (1974).
5. W. R. BURRUS, "How Channeling Between Chunks Raises Neutron Transmission Through Boral," *Nucleonics*, **16**, *1* (Jan. 1958).
6. AECM 0530, "Nuclear Criticality Safety," Atomic Energy Commission Manual, Appendix, Sec. III (Sep. 1968).
7. USAS N6.1 - 1967 revision, "Safety Standard for Operations with Fissionable Materials Outside Reactors," Sec. 4.2.3, United States of America Standards Institute (1967).
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2. Experimental Measurements with Arrays of $U(97.7)F_6$ Neutron-Coupled Through Concrete, *J. T. Thomas (UCC-OR)*

Critical experiments were performed at the Oak Ridge Critical Experiments Facility as part of a nuclear criticality safety evaluation program. The fissile material was solidified UF_6 in transport cylinders designated[1] as "UF_6 cylinder Model 8A." The isotopic composition of the uranium was 97.66 wt% ^{235}U, 0.77 wt% ^{234}U, 0.26 wt% ^{236}U, and 1.34 wt% ^{238}U. The hydrogen-to-uranium atomic ratio in the fissile material did not exceed 0.088. The cylinders were of Monel metal with an inside diameter of 20.3 cm, a wall thickness of 4.8 mm, a height of 1.25 m, and had an average tare weight of 45.4 ± 0.2 kg. The six cylinders used in these experiments had mass loadings between 108.0 and 111.5 kg UF_6 with an average of 110.4 kg UF_6. The height of UF_6 in the cylinders varied, resulting in estimated densities from 4.2 to 4.6 with an average of 4.4 g UF_6/cm^3.

The reflector for the arrays was constructed of concrete blocks 10.2 × 20.3 × 40.6 cm having a density of 2.15 g/cm^3. The chemical and spectrographic analysis of the concrete and the corresponding element number densities are given in Table I.

TABLE I

Chemical and Spectrographical Analysis of Concrete*

Element	Atom Densities, cm^{-3}	Element	Atom Densities, cm^{-3}
H	4.24×10^{21}	Cl	1.9×10^{19}
C	1.13×10^{22}	K	3.11×10^{20}
O	4.02×10^{22}	Ca	7.27×10^{21}
Na	7.9×10^{19}	Ti	4.0×10^{19}
Mg	4.99×10^{21}	Mn	1.2×10^{19}
Al	3.75×10^{20}	Fe	1.29×10^{20}
Si	1.93×10^{21}	Sr	8.9×10^{18}
S	1.0×10^{20}	Ba	3.9×10^{18}

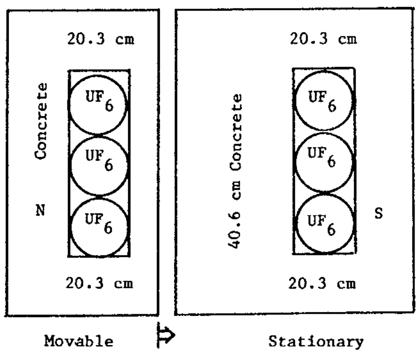
*Concrete shielding blocks, 10.2 x 20.3 x 40.6 cm at a density of 2.15 g/cm^3.

The experimental assembly consisted of two parallel linear 1 × 3 × 1 arrays of cylinders, one on each half of the tables comprising the Horizontal Displacement Criticality Testing Unit. The cylinders in an array were in a line perpendicular to the direction of table motion. Each array was closely reflected on five sides by 20.3-cm thickness of concrete. The remaining facing surfaces of the arrays, also reflected by close-fitting concrete, had different concrete thicknesses, 10.2 cm on the movable table and 40.6 cm on the stationary table. The total thickness of concrete between the two arrays was 50.8 cm. The cylinders in each array were in contact, center separation of 22.53 cm, and the distance between centers of the parallel arrays was 73.3 cm at table closure.

The assembly, as described, was subcritical, but exhibited an apparent neutron source multiplication greater than 5. Criticality was achieved by increasing the outer-surface concrete reflector thickness from 20.3 to 30.5 cm of the array on the movable table; i.e., the surface perpendicular to the direction of table motion. Criticality occurred at a table separation of 0.39 cm, and at table closure the k_{eff} of the assembly was measured as 1.0007. A second similar addition to the outer reflector surface on the stationary table resulted in criticality at a table separation of 7.36 cm. A summary of these data appears in Table II along with a schematic diagram of the experimental arrangement.

TABLE II

Summary of UF_6 Critical Configurations



Concrete Reflector Thickness, cm		Table Separation, cm at Critical	Remarks
N	S		
20.3	20.3	--	Assembly subcritical.
30.5	20.3	0.39	k_{eff} = 1.0007 at table closure.
30.5	30.5	7.36	Δk_{eff} > $1.00 at table closure.

These experiments demonstrate the misconception of regarding ordinary concrete as an isolating[2-5] medium for neutrons from a neutron chain-reacting system. It is possible, however, for nuclear criticality safety purposes to define a level of reactivity due to neutron coupling among storage areas that may be neglected. Such a quantity would depend on the neutron multiplication factors of the storage areas, the number of areas, the thicknesses of concrete separating the areas,[6] and an acceptable margin of safety in the operations.

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3. *Nuclear Safety Guide*, TID-7016, rev. 1 (1961).
4. C. L. BROWN, "Criticality Safety in Transportation and Storage," *Proc. Nuclear Criticality Safety*, pp. 177-188, SC-DC-67-1305 (1966).
5. F. G. WELFARE, "KENO Calculations Pertaining to Interaction Between Low-Enriched Fissile Arrays," *Trans. Am. Nucl. Soc.*, **17**, 268 (1973).
6. J. T. THOMAS, "The Criticality of Cubic Arrays of Fissile Material," Y-CDC-10, Union Carbide Corp., Nucl. Div. (1972).

3. Criticality Safety Analysis of the Special BNW Nuclear Materials Storage Facility, *L. C. Davenport (BNW)*

A storage facility has been constructed to accommodate plutonium, enriched uranium, and other special nuclear materials at Pacific-Northwest Laboratories (Battelle-Northwest). The facility is designed to enhance plutonium containment, fire protection, safeguards, and criticality safety. The major storage capacity is provided by a 218-tube array consisting of steel tubes horizontally encased in concrete. To maximize the amount of material that may be stored, this array is designed with only 14- or 16-in. center-to-center spacing

TABLE I

MONTE CARLO ANALYSIS OF THE BNW TUBULAR STORAGE ARRAY

Tube Loading	Tube Size	Enrichment	Neutron Moderation	$k_{eff} \pm \sigma$ Single Tube[a]	Storage Array[b]	Applicable Limit
U-Metal	8"Sq.	5 wt% ^{235}U	Unmoderated	0.649 ± .007	0.875 ± .006[e]	k_{eff} <0.95
U-Metal	8"Circular	5 wt% ^{235}U	Unmoderated	0.602 ± .005	0.785 ± .006[e]	k_{eff} <0.95
U-Metal	8"Sq.	10 wt% ^{235}U	Unmoderated	-----	1.045 ± .006	Mass Limit; Double Batch Safe
PuO_2-UO_2[c]	8"Sq.	4 wt% $^{239}PuO_2$	Unmoderated	0.568 ± .005	0.832 ± .007[e]	k_{eff} <0.95
PuO_2-UO_2[c]	8"Sq.	4 wt% $^{239}PuO_2$	H/Pu = 6.71	0.619 ± .006	0.868 ± .006[e]	k_{eff} <0.95
PuO_2-UO_2-Polystyrene[d]	8"Sq.	H/Pu = 210, H/U = 358	Intermediate	0.669 ± .008	0.840 ± .008[e]	k_{eff} <0.95
U-Metal & H_2O	8"Sq.	2.25 wt% ^{235}U	$H/^{235}U$ = 243.8 (3.8 g U/cc)	0.828 ± .006	0.924 ± .006[e]	k_{eff} <0.95
U-Metal & H_2O	8"Sq.	3 wt% ^{235}U	$H/^{235}U$ = 264.6 (2.8 g U/cc)	-----	0.976 ± .006	Mass Limit; Double Batch Safe
U-Metal & H_2O	8"Sq.	5 wt% ^{235}U	$H/^{235}U$ = 189.8 (2.4 g U/cc)	-----	1.065 ± .007	Mass Limit; Double Batch Safe
U-Metal & H_2O	8"Sq.	5 wt% ^{235}U	$H/^{235}U$ = 152.3 (2.9 g U/cc)	-----	1.092 ± .008	Mass Limit; Double Batch Safe
UO_2	4"Circular	30 wt% ^{235}U	Unmoderated	0.604 ± .005	0.804 ± .008[e]	k_{eff} <0.95
U-Metal & H_2O	4"Circular	23 wt% ^{235}U	$H/^{235}U$ = 5.00	0.728 ± .007	0.903 ± .008[e]	k_{eff} <0.95
U-Metal	4"Circular	25 wt% ^{235}U	Unmoderated	-----	0.933 ± .009	Mass Limit; Double Batch Safe
U-Metal	4"Circular	30 wt% ^{235}U	Unmoderated	-----	0.973 ± .007	Mass Limit; Double Batch Safe
U-Metal	4"Circular	94 wt% ^{235}U	Unmoderated	-----	1.401 ± .008	Mass Limit; Double Batch Safe

[a]Each single tube was fully reflected by concrete, 16" thickness minimum.

[b]Storage array of 8" square tubes (7.625" inside, 0.1875" wall thickness) are 14 tubes wide by 5 tubes high by 80" deep; 16" center-to-center.
Storage array of 8" SCH 40 tubes are 14 tubes wide by 5 tubes high by 80" deep; 16" center-to-center.
Storage array of 4" SCH 40 tubes was taken to be 7 tubes wide by 8 tubes high by 80" deep; 14" center-to-center (78 tubes total in a L-shaped configuration in actual array).

Each storage array was fully reflected by concrete having a density of 2.281 g/cm^3 and a composite aggregate of limestone and silicates. The composition was H - 0.008523, C - 0.020253, O - 0.034590, Na - 0.000020, Mg - 0.001860, Al - 0.000565, Si - 0.001700, K - 0.000040, Ca - 0.011126, Fe - 0.000190 atoms/barn-cm.

[c]Natural uranium 0.72 wt% ^{235}U.

[d]580 g (Pu + U)/liter at 14.62 wt% Pu; H/(Pu + U) = 30.6;
^{240}Pu content of Pu = 8.0 wt%; ^{235}U content of U = 0.151 wt% ^{235}U;
23.6 liters of solid fuel compact per tube.

[e]Meets criticality safety criterion for storage.