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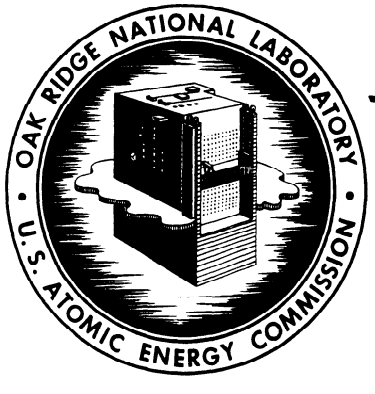

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2. Critical Experiments

2.1 CRITICALITY OF A SPHERE OF U(4.98)O_2F_2 SOLUTION

E. B. Johnson

An extensive program of critical experiments with an aqueous solution of UO_2F_2 in which the uranium is enriched to 4.98% in ^{235}U has been under way for some time. Earlier measurements described the critical spacing of a number of cylinders of the solution contained in aluminum and polyethylene vessels[1,2] to provide guidance in storage and transport of low-enriched uranium. More recent measures have attempted to define the critical quantity of the solution, essentially unreflected, in single units of simple geometry. The results of these experiments will guide the application of analytical methods and the selection of nuclear properties, particularly neutron cross sections, necessary to satisfactorily calculate the effective neutron multiplication factor.

The first of the more recent experiments consisted of a cylinder of solution contained in thin stainless steel.[3] The experimentally observed value of k_{eff} was 1.000, which is to be compared with 1.002 calculated[3] by S_4 transport theory and with 0.99 calculated (Sect. 2.3) with the O5R Monte Carlo code.

For the second experiment of this type a spherical container 19.99 ± 0.01 in. in inside diameter was constructed of 0.02-in.-thick stainless steel. The dimensions and shape were preserved by the installation of "ribs" as shown in Fig. 2.1.1. The sphere was suspended by cables to reduce the effect of support structures. The UO_2F_2 solution contained in this sphere was critical at 19°C. The ^{235}U content of the uranium was 4.98%, and the chemical concentration at this temperature was 910.18 g of uranium per liter at a density of 2.0298 g/cm^3, corresponding to an H:^{235}U atomic ratio of 490. The reactivity contributed by the container wall, the supporting members, and the column of solution in the filling connection was determined experimentally to be 16.8 cents. On the basis of β_{eff} = 0.0075, k_{eff} of the solution was 0.999. The calculated value was 0.99 (Sect. 2.3).

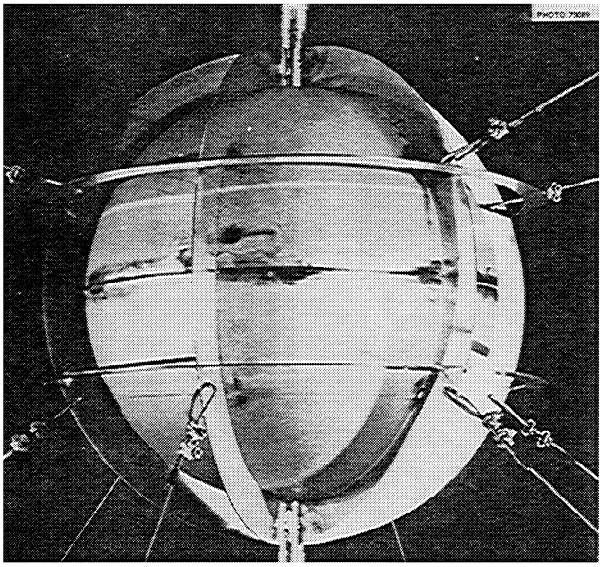

Fig. 2.1.1. Stainless Steel Sphere Used in Critical Experiments with Uranyl Fluoride Solutions.

An indication of the neutron spectrum within the sphere and on the surface of its container was obtained from irradiated U(93) foils with and without cadmium covers. The cadmium fraction had a constant value of 0.929 across a diameter; the value on the surface of the container was 0.855.

References

[1]E. B. Johnson and D. F. Cronin, *Neutron Phys. Div. Ann. Progr. Rept. Aug. 1, 1964,* ORNL-3714, p. 31; E. B. Johnson and D. F. Cronin, *Trans. Am. Nucl. Soc.* **17**, 301 (1964).

[2]E. B. Johnson, *Neutron Phys. Div. Ann. Progr. Rept. Aug. 1, 1965,* ORNL-3858, p. 15.

[3]J. Wallace Webster and E. B. Johnson, *Criticality of a Single Unit of Aqueous Uranyl Fluoride Solution Enriched to 5% in* ^{235}U, ORNL-TM-1195 (1965).