REFERENCE 54

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7. Critical Measurements of a Water-Reflected Enriched Uranium Sphere, *Cleo C. Byers, Jerry J. Koelling, Gordon E. Hansen, David R. Smith (LASL), Howard R. Dyer (UCC-OR)*

Experimental determination of the critical state of a fully reflected 97.67% enriched uranium metal sphere has been made to provide a benchmark value with which machine calculations may be compared. The sphere mass and density are 22,159.92 g and 18.794 ± 0.010 g/cm^3, respectively. The total amount of impurities in the metal is <390 μg/g. The major impurities are listed in Table I.

TABLE I

Chemical Analysis of Metal (μg/g)

P < 100	Mo < 50	Fe < 10
Ca < 10	Nb < 10	Sr < 20
Zn < 10	Ni < 15	W < 100
As < 10	Si < 25	Others < 30

Figure 1 illustrates the experimental arrangement in which a 60-cm-diam fill tank was filled with water to a depth of approximately 70 cm. This tank was placed on the hydraulic lift of the critical assembly facilities Venus machine and was connected by a 5-cm-diam flexible line to a similar stationary experimental assembly tank.

The assembled uranium sphere was placed on a Plexiglas stand in this stationary tank containing two horizontal dry well ports approximately 10 cm below the bottom of the sphere to accommodate BF_3 neutron detectors.

Water could be transferred into and out of the assembly tank in a controlled manner by raising or lowering the hydraulic lift from the remote control console for this assembly. Additionally, the water could be drained rapidly from the assembly tank by activation of a scram valve in a 5-cm line in the bottom of the tank.

In the first series of measurements, a neutron source was positioned at the top of the tank directly above a beryllium mockup of the uranium assembly. In this way the water level could be calibrated on the ram position indicator with relation to the assembly and a series of unmultiplied counts taken to be used in the multiplication measurements during the approach to critical.

The uranium hemispheres as received proved to be too reactive and they were subsequently remachined to provide the final configuration.

The sphere, mounted on the support stand, and the water were allowed to reach an equilibrium temperature of 16.3°C prior to the final measurement. Figure 2 shows the resulting reactivity versus water height above the sphere.

At the 16.5-cm water level, the observed 30.8 ± 0.2 cents above delayed critical corresponds to the reproduction number k = 1 + 0.308 β_{eff} = 1.0020 ± 0.0002. By calculation, replacement of the support stand by water reduces k by 0.0018 ± 0.0004, and extension of the water thickness to infinity increases k by 0.0001. By specifying the nominal density, we can transfer the geometry uncertainty to an equivalent reproduction number uncertainty of ±0.0002. Thus, for the specification

$$
\begin{aligned}
r_{core} &= 6.5537 \text{ cm} \\
N(^{234}U) &= 0.00053 \text{ atoms/b-cm} \\
N(^{235}U) &= 0.04703 \text{ atoms/b-cm} \\
N(^{236}U) &= 0.00010 \text{ atoms/b-cm} \\
N(^{238}U) &= 0.00049 \text{ atoms/b-cm} \\
r_{reflector} &= \infty \\
N(H) &= 0.06679 \text{ atoms/b-cm} \\
N(O) &= 0.03340 \text{ atoms/b-cm,}
\end{aligned}
$$

we obtain k = 1.0003 ± 0.0005.

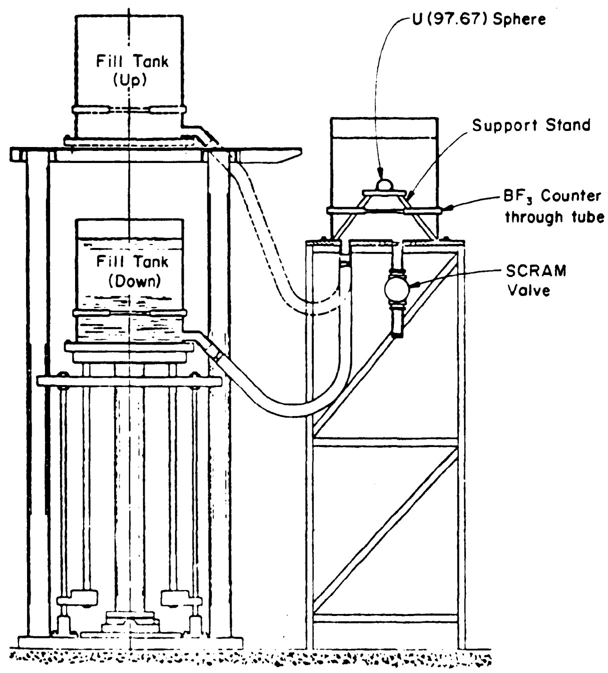

Fig. 1. Experimental setup at the LASL critical assembly facility.

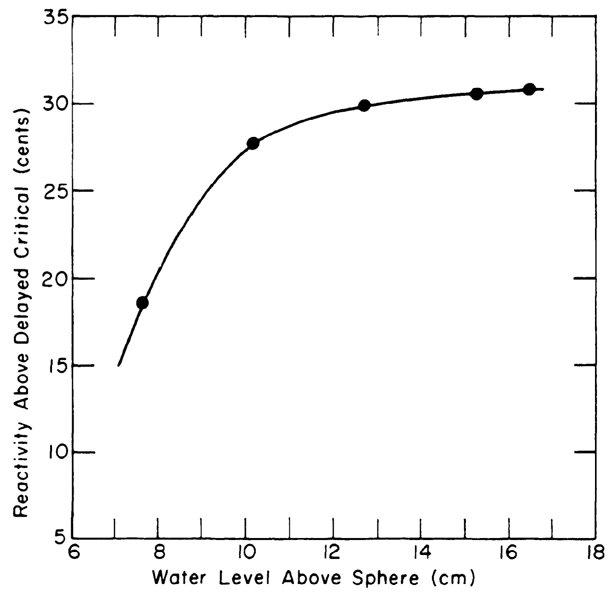

Fig. 2. Reactivity versus water height above sphere.