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VOLUME 16
TANSAO 16 1-364 (1973)

1973 ANNUAL MEETING

CHICAGO, ILLINOIS

JUNE 10-14, 1973

AMERICAN NUCLEAR SOCIETY

TRANSACTIONS

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OF THE
AMERICAN NUCLEAR SOCIETY
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Palmer House Hotel | June 10-14, 1973 | Chicago, Illinois

Printed in USA

4. Critical Mass Laboratory Program in France, *P. R. Lécorché (CEA-Saclay)*

Experimental nuclear criticality safety studies started in Saclay in 1960 with ALECTO experiments using nitrate solutions of ^{239}Pu, ^{235}U, and ^{233}U (Ref. 1).

Since 1963 they have been conducted mainly at the VALDUC Critical Mass Laboratory. Plutonium nitrate solutions were used in various geometries: slabs, cylinders, and annular cylinders. The effects of acid molarity and ^{240}Pu content were studied; ^{240}Pu content varied from 1.5 up to 10 wt% (Refs. 2 and 3). Some experiments were made with a small amount of plutonium containing 37 w% ^{240}Pu.

The criticality of uranium at low H/U atomic ratios (5.7 to 82) has been investigated by mixing liquid $U(93)F_6$ and HF in water-reflected spheres.[4] These experiments showed the important effect of scattering materials on critical masses at low H/U ratios.[5]

Some interaction studies have been made using 294-mm-i.d. cylinders containing either uranyl or plutonium nitrate solutions and 250-mm-i.d. cylinders with plutonium nitrate solutions.[6] Neutronic isolating properties of different materials have been studied in the course of these experiments.

It has been shown, for example, that lead, while being a good reflector, has very poor isolating properties. The insertion of a slab of lead even 20 cm thick between two interacting cylinders decreases the critical height.

Experiments on heterogeneous poisoning of plutonium nitrate solutions by borosilicate glass pipes or Rashig rings have been reported.[7]

More recent studies have been related to the fast reactor and light-water reactor fuel cycles.

A series of experiments has been made using variable pitch lattices of Rapsodie fuel pins either in water, in nitric acid, or in plutonium nitrate solution. They showed or confirmed that:

1. The same lattice is more reactive in water than in nitric acid.
2. The same lattice is more reactive in water than in concentrated plutonium nitrate solution provided the pitch is less than or equal to the optimum pitch in water.

The criticality of 4 w% enriched UO_2F_2 aqueous solution has been investigated in three geometries:

1. a stainless-steel 500-mm-i.d. cylinder (wall thickness 3 mm) either bare or fully reflected, or bottom and side reflected
2. a stainless-steel 792-mm-i.d. cylinder (wall thickness 4 mm) bottom and sides reflected
3. a Monel 540-mm-i.d. sphere (wall thickness 4 mm) fully reflected.

Uranium concentration was varied from 0.548 up to 1.084 g/cm^3. Main results are:

1. 500-mm-i.d. cylinder:
    minimum critical mass -
    - fully reflected: 79 kg - U concentration: 1.010 g/cm^3
    - no top reflector: 84 kg

    minimum critical concentration -
    - 0.630 g/cm^3
2. 792-mm-i.d. cylinder:
    minimum critical mass -
    - no top reflector: 136 kg - U concentration: 0.800 g/cm^3

    minimum critical concentration -
    - 0.450 g/cm^3
3. 540-mm-i.d. sphere:
    critical concentration -
    - fully reflected: 0.953 g/cm^3 corresponding to a 77-kg critical mass.

In additional experiments, the 500-mm-i.d. cylinder was surrounded by a 150-mm-thick lead reflector (no top or bottom reflector). At 0.800 g/cm^3 concentration, the critical mass was the same as with a full water reflector.

Planned experiments are:

1. tests on poisoning effects of iron
2. studies on 80% fissile (^{239}Pu + ^{241}Pu) plutonium nitrate solutions either in annular cylinders or in a parallelepiped vessel having a square base 1.300 × 1.300 mm. Experiments with low-concentration solutions in this last vessel are intended to determine more precisely the influence of finite dimensions in big vessels. Temperature and acid molarity effects shall also be investigated.
3. studies of lattices of fast reactor fuel rods in water, nitric acid, and fissile solutions.

As for the future, it seems that experimental nuclear criticality safety studies with Pu, ^{235}U, and ^{233}U should be limited to specific experiments related to peculiar uses or processes. Experiments with fissile actinides should be planned when these isotopes will be produced in sufficient amount.

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