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SUBJECT: Irradiation Experiment on Aluminum Fuel
Element Containing U_3O_8 Dispersion

TO: Listed Distribution

FROM: R. J. Beaver

Reference: (a) ORNL-MTR-40, AEC Form 320, dated April 12, 1957.

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I. Purpose

In accordance with reference (a) a request was submitted to evaluate the irradiation behavior of aluminum plate-type fuel elements, in which the uranium was incorporated as a dispersion of U_3O_8 in aluminum. The U_3O_8 is one of the important materials in establishing reliable and economical procedures for manufacturing aluminum MTR-type fuel elements under the Atoms for Peace Plan in which uranium, with a maximum enrichment of 20% in the U-235 isotope, is specified. This enrichment specification necessitates a high total uranium investment in each fuel element. U_3O_8 offers the potential of accomplishing this objective, however, its behavior under actual operating conditions must be determined.

II. Design of Test Component

The test assembly contains 19 plates spaced at 116 mil intervals. The design is patterned after the MTR Mark XI fuel element. The seventeen inner plates are 50 mils thick, with a clad-core-clad thickness of 15-20-15 mils. The top and bottom plates are 65 mils thick, with a clad-core-clad thickness of 22 1/2-20-22 1/2. Pertinent design details are listed in Table I. Materials data of the fuel core are itemized in Table II. The enrichment factor may vary between 19.0 and 20.0%, which will reflect a slight change in the mass of total uranium.

III. Physical and Nuclear Data

The physical and nuclear data for the test element are listed in Table III. The test component contains approximately 3628 grams of aluminum, 974 grams of uranium, 17 grams of silicon and 176 grams of oxygen, calculated on the basis of 60 cm effective length. The total absorption cross-section of these materials for thermal (0.025 ev) neutron is 402.40 cm^2 and 336.48 cm^2 with and without water, respectively. The test component contains 190 grams of U-235, resulting in a fission

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cross-section of 280.00 cm^2 . The thermal and fission cross-section values used for these calculations were 680 and 575 barns, respectively.

IV. Construction of Test Component

The test plates will be fabricated with techniques similar to those used in roll bonding MTR fuel plates. The fuel plates will be curved and joined into an assembly by brazing, utilizing current procedures for brazing MTR assemblies. The test assemblies will be identified as ORNL-40-3 and ORNL-40-4, respectively, and will contain markings on the side plates to permit machining of individual plates from the assembly for post irradiation examination.

V. Time of Irradiation

It is desirable to irradiate ORNL-40-3 to a minimum burnup of U-235 atoms of 30%, or 5.5×10^{20} nvt, and ORNL-40-4 to a minimum burnup of U-235 atoms of 60%, or 14.4×10^{20} nvt.

R. J. Beaver

RJB: lmp

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TABLE I

DESIGN DATA ON U_3O_8 -ALUMINUMTEST COMPONENT FOR MTR IRRADIATION-ORNL-MTR-40

Number of Elements	2
Minimum Irradiation, nvt	ORNL-40-3 5.5×10^{20} ORNL-40-4 14.4×10^{20}
Number of Plates Per Element	19
Spacing Between Plates, mils	$116 \pm 10\%$
Width of Fuel Section, inches	$2.470 \pm 1/32$
Length of Fuel Section, inches	$23 \frac{5}{8} \pm 1/2$
Thickness of Fuel Section, mils	20
Thickness of Cladding, mils	long plates: $22 \frac{1}{2}$ short plates: 15
Overall Plate Width and Length, inches	long plates: $2.8 \times 28 \frac{5}{8}$ short plates: $2.8 \times 24 \frac{5}{8}$
Core Mixture Composition, wt %	U_3O_8 64.87 Al 35.13
Core Mixture, Composition in, vol %	U_3O_8 37.23 Al 62.77
U-235 Enrichment, %	19.5 ± 0.5
U-235 Content Per Plate, gms	10.00 ± 0.10
U-235 Content Per Assembly, gms	190 ± 1.00
U-235 Distribution, gm/cm^2	Minimum: 0.0255 Maximum: 0.0277
Type of MTR Assembly	Mark XI
Side Plates	ORNL Dwg. D-21090

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TABLE II

MATERIALS DATA OF POWDERED FUEL CORE COMPACT

CORE VOLUME BASED ON ONE PLATE - 1.181-in³ or 19.34 cm³

<u>Material</u>	<u>cm³ Volume</u>	<u>% Volume</u>	<u>gms Weight</u>	<u>% Weight</u>	<u>Gm-Mole Fraction</u>	<u>Atomic %</u>
U ₃ O ₈	7.20	37.23	60.54	64.87	--	--
U-235	--	--	10.00	--	--	--
U-234 and U-238	--	--	41.28	--	--	--
U-Total	--	--	51.28	--	0.216	10.37
Oxygen	--	--	9.26	--	0.564	--
Aluminum	<u>12.14</u>	<u>62.77</u>	<u>32.78</u>	<u>35.13</u>	<u>1.303</u>	<u>--</u>
Totals	19.34	100.00	93.32	100.00	2.083	10.37

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TABLE III

PHYSICAL AND NUCLEAR DATA ON U_3O_8 -ALUMINUM
TEST COMPONENT FOR MTR IRRADIATION-ORNL-MTR-40

<u>Material</u>	cm^2 <u>Cross-Sectional Area</u>	cm^3 <u>Volume(1)</u>	<u>gms Mass</u>	cm^2 <u>Absorption Cross-Section(2)</u>	cm^2 <u>Fission Cross-Section</u>
Uranium-235	--	--	190.00	330.98	280.00
Uranium-234 and 238	--	--	784.32	5.50	--
Oxygen	--	--	175.94	0.00	--
U_3O_8	2.28	136.80	1150.26	336.48	--
Aluminum	22.40	1343.70	3627.99	17.82	--
Silicon	0.12	7.19	16.77	0.04	--
Water (3)	37.47	2248.20	--	48.06	--
<hr/>					
Total Solids or Metals	24.80	1487.69	4795.02		
Metal to Water Volume Ratio - 0.66					
Total Absorption Cross-Section, cm^2				402.40	
Fission Cross-Section, cm^2					280.00

- (1) Based on 60 cm effective length
 (2) Cross-Section of 0.025 ev neutron
 (3) Includes one-half of water spacing between adjacent MTR fuel assemblies

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