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SUBJECT: Irradiation Experiment on Aluminum Fuel Plates Containing
a 48 Wt % Uranium - 3 Wt % Silicon - 49 Wt % Aluminum Alloy
With 20% Enrichment in the U-235 Isotope

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TO: J. E. Cunningham

FROM: R. J. Beaver

REFERENCE (a) ORNL-MIR-40, AEC Form 320, dated April 11, 1957.

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IRRADIATION EXPERIMENT ON ALUMINUM FUEL PLATES CONTAINING A 48 WT % URANIUM - 3 WT % SILICON - 49 WT % AL ALLOY WITH 20% ENRICHMENT IN THE U-235 ISOTOPE

I. Purpose

In accordance with Reference (a), a request was submitted to evaluate behavior of aluminum fuel elements, containing a 48 wt % U - 3 wt % Si - 49 wt % Al alloy, in which the uranium is enriched in the U-235 isotope at the 20% level. This alloy greatly minimizes fabrication problems associated with the binary 48 wt % U-Al previously tested.

II. Design of Test Component

The test assembly contains 18 plates spaced at 117-mil intervals. Each plate is a composite consisting of 17-26-17 mil clad-core-clad thickness, with a total thickness of 60 mils. Design details of the test component are listed in Table I. Materials data of the fuel core are itemized in Table II. The enrichment factor may vary between 19.5 and 20.0 percent, which will reflect a slight change in the total uranium weight percent.

The frame material of the composite plate is a type 5050 aluminum alloy, with a nominal composition of 98.5% Al - 1.5% Mg. This alloy is required to minimize localized clad thinning at the core ends.

III. Physical and Nuclear Data

The physical and nuclear data for the test element are listed in Table III. The test component contains approximately 3865 grams of aluminum, 950 grams of uranium, 77 grams of silicon and 2 grams of magnesium, calculated on the basis of a 60 cm. effective length. The total absorption cross section of these materials for thermal (0.025 ev) neutrons is 401.60 cm² and 355.62 cm² with and without water, respectively. The test component contains 190 grams of U-235, resulting in a fission cross section of 280.0 cm². The thermal and fission cross-section values used for these calculations were 680 and 575 barns, respectively.

IV. Construction of the Test Component

The test plates will be fabricated with techniques similar to those used in roll bonding the conventional 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-40-1 and ORNL-40-2, respectively, and will contain markings on the side plates to permit machining of individual plates from the assembly for post irradiation examination.

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V. Time of Irradiation

It is desirable to observe the performance of these elements after irradiation periods of 5.5×10^{20} mvt and 14.4×10^{20} mvt, respectively. The test elements are designed to be substituted directly into the active lattice and serve as fuel assemblies for the MTR. The exact positions the test elements will occupy during irradiation will be determined by the Phillips Petroleum Company personnel.

R. J. Beaver
Metallurgy Division

RJB:mw

Attachments: Tables I, II, III

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Table I

DESIGN DATA ON ASSEMBLY CONTAINING 48 Wt % U - 3 Wt % Si - 49 Wt % Al ALLOY
FOR IRRADIATION TESTING IN THE MIR

Number of Test Elements	2
Minimum Irradiation, mvt	ORNL-40-1 5.5×10^{20} ORNL-40-2 14.4×10^{20}
<u>Fuel Plates</u>	
Number	18
Material:	
Cladding	Type 1100 Al
Frame	Al-Clad Type 5050 Al
Width of Fuel Section, inches	$2.470 \pm 1/32$
Length of Fuel Section, inches	$23-5/8 \pm 1/2$
Thickness of Fuel Section, mils	26
Thickness of Cladding, mils	17
Total Thickness, mils	60
Overall Plate Width and Length, inches	Short Plates: $2.8 \times 24-5/8$ Long Plates: $2.8 \times 28-5/8$
<u>Fuel Core Composition</u>	
Weight Percent:	
Uranium	48.0
Silicon	3.0
Aluminum	49.0
Volume Percent:	
UAl ₃	41.7
Al	58.3
U-235 Enrichment, %	19.5 ± 0.5
U-235 Content Per Plate, Grams	10.56
U-235 Content Per Assembly, Grams	190 ± 1.00
U-235 Distribution, gms/cm ³	Minimum: 0.027 Maximum: 0.029
<u>Side Plates:</u>	
Material	Type 1100 Al
Overall Dimensions, inches	$3.169 \times 0.188 \times 28.625$
Drawing No.	ORNL Dwg. D-22055

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Table II

MATERIALS DATA ON FUEL CORE IN FUEL PLATE OF TEST ASSEMBLY

Core Volume Based on One Plate: 1.536 in³ or 25.16 cm³

<u>Material</u>	<u>Weight Gms</u>	<u>Weight %</u>	<u>Volume %</u>	<u>Gms, Mole Fraction</u>	<u>Atomic %</u>
U Total	52.80	48.0		0.22	9.4
U-235	10.56				
U-238	42.24				
UAl ₃	71.28		41.7		
Silicon	3.33	3.0		0.12	
Aluminum	<u>53.87</u>	<u>49.0</u>	<u>58.3</u>	<u>2.00</u>	<u> </u>
T O T A L	110.00	100.00	100.0	2.34	

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Table III

PHYSICAL AND NUCLEAR DATA ON TEST ASSEMBLY
CONTAINING 48 Wt % U - 3 Wt % Si - 49 Wt % Al ALLOY

<u>Material</u>	<u>cm² Cross Section</u>	<u>cm³ Volume (1)</u>	<u>gms Mass</u>	<u>cm² Absorption (2) Cross Section</u>	<u>cm² Fission Cross Section</u>
U-235			190.08	331.10	280.00
U-238			760.32	5.34	
UAl ₃	3.15	188.82	1283.98		
Aluminum	23.85	1310.66*	3864.82	19.00	
Silicon	0.55	32.92	76.71	0.18	
Magnesium	0.00	0.10	1.75	0.00	
Water (3)	35.79	2147.40	—	45.98	—
TOTAL Solids or Metals	27.55	1532.50	4893.68		
Metal-to-Water Volume Ratio 0.71					
Total Absorption Cross Section				401.60	
Total Fission Cross Section					280.00

* Does not include Al in UAl₃.

(1) Based on 60 cm effective length.

(2) Cross Section of 0.025 ev neutrons.

(3) Includes one half of water spacing between adjacent MIR fuel elements.

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