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CARBIDE AND CARBON CHEMICALS COMPANY

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SUBJECT: Irradiation Experiment on Uranium Dioxide-Aluminum
Powder Fuel Plates. Irradiation Request ORNL-22

TO: J. E. Cunningham

FROM: R. J. Beaver

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SECRET COVER SHEET

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I. Purpose

The purpose of this test is to evaluate the irradiation behavior of uranium dioxide-aluminum powder fuel elements under high burn-up conditions.

The uranium dioxide and aluminum powder is an important material combination for circumventing difficulties encountered in the fabrication of wrought uranium-aluminum alloys containing high uranium investments. There is an excellent possibility that requests will be submitted under the Atoms for Peace Plan for MTR-type elements to be constructed for service in research reactors. Inasmuch as the uranium released under this program will be 20% enriched material, a high total uranium investment per fuel element will be required. As a result, the uranium dioxide-aluminum powder combination will be given foremost consideration as the fuel plate material.

Information on the performance of the uranium dioxide-aluminum powder fuel elements under irradiation is limited to a cursory test in the LTR. It is therefore proposed that two full-sized elements be constructed in accordance with Mark XI design, and be irradiated in the active lattice of the MTR for six and twelve weeks, respectively.

II. Design of Test Component

The test assemblies are modified MTR Mark XI elements and contain 19 plates spaced at 111 mils intervals. The top and bottom plates are 65 mils thick with the seventeen inner plates 55 mils thick. Design details of the test component are listed in Table I. Materials data on the powdered fuel core compact are itemized in Table II. The enrichment factor may vary between 19 and 20% which will reflect a slight change in the uranium dioxide weight percent.

III. Physical and Nuclear Data

The physical and nuclear data for the test elements are listed in Table III. The test component contains approximately 3907 grams of aluminum, 1049 grams of uranium dioxide and 16.77 grams of silicon 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 384.5 cm^2 and 337.4 cm^2 with and without water respectively.

CLASSIFICATION CANCELLED
DATE <u>1-4-56</u>
For The Atomic Energy Commission
<i>F. Z. Canale</i>
Chief, Declassification Branch <i>jl.</i>

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TABLE I

DESIGN DATA ON URANIUM DIOXIDE-ALUMINUM TEST
COMPONENT FOR MTR IRRADIATION - ORNL-22

Number of Elements	2	
Irradiation Time	ORNL 22-1	6 weeks
	ORNL 22-2	12 weeks
Number of Fuel Plates per Element		19
Nominal water gap spacings, mils		111
Width and length of active portion of plate, inches		2.5 by 23 5/8
Total thickness of active plates per element		Two - 0.065 inches Seventeen - 0.055 inches
Over-all plate width and length per element, inches		Two - 2.8 x 28 5/8 Seventeen - 2.8 x 24 5/8
Clad-core-clad thickness per element, mils		Two - 20-25-20 Seventeen - 15-25-15
Core mixture composition, wt %		UO ₂ - 54.00 Al - 46.00
U-235 Enrichment, %		19.4
U-235 Content per plate, gms		9.47
U-235 Content per assembly, gms		180.00
U-235 Fuel distribution, gm/cm ²		0.025
Type of MTR assembly		Mark XI (modified)
Side Plates - ORNL Dwg. D-21090		
Over-all dimensions, inches		3.169 x 0.188 x 28 5/8
Grooves - Two .070 inches		
Seventeen .060 inches		

TABLE II

MATERIALS DATA OF POWDERED FUEL CORE COMPACT

Core Volume Based on One Plate ----- 1.476 in³ or 24.17 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>
Uranium Dioxide	5.06	20.94	55.23	54.00		
U-235			9.47			
U-234 and U-238			39.15			
U-Total			48.59		0.204	8.63
Oxygen			6.64		0.415	
Aluminum	17.35	71.78	47.03	46.00	1.744	
Void	1.76	7.28				
Totals	24.17	100.00	102.26	100.00	2.363	

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TABLE III

PHYSICAL AND NUCLEAR DATA ON TEST ASSEMBLY MTR
IRRADIATION REQUEST - ORNL - 22

Material	cm ² Cross- Sectional Area	cm ³ Volume(1)	gms Mass	cm ² Absorption Cross-Section(2)	cm ² Fission Cr-Section
Uranium - 235			179.44	312.6	264.3
Uranium 234 and 238			743.77	5.2	
Oxygen			126.12	0.0	
Uranium Dioxide	1.60	96.27	1049.33	317.8	
Aluminum	24.03	1441.60	3906.78	19.2	
Silicon	0.12	7.29	16.77	0.4	
Water (3)	36.64	2198.40		47.1	
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Total Solids or Metals	25.75	1545.16	4972.88		
Metal to Water Volume Ratio - 0.70					
Total Absorption Cross-Section, cm ²				384.5	
Fission Cross-Section, cm ²					264.3

(1) Based on 60 cm effective length

(2) Cross-Section of 0.025 ev neutrons

(3) Includes one-half of water spacing between adjacent MTR fuel elements

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The test component contains 180 grams of U-235 which gives a fission cross-section of 264 cm^2 . The thermal absorption and fission cross-section values used in the above calculations were 680 and 575 barns respectively.

The metal to water ratio for the test unit is 0.70. The ratio was calculated on the basis of assigning one-half the water gap spacing between adjacent fuel assemblies to the test element.

IV. Construction of the Test Component

The 19-plate test element is fabricated in accordance with the techniques developed for manufacturing the Geneva Conference Fuel Element. The fuel cores are prepared by blending the specified quantities of uranium dioxide and aluminum powder and cold pressing into compacts. The methods employed in the fabrication of the fuel plates and construction of the assemblies are similar to the techniques presently followed for the production of standard MTR fuel assemblies.

V. Time of Irradiation

It is desirable to observe the performance of one element during a six week period, and the performance of another element during a 12 week period.

The test elements are designed to be substituted directly into the active lattice and serve as MTR fuel assemblies. The exact positions the test elements will occupy during irradiation will be determined by Phillips Petroleum Company personnel.

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R. J. Beaver

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