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POST-IRRADIATION EXAMINATION OF BUMPER ELEMENTS WITH HIGH IN-REACTOR WEIGHT LOSSES (RM-418)

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HW-69064

POST-IRRADIATION EXAMINATION OF BUMPER ELEMENTS WITH HIGH IN-REACTOR WEIGHT LOSSES

(RM-418)

by

W. J. Gruber

Radiometallurgy Laboratory Operation
Materials Development Operation
REACTOR AND FUELS RESEARCH
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April 3, 1961

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POST-IRRADIATION EXAMINATION OF BUMPER ELEMENTS WITH HIGH IN-REACTOR WEIGHT LOSSES (RM-418)

INTRODUCTION

Three natural uranium, X-8001 aluminum clad, I&E Hanford production fuel elements, which were irradiated in 3363-D as part of PT-IP-262-A, were selected for detailed examination in the Radiometallurgy Laboratory. The three pieces were from the same tube and each had lost about 15 grams of cladding during irradiation. Examination was requested to determine the extent of the corrosion and whether the attack was uniform or localized. Also, measurement of the uranium fuel was requested to reveal any change that occurred during irradiation.

Fuel Element History

Lot and Fuel Type	KL-465-D	---	---
Series and Piece #	78U-5	78U-7	78U-9
Charge Date	5-13-60	---	---
Discharge Date	10-19-60	---	---
Tube Factor	1.356	---	---
Exposure	1094 MWD/T	---	---
Weight Loss	13.95 gm	16.60 gm	16.69 gm

SUMMARY AND CONCLUSIONS

Corrosion was general rather than localized and occurred over approximately three-fourths of the surface. In each element about one-fourth of the surface on one side was virtually unattacked and was probably the area that lay between the ribs of the process tube during irradiation. In one element localized attack occurred beside two of the bumpers.

External aluminum cladding thicknesses ranged from 0.020 to 0.043 inch. About 0.005 inch of the spire surface was removed by corrosion. Both internal and external dimensions of the uranium increased. The average external diameter was 0.010 inch larger and the average internal diameter was 0.011 inch larger than the average pre-irradiation diameter measurements. The growth was not uniform as ellipticity up to 0.028 inch was observed.

DETAILS

The three elements were visually examined and photographed (Figure I). Piece Number 5 contained "ledging" attack and there was localized corrosion in the form of grooves along two of its bumpers. The corrosion in Piece Number 7 and 9 appeared very uniform and no areas of localized attack were observed. Orientation of the elements was not known as no rib marks were visible.

Perpendicular diameter measurements were obtained one inch from each end and at the midpoint to determine the area of maximum corrosion in each element (Table I). Using the diameter measurements as a guide, two wafers were removed from each element to compare the areas of minimum and maximum corrosion. After part of the measurement data from the wafers had been gathered and reviewed it was evident that the variations in the as-received diameter measurements were not necessarily indicative of corrosion so an additional wafer was removed from elements 7 and 9. At this time Piece Number 5 had already been returned for processing so data was available from only two wafers from that element.

The wafers were ground to remove the burrs and metal distorted by the abrasive cutoff wheel and then polished. The areas of maximum and minimum cladding thickness were diametrically opposed on the periphery and probably represented the top and bottom of the elements during irradiation (Figures 2 and 3). Wafers prefixed A are from Piece 5, B from Piece 7, and C from Piece 9. Two sets of measurements were obtained from each wafer. One set was taken along the diameter that connected the areas of the maximum and minimum cladding thickness, and the second set of measurements was made perpendicular to the first. Measurements of cladding OD, uranium OD, uranium ID, and spire ID were obtained (Table II). The measurements were made optically with a measuring microscope and are accurate to ± 0.002 inch.

Maximum and minimum cladding thicknesses were obtained using a Filar eyepiece with the remote metallograph and appear in Table III. The measurements are near but may not coincide with the sites where diameter measurements were made.

The maximum and minimum Al-Si and spire wall thicknesses were obtained from wafers B-1 and C-3 and appear in Table IV.

In reviewing the data in Tables II and III, it is evident that the corrosion in all three elements was nearly identical and that much of the variation in the diameters was the result of non-uniform uranium growth. Also, the average cladding loss was 0.010 inch greater than was indicated by the difference in pre- and post-irradiation external cladding diameters.

The average amount of spire surface removed by corrosion was calculated to be 0.005 inch. The actual spire thickness measurements in Table IV bear out the calculation quite well. The calculation was made using the pre-irradiation measurements in Table II, assuming that the spire braze remained bonded to the uranium. For the cross sectional area of the spire and Al-Si to remain constant during a change in the uranium ID, the spire ID must change more than the uranium ID. In this particular case a 1.0 mil change in the uranium ID will

result in a 1.29 mil change in the spire ID. It is obvious that an increase in the uranium ID would put the spire bond in tension and it is quite probable that uranium growth has been a contributing factor in unbonded spires in irradiated fuels.

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TABLE I

AS RECEIVED DIAMETER MEASUREMENTS

Piece 78U-5			
	Male End	Midpoint	Female End
0°	1.450	1.444	1.449
90°	1.441	1.445	1.435

Piece 78U-7			
	Male End	Midpoint	Female End
0°	1.437	1.436	1.438
90°	1.435	1.438	1.432

Piece 78U-9			
	Male End	Midpoint	Female End
0°	1.433	1.449	1.452
90°	1.434	1.447	1.448

TABLE II

Wafer	Diameter	Cladding OD	Uranium OD	Uranium ID	Spire ID
A-2	D1	1.432	1.359	0.425	0.333
	D2	1.452	1.370	0.431	0.333
A-5	D1	1.440	1.362	0.425	0.333
	D2	1.444	1.365	0.425	0.332
B-1	D1	1.440	1.365	0.433	0.345
	D2	1.443	1.365	0.428	0.338
B-2	D1	1.433	1.364	0.424	0.334
	D2	1.454	1.371	0.432	0.339
B-4	D1	1.437	1.364	0.429	0.336
	D2	1.444	1.367	0.426	0.333
C-2	D1	1.444	1.347	0.419	0.328
	D2	1.456	1.375	0.425	0.335
C-3	D1	1.438	1.370	0.423	0.331
	D2	1.446	1.373	0.424	0.334
C-5	D1	1.433	1.356	0.424	0.331
	D2	1.450	1.375	0.433	0.342
(1)		1.446	1.356	0.416	0.312
(2)		1.443	1.366	0.427	0.335

(1) Average Pre-Irradiation Measurements
(2) Average Post-Irradiation Measurements

TABLE III

External Cladding Thickness Excluding Al-Si x 10^{-3} Inches		
Wafer	Maximum	Minimum
A-2	43.4	24.6 (*19.7)
A-5	42.3	23.1
B-1	41.3	22.0
B-2	41.0	23.6
B-4	41.0	23.6
C-2	37.6	25.1
C-3	34.1	20.4
C-5	37.6	29.4

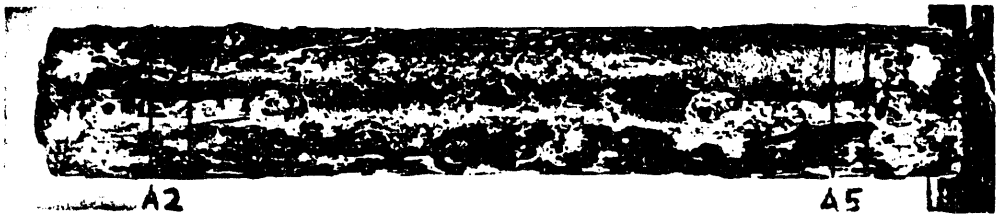
*Thickness in groove beside bumper.

TABLE IV

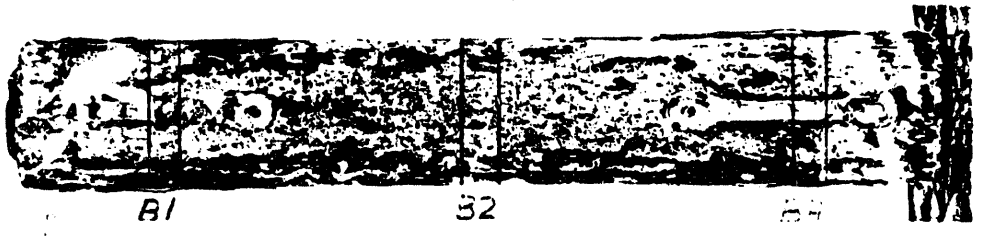
Spire and Al-Si Thickness x 10^{-3} Inches						
Wafer	External Al-Si		Spire Al-Si		*Spire Wall	
	Max	Min	Max	Min	Max	Min
B-1	12.8	1.1	9.4	8.9	38.1	37.5
C-3	7.0	4.0	6.0	4.5	38.4	37.6

*Readings do not include Al-Si.

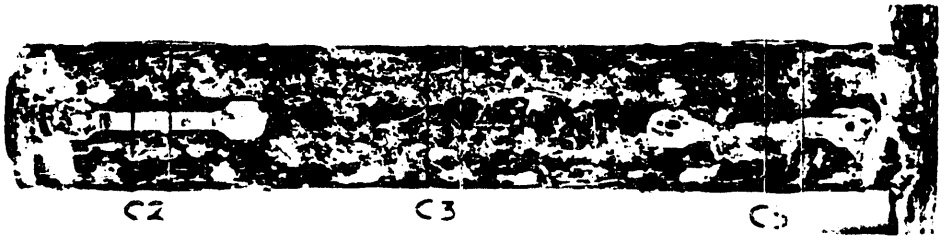
FIGURE I



A1894 Piece 78U-5 ½X



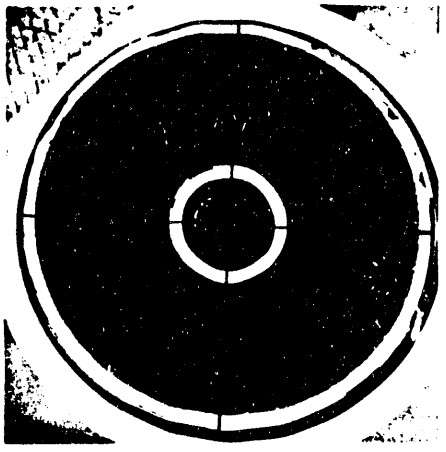
A1897 Piece 78U-7 ½X



A1903 Piece 78U-9 ½X

The lines indicate where sections were made and the identification number of each wafer is shown.

FIGURE II



A2138 Wafer A-2

A2140 Wafer A-5

A2902 Wafer B-1

A2466 Wafer B-2

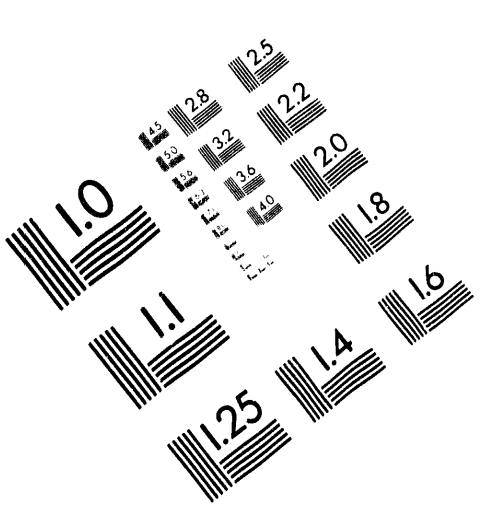
A2468 Wafer B-4

FIGURE III

A2510 Wafer C-2

A2904 Wafer C-3

A2512 Wafer C-5



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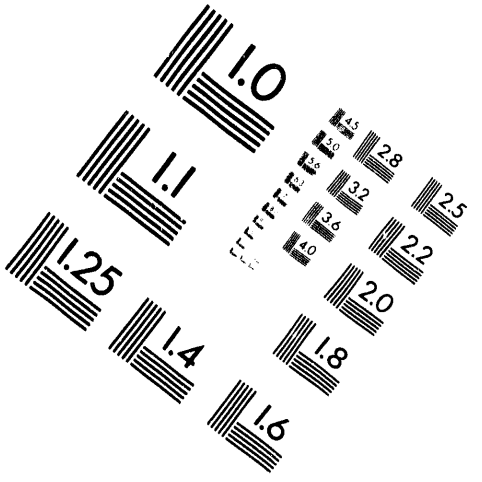

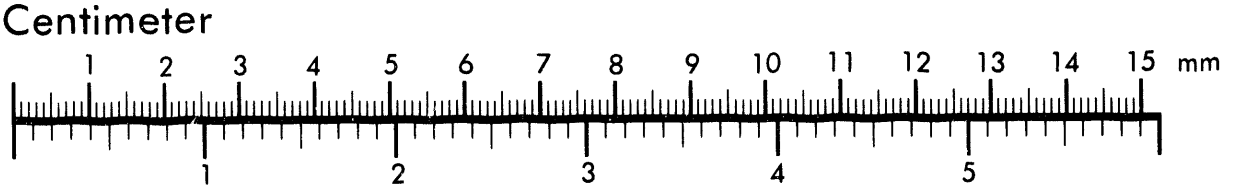

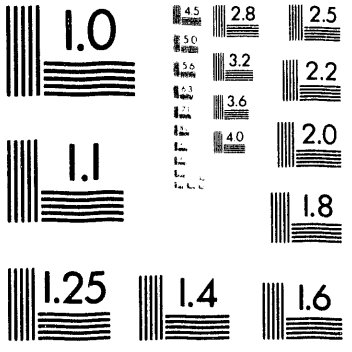

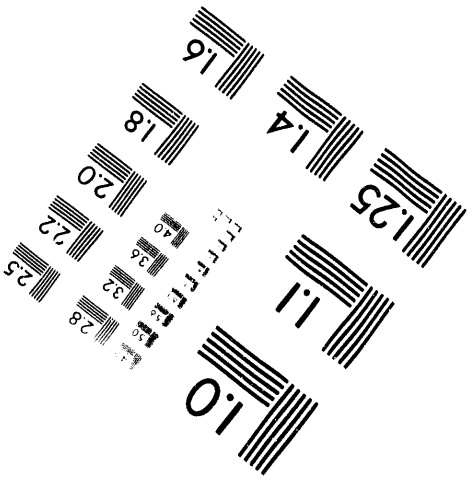

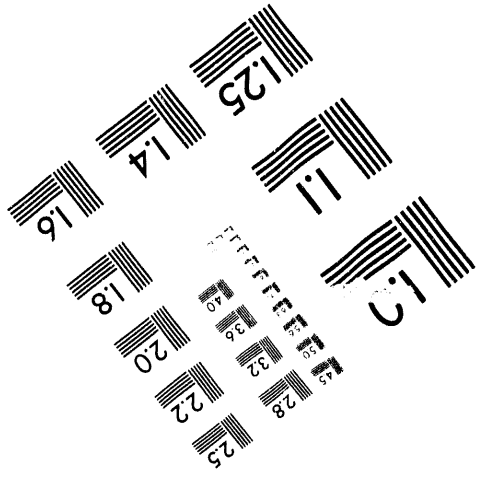

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