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POST-IRRADIATION MEASUREMENTS OF PT-546 FUEL ELEMENTS

AUTHOR

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This document consists of
10 pages

H. F. Tew, Supervisor
Process Development
Fuels Engineering Operation

POST-IRRADIATION MEASUREMENTS OF PT-546 FUEL ELEMENTS

Reference: HW-75465, "Production Test IP-546-A, Irradiation of Hot-Die Size Diffusion Bonded Fuel Elements," by K. L. Hladek and C. A. Burgess, dated June 27, 1963.

INTRODUCTION

Early in December 1963 eighteen natural uranium columns irradiated under provision of PT-546 (Reference) were discharged from C Reactor. Fifteen (15) of these columns contained alternately charged HDS (test) and AlSi (control) fuel elements in the downstream half (positions 1-16); two columns were charged full length with HDS material; and one column was charged full length with AlSi material. All canned pieces were nominally C5NS dimensions except that the HDS pieces were slightly longer than the standard AlSi pieces.

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Uranium fabrication history, through heat treatment, was controlled and equivalent for both test (HDS) and control (AlSi) material. For these eighteen columns average exposure was ~960 Mwd/ton, average tube power was ~1125 kw, and average tube outlet temperature was ~100 C.

Two striped charges were discharged in September 1963 @ 370 Mwd/ton.

This report presents results of the post-irradiation measurements that have been completed and analyzed as of this date. A second set of measurements for a portion of the material is being programmed.

SUMMARY

Except for post-irradiation warp and profile types, significant differences between the HDS (test) and AlSi (control) groups were detected for every measured dimensional characteristic. In general, fuel diametral changes (ΔOD_1 , ΔOD_2 , ΔOD_3 , and average ΔID) were greater for the HDS material. Weight losses for the HDS material were 20-25% greater than for the AlSi material. Presently no data for comparing length and volume changes (ΔL and ΔV) are available. It may develop that some post-irradiation length measurements can be obtained at the 105-C Metal Examination Facility.

Extensive hot-cell work is indicated to obtain information to clearly establish the cause(s) of the observed difference.

DISCUSSION

Various measurements of the test and control pieces from the fifteen high-exposure striped columns are summarized in Table I below:

TABLE I

<u>Characteristic</u>	<u>Difference Significant?</u>	<u>Averages</u>	
		<u>HDS</u>	<u>AlSi</u>
ΔOD_1	yes	11.83 mils	8.25 mils
ΔOD_2	yes	16.63 mils	8.97 mils
ΔOD_3	yes	10.33 mils	7.64 mils
$\sqrt{\text{warp}}$	no	- - - - - 2.49	$\sqrt{\text{mils}}$ - - -
Av. ΔID	yes	~10 mils	~4.5 mils
Fuel Element Weight Loss	yes	1.98 grams	1.61 grams*

* Based on data from eight striped charges on which weight measurements had been completed.

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It can be seen that except for warp, significant differences between the test and control groups were detected in every objectively measured characteristic; TFC's were not compared but it is a foregone conclusion that a significant difference exists. The difference in weight loss possibly stems from the differences in dimensional behavior. No significant differences were noted in the subjective visual examinations.

In the relative sense the HDS and AlSi pieces discharged at low exposure behaved similarly to the higher exposure material. Average ΔOD_2 for the HDS pieces was significantly higher than for the AlSi controls -- 5.54 mils versus 3.07 mils. Average ΔID 's were significantly different -- 3.16 mils for the HDS and 0.85 mils for the AlSi. The difference in ΔOD_1 was not significant; however, the tendency was in the same direction as exhibited by the higher exposure group.

For some characteristics, the magnitude of the "difference" between the two fuel types is dependent upon position in the tube. This is illustrated in Figures 1 through 3, where "eyeballed" curves are plotted.

Profile type data--single and double bend warps, and within-fuel element diametral nonuniformity--is shown in Table II. For comparison purposes similar data for C6N (overbore) fuel and PT-216 samples from PDQ Runs 14 through 19 are shown in Tables III and IV. With respect to profile types the HDS and AlSi pieces in this test were not significantly different from each other. Most obvious, however, is the fact that some 56% of the PT-546 pieces exhibited double bends; this compares with 6% for the PT-216 material and 9% for the overbore fuel.

Figure 4 shows average ΔID versus position for the full-length columns. Note the similarity between the full-length AlSi column with the behavior exhibited by the AlSi pieces from the striped columns. (Figure 2)

The curve for HDS material is obviously different. Coming in from either end of the column the ΔID 's quickly reach a level of 10-12 mils and essentially remain there. Such a front-to-rear pattern of ΔID 's has not been previously observed on any sets of data for AlSi fuel elements.

From inspection of the ΔID versus position curves for the AlSi material (Figures 2 and 4) it seems clear enough that ID changes are controlled by both core behavior (assuming can and core are integral) and corrosion, depending on position in the charge. Thus, one might estimate the extent of spire corrosion by comparing ΔID 's from upstream and "corresponding" downstream positions under the assumption that the observed difference arises from corrosion. Employing this method; it would appear that in the position of maximum fuel weight loss (i.e., around position 9) that spire corrosion for the AlSi pieces in the striped charges was approximately 2-2.5 mils (Figure 2). This corresponds to 1-1.25 grams, which yields an estimate that 30-38% of the total fuel weight loss was incurred in the spire.

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TABLE II
PROFILE TYPE DISTRIBUTION - PT-546

Bending →		1	2	3	Totals
↓ Diametral Nonuniformity
1		18.6%	0.9%	25.2%	44.7%
2		4.3%	---	6.7%	11.0%
3		3.8%	1.4%	2.4%	7.6%
4		2.4%	0.5%	7.1%	10.0%
5		1.9%	---	2.4%	4.3%
6		1.9%	---	5.2%	7.1%
7		0.9%	0.5%	1.9%	3.3%
8		5.7%	1.4%	4.8%	11.9%
Totals		39.5%	4.7%	55.7%	99.9%

PROFILE TYPE CODE

1st Digit Refers to Bending

1. No Bend
2. Single Bend (Quadratic)
3. Double Bend (Cubic)

2nd Digit Refers to Diametral Nonuniformity

1. Uniform
2. Simple Barrel
3. Increasing Uniformly from Male End
4. Decreasing Uniformly from Male End
5. Increasing and Barrel
6. Decreasing and Barrel
7. Dog Bone
8. Cubical

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TABLE III

PROFILE TYPE DISTRIBUTION C-OVERBORE

(Based on 1124 Fuel Elements)

I II				Totals
	1	2	3	
1	15.3%	6.9%	1.7%	23.9%
2	20.7%	11.9%	4.0%	36.6%
3	6.1%	2.6%	0.3%	9.0%
4	3.0%	1.3%	0.4%	4.7%
5	2.8%	2.2%	0.8%	5.8%
6	2.8%	2.0%	0.3%	5.1%
7	2.4%	0.7%	---	3.1%
8	6.5%	3.6%	1.7%	11.8%
Total	59.6%	31.2%	9.2%	100.0%

TABLE IV

PROFILE TYPE DISTRIBUTION STANDARD TYPE

(Based on 5519 Fuel Elements)
PDQ Runs 14-19

I II				Totals
	1	2	3	
1	36.3%	13.2%	2.4%	51.9%
2	3.6%	1.6%	0.5%	5.7%
3	9.7%	4.3%	0.6%	14.6%
4	6.2%	4.0%	0.9%	11.1%
5	1.2%	0.6%	0.1%	1.9%
6	1.9%	1.0%	0.5%	3.4%
7	1.2%	0.8%	0.2%	2.2%
8	5.2%	3.0%	1.0%	9.2%
Total	65.3%	28.5%	6.2%	100.0%

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The proportion of weight loss in the spire for the HDS pieces cannot be similarly estimated. Speculating from the relative shapes of HDS and AlSi curves in the downstream portion of the striped charges, it would appear that spire corrosion might be considerably less for the HDS material. If this is true, it is difficult to account for such a phenomenon other than by a lesser amount of heat being transferred through the spire of the HDS material because local water temperatures should be equivalent for both the test and control groups. The facts of the matter, however, will have to be established from the radiomet examinations.

R. R. Bloomstrand

R. R. Bloomstrand, Engineer
Product Quality Engineering

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