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POST IRRADIATION EXAMINATION OF KER-1-3

SEVEN ROD CLUSTER FUEL ELEMENTS (RM-277)

by

W. J. Gruber

October 19, 1959

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POST IRRADIATION EXAMINATION OF KER-1-3
SEVEN ROD CLUSTER FUEL ELEMENTS (RM-277)

INTRODUCTION

Two coextruded, Zr-2 clad, natural uranium, seven rod cluster fuel elements were irradiated to a calculated exposure of 1250 MWD/T in the KER Facility and discharged 1-16-59. The fuel elements were NPR candidate fuel and examination was requested to determine the behavior of coextruded, Zr-2 clad, natural uranium irradiated at core temperatures of approximately 425°C. The elements were transferred to the Radiometallurgy Laboratory 2-25-59.

SUMMARY AND CONCLUSIONS

The elements demonstrated excellent in reactor performance with no significant changes in either the fuel or the hardware.

Detailed examination of the central rod and two peripheral rods from one of the clusters showed no microcracks in the uranium. Moderate growth was observed in the fuel at the unrestricted rod ends.

DETAILS

The clusters were photographed and visually examined shortly after they were received. (Figure 1.) The clusters were assigned sample numbers 277 A and 277 B. 277 A was made up of rods # 2,3,4,5,6,7, and 8, and 277 B was made up of rods # 9, 10, 11, 12, 13, 14, and 15. Two rods # 12 and 14 were broken loose from 277 B in handling in the 327 Building basin.

Visual examination showed the oxide layer formed on autoclaving was still intact and inter rod spacing was uniform. Measurement of the inter rod spacing at the center and each end of the elements revealed a slight reduction at the center of the cluster. Pre-irradiation measurements showed that the bowing existed prior to irradiation.

The rods were separated and no warp was detected upon visual examination. Micrometer measurements of the individual rods included the diameter at each end and the midpoint of the rods, and the length. (Table 1.)

Rod #9, the central rod, and #10 and 14, peripheral rods, were selected for detailed examination. A replica of a selected surface area of rod #10 was made and submitted to Physical Metallurgy Operation for electron microscope examination to compare with a replica of the area made prior to irradiation.

One metallography and burnup analysis sample was sectioned from each of the rods # 9, 10, and 14. In addition a density sample was removed from the midpoint and near one end of rods #9 and 14. The ends of rods #9 and 14 were sectioned longitudinally so the gap between the fuel and the end plugs could be examined.

Density measurements were made by first machining the rods through the Zr-2 cladding and into the fuel approximately .010 inches, and obtaining density data from the remaining uranium. An unirradiated standard from the same fabrication as the cluster was similarly prepared and its density obtained for comparison with the irradiated

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material. The results may be seen in Table II.

One sample each from rods #9, 10, and 14 was dissolved and the solution was submitted to Analytical Operation for U_{235} burnup analysis. Analysis showed a U_{235} burnup of 0.138 a/o in rod #9 and 0.172 a/o in rod #10. The results from rod #14 were obviously in gross error and will be rerun.

The longitudinal sections of the extremities of the rods revealed that moderate growth had occurred at the unrestricted rod ends. (Figure II) The amount of growth present appeared to be dependent on the distance of the material from the central axis of the rod where growth was greatest.

Metallography was obtained from samples removed from the proximity of the midpoints of #9, 10, and 14. Grain size from surface to core was uniform and no microcracks were observed. The uranium to Zircaloy 2 bonds were excellent and the grains size of the cladding was uniform. (Figure III and IV.) Replicas of the etched surfaces of the three metallographic samples were made and submitted to Physical Metallurgy Operation for electron microscope studies.

Hardness data was obtained from the samples used for metallographic examination. Readings were uniform across the sample from outer surface to core. Average hardness readings may be seen in Table III.

The original data may be seen in HWN-1797.

W. J. Gruber, Engineer
Radiometallurgy Laboratory
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TABLE I
LENGTH AND DIAMETER MEASUREMENTS

ROD #	Diam. 1 1/4" from Numbered End		Diam. at Midpoint		Diam. 1 1/4" from Plain End		LENGTH
	0°	90°	0°	90°	0°	90°	
277 A							
2	.633	.635	.633	.634	.635	.634	13.195
3	.633	.634	.633	.633	.634	.634	13.194
4	.634	.629	.630	.635	.631	.633	13.188
5	.633	.634	.634	.634	.634	.635	13.176
6	.632	.634	.634	.633	.634	.633	13.176
7	.634	.634	.633	.635	.635	.636	13.184
8	.634	.632	.633	.634	.637	.636	13.195
277 B							
9	.631	.630	.632	.631	.631	.631	13.245
10	.634	.631	.634	.635	.632	.633	13.228
11	.632	.634	.632	.634	.632	.634	13.240
12	.632	.631	.631	.631	.632	.632	13.234
13	.628	.628	.633	.635	.629	.628	13.229
14	.632	.633	.639	.638	.633	.633	13.238
15	.633	.634	.636	.635	.631	.628	13.230

Pre-irradiation diameter measurements of the rods were .631 ± .003 inches.

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TABLE II

DENSITY DATA

	Midpoint	End
Rod #9	18.88 @ 20.4°C	18.80 @ 20.5°C
Rod #14	18.72 @ 20.4°C	18.89 @ 20.4°C
Standard	18.89 @ 20.5°C	

TABLE III

HARDNESS DATA

Average Hardness (Rockwell A Scale)

Rod #9	$68.3 \pm \begin{smallmatrix} 1.5 \\ 1.3 \end{smallmatrix}$
Rod #10	$68.7 \pm \begin{smallmatrix} 1.1 \\ 1.8 \end{smallmatrix}$
Rod #14	$69.0 \pm \begin{smallmatrix} 2.0 \\ 1.5 \end{smallmatrix}$

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Neg. #12324 277-B Cluster as Received
The numbered ends of the rods are to the right.

1/2X

Neg. #11321 277-B Cluster 1-1/2X
Rods 12 and 14 were broken from the cluster in 327 Bldg. basin.

FIGURE I

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Fig. #11426
Recessed End of Rod #9

Fig. #11426
Plain End of Rod #9

Fig. #11426
Recessed End of Rod #10

Fig. #11426
Plain End of Rod #10

In fabrication the gap between the fuel and the endcap was approximately .020 inches. The magnifications indicated on the photographs above are approximations.

FIGURE II

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Fig. #1530

Photomicrograph of a vacuum cathodic etched Zr-2 canwall under polarized light. The photomicrograph was typical of the Zr-2 rods from all the rods which were examined.

Fig. #1536

Photomicrograph of vacuum cathodic etched Zr-2 canwall under polarized light. The photomicrograph was typical of the Zr-2 rods from all the rods which were examined.

FIGURE III

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Neg. #11705 250X
Etched uranium at the core of
rod #14.

Neg. #11599 250X
Etched uranium 0.060 inches
from the cladding of rod #14.

Neg. #11602 3000X
Typical appearance of the bond between the coextruded uranium
and Zr-2 cladding after the vacuum cathodic etching.

FIGURE IV

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