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EXAMINATION OF FOUR IRRADIATED
KVNS FUEL ELEMENTS - RM C-440

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EXAMINATION OF FOUR IRRADIATED
KVNS FUEL ELEMENTS (RM C-441)

W. J. Gruber
September 1, 1964

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EXAMINATION OF FOUR IRRADIATED KVNS FUEL ELEMENTS (RM C-440)

W. J. Gruber
September 1, 1964

Introduction

Four KVNS production fuel elements which had operated for 66 days were submitted to the Radiometallurgy Laboratory for examination after being subjected to unusual conditions during shutdown. It was believed that the elements may have been at elevated temperatures for as long as 4-1/2 hours ⁽¹⁾ after shutdown. An abnormal film which appeared to be boiler scale was observed on some of the elements when they were examined in the basin immediately after discharge. Four elements were selected for metallurgical examination to determine whether they had been overheated and to assess any resulting damage or change.

Details of Examination

Visual examination revealed that the surfaces of the elements were coated with the reddish brown film normally observed on irradiated elements and that the film was heavier than usual (Figure 1). An accurate measure of the thickness was not made, however it was noted that the film on two elements sloughed off in fine flakes during handling, indicating that it was several mils thick and not firmly fixed to the element surface.

The end data on all four elements was KV095M.

It was decided to metallurgically examine the uranium, the uranium to Al-Si bonds, the Al-Si, and the aluminum cladding beneath the supports to determine in-reactor operating temperatures of the components and to detect any damage.

Three elements were sectioned to remove two wafers from each. One wafer was removed from the portion of the element that appeared to have been at the highest temperature. The second wafer was removed so a cross section of a support tab and

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(1) Personal communication with K. L. Hladek

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the cladding beneath it near a support weld could be examined. The first wafer was examined to determine the condition of the uranium, the uranium to Al-Si bond, and the Al-Si. The second wafer was examined to determine the extent of corrosion in the cladding adjacent to and under the supports.

Both internal and external uranium to Al-Si bonds in all three elements were in excellent condition indicating that the operating temperature had not been excessive and that there were no severe thermal shocks (Figure 2).

The microstructure of the uranium in the three elements was typical of a low temperature irradiation with no indication of annealing (Figure 4). The average temperature during the 66 days was probably not greater than 400°C.

The extent of spheroidization of Al-Si eutectic can be used to accurately determine the average operating temperature if the time at temperature is known (2). Very little spheroidization occurred in any of the elements (Figure 2). The condition of the eutectic indicated that the average temperature of the Al-Si did not exceed 320°C during the 4-1/2 hour shutdown period or 240°C during the 66 day operating period.

Corrosion occurring in the cladding adjacent to or under the supports in any of the three elements was negligible (Figure 5). Had steam formed on the surface of the elements for a period longer than a few minutes either during the shutdown or operation, corrosion of the cladding in this area would have been visible.

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(2) Todd, R.H., "Metallographic Study of the Annealing Behavior of Aluminum-Silicon Eutectic Alloy", HW-69401, Unclassified, June 1961.

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Summary and Conclusion

The elements incurred no damage as the result of unusual shutdown conditions. The only fact which indicated operation at elevated temperature was the formation of a heavier than normal surface film.

Metallurgical examination disclosed that the average temperature of the AlSi was not greater than 320°C during the shutdown period or 240°C during operation. No annealing of the uranium was observed. The uranium to Al-Si bonds were in excellent condition and no excessive corrosion beneath the support tabs was observed.

W. J. Gruber, Engineer
Radiometallurgy Laboratory

WJG:o'b

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Figure 1

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C2414

1/2X

C2416

1/2X

C2407

C2409

The photographs show two elements as received. The two top photos are opposite sides of one element, and two photos at the bottom are the second. Note heavy film on the surface of the elements.

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Figure 2

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C1949

250X

C1950

250X

The typical appearance of the Al-Si, adjacent cladding (top), and uranium (bottom) are shown after polishing and etching with an 0.5% solution of HF in water. Virtually no spheroidization of the Al-Si occurred. The uranium rich intermetallic, seen as a black line between the Al-Si and U, was not broken in any of the elements.

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Typical appearance of macrostructure. No evidence of overheating or high operating temperature was observed.

C2510

3X

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Figure 3

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Microstructure of uranium was typical
of low temperature irradiation.

250X

C2524

250X

C2523

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Figure 4

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Figure 5

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C1946

250X

C1947

250X

Two views of a support and the cladding beneath it adjacent to a support weld are shown. Note that corrosion attack is negligible.

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