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WANL-TME-1699

October 27, 1967

Subcontract NP-1

Westinghouse Astronuclear Laboratory

FINAL REPORT ON TEST SPECIFICATION
III-4A REVERSE COATING (U)

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WANL-TME-1699
October 27, 1967

TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
	INTRODUCTION	i - ii
I.	EXPERIMENTAL PLAN	1 - 2
II.	DISCUSSION OF RESULTS	2 - 7
III.	CONCLUSIONS	7 - 8

ILLUSTRATIONS

PHOTOMICROGRAPHS OF REPLICATED CHANNELS L-234	4
PHOTOMICROGRAPHS OF REPLICATED CHANNELS M-77	5
REVERSE COAT FIXTURE (ATTACHMENT "A")	9

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October 27, 1967

INTRODUCTION

CND

Since the NRX-A4 and NRX-A5 reactor tests indicated large cracks formed by high deposition temperatures and large differences between coating temperatures and reactor temperatures were detrimental to reactor performance, it was deemed advisable to attempt coating at temperatures which resembled reactor temperatures as nearly as possible.

CCD

For this reason, it was proposed that the direction of gas during coating be reversed (serial numbered end to un-numbered end). Coating in this manner combined with generally lower temperatures would result in a better match of coating temperatures with reactor operating temperatures.

U

The primary objective of this Test Specification was to demonstrate the validity of this theory through a comparison of a run made in this manner versus one made using NRX-A6-1 coating parameters. The comparison and evaluation was to be made using the following criteria:

1. Dimensional Inspection
2. Non-Destructive Testing
3. Replication & Photomicrography
4. Stoichiometry
5. Corrosion Testing

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October 27, 1967

CP- A secondary objective was to demonstrate the feasibility of a new fixture which permitted coating gases to enter the element in the "reverse" manner.

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October 27, 1967

I. EXPERIMENTAL PLAN

C-7
Six WANL as-leached fuel elements made to the NRX-A6 drawing and containing NRX-A6 quality fuel beads were selected and placed in the reverse coat fixture with the serial numbered ends of the elements located at the top of the furnace. A sketch (Attachment A) illustrates the design features of the fixture. Note that both the bores and the O.D. of elements can be coated in a sequential manner using this fixture. Argon protects the O.D. while coating the bores and vice versa.

C-7
The Run(L-237) was made using the following parameters. (The parameters for the NRX-A6-1 type run ((M-77)) are shown for comparison.)

	<u>L-237</u>	<u>M-77</u>
Run Time (Hours)	14	8
Temperature, Un-numbered end (°C)	1800	1850
Temperature, mid-band of element (°C)	1600	1965
Temperature, serial numbered end (°C)	1450	2065
Flow, Argon (LPMPE)	3.7	0.93
Flow, HCL (LPMPE)	0.84	0.80

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October 27, 1967

	<u>L-237</u>	<u>M-77</u>
Flow, Hydrogen (LPMPE)	0.12	0.07
Flow, Salt (LPMPE)	0.11	0.07

Note the large difference in mid-band coating temperature.

U

The elements were then processed through Inspection and shipped to WANHES for corrosion testing in accordance with the Test Specification.

II. DISCUSSION OF RESULTS

CRD

The fuel elements in L-237 gained an average of 56.3 grams during coating while the M-77 elements gained 75.8 grams.

CRD

The coating thickness of the two runs as measured by the internal beta-backscatter technique was as follows:

	<u>COATING THICKNESS (MILS)</u>	
<u>DISTANCE FROM S/N END (IN)</u>	<u>L-237</u>	<u>M-77</u>
10	1.1	2.1
20	1.3	2.2
30	1.6	2.2
40	2.0	2.1
50	2.6	2.0

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October 27, 1967

CRD

The number of cracks per longitudinal inch of coating were counted using a binocular microscope. It was postulated that a higher number of cracks per inch would be desirable since the width of each crack would of necessity be less.

<u>DISTANCE FROM S/N END (IN)</u>	<u>NO. OF CRACKS PER INCH</u>	
	<u>L-237</u>	<u>Channel 11</u> <u>M-77</u>
16	60	8
21	113	9
26	39	7
31	34	9
36	32	11
41	38	12

Channels 10, 11 and 12 of an element from both runs were replicated using the pressurized/heated PVC tubing technique. Photos of these replicas at 20" and 40" from the S/N end are shown as follows:

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October 27, 1967

PHOTOMICROGRAPHS OF REPLICATED CHANNELS

L-237

Element 39-32406 Channel 11
20" from Serial Number End

Element 39-32406 Channel 11
40" from Serial Number End

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October 27, 1967

PHOTOMICROGRAPHS OF REPLICATED CHANNELS

M-77

Element 99-31643 Channel 9
20" from Serial Number End

Element 99-31643 Channel 9
40" from Serial Number End

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October 27, 1967

Note the much narrower, more frequent cracks in the photos of L-237. Also note the presence of transgranular cracks in L-237. This is indicative of coatings with better adherence.

CRD

The stoichiometry (Carbon/Niobium Ratio) of the bore coatings at 15" and 45" were measured for each of the runs via X-ray techniques.

<u>DISTANCE FROM S/N END (IN)</u>	<u>STOICHIOMETRY (C/NB)</u>	
	<u>L-237</u>	<u>M-77</u>
14	0.89	Not Avail.
45	0.91	0.91

After viewing the elements submitted for corrosion test, WANHES personnel determined that they could not be given a valid corrosion test. The reason for this opinion was the fact that the exterior was coated for a distance of only 1/2". This was an insufficient length to protect the element from severe corrosion in the hot-end chuck area.

CRD

With respect to the secondary objective of the Specification, the new design did not prove acceptable for coating elements with 3" long back coats. It should be pointed out, however, that the fixturing was originally designed for sequentially reverse coating the bores and the entire O.D. of elements, and for this purpose, it has proven to be acceptable.

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October 27, 1967

III. CONCLUSIONS

CRD

The basic purpose of the Specification was to make a run in which the coating temperatures matched those of the reactor and demonstrate its superiority over previously used parameters.

CRD

Although it was impossible to validate the theory through a comparison or corrosion tests, photographic evidence of more adherent coatings with narrower room temperature cracks strongly suggests that the cracks would be narrower at operating temperatures if lower coating temperatures are used. With narrower cracks and better adherence at operating temperatures, an improvement in corrosion behavior should be observed.

CRD

It should be mentioned that although reversing the direction of coating gas improves the relationship of coating temperatures to operating temperatures, it is impossible to precisely match the reactor gradient due to furnace limitations. In addition, it would be impossible to deposit niobium carbide at the low temperatures observed near the entrance end of the reactor. For these reasons, it was decided to match the mid-band temperatures only.

UJ

Meanwhile, adjustment of the end temperatures must be a compromise between:

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1. The intent of lower S/N end-hotter un-numbered end coating temperatures.
2. The establishment of the desired coating thickness profile.

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Attachment "A"

REVERSE COAT FIXTURE

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