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Westinghouse Astronuclear Laboratory

FINAL REPORT ON TEST SPECIFICATION III-11A
EXTERNAL SURFACE TREATMENT

(Title Unclassified)

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INTRODUCTION

(C) A number of the fuel elements located near the periphery of the NRX series reactors require full length exterior coatings. Exterior (O.D.) coating of NRX-A5 elements, and that prior to NRX-A5, was conducted in a separate coating operation, subsequent to the coating of bores. During the bore coating operation, a tight fitting seal at the hot end of the element prevented the coating gases from passing along the outside of the element. During O.D. coating, the gases were diverted into two streams, one over the element exteriors, and the other through the bores. This required two heating cycles and two sets of fixturing, both of which are time consuming and costly. An additional, and unquestionably the most important, consideration was that control of the proper coating chemistry was extremely critical, particularly of the gas passing through the bores. If the proper concentrations and temperatures were not maintained, "chewing reactions" developed which resulted in stripping and/or grain boundary attack. This resulted in poor corrosion performance. It was not that the two-step process (bore coat followed by a separate O.D. coat) could not produce high quality elements, but that it could not consistently produce high quality elements that led us to examining other approaches to coating the O.D. of elements.

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- (C) Still a fourth factor was a reason for considering other techniques. It was observed that heating cycles subsequent to bore coating altered the crack patterns formed during the cooldown from the bore coating operation. In general, it was noticed that the small cracks disappeared and the largest cracks became larger. Since the width of the largest cracks was believed related to corrosion performance, it was deemed desirable to keep the size of the largest cracks at a minimum. As a result, any heating cycles which caused large cracks to become larger should be eliminated.
- (C) Lastly, it was believed from a review of the NRX-A4 and NRX-A5 reactor test results that large cracks formed by high deposition temperatures and large differences between coating temperatures and reactor temperatures were detrimental to reactor performance. It was therefore proposed to reverse the direction of coating gas (S/N end to hot end) so that the temperature profile during coating could more closely match that of the reactor. This then permitted fixturing to be devised which would enable us to coat the bores and the O.D. of the elements sequentially in the same fixture and during the same heating cycle. This would not only result in a sizeable cost reduction, but also take advantage of any potential gains in corrosion performance accruing from the elimination of a heating cycle subsequent to bore coating.

(C) It should be emphasized that the primary purpose of the work defined by this test specification was to develop an O.D. coating process which would consistently pass the screening corrosion test, and that such considerations as cost were of secondary importance. In addition to corrosion testing the elements, the evaluation program consisted of the following:

1. Dimensional Inspection
2. Non-Destructive Testing
3. Replication and Photomicrography
4. Stoichiometry

I. EXPERIMENTAL PLAN

(U) Ten as-leached elements made to the NRX-A6 drawing and containing NRX-A6 quality fuel beads were selected and placed in each O.D. run. It was initially intended to include five (5) Y-12 matrix elements as well as five (5) WANL matrix elements so that an evaluation of matrix and substrate effects upon corrosion performance could be accomplished. However, the lack of a sufficient quantity of Y-12 matrix elements at the time prevented a thorough study of this variable.

(C) Four (4) O.D. runs and two (2) bore coat runs were made in conjunction with this work. The four (4) O.D. runs were:

<u>Test Spec. Coating Batch Number</u>	<u>Furnace Run Number</u>	<u>Description of Process</u>
1	L-235	O.D. run with a bore purge*
2	L-234	Sequential bore / O.D. run*
3	L-236	Sequential O.D. / bore run*
4	F-315	Standard NRX-A5 O.D. run without a bore purge

* Figure 1 illustrates the key design features of the fixture used for these runs.

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(C) The two (2) bore coat runs were made to supply elements for the two (2) independent O.D. runs, Coating Batch 1 (L-235) and Coating Batch 4 (F-315). At the time a parallel effort was being made to determine the optimum bore cycle (see TME-1669). The 14-hour bore cycle was selected as a "Best Guess" for the two (2) sequential runs, while elements supplied for the two (2) independent O.D. runs consisted of both 24-hour (L-231) and 14-hour (L-232) bore coats.

(C) A comparison of the parameters during the O.D. coat portion of the runs is shown below:

	<u>L-235</u>	<u>L-234</u>	<u>L-236</u>	<u>F-315</u>
Run Time (Hours)	2.5	2.5	2.5	2.5
Temperature, un-numbered end (°C)	1675	1675	1675	1550
Temperature, mid-band of element (°C)	1610	1610	1610	1600
Temperature, serial numbered end (°C)	1550	1550	1550	1650
Flow, Argon (LPMPE)	2.40	2.40	2.40	2.40
Flow, HCl (LPMPE)	0.84	0.84	0.84	0.84
Flow, Hydrogen (LPMPE)	0.12	0.12	0.12	0.12
Flow, Salt (LPMPE)	0.11	0.11	0.11	0.11

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- (C) A comparison of the parameters during the bore portion of the sequential runs and the two independent bore coat runs follows:

	<u>L-231</u>	<u>L-232</u>	<u>L-234</u>	<u>L-236</u>
Run Time (Hours)	24	14	14	14
Temperature, un-numbered end (°C)	1650	1730	1800	1800
Temperature, mid-band (°C)	1500	1680	1600	1600
Temperature, serial numbered end (°C)	1400	1620	1450	1450
Flow, Argon (LPMPE)	0.86	0.86	3.70	3.70
Flow, HCl (LPMPE)	0.43	0.43	0.84	0.84
Flow, Hydrogen (LPMPE)	0.06	0.06	0.13	0.13
Flow, Salt (LPMPE)	0.06	0.06	0.11	0.11

- (C) After coating, the elements were processed through Inspection for corrosion testing in accordance with the test specification. In addition, a number of elements were coated with molybdenum ("X" coat), inspected, and shipped for corrosion testing.

II. DISCUSSION OF RESULTS

(C) The following is a summary of the weight gains encountered during coating:

L-231 (24-Hour Bore Coat): 44 grams

L-232 (14-Hour Bore Coat): 58 grams

L-235 (Run 1, O.D. only): 11 grams

L-234 (Run 2, Bore/O.D.): 74 grams

L-236 (Run 3, O.D./Bore): 76 grams

F-315 (Run 4, O.D. only): 13 grams

(C) It should be noted that all elements from both sequential runs had coarse crystalline deposits on their un-numbered (hot) ends, particularly at the intersection of surfaces. This played a significant role in their corrosion behavior. (See "Discussion of Results" and "Conclusions.") The cause of this phenomenon was subsequently believed to be the result of gas phase reactions whereby impure shell gas reacted with bare graphite surfaces to form CO in purge gases which, in turn, reacted with NbCl_x vapors, where the purge stream and coating stream came in contact with each other.

(C) The coating thickness of the runs after both bore and O.D. coating is indicated on Figures 2 through 7. Both the internal and external thicknesses were measured via beta backscatter techniques. As can be seen from the data, all of the 14-hour bore runs had somewhat thicker mid-band

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coatings than desired.

(C) One element from each run combination was channel replicated and then sectioned for stoichiometry and metallography. Channel replication was performed by inserting small diameter PVC tubing into the channel, applying internal pressure on the tubing, heating it under pressure, cooling it under pressure, and removing the tube after the pressure had been relieved. In this manner, the surface irregularities of the channel are transferred to the surface of the tubing. The surface of the tubing is then photographed through the use of a metallograph. Figures 8 through 16 are replicate photographs of the two (2) independent bore coat runs and the four (4) O.D. runs. Each figure consists of two (2) photographs of the same channel of the same element, one at 20" from the serial numbered end and the other at 40".

(C) Note that the cracks at both locations are somewhat narrower in the 24-hour bore coat runs (Figures 8, 11, and 15) than in the 14-hour runs. Also, note that in the only direct comparison between matrices (Figures 9 and 10), the coating on the Y-12 matrix appears slightly more adherent (transgranular cracking) and the cracks may be slightly narrower. Neither of these observations appear significant, however, particularly since a review of the entire surface of both replicas showed similar structures throughout.

- (C) The stoichiometry measurements are shown in Table I. One apparent correlation of stoichiometry with coating cycle is that the values are slightly lower in the run in which the O.D. cycle precedes the bore cycle (L-236). Also noted is a gradient in the two-step runs that is not evident in the sequential runs. This behavior appears anomalous, however, because the gradient is reversed from that which would be expected.
- (C) Results of the metallographic examinations are shown in Figures 17 through 20. Each is a plot of a particular technique of evaluating the adherence characteristics of the coating in Channel 11 versus distance from the serial numbered end. Figure 17 shows crack frequency behavior (or number of cracks per linear inch) and assumes that the higher frequencies are indicative of better adherence.
- (C) Figure 18 illustrates the width of the gap between the underside of the coating and the substrate. It is assumed that narrower gaps are the result of more adherent coatings.
- (C) Figure 19 is another technique for adherence evaluation. Here a transverse section through the channel is examined with the number of columnar grains (those which extend through the entire thickness of coating) being expressed as a percentage of the total number of grains in the section. It is postulated that a non-columnar, fine-grained structure is more adherent.

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(C) Figure 20 shows the number of cracks passing through grains expressed as a percentage of the number of cracks passing through grains and around grains. It is postulated that good adherence is demonstrated here by cracking through (trans) grains rather than in the grain boundaries.

(C) If all of the above assumptions were true, examination should reveal a direct or inverse relationship between each of the characteristics for a particular run. For example, element 79-33297 has the following general characteristics when compared with the remaining elements:

1. High Crack Count
2. Narrow Gap Width
3. Low Percentage of Columnar Grains
4. High Percentage of Transgranular Cracks

This behavior is consistent with the assumptions. Note also that element 59-32002 is about average in all characteristics. Meanwhile, element 39-32419 has a low crack count and a large gap, but has an average percentage of columnar grains and higher than average percentage of transgranular cracks. In addition, note the anomalous behavior of element 79-33274. It has an average crack count and columnar structure at most locations but has zero gap width with a low percentage of transgranular cracks.

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- (U) An analysis of these results indicates that it is somewhat dangerous to characterize a coating on the basis of one evaluation technique. Continued effort in developing the techniques and training of metallographic technicians should improve this situation.
- (C) Several of the elements from each of the runs received an overcoating of molybdenum ("X" coat) in their channels after NbC coating. Elements were shipped to WANHES for corrosion testing in both the "As-NbC-Coated" and "As-X-Coated" Conditions. A summary of the test results is presented on Tables II, III, IV, and V for O.D. runs L-235, L-234, L-236, and F-315, respectively. The first element from a given run was scheduled for a straight 60 minutes at 875 Kw with a differential pressure of 30 PSIG. The second was scheduled for a (30 plus 20) minute cyclic test at the same conditions.
- (C) A review of the data indicates the following:
1. "X" coated elements withstand the test conditions longer than non-"X" coated elements.
 2. The two (2) bore/O.D. runs behaved quite poorly in the test environment, but this is attributed primarily to the hot end crystalline condition.
 3. The standard NRX-A5 two-step process (F-315) yielded the lowest weight losses during testing. (See "Conclusions.")

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4. The 24-hour bore coat process resulted in better weight loss performance than did the 14-hour bore coat process (See Table VI.).

III. CONCLUSIONS

- (C) The basic purpose of this test specification was to develop an O.D. coating process which would produce acceptable NRX-A6 fuel elements. In this context, the specification was unsuccessful. None of the processes (as they were defined in this work) would consistently produce good NRX-A6 quality elements. It was noticed that the bore performance of the sequential runs was superior to that of NRX-A5 type run. However, the poor end performance of elements in these runs negated any potential benefits that may have been derived from the reverse sequential process. A concerted effort was subsequently directed at resolution of the coarse crystalline deposit problem.
- (C) The solution to the crystalline problem, combined with the work in this specification, led to the development of a superior fuel element. The 14-hour bore/O.D. sequential process was selected for the manufacture of NRX-A6 elements and the weight losses encountered during the 875 Kw - (30' + 30') test of NRX-A6 elements are equal to or better than the 875 Kw - (30' + 20') results on the NRX-A5 elements in this specification.

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- (U) No conclusions can be drawn at this time regarding the effects of matrix differences upon corrosion performance. However, correlation work should continue in this area because the more stringent test conditions of the future will undoubtedly illustrate performance differences related to substrate and matrix characteristics.
- (C) The sequential fixture was found to be suitable for production NbC coating of the bores and entire O.D. surfaces of fuel elements. An extension of this coating technique for bore/back coating appears quite feasible.
- (C) The lower weight losses indicated during corrosion testing by the 24-hour bore coat processed elements (See Table VI.) indicate that it may be advisable to investigate longer bore coat times in the sequential process. Added impetus in this direction will be achieved by continued improvement in equipment reliability.

Figure 1. Bore/O.D. Fixture

Figure 2. Run L-232/L-235, Element 59-32002

Figure 3. Run L-231/L-235, Element 79-33274

COATING THICKNESS PROFILE

Figure 4. Run L-234, Element 39-32419

Figure 5. Run L-236, Element 59-32605

COATING THICKNESS PROFILE

Figure 6. Run L-232/F-315, Element 59-31938

Figure 7. Run L-231/F-315, Element 79-33297

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Figure 8

L-231 Only

Element 99-76035, Channel 10

20" From Serial Number End -
250X

40" From End - 250X

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Figure 9

L-232 Only

Element 99-76407, Channel 10
(Y-12 Matrix)

20" From Serial Number End -
250X

40" From Serial Number End -
250X

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Figure 10

L-232 Only

Element 39-32415, Channel 10
(WANL Matrix)

20" From Serial Number End -
250X

40" From Serial Number End -
250X

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Figure 11

L-231/L-235

Element 89-32821, Channel 10

20" From Serial Number End -
250X

40" From Serial Number End -
250X

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Figure 12

L-232/L-235

Element 59-32002, Channel 10

20" From Serial Number End -
250X

40" From Serial Number End -
250X

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Figure 13

L-234 Only

Element 39-32419, Channel 10

20" From Serial Number End -
250X

40" From Serial Number End -
250X

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Figure 14

L-236 Only

Element 79-34100, Channel 10

20" From Serial Number End -
250X

40" From Serial Number End -
250X

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Figure 15

L-231/F-315

Element 79-33297, Channel 10

20" From Serial Number End -
250X

40" From Serial Number End -
250X

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Figure 16

L-232/F-315

Element 59-31938, Channel 10

20" From Serial Number End -
250X

40" From Serial Number End -
250X

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Figure 17. Crack Frequency vs. Distance from S/N End

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Figure 18. Average Gap Width (In.) vs. Distance from S/N End

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Figure 19. Percent of Columnar Grains vs. Distance from S/N End

Figure 20. Percent Transgranular Cracks vs. Distance from S/N End

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Table I

Stoichiometry (C/Nb Ratio) of NbC

<u>Run No.</u>	<u>Element S/N</u>	<u>14" From S/N End</u>	<u>45" From S/N End</u>
L-231 (Only)	79-33197	0.91	0.86
L-231/L-235	79-33274	0.95	0.91
L-232/L-235	59-32002	0.95	0.91
L-234	59-32603	0.94 (0.97*)	0.91 (0.95*)
L-234	39-32419	0.92	0.91
L-236	59-32609	0.84 (0.95*)	0.85 (0.95*)
L-236	79-34100	0.86	0.86
L-231/F-315	79-33297	0.97	0.85
L-232/F-315	59-31938	0.90	0.85

* Matrix/NbC Interface. All other measurements taken on side opposite matrix.

Table II. O.D. Coating Run No. L-235, Corrosion Summary

Bore Coat/"X" Coat								
Element S/N	Run Nos.	Test Time Min.	Power K.W.	ΔP (PSIG)	Weight Loss (GM)	BAR	Wt. Loss Per Min.	Comments
39-32414	L-232/ AA-019	30 + 16.8	$\frac{883}{878}$ $\frac{888}{879}$	30.8	18.2	50	0.49	Pre-Test Bar - 95 Broke @ 13-3/4 Corr. Ch. 1 through 10 Bar 1/2" - Back Coat flaked from 10-1/2 - 45 Corr A B D E F Flats 49-1/4 - 51 FH A Flat 14-48 F Flat - 48 B 48 C 47-48
79-33212	L-231/ AA-019	60	$\frac{905}{890}$	30	14.6	100	0.24	Stoned 15-16, 26-27, 37-38, 48-49 before test - Corr. Hole A & B Flats @ 51-1/4"
79-33273	L-231/ AA-019	30 + 20	$\frac{911}{895}$ $\frac{901}{893}$	31.6	13.5	75	0.27	
39-32411	L-232/ AA-019	45.8	$\frac{894}{876}$	30.5	17.4	80	0.38	Special Test in Diffuser Element broke @ 12.5
59-33966	L-232/ AA-019	19.1 + 10.9 + 6.5	$\frac{905}{893}$	29.4	13.2	90	0.36	5 FH 0-48 Abort 19.1 Trans leak Abort 10.9 chuck fail Abort 6.5 pin holes

Table II. (Continued) O.D. Coating Run No. L-235, Corrosion Summary

Bore Coat/"X" Coat								
Element S/N	Run Nos.	Test Time Min.	Power K.W.	ΔP (PSIG)	Weight Loss (GM)	BAR	Wt. Loss Per Min.	Comments
49-27458	L-231/ AA-019	20	$\frac{893}{892}$	30.8	7.1	83	0.35	Abort 20 - Break @ 51 NFT broke off
89-32821	L-231/ AA-019	10 + 40	$\frac{897}{897} \frac{897}{886}$	30.6	18.8	70	0.37	Large corr. hole A E F 48-51

Table III. O.D. Coating Run No. L-234, Corrosion Summary

"X" Coat								
Element S/N	Run No.	Test Time Min.	Power K.W.	ΔP (PSIG)	Weight Loss (GM)	BAR	Wt. Loss Per Min.	Comments
39-32420	None	40' 45"	<u>875</u> 874	30	13.8	80	0.33	Corrosion Bar - Ch. 2, 3, 7 - 1/4 Back Broke @ 21-1/4 - Corrosion 3 PH 2 @ 22 C flat, 1 @ 50 E flat
79-34098	None	28	<u>877</u> 879	30	21.3	15	0.76	Broke @ 17-3/4 Corrosion Bar Up to 3/8 Back
79-34099	None	4' 50"	<u>886</u> NA	30	28	98	5.6	S/C all flats 50-52 Corrosion Bar Ch. 3 - 1/4 Back Abort cracked chuck could not fit because of S/C coat blistered 30-38 all flats
39-32423	None	28' 41"	<u>874</u> 878	30	16.9	0	0.58	Abort loss of D/P - 4 - PH - 2 @ 50-1/2 - 1 @ 44 - 1 @ 46 Corrosion all bar channels 1/2" Back A flat 50-1/2 F flat 46 B flat 50-1/2 Coat flaked all flats D flat 44 30-44
39-32421	AA-017	30 + 30	<u>899</u> <u>906</u> 894 894	32	22.5	0	0.37	Estimate 9.3 G loss due to back corrosion.

Table III. (Continued) O.D. Coating Run No. L-234, Corrosion Summary

"X" Coat

Element S/N	Run No.	Test Time Min.	Power K.W.	ΔP (PSIG)	Weight Loss (GM)	BAR	Wt. Loss Per Min.	Comments
59-32604	AA-017	10 + 29.7	$\frac{913}{909}$ $\frac{901}{884}$	31.5	16.8	0	0.42	Abort loss of D.P. hole in chuck tip corroded away 1/2" back.
79-32422	AA-017	60	$\frac{908}{885}$	31.5	13.9	85	0.23	Break 50 $\pm$ 51 during removal.
79-32424	AA-017	30 + 20	$\frac{888}{878}$ $\frac{885}{879}$	31	21.9	0	0.43	Corrosion bar channel - 1/2" back.

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Table IV. O.D. Coating Run No. L-236, Corrosion Summary

"X" Coat

Element S/N	Run No.	Test Time Min.	Power K.W.	Δ P (PSIG)	Weight Loss (GM)	BAR	Wt. Loss Per Min.	Comments
39-34101	None	31' 34"	$\frac{900}{893}$	30	21.2	20	0.67	Broke @ 19-3/8 chip bar channel 19 Corroded all flats 51-52-1/8 7 FH 2 @ 49-51 A flat 50-51 C flat 22-49 B flat 23 D flat 49-49-1/2
39-34102	None	30 + 15' 28"	$\frac{887}{884} \frac{902}{889}$	30	25.2	0	0.54	Broke @ 20-1/2 End corroded away 1" back 5 FH 1 @ 19 - .2 @ 40 - 1 @ 45 - 1 @ 50 A flat 50 D flat 19 C flat 40-1/4-45 E flat 40-1/4
59-32610	None	9' 30"	$\frac{900}{894}$	30	4.6	50	0.48	Abort loss of D.P. cracked chuck Recycle 2 FH 50-51 A flat 51 B flat 50
59-32612	None	30	$\frac{890}{872}$	30	12.2	0	0.40	Cleaned coating from hot end holes before test Corr. all bar ch. 1/4 back

Table IV. (Continued) O.D. Coating Run No. L-236, Corrosion Summary

"X" Coat

Element S/N	Run No.	Test Time Min.	Power K.W.	ΔP (PSIG)	Weight Loss (GM)	BAR	Wt. Loss Per Min.	Comments
79-34104	AA-019	60	$\frac{903}{887}$	65	26.3	0	0.43	Stoned element before test 15-16, 26-27, 37-38, 48-49, 1 FH A flat @51 before test - Corr. all bar ch. up to 1"
79-34103	AA-019	8.7	893	31	21.0	0	2.40	Broke @ 2' 6" - 48-1/2" & 51" 2 FH C flat 48-1/2 D flat 48-1/2
59-32605	AA-019	60	$\frac{904}{886}$	30	22.4	0	0.37	Break @ 51
59-32613	AA-019	30 + 20	$\frac{905}{903}$ $\frac{900}{895}$	25	28.2	0	0.56	3 FH E flat 48-1/2, 49, 50

Table V. O.D. Coating Run No. F-315, Corrosion Summary

Bore Coat/"X" Coat								
Element S/N	Run No.	Test Time Min.	Power K.W.	P (PSIG)	Weight Loss (GM)	BAR	Wt. Loss Per Min.	Comments
89-32718	L-231/ AA-019	30 + 20		31	11.6	95	0.23	
39-32412	L-232/ AA-020	60	$\frac{901}{886}$	30	11.5	100	0.19	2 PH @ 51 D & E flat
99-76154	L-232/ AA-019	41.3	$\frac{899}{892}$	31.9	7.6	98	0.18	Broke @ 9-1/2" 1 PH 11" A flat
99-76375	L-232/ AA-019	30	$\frac{904}{882}$	31.3	12.6	100	0.42	Broke coming down in power after 1st cycle @ 10-1/4" Cracks from 8-1/2-14 1 PH @ 12" E & F apex
99-30972	L-231/ AA-019	30 + 20	$\frac{900}{895}$ $\frac{900}{897}$	30.3	12.1	91	0.24	1 PH @ 3" C flat
69-33196	L-231/ AA-020	31.4 + 28.6	$\frac{904}{891}$	30.8	19.1	70	0.31	Abort 31' 24" cracked retainer Recycle Broke @ 51 unloading

Table V. (Continued) O.D. Coating Run No. F-315, Corrosion Summary

Bore Coat/"X" Coat

Element S/N	Run No.	Test Time Min.	Power K.W.	P (PSIG)	Weight Loss (GM)	BAR	Wt. Loss Per Min.	Comments
79-33301	L-231/ AA-020	30 + 20	$\frac{913}{903}$ $\frac{920}{910}$	30	13.4	80	0.27	1 PH @ 51 D flat
59-31934	L-234/ AA-019	34.3 + 25.7	$\frac{902}{895}$	32.2	30	95	0.50	Hot end chuck failure @ 34.3' Recycle
39-32413	L-232/ AA-019	30 + 20	$\frac{885}{875}$ $\frac{888}{873}$	32.3	12.6	98	0.25	3 PH B flat 43 E flat 42 F flat 43
39-75900	L-231/ AA-019	30 + 20		29.5	10.7	100	0.21	

Table VI. Corrosion Results Comparison, 24-Hour Bore Coat Process vs. 14-Hour Bore Coat Process

24 Hour Bore Coat (L-231):

<u>O. D.</u> <u>Run No.</u>	<u>Element</u> <u>S/N</u>	<u>Wt. Loss/</u> <u>Min. (G)</u>
L-235	79-33212	0.24
L-235	79-33273	0.27
L-235	49-27458	0.35
L-235	89-32821	0.37
L-231/L-235 Avg.		- <u>0.31</u>

F-315	89-32718	0.23
F-315	99-30972	0.24
F-315	69-33196	0.31
F-315	79-33301	0.27
F-315	99-75900	0.21

L-231/F-315 Avg. - 0.25

Composite 24 Hour Avg..... 0.28

14 Hour Bore Coat (L-232):

<u>O.D.</u> <u>Run No.</u>	<u>Element</u> <u>S/N</u>	<u>Wt. Loss/</u> <u>Min. (G)</u>
L-235	39-32414	0.49
L-235	39-32411	0.38
L-235	59-33966	0.36

L-232/L-235 Avg. - 0.41

F-315	39-32412	0.19
F-315	99-76154	0.18
F-315	99-76375	0.42
F-315	59-31934	0.50
F-315	39-32413	0.25

L-232/F-315 Avg. 0.31

Composite 14 Hour Avg..... 0.35