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Astronuclear Laboratory

(1)

WANL-TME-1479
August, 1966

MASTER

EVALUATION OF EXTRUDED-TO-SIZE ELEMENTS

(Title Unclassified)

Classification cancelled (or changed to) by authority of [redacted] by H. F. C. TIC, date SEP 12 1973

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SPECIAL REVIEW FINAL DETERMINATION Class. Date 4-14-82 Reviewer TR Class: U

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[redacted]RMATION CATEGORY
Confide[redacted]l-Restrict[redacted] Data
[redacted] 9/8/65
Authorized Cl[redacted] Date

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INTRODUCTION

One of the fuel element production processes being evaluated in the NRX-A5 development program is the process of extruding the bores of elements to size followed by coating in the leached or non-leached condition.

The corrosion properties of these extruded to size (ETS) elements were evaluated through a series of hydrogen corrosion tests. Additional evaluations were made by metallographic examinations, electrical resistance, and accelerated hydrolysis studies.

HYDROGEN CORROSION

A total of 11 ETS elements representing five coating batches and eight extrusion batches were hydrogen corrosion tested to evaluate their corrosion behavior. A summary of these test results along with results for similar tests of standard production elements, coated in the leached or non-leached condition, is given in Table I.

Although the hydrogen test results show little difference in 10-minute weight losses, there is a tendency for the ETS elements to have larger 30-minute weight losses as shown in Figure 1. This additional weight loss in the ETS elements appears to be due to increased corrosion in the mid-band region as reflected in the electrical resistance curves. The resistance curves show a much wider mid-band peak for the ETS elements than is seen in elements with standard reamed bores. It should also be noted that two ETS elements failed in the mid-band region, one after 27 minutes of testing and one after 30 minutes. There were no failures in the elements with reamed bores.

METALLOGRAPHY

One of the most noticeable effects of extruding bores to size is the formation of large porous areas near the coating-graphite interface that protrude into the channels. It appears that some of these areas form when damaged fuel beads expand (due to interaction

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Table I - Hydrogen Testing of Extruded to Size Elements

Coating Batch	Element	Lot	Type[1]	Test	ΔW (gms)	End (BAR/CAR)	Comments
L-117	99-24005	XII	ETS, leached	IB 5 + 5	3.3	97/97	
				+ 20	16.9	80/75	Axial cracks at chuck contact area.
	99-24036	XII	ETS, not leached	IB 5 + 5	4.2	75/75	Hole at 50"
				2nd test aborted			
	39-24130	XII	ETS, leached	IB 5 + 5	3.7	97/97	Hole in chuck area.
				+ 20	13.0	90/90	3 holes in chuck area.
	39-24097	XIII	ETS, not leached	IB 5 + 5	4.0	100/99	Coating flaking on flats.
				+ 20	19.4	70/65	
	89-23368	XII	STD, not leached	IB 5 + 5	3.9	90/90	Shoulder corrosion
	79-23146	XII	STD	IB 5	1.8	95/95	
				+ 5	2.2	94/94	
				+ 20	11.5	40/40	
C-226	39-24105	XIII	ETS, not leached	IB 5 + 5	3.7	95/80	Hole in chuck area.
				17.2	22.7	0/0	Corrosion failure at 22".
	39-24151	XII	ETS, leached	IB 5 + 5	2.8	80/80	Hole in chuck area.
				+ 14.0	20.8	0/0	Arcing in chuck area.
	39-24015	XII	ETS, leached, hydrolyzed[2]	IB 10	4.1	65/65	Shoulder corrosion.
	89-23418	XII	STD, not leached	IB 10	2.4	99/99	Shoulder corrosion.
				+ 17	7.7	90/90	Aborted test.
	79-23149	XII	STD	IB 5 + 5	3.1	90/90	
F-192	39-24131	XII	ETS, leached	IB 5 + 5	2.8	90/90	Hole in chuck area.
				+ 20	10.7	40/40	Hole in chuck area.
F-193	39-24132	XII	ETS, leached	IB 5 + 5	2.8	80/75	
	39-24103	XIII	ETS, not leached	IB 5 + 5	2.9	65/65	
	89-23336	XII	STD, not leached	IB 5 + 5	2.5	100/99	
				+ 20	9.2	75/75	Arcing in chuck area.

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Table I (cont.)

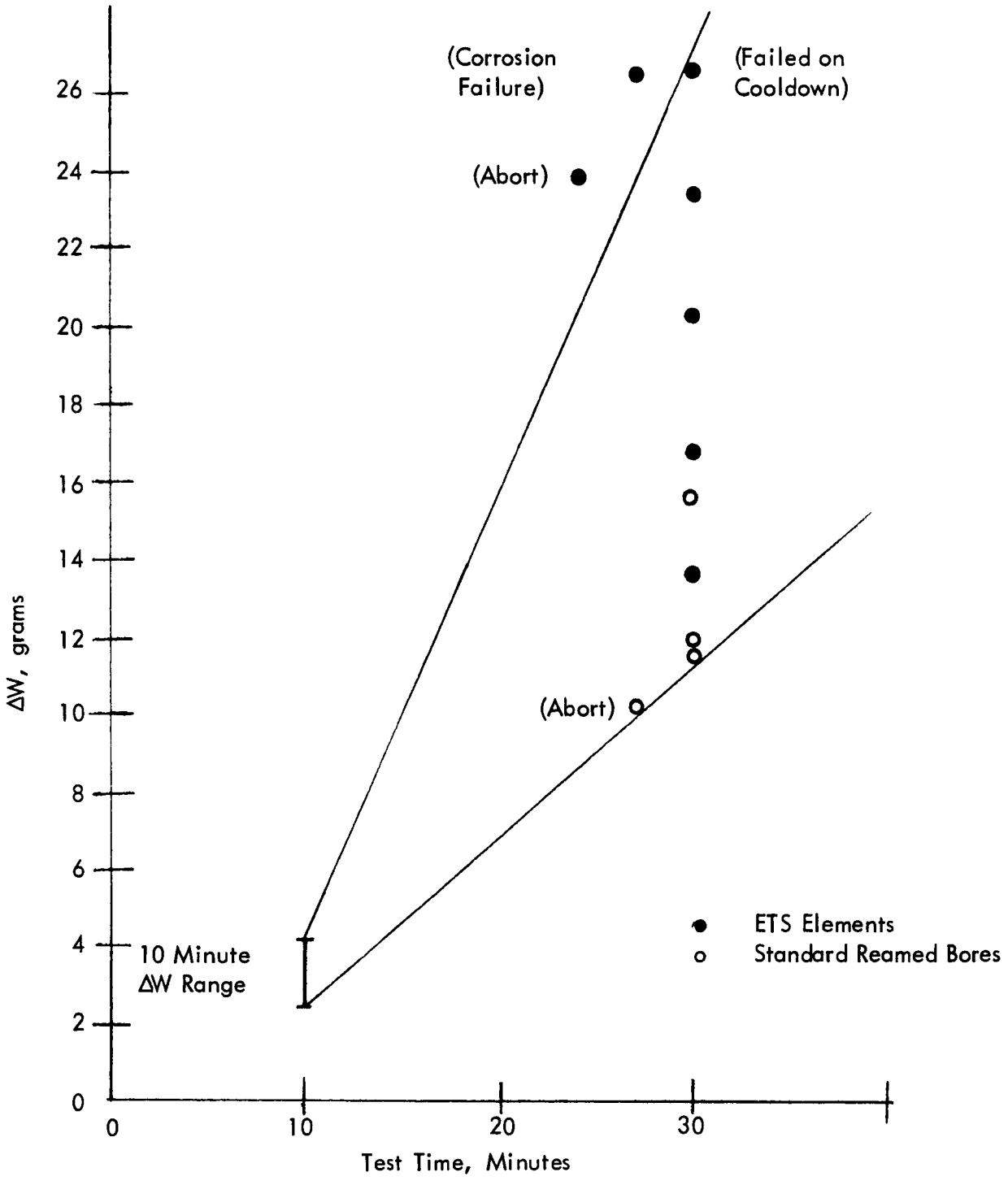
Coating Batch	Element	Lot	Type[1]	Test	ΔW (gms)	End (BAR/CAR)	Comments
F-194	99-24035	XII	ETS, leached	IB 5 + 5	4.0	30/20	
				+ 20	22.5	0/0	Failure at 21"
	99-23631	XII	STD	IB 5 + 5	3.0	100/98	
				+ 20	8.5	80/75	

(1) ETS - Bores extruded to size
STD - Standard reamed bore

(2) Hydrolysis conditions - 100% humidity, 100°C, 48 hours

WANL-TME-1479
August, 1966

FIGURE 1 - Comparison of IB Corrosion Behavior of ETS and Standard Reamed Elements



of exposed UC_2 with binder), forcing relatively large volumes of matrix material toward the channel. Two typical porous areas are shown in Figure 2. It should also be noted that this type of defect was observed in earlier ETS elements.

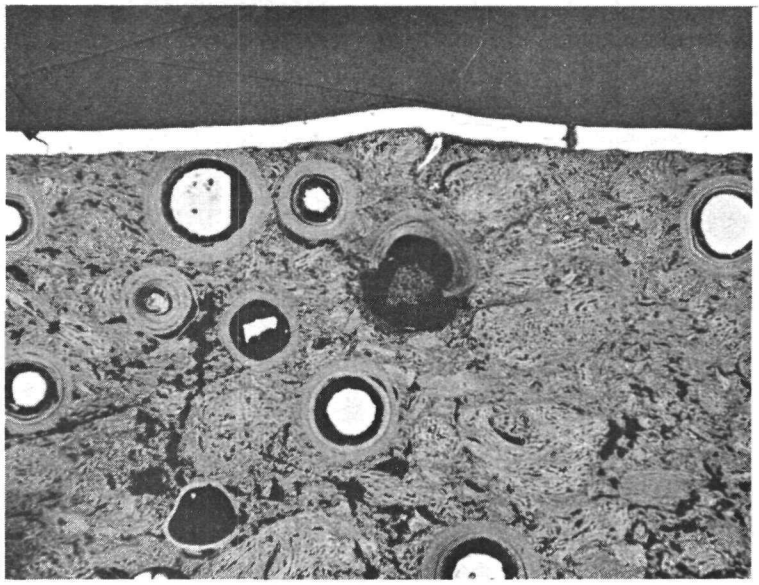
The adherence of the channel coating on the ETS elements appears to be a function of the leach. Metallography of a leached element from coating batch F-193 revealed a non-adherent coating while the non-leached element from the same batch has an adherent coating over most of the length.

Further evaluation of the ETS elements was made by accelerated aging of the fuel beads which was accomplished by exposing ETS elements to a hydrolyzing environment. Metallography of ETS leached and non-leached elements show no hydrolysis of the fuel beads after treatment at 100% relative humidity, 73°C for four hours. To determine if fuel bead aging has any effect on the corrosion properties of ETS elements, a leached ETS element was subjected to hydrolyzing conditions of 100% humidity, 100°C for 48 hours. Subsequent hydrogen testing of this element at 1B-10 conditons revealed no abnormal behavior.

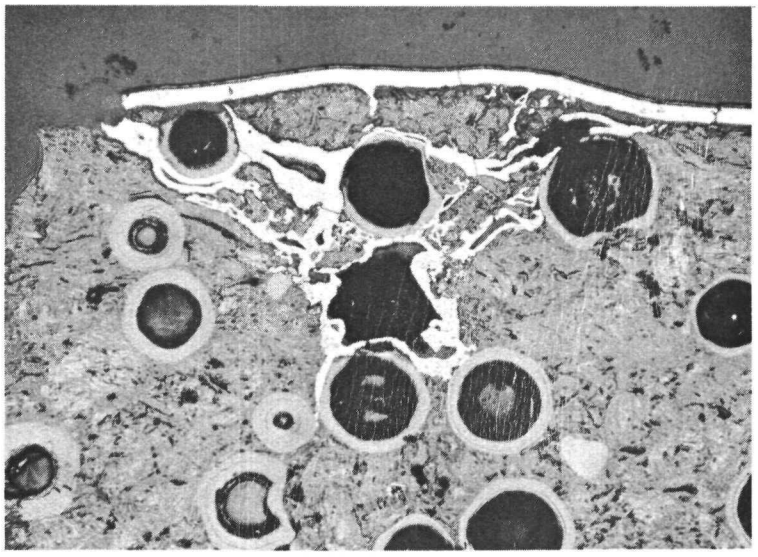
SUMMARY

The limited number of corrosion tests performed on ETS leached and non-leached elements show that these elements have poorer corrosion behavior than do standard reamed elements. The standard elements had an average ΔW of 12.3 grams while the ETS elements had an average ΔW of 20.0 grams for 30 minutes of testing at IB temperatures. The additional weight loss observed in the ETS elements is believed to occur in the mid-band region. In addition, two ETS elements failed due to mid-band corrosion while the elements with reamed bores had no failures.

The major effect resulting from extruding elements to size that can be seen in the microstructure of these elements is the presence of large porous areas which extend into the channels. There are indications that some of these areas may break away during hydrogen testing allowing large areas of graphite exposed during subsequent tests.



(a) Damaged Bead Causing Buckling of Matrix



(b) Porous Area

FIGURE 2 ETS Defects 100X