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PT-IP-297-A-FP, THE EFFECT OF AUTOCLAVE FILM DAMAGE ON THE INCIDENCE OF GROOVE PITTING ON X-8001 ALLOY FUEL JACKETS

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PT-IP-297-A-FP, THE EFFECT
OF AUTOCLAVE FILM DAMAGE ON THE
INCIDENCE OF GROOVE PITTING ON
X-8001 ALLOY FUEL JACKETS

OBJECTIVE

The objective of this test is to evaluate the hypothesis that autoclave film damage is a necessary condition for groove pitting of X-8001 alloy fuel cladding.

TEST SUMMARY

Sixteen charges of fuel having alternated X-8001 clad elements on which the oxide layer has been disturbed, is not uniform, and is both undisturbed and uniform, will be irradiated in new process tubes under flow controlled conditions to 800 MWD/T exposure in an old reactor.

BASIS AND JUSTIFICATION

The persistence of peculiar groove pitting which appears intermittently on X-8001 aluminum alloy clad fuel elements in the old reactors continues to be a problem. Radiometallurgical examination of many fuel elements having these pits has never revealed evidence of intergranular corrosion; rather, the corroded surfaces appear to have had mechanical work performed on them. Several mechanisms for this type of attack are proposed. These include: a) segregation of alloying constituents on the cladding surface; b) formation of a brittle oxide film which may be mechanically damaged by flowing water¹; c) "cavitation" like attack on the surface of downstream pieces because of high water temperature - low vapor-pressure relationship; and d) mechanical damage to the autoclave film resulting in sacrificial corrosion in the damaged area. These latter "grooves" appear to be the result of scratches, but may be caused by other mechanical damage to the film.

An in-reactor test² to reproduce the "grooving" phenomena was interrupted by a failure which necessitated discharge of the entire test at about 50 percent of goal exposure. Coincidental with the in-reactor test, arrangements were made with the vendor for increased "scalping" of the bloom stock from which X-8001 alloy components were fabricated, to reduce observed nickel segregation. The apparent relief of the groove-pitting problem, which coincided with increased utilization of the segregation-free components, resulted in a de-emphasis of testing programs to reproduce the groove-pitting phenomena. Subsequent experience has shown that in spite of the improvement in jacket surface fabrication, decrease in the incidence of groove pitting may have been a result of lower tube outlet temperatures and that once again it is a serious corrosion problem in the old reactors. Recent experience in D, DR, and H Reactors has indicated that groove pitting may be associated with side failures (although conclusive proof is missing, the presence of groove pitting in the vicinity of the failure point on three recent failures in these reactors could be circumstantial evidence). In addition, a production test³ to evaluate core stability recently discharged from DR Reactor contained pieces with both longitudinal and transverse pits which appear to support the hypothesis that groove pitting may be initiated by damage to the oxide film.

Photographs of pieces from the charges in which ruptures occurred in D and DR Reactors show various degrees of groove pitting may be present on a single piece.

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There appeared to be large, deep (20-30 mils) filmed-over pits adjacent to tear-drop shaped pits of shallow to medium depth (0-20 mils) having one side shiny (to the downstream side) or the entire surface shiny, showing active corrosion (or erosion) was taking place at the time of discharge. In addition to the above, most pieces had at least one long (1-6 inches) groove which had clean exposed surfaces indicating active corrosion. Failures of this type at the older reactors have generally occurred in new tubes in which the reduced top annulus provided the necessary flow and temperature conditions to cause groove pitting; however, a failure in an old tube in H Reactor (installed in 1956) which exhibited groove pitting, possibly de-emphasizes the new tube as an essential cause.

In summary, in spite of improved jacket surfaces from additional scalping operations, the groove pitting of X-8001 aluminum alloy jacketed fuel elements continues. The postulated mechanism has been revised to include as suspected causes brittle or damaged oxide film, unusual flow and temperature conditions, and normal corrosive mechanisms.

Flow tests under extreme temperature conditions are underway in mock-up facilities; however it remains that the final, conclusive testing must be done in-reactor. Since the conversion to X-8001 aluminum alloy jackets has reached a point where over seventy percent of I&E fuel elements in old reactors are clad in the nickel aluminum alloy, it is desirable to determine the cause or causes of the phenomena and take necessary steps to eliminate or reduce the hazard of groove pitting of X-8001 alloy cladding. To provide the necessary experience, this test is proposed to attempt to determine the cause of these phenomena and possibly infer means of eliminating groove pitting. Further, since the source of groove pitting has not been pinpointed, this program will include a series of sub-tests designed to evaluate the most probable sources. Currently in the old reactors, the use of water-mixing pieces to reduce tube corrosion may show if the high top annulus temperature is a primary cause and if water-mixing pieces may be used to prevent groove pitting.

The appearance of transverse grooves to a depth of 0.038 inch on recently discharged X-8001 clad PT elements strongly suggests a primary influence of minor damage to the autoclave film, such as scratches or gouges. These transverse grooves have not been noted on C-64 clad elements to the degree noted on X-8001.

This test therefore will through closely controlled reactor variables, attempt to evaluate the effect of scratches applied in a peculiar design on the pitting performance of X-8001 clad fuel.

TEST DETAILS

A. Fuel Elements

Fuel elements for this test will be normal production OIIN geometry, clad in X-8001 alloy. All elements will be canned within process specifications. After autoclaving sufficient elements for sixteen charges will be removed from the production stream for marking. Using a sharp corundum tool, special scratch patterns up to 4 mils deep, as outlined in the test design⁴, will be applied to selected elements. After marking, each piece will be photographed and measurements of weight, outside and inside diameter and warp will be recorded.

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Sixteen charges having the four types of test elements alternated in a modified latin square arrangement in the downstream half of each charge will be assembled and marked with column and position numbers and shipped to the chosen reactor.

B. Tubes-Reactor

Since the likelihood of detecting groove pitting appears greatest in a new process tube due to its eccentric positioning of the fuel and decreased flow, this configuration will be required. Since F Reactor is the only old reactor undergoing major central zone tube replacement, it is chosen for this test, and tubes having been installed less than six months will be used. To permit this discharge of up to 16 charges of under-exposed (green) fuel is authorized.

C. Charging

Since all elements used for this test will be specially marked, extreme care will be required during the charging operation to prevent spurious scratching other than that obtained in the charge machine and tube. Therefore each element should be individually moved to the charge pallet and individually placed on the charging tray using extreme caution. All possible soluable oil flow should be permitted to the charge machine also to minimize charging scratching.

D. Irradiation

During irradiation daily temperature and weekly flow data will be required in order that calculations of each fuel element's environment may be determined.

Should abnormal flows be observed for any of the test columns, the venturi will be replaced with a calibrated one, and if a high flow is still present, solid aluminum dummys may be inserted in the downstream dummy train at the first practical time.

Since mixer elements could conceivably affect the critical factors affecting groove pitting no mixers will be used in this test.

D. Discharge

All sixteen columns shall be discharged and picked up special for post-irradiation examination after irradiation to 800 MWD/T goal exposure.

F. Post-Irradiation Examination

After irradiation all columns will be shipped to 105-C Metal Examination Facility for visual examination and photographing of the downstream sixteen pieces from each column. In addition weight loss, outside and inside diameters, and warp will be required for the same pieces. Selected pieces may also be examined in the radiometallurgy laboratory if warranted.

G. Hazards

Since this test involves a slightly higher than normal goal exposure and no mixer, calculated rupture potential will be increased slightly (about a factor of 2 from the exposure increase and less than a factor of 2 from the mixer elimination); however, for a test of this size, this should result in only a

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negligible increase in pile rupture potential. Scratching will be less than 4 mils deep or less than 15% of the canwall thickness, and within normal marred surface reject specifications, and should therefore not contribute to fuel failure in any manner other than as a point of groove pitting initiation (the test objective is to determine this). In either event, there is the chance that fuel in this test may fail, and should two failures be sustained, the test may be discharged provided the remaining columns can be picked up special. As with any rupture, the risk of a tube leak is increased; however, this is unavoidable for this test.

H. Costs

All incremental costs incurred as a direct result of this test may be charged to XXXX-5320-XXX.54. Outage time required for this test is listed below for scheduling purposes:

<u>Job</u>	<u>Elevator Time</u>	<u>Manpower</u>
1. Charge-discharge sixteen columns.	2 hrs.	6 mh
	4 hrs.	20 mh
Total	6 hrs.	26 mh
2. Discharge and pickup specially sixteen columns.		
3. In addition sufficient time to remove up to two ruptures is authorized by this test, as is the necessary time to install special venturi, and modify downstream dummy trains and replace tubes if required.		

RESPONSIBILITIES

Fuels Preparation Department

Manufacturing Operation

The Manufacturing Operation shall be responsible for canning all pieces by the "F" Process for normal quality control, and for pre-irradiation measurements and marking.

Engineering Operation

The Engineering Operation shall be responsible for liaison in the 300 Area portion of this test and for providing technical assistance.

Irradiation Processing Department

Research and Engineering Section

Process Technology Subsection shall be responsible for assistance in scheduling choosing of test channels, and charging of the test, and for forwarding of operating data to the author.

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Process and Reactor Development Subsection shall be responsible for coordination of the test, channel choice, data analysis, and reporting of irradiation experience. A representative of Process and Reactor Development shall also observe charging of the test.

Component Testing Operation shall be responsible for obtaining post-irradiation examination data.

F Reactor Operation

F Processing Operations will be responsible for planning, scheduling, the operational safety, and the production continuity of the reactor; for charging of the test under the direction of Research and Engineering representative; and for collection of routine operating data for the test.

Reactor Fuels Unit
Process & Reactor Development Subsection
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

RE Hall/klm

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REFERENCES

1. Krenz, F. H. Corrosion of Aluminum Nickel Type Alloys in High Temperature Aqueous Service, Corrosion 13, 575t-81t (1957)
2. Miller, N. R. Production Test IP-124-A, Investigation of Conditions Leading to the Severe Pitting of M-388 Alloy Slug Jackets, HW-54010. December 3, 1957. (SECRET)
3. Hall, R. E. Production Test IP-220-A-FP, Evaluation of the Dimensional Instability of Core Blank Heat-Treated Uranium, HW-59222. February 11, 1959. (SECRET)
4. Hall, R. E. and Hodgson, W. H. Design of Production Test IP-297-A-FP, The Effect of autoclave Film Damage on the Incidence of Groove Pitting on X-8001 Alloy Fuel Jackets, HW-63122 A. December 22, 1959. (SECRET)

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