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This document consists of 7 pages.

PRODUCTION TEST IP-262-A-11-FP

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EVALUATION OF PROJECTION FUEL ELEMENTS FOR USE IN RIBBED
PROCESS TUBES - DEMONSTRATION LOADINGS

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PRODUCTION TEST IP-262-A-11-FP
EVALUATION OF PROJECTION FUEL ELEMENTS FOR USE IN RIBBED
PROCESS TUBES - DEMONSTRATION LOADINGS

OBJECTIVE

The objective of this test is to demonstrate the feasibility of projection fuel elements for use in existing process tubing and to determine the reduction in rupture rates or hot-spot incidence so achieved.

TEST SUMMARY

This test is to authorize, a) charging 20 columns of bumper type fuel elements and 20 columns of control elements per reactor into B, D, DR, F, and H Reactors for irradiation up to 1200 MWD/T exposure, and b) irradiation of four columns each of enriched (0.947%) bumper and enriched (0.947%) normal type fuel elements until two ruptures are sustained in each (or until one group shows a significant improvement).

BASIS AND JUSTIFICATION

One of the three major categories of HAPO fuel element failures is the side-corrosion type of failure. Past experience has indicated that uniform corrosion, as calculated with existing techniques, could not account for the majority of these failures; but rather, some rapid corrosive mechanism must be assumed. It has been demonstrated previously⁽¹⁾ that misalignment of fuel elements in a process tube will produce a hot-spot type flow pattern and area of heavy corrosion. Calculations by Wood⁽²⁾ indicate that temperatures sufficiently high to produce a steam jacket on the fuel element can be obtained with local annulus clearance reductions to a value of less than 15 mils. Steam jacketing of an area of slug surface could permit further surface temperature increases, sufficient to initiate intergranular attack with relatively short incubation periods, and presumably failure if imperfect Al-Si bonds are exposed. Even without reaching the steam jacketing condition, sufficiently high surface temperatures can be reached to give more rapid than predicted corrosion rates; however, this effect is small unless several elements are misaligned as a group.

The use of a projection attached to the side of the fuel element to assure alignment has been proposed and it is possible to prepare on a production scale projection elements which will guarantee an annular clearance of 15 mils. This element, termed a "bumper slug", is designed to be supported on the ribs of the process tube, oriented such that the projections reduce the degree of possible misalignment. Testing to date has been directed along the lines of the self-supported types of fuel element primarily; wherein it has been demonstrated that the supports have sufficient strength, do not of themselves create a corrosion problem and in actuality most likely eliminate any hot-spot areas. In addition, a preliminary test loading of bumper fuel elements is under irradiation in KW Reactor. This test is designed to indicate potential problem areas and to evaluate discharge problems. It also is designed to prove that at current operating conditions, hot-spots are in fact eliminated. This test is scheduled for discharge about July 1959.

(1) HW-55789, "Final Report on PT-105-634⁴A, In Pile Cocked Slug Tests," PB McCarthy, 6-2-58.

(2) HW-59168, "A Postulated Hot-Spot Failure Mechanism," EC Wood, 2-9-59.

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In order that fuel elements of the bumper type may be available by the summer of 1960, a demonstration loading of significant numbers of columns of these elements must be made by about July 1959. Even though the test in KW Reactor will not be discharged by this time, preliminary discharging will have been accomplished and if unforeseen problems are evidenced, this test shall be cancelled. The bulk of the KW test will be discharged during August 1959 (or possibly the end of July) and negative results from this test shall be the basis for discharge of the individual reactor demonstration loads as well as the high exposure test.

In order that a significant number of columns for the demonstration loading may be achieved, and since charge machines will not be available, it is desirable to put a portion of this loading into each of the older reactors, B, D, DR, F and H to distribute outage time losses. The high exposure test will probably result in significant outage time losses; however, it will yield necessary data which must be available before a decision may be made to convert the reactors to this fuel. F Reactor has been chosen for this test since equivalent outage time losses are currently scheduled under other testing programs for the other older reactors.

TEST DETAILS

1. Fuel Elements

All fuel elements utilized for this test shall be normal production OIIN and OIIE with projections resistance spot welded to the sides of the slug, 4 at each end of 90° centers.

Fuel OD	1.445" or 1.440
ID	0.310"
Effective OD	1.525"
Rib Height	0.040"
Guaranteed Annulus	0.015"

2. Pre-Irradiation Measurements

- a) Each fuel element utilized in the high exposure portion of this test shall be weighed, measured and numbered prior to shipment to the F Reactor.
- b) All fuel elements utilized in the demonstration loading shall be numbered and assembled into charges of 34 pieces each. Thirty spare pieces shall be shipped to each reactor with the 20 columns. Weight shall be recorded for each piece in the downstream portion of all charges including controls.

3. Charging

All columns in this test except the control material must be hand charged since insufficient front nozzle clearance exists. This requires:

- a) Removal of rear face caps
- b) Removal of front nozzle
- c) Radiation monitoring coverage during hand charging
- d) Return of tubes to normal after charging.

All columns are to be charged with the slugs in numerical order with piece number one downstream. Charge numbers for each column are to be recorded.

All of the control columns for the tests may be machine charged, provided the fuel elements are in order and the series number is recorded.

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Charging (cont'd)

Charge makeup for the natural elements charged as the demonstration load shall be the same as for other natural uranium columns in each reactor, centered with a normal downstream dummy charge. The enriched columns shall be 38 pieces in length at F Reactor and shall be charged so as to be centered in the reactor. This will require that the natural uranium downstream dummy charge be lengthened by 26".

Loading Schedule

Charge**		Pieces***	Per Charge	Goal	Special Pickup
1	B,D,DR,F,H OIIN Bumper Elements	34	400 MWD/T	No	
2-3	B,D,DR,F,H " " "	34	800	No	
4-20	B,D,DR,F,H " " "	34	1200	10 columns	
21	B,D,DR,F,H OIIN Control Elements	34	400	No	
22-23	" " " " " " " "	34	800	No	
24-40	" " " " " " " "	34	1200	10 columns	
41-44	F OIIE Bumper Elements	38	RTR*	4 columns	
45-48	F OIIE Control Elements	38	RTR	4 columns	

* Run to rupture or to high exposure.

** Charges 1-40 shall be prepared for each reactor indicated.

*** Or different where appropriate.

4. Irradiation

During irradiation, weekly flow and daily temperature data for each of the columns in the run-to-rupture portion of this test shall be recorded. No special data are required for the demonstration loadings.

The high exposure test shall be irradiated until two ruptures occur in one type of material and thereafter until a statistically significant difference is observed of at least a factor of 20. The high exposure test shall be discharged irrespective of experience after two failures occur in the bumper portion of the loading; all demonstration loadings may be discharged at the request of the author if no further data are required after two failures are sustained.

After exposure, all columns of the high exposure test shall be picked up special. In addition ten columns per reactor demonstration load will also be picked up special with ten columns of controls as chosen by the author.

5. Post Irradiation Examination

After irradiation, all pieces picked up for special examination shall be weighed and measured to determine weight loss, warp, and general fuel condition. Selected elements may be examined further in the radiometallurgy laboratory. Hot-spot flow patterns shall be observed (if present) and held for visual examination by the author.

6. Hazards

Hazards peculiar to this test are primarily associated with the presence of the bumpers on the fuel surface. These arise from the fact that the bumpers do restrict fuel element displacement in the process tube so that it is conceivable that these elements could stick tighter after rupture than do smooth elements, although rib collapsibility should reduce the problems associated with this. They also could cause damage during handling of the bumpers; however, laboratory testing

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to evaluate this problem indicated no problems. Should the results of the KW Reactor test prove this concept to not be feasible, this test will be cancelled.

7. Thermocouple Probes

In order that a measure of the effect of the projections upon annular temperature distribution may be obtained, the first two columns charged into D Reactor shall have downstream thermocouple probes installed.

8. Costs

All incremental costs directly attributable to this test may be charged to XXX-5320-XXX.04. Outage time requirements are listed below for scheduling purposes.

Job	Processing Time	Elevator Time
1. Discharge tubes with solid aluminum dummies	--	--
2. Remove front face nozzles	1 mh/tube	1/4 hr/tube
3. Hand charge tubes with test material	3/4 mh/tube	1/4 hr/tube
4. Replace front nozzles	1 mh/tube	1/4 hr/tube
5. Install thermocouple probes	2 mh/tube	1/2 hr/tube
6. Remove probes	1/2 mh/tube	1/4 hr/tube
7. Discharge and pick up special	1-1/2 mh/tube	1/4 hr/tube

In addition up to four ruptures are authorized. (High Exposure Test, F Reactor)

RESPONSIBILITIES

Fuels Preparation Department

Manufacturing Operation shall be responsible for fabrication of all elements used in this test and provision of elements to others for attachment of the projections; and shall be responsible for element equality, and preexposure measurements of all pieces.

Engineering Operation shall be responsible for attachment of the projections, liaison contact and coordination of the 300 Area portion of this test.

Irradiation Processing Department

Research and Engineering Operation

Process Technology Operation will be responsible for providing assistance in pre-shutdown scheduling and charging, reporting of operating data to the author, for specifying of operating limits and for specifying column locations.

Process and Reactor Development Operation shall be responsible for coordination of the test analysis of operating data, reporting of in-reactor performance, for determining when to discharge the high exposure test, and for requesting early discharge of specified material.

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Component Testing Operation shall be responsible for post-irradiation fuel element examination and measurement.

Reactor Operations

The Processing Operation involved shall be responsible for scheduling, the operational safety, and production continuity of the reactor, charging of test material under the direction of representatives of Research and Engineering, and for collection of operating data.

The Maintenance Operations shall be responsible for all maintenance required by this test to include nozzle removal and thermocouple probe installation.

Reactor Fuels Unit
Research and Engineering
IRRADIATION PROCESSING DEPARTMENT

RE Hall/cn

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