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IRRADIATION PROCESSING DEPARTMENT

October 19, 1960

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PRODUCTION TEST IP-363-A
IRRADIATION OF ZR-2 JACKETED ENRICHED SINGLE
TUBE FUEL ELEMENTS IN THE KER LOOPS

OBJECTIVE

The objective of this production test is to evaluate the behavior during irradiation of nominally 1.739 inch OD., 1.074 inch ID., Zircaloy-2 jacketed single tube fuel elements with brazed end closures at operating conditions somewhat more severe than those expected for N Reactor fuel element outer tubes.

SUMMARY

Enriched single tube elements with brazed end closures and modified fuel element supports are authorized for irradiation in the KER loops to an exposure no higher than 4000 MWD/T. A typical loading and set of operating conditions are given; these may be modified, however, by obtaining appropriate approvals.

BASIS AND JUSTIFICATION

The enriched single tube element has been specifically designed as a test element to simulate, in the KER loops, the conditions to which an N Reactor outer fuel tube will be subjected during irradiation. As a test element, each of the parameters believed to be significant in fuel behavior - surface heat flux, uranium temperature, jacket temperature, radius of curvature, and fuel exposure - have been increased in severity over the conditions expected for the N Reactor fuel. Irradiation of the test element, then, should provide a demonstration of the behavior of the N outer tube and reveal gross problem areas, if they exist.

The test elements have been fabricated with the Be-Zr alloy brazed end closure planned for use on N Reactor fuel. Iron supports have been used to minimize process tube scratching. This production test will provide the first irradiation testing of these two developments.

TEST DETAILS

1. Fuel Elements

a. Geometry

Each element consists of a single 1.6% enriched coextruded Zr-2 jacketed tube 18 inches long containing 17.6 inches of uranium. The tubes were extruded to a nominal 1.739 inch OD and 1.074 inch ID. After braze closure and heat treatment, the outer diameters of the tubes average $1.748 \pm \begin{smallmatrix} .006 \\ .008 \end{smallmatrix}$ inches. The braze closure procedure causes an increase in diameter at the ends to $1.770 \pm \begin{smallmatrix} 0.005 \\ 0.007 \end{smallmatrix}$ inches. The Zr-2 jacket is nominally 0.025 inch thick. Each element contains a 0.740 inch solid Zr-2 rod the same length as the fuel tube mounted concentrically in the fuel tube to provide balanced coolant flow over the two heat generating surfaces.

b. Closure

The 0.200 inch thick end caps are affixed by the brazing procedure described

in HW-66807.⁽¹⁾ The end caps are brazed, faced, and fusion welded over the braze zone.

c. Supports

The fuel tube is supported at each end by four 1/4 inch wide semi-flexible iron supports mechanically held to the fuel element by 1/8 inch Zr-2 studs spot welded to the fuel element jacket. The studs pass through matching holes in the support and the protruding ends are friction heated and upset to hold the support in position.

The Zr-2 inner rod is held in position by three semi-flexible Zr-2 supports spot welded to the rod at each end.

d. Fabrication and Inspection

Just back The fuel tubes were coextruded by FPD. After cutting to length and chemically milling the ends, 0.200 inch end cap rings were brazed with a Zr-5 w/o Be brazing alloy by FPD using the braze procedure planned for N Reactor fuel. The fuel elements were beta heat treated using an oil-^a bath quench; support studs were spot welded to the jackets; and the elements were autoclaved for ~~40 hours in 300°C water and~~ 40 hours in 400°C steam.

The elements were nondestructively tested for jacket thickness, jacket-uranium bonding, braze-uranium bonding, and uranium grain size. ?

2. Loading

The tube loading planned for these elements is given in Table 1. The loading may be changed if a revised loading approved by Process Technology Operation and Process and Reactor Development Operation is provided prior to charging. Coupon holders of a design approved by Coolant Testing Operation and Process and Reactor Development Operation may be included in the charge in positions not affecting the fuel element test.

3. Irradiation Facility

The fuel elements may be irradiated in any KER high temperature recirculating loop. The loading and operating conditions given in this document are valid for loops 2, 3, and 4. Irradiation in Loop 1 will require revised operating conditions applicable to this loop.

4. Operating Conditions

The coolant will be pressurized water with the pH adjusted to 10.0 ± 0.5 by the addition of LiOH. The low pressure trip will be set at 1500 psig. For a charge in loops 2, 3, or 4, the desired operating flow is 60 gpm, the low flow trip will be set at 48 gpm, and the high outlet temperature trip, maximum operating outlet temperature, desired operating outlet temperature, and boiling point suppression trip given in Figure 1 will apply. Outlet temperatures at or below the maximum operating outlet temperature, Figure 1, may be specified at the discretion of the test-author. For either a changed loading, or irradiation in KER-1, revised operating conditions approved by Process

(1) Alexander, W.K. Preliminary Process Specification CX 707.0, HW-66807, November 1, 1960 (Confidential).

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Technology Operation and Process and Reactor Development Operation will be provided prior to charging.

If recirculation with system pressures less than 1500 psig is required, the outlet temperature will be reduced and maintained at least 100°C below the system saturation temperature.

5. Power and Temperature Limits

The operating conditions have been chosen so that surface boiling will not occur on the fuel elements during normal operation, burnout will not occur at the limiting trip conditions, and the maximum uranium temperature will not exceed 600°C.

6. Exposure

The maximum exposure authorized by this production test is 4000 MWD/T.

7. Special Procedures

The fuel elements from this production test will be discharged into a special tray according to procedures developed by the KE Maintenance Operation.

8. Priority

Additional down-time is authorized if charging or discharging cannot be accomplished during a normal outage.

9. Costs

a. Cost Code: XXX-5R24-XXX.75

b. Time for each loading:

	<u>Elevator Time, Hours</u>		<u>Manhours</u>
	<u>Front</u>	<u>Rear</u>	
Charge	1	1	4
Discharge	2	4	10
	3	5	14

c. Reactivity change: The test loading will have a reactivity intermediate between that of a dummy charge and a standard charge of normal fuel elements.

10. Data Desired

Routine operating data, including coolant flow, inlet and outlet temperature and pressure, system pressure, and operating time at temperature, will be taken during irradiation.

11. Hazards

Assessment of the hazards associated with the fuel elements authorized by this test is not simple. A new geometry, closure, and support system are being irradiated for the first time. The goal exposure is set higher than the maximum exposure attained so far in the loops. These factors alone would indicate a high probability of failure. On the other hand, the fuel has been extruded by FPD with better jacket thickness and uniformity than

material previously available, more precise nondestructive methods for measuring jacket thickness and bonding have been used, and a dual steam-water autoclave step has been incorporated in the testing cycle. In addition, the large fuel outside diameter may permit exposures up to 4000 MWD/T without failure by the localized jacket thinning mechanism observed on KER loop high exposure failures.

Although fuel failure is possible, the importance of the concepts incorporated in these elements to the N Reactor fuel program justifies an unscheduled reactor outage, if it should occur.

RESPONSIBILITIES

Fuels Preparation Department

Engineering Section

Coextruded Product Engineering is responsible for coextruding the fuel elements and applying the brazed end closures.

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Fuels Development Operation

Fuel Element Design Operation is responsible for the heat-treatment, applying fuel supports, assembly, and testing of the elements, analysis of data, and issuance of technical reports.

Irradiation Processing Department

Research and Engineering Operation

Component Testing Operation is responsible for post-irradiation examination and testing of components in the test charge.

Coolant Testing Operation is responsible for:

- a. Operation of the KER Loops.
- b. Taking basic operating data.
- c. Scheduling the loop charge with the concurrence of KE Processing Operation.
- d. Reactor safety and production continuity as they are affected by loop operation.

Process and Reactor Development Operation is responsible for:

- a. Technical aspects of the fuel element irradiation.
- b. Termination of the production test and issuance of the final report.

KE-KW Reactor Operation

KE Processing Operation is responsible for:

- a. Operational safety.
- b. Production continuity, except where inconsistent with provisions of this test.
- c. Special discharges.

W. S. Kratzer
Process and Reactor Development
Research and Engineering
IRRADIATION PROCESSING DEPARTMENT

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TABLE 1

FUEL ELEMENT LOADING PATTERN

<u>Position</u> (from downstream end of process tube)	<u>Number</u>	<u>Material</u>
1	1	8 inch stainless steel triangular perf
2-30	29	8 inch numbered cylindrical carbon steel spacers
31	1	8 inch stainless steel triangular perf
32-35	4	16 16 inch fuel elements
36	1	8 inch stainless steel triangular perf

FIGURE I

Operating temperatures and trip settings
as a function of the observed tube ΔT .

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