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TITLE

PRODUCTION TEST IP-377-A, IRRADIATION
OF N-REACTOR INNER FUEL TUBES IN
THE KER LOOPS

AUTHOR

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IRRADIATION PROCESSING DEPARTMENT

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PRODUCTION TEST IP-377-A,
IRRADIATION OF N-REACTOR INNER FUEL TUBES
IN THE KER LOOPS

OBJECTIVE

The objective of this production test is to evaluate the behavior of N-Reactor inner fuel tubes during irradiation in the KER Loops at conditions equivalent to those expected in the N-Reactor.

SUMMARY

Natural and .947% enriched Zircaloy-2 jacketed N-Reactor inner fuel tubes (NIN-1 and NIE-1) will be irradiated in the KER Loops to exposures no greater than 3500 MWD/T. The elements have brazed end closures and Zircaloy-2 supports and are contained in Zr-2 flow distributing sleeves.

BASIS AND JUSTIFICATION

The NIN-1 and NIE-1 elements authorized by this production test have been prepared with the same dimensions and by the same procedures as are planned for the N-Reactor inner fuel tubes. Irradiation of the elements in Zr-2 flow distributing sleeves in the KER Loops will provide fuel element heat fluxes and jacket and uranium temperatures equivalent to those expected in N-Reactor. Irradiation of these elements is planned as a demonstration of the behavior of N-Reactor inner fuel tubes operating at N-Reactor conditions.

The maximum exposure of 3500 MWD/T is considerably above the exposure planned for N-Reactor fuel. This high maximum exposure is set to permit flexibility in selecting discharge exposures for loadings of NIN-1 and NIE-1 elements up to 1.5 times the maximum N-Reactor exposure.

TEST DETAILS

1. Fuel Elements

The fuel elements consist of nominally 1.253 inch OD, 0.439 inch ID single tube elements with 0.040 inch Zr-2 jackets on the outer surfaces and 0.025 inch jackets on the inner surfaces. Elements containing natural uranium (NIN-1) and .947% enriched uranium (NIE-1) are authorized. The fuel element length may be any value between twelve and twenty-four inches, although the two sizes planned for irradiation have lengths of sixteen and twenty-four inches. The 0.200 inch end caps are affixed by brazing with a Zr-5 w/o Be braze alloy.⁽¹⁾

The fuel tubes are supported in Zr-2 flow distributing sleeves the same length as the fuel elements. The sleeves are 1.500 inch ID, 1.900 inch OD, although the sleeve OD may be reduced in diameter down to 1.840 inch minimum if this becomes necessary because of process tube distortion or unavailability of sleeve material.

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

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Semi-flexible supports are used on both the fuel elements and the sleeves. The elements have four Zr-2 supports at each end welded to the fuel jacket; the sleeves have four iron supports at each end mechanically fastened to Zr-2 studs spot welded to the sleeves.

The elements are prepared by brazing the end caps, beta heat treating, spot welding the fuel supports, and autoclaving for 36 hours or more in 350°C water and for 36 hours or more in 350°C steam. The water autoclave step may be omitted for some loadings if it appears to have little usefulness. Inspection steps include non-destructive testing for jacket thickness, jacket-uranium bonding, braze-uranium bonding, and uranium grain size.

2. Loading

The tube loading will be given in a document approved by Process Technology Operation and Process and Reactor Development Operation 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 KEF high temperature recirculating 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 with a low flow trip of 48 gpm. For a charge in loop 1, the desired operating flow is 50 gpm with a low flow trip of 40 gpm. The high outlet temperature trip, maximum operating outlet temperature, desired operating outlet temperature (which can be varied at the discretion of the test author as long as it does not exceed the maximum operating outlet temperature), and boiling point suppression trip will be given for each loading in a document approved by Process Technology Operation and Process and Reactor Development Operation prior to charging.

If recirculation with system pressures less than 1500 psig is required, the outlet temperature will be reduced and maintained at a temperature such that fuel surface temperatures will be less than the coolant saturation temperature and local channeled coolant temperatures are sufficiently below the coolant saturation temperature to preclude sub-cooled burnout.

5. Power and Temperature Limits

The operating conditions will be 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 3500 MWD/T.

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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:

	Elevator Time, Hours		Manhours
	Front	Rear	
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

As with most of the previous KER Loop charges, a definite possibility of fuel failure exists. Hopefully, however, the combination of brazed end closures and thick jackets on the outer fuel surfaces will minimize the failure probability. If a failure should occur, the Zr-2 flow distributing sleeves around the elements should preclude hydriding damage to the process tubes.

RESPONSIBILITIES

Fuels Preparation Department

Engineering Section

Coextruded Product Engineering is responsible for preparing the fuel elements.

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Fuels Development Operation

Fuel Element Design Operation is responsible for fuel evaluation, analysis of data, and issuance of technical reports.

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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. K. Kratzer
Process and Reactor Development
Research and Engineering
IRRADIATION PROCESSING DEPARTMENT

WKK:kmn

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END