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TITLE

PRODUCTION TEST IP-364-A, IRRADIATION OF
ENRICHED TUBULAR ELEMENTS WITH FE-BE-ZR
BRAZED CLOSURES IN THE KER LOOPS

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By Authority of *CG-PR-2*

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PRODUCTION TEST IP-364-A,
IRRADIATION OF ENRICHED TUBULAR ELEMENTS
WITH FE-BE-ZR BRAZED CLOSURES IN THE KER LOOPS

OBJECTIVE

The objective of this production test is to evaluate the behavior of brazed fuel element end closures prepared with a 12 w/o Iron, 4 w/o Beryllium, 84 w/o Zirconium braze alloy during high temperature irradiation in the KER Loops.

SUMMARY

Co-extruded Zircaloy-2 jacketed tube-and-tube fuel elements containing 1.6% enriched 2 w/o Zr alloyed uranium fabricated with brazed end closures will be irradiated in the KER Loops to an exposure no greater than 2500 MWD/T.

BASIS AND JUSTIFICATION

Brazed closure techniques are being developed for use on N Reactor fuel elements. The first braze material considered was a Zr-5 w/o Be alloy which will be tested in the KER Loops under PT-IP-363-A.(1) Other braze alloys are being studied, and the one authorized by this test, Zr-12 w/o Fe-4 w/o Be, has the advantage of requiring a brazing temperature 100°C lower than that required for the Zr-5 w/o Be alloy (950°C as compared to 1050°C). The corrosion resistance of both alloys appears to be almost as good as Zr-2. This production test authorizes the irradiation testing of the Zr-12 w/o Fe-4 w/o Be braze alloy as a back-up brazing material for the Zr-5 w/o Be alloy.

TEST DETAILS

1. Fuel Elements

The fuel elements consist of two concentric Zircaloy-2 jacketed fuel tubes containing 1.6% enriched, 2 w/o Zr alloyed uranium. The outer tube is 1.820 inches OD, 1.450 inches ID, and the inner tube is 1.050 inches OD, 0.500 inches ID. Both tubes are 16.9 inches long with 0.25 inch end caps brazed with a Zr-12 w/o Fe-4 w/o Be braze alloy. Both tubes have nominally 0.020 inch thick Zr-2 jackets. The fuel element outer tubes are 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 inner tubes have normal Zr-2 semi-flexible supports. The brazed end closures were prepared by:

- a. Chemically milling the ends of the elements.
- b. Adding powdered braze alloy to the counterbored ends and inserting the Zr-2 cap ring with 0.005 inch radial clearance.

-
1. Kratzer, W. K. Production Test IP-363-A, Irradiation of Zr-2 Jacketed Enriched Single Tube Fuel Elements in the KER Loops, HW-67168. October 19, 1960.

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- c. Induction heating in vacuum to 950°C, holding this temperature for one minute, and cooling in vacuum with the cap under load.
- d. Facing and electron beam welding under vacuum.
- d. Autoclaving for 72 hours in 300°C water and 48 hours in 400°C steam.

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, desired operating outlet temperature, and boiling point suppression trip given in Figure 1 will apply. For either a changed loading, or irradiation in KER-1, revised operating conditions approved by Process 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 2500 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

Although the KER sized tube-and-tube fuel element stock has been irradiated in the KER Loops to exposures greater than 3000 MWD/T before failing, the probable exposure limit set by the brazed end closures is not known. This test represents the first irradiation of the Zr-12 w/o Fe-4 w/o Be braze alloy. Out-of-reactor testing of the material, however, indicates that it should have adequate corrosion resistance to withstand the conditions imposed by this production test.

RESPONSIBILITIES

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Fuels Development Operation

Fuels Fabrication Development Operation is responsible for preparation of the elements, 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 & Reactor Development Subsection
Research & Engineering Section
IRRADIATION PROCESSING DEPARTMENT

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TABLE I.

PROCESS TUBE LOADING

<u>Position*</u>	<u>Number</u>	<u>Material</u>
1	1	8" stainless steel triangular perf.
2-30	29	8" numbered cylindrical carbon steel spacers
31	1	8" stainless steel triangular perf.
32-35	4	17" fuel elements
36	1	8" stainless steel triangular perf.
37-44	8	8" numbered cylindrical carbon steel spacers
45	1	8" stainless steel triangular perf.

*From downstream end of process tube.

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FIGURE I

operating temperatures and trip settings
as functions of the observed tube ΔT .

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10/6/94

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