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PRODUCTION TEST IP-544-A, IRRADIATION OF 1.6% ENRICHED THICK WALLED SINGLE TUBE ELEMENTS IN KER-1 AND 2

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December 12, 1962

PRODUCTION TEST IP-544-A, IRRADIATION OF 1.6% ENRICHED THICK WALLED SINGLE TUBE ELEMENTS IN KER-1 & 2

OBJECTIVE

The objective of this production test is to authorize the irradiation of coextruded Zr-2 jacketed thick walled 1.6% enriched tubular elements in KER loops 1 and 2 to evaluate the swelling behavior of fuel elements at high uranium temperatures.

SUMMARY

Coextruded Zr-2 jacketed 1.6% enriched tubular fuel elements 1.79 inch OD, 0.97 inch ID, and 12 inches long will be irradiated in KER loops 1 and 2 to exposures no greater than 2500 MWD/T.

BASIS AND JUSTIFICATION

The N reactor fuel element with its tube-and-tube geometry was designed to operate at a low uranium temperature to avoid excessive fuel swelling. Irradiation tests of N fuel inner tubes[1]* and N fuel assemblies[2] have shown that the swelling was no greater than was anticipated. A single tube element for use in N reactor would cost less to manufacture than the current tube-and-tube element, but would operate at higher uranium temperatures. This test is intended to evaluate the uranium swelling and distortion of coextruded Zr-2 jacketed tubular elements operating at N reactor environmental conditions but with considerably higher uranium temperatures than those occurring in normal N reactor fuel.

N reactor fuel elements have been, and are being, irradiated in the KER loops at maximum uranium temperatures below 450°C.[2] N reactor inner fuel tubes[1] and 1.6% enriched single tubes[3] have been irradiated at maximum uranium temperatures of about 500°C. The fuel elements authorized by this production test will be irradiated with maximum uranium temperatures in the 550 - 600°C temperature range. Evaluation of fuel performance at these temperatures will provide information useful in the design and analysis of single tube fuel elements for use in N reactor.

TEST DETAILS

1. Fuel Elements

The fuel elements are Zr-2 jacketed coextruded tubular elements containing 1.6% enriched uranium. The nominal fuel dimensions are given in Table 1.

TABLE 1
Nominal Fuel Dimensions

Jacketed OD	1.79 inches
Jacketed ID	0.97 inches
Overall length	12 inches
End cap thickness	0.25 inches
Jacket thickness, outer surface	0.030 inches
Jacket thickness, inner surface	0.020 inches
Diameter inert inner rod	0.592 inches

A Zr-2 rod is mounted coaxially in the center hole of each fuel element to provide the desired flow split through and around the element.

The fuel elements are prepared by the same procedures[4] as standard N reactor fuel elements except for changes necessitated by the different fuel dimensions. Standard N reactor outer fuel tube supports modified slightly to provide the appropriate rail height are used to position the elements axially in the process tube.

2. Loading

The tube loadings shall consist of fuel elements authorized by this production test and spacers authorized by PT-IP-536-A[5]. Detailed tube loadings will

* References are listed at the end of the document.

be given in a document approved by the Managers of the Process and Reactor Development Sub-Section and the Process Technology Sub-Section prior to charging.

3. Irradiation Facility

The fuel elements authorized by this production test may be irradiated in KER loops 1 and 2, tubes 2160-KE and 2864-KE.

4. Operating Conditions

All operation will be in accordance with the reactor Process Standards applicable to KER-1 and 2 except that maximum uranium temperatures up to 650° C are authorized. This is an exception to Process Standard K040, section 40.01, HW-46000-K, which restricts the maximum fuel uranium temperature to 600° C. The coolant will be pressurized water with the pH adjusted to 10.0 ± 0.5 by the addition of LiOH or NH_4OH. The low pressure trip will be set according to the applicable Process Standards. The desired operating flow is 40,000 lbs/hr with a low flow trip of 32,000 lbs/hr. 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 the Managers of the Process and Reactor Development Sub-Section and the Process Technology Sub-Section prior to charging.

If recirculation with system pressures less than those specified by the process standards 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. Outlet temperature values to satisfy this requirement will be provided by the test authors in a document approved by the Managers of the Process and Reactor Development Sub-Section and the Process Technology Sub-Section prior to charging.

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, sub-cooled burnout will not occur at the limiting trip conditions, and the maximum uranium temperature will not exceed 650° C.

6. Exposure

The maximum exposure authorized by this production test is 2500 MWD/T.

7. Special Procedures

Fuel elements will be discharged into a special tray according to procedures developed by the KE Maintenance Operation.

8. Priority

Additional downtime is authorized if charging and discharging cannot be accomplished during a normal outage.

9. Costs

a. Cost Code: XXXX -4550-XXX. 73

b. Time for each loading:

	Elevator Time, Hours		Manhours
	Front	Rear	
Normal charging	1	1	6
Tray discharging	2	4	18

10. Data Desired

a. Coolant Testing Operation: Routine operating data will be required.

b. KE Processing Operation: Spline flux measurements will be requested in tubes adjacent to KER-1 and 2 when these measurements can be made.

c. Component Testing Operation: Detailed fuel element post-irradiation examinations will be requested by the test author for each charge.

11. Hazards

The principal hazards associated with this test are those related to fuel failure. Since the fuel elements are not irradiated in sleeves, fuel failure will not only cause an unscheduled reactor outage but may, if the failure is on the outer fuel surface, require replacement of the process tube. The normal trip systems in the loops provide adequate reactor safety in the event of fuel swelling or fuel failure.

RESPONSIBILITIES

N Reactor Department

N Reactor Fuels Section

N Fuel Product Engineering Subsection

Product Development and Specifications is responsible for procuring the fuel elements, obtaining non-routine measurements, maintaining records, and coordinating fuel element preparation.

[redacted]

RESPONSIBILITIES (continued)

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Metallurgy Development Operation

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

Irradiation Processing Department

Research and Engineering Section

Testing Subsection

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

Coolant Testing 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.

Manufacturing Section

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
Chemistry and Metallurgy Subsection
N Reactor Department

M. J. Wise
Testing Subsection
Irradiation Processing Department

WKK:MJW:gb

REFERENCES

1. Kratzer, W. K. Production Test IP-377-A, Irradiation of N Reactor Inner Fuel Tubes in the KER Loops, HW-67756, December 13, 1960 (SECRET)

2. Kratzer, W. K. Production Test IP-477-A, Irradiation of N Reactor Fuel Elements in KER Loops 3 and 4, HW-72269, January 9, 1962, (SECRET)

3. Kratzer, W. K., PT IP 363-A, Irradiation of Zr-2 Jacketed Enriched Single Tube Fuel Elements in the KER Loops, HW-67168, October 19, 1960 (SECRET)

4. Coextrusion Process Specifications, HW-69941 REV., June, 1962 (CONFIDENTIAL)

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