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W T L E

Production Test IP-226-A:
Irradiation of Enriched Seven-Rod Cluster
Elements With Twenty and Thirty Mil
Zircaloy-2 Jackets.

AUTHOR

W. K. Kratzer

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January 8, 1959

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PRODUCTION TEST EP-226-A

IRRADIATION OF ENRICHED SEVEN-ROD CLUSTER ELEMENTS
WITH TWENTY AND THIRTY MIL ZIRCALOY-2 JACKETS

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OBJECTIVE

The objective of this production test is to compare the effects of thirty and twenty mil Zircaloy-2 jackets on the behavior of 0.593 inch diameter enriched uranium rod.

SUMMARY

Seven enriched seven-rod cluster elements, three with thirty mil Zircaloy-2 jackets and four with twenty mil Zircaloy-2 jackets, will be irradiated at high temperature to an exposure of 4500 MWD/T. Coolant temperatures in the internal and external flow channels will be measured during irradiation.

BASIS AND JUSTIFICATION

Preliminary high temperature irradiation testing of co-extruded Zircaloy-2 jacketed rod in the KER Loops has been done with 0.030 inch thick jackets. A reduction in jacket thickness, provided it introduces no fuel element behavior problems, would reduce the fuel element cost and decrease the maximum uranium temperature at a given specific power and coolant temperature. This test is intended to compare the behavior of seven-rod cluster elements with twenty and thirty mil Zircaloy-2 jackets when irradiated to 4500 MWD/T at surface temperatures between 270 and 290°C.

TEST DETAILS

1. Fuel Elements

The individual rods in the seven Zircaloy-2 jacketed 1.6% enriched seven-rod cluster elements are 0.593 inches in diameter and 13 inches long. Each rod contains 11.4 inches of uranium. Rods in four of the elements have a 0.553 inch uranium diameter and 0.020 inch thick jackets; rods in the other three elements have a 0.533 inch uranium diameter and 0.030 inch jackets. The individual rods are held in the form of a seven-rod cluster by triangular end supports which also center the cluster in the process tube. The fuel elements have been visually examined, ultrasonically tested for jacket-uranium bonding, and autoclaved at 270°C and 2250 psig.

A stainless steel dummy seven-rod cluster containing thermocouples to measure the coolant temperature in the various flow channels will be aligned with the column of fuel elements. The dimensions of the dummy are the same as those of the active elements.

Two types of corrosion coupon holders are authorized for use in the tube charge. The internal flow coupon holders consist of an eight-inch length of 1-1/4 inch Schedule 40 stainless steel pipe with supports welded to the pipe to center it in the process tube. Plate coupons are mounted in longitudinal internal grooves in the pipe. The external flow coupon holders consist of an eight-inch long one-inch square stainless steel block to which

* SK-1-22424, SK-1-22435

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grooved overhanging stainless steel plates are attached on two opposite sides. Plate coupons are mounted in the grooves parallel to the long axis of the block. In both types of coupon holders the coupons are held in the grooves by stainless steel wires passing through the holders and crimped on the outside. A 7/16 inch hole is drilled longitudinally through the external flow coupon holders to accommodate thermocouple wires.

2. Loading

The loading will consist of the thermocouple train downstream, seven enriched seven-rod cluster elements with the thirty mil and twenty mil jacketed elements alternated starting with a thirty mil jacketed element next to the thermocouple train, and up to twenty-five eight inch spacers, perfs, and coupon holders upstream.

The thermocouple train will consist of twenty-seven eight-inch perfs, spacers, or coupon holders and the thirteen-inch stainless steel cluster dummy. Up to four external flow coupon holders are authorized for use in the thermocouple train and up to four internal or external flow coupon holders are authorized in the column of spacers upstream of the active charge.

If, for any reason, the loading must be modified, Process and Reactor Development Operation will provide a revised loading pattern and set of operating conditions prior to charging. If a revised set of operating conditions cannot be obtained, the loop will be operated at low temperature until a new set of operating conditions has been provided.

3. Irradiation Facility

The fuel elements will be irradiated in KER Loop 1, Tube 2160-KE. The loop consists of a 2.089 inch Zircaloy-2 process tube through which coolant of controlled composition, pressure, and temperature is recirculated.

4. Operating Conditions

The coolant will be pressurized water with the pH adjusted to 9.0 to 11.0 by the addition of LiOH. The operating conditions are:

- a. Desired operating flow - 50 GPM.
- b. Low flow trip - 40 GPM.
- c. Low pressure trip - 1150 psig.
- d. High outlet temperature trip - as shown in Figure 1.
- e. Desired operating outlet temperature - as shown in Figure 1.
- f. Boiling point suppression trip - as shown in Figure 1.

If recirculation with system pressures less than 1150 psig is required, the outlet temperature should be reduced and maintained at least 100°C below the system saturation temperature.

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5. Power and Temperature Relationships

The high outlet temperature trip, desired operating outlet temperature, and boiling point suppression trip have been set as functions of the observed tube ΔT so that, regardless of the power produced by the fuel elements, the fuel element surface temperature will not exceed the system saturation temperature during normal operation; the fuel elements will not burn out at the limiting trip conditions⁽¹⁾, and bulk boiling will not occur in the tube. The maximum uranium temperature, as calculated, should not exceed 660°C.

6. Exposure

The maximum exposure authorized for the fuel elements in this production test is 4500 MWD/T.

7. Special Procedures

The fuel elements and thermocouple train will be charged from the rear face with the elements and thermocouple dummy aligned by the positioning pins on the elements. The upstream column of spacers and coupon holders will be charged from the front after the cluster elements are in position.

The fuel elements from this production test will be discharged into a special tray to avoid damage resulting from their fall to the basin. A detailed discharge procedure approved by KE Processing operation and Coolant Testing Operation will be issued prior to discharge.

8. Priority

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

9. Costs

a. Cost Code - XXX.5320-XXX.14

b. Time

	<u>Elevator Time, Hours</u>		<u>Manhours</u>
	<u>Front</u>	<u>Rear</u>	
Charge	1	3	8
Discharge	1	4	10
	2	7	18

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.

(1) F. W. Van Wormer, "Burnout Limits in KER Loops, Rod-and-Tube and Seven-Rod Cluster Fuel Elements", September 18, 1958.

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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. Temperatures from the in-reactor thermocouples will be continuously recorded.

11. Hazards

Failure of the cluster elements is improbable. The corrosion resistance of the Zircaloy-2 jackets, the high operating temperature, and the extended surface geometry should preclude either a jacket or a core failure. If a failure should occur, there is sufficient volume in the coolant channel to accommodate the uranium-water reaction products from a failure without process tube splitting.

12. Deviation From Process Standards

This production test authorizes deviation from Process Standard K-040, Section 40.01, which limits the maximum uranium temperature to 600 °C. Uranium temperatures up to 650°C may occur at maximum tube power conditions, although the anticipated maximum uranium temperature will be less than 600°C.

RESPONSIBILITIES

Hanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Fuels Development Operation

Fuels Design is responsible for the fabrication of the cluster elements, analysis of data, and issuance of technical reports.

Reactor Engineering Development Operation

Coolant Systems Development Operation has engineering responsibility for assembly, installation, and functional checking of the thermocouple train, 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 KKK loops.
- b. Taking basic operating data.
- c. Scheduling the loop charge with the concurrence of KE Processing Operation.

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Process and Reactor Development Operation is responsible for:

- a. Technical aspects of the fuel element irradiation.
- b. Analysis of fuel performance data and flow channel temperature data.
- c. 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 the provisions of this test.

Reactor Fuels Operation
Process & Reactor Development Operation
IRRADIATION PROCESSING DEPARTMENT

WK Kratzer:dgm

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FIGURE 1
Operating Temperature and
Settings as a function of
Observed Tube ΔT

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