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STANDARD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

TITLE

PRODUCTION TEST IP-237-A
IRRADIATION OF ENRICHED SEVEN-ROD
CLUSTER ELEMENTS FOR ETR TESTING

AUTHOR

W. K. Kratzer

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February 23, 1959

PRODUCTION TEST IP-237-A
IRRADIATION OF ENRICHED SEVEN-ROD CLUSTER ELEMENTS
FOR ETR TESTING

OBJECTIVE

The objective of this production test is to irradiate two enriched seven-rod Zircaloy-2 jacketed cluster elements to 1000 MWD/T and two to 2000 MWD/T for failure testing in the ETR.

SUMMARY

Two Zircaloy-2 jacketed seven-rod cluster elements will be irradiated in the 3674 KE front-to-rear test hole to an exposure of 1000 MWD/T and two elements will be irradiated in the 3674KW front-to-rear test hole to an exposure of 2000 MWD/T. After irradiation, the elements will be sent to the ETR where they will be ruptured during reactor operation to determine the failure characteristics of co-extruded Zircaloy-2 jacketed cluster elements.

BASIS AND JUSTIFICATION

Although appreciable experience has been gained with the irradiation of co-extruded Zircaloy-2 jacketed cluster elements in high temperature water in the KER loops, the behavior of the irradiated rod during failure in high temperature water while the fuel element is generating power has not been experimentally observed. To avoid the disadvantages associated with incurring a deliberate failure in the KER loops, a test is planned in which the cluster elements will be irradiated to the desired exposure at HAPO, discharged, and loaded in a high temperature recirculating loop in the ETR. While the reactor is operating, and the fuel elements are generating power in high temperature water, one of the rods will be deliberately failed to determine the rapidity, extent, and severity of damage to the element under conditions approaching those of an NPR. This production test authorizes the first step in the overall test, namely, the HAPO irradiation of the four cluster elements.

TEST DETAILS

1. Fuel Elements

The four fuel elements will each consist of seven 1.6% enriched co-extruded Zircaloy-2 jacketed rods arranged in a cluster as shown in Figure 1. Each

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rod is 0.593" in diameter with a 0.030" jacket. The clearance between rods is 0.055". The individual rods are 11.3" long with 10.0" of uranium. The cluster assembly, including the end fittings for handling at the ETR, is 13.4" long.

One rod in each cluster has been defected by drilling a 0.025" hole through the jacket into the uranium. The hole is covered by a defect cap, as shown in Figure 1, welded to the jacket to prevent water entry during the preliminary HAPO irradiation. This defect cap will be sheared off in the ETR to produce the desired failure.

All fuel elements have been visually examined, ultrasonically tested for jacket-uranium bonding, and autoclaved for 100 hours in 300°C water at 1300 psig.

Each cluster assembly will be loaded in an aluminum basket designed to adapt the cluster to the 2.8" ID front-to-rear test hole inner tube. The basket consists of a 17.5" long aluminum tube 2.8" OD and 2.0" ID with triangular end spiders welded to the basket to retain the cluster elements in the basket and permit coolant flow through the cluster.

2. Loading

The two basket assemblies in each tube will be positioned at the mid-point of the active zone. The tube loading from the downstream end will consist of five 24" tubulars, ten 12" solid dummies, one 24" perforated tubular, and the two basket assemblies.

3. Irradiation Facility

The fuel elements will be irradiated in the front-to-rear test hole tubes 3674 KE and 3674 KW. Each test hole contains two concentric aluminum tubes with coolant flow (independent of the flow to the fuel elements) between them. The rear nozzle design for each test hole will permit the discharge of the inner concentric tube under high dose rate conditions.

4. Power and Temperature Relationships

The two fuel elements in each charge should produce a maximum of 300 KW, or 26.6 KW/ft/rod. The test holes will have Pannellit gauges with a 10 to 90 trip range, one inch outlet pigtails, and, tentatively, a 0.330" upstream orifice and a 0.375" downstream orifice. The calculated operating conditions are given in Table 1. Prior to charging the test the flow splits through and around the basket assemblies will be experimentally measured, and, if the operating conditions based on the measured flow splits are less conservative than those in Table 1, a larger upstream orifice will be used to increase the coolant flow and pressure at the fuel elements.

TABLE I
OPERATING CONDITIONS AT 300 KW TUBE POWER

Operation	Tube Flow, gpm	Element Flow, gpm	Tube Outlet Temp., °C	Max. Fuel Element Surface Temp., °C	Coolant Saturation Temp., °C
Equilibrium	52	47	37	152	189
Pannellit Trip	38	34	45	182	183

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5. Exposure

Two fuel elements will be irradiated to an exposure of 1000 MWD/T and two to 2000 MWD/T.

6. Special Procedures

Both charges will be discharged into a special tray to prevent damage to the fuel elements resulting from the fall to the basin. The twenty-eight inch folding tip off (SK-1-22182, SK-1-22183, SK-1-22184) used for previous basket discharges from the test holes will be used with the discharge tray being fabricated for discharges from the KER loops. A detailed discharge procedure approved by the Reactor Processing Operations and Irradiations Testing Operation will be provided prior to discharge.

7. Priority

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

8. Costs

a. Cost Code: XXXX-5320-XXX.09

b. Time for each loading:

	<u>Elevator time, hours</u>		<u>Manhours</u>
	<u>Front</u>	<u>Rear</u>	
Charge	1	1	4
Discharge	1	4	10
	2	5	14

c. Reactivity Loss: Each loading will have six to ten in-hours loss as compared to an empty, dry tube.

9. Data Desired

Inlet and outlet temperatures and Pannellit and header pressures should be recorded daily for the front-to-rear test hole and selected surrounding tubes.

10. Rupture Detection

Coolant from the front-to-rear test hole will be tied into one point on the existing reactor gamma monitoring system to provide a continuous check on the tube activity.

11. Hazards

Failure of the Zircaloy-2 jacketed cluster elements is unlikely. The corrosion resistance of the jackets and the extended surface geometry should preclude either a jacket or a core failure. No increase in failure probability should arise from the covered jacket defects, as the elements have successfully passed an autoclave test at 300°C and 1300 psig. If a failure should occur, the multiple coolant channel through the cluster elements and around the basket assembly would prevent complete flow blockage.

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RESPONSIBILITIES

Sanford Laboratories Operation

Reactor and Fuels Research and Development Operation

Fuels Development Operation

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

Irradiation Processing Department

Research and Engineering Operation

Irradiation Testing Operation is responsible for:

- a. Charging the fuel elements.
- b. Scheduling the charges with the concurrence of the Reactor Processing Operation.
- c. Technical operation of the test hole facility.

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 and KW Processing Operations are responsible for:

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

WK Kratzer:dgm

Reactor Fuels Operation
Process & Reactor Development Operation
IRRADIATION PROCESSING DEPARTMENT

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FIGURE 1

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