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PRODUCTION TEST IP-510-A, IRRADIATION OF
CLADDING STUDIES CAPSULES, SERIES II

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PRODUCTION TEST IP-510-A, IRRADIATION OF CLADDING
STUDIES CAPSULES, SERIES II

by

W. K. Kratzer
Reactor Fuels
Process and Reactor Development

June 14, 1962

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DECLASSIFIED**OBJECTIVE**

The objective of this production test is to evaluate the effect of Zr-2 jacket uniformity, thickness, and temperature on non-uniform clad straining of coextruded Zr-2 jacketed rod samples.

SUMMARY

Twenty-five Zr-2 capsules, each containing three coextruded Zr-2 jacketed rod samples, and four Zr-2 thermocouple capsules, each containing one coextruded Zr-2 jacketed rod sample instrumented with a thermocouple to measure the uranium temperature, will be irradiated in four process tubes in F Reactor to exposures up to 2000 MWD/T. Three process tubes will contain six three-sample capsules and a thermocouple capsule; the fourth tube will contain seven three-sample capsules and a thermocouple capsule.

A full column of numbered normal fuel elements will be irradiated in columns adjacent to each of the test columns to determine the front-to-rear flux distribution.

Approximately 100 days of equilibrium operation will be required to complete the test. Special pick-up will be required for the four test and four adjacent control columns.

BASIS AND JUSTIFICATION

Several coextruded Zr-2 jacketed fuel elements have failed during high temperature irradiation testing by a mechanism involving localized straining of the fuel element jacket. Fuels Development Operation, HLO, is carrying on a program to identify and evaluate the fuel parameters affecting this type of failure. The irradiation testing phase of this program consists of irradiating coextruded Zr-2 jacketed rod samples incorporating different levels of the parameters of concern and observing the resulting jacket straining and splitting. Since a relatively large number of samples are involved, many of which will experience jacket splits, the samples are sealed in Zr-2 capsules with NaK as a heat transfer medium and irradiated in normal reactor process tubes.

A previous attempt to evaluate the effect of jacket thickness, temperature, and uniformity^(1,2) was terminated by failure of one of the capsules because of inadequate capsule cooling. A subsequent irradiation test⁽³⁾ showed that the difficulties that caused the failure had been corrected. This production test

- (1) Weber, JW, Proposal for the Irradiation of Cladding Studies Capsules, HW-67264, November 1, 1960 (Secret).
- (2) Kratzer, WK, Production Test IP-402-A, Irradiation of Zr-2 Cladding Studies Capsules, HW-68970, March 24, 1961 (Secret).
- (3) Kratzer, WK, Supplement A, Production Test IP-402-A, Irradiation of Zr-2 Cladding Studies Capsules, HW-71648, November 9, 1961 (Secret).

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is intended to achieve the objectives of the original production test, evaluation of the effect of jacket uniformity, thickness, and temperature on clad splitting, that were not attained because of fuel failure. (4)

TEST DETAILS

1. Fuel Elements

a. Coextruded Samples

The Zr-2 jacketed rod samples are three-inch-long sections of 0.590-inch O.D. Zr-2 jacketed coextruded rod containing 1.47% enriched uranium. Unbonded Zr-2 end caps are welded to the rod samples. The thermocouple samples differ from the other samples by having an axial hole drilled into the uranium into which is inserted a 1/16-inch stainless steel jacketed chromel-alumel thermocouple. The thermocouple passes out of the sample and the capsule through a series of Swage-Lok fittings. The design of the two types of samples is shown in SK-3-9635.

b. Zr-2 Capsules

Two types of Zr-2 capsules will be used, one containing three rod samples and one containing one rod sample instrumented with a thermocouple. Each capsule consists of a cylindrical chamber containing the centered rod samples surrounded by NaK and a separate NaK expansion chamber at one end. The capsules are 0.8 to 1.0 inch O.D. and are contained in a 1.44-inch O.D., 1/16-inch wall perforated open-ended aluminum sleeve to position the capsule in the process tube. The capsule-sleeve assemblies containing a thermocouple are about 14-inches long; the other capsule-sleeve assemblies are about 15-inches long. The design of the two types of assemblies is shown in H-3-9599.

c. Thermocouple Trains

The purpose of the thermocouple capsules containing the single rod sample is to obtain actual measurements of the uranium temperature of one sample in each column during irradiation. These temperatures, in conjunction with the powers of the surrounding tubes, provide the basis for calculating the individual powers, temperatures, and exposures of the remaining samples in the column.

Each thermocouple train consists of the 14-inch thermocouple capsule upstream, 26.8-inch perfs, and the modified nozzle plug and cap. The arrangement of the thermocouple train is similar to the standard reactor thermocouple probe with the probe head replaced by the thermocouple capsule and with one thermocouple instead of 8.

d. Adjacent Monitor Elements

A tube of numbered normal fuel elements will be irradiated adjacent to each of the capsule columns. The numbered elements will be discharged at the same time as the capsule columns and weaseled to determine the front-to-rear flux distribution.

(4) Weber, JW, Proposal for the Irradiation of Cladding Studies Capsules, Series II, HW-73553, May 3, 1962 (Secret)

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2. Loading

The process tube loading for each of the 4 capsule columns will consist of the 18 $\frac{1}{2}$ -foot thermocouple train downstream, 6 capsules (7 in 1 tube only), 2 8-inch perfs, and an upstream dummy pattern specified by the Process Engineer to provide appropriate flow and Panellit protection. A detailed loading for each tube will be provided prior to charging.

One process tube adjacent to each of the 4 capsule columns will be loaded with a charge of numbered normal fuel elements. These adjacent tubes will be charged and discharged at the same time as the capsule tubes.

Discharge of green metal is authorized to make tube positions available for initial charging. Discharge of adjacent monitor columns short of goal is also authorized.

3. Irradiation Facility

The capsules will be irradiated in F Reactor in process tubes selected by the Pile Physicist and Process Engineer.

4. Charge, Discharge, and Special Pickup

Process tubes containing the test capsules will be loaded by hand, the capsules and thermocouple train from the rear face and the upstream dummies from the front. The adjacent monitor tubes of numbered normal elements may be charged by any desired means as long as the identity of the elements is retained. A detailed charge and discharge procedure will be provided by the test author prior to charging. Both test and monitor tubes will require special pickup. Test and monitor elements from each pair of tubes may be stored in one bucket; however, elements from different tube pairs should not be mixed.

5. Operating Conditions

The process tubes containing the test capsules will produce about 100-110 KW and will operate with a 10-15°C coolant Δ T.

Orifice size and upstream dummy configuration will be selected by the Process Engineer to provide the appropriate Panellit pressure.

The expected power and temperature conditions for the uranium samples in each capsule are given in Table 1 based on the arrangement of the capsules in each test column shown in Figure 1.

6. Compliance with Process Standards

This test authorizes deviation from Process Standards F-010 and A-050, HW-46000-F.

7. Process Tube Selection

The process tube locations for the test and monitor columns will be selected by the Pile Physicist and Process Engineer to provide an adjacent tube power as near 750 KW as possible.

8. Exposure

One of the test columns will be irradiated to a specimen exposure of about 1000 MWD/T and the other three test columns will be irradiated to specimen exposures of about 2000 MWD/T. These exposures will take about 50 and 100 operating days to attain.

9. Special Procedures

The special procedures required for this test include:

- a. Probing the test columns with a 1.44 inch O.D., 15 inch long probe prior to charging.
- b. Manual charging the test columns, the capsules and thermocouple trains from the rear face and the upstream dummies from the front.
- c. Maintaining identity of numbered elements in control columns.
- d. Special pickup of both test and control columns.
- e. Reporting data daily on form provided by the test author. 1-13

10. Costs

- a. Cost code for incremental costs: XXXX-5R24-XXX.73.

- b. Time for each column:

	<u>Elevator time, hours</u>		<u>Manhours</u>
	<u>Front</u>	<u>Rear</u>	
Charge test column	1/2	1	4
Discharge test column	1/4	1/2	2
Charge monitor column	1/4	--	1/2
Special Pickup	--	--	1/2

- c. Reactivity loss: Reactivity of each test column will be about the same as a column of dummies. There is no loss associated with the monitor columns.

11. Data Desired

Operating data from the test and monitor columns and from certain surrounding tubes will be supplied on forms provided by the test author. Elements discharged from the monitor columns will be weaseled to obtain the front-to-rear flux distribution.

12. Test Duration

Test authorization will be terminated one year from the date of initial charging or on December 31, 1963, whichever occurs earlier, unless extended by a supplement. Termination of the test or any part thereof as the result of fuel failure or other operating difficulties is the responsibility of the Manager, F Processing with concurrence of the test author.

13. Hazards

The greatest hazard associated with this test is an unscheduled reactor shutdown resulting from capsule failure. Such a failure is apt to release large quantities of gas. The undesirable effects of a gassing failure can

be minimized by delaying the discharge of the failed capsule until late in the outage and canning the capsule immediately after discharge.

Rupture removal procedures and equipment applicable to normal fuel charges are applicable to the capsule columns. Time required before water can be shut off indefinitely to the capsule columns will be provided prior to charging.

RESPONSIBILITIES

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Hanford Laboratories Operation

Fuels Development Operation

Fuel Element Design Operation is responsible for fabricating the test capsules, pre-irradiation inspection and testing, analyzing test data, and reporting test results.

Irradiation Processing Department

Research and Engineering Section

Process and Reactor Development Subsection

Reactor Fuels is responsible for coordination and conduct of the production test and all technical aspects of the test relating to the capsules and fuel specimens.

Reactor Engineering is responsible for providing infinite water shut-off times for the capsule columns.

Process Technology Subsection

Process Engineering is responsible for selection of process tubes for the test in conjunction with the Pile Physicist, establishing the dummy pattern, orifice sizes, and operating conditions for the test columns, assistance in charging the test columns, and liaison with the Processing Operation in obtaining test data.

Operational Physics Subsection

Pile Physics is responsible for selection of the process tubes for the test in conjunction with the Process Engineer.

Testing Subsection

Irradiation Testing is responsible for assistance in assembly, charging, and maintenance of thermocouple trains.

Component Testing is responsible for weaseling the control elements and examination of test and control elements after discharge if this should be necessary.

RESPONSIBILITIES (continued)

Irradiation Processing Department

Manufacturing Section

F Reactor Subsection

F Processing Operation is responsible for scheduling the test, operational safety and production continuity of the reactor, and collection of operating data.

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

WKK:gb

TABLE I - EXPERIMENTAL CONDITIONS

Capsule Designation	Fuel	Sample Zr-2 Cladding Thickness, Inch	Temperature - C			Desired Exposure, MWD/T	Sample Power, kw/ft
			Uranium Axial	Uranium Surface	Cladding Surface		
A3U11	1.47% E Unalloyed	0.030	477	318	240	1000	20
A3U21	"	0.030	513	358	280	1000	20
A3U22	"	0.030	513	358	280	1000	20
A3U31	"	0.030	548	398	320	1000	20
A3A21	1.47% E 2 w/o Zr	0.030	454	337	280	1000	14.6
A4U21	1.47% E Unalloyed	0.040	537	391	288	1000	19.2
B3U11	1.47% E Unalloyed	0.030	477	318	240	2000	20
B3U12	"	0.030	477	318	240	2000	20
B3U21	"	0.030	513	358	280	2000	20
B3U22	"	0.030	513	358	280	2000	20
B3U23	"	0.030	513	358	280	2000	20
B3U24	"	0.030	513	358	280	2000	20
B3U31	"	0.030	548	398	320	2000	20
B3A21	1.47% E 2 w/o Zr	0.030	454	337	280	2000	14.6
B3A22	"	0.030	454	337	280	2000	14.6
B4U11	1.47% E Unalloyed	0.040	503	350	247	2000	19.2
B4U21	"	0.040	537	391	288	2000	19.2
B4U22	"	0.040	537	391	288	2000	19.2
A4U2TC1	1.47% E Unalloyed	0.040	537	391	288	1000	19.2
B4U2TC1	"	0.040	537	391	288	2000	19.2
B4U2TC2	"	0.040	537	391	288	2000	19.2
B4U2TC3	"	0.040	537	391	288	2000	19.2
SR11	1.47% E Unalloyed	0.030	513	391	280	2000	20
SR21	"	0.030	513	391	280	2000	20
SV11	"	0.030	513	391	280	2000	20
SV21	"	0.030	513	391	280	2000	20
SV2M1	"	0.030	513	391	280	2000	20
SV2M2	"	0.030	513	391	280	2000	20
SV2M3	"	0.030	513	391	280	2000	20

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FIGURE I

Arrangement of Capsules in Each Column

A4U2TC1 A4U21 A3U21 A3A21 A3U22 A3U11 A3U31

Tube 1 - Exposure 1000 MWD/T

B4U2TC1 B4U21 B3U21 B3U31 B4U11 B4U22 B3U22

Tube 2 - Exposure 2000 MWD/T

B4U2TC2 B3U23 B3A21 B3U11 B3U12 B3U24 B3A22

Tube 3 - Exposure 2000 MWD/T

B4U2TC3 SR11 SR21 SV21 SV11 SV2M1 SV2M2 SV2M3

Tube 4 - Exposure 2000 MWD/T

← Downstream

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APPROVALS

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