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TITLE

PRODUCTION TEST IP-644-D
FUEL SURFACE CRUD MONITOR IRRADIATION

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AUTHOR

R. Neidner

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This document classified by

C. B. Lewis

This document consists of 11
pages.

PRODUCTION TEST IP-644-D
FUEL SURFACE CRUD MONITOR IRRADIATION

Classification Cancelled and Changed To

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By Authority of D S Lewis

CG-PR-2, 4-5-94

By J E Savely 4-16-94

Verified By Jerri Maley
4-18-94

R. Neidner

December 16, 1963

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HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRODUCTION TEST IP-644-D
FUEL SURFACE CRUD MONITOR IRRADIATION

1. 2. AEC-RLOO, Attn: RL Plum	19. LE Kuhlken
3. AEC-RLOO, Attn: PM Midkiff	20. GA Last
4. AEC-RLOO, Attn: CN Zangar	21. MC Leverett
5. DG Albertson	22. CG Lewis
6. TW Ambrose	23. HI Lewis
7. JA Ayres	24. M. Lewis
8. LV Barker	25. JE Minor
9. RS Bell	26. R. Neidner
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PRODUCTION TEST IP-644-D
FUEL SURFACE CRUD MONITOR IRRADIATION

Objective

The objective of this test is to demonstrate and evaluate the design of the proposed N-Reactor fuel surface crud monitor to be used in the N Reactor tube pattern.

Summary

This test authorizes the irradiation of instrumented thorium-uranium crud monitors having a brazed interface seal between the Zr-2 end cap and thermocouple sheath. The irradiations are authorized for either KER-1, -2, -3, or -4. The right cylindrically-shaped crud monitor simulates the OD surface of an inner fuel tube (NIEL) of an N-Reactor production fuel assembly (NAEL).

Basis and Justification

Power ascension of N Reactor is presently planned for May 1964. During this program of bringing the reactor to full power, a device is needed to monitor for the build up of a low-heat-transfer film on the fuel element surfaces. Significant film build-up may result at high surface temperatures and may lead to eventual serious fuel swelling consequences. The possibility of encountering significant crud concentrations in recirculating coolant is most likely during the early stages of high temperature operation. In addition, the experience of operation using NH_4OH for pH control is relatively small and the possible cruding problem using NH_4OH may not be fully characterized until after NPR startup. One method to monitor for the existence of a serious crud film on the fuel surfaces is to measure a calibrated internal fuel temperature or its relative change by a reliable crud monitor. The monitor authorized by this production test is the result of extensive development and reflects the knowledge gained through earlier experimentation both in-reactor and ex-reactor. The probe was designed to approximate as close as practical fuel element conditions, such as: Zr-2 heat-transfer surface, heat flux, and configuration.

The basic design of this crud monitor has been successfully demonstrated in the Engineering Test Reactor at Idaho Falls, Idaho at conditions more severe than possible in the KER loops. An exact duplicate of the monitors to be irradiated in the KER loops, received three weeks' exposure during ETR cycle 59, and sustained thirteen temperature and thermal stress cycles. Preliminary post-irradiation examination indicated the absence of any deleterious or questionable conditions to have occurred to the crud probe during this irradiation.

Test Details

1. Crud Monitor Fuel Element

The specially designed thorium-uranium fuel element is shown in Figure 1. The element was fabricated by first coextruding the Zr-2 core, the

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FIGURE 1. CROSS-SECTION OF THERMOCOUPLED ELEMENT ASSEMBLED IN ITS SLEEVE.

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thorium 1.5 w/o enriched uranium - 1 w/o zirconium fuel material, and the Zr-2 cladding. The Zr-2 sheathed chromel-alumel thermocouple, Zr-2 core sleeve and Zr-2 end cap were brazed in place using a zirconium 5 w/o beryllium alloy. The cone-shaped sleeve provides support for the thermocouple and acts as a temperature transition piece to minimize possible diffusion of hydrogen to the thermocouple sheath at the point of entry into the crud monitor. The crud monitor is supported within a Zr-2 sleeve by standard NIEL buggy spring supports.

Radiographs of the braze at both ends were taken at 0° and 90° to check for voids, thorium contamination, or lack of bond. The completed element was autoclaved for 72 hours in 400 C steam. All pre-irradiation tests were 100 per cent satisfactory.

2. Crud Monitor Trains

The crud monitor train for KER-1 and KER-2 consists of a two-inch nozzle insert, three 8-inch triangular spacers, eleven 16-inch tubular spacers, and a 6.5 inch crud probe element contained in a 10-inch sleeve 1.9 inch OD x 1.5 inch ID. The assembled train is shown in Figure 2, SK-1-27896. The 1/8 inch Zr-2 clad and 1/16 inch stainless steel clad thermocouples and stainless steel cable are contained by 3/8 inch rings in the spacers to prevent vibration.

The crud monitor train for KER-3 and KER-4 consists of a four-inch nozzle insert, thirteen standard 15.5 inch modified N spacers and a 6.5 inch crud probe element contained in a 2.404 inch OD x 1.5 inch ID, 10 inch long Zr-2 sleeve. The sleeve has the same OD and same support rails and feet as an N outer tube. The assembled train is shown in Figure 3, SK-1-27897. The 1/16 inch stainless steel clad and 1/8 inch Zr-2 clad thermocouple, and the 1/16 inch stainless steel cable are contained in 1/4 inch stainless steel tubes centered in the spacers to prevent vibration in the coolant flow stream.

3. Loading

Tube loadings will include one of the crud probe train assemblies authorized by this production test. The crud probe train will be charged in conjunction with one or more other authorized production test that will provide adequate loop heat generation to approximate N Reactor reference temperatures. Detailed tube loadings will be given in a document approved by the managers of Testing, Process and Reactor Development, and Process Technology Subsections prior to charging.

4. Irradiation Facilities

The crud monitor trains authorized by this production test may be irradiated in KER-1, -2, -3, and -4.

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5. Operating Conditions

All operation will be in accordance with the Reactor Process Standards applicable to the KER loops, and Production Test 638-D, which authorizes new loop settings for low pressure trip, high temperature trip, and maximum operating temperature, when loop operation is required at N-Reactor conditions.

The coolant will be pressurized water with the pH controlled between 7.0 and 10.5 by the addition of either LiOH or NH_4OH . The low pressure trip will be set according to the applicable Process Standard or PT-IP-638-D, as specified above. The desired operating flow is 36,000 lb/hr for KER-1 and -2, and 80,000 lb/hr for KER-3 and -4.

The high outlet temperature trip, maximum operating outlet temperature, and boiling point suppression trip will be given for each loading in a document approved by the managers of Testing, Process and Reactor Development, and Process Technology Subsections prior to charging.

6. Power and Temperature Limits

The operating conditions will be chosen so that surface boiling will not occur on the fuel elements during normal operation, subcooled burnout will not occur at the limiting trip conditions, and the maximum fuel temperature will not exceed 600 C. Failure of a crud probe element will immediately terminate this production test authorization and will be cause to discharge a similar concurrently charged crud probe.

7. Exposure

The maximum exposure authorized for the crud probe is 2500 MWD/T.

8. Charge-Discharge Procedure

- a. Pre-Charging Checks - The assembled crud probe train will be charged in an appropriately distorted KER-sized mockup tube to assure capability of reactor charging, then pressure tested at 4000 psi cold in a pressure tube to verify the tightness of the pressure fittings.
- b. Charging Procedure - The crud probe trains authorized in this production test may be charged either upstream or downstream. The design of the train permits either location. Except for charging the crud probe train from the rear when it is used, all other components of each charge will be normally charged from the front face. After each tube is fully charged, the nozzle caps will be replaced and the tube pressure tested.
- c. Discharge Procedure - Sheet metal rupture shielding will be hung to prevent the thermocouple wires from becoming entangled with the rear tube hardware. The nozzle cap will be removed, the crud probe train pulled out a few inches and the nozzle insert cut off and saved. The hinged tip-off will be mounted on the rear nozzle. The fuel elements of the charge will be tray-discharged when feasible, the crud probe train will be discharged directly into the basin. Detailed discharge

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procedures for upstream or downstream train loadings will be prepared by Coolant Testing to the mutual satisfaction of the customer and KE Processing.

9. Decontamination

During the period required to perform this production test, decontamination of the loop will be accomplished as required. The agents and procedure for decontamination will first be documented and approved by the managers of Testing, Process and Reactor Development and Process Technology Subsections.

10. Priority

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

11. Work Platform Time

	<u>Hours</u>	
	<u>Front</u>	<u>Rear</u>
Normal charging	1	1
Train discharging and tray discharge of fuel	2	4

12. Hazards

The principal hazard associated with this test is an unscheduled reactor outage resulting from cladding failure of the crud probe. Zr-2 sleeves around the crud probe should preclude damage to the process tube if probe failure should occur. The probe and sleeve have the same orientation as that of the NIEL fuel elements, that is: a one-inch OD fuel element centered within a thick-walled Zr-2 tube. This orientation precludes complete tube flow stoppage and a swollen fuel surface would not come in contact with the pressure tube.

As described earlier in this document, the soundness of the basic design has been demonstrated by an irradiation in the ETR.

Responsibilities

Irradiation Processing Department

Research and Engineering Section

Testing Subsection - has the over-all responsibility for the production test, including safety and adequacy of the test elements, test design, and special procedures for the tests.

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Component Testing is responsible for post-irradiation visual observation of the crud probe and diameter measurements while in the 105 KE Building.

Coolant Testing is responsible for:

- 1) Operation of the KER loops
- 2) Preparation of the train discharge procedure
- 3) Taking basic data
- 4) Scheduling each loop charge with the concurrence of KE Processing
- 5) Reactor safety and production continuity as they are affected by loop operation

Manufacturing Section

KE-KW Reactor Operation

KE Processing is responsible for performing special discharges.

Senior Engineer, Testing

R. Weidner:bmr

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Approvals

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Applied Reactor Engineering

R. S. Bell R. S. Bell, Acting Manager
Manufacturing

Date of Issue: 1-15-64

1 ARRANGEMENT

2 ASSEMBLY

3 MATL. SHELBY TUBING OR
EQ. 1 1/2 OD x 3/8 WALL
MILD STL.

4 AS SHOWN
MATL. SUPPLIED BY CUSTOMER

5 AS NOTED
MATL. SUPPLIED BY CUSTOMER

A schematic diagram of a 9-in-line engine. It shows a horizontal row of nine cylinders. The first cylinder on the left is labeled with a circled '3'. The fifth cylinder from the left is labeled with a circled '5'. The ninth cylinder on the right is labeled with a circled '13'. Below the first cylinder, the text '9 IN LINE REQ'D' is written.

⑥ MATL. 306 SST

⑦ 304 SST
1/2 THICK

- 8 SWAGelok MALE CONNECTOR
#100-1-2BT-316 (MODIFY)
- 9 SWAGelok MALE CONNECTOR
#200-1-2BT-316 (MODIFY)

UNLESS OTHERWISE SPECIFIED

1. TOLERANCES: FRACTIONAL $\pm \frac{1}{64}$ DECIMAL $\pm .005$
2. FINISH $\sqrt{63}$
3. ALL MATERIAL TO BE AS SPECIFIED OR APPROVED EQUAL QUALITY.

SK-1-27896	7/1	0
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Fig. 2

[illegible]

1 ASSEN

2 MODIFY PART # 1 ON H-1-23591 AS SHOWN

3 MODIFY PART # 1 AS SHOWN

NOTE
1. PT. # 7 TYPICAL BRACKET ONE END.
2. PT. # 8 TYPICAL BRACKET FOR BOTH ENDS.

7 INNER TUBING SHORTENED AS : (MODIFY PT. # 1 H-1-28730)

8 INNER TUBING FULL LENGTH

DATE

FILMED

7/26/94

END