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PRODUCTION TEST IP-584-D, SUPPLEMENT B
IRRADIATION OF TARGET ASSEMBLIES IN THE KER
LOOPS

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PRODUCTION TEST IP-584-D, SUPPLEMENT B
IRRADIATION OF TARGET ASSEMBLIES IN THE KER LOOPS

MASTER

T. L. Deobald

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April 28, 1964

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRODUCTION TEST IP-584-D, SUPPLEMENT B
IRRADIATION OF TARGET ASSEMBLIES IN THE KER LOOPS

OBJECTIVE

The objective of this supplement to Production Test IP-584-D⁽¹⁾ is to authorize low exposure (5-8 GVR*) irradiation tests of the following lithium-containing target materials:

Magnesium - 14 per cent lithium alloy
Lithium-aluminate (LiAlO_2)
Lithium-silicate (Li_2SiO_3)
Lithium-aluminate - aluminum cermet
Lithium-silicate - aluminum cermet

SUMMARY

Lithium target materials will be contained in 4.50 inch long aluminum cans which are clad with 35 mil Zircaloy-2 alloy. The target elements will be contained in 1.9 inch OD, 1.5 inch ID Zircaloy-2 flow distributing sleeves. The target element assemblies and N Reactor inner fuel elements (NIE-1) in Zircaloy-2 sleeves, will be irradiated in KER-1 or KER-2 at operating conditions approximating N Reactor operation. The exposure will be approximately 5-8 GVR.

BASIS AND JUSTIFICATION

The research and development effort undertaken to evaluate target materials for use in N Reactor includes the investigation of materials other than the Al-Li alloys presently being tested. Nuclear safety requirements make it necessary to utilize ceramic or cermet materials. Testing of other metallic, ceramic, and cermet target materials must begin since there are no data available on their irradiation behavior. This test will provide information on irradiation behavior of natural lithium-bearing materials and provide samples which can be used to determine production and extraction information.

TEST DETAILS

Lithium-Bearing Materials⁽²⁾

1. Magnesium - 14 per cent lithium alloy - This is a single-phase alloy similar in behavior to the single-phase aluminum-lithium alloys.
2. Lithium-aluminate (LiAlO_2) - This is a ceramic material swaged to approximately 75 per cent of theoretical density. The melting point is 1625 C, and it is insoluble in hot water. Gas retention is expected to be good.

*GVR - Gas Volume Ratio = $\frac{\text{cc of } (\text{T}_2 + \text{He}) \text{ at STP}}{\text{cc of target material}}$

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Lithium-Bearing Materials (continued)

3. Lithium-silicate (Li_2SiO_3) - This is a ceramic material swaged to approximately 75 per cent theoretical density. The swelling point is 1201 C, and it decomposes slowly in hot water. Gas retention is expected to be good.
4. 50 per cent lithium-silicate - 50 per cent lithium aluminate
5. 40 per cent LiAlO_2 - Aluminum Cermet - Forty volume per cent of the ceramic LiAlO_2 dispersed in an aluminum matrix. Gas retention is expected to be good.
6. 50 per cent LiAlO_2 - Aluminum Cermet
7. 40 per cent Li_2SiO_3 - Aluminum Cermet - Forty volume per cent of the ceramic Li_2SiO_3 dispersed in an aluminum matrix. Gas retention is expected to be good.
8. 50 per cent Li_2SiO_3 - Aluminum Cermet

Target Elements

The target elements consist of a 0.625 inch OD by 3.5 inch long target material cores fitted in 0.030 inch wall aluminum sleeves with 0.375 inch thick aluminum end plugs welded at each end. The void space within the aluminum can is filled with helium to facilitate heat transfer and permit helium leak testing after welding. Two aluminum clad assemblies are fitted into an 0.035 inch wall Zircaloy-2 sleeve with 0.375 inch Zircaloy-2 end plugs welded at each end. The completed assembly is 9 inches long and 0.756 inches OD.

Three Zircaloy-2 supports 0.375 inches high are welded to each end of the target element to position it axially in a standard 1.9 inch OD by 1.5 inch ID Zircaloy-2 flow distributing sleeve. The flow distributing sleeves are 18.5 inches long and contain two 9-inch target elements.

All welds in the target elements are inspected by x-ray examination and helium leak testing. A complete description of the fuel elements and fabrication procedure is given in HW-76977(3). Element dimensions and assembly are shown in the appended drawing, H-3-70838.

Heater Elements

Five inner fuel elements, authorized by Production Test IP-536-A⁽⁴⁾ or its supplements or other valid production tests, will be used to provide heat to the process tube to permit operation at the desired temperature.

Sleeves, Spacers, and Coupon Holders

The Zircaloy-2 sleeves used around the target assemblies will be the same as shown in SK-3-8453 or SK-3-8454 and approved by Production Test IP-536-A, except that the length is 18.5 inches. Carbon steel spacers, H-1-33507, and stainless steel spacers, H-1-20543, authorized by Production Test IP-536-A will be used in the tube loadings. Coupon holders of a design shown in H-1-33584 and SK-23419, authorized by Production Test IP-567-D⁽⁵⁾ are authorized for use in process tube loadings.

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Irradiation Facility

The elements authorized by this supplement to Production Test IP-584-D will be irradiated in KER Loops 1 and 2, tubes 2160-KE and 2864-KE.

Loading

The tube loadings shall consist of fuel elements and components authorized by this production test or other approved production tests applicable to KER-1 and KER-2.

Operating Conditions

All operation will be in accordance with the Reactor Process Standards applicable to KER-1 and KER-2 and with normal loop operating practices.

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 Production Test IP-638-D(7). The desired operating flow is 36000 lb/hr or greater with a low flow trip set according to the applicable Process Standard. The high outlet temperature trip, maximum operating temperature, desired operating outlet temperature, and boiling point suppression trip will be given for each loading in a document approved by the managers of the Testing, Process and Reactor Development, and Process Technology Subsections 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 author in a document approved by the managers of Testing, Process and Reactor Development, and Process Technology Subsections prior to charging.

Power and Temperature Limits

The operating conditions will be chosen so that surface boiling will not occur on any of the fuel elements during normal operation, sub-cooled burnout will not occur at the limiting trip conditions, and the maximum uranium temperature of the heater elements will not exceed 600 C.

Exposure

The maximum exposure authorized for the target elements is 10 GVR, and for the N inner fuel elements, 2500 MWD/T. The maximum GVR rate will be in the lithium-silicate element, and allows 27 effective operating days of exposure. The estimated GVR's for one cycle (21-day exposure) are:

Mg-14% Li	5.5	40% LiAlO_2 -Al	3.1
LiAlO_2	6.0	40% Li_2SiO_3 -Al	4.4
Li_2SiO_3	7.9	60% LiAlO_2 -Al	4.6
50% LiAlO_2 - 50% LiSiO_3	7.0	60% Li_2SiO_3 -Al	6.6

Special Procedures

The KER loop delayed neutron monitor in the safety circuit will detect heater element failure, but will not detect failure of a target element. A gamma monitor

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Special Procedures (continued)

and a single-channel analyzer will be installed to monitor KER loop coolant for Al²⁸ to detect target element failure.⁽¹⁾ Loop water samples will be taken twice weekly for tritium oxide analysis. A significant increase in Al²⁸ or T₂O activity will require an immediate cool-down of the loop. Confirmation of a failure, through further water sampling, will require that the loop remain cold, water samples be taken daily, and the test discharged at the next outage. Tritium oxide in excess of 100 μ 'cc will require that a reactor shutdown be considered. A reactor shutdown will be contingent upon an agreement reached between the Supervisor, Coolant Testing and the Manager, KE Processing. Radiological control measures provided by the KE Reactor Radiation Monitoring Supervisor will be put into effect by KE Processing and Coolant Testing upon detection of a significant increase in Al²⁸ or T₂O activity.

Priority

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

Costs

Time for each loading:

	<u>Elevator Time, Hours</u>		<u>Man-Hours</u>
	<u>Front</u>	<u>Rear</u>	
Normal Charging	1	1	6
Tray Discharging	2	4	18

Data Desired

Coolant Testing - Routine operating data will be required.

Hazards

The principal hazard associated with irradiation of lithium-aluminum elements is the radiological hazard caused by tritium oxide, T₂O, in the loop coolant from a target element failure. After twelve days irradiation, dissolution of a target element in the loop would produce hazardous concentrations of HTO and T₂O if the water or water vapor should be breathed, absorbed through the skin, or ingested. To minimize the hazard to personnel, the reactor will be shut down and the loop put on single-pass as soon as a target element failure is detected. Radiological control procedures will be promptly initiated to further minimize personnel contact with the contaminated coolant or water vapor.

Duration of Test

This production test supplement will be terminated two years from the date of issuance or at the time of a verified target element failure.

RESPONSIBILITY

Irradiation Processing Department

Test Engineering

Test Engineering will have over-all responsibility for the production test, including responsibility for safety and adequacy of the test elements and test design.

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Coolant Testing

Coolant Testing will be responsible for operation of the KER loops, taking basic operating data, scheduling the loop charge with the concurrence of KE Processing, reactor safety and production continuity as they are affected by loop operation, monitoring of loop coolant for target failure and radiological hazards, administering radiological control procedures for Coolant Testing personnel upon detection of a tritium hazard, and notifying KE Processing of a suspected cladding failure.

KE Processing

KE Processing will be responsible for providing radiological control procedures and for administering radiological control procedures for their personnel.

T. L. Deobald

Engineer
Test Engineering

TL Deobald:mkc

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