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ASSEMBLIES IN THE KER LOOPS

By

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C. B. Lewis

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May 8, 1963

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

OBJECTIVE

The objective of this production test is to evaluate the behavior of Li-Al elements at N reactor operating conditions. Specifically, the test is intended to determine:

- a. The rate of swelling of the Li-Al alloy.
- b. The effect of irradiation on the mass transport of Li and T in the target assembly.
- c. Effect of Al surface treatment on the transport of Li and T.

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SUMMARY

Nine inch long aluminum clad Li-Al alloy target elements contained in 35 mil wall Zr-2 cans are authorized for irradiation in KER-1 and KER-2 for up to 150 equilibrium operating days. The Li-Al elements will be irradiated in 1.9 inch OD, 1.5 inch ID Zr-2 flow distributing sleeves. Normal N inner fuel elements in Zr-2 sleeves will be included in the tube loadings to provide sufficient heat to maintain the loop at the desired operating temperature.

BASIS AND JUSTIFICATION

Production of tritium as well as plutonium in N reactor may be economically desirable. Operating experience with Li-Al elements at HAP0 and Savannah River, however, has been restricted to low temperature irradiation. This production test authorizes the irradiation of Li-Al alloy elements at N reactor operating conditions to evaluate target element swelling and Li and T migration. Information from the test will be used in the design of Li-Al alloy elements for N reactor.

TEST DETAILS

1. Li-Al Elements

The Li-Al elements consist of 0.625 inch OD, 0.250 inch ID, 7.5 inch long tubular elements fitted into 0.030 inch wall aluminum sleeves with 0.375 inch thick aluminum end plugs welded at each end. The aluminum clad assembly is then fitted into a 0.035 inch wall Zr-4 can with 0.375 inch Zr-2 end plugs welded at each end. The 0.250 inch center core hole and the spaces between the Li-Al element, the aluminum can, and the Zr-4 can are filled with He to facilitate heat transfer and permit helium leak testing after welding. The completed assembly is 9.0 inches long and 0.756 inch OD.

Three Zr-2 supports 0.375 inch high are welded to each end of the Li-Al element assembly to position it axially in a standard 1.9 inch OD, 1.5 inch ID Zr-2 flow distributing sleeve such as is used for irradiating N inner fuel elements in KER-1 and 2. The Zr-2 flow distributing sleeves are 18.5 inches long, each containing two 9 inch Li-Al assemblies.

The Li-Al alloy in each assembly contains either 1 or 2 w/o Li with the concentration of Li⁶ adjusted in either case to 0.40 w/o.

All welds in the Li-Al element are inspected by x-ray examination and helium leak testing. The completed assembly has been autoclaved at 300°C for 48 hours or longer.

A complete description of the fuel elements and fabrication procedure is given in HW-76977⁽¹⁾. Element dimensions and assembly are shown in the appended drawing, H-3-20838.

2. Heater Elements

N inner fuel elements authorized by PT-IP-536-A⁽²⁾ will be used to provide heat to the process tube to permit operation at the desired temperature.

(1) Gelezunas, V.L. Proposal for Irradiation of Target Assemblies, HW-76977, March 18, 1963, (SECRET).

(2) Kratzer, W.K. Production Test IP-536-A, Irradiation of N-Reactor Inner Fuel Tubes in KER Loops 1 and 2, HW-75280, October 16, 1962 (SECRET).

3. Sleeves, Spacers, and Coupon Holders

The Zr-2 sleeves used around the Li-Al assemblies will be the same as shown in SK-3-8453 or SK-3-8454 and approved by PT-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 PT-IP-536-A will be used in the tube loadings. Coupon holders of a design shown in H-1-33584 and SK-1-23419 authorized by PT-IP-567-D⁽³⁾ are authorized for use in process tube loadings.

4. Irradiation Facility

The elements authorized by this production test will be irradiated in KER loops 1 and 2, tubes 2160-KE and 2864-KE.

5. 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. One tube loading planned for KER-1 and KER-2 is given in Table 1. Other tube loadings may be used provided they are approved by the Managers of the Process and Reactor Development Subsection and Process Technology Subsection prior to charging.

6. 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 practice.

The coolant will be pressurized water with the pH adjusted to 10.0 ± 0.5 by the addition of Li-OH or NH_4OH . The low pressure trip will be set according to the applicable process standards. The desired operating pressure is 1600 psig. The desired operating flow is 40,000 lbs/hr with a low flow trip of 32,000 lbs/hr. If the desired flow is not attainable, the operating flow may be set at 36,000 lbs/hr with the low flow trip set at 28,800 lbs/hr. For the tube loading given in Table 1 and either operating flow, the high outlet temperature trip shall be set at 297°C , the maximum operating outlet temperature at 282°C , and the boiling point suppression trip set according to the process standards. For tube loadings other than the one given in Table 1, the high outlet temperature trip, maximum operating outlet temperature, and boiling point suppression trip will be given in a document approved by the managers of the Process and Reactor Development Subsection and the Process Technology Subsection prior to charging.

If recirculation with system pressures less than those specified by Process Standards is required, the outlet temperature will be reduced and maintained at a temperature such that the fuel surface temperature 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. For the loading given in Table 1, the high outlet temperature trip will be set at 200°C for a low pressure trip of 500 psig and a low flow trip of either 32,000 or 28,800 lbs/hr. For other loadings, trip settings will be given in a document approved by the managers of the Process and Reactor

(3) Kratzer, W.K., Loading, Operating Conditions, and Water Shutoff Times for a Charge of Six N Reactor Inner Fuel Tubes and for Two Charges of Dummies in KER-1 and 2, PT-IP-536-A, HW-75353, October 23, 1962 (SECRET)

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Development Subsection and the Process Technology Subsection prior to charging.

Allowable water shut-off times for the loading in Table I are given in HW-75353⁽⁴⁾.

7. 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.

8. Exposure

The maximum exposure authorized for the Li-Al elements is 150 equilibrium operating days and for the N inner fuel elements 2500 MWD/T.

9. 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 and a single channel analyzer will be installed to monitor KER loop coolant for Al^{28} to detect target element failure. Although the gamma monitor and analyzer are not in the reactor safety circuit, indications of a target element failure will require an immediate reactor shutdown and diversion of the loop to single-pass operation. Figure I schematically shows the technique to be used for detecting the Al^{28} .

Radiological control measures provided by Radiological Engineering, IPD, and the KE Reactor radiation analyst will be put into effect to protect personnel from contact with loop coolant potentially contaminated with T_2O .⁽⁵⁾

10. Priority

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

11. Costs

a. Cost Code: XXXX-4550-XXX.73

b. Time for each loading:	Elevator Time, Hours		Manhours
	Front	Rear	
Normal charging	1	1	6
Tray discharging	2	4	18

12. Data Desired

a. Coolant Testing Operation: Routine operating data will be required.

(4) Kratzer, W.K., Loading, Operating Conditions, and Water Shut-off Times for a Charge of Six N Reactor Inner Fuel Tubes and for Two Charges of Dummies in KER-1 and KER-2, PT IP-536-A, HW-75353, October 23, 1962 (SECRET)

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Data Desired (continued)

- b. Component Testing Operation: Detailed fuel element post-irradiation examinations will be requested by the test author for each charge.

13. Hazards

The principal hazard associated with irradiation of Li-Al elements is the radiological hazard caused by tritium oxide, T₂O, in the loop coolant from a target element failure. After twenty-five 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.

14. Duration of the Test

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

RESPONSIBILITIES

N Reactor Department

N Reactor Fuels Section

N Fuel Product Engineering Subsection

Product Development and Specifications is responsible for procuring, measuring, maintaining records, and coordinating preparation of the heater elements.

Hanford Laboratories

Reactor and Fuels Research and Development Operation

Metallurgy Development Operation

Fuel Element Design Operation is responsible for target element preparation and evaluation, analysis of data, and issuance of technical reports.

Irradiation Processing Department

Research and Engineering Section

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

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RESPONSIBILITIES (continued)

Component Testing is responsible for post-irradiation examination of elements in the test charge.

Coolant Testing is responsible for:

- a. Operation of the KER loops.
- b. Taking basic operating data.
- c. Scheduling the loop charge with the concurrence of KE Processing Operation.
- d. Reactor safety and production continuity as they are affected by loop operation.
- e. Detection of radiological hazard.
- f. Initiation of radiological control procedures should a failure occur.

Manufacturing Section

KE-KW Reactor Operation

KE Processing Operation is responsible for:

- a. Providing radiological procedures and necessary training for control of T₂O hazards and the instrumentation for detection and measurement of T₂O.
- b. Production continuity, except where inconsistent with provisions of this test.
- c. Special discharges.

R. Neidner
Testing Subsection
IRRADIATION PROCESSING DEPARTMENT

RN:WKK:gb

- (5) Letter, PC Jerman to WK Kratzer, "Irradiation of Li-Al Target Elements", May 10, 1963 (confidential)

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TABLE I

Tube Loading for Li-Al Elements in KER-1 and KER-2

<u>Position from downstream end of process tube</u>	<u>Number of pieces</u>	<u>Description</u>
1-3	3	8 inch triangular perfs
4-23	20	8 inch tubular spacers
24	1	8 inch triangular perf
25	1	17 inch NIE-1 element
26	1	8 inch triangular perf
27	1	17 inch NIE-1 element
28	1	8 inch triangular perf
29	1	8 inch triangular coupon holder or 8 inch triangular perf
30-33	4	18.5 inch Li-Al element-sleeve assemblies, each containing two 9-inch Li-Al elements
34	1	8 inch triangular coupon holder or 8 inch triangular perf
35	1	8 inch triangular perf
36	1	17 inch NIE-1 element
37	1	8 inch triangular perf
38	1	17 inch NIE-1 element
39	1	8 inch triangular perf

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