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KER-4 OPERATING REPORT
TEST K-4-14
PT IP-477-A
PT IP 482-A

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AUTHOR

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July 3, 1963

KER-4 OPERATING REPORT

TEST K-4-14

PT IP-477-A

PT IP-482-A

IRRADIATION OF N REACTOR FUEL ELEMENTS IN KER-4

I. Introduction

Test K-4-14 was the second "full charge" test to be irradiated in KER-4 following loop modification under Project CGI-839. It provided an opportunity to accumulate additional data on the behavior of N Reactor fuel elements at conditions equivalent to or more severe than those anticipated in N Reactor during Phase I, equilibrium operation.

II. Objective

Specific objectives of the fuel element testing program included:¹

- A. Measurement of fuel distortion and swelling.
- B. Evaluation of irradiation damage to the jacket-uranium bond and to the uranium core.
- C. Evaluation of the performance of the fuel element support system.

III. Summary

- A. Date Charged: September 26, 1962
- B. Fuel Elements: A total of fourteen 23-inch NAEI elements was charged. Enrichment was 0.947 per cent.
- C. Exposure: The elements were charged a total of approximately 5,500 hours. Of this time, the reactor operated approximately 4,243 hours. The loop was at the desired operating conditions 2,685 hours, or approximately 63 per cent of reactor operating time.
- D. Date Discharged: May 13, 1963
- E. Reason for Discharge: goal exposure

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IV. Test Details

A. Tube Charge Order

<u>Position From Downstream End</u>	<u>Number of Pieces</u>	<u>Description</u>
1-8	8	16-inch tubular perfs
9-22	14	23-inch NAE1 elements
23-26	4	16-inch tubular perfs

B. Fuel Elements

Each of the fuel elements charged consisted of two coextruded Zr-2 jacketed self-supported uranium tubes concentrically nested, one within the other, to provide an element with four heat transfer surfaces and three coolant channels. The nominal outer tube dimensions are 2.404 inch OD and 1.758 inch ID with 0.020 inch Zr-2 jackets. The inner tubes are a nominal 1.254 inch OD and 0.439 inch ID with a 0.035 inch Zr-2 jacket on the outer surface and a 0.020 inch jacket on the inner surface. Both tubes have 0.200 inch Zr-2 brazed end caps. The elements are 23.2 inches in length and have an enrichment of 0.947 per cent.¹

C. Spacers

The spacers are perforated carbon steel cylinders measuring 16 inches in length with a 2.25 inch OD and 1.98 inch ID. Each spacer is supported by four 0.44 inch diameter ball bearings at each end which makes the over-all outer spacer support circle diameter of 2.67 inches.¹

D. Operating Conditions

The desired operating conditions for Test K-4-14 were as follows:

1. Pressure: 1555 psi at tube outlet
2. Temperature: 285 C at tube outlet
3. Flow: 80,000 lb/hour
4. pH: 10.0 $\pm$ 0.5

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E. Secondary Testing

1. Mock-up Tube

Coupon holders containing test specimens of stainless steel, carbon steel and Inconel X, originally charged on July 10, 1962, were left in the mock-up tube at the start of Test K-4-14. On November 14, 1962, three of these holders containing stainless and carbon steel coupons were discharged. The remainder were left charged for the duration of the test period.

2. Special Chemical Injection

Past experience of operating a loop at low temperature has revealed a high concentration of oxygen in the loop water. For this reason, a special test was initiated on April 4, 1963 which involved the use of hydrazine in an effort to reduce or eliminate the high oxygen content. Hydrazine solution made up in a head tank at a ratio of 30 ml hydrazine per gallon of water was added to the make-up water of KER-4 by means of an injection pump at a rate of 55 ml per minute. Simultaneously, a continuous feed and bleed of 1 gallon per minute was maintained on the loop. A maximum limit of 1 ppm hydrazine, authorized by PT IP-482-A, was specified for the test. Due to necessary outage work to be performed on the loop, the test was concluded on April 10, 1963.

V. Operating History

A. Fuel Element History

The fuel elements charged under Test K-4-14 accumulated a total exposure period of 4,243 hours during reactor operation. During this time, the loop operated a total of 2,685 hours at specified test conditions and 3,209 hours at high temperature (200 C and above). KER-4 accumulated 712 hours of single-pass operation (during reactor operation) between April 12 and May 12, 1963 due to primary pump failure. A total of 492 hours at less than desired run conditions was also accumulated during reactor operation when a high bearing temperature on recirculation pump #1 limited the temperature at which the loop could be operated. The duration of the test, as measured from original loading time to final discharge, was 5,499 hours. Table I points out the total hours as well as percentages of reactor operating time for the various phases of loop operation. Graph 1 shows the daily average tube outlet temperature, and Graph 2 illustrates the daily average tube differential temperature.

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B. Water Quality

Water quality during this test was maintained by means of routing a small portion of loop water through a clean-up system. Two ion columns, used to maintain control of pH and the purity of the water, contained XE-154 nuclear grade lithium-regenerated resin and XE-150, a neutral resin. The neutral resin, generally used for clean-up of the loop water following the transition from single-pass to recirculation operation, could also be used to lower the pH if necessary. On November 12, 1962, it was found necessary to replace the depleted XE-150 resin which had been in use since June 11, 1962. The depleted XE-154 resin was replaced on February 9, 1963 after having been in service since May 14, 1962.

Samples of the loop water, taken periodically, were analyzed by means of the wet chemical analysis and modified Winkler method for the purpose of determining impurity concentrations and dissolved oxygen content. Records were maintained on the concentrations of such impurities as silica, chloride, hydrogen peroxide, turbidity, total solids, iron and aluminum. Also recorded were specific resistance, pH and dissolved oxygen content.

C. Equipment Experience

1. Primary Pump Failures²

On December 1, 1962 during a reactor outage, the KER-4 recirculation pump (#368560) in position 2 registered an increase in top bearing temperature. Although no other indications of pump malfunction were indicated, it was replaced with pump #368562. Disassembly of pump #368560 disclosed a broken thermal barrier seal weld. This pump had been installed December 29, 1961 and accumulated 5,505 hours operating time in that position.

During normal operation of KER-4 on February 18, 1963, a high upper bearing temperature was noted on the #1 recirculation pump (#368558), and loop temperature was lowered slightly to prevent the bearing temperature from exceeding 60 C. This condition prevailed until the reactor outage of March 4, 1963, at which time the pump was removed from service and replaced with the repaired pump (#368560). Upon disassembly, pump #368558 was found to have a crack in the cooling water jacket adjacent to the thermal barrier. This pump had been installed on May 7, 1962 and accumulated 5,789 hours of operating time.

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On April 2, 1963 during normal loop and reactor operation, the KER-4 #1 pump suddenly dropped out; however, normal flow was maintained by the #2 pump. During the next reactor outage, the pump performed normally on a trial run but failed to start upon placing the loop in-reactor. An investigation revealed a fault-to-ground in the pump wiring, and it was replaced with a spare. Continued investigation did not indicate where the malfunction originated as further control circuit and drop-out tests revealed only that the contactors within the breaker had a tendency to cause single-phasing on the spare pump. These contactors had suffered slight damage previously and, consequently, it is believed that the pump failure was caused by the switch-gear failure.³ New silver-faced contacts were installed and additional tests have met with favorable results.⁴ The damaged pump was shipped to the Byron Jackson Company for necessary repairs. It had been in service since March 4, 1963 and had accumulated only 628 hours of operating time in position.

2. Instrument Power Circuit Malfunction

On February 13, 1963, a loose terminal in the I.P. power distribution panel caused a lead wire to arc and create blips on all instruments fed by that power source. The reactor scrambled due to an indicator trip on KER-4.

3. Main Loop Flow Control Valve Failure

On March 3, 1963, an increase over the normal flow was noted on the influent flow of KER-4 and could not be corrected as the flow control valve was already resting on the low flow stop. Inspection of the valve revealed an abnormal vibration and noise occurring within the valve assembly. On March 4, 1963, loop temperature was lowered to minimum when the vibration grew worse. When the valve was disassembled, it was found that the valve plug had become disengaged from the stem and had ruined the inner valve. A new stem, plug and seat were installed. To prevent any future recurrence of this nature, a locking pin was inserted through the plug and stem and the plug was then backwelded to the stem.

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4. Routine Maintenance

During Test K-4-14, the policy of replacing the pressurizer rupture disc once each month was carried out. The pressurizer relief valves were also inspected, replaced and set to 1560 psi on December 27, 1962 in accordance with the prescribed Process Standard.

Technician, Coolant Testing

KC Oberg:pb

References

1. HW-72269, "Production Test IP-477-A, Irradiation of N Reactor Fuel Elements in KER Loops 3 and 4", WK Kratzer, January 9, 1962 (Secret)
2. Pump Failure Reports 1-9, 2-10 and 2-11, RO Carlson, December 16, 1962, May 6, 1963 and April 22, 1963, respectively
3. Letter, "KER-4 #1 Pump and Switchgear Failure", RH Dalry to LV Barker, April 19, 1963
4. Letter, "KER-4 Pump #1 Switchgear", RH Dalry to LV Barker, May 8, 1963

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TABLE I

Loop Operating History

<u>Operating Condition - Reactor Operating</u>	<u>Hours</u>	<u>Per Cent of Reactor Operating Time</u>
Desired test conditions	2,685	63
Raising loop temperature following reactor startups	326	8
Lowering loop temperature prior to reactor shutdown	28	(less than 1)
Recirculation operation at less than desired test conditions due to equip- ment failures	492	12
Single-pass operation	<u>712</u>	<u>17</u>
Total	4,243	100
<u>Operating Condition - Reactor Down</u>	<u>Hours</u>	
Recirculation operation	608	
Single-pass operation	<u>648</u>	
Total	1,256	

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MARCH

APRIL

MAY

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GRAPH 1

TEST K-4-01

DAILY AVERAGE OUTLET

TEMPERATURE °C.

MARCH

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DECEMBER 15 20 25 JANUARY 5 10 15 20 25 FEBRUARY 5 10 15 20 25 MARCH 5 10 15 20 25 APRIL 5 10 15 20

New AE-150 tank was installed in the clean up ion column on Feb. 2, 1963 which reflects in a corresponding decrease of SiO_2 .

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GRAPH 6

July 3, 1963

TEST K-1-114

EGGF O₂ CONTENT ppm.

(*) High oxygen content during this period was caused by loop operation at minimum temperature due to a pump failure. The content of oxygen ranged from 12.0 to 15.8 ppm. during this portion of the test.

MARCH

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MARCH

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GRAPH 7

TEST K-4-14

LOOP H_2O_2 CONCENT. PPM.

NOTE: The high content of H_2O_2 commencing on April 2, 1963 was the result of lowering loop temperature to a minimum. Following the start of hydrazine addition to KXL-1 on April 4, 1963, a definite drop in concentration of H_2O_2 can be seen.

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