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KER-4 OPERATING REPORT
TEST K-4-15, PT IP-477-A
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KER-4 OPERATING REPORT
TEST K-4-15, PT IP-477-A
PT IP-477-A, SUPPLEMENT B

I. Introduction

The purpose of this test was to further evaluate the behavior of N Reactor fuel elements at conditions equivalent to or more severe than those expected at N Reactor.

II. Summary

- A. Date Charged: June 2, 1963
- B. Fuel Elements: A total of fourteen 23.2 inch NAEI elements with an enrichment of 0.947 per cent were charged.
- C. Exposure: The fuel elements were charged a total of 5,661 hours. Of this period, the reactor operated 3,841 hours and the loop was at desired operating conditions 3,292 hours or 86 per cent of reactor operating time.
- D. Date Discharged: January 24, 1964
- E. Reason for Discharge: Goal exposure reached

III. 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 NAEI elements
23-26	4	16-inch tubular perfs

B. Fuel Elements¹

The fuel elements 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 were 2.404 inch OD, 1.758 inch ID with 0.020 inch Zr-2 jackets. The inner tubes were nominally 1.254 OD, 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 had 0.200 inch Zr-2 brazed end caps. The elements contained 0.947 per cent enriched uranium and were 23.2 inches in length.

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C. Spacers

The spacers used (commonly referred to as "perfs") were carbon steel cylinders measuring 16 inches in length with a 2.25 inch OD and a 1.98 inch ID. Each spacer is supported by four 0.44 inch diameter ball bearings at each end which makes the overall outer spacer support circle diameter of 2.67 inches.¹

D. Operating Conditions

The desired operating conditions for test K-4-15 were as follows:

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

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 throughout test K-4-15.

2. Use of NH₄OH for pH Control

From previous studies made, it has been found that Zr-2 may be susceptible to crevice corrosion during nuclear boiling in reactor water containing LiOH for pH control. Crevice corrosion probably does not occur in coolant containing NH₄OH. Although normal N Reactor operation will be without boiling, it is inevitable that some of the fuel elements in the reactor will at times be subjected to nucleate boiling conditions.² Under Supplement B, PT IP-477-A, a test program was begun on December 16, 1963 using NH₄OH as a means of pH control throughout the remainder of test K-4-15. A feed solution, made up of 20 ml stock solution NH₄OH per gallon of water, was injected into the loop make-up water by means of an injection pump with adjustable stroke control. Simultaneously, a continuous feed and bleed was maintained on the loop for the purpose of maintaining high purity quality of the loop water and a desired pH control.

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IV. Operating History

A. Fuel Element History

The fourteen NAE1 fuel elements, charged under test K-4-15, accumulated a total exposure period of 3,842 hours during reactor operation. Of this time, the KER-4 loop operated a total of 3,292 hours at specified test conditions and was never on single-pass operation during reactor operation. A total of 50 hours was accumulated at less than desired test conditions during reactor operation as a result of equipment failures. The duration of the test, as measured from the time of loading to final discharge was 5,661 hours. Final discharge was accomplished by expelling the fuel elements into a special tray in accordance with procedures developed by KE Maintenance Operation. Table 1 lists the total hours and percentages of reactor operating time for the various phases of loop operation.

B. Water Quality

Prior to the use of NH_4OH for pH control, water quality was maintained by means of routing a small portion of loop water through a clean-up system. Two ion columns, one containing XE-150 (a neutral base resin) and the other containing XE-154 (a nuclear grade lithium-regenerated resin) were used for maintaining water purity and pH control. On November 15, 1963, it was necessary to replace the depleted XE-154 with new resin. IRC-50 resin was substituted for the XE-154 and is also a nuclear grade lithium-regenerated resin. The neutral XE-150 resin, originally charged on November 12, 1962, was suitable for use throughout this entire test.

Samples of loop water taken periodically were processed and analyzed in the 1706-KE laboratory. Sample data records were maintained on pH, specific resistance, oxygen, NH_3 , SiO_2 , chlorides, H_2O_2 , total solids, and turbidity.

C. Equipment Experience

1. Raw Water Pump Failure

On June 17, 1963, the failure of a raw water pump which supplies water to the primary heat exchangers of the KER loops left the heat exchangers with only the back-up service water supply to serve as coolant. The loop temperature was lowered 10 C as a precautionary measure for a period of five hours until raw water service was again restored.

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2. Air Operated Valve Diaphragm Failure

A reactor scram occurred on July 14, 1963 when the KER-4 emergency storage tank air operated valve diaphragm failed, permitting the valve to open and route loop flow through the emergency storage tank. The sudden change of flow resulted in a surge of pressure on the effluent end of the reactor tube causing the high pressure dump indicator to trip. Immediately, the dump valve opened, dumping the loop, and the reactor scrammed. Later investigation revealed that the pressure regulating valve supplying air to the emergency storage tank valve diaphragm had failed first and the additional air pressure was actually responsible for the emergency storage tank valve diaphragm failure. To prevent recurrence of this nature new pressure regulating air valves were installed and an improved type of diaphragm was installed in all critical air operated valves throughout the KER-4 loop and other KER loops as well.

3. Primary Pump Replacement

Vibration activity was noted to be increasing on pump No. 368562 prior to a scheduled reactor outage on October 8, 1963 and although there were no other indications to signify a pending pump failure, the pump was removed from service for inspection and replacement of modified thrust bearings. When disassembled, it was found to be in good condition and revealed only the normal amount of wear. Pump No. 368562 acquired a total of 5,385 hours of service in the No. 2 position of KER-4 before being replaced with pump No. 368561.³

4. Primary Pump Failure

On December 27, 1963, pump No. 368561, operating in the No. 2 position, performed erratically while the loop was at minimum operating conditions in conjunction with a special test in progress on another KER loop. It was removed from service and replaced with pump No. 368557 while the loop continued to recirculate in-reactor. When disassembled, pump No. 368561 was found to have a broken first stage impeller. It had operated a total of 1,298 hours in position and accumulated 3,223 hours of lifetime operation.

5. Main Loop Flow Air Operated Valve Malfunction

On December 15, 1963, while raising loop temperature, it became necessary to operate at a slightly reduced loop temperature for approximately 39 hours due to inadequate flow control. During the following reactor outage, the loop was placed on single-pass and the flow valve disassembled and repaired. A new plug and seat were installed and no further problems were experienced in later operating periods.

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6. Routine Maintenance

Mechanical and instrumental maintenance was carried out on a routine basis during test K-4-15. The pressurizer rupture discs were changed monthly and instruments and valves were inspected and calibrated under a prescribed program.

Technician, Coolant Testing

KC Oberg:smc

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. HW-75772, Supplement B, Production Test IP-477-A, Irradiation of N Reactor Fuel Elements in KER Loops 3 and 4, MJ Wise and WK Kratzer, November 29, 1962 (Secret).
3. CnT-3, Operating Experience Report - Testing Subsection, RO Carlson, dated October 17, 1963.
4. CnT-6, Operating Experience Report - Testing Subsection, RO Carlson, dated January 28, 1964.

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TABLE 1

LOOP OPERATING HISTORY

<u>Operating Condition - Reactor Operating</u>	<u>Hours</u>	<u>Per Cent of Reactor Operating Time</u>
Desired test conditions	3,292	86
Raising loop temperature following reactor startups	289	7.5
Lowering loop temperature prior to reactor shutdown	58	1.5
Recirculation operation at less than desired test conditions due to equipment failures	50	1
Recirculation operation at less than desired test conditions due to special requirements (special KER-2 test of NPR rupture monitor prototype)	152	4
Single-pass operation	<u>0</u>	<u>0</u>
Total	3,841	100

<u>Operating Condition - Reactor Down</u>	<u>Hours</u>
Recirculation operation	606
Single-pass operation	<u>1,213</u>
Total	1,819

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TABLE 2

SAMPLE DATA RESULTS - TEST K-4-15

		<u>June</u>	<u>July</u>	<u>Aug.</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>	<u>Dec.</u>	<u>Jan.</u>
Chlorides (ppm)	High	.06	.19	.17	.58	.28	.41	<.05	<.05
	Low	<.05	<.05	.06	.13	.13	<.05	<.05	<.05
	Normal	<.05	.08	.12	.33	.17	.07	<.05	<.05
H ₂ O ₂ (ppm)	High	.21	.19	5.25	2.05	---	1.05	<.1	<.1
	Low	<.1	.13	.25	.1	---	<.1	<.1	<.1
	Normal	.08	.08	1.11	.76	.15	.18	<.1	<.1
SiO ₂ (ppm)	High	.60	3.76	2.54	1.85	---	1.4	.08	.23
	Low	.08	.94	.16	.22	---	<.01	.01	.01
	Normal	.41	2.34	1.70	1.16	.69	.16	.03	.12
O ₂ (ppm)	High	2.30	2.88	3.40	6.88	6.0	7.2	.52	.46
	Low	<.005	<.005	2.20	.10	5.2	<.005	<.005	<.005
	Normal	.77	1.24	2.60	3.58	5.57	2.97	.05	.03
pH (lab)	High	10.25	10.20	10.40	10.20	10.25	10.25	10.23	10.40
	Low	9.50	8.90	9.90	9.17	9.90	9.65	9.85	9.75
	Normal	9.98	9.91	10.04	9.90	10.00	9.97	10.07	10.10
Total Solids (ppm)	High	13.0	18.5	18.5	23.0	11.5	22.5	7.5	5.0
	Low	4.0	.1	3.0	2.0	6.0	2.0	<.5	<.5
	Normal	8.9	6.3	11.24	12.38	8.72	7.59	3.24	.98
Turbidity	High	4.0	8.0	2.6	10.0	.6	.8	2.0	.8
	Low	.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
	Normal	.67	.88	.46	.84	.33	.12	.22	.12
Specific Resistance	High	317,750	122,000	48,600	54,700	152,000	89,000	70,000	81,000
	Low	24,290	28,900	28,500	31,800	38,000	30,000	22,000	19,000
	Normal	56,500	49,900	41.100	41,420	51.490	46,600	42,650	32,950
NH ₃ (ppm)	High						27.8		40.0
	Low						10.75		.25
	Normal						15.46		14.97

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TABLE 3SPECIAL DATA RESULTS ON SAMPLES K-4-15

		<u>Dec.</u>	<u>Jan.</u>
NH ₃ (ppm)	High	---	58.8
	Low	---	12.25
	Normal	10.0	16.74
N ₂ H ₄ (ppm)	High	44.0	---
	Low	3.5	---
	Normal	29.8	---
pH	High	10.25	10.45
	Low	9.70	9.20
	Normal	10.05	10.11
Total Solids (ppm)	High	9.0	2.5
	Low	3.2	.5
	Normal	5.23	1.5
Turbidity	High	2.50	1.2
	Low	.20	.1
	Normal	.45	.23
Specific Resistance	High	50,000	62,000
	Low	22,000	16,000
	Normal	34,670	31,600

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