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KER-4 OPERATING REPORT
TEST K-4-13
PT IP-477-A

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KER-4 OPERATING REPORT

TEST K-4-13

PT IP-477-A

IRRADIATION OF N REACTOR FUEL ELEMENTS IN KER LOOPS 3 AND 4

I. Introduction

The purpose of Test K-4-13 was to evaluate the behavior of N Reactor fuel elements at conditions equivalent to or more severe than those expected in N Reactor during Phase I, equilibrium operation. Specific objectives of Test K-4-13 were:

- 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.

II. Summary

- A. Date Charged: April 27, 1962
- B. Fuel Elements: Fourteen 23-inch NAE1, 0.947 per cent enriched uranium elements were charged.
- C. Exposure: The fourteen fuel elements were charged in KER-4 a total of 3796.5 hours. Of this time, the loop was at desired operating conditions 2049 hours or 54 per cent of total time charged and was at desired operating conditions 67.1 per cent of the time the reactor was operating.
- D. Date Discharged: September 25, 1962
- E. Reason for Discharge: The desired exposure for the elements had been attained.

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 perms
9-22	14	23-inch NAE1 elements
23-26	4	16-inch tubular perms

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B. Fuel Elements

The fuel elements consisted of two coextruded Zircaloy-2 jacketed self-supported uranium tubes concentrically oriented, 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 and 1.758 inch ID with 0.020 inch Zircaloy-2 jackets. The inner tubes were nominally 1.254 inch OD and 0.439 inch ID with a 0.035 inch Zircaloy-2 jacket on the outer surface and a 0.020 inch jacket on the inner surface. Both tubes had 0.020 inch Zircaloy-2 brazed end caps. The 23.2 inch long elements were 0.947 per cent enriched uranium.¹

C. Mock-up Tube

The twelve coupon holders containing test specimens of stainless steel, carbon steel, zirconium and Inconel, which were charged into the mock-up tube on March 6, 1962, were discharged on July 10, 1962. Immediately following, the mock-up tube was recharged with nine coupon holders containing test specimens of stainless steel, carbon steel, zirconium and Inconel.

D. Operating Conditions

The desired operating conditions for Test K-4-13 were:

1. Pressure: 1555 psi at tube outlet
2. Temperature: 285 C at tube outlet
3. Flow: 80,000 lb/hr indicated by inlet flow orifice
4. pH: 10.0 $\pm$ 0.5

E. Operating History

The duration of Test K-4-13 was 3796.5 hours, as measured from the time of charging, April 27, 1962, until the tube was discharged on September 25, 1962. The time the loop operated at various conditions is shown by Table I. Graph 1 shows the daily average tube outlet temperature, and Graph 2 shows the daily average tube temperature differential.

F. Water Quality

Water quality was maintained primarily by routing a portion of the main loop flow through an ion exchange column charged with XE-154 resin, a high pH LiOH regenerated resin. The flow through the ion column averaged 2.3 gpm during

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Test K-4-13. On May 14, 1962, it was necessary to change the XE-154 resin as the periodic samples of loop water contained high silicate and chloride ion content. Graphs 3 and 4 clearly indicate the depletion and fouling of the resin following breakage of the primary pump graphitar bearings. This resin had been in use since December 24, 1961. An alternate column charged with XE-150 resin, a neutrally regenerated resin, was used to clean up the loop water each time the loop was drained and refilled. This resin was also replaced on June 11, 1962 after being in use since December 24, 1961. Additional control of loop water pH was obtained by the addition of a concentrated LiOH (25 gram/liter) solution. The LiOH solution was added to the loop through bombs containing approximately 70 ml of LiOH solution. A total of 142 bombs or 258.5 grams of LiOH was added during Test K-4-13. The daily loop pH, shown on Graph 5, was obtained by using a temperature compensating potentiometer on the pH meter. Graph 5 also shows the loop pH as obtained by allowing the loop water sample to cool to room temperature before measuring the pH.

Periodic samples of the loop water were taken to determine the loop water quality. The impurity concentrations of the chloride, sulfate, silicate ions, hydrogen peroxide and total solids were obtained by wet chemical analysis. Table II shows the average loop impurity concentrations. Periodic samples were also taken to determine the dissolved oxygen content of loop water using the modified Winkler method. The loop water dissolved oxygen content is shown by Graph 6. The silicate and chloride ion concentrations are shown by Graphs 3 and 4, respectively. Hydrogen peroxide concentration, specific resistance, total solids and turbidity are shown by Graphs 7, 8, 9 and 10, respectively.

G. Test Termination

Test K-4-13 was terminated on September 25, 1962 as the tube charge had attained the desired exposure goal.²

H. Equipment Experience

1. On May 4, 1962, primary pump No. 1 failed due to a broken impeller.³ The loop temperature was reduced to minimum and held there until May 8, 1962 when the failed pump was replaced. Loop temperature was then returned to the desired operating condition.
2. On May 10, 1962, an appreciable increase in vibration and bearing temperature on primary pump No. 2 was noted. The pump was removed from service and the loop temperature again lowered to minimum. On May 11, 1962, during a trial run, the pump appeared normal so it was placed back in service and the loop temperature was raised to the desired operating condition.

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3. On May 12, 1962, the loop outlet temperature was lowered to 220 C as the loop strainers began to plug due to the graphitar particles that were spread through the loop when the primary pump impeller and bearings failed on May 4, 1962. On May 14, 1962, while the reactor was down, the loop was placed on single-pass and the loop strainers were cleaned and replaced.
4. On May 24, 1962, a rear face nozzle-to-gunbarrel leak developed during pressure testing of the reactor portion of the loop. Due to the lack of time to repair the leak before reactor startup, the loop remained on single-pass until the next reactor outage of June 21, 1962.
5. On June 25, 1962, a loop check valve, located in the Ball 3-x room, developed a leak and was subsequently repaired during the reactor outage of July 10, 1962.
6. On July 16, 1962, a rupture disc on the primary heat exchanger cooling water side was ruptured. Since the reactor was already down, replacement of the rupture disc required only that the loop be placed on single-pass operation.
7. On September 3, 1962, a leak was discovered on the primary heat exchanger 3-way valve grease plug. The loop outlet temperature was lowered slightly to permit inspection of the leak. The leak was found to be of a minor nature, so the loop temperature was again returned to the normal operating level. The leak was later repaired on September 6, 1962, during the following reactor outage, by replacing the plug and backwelding.
8. During Test K-4-13, the program of replacing the pressurizer rupture discs was continued on a once-per-month basis.

J. P. Davis

Technician, Coolant Testing

JP Davis:pb

References

1. HW-72269, "Production Test IP-477-A", W. K. Kratzer, January 9, 1962
2. Personal communication with W. K. Kratzer, September 24, 1962
3. Coolant Testing Unit Operating Experience Report, R. O. Carlson, July 2, 1962

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TABLE I
LOOP OPERATING TIME BREAKDOWN

<u>Condition</u>	<u>Hours</u>	<u>Per Cent of Total Time</u>
At Run Condition of 285 C Tube Outlet Temperature	2049.0	54.0
Raising Loop Temperature After Reactor Startup	274.5	7.3
Lowering Loop Temperature Before or After Reactor Scram or for Instrument Work	52.0	1.4
Recirculation In-Reactor with Reactor Down	405.0	10.4
Single-Pass Operation with Reactor Down	313.5	8.4
Single-Pass Operation with Reactor Operating	577.0	15.1
At Run Condition of 220 C Tube Outlet Temperature	32.5	0.9
Loop at Minimum Temperature with Reactor Operating	93.0	2.5
Total	3796.5	

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TABLE II
AVERAGE LOOP IMPURITY CONCENTRATIONS

Chloride	< 0.05 ppm
Hydrogen Peroxide	1.7 ppm
Silica Dioxide	0.47 ppm
Oxygen	2.27 ppm
Total Solids	10.7 ppm
Turbidity	1.1 ppm
Sulfate Ion (SO_4) ⁼	< 0.5 ppb
Specific Resistance	687,640 ohm/cm

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GRAPH 3
TEST K-4-13 SiO_2 ppm.

SEPTEMBER

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GRAPH 4
TEST K-4-13

CHLORIDE ppm.

0.7

0.6

0.5

0.4

0.3

0.2

0.1

<0.05

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GRAPH 5

TEST K-4-13

AVERAGE LOOP pH

11.0

10.5

10.0

9.5

9.0

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GRAPH 7

TEST K-4-L3

LOOP H_2O_2 CONTENT ppm.

4.0

3.0

2.0

1.0

0.9

0.8

0.7

0.6

0.5

0.4

0.3

0.2

0.1

0.1

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GRAPH 9

TEST K-4-13

TOTAL SOLIDS ppm.

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25 5 10 15 20 25 5 10 15 20 25 5 10 15 20 25

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GRAPH 10

TEST K-4-13

RELATIVE TURBIDITY ppm.

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END