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NATIONAL
LABORATORY

**Oak Ridge Research Reactor
Quarterly Report
January, February, and
March 1981**

S. S. Hurt, III
E. D. Lance

OPERATED BY
UNION CARBIDE CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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OPERATIONS DIVISION

OAK RIDGE RESEARCH REACTOR QUARTERLY REPORT
JANUARY, FEBRUARY, AND MARCH 1981

S. S. Hurt, III
E. D. Lance

SPONSOR: J. H. Swanks
Director, Operations Division

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OAK RIDGE RESEARCH REACTOR QUARTERLY REPORT
JANUARY, FEBRUARY, AND MARCH 1981

S. S. Hurt, E. D. Lance

SUMMARY

The ORR operated at an average power level of 27.9 MW for 88.9% of the time during January, February, and March of 1981.

The reactor was shut down on seventeen occasions, seven of which were unscheduled. Reactor downtime needed for refueling, maintenance, and checks was normal, with the reactor remaining available for use 92.6% of the time.

Maintenance activities, both mechanical and instrument, were essentially routine in nature with the exception of one Reactor Instrumentation and Controls Design Change Memo and one Mechanical Design Change Memo.

Special tests or measurements completed during this quarter are reported in a summary entitled, "ORR Reactivity and Flux Comparisons between a 280 g, 45 Weight Percent Enriched Texas Instrument Fuel Element and a 265 g Standard 93 Weight Percent Enriched Texas Instrument Fuel Element."

POWER HISTORY

The power history for the quarter is displayed in Figs. 1-3.

OPERATIONS

The basic operating data presented in Table 1 indicates that the ORR operation for the quarter, except for operation at 27 MW by experimenter request, was normal as compared with recent experience.

Details relative to cycles of operation during the quarter are given in Table 2.

JANUARY 1981

ORNL-DWG 81-16674

FIG. 1

FEBRUARY 1981

ORNL-DWG 81-16675

FIG. 2

MARCH 1981

ORNL-DWG 81-16676

FIG. 3

Table 1. ORR Basic Operating Data
 Period: January, February, and March 1981

	This Quarter	Last Quarter	Year To Date	Jan thru Mar '80
Total energy, MWd	2,228.6	2,048.9	2,228.6	2,480.4
Average power, MW/operating h	27.9 ^a	28.7	27.9	29.9
Time operating, %	88.9	77.7 ^b	88.9	91.3
Availability, %	92.6	91.3	92.6	93.7
Reactor water radioactivity, $\frac{\text{c/min}}{\text{ml}}$ (av)	19,500	20,900	19,500	21,600
Pool water radioactivity, $\frac{\text{c/min}}{\text{ml}}$ (av)	330	288	330	560
Reactor water resistivity, ohm-cm (av)	1,799,000	1,663,750	1,799,000	1,671,000
Pool water resistivity, ohm-cm (av)	2,074,000	2,073,833	2,074,000	855,000
Fuel elements depleted	14	9	14	21
Average burnup of fuel ele- ments depleted, %	53.0	50.4	53.0	45.1
Shim rods depleted	2	2	2	2
Average burnup of shim rods depleted, %	77.1	79.0	77.1	75.0
Radioisotope samples	29	53	29	25
Research samples	0	0	0	0

^aAverage power low due to operating at 27 MW for OC-4 experiment.

^bTime operating lower than normal due to experiment.

Table 2. Cycles of Operation

Cycle No.	Date Begun	Date Ended	Accumulated Energy (MWd)
155	November 23, 1980	February 2, 1981	846.6 ^a
156	February 5, 1981	In progress	1,382.1

^aMWd this quarter.

FUEL USAGE AND INVENTORY

Fourteen fuel elements and two shim rods were declared spent during the quarter with an average burnup of 53.0% for the fuel elements and 77.1% for the shim rods. Thirty-six fuel elements and two shim rods were shipped to Savannah River Plant for chemical separation. Twenty-eight new fuel elements and two new shim rods were placed in service.

Other details of fuel usage and inventory may be found in Tables 1 and 3.

Table 3. ORR Fuel Status

	This Quarter	Last Quarter	Jan thru March '81	Jan thru Mar '80
Depleted fuel elements transferred for chemical separation	36	45	36	48
Average percent burnup of fuel elements transferred	48.5	44.9	48.5	52.7
New elements start of quarter	62	69	62	44
New elements received	28	19	28	21
New elements placed in service	28	26	28	26
New elements end of quarter	62	62	62	39
Special or test elements	21	21	21	27
Depleted shim rods transferred for chemical separation	2	6	2	4
Average percent burnup of shim rods transferred	74.2	75.7	74.2	77.3
New shim rod elements start of quarter	23	23	23	6
New shim rod elements received	0	0	0	7
New shim rod elements placed in service	2	2	2	2
New shim rod elements end of quarter	21	23	21	11

SHUTDOWNS AND POWER REDUCTIONS

Reactor downtime (power level $<N_L$) totaled approximately 240 hours. A summary of the shutdowns is given in Table 4, and details of each are contained in Table 5. Table 6 offers information relative to unscheduled shutdowns, while Table 7 offers information relative to power reductions which did not result in a shutdown.

Table 4. Summary of Shutdowns

Description of Shutdown	Number	Downtime (h)
<u>Scheduled</u>		
Regular, end of cycle	1	84.150
Regular, refueling	2	13.800
Special, refueling, and experiment	2	69.533
Special flux runs	<u>5</u>	<u>47.233</u>
Subtotal:	10	214.716
<u>Unscheduled</u>		
Equipment failure, experiment	<u>7</u>	<u>25.167</u>
Subtotal:	<u>7</u>	<u>25.167</u>
TOTAL:	<u>17</u>	<u>239.883</u>

Table 5. ORR Schedule Shutdowns, Details

Date	Duration	End Cycle	Remarks
1-7-81	8.667	155-E	The reactor was refueled.
1-15-81	27.400	155-F	The shutdown activities included: 1) refueling, 2) the temporary removal of OC-4 experiment, 3) the reinsertion of HFED experiment into the core, 4) the replacement of filters in the NOG east bank, and 5) the removal of six samples from the isotope stringer.
2-2-81	84.150	155-H	The shutdown activities included: 1) refueling, 2) the removal of MFE-5 experiment, 3) the reinsertion of the OC-4 experiment, 4) the replacement of batteries on Nos. 1 and 3 dc units, 5) the repairs to the No. 1 shim-rod drive unit, and 6) the installation of new charcoal filters for the cell ventilation filter pit.
2-5-81	4.167	-	The completion of flux run No. 156-AX4.
2-6-81	4.650	-	The completion of flux run No. 156-AX5.
2-6-81	6.133	-	The completion of flux run No. 156-AX6.
2-24-81	5.133	156-A	The reactor was refueled.
3-16-81	42.133	156-B	The shutdown activities included: 1) refueling, 2) the temporary removal of OC-4 experiment, 3) the installation of MFE-4A experiment, 4) the repair of a leak on the degasifier cation column, and 5) the preliminary testing for the new syphon-break system.
3-17-81	1.950	-	The end of HFED flux run No. 1
3-18-81	30.333	-	The completion of the HFED flux run No. 2.

Table 6. ORR Unscheduled Shutdowns, Details

Date	Duration	Erd Cycle	Remarks
1-7-81	2.017	-	The reactor was manually scrammed at 6 MW on a startup following refueling due to a foreign object on the HFED experiment (later determined to be the experiment's lifting arm). The experiment was removed from the reactor. An inspection of the experiment indicated that a lifting arm had broken, presenting no problem to the experiment.
1-19-81	0.067	-	The power sagged below N_L when low temperature setbacks were received from MFE-4A and MFE-5.
1-19-81	4.216	-	The setbacks which caused preceding shutdown could not be cleared in time to return the reactor to power (xenon poisoning). The reactor was refueled.
1-20-81	8.650	-	The loss of one of the two remaining thermocouples on MFE-4A experiment required that the reactor be manually scrammed. (It was previously determined that the experiment could not be run with less than two reliable thermocouples.)
1-20-81	1.150	-	The MFE-4A experiment lost two of the three thermocouples which had been repaired during the previous unscheduled shutdown. The reactor was reversed manually to subcritical state.
1-20-81	8.950	-	The reactor was manually scrammed when all repaired thermocouples were lost on MFE-4A. The experiment was removed from the reactor.
1-22-81	0.117	-	The reactor power sagged below N_L after a low pressure setback was received from MFE-5 experiment.

Table 7. Reductions in ORR Power not Resulting in Shutdowns

Date	Source of Signal	Type of Signal	Lowest Power (MW)	Comments
1-6-81	Servo control	Insert error	18	The servo system malfunctioned, lowering the power to 18 MW.
1-19-81	MFE-4A	Setback	12	The reactor was set back when a high temperature setpoint was reached due to a bad thermocouple.
2-1-81	South facility	Setback	21	A reactor setback resulted from a spurious high temperature signal (experiment piping).

INSTRUMENTATION AND REACTOR CONTROLS

The performance of the instrumentation for the complex was satisfactory and maintenance required is indicated in Table 8. There was one Instrumentation and Controls Design Change Memo completed during the quarter as shown in Table 9.

PROCESS SYSTEM

The performance of the process system was satisfactory and maintenance required is indicated in Table 10.

MECHANICAL COMPONENT

The performance of the mechanical components was satisfactory and only routine maintenance was required with the exception of No. 1 shim-rod drive unit as listed under mechanical components in Table 11. There was one Mechanical Design Change Memo initiated during the quarter as shown in Table 12.

EXPERIMENT FACILITIES, GASEOUS WASTE FILTERS, AND CORE CHANGES

Experiment facility usage is given in Table 13. Table 14 summarizes the results of efficiency tests of the various gaseous waste filters. The core configurations used during the quarter are shown in Figs. 4, 5, 6, 7, 8, 9, and 10.

Table 8. Maintenance and Changes, Instrumentation and Controls

Date	Component	Trouble	Corrective Action
<u>No. 2 Counting-Rate Channel</u>			
3-2-81	Count-rate recorder	Erratic readout	The count-rate meter was replaced.
3-5-81	Count-rate recorder	Erratic readout	The count-rate meter was replaced.
3-6-81	Count-rate recorder	Erratic readout	The count-rate meter preamplifier was replaced.
<u>No. 1 Log-N Channel</u>			
2-10-81	Ionization chamber	Chamber failure	A new chamber No. RS-C-1-1210, serial No. X-5922, IC-20138 was installed. Also a new power supply was installed as indicated in I&C Change Memo 117.
<u>No. 2 Log-N Channel</u>			
3-11-81	Log-N period	Erratic readout	The amplifier was replaced.
2-11-81	Log-N chamber	Saturation checks	The checks were in limits and the chamber placed in service.
2-10-81	Ionization chamber	Saturation checks	The checks were in limits and the chamber placed in service.

Table 8. Maintenance and Changes, Instrumentation and Controls (Cont'd)

Date	Component	Trouble	Corrective Action
<u>Servo Channel</u>			
1-6-81	Servo amplifier	Erratic behavior	The amplifier was replaced.
1-15-81	Servo chamber	Unsatisfactory saturation curve	The voltage was increased from 300 to 400 volts.
1-22-81	Ionization chamber	Chamber failure	The No. 2 safety chamber was connected to servo.
<u>Process Instrumentation Reactor Secondary Cooling System</u>			
3-12-81	pH recorder	Control range	The pH alarm setpoints were changed to a range of 7.0 to 7.5.
3-27-81	pH probes	Probe failure	The probes were replaced.
3-27-81	pH recorder amplifier	Erratic readout	The amplifier was replaced.

Table 9. Instrumentation and Controls Design Change Memo ORR-117

Title of Change	Reason for Change	Remarks
Compensated ion chamber power supply	Replacement of obsolete equipment	<p>The present compensated ion chamber power supply is a vacuum tube type and has no provisions for changing the output voltage to match the compensating and saturation characteristics of the present-day ion chambers.</p> <p>The vacuum tube power supply was replaced with a solid state unit with zener diode regulation. The output voltage taps are provided to allow adjustment of positive and negative voltages to permit proper match to the chamber operating characteristics. The first replacement was installed on the No. 1 Log-N channel this quarter.</p>

Table 10. Process Systems, Maintenance and Changes

Date	Component	Remarks
<u>Reactor Primary Water System</u>		
3-16-81	Degasifier demineralizer	A leak on the cation column was repaired.
<u>Reactor Secondary Cooling System</u>		
3-23-81	Bypass waterline	Two water leaks were repaired.
3-25-81	Bypass valve	The linkage to the valve was repaired.
<u>Emergency Cooling System</u>		
2-4-81	No. 1 dc unit	New batteries were installed.
2-5-81	No. 3 dc unit	New batteries were installed.
2-6-81	Nos. 1, 2, and 3 dc units	Alarm checks were made with satisfactory results.
<u>Emergency Electrical Systems</u>		
2-3-81	Diesel generator	The routine end-of-cycle load test was performed with satisfactory results.
2-6-81	Diesel generator	A new radiator module was installed.

Table 11. Mechanical Components

Date	Component	Remarks
2-3-81	No. 1 shim-rod drive unit	The following maintenance was completed: 1) a new seal was installed on the shock absorber assembly, 2) a new seal housing was installed, and, 3) the D-4 operator unit was replaced with the rebuilt E-5 operator unit.

Table 12. Mechanical Design Change Memo ORR-27

Title of Changes	Reason for Change	Remarks
Revision to syphon-break system - Addition of check valves at top of reactor tank	The syphon-break system will be revised so that it will be effective with the pool water at the normal operating level. New check valve(s) will be connected to the reactor tank above the core to provide cooling water from the pool should the syphon-break action occur. These changes are recommended in ORNL/CF-80/230, a report by S. Hodge dealing with the effects of hypothetical major leakage in the ORR primary system.	<p>Additional syphon-break lines will be installed with open ends above the normal pool level, and appropriate check valve(s) will be connected to the reactor tank. The check valve(s) will be open to the pool to allow pool water to cool the reactor should it become necessary.</p> <p>Appropriate instrumentation will be added to scram the reactor and stop (shut down) the main pumps upon indication of a large leak in the primary system. Changes related to instrumentation will be specified in a separate Instrumentation and Controls Design Change Memo.</p>

Table 13. Experiment Facility Usage

Facility	Access Flange	Date Installed	Date Removed	Description of Experiment	Division or Other Sponsor	
A-2	None	4-17-81		Long half-life fission products	Operations	
C-1	None	6-26-79		Isotopes (iridium samples)	"	
C-7		11-13-80	2-4-81	Cyclic stress materials fusion	Engineering Technology	
D-8	V-3	6-26-80		Gamma Thermometer Proof Test (GTIG)	"	"
E-3	V-7	6-8-80	1-20-81	Materials test fusion program	"	"
E-3	C-9	3-16-81		Materials test fusion program	"	"
E-5	V-6	11-10-80	1-20-81	Creep test (HTGR)	"	"
E-5	V-6	2-4-81	3-16-81	Creep test (HTGR)	"	"
E-7	V-5	10-21-80	1-7-81	Aluminum-base dispersion type fuel plates	"	"
E-7	V-5	1-15-81	2-4-81	Aluminum-base dispersion type fuel plates	"	"
Poolside Window	None	4-21-80		LWR Metallurgical Pressure Vessel Benchmark facility	"	"
Poolside Window	None	6-26-80		Pressure vessel simulator and dummy surveillance capsule B	"	"
HB-1	None	9-78		Neutron spectrometer	Solid State Physics	
HB-2	None	9-78		Neutron spectrometer	"	"
HB-3	None	11-1-58		Neutron diffraction experiment	"	"
HB-4	None	9-78		Neutron spectrometer	"	"
HB-6	None	4-76		Neutron small angle scattering	"	"
HN-3	None	11-59		Activation analysis	Analytical Chemistry	
HN-4	None	12-15-63		Neutron diffraction experiment	Instrumentation and Controls	

Table 14. Status of Filters - Gaseous Waste System

Type Filter	Bank Designation	Date Installed	Date Last Tested	Type Test	Retention Efficiency (%)
<u>Cell-Ventilation System</u>					
CWS	Overall ^a	North, 4-16-80 South, 1-12-75	3-6-81	DOP	99.981
Charcoal	Both banks	North, 9-16-74 South, 2-2-81	2-10-81	Elemental Iodine	99.99
Charcoal	Both banks	North, 9-16-74 South, 2-2-81	2-12-81	Methyl Iodide	99.97
<u>Basement Hood Exhaust</u>					
CWS	South	3-10-80	3-6-81	DOP	99.987
CWS	North	3-10-80	3-6-81	DOP	99.996
<u>Normal Off-Gas</u>					
CWS	West	11-10-80	3-6-81	DOP	99.993
Charcoal	West	11-10-80	11-12-80	Elemental Iodine	99.99
CWS	East	1-15-81	3-6-81	DOP	99.993
Charcoal	East	1-15-81	1-20-81	Elemental Iodine	99.99
Charcoal	West	11-10-80		Methyl Iodide	99.98
Charcoal	East	1-15-81	1-22-81	Methyl Iodide	99.98
<u>Pressurizable Off-Gas^b</u>					

^aThe CWS filters in the cell-ventilation system were checked in series.

^bThe POG system is on standby; therefore, all filter tests have been discontinued.

ORR LATTICE LOADING

For Fuel Cycles 155-E

	1	2	3	4	5	6	7	8	9
A	BE	¹³³ XE	F	F	F	F	F	BE	BE
B	BE	F	F	SR	F	SR	F	BE	BE
C	ISO	F	AL	F	F	F	E	F	BE
D	BE	F	F	SR	F	SR	F	E	BE
E	BE	F	E	F	E	F	E	F	BE
F	BE	F	F	SR	F	SR	F	F	BE
G	BE	BE	BE	BE	BE	BE	BE	BE	BE

<u>LATTICE COMPONENT</u>	<u>NUMBER</u>
Fuel (F)	<u>27</u>
Shim Rod (SR)	<u>6</u>
Beryllium (BE)	<u>22</u>
Experiment (E)	<u>5</u>
Xenon Sleeve (¹³³ XE)	<u>1</u>
Isotope Stringer (ISO)	<u>1</u>
Aluminum (AL)	<u>1</u>

Fig. 4. ORR Lattice Configuration - January 1, 1981 -
January 7, 1981

ORR LATTICE LOADING

For Fuel Cycles 155-F

	1	2	3	4	5	6	7	8	9
A	BE	¹³³ XE	F	F	F	F	F	BE	BE
B	BE	F	F	SR	F	SR	F	BE	BE
C	ISO	F	AL	F	F	F	E	F	BE
D	BE	F	F	SR	F	SR	F	E	BE
E	BE	F	E	F	E	F	F	F	BE
F	BE	F	F	SR	F	SR	F	F	BE
G	BE	BE	BE	BE	BE	BE	BE	BE	BE

<u>LATTICE COMPONENT</u>	<u>NUMBER</u>
Fuel (F)	<u>28</u>
Shim Rod (SR)	<u>6</u>
Beryllium (BE)	<u>22</u>
Experiment (E)	<u>4</u>
Xenon Sleeve (¹³³ XE)	<u>1</u>
Isotope Stringer (ISO)	<u>1</u>
Aluminum (AL)	<u>1</u>

Fig. 5. ORR Lattice Configuration - January 7, 1981 -
January 15, 1981

ORR LATTICE LOADING

For Fuel Cycles 155-G

	1	2	3	4	5	6	7	8	9
A	BE	^{133}Xe	F	F	F	F	F	BE	BE
B	BE	F	F	SR	F	SR	F	BE	BE
C	ISO	F	AL	F	F	F	E	F	BE
D	BE	F	F	SR	F	SR	F	E	BE
E	BE	F	E	F	AL	F	E	F	BE
F	BE	F	F	SR	F	SR	F	F	BE
G	BE	BE	BE	BE	BE	BE	BE	BE	BE

<u>LATTICE COMPONENT</u>	<u>NUMBER</u>
Fuel (F)	<u>27</u>
Shim Rod (SR)	<u>6</u>
Beryllium (BE)	<u>22</u>
Experiment (E)	<u>4</u>
Xenon Sleeve (^{133}Xe)	<u>1</u>
Isotope Stringer (ISO)	<u>1</u>
Aluminum (AL)	<u>2</u>

Fig. 6. ORR Lattice Configuration - January 15, 1981 -
January 20, 1981

ORR LATTICE LOADING

For Fuel Cycles 155-H

	1	2	3	4	5	6	7	8	9
A	BE	^{133}XE	F	F	F	F	F	BE	BE
B	BE	F	F	SR	F	SR	F	BE	BE
C	ISO	F	AL	F	F	F	E	F	BE
D	BE	F	F	SR	F	SR	F	E	BE
E	BE	F	AL	F	AL	F	E	F	BE
F	BE	F	F	SR	F	SR	F	F	BE
G	BE	BE	BE	BE	BE	BE	BE	BE	BE

<u>LATTICE COMPONENT</u>	<u>NUMBER</u>
Fuel (F)	<u>27</u>
Shim Rod (SR)	<u>6</u>
Beryllium (BE)	<u>22</u>
Experiment (E)	<u>3</u>
Xenon Sleeve (^{133}XE)	<u>1</u>
Isotope Stringer (ISO)	<u>1</u>
Aluminum (AL)	<u>3</u>

Fig. 7. ORR Lattice Configuration - January 20, 1981 -
February 2, 1981

ORR LATTICE LOADING

For Fuel Cycles 156-A

	1	2	3	4	5	6	7	8	9
A	BE	¹³³ XE	F	F	F	F	F	BE	BE
B	BE	F	F	SR	F	SR	F	BE	BE
C	ISO	F	AL	F	F	F	AL	F	BE
D	BE	F	F	SR	F	SR	F	E	BE
E	BE	F	AL	F	E	F	F	F	BE
F	BE	F	F	SR	F	SR	F	F	BE
G	BE	BE	BE	BE	BE	BE	BE	BE	BE

LATTICE COMPONENTNUMBER

Fuel (F)

28

Shim Rod (SR)

6

Beryllium (BE)

22

Experiment (E)

2Xenon Sleeve (¹³³XE)1

Isotope Stringer (ISO)

1

Aluminum (AL)

3Fig. 8. ORR Lattice Configuration - February 6, 1981 -
February 24, 1981

ORR LATTICE LOADING

For fuel Cycles 156-B

	1	2	3	4	5	6	7	8	9
A	BE	¹³³ XE	F	F	F	F	F	BE	BE
B	BE	F	F	SR	F	SR	F	BE	BE
C	ISO	F	AL	F	F	F	AL	F	BE
D	BE	F	F	SR	F	SR	F	E	BE
E	BE	F	AL	F	E	F	E	F	BE
F	BE	F	F	SR	F	SR	F	F	BE
G	BE	BE	BE	BE	BE	BE	BE	BE	BE

LATTICE COMPONENTNUMBER

Fuel (F)

27

Shim Rod (SR)

6

Beryllium (BE)

22

Experiment (E)

3Xenon Sleeve (¹³³XE)1

Isotope Stringer (ISO)

1

Aluminum (AL)

3Fig. 9. ORR Lattice Configuration - February 24, 1981 -
March 16, 1981

ORR LATTICE LOADING

For Fuel Cycles 156-C

	1	2	3	4	5	6	7	8	9
A	BE	^{133}XE	F	F	F	F	F	BE	BE
B	BE	F	F	SR	F	SR	F	BE	BE
C	ISO	F	AL	F	F	F	AL	F	BE
D	BE	F	F	SR	F	SR	F	E	BE
E	BE	F	E	F	AL	F	E	F	BE
F	BE	F	F	SR	F	SR	F	F	BE
G	BE	BE	BE	BE	BE	BE	BE	BE	BE

<u>LATTICE COMPONENT</u>	<u>NUMBER</u>
Fuel (F)	<u>27</u>
Shim Rod (SR)	<u>6</u>
Beryllium (BE)	<u>22</u>
Experiment (E)	<u>3</u>
Xenon Sleeve (^{133}XE)	<u>1</u>
Isotope Stringer (ISO)	<u>1</u>
Aluminum (AL)	<u>3</u>

Fig. 10. ORR Lattice Configuration - March 19, 1981 -
March 31, 1981

SPECIAL TEST

ORR Reactivity and Flux Comparisons Between a 280 g, 45 Weight Percent, Enriched Texas Instruments Fuel Element and a 265 g Standard 93 Weight Percent Enriched Texas Instruments Fuel Element

Reactivity and flux measurements comparing a reduced enrichment Texas Instruments fuel element (element T-292X, 280 g, 45 weight percent enrichment) to a standard ORR element (element TX-264, 265 g, 93 weight percent enrichment) have been made in the ORR. The reactivity measurements were made by interchanging these elements in core position E-2 and using the critical position of the No. 6 control rod as a reactivity gauge. The 280 g reduced enrichment element was found to be slightly less reactive than the 265 g enriched standard (280 g worth is $-0.0265\% \Delta k/k$ with respect to the 265 g element). This difference is insignificant and is due to the increased U-238 content of the low enriched element (approximately 342 g of U-238 in the 280 g, 45 weight percent element as compared to approximately 20 g of U-238 in the 265 g, 93 weight percent element).

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