**Bulk Shielding Facility Quarterly Report
April, May, and June of 1978**

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E. D. Lance
J. R. Thomas

OAK RIDGE NATIONAL LABORATORY
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OPERATIONS DIVISION

BULK SHIELDING FACILITY QUARTERLY REPORT
APRIL, MAY, AND JUNE OF 1978

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SPONSOR: J. A. Cox
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November, 1978

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BULK SHIELDING FACILITY QUARTERLY REPORT

APRIL, MAY, AND JUNE OF 1978

S. S. Hurt, III, E. D. Lance, and J. R. Thomas

SUMMARY

The BSR operated at an average power level of 1,771 kW for 64.78% of the time during April, May, and June. Water-quality control in both the reactor primary and secondary cooling systems was satisfactory.

The BSR was operated at low and variable power during this quarter for 52.684 hours as part of the training programs for nuclear engineering students from the University of Tennessee and Mississippi State University.

The PCA was also used in the above-mentioned training programs and was operated on four occasions when Mississippi State University students actively participated in training laboratories. The PCA was also operated on sixteen occasions for the Pressure Vessel-Simulator Benchmark Experiment.

BULK SHIELDING REACTOR

Operations

During this quarter, the reactor operated primarily for the irradiation of research experiments. It was operated at low and variable power (3.72% of the operating time) to enable nuclear engineering students from the University of Tennessee and Mississippi State University to perform training labs described elsewhere in this report. Basic operating data for this period are given in Table 1.

Table 1. Basic Operating Data
(April, May, and June of 1978)

	This Quarter	Last Quarter	Year To Date
Total energy, kWd	104,326	120,697	225,023
Average power, kW/operating hr	1,771	1,952	1,862
Time operating, %	64.78	68.71	66.74
Reactor availability, %	75.63	88.88	82.26
Reactor water radioactivity, counts min ⁻¹ ml ⁻¹ (av)	2,067	2,226	2,146
Reactor water resistivity, ohm-cm (av)	1,082,000	1,035,000	1,058,000
Standard fuel elements, depleted	0	13	13
Control fuel elements, depleted	0	0	0
Research samples	71	96	167

Core loading 45 (Figure 1) was converted to core loading 46 (Figure 2) on April 18, 1978 for Low Temperature Irradiation Facility (LTIF) irradiations. Core 46 was accomplished by replacing fuel elements in CP-89 and in CP-79 with aluminum core pieces. Core loading 46 had an initial operating mass of 4,487 g which, when against the LTIF Experiment Complex, provided an excess reactivity of 4.77% $\Delta k/k$ (2.22% $\Delta k/k$ excess reactivity above xenon equilibrium). Core loading 46 was converted back to core loading 45 on April 24, 1978 after completion of the LTIF irradiations.

Core loading 45 was converted to core loading 47 (Figure 3) on May 4, 1978 to provide adequate excess reactivity for versatile operation. The initial operating mass (4,936 g ²³⁵U) of core loading 45 had been reduced to 4,869 g due to burnup, thereby reducing the excess reactivity from 5.25% $\Delta k/k$ to ~3.86% $\Delta k/k$ (1.31% $\Delta k/k$ excess reactivity above xenon equilibrium).

Core loading 47 was accomplished by installing four new control rod fuel elements and replacing two partially-depleted MTR-series and two

partially depleted USN-series fuel elements with four lighter weight partially depleted MTR-series fuel elements. Core loading 47 had an initial operating mass of 4,892 g which provided an excess reactivity of 5.20% $\Delta k/k$ (2.65% $\Delta k/k$ excess reactivity above xenon equilibrium).

Core loading 47 was temporarily converted to core loading 48 (Figure 4) on June 7, 1978 for LTIF irradiations. The initial operating mass (4,892 g ^{235}U) of core loading 47 had been reduced to 4,804 g due to burnup, thereby reducing the excess reactivity from 5.20% $\Delta k/k$ to 3.95% $\Delta k/k$ (1.40% $\Delta k/k$ excess reactivity above xenon equilibrium).

Core loading 48 was accomplished by replacing the MTR-series fuel element in CP-89 and the USN-series fuel element in CP-19 with two aluminum core pieces.

After completion of the LTIF irradiations, core loading 48 was converted to core loading 49 (Figure 5) on June 28, 1978 to provide excess reactivity for versatile operation. Core loading 49 was accomplished by removing the two aluminum cans in CP-79 and CP-89 (temporarily used for LTIF irradiations in core 48) and reinstalling the USN- and the MTR-series fuel elements used in core 47. Two partially depleted Bulk Shielding Reactor (BSR)-series fuel elements and two partially depleted MTR-series fuel elements were replaced with two partially depleted and two new USN-series fuel elements. The USN-series fuel element in CP-78 was moved to CP-88 and a Naval Research Laboratory (NRL) experiment installed in CP-78.

Core 49 had an initial operating mass of 4,978 g which provided an excess reactivity of 5.35% $\Delta k/k$ (2.80% $\Delta k/k$ excess reactivity above xenon equilibrium).

81	82	83	84	A1	FC	A1	A1	M-15-H 193
71	72	73	74	A1	A1	M-7-H 171	YZP 0046 195	YZP 0047 192
61	62	63	64	M-1-H 155	BSF-S-9 56	E NRL	BSF-S-10 56	M-2-H 152
51	52	53	54	YZP C042 198	M-13-H 171	M-6-H 170	M-14-H 166	YZP 003X 199
41	42	43	44	M-17-H 173	BSF-S-13 75	YZP 0044 200	BSF-S-14 74	M-12-H 178
31	32	33	34	M-20-H 189	M-10-H 165	M-16-H 167	M-11-H 159	M-19-H 189
21	22	23	24	M-196-D 148	BSF-S-11 59	YZP 0030W 199	BSF-S-12 58	M-323-A 146
11	12	13	14	A1 PLUG	M-9-H 170	M-18-H 193	M-8-H 171	M-3-H 149

BSR CORE

45
LOADING NO.
March 15, 1978
DATE
5.25%
EXCESS REACTIVITY
4,936 gm
OPERATING MASS

ROD POSITIONS AT CRITICAL (With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	9.80	11.00
2	9.80	11.00
3	9.80	11.00
4	9.80	11.00
5	23.00	11.00
6	23.00	11.00

REMARKS:

Figure 1. Core Loading 45 BSR

BSR CORE

46
LOADING NO.
April 18, 1978
DATE
4.77%
EXCESS REACTIVITY
4,487 gm
OPERATING MASS

ROD POSITIONS AT CRITICAL (With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	10.40	11.40
2	10.40	11.40
3	10.40	11.40
4	10.40	11.40
5	23.00	11.40
6	23.00	11.40

REMARKS:

Figure 2. Core Loading 46 BSR - Used for LTIF Experiment Runs

81	82	83	84	A1	FC	A1	A1	M-15-H 192
71	72	73	74	A1	A1	M-7-H 169	YZP 0046 193	YZP 0047 190
61	62	63	64	M-13-H 168	B-198-C 70	E NRL	B-199-C 71	M-14-H 163
51	52	53	54	YZP 0042 196	M-1-H 153	M-6-H 168	M-2-H 151	YZP 003X 197
41	42	43	44	M-17-H 170	BSF-S-15 96	M-20-H 186	BSF-S-16 96	M-12-H 176
31	32	33	34	M-5-H 153	M-10-H 158	M-16-H 164	M-11-H 156	M-4-H 156
21	22	23	24	M-196-D 146	BSF-S-13 73	M-19-H 187	BSF-S-14 72	M-323-A 145
11	12	13	14	A1 PLUG	M-9-H 165	M-18-H 191	M-8-H 170	M-3-H 148

EAST

D₂O

TANK

BSR CORE

47

LOADING NO.

May 4, 1978

DATE

5.20%

EXCESS REACTIVITY

4,892 gm

OPERATING MASS

ROD POSITIONS AT CRITICAL
(With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	9.75	11.18
2	9.75	11.18
3	9.75	11.18
4	9.75	11.18
5	23.00	11.18
6	23.00	11.18

REMARKS:

Figure 3. Core Loading 47 BSR

BSR CORE

48

LOADING NO.

June 7, 1978

DATE

4.60%

EXCESS REACTIVITY

~4,437 gm

OPERATING MASS

ROD POSITIONS AT CRITICAL (With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	10.76	11.75
2	10.76	11.75
3	10.76	11.75
4	10.76	11.75
5	23.00	11.75
6	23.00	11.75

REMARKS:

Figure 4. Core Loading 48 BSR - Used for LTIF Experiment Runs

81	82	83	84	A1	FC	A1	YZP 0046 190	M-15-H 190
71	72	73	74	A1	A1	M-7-H 167	E NRL	YZP 0047 188
61	62	63	64	M-13-H 165	B-192-C 69	E NRL	B-199-C 70	M-14-H 161
51	52	53	54	YZP 0042 192	M-1-H 150	YZP 0044 196	M-2-H 147	YZP 003X 193
41	42	43	44	YZP 0048 203	BSF-S-15 94	M-20-H 181	BSF-S-16 94	YZP 003Y 204
31	32	33	34	M-5-H 151	M-10-H 154	YZP 003W 196	M-11-H 152	M-4-H 153
21	22	23	24	M-16-H 160	BSF-S-13 72	M-19-H 183	BSF-S-14 71	M-6-H 165
11	12	13	14	A1 PLUG	M-9-E 166	M-18-H 188	M-8-H 167	M-3-H 146

BSR CORE

49

LOADING NO.

June 28, 1978

DATE

5.35%

EXCESS REACTIVITY

4,978 gm

OPERATING MASS

ROD POSITIONS AT CRITICAL (With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	9.54	10.71
2	9.54	10.71
3	9.54	10.71
4	9.54	10.71
5	23.00	10.71
6	23.00	10.71

REMARKS:

Figure 5. Core Loading 49 BSR

Shim-Rod Calibrations

The BSR shim rods were calibrated after core loading 47 had been established. The total worth of all six rods was found to be 11.404% $\Delta k/k$. The operating limit requirement that the reactor be operated with the ganged rods (all six) withdrawn at least 50% of their worth thus required that the rods be >10.60 in. withdrawn (all six rods ganged) when the reactor becomes critical for power operation. With rods 5 and 6 at 23 in. withdrawn, rods 1, 2, 3, and 4 can be withdrawn (ganged) to 9.10 in. to comply with the same operating limit.

Calibration of the shim rods was spot checked and No. 6 shim rod was completely recalibrated after core loading 49 had been established. The total worth of all six rods was found to be 11.045% $\Delta k/k$. The operating limit requirement that the reactor be operated with the ganged rods (all six) withdrawn at least 50% of their worth thus required that the rods be ≥ 10.60 in. withdrawn (all six rods ganged) when the reactor becomes critical for power operation. With rods 5 and 6 at 23 in. withdrawn, rods 1, 2, 3, and 4 can be withdrawn (ganged) to 9.40 in. to comply with the same operating limit.

Shutdowns

There were three unscheduled shutdowns during the quarter: one from experiment setback, one when No. 2 rod dropped, and one from a false fast scram signal from the period sigma amplifier. Table 2 is a list of both scheduled and unscheduled shutdowns.

Table 2. Analysis of Shutdowns

Description of Shutdown	Number	Downtime (hrs)
Scheduled		
Experimenters:		
No request to operate	3	75.317
Experiment insertion, removal, or data taking	9	161.283
Reactor Operations:		
ORNL Family Day	1	17.117
Decay for refueling	2	118.750
Refueling critical runs	10	33.183
Shim-rod calibrations	2	1.333
BSR quarterly shutdown and maintenance	6	360.716
Xenon override experiment	<u>2</u>	<u>0.367</u>
<u>Subtotal:</u>	35	768.066
Unscheduled		
Experimenters:	1	0.167
Reactor Operations:	<u>2</u>	<u>0.700</u>
<u>Subtotal:</u>	3	0.867
<u>TOTAL:</u>	<u>38</u>	<u>768.933</u>

Maintenance and Changes

Maintenance or changes to the instrumentation and mechanical components in the complex are listed in Tables 3 and 4.

Table 3. Maintenance and Changes, Instrumentation and Controls

Date	Component	Trouble or Change	Reason or Maintenance
4-12-78	No. 2 safety channel	Spiking	The recorder amplifier was replaced.
4-13-78	Counting-rate channel	Noisy	The pre-amp was replaced.
4-13-78	Log-N channel	Fast false scram signal from the period sigma amplifier	A faulty noise filter register was replaced.
4-14-78	Safety trouble monitor	Routine check	A faulty R-6 relay in the safety trouble monitor was replaced.
4-19-78	Facility radiation and contamination monitoring system	Routine	Bimonthly checkout.
4-24-78 through 5-1-78	Instrumentation	Routine	Quarterly checks.
4-25-78	Log-N channel	The Log-N amplifier did not meet specifications	The amplifier was retubed.
5-1-78	Sola transformers	Preventive maintenance	Installed two new sola transformers for L-21 and L-22. Temporarily connected a recorder to monitor the output of the sola for L-21 to the three safety and Log-N sigma amplifiers.

Table 3. (Continued)

Date	Component	Trouble or Change	Reason or Maintenance
6-7-78	Facility radiation and contamination monitoring system	Routine	Bimonthly checkout.
6-7-78	Servo channel	Faulty demand meter braking action	The servo demand motor brake power supply was repaired.
6-7-78 through 6-9-78	Servo channel	I & C design change memo BSR - 2 MW - 49	To upgrade the BSR servo drive mechanism, the two electro-mechanical relays in the drive motor circuit (K-10 and K-23) were replaced with solid-state relays. The new K-23 failed twice and was replaced. However, during reactor operation the relays did not function properly, resulting in two decreases in power from 1200 kW to 1130 kW and 600 kW; so the reactor was shutdown for further investigation.
6-12-78 and 6-13-78	Servo channel	I & C design change memo BSR - 2 MW - 49	The solid state relays K-10 and K-23 were replaced by electro-mechanical relays, which restored the system to the condition existing prior to the above stated change.
6-13-78	Regulating rod position recorder	Drive motor coupling slipping	Replaced the coupling on the drive motor to the pot and span lower limit switch.
6-19-78	Log-N channel	Would not calibrate	Replaced the Log-N amplifier.

Table 4. Maintenance and Changes, Mechanical System

Date	Component	Trouble or Change	Reason or Maintenance
4-24-78	Shim-rod assemblies Nos. 1, 2, 3, 4, 5, and 6	Routine inspection	The shim-rod assemblies were removed to the underwater work platform for inspection as follows: (1) visual inspection - no evidence of cracks, (2) straight-edge inspection - results satisfactory, (3) gauged, using 0.010 and 0.020 in. oversized gauges and feeler gauges - results satisfactory. Rust was cleaned from the armatures and magnets. The clutch switches were cleaned and the guide tubes brushed.
4-25-78	Shim-rod drive assembly No. 6	Insulation on the clutch switch leads deteriorated	A new clutch switch and new leads were installed.
6-7-78	Shim-rod drive assembly No. 2	Clutch switch failed	The rod drive unit was removed and a new clutch switch installed.

Fuel

Changes in the fuel inventory are reflected in Table 5.

Table 5. Fuel and Shim Rod Status

	This Quarter	Last Quarter	Year To Date
Fuel elements depleted	0	13	13
Control-rod fuel elements depleted	0	0	0
New fuel elements placed in service	2	4	6
New control-rod fuel elements placed in service	4	0	4
New fuel elements available for use	6	8	6
New control-rod fuel elements available for use	2	6	2
Partially depleted fuel elements available for use	4	2	4
New shim rods placed in service	0	0	0
Boron stainless steel shim rods in use	6	6	6
Boron stainless steel shim rods available for use	2	2	2

Experiment Facilities Assignment

Facility assignments are listed in Table 6. The tubes of the east D₂O tank are not permanently assigned; they are used by various laboratory personnel for short-term sample irradiations.

Table 6. Facilities Assignment

Facility	Location	Division or Sponsor
Liquid helium cryostat	Southwest corner of pool using west D ₂ O tank	Solid State
Liquid nitrogen cryostat	On instrument bridge	Solid State
Ambient temperature facility	North face of core	Solid State
Heavy Section Steel Experiment	North and west face of core	Metals and Ceramics
Fast-neutron tube	Core position 15	Solid State
Water-cooled tube	Core position 15	Solid State
Dry thermal-neutron tubes ^a (D-3-1 and -2)	East D ₂ O tank	Operations
Wet thermal-neutron tubes ^a (D-4-1 and -2, D-6-1, -2, -3, -4, and -5)	East D ₂ O tank	Operations

^aThese facility tubes are for sample irradiations and are used by personnel of several divisions, primarily Analytical Chemistry and Solid State Divisions.

Demineralizer Performance

Table 7 gives detailed information on the condition of the primary water system for the preceding year and pertinent data on the performance of the bypass demineralizer.

Table 7. Demineralizer Performance Data

Run No.	Initiation Date	Termination Date	Throughput (gallons)	Gross Gamma (Counts min ⁻¹ ml ⁻¹)		pH		Specific Resistance (ohm-cm)	
				In	Out	In	Out	In	Out
39	1-9-74	3-13-74	1,320,000	1,931	101	6.2	6.0	666,000	908,000
40 ^a	3-15-74	7-30-74	1,400,000	9	0	6.2	6.0	364,000	1,132,000
41	8-16-74	12-4-74	1,500,000	2,316	385	5.8	5.8	630,000	895,000
42 ^b	12-17-74	4-15-75	3,850,000	2,116	119	5.8	6.0	1,018,000	1,611,000
43	4-16-75	7-7-75	2,550,000	2,712	174	5.7	5.8	937,000	1,823,000
44	7-10-75	11-5-75	2,750,000	2,528	144	5.7	5.9	968,000	1,428,000
45	11-5-75	4-29-76	2,325,000	2,146	154	5.3	5.5	902,000	1,593,000
46	4-30-76	9-2-76	2,800,000	1,430	124	5.4	5.6	1,085,000	1,808,000
47	9-2-76	1-27-77	3,450,000	1,700	126	5.4	5.6	975,000	1,548,000
48	2-1-77	4-22-77	2,000,000	2,026	146	5.6	5.7	1,052,000	1,971,000
49	4-25-77	9-21-77	2,700,000	2,005	140	5.6	5.8	1,054,000	1,815,000
50	9-22-77	3-6-78	2,950,000	1,585	134	5.5	5.7	1,191,000	1,953,000
51	3-8-78	In Service	1,850,000	2,067	123	5.6	5.8	1,082,000	1,847,000

^aThe reactor was shut down during the entire run.

^bNew resin in the demineralizer column.

Special Tests

Efficiency Tests

Tests were performed by Quality Assurance and Inspection Department personnel on the cell ventilation filters. Details are given in Table 8.

Table 8. Efficiency Tests Results, Filters

Date	Unit	Type Test	Efficiency (%)
5-11-78	Center bank	Elemental iodine	99.92
5-16-78	North bank	Elemental iodine	99.99
5-16-78	South bank	Elemental iodine	99.99
6-22-78	North bank	Methyl iodide	19.31
6-22-78	Center bank	Methyl iodide	19.67
6-22-78	South bank	Methyl iodide	40.19

Special Programs

The University Engineering Department Experiments

The BSR was used for a training lab for university nuclear engineering students as described below.

Xenon Buildup and Decay Experiments

On April 7, 1978, and on May 19, 1978, following operation at 2 MW to achieve xenon equilibrium, the power level of the BSR was reduced to 4 kW to begin an experiment for students from Mississippi State University and the University of Tennessee to study the buildup and decay of xenon in the BSR core. The students performed all activities associated with the experiment under the direct supervision of an Operations Division

supervisor. The experiment was an exercise in: (1) maintaining the reactor critical at 4 kW, (2) determining the reactivity worth of a shim rod under varying concentrations of xenon, and (3) determining the reactivity worth of xenon in the core as a function of time.

Operational Activities

The operational activities for the quarter are reflected in Table 9.

Table 9. Operational Activities

Date	Remarks
4-24-78	All fuel elements including shim-rod fuel elements were visually inspected with satisfactory results.
5-1-78	The emergency electrical power quarterly test was completed with satisfactory results. The test was performed by turning the emergency power transfer switch (circuit 18 in electrical power panel DP-1) to "OFF", thereby starting the ORR diesel generator which supplied electrical power to designated circuits in the control and pool rooms.
5-1-78	The containment system quarterly functional checks were performed with satisfactory results.

POOL CRITICAL ASSEMBLY

Operations

The PCA was used 34.6 hours as an experiment facility for the benefit of nuclear engineering students from Mississippi State University. Operational activities in preparing the facility for use included a check-out of the reactor control instrumentation and preparation of the required loadings. The operational activities are listed in Table 10 (Usage of Pool Critical Facility). The PCA maintenance is listed in Table 11.

Table 10. Usage of Pool Critical Facility

Date	Operational Activity	Purpose	Hours Used
4-3-78 and 4-4-78	Established cores Nos. 227 and 228 to obtain a critical mass following the standard approach-to-critical procedures.	Training lab for Mississippi State University nuclear engineering students.	18.7
4-5-78	Established core No. 77 to permit calibration of the regulating rod and the performance of the importance function experiment.	Training lab for Mississippi State University nuclear engineering students.	15.9

Table 11. PCA Maintenance

Date	Component	Trouble or Change	Action
4-5-78	Monitron No. 2	Spiking	The monitron was retubed to correct the trouble.
4-13-78	No. 3 shim rod	The shim rod would not withdraw	The No. 3 shim-rod assembly was removed and the armature which had come loose from the shim rod was repaired.
5-4-78 through 5-12-78	Instrumentation	Routine	Quarterly checks.
5-5-78	Servo channel	Faulty power supply	A resistor and a capacitor were replaced in the power supply to correct the trouble.
5-11-78	No. 1 seat switch	Did not meet electrical leakage specifications	The shim-rod assembly was removed and a new seat switch was installed.

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