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BULK SHIELDING FACILITY QUARTERLY REPORT APRIL, MAY, AND JUNE OF 1973

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OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION • FOR THE U.S. ATOMIC ENERGY COMMISSION

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OAK RIDGE NATIONAL LABORATORY
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UNION CARBIDE CORPORATION
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SUMMARY

The BSR operated at an average power level of 1,805 kw for 47.11% 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 106.750 hours as part of the training programs for nuclear engineering students from the University of Tennessee and for Tennessee Valley Authority (TVA) personnel from Browns Ferry.

The PCA was also used in the above-mentioned training programs and was operated on nine occasions when TVA personnel or University of Tennessee students actively participated in training laboratories.

BULK SHIELDING REACTOR

Operations

During this quarter, the reactor operated 47.11% of the time primarily for the irradiation of research experiments. It was operated at low and variable power (10.38% of the operating time) to enable nuclear engineering students from the University of Tennessee and TVA personnel from Browns Ferry 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 through June, 1973)

	This Quarter	Last Quarter	Year To Date
Total energy, kwd	77,352	35,182	112,534
Average power, kw/operating hr	1,805	1,477	1,641
Time operating, %	47.1	26.5	36.8
Reactor availability, %	94.1	93.0	93.6
Reactor water radioactivity, counts min^{-1} ml^{-1} (av)	1,962	1,275	1,618
Reactor water resistivity, ohm-cm (av)	900,000	995,000	948,000

Table 1. (Continued)

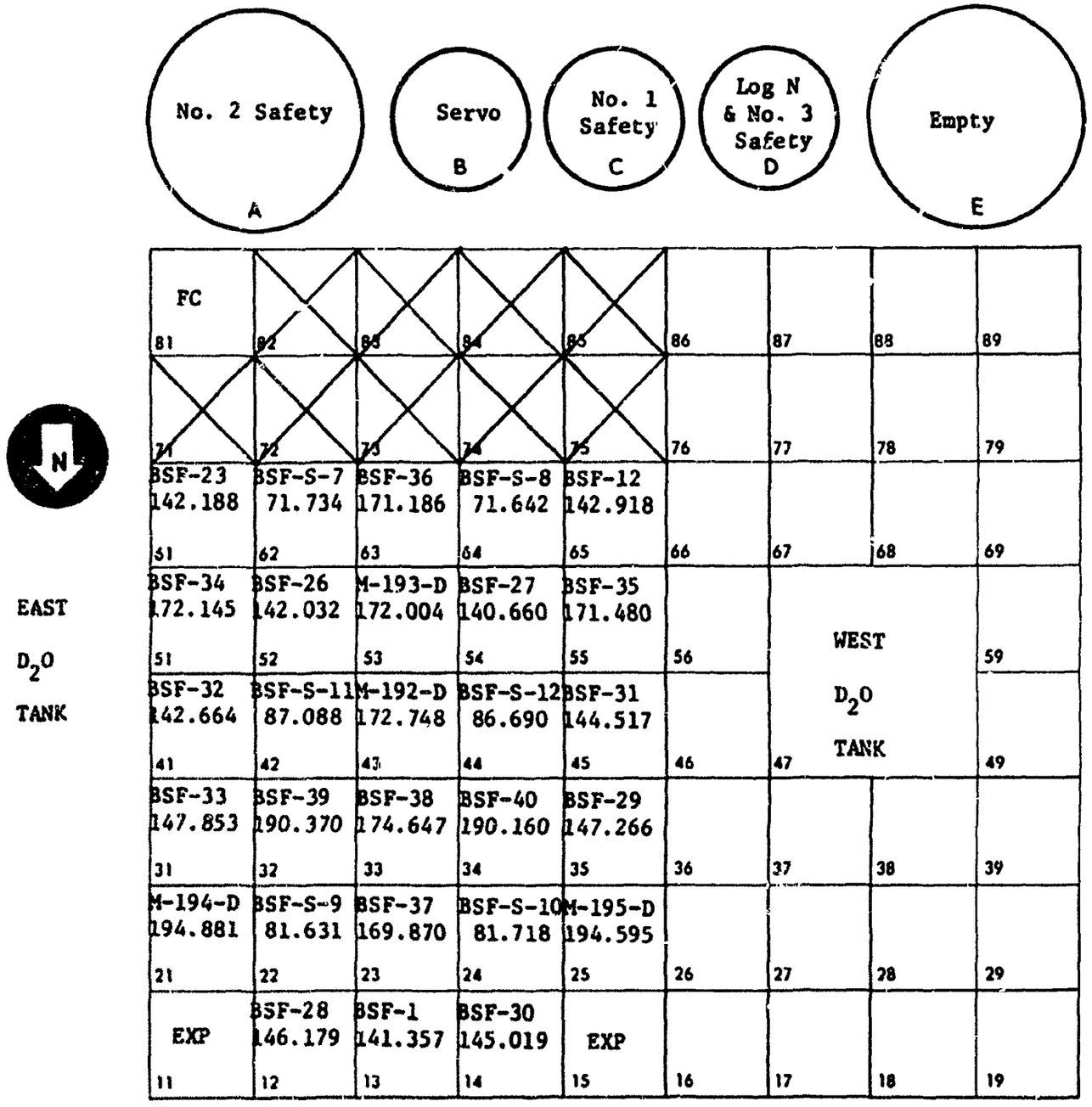
	This Quarter	Last Quarter	Year To Date
Standard fuel elements depleted	2	0	0
Control fuel elements depleted	0	0	0
Research samples	47	22	69

Core loading 23 (Figure 1) was replaced by core loading 24 (Figure 2) on April 24, 1973, to provide adequate excess reactivity for versatile operation. The initial operating mass (4037.242 g ^{235}U) of core loading 23 had been reduced to 3951.063 g due to burnup, thereby reducing the excess reactivity from 5.28% Δk/k to ∿4.12 Δk/k (∿1.57% excess reactivity above xenon equilibrium).

Core loading 24 was accomplished by replacing two depleted BSF-series fuel elements with new LITR-series fuel elements. Core loading 24 had an initial operating mass of 4076.520 g which provided an excess reactivity of 5.53% Δk/k (2.98% Δk/k excess reactivity above xenon equilibrium). At the end of the quarter, the excess reactivity was ∿4.60% Δk/k (∿2.05% Δk/k excess reactivity above xenon equilibrium).

Shutdowns

There were no unscheduled shutdowns during the quarter. Table 2 gives an analysis of the scheduled shutdowns.



ORNL DWG. 73-6050

BSR CORE

23
LOADING NO.

November 15, 1972
DATE

Excess Reactivity - 5.28%
CRITICAL MASS

4037.242
OPERATING MASS

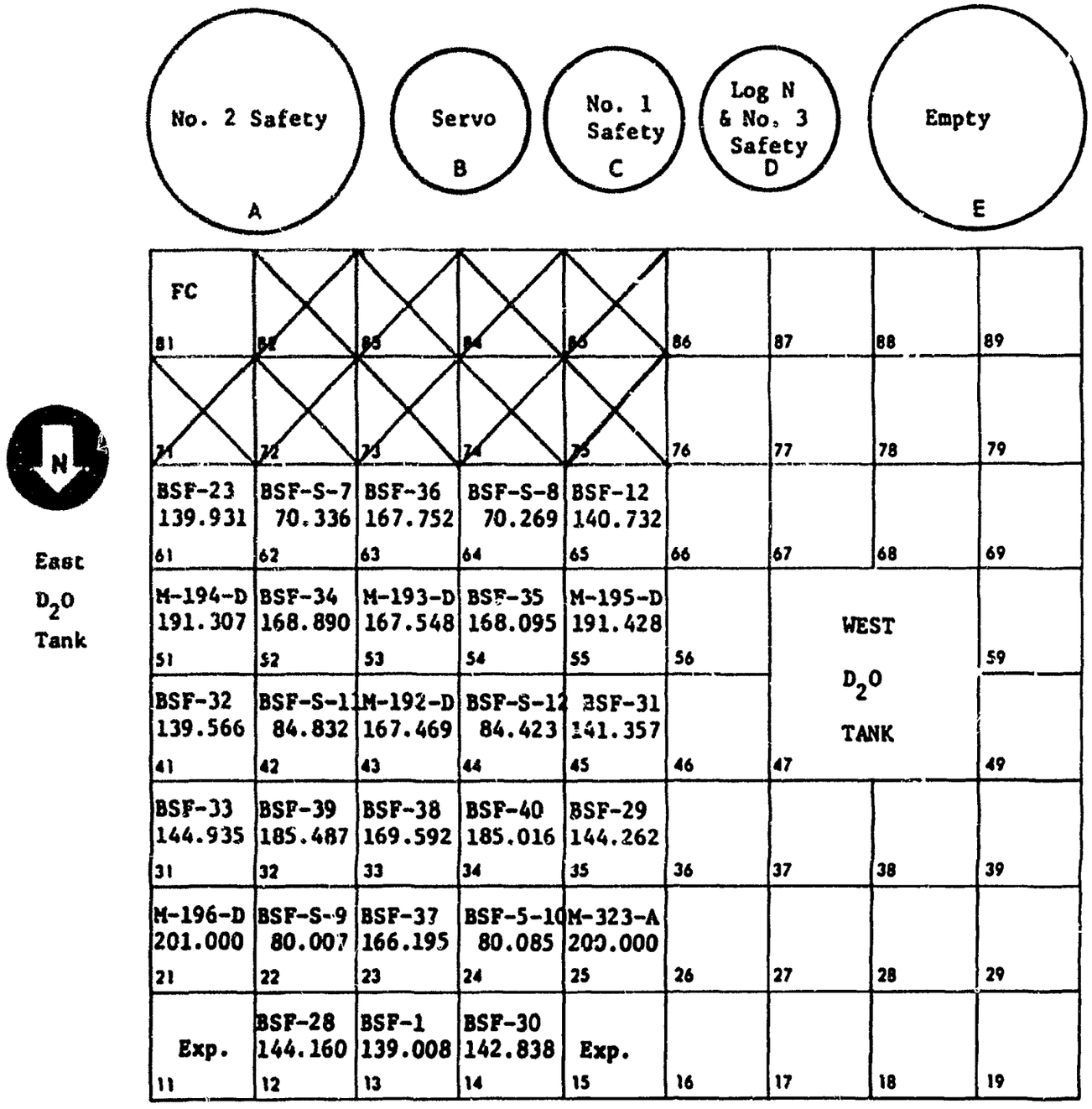
ROD POSITIONS AT CRITICAL
(With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	10.23	11.38
2	10.23	11.38
3	10.23	11.38
4	10.23	11.38
5	23.00	11.38
6	23.00	11.38

REMARKS:

Kwhr at beginning - 42,859,864

Fig. 1. Core Loading 23 - BSR



ORNL DWG. 73-11192

BSR CORE

24
LOADING NO.

April 24, 1973
DATE

Excess Reactivity - 5.53%
CRITICAL MASS

4076.520
OPERATING MASS

ROD POSITIONS AT CRITICAL
(With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	9.86	11.18
2	9.86	11.18
3	9.86	11.18
4	9.86	11.18
5	23.00	11.18
6	23.00	11.18

REMARKS:

Kwhr at beginning - 44,494,900

Fig. 2. Core Loading 24 - BSR

Table 2. Analysis of Shutdowns

Description of Shutdown	Number	Downtime (hrs)
Scheduled		
Experimenters:		
No request to operate	19	1,026.802
Repositioning of the reactor	2	0.600
Experiment insertion or removal	5	11.451
Subtotal	26	1,038.853
Reactor Operations:		
Refueling critical runs	3	19.916
Special	1	5.400
Quarterly instrument checks	1	72.483
TVA personnel training	53	10.700
University students training	3	7.216
Subtotal	61	115.715
Unscheduled		
Experimenters	0	0.000
Reactor Operations	0	0.000
Subtotal	0	0.000
Total	87	1,154.568

Maintenance and Changes

Changes made in the reactor control instrumentation to improve operating conditions are documented by the BSR control-change-memoranda system. Those changes which were made during this report period are listed in Table 3. Maintenance or changes on the instrumentation and mechanical components in the complex are listed in Tables 4, 5, and 6. Table 7 presents the status of the ionization and fission chambers.

Fuel

Changes in the fuel inventory are reflected in Table 8.

Table 3. Instrumentation and Controls Change Memoranda Completed During This Report Period

Change Memo No.	Subject	General Description
BSR-2MW-39	Slow scram circuits	The "Raise-Clutch" switch and the "Key" switch had contacts which operated both slow scram relays as well as interrupting magnet amplifier power. To eliminate duplication of slow scram functions which are felt to be unnecessary and in order to have closer compliance with C16-1T, the above-mentioned switch contacts were removed from the slow scram relay circuits. The magnet amplifier power circuit remains "as is" with no change.

Table 4. Maintenance and Changes, Instrumentation and Controls

Date	Component	Trouble or Change	Reason or Maintenance
4-2-73	Log-N channel	Excessive noise	The voltage regulator tube in the log-N amplifier was replaced to correct the condition.
4-11-73	Counting-rate channel	Excessive noise	The pre-amplifier was replaced.
4-11-73	Log-N channel	Excessive noise	The Log-N amplifier was replaced.
4-13-73	Counting-rate channel	Excessive noise	The counting-rate meter was replaced.
4-16-73	No. 1 TV Cohu receiver	Loss of picture	The high voltage wire was replaced.
4-19-73	Counting-rate channel	Excessive noise	The counting-rate meter was replaced.
4-23-73	Decay tank gamma monitor	Downscale drift	The faulty gamma monitor was replaced with a spare unit.
5-7-73 5-8-73 5-9-73	Instrumentation	Routine	Quarterly checks were made.
5-8-73	"Raise-Clutch" switch and "Key" switch	Made changes in accordance with Reactor Instrument and Controls Design Change Memorandum No. BSR-2MW-39	The "Raise-Clutch" switch and the "Key" switch have contacts which operate both slow scram relays as well as interruptions of the magnet power supply current. Since this duplication of scram function is unnecessary and in order to comply with C16-1T, the following change was made: the "Raise-Clutch" switch and the "Key" switch contacts were removed from the slow scram relay circuit. The magnet power supply circuit remains as is with no change.

Table 4. (continued)

Date	Component	Trouble or Change	Reason or Maintenance
5-9-73	Northwest monitron (pool room)	Inoperative	Two faulty diodes were replaced.
6-5-73		Routine	The quarterly check was performed.

Table 5. Maintenance and Changes, Mechanical System

Date	Component	Trouble or Change	Reason or Maintenance
4-19-73	Secondary basin float controlled water makeup valve	Improper operation	The valve was removed, cleaned, a new grease fitting installed, and the valve reinstalled.
5-7-73	Shim-rod assemblies No. 3 and No. 5	Routine inspections	The shim-rod assemblies were removed to the underwater work platform for inspection as follows: visual inspection--no evidence of cracks; straight edge inspection--results satisfactory; gauged using 0.010 in. and 0.020 in. oversized gauges--results satisfactory; rust cleaned from the armatures and magnets; cleaned the clutch switches; and brushed the guide tubes. See Appendix A for a detailed inspection report.
5-8-73	Shim-rod drive assembly No. 4	Sluggish action of the clutch switch push rod	The shim-rod drive assembly was removed for clutch switch assembly cleaning as follows: the clutch switch push rod was found to be somewhat tight in the magnet groove due to rust accumulation. The rust was cleaned from the groove to eliminate the condition.

Table 6. Maintenance and Changes, Process System

Date	Component	Trouble or Change	Reason or Maintenance
4-30-73	Skimmer pump	Excessive packing gland water leak	New packing glands were installed.
5-1-73	Demineralizer acid regenerant tank	Sight-glass tube plugged	The acid regenerant tank was cleaned.
5-6-73	Secondary tower basin	Routine cleaning and inspection	The tower basin was drained, cleaned, and refilled. A broken connection on the acid header was repaired.
6-8-73	Steam jet for sump in old vault	Inoperative	The steam jet was repaired.

Table 7. Status of Ionization Chambers

Chamber Serial No.	Location	Date Present Service Started	Previous Service	Remarks
		Chambers in Service		
CTC-3 (J-118)	Position A, No. 2 safety	10-8-69	LITR	The chamber was modified for underwater service in 1969.
PCP-III-106, SN-66-1	Position B, servo	1-29-68	None	The uncompensated section of this dual chamber failed on June 16, 1969, while in service as the No. 2 safety.
CTC-4 (C-771)	Position C, No. 1 safety	12-1-69	LITR	The chamber was modified for underwater service in 1969.
PCP-III-106, SN-66-4	ORR instrument shop	8-26-70	BSR	This dual chamber was installed in the BSR in June, 1969. In May, 1969, the uncompensated section failed. The chamber was removed for repairs. In August, 1970, the chamber was reinstalled in the BSR. In January, 1973, the chamber was removed from Position D for maintenance. The uncompensated section had an abnormal condition of not being fully saturated on saturation characteristic checks.

Table 7. (Continued)

Chamber Serial No.	Location	Date Present Service Started	Previous Service	Remarks
		Chambers Not in Service		
PCP-III-106, SN-66-3	Position D, Log-N and No. 3 safety	1-24-73	BSR and ORR	This dual chamber was installed in the BSR in December, 1967. In March, 1969, the chamber was removed for repairs due to failure of the uncompensated section. In November, 1969, the chamber was installed in the BSR. In April, 1970, the uncompensated section failed. In August, 1970, the compensated section failed. The chamber was removed for repairs. In May, 1971, the chamber was installed in the ORR. In November, 1971, the chamber was removed for repairs. In October, 1972, the chamber was installed in the BSR as a spare chamber. In January, 1973, the chamber was transferred from Position E (spare chamber location) to Position D for present service.
C-1045	CP-81, fission chamber	10-1-69	PCA	This fission chamber assembly was transferred to the BSR from the PCA in October, 1969.

Table 7. (Continued)

Chamber Serial No.	Location	Date Present Service Started	Previous Service	Remarks
CTC-2 (C-768)	BSR storage	August, 1970	LITR and BSR	The chamber was modified for underwater service in 1969. The chamber was installed in the BSR in April, 1970. In August, 1970, the chamber was removed to storage due to installation of a dual chamber. In January, 1973, the chamber was transferred to the ORR for service.
PCP (old type, no serial number)	Warehouse storage		BSR	This chamber is of the old type and will be repaired if needed.
CIC (No. 62)	BSR storage		BSR	This chamber is reserved for the PCA but can be used in an emergency for the BSR.
COC (No. 63)	BSR storage		BSR	This chamber is reserved for the PCA but can be used in an emergency for the BSR.
PCP (Q975, No. 2)	BSR storage		BSR	This chamber is reserved for the PCA but can be used in an emergency for the BSR.

Table 8. Fuel and Shim Rod Status

	This Quarter	Last Quarter	Year To Date
Fuel elements depleted	2	0	2
Control-rod fuel elements depleted	0	0	0
New fuel elements placed in service	2	0	2
New control-rod fuel elements placed in service	0	0	0
New fuel elements available for use	0	2	2
New control-rod fuel elements available for use	8	8	8
Partially depleted fuel elements available for use	0	0	0
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 9. The tubes of the east D_2O tank are not permanently assigned; they are used by various Laboratory personnel for short-term sample irradiations.

Table 9. Facilities Assignment

Facility	Location	Division or Sponsor
Liquid helium cryostat	Southwest corner of pool using west D_2O tank	Solid State
Liquid nitrogen cryostat	On instrument bridge	Solid State
Ambient temperature facility	North face of core	Solid State
Front-face tube	North face of core	Solid State
Fast-neutron tube	Core position 15	Solid State
Water-cooled tube	Core position 11	Solid State
Dry thermal-neutron tubes* (N-4 and S-3)	East D_2O tank	Operations

Table 9. (Continued)

Facility	Location	Division or Sponsor
Dry thermal-neutron tubes* (east, center, southwest, and northwest)	East D_2O tank	Operations

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

Demineralizer Performance

Table 10 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.

Operating Manual

Changes which were made to the BSR operating manual during this quarter are listed in Table 11.

Special Tests

Efficiency Tests

Tests were performed by Inspection Engineering on the cell ventilation filters. The results of the tests are tabulated in Table 12.

Special Programs

The BSR was used as a training facility for nuclear engineering students from the University of Tennessee and TVA trainees from the Browns Ferry nuclear power reactor.

Three demonstration-type experiments or labs (see description below) were performed by the TVA trainees. Other experiments were performed at the Pool Critical Assembly and are described elsewhere in this report.

Table 10. Demineralizer Performance Data

Run No.	Initiation Date	Termination Date	Throughput (gal)	Gross Gamma (Counts min^{-1} ml^{-1})		pH		Specific Resistance (ohm-cm)	
				In	Out	In	Out	In	Out
28	1-20-72	3-28-72	1,840,600	1,778	117	5.8	5.8	874,000	1,301,000
29	3-29-72	6-1-72	1,885,700	1,716	153	6.0	6.0	950,000	1,737,000
30	6-8-72	8-3-72	1,761,600	1,682	157	5.9	6.0	853,000	1,405,000
31	8-7-72	10-13-72	1,778,616	2,308	156	5.9	5.9	777,000	1,183,000
32	10-13-72	1-3-73	1,837,600	1,848	120	5.7	5.8	855,000	1,261,000
33	1-4-73	3-5-73	1,614,000	1,280	115	5.7	5.8	1,008,000	1,430,000
34	3-6-73	4-30-73	1,393,200	1,884	181	5.7	5.7	873,000	1,363,000
35	5-2-73	In service	2,060,000	2,072	120	5.8	5.8	896,000	1,209,000

Table 11. Revisions to BSR Operating Manual (ORNL-TM-2676)

Date	Section	Remarks
4-27-73 and 5-7-73	Table of Contents	The contents section was updated to maintain a current listing.
4-27-73	Section 3. Waste Disposal System	The descriptive section on Liquid and Gaseous Waste Disposal Systems was revised and updated to reflect various minor improvements.
5-7-73	Section 15. Maintenance Management at the BSF	This addition to the manual provides documentation of important maintenance procedures.
5-7-73	Distribution List	The list was updated.

Table 12. Efficiency Test Results, Filters

Date	Unit	Type Test	Efficiency (%)
4-18-73	North Bank	Methyl iodide	19.0
4-18-73	Center Bank	Methyl iodide	56.0
4-18-73	South Bank	Methyl iodide	70.0
4-25-73	South Bank	Elemental iodine	99.980
6-7-73	North Bank	Methyl iodide	14.84
6-7-73	Center Bank	Methyl iodide	56.42
6-7-73	South Bank	Methyl iodide	75.36
6-11-73	North Bank	Elemental iodine	99.950
6-27-73	North, Center and South Banks	DOP	99.998

Xenon Buildup and Decay Experiment

Following operation at 2 Mw to achieve xenon equilibrium, the power level of the BSR was reduced to 4 kw to initiate the study of the buildup and decay of xenon in the BSR core. The TVA trainees performed all activities associated with the experiment under the direct supervision of an Operations Division supervisor. The experiment, performed on a 24-hr-day schedule until completion, was an exercise in: (1) startup of the reactor, maintaining the reactor critical at 4 kw, and shutdown of the reactor at 15- to 30-minute intervals; (2) shim-rod reactivity worth measurements under varying concentrations of xenon following each reactor startup; and (3) determining the reactivity worth of xenon in the core as a function of time.

Measurement of Half-Life of Simple Radioactive Decay

Five aluminum samples were irradiated at the east face of the east D_2O tank for 10, 8, 6, 4, and 2 minutes, respectively. These samples were used to provide experience in: (1) handling of radioactive materials; (2) measuring the half-life of a radioactive sample; and (3) determining the saturated activity for the neutron source used for activation. The TVA trainees performed all activities associated with the experiment under the direct supervision of an Operations Division supervisor.

Chamber Classes

These labs were conducted by an engineer of the Instrumentation and Controls Division and were designed to familiarize the trainees with: (1) instrumentation used in the counting-rate channel; (2) behavior of the fission chamber; (3) counting rate versus PHS with the neutron source present; (5) uncompensated ionization chamber; and (6) compensated ionization chambers.

Operational Activities

Date	Remarks
5-7-73	The "BSR Emergency Electrical Power Quarterly Test" was completed with satisfactory results.
5-15-73	BSR Containment System Quarterly Functional Checks were completed with satisfactory results.
5-16-73	Annual reactor control cables and messengers were inspected with satisfactory results.
5-31-73	The spectrometer hoist was removed from the bay area.

POOL CRITICAL ASSEMBLY

Operations

The PCA was used 36.9 hrs as a training facility for the benefit of the University of Tennessee nuclear engineering students and trainees from the TVA Browns Ferry nuclear power reactor. Operational activities in preparing the facility for use included a checkout of the reactor control instrumentation and preparation of the required loadings. The operational activities are listed in Table 13 (Usage of Pool Critical Facility). The PCA maintenance is listed in Table 14.

Table 13. Usage of Pool Critical Facility

Date	Operational Activities	Purpose	Hours Used
4-4-73	Established core No. 139 to obtain a critical mass following the standard approach-to-critical procedure.	Training lab for the TVA trainees from the Browns Ferry nuclear power reactor.	10.2
4-5-73 4-6-73	Established core No. 77 to permit calibration of the regulating rod and the performance of the importance function experiment.	Training lab for the TVA trainees from the Browns Ferry nuclear power reactor.	8.6
4-10-73 4-11-73 4-12-73	Established core No. 77 to permit calibration of the regulating rod.	Training lab for the University of Tennessee nuclear engineering students.	9.2
4-24-73 4-25-73 4-26-73	Used core No. 77 to perform the importance function experiment.	Training lab for the University of Tennessee nuclear engineering students.	8.9

Table 14. PCA Maintenance

Date	Component	Trouble or Change	Reason or Maintenance
4-11-73	Auxiliary counting-rate channel	Excessive noise	Replaced the preamplifier with a spare unit to correct the condition.

SHIM ROD INSPECTION

I. Shim-rod identity, BS-5; core position, CP-42; shim rod No. 3.

A. Measurements previous to installation of new shim rod--no record.

B. Underwater inspection and measurements using oversized gauges along with feeler gauges and a straight edge, May 7, 1973.

1. 0.895-in. gauge minus feeler gauge (flat side); 2.270-in. gauge minus feeler gauge (edge side).

	Flat Side	Edge Side
Bottom	0.888 in.	2.259 in.
Middle	0.882 in.	2.258 in.
Top	0.885 in.	2.259 in.

2. Straight-edge inspection of flat side--irregular surface to 0.010 in.

3. Straight-edge inspection of edge side--irregular surface to 0.015 in.

4. Visual inspection using magnifying glass--no evidence of cracks.

II. Shim-rod identity, BS-3; core position, CP-62; shim rod No. 5.

A. Measurements previous to installation of new shim rod, January 4, 1967.

1. Micrometer readings (out of water)

	Flat Side	Edge Side
Bottom	0.861 in.	2.236 in.
Middle	0.866 in.	2.235 in.
Top	0.866 in.	2.243 in.

2. Straight-edge inspection (out of water)--irregular surface to 0.005 in.

B. Underwater inspection and measurements using oversized gauges along with feeler gauges and a straight edge, May 5, 1973.

1. 0.885-in. gauge minus feeler gauge (flat side); 2.260-in. gauge minus feeler gauge (edge side).

	Flat Side	Edge Side
Bottom	0.881 in.	2.258 in.
Middle	0.882 in.	2.257 in.
Top	0.883 in.	2.256 in.

2. Straight-edge inspection of flat side--irregular surface to 0.016 in.
3. Straight-edge inspection of edge side--irregular surface to 0.010 in.
4. Visual inspection using magnifying glass--no evidence of cracks.

The shim rods, when inspected prior to installation in the reactor, were found to vary considerably in thickness and width. It is very difficult to measure the rods under water (micrometer versus oversized gauges and feeler gauges); however, it is apparent that the dimensions have not changed more than a few thousandths of an inch.