**Bulk Shielding Facility Quarterly
Report July, August,
and September of 1976**

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J. R. Thomas

OAK RIDGE NATIONAL LABORATORY

OPERATED BY UNION CARBIDE CORPORATION FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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OPERATIONS DIVISION

BULK SHIELDING FACILITY QUARTERLY REPORT

JULY, AUGUST, AND SEPTEMBER OF 1976

S. S. Hurt, III
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SUMMARY

The BSR operated at an average power level of 1,637 kW for 50.05% of the time during July, August, and September. 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 27.327 hours as part of the training programs for nuclear reactor operator trainees from Memphis State University.

The PCA was also used in the above-mentioned training programs and was operated on six occasions when the Oak Ridge Associated Universities or Memphis State University students actively participated in training laboratories.

BULK SHIELDING REACTOR

Operations

During this quarter, the reactor operated 50.05% of the time primarily for the irradiation of research experiments. It was operated at low and variable power (2.47% of the operating time) to enable nuclear reactor operator trainees from Memphis 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
(July, August, and September of 1976)

	This Quarter	Last Quarter	Year To Date
Total energy, kWd	75,365	50,301	163,078
Average power, kW/operating hr	1,637	1,756	1,795
Time operating, %	50.05	31.49	34.06
Reactor availability, %	90.02	60.60	64.82
Reactor water radioactivity, counts min ⁻¹ ml ⁻¹ (av)	1,282	1,349	1,620
Reactor water resistivity, ohm-cm (av)	1,184,000	1,109,000	1,080,000
Standard fuel elements depleted	0	0	0
Control fuel elements depleted	0	0	0
Research samples	30	50	116

Core loading 31 (Figure 1) has been in service during this entire report period. The initial operating mass (4995 g ²³⁵U) has been reduced to ~4900 g due to burnup, thereby reducing the excess reactivity from 5.49% Δk/k to ~4.05% Δk/k (~1.50% Δk/k excess reactivity above xenon equilibrium).

The west D₂O tank was removed in September and BSR core loading No. 31 was temporarily repositioned four rows west in the grid plate using standard procedures (Figure 2). An aluminum plate was placed over the empty grid positions created by the core shift. Core 31 will be returned to the original position on the grid after completion of an experimental run at the Low Temperature Irradiation Facility.

M-192-D 130 81	FC 82	A1 83	A1 84	BSF-38 134 85	86	87	88	89
FZC 003T 188 71	A1 72	A1 73	A1 74	FZC 003U 188 75	76	77	78	79
FZC 003N 178 61	BSF-S-9 67 62	BSF-36 139 63	BSF-S-10 67 64	FZC 003P 177 65	66	67	68	69
M-13-H 202 51	M-194-D 153 52	FZC 003Q 182 53	M-195-D 153 54	M-14-H 203 55	56	57	58	59
BSF-39 150 41	BSF-S-11 90 42	BSF-34 135 43	BSF-S-12 89 44	BSF-40 148 45	46	D ₂ O Tanks 47	48	49
FZC 003X 198 31	FZC 003R 179 32	BSF-35 135 33	FZC 003S 173 34	FZC 003Y 197 35	36	37	38	39
M-196-D 169 21	BSF-S-13 68 22	BSF-37 136 23	BSF-S-14 67 24	M-323-A 172 25	26	27	28	29
BSF-28 132 11	FZC 003W 193 12	M-12-H 202 13	FZC 003V 196 14	Plug 15	16	17	18	19

BSR CORE

31	
LOADING NO.	
June 21, 1976	
DATE	
Excess Reactivity - 5.49%	
4995 gm	
OPERATING MASS	
ROD POSITIONS AT CRITICAL (With Operating Mass)	
ROD NO.	IN. WITHDRAWN
1	10.86 9.12
2	10.86 9.12
3	10.86 9.12
4	10.86 9.12
5	10.86 23.00
6	10.86 23.00
REMARKS:	

Figure 1. Core Loading 31 - BSR.

81	82	83	84	85	86	87	88	89
	EAST	SIDE		M-192-D 130	FC	A1	A1	BSF-38 134
71	72	73	74	75	76	77	78	79
	GRID			FZC 003T 188	A1	A1	A1	FZC 003U 188
61	62	63	64	65	66	67	68	69
	HOLES			FZC 003N 178	BSF-S-9 67	BSF-36 139	BSF-S-10 67	FZC 177
51	52	53	54	55	56	57	58	59
	COVERED			M-13-H 202	M-194-E 153	FZC 003Q 182	M-195-D 153	M-14-H 203
41	42	43	44	45	46	47	48	49
	BY			BSF-39 150	BSF-S-13 90	BSF-34 135	BSF-S-14 89	BSF-40 148
31	32	33	34	35	36	37	38	39
	AN			FZC 003X 198	FZC 003R 179	BSF-35 135	FZC 003S 178	FZC 003Y 197
21	22	23	24	25	26	27	28	29
	ALUMINUM			M-196-D 169	BSF-S-11 68	BSF-37 136	BSF-S-12 67	M-323-A 172
11	12	13	14	15	16	17	18	19
	PLATE			BSF-28 132	FZC 003W 193	M-12-H 202	FZC 003V 186	Ex

BSR CORE

31 (Test)

LOADING NO.

September 16, 1976

DATE

Excess Reactivity - 4.10%

4910 gm.

OPERATING MASS

ROD POSITIONS AT CRITICAL (With Operating Mass)

ROD NO.	IN. WITHDRAWN
1	10.50
2	10.50
3	10.50
4	10.50
5	23.00
6	23.00

REMARKS:

West D₂O tank replaced by
LATIF D₂O tank.

Figure 2. Core Loading 31 (Test) - BSR.

Shutdowns

There was one unscheduled shutdown during the quarter from an LTIF experiment setback. Table 2 gives an analysis of both scheduled and unscheduled shutdowns.

Table 2. Analysis of Shutdowns

Description of Shutdown	Number	Downtime (hrs)
Scheduled		
Experimenters:		
No request to operate	14	517.466
Experiment insertion or removal	8	365.083
Repositioning of the reactor	3	3.000
Reactor Operations:		
BSR quarterly shutdown	1	102.600
Xenon decay for repositioning Core 31 in grid assembly	1	62.400
Student training	15	2.740
Reloading critical runs	4	49.400
Subtotal	46	1,102.689
Unscheduled		
Experimenters	1	0.283
Reactor Operations	0	0.000
Subtotal	1	0.283
Total	47	1,102.972

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.

Changes made in the mechanical systems to improve operating conditions and/or to perform special tests are documented by the BSR mechanical design change memoranda system. Those changes which were made during this report

period are listed in Table 4. Maintenance or changes on the instrumentation and mechanical components in the complex are listed in Tables 5, 6, and 7. Table 8 presents the status of the ionization and fission chambers.

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

Change Memo No.	Subject	General Description
BSR-2MW-44	Preferred Rod Insert Negative Period Inhibit	<p>To allow reactor power reductions to more closely follow decreases in servo demand settings. The net effect of this change will be to allow the preferred rod to help the regulating rod maintain the 27-second negative period called for by automatic reductions in servo demand setpoint. Once a preferred rod insert request has been established (through regulating rod insert limit), the preferred rod will insert uninterrupted until the insert request has been cleared. This change will be effective in the high-power mode of operation only.</p> <p>The change involves modification to improve reliability and does not change the function of the protective system.</p>
BSR-2MW-45	Experiment Tie-In System	<p>To provide two independent channels of experiment setback protection with backup reverse. This change replaces the experimenter's backup reverse channel with a second channel of setback protection. Both channels of setback are provided with backup reverse.</p> <p>The change involves modification to improve reliability and does not change the function of the protection system.</p>

Table 3 (Continued)

Change Memo No.	Subject	General Description
BSR-2MW-46	BSR Power Readout in the HSST Experiment Control Room	<p>To provide the HSST experiment with a signal proportional to reactor power, a 20-ohm retransmitting slide wire was installed in the picoammeter recorder and interconnecting cable installed in the reactor control room and the HSST experiment control room.</p> <p>The change involves modification to supply reactor power readout to the data logging station in the experiment control room.</p>

Table 4. Mechanical Design Change Memoranda
Completed During This Report Period

Change Memo No.	Subject	General Description
BSR-2MW-6, Rev. 1	Modification to Inlet Manifold and Protection Bar for the Core ΔT	The capped end of the aluminum inlet manifold extended 2.125 inches beyond the west D ₂ O tank. To allow proper alignment between the west D ₂ O tank and the stationary D ₂ O tank (originally the east D ₂ O tank), the excess part of the inlet manifold and protection bar was sawed off even with the west D ₂ O tank and re-capped.

Table 5. Maintenance and Changes, Instrumentation and Controls

Date	Component	Trouble or Change	Reason or Maintenance
7-16-76	Public-address system	Inoperative.	The amplifier was retubed.
7-22-76	No. 3 safety and Log-N channel (dual ionization chamber PCP-III-106-A, SN-72-2)	The chamber was repositioned and the safety section calibrated with a change of resistors as per procedure IPC-3.	To achieve proper tracking and readout agreement between the two channels.
7-22-76	Secondary pH control system	Faulty action of controller ApHRC-14.	An existing switch in the controller, which cuts the current off to the acid motor when the pH decreases ≤ 5.3 , was activated.
7-29-76	Counting rate channel	Erratic.	Replaced an electronic tube in the count rate meter.
8-6-76	Facility radiation and contamination monitoring system	Routine.	Bimonthly checkout.
8-16-76 thru 8-20-76	Instrumentation	Routine.	Quarterly checks.

Table 5. (continued)

Date	Component	Trouble or Change	Reason or Maintenance
8-18-76	Reactor ΔP	Alarm and scram set-point changes.	Due to changes in the core configuration (i.e., 27 fuel elements and 6 shim rods in Core 31) the ΔP setpoints were changed corresponding with the flow setpoints as follows: 3.4 psig (850 gpm) alarm 2.7 psig (750 gpm) scram.
8-19-76	ΔT thermohms	Inlet thermohm resistance to ground checked low.	The inlet and exit thermohms were replaced and calibrated with satisfactory results.
8-26-76 and 8-27-76	Public-address system	Signal distorted.	Temporarily replaced the amplifier with a spare unit until the original could be repaired in the shop and returned to service.
8-30-76	Reactor outlet temperature thermocouple	A new outlet temperature thermocouple was installed.	To check if temperature readout was correct. The readout agreed with the original thermocouple.

Table 5. (continued)

Date	Component	Trouble or Change	Reason or Maintenance
8-30-76	Dual ionization chamber PCP-III-106, SN-72-1	Being used as servo chamber only in Position B. Connected the uncompensated section to 2 safety chamber.	Saturation characteristics checks were satisfactory. The chamber CTC-3 (J-118) in Position A previously being used as No. 2 safety now becomes a spare chamber.
9-8-76	ΔT thermohms	Calibration recheck.	The thermohms were removed and the calibration of the complete ΔT system was rechecked. Results were satisfactory.
9-9-76	Reactor outlet temperature thermocouple	An additional thermocouple was installed in the outlet water line near the outlet ΔT thermohm.	The originally installed thermocouple is located off-center in the plenum below the core and indicates variable outlet water temperature depending upon the core configuration. The location of a thermocouple in the outlet water line gives a dependable temperature readout since it indicates the temperature of all of the water that has passed through the core.

Table 6. Maintenance and Changes, Mechanical System

Date	Component	Trouble or Change	Reason or Maintenance
8-18-76	Reactor secondary tower, north fan	Coupling slipping.	Replaced the rotor, seals and 6 1/2 lbs of stainless steel shot in the Dodge Flexidyne coupling to correct the trouble.
9-15-76	Shim-rod drive assembly No. 6	Sluggish action of the clutch switch.	With the rod drive unit removed, the push rod on the clutch switch was cleaned to correct the trouble.

Table 7. Maintenance and Changes, Process System

Date	Component	Trouble or Change	Reason or Maintenance
8-11-76	ΔT inlet manifold	Proper alignment between the two D ₂ O tanks on the west side of the core was prevented by the end of the inlet manifold and protection bar.	The protection bar and capped end of the inlet manifold were sawed off even with the west D ₂ O tank and the end of inlet manifold recapped in accordance with Mechanical Design Change Memo No. BSR-2MW-6-Rev. 1.
9-3-76	Secondary tower basin corrosion sample holder	Installed a new PVC sample holder.	Routine replacement of a rusted pipe sample holder.
9-30-76	Skimmer pump	Faulty pump motor bearings.	The motor was replaced.

Table 8. Status of Ionization Chambers

Chamber Serial No.	Location	Date Present Service Started	Previous Service	Remarks
<u>Chambers in Service</u>				
PCP-III-106, SN-72-1	Position B, servo and No. 2 safety	5-12-75	None	This new chamber was installed in the BSR in May, 1975.
CTC-4 (C-771)	Position C, No. 1 safety	12-1-69	LITR	The chamber was modified for under- water service in 1969.
PCP-III-106A, SN-72-2	Position D, Log-N and No. 3 safety	11-13-73	None	This new dual chamber was installed in the BSR in November, 1973.
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.
<u>Chambers Not in Service</u>				
CTC-3 (J-118)	Position A, spare		LITR and BSR	The chamber was modified for under- water service in 1969. Removed from service as BSR No. 2 safety in August, 1976.

Table 8. (continued)

Chamber Serial No.	Location	Date Present Service Started	Previous Service	Remarks
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 ESR.
CIC (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.
PCP-III-106, SN-66-1	BSR storage		BSR	Used as No. 2 safety and servo. Safety section failed in June, 1969; servo section failed in May, 1975.

Table 8. (continued)

Chamber Serial No.	Location	Date Present Service Started	Previous Service	Remarks
PCP-III-106, SN-66-3	ORR beam tube storage		BSR and ORR	Used BSR and ORR 1967 through 1973. Last removed November, 1973.
PCP-III-106, SN-66-4	ORR instrument shop		BSR	Used in the BSR from 1968 to January, 1973. Repaired in 1969.

Fuel

There were no changes in the number of components in the fuel inventory; however, the fuel inventory is listed in Table 9.

Table 9. Fuel and Shim Rod Status

	This Quarter	Last Quarter	Year To Date
Fuel elements depleted	0	0	0
Control-rod fuel elements depleted	0	0	0
New fuel elements placed in service	0	3	5
New control-rod fuel elements placed in service	0	0	0
New fuel elements available for use	6	6	6
New control-rod fuel elements available for use	6	6	6
Partially depleted fuel elements available for use	2	2	2
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 10. The tubes of the stationary D₂O tank are not permanently assigned; they are used by various Laboratory personnel for short term sample irradiations.

Table 10. 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
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)	Stationary D ₂ O tank	Operations
Dry thermal-neutron tubes* (east, center, southwest, and northwest)	Stationary D ₂ O 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 11 gives detailed information on the condition of the primary water system for the preceding years and pertinent data on the performance of the bypass demineralizer.

Table 11. 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
33	1-4-73	3-5-73	1,514,000	1,280	115	5.7	5.8	1,008,000	1,430,000
34	3-6-73	4-30-73	1,393,200	1,848	181	5.7	5.7	873,000	1,363,000
35	5-2-73	7-2-73	2,060,000	2,072	120	5.8	5.8	896,000	1,209,000
36	7-3-73	9-4-73	1,900,000	1,672	116	5.8	5.8	792,000	1,270,000
37	9-4-73	11-12-73	1,300,000	2,021	107	5.9	6.0	682,000	1,144,000
38	11-14-73	1-7-74	1,592,000	1,353	98	5.7	5.7	738,000	1,102,000
39	1-9-74	3-13-74	1,320,000	1,931	101	6.2	6.0	666,000	908,000
40*	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**	12-17-74	4-15-75	3,350,000	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	2,300,000	1,430	124	5.4	5.6	1,085,000	1,808,000
47	9-2-76	In Service	775,000	1,282	96	5.5	5.7	1,184,000	2,067,000

*The reactor was shut down during the entire run.

**New resin in the demineralizer columns

Special Tests

Efficiency Tests

Tests were performed by Inspection Engineering on the cell ventilation filters. Details are given in Table 12.

Table 12. Efficiency Tests Results, Filters

Date	Unit	Type Test	Efficiency (%)
8-19-76	North Bank	Elemental Iodine	99.94
9-16-76	South Bank	Elemental Iodine	99.83

Special Programs

The University Nuclear Engineering Department Experiments

The BSR was used for a training lab for nuclear reactor operator trainees as described below:

Xenon Buildup and Decay Experiment. - On July 1, 1976, 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 Memphis State University 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, performed on a 24-hr-day scheduled until completion on July 2, 1976, 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

Date	Remarks
8-18-76	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.
8-18-76	The containment system quarterly functional checks were performed with satisfactory results.
8-20-76	The annual inspection of the reactor control cables and messengers was completed with satisfactory results.

POOL CRITICAL ASSEMBLY

Operations

The PCA was used 49.3 hours as a training facility for the benefit of nuclear reactor operator trainees from Memphis State University and personnel from the Oak Ridge Associated Universities. 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 Activity	Purpose	Hours Used
7-1-76 and 7-2-76	Established Core No. 77 to permit calibration of the regulating rod and the performance of the importance function experiment.	Training lab for Memphis State University students.	16.1
8-2-76 and 8-3-76	Established Cores No. 187 and 188 to obtain a critical mass following the standard approach-to-critical procedure.	Training lab for Oak Ridge Associated Universities personnel.	19.5
8-4-76 and 8-5-76	Established Core No. 77 to permit calibration of the regulating rod and the performance of the importance function experiment.	Training lab for Oak Ridge Associated Universities personnel.	13.7

Table 14. PCA Maintenance

Date	Component	Trouble or Condition	Action
7-29-76	No. 2 control rod drive assembly	Malfunction of the clutch switch	The drive unit was removed and the clutch switch push rod cleaned.

Experiments

Experiments were conducted at the PCA by students from the Nuclear Engineering Departments of Memphis State University and Oak Ridge Associated Universities as indicated in Table 13. These experiments are described briefly and were directly supervised by the training supervisor of the Operations Division.

Approach-to-Critical

To demonstrate the technique of assembling a reactor core, a critical mass was loaded by the trainees following the standard approach-to-critical procedure.

Regulating-Rod Calibration

A technique used in calibrating reactor control rods was demonstrated by using the period method in calibrating the regulating rod. The exercise was performed by the trainees.

Statistical Weight

An experiment was performed to determine the effect of absorbers on the reactivity as a function of position in a special fuel element located in the reactor core. Using guidelines provided by the Operations Division supervisor, the experiment was performed by the trainees.

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