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**Bulk Shielding Facility Quarterly Report
January, February, and March of 1977**

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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

JANUARY, FEBRUARY, AND MARCH OF 1977

S. S. Hurt, III
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J. R. Thomas

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SUMMARY

The BSR operated at an average power level of 1,975 kw for 75.47% of the time during January, February, and March. 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 45,567 hours as part of the training programs for nuclear reactor operator trainees from Memphis State University.

The PCA was also used in training programs and was operated on thirty-three occasions when Memphis State University, the University of Tennessee, Louisiana State University, the University of Oklahoma, or Mississippi State University students actively participated in training laboratories.

BULK SHIELDING REACTOR

Operations

During this quarter, the reactor operated 75.47% of the time primarily for the irradiation of research experiments. It was operated at low and variable power (2.80% 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
(January, February, and March of 1977)

	This Quarter	Last Quarter	Year To Date
Total energy, kwd	134,173	131,833	134,173
Average power, kw/operating hr	1,975	1,836	1,975
Time operating, %	75.47	78.01	75.47
Reactor availability, %	90.81	85.10	90.81
Reactor water radioactivity counts min ⁻¹ ml ⁻¹ (av)	1,917	1,547	1,917
Reactor water resistivity ohm-cm (av)	1,072,000	1,015,000	1,072,000
Standard fuel elements depleted	0	0	0
Control fuel elements depleted	0	0	0
Research samples			

Core loading 32 (Figure 1) was replaced by core loading 33 (Figure 2) on January 27, 1977, to provide adequate excess reactivity for versatile operation. The initial operating mass (4822 g ²³⁵U) of core loading 32 had been reduced to 4691 g due to burnup, thereby reducing the excess reactivity from 5.25% $\Delta k/k$ to $\sim 3.7\%$ $\Delta k/k$ ($\sim 1.15\%$ excess reactivity above xenon equilibrium).

Core loading 33 was accomplished by replacing one partially depleted B3F-series fuel element with one new MTR-series fuel element. Core loading 33 had an initial operating mass of 4772 g which provided an excess reactivity of 5.50% $\Delta k/k$ (2.95% $\Delta k/k$ excess reactivity above xenon equilibrium). At the end of the quarter, the excess reactivity was $\sim 4.05\%$ $\Delta k/k$ ($\sim 1.50\%$ $\Delta k/k$ excess reactivity above xenon equilibrium).

M-15-H 203 81	F.C. 82	Al. 83	Al. 84	Al. 85				
FZC 003T 185 71	FZC 003U 183 72	Al. 73	Al. 74	Al. 75				
FZC 003W 173 61	BSF-S-9 64 62	BSF-36 133 63	BSF S-10 64 64	FZC 003P 171 65				
M-13-H 195 51	M-194-D 145 52	FZC- 003Q 172 53	M-14-H 195 54	M-195-D 145 55		D ₂ O		
BSF-39 143 41	BSF-S-13 86 42	BSF-34 127 43	BSF-S-14 85 44	BSF-40 141 45		TANK		
FZC 003R 170 31	FZC 003X 191 32	M-16-H 204 33	FZC 003Y 189 34	FZC 003S 169 35	36	37	38	39
M-196-D 164 21	BSF-S-11 66 22	BSF-37 129 23	BSF-S-12 65 24	M-323-A 165 25				
BSF-28 129 11	FZC 003W 185 12	M-12-H 196 13	FZC 003V 190 14	Plug 15	16	17	18	19

BSR CORE

32
LOADING NO.
November 29, 1976
DATE
Excess Reactivity - 5.25%
CRITICAL MASS
4822 gm
OPERATING MASS

ROD POSITIONS AT CRITICAL (With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	11.05	9.39
2	11.05	9.39
3	11.05	9.39
4	11.05	9.39
5	11.05	23.00
6	11.05	23.00

REMARKS:

Figure 1. Core loading 32 - BSR

BSR CORE

33
LOADING NO.
January 27, 1977
DATE
Excess Reactivity 5.50%
CRITICAL MASS
4772 gm
OPERATING MASS

ROD POSITIONS AT CRITICAL (With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	10.77	9.01
2	10.77	9.01
3	10.77	9.01
4	10.77	9.01
5	10.77	23.00
6	10.77	23.00

REMARKS:

M-15-H 201 31	F.C. 82	Al. 83	Al. 84	Al. 85				
M-6-H 182 71	M-7-H 181 72	Al. 73	Al. 74	Al. 75				
M-1-H 169 61	BSF-3-9 62	ESF-36 128 63	BSF-S-10 62 64	M-2-H 167 65				
M-13-H 190 51	M-194-D 140 52	M-3-H 166 53	M-14-H 188 54	M-195-D 141 55		D ₂ O 58		
ESF-39 139 41	BSF-S-13 84 42	M-17-H 202 43	BSF-S-14 83 44	BSF-40 136 45		TANK 48		
M-4-H 166 31	M-10-H 184 32	M-16-H 195 33	M-11-H 182 34	M-S-H 164 35				
M-196-D 161 21	BSF-S-11 64 22	BSF-37 125 23	BSF-S-12 64 24	M-323-A 161 25				
BSF-28 126 11	M-9-H 181 12	M-12-H 192 13	M-8-H 186 14	Plug 15				

Figure 2. Core loading 33 - BSR

Shutdowns

There was one unscheduled shutdown during the quarter when No. 1 rod dropped. Table 2 gives an analysis of the scheduled shutdowns.

Table 2. Analysis of Shutdowns

Description of Shutdown	Number	Downtime (hrs)
Scheduled		
Experimenters:		
No request to operate	4	182.268
Repositioning of the reactor	4	54.450
Experiment insertion, removal, or data taking	11	86.717
Reactor Operations:		
Servo system, trouble shooting, and surveillance	3	25.817
Xenon decay for refueling	1	33.700
Refueling critical runs	2	0.250
No. 1 shim rod drive assembly maintenance	1	63.550
Quarterly	1	72.500
University nuclear reactor operator training	64	8.000
Subtotal	91	527.252
Unscheduled		
Experimenters:	0	0.000
Reactor Operations:	1	2.583
Subtotal	1	2.583
Total	92	529.835

Maintenance and Changes

Maintenance or changes on 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
1-5-77	Servo channel	Momentary faulty operation of servo	Replaced servo demand and limit switch chassis, servo amplifier, and micromicroammeter.
1-7-77	Multipoint temperature recorder TR-16	Erratic readout	Replaced the rotary switch wiper to correct the trouble.
1-13-77	Servo channel	Replacement of original amplifier	Reinstalled the original servo amplifier after repairs were completed.
1-13-77	Log-N channel	Sluggish response	Replaced the recorder amplifier to correct the trouble.
1-24-77 through 1-26-77	Instrumentation	Routine	Quarterly checks.
1-26-77	Counting-rate channel	Erratic operation	A faulty slide wire in the period recorder was replaced.
1-26-77	Counting-rate channel	Inersensitive response	Replaced the count rate recorder amplifier to correct the trouble.
2-2-77	Facility radiation and contamination monitoring system	Routine	Bi-monthly checkout.
2-2-77	Servo channel	Preventive maintenance	The servo amplifier was replaced.

Table 3. (Continued)

Date	Component	Trouble or Change	Reason or Maintenance
2-7-77 through 2-11-77	Servo channel	Trouble shooting	<p>Hooked up recording surveillance monitoring equipment to record any malfunction of the following components:</p> <ol style="list-style-type: none"> 1. No. 4 shim rod withdraw coil. 2. No. 4 shim rod withdraw contact. 3. No. 4 shim rod insert coil. 4. No. 4 shim rod insert contact. 5. Top of Log Pot (μA output voltage). 6. Wiper of Log Pot. 7. Servo reference voltage. 8. Servo withdraw relay coil.
2-7-77	Log-N channel	Erratic period readout	Replaced the Log-N amplifier and the Log-N period recorder amplifier.
2-7-77	Log-N channel	Drift of Log N recorder readout	Replaced the Log-N recorder.
2-11-77	TR-16 multipoint temperature recorder	Inoperative	Replaced the faulty chart drive motor.

Table 3. (continued)

Date	Component	Trouble or Change	Reason or Maintenance
2-15-77	No. 3 safety channel	Slow recorder response	Replaced the recorder amplifier to correct the trouble.
2-14-77 through 3-24-77	Servo channel	Trouble shooting	Continued surveillance monitoring of the system with recording equipment. No malfunction occurred.
3-24-77	Servo channel	Trouble shooting	The surveillance monitoring system had received no false alarm signals since its installation on 2-7-77 and so it was removed.
3-30-77	Ionization chambers	Routine checks	Ionization characteristics checks were made on the No. 1 safety, No. 3 safety, and Log-N chambers with satisfactory results.

Table 4. Maintenance and Changes, Mechanical System

Date	Component	Trouble or Change	Reason or Maintenance
1-24-77	Shim-rod drive assembly No. 1	Sluggish action of the clutch switch	The rod drive unit was removed and the push rod on the clutch switch cleaned to correct the trouble.
3-4-77	No. 1 shim-rod magnet	Dropped No. 1 shim rod. No magnet current after drive run down when rod clutched	Replaced the magnet switch module, which did not restore current to the No. 1 shim-rod magnet. The rod drive unit will be removed next week for further checks and repairs.
3-7-77	Shim-rod drive assembly No. 1	Dropped No. 1 rod on 3-4-77. No current to the No. 1 magnet	The rod drive unit was removed and the faulty magnet coil was replaced to correct the trouble.
3-25-77	Shim rod drive assembly No. 4	Sluggish action of the clutch switch	The rod drive unit was removed and the push rod on the clutch cleaned to correct the trouble.

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	0	0
Control-rod fuel elements depleted	0	0	0
New fuel elements placed in service	1	2	1
New control-rod fuel elements placed in service	0	0	0
New fuel elements available for use	17	4	17
New control-rod fuel elements available for use	6	6	6
Partially depleted fuel elements available for use	6	5	6
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 stationary 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
Front-face tube	North face of core	Solid State
Heavy Section Steel Experiment	North and East face of core	Metals and Ceramics
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, south- west, 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 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 (gal.)	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	1,614,000	1,280	115	5.7	5.8	1,008,000	1,430,000
34	3-6-73	4-30-73	1,393,200	1,848	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	1,692,000	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	3,850,000	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	In Service	1,600,000	2,026	146	5.6	5.8	1,072,000	2,148,000

*The reactor was shut down during the entire run.

**New resin in the demineralizer columns.

Special Programs

The University Nuclear Engineering Department Experiments

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

Xenon Buildup and Decay Experiments. On January 8, 1977, 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 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
1-24-77	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.
1-27-77	The containment system quarterly functional checks were performed with satisfactory results.

Building Evacuation

On January 28, 1977, the BSR was being started up in instrument start and at ~200 watts the FRCAS indicated high level alarms on the three high radiation module units and the initiation of the building evacuation. The instrument start mode was terminated and the reactor made subcritical. Research personnel evacuated the building and assembled at the assembly point in <30 seconds. The Health Physicist and Laboratory Shift Supervisor responded to the area.

The building evacuation was not a drill; however, the signal which was initiated from the FRCAS was apparently caused by a momentary change in the building electrical voltage which was visually observed as a slight change in the building lighting intensity. The individual building monitrons did not initiate the FRCAS alarms. After evaluation of the problem, the Emergency Control Center was notified that the evacuation was false and the reactor startup was resumed. Form UCN-2897 was completed.

POOL CRITICAL ASSEMBLY

Operations

The PCA was used 284.2 hours as an experiment facility for the benefit of nuclear engineering students from Memphis State University, the University of Tennessee, the University of Oklahoma, Louisiana State University, and Mississippi State University. 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 8 (Usage of Pool Critical Facility). The PCA maintenance is listed in Table 9.

Table 8. Usage of Pool Critical Facility

Date	Operational Activity	Purpose	Hours Used
1-4-77 and 1-5-77	Established Cores Nos. 193 and 194 to obtain a critical mass following the standard approach-to critical procedure.	Training lab for the Memphis State University students.	27.6
1-6-77 and 1-7-77	Established Core No. 77 to permit calibration of the regulating rod and the performance of the Importance Function Experiment.	Training lab for the Memphis State University students.	16.6
1-10-77 and 1-11-77	Established Cores Nos. 195 and 196 to obtain a critical mass following the standard approach-to-critical procedure.	Training lab for the Memphis State University students.	25.5
1-12-77 and 1-13-77	Established Core No. 77 to permit calibration of the regulating rod and the performance of the Importance Function Experiment.	Training lab for the Memphis State University students.	16.7
1-31-77 through 2-4-77	Established Cores No. 197, 198, 199, 200, and 201 to obtain a critical mass following the standard approach-to-critical procedure.	Training lab for the University of Tennessee nuclear engineering students.	56.6
2-7-77 through 2-11-77	Established Core No. 77 to permit calibration of the regulating rod.	Training lab for the University of Tennessee nuclear engineering students.	26.4
2-14-77 through 2-18-77	Used Core No. 77 to perform the Importance Function Experiment.	Training lab for the University of Tennessee nuclear engineering students.	22.3

Table 8. (Continued)

Date	Operational Activity	Purpose	Hours Used
2-22-77	Established Core No. 202 to obtain a critical mass following the standard approach-to-critical procedure.	Training lab for the Louisiana State University nuclear engineering students.	12.3
2-22-77	Established Core No. 77 to permit calibration of the regulating rod and the performance of the Importance Function Experiment.	Training lab for the Louisiana State University nuclear engineering students.	8.1
3-21-77 and 3-24-77	Established Cores No. 203 and 204 to obtain a critical mass following the standard approach-to-critical procedures.	Training lab for the University of Oklahoma nuclear engineering students.	23.5
3-23-77 and 3-24-77	Established Core No. 77 to permit calibration of the regulating rod and the performance of the Importance Function Experiment.	Training lab for the University of Oklahoma nuclear engineering students.	13.9
3-28-77 and 3-29-77	Established Cores Nos. 205 and 206 to obtain a critical mass following the standard approach-to-critical procedures.	Training lab for Mississippi State University nuclear engineering students.	20.7
3-30-77 and 3-31-77	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.	14.0

Table 9. Pool Critical Facility Maintenance

Date	Component	Trouble or Change	Reason or Maintenance
1-17-77 through 1-19-77	Instrumentation	Routine	Quarterly checks.
3-14-77 through 3-17-77	Instrumentation	Routine	Quarterly checks.

Experiments

Experiments were conducted at the PCA by students from the Nuclear Engineering Departments of Mississippi State University, Memphis State University, the University of Tennessee, Louisiana State University, and the University of Oklahoma as indicated in Table 8. 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 nuclear engineering students 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 nuclear engineering students.

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 supervisor, the experiment was performed by the nuclear engineering students.

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