**Bulk Shielding Facility Quarterly Report
October, November, and December of 1977**

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

MASTER

OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION • FOR THE DEPARTMENT OF ENERGY

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
Price: Printed Copy \$4.50 ; Microfiche \$3.00

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, contractors, subcontractors, or their employees, makes any warranty, express or implied, nor assumes any legal liability or responsibility for any third party's use or the results of such use of any information, apparatus, product or process disclosed in this report, nor represents that its use by such third party would not infringe privately owned rights.

Contract No. W-7405-eng-26

OPERATIONS DIVISION

BULK SHIELDING FACILITY QUARTERLY REPORT

OCTOBER, NOVEMBER, AND DECEMBER OF 1977

S. S. Hurt, III

E. D. Lance

J. R. Thomas

Date Published — June, 1978

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

NOTICE This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

CONTENTS

	<u>Page</u>
SUMMARY	1
BULK SHIELDING REACTOR	1
Operations	1
Shutdowns	10
Maintenance and changes	10
Fuel	14
Experiment facilities assignment	14
Demineralizer performance	15
Special Tests	17
Efficiency tests	17
Operational Activities	17
Building Evacuation Drill	18
POOL CRITICAL FACILITY	19
Operations	19
Experiments	21
Approach-to-critical	21
Regulating rod calibration	21
DISTRIBUTION	23

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

FIGURE LIST

<u>Caption</u>	<u>Page</u>
Figure 1. Core Loading 38 BSR Used for LTIF Experiment Runs	3
Figure 2. Core Loading 39 BSR	4
Figure 3. Core Loading 40 BSR	5
Figure 4. Core Loading 41 BSR Used for LTIF Experiment Runs	7
Figure 5. Core Loading 42 BSR	8
Figure 6. Core Loading 43 BSR	9

BULK SHIELDING FACILITY QUARTERLY REPORTOCTOBER, NOVEMBER, AND DECEMBER OF 1977

S. S. Hurt, III

E. D. Lance

J. R. Thomas

SUMMARY

The BSR operated at an average power level of 1,981 kW for 43.62% of the time during October, November, and December. Water-quality control in both the reactor primary and secondary cooling systems was satisfactory.

The PCA was used in training programs and was operated on one occasion when the University of Kentucky students actively participated in training laboratories.

BULK SHIELDING REACTOR

Operations

During this quarter, the reactor operated primarily for the irradiation of research experiments. Basic operating data for this period are given in Table 1.

Table 1. Basic Operating Data
(October, November, and December of 1977)

	This Quarter	Last Quarter	Year To Date
Total energy, kWd	79,548	40,515	320,183
Average power, kW/operating hr	1,981	1,868	1,911
Time operating, %	43.62	23.58	45.62
Reactor availability, %	84.88	85.87	83.41
Reactor water radioactivity, counts min ⁻¹ ml ⁻¹ (av)	1,422	1,673	1,740
Reactor water resistivity, ohm-cm (av)	1,315,000	1,203,000	1,164,000
Standard fuel elements, depleted	0	0	0
Control fuel elements, depleted	0	0	0
Research samples	72	60	262

Core loading 39 (Figure 2) was temporarily converted back to core loading 38 (Figure 1) on October 3, 1977 for a LTIF experiment run. Core 38 was accomplished by replacing the three MTR-series fuel elements in CP-78, CP-79, and CP-89 with three aluminum core pieces and replacing the CP-19 experiment facility in CP-19 with a BSF-series fuel element.

Core loading 38 was converted back to core loading 39 on October 6, 1977 after completion of the LTIF experiment run. Core 39 was accomplished by replacing the three aluminum core pieces in CP-78, CP-79, and CP-89 with three MTR-series fuel elements and replacing the BSF-series fuel element in CP-19 with the CP-19 experiment facility.

Core loading 39 (Figure 2) was replaced by core loading 40 (Figure 3) on November 4, 1977. The initial operating mass (4,584 g ²³⁵U) of core loading 39 had been reduced to 4,528 g due to burnup, thereby reducing the excess reactivity from 4.17% $\Delta k/k$ to $\sim 3.18\% \Delta k/k$ ($\sim 0.63\% \Delta k/k$ above xenon equilibrium).

Core 40 was accomplished by removing one partially depleted BSF-series fuel element and adding two new U. S. Nuclear-series fuel elements. Core 40 had an initial operating mass of 4,809 g which provided an excess

BSR CORE

38

LOADING NO.

September 7, 1977

DATE

Excess Reactivity 5.15%

4,168 gm

OPERATING MASS

ROD POSITIONS AT CRITICAL
(With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	10.32	11.33
2	10.32	11.33
3	10.32	11.33
4	10.32	11.33
5	23.00	11.33
6	23.00	11.33

REMARKS:

Figure 1. Core Loading 38 BSR Used for LTIF Experiment Runs

				A1	FC	A1	A1	M-15-H 199
81	82	83	84	85	86	87	88	89
				A1	A1	A1	M-7-H 178	M-6-H 178
71	72	73	74	75	76	77	78	79
	EAST			M-1-H 161	BSF-S-9 58	BSF-36 121	BSF-S-10 58	M-2-H 160
61	62	63	64	65	66	67	68	69
	D ₂ O			M-13-H 181	M-194-D 131	M-3-H 156	M-14-H 177	M-195-D 133
51	52	53	54	55	56	57	58	59
	TANK			BSF-39 132	BSF-S-13 80	M-17-H 186	BSF-S-14 79	BSF-40 128
41	42	43	44	45	46	47	48	49
				M-20-H 198	M-10-H 171	M-16-H 180	M-11-H 170	M-19-H 199
31	32	33	34	35	36	37	38	39
				M-196-D 155	BSF-S-11 62	M-12-H 184	BSF-S-12 61	M-323-A 153
21	22	23	24	25	26	27	28	29
				PLUG	M-9-H 176	M-18-H 201	M-8-H 178	EXP
11	12	13	14	15	16	17	18	19

BSR CORE

39

LOADING NO.

September 19, 1977

DATE

Excess Reactivity 4.17%

4,584 gm

OPERATING MASS

ROD POSITIONS AT CRITICAL (With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	11.56	12.80
2	11.56	12.80
3	11.56	12.80
4	11.56	12.80
5	23.00	12.80
6	23.00	12.80

REMARKS:

Figure 2. Core Loading 39 BSR

BSR CORE

40

LOADING NO.

November 4, 1977

DATE

Excess Reactivity 5.22%

4,809 gm

OPERATING MASS

ROD POSITIONS AT CRITICAL (With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	9.83	11.52
2	9.83	11.52
3	9.83	11.52
4	9.83	11.52
5	23.00	11.52
6	23.00	11.52

REMARKS:

Figure 3. Core Loading 40 BSR

reactivity of 5.22% $\Delta k/k$ (2.67% $\Delta k/k$ excess reactivity above xenon equilibrium).

Core 41 (Figure 4) was also temporarily established on November 4, 1977 for future LTIF experiment runs, by replacing two U. S. Nuclear-series fuel elements and one MTR-series fuel elements in CP-78, CP-79, and CP-89 with aluminum cans. Core 41 had an initial mass of 4,212 g which, when against the LTIF experiment complex, provided an excess reactivity of 5.07% $\Delta k/k$ (2.52% $\Delta k/k$ excess reactivity above xenon equilibrium). Core 41 was converted back to core 40 on the same date.

Core 40 loading was converted to core 41 loading on November 8, 1977 for a LTIF experiment run.

Core 41 loading was converted back to core 40 loading on November 16, 1977 after completion of the LTIF experiment run.

Core loading 40 (Figure 3) was converted to core loading 42 (Figure 5) on December 19, 1977 for NRL experiments by replacing the aluminum can in CP-77 with the MTR-series fuel element from CP-67 and installing the NRL core piece in CP-67.

The initial operating mass (4,807 g ^{235}U) of core loading 40 had been reduced to ~4,778 g due to burnup.

Core 42 had an initial operating mass of 4,778 g ^{235}U which provided an excess reactivity of 3.50% $\Delta k/k$ (0.95% $\Delta k/k$ excess reactivity above xenon equilibrium).

Core loading 42 (Figure 5) was replaced by core loading 43 (Figure 6) on December 29, 1977 to establish enough excess reactivity to overcome peak xenon. The initial operating mass (4,778 g ^{235}U) of core loading 42 had been reduced to 4,753 g due to burnup, thereby reducing the excess reactivity from 3.50% $\Delta k/k$ to 3.05% (0.50% $\Delta k/k$ excess reactivity above xenon equilibrium).

Core loading 43 was accomplished by replacing two partially depleted BSF-series fuel elements with two heavier partially depleted MTR-series fuel elements. Core loading 43 had an initial operating mass of 4,815 g ^{235}U which provided an excess reactivity of 4.15% $\Delta k/k$ (1.60% $\Delta k/k$ excess reactivity above xenon equilibrium).

BSR CORE

41

LOADING NO.

November 4, 1977

DATE

Excess Reactivity 5.07%

4,212 gm

OPERATING MASS

ROD POSITIONS AT CRITICAL (With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	10.36	11.49
2	10.36	11.49
3	10.36	11.49
4	10.36	11.49
5	23.00	11.49
6	23.00	11.49

REMARKS:

Figure 4. Core Loading 41 BSR Used for LTIF Experiment Runs

81	82	83	84	A1	FC	A1	A1	M-15-H 197
71	72	73	74	A1	A1	M-7-H 176	YZP 0046 202	YZP 0047 198
61	62	63	64	M-1-H 160	BSF-S-9 58	E (NRL)	BSF-S-10 58	M-2-H 158
51	52	53	54	M-13-H 179	M-194-D 129	M-6-H 177	M-14-H 174	M-195-D 132
41	42	43	44	BSF-39 130	BSF-S-13 79	M-17-H 183	BSF-S-14 77	BSF-40 126
31	32	33	34	M-20-H 196	M-10-H 169	M-16-H 177	M-11-H 168	M-19-H 197
21	22	23	24	M-196-D 153	BSF-S-11 61	M-12-H 182	BSF-S-12 60	M-323-A 151
11	12	13	14	A1 PLUG	M-9-H 174	M-18-H 199	M-8-H 176	M-3-H 153

BSR CORE

42

LOADING NO.

December 19, 1977

DATE

Excess Reactivity 3.50%

~4,809 gm

OPERATING MASS

ROD POSITIONS AT CRITICAL (With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	12.75	13.80
2	12.75	13.80
3	12.75	13.80
4	12.75	13.80
5	23.00	13.80
6	23.00	13.80

REMARKS:

Figure 5. Core Loading 42 BSR

BSR CORE

43

LOADING NO.

December 29, 1977

DATE

Excess Reactivity 4.15%

4,815 gm

OPERATING MASS

ROD POSITIONS AT CRITICAL
(With Operating Mass)

ROD NO.	IN. WITHDRAWN	
1	11.58	12.60
2	11.58	12.60
3	11.58	12.60
4	11.58	12.60
5	23.00	12.60
6	23.00	12.60

REMARKS:

Figure 6. Core Loading 43 BSR

Shutdowns

There were no unscheduled shutdowns during the quarter. 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	14	879.283
Experiment insertion, removal, or data taking	8	23.234
Repositioning of the reactor	4	9.183
Reactor Operations:		
Xenon decay for refueling	2	102.850
Refueling critical runs	8	16.050
BSR quarterly shutdown and maintenance	2	214.767
<u>Subtotal:</u>	38	1,245.367
Unscheduled		
Experimenters:	0	0
Reactor Operations:	0	0
<u>Subtotal:</u>	0	0
TOTAL:	38	1,245.367

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
10-6-77	Facility radiation and contamination monitoring system	Routine	Bimonthly checkout.
10-17-77 through 10-21-77	Instrumentation	Routine	Quarterly checks.
10-18-77	Counting-rate channel	Did not meet specifications	Replaced the scalar panel.
10-19-77	No. 1 safety channel	Sluggish recorder response	The recorder balance motor was replaced.
10-19-77	Facility radiation and contamination alarm system	Poolside CAM inoperative	A fuse was replaced to correct the trouble.
10-20-77	Ionization chambers PCP-111-106, SN-72-1, Log-N and No. 3 safety in position B, and CTC-4 (C-771) No. 1 safety in position C	The chamber positions were swapped	To reposition the Log-N chamber nearer the center line of the core in position C.
10-21-77	Public address system	Equipment updating	The amplifier was replaced with a new solid-state amplifier.
10-24-77 through 10-25-77	Instrumentation	Routine	Quarterly checks.

Table 3. (Continued)

Date	Component	Trouble or Change	Reason or Maintenance
10-24-77 through 10-26-77	Ionization chamber PCP-111-106, SN- 72-1, Log-N and No. 3 safety in position C	The compensated section failed	The chamber was replaced with a new spare chamber PCP-111-106, SN-66-7, but the compensated section of this chamber also failed and was replaced with another new chamber PCP-111- 106, SN-66-8.
10-25-77	Ionization chamber CTC-4 (C-771) No. 1 safety in posi- tion B	The chamber did not fit properly in the lead shield and was removed to the north pool storage as a spare chamber	The chamber was replaced with a spare chamber CTC-3 (J-118).
10-27-77	Facility radiation and contamination alarm system	Pump house monitron inop- erative	The unit was returned to service after being repaired in the instrument shop.
11-28-77	Counting-rate channel	No response on period recorder	A faulty slide wire in the period re- corder was replaced.
12-6-77	Facility radiation and contamination monitoring system	Routine	Bimonthly checkout.
12-14-77	Regulating rod position recorder	Poor response	Replaced the recorder amplifier and cleaned the slide wire.

Table 4. Maintenance and Changes, Process System

Date	Component	Trouble or Change	Reason or Maintenance
10-18-77	Secondary tower basin	Routine cleaning and inspection	The secondary tower basin was drained, cleaned, and refilled.
11-17-77	Secondary pump off-on switch	Inoperative	The switch was removed to the shop, repaired, and reinstalled.
11-17-77	Secondary system blowdown valve HCV-80	Seat leak	The valve was replaced.

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	2	3	6
New control-rod fuel elements placed in service	0	0	0
New fuel elements available for use	12	14	12
New control-rod fuel elements avail- able for use	6	6	6
Partially depleted fuel elements available for use	11	9	9
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 or 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
33	1-4-73	3-5-73	1,614,000	1,280	115	5.7	5.8	1,008,000	1,430,000
34	3-5-73	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 ^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	In Service	2,300,000	1,422	144	5.6	5.8	1,315,000	2,198,000

^aThe reactor was shut down during the entire run.

^bNew resin in the demineralizer columns.

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 (%)
11-8-77	North Bank	Elemental Iodine	99.914
11-8-77	Center Bank	Elemental Iodine	99.902
11-8-77	South Bank	Elemental Iodine	99.910
12-7-77	North Bank	Methyl Iodine	69.79
12-7-77	Center Bank	Methyl Iodine	30.04
12-7-77	South Bank	Methyl Iodine	51.08

Operational Activities

Date	Remarks
10-18-77	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.
10-19-77	The containment system quarterly functional checks were performed with satisfactory results.

Building Evacuation Drill

An unannounced building evacuation drill of the BSF simulating a condition of an impending radiation problem from an experiment, to test the response of the personnel in the building and action of the local emergency squad, was successfully completed on November 15, 1977.

POOL CRITICAL ASSEMBLY

Operations

The PCA was used 12.6 hours as an experiment facility for the benefit of nuclear engineering students from the University of Kentucky. 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 9 (Usage of Pool Critical Facility). The PCA maintenance is listed in Table 10.

Table 9. Usage of Pool Critical Facility

Date	Operational Activity	Purpose	Hours Used
11-17-78	Established core No. 217 to obtain a critical mass following the standard approach-to-critical procedure. Established core No. 77 to permit calibration of the regulating rod.	Training lab for the University of Kentucky nuclear engineering students.	12.6

Table 10. Pool Critical Facility Maintenance

Date	Component	Trouble or Change	Reason or Maintenance
11-9-77 through 11-16-77	Instrumentation	Routine	Quarterly checks.
11-14-77	No. 2 control rod drive assembly	Malfunction of the clutch switch	The drive unit was removed and the clutch switch push rod cleaned to correct the trouble.

Experiments

Experiments were conducted at the PCA by students from the Nuclear Engineering Department of the University of Kentucky as indicated in Table 9. 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.

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

INTERNAL DISTRIBUTION

ORNL/TM-6389

1. R. G. Berggren
2. G. H. Burger
3. C. D. Cagle
4. W. R. Casto
5. J. W. Cleland
6. G. H. Coleman
7. R. R. Coltman, Jr.
8. J. A. Conlin
9. J. A. Cox
10. W. A. Duggins
11. J. M. Guinn, Jr.
12. R. H. Guymon
13. T. P. Hamrick
14. S. S. Hurt, III
15. G. H. Jenks
16. L. P. Jernigan
17. E. B. Johnson
18. E. D. Lance
19. D. L. Laughlin
20. R. V. McCord
21. F. H. Neill
22. T. B. Nixon
23. L. C. Oakes
24. J. H. Pemberton
25. H. Postma
26. M. E. Ramsey
27. W. H. Sides
- 28-29. J. R. Thomas
30. K. W. West
31. M. K. Wilkinson
32. F. W. Young
- 33-34. Laboratory Records Department
35. Laboratory Records, ORNL R.C.
- 36-37. Central Research Library
38. ORNL Patent Office

EXTERNAL DISTRIBUTION

39. K. M. Akhtar, Head, Reactor Operations Maintenance Division
Pakistan Institute of Nuclear Science and Technology, Post
Office Nilore, Rawalpindi, Pakistan
40. R. D. Martin, Ford Nuclear Reactor, University of Michigan,
2301 Bonisteel Boulevard, Ann Arbor, Michigan 48104
41. J. D. Randall, Director, Nuclear Science Center, Texas A&M
University, College Station, Texas 77843
- 42-43. E. S. Beckjord, Division of Reactor Development and Demonstra-
tion, Department of Energy, Germantown, Maryland 20767

EXTERNAL DISTRIBUTION (Continued)

- 44. Safety and Environmental Control Division, DOE-ORO
- 45. Research and Technical Support Division, DOE, Oak Ridge
- 46-72. Technical Information Center, Oak Ridge