ORNL/TM-10276

ornl

OAK RIDGE
NATIONAL
LABORATORY

MARTIN MARIETTA

Oak Ridge Research Reactor Quarterly Report July, August, and September 1986

T. P. Hamrick
M. K. Ford

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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
NTIS price codes—Printed Copy: A03; Microfiche A01

ORNL/TM-10276

Operations Division
Reactor Operations Section

OAK RIDGE RESEARCH REACTOR QUARTERLY REPORT
JULY, AUGUST, AND SEPTEMBER 1986

T. P. Hamrick
M. K. Ford

SPONSOR: J. H. Swanks
Operations Division

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

Prepared by the
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
operated by
Martin Marietta Energy Systems, Inc.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-84OR21400

CONTENTS

LIST OF FIGURES

LIST OF TABLES

OAK RIDGE RESEARCH REACTOR QUARTERLY REPORT
JULY, AUGUST, AND SEPTEMBER 1986

SUMMARY

The ORR operated at an average power level of 29.9 MW for 83.9% of the time during July, August, and September of 1986.

The reactor was shut down on seven occasions, six of which were scheduled. Reactor downtime needed for refueling and checks was normal. The reactor remained available for operation 86.3% of the time.

Maintenance activities, both mechanical and instrument, were essentially routine in nature.

POWER HISTORY

The power history for the quarter is displayed in Figs. 1 through 3.

OPERATIONS

The basic operating data presented in Table 1 indicate that the ORR operation for the quarter was normal.

Details relative to cycles of operation during the quarter are given in Table 2.

ORNL/DWG-86-16977

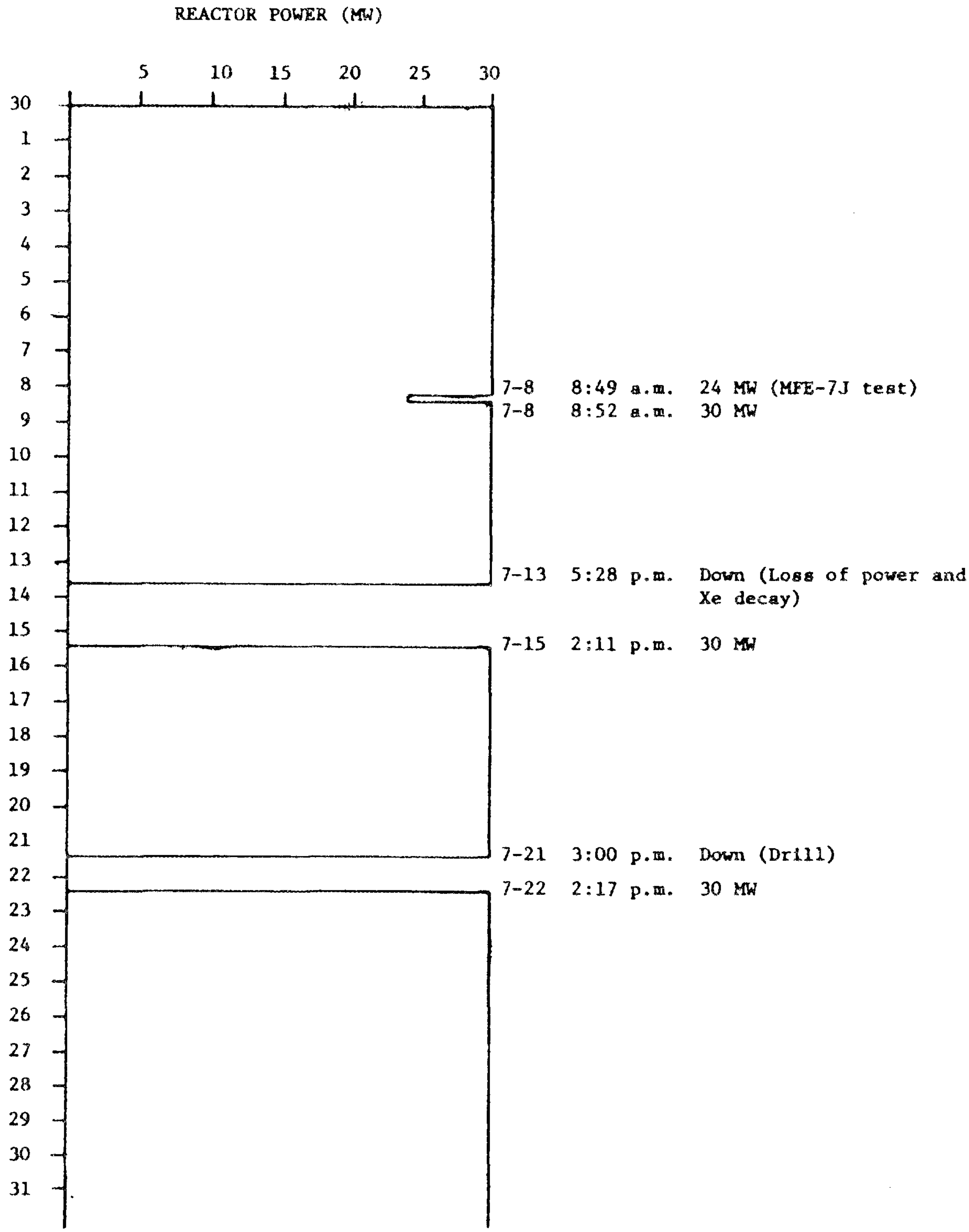

Fig. 1. Reactor power history - July 1986.

ORNL/DWG-86-16976

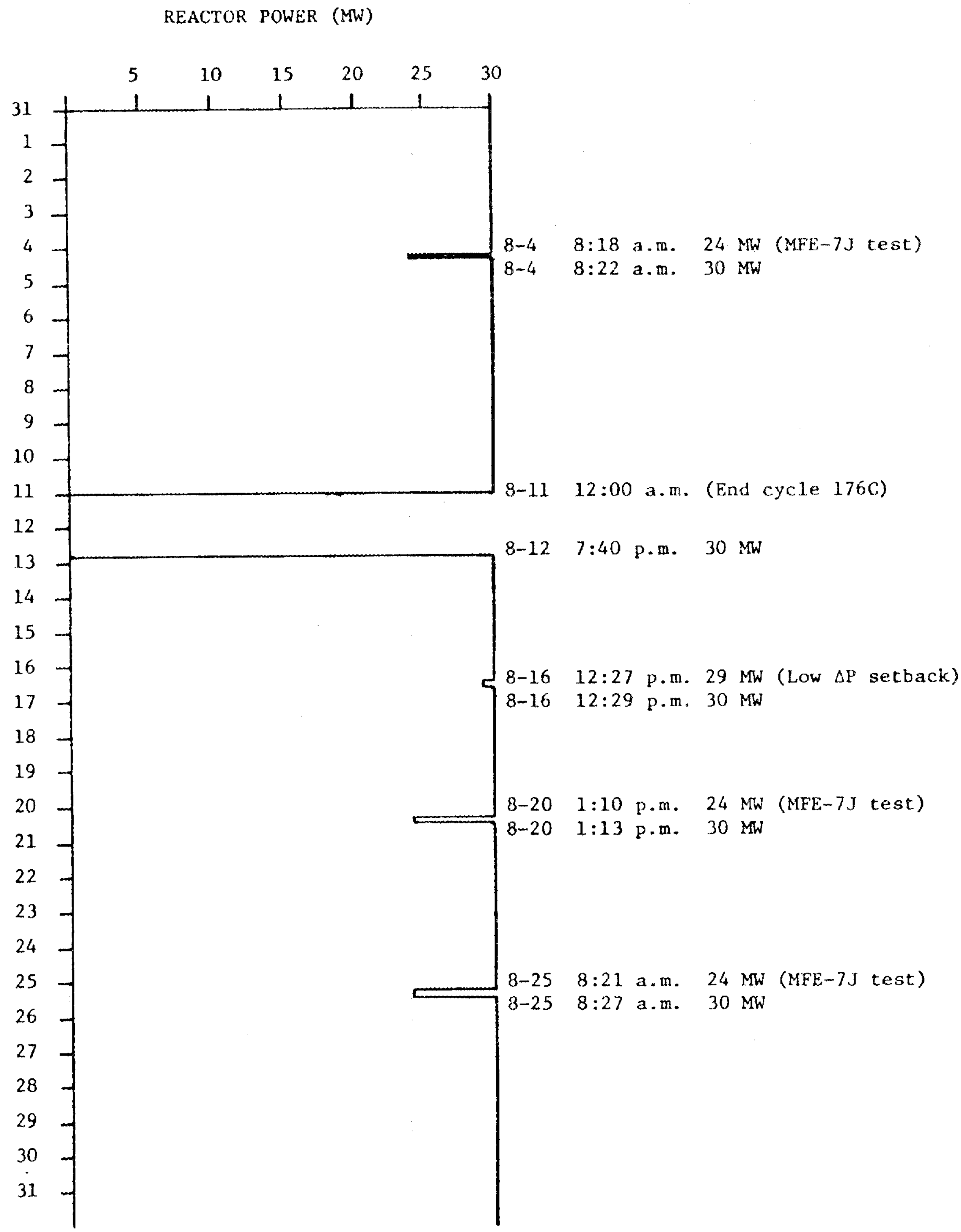

Fig. 2. Reactor power history - August 1986.

ORNL/DWG-86-16975

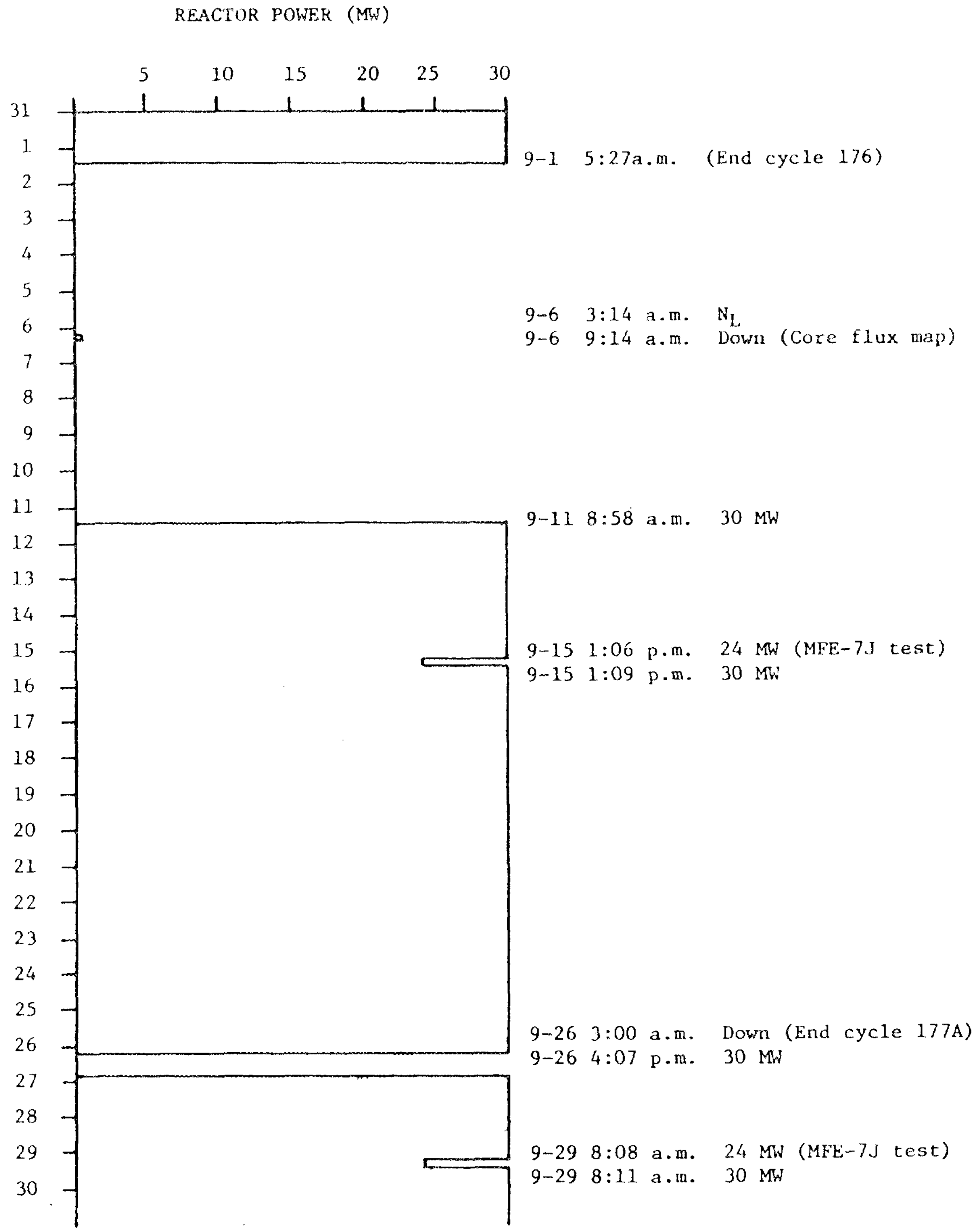

Fig. 3. Reactor power history - September 1986.

Table 1. Basic operating data
(July–September 1986)

	This quarter		Last quarter		Jan.–Sept. 1986		Jan.–Sept. 1985
Total energy, MWd	2,303.9		1,582.3		5,920.3		6,410.9
Average power, MW	29.9		29.7		29.8		29.9
Time operating, %	83.9		58.5		72.8		76.8
Availability, %	86.3		66.0		83.0		82.2
Reactor water radioactivity, cpm/ml (av)	38,000		43,200		39,900		29,033
Pool water radioactivity, cpm/ml (av)	1,600		1,390		1,423		877
Reactor water resistivity, ohm-cm (av)	1,375,000		1,359,000		1,327,667		1,602,667
Pool water resistivity, ohm-cm (av)	951,000		917,000		933,667		1,082,667
	HEU	LEU	HEU	LEU	HEU	LEU	HEU
Fuel elements depleted	18	0	13	0	45	0	67
Average burnup of fuel elements depleted, %	52.3	NA	48.9	NA	50.1	NA	45.9
Shim-safety rods depleted	0	0	2	0	4	0	6
Average burnup of shim-safety rods depleted, %	NA	NA	74.9	NA	76.2	NA	77.1
Radioisotope samples	0		0		0		0
Research samples	24		27		88		19

Table 2. Cycles of operation

Cycle No.	Date begun	Date ended	Accumulated energy (MWd)
176	May 12, 1986	September 1, 1986	2,339.2
177	September 11, 1986	In progress	573.7

FUEL USAGE AND INVENTORY

HIGH-ENRICHED URANIUM (HEU)

Eighteen HEU fuel elements were declared spent during this quarter.

LOW-ENRICHED URANIUM (LEU)

Nineteen new LEU fuel elements were received during this quarter.

Other details of fuel usage and inventory may be found in Table 3.

SHUTDOWNS AND POWER REDUCTIONS

Reactor downtime (power level $<N_L$) totaled approximately 332 hours. A summary of the shutdowns is given in Table 4, and details of each scheduled shutdown are contained in Table 5. Table 6 describes unscheduled shutdowns, while Table 7 describes power reductions which did not result in shutdowns.

Table 3. Fuel status

	This quarter	Last quarter	Jan.-Sept. 1986	Jan.-Sept. 1985
HEU				
Depleted fuel elements transferred for chemical recovery	0	46	46	44
Average percent burnup of fuel elements transferred	—	46.8	46.8	44.0
New elements, start of quarter	139	139	—	—
New elements received	0	0	0	57
New elements placed in service	0	0	2	41
New elements, end of quarter	139	139	—	—
Special or test elements	21	21	21	21
Depleted shim-safety rod elements transferred for chemical recovery	0	5	5	4
Average percent burnup of shim-safety rods transferred	—	81.8	81.8	82.2
New shim-safety rod elements, start of quarter	8	8	—	—
New shim-safety rod elements received	0	0	0	1
New shim-safety rod elements placed in service	0	0	2	6
New shim-safety rod elements, end of quarter	8	8	—	—

Table 3. (continued)

	This quarter	Last quarter	Jan.-Sept. 1986	Jan.-Sept. 1985
LEU				
Depleted fuel elements transferred for chemical recovery	0	0	0	0
Average percent burnup of fuel elements transferred	—	—	—	—
New elements start of quarter	46	54	—	—
New elements received	19	0	80	0
New elements placed in service	13	8	48	0
New elements end of quarter	52	46	—	—
Special or test elements	0	0	0	0
Depleted shim-safety rod elements transferred for chemical recovery	0	0	0	0
Average percent burnup of shim-safety rods transferred	—	—	—	—
New shim-safety rod elements start of quarter	8	8	0	0
New shim-safety rod elements received	0	0	12	0
New shim-safety rod elements placed in service	0	0	0	0
New shim-safety rod elements end of quarter	8	8	8	—

Table 4. Analysis of shutdowns

Description of shutdown	Number	Downtime (h)
Scheduled		
Regular, end of cycle	1	117.783
Special, flux run	1	117.600
Special, refueling and experiment work	2	30.500
Special, power outage and xenon decay	1	43.066
Special, building emergency and evacuation drill	1	22.150
Subtotal:	6	331.099
Unscheduled		
Electrical power outage or surge	1	0.367
Subtotal:	1	0.367
TOTAL:	7	331.466

Table 5. Scheduled shutdowns, details

Date	Duration (h)	End cycle	Remarks
7-13-86	43.066	—	The reactor was manually scrammed to allow xenon to decay following an unscheduled shutdown due to a thunderstorm. Loss of power to the pump house, Building 3085, prohibited continuing operation above N_L
7-21-86	22.150	176B	A building emergency and evacuation drill was held to simulate a large leak in the primary cooling system with a subsequent automatic reactor scram. The reactor was refueled
8-11-86	18.267	176C	The reactor was refueled, and flow checks were made on the D_2O tank
9-1-86	117.783	176	Shutdown activities included: (1) refueling; (2) flux and gamma-heating measurements for the RERTR program; (3) replacing pump seals on No. 1 primary pump; (4) replacing the north and south shim-safety rod hold-down arms; and (5) inspecting all seismic restraint welds by Quality Department
9-6-86	117.600	—	A six-hour core flux map run at N_L was completed. Gamma-heating measurements for the LEU program were attempted and will be completed at a later date
9-26-86	12.233	177A	The reactor was refueled, shim-safety rods changed, and the HFED experiment was measured and reconfigured

Table 6. Unscheduled shutdowns, details

Date	Duration (h)	End cycle	Remarks
7-13-86	0.367	—	Thunderstorm caused momentary power outage to Building 3042 and a complete power outage to Building 3085 (pump house)

Table 7. Reductions in power not resulting in shutdowns

Date	Source of signal	Type of signal	Lowest power (MW)	Comments
7-8-86	Manual	Demand lowered	24	The power was lowered for continuity checks on MFE-7J
7-28-86	Manual	Demand lowered	24	The power was lowered for continuity checks on MFE-7J
8-4-86	Manual	Demand lowered	24	The power was lowered for continuity checks on MFE-7J
8-12-86	Safety system	Setback	27	Reactor power increased above the set point while increasing reactor power from 27 MW to 30 MW (during a startup)
8-16-86	Reactor ΔP	Setback	29	A setback occurred due to low ΔP across core
8-20-86	Manual	Demand lowered	24	The power was lowered for continuity checks on MFE-7J
8-25-86	Manual	Demand lowered	24	The power was lowered for continuity checks on MFE-7J
9-15-86	Manual	Demand lowered	24	The power was lowered for continuity checks on MFE-7J
9-22-86	Manual	Demand lowered	24	The power was lowered for continuity checks on MFE-7J
9-29-86	Manual	Demand lowered	24	The power was lowered for continuity checks on MFE-7J

INSTRUMENTATION AND REACTOR CONTROLS

The performance of the instrumentation for the facility was satisfactory, and maintenance required is indicated in Table 8.

PROCESS SYSTEMS

The performance of the process systems was satisfactory, and maintenance required is indicated in Table 9.

MECHANICAL COMPONENTS

The performance of the mechanical components was satisfactory, and maintenance required is indicated in Table 10.

EXPERIMENT FACILITIES, GASEOUS-WASTE FILTERS, AND CORE CHANGES

Experiment facility usage is given in Table 11. Table 12 summarizes the results of efficiency tests of the various gaseous-waste filters. The core configurations used during the quarter are shown in Figs. 4 through 10.

Table 8. Maintenance and changes, instrumentation and controls

Date	Component	Trouble or change	Reason or maintenance
7-2-86	No. 1 count rate recorder	Chart advance	The chart drive motor was replaced
7-15-86	Servo channel ion chamber	Faulty ion chamber	The servo ion chamber was replaced
7-15-86	No. 1 dc unit	Faulty alarm module	The voltage alarm module was replaced
7-23-86	Servo channel flux amplifier	Erratic	The flux amplifier was replaced
7-25-86	Servo channel flux amplifier	Upgrade	A ground circuit in the flux amplifier was modified
8-12-86	Reactor core differential pressure channel	Set point modification	The alarm, setback, and scram set points were recalibrated and adjusted
8-13-86	Servo channel	Erratic	The servo flux amplifier was replaced
8-18-86	Servo channel	Erratic	The servo tachometer was adjusted
8-20-86	N-16 south channel	Inoperative recorder	The recorder amplifier was replaced
8-25-86	Servo channel	Tachometer modification	The sensitivity of the servo tachometer feedback amplifier was increased

Table 8. (Continued)

Date	Component	Trouble or change	Reason or maintenance
8-26-86	North gamma channel	Erratic	The recorder amplifier was replaced
9-9-86	Servo channel	Erratic	A diode in the 3-kW selector range circuit was replaced
9-10-86	Reactor core differential pressure channel	Set point modification	The alarm, setback, scram, and sensitivity set points were adjusted
9-10-86	FRCAS	Upgrade	A circuit was installed to alarm in the Laboratory shift supervisor's control room
9-23-86	No. 1 pump cell monitron	Erratic	The amplifier was repaired
9-29-86	Normal off-gas channel	Erratic	A radiation module was replaced

Table 9. Process systems, maintenance and changes

Date	Component	Remarks
		Reactor primary cooling system
9-2-86	No. 1 primary pump	The pump seals and bearings were replaced
		Pool secondary cooling system
7-22-86	Tower fan	The fan motor was replaced
8-21-86	Acid addition system	A leak in the acid addition line was repaired
9-5-86	Secondary pump	The pump bearings were repacked
		Emergency cooling system
7-15-86	No. 1 dc unit	The voltage alarm module was replaced
		Syphon break system
8-11-86	Slant tubes	The gaskets on the slant tube check valve piping were replaced
		Miscellaneous
7-1-86	Overhead crane	A brake solenoid on small block was repaired
7-28-86	No. 3 sump pump	The sump pump was replaced
9-11-86	West truck doors	The air lines to the door operators were replaced
9-15-86	Process drain line	The drain line from Building 3042 to sump 245 was repaired

Table 10. Reactor mechanical components, maintenance and changes

Date	Component	Remarks
9-1-86	South hold-down arm	The south hold-down arm was replaced
9-1-86	North hold-down arm	The north hold-down arm was replaced

Table 11. Experiment facility usage

Facility	Access flange	Date installed	Date removed	Description of experiment	Division or sponsor
C-3	V-10	6-28-85		Material test, fusion program (MFE-7J)	Engineering Technology
C-7	V-2	6-28-85		Material test, fusion program (MFE-6J)	Engineering Technology
E-3	None	6-28-85		Aluminum-base, dispersion-type fuel plates (HFED)	Engineering Technology
HB-1	None	9-78		Neutron spectrometer	Solid State Physics
HB-2	None	11-1-58		Neutron diffraction experiments	Solid State Physics
HB-4	None	9-78		Neutron spectrometer	Solid State Physics
HB-6	None	4-76		Neutron small-angle scattering facility	Solid State Physics
HN-3	None	11-59		Activation analysis	Analytical Chemistry
HN-4	None	12-15-63		Neutron diffraction experiment	Instrumentation and Controls
South facility	None	12-16-63		Cold-finger plug[a]	Operations

[a]The facility is on standby.

Table 12. Status of filters, gaseous waste systems

Type filter	Bank designation	Date last changed	Date last tested	Type test	Retention efficiency (%)
		Cell-ventilation system			
CWS	Overall[a]	North, 4-16-80 South, 8-14-85	9-23-86	DOP	99.995
Charcoal	Both banks	North, 11-9-83 South, 8-14-85	5-31-86	Elemental iodine	99.900
		Basement hood exhaust			
CWS	South	3-11-80	9-23-86	DOP	99.998
CWS	North	3-11-80	9-23-86	DOP	99.996
		Normal off-gas			
CWS	West	8-14-85	9-23-86	DOP	99.780
Charcoal	West	8-14-85	5-20-86	Elemental iodine	99.980
CWS	East[b]	9-5-86	9-23-86	DOP	99.968
Charcoal	East[b]	9-5-86	9-23-86	Elemental iodine	99.985

[a]The CWS filters in the cell-ventilation system were checked in series.
[b]Not in service.

ORNL/DWG-86-16968

Lattice loading

For fuel cycles 176-B

	1	2	3	4	5	6	7	8	9
A	Be	F	F	F	F	F	F	F	Be
B	Be	Be	F	SR	F	SR	F	Be	Be
C	Be	F	MFE 7J E	F	F	F	MFE 6J E	F	Be
D	Be	F	F	SR	F	SR	F	F	Be
E	Be	F	HFED E	F	Be	F	Al	F	Be
F	Be	Be	F	SR	F	SR	F	Be	Be
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

Lattice component	Number
Fuel (F)	27
Shim-safety rod (SR)	6
Beryllium (Be)	26
Experiment (E)	3
Aluminum (Al)	1

Fig. 4. Lattice configuration - June 27-July 21, 1986.

ORNL/DWG-86-16969

Lattice loading

For fuel cycles 176-C

	1	2	3	4	5	6	7	8	9
A	Be	F	F	F	F	F	F	F	Be
B	Be	Be	F	SR	F	SR	F	Be	Be
C	Be	F	MFE 7J E	F	F	F	MFE 6J E	F	Be
D	Be	F	F	SR	F	SR	F	F	Be
E	Be	F	HFED E	F	F	F	Al	F	Be
F	Be	Be	F	SR	F	SR	F	Be	Be
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

Lattice component	Number
Fuel (F)	28
Shim-safety rod (SR)	6
Beryllium (Be)	25
Experiment (E)	3
Aluminum (Al)	1

Fig. 5. Lattice configuration - July 22-August 11, 1986.

ORNL/DWG-86-16970

Lattice loading

For fuel cycles 176-D

	1	2	3	4	5	6	7	8	9
A	Be	F	F	F	F	F	F	F	Be
B	Be	Be	F	SR	F	SR	F	Be	Be
C	Be	F	MFE 7J E	F	F	F	MFE 6J E	F	Be
D	Be	F	F	SR	F	SR	F	F	Be
E	Be	F	HFED E	F	Al	F	Al	F	Be
F	Be	Be	F	SR	F	SR	F	Be	Be
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

Lattice component	Number
Fuel (F)	27
Shim-safety rod (SR)	6
Beryllium (Be)	25
Experiment (E)	3
Aluminum (Al)	2

Fig. 6. Lattice configuration - August 12-September 1, 1986.

ORNL/DWG-86-16971

Lattice loading

For fuel cycles 177-AX1

	1	2	3	4	5	6	7	8	9
A	Be	Be	F	F	F	F	F	Be	Be
B	Be	Be	F	SR	F	SR	F	Be	Be
C	Be	F	MFE 7J E	F	F	F	MFE 6J E	F	Be
D	Be	F	F	SR	F	SR	F	F	Be
E	Be	F	HFED E	F	Al	F	Al	F	Be
F	Be	Be	F	SR	F	SR	F	Be	Be
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

Lattice component	Number
Fuel (F)	25
Shim-safety rod (SR)	6
Beryllium (Be)	27
Experiment (E)	3
Aluminum (Al)	2

Fig. 7. Lattice configuration - September 1-6, 1986.

ORNL/DWG-86-16972

Lattice loading

For fuel cycles 177-AX2

	1	2	3	4	5	6	7	8	9
A	Be	Be	F	F	F	F	F	Be	Be
B	Be	Be	F	SR	F	SR	F	Be	Be
C	Be	F	MFE 7J E	F	F	F	MFE 6J E	F	Be
D	*	F	F	SR	F	SR	F	F	*
E	Be	F	HFED E	F	Al	F	Al	F	Be
F	Be	Be	F	SR	F	SR	F	Be	Be
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

*Fission chamber

Lattice component	Number
Fuel (F)	25
Shim-safety rod (SR)	6
Beryllium (Be)	25
Experiment (E)	3
Aluminum (Al)	2
Fission chamber	2

Fig. 8. Lattice configuration - September 6-10, 1986.

ORNL/DWG-86-16973

Lattice loading

For fuel cycles 177-A

	1	2	3	4	5	6	7	8	9
A	*	Be	F	F	F	F	F	Be	*
B	Be	Be	F	SR	F	SR	F	Be	Be
C	Be	F	MFE 7J E	F	F	F	MFE 6J E	F	Be
D	Be	F	F	SR	F	SR	F	F	Be
E	Be	F	HFED E	F	Al	F	Al	F	Be
F	Be	Be	F	SR	F	SR	F	Be	Be
G	*	Be	Be	Be	Be	Be	Be	Be	*

*Dummy Element

Lattice component	Number
Fuel (F)	25
Shim-safety rod (SR)	6
Beryllium (Be)	23
Experiment (E)	3
Aluminum (Al)	1
Dummy Elements	4

Fig. 9. Lattice configuration - September 11-26, 1986.

ORNL/DWG-86-16974

Lattice loading

For fuel cycles 177-B

	1	2	3	4	5	6	7	8	9
A	*	Be	F	F	F	F	F	Be	*
B	Be	Be	F	SR	F	SR	F	Be	Be
C	Be	F	MFE 7J E	F	F	F	MFE 6J E2	F	Be
D	Be	F	F	SR	F	SR	F	F	Be
E	Be	F	HFED E	F	Al	F	Al	F	Be
F	Be	Be	F	SR	F	SR	F	Be	Be
G	*	Be	Be	Be	Be	Be	Be	Be	*

*Dummy elements

Lattice component	Number
Fuel (F)	25
Shim-safety rod (SR)	6
Beryllium (Be)	23
Experiment (E)	3
Aluminum (Al)	2
Dummy elements	4

Fig. 10. Lattice configuration - September 26-30, 1986.

SPECIAL TESTS CONDUCTED FOR THE LEU WHOLE-CORE DEMONSTRATION
(R. W. Hobbs)

1. Configuration 177-AX1 (9-4-86 to 9-7-86)

   Core physics measurements were made this quarter and include:

   a. a core flux mapping by Co-activation;

   b. shim-safety rod calibrations;

   c. β_{eff}/ℓ measurements; and

   d. gamma heating (testing for flow vibration was accomplished on the redesigned apparatus; no measurements were taken).

2. Fuel element gamma scanning

   a. Data have been gathered on all cores from 174-C to date.

   b. The data for the 1596 keV line of La-140 for the elements scanned from cores 176-C through 177-A have been analyzed and are available on request.

INSPECTION OF THE REACTOR-POOL PRESSURE-EQUALIZATION SYSTEM—SEISMIC-RESTRAINT SYSTEM

On September 2, a visual inspection was performed on the welds for both north and south restraint systems.

All welds were found to be in accordance with the drawing specifications and are satisfactory for service. A requirement was stipulated that one of the drawings be revised on a particular restraint weld to allow the option to bolt or weld, dependent on the availability to make a bolted connection.

SUMMARY OF SURVEILLANCE TESTS

Table 13 is a tabulation of the completion dates of the surveillance tests required by the Technical Specifications. This table contains all the surveillance tests scheduled for frequencies of one quarter or longer. Other surveillance requirements which are not reported are satisfied by routine completion of daily and weekly check sheets, start-up checklists, hourly data sheets, the operating log book, and miscellaneous quality assurance tests.

Table 13. Summary of surveillance tests

Test	Most recent	Previous
Biennially		
Primary cooling flow channel calibration		
Direct flow channel	9-5-86	8-8-85
Core ΔP channel	9-5-86	8-14-85
^{16}N channel calibration	9-5-86	5-8-86
North-facility flow channel calibration	5-8-86	4-25-84
South-facility flow channel calibration	5-8-86	4-25-84
Normal off-gas vacuum monitor calibration	9-5-86	8-12-85
Building ventilation flow monitor calibration	11-22-85	10-25-84
The dc pony motor battery bank		
Load-test No. 1 bank	9-1-86	11-3-85
Load-test No. 2 bank	5-4-86	11-3-85
Load-test No. 3 bank	2-20-86	11-3-85
Annually		
Safety-level channels calibration	9-4-86	5-8-86
Log-N channels calibration	9-5-86	5-8-86
ΔT channels calibration	3-6-86	8-21-85
Reactor water exit temperature channels calibration	3-6-86	8-21-85
Fission chamber channels calibration	9-5-86	5-8-86
Speed measurements of the shim-safety rod drive motors	9-26-86	5-6-86

Table 13. (Continued)

Test	Most recent	Previous
Annually (continued)		
Calibration of shim-safety rods	9-7-86	6-13-86
Reactivity assigned to the servo-control system	9-7-86	6-13-86
Semiannually		
Pressure-drop measurements across NOG filters	9-28-86	6-29-86
NOG filter system efficiency		
Elemental iodine test - east bank	9-23-86	12-5-85
Elemental iodine test - west bank	5-20-86	12-3-85
Dioctyl phthalate test - east bank	9-23-86	3-7-86
Dioctyl phthalate test - west bank	9-23-86	3-7-86
Containment closure system function test	9-2-86	5-6-86
Cell-ventilation filter system efficiency		
Elemental iodine measurements	5-31-86	12-10-85
Dioctyl phthalate measurements	9-23-86	3-7-86
Radiation monitoring equipment calibration	7-14-86	5-4-86
Stack radiation monitor calibration	5-6-86	10-8-85
Quarterly		
Primary coolant flow channels tested	9-5-86	5-8-86
^{16}N channels tested	9-4-86	5-8-86
North-facility flow channels tested	9-5-86	5-8-86
South-facility flow channels tested	9-5-86	5-8-86
Normal off-gas vacuum monitor tested	9-5-86	5-8-86

Table 13. (Continued)

Test	Most recent	Previous
Quarterly (continued)		
Building ventilation flow monitor tested	9-5-86	5-8-86
Manual scrams tested	9-5-86	5-8-86
Measurement of release time and time of flight for the shim-safety rods	9-26-86	5-6-86
Subcriticality with each shim-safety rod at its upper limit while all other shim-safety rods are fully inserted	9-26-86	5-6-86

ORNL/TM-10276

INTERNAL DISTRIBUTION

1. S. J. Ball
2-3. G. H. Burger
4. T. E. Cole
5. G. H. Coleman
6. B. L. Corbett
7. W. A. Duggins
8-12. M. K. Ford
13. T. A. Gabriel
14. T. P. Hamrick
15. E. E. Hill
16. R. W. Hobbs
17. S. A. Hodge
18. S. S. Hurt
19. E. B. Johnson
20. R. R. Judkins
21-22. F. B. K. Kam
23. M. W. Kohring
24. R. V. McCord
25. F. E. Muggridge
26. E. Newman
27. K. H. Poteet
28. L. P. Pugh
29. J. A. Ray
30. R. L. Senn
31. J. A. Setaro
32. R. M. Stinnett
33. J. H. Swanks
34. K. R. Thoms
35. K. W. West
36. R. S. Wiltshire
37-38. Laboratory Records Department
39. Laboratory Records, ORNL R.C.
40-41. Central Research Library
42. Document Reference Section
43. ORNL Patent Section

EXTERNAL DISTRIBUTION

44. N. Goldenberg, Director, Safety, QA, and Safeguards, Office of Support Programs, Department of Energy, Germantown, Maryland 20545
45. J. N. Maddox, ER73, Mail Stop G226 GTN, Office of Health and Environmental Research, Office of Energy Research, Department of Energy, Washington, DC 20545
46. C. Moller, Atomic Energy Board, Pelindaba, Private Bag X256, Pretoria, SOUTH AFRICA
47. M. Jacquemain, Head, Technical Department ILL, Institute Max Von Laue-Paul Langevin, CEDEX 156, 38 Grenoble-Gare, FRANCE
48. J. A. Lenhard, Office of Assistant Manager for Energy Research and Development, Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tennessee 37831
49. M. Nakai, NAIG Nuclear Research Laboratory, Nippon Atomic Industry Group Co., Ltd., 4-1, Ukishimacho, Kawaskaki City, JAPAN
50. R. J. Swanenburg de Veye, Head, Research Reactor Department, Energy Centrum Nederland Westerduinweg, 3-Petten (NH), THE NETHERLANDS
51. L. E. Temple, Director, Construction Management, Office of Energy Research, Department of Energy, Washington, D.C. 20585
52. A. C. Woods, A.A.E.C. Research Establishment, New Illawarr Road, Lucas Heights, N.S.W., AUSTRALIA
53. Safety and Environmental Control Division, Department of Energy, Oak Ridge, Tennessee 37831
54-83. Technical Information Center, DOE, Oak Ridge, Tennessee 37831