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ORNL-TM-351

ORR OPERATIONS

FOR PERIOD APRIL 1961 TO APRIL 1962

J. A. Cox

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FOR PERIOD APRIL 1961 TO APRIL 1962

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DATE ISSUED

OCT 16 1962

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Oak Ridge, Tennessee
operated by
UNION CARBIDE CORPORATION
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U. S. ATOMIC ENERGY COMMISSION

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INTRODUCTION

This fourth year of operation of the Oak Ridge Research Reactor is the first full year at a power level of 30 megawatts. On-stream time at this power level has been relatively steady with 75.4 and 83.7 percent operating time for the lowest and highest quarters, respectively. A wide variety of experiments has been conducted at the different facilities with facility use at 88% as of March 31, 1962.

Modification of the ball-latch mechanism of the shim-rod-drives is underway. Changes in the components of the primary cooling system include modification of the primary bypass control valve and the addition of a d-c pony motor at the No. 3 primary pump. This addition will increase the reliability of adequate water flow for afterheat cooling.

A study of the lowered efficiency of the pool-cooling heat exchanger disclosed that the interior of the tubes was being fouled by a microorganism which was probably growing in the pool demineralizer and was being deposited in the heat exchanger. Cleaning the tubes with brushes restored the efficiency of the heat exchanger to near normal; and, sterilizing the anion resin is expected to control the growth of the fouling organism.

During the February 11-16 end-of-cycle shutdown, a leak was detected in the pool liner near where a 6-in. pool water line penetrated the liner. The leak was repaired and a vacuum system was installed to dry out the area and prevent other possible leaks at this point.

The early detection of boiling in the core of the ORR is information that could further minimize the possibility of a partial meltdown caused by either restricted cooling, due to foreign particles in the coolant water, or hot spots, from irregularities in fuel density and other fuel deformities. Studies have indicated that two detection methods show promise; and, because of the urgency of the problem, work is proceeding simultaneously on both.

PART I

Taken from OPERATIONS DIVISION QUARTERLY REPORT

April - June, 1961, ORNL CF-61-6-115

REACTOR OPERATIONS

QUARTERLY REPORT

Summary

The ORR operating time increased to 81.2% for the quarter in spite of shim-rod drive troubles which required that several drives be changed. Harder components have been installed in all of the ball-latch mechanisms, and these appear to be giving better service than the original components.

A boiling detection device is being designed for the ORR to give added safety in the event of a local blockage in the fuel.

1. OAK RIDGE RESEARCH REACTOR

1.1. Operations

W. R. Casto

Operations

The ORR was operated during this period at a power level of 30 Mw. Total operating time for the quarter was 177.27 hours. The operating data are given in Table 1.1.

Table 1.1. ORR Operations

Period April 1, through June 30, 1961

	This Quarter	Last Quarter	Year to Date
Total energy, Mwd	2197.5	2136.7	4334.2
Average power, Mw/operating hr	29.8	29.7	29.8
Time operating, %	81.2	80.0	80.6
Reactor water radioactivity, c/m/ml (av)	30,236	38,622	34,406
Pool water radioactivity, c/m/ml (av)	1368	900	1135
Reactor water resistivity, ohm-cm (av)	524,000	501,000	513,000
Pool water resistivity, ohm-cm (av)	704,000	669,000	687,000
Research samples	7	9	16
Radioisotope samples	103	109	212

The core configuration at the end of the quarter is indicated in Figure 1.1.

Cycles of operation during this period are shown in Table 1.2.

Table 1.2. ORR Cycles of Operation

Cycle No.	Date Begun	Date Ended	Accumulated Energy (Mwd)
33	March 17, 1961	May 7, 1961	1,382.6*
34	May 19, 1961	In progress	1,223.6

*Accumulated energy for cycle 33 during this quarter was 973.9 Mwd.

Figures 1.2 and 1.3 indicate the positions of the shim rods during cycles 33 and 34.

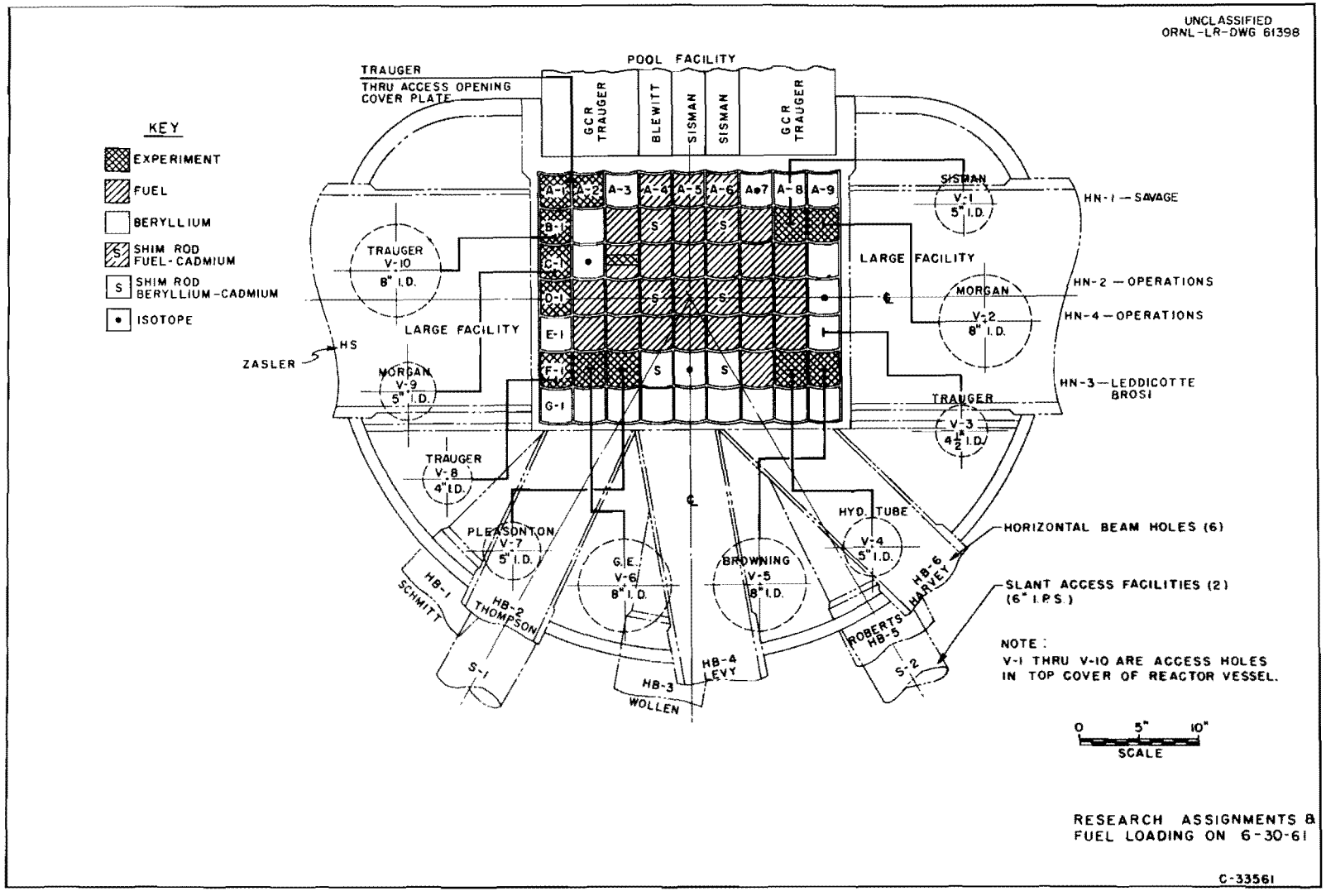

Fig. 1.1. O.R.N.L. Research Reactor Lattice Pattern and Experiment Locations

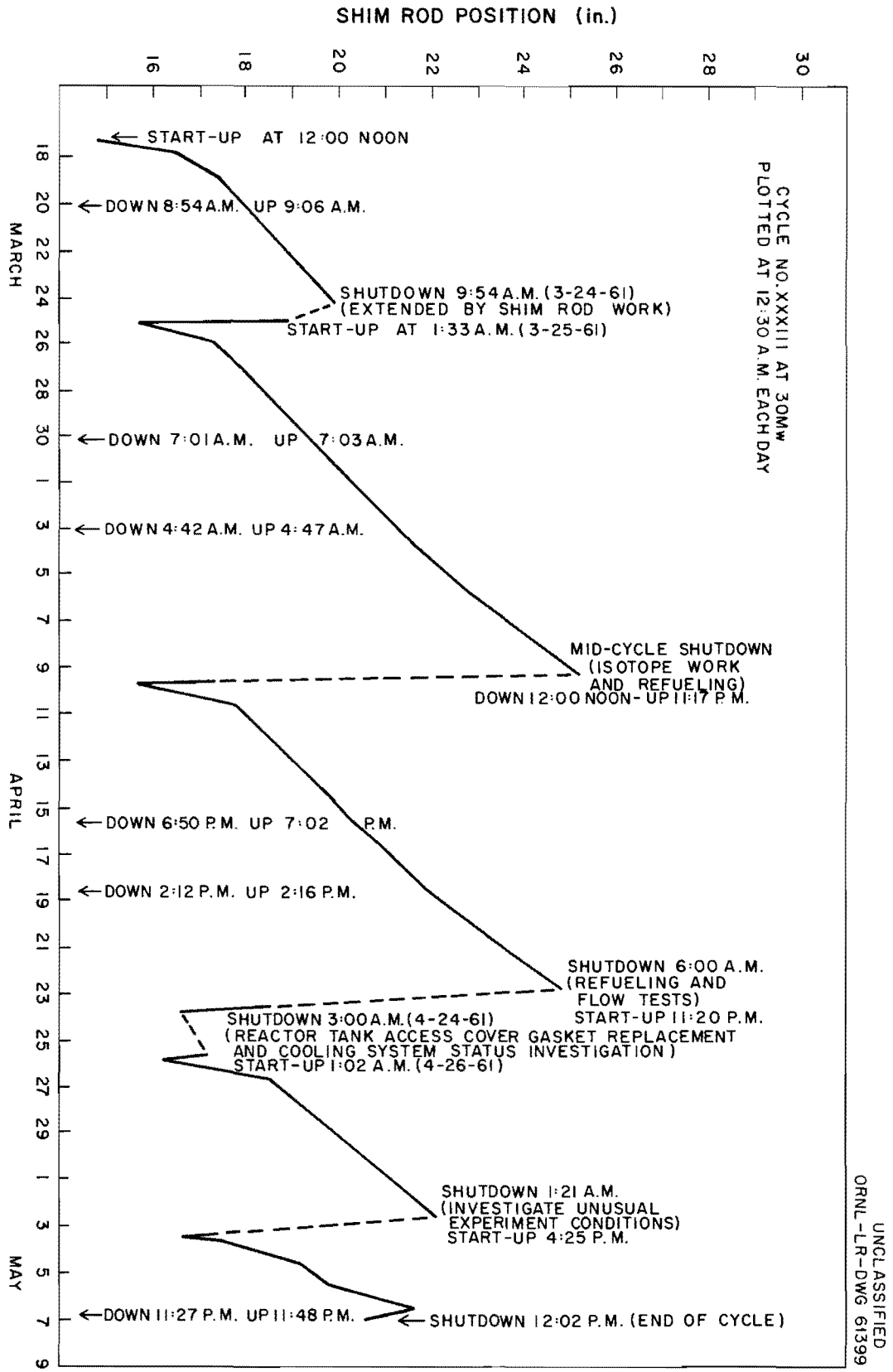

Fig. 1.2. Shim Rod Position vs. Time

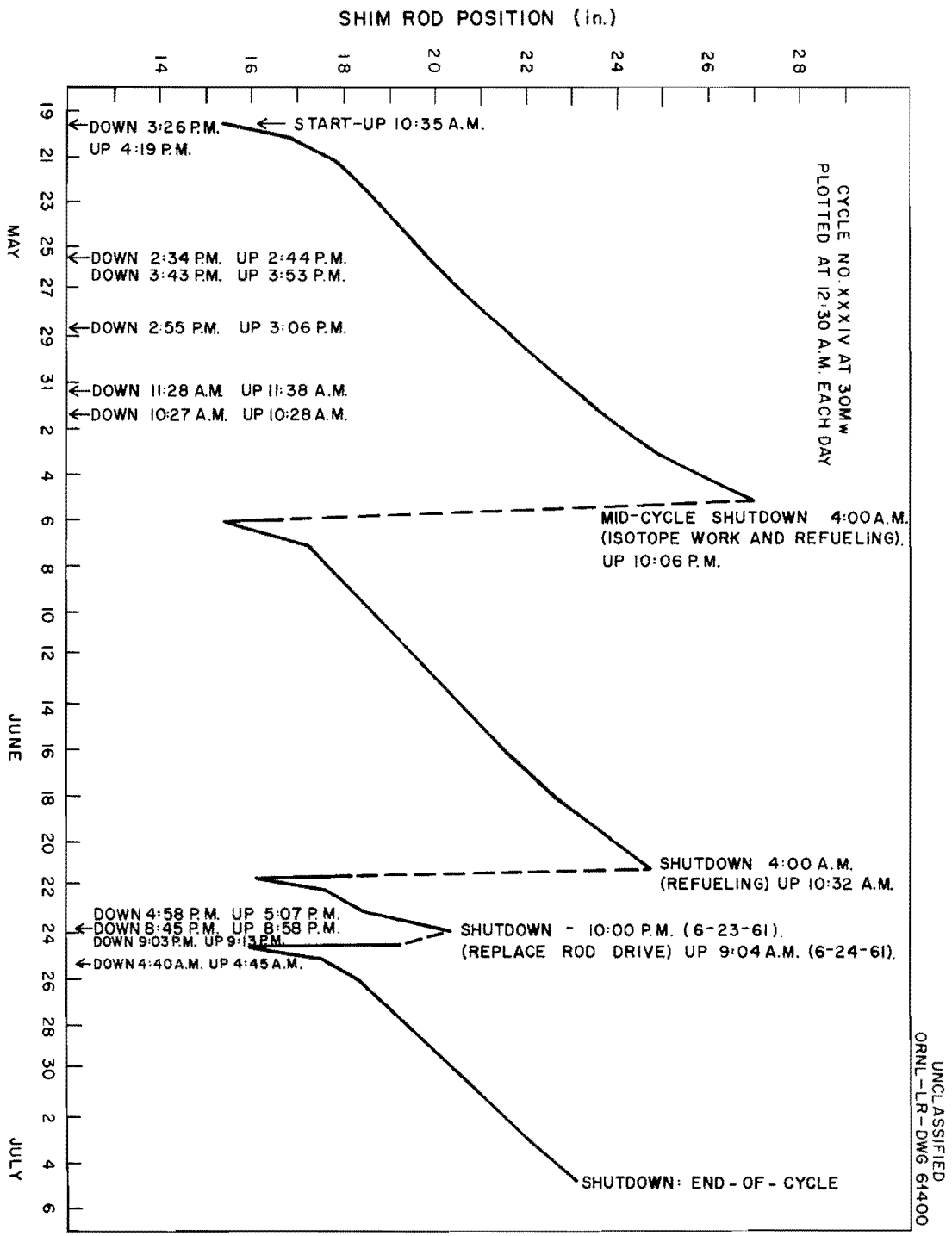

Fig. 1.3. Shim Rod Position vs. Time

Shutdowns

One major shutdown occurred during this quarter.

May 7 through May 18, 1961. Activities during this period included installation of the gas-cooled loop No. 1 in-core experiment tube; replacement of the GCR capsule experiments; removal from CP-F2 of the in-core experiment tube and associated in-pool piping; reinstallation of the permanent fission-chamber drive units; and removal of eight and insertion of seven experiments (excluding those indicated above). A series of critical tests and shim-rod worth tests were also performed. In addition, two tests were run to determine stresses in the north facility obround transition piece due to thermal cycling. These tests were unsuccessful due to failure of the measuring equipment. Although these last two tests were part of the scheduled work to be performed during this shutdown, they involved reactor operation at accountable power levels and, therefore, are recorded as separate shutdowns (see Table 1.4, Analysis of ORR Shutdowns). For this reason the end-of-cycle 33 shutdown is indicated as being terminated on May 18, 1961, although cycle 34 proper did not begin until May 19, 1961.

Table 1.3 lists the unscheduled shutdowns which occurred this quarter.

Table 1.3. Unscheduled Shutdowns at the ORR

Date	Duration (hr)	Remarks
4-4-61	0.083	Setback from MSR experiment. Failure of electronic tube in recorder.
4-15-61	0.200	Real cause; electric power failure (human error) resulted when a K-25 substation operator pulled the wrong breaker. This cut off power to the reactor primary and secondary cooling pumps, reactor cooling tower, pool secondary cooling pump, and pool cooling tower. A scram resulted from low primary cooling flow.
4-18-61	0.067	Shim (auxiliary) rod No. 1 dropped, reason unknown.
5-6-61	0.350	Scram from GCRP capsule No. 3 experiment. A temperature recorder fuse blew; a replacement fuse also blew; and the "instrument power" breaker was tripped which scrammed the reactor.
5-25-61	0.167	Shim rod No. 6 dropped, reason unknown. However, an intentional drop one hour later revealed foreign material on the magnet keeper. This material was removed. (See Table 1.5.)

Table 1.3. Continued

Date	Duration (hr)	Remarks
5-28-61	0.183	Shim rod No. 6 dropped, reason unknown.
5-31-61	0.167	Shim rod No. 6 dropped, reason unknown.
6-1-61	0.017	Setback from MSR experiment. Failure of a feedback bellows in a ΔP transmitter resulted in a "low mass flow" indication.
6-23-61	0.183	Shim rod No. 6 dropped.
6-23-61	0.217	Shim rod No. 6 dropped.
6-23-61	0.167	Shim rod No. 6 dropped. Following recovery from this rod drop, preparation was made to replace the drive tube. Investigation revealed a slight leak in the bellows seal. (See Table 1.5.)
6-25-61	0.083	Setback from MSR experiment. Failure of an electronic tube resulted in "upscale burnout" of a recorder.

There was one shutdown for real cause (4-15-61); i.e., where such a condition existed that without reactor power reduction an experiment and/or the reactor could be damaged.

Table 1.4 gives the analysis of the causes of shutdowns for this quarter.

Table 1.4. Analysis of ORR Shutdowns

Description	Number	Downtime (hr)
Scheduled Shutdowns		
Regular, end of cycle	1	257.467
Regular, midcycle and isotope work	2	29.384
Regular, refueling	2	23.866
Control-rod drive repair	1	11.067
Control-rod drive testing	1	0.167
Reactor tank access cover gasket replacement and cooling system status investigation	1	46.033
Investigation of unusual conditions, experiments	2	15.900
Termination of special tests	2	25.550
Subtotal	12	409.434

Table 1.4. Continued

Description	Number	Downtime (hr)
Unscheduled Shutdowns		
Instrument failure, reactor controls	0	0
Instrument failure, experiments	4	0.533
Rod drops, reason unknown	4	0.584
Rod drops, leak resulting in magnet failure	3	0.567
Human error (resulting in electrical power failure)	1	0.200
Subtotal	12	1.884
Total	24	411.318

Reactor Controls

Maintenance and Modifications. During the shutdown ending cycle 33, the gamma chamber installed on the east end of the north thermal shield was removed from the reactor due to a rupture of the tygon tubing containing the chamber leads. Two gamma chambers (Q-1842) were installed in four-inch-diameter housings (Q-1757-3) with revised bonnets. This permitted the gamma chamber to be installed in the standard ORR ionization chamber positions.* One was installed in position No. 1, and its signal is monitored on a spare recorder with no connection to the safety system. The second chamber was installed in position No. 8 and its signal fed to the recorder previously connected to the north chamber. The status of the south chamber was unchanged. Both the chamber in position No. 8 and the south chamber cause reactor scram at a recorder setpoint of 148 on a 0-150 scale. The two new chambers do not include sensitivity switches because previous investigation had shown that an increase in chamber current during a reactor operating cycle did not occur in these positions.

During this shutdown, wiring checks of the AC power to the subpile room fission-chamber preamplifiers revealed that the subpile-room Sola transformer was connected in series with the control room, count-rate-channel Sola transformer. Manufacturer's information indicates that such transformers should not be in series since, under certain load conditions,

*These standard positions are to the east of the reactor tank and are numbered from south to north as No. 1 through No. 8.

the reflected impedance will result in an extreme leading power factor. The subpile room transformer was reconnected to a "raw" AC bus.

Table 1.5. Reactor Controls--ORR

Date	Description
4-2-61	The controller for the by-pass control valve on the reactor secondary cooling system was not operating properly, resulting in reactor power fluctuations. Adjustment of the controller corrected the difficulty.
4-4-61	The servo amplifier was replaced in an attempt to improve reactor control. The replacement did not eliminate control difficulties, and it was determined that fluctuation of control room temperature was the primary cause.
4-11-61	Minor power fluctuations occurred.
4-13-61	Minor power fluctuations occurred.
4-18-61	Auxiliary shim rod No. 1 dropped, reason unknown.
4-23-61	Auxiliary shim rod No. 1 failed to drop when scrammed after reactor power had been manually reduced to 1% of full power for supplementary refueling. All other rods dropped properly, and the reactor was shut down. The No. 1 shim rod was driven to "seat" limit and then withdrawn 3 inches and again failed to drop when scrammed until the magnet housing was jarred. This drive unit had been installed 1-16-61 as a routine replacement and contained old components (head, balls, and plunger). It was replaced with a unit having new components (head, balls, and plunger).
4-25-61	During prestartup checks following a shutdown to repair the reactor tank access cover gasket and to investigate the status of the reactor cooling system, auxiliary shim rod No. 2 dropped properly with no cooling flow. Further checks with full flow revealed that the rod would not drop until flow was reduced to 16,500 gpm. This unit had been installed 1-17-61 as a routine replacement and contained old components. It had dropped on all previous occasions on April 23, 24, and 25, 1961. This unit was replaced with a unit containing new components.
4-28-61	Log N channel No. 2 became erratic.
5-1-61	Log N channel No. 2 amplifier and micromicroammeter were replaced.
5-2-61	Minor power fluctuations occurred.
5-3-61	During reactor startup following shutdown for experiment removal, difficulty was experienced in obtaining "run" mode. The log N chambers were withdrawn slightly and "run" obtained.

Table 1.5. Continued

Date	Description
5-4-61	Minor power fluctuations occurred. The difficulty in obtaining "run" on 5-3-61 was found to have been caused by the servo amplifier's "zeroing" circuit having drifted.
5-7-61	During this shutdown (end of cycle 33), it was found that the exhaust fan for the amplifier cabinet containing the servo amplifier was defective. Insufficient air flow left the amplifier unprotected from changing temperature conditions in the control room. This fan was replaced, and the minor power fluctuations of the type previously observed did not recur until a month later.
5-18-61	The signal from the permanent fission channel was lost. It is believed to have been caused by a short in the cable from the preamplifier to the control room.
5-18-61	During startup checks shim rod No. 5 was found to be sticking in the seat position. The shock absorber was removed and found to contain debris which included a short piece of welding rod. The shock absorber was replaced with a spare.
5-24-61	Preamp grid offset in the period sigma amplifier gave a safety trouble alarm. An electronic tube was found to have failed in the No. 2 log N period amplifier.
5-25-61	Shim rod No. 6 dropped. The reactor was brought back to power with no apparent difficulties. With the rod withdrawn 20 inches the components in the subpile room were examined. A slight air gap, sufficiently wide to permit the passage of air, was detected between the magnet and keeper. When an upward force was exerted on the keeper, the air gap disappeared. Immediately upon relieving the force, however, the air gap reappeared. After about an hour, xenon had been reduced to about the equilibrium concentration. The rod was tested by reducing the magnet current. Shortly after the reduction began the gap widened; the rod dropped when the magnet current had been reduced to about 20 milliamperes. An investigation of the magnet and magnet keeper indicated the presence of foreign matter, possibly due to a small water leak at some previous time. This foreign matter was removed. Since the drive assembly operated in the normal manner during the recocking operation and since the "drop current" was within the specified limits of 15 ± 10 milliamperes, reactor operation was resumed. This magnet has a special annealed core and is being tested for the Instrumentation and Controls Division.

Table 1.5. Continued

Date	Description
5-28-61	Shim rod No. 6 dropped, reason unknown.
5-31-61	Shim rod No. 6 dropped, reason unknown. This rod drive was scheduled to be replaced during the next refueling shutdown.
6-4-61	On one occasion the servo-controlled rod (No. 6) failed to withdraw, although a withdrawal error existed in the servo system and the rod-drive motor had power. This situation was scheduled to be investigated during the next refueling shutdown.
6-5-61	During the midcycle shutdown, the drive tube for No. 6 shim rod was replaced with a spare unit containing new components. The gear box for this shim-rod drive position was opened for inspection. Both the gears and bearings were replaced with new parts. The relays on the motor control circuit were replaced. Both the "insert" and "withdraw" relay had badly burned contacts. The permanent fission chamber was replaced; however, on checking this installation, it was found to be unreliable. Operation was resumed on poolside spare.
6-7-61	The No. 1 log N channel became erratic, and the selector switch was changed to the No. 2 log N channel. Just prior to this time, the reactor power became unsteady; and the recorder traces were of the same appearance as were observed when the control room air conditioner was thought to be the cause.
6-21-61	The count rate meter bias voltage was adjusted to correct a false period indication. The null point had drifted and indicated a constant 300-second period.
6-23-61	Shim rod No. 6 dropped. After picking up the rod and resuming operation, a slight leak was observed around the bottom seal. The moisture was wiped off twice, and inspection of the tube revealed no additional external leakage for about four hours. Leakage inside the drive tube was suspected due to erratic magnet amplifier current during the startup. A second drop occurred about four hours after the first. After recocking an air gap appeared between the magnet and magnet housing. An attempt was made to close the gap, resulting in another rod drop. Operation was resumed, and arrangements were initiated to change the drive unit. A spare unit with new components was installed. This unit had been previously assembled and dimensionally checked (diameter of extended balls was 2.021 inches). The old unit was rechecked and the extended ball diameter found to be

Table 1.5. Continued

Date	Description
	2.021 inches. The old unit was later found to have a slight leak, and the magnet was damaged due to electrical shorting.
6-25-61	Following reloading and a critical run, the reactor startup was initiated. When the rods were withdrawn about half the distance to the previously determined critical position, the fission chamber became erratic and all rods were reversed to their lower limits. It was found that the count rate meter was no longer functioning properly, and a spare count rate meter was installed. Following this replacement, a normal reactor startup was accomplished.

Reactor Primary Cooling System

Operating Experience. On April 23, 1961, a series of tests were performed on the ORR primary water system including the Trane air coolers. The tests were designed to obtain data for analog computer analysis of temperature and flow-control problems encountered in using the Trane coolers with the evaporative cooling towers.

The conditions required of one phase of the tests were as follows: the shell-and-tube heat exchangers and Trane coolers were valved out of the system; flow was established through the butterfly control valve.[1] The reactor water flow had been adjusted at about 14,000 gpm with the No. 2 and No. 3 primary pumps operating and the by-pass valve opened about 55°, giving a ΔP across the by-pass valve of about 3.5 psi. To expand the ΔP-versus-flow relationship through the by-pass line, the No. 1 primary pump was started and its discharge valve opened slightly to increase the flow in order to obtain another point on the curve. At this time personnel located in the by-pass pit heard a loud vibration and an increase in water turbulence in the by-pass valve. The person controlling the flow from the ORR control room observed a rapid rise in ΔP across the by-pass valve and immediately shut off pumps No. 1 and No. 2. Immediately, the check valves

[1] J. A. Cox, Reactor Operations, Radioactive Wastes Operations, and Hot Cells Operations Quarterly Report, July - September, 1960, ORNL CF-60-9-121, (Jan. 23, 1961).

located on the discharge side of these two pumps closed; and personnel in the pump house area, by-pass pit, and the Trane cooler area heard a loud water hammer. The testing was halted, and an inspection of the primary pumps and their check valves indicated no apparent physical damage to these components. This phase of the planned testing was not resumed; but other flow tests were conducted as scheduled. After these, the reactor access cover was removed; and inspection of the reactor core revealed no abnormal conditions.

The reactor cooling system was then returned to the normal operating condition, prestartup checks were made, and reactor startup was initiated. For approximately one hour while the reactor was operated at 5 Mw, close observation was made of all instrumentation to assure that all components were working properly and that equilibrium operating conditions were normal. Since no abnormalities were detected, the reactor power was raised to 20 Mw.

Shortly after the power increase, the temperature of the pool water began to increase and leakage of reactor water into the pool was suspected. The reactor was shut down, and an investigation revealed that a section of the gasket between the reactor tank top and the access cover was missing. The ruptured gasket was replaced, and a detailed examination was made of all other components in the system. This inspection revealed no leaks or damaged parts. Precision measurements inside the core housing indicated that no damage had occurred.

It is now believed that when the check valves closed, a shock wave was transmitted back through the lines to the reactor tank. As a result of this incident, an engineering study is in progress to determine the modifications necessary to preclude such shock waves. Until such modifications are made, standard operating procedure will be to close the pump discharge valve before stopping one of the pumps.

Degasifier Data. An investigation was made of the efficiency of the degasifier in the ORR reactor primary cooling system. Samples of gas were obtained from water samples taken at the inlet and exit water lines to the degasifier. A gamma ray spectrum analysis was performed on these samples and the activities of Xe^{135} and A^{41} determined. The results of this analysis are presented in Table 1.6.

Table 1.6. ORR Degasifier Efficiency

Degasifier Flow Rate (gpm)	Radionuclide	Decay Time From Sampling (Min)	Radioactivity Ratio* Inlet Water / Exit Water
50	A^{41}	3	0.014 ± 0.007
	Xe^{135}	3	0.013 ± 0.003
	A^{41}	14	0.010 ± 0.005
	Xe^{135}	14	0.010 ± 0.002
75	A^{41}	3	0.023 ± 0.006
	Xe^{135}	3	0.037 ± 0.005
	A^{41}	14	0.016 ± 0.005
	Xe^{135}	14	0.030 ± 0.005

*The factor limiting the accuracy of the determination of the ratio is the low count rate of the radionuclides in the exit water.

Leakage Detection System. Early in this period, an increased volume of condensate was collected from the annular region between the concrete and a section of the 24-in. south inlet water line (line 110).[2] The section of line involved runs from the pipe chase to the west of a type "I" anchor.[3] A special test was conducted on May 16, 1961, to determine if a leak existed. The water level in the reactor vessel was lowered to expose a portion of the inlet water line, the annular region was pressurized with helium to 20 psi, and a helium leak detector was positioned to monitor the air in the reactor vessel. From analysis of the test results it was concluded that positive indication of a leak does exist; however, it is impossible to evaluate the exact size of the leak from the results obtained. Continued observations are being made on a routine basis by the volume of condensate collected from this annular region. Engineering studies have been initiated to evaluate repair methods to be used should a serious leak occur.

[2] J. A. Cox, Reactor Operations and Radioactive Wastes Operations Quarterly Report, January - March, 1960, ORNL CF-60-3-148, (May 24, 1960).

[3] J. A. Cox, Operations Division Quarterly Report, January - March, 1959, ORNL CF-59-3-1, (June 23, 1959).

Pool Cooling System

Heat Exchanger Fouling. On May 8, 1961, the shell-and-tube heat exchanger was disassembled for inspection and cleaning of the exterior of the tube bundle and the shell section; pool secondary cooling water is circulated through the region between these components. The inspection revealed that the exterior of the tube bundle had less foreign matter adhering to the tubes than on previous inspections; however, the tube bundle had been cleaned two months prior to this inspection. In addition, it was found that the interior of the tubes, through which pool primary water is circulated, contained foreign matter in the form of a brown sludge. The interior of the tubes was cleaned by flushing each tube individually with process water, loosening the foreign matter with long handled brushes, and reflushing each tube. Approximately one cup of the material was removed from each tube, and a sample was sent to the Biology Division for analysis.

In order to clean the exterior of the tube bundle and the shell section, the heat exchanger was reassembled and isolated from the remaining portion of the pool secondary cooling system. Temporary piping was arranged so that the pool primary circulating pump could be used to circulate a cleaning solution. A mixing tank and an auxiliary pump was provided to prepare the solution and introduce it into the system to be cleaned.

This solution was prepared by dissolving 16.7 lb of chromic acid (technical grade) and adding 3.5 gallons of concentrated phosphoric acid (USP-NF) for each 100 gallons of solution prepared.* It was planned to circulate the solution at room temperature for about four hours. After about one hour, the heat input from the circulating pump resulted in a considerable temperature rise. Since an alternate method proposed was to circulate the solution at 80°C for 45 minutes, the circulation was terminated and the cleaning solution was drained. Clean water was introduced into the system and circulated for about one hour. The heat

*This solution was selected rather than one employing alkaline cleaners in order to reduce attack on the aluminum-base metal and to reduce the quantity of hydrogen released and, thereby, the attendant explosion hazard.

exchanger was then drained and disassembled. The appearance of the exterior of the tube bundle at this time is as shown in Figure 1.4. The fact that material remained undissolved on one portion is attributed to nonuniform circulation.

The results of the cleaning operation were very successful as indicated by the performance of the heat exchanger during subsequent operation. Measurements at the time indicated that the heat-transfer coefficient of the heat exchanger had increased to approximately the normal value.

Operating Data. The Biology Division's analysis of the sample submitted indicated that the material was definitely biological in nature and that only a small percentage of the organisms were living. It was suggested that these organisms probably were not growing in the heat exchanger but were accumulating there after growth at another point. Samples of pool demineralizer cation and anion resins were, therefore, sent to the Biology Division for analysis.

The results of this analysis indicated appreciable numbers of living bacteria contained in the resin samples and particularly in the anion resin which contained approximately 10^4 live organisms per milliliter of resin. The number observed in the sample of cation resin was much lower relative to the number in the anion resin. Contact with the manufacturer of the resins revealed that bacterial growth in resin beds is commonly encountered where these units are overdesigned in order to obtain extended service between regenerations. In units frequently regenerated, biological growth is kept to a minimum because the regenerant chemicals are usually toxic to living organisms. The manufacturer further indicated that the anion resin (IRA-400) could be sterilized satisfactorily by treatment with an aqueous solution containing 100 ppm of a quaternary amine-type bactericide. The sterilization should be carried out on an exhausted resin bed which will be regenerated immediately following the sterilization. During the end-of-cycle shutdown in July, 1961, it is planned to sterilize the pool anion resin bed.

Mechanical Control Redesign

The redesigned ball-latch release mechanism was tested on a test unit.[4]

[4] J. A. Cox, Reactor Operations, Radioactive Wastes Operations, and Hot Cells Operations Quarterly Report, January - March, 1961, ORNL CF-61-3-138, (July 5, 1961).

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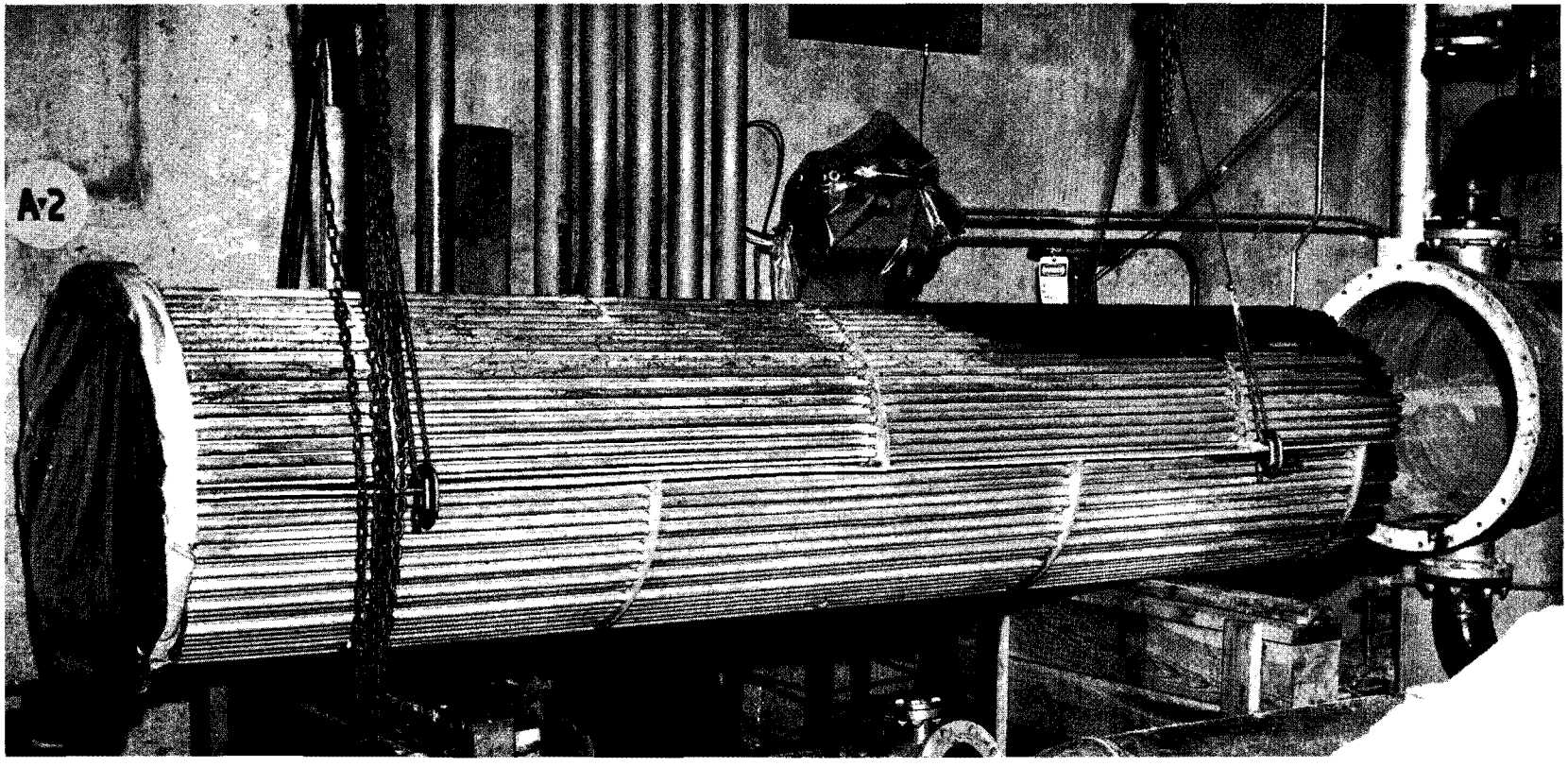

Fig. 1.4. Tube Bundle--ORR Pool Heat Exchanger Following Circulation of Cleaning Solution May 1961

The results indicated that the new plunger with a 27° taper, rather than the original 6° taper, resulted in an unacceptable variation in magnet drop current. Further design work is in progress on these components.

Fuel Handling.

The second fuel shipping carrier was on hand at the end of the quarter and is scheduled for testing following the end-of-cycle shutdown in July, 1961.

Operating Procedures.

The four most important ORR procedure memoranda issued during the period were for the following:

1. ORR Procedure Memorandum No. 176 - To restate the purpose of the "by-pass" switch and the "fast period permit" button and to prohibit their use except by shift and day supervisors.
2. ORR Procedure Memorandum No. 177 - To provide rules for operation of the three reactor primary cooling pumps to preclude generation of shock waves pending modification of the system.
3. ORR Procedure Memorandum No. 180 - To provide a detailed formal description of the reactor secondary cooling system and procedures for operations involving this system. An attachment provided by the Instrumentation and Controls Division gives a detailed description of the electronic and pneumatic controls for this system and its interdependence upon the control system for the reactor primary cooling system.
4. ORR Procedure Memornadum No. 181 - To provide a detailed and formal description of the mechanical components of the permanent ORR fission chamber drive assembly and to provide procedures for removal and replacement of these components.

Experiments in the ORR

Table 1.7 outlines the assignment of ORR experiment facilities.

Table 1.7. ORR Facility Assignment

Facility	Access Flange	Nature of Experiments	Division Sponsor
		Core Positions	
A-1 and 2	V-11	Pressurized water loop, MSR	Reactor
A-3 and 7, C-2, D-9, and F-5		Radioisotope production	Isotopes
B-1	V-10	Gas-cooled loop No. 1	Reactor
B-8 and C-3	V-1 and 3	Radiation damage studies	Solid State
B-9	V-2	Gas-cooled loop	Solid State
C-1	V-9	Fuel tests	Solid State
D-1		Radiation damage	Isotopes (Naval Research Laboratory)
F-1 and E-9	V-8 and 3	Solid fuel studies	Reactor
F-2	V-6	Fuel tests	Reactor (GE)
F-3	V-7	Ne^{23}	Physics
F-8	V-4	Hydraulic rabbit	Isotopes--Solid State
F-9	V-5	Fuel meltdown	Reactor Chemistry
		Pool Face Positions	
P-1, 2, 3, 7, 8, and 9		EGCR Capsule irradiations	Reactor
P-4, 5, and 6		Radiation damage	Solid State
		Large Facilities	
HN-1		Homogeneous fuel loop	Reactor Chemistry
HN-3		Pneumatic rabbit for activation analysis	Chemistry--Analytical Chemistry
HN-2 and 4			Operations
HS		Gas-cooled loop No. 2	Reactor

Table 1.7. Continued

Facility	Access Flange	Nature of Experiments	Division Sponsor
		Beam Holes	
HB-1		Magnetic analysis of fission fragments	Physics
HB-2		Neutron spectrometer	Solid State
HB-3		Neutron spectrometer	Physics
HB-4		Neutron spectrometer	Chemistry
HB-5		Neutron spectrometer	Physics
HB-6		Time-of-flight spectrometer	Physics

A list of new experiments operated during the quarter is given in Table 1.8.

Table 1.8. New ORR Experiments Installed or Operated

Date Installed	Division Sponsor	Expected Duration	Facility	Experiment Description
5-8-61	Reactor	2 months	B-1	Experiment tube with "weld metal" specimen
5-10-61	Reactor	5 months	P-1, 2, 3, 7, 8, and 9	Capsule experiments containing UO_2 pellets
5-12-61	Solid State	4 months	C-1	Ceramic fuel test
5-12-61	Solid State	2 months	P-6	Zircalloy II - tube burst
5-12-61	Solid State	2 months	P-5	Inconel tube burst
5-16-61	Solid State	2 months	B-8	Beryllium tube burst
5-16-61	Isotopes (Naval Research Laboratory)	2 months	D-1	"Charpy" steel specimens
5-22-61	Reactor Chemistry	6 hours	F-9	Fuel meltdown

Experiment Shutdowns

On two occasions during the quarter, the ORR was intentionally shut down to investigate unusual conditions associated with experiments.

1. At 12:45 a.m., May 3, 1961, an alarm was received from a radiation monitron mounted on the north side of the reactor pool. Water spray was detected escaping from the CP-B9 experiment thermocouple header box located near the monitron. Constant air monitors

indicated an increase in air activity in the building. A day-shift supervisor was contacted; and, upon his instructions, the reactor power was reduced to N_L (1% of normal full power). Upon lowering the power the water spray stopped, but air activity had reached masking tolerance in some areas of the ORR building. The reactor was shut down at 1:21 a.m., and an investigation was begun to determine the cause of the conditions observed.

This experiment had been installed in the reactor during the end-of-cycle shutdown in January, 1961, and contained a capsule with 2 pellets of UO_2 (0.164 g of U^{235} dispersed in graphite and coated with Si-SiC). On January 28, 1961, a leak in the system resulted in air activity in the equipment cell. The sample was withdrawn from the core region on January 30, 1961. It remained undisturbed until the end-of-cycle shutdown in March, 1961, when it was necessary to remove the experiment tube containing the sample tp permit other shutdown work to be completed. The experiment was later reinstalled with the sample withdrawn "out of flux"; and an agreement with the experimenter provided that the system would remain under off-gas until the May, 1961, end-of-cycle shutdown when the sample would be removed.

Investigation revealed that valves in the pool which should have been opened after the experiment was reinstalled and before reactor startup were closed. These valves were then opened to place the system under off-gas. Further, it was found that the purge gas flowmeter for the containment monitoring system indicated approximately zero instead of the normal 1 scf per minute. An attempt was made to adjust and obtain proper flow, but this was unsuccessful because a purge-gas vacuum line was found disconnected.

It appears that during the experiment reinstallation in March, 1961, water leaked into the experiment tube. Since the tube was not placed under off-gas, this water was contained in a closed system with the result that a pressure build up occurred after reactor operation began. It is assumed that this pressure was contained until an Amphenol connector at the header box ruptured.

After the building air activity reached a normal level, the reactor was reloaded; and the experiment tube containing the fuel sample was removed from the reactor. Prestartup checks were made, and reactor operation was resumed.

2. At 3:24 p.m., May 19, 1961, a heavy plastic tube connecting the pool-side experiment in position P-6 to the experiment header box at the north side of the reactor pool ruptured. Several gallons of pool water were expelled onto the floor area. The reactor was shut down at 3:26 p.m. to investigate the circumstances since it was not known at that time which experiment was involved. Inspection indicated no apparent damage to the reactor or its components. Since the experimenter was pressurizing the P-6 experiment at the time the rupture occurred, he was requested to pressurize his header box slightly to determine if his experiment was involved. Approximately 10 psi was applied to the header box, and the rupture in the plastic line was detected.
The plastic-tube and header-box sections are normally operated at atmospheric pressure. The experimenter, in the course of applying pressure to this section, did not take proper steps to assure that overpressure protection was included. He, therefore, subjected the section of tubing to about 300 psi of helium. Since the experiment was no longer in operation and since no apparent damage resulted to the reactor, reactor operation was resumed.

1.2. The Development of a Device for the Detection of Boiling in the ORR

F. T. Binford

One of the mechanisms most likely to cause damage to a water-cooled reactor of the ORR type is overheating of the fuel plates resulting in burnout. The burnout phenomenon has been described in the literature[1, 2] and is illustrated graphically in Figure 1.5. In this figure the heat flux is plotted against ΔT, the difference between the temperature of the heated surface and the saturation temperature of the bulk fluid. The region AB represents that part of the curve where heat transfer occurs by forced convection. The surface temperature at B may be slightly above the saturation temperature. At B boiling commences at the heated surface. Initially, bubbles arise from a few points of nucleation. These nucleation points become more numerous as the heat flux is raised. In the region BC this nucleate boiling enhances the heat transfer because of the heat of vaporization required to cause formation of the bubble. This effect results in an increase in the slope of the curve as shown. As the heat flux is further increased above C, the bubbles begin to become so numerous that they interfere with one another. This coalescing of the bubbles results in the formation of a blanket or film of steam on the heat-transfer surface which insulates it and forces the surface temperature higher. Finally, when the heat flux is increased to D, the steam film is so effective in insulating the fuel surface that the temperature rises sharply even if there is no increase in heat flux and, in fact, will usually continue to rise despite a rather sizable decrease in heat flux.

Strictly speaking, the term "burnout" applies to that point on the curve at which melting or serious structural damage to the fuel occurs. This may actually lie somewhere between E and F; however, since the temperature continues to rise even with a decrease in heat flux once the point D is reached,

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[1] W. H. McAdams, Heat Transmission, 3d ed., p 370, McGraw-Hill, New York, 1954.

[2] M. Jakob, Heat Transfer, chapt 29 vol I, p 580 vol II, Wiley, New York, 1949, 1957.

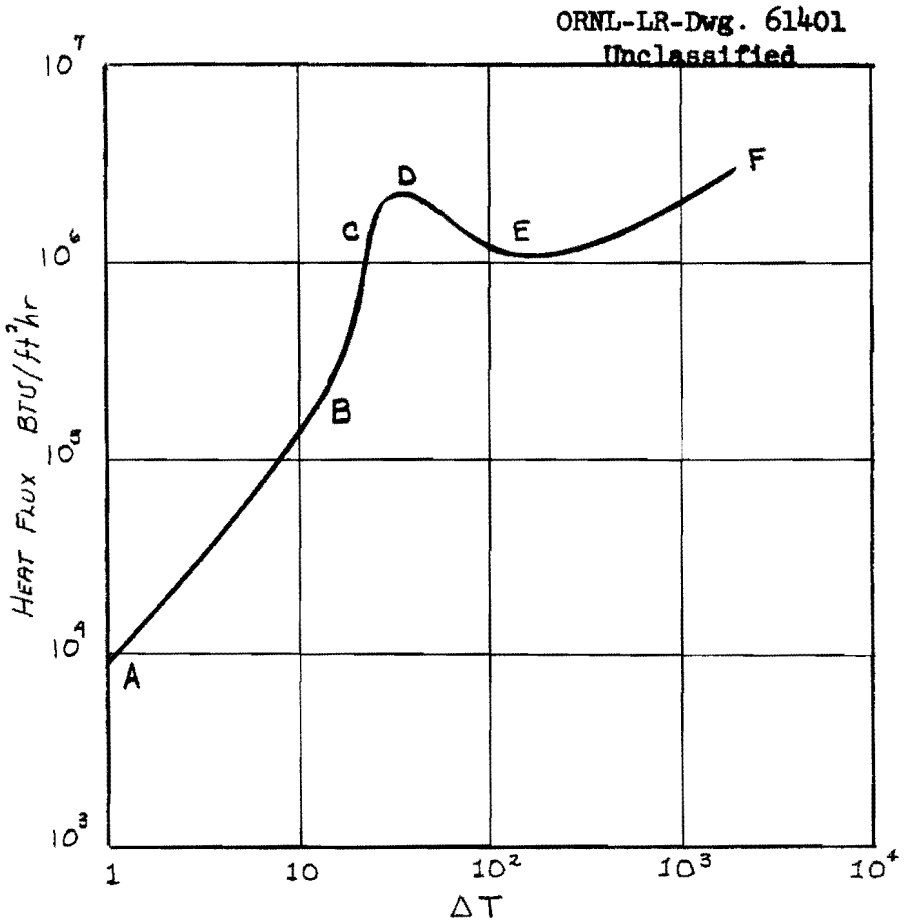

Fig. 1.5. Relationship Between Heat Flux and Temperature Difference Showing the Various Regimes of Boiling

it seems reasonable to assume that damage will occur in the reactor if the point D is reached. This point will, accordingly, be called the "burnout point."

Reactors such as the ORR, LITR, and HFIR are designed to operate in the forced convection region AB. However, provided the magnitude of the void coefficients are small, and the void volume is also small, no serious difficulty should be encountered even if the heat flux is great enough to cause some portions of the core to operate in the nucleate boiling region BC. In fact, the most efficient use of the cooling system is realized in this region.

The precise shape of the heat flux-ΔT curve will depend upon a number of parameters including the pressure, the coolant velocity, the subcooling, and the hydraulic diameter. Correlations exist[3] which permit the prediction of the burnout heat flux fairly accurately provided these parameters are known. While it is possible to know the nominal value of these parameters, it is very difficult, from a practical standpoint, to know them with sufficient accuracy at every point in the core. Moreover, because of local flux gradients and irregularities in fuel density, it is not possible to predict the exact heat flux at every point in the core. This combination of uncertainties, usually grouped together under the heading of "hot-spot analysis," opens up the possibility that, even though the reactor is designed to operate well down in the forced convection region, certain portions of it may be operating in or near the nucleate boiling region. It follows that if the heat flux of the reactor is increased until it is operating nominally in the nucleate boiling region, certain portions of it may be operating dangerously close to burnout. For this reason both the ORR and the LITR are operated nominally well below the point at which nucleate boiling is expected to occur.

In addition to the uncertainties mentioned above, there exists the distinct possibility that the blocking of a fuel channel by a foreign object in the ORR might sufficiently restrict the coolant flow to permit

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[3] J. F. Wett, Jr., Nuclear Safety, 2(3), 10 (March 1961).

burnout to occur. Moreover it is recognized that the inadvertant reversal of one of the nonuniformly loaded fuel plates during manufacture would very probably lead to burnout in the HFIR core if that core were brought to full power. For these reasons, it is considered highly desirable to develop a device which will warn of the approach to burnout conditions and thus enable corrective measures to be taken before any serious damage is done.

The most promising procedure appears to be the development of a device which will detect the onset of boiling. It would be highly desirable if the device could differentiate between nucleate boiling and film boiling; i.e., could indicate whether or not the condition BC or the condition CD obtains. During the initial tests of the ORR, boiling was detected by means of a sensitive fast recorder connected to a neutron monitoring device.[4] The indication of boiling was a characteristic fluctuation of the neutron current reading the monitoring device because of the variation in moderator density due to bubble formation. In this case, what was actually detected was probably the evolution of noncondensible gases from the heated water; however, the indications of boiling occurred under approximately the conditions predicted by theory. An attempt to refine this method and to differentiate between nucleate and film boiling at the WTR[5] was terminated abruptly by the burnout of a fuel element.

It seems clear that boiling can be detected by observing fluctuations in the neutron density. It is not clear at this point how well developed the boiling must be in order to be detected, nor whether what is seen is extensive nucleate boiling or a small region of bulk boiling. A boiling detection device of the same general type used in the ORR tests is being developed and will be installed on the ORR. This instrument will not be used to control the reactor, but merely as a warning device over and above the present control system. Its use, however, should drastically reduce the danger of burnout due to channel blockage. The most obvious advantage

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[4] J. A. Cox, Operations Division Quarterly Report, April - June, 1958, ORNL CF-58-6-122, (Oct. 13, 1958).

[5] Report on WTR Fuel Element Failure April 2, 1960, WTR-49.

of the installation of such an instrument on the HFIR is that it permits a final quality control inspection of each core for reversed plates. If each new core is brought up to full power in steps of several megawatts, a faulty core can be detected by the onset of boiling before the power is high enough to damage it.

In addition to the foregoing, a serious effort is under way to develop an instrument which will give both qualitative and quantitative information concerning boiling in the core. Two methods of approach are being studied. The first of these is a refinement of the neutron density fluctuation method in which characteristic frequencies present during boiling are sought. A modification of this is the development of a device which, taking the neutron density fluctuations as input data, will continuously display the reactor transfer function. The second approach involves a study of the acoustical noise associated with the formation and collapse of small bubbles. Again characteristic frequencies are sought.

It is expected to test these methods in the ORR or LITR by using an electrically heated element located in an experimental position to produce boiling in the core. The actual condition of the surface can be monitored by thermocouples and the results of the instrument measurements compared.

PART II

Taken from OPERATIONS DIVISION QUARTERLY REPORT

July - September, 1961, ORNL CF-61-9-68

REACTOR OPERATIONS

QUARTERLY REPORT

Summary

The ORR operated very well during the quarter although two scheduled one-week shutdowns and a six-day shutdown to change rod drives reduced the operating time to 75.4%.

1. OAK RIDGE RESEARCH REACTOR

1.1. Operations

W. R. Casto

Operations

The ORR was operated during this period at a power level of 30 Mw. Total operating time for the quarter was 1665.7 hrs. The operating data are given in Table 1.1.

Table 1.1. ORR Operations

Period July 1 through September 30, 1961

	This Quarter	Last Quarter	Year to Date
Total energy, Mwd	2065.7	2197.5	6399.9
Average power, Mw/operating hr	29.8	29.8	29.8
Time operating, %	75.4	81.2	78.8
Reactor water radioactivity, $\frac{c/m}{ml}$ (av)	28,165	30,236	32,303
Pool water radioactivity, $\frac{c/m}{ml}$ (av)	991	1368	1086
Reactor water resistivity, ohm-cm (av)	484,000	524,000	503,000
Pool water resistivity, ohm-cm (av)	662,00	704,000	678,000
Research samples	13	7	29
Radioisotope samples	147	103	359

The core configuration at the end of the quarter is indicated in Figure 1.1.

Cycles of operation during this period are shown in Table 1.2.

Table 1.2. ORR Cycles of Operation

Cycle No.	Date Begun	Date Ended	Accumulated Energy (Mwd)
34	May 19, 1961	July 4, 1961	1,333.6*
35	July 12, 1961	August 27, 1961	1,172.1
36	September 2, 1961	In progress	783.6

*Accumulated energy for cycle 34 during this quarter was 110 Mwd.

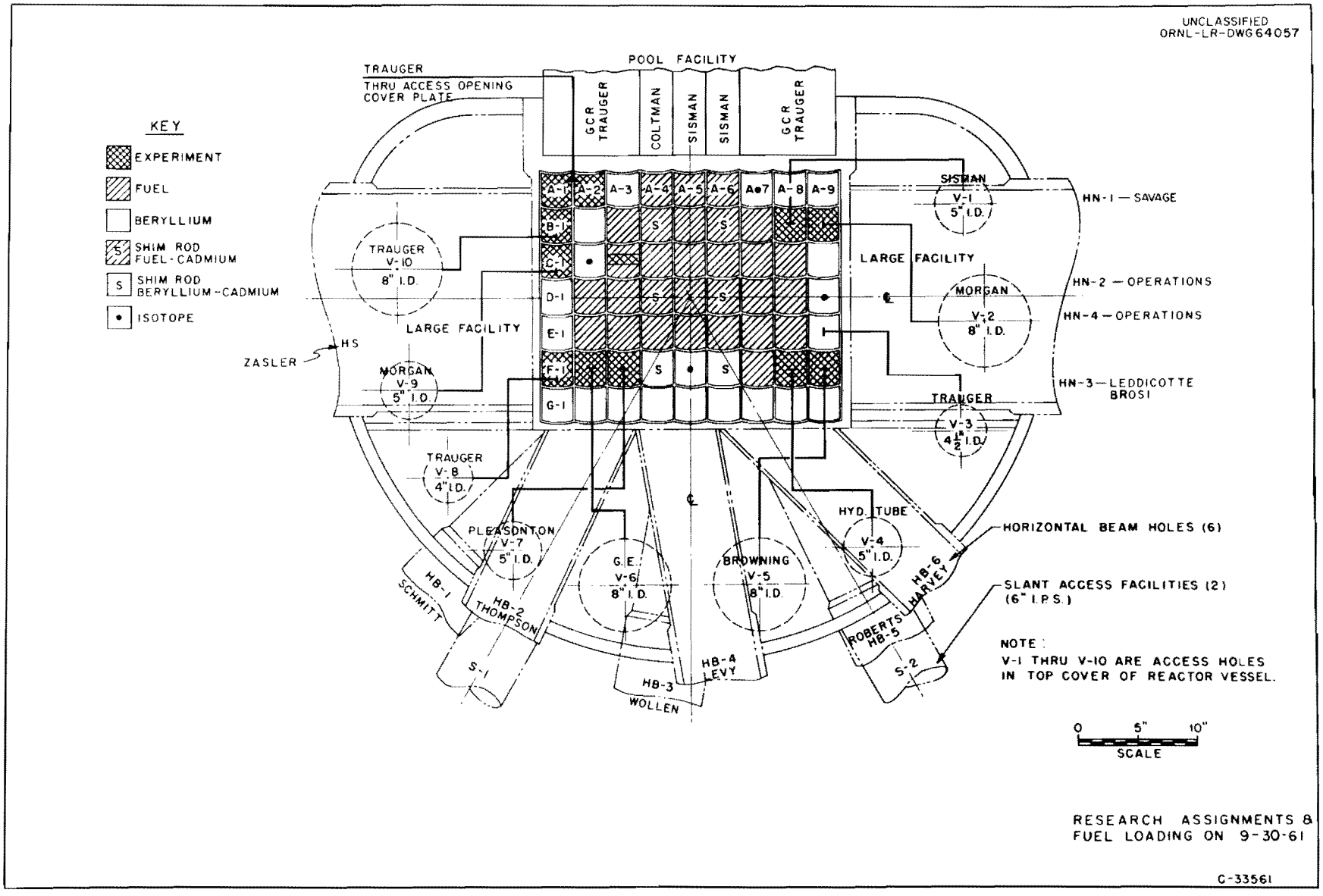

Fig. I.1 O.R.N.L. Research Reactor Lattice Pattern and Experiment Locations

Figures 1.2 and 1.3 indicate the positions of the shim rods during cycles 35 and 36 (in progress).

Shutdowns

Two major shutdowns occurred during the quarter.

July 4 through July 12, 1961. Four experiments were installed during this period, and five were removed. The B-9 and F-2 access tubes were also installed in the reactor tank preparatory to experiment installation; and the MSR fuel specimens were replaced. Piping installation for GCR loop No. 2 required partial drainage of the south facility.

The pool demineralizer anion column was treated with an amine-type bactericide.[1] Tests of the hydraulic-tube facility resulted in increasing the total number of samples allowed in the facility from eight to twelve; i.e., from two to three samples per tube. It was determined that the experiments adjacent to the Be-Cd shim rods (F-4 and F-6 core positions) did not interfere with these rods during the lower three inches of movement.

Deflection of the poolside "window," or flat side, as a function of pressure in the reactor tank was measured.[2] Three flux measurements were made at the HN-1 facility, requiring special core configurations and approximately half-hour "runs" at N_L. A flux-trap experiment was conducted in the D-8 position.

August 27 to September 2, 1961. Five experiments were installed during this period, and six were removed. In addition, new fuel specimens were introduced into C-1 and GCR loop No. 1; prior to this time, loop No. 1 had not contained fuel. The HN-1 liner was replaced, requiring the draining of the north facility and removal of fuel from the core. At the same time, radiation readings were made at the south facility with the 24-in. plug drained.

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[1] J. A. Cox et al., Reactor Operations, Radioactive Waste Operations, and Hot Cell Operations Quarterly Report, April - June, 1961, ORNL CF-61-6-115, (September 18, 1961).

[2] A. A. Abbatiello, Pressure Deflection of the ORR Window, ORNL CF-61-8-1, (August 1, 1961).

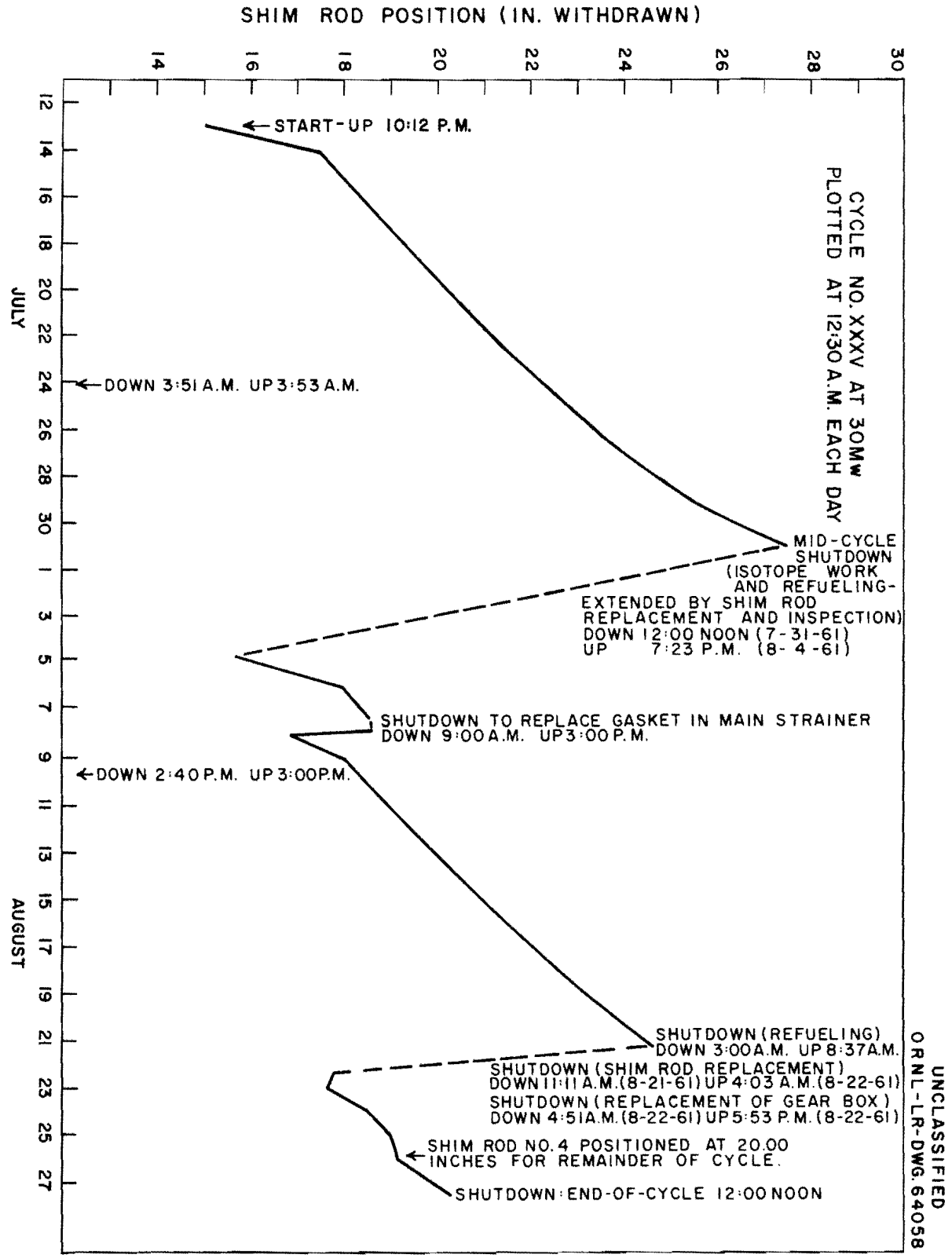

FIG. 1.2 SHIM ROD POSITION VS. TIME

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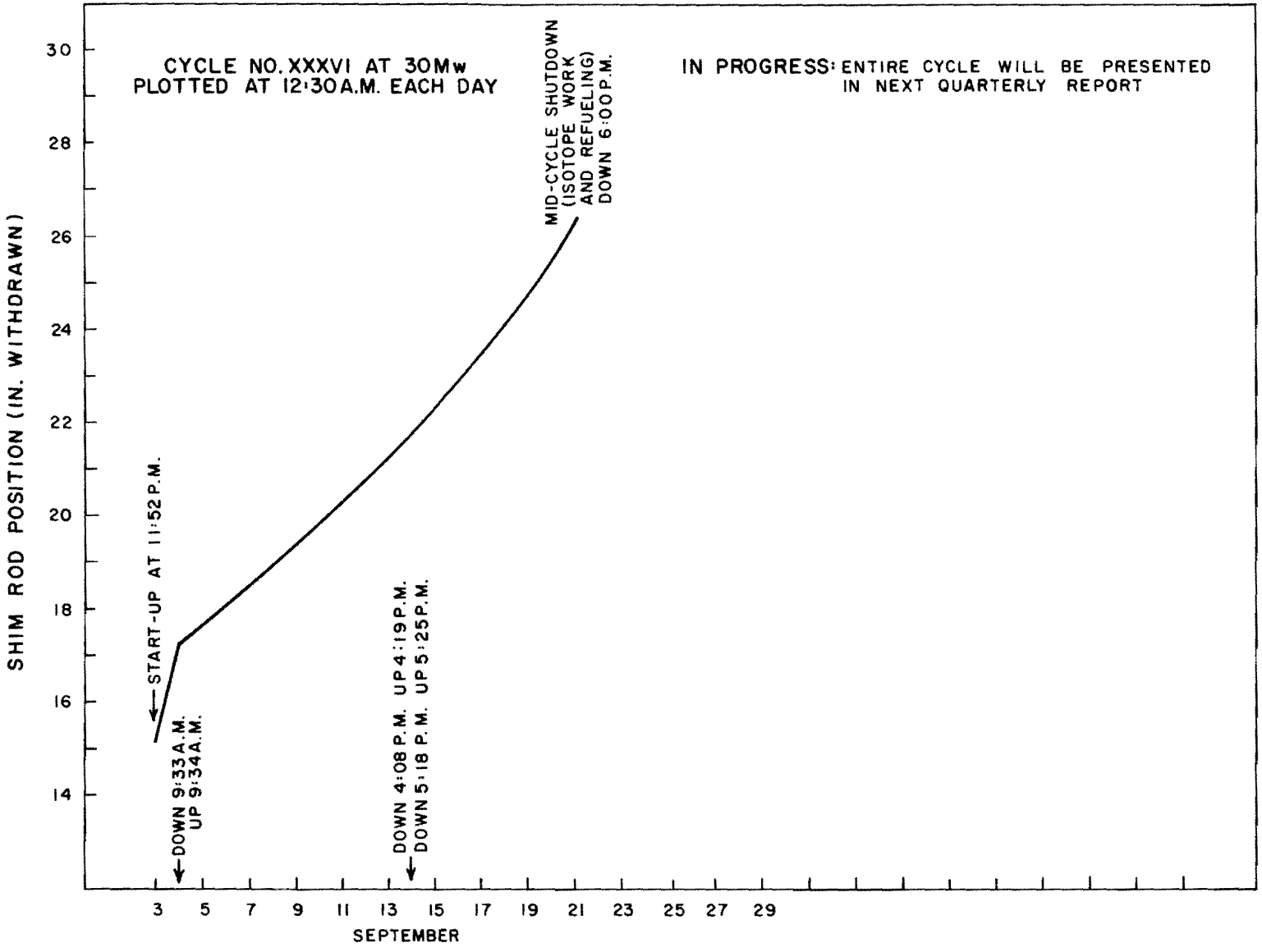

FIG. 1.3 SHIM ROD POSITION VS. TIME

Principal operational activities included the second cleaning of the inside of the tubes of the pool heat exchanger; the isolation of the Trane coolers from the reactor primary system; and minor improvements at the hydraulic-tube facility.

Thermal stresses in the north facility obround transition piece were measured while cycling the temperature of the reactor. This involved operating the reactor at intermediate power levels followed by a shutdown (see Table 1.3.). The end-of-cycle-35 shutdown was terminated at 8:00 a.m., September 2, 1961, although cycle 36 proper did not begin until 11:52 p.m., because of the shutdown referred to above.

Table 1.3. Analysis of ORR shutdowns

Description	Number	Down Time (hr)
Scheduled Shutdowns		
Regular, end of cycle	2	338.200
Regular, midcycle and repair of drive units	1	115.383*
Regular, refueling	2	10.367
ORNL Open House and isotope work	1	36.633
Reactor primary cooling system strainer gasket replacement	1	6.000
Termination of thermal-stress run	1	12.917
Thermal cycling of gas-cooled loop No. 1	1	0.017
Subtotal	9	519.517
Unscheduled Shutdowns		
Instrument failure, reactor controls	0	0
Instrument failure, experiments	1	0.033
Rod drops, reason unknown	2	0.250
Rod drops, leak resulting in magnet failure	1	16.867
Power failure	1	0.350
Rod-drive gear box replacement	1	5.033
Human error	2	0.233
Subtotal	8	22.766
TOTAL	17	542.283

*Approximately 100 hr of this shutdown was an extension to remove and investigate the condition of shim-rod drive units.

Table 1.4 lists the unscheduled shutdowns which occurred this quarter.

Table 1.4. Unscheduled Shutdowns at the ORR

Date	Duration (hr)	Remarks
7-24-61	0.033	Setback from C-1 experiment. Failure of a thermocouple resulted in upscale burn-out action at the temperature recorder.
8-9-61	0.350	Power failure due to electrical storm. The feeder from K-25 to the Building 3000 substation was struck by lightning.
8-21-61	16.867	Shim rod No. 5 dropped. Power was held at N_L until investigation revealed water on the magnet keeper. The drive unit was changed, and a faulty bellows seal was found to be the cause. The replacement unit also leaked at the bellows seal, and it was necessary to install a third unit.
8-22-61	5.033	Faulty gear box on No. 5 shim-rod drive was replaced.
9-2-61	0.050	Inadvertant back-up reverse due to high reactor temperature during a thermal stress measurement on the reactor tank involving heating of the reactor water at low power. The setback contacts were found to be set at a temperature only slightly higher than those for the back-up reverse; therefore, instead of a setback as was planned, a reverse occurred with a shutdown as a result.
9-14-61	0.183	Scram from B-8 experiment. The pressure monitor for the experiment "can" was actuated momentarily when the specimen pressure was bled to the off-gas line too rapidly. The "can" itself was not pressurized.
9-14-61	0.117	Shim rod No. 1 dropped, reason unknown.
9-30-61	0.133	Shim rod No. 1 dropped, reason unknown.

There was one shutdown for real cause (9-2-61); i.e., where such a condition existed that without reactor power reduction an experiment and/or the reactor could be damaged.

Reactor Controls

Maintenance and Modifications. During the shutdown ending cycle 34, modification was made to the reactor controls circuitry associated with the "test" mode of operation. This mode originally permitted operation at low levels under conditions of low water flow by by-passing reactor scrams from

low flow, reactor differential pressure, outlet temperatures, and differential temperature. Although control features are provided to prevent operation of the reactor at power levels above about 2% of full power, it was determined that by-passing of scrams from outlet temperatures and differential temperatures was unnecessary and undesirable. The circuitry was modified so that only scrams from low flow and low reactor differential pressure are by-passed in the "test" mode. During the same shutdown, a modification was made to the circuit which provided for a setback upon the stopping of one of the reactor primary cooling pumps. This setback was to be initiated by a decrease of reactor flow to 16,000 gpm and a reactor differential pressure of 20 psi. It was found that under certain conditions stopping of one pump would not result in reduction of these parameters to the setback point. Since such a setback was determined to be desirable, the setpoints were raised to 17,000 gpm and 21.4 psi, respectively. The point at which the setback was to be terminated was also raised from 0.5 N_F (about 15 Mw) to 0.6 N_F (about 18 Mw) since operation with two pumps at 20 Mw was standard procedure prior to August, 1960.

During the shutdown ending cycle 35, modifications were made to equipment and special maintenance was performed on the No. 4 and 6 shim-rod drive units to reduce or prevent moisture from reaching and eventually damaging the insulation of the magnet coils. Drain holes were drilled in the magnet armature according to drawing RC-2-10-4A, Revision 4. Modification of other armatures is scheduled to be completed by the end of December, 1961. A sealing compound was applied to openings at the top of the magnet shell, and the bottom of the magnet coils were also cleaned and sealed. This treatment will be discontinued as soon as modified, moisture-resistant coils are available.

During the same shutdown, modification of the log count-rate meter (Q-1881) was performed to improve the linearity of the instrument, particularly at low counting rates. This change also provides for greater accuracy in the period readout and is detailed in ORR Reactor Control Change Memorandum No. 46.

Reactor controls difficulties which required maintenance are listed in Table 1.5.

Table 1.5. Reactor Controls - ORR

Date	Description
7-4-61	The gasoline emergency pump did not start during shutdown checks. The "run" light in the control room, which is essential to the circuit, was found to be the wrong size. The condition was corrected.
7-7-61	The drive tube for the No. 4 shim rod was replaced as part of the routine maintenance program.
7-8-61	The ionization chamber for the No. 2 Log N was replaced as a preventive maintenance step (routine).
7-12-61	The electrical portion of the seat switch for the No. 1 rod was replaced due to faulty contacts.
7-13-61	The No. 1 Log-N channel became slightly erratic. No reason was found, and the condition cleared itself.
7-23-61	The No. 1 Log-N channel period indication became erratic. The reason for the fluctuation was not apparent.
7-25-61	The No. 1 Log-N amplifier was replaced in order to reduce the noise in the channel.
7-31-61	The No. 1 shim rod failed to drop until 30 seconds after scramming the reactor for the midcycle refueling shutdown. It was decided to change and examine all the shim-rod drive units since this was the first time a unit with the redesigned plunger had failed.
7-31-61	Changed the No. 1 rod drive unit.
7-31-61	The ionization chamber for the No. 1 Log-N channel was found to be defective in that proper compensation was not possible. The spare chamber exhibited the same characteristics, and both chambers were scheduled for repair.
8-1-61	Changed the No. 3 drive unit.
8-2-61	Changed the No. 4 and 5 drive units.
8-3-61	Changed the No. 2 and 6 drive units.
8-3-61	Replaced the No. 1 Log-N ionization chamber and compensated the replacement.
8-4-61	Replaced the gear box on the No. 5 rod drive after startup to N_L revealed that the rod was not being withdrawn at the proper speed. The worm gear was broken.
8-7-61	The MSR E-panel was found to be defective in that the make-up scram relay would not function. This defect was discovered while the reactor was being shut down for repairs to the primary cooling system.

Table 1.5. (Continued)

Date	Description
8-21-61	Dropped the No. 5 shim rod. Investigation revealed a possible bellows seal leak; therefore, the drive unit was replaced. The second drive unit also leaked at the bellows seal. A third unit was installed and proved satisfactory.
8-22-61	Replaced the gear-box portion of the No. 5 drive unit. The rod did not withdraw at the proper speed during startup to N_L. The lead screw guide pin was found to be defective on the unit removed.
8-25-61	A leak was found at the seal where the No. 4 drive tube enters its shock absorber section. The rod was withdrawn ~1 inch to stop the leak. No trouble was found during the end-of-cycle-35 shutdown.
8-30-61	Modified magnet keepers were installed on the No. 4 and 6 drive units. The modifications will allow water drainage in case of bellows seal leaks thus alleviating shorts in the magnet coils (refer to ORNL Dwg. RC-2-10-4A, Rev. 4).
9-5-61	The No. 1 safety spiked upscale to 118 N_L, resulting in a reactor setback. The amplifier was replaced.
9-8-61	The No. 1 safety spiked upscale to 130 N_L while the associated chamber was being repositioned. This reversed the reactor power to 15 Mw. After the reactor power level was increased to 30 Mw, the standard cell in the No. 1 safety recorder was replaced, resulting in a much lower indication. The associated chamber was again repositioned, this time without incident. Further investigation of the trouble in the No. 1 safety channel was initiated.
9-11-61	Magnet amplifier 6A failed. The load was transferred automatically to amplifier 6B as designed. Amplifier 6A was found to have faulty electronic tubes and was replaced.
9-20-61	Small, rapid oscillations in the No. 1 ΔT reading were recorded. Investigation revealed no cause.
9-21-61	The No. 1 and 2 safeties did not indicate zero after the reactor had been shut down for refueling. The preamplifier was replaced in the No. 1 circuit while the No. 2 circuit required only slight zeroing adjustments.
9-23-61	The No. 1 shim rod dropped without cause while the reactor was being shut down for the ORNL Open House. The subpile room components and magnet amplifiers revealed no abnormal conditions.

Table 1.5. (Continued)

Date	Description
9-25-61	A thorough check of the No. 1 safety circuit was made, exclusive of the chamber. No trouble was found. Replacement of the chamber is scheduled for the next end-of-cycle shutdown; meanwhile, no credit is taken for this channel.
9-25-61	The servo amplifier was replaced as a routine maintenance measure.
9-27-61	A constant, positive period was observed in the count-rate channel. Adjustments of the count-rate meter were necessary.
9-27-61	The No. 1 ΔT readings were erratic. An investigation revealed no trouble.
9-28-61	The No. 1 safety readings were erratic.
9-29-61	The No. 1 safety and the No. 1 ΔT readings were erratic.
9-29-61	The reactor secondary inlet temperature probe TT47A was replaced as a routine preventive maintenance step.
9-30-61	The No. 1 safety readings were erratic.
9-30-61	Auxiliary shim rod No. 1 dropped without cause. The subpile room components and the magnet current were normal.

Reactor Primary Cooling System

Operating Experience. On August 5, 1961, a leak of approximately 15 gpm was observed at the strainer in the 24-in. cooling water return line. Investigation revealed that the gasket was faulty. The reactor was shut down on August 7, 1961, for repair. Refueling was also accomplished during the shutdown which lasted 6 hours.

Modifications. The D-C pony motor and associated equipment was installed at the No. 3 primary pump. Indicators for battery and motor current and voltage readings for all three D-C pony motors were installed in the control room, and high and low voltage and current alarms were provided. This added instrumentation will reduce the number of operator checks at the local panel board resulting in a savings in time and a reduction in personnel radiation exposure.

Degasifier. On September 4, 1961, at approximately 10:00 p.m., all the constant air monitors in the ORR indicated a definite increase in air activity. An investigation was begun in an attempt to determine the source

of the activity. By 9:00 a.m., September 5, 1961, it had been determined that the activity was primarily cesium and rubidium and that the primary source was the sump located in the basement pipe tunnel. Difficulty was encountered in determining the source, as the activity was quite general throughout the basement. Several secondary sources were investigated during the search, and some activity was found to be originating at the floor drains and in the subpile room.

During the 8-4 shift on September 5, 1961, the streams of water entering the sump were sampled. It was found that the degasifier cooling water was radioactive--counting ~1600 c/m. Since this was an abnormal condition, the degasifier was removed from service; and the activity decreased to a normal level. The after-condenser portion of the degasifier which receives a mixture of steam and gases from the vacuum jet was suspected as the source; and when it was disassembled on September 6, a leak was found in one of the tubes. Repairs were made, and the degasifier was returned to service.

Pool Cooling System

Heat-Exchanger Fouling. On August 28, 1961, the head was removed from the pool heat exchanger to permit inspection of the interior of the tubes. Foreign material in the form of brown sludge was again found, although the quantity per tube was approximately 1/2 cup and therefore less than the previous occasion.[1] The tubes were cleaned with long-handled brushes and rinsed thoroughly. After this cleaning, the heat transfer was much improved.

Secondary Cooling Tower. On September 30, 1961, at about 5:30 p.m., a sharp increase in pool secondary water flow was noted. An increase in temperature also occurred with no apparent cause. Inspection of the tower revealed that three of six blades had been broken from the tower fan and that the shaft connecting the motor to the gear box was broken. The reactor power was reduced to 15 Mw until emergency measures could be taken to provide adequate cooling. This was accomplished by adding sufficient cold

[1] J. A. Cox et al, Reactor Operations, Radioactive Wastes Operations, and Hot Cells Operations, Quarterly Report April - June, 1961, ORNL CF-61-6-115, (September 18, 1961).

process water to the system while removing part of the water returning to the tower. The reactor power was increased to 30 Mw after these steps were taken, and repair of the tower was in progress at the end of the quarter.

Fuel Handling

Three shipments of seven "spent" fuel elements each were made to the chemical processing plant utilizing the new shipping carrier. Since ~30 elements were added to the "spent" element inventory, no progress was made in alleviating the ORR pool storage problem; however, four shipments were made from the canal in Building 3001 during the period, using the original carrier. Thus, from both storage areas seven shipments, or a total of 49 elements, were shipped. Since a round trip to the processing plant should normally require a maximum of 14 days, use of the second carrier was necessary to maintain the normal number of shipments. During this period the time required for shipments was 25, 9, and 28 days.

Mechanical Controls

A task force consisting of Reactor Division personnel has been assigned to study the ORR shim-rod release and drive mechanism. The primary responsibilities of this group are: (1) to investigate ORR shim-rod drive troubles; (2) to provide technical assistance for proper maintenance and shop fabrication work on drive components; (3) to provide technical inspections of all drive units during assembly and disassembly; (4) to establish a development program which will provide a trouble-free drive unit; and (5) to test components in a hydraulic test stand which will simulate operating flow conditions. The interim corrective program consists of replacing all drive units with units containing: (1) plungers of known hardness of Rockwell C-56 or greater; (2) waterproof magnet coils; and (3) modified magnet keepers which prevent accumulation of water in this area in the event of leakage. Rigid inspections of all assembled drive units will be made before installation.

Operating Procedures

The eight most important ORR procedure memoranda issued during the period were as follows:

1. ORR Procedure Memorandum No. 182 - To provide a formal procedure for removal and replacement of a shim-rod shock absorber assembly.

2. ORR Procedure Memorandum No. 188 - To provide a formal procedure for the insertion and removal of fuel elements in the ORR core. (This procedure, in part, combines several previous procedures.)
3. ORR Procedure Memorandum No. 190 - To provide a detailed formal description of the ORR emergency D-C pony motors, and to provide a procedure which outlines minimum emergency cooling requirements. (This procedure, in part, represents an updating of previous procedures.)
4. ORR Procedure Memorandum No. 191 - To provide a formal procedure for handling the hold-down arms. (This procedure, in part, represents an expansion of a previous procedure.)
5. ORR Procedure Memorandum No. 192 - To provide a formal procedure to be followed when inserting, fitting, or removing experiments in the ORR core.
6. ORR Procedure Memorandum No. 196 - To provide a detailed formal procedure for sawing the ends from ORR fuel elements and shim rods.
7. ORR Procedure Memorandum No. 197 - To provide a formal detailed procedure to be used during the replacement of a control-rod drive tube. This procedure also outlines a detailed inspection procedure to be used while disassembling the drive tube which is removed.
8. ORR Procedure Memorandum No. 199 - To provide a detailed description of, and an operating procedure for, the pool cooling control system after slight alterations.

Experiments in the ORR

Table 1.6 outlines the assignment of ORR experiment facilities.

Table 1.6. ORR Facilities Assignment

Facility	Access Flange	Nature of Experiment	Division Sponsor
		Core Positions	
A-1 and 2	V-11	Pressurized water loop, MSR	Reactor
A-3 and 7 C-2, D-9 and F-5		Radioisotope production	Isotopes
B-1	V-10	Gas-cooled loop No. 1	Reactor

Table 1.6. (Continued)

Facility	Access Flange	Nature of Experiment	Division Sponsor
B-8 and C-3	V-1 and 3	Radiation damage studies	Solid State
B-9	V-2	Gas-cooled loop	Solid State
C-1	V-9	Fuel tests	Solid State
D-1		Radiation damage	Isotopes (Naval Research Laboratory)
F-1 and E-9	V-8 and 3	Solid fuel studies	Reactor
F-2	V-6	Fuel tests	Reactor (GE)
F-3	V-7	Ne^{23}	Physics
F-8	V-4	Hydraulic rabbit	Isotopes--Solid State
F-9	V-5	Fuel meltdown	Reactor Chemistry
		Pool Face Positions	
P-1, 2, 3, 7, 8, and 9		EGCR capsule irradiations	Reactor
P-4, 5, and 6		Radiation damage	Solid State
		Large Facilities	
HN-1		Homogeneous fuel loop	Reactor Chemistry
HN-3		Pneumatic rabbit for activation analysis	Chemistry--Analytical Chemistry
HN-2 and 4			Operations
HS		Gas-cooled loop No. 2	Reactor
		Beam Holes	
HB-1		Magnetic analysis of fission fragments	Physics
HB-2		Neutron spectrometer	Solid State
HB-3		Neutron spectrometer	Physics
HB-4		Neutron spectrometer	Chemistry
HB-5		Neutron spectrometer	Physics
HB-6		Time-of-flight spectrometer	Physics

A list of new experiments operated during the quarter is given in Table 1.7.

Table 1.7. New ORR Experiments Installed or Operated

Date Installed	Division Sponsor	Expected Duration	Facility	Experiment Description
7-8-61	Physics	Indefinite	P-4	He^6 recoil experiment
7-8-61	Solid State	2 months	P-5	Columbium tube burst
7-8-61	Solid State	2 months	P-6	Stainless steel tube burst
7-9-61	Solid State	2 months	B-8	Creep-type experiment
8-11-61	Reactor (General Electric)	3 days	F-2	Au sample
8-28-61	Solid State	2 months	B-8	Be tube burst
8-29-61	Solid State	Indefinite	B-9	Fuel capsule (0.274 g U^{235})
8-29-61	Solid State	2 months	P-5	Stainless steel tube burst
8-29-61	Solid State	Indefinite	P-5 Piggy Back	Flux monitoring facility
8-30-61	Solid State	2-4 months	C-1	UO_2 crystal 0.2% enriched in U^{235}
8-30-61	Reactor Chemistry	Indefinite	HN-1	Replaced the liner
9-23-61	Solid State	2 months	P-6	Zirconium tube burst

Unusual Occurrences. Two occurrences during the quarter directly attributable to experiments took place September 26, 1961. About 3:00 a.m. an increase in air activity occurred on the second and third levels at the ORR. Investigation revealed that the activity was originating from the B-8 experiment and, more specifically, from Room 207 (north side, second level). It was later determined that when a tube-burst experiment ruptured (as designed) the experiment container was slightly pressurized. The can atmosphere diffused through a faulty back-pressure regulator into the room. Repairs and revisions to the system were completed the same day, thus insuring against recurrent air activity from this experiment.

The second occurrence was at 2:00 p.m. when a high radiation back-

ground was found at the poolside. The source was the B-9 experiment header box at which a reading of 1 r/hr was obtained. It was concluded, from analyses of the samples, that the sample had ruptured and that gas from the B-9 primary system was leaking into a purge line which monitors the experiment secondary system. The activity decreased rapidly due to decay and to the air sweep through the header box. No significant personnel exposure was encountered, and the experiment was removed from the high-flux zone and placed in a stand-by condition for removal during the next major shutdown.

Special Tests

Reactivity Measurement. The reactivity effect of the proposed BeO + B_4C experiment, to be installed in core position F-2, was determined to be $\sim -0.26\% \frac{\Delta k}{k}$.

Ionization Chamber Test. In an attempt to lengthen the operating life of the ionization chambers at the ORR, a test assembly was constructed in which the sensing chamber itself was moved from its normal location in the front end of the assembly to a position near the rear of the assembly. This arrangement eliminates the need for jumper leads inside the assembly which are subject to radiation damage but makes it necessary to use aluminum weights in the front to prevent floating. This test assembly was installed in chamber position No. 1. (These standard positions are to the east of the reactor tank and are numbered from south to north as No. 1 through 8). However, it was found that even with the chamber fully inserted an insufficient signal was produced. A shortened assembly which will eliminate the need for weights and also allow the chamber to be positioned closer to the reactor will be tested during next quarter.

1.2. Boiling Detection in the ORR

A. L. Colomb

Two detection methods were selected, and work is proceeding simultaneously on both.

The first method is based on a frequency analysis of the neutron level statistical fluctuations. It is known[1] that boiling will produce a peak at a definite frequency in the amplitude spectrum of the neutron level statistical fluctuations.

In order to find at what frequency this peak will occur in the ORR, a nichrome electric heater is under construction and will produce localized boiling in the reactor core.

The neutron level fluctuations will be detected with an ionization chamber and amplified with a specially designed, low-frequency, low-noise, A-C amplifier. The fluctuations' time record will be Fourier analyzed to find the boiling frequency. Once this frequency is known, a band-pass filter will be installed at the output of the amplifier. The output of the filter will be rectified and displayed on a recorder. The magnitude of the rectified signal will be an indication of the amount of boiling present in the reactor.

Figure 1.4 shows the block diagram of the boiling detector instrumentation. It is hoped to have the heater installed in the reactor during the December, 1961, shutdown and, thus, to have the boiling detector calibrated early in 1962.

The second method, based on an analysis of the acoustical noise of a system, is in an early experimental stage. It is known that boiling cavitation produces a noise of a definite audio frequency and can be detected by a special analysis of the system noise. In order to determine if this method could be applicable to a reactor hydraulic system, a hot water loop simulating ORR flow conditions is under construction.

It will be possible to produce boiling at a given location in the loop. A water-tight, high-temperature microphone will be installed in

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[1] J. A. De Shong, Jr., J. Nucl. Energy, Part A, 10, 147 (1959).

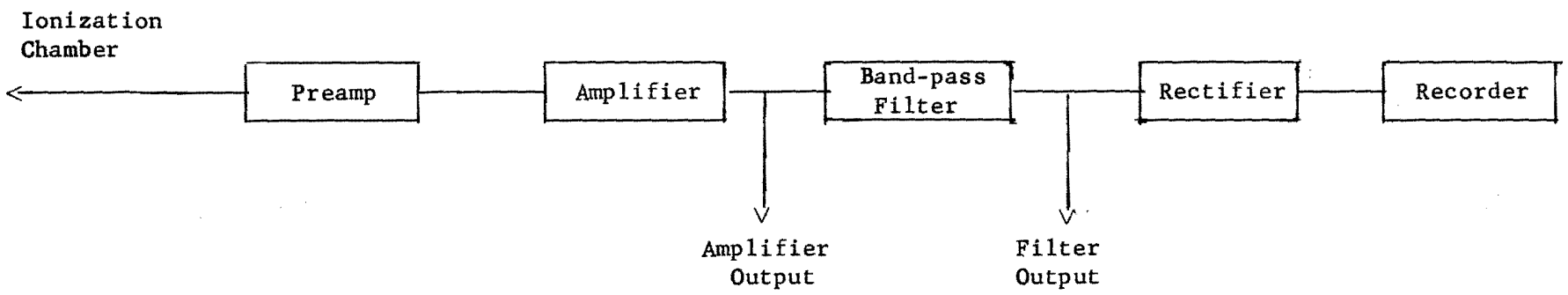

Figure 1.4. Boiling Detector Block Diagram

the loop plenum. The acoustical noise spectrum, with and without boiling, will be analyzed with an audio-wave analyzer.

PART III

Taken from REACTOR OPERATIONS QUARTERLY REPORT

October - December, 1961, ORNL CF-61-12-78

REACTOR OPERATIONS

QUARTERLY REPORT

Summary

The ORR operated 81.1% of the time during the last quarter in spite of the fact that two major end-of-cycle shutdowns occurred. Work is proceeding on testing a boiling detector to determine if this will give warning of blockage of one or more coolant channels.

1. OAK RIDGE RESEARCH REACTOR

1.1. Operations

W. R. Casto

Operations

The ORR was operated during this period at a power level of 30 Mw. Total operating time for the quarter was 1790.9 hrs. The operating data are given in Table 1.1.

Table 1.1. ORR Operations

Period October 1 through December 31, 1961

	This Quarter	Last Quarter	Year to Date
Total energy, Mwd	2216.9	2065.7	8616.8
Average power, Mw/operating hr	29.7	29.8	29.8
Time operating, %	81.1	75.4	79.4
Reactor water radioactivity, $\frac{c/m}{ml}$ (av)	31,360	28,165	32,068
Pool water radioactivity, $\frac{c/m}{ml}$ (av)	878	991	1034
Reactor water resistivity, ohm-cm (av)	431,000	484,000	485,000
Pool water resistivity, ohm-cm	593,000	662,000	657,000
Research samples	11	13	40
Radioisotope samples	96	147	455

The core configuration at the end of the quarter is indicated in Figure 1.1.

Cycles of operation during this period are listed in Table 1.2.

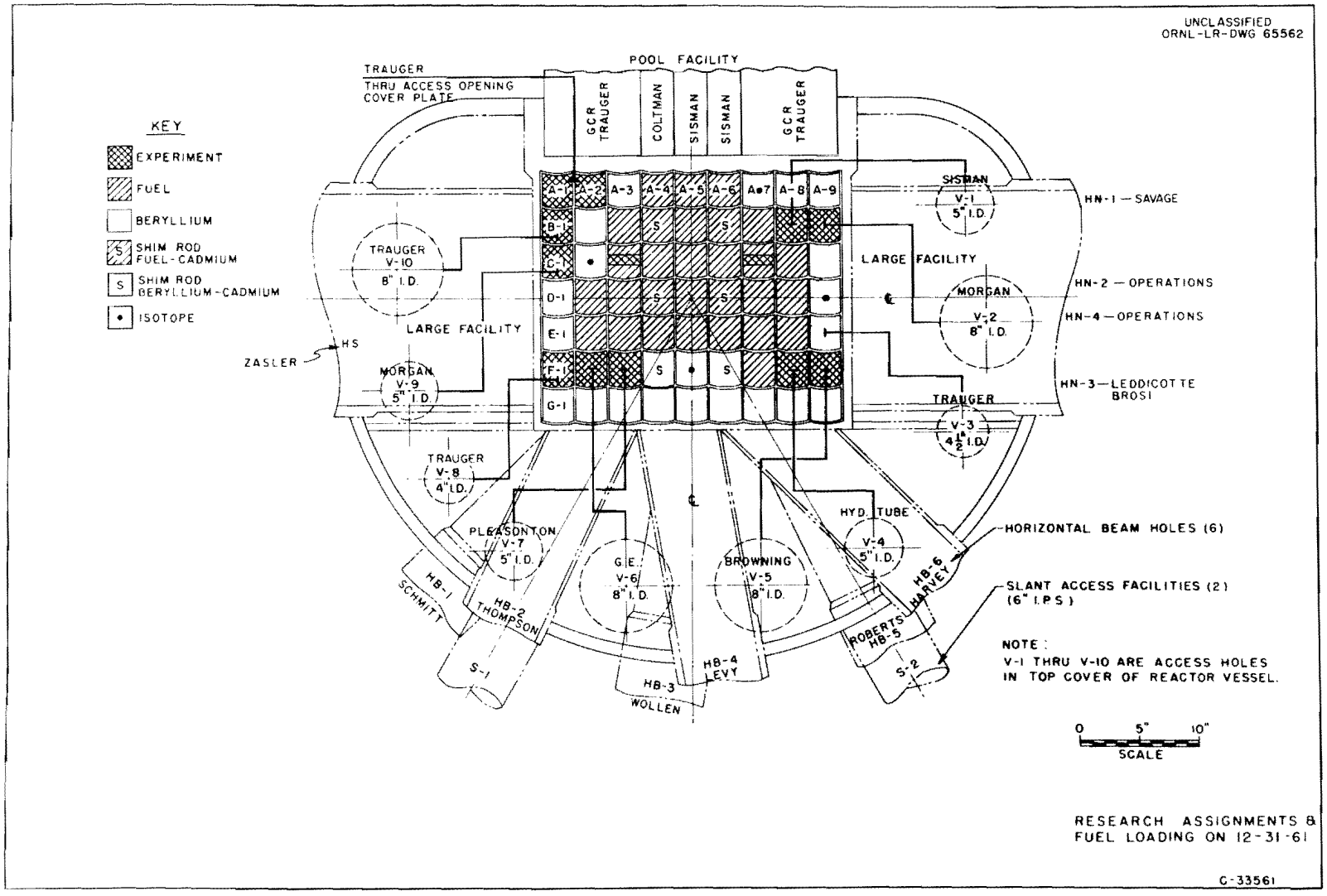

Fig. 1.1 O.R.N.L. Research Reactor Lattice Pattern And Experiment Locations

Table 1.2. ORR Cycles of Operation

Cycle No.	Date Begun	Date Ended	Accumulated Energy (Mwd)
36	September 2	October 22	1398.2*
37	October 31	December 17	1323.8
38	December 22	In progress	278.5

*Accumulated energy for cycle 36 during this quarter was 614.6 Mwd.

Figures 1.2, 1.3, and 1.4 indicate the gang-rod position versus time for the fuel-cadmium shim rods during cycles 36, 37, and 38 (in progress).

Shutdowns

Two major shutdowns occurred during the quarter, ending cycles 36 and 37.

October 22 through October 31. Six experiments were removed during this shutdown, and seven were installed. The 24-inch shielding plug and associated piping were installed for GCR loop No. 2 at the south facility. Fuel specimens were replaced in the MSR loop, GCR loop No. 1, and B-9 facility.

The primary-water bypass valve was replaced with a new unit designed to prevent excessive shaft deflection and subsequent binding of the valve. The F-8 hydraulic-tube system was provided with instruments to monitor the cooling water flow to tubes 1, 2, and 3 used for irradiating fissionable materials. The monitors are connected to the reactor safety circuit through a normal "E" panel. Other instrumentation changes completed during this shutdown are itemized in the reactor controls section of this report.

ORNL-LR-Dwg. 66196
Unclassified

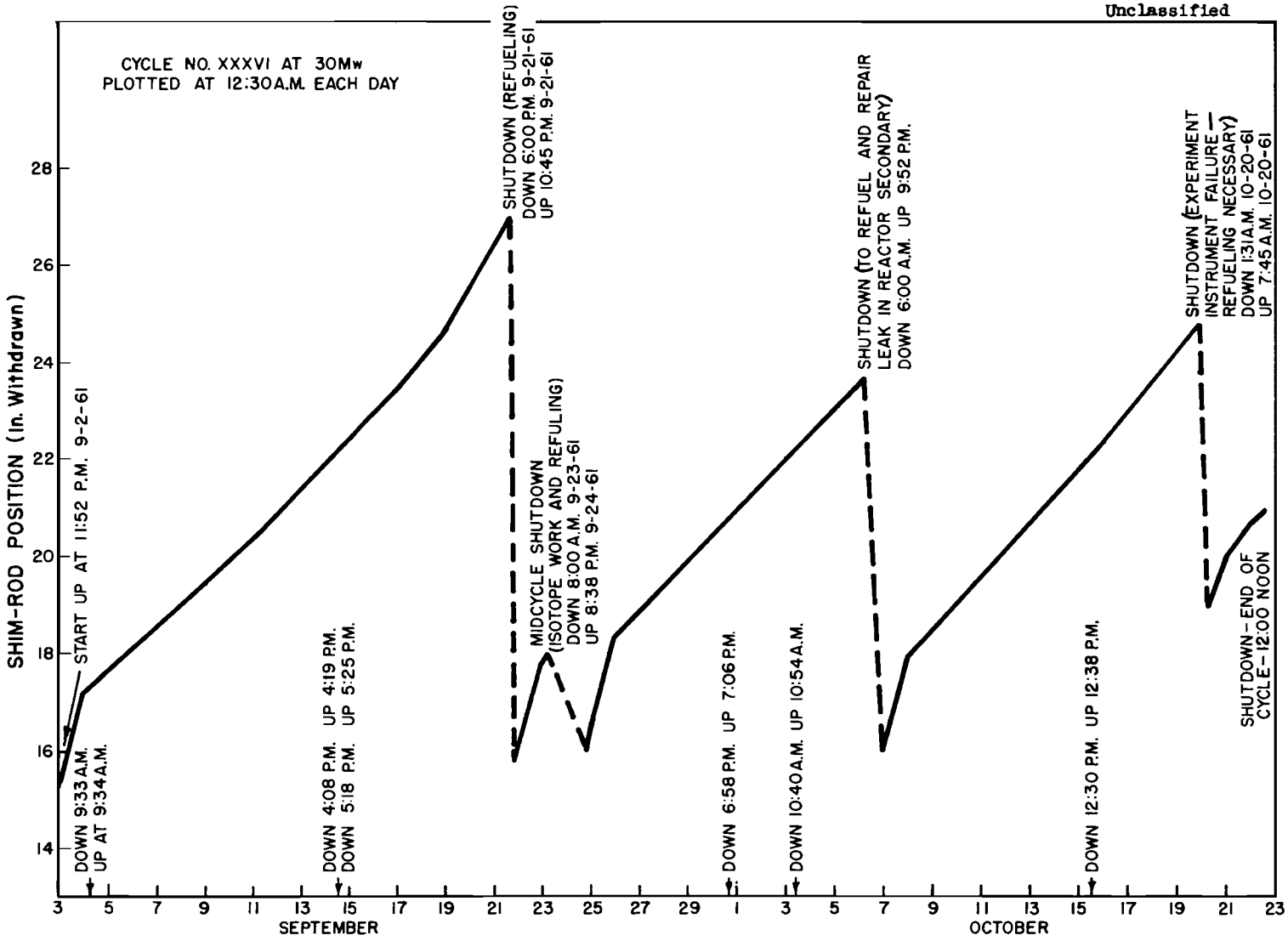

Fig. 1.2 SHIM-ROD POSITION VS. TIME

ORNL-LR-Dwg. 66197
Unclassified

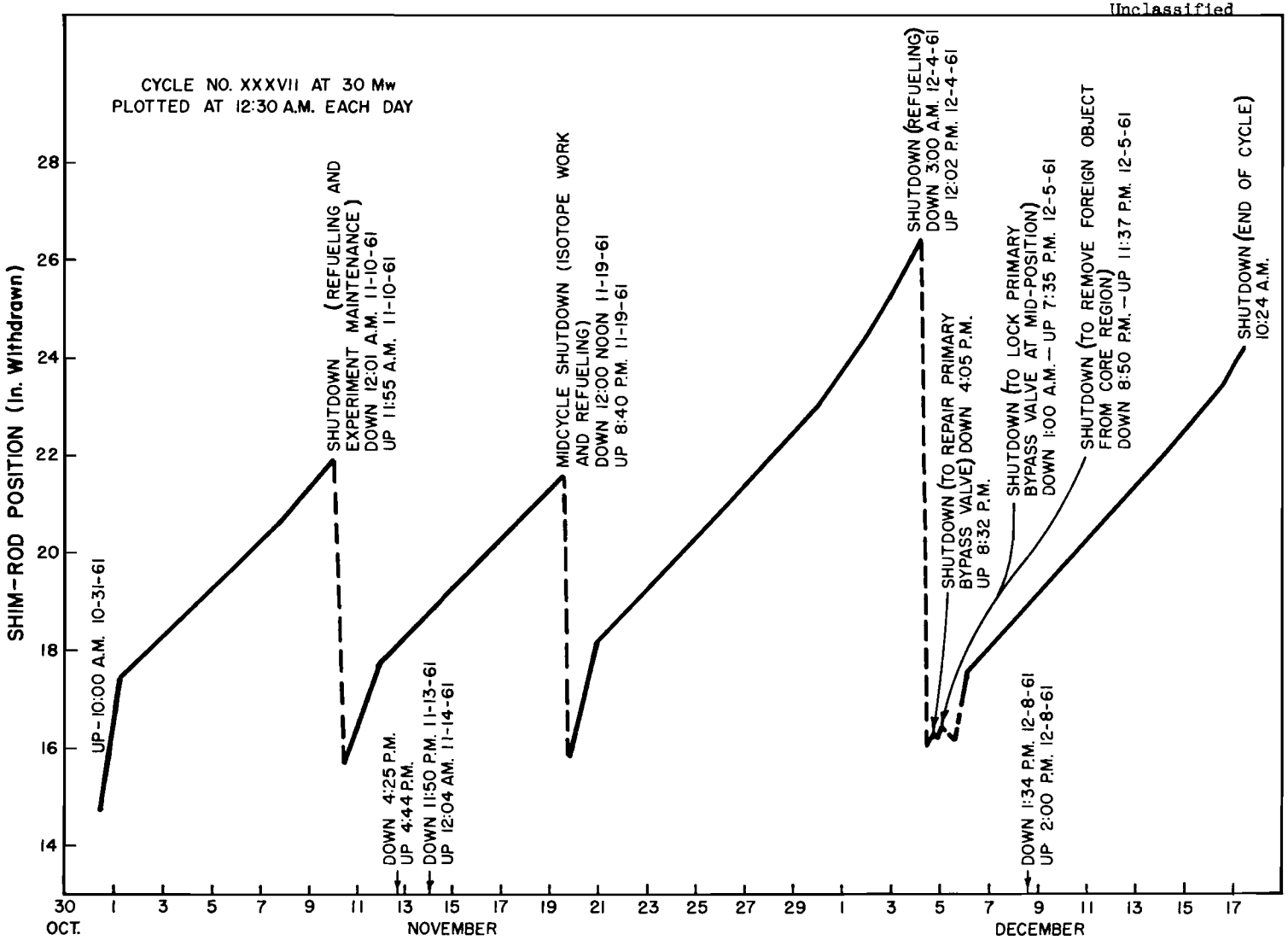

Fig. 1.3 SHIM-ROD POSITION VS. TIME

ORNL-LR-Dwg. 66198
Unclassified

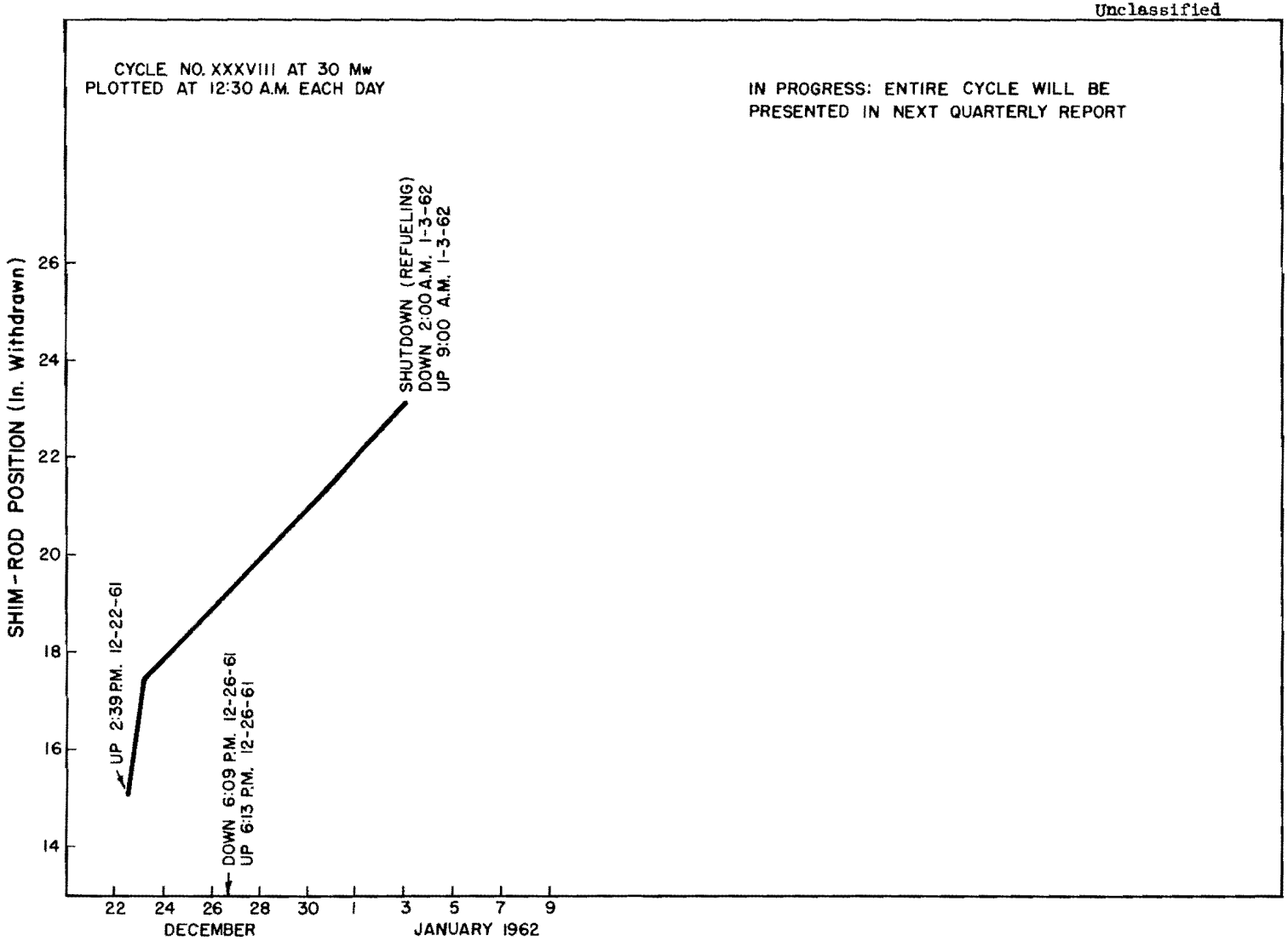

Fig. 1.4 SHIM-ROD POSITION VS. TIME

Special tests performed during the shutdown included a three-day test run of the decontamination scrubber, a determination of facility cooling-flow variation as a function of primary cooling-flow rate, and a test to determine the reactivity effect due to inverting partially depleted fuel elements.

December 17 through December 22. Six experiments were installed during this shutdown, and five were removed. The in-pool piping for the B-9 experiment was replaced, and a new fuel specimen was installed. Fuel specimen replacements were made at the GCR loop No. 1 and the C-1 facility. The charcoal trap and related piping for the F-2 experiment was removed from the reactor pool for alteration.

It was again necessary to change the primary-water bypass valve due to binding. The original unit which had been removed during the previous shutdown was altered and reinstalled. The component parts of the decontamination scrubber were cleaned and tested, and the unit's absolute filters were replaced. Operating characteristics have greatly improved.

A reactivity worth measurement was made for a half-fuel-element experiment in the C-7 position, and a special flow check at the south facility was made to obtain design information for the GCR loop No. 2 experiment.

A summary of the ORR shutdowns for the quarter is given in Table 1.3.

Table 1.3. Summary of ORR Shutdowns

Description	Number	Down Time (hr)
Scheduled Shutdowns		
Regular, end-of-cycle	2	338.250
Regular, midcycle and isotope	1	8.667
Regular, refueling	1	9.033
Refueling and repair of leak in reactor secondary cooling system	1	15.867
Refueling and experiment maintenance	1	11.917
Repair of primary bypass valve	2	23.033
Removal of foreign object from core region	1	2.783
Subtotal	9	409.550
Unscheduled Shutdowns		
Instrument failure, reactor controls	0	0
Instrument failure, experiment	5	6.984
Rod drops, reason unknown	1	0.133
Power outage	1	0.433
Subtotal	7	7.550
TOTAL	16	417.100

Table 1.4 explains the unscheduled shutdowns which occurred this quarter.

Table 1.4. Unscheduled Shutdowns of the ORR

Date	Duration (hr)	Remarks
10-3-61	0.233	Scram from GCPR Capsule Experiment No. 8 due to loss of instrument power. The circuit breaker was found tripped for no apparent reason.
10-15-61	0.133	Shim rod No. 4 dropped, reason unknown.
10-20-61	6.233	Scram from GCPR Capsule Experiment No. 8. Same as shutdown of 10-3-61 except that refueling was necessary due to xenon poisoning.
11-12-61	0.217	Scram from GCPR Capsule Experiment No. 8. Same as shutdown of 10-3-61.
11-13-61	0.234	Scram from GCPR Capsule Experiment No. 8. Same as shutdown of 10-3-61. An investigation was made during the midcycle shutdown, and a short was found in a temperature recorder.
12-8-61	0.433	Scram due to electrical power failure. A substation breaker opened on one phase of the power supply due to a short between sagging power lines.
12-26-61	0.067	Setback from the B-9 Experiment. Failure of electronic tubes in a temperature recorder resulted in upscale burnout action.

There were no shutdowns due to real cause; i.e., no condition existed such that without reactor power reduction an experiment and/or the reactor might be damaged.

Reactor Controls

Maintenance and Modification. During the shutdown at the end of cycle 36 in October, 1961, changes were made in the instrumentation which

monitors the coolant flow to the north and south facilities. The coolant flow rates for both facilities are now regarded as reactor operating parameters, and their monitoring instrumentation is tied directly into the reactor control system. However, the flow monitoring instrumentation for the GCR loop No. 2 test plug has an independent tie-in by way of an "E" panel circuit.

During the same shutdown, the gamma chambers in standard ORR ionization chamber positions No. 1 and 8 were both connected to the safety circuit, and sensitivity switches were no longer required.[1] During the shutdown ending cycle 37 in December, 1961, the function of the gamma chamber in position No. 8 was transferred to a chamber located in the original vertical position southeast of the reactor tank. This change was required to utilize position No. 8 in the reactor boiling detection program. Installation of a sensitivity switch was again required for the chamber located in the vertical position.

During the shutdown ending cycle 36 in October, 1961, a modified, waterproof can containing a standard ORR PCP safety chamber (Q-975) was installed in the No. 1 safety channel. The modification consists of combining the chamber connector head and the waterproof-housing connector plate into a single unit. As a result, the chamber was about 10 in. from the nose of the standard waterproof can (Q-1656). The can

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[1] J. A. Cox et al., Reactor Operations, Radioactive Wastes Operations, and Hot Cells Operations Quarterly Report, April-June, 1961, ORNL-CF-61-6-115 (September 18, 1961).

was then reduced by 10 in. by cutting and welding. This change will aid in improving repair and maintenance as well as in eliminating some items which were highly susceptible to damage by gamma radiation. This modification will be incorporated into the remaining two channels during routine replacements.

By the end of the quarter, all six shim rods had been equipped with modified magnet keepers; and all rods, with the exception of shim rod No. 5 (CP-B6), are equipped with new, modified, moisture-resistant magnet coils.[2]

A chronological listing of reactor controls maintenance, modification, and difficulties is given in Table 1.5.

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[2] J. A. Cox *et al.*, Reactor Operations, Radioactive Wastes Operations, and Hot Cells Operations Quarterly Report, July-September, 1961, ORNL-CF-61-9-68 (January 3, 1962).

Table 1.5. Reactor Controls - ORR

Date	Description
10-2-61	The No. 1 (auxiliary) shim rod dropped, reason unknown. Observations of subpile room components and magnet current revealed no abnormalities.
10-3-61	It was discovered that the No. 1 ΔT recorder was indicating 0.8°F high. The electronic tubes were replaced in the recorder amplifier.
10-3-61	Investigation continued to determine the difficulty in the No. 1 level safety channel which continued from last quarter. A spare recorder was installed in parallel with the permanent recorder. Subsequent data indicated that the ion chamber was the cause of the difficulty. Since this channel was considered unreliable, a "safety trouble" condition was simulated so that failure of one of the two remaining channels would initiate a reactor shutdown.
10-5-61	Since no safety credit was taken for the No. 1 level safety channel, an experimental chamber was connected to the No. 1 safety recorder. This chamber was a prototype of the shortened PCP chamber.
10-6-61	During a scheduled shutdown, the No. 1 (auxiliary) shim rod failed to drop until ~30 seconds after the scram signal. The rod drive was replaced with a unit containing a modified magnet keeper, modified (waterproof) magnet coil, new plunger, and new balls. When electrical power was restored following this replacement, a short to ground occurred and replacement of all wires from the drive unit to the subpile room terminal strip was required.
10-15-61	The No. 4 shim rod dropped, reason unknown. Observation of subpile room components and magnet current revealed no abnormalities.
10-23-61	The No. 1 level safety chamber was replaced by the modified unit consisting of a standard PCP chamber in a shortened waterproof container. Also, the gamma chamber in the vertical position southeast of the reactor tank was moved to standard ion chamber position No. 1.

Table 1.5. (Continued)

Date	Description
10-24-61	A routine replacement of the No. 4 shim-rod drive unit was made. The unit installed contained a modified magnet keeper, old-type magnet coil, new plunger (Rockwell hardness C-59), and new balls.
10-26-61	A routine replacement of the No. 6 shim-rod drive unit was made. The unit installed contained a modified magnet keeper, modified (waterproof) magnet coil, new plunger (Rockwell hardness C-59), and new balls.
10-27-61	The No. 2 (auxiliary) shim-rod drive unit was replaced due to evidence of water leakage. The unit installed contained a modified magnet keeper, modified (waterproof) magnet coil, new plunger (Rockwell hardness C-59), and new balls.
10-31-61	The gamma chamber channel (ion chamber position No. 1) recorder amplifier was temporarily out of service. Replacement of a blown electrical fuse corrected the difficulty.
11-2-61	Due to erratic behavior of the No. 2 level safety readings, a spare recorder was installed in parallel with the permanent recorder. Fast-speed recorders were installed to monitor the chamber and preamplifier signals. During this investigation a "safety trouble" condition was simulated so that failure of one of the two remaining channels would initiate a reactor shutdown.
11-3-61	As a result of the investigation of No. 2 level safety channel, the recorder amplifier was replaced and the circuit returned to normal.
11-5-61 to 11-9-61	Fluctuations occurred in reactor ΔT, reactor coolant flow rate, and outlet temperature. It was determined that the cooling-system temperature controls were not functioning properly. The gain was increased on the controller for the secondary cooling-system bypass valve.

Table 1.5. (Continued)

Date	Description
11-14-61	Upscale spikes occurred on the count-rate and count-rate-period recorders. The N^{16} recorder spiked downscale at the same time. A check by I & C personnel revealed no reason for these spikes. Since no other channels indicated such changes and since the power supplies for the N^{16} monitor and for the fission chamber preamplifier are located in the basement, the cause was assumed to be a local electrical surge.
11-19-61	Approximately 25 minutes after the reactor was shut down for a midcycle isotope and refueling shutdown, a reduction of about 200 gpm in primary reactor-water flow occurred. About 20 minutes after the air pressure to the primary bypass valve operator indicated that the valve was closed, a second reduction of about 700 gpm occurred. These flow reductions appear to have been caused by sticking of the primary-coolant bypass control valve.
11-23-61 through 11-26-61	Upscale spikes were observed on the No. 1 Log-N period recorder. All other channels indicated normal readings.
11-27-61	The No. 1 Log-N amplifier was replaced with a spare, and no further spikes were observed on the No. 1 Log-N period recorder.
11-29-61	A loud-speaker was installed at poolside to provide audible indication of the fission-channel counting rate. This will be used during reloading operations.
12-1-61	Spikes occurred on the No. 2 Log-N period and the count-rate-period recorders. All other recorders indicated normal conditions and no explanation was found.
12-4-61	During startup checks after refueling, the No. 1 Log-N chamber was found to be overcompensated, the No. 2 Log-N chamber power supply was faulty, and the servo chamber was found to be 10% overcompensated. The No. 2 Log-N power supply was replaced with a spare, and the No. 1 Log-N chamber was compensated.

Table 1.5. (Continued)

Date	Description
12-4-61	After the startup, the reactor primary-coolant bypass control valve stuck in the open position. The reactor was shut down and repair was attempted with the system full of water. The valve appeared to be working properly; however, after the subsequent startup and resulting increase in the cooling system temperature, the valve stuck again. The reactor was operated at full power for the remainder of the day.
12-5-61	The reactor was shut down and a portion of the primary cooling system was drained to repair the bypass valve. It was found that the necessary repairs would require more shutdown time than the condition of the system justified; therefore, the valve was set in the normal operating position with a constant air pressure on the valve operator. Reactor operation continued under these conditions with repair scheduled for the next end-of-cycle shutdown in January, 1962.
12-13-61	The No. 1 Log-N recorder was erratic and the control system was switched to the No. 2 Log-N channel. Later, spikes to 9 and 5.5 sec occurred on the No. 1 Log-N period recorder. These fluctuations were not indicated on the other channels, and no cause for the spikes was found. The following week during the shutdown ending cycle 37, a check of the electronic tubes in the period recorder amplifier revealed several weak tubes.
12-14-61	The count-rate recorder spiked downscale, and when this channel returned to normal a 15-sec period was indicated on the period recorder. No further trouble was encountered and because there were craftsmen working in the subpile room, it is believed that one of these men, although properly supervised, accidentally bumped the preamplifier.
12-18-61	Due to excessive magnet release time (>100 milliseconds) during postshutdown tests, the No. 2 (auxiliary) shim-rod drive unit was replaced. The unit installed contained a modified magnet keeper, modified (waterproof) magnet coil, new plunger (used previously in stress lab studies), and new balls.

Table 1.5. (Continued)

Date	Description
12-18-61	A replacement of the No. 3 shim-rod drive unit was made due to previous evidence of water leakage. The unit installed contained a modified magnet keeper, modified (waterproof) magnet coil, new plunger (Rockwell hardness C-58), and new balls.
12-19-61	Due to an excessive magnet release time (~35 milliseconds) during postshutdown tests, the No. 1 (auxiliary) shim-rod drive unit was replaced. The unit installed contained a modified magnet keeper, modified (waterproof) magnet coil, new plunger (Rockwell hardness C-56), and new balls.
12-20-61	A special PCP chamber with a preamplifier in the chamber housing, which will be used in the boiling detection study, was installed in ion chamber position No. 8. The gamma chamber, channel No. 1 previously located in that position was moved to the original vertical position southeast of the reactor tank.
12-21-61	The reactor primary cooling-system bypass control valve was replaced with a spare unit. This spare unit was the valve originally in the 30-Mw cooling system which had been removed and modified.
12-22-61	During prestartup tests (on 12-21-61), excessive friction had been observed during the recocking of drive unit for shim rod No. 6; furthermore, with higher cooling-water flow rates a greater reduction of magnet current was required to drop the rod than was required with lower flow rates. The drive unit was replaced with a spare unit which contained a modified magnet keeper, modified (waterproof) magnet coil, new plunger (Rockwell hardness C-59), and with 4 new balls (the remaining 4 balls had been previously used but were in good condition.

Building Containment

During the special tests run on the scrubber, and later during the routine containment test, some difficulty was experienced in obtaining the minimum negative pressure required inside the building. Several leaks were found principally around personnel doors and cable entrances. Repairs were made so that minimum requirements were met before cycle 37 operation was begun.

Work continued toward further improvement of the containment; and all holes, cracks, and other leaks were patched or caulked. The scrubber filters were changed during the December shutdown, and the scrubber packing was thoroughly cleaned. This reduced the pressure drop across the scrubber unit, including the filters, from 8.38 in. w.g. to 7.38 in. w.g. The minimum requirements for building containment were easily exceeded during the December test.

Reactivity Measurements

The reactivity effect of the proposed radiation damage experiment, to be installed in core position C-7, was determined to be $-\sim 0.35\% \Delta k/k$.

Reactor Primary Cooling System

Operating Experience. The 24-in. primary bypass control valve continued to be troublesome. The original unit, installed in July, 1960, was not equipped with inboard bearings, which resulted in binding due to deflection of the shaft under full flow conditions. The pneumatic actuator for this valve was also undersized. Alterations to this valve did not provide completely satisfactory operation, and a new unit of different design was installed during the October, 1961, shutdown.

On November 19, 1961, unexplained primary-coolant flow fluxuations indicated that the new bypass valve was binding. Similar indications were observed during November, 1961, and on December 4, 1961, the valve stuck in the open position during startup after the refueling shutdown. Two attempts were made to free the valve (12-4 and 12-5), and then it was locked in position at approximately 40% open until the December shutdown when the original valve (with a larger positioner) was reinstalled. Operation to date has been satisfactory.

Modifications. A bearing-temperature monitoring system was installed on the primary pumps. The recorder for this system is located in the primary pump-house instrument room away from high radiation backgrounds. A high-temperature alarm was provided in the ORR control room.

Reactor Secondary Cooling System

Operating Experience. On October 3, slippage in a mechanical joint in the secondary cooling system resulted in a water leak of approximately 100 gpm. The leak worsened until approximately 250 gpm of water were being lost by October 4 when the system pressure was reduced and the leak was partially stopped. The reactor was operated until October 6 when repairs were made.

Fuel Handling

Forty-two spent fuel elements were shipped from the ORR to the chemical processing plant in Idaho, and four experimental elements were removed from the ORR pool storage. Approximately 30 fuel elements were added to the spent inventory; therefore, 16 storage spaces were gained during the quarter. In addition, 56 fuel elements were shipped to the processing plant from the canal in Building 3001. Total processing plant shipments

were double those of the previous quarter when 49 elements were shipped. This reflects the expected increased efficiency resulting from placing the new carrier and a second truck in service. The average time between shipments was 13 days; however, the last shipment for the quarter was made December 4, 1961.

Reactivity Effects of Inverting Partially Spent Fuel Elements

On October 29 and 30, 1961, a test was made to determine the reactivity effect of inverting seven fuel elements with a burn-up of 22-31%. The results of the tests indicated that the immediate effect was an increase in reactivity of $\sim$0.8% $\Delta k/k$ with all shim rods positioned at $\sim$14-15 in. out. The effect of inverting three of the elements resulted in a reactivity change of +0.23% $\Delta k/k$.

There is some doubt, however, that inverting elements will produce a net positive reactivity change over an operating cycle since the shifting of the peak flux from a zone of high fuel concentration at the beginning of a cycle to a zone of lower fuel concentration later in the cycle may reduce the over-all reactivity effect. For this reason the ORR fuel is not being inverted at the present time. It is planned to conduct further tests on this as time permits.

Operating Procedures

The six most important ORR procedure memoranda issued during the period were as follows:

1. ORR Procedure Memo No. 204 - To provide a formal procedure for checking and adjusting the limit switches associated with the shim-rod drives.

2. ORR Procedure Memo No. 205 - To provide a formal description and operating procedure for the automatic pH control system for the reactor secondary cooling-system water.
3. ORR Porcedure Memo No. 206 - To provide a description of the newly installed instrumentation monitoring coolant flows in the north and south facilities.
4. ORR Procedure Memo No. 208 - To formally state the operating limitations upon failure of reactor instrumentation.
5. ORR Procedure Memo No. 209 - To formally state limitations on personnel present in the control room during reactor startups.
6. ORR Procedure Memo No. 210 - To provide a formal procedure to be followed when experiment changes are necessary.

Experiments in the ORR

Table 1.6 outlines the assignment of the ORR experiment facilities.

Table 1.6. ORR Facilities Assignment

Facility	Access Flange	Nature of Experiment	Division Sponsor
		Core Positions	
A-1 and 2	V-11	Pressurized water loop, MSR	Reactor
A-3 and 7, C-2, D-9, and F-5		Radioisotope production	Isotopes
B-1	V-10	Gas-cooled loop No. 1	Reactor
B-8 and C-3	V-1 and 3	Radiation damage studies	Solid State
C-7		Radiation damage studies	Solid State
B-9	V-2	Fuel tests	Solid State

Table 1.6. (Continued)

Facility	Access Flange	Nature of Experiment	Division Sponsor
C-1	V-9	Fuel tests	Solid State
F-1 and E-9	V-8 and 3	Fuel tests	Reactor
*E-8	V-2	Hyd. tube No. 2	Isotopes--Chemistry
*F-2	V-6	Fuel tests	Reactor (General Electric)
F-3	V-7	Ne^{23} studies	Physics
F-8	V-4	Hyd. tube No. 1	Isotopes--Solid State
F-9	V-5	Fuel meltdown tests	Reactor Chemistry
		Pool Face Positions	
P-1, 2, 3, 7, 8, and 9		EGCR capsule irradiations	Reactor
P-4, 5, and 6		Radiation damage studies	Solid State
		Large Facilities	
*HN-1		Thoria slurry loop	Reactor Chemistry
HN-3		Pneumatic rabbit for activation analysis	Chemistry--Analytical Chemistry
HN-2 and 4		Not in use	
*HS		Gas-cooled loop No. 2	Reactor

*Indicates that final experiment installation is incomplete.

Table 1.6. (Continued)

Facility	Access Flange	Nature of Experiment	Division Sponsor
		Beam Holes	
HB-1		Magnetic analysis of fission fragments	Physics
HB-2		Neutron spectrometer	Solid State
HB-3		Neutron spectrometer	Physics
HB-4		Neutron spectrometer	Chemistry
HB-5		Neutron spectrometer	Physics
HB-6		Time-of-flight neutron spectrometer	Physics

A list of new experiments operated during the quarter is given in Table 1.7.

Table 1.7. New Experiments Installed or Operated

Date Installed	Division Sponsor	Expected Duration	Facility	Experiment Description
10-11-61	Reactor (General Electric)	2 days	F-2	Cu sample
10-15-61	Reactor (General Electric)	2 days	F-2	Cu sample
10-30-61	Reactor	6 months	P-1 and P-9	Capsule irradiation - UC_2 coated with graphite
10-30-61	Reactor	6 months	P-3 and P-8	Capsule irradiation - UO_2 pellets
*10-23-61	Solid State	6 days	B-9	Fuel test

*Leaks were found in the B-9 containment, making it necessary to remove the fuel capsule before startup.

Table 1.7. (Continued)

Date Installed	Division Sponsor	Expected Duration	Facility	Experiment Description
10-30-61	Solid State	2 months	B-8	Creep test - SS and graphite
10-30-61	Reactor	4 months	B-1	EGCR prototype fuel element
10-30-61	Physics-Chemistry	6 months	F-3	Ne^{23} recoil
10-30-61	Reactor	2 months	A-2	UO_2 fuel specimen No. 6
11-6-61	Reactor (General Electric)	2 days	F-2	Cu sample
11-13-61	Reactor Chemistry	11 days	F-9	Fuel meltdown
11-24-61	Reactor (General Electric)	3 days	F-2	Au sample
12-7-61	Isotopes	1 month	P-5 (Piggy-back)	Mild-steel piston rings
12-10-61	Reactor (General Electric)	3 days	F-2	Au sample
12-18-61	Reactor	6 months	P-3 and P-7	Capsule irradiation, ThO_2 and UO_2 granules
12-17-61	Reactor	4 months	B-9	Fuel specimen
12-19-61	Solid State	2 months	P-5	Inconel tube burst
12-19-61	Solid State	2 months	P-6	Stainless steel tube burst
12-19-61	Solid State	2 months	B-8	Creep test - SS and graphite
12-19-61	Reactor	16 weeks	B-1	EGCR prototype fuel element varying enrichment up to 1.1%
12-22-61	Solid State	Indefinite	C-7	Radiation damage to metals

1.2. Boiling Detection Program

A. L. Colomb

In-Reactor Experiment

The purpose of this experiment is to determine whether the reactor neutron-level statistical fluctuations can indicate the presence of boiling in the core and, if so, what sensitivity can be obtained.

The detection apparatus described in the July-September, 1961, quarterly report[1] has been completed and tested. The electronic circuit used is described in Drawing Q-2284-1.

A boiling-generating apparatus consisting of a nichrome heater capable of producing approximately 1 kw of heat per square inch has been designed and is now in an advanced stage of construction. It has been approved by the Experiment Review Committee and will be installed in the ORR during the shutdown beginning February 11, 1962.

Out-of-Reactor Loop

The design of this hot-water loop has been completed, and most of the loop is already built. The test section (i.e., a water channel simulating an ORR cooling channel with transparent walls) is still under construction and will be completed by the end of March, 1962.

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[1] J. A. Cox, Reactor Operations Quarterly Report, ORNL CF-61-9-68, (July-September, 1961).

1.3. Comments on Xenon and Samarium Poisoning Effect at ORR Startup

A. L. Colomb

The fast reactivity variation at the beginning of an ORR fuel cycle is the result of the combination of xenon buildup and samarium burnup.

Using elementary theory, the negative reactivity introduced by xenon at saturation in an operating reactor can be shown to be

$$\frac{\Delta k}{k} = -Pf$$

f = reactor thermal utilization,

or

$$\frac{\Delta k}{k} = -\frac{X_0 \sigma_{Xe} f}{\Sigma_u} = -\frac{(\gamma_I + \gamma_{Xe})\,\Sigma_f\, f}{\left(\frac{\lambda_{Xe}}{\sigma_{Xe}\phi_0} + 1\right)\Sigma_u} .$$

Remembering that in a homogeneous, highly enriched reactor

$$k_\infty = \eta f = \nu \frac{\Sigma_f}{\Sigma_u} \times \frac{\Sigma_u}{\Sigma_R}$$

one gets

$$\frac{\Delta k}{k} = \frac{(\gamma_I + \gamma_{Xe})}{\left(\frac{\lambda_{Xe}}{\sigma_{Xe}\phi_0} + 1\right)} \times \frac{\overline{k_\infty}}{\nu} .$$

Using the same procedure, the negative reactivity introduced by samarium at saturation during reactor operation is

$$\frac{\Delta k}{k} = -\frac{\gamma_{Pm}\,\overline{k_\infty}}{\nu} .$$

After shutdown, samarium buildup to a new steady value is given by

$$\frac{\Delta k}{k} = -\gamma_{Pm}\frac{\overline{k_\infty}}{\nu}\left[\frac{\phi_0}{\lambda_{Pm}} + \frac{1}{\sigma_{Sm}}\right]\sigma_{Sm} .$$

If the reactor is started once samarium has reached its shutdown steady value, the negative reactivity due to samarium will decrease until it

reaches its operating, steady-state value. The positive reactivity introduced into the reactor by this effect will be

$$\frac{\Delta k}{k} = \gamma_{Pm} \frac{\overline{k_\infty}}{\nu} \frac{\phi_0}{\lambda_{Pm}} \sigma_{Sm} \ .$$

Superposing this result with that of xenon one gets

$$\frac{\Delta k}{k} = - \frac{\overline{k_\infty}}{\nu} \left[\frac{\gamma_I + \gamma_{Xe}}{\left(\frac{\lambda_{Xe}}{\sigma_{Xe} \phi_0} + 1 \right)} - \gamma_{Pm} \frac{\phi_0}{\lambda_{Pm}} \sigma_{Sm} \right] .$$

Figure 1.5 shows the reactivity behavior of the two effects with respect to reactor power. These curves were calculated with a flux-to-power ratio corresponding to that of the ORR.

It is interesting to note that for a reactor power of 66.5 Mw, the two effects just compensate each other.

Using a $\overline{k_\infty}$ of 1.68, which is representative for the ORR, one finds that the negative reactivity introduced in the reactor by xenon and samarium is equal to 2.4% $\frac{\Delta k}{k}$.

The shim rods reactivity value varies between 1 and 1.3% $\frac{\Delta k}{k}$ per inch; therefore, approximately 2 inches of rod should be withdrawn to compensate for xenon and samarium effect. This is approximately the rod change observed at the beginning of each cycle.

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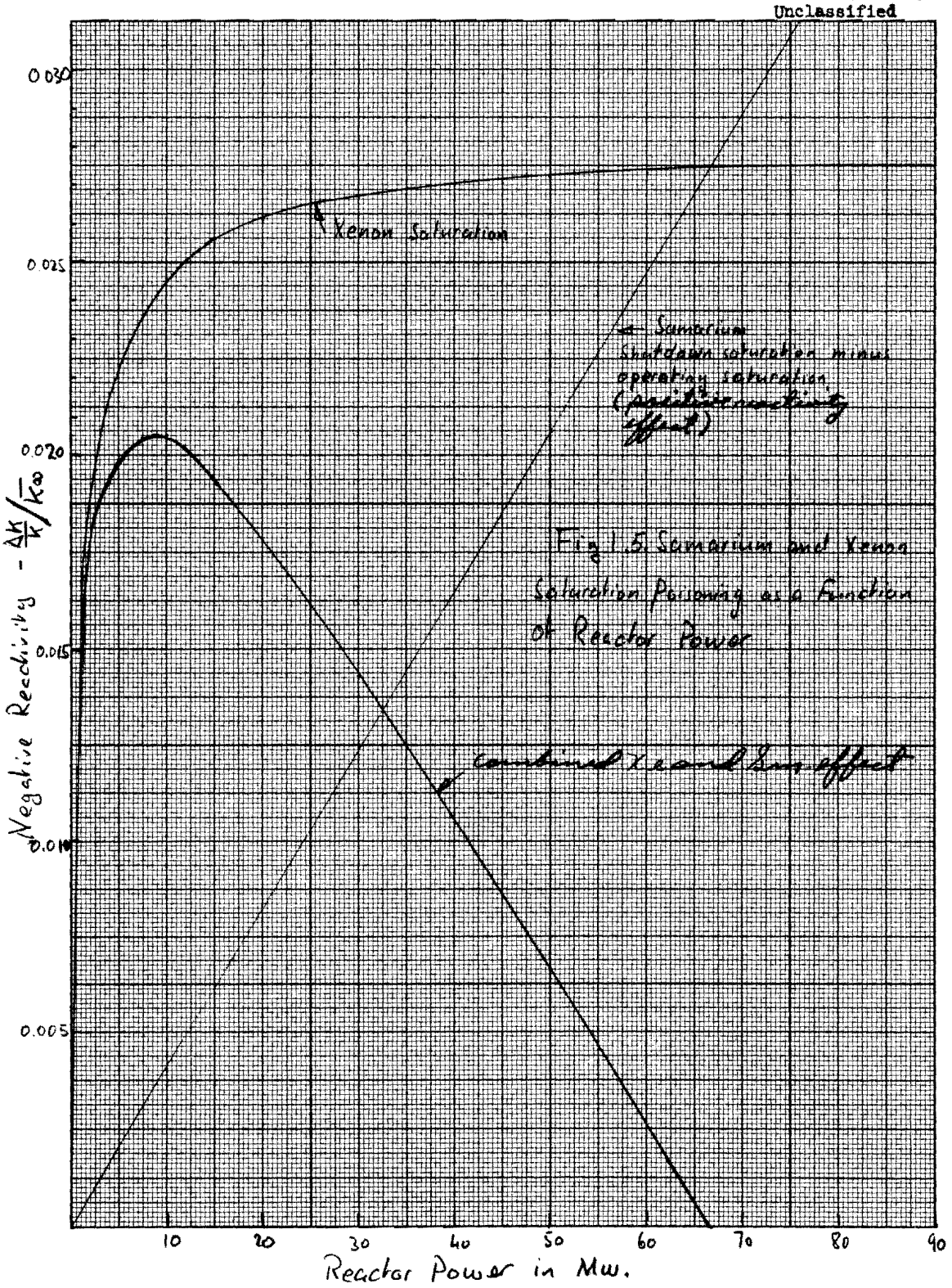

Fig. 1.5. Samarium and Xenon Saturation Poisoning as a Function of Reactor Power

PART IV

Taken from REACTOR OPERATIONS QUARTERLY REPORT

January - March, 1962, ORNL CF-62-3-94

REACTOR OPERATIONS

QUARTERLY REPORT

Summary

The ORR operated 83.7% of the time during this quarter, and this represents a new record. Encouraging results have been obtained on boiling detector tests made with an electrically heated plate in the reactor core. Further work will be done as soon as a new experiment assembly has been built.

1. OAK RIDGE RESEARCH REACTOR

1.1. Operations

W. R. Casto

Operations

The ORR was operated during this period at a power level of 30 Mw. Total operating time for the quarter was 1808.1 hr. The operating data are given in Table 1.1.

Table 1.1. ORR Operations

Period January 1 through March 31, 1962

	This Quarter	Last Quarter	Year to Date
Total energy, Mwd	2242.2	2216.9	2242.2
Average power, Mw/operating hr	29.8	29.7	29.8
Time operating, %	83.7	81.1	83.7
Reactor water radioactivity, $\frac{c/m}{ml}$ (av)	33,751	31,360	33,751
Pool water radioactivity, $\frac{c/m}{ml}$ (av)	2,088*	878	2,088
Reactor water resistivity, ohm-cm (av)	446,000	431,000	446,000
Pool water resistivity, ohm-cm (av)	529,000	593,000	529,000
Research samples	16	11	16
Radioisotope samples	131	96	131

*Reflects leakage of rhenium into the pool water from the irradiation facility in F-2 core position.

The core configuration at the end of the quarter is indicated in Figure 1.1.

Cycles of operation during this period are shown in Table 1.2.

Table 1.2. ORR Cycles of Operation

Cycle No.	Date Begun	Date Ended	Accumulated Energy (Mwd)
38	December 22	February 11	1440.5*
39	February 11	In progress	1080.2

*Accumulated energy for cycle 38 during this quarter was 1162.0 Mwd.

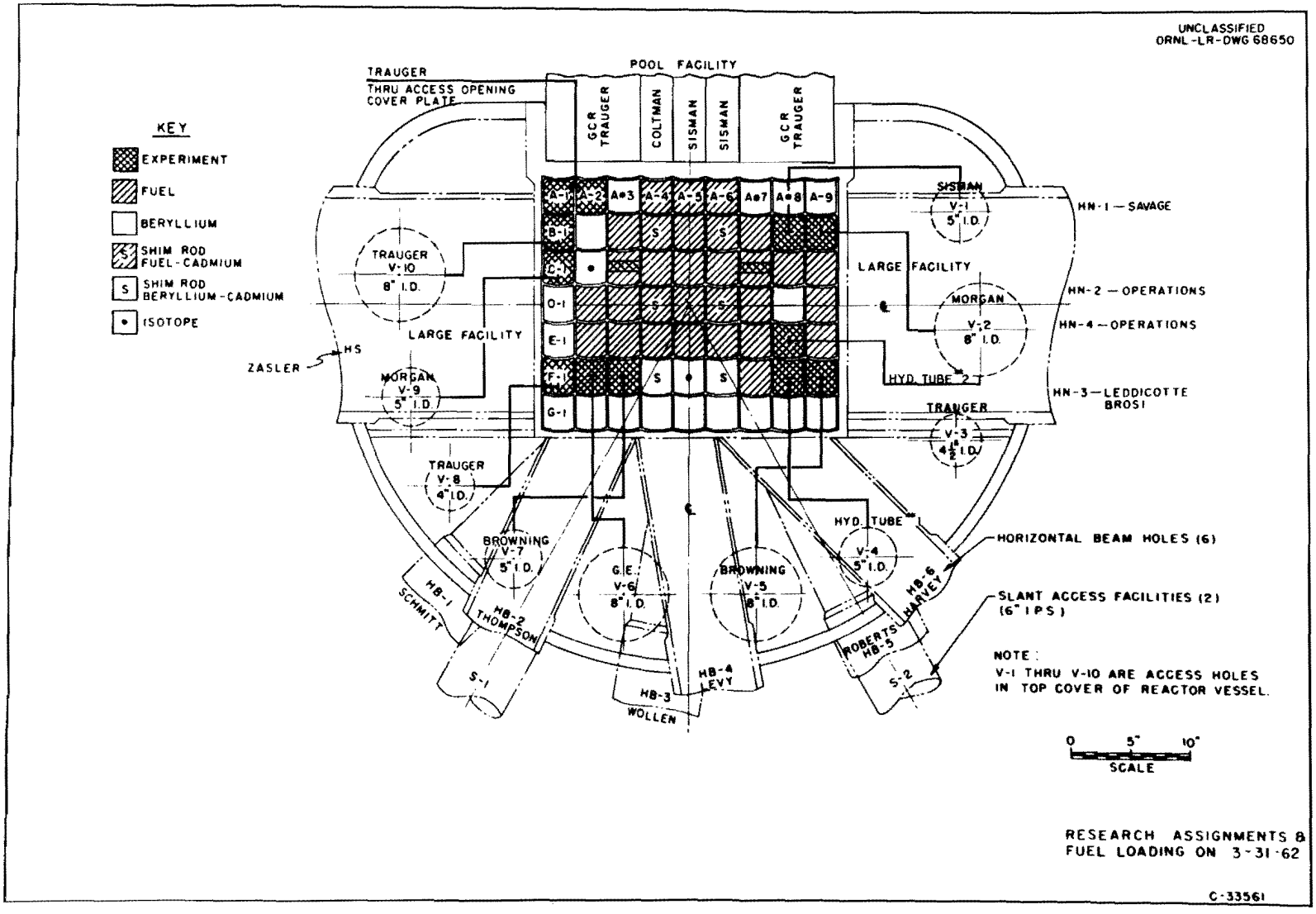

Fig. 1.1. ORNL Research Reactor Lattice Pattern and Experiment Locations.

Figures 1.2 and 1.3 indicate the gang-rod position for the fuel-cadmium shim rods during cycle 38 and cycle 39 (in progress).

Shutdowns

One major shutdown occurred during the quarter, ending cycle 38.

February 11 through February 16, 1962. Seven experiments were removed during this shutdown and eight were installed. In-pool piping for the hydraulic-tube facility No. 2 (core position E-8) was started, and alterations to the piping for the F-2 experiment were made. Fuel capsules were replaced in the MSR Loop and GCR Loop No. 1.

An inspection of the south reactor shell-and-tube heat exchanger was made through the inlet pipe, and the impingement baffle was found to be intact. It was surmised that the leak which occurred on 1-26-62 was due to vibration from water flow over the tubes at the inlet end.

Special tests conducted during the shutdown included a "caustic usage" test at the decontamination scrubber, a flux mapping of the core to determine the flux distribution with the new core configuration (see Figure 1.1), and a test to determine the reactivity worth of the air-cooled fuel capsule experiment in core position F-2.

A summary of the ORR shutdowns for the quarter is given in Table 1.3.

Table 1.3. Summary of ORR Shutdowns

Description	Number	Down Time (hr)
Scheduled Shutdowns		
Regular, end-of-cycle	1	188.400
Regular, midcycle and isotope	2	21.383
Regular, refueling	1	7.000
Refueling, replacement of scrubber pump, and experiment maintenance	1	17.833
Refueling, experiment maintenance, and replacement of No. 3 drive tube	1	16.717
Repair of reactor heat exchanger	1	12.400
Isotope and refueling	1	6.533
Check of new low-level scram instrumentation	1	0.633
Insertion of Pa^{231} samples	1	0.133
Removal of Pa^{231} samples	1	0.517

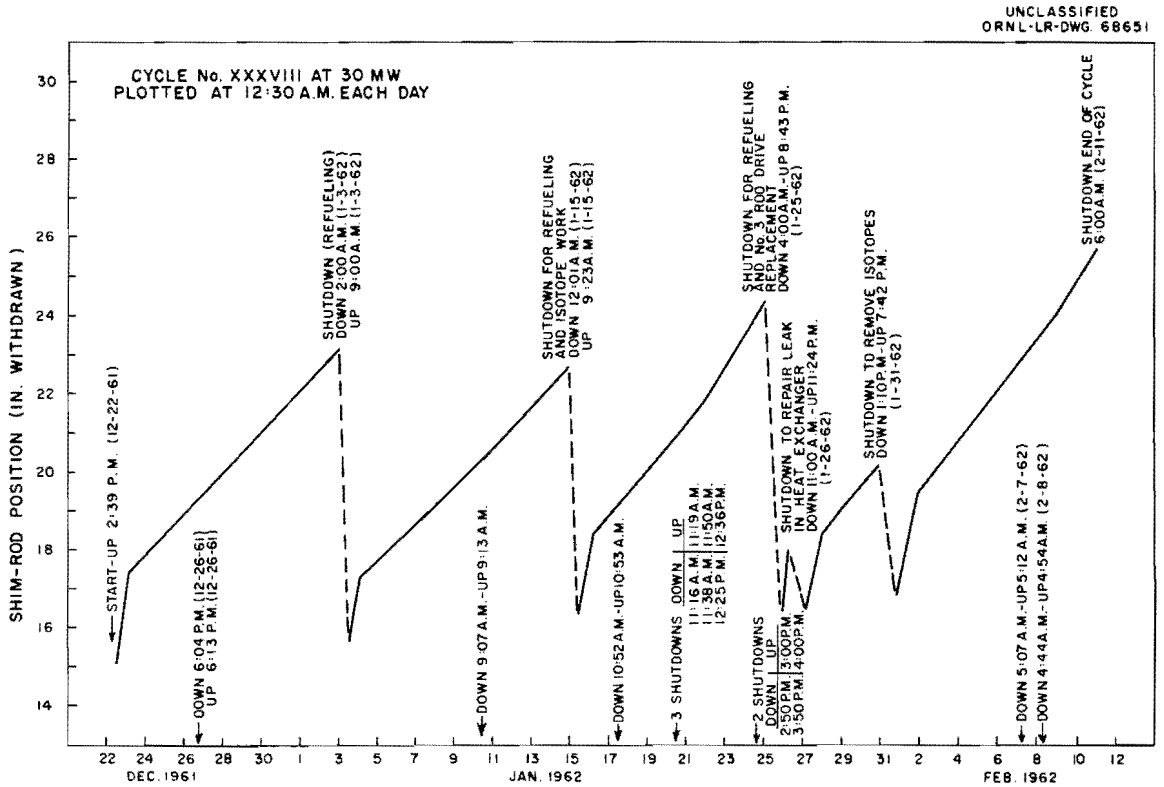

Fig. 1.2. Shim-Rod Position vs Time.

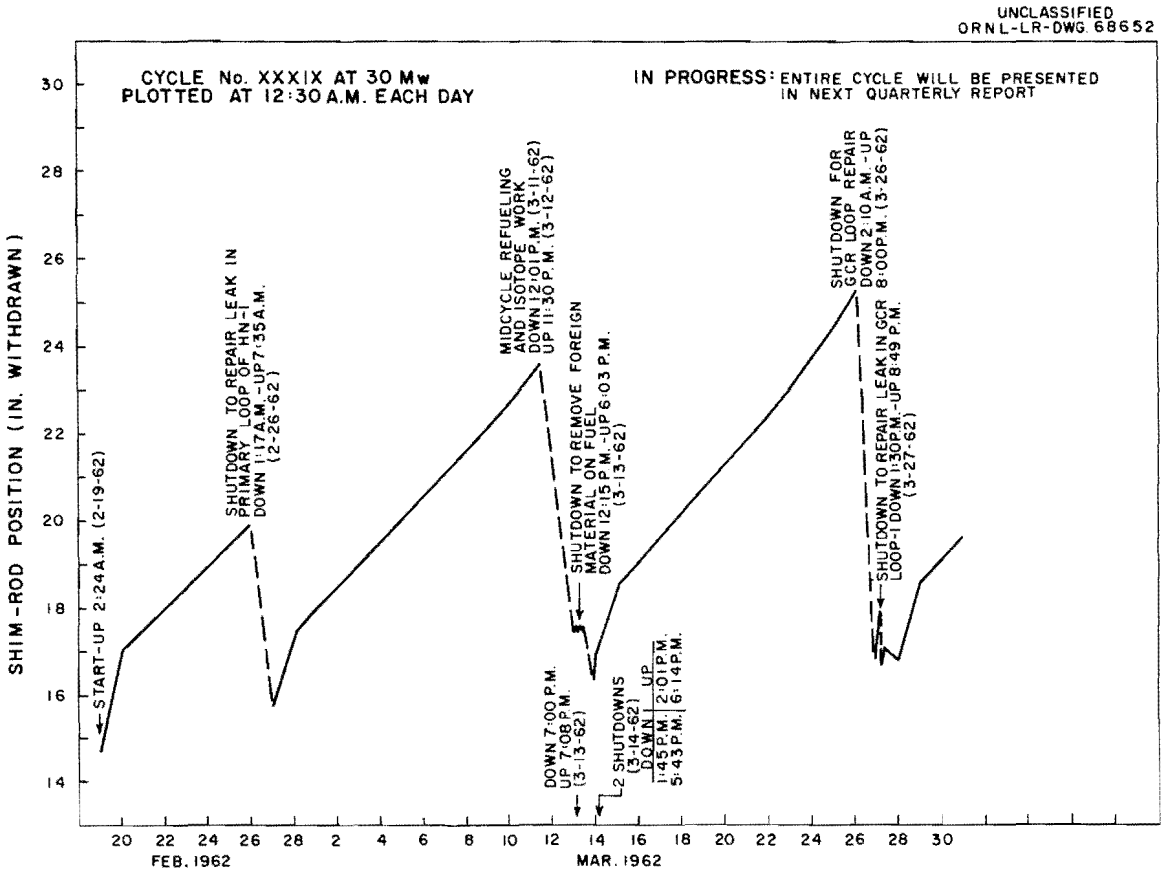

Fig. 1.3. Shim-Rod Position vs Time.

Table 1.3. (Continued)

Description	Number	Down Time (hr)
Experiment maintenance, refueling necessary	2	37.617
Removal of foreign object from core and replacement of No. 3 drive tube	1	18.300
Subtotal	14	327.466
Unscheduled Shutdowns		
Instrument failure, reactor controls	0	0.000
Instrument failure, experiment	1	0.083
Rod drops, reason unknown	5	0.617
Rod drops, leaking bellows seal in drive assembly	2	0.334
Loss of off-gas vacuum	1	0.100
Low flow at hydraulic tube during Pa^{231} irradiation	1	0.267
Subtotal	10	1.401
TOTAL	24	328.867

Table 1.4 explains the unscheduled shutdowns which occurred during the quarter.

Table 1.4. Unscheduled Shutdowns of the ORR

Date	Duration (hr)	Remarks
1-10-62	0.100	Loss of off-gas vacuum due to a frozen instrument line at the stack area.
1-17-62	0.017	Shim rod No. 3 dropped; reason unknown.
1-20-62	0.050	Shim rod No. 3 dropped; reason unknown.
1-20-62	0.200	Shim rod No. 3 dropped; reason unknown.
1-20-62	0.183	Shim rod No. 3 dropped; reason unknown.
1-24-62	0.167	Shim rod No. 3 dropped; water leak caused magnet failure.
1-24-62	0.167	Shim rod No. 3 dropped; water leak caused magnet failure.
2-7-62	0.083	Setback from MSR experiment; failure of a thermocouple caused upscale drive of a temperature recorder.

Table 1.4. (Continued)

Date	Duration (hr)	Remarks
2-8-62	0.167	Shim rod No. 4 dropped; reason unknown.
3-14-62	0.267	Low-flow setback from the hydraulic-tube facility during the Pa^{231} irradiation; a back-up reverse occurred.

There were two shutdowns for real cause, 1-10-62 and 3-14-62; i.e., a condition existed wherein a safety device required that the reactor shut down.

Reactor Controls

Maintenance and Modifications. A considerable number (64) of operating inconveniences were caused by momentary setbacks from GCR Loop No. 1. "Catchers" were installed on various components in the instrumentation circuit to locate the source of these "false" abnormal conditions. Several switches were found to be sources of trouble on an intermittent basis. Replacement of switches was made on several occasions; however, it was later found that the switches in question, initially installed in the "make-up aspect", performed satisfactorily after changing the operating aspect to "drop out". This change minimized the "false" signals from the above source.

Low-Level Scram Protection. The reactor control circuitry has been modified as detailed in Reactor Control Change Memorandum No. 53, Addendum No. 1, to provide additional safety protection when operating the reactor at low power (less than ~ 450 kw) without normal water flow. This change in circuitry increases the sensitivity of the No. 3 safety channel by a factor of 100 when the "raise-test" switch is placed in the "test" position and a scram will be produced through the "fast scram" circuitry when the reactor power exceeds ~ 450 kw. This change in circuitry was completed on February 11, 1962.

Magnet Amplifier Modification. To afford protection against changes in gain of the magnet amplifiers, the two-watt, carbon resistors were replaced by ten-watt, wire-wound resistors which are less likely to undergo a change in value due to excessive heating. In addition, a 100-ohm, one-watt resistor was installed in series with the power transformer and power rectifier to produce an open circuit if a short circuit should occur.

Details of these changes are listed in Reactor Control Change Memorandum No. 57. This modification was completed during the February shutdown.

Addition of Low-Cell-Ventilation Setback to Control System. A flow switch has been installed in the cell-ventilation duct and associated circuitry provided to initiate a reactor setback when the flow through the duct decreases to 2500 cfm. The normal flow is ~ 6000 cfm. This addition is described in Reactor Control Change Memorandum No. 56 and was completed during the February shutdown.

Reactor-Power-Level Distribution System. A system for displaying reactor power by utilizing the signal output of the "Doelcam" of the servo amplifier was installed with a read-out in the ORR control room. This is being expanded to provide reactor-power information to each experiment site and will be completed in the immediate future. Details of this change are included in Reactor Controls Change Memorandum No. 54.

Miscellaneous Relocations and Additions in ORR Control Room. Several location changes of instruments have been made in the ORR panel board to provide additional space for the installation of instrumentation for a second fission-count-rate channel. These changes included: installation of log-count-rate and count-rate-period recorders; relocation of the N^{16} recorder; installation of power supply, etc., for a new count-rate channel. These changes are detailed in Reactor Controls Change Memorandum No. 55 and were completed during the February shutdown.

A chronological listing of reactor-control maintenance, modifications, and difficulties is given in Table 1.5.

Table 1.5. ORR Reactor Controls

Date	Description
1-3-62	Startup checks revealed erratic operation of the No. 2 Log-N channel. The cause was determined to be a defective switch in the amplifier, which was replaced.
1-17-62	The No. 3 shim rod dropped; reason unknown. A visual check of all components of the rod controls revealed no abnormalities.
1-20-62	The No. 3 shim rod dropped three times. A slight leak through the bellows seal inside the drive tube was evident.

Table 1.5. (Continued)

Date	Description
1-20-62	The reactor was found to be operating very near the upper limit of the servo control range. Chamber adjustments were made on 1-23-62 to compensate for this condition, and the amplifier gain and damping was adjusted.
1-20-62	The reactor-water activity recorder was found to be inoperative due to a faulty transformer. Repairs were made and the unit was returned to service.
1-24-62	The No. 3 shim rod dropped twice, apparently due to the leak through the bellows seal. The magnet current was increased to prevent recurring drops until a reactor shutdown could be scheduled.
1-25-62	The No. 3 shim-rod drive was replaced. The unit installed contained a modified magnet keeper, modified (water-proof) magnet coil, new-type plunger (Identification "P"), and new balls.
2-8-62	The No. 4 shim rod dropped; reason unknown. A visual check of all the exposed components of the rod controls revealed no abnormalities.
2-10-62	Unexplained erratic readings were observed on the auxiliary count-rate recorder.
2-12-62	A routine replacement of the No. 4 shim-rod drive was made. A small aluminum chip was found in the ball-latch mechanism of the drive tube which was removed. The unit installed contained a modified magnet keeper, modified (waterproof) magnet coil, new-type plunger (Identification "N") (Rockwell hardness C-58), and new balls.
2-12-62	A routine replacement of the servo chamber was made.
2-13-62	A routine replacement of the No. 5 shim-rod drive unit was made. The unit installed contained a modified magnet keeper, modified (waterproof) magnet coil, new-type plunger (Identification "M") (Rockwell hardness C-59), and new balls.
2-13-62	The modification of the No. 3 safety sigma amplifier associated with the reduction of the power-level scram point for low-flow operation was completed in accordance with Reactor Control Change Memorandum No. 53.

Table 1.5. (Continued)

Date	Description
2-14-62	The No. 1 rod-drive unit was replaced due to the presence of foreign material on the magnet keepers and push rod. The unit installed contained a modified magnet keeper, a modified (waterproof) coil, a new-type plunger (Identification "H") (Rockwell hardness C-57), and new balls.
2-16-62	The No. 6 shim rod would not scram during the prestartup rod checks. Preparations were made to replace the drive unit.
2-17-62	The No. 6 rod-drive unit was replaced. The unit installed contained a modified magnet keeper, a modified (waterproof) coil, a new-type plunger (Identification "L") (Rockwell hardness C-56), and new balls.
2-18-62	The No. 1 Log-N period amplifier became inoperable due to a defective electronic tube. Repairs were made.
2-18-62	The southeast gamma chamber became inoperable due to a short. Preparations for replacement during the end-of-cycle shutdown were made.
2-26-62	The compensation of the servo chamber was adjusted from 1.8% to 3% (undercompensated).
3-2-62	The count-rate meter for the auxiliary fission-chamber channel was replaced due to erratic indications.
3-4-62	The No. 3 safety-recorder signal became erratic. There was no apparent reason and all other instrumentation was normal.
3-6-62 to 3-9-62	The No. 3 safety channel was removed from the safety circuit in an attempt to determine the cause of the irregular operation. No cause for the trouble was found, however, and the unit was put back into service on 3-9-62
3-5-62	A new pulse amplifier was installed for the poolside auxiliary fission-chamber channel in a further attempt to correct the erratic behavior.
3-11-62	The No. 6 rod drive failed to recock after the reactor was scrammed as scheduled. It was necessary to assist the unit manually in order to obtain the cocked mode.
3-11-62	During prestartup checks, it became evident that foreign material was present in the shock absorber for No. 6 rod. Preparation was made to change out this unit.

Table 1.5. (Continued)

Date	Description
3-12-62	The shock absorber for No. 6 shim rod was replaced. The unit removed contained small aluminum particles. The drive unit for this shim rod was also replaced. The unit installed contained a modified magnet keeper, a modified (waterproof) magnet coil, a new-type plunger (Identification "J") (Rockwell hardness C-59), and new balls.
3-13-62	The No. 3 shim-rod drive unit was replaced after it failed to recock during startup checks. The unit installed contained a modified magnet keeper, a modified (waterproof) coil, a new type plunger (Identification "K") (Rockwell hardness C-58), and new balls.
3-19-62	The reactor secondary-water activity monitor was installed.
3-26-62	The scrubber pump was replaced due to a burned-out motor discovered during the daily check of the unit.

Mechanical Controls

As a result of recent study by members of the ORR Control Drive Study Group on variables which could contribute to "unscheduled scrams", interim modifications as detailed in ORR Mechanical Control Change M-1 were proposed and accepted. They are being incorporated into all drive units as scheduling permits and consist of the following:

1. Assuring that the bottom end of the push rod is centered within the existing machine tolerances of the bellows sleeve and adaptor (this is effected by increasing the cross-sectional area of the bottom end of the push rod);
2. Assuring that the magnet center hole is concentric with a theoretical center line and that the face of the magnet is perpendicular to the center line of the center hole;
3. Obtaining new push-rod extensions with increased diameters to minimize possible tilt between the push-rod extension and the supporting face of the magnet keeper; and
4. Assuring a uniform supporting surface on the magnet keeper by reinforcing and lapping as needed but not to exceed 0.004-inch of material removed.

These changes are shown on drawing D-47362.

Building Containment

Scrubber Test. The scrubber was operated continuously, except during short intervals of sampling from 9:00 p.m., February 12, 1962, to 1:30 p.m., February 16, 1962. No operational difficulties were encountered during this test period. Sampling procedures and sump-level measurements during the test indicated a loss of approximately 20 gallons of water per hour of operation, with indications of some loss of caustic. It was recognized that the test of caustic usage was somewhat inconclusive, and a more complete test is planned for the shutdown at the end of cycle 39.

Scrubber Reliability. Increased maintenance and improvements in daily operating checks have improved the scrubber reliability as presently operated; i.e., "start on demand". Further improvement in reliability of the unit is anticipated prior to its replacement by charcoal filters. This will be accomplished by:

1. Operating the scrubber continuously by recirculating water,
2. Providing a back-up pumping device (steam jet or air pump),
3. Providing reliable instrumentation and controls to dump caustic on demand, and
4. Providing a second ionization chamber to monitor the radioactivity of the air which is exhausted through the 24-in. duct.

A complete description of the revised system will be presented in the next quarterly report.

Reactivity Measurements

The reactivity effect of the flat-plate, nichrome-fuel-element experiment in core position F-2 was determined to be minus $\sim 0.05\% \frac{\Delta k}{k}$. This experimental fuel element contains approximately 0.2 grams of U^{235}.

Special Irradiations

On 2-5-62 a special experiment to irradiate about 8 gms of protactinium was conducted in hydraulic tube No. 1. The purpose of this experiment was to develop the technique for handling, etc., in preparation for future irradiations. To minimize the hazards during the irradiation period, the following procedure was used:

1. The hydraulic-tube system was valved to use reactor water as the driving and cooling medium, with the effluent routed through the degasifier and demineralizers and then back to the reactor system.

2. The reactor was made subcritical for both the insertion and removal of the sample.
3. A water sample was taken from the effluent of the loading station after the Pa sample was returned to the loading station and prior to exposing the Pa sample to pool water. This water was analyzed for Pa^{232} and results were negative.
4. The Pa sample was loaded into a shielded container, and current "Radiation and Control" rules were observed.

On 3-12-62 four samples of Pa^{231} (~ 8 gms each) were irradiated in the hydraulic tube under the same conditions as described above. The operation was without incident.

Reactor Primary Cooling System

Operating Experience. During January 1962, radioactivity was detected in the reactor secondary-water system. This, after evaluation, prompted a reactor shutdown (1-26-62) to determine which heat exchanger was leaking. After isolating all heat exchangers from the secondary system and maintaining pressure on the primary side, pressure changes were observed; also the water on the secondary side of the units was checked for changes in radioactivity. Both tests aided in locating the leaking unit. A further test, which included removing the head section on the secondary side with the primary side pressurized, located the exact source of the leak. Two tubes which had broken at the tube sheet were then plugged since it was not feasible to replace the tubes at the time. Inspection of the impingement baffle located at the primary-line inlet revealed no abnormalities. Operation is continuing using the repaired heat exchanger while further investigations are being conducted to determine the cause of failure. It was surmised that mechanical vibration due to the flow of water over the tubes near the inlet to the heat exchanger caused the tube failure. Since the repaired unit has been returned to service, no radioactivity has been observed in the secondary system water.

Pool Primary-Water System

Operating Experience. A leak in the pool liner was found during the end of cycle-38 shutdown. Water was observed to be entering the pool through a very small hole in the liner near the penetration for the pool cooling-pump suction line. Further investigation revealed that the liner

was extremely corroded all around the penetration. Portions of the liner were removed, and a patch was installed. Included in the patch was a small line to be used for evacuating the area around the pipe. Some difficulty was encountered in obtaining a good vacuum due to line leaks; however, it was later determined that there was very little water in the area around the pipe penetration. Cold traps placed in the vacuum line indicated a water collection rate of ~ 2 ml/hr. The vacuum line was connected to the off-gas system, and periodic cold-trap checks will be made.

To determine if further damage to the pool liner exists, a visual inspection will be made during each end-of-cycle shutdown. A program of inspection through the use of ultrasonics has also been proposed.

Contamination Experience. On March 5, 1962, routine checks of the pool-water activity indicated excessive radioactivity. Analyses of samples of the water indicated that the source of the activity was a sample of unencapsulated rhenium metal which was undergoing irradiation in the open-tube F-2 facility. The sample was transferred to the north hot cell and was canned to prevent further contamination.

During the period of contamination of the pool, maximum radiation readings observed were:

1. Contact with the pool anion column 5r/hr.
2. Two inches above the pool water 100 mr/hr.

Samples of the pool water were counted and found to be higher than normal by a factor of 70. After about four days the pool-water activity returned to normal.

Fuel Handling

Sixty-three spent fuel sections were shipped from the ORR to the chemical processing plant in Idaho. Fifty-nine of these were fuel elements and four were shim-rod fuel sections. Approximately 39 elements were added to the inventory of spent fuel sections; therefore, 24 storage spaces were gained during the quarter.

The number of ORR spent fuel sections on hand has now been reduced to the point that shipments from the ORR, using both carriers, can be made at the rate of approximately three per quarter. This corresponds to the normal burn-up rate for 30-Mw operation.

Operating Procedures

The seven most important ORR procedure memoranda issued during the period are as follows:

1. ORR Procedure Memo No. 213 -- To provide a procedure for the handling and use of spare parts for the shim-rod drives.
2. ORR Procedure Memo No. 214 -- To provide a formal procedure for the radiation monitoring of samples handled by Operations personnel.
3. ORR Procedure Memo No. 215 -- To provide a procedure describing the proper use of the low-level scram circuitry.
4. ORR Procedure Memo No. 216 -- To provide a formal outline of the procedure for training prospective Reactor Operations shift supervisors.
5. ORR Procedure Memo No. 217 -- To provide a formal procedure describing the use of work permits.
6. ORR Procedure Memo No. 218 -- To provide a guide for the use of personal radiation monitors in the ORR pools.
7. ORR Procedure Memo No. 219 -- To provide a formal procedure for maintaining a supply of clean gas masks in the ORR building.

Experiments in the ORR

Table 1.6 outlines the assignment of the ORR experiment facilities.

Table 1.6. ORR Facilities Assignment

Facility	Access Flange	Nature of Experiment	Division Sponsor
		Core Positions	
A-1 and 2	V-11	Pressurized water loop, MSR	Reactor
A-3, 7, and 8, C-2, and F-5		Radioisotope production	Isotopes
B-1	V-10	Gas-cooled Loop No. 1	Reactor
B-8 and C-3	V-1 and 3	Radiation-damage studies	Solid State
C-7		Radiation-damage studies	Solid State
B-9	V-2	Fuel tests	Solid State
C-1	V-9	Fuel tests	Solid State
F-1* and E-9	V-8 and 3	Fuel tests	Reactor

*Final experiment installation is incomplete.

Table 1.6. (Continued)

Facility	Access Flange	Nature of Experiment	Division Sponsor
E-8	V-2	Hydraulic tube No. 2	Isotopes--Chemistry
F-2	V-6	Fuel tests	Reactor (G.E.)
F-3*	V-7	Fuel-meltdown tests	Reactor Chemistry
F-8	V-4	Hydraulic tube No. 1	Isotopes--Solid State
F-9	V-5	Fuel meltdown tests	Reactor Chemistry
		Poolside Positions	
P-1, 2, 3, 7, 8, and 9		GCR capsule irradiations	Reactor
P-4, 5, and 6		Radiation-damage studies	Solid State
		Large Facilities	
HN-1		Thoria-slurry loop	Reactor Chemistry
HN-3		Pneumatic rabbit for activation analysis	Chemistry--Analytical Chemistry
HN-2 and 4		Not in use	
HS*		Gas-cooled Loop No. 2	Reactor
		Beam Holes	
HB-1		Magnetic analysis of fission fragments	Physics
HB-2		Radiation-damage studies	Solid State
HB-3		Neutron spectrometer	Physics
HB-4		Neutron spectrometer	Chemistry
HB-5		Neutron spectrometer	Physics
HB-6		Time-of-flight neutron spectrometer	Physics

*Final experiment installation is incomplete.

A list of new experiments operated during the quarter is given in Table 1.7.

Table 1.7. New Experiments Installed or Operated

Date Installed	Division Sponsor	Expected Duration	Facility	Experiment Description
1-9-62	Reactor Chemistry	1 week	F-9	Fuel meltdown
1-20-62	Reactor (G.E.)	9 days	F-2	Cu sample encased in Al
1-31-62	Reactor (G.E.)	3 days	F-2	Cu sample encased in Al
2-4-62	Reactor (G.E.)	1 day	F-2	Cu sample encased in Al
2-7-62	Reactor (G.E.)	1 day	F-2	Cu sample encased in Al
2-12-62	Reactor Chemistry	1 year	HN-1	Loop recirculating ThO_2 suspension in D_2O at 5 gpm
2-13-62	Reactor	6 months	P-2, P-7, and P-8	GCR capsule experiments
2-13-62	Solid State	4 months	B-8	Be irradiation study
2-13-62	Reactor	1 cycle	B-1	GCR-type gas-cooled fuel element
2-14-62	Solid State	8 weeks	P-5	Columbium tube burst
2-14-62	Solid State	16 weeks	P-6	Zircoloy-2 tube burst
2-14-62	Reactor	16 weeks	A-1, A-2	UO_2 fuel specimen No. 5
2-19-62	Reactor Chemistry	3 days	F-9	Fuel meltdown, UO_2-ThO_2
2-27-62	Reactor (G.E.)	2 days	F-2	Cu sample encased in Al
3-4-62	Reactor (G.E.)	3 days	F-2	Rhenium sample
3-11-62	Operations	Indefinite	E-9	Boiling detector
3-13-62	Chemical Technology	10 hours	F-8	41 grams Pa^{231}
3-20-62	Reactor (G.E.)	2 days	F-2	Flat Cu sample encased in Al
3-20-62	Reactor Chemistry	3 days	F-9	Fuel meltdown, UO_2-ThO_2
3-23-62	Reactor (G.E.)	3 days	F-2	Gold foil
3-28-62	Reactor Chemistry	4 days	F-9	Fuel meltdown

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