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OAK RIDGE RESEARCH REACTOR QUARTERLY REPORT
JULY, AUGUST, AND SEPTEMBER OF 1966

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SUMMARY

The ORR operated 83.6% of the time during the quarter, accumulating 2286 Mwd at an average operating power level of 29.7 Mw. The quality of both the pool and reactor water showed considerable improvement as a result of the recent replacement of resins in the demineralizer systems.

There were twenty shutdowns, five of which were scheduled for training purposes. Total downtime increased unexpectedly because of the failure of the Molten Salt experiment (42 hours) and because of flood damage to electrical equipment in the primary and secondary pump houses (55.7 hours).

The instrumentation for the facility continued to operate quite satisfactorily although considerable difficulty has been experienced with the mechanical portion of the fission chamber drives.

The aluminum-cadmium shim-safety rods, used in core position F-4 and F-6, were found to be bent or bowed and were removed from service. Fast neutron damage, similar to that suffered by beryllium, is suspected as being the cause of the deformation of the aluminum.

Shim-rod vibration,¹ and the accompanying slight power oscillation, was further investigated and was found to be dependent upon shim-rod position. The evidence further indicates that much of the problem is related to shim rod No. 3 (core position B-4). As a part of this work, the lower shim-rod bearings were sized (functional check) and found to be satisfactory.

No significant experiment assignment or lattice configuration changes were made.

¹W. H. Tabor and S. S. Hurt, III, Oak Ridge Research Reactor Quarterly Report - October, November, and December of 1965, ORNL TM-1503 (April 1966).

OPERATIONS

Pertinent operating data for the quarter are compared with data from the previous quarter, the year to date, and a comparable portion of 1965 in Table 1 below. The notable drop in the radioactivity of the pool water is probably a result of replacing the resins in the demineralizer beds. The increased number of research samples reflects the use of the hydraulic tubes for short-term irradiations, most of which were materials tests.

Table 1. ORR Basic Operating Data
(July 1, 1966, Through September 30, 1966)

	This Quarter	Last Quarter	Year To Date	Jan. thru Sept., 1965
Total energy, Mwd	2,286.1	2,235.5	7055.2	6,843.8
Average power, Mw/operating hr	29.7	29.8	29.8	29.7
Time operating, %	83.6	82.6	86.7	84.2
Reactor water radio- activity, $\frac{\text{c}}{\text{ml}}$ (av)	36,900	40,591	36,000	42,200
Pool water radio- activity, $\frac{\text{c}}{\text{ml}}$ (av)	790	875	835	1030
Reactor water resis- tivity, ohm-cm (av)	1,100,000	1,086,000	1,101,000	911,300
Pool water resis- tivity, ohm-cm (av)	715,000	480,000	617,000	628,300
Fuel elements depleted	47	34	110	107 (2)*
Shim rods depleted	4	4	10	10
Research samples	38	25	69	25
Radioisotope samples	184	180	578	606

*The number in parentheses refers to the half fuel elements depleted and is also included in the total.

Data relative to operating cycles 67, 68, and 69 are presented in Table 2. Figures 1, 2, and 3 are plots of rod position (ganged) versus time for shim rods 3, 4, 5, and 6. Shim-safety rods 1 and 2 are operated at the fully withdrawn position.

Table 2. ORR Cycles of Operation

Cycle No.	Date Begun	Date Ended	Accumulated Energy (Mwd)
67	June 13, 1966	July 24, 1966	1,196.80*
68	July 28, 1966	September 17, 1966	1,347.39
69	September 22, 1966	In Progress	241.12

*Energy accumulated this quarter was 499.28 Mwd.

FIG.1 SHIM ROD POSITION Vs TIME (CYCLE No. 67)

FIG. 2 SHIM ROD POSITION Vs. TIME (CYCLE No. 68)

FIG. 3 SHIM ROD POSITION Vs TIME (CYCLE No. 69)

SHUTDOWNS AND POWER REDUCTIONS

Forty-two unexpected (although scheduled) hours were added to the quarter's total downtime by the shutdown required for removal of the failed Molten Salt Loop. Normally, such experiment-removal work would be scheduled for regular end-of-cycle shutdowns.

The reactor was shut down and then restarted on five occasions to provide training (simulating unscheduled scrams) for Operations personnel. These scheduled shutdowns occurred a few minutes prior to other scheduled shutdowns, thus minimizing the inconvenience to experimenters. The practice of making such training startups has been established to assure that members of the Reactor Operations Department remain familiar with startup procedures.

Four unscheduled shutdowns resulted from electrical power disturbances caused by thunderstorms. One additional shutdown, resulting from a plant-wide power outage, was of sufficient duration to require refueling. Unscheduled downtime was further increased (55.733 hours) because of flood damage to electrical gear in Buildings 3103 and 3185 which occurred while the reactor was shut down. Details of the repairs necessary are given in Appendix A.

The shutdowns for the quarter are summarized in Table 3, and details are presented in Tables 4 and 5.

Reductions in the reactor power level which do not result in downtime are of interest to the operator and experimenter and are detailed in Table 6.

Table 3. Summary of ORR Shutdowns

Description or Reason	Number	Downtime (hr)
Scheduled		
Regular, end of cycle	2	222.099
Regular, midcycle isotope work and refueling	2	12.667
Regular, refueling	1	6.150
Regular, refueling and limited experiment work	1	6.200
Special; experiment removal	1	42.000
Special, training of personnel	<u>5</u>	<u>0.717</u>
Subtotal	12	289.833
Unscheduled		
Instrument trouble, experiments	2	0.453
Human error	1	0.050
Electrical power outage or voltage surge	5	9.883
Flood damage (extension of scheduled shutdown)	<u>0</u>	<u>55.733</u>
Subtotal	<u>8</u>	<u>66.119</u>
Total	20	355.952

Table 4. Unscheduled Shutdowns of the ORR, Details

Date	Duration (hr)	Remarks
7-3-66	0.583	This shutdown resulted from a momentary electrical power outage caused by a thunderstorm.
7-14-66	0.250	A momentary power outage during a thunderstorm shut the reactor down.
7-14-66	0.050	The reactor power was inadvertently allowed to sag below N_L during the startup following the power outage of this date.
7-15-66	0.217	A momentary power outage during a thunderstorm shut the reactor down.
8-1-66	0.400	The reactor power was inadvertently allowed to sag below N_L following an experiment setback (false) from the Loop II facility (18-in. plug temperature).
8-9-66	0.053	The reactor power sagged below N_L following a setback caused by a thermocouple failure at the F-9 experiment.
8-11-66	55.733	The scheduled shutdown of August 10, 1966, was extended because of the flood damage in the reactor primary and secondary pump houses.
8-19-66	0.500	An electrical power surge, caused by lightning, resulted in an unscheduled scram.
9-30-66	<u>8.333</u>	A plant-wide power outage caused by a grounded circuit at the primary substation resulted in a shutdown ending fuel cycle 69A.
	66.119	Total

Table 5. ORR Scheduled Shutdowns, Details

Date	Duration (hr)		Remarks
7-11-66	5.617	67B	The reactor was shut down for midcycle refueling and isotope work.
7-24-66	0.083		The reactor was shut down to permit a startup to low power for training purposes.
7-24-66	93.183	67C	End of operating cycle 67. Seven experiments were removed and six were installed. The collimator plug at HB-1 was removed for repairs. Reactor heat exchangers Nos. 2 and 4 were inspected, the cell ventilation roughing filters were replaced, and the control room portion of the reactor "noise" instrumentation was installed.
8-8-66	0.250		The reactor was shut down to simulate an unscheduled shutdown for training startups.
8-8-66	6.200	68A	The reactor was shut down for refueling, and limited experiment work at the Molten Salt Loop, where the small equipment chamber was opened to investigate a water leak.
8-10-66	42.000		This shutdown was scheduled to permit removal of the Molten Salt Loop which failed (breach of primary containment) on August 8, 1966. Operation from August 8, to August 10, 1966, was permitted because the loop had been withdrawn from the high-flux zone. This shutdown was extended to permit repairs after flood damage occurred at the primary and secondary pump houses on August 11, 1966.
8-25-66	0.200		The reactor was shut down to permit a training startup to low power.
8-25-66	0.017		The reactor was shut down from low power to permit startup training.
8-25-66	7.050	68B	The reactor was shut down for midcycle refueling and isotope work.
9-6-66	6.150	68C	The reactor was shut down for refueling.

Table 5. (Continued)

Date	Duration (hr)	End Cycle	Remarks
9-17-66	0.167		The reactor was shut down to facilitate training startups.
9-17-66	<u>128.916</u>	68D	This shutdown terminated operating cycle 68. End-of-cycle experiment activities included the removal or replacement of five in-core experiments, three poolside experiments, and the reinstallation of the collimator plug at HB-1. Maintenance activities included inspection of the No. 2 primary check valve and DOP efficiency checks of the absolute filters at the pressurizable off-gas and cell ventilation filter pits.
	289.833	Total	

Table 6. Reductions in ORR Power Not Resulting in Shutdowns

Date	Source of Signal	Type of Signal	Lowest Power (Mw)	Comments
Unscheduled				
7-3-66	F-2 experiment (GE)	Setback	9.0	Water was added to the make-up head tank at too fast a rate. The turbulence created caused a false low-level signal.
8-24-66	Normal off-gas instrumentation	Setback	0.3 (N _L)	The pressure in the normal off-gas system increased apparently because of an unscheduled release of a large quantity of gas into the system. The source of the trouble was not found; however, it was determined that it was not within the Reactor Operations complex (ORR-LITR OGR-BSR).
Scheduled				
8-5-66	Reactor controls (manual)	Setback	N _L	The power was reduced to permit orderly draining of the small equipment chamber at the Molten Salt Loop (water-level-high alarm had been actuated earlier).
8-5-66	HN-1 (Molten Salt Loop)	Setback	N _L	This signal was a scheduled check of the experiment instrumentation following minor changes.
8-22-66	ORR controls	Controlled power reduction	15	The power was reduced to permit investigation of relay "noise" in the starter circuit of the No. 1 primary pump which required that the pump be stopped.

INSTRUMENTATION AND CONTROLS

A chronological listing of significant maintenance or changes to the instrumentation and Controls for the ORR complex is presented in Table 7. Information relative to the shim-control rods and shim-safety rods, however, is included elsewhere.

Table 7. Maintenance and Changes, Reactor Instrumentation and Controls

Date	Component	Trouble or Change	Reason or Maintenance
Safety System			
9-6-66	Magnet amplifier 6A and 6B	Units replaced	Slight magnet current changes had been noted on September 3, 1966, and faulty tubes in the amplifier were suspected. The trouble did not recur.
No. 1 Count-Rate Channel			
8-3-66	Fission chamber drive	Would not retract	The assembly was removed from the guide tube, inspected, adjusted, and returned to service.
8-19-66	Fission chamber drive	Would not retract	Channel 2 was selected as the operating channel.
No. 2 Count-Rate Channel			
8-14-66	Count rate A-1 amplifier	Unit replaced	Difficulty with calibration was encountered on August 12, 1966, and the trouble was traced to the amplifier.
9-20-66	Count rate meter	Unit replaced	This unit was replaced to correct slightly erratic behavior as shown at the recorder.
No. 1 Log-N Channel			
	None	None	No significant changes were necessary.

Table 7. (Continued)

Date	Component	Trouble or Change	Reason or Maintenance
No. 2 Log-N Channel			
8-14-66	Log-N amplifier	Unit replaced	Occasional increases in the width of the period recorder trace)from ± 400 sec to ± 100 sec) prompted the change. Some improvement was noted.
8-26-66	Recorder	Pen stuck	Minor mechanical repairs were made which corrected the trouble.
No. 1 Safety Channel			
9-19-66	Chamber	Unit replaced	The old-type chamber (position 6) was replaced with dual chamber No. 66-9 (position 7). The old chamber had been troublesome on August 6 and 20, 1966, and on September 3, 1966, because of a tendency to bind in the guide.
No. 2 and No. 3 Safety Channels			
	None	None	No changes were necessary.
Servo Channel			
7-26-66	Power integrator	Added to system	This portion of the system was added to provide a constant readout of megawatt hours accumulated.

Table 7. (Continued)

Date	Component	Trouble or Change	Reason or Maintenance
Micromicroammeter Channel			
9-12-66	Recorder amplifier	Unit replaced	This change was prompted by erratic recorder readout which was determined to be localized in the recorder. Further difficulties did not occur.
Gamma Channels			
	None	None	No significant maintenance was required.
North ¹⁶ N Channel			
	None	None	No significant maintenance was required.
South ¹⁶ N Channel			
9-22-66	Recorder amplifier	Unit replaced	Slightly erratic readout at the recorder prompted this action. The trouble did not recur.
Radiation Monitoring Channels			
7-4-66 and 9-13-66	Reactor secondary radiation detector	False alarms from upscale drift and spikes	Changing weather conditions (rain) apparently cause this trouble.

Table 7. (Continued)

Date	Component	Trouble or Change	Reason or Maintenance
Process Instrumentation			
7-6-66	Reactor secondary bypass valve	Broken air line	The faulty component was repaired.
8-12-66	Reactor primary flow d/p cell	Cleaned and calibrated	This action was taken after the primary pump house and the adjoining sumps were flooded on August 11, 1966.
8-12-66	Reactor secondary controls	Partially flooded on August 11, 1966	The recorders (basin temperature and secondary mean temperature) were removed for cleaning and repairing. Two pressure switches were replaced (TX 48E and TX 48F) and two pressure switches were cleaned (TX 48C and TX 48D).

PROCESS SYSTEMS

The tritium content of the reactor water was measured on two occasions. The results are reported below.

<u>Date</u>	<u>dis min⁻¹ ml⁻¹, ³H</u>
July 27, 1966	9.28 x 10 ³
September 14, 1966	8.73 x 10 ³

Maintenance and changes to the piping and equipment in the various process systems are listed in Table 8. Of particular interest is the damage to electrical equipment in the primary and secondary pump houses on August 11, 1966, the details of which are rather lengthy and are given in Appendices A, B, C, and D.

Flood conditions at the primary pump house were apparently a result of changes to normal drainage paths brought on by construction work in the vicinity of Building 3010. The sumps immediately adjacent to Building 3085 were flooded, and the floor of the building was covered to a depth of about 3 inches. Damage was limited to flow instrumentation, the reactor water radioactivity probe, and the sump pumps for pits 2 and 4.

Floodwater at the secondary pump house also resulted from changes made by construction forces. In this case, the upstream opening of the culvert under the plant road near the north perimeter fence had been covered with chain-link fencing. This fencing was choked with debris during the storm, creating a very effective dam which diverted the swollen stream through the pump house via the ditch north of the road, the road itself, and the normal drainage paths east of the building. The secondary pump house was filled to a depth of 34 1/2 inches above the floor. Water damage occurred at the 2300/480-v transformer, the 2300-v pump starter cubicles (3), the 480-v fan starter cubicles, the instrument control panel, miscellaneous low-voltage equipment, and the three secondary pump motors which were 1/3 to 1/2 submerged.

It is also interesting to note that the inspection of reactor heat exchangers Nos. 2 and 4 revealed much improvement in corrosion control at

the inlet and exit heads. This improvement is believed to be due to the recent practice of tripling the chromate concentration for a short time at the beginning of each operating cycle when it is necessary to drain and refill the tower basin.

Table 8. Process Systems, Maintenance and Changes

Date	Component	Remarks
Reactor Primary System		
7-25-66	No. 3 pump exit check valve	This Mission check valve was inspected and no excessive wear was found.
8-11-66	Primary pump house	The pump house and adjacent sumps were flooded. Details relative to damage and repairs are given in Appendix A.
8-25-66	Starter controls for No. 1 primary pump	Excessive vibration within the starter on August 17, 1966, and again on August 22, 1966, prompted an investigation which revealed a loose bolt in the starter relay. Repairs were made, and the unit was returned to service.
9-19-66	No. 2 pump exit check valve	This Mission check valve was inspected and found to be in good repair.
9-20-66	No. 2 primary pump motor	This motor was removed and shipped to the Oak Ridge Gaseous Diffusion Plant (ORGDP) for shop repairs after measurements indicated a low resistance to ground. A spare motor which required a special adapter was installed.
Reactor Secondary System		
7-25-66	Heat exchangers Nos. 2 and 4	The tube side (secondary) of these heat exchangers was inspected as part of the routine maintenance program. The tubes were quite clean, and the heads showed almost no corrosion.
8-11-66	Secondary pump house	The secondary pump house was flooded to a depth of ~32 in. The repairs and clean-up work related to the flood are described in Appendix A.
9-19-66	Reactor tower fan gear boxes	The lubricant was changed as part of the routine maintenance program.
Pool Primary System		
7-13-66	Pool demineralizer	The spent resin in the anion column was replaced with 35 cubic feet of IRA 400 resin.

Table 8. (Continued)

Date	Component	Remarks
7-25-66	Pool primary pump	The bearings and seals for this pump were replaced.
Pool Secondary System		
9-19-66	Cooling tower	The water make-up valve (float controlled) was replaced because of excessive wear.
Pressurizable Off-Gas System		
7-26-66	Filter pit	A routine inspection revealed no abnormal conditions.
7-27-66	Blower controls	Instrumentation was added which will effect automatic change over to the auxiliary blower.
Emergency Diesel Generator System		
7-8-66	Battery charger	The battery charger was found to be inoperative, and it was necessary to replace five batteries in the starter circuit. The rectifiers in the charger were replaced, thus correcting the trouble.
9-20-66	Fuel filter	A ruptured fuel line was repaired.
Cell-Ventilation System		
7-25-66	Prefilters	The prefilters were replaced. Routine checks had indicated an increase in pressure drop across these filters from 0.30 in. H ₂ O to 0.88 in. H ₂ O over a period of about one year. The pressure drop across the new prefilters was 0.33 in. H ₂ O.
7-25-66	Back draft damper at electric blower	A second damper was installed in series with the original damper. This addition increases the reliability of the system by lessening the possibility that recirculating will occur with the steam blower in service.

REACTOR MECHANICAL COMPONENTS

Lower Shim-Rod Bearings

A functional check of the lower shim-rod bearings was made on July 27, 1966, using a gauge block. This check was prompted by an apparent increase in shim-rod vibration or oscillation due to water flow, as reported in the section of this report entitled "Special Tests". Such an increase in rod movement could result from loss-of-spring strength in the lower bearings.

The gauge block used for the check was not equipped to measure the spring strength directly; rather, comparative checks were made. The springs for the upper rollers for the No. 5 lower bearing seemed weaker than normal, with several other springs slightly stronger. Deviations from what was considered normal are listed below in Table 9. Although the actual spring strength was not measured, it was concluded that the lower bearings are not a major factor in the shim-rod vibration problem.

Table 9. Inspection of Lower Bearings, Details

Bearing No.	Core Position	Rollers	Remarks
1	F6	Lower east	Tighter than others
2	F4	East and west	Unable to check, no explanation
3	B4		All rollers normal
4	D4	Lower east	Tighter than others
5	B6	Top	Looser than others
5	B6	Lower east	Tighter than others
6	D6		All rollers normal

Shim Safety Rods 1 and 2

A routine test of shim-rod freedom-of-movement prior to the startup on September 20, 1966, revealed that shim-safety rods 1 and 2 (aluminum cadmium) were tighter than usual. The No. 2 rod, in fact, would not fall freely into its seat without water flow. This rod was removed from the

lattice and, when examined under water, did not appear to be straight. Preliminary measurements using a straight edge indicated that both aluminum-cadmium rods were bent or bowed. It is suspected that the aluminum section of these rods has suffered radiation damage similar to that evidenced by beryllium-cadmium rods previously used in shim-rod positions 1 and 2. Preparations for hot-cell measurements of the bowing were under way at the end of the quarter.

Both shim rods 1 and 2 were replaced with spent fuel-cadmium rods (~70 grams ^{235}U each) which functioned as designed.

FUEL

Changes in the fuel inventory are indicated in Table 10.

Table 10. ORR Fuel Status

	This Quarter	Last Quarter	Year To Date
Depleted fuel elements transferred for chemical separation	12	52 (1)	90 (3)*
Average % burnup of fuel elements	32.6	33.1	34.0
New fuel elements placed in service	29	36	102
New fuel elements available for use	203 (4)*	232 (4)*	
Depleted shim rods transferred for chemical separation	2	4	
Average % burnup of shim rods	62.0	56.1	56.1
New shim rods placed in service	4	4	10
New shim rods available for use	4	4	
New shim-rod fuel section available for use	21	21	

*The number in parentheses refers to the half-fuel elements involved and is also included in the total.

EXPERIMENT FACILITIES AND LATTICE CONFIGURATION

Facility assignments at the ORR are listed in Table 11, which is self-explanatory and supplements Figure 4 which shows the lattice configuration at the end of the quarter. There were no significant changes in the lattice or facility assignments; however, attention is called to the change at core position B-1 (Loop 1). The in-core section of this experiment was removed on April 15, 1966, but the change was not properly reported in the previous quarterly report. Usage of the facilities is shown Table 12.

The collimator plug at beam-hole facility HB-1 was removed after the cooling water lines were ruptured on July 27, 1966. The break in the lines occurred at a point very near the aluminum "window" in the collimator plug, and in-place repairs were not possible. The beam-hole liner was cleaned (a white deposit was found in the lower half of the liner) and a dummy plug was installed. The collimator plug was repaired by installing bulk-head fittings in the window and was reinstalled on September 19, 1966. The beam-hole liner was inspected at that time and was found to be quite clean. There was little evidence of corrosion.

Radiological and spectrographic analyses of the white deposit were made. The reports of these analyses indicate very clearly that the deposit was mostly aluminum oxide mixed with small amounts of stainless steel corrosion products. The radio-nuclides found were ^{51}Cr and ^{60}Co with traces of ^{59}Fe . Spectrographically, aluminum was very strong; Fe, strong; Si, medium; Cu, a trace; Mg, Mn, and Cr, faint trace; and Mo, very faint trace; Ni and Ca were listed as very weak.

Table 11. ORR Facilities Assignment

Facility	Access Flange	Nature of Experiment	Division or Other Sponsor
Lattice Positions			
A-1 [*]	V-11	On standby	Operations
A-2	V-11	Uninstrumented and instrumented capsule irradiations	General Electric
A-3, A-7 C-2, and F-5		Radioisotope production	Isotopes
A-9	V-2	Fuel tests	Reactor Chemistry
B-1 ^{**}	V-10	Gas-cooled loop No. 1	Reactor
B-8	V-1	Radiation-damage studies	Metals and Ceramics
B-9	V-2	Fuel tests	Reactor Chemistry
C-1	V-9	Fuel tests	Reactor Chemistry
C-3		(Half-fuel position, on standby)	Solid State
D-8	V-3	Hydraulic-tube No. 2	Isotopes-- Chemistry
F-1	V-8	On standby	Reactor
F-2	V-6	Fuel tests, radiation-damage tests	General Electric
F-3	V-7	Fuel-meltdown test samples, preirradiation	Reactor Chemistry
F-7		Available for capsule-type experiments	Unassigned
F-8	V-4	Hydraulic-tube No. 1	Isotopes-- Solid State
F-9	V-5	Fuel melting tests	Reactor Chemistry

* Final experiment installation is incomplete.

** In-core section temporarily removed on April 15, 1966.

Table 11. (Continued)

Facility	Access Flange	Nature of Experiment	Division or Other Sponsor
	North slant tube		Unassigned
	South slant tube		Unassigned
Poolside Positions			
P-1, P-2 P-3, P-4, P-7, P-8, P-9		GCR capsule irradiations	Reactor
P-5		Radiation-damage studies	Metals and Ceramics
P-6		Radiation-damage studies	Solid State
Large Facilities			
HN-1		Molten Salt Loop experiment	Reactor Chemistry
HN-2		Pneumatic tube for high-speed rabbits (activation analysis)	Chemistry
HN-3		Pneumatic tube for activation analysis	Chemistry- Analytical Chemistry
HN-4		Neutron spectrometer	Solid State
HS		Gas-cooled loop No. 2 (on standby)	Reactor
Beam Holes			
HB-1		Fission fragments studies	Physics
HB-2		Neutron spectrometer	Solid State- Physics
HB-3		Neutron spectrometer	Solid State
HB-4		Neutron spectrometer	Chemistry
HB-5		Neutron spectrometer	Physics

Table 11. (Continued)

Facility	Access Flange	Nature of Experiment	Division or Other Sponsor
HB-6		Time-of-flight (neutron spectro- meter)	Physics
		Reflector Holes	
1,2,3, 5,6, 8,9, 10		Capsule-type experiments	Unassigned
4 and 7		Isotope development	Isotopes

Table 12. Experiment Facility Usage

Facility	Date Installed	Date Removed	Description of Experiment	Division or Other Sponsor
A-2	7-14-66		ORTC-1 tungsten-rhenium thermo-couple test	General Electric
A-9	9-23-66		Capsule A9-8, pyrolytic-carbon coated UO_2 particles (0.212 grams ^{235}U)	Reactor Chemistry
E-1			The in-core section of the Loop I experiment remained out of the reactor throughout the quarter	Reactor
B-8	4-15-66	9-17-66	ORR-159, 31 stainless steel specimens, 1 graphite specimen	Metals and Ceramics
B-8	9-22-66		ORR-169, 96 stainless steel tensile specimens	Metals and Ceramics
B-9	6-13-66	9-17-66	Capsule B-9-31, pyrolytic-carbon coated UO_2 particles, 0.181 grams ^{235}U	Reactor Chemistry
B-9	9-22-66		Capsule B9-32, pyrolytic-carbon coated UO_2 (0.23 grams ^{235}U)	Reactor Chemistry
C-1	2-9-66		Capsule C1-18, hollow cylinder of UO_2 (0.1 gram ^{235}U), irradiated throughout the quarter	Reactor Chemistry
D-8			Hydraulic tube No. 2 used for isotope production and short-term irradiations.	Isotopes and Chemistry

Table 12. (Continued)

Facility	Date Installed	Date Removed	Description of Experiment	Division Other Sponsor
F-2	6-13-66	7-26-66	ORRF-1, refractory fuel test	General Electric
F-2	8-3-66	8-18-66	ORM-50, Hastelloy R-235 specimens	General Electric
F-2	8-23-66		ORM-48, Hastelloy R-235 specimens removed temporarily from September 16 to 26, 1966, to permit maintenance at the positioning mechanism	General Electric
F-3 (position 1)	4-13-66	7-24-66	Capsule 48B, ~6 grams UO_2 , Zircaloy clad	Reactor Chemistry
F-3 (position 1)	9-22-66		Capsule A1, Zircaloy-clad UO_2 , 5.971 grams, 10.24% enriched	Reactor Chemistry
F-3 (position 2)	12-16-65	7-24-66	Capsule 46B, stainless steel clad UO_2 (~6.2 grams UO_2) irradiated throughout the quarter	Reactor Chemistry
F-3 (position 2)	7-27-66	9-17-66	Capsule 53B, stainless clad UO_2 (~0.6 grams)	Reactor Chemistry
F-3 (position 2)	9-22-66		Capsule A2, Zircaloy clad UO_2 , 5.956 grams UO_2 (10.24% enriched)	Reactor Chemistry
F-3 (position 3)	9-22-66		Capsule A3, 5.964 grams of UO_2 (10.24% enriched), clad with Zircaloy-2	Reactor Chemistry
F-3 (position 4)	4-13-66	9-17-66	50B capsule, Zircaloy-2 clad UO_2	Reactor Chemistry

Table 12. (Continued)

Facility	Date Installed	Date Removed	Description of Experiment	Division or Other Sponsor
F-3 (position 4)	9-22-66		Capsule A4, 5.962 grams UO_2 (10.24% enriched), Zircaloy-2 cladding	Reactor Chemistry
F-3 (position 5)	4-13-66	9-17-66	Capsule 51B, ~6 grams of UO_2 , Zircaloy clad	Reactor Chemistry
F-3 (position 5)	9-22-66		Capsule A6, 5.9339 of UO_2 (10.24% enriched)	Reactor Chemistry
F-3 (position 6)	4-13-66	9-17-66	51B capsule, Zircaloy clad UO_2	Reactor Chemistry
F-3 (position 6)	9-22-66		Capsule A6, 5.933 grams UO_2 (10.24% enriched)	Reactor Chemistry
F-8	6-2-64		Hydraulic tube No. 1 for iso- tope production and short-term irradiations	Isotopes
F-9	6-28-66	7-1-66	Charcoal ignition experiment No. 2; experiment aborted because of a break in the secondary contain- ment system	Reactor Chemistry
F-9 H_2O "through" holes	8-9-66	8-19-66	Charcoal ignition experiment No. 2 No usage throughout the quarter	Reactor Chemistry
GCR-3	3-13-65		03-9, (MPRE capsule) UO_2 fuel in stainless steel can with Nak blan- ket, irradiated throughout the quarter	Reactor

Table 12. (Continued)

Facility	Date Installed	Date Removed	Description of Experiment	Division or Other Sponsor
GCR-4	4-8-64	7-25-66	04-8, EGCR-type capsule containing UO ₂ pellets in stainless steel can	Reactor
GCR-4	7-25-66		04-P5, capsule containing UO ₂ fuel pellets in Hastelloy-X can in NaK ~36 grams ²³⁵ U	Reactor
GCR-6	3-12-65	7-25-66	06-9 (MPRE capsule) UO ₂ fuel in stainless steel can	Reactor
GCR-7	10-21-65		Capsule C7A-10, extensiometer experiment, irradiated throughout the quarter	Reactor
P-4	4-15-66	7-25-66	GCRE capsule P4B4, ~37 grams of ²³⁵ U	Reactor
P-4	7-25-66	9-17-66	Experiment ORR-167, 34 INOR-8 tensile specimens	Metals and Ceramics
P-4	9-22-66		Dummy experiment ORR-71	Solid State
P-4 ^a	9-22-66		ORR 79-100 Charpy steel specimens	Solid State
P-5	4-15-66	9-17-66	Experiment ORR-157, creep test of graphite beams	Metals and Ceramics
P-5	9-22-66		Experiment ORR-168, stainless steel specimens	Metals and Ceramics
P-5 ^a	6-13-66	7-25-66	ORR SS-81, carbon steel tensile specimens and flux monitors (Cd covered)	Solid State

^aFirst piggy-back position

Table 12. (Continued)

Facility	Date Installed	Date Removed	Description of Experiment	Division Other Sponsor
P-5 ^a	9-22-66		ORR-170, 47 stainless steel tensile specimens	Metals and Ceramics
P-6	6-13-66	7-25-66	Experiment ORR-164, INOR-8 creep strength and ductility tests	Metals and Ceramics
P-6	7-25-66	9-17-66	Experiment ORR-166, INOR-8 tensile specimens	Metals and Ceramics
P-6	9-22-66		Experiment ORR-163, 32 INOR-8 tensile specimens	Metals and Ceramics
P-6 ^a	6-13-66	7-25-66	ORR-82, 50 Charpy steel specimens, (ASTM-A-212B) Cd covered	Solid State
P-6 ^a	7-25-66		Experiment ORR-80, 50 Charpy steel (A212B) specimens electrically heated to 650°F	Solid State
P-6 ^b	6-13-66		1 Kg Cu, 200 g Ag, 50 g Cd foil	Solid State
Other pool-side	8-2-66	8-2-66	304 stainless steel specimens, 4 hours' irradiation open poolside area	Isotopes
Other pool-side	9-6-66	9-6-66	0.1 mg ¹²⁹ I	Chemistry
HB-1	9-18-66		The collimator plug was reinstalled	Physics
HN-1	6-7-66	8-11-66	Molten Salt Loop No. 1	Reactor Chemistry

^aFirst piggy-back experiment^bSecond piggy-back experiment

Fig. 4 Research Assignments and Fuel Loading 9-30-66

SPECIAL TESTS

Shim-Rod Calibration

T. P. Hamrick

Aluminum-cadmium shim-safety rods in core positions F-6 and F-4 (rod Nos. 1 and 2, respectively) were calibrated on August 12, 1966, by determining the differential rod worth using the period method. Each rod was calibrated individually, and then the worth of the two rods was measured simultaneously. Differential and integral reactivity worth curves from these data are shown as Figures 5, 6, and 7. Total reactivity worths are tabulated below.

<u>Shim-Safety Rod</u>	<u>Total Worth $\frac{\Delta k}{k}$</u>
No. 1	1.16
No. 2	1.40
No. 3	2.36

ORNL DWG. 67-2596

Figure 5. Differential and Integral Worth Curves,
No. 1 Rod (Al-Cd), ORR, August 12, 1966

ORNL DWG. 67-2597

Figure 6. Differential and Integral Worth Curves,
No. 2 Rod (Al-Cd), ORR, August 12, 1966

ORNL DWG. 67-2598

Figure 7. Differential and Integral Worth Curves, Nos. 1 and 2 Al-Cd Rods (ganged), ORR, August 12, 1966

Shim-Rod Vibration

At startup, following the midcycle refueling shutdown on July 11, 1966, the recorder trace for the log-N period was found to be twice the normal width. Visual inspection of the core using the underwater omni-scope revealed that the No. 3 shim rod was vibrating more than the other rods, and several observers agreed that this rod was moving more than usual. On July 13, 1966, shim rods 3, 4, 5, and 6 were repositioned (unbalanced) to determine the effect of shim-rod position on the vibration. Results of the test are presented in Table 13. It is readily evident that the width of the recorder trace was dependent upon the position of the No. 3 shim rod. This evidence prompted a check of the lower shim-rod bearings, the results of which are presented elsewhere in this report.

Table 13. Vibration of Shim Rods, Special Tests

Shim Rods	Position (in.)	Log-N Period Recorder Trace
Nos. 1 and 2 Nos. 3, 4, 5, and 6	Upper limit 18.350	About 2 times normal width
Nos. 1 and 2 No. 3 Nos. 4, 5, and 6	Upper limit 21.350 17.760	About normal width
Nos. 1 and 2 No. 4 Nos. 3, 5, and 6	Upper limit 21.350 17.050	About 4 times normal width
Nos. 1 and 2 No. 5 Nos. 3, 4, and 6	Upper limit 21.350 17.950	About 2 times normal width
Nos. 1 and 2 No. 6 Nos. 3, 4, and 5	Upper limit 21.350 17.410	About 3 times normal width
Nos. 1 and 2 No. 3 Nos. 4, 5, and 6	Upper limit 16.350 18.790	About 4 times normal width

APPENDIX A

Events Related to the Flood
of the Primary and Secondary Pump Houses
August 11, 1966
(by Shifts)

4-12 Shift, August 11, 1966 (D Shift)

1. A false high-temperature alarm (reactor primary pump bearings) occurred at 7:45 p.m. Lights on the graphic panel also indicated that the secondary pumps were running.
2. The ORR shift engineer called the Laboratory shift supervisor's office to obtain the services of the shift electrician. A member of the Guard Department answered the phone and informed the ORR shift engineer that he had received reports of an overflow condition at the 30-Mw tower.
3. A reactor operator was dispatched to the reactor secondary tower to ascertain what the trouble might be. He reported that the reactor secondary pump house was flooded to a level above the stairwell and that the primary pump house was flooded to a depth of about 3 in. above the floor level.
4. The ORR supervisor and assistant supervisor were notified of the flood. The ORR assistant supervisor came from Oak Ridge to the reactor secondary pump house.
5. At 8:40 p.m., the breaker for circuit 14, substation 4000, was opened, thus severing power to the reactor primary pumps (2400 v), sump pumps and lighting at the primary pump house (480 v), part of the time-of-flight experiment (480 v), miscellaneous sump pumps in the heat exchanger area (480 v), and the No. 2 fan at the 30-Mw cooling tower (480 v).
6. At 9:08 p.m., the breaker for circuit 2, substation 3000, was opened. This circuit supplied power to the secondary pumps (2400 v) and the No. 1 fan at the 30-Mw cooling tower (480 v).
7. The remainder of the 4-12 shift was used to drain the pits at the primary pump house, remove the water from the secondary pump house, and effect measures to prevent a recurrence of the flood conditions.

The regular 4-12 shift maintenance crew assisted in setting up a Whirley pump in the newly formed lake north of the plant road near the perimeter fence. At shift change, the secondary pump house was drained, the strainer pit was drained, and the pump at the dammed culvert was in operation.

12-8 Shift, Friday, August 12 (C Shift)

During this shift the flooded areas were cleaned up in preparation for maintenance work. Certain electrical circuits were also switched back on so that sump pumps, lights, the air-conditioning system, and other miscellaneous equipment could be used. The following procedure was followed.

Primary System

1. The disconnects on the power pole north of Building 3085 (2300 v) for the reactor primary pumps were opened.
2. The 440-v breakers to the sump pumps and to the lighting transformer at the primary pump house were opened.
3. Individual low-voltage breakers for equipment in the various pits were opened.

Secondary System

1. The main 2300-v breaker was pulled, opening the circuit to the transformer and the pump-motor starters.
2. The 440-v transfer switches, which supply power to the tower fans, were opened. (The 440-v system at the secondary pump house can be fed from circuit 2, substation 3000, or from circuit 14, substation 4000).
3. "Do not operate" tags were attached to the switches at the secondary pump house.

Upon completion of the switching described above, the 2300-v circuits, Nos. 2 and 14, were energized; and the equipment needed at the primary pump house was returned to service. No difficulty was experienced at this time, although it was later learned that the electrical leads to the sump pumps in pits 2 and 4 (440 v) were "partially grounded".

8-4 Shift, Friday, August 12 (A Shift)Secondary System

1. The three secondary pump motors were removed and shipped to the ORGDP shop for repairs. Details are given in Appendix C.
2. Repairs to the electrical switchgear and the 2300/480-v transformer were started. The 2300-v equipment was assigned to G. B. Young, while the lower voltage switchgear and equipment was assigned to E. Hobson, assisted by O. M. Thomas. Details of repairs to the electrical systems (secondary) are given in Appendices B and D.
3. Two Foxboro recorders (basin temperature and secondary mean temperature) were removed from the secondary instrument panel for bench repairs. These recorders are not essential to operation of the system and will be replaced at a later date.
4. Pressure switches TX 47E and TX 47F for fan-speed-timer override and acid-addition control, respectively, were replaced.
5. Fan-control-timer bypass switches TX 48C and TX 48D were cleaned and checked.
6. The secondary pump house was policed and scrubbed.

Primary System

1. The Instrumentation and Controls Division:
 - a. Cleaned and calibrated the primary flow instrumentation.
 - b. Cleaned and checked the reactor water radioactivity probe.
2. The primary pump starter cubicles were checked, and the circuits were checked for resistance to ground. The results were: No. 1 pump motor, 30 megohm; No. 2 pump motor phases A and B, 450,000 ohm, and phase C, 500,000 ohm; and No. 3 pump motor, 30 megohm.
3. The wiring in the cable pits was found to be intact, and the system was judged ready for service after being cleaned.

4-12 Shift, Friday, August 12 (D Shift)Secondary System

Work continued toward cleanup of the electrical components in both the 2300-v and low-voltage systems. It was thought that the work, excepting the 2300/480-v transformer, was about 95% completed by midnight.

Primary System

1. The disconnects on the pole north of Building 3085 (2300 v) were closed, and the primary pumps were operated satisfactorily.
2. The scram switch, at 14,000 gpm, was tested and found to be operating properly.

12-8 Shift, Saturday, August 13 (B Shift)

1. The reactor was used to perform shim-rod calibrations.
2. Data were obtained to verify the ΔP (reactor) versus flow curve.
3. The 2300/480-v transformer continued to dry. Other coils and parts removed from the electrical system were dried.

8-4 Shift, Saturday, August 13 (A Shift)Secondary System

1. The mixer and pump for the Oracol treatment solution was checked and found to be operating properly.
2. The acid pumps were checked (part of the control circuit was jumpered to simulate one secondary pump running). The acid pumps operated satisfactorily after one wire on a relay (found to be connected to the wrong terminal) was properly connected.
3. The north tower fan was started and operated satisfactorily.
4. The south tower fan failed to operate properly, i.e., the circuit breaker opened about ten seconds after the fan was started. This trouble was traced to an incorrect setting on a low-speed-overload switch. This setting had been inadvertently changed during the cleanup program.
5. The No. 1 pump motor was aligned, coupled to the pump, and ready for electrical connections. The motor for the No. 2 pump was delivered outside the secondary pump house.
6. The coils for the secondary pump motor starters were found to be shorted to the cores. One replacement coil was found, and repairs were made to the other two coils.

4-12 Shift, Saturday, August 13 (D Shift)

1. Voltage fluctuations in the 440-v system were traced to partially grounded circuits at sumps 2 and 4 at the primary pump house. Temporary pumps were installed in these sumps until repairs could be made.
2. The current transformers for overload protection at the secondary pump starters (3 each) were found to be still wet. These transformers were removed and dried.

12-8 Shift, Sunday, August 14 (D Shift)

1. Work was continued toward drying and installing the overload protectors for the secondary pump starters.
2. Upon completion of item 1, above, the secondary pumps were checked and started and operated successfully.
3. Final preparations were made, and the reactor was started up to power; however, the secondary bypass valve would not control properly and repairs were initiated.

8-4 Shift, Sunday, August 14 (A Shift)

1. The air supply to temperature transmitter 47A was found to be valved off, causing the trouble with the secondary valve.
2. The south reactor tower fan stopped after operating about 2 hours at high speed. This trouble was eventually traced to the high-speed overload switches (magnetic), which were opening because of low voltage on the 480-v system. The overload switches were adjusted to a higher setting (~135% of normal load), and the fan operated satisfactorily.

APPENDIX B

Repairs to 440-, 230-, and 120-Volt Equipment
at the 30-Mw Cooling Tower Following the Flood
of August 11, 1966

A. Equipment replaced

1. Fan No. 1 starter
 - a. 120-v control relay, 1CR
 - b. 120-v time delay relay, 9TD
 - c. Reset pushbutton
 - d. Overload reset relay, 4CR
2. Fan No. 2 starter
 - a. 120-v control relay, 1CR
 - b. 120-v time delay relay, 9TD
 - c. 120-v control relay, 2CR
 - d. Reset pushbutton
 - e. Overload reset relay, 4CR
3. Fan No. 1 heater contactor
 - a. Control transformer and secondary fuse
 - b. Contactor
4. Fan No. 2 heater contactor
 - a. Control transformer and secondary fuse
 - b. Contactor
5. Acid pump No. 1
 - a. Breaker
 - b. Starter
6. Acid pump No. 2
 - a. Breaker
 - b. Starter

B. Equipment reused (cleaned, dried, and repaired)

1. Fan No. 1 starter
 - a. 120-v control relay, CR2
 - b. Two overload relays (low speed)
2. Fan No. 2 starter: two overload relays (low speed)
3. Fan No. 2 reversing contactor: complete (except coil on reversing section is to be replaced)
4. Acid pump No. 1: "hand off auto" selector switch
5. Acid pump No. 2: "pump 1 - pump 2" selector switch

APPENDIX C

Repairs to the Secondary Pump Motors (ORGDP Shop)

Date	Time	Hours in Oven	°F	Megohm	Remarks
Motor No. 1					
8-12-66	1:00 p.m.	0		0	Cleaned bearings
8-13-66	8:00 a.m.	18	220	~1000	and repacked with grease. High-potential checked at 2500 v. Assem- bled motor; put on test stand and ran it for ~20 minutes. Shipped to ORNL at 11:00 a.m., August 13, 1966.
Motor No. 2					
8-12-66	1:00 p.m.	0		0	Cleaned bearings.
8-13-66	8:00 a.m.	18	220	1 1/2	High-potential checked at
8-13-66	10:00 a.m.	2	270	4 1/2	2500 v. Assem- bled and put
8-13-66	12:30 p.m.	2 1/2	270	1 1/2	on test stand; ran for ~20 minutes. Motor then checked (with a Megger meter) 100 megohm. In- board and out- board bearings were scored. Shipped to ORNL at 2:30 p.m., August 13, 1966
Motor No. 3					
8-12-66	1:00 p.m.	0		0	Cleaned bearings.
8-13-66	8:00 a.m.	18	220	1/2	High-potential checked at
8-13-66	10:00 a.m.	2	270	1	2500 v. Assem- bled and put on
8-13-66	12:30 p.m.	2 1/2	270	3	test stand; ran for 20 minutes. Motor still checked 3 megohm. Shipped to ORNL at 4:00 p.m., August 13, 1966.

APPENDIX D

2300-V System Repairs, ORR 30-Mw Tower

Equipment	Date	Fuses	Resistance to Ground, Megohm		Coil	Remarks
			Left Current Transformer	Right Current Transformer		
Starter cubicle, No. 1 pump	8-12-66	OK	<1	<1	Low to core	
Starter cubicle, No. 1 pump	8-14-66	OK	40	110	OK	Baked current transformers 6 hours. Baked starting coils 3 hours and reinsulated with glass tape and varnish.
Starter cubicle, No. 2 pump	8-12-66	2 bad	~0.04	~0.06	Low to core	
Starter cubicle, No. 2 pump	8-14-66	OK	45	57.5	OK	Baked current transformers 3 hours. Baked starting coil 3 hours and reinsulated with glass tape and varnish. Replaced two fuses from spare parts stock.
Starter cubicle, No. 3 pump	8-12-66	OK	~35	~35	Low to core	
Starter cubicle, No. 3 pump	8-14-66	OK	~35	~35	OK	Replaced starting coil with new coil from spare parts stock.

APPENDIX D (Continued)

230C-V System Repairs, ORR 30-Mw Tower

Equipment	Date	Fuses	Resistance to Ground, Megohm		Coil	Remarks
			Left Current Transformer	Right Current Transformer		
2300/480-v transformer	8-12-66					The transformer resistance to ground was quite low; a drying process using heaters, heat lamps, and a current source was used. On August 15, 1966, transformer moved to ORGDP and oven dried.
2300/480-v transformer	8-17-66					Resistance to ground checked 10,000 megohms at 500 v.

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