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HIGH FLUX ISOTOPE REACTOR QUARTERLY REPORT

APRIL, MAY, AND JUNE OF 1967

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SUMMARY

Four HFIR fuel cycles were completed this quarter, but two of these were atypically short. One was terminated early because of a suspected leaking fuel element and the other was shortened by the failure of both pressurizer pumps. Despite an extra end-of-cycle shutdown, the operating time percentage increased to 83.3%. A fuel element without combs was built, tested, and run at power; but this test was stopped because of increased coolant system radioactivity.

OPERATIONS

Basic operating data for the quarter are listed in Table 1.

The starting and ending dates for cycles 10, 11A, 12, 13, and 14 are presented in Table 2. Cycle 10 was interrupted twice by shutdowns to remove leaking target rods. Cycle 11A was terminated early because of a suspected leaking fuel element. If it is determined that this fuel element is not leaking, it will be run again as 11B. Cycle 13 was shortened by the failure of both pressurizer pumps. Figure 1 is a plot of the symmetric plate positions versus accumulated megawatt days for cycles 10, 11A, 12, 13, and 14.

Table 1. HFIR Basic Operating Data
(April 1 through June 30, 1967)

	This Quarter	Last Quarter	Year To Date
Total energy, Mwd	7559.2	6795.8	14,355
Average power, Mw/operating hr	99.8	99.6	99.7
Time operating, %	83.3	75.8	79.5
Reactor water radioactivity, $\frac{c/min}{ml}$ (av)	341,000	359,000	
Pool water radioactivity, $\frac{c/min}{ml}$ (av)	119	106	
Reactor water resistivity, ohm-cm (av)	0.400×10^6	0.315×10^6	
Pool water resistivity, ohm-cm (av)	1.560×10^6	2.09×10^6	

Table 2. HFIR Cycles of Operation

Cycle No.	Date Started	Date Ended	Accumulated Power (Mwd)
10	3-13-67	4-11-67	2366
11A	4-18-67	4-24-67	575
12	4-25-67	5-18-67	2306
13	5-22-67	6-11-67	2026
14	6-14-67	In progress	

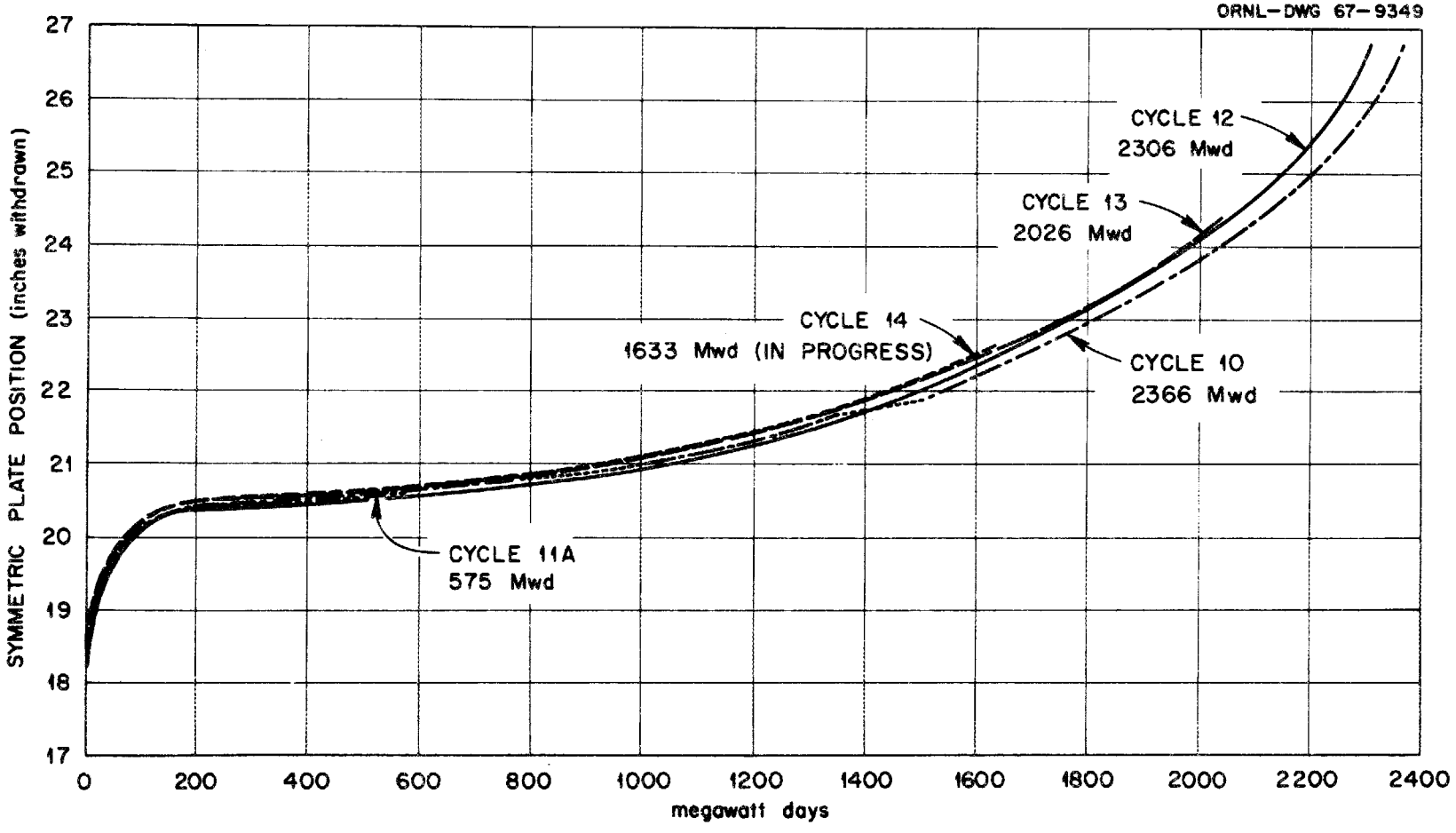

Fig. 1. Symmetric Plate Positions vs Accumulated Megawatt Days -- Cycles 10, 11A, 12, 13, and 14.

SHUTDOWNS

A summary of the HFIR shutdowns for the quarter is given in Table 3. Table 4 gives further details of the shutdowns.

Table 3. Summary of HFIR Shutdowns

Reason	Number	Downtime (hr)
	Scheduled	
End of Cycle	3	281.451
	Unscheduled	
Mechanical failure	2	65.117

Table 4. Description of HFIR Shutdowns

Date	Downtime (hr)	Remarks
		Scheduled
4-11-67	165.700	Fuel cycle 10 was completed at 11:30 p.m. A total power generation of 2366 Mwd was obtained on elements 20-O and 20-I.
4-24-67	25.967	Fuel cycle 11A was terminated at 6:12 p.m. because of a suspected leaking fuel element.
5-18-67	89.784	Fuel cycle 12 was completed at 10:53 p.m. A total power generation of 2306 Mwd was obtained on elements 24-O and 24-I.
		Unscheduled
4-4-67	0.167	An accidental scram occurred during the safety system test of the channel 3 heat power. A high inlet temperature scram was received on channel 2 at the same time due to a leaky valve in the hot-water injection system.
6-11-67	64.950	Failure of the magnetic couplings on both main pressurizer pumps forced a reactor shutdown. This shutdown terminated cycle 13 during which a total power generation of 2026 Mwd was obtained on fuel elements 8-O and 8-I.

INSTRUMENTATION AND CONTROLS - MAINTENANCE AND CHANGES

The more significant changes and maintenance performed on the various instrumentation subsystems are described below.

Control System

During reactor operation at 100 Mw, servo channel 1 malfunctioned and tried to increase the reactor power. The other two servo channels operated properly and prevented any appreciable power rise. Channel 1 appeared to have lost its flux signal, so its motor was temporarily deenergized. When this channel was reenergized, it operated properly and no abnormality could be found. This behavior was repeated about a week later. During a more thorough check of this system after reactor shutdown, it was discovered that the wiring for the main -32 v supply to the servo voltage regulators was very loose at a terminal strip. The servo malfunction could be reproduced by jiggling the loose wires. Since the wires were tightened, the trouble has not recurred.

All three servo heat-power channels were recalibrated with the reactor at power. Although the design of these thermobulbs supposedly precluded ambient temperature effects, it has been found that these temperature measuring systems are apparently sensitive to ambient temperature. In the future all heat-power calibrations will be done with the reactor at power. After recalibrating the servo heat-power systems, it was necessary to raise the reactor power ~3% to maintain an indicated level of 100 Mw. Since this recalibration, the fuel element lifetime has also decreased ~3%.

Safety Channels

The work described on HFIR instrumentation change memo No. 10 was completed this quarter. This modification was made to protect the input transistor in the flux amplifiers from damage caused by excessively high input currents. Also, a new model transistor with a lower noise output was used in the circuit to replace the original input transistor.

A tabulation of spurious single-channel trips has been made for this quarter and is presented in Table 5. All three safety channels were in service each time a trip occurred, so no actual reactor scrams resulted from the spurious trips.

Table 5. Spurious Single-Channel Trips in the HFIR Safety System

Date	Remarks
4-10-67	Two separate trips occurred in channel 1 about one hour apart. Latch lights indicating rate and level trips appeared each time. The afterheat operational amplifier was replaced to correct the trouble.
5-25-67	Two separate trips occurred in channel 3 a few minutes apart. Latch lights indicating rate and level trips appeared each time. The cause of the trips was not determined, but no further trips occurred.

Wide-Range Counting Channels

The channel 3 fission-chamber drive motor failed twice this quarter. After an accidental scram, the fission chamber would not move. Its drive motor was found shorted. This short apparently caused the servo amplifier to fail. About one week later during an end-of-cycle shutdown, the drive motor failed again. This failure was caused by the fission chamber hitting its mechanical insert limit before the insert limit switch was actuated. This condition required the drive motor to run continuously until it failed. A circuit incorporating a fuse is being designed for the drive motors to prevent failures of this type in the future.

Instrumentation Change Memos

Instrumentation change memos describing work completed this quarter are listed in Table 6.

Table 6. Instrumentation Change Memos

Memo No.	Subject	General Description
9	HFIR computer	Various switches, circuits, and relays were installed for later use by the HFIR on-line computer.
14	Hydraulic tube facility	The instrumentation for the hydraulic tube facility was modified to provide a signal proportional to the flow of coolant water through the tube. This signal will operate a flow recorder and provide a low-flow alarm.
15	Regulating channel ramp generator	To correct a wiring error, the potentiometer circuits in the ramp generators for the regulating channels were modified.

PROCESS SYSTEMS

Maintenance and changes in the various process systems are listed in Table 7.

Table 7. Process Systems - Maintenance and Changes

Date	Component	Remarks
		Primary System
4-18-67 to 4-25-67	Pony motor PU-1F battery charger	During a routine battery life test, it was discovered that the PU-1F batteries were not fully charged. The trouble was traced to the battery charger which was out of adjustment.
5-22-67	Pony motor PU-1E battery charger	During a routine battery life test, it was discovered that the PU-1E batteries were not fully charged. Three rectifying diodes had burned out in the battery charger shortly before the life test was started.
6-9-67 to 6-11-67	Pressurizer pumps PU-4A and PU-4B	The magnetic couplings (speed reducers) failed on both pressurizer pumps. It was necessary to shut down the reactor while these units were repaired.
		Miscellaneous
5-19-67	Air compressor C-1C	The Joy air compressor (C-1C) was overhauled for the first time after ~1 year of operation. The piston rings were worn, and the cylinder was scored.
5-24-67	Plant demineralizer	Old resin was removed from the plant demineralizer and replaced with 13 ft^3 of cation resin IR-200 and 15 ft^3 of anion resin IR-402. During the resin replacement, an internal inspection revealed that the raw water flow distributor was broken. A new distributor made of stainless steel was installed to replace the original plastic component.

FUEL

The status of the HFIR fuel, target, and control-plate inventory is indicated in Table 8.

Table 8. HFIR Material Inventory

Item	This Quarter	Last Quarter
New fuel elements placed in service	4	3
New fuel elements available for use	20	17
Spent fuel elements on hand	11	9
Spent fuel elements shipped	2	0
New sets of shim plates placed in service	0	1
New sets of shim plates available for use	0	0
Plutonium target rods ready for use	16	21
Plutonium target rods inserted in reactor	8*	1

*Includes six experimental low density rods.

The accumulated number of tensioning cycles on the reactor vessel head studs is presented in Table 9. These studs were designed for a fatigue life of 40 cycles loading due to tensioning of the bolts and 730 full-pressure cycles.

Table 9. Vessel Head Stud Tensioning Cycles

Type Cycle	This Quarter	Last Quarter	Total To Date
Head bolts tensioned			10
1500 psig			10
950 psig			198
650 psig	8	10	238
Total			456

OPERATIONAL NOTES AND SPECIAL TESTS

Test of Modified Fuel Element

One of the last operations in the manufacture of HFIR fuel elements is the installation of spacer combs at the top and bottom of the plates. When these combs are welded, there is an appreciable risk of damaging a nearly complete assembly. Since there was some doubt as to whether the combs were really necessary for plate stability, an experimental fuel element, 19-O and 19-I, was fabricated without combs. It was planned to hydraulically test this element in the reactor and then run it for a complete cycle to evaluate its performance.

The test element was installed in the reactor and operated for 34 hours under normal flow conditions; i.e., 650 psig and ~16,000 gpm flow. It was then removed and subjected to a thorough mechanical inspection. No structural changes or damage of any sort were found.

The element was reinstalled in the reactor and a normal power cycle was started. Soon after the reactor reached 100 Mw, it became obvious that a significantly higher-than-normal fraction of fission products was being released into the primary coolant. Various radioactivity monitors indicated levels 50 to 100% higher than had been previously observed, although still far below the level which would necessitate an immediate reactor shutdown.

It was decided to continue operation for a few days while closely observing the radioactivity levels. Any abrupt increase in any radiation level would have caused the reactor to be shut down immediately. However, the radiation levels maintained their original values without any significant increase or decrease. The reactor was shut down after accumulating 575 Mwd on the experimental fuel element because it was felt that conditions were sufficiently different from normal operation to indicate a possible fuel cladding failure.

Underwater examination of the experimental fuel element after its removal from the reactor did not reveal any abnormalities. Laboratory analyses, which were completed after the reactor had been shut down, of

the fission products in the cooling water showed no apparent differences among the volatile iodines, gas daughters strontium and barium, and non-volatile molybdenum and neptunium. This leads to the conclusion that the exposed uranium which produced the fission products was in a thin film, i.e., surface contamination. Therefore, this element will probably be returned to the reactor for the completion of its cycle.

Target Rod Ruptures

Ruptures of the ^{242}Pu target rods continued to occur. At the end of this quarter, cracks had been found in eight of the original seventeen Savannah River target rods. Since the primary coolant alpha activity level is rising during the cycle in progress at the end of the quarter, it is probable that additional target rods are ruptured. Thus far, all of the ruptures have occurred in the Savannah River target rods.

WATER SYSTEMS

Operation of the HFIR demineralizers during this quarter is summarized in Table 10. Results of various water analyses performed by the analytical laboratories are tabulated in Table 11.

Table 10. Demineralizer Data: April 1 - June 30, 1967

Column	Run No.	Starting Date	Termination Date	Throughput Gallons	Specific Resistance (ohms-cm) Influent	Specific Resistance (ohms-cm) Effluent	pH Influent	pH Effluent	Gross Activity (counts min^{-1} ml^{-1}) Influent	Gross Activity (counts min^{-1} ml^{-1}) Effluent
					Pool System					
Cation	3	12-15-66	5-22-67	41,260,000	1.45×10^6		5.8		115	
Anion	3	12-15-66	5-22-67	41,260,000		2.09×10^6		5.9		16
Cation	4	5-22-67		11,634,000	1.66×10^6		5.9		124	
Anion	4	5-22-67		11,634,000		3.05×10^6		6.2		20
					Reactor System					
West Cation	3	3-23-67	4-4-67	3,373,000	0.33×10^6		5.0		304,000	
West Anion	3	3-23-67	4-4-67	3,373,000		3.04×10^6		6.2		1200
East Cation	4	4-4-67		1,926,000	0.27×10^6		5.0		366,000	
East Anion	4	4-4-67		1,926,000		2.27×10^6		6.2		2660
West Cation	4	4-10-67		18,088,000	0.37×10^6		5.0		353,000	
West Anion	4	4-10-67	6-4-67	12,788,000		1.94×10^6		6.1		1080
West Anion	5	6-8-67		5,300,000		2.09×10^6		6.2		20,980
					Plant Demineralizer					
Monobed	137	3-31-67	4-7-67	18,520						
Monobed	138	4-7-67	4-9-67	20,210						
Monobed	139	4-9-67	4-13-67	20,520						
Monobed	140	4-13-67	4-14-67	20,680						
Monobed	141	4-14-67	4-16-67	21,240						
Monobed	142	4-16-67	4-19-67	24,140						
Monobed	143	4-19-67	5-9-67	17,360						
Monobed	144	5-9-67	5-20-67	15,840						
Monobed	145	5-20-67	5-20-67	16,565						
Monobed	146	5-21-67	5-22-67	16,805						
Monobed	147*	5-22-67	5-24-67	14,090						
Monobed	148	5-24-67	6-13-67	22,890						
Monobed	149	6-13-67								

*This cycle was terminated early and the resin in the demineralizer was replaced.

Table 11. Water Analysis Results

Date	Total Solids (ppm)	Non-Volatile Material (ppm)	Si (ppm)	Cl (ppm)	Cu (ppm)	Hg (ppm)	Na (ppm)	Ca (ppm)	Al (ppm)	Conductivity (mhos)	pH	$CaCO_3$ (ppm)	$CrO_4^{=}$ (ppm)	O_2 (ppm)	H_2O_2 (ppm)	NO_3 (ppm)	H_2 (ppm)	NO_2 (ppm)	^3H (dis $min^{-1}ml^{-1}$)
										Primary Water									
4-4-67	3.40	0.40	2.1	<1.0	<0.5	<0.5	<0.2		<0.2	2.85×10^{-6}					8.5	0.54	1.6	0.1	
5-12-67	2.40	<0.01	<0.13	<1.0	0.08	<1.0	<0.2		<1.0	2.35×10^{-6}				24	8.2	0.27	1.9	<0.5	2.39×10^{5}
6-28-67	2.40	1.20	1.0	<1.0	<0.4	<1.0	<0.2		<0.2	3.30×10^{-6}				21	10.5	1.30	1.65	0.1	
										Pool Water									
4-4-67	3.60	0.20	2.5	<1.0	<0.5		<0.2	<0.5		8.26×10^{-7}									
5-12-67	2.40	<0.01	<0.13	<1.0	0.12		<0.2	<0.2		1.24×10^{-6}									
6-28-67	1.80	0.60	1.0	<1.0	<0.4		<0.2	<1.0		9.42×10^{-7}									
										Secondary Water									
4-4-67				19.5							6.7	614	21.4						
5-12-67				14.0							6.7	445	19.5						
6-28-67				15.0							6.7	395	15.6						

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