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HIGH FLUX ISOTOPE REACTOR
QUARTERLY REPORT OCTOBER,
NOVEMBER, AND DECEMBER OF 1972

R. V. McCord
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Contract No. W-7405-eng-26

Operations Division

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SUMMARY

Two long shutdowns, one of 107 hours for a semiannual component inspection and the other of 59 hours caused by terrorist threats, reduced the operating time to 90.2% this quarter. However, the operating time for the year of 1972 was 93.3%, a record high for the HFIR. A broken lower track bearing mount discovered during the component inspection necessitated replacement of the lower track assembly. All four pieces of semipermanent beryllium were replaced because of cracks after accumulating ~190,000 MWd of exposure (neutron fluence for $E > 0.821$ MeV of $\sim 2.5 \times 10^{22}$ NVT).

OPERATIONS

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

Table 1. HFIR Basic Operating Data
(October 1 through December 31, 1972)

	This Quarter	Last Quarter	Year To Date
Total energy, MWd	8,179	8,914	33,811
Average power, MW/operating hr	98.5	99.9	99.0
Time operating, %	90.2	97.0	93.3
Reactor availability, %	90.7	97.0	93.7
Reactor water radioactivity, $\frac{\text{c/min}}{\text{ml}}$ (av)	467,100	258,500	
Pool water radioactivity, $\frac{\text{c/min}}{\text{ml}}$ (av)	7,540*	1,550*	
	179**	65**	

*Higher than normal because leaking primary water was being diverted directly to the pool demineralizer where this sample was taken.

**Average radioactivity of bulk pool water.

The starting and ending dates for cycles 82, 83, 84, 85, and 86 are presented in Table 2. Cycle 86 was still in progress at the end of the quarter and 1715 MWd had been accumulated.

Table 2. Cycles of Operation

Cycle No.	Date Started	Date Ended	Accumulated Power (MWd)
82	9-10-72	10-3-72	2333
83	10-8-72	10-23-72	1518
84	10-24-72	11-19-72	2337
85	11-19-72	12-13-72	2309
86	12-13-72	In progress	1715

The status of the HFIR fuel and control-plate inventory is indicated in Table 3.

Table 3. HFIR Material Inventory

Item	This Quarter	Last Quarter
New fuel elements placed in service	4	3
New fuel elements available for use	46	46
Spent fuel elements on hand	12	12
Spent fuel elements shipped	4	2
New sets of shim plates placed in service	0	0
New sets of shim plates available for use	3	3

SHUTDOWNS

A summary of the HFIR shutdowns for the quarter is presented in Table 4. Table 5 gives further details of the shutdowns.

Table 4. Summary of HFIR Shutdowns

Type	Number	Downtime (hr)
Scheduled		
End of cycle	4	156.951
Unscheduled		
Administrative	1	59.017

Table 5. Description of HFIR Shutdowns

Date	Downtime (hr)	Remarks
Scheduled		
10-3-72	107.217	Fuel cycle 82 was completed at midnight. A total power generation of 2333 MWd was obtained on fuel elements 81-0 and 81-I. The shutdown was extended to complete the semiannual core inspection, replace upper and lower track bearings and control plate extension tubes, and complete various maintenance items.
10-23-72	20.417	Fuel cycle 83 was completed at 4:00 p.m. A total power generation of 1518 MWd was obtained on fuel elements 82-0 and 82-I. The fuel cycle was terminated early because of an abnormally high rate of fission product release from the fuel element.
11-19-72	15.200	Fuel cycle 84 was completed at 8:18 a.m. A total power generation of 2337 MWd was obtained on fuel elements 86-0 and 86-I.
12-13-72	14.117	Fuel cycle 85 was completed at 1:53 a.m. A total power generation of 2309 MWd was obtained on fuel elements 117-0 and 117-I.
Unscheduled		
11-11-72	59.017	The reactor was shut down at 7:32 a.m. as a precaution against possible damage to the reactor building threatened by hijackers of a jet airplane. The reactor remained shutdown until xenon decay permitted a restart.

OPERATIONAL NOTES AND SPECIAL TESTS

Lower Track Bearing Failure

During the end-of-cycle 82 semiannual inspection of the reactor internal components, an inner control cylinder guide bearing on the lower tracks appeared to be "cocked". Closer examination of the bearing mount during replacement of the bearing revealed that one side of the mount appeared to be broken and the bearing had lost some of its balls. These bearings are visually inspected every six months and replaced every eighteen months. At the last bearing replacement, which occurred approximately one year ago, and at the last visual inspection, about six months ago, the bearing mount and bearing appeared to be normal.

Failure of the bearing mount prevented further use of the lower track assembly. The defective assembly was removed from the reactor for later inspection and possible repair. A new lower track assembly with new bearings in place was installed in the reactor.

An examination of the supposedly broken bearing mount revealed that it had failed because of abrasion. Evidently the bearing failed by unusually rapid wear and permitted the outer bearing race to wear against the bearing mount. Continued rubbing of the hard bearing race eventually cut through the relatively soft bearing-mount material. Evidence of such abrasion was apparent on the broken mount and on the surface of the bearing race.

Previous experience with this type of ball bearing has shown that when the original ball diameter of 0.1875 in. has been reduced to ~0.172 in. by wear the balls are small enough to slip out of the race. Nine of the thirteen original balls in this bearing were recovered. Their diameter measured ~0.171 in. Other bearings removed from the lower track assembly had an identical operating history, but their balls had worn to a diameter of 0.182 in., the expected amount.

Excessive bearing wear and eventual failure was attributed to improper mounting of the bearing in the track assembly. These bearings had been remotely installed in the intensely radioactive lower track assembly and visually inspected via periscope for proper seating. Repeated trials of the bearing installation procedure using new components revealed that in a small percentage of the installations the bearing failed to seat properly

and, furthermore, such improper seating was virtually impossible to detect by a remote visual inspection. Improper seating such as was observed would result in increased loading forces on the bearing.

It is postulated that the failed bearing was installed improperly in its mounting and that the faulty installation was not detected by a visual examination. The increased bearing load caused the balls to wear faster than normal until eventually some balls were lost. The outer race then abraded the bearing mount and caused it to fail.

A "go-no go" gauge has been developed to check the track bearings for proper positioning. This gauge will be used in conjunction with visual observations during component inspections and immediately after bearing replacements. Improper bearing seating of the type which caused the bearing to fail will be detected by this gauge.

Cracking of Semipermanent Beryllium

During disassembly of the reactor to remove the lower tracks, the disengagement of the removable beryllium assembly was more difficult than normal. After other components were removed, inspection of the removable beryllium and the semipermanent beryllium into which it fits revealed that two quadrants of the semipermanent beryllium appeared to be cracked. Also, gauging indicated that swelling had occurred. Closer examination and removal revealed that each of the four pieces (~15 in. arc length x ~1 1/4 in. thick x 24 in. long) had broken into several parts which were removed without difficulty. It is probable that the radiation-induced swelling had caused some binding between the removable and semipermanent reflectors and this exerted enough stress to crack the already embrittled pieces of the semipermanent reflector.

The semipermanent beryllium had been in the reactor for more than 190,000 MWd. Its center had been exposed to a thermal neutron fluence of $>10^{23}$ NVT and a fast ($E > 0.821$ MeV) fluence of $\sim 2.5 \times 10^{22}$ NVT. Beryllium damage after this exposure to high neutron fluxes is to be expected. Removable reflector assemblies, which are exposed to higher fluxes than the semipermanent beryllium, have been replaced after ~75,000 MWd of exposure because of swelling. It was planned to replace the semipermanent

beryllium when radiation damage became apparent. The semipermanent beryllium will be replaced in the future when radiation damage indicates the need.

Leaking Fuel Element

After operating for 15 days in cycle 83, the reactor was shut down because of steadily increasing amounts of fission products in the cooling water. All experiments and target irradiations appeared to be normal; so it was suspected that the fission products were leaking out of the fuel element. Although the absolute level of radioactive contamination was tolerable for operation and only a small amount of radioactive noble gases was being released to the environment, the rate of activity increase projected to the end of the fuel cycle might have attained a level which would have caused some operating inconveniences.

Reactor operation with a new fuel element resulted in a decreasing level of fission products in the cooling water. The source of radioactivity was either the old fuel element or an experiment which was removed during the shutdown. Examination of the experiment in a hot cell revealed that its outer shell was intact and that it had not been leaking in the reactor. This indicates that the source of contamination was the fuel element.

The HFIR has used 83 fuel assemblies containing 44,820 individual fuel plates. In this number of plates there have been two possible leakers and in one case (element 19) it was possible to operate for the whole fuel cycle. This is an acceptably small incidence of leakers and the cost of identifying which of the approximately 540 plates was leaking would be so great that further action does not seem warranted.

PLANT MAINTENANCE

Maintenance and changes in the various process systems are listed in Table 6.

INSTRUMENTATION AND CONTROLS

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

Table 6. Process System - Maintenance and Changes

Date	Component	Remarks
Primary System		
10-5-72	Control rod guide tracks	Bearings were replaced in the upper control rod guide tracks and the complete lower track assembly was replaced.
10-6-72	Semipermanent beryllium	All four pieces of the semipermanent beryllium were replaced when the old components were found to be cracked.
10-6-72	Control rods	As part of the preventive maintenance program, push rod seal housings were changed on control rod drives No. 1 and No. 4.
10-24-72	Letdown valve	The letdown valve in heat exchanger cell 111 was replaced because of an external leak.
11-6-72	Heat exchanger	A leaking flange gasket was repaired on the heat exchanger in the hot-water-injection system.
11-28-72	Pony motor	Brushes were replaced in pony motor PU-1H.
Miscellaneous		
10-20-72	Cooling tower	The motor on cooling tower fan 4A-1 was replaced because of excessive vibration.
11-27-72	Air compressor	All four intake and all four exhaust valves on air compressor C-1A were replaced during a preventive maintenance check.
12-20-72	Air compressor	All four intake and all four exhaust valves on air compressor C-1B were replaced during a preventive maintenance check.

Table 7. Instrumentation - Maintenance and Changes

Date	Component	Remarks
Safety System		
10-6-72	Amplifier	A redesigned failed fuel element detector (FFED) amplifier was installed in channel No. 1 as authorized by Instrumentation and Controls Change Memorandum No. 74.
10-31-72	Amplifier	A redesigned FFED amplifier was installed in channel No. 3 as authorized by Instrumentation and Controls Change Memorandum No. 74.
Wide-Range Counting System		
10-8-72	Relay	A relay in the period monitoring circuit was replaced because of broken contacts. The broken contacts simulated a short period and inhibited control rod movement.
10-23-72	Chamber drive	After failing to insert at the end of cycle 83, the No. 2 chamber drive rack was found rusted and frozen to the gear block. The motor was replaced and the drive rack and gear block cleaned.
11-20-72	Amplifier	To correct some erratic performance, the dual operational amplifier "Function Generator and Pile Power" in channel No. 1 was replaced.
Miscellaneous		
10-5-72	Shutdown signal	A "reactor shutdown" signal was provided for experimenters from the control rod clutch relays as authorized by Instrumentation and Controls Change Memorandum No. 75.

SYSTEM SURVEILLANCE TESTS AND RESULTS

Vessel Head Studs

The accumulated number of tensioning cycles on the reactor vessel head studs is presented in Table 8. These studs were designed for a fatigue life of 40 cycles loading due to tensioning of the bolts and 730 full-pressure (1000 psig) cycles. Installation of new reactor vessel head studs was completed in June, 1972. The numbers in Table 8 represent the maximum cycles to which any new stud has been exposed.

Table 8. Vessel Head Stud-Tensioning Cycles

	This Quarter	Last Quarter	Total To Date
Head bolts tensioned			3
1500 psig			0
950 psig			0
650 psig	5	3	20

Stack Filters

Stack filtering systems in the special building hot exhaust (SBHE) system were tested for particulate removal efficiency. Results of the most recent tests are tabulated in Table 9.

Table 9. Particulate Removal Efficiency Tests

Filter Bank	Date of Test	Filter Position	Particulate Retention Efficiency, %
SBHE, West	10-26-72	South	99.995
		North	99.953
SBHE, Center	10-26-72	South	99.992
		North	99.968
SBHE, East	10-26-72	South	99.990
		North	99.960

REACTOR DESIGN CHANGES

Instrumentation change memoranda which describe work completed this quarter are tabulated in Table 10.

Table 10. Instrumentation Change Memoranda

Memo No.	Subject	General Description
76	Operational amplifiers	Solid state amplifiers which will replace the mechanical chopper stabilized amplifiers of the original design have been developed and tested. This memorandum authorizes installation of the new amplifiers as needed.
77	OR gate modifications	To provide a buffered input from the rod time-of-flight measurement system and to provide additional inputs for later use, three new OR gate inputs with opto-isolators will be installed in each channel. The opto-isolators are light emitting diode-photosensitive transistor pairs which provide electrical isolation.

Mechanical change memoranda which describe work completed this quarter are tabulated in Table 11.

Table 11. Mechanical Change Memoranda

Memo No.	Subject	General Description
41	Stress-corrosion experiment	To test the stress-corrosion cracking potential of the HFIR primary coolant on stainless steel, corrosion specimens will be exposed in the inlet side of primary heat exchanger "A". Four racks containing 44 specimens each will be exposed simultaneously. A steel shroud encloses the specimen racks to prevent the escape of any loose parts into the primary system.

REVISIONS TO THE HFIR OPERATING MANUAL

Revisions and additions to the HFIR operating manual which have been published this quarter are tabulated in Table 12.

Table 12. HFIR Manual Revisions

Date	Section No.	Subject	General Description
10-13-72	II--4.2	Component replacement	The upper track replacement procedure was slightly revised to reflect the improved tools and handling methods which have been developed.
9-18-72	I--3	Instruments and controls	The descriptive section on instruments and controls was given a general revision and update to reflect various minor improvements put into effect.

REACTOR EXPERIMENTS

Experiment Facilities

Usage of the various HFIR experiment facilities is tabulated in Table 13.

Table 13. Experiment Facility Usage

Facility	Description	Division
RB-1	Isotope production	Isotopes
RB-2	Isotope production	Isotopes
RB-3	Isotope production	Isotopes
RB-4	HFIR tensile specimens	Operations
RB-5	HTGR fuel irradiations	Reactor
RB-6	Isotope production	Isotopes
RB-7	HTGR fuel irradiations	Reactor
RB-8	Isotope production	Isotopes

Table 13. (continued)

Facility	Description	Division
CR-1	Isotope production	Isotopes
CR-2	Isotope production	Isotopes
CR-3	Isotope production	Isotopes
CR-4	Isotope production	Isotopes
CR-5	Isotope production	Isotopes
CR-6	Isotope production	Isotopes
CR-7	Isotope production	Isotopes
CR-8	Isotope production	Isotopes
VXF-1	HFIR corrosion specimen	Operations
VXF-7	Pneumatic tube	Analytical Chemistry
EF-2	Noise analysis studies	Instrumentation and Controls and Operations
HB-1	Neutron diffractometer	Solid State
HB-2	Neutron diffractometer	Chemistry
HB-3	Neutron diffractometer	Solid State
HB-4	Neutron diffractometer	Solid State

HFIR Target Loading

A description of the HFIR target loading for each of the operating cycles this quarter is presented in Figures 1, 2, 3, 4, and 5.

<u>TARGET TYPE</u>	<u>NUMBER</u>
PLUTONIUM (Pu)	<u> - </u>
CURIUM (Cm)	<u> 26 </u>
STAINLESS STEEL (SST)	<u> - </u>
GRAPHITE (C)	<u> 4 </u>
ALUMINUM (Al)	<u> 2 </u>
HYDRAULIC TUBE (HT)	<u> 1 </u>

Fig. 1. HFIR Target Loading for Cycle 82 - September 10, 1972

<u>TARGET TYPE</u>	<u>NUMBER</u>
PLUTONIUM (Pu)	-
CURIUM (Cm)	26
STAINLESS STEEL (SST)	-
GRAPHITE (C)	4
ALUMINUM (Al)	2
HYDRAULIC TUBE (HT)	1

Fig. 2. HFIR Target Loading for Cycle 83 - October 8, 1972

TARGET TYPENUMBER

PLUTONIUM (Pu)

-

CURIUM (Cm)

27

STAINLESS STEEL (SST)

-

GRAPHITE (C)

3

ALUMINUM (Al)

3

HYDRAULIC TUBE (HT)

1

Fig. 3. HFIR Target Loading for Cycle 84 - October 24, 1973

TARGET TYPENUMBER

PLUTONIUM (Pu)

-

CURIUM (Cm)

26

STAINLESS STEEL (SST)

-

GRAPHITE (C)

4

ALUMINUM (Al)

-

HYDRAULIC TUBE (HT)

1

Fig. 4. HFIR Target Loading for Cycle 85 - November 19, 1972

TARGET TYPENUMBER

PLUTONIUM (Pu)

-

CURIUM (Cm)

26

STAINLESS STEEL (SST)

-

GRAPHITE (C)

4

ALUMINUM (Al)

-

HYDRAULIC TUBE (HT)

1

Fig. 5. HFIR Target Loading for Cycle 86 - December 13, 1972

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