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High Flux Isotope Reactor Quarterly Report January Through March 1987

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Research Reactors Division

HIGH FLUX ISOTOPE REACTOR QUARTERLY REPORT
JANUARY THROUGH MARCH 1987

B. L. Corbett, M. B. Farrar, and E. M. Shirley

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HIGH FLUX ISOTOPE REACTOR QUARTERLY REPORT
JANUARY THROUGH MARCH 1987

SUMMARY

The end-of-cycle 287 shutdown was begun on November 14, 1986, and extended indefinitely to investigate the embrittlement of reactor vessel materials due to radiation damage. This shutdown was extended through the first quarter of 1987. Activities at the High Flux Isotope Reactor (HFIR) during the quarter have centered on maintenance, calibration, and modification of reactor systems. Analytical efforts continue to determine whether or not the HFIR can be operated safely with the present damaged vessel. Also, preliminary studies are being conducted to investigate the feasibility of annealing the damaged vessel or replacing it with a new vessel.

OPERATIONS

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

Table 1. HFIR basic operating data
(January 1 - March 31, 1987)

	This quarter	Last quarter	Year to date
Total energy, MWd	0	4060	0
Time operated, h	0	975.368	0
Average operating power, MW	0	99.9	0
Time operating, %	0	44.2	0
Reactor availability, %	0	44.2	0
Reactor water radioactivity, cpm/ml (av)	45	259,436	
Pool water radioactivity	5	46	

INVESTIGATION OF THE REACTOR PRESSURE VESSEL EMBRITTLEMENT

(Reference: ORNL/TM-10390, High Flux Isotope Reactor Quarterly Report, October through December 1986)

The investigation of the HFIR pressure vessel embrittlement problem continued through the first quarter of 1987. The emphasis of this investigation is to determine a basis for continued operation of the HFIR until a new pressure vessel can be procured or an in-situ method of annealing can be developed for the present HFIR vessel. These efforts involve first, an in-depth analysis of the state of the vessel at core elevations to be followed by a determination of an operating philosophy

and system configuration which will allow for safe operation of the reactor based on the vessel analysis.

It was determined that the data collected from the HFIR pressure vessel surveillance specimens were not adequate to provide a complete characterization of the vessel materials at the core centerline; therefore, a program of HFIR vessel materials irradiation was conducted at the ORR. This program involved the irradiation of nozzle weld materials, cloned seam-weld material, and shell material specimens with V-notch orientations cut relative to the rolling, cross-rolling, and thickness directions not represented in the surveillance program. Shell material specimens were also used to index the irradiation damage of the ORR irradiated specimens to the original specimens. Data from this program were combined with the ductility and flux data collected in the HFIR pressure vessel surveillance program to characterize the condition of the vessel wall at various points of interest. Linear elastic fracture mechanics is being applied to analyze these points of interest in accordance with the ASME Boiler and Pressure Vessel Code along with a probabilistic fracture mechanics analysis method developed for the NRC. These analyses are currently ongoing at the conclusion of the quarter.

Also, discussions are currently being conducted to develop a new operating philosophy and system configuration which can deal safely with the reactor vessel in an embrittled state. The discussions, at this time, are based on preliminary results from the vessel materials analysis. The scope of the operating philosophies being discussed include methods for shutting the reactor down prior to a cold shock of the vessel, methods of maintaining the vessel wall at operating temperatures following a scram, pressure relief systems to preclude pressurized cold shock of the vessel, methods for heating the HFIR coolant systems to operating temperatures prior to startup, and new nominal operating parameters. These discussions also continue at the conclusion of the quarter.

The status of the HFIR fuel and control-plate inventories on the last day of the quarter are indicated in Table 2. Only fuel assemblies which have undergone testing at the critical facility are included in this inventory.

SHUTDOWNS

The reactor remained shutdown through the first quarter of 1987 while investigations into the embrittlement of the reactor vessel continued. Total downtime for the quarter was 2160 hours, all of which is designated as unscheduled (see Table 3 for further details).

LOW-POWER OPERATIONS

No Mode 2 or Mode 3 runs were performed during the first quarter.

Table 2. HFIR material inventories

Item	This quarter	Last quarter
New fuel assemblies placed in service	0	2
New fuel assemblies available for use at end of quarter (EOQ)	25	8
Spent fuel assemblies on hand at EOQ	12	11
Spent fuel assemblies shipped	1	3
New sets of control plates places in service	0	0
New sets of control plates available for use at EOQ	3	3
New control cylinders placed in service	0	0
New control cylinders available for use at EOQ	1	0

Table 3. Description of HFIR shutdowns

Date	Downtime, h	Remarks
--	2160.000	The scheduled end-of-cycle 287 shutdown, which began on November 14, 1986, was extended to investigate the embrittlement of the reactor vessel due to radiation damage. All downtime following the originally scheduled cycle 288 startup date was designated as unscheduled downtime. This shutdown continued through the entire first quarter of 1987.

PLANT MAINTENANCE

Maintenance and changes in the various process systems are listed in Table 4.

Table 4. Process systems - maintenance and changes

Date	Component	Remarks
		Primary system
1/21	Primary heat exchanger	An eddy current inspection of the new cell 110 primary heat exchanger was completed.
1/21	Shroud flange	HIFI Phase 2 changes were completed on the shroud flange.
1/26	Vessel head stud	Reactor vessel head stud #72-3 was removed from position 21 for x ray and ultrasonic inspection. Temporary stud #72-22 was installed.
1/30	Primary heat exchanger	An ultrasonic inspection of the new cell 110 primary heat exchanger was completed.
2/2	Primary heat exchanger	The x-ray inspection of the new cell 110 primary heat exchanger was completed.
2/5	Control rod drive 3	The insert limit switch was replaced.
2/5	Equalizing valve cell 113, HCV-180A	The equalizing valve was replaced.
2/6	Equalizing valve cell 110, HCV-583A	The equalizing valve was replaced.
2/9	Primary system decay header	Flushing of the decay header was completed to lower the background radiation levels.
2/10	Control rod drive 3	The upper O-ring and seal housing were replaced.
2/11	Control rod drive 3	The rod drive was replaced.
2/24	Primary pumps	Ground fault relays for the primary pumps were calibrated and reinstalled.
2/25	Pressurizer pumps	Ground fault relays were calibrated and reinstalled.
2/27	Pressurizer pumps PU-4A and PU-4B	High pressure cut-off switches were calibrated.

Table 4. Continued

Date	Component	Remarks
		Primary system
3/6	Primary heat exchanger	An eddy current inspection of the new cell 113 primary heat exchanger was completed.
3/16	Corrosion specimens	Specimens removed from the old cell 113 heat exchanger were decontaminated and shipped for evaluation.
3/23	Primary inlet strainer	The inlet strainer hatch springs were replaced.
3/24	Fission chamber thimble	The channel 3 fission chamber thimble seal was replaced.
3/25	Primary inlet strainer	The inlet strainer was inspected.
3/25	Fission chamber thimble	The channel 2 fission chamber thimble seal was replaced.
		Secondary
2/12	HIC-377 control valve	The air bleed vent valve was rebuilt and reinstalled.
2/20	Secondary pump flume screens	Construction of new flume screens was completed.
2/24	Tower fans	Cooling tower fan time delay relays were rebuilt.
2/24	Secondary pump, PU-6B	Ground fault relay was calibrated and reinstalled.
2/25	Secondary pump, PU-6A and PU-6C	Ground fault relays were calibrated and reinstalled.
3/5	Corrosion inhibitor storage tank	The tank contents were pumped to a storage tanker for repair of a small leak on the bottom of the tank. Tank repairs were completed on 3/10.

Table 4. Continued

Date	Component	Remarks
		Miscellaneous
1/10	High bay crane	Seismic tie-down safety brackets were installed on the crane.
1/19	Steam system	A small leak in the east-west steam line on the north side of the cooling tower was repaired.
1/20	50-ton crane	A load test of the 50-ton crane was completed satisfactorily.
1/30	2.4-kV switchgear	A PCB capacitor was replaced.
2/3	PWD monitoring station 1	The flow measurement weir was replaced.
2/9	Fuel shipping cask	Quality Department performed a dye-penetrant inspection on the lifting lugs.
2/12	PWD monitoring station 2	The flow measurement weir was replaced.
2/24	PWD deep sump steam station	Steam leaks were repaired at the steam station.
2/27	Ground fault relays	The relays were calibrated and installed for feeders 234 and 294 and the 2.4-kV switchgears.
3/3	Pool cleanup pump, PU-7A	The pump bearings were inspected due to noisy operation.
3/17	Evacuation horn station 3	The station was relocated due to construction of the new Neutron Activation Laboratory.
3/23	Switchgear batteries and charger	A new switchgear battery charger and battery bank were installed.

INSTRUMENTATION AND CONTROLS

Maintenance and changes in the various instrumentation systems are listed in Table 5.

Table 5. Instrumentation - maintenance and changes

Date	Component	Remarks
1/2	Vessel temperature indicator	The digital indicator in Building 7910 was calibrated.
1/2	Deaerator CHOG temperature indicator controller	The temperature indicator-controller TIC-476 was calibrated.
1/6	Calibration program	Following instruments were calibrated: FR-216 and FR-258.
1/8	Primary deaerator level control transmitter, LCT-202	Level control transmitter was calibrated.
1/9	Pool deaerator level control transmitter, LCT-454	Level control transmitter was calibrated.
1/13	Secondary pH system, ApHI-334	The old monitoring system was replaced with a new system.
1/15	Calibration program	Following instruments were calibrated: LT-710, LSS-710, FT-917, PDI-238, and PDI-338.
1/19	Calibration program	Following instruments were calibrated: LS-202A, LS-202B, FS-216, and PI-226.
1/20	Calibration program	Following instruments were calibrated: PDT-280, PDT-281, PDT-282, PDT-283, PDT-284, and PDT-285.
1/22	Calibration program	Following instruments were calibrated: PT-400, PT-201, LI-454, LI-202, PS-905, PS-906, PI-905, and PI-906.
1/23	Calibration program	Following level switches were calibrated: LS-422, LS-458, and LS-463.
1/28	Servo system	Diodes D-007 and D-008 were replaced in drawer R-1 per change memo HFIR-100.

Table 5. Continued

Date	Component	Remarks
2/18	Pony motor current alarms	The pony motor current high and low alarms were calibrated as follows: EIS-113A, EIS-117A, EIS-121A, EIS-198A, EIS-113B, EIS-117B, EIS-121B, and EIS-198B.
2/19	Rod drive timers	The rod drive timers in the auxiliary control room were calibrated.
2/20	Calibration program	Following instruments were calibrated: XWM-100-4B, XWM-100-5B, XWM-100-6B, FSS-HB-1, FSS-HB-2, FSS-HB-3, FSS-HB-4, and FS-RP1/RP3.
2/26	Safety channel 2	The resistance converter range unit was replaced in the inlet temperature module.
3/9	Pool surge tank level transmitter, LT-401	The level transmitter was calibrated.
3/13	Hydraulic tube flow instrumentation	The flow instrumentation at the operating station was calibrated.
3/16	Calibration program	Process waste and stack activity monitors were calibrated.
3/17	Computer hyscan system	The scanivalve on the computer hyscan system was calibrated.
3/19	Primary and pool demineralized water make-up indications.	Following instruments were calibrated: FR-215, FR-407, FQ-215, and FQ-407.
3/20	Cooling tower basin low-level alarm float switch	The basin low-level alarm float switch was replaced.
3/27	Calibration program	Following instruments were calibrated: PdI-900, PdI-901, PdI-902, PDT-902, PDT-RP4/RP3, PDT-RP4/RP2, and PDT-RP4/N16.
3/30	Calibration program	Following instruments were calibrated: PDT-900 and PDT-901.

SYSTEM SURVEILLANCE TESTS AND RESULTS

VESSEL HEAD STUDS

The accumulated number of tensioning cycles on the reactor vessel head studs is presented in Table 6. These studs were designed for a fatigue life of 40 cycles loading due to tensioning of the bolts and 730 full-pressure 6.9 MPa (1000-psig) cycles. Installation of new reactor vessel head studs was completed in June 1972. In November 1983, stud 72-1 was replaced by stud 73-9 because of a small anomaly discovered during previous ultrasonic inspections. These numbers in Table 6 represent the maximum cycles to which any stud has been exposed.

The annual ultrasonic inspection of all reactor vessel studs and nuts was completed on September 30, 1986. An indication was noted on stud 72-3 at a depth of 15 in. equal to 87% of the amplitude received from a 0.134-in. calibration notch. This depth corresponds to the point at which the center drilled holes intersect. A reinspection of this stud was scheduled for the following shutdown and was performed on October 24, 1986. This inspection confirmed the results of the previous inspection in September. A more detailed inspection was deemed necessary; therefore, stud 72-3 was removed and replaced with a temporary stud (72-22). A detailed radiographic and ultrasonic inspection of the stud was performed. The radiographic examination revealed only a mismatch in the center drilled holes. The ultrasonic inspection results, however, were not consistent with the radiographic examination results so it was decided that a new stud should be placed in position 21 prior to restart.

Table 6. Vessel head stud-tensioning cycles

	This quarter	Last quarter	Total to date
Head bolts tensioned	0	0	8*
10.3 MPa (1500 psig)	0	0	0
6.5 MPa (950 psig)	0	0	11
5.2 MPa (750 psig)	2	6	215
4.5 MPa (650 psig)	0	0	117

*Stud 72-3 has been tensioned nine times to date.

STACK FILTERS

Stack filtering systems in the special building hot exhaust (SBHE) and hot off-gas (HOG) systems were tested for particulate and iodine removal efficiencies. Results of the most recent tests are tabulated in Table 7.

Table 7. Particulate and iodine removal efficiencies

Filter bank	Elemental iodine				Filter position	Particulate retention			
	Last test		Previous test			Last test		Previous test	
	Date	Eff.,%	Date	Eff.,%		Date	Eff.,%	Date	Eff.,%
SBHE, west	10/7/86	99.967	4/22/86	99.981	South	3/31/87	99.99	9/22/86	99.99
					North	3/31/87	99.99	9/22/86	99.99
SBHE, center	10/24/86	99.992	4/18/86	99.975	South	3/31/87	99.99	9/22/86	99.99
					North	3/31/87	99.99	9/22/86	99.98
SBHE, east	10/16/86	99.950	4/24/86	99.964	South	3/31/87	99.99	9/22/86	99.99
					North	3/31/87	99.99	9/22/86	99.99
CHOG, West	11/13/86	99.988	4/15/86	99.992					
HOG, Center	11/4/86	99.992	4/30/86	99.799[a]					
OHOG, east	11/6/86	99.995	4/16/86	99.954					

[a]Below minimum acceptable efficiency.

SUMMARY OF SURVEILLANCE TESTS

Table 8 is a tabulation of the completion dates of the surveillance tests required by the Technical Specifications. This table contains all the surveillance tests scheduled for frequencies of one month or longer. Other surveillance requirements, which are not reported, are satisfied by the routine completion of daily and weekly check sheets, startup checklists, hourly data sheets, the operating logbooks, and miscellaneous quality assurance tests.

REVISIONS TO THE HFIR OPERATING MANUAL

There were no revisions to the HFIR Operating Manual during the quarter.

UNUSUAL OCCURRENCES

There were no unusual occurrence reports issued during the quarter.

REACTOR EXPERIMENTS

EXPERIMENT FACILITIES

Assignments of the various HFIR experiment facilities are tabulated in Table 9.

Table 8. Summary of Technical Specification surveillance tests

Test	Most recent test	Previous test	Previous test
Decennial tests			
Pressure boundary components	11/83	7/75	NA
Annual tests			
Count rate channel A calibration	10/28/86	3/11/86	2/6/85
Count rate channel B calibration	2/2/87	3/12/86	2/8/85
Count rate channel C calibration	2/11/87	3/13/86	2/19/85
Normal emergency systems	7/22/86	11/20/85	5/29/85
Poison injection system	8/14/86	8/16/85	10/29/84
Pressurizer pump high-pressure cutoff	2/27/87	2/6/86	2/22/85
Pressure relief valves	11/19/86	11/15/85	10/3/84
Reactor vessel head studs	9/30/86	11/18/85	10/4/84
Radiation block valve test	9/8/86	9/30/85	10/29/84

Table 8. Continued

Test	Most recent test	Previous test	Previous test
Annual tests			
Reactor bay in-leakage test	9/8/86	9/30/85	10/4/84
Reactor components	11/16/86	9/28/85	10/4/84
Safety channel A calibration	9/17/86	2/10/86	2/28/85
Safety channel B calibration	9/18/86	2/10/86	3/1/85
Safety channel C calibration	9/22/86	2/10/86	3/4/85
Servo channel A calibration	7/29/86	2/19/86	2/5/85
Servo channel B calibration	7/29/86	2/19/86	2/5/85
Servo channel C calibration	7/29/86	2/19/86	2/5/85
Speed of shim and regulating drives	1/29/87	11/20/85	11/19/84
Switchgear battery load test	5/12/86	5/8/85	4/30/84
Vessel material sample hole inspection	NA	NA	NA
Main pump low-pressure cutoff	11/14/86	10/25/86	9/29/86
Semiannual tests			
Pony motor battery E	9/8/86	5/11/86	2/6/86
Pony motor battery F	10/2/86	6/28/86	3/25/86
Pony motor battery G	10/25/86	7/11/86	6/4/86
Pony motor battery H	8/13/86	4/18/86	1/13/86
Radiation monitoring equipment	3/20/87	1/9/87	11/12/86
Monthly tests			
Cadmium nitrate tests	3/29/87	2/28/87	1/31/87
Diesel run test, No. 1	3/31/87	2/24/87	1/27/87
Diesel run test, No. 2	3/24/87	2/24/87	1/27/87

Table 9. Experiment facility assignments

Facility	Description	Sponsor
PTP-A1	Materials studies	Fusion Energy
PTP-A4	Materials studies	Fusion Energy
PTP-D1	Materials studies	Fusion Energy
PTP-D7	Materials studies	Fusion Energy
PTP-G4	Materials studies	Fusion Energy
PTP-G7	Materials studies	Fusion Energy
RB-1	Isotope production	Operations
RB-2	Isotope production	Operations
RB-3	Isotope production	Operations
RB-4	Isotope production	Operations
RB-5	Fuel studies	Engineering Technology
RB-6	Fuel studies	Engineering Technology
RB-7	Isotope production	Operations
RB-8	Isotope production	Operations
CR-1	Isotope production	Operations
CR-2	Isotope production	Operations
CR-3	Isotope production	Operations
CR-4	Isotope production	Operations
CR-5	Isotope production	Operations
CR-6	Isotope production	Operations
CR-7	Isotope production	Operations
CR-8	Isotope production	Operations
VXF-1	Isotope production	Operations
VXF-2	Isotope production	Operations
VXF-3	Isotope production	Operations
VXF-4	Isotope production	Operations
VXF-5	Isotope production	Operations
VXF-7	Pneumatic tube	Analytical Chemistry
VXF-8	Isotope production	Operations
VXF-9	Isotope production	Operations
VXF-10	Isotope production	Operations
VXF-11	Isotope production	Operations
VXF-12	Isotope production	Operations
VXF-13	Isotope production	Operations
VXF-14	Isotope production	Operations
VXF-15	Isotope production	Operations
VXF-16	Isotope production	Operations
VXF-17	Isotope production	Operations
VXF-18	Isotope production	Operations
VXF-19	Isotope production	Operations
VXF-20	Isotope production	Operations
VXF-21	Isotope production	Operations
VXF=22	Isotope production	Operations
HB-1	Neutron diffractometer	Solid State
HB-2	Neutron diffractometer	Chemistry
HB-3	Neutron diffractometer	Solid State
HB-4	Neutron diffractometer	Solid State
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