The University of Michigan
MICHIGAN MEMORIAL – PHOENIX PROJECT
PHOENIX MEMORIAL LABORATORY FORD NUCLEAR REACTOR
ANN ARBOR, MICHIGAN 48109-2100

30 March 2003

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Licensee: Docket 50-2, License R-28

Dear Sir or Ma'am;

Enclosed is the written annual report required by Technical Specifications for the period of 01 January through 31 December 2002.

If there are any questions regarding this report, please feel free to contact me at (734) 764-6213.

Respectfully,

Christopher W. Becker
Nuclear Reactor Laboratory Manager

Encl: Report of Reactor Operations, Ford Nuclear Reactor January 1 - December 31, 2002

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FORD NUCLEAR REACTOR

Docket No. 50-2
License No. R-28

REPORT OF REACTOR OPERATIONS

This report reviews the operation of the University of Michigan's Ford Nuclear Reactor for the period January 1 to December 31, 2002. The report is to meet the requirement of Technical Specifications for the Ford Nuclear Reactor. The format for the sections that follow conforms to Section 6.6.1 of Technical Specifications.

The Ford Nuclear Reactor is operated by the Michigan Memorial Phoenix Project of the University of Michigan. The Project, established in 1948 as a memorial to students and alumni of the University who served and the 588 who died in World War II, encourages and supports research on the peaceful uses of nuclear energy and its social implications. In addition to the Ford Nuclear Reactor (FNR), the Project operates the Phoenix Memorial Laboratory (PML). These laboratories, together with a faculty research grant program, are the means by which the Project carries out its purpose. The operation of the Ford Nuclear Reactor provides major assistance to a wide variety of research and educational programs. The reactor provides neutron irradiation services and neutron beamport experimental facilities for use by faculty, students, and researchers from the University of Michigan, other universities, and industrial research organizations. Reactor staff members teach classes related to nuclear reactors and the Ford Nuclear Reactor in particular and assist in reactor-related laboratories.

1. OPERATIONS SUMMARY

In January 1966, a continuous operating cycle was adopted for the Ford Nuclear Reactor at its licensed power level of two megawatts. The cycle consisted of approximately 25 days at full power followed by three days of shutdown maintenance. In June 1975, a reduced operating cycle consisting of ten days at full power followed by four days of shutdown maintenance was adopted. A typical week consisted of 120 full-power operating hours. In July 1983, the reactor operating schedule was changed to Monday through Friday at licensed power and weekend shutdowns. Periodic maintenance weeks were scheduled during the year. In January 1985, a cycle consisting of four days or 96 full-power operating hours per week at licensed power followed by three days of shutdown maintenance was established in order to eliminate the periodic shutdown maintenance weeks needed in the previous cycle. Beginning July 1, 1987, the reactor operating cycle returned to ten day operation at full power followed by four days of shutdown maintenance. This calendar year began with cycle 467 and ended with cycle 479. A typically cycle covers four weeks: two of the ten day - four day sequences.

The reactor operates at a maximum power level of two megawatts which produces a peak thermal flux of approximately $2x10^{13}$ $n/cm^2/sec$. An equilibrium core configuration consists of approximately 41 standard and 4 control, 19.75% enriched, plate-type fuel elements. Standard elements contain 167 gm of U235 in 18 aluminum clad fuel plates. Control elements, which have control rod guide channels, have nine plates and contain 83 gm of U235. Overall active fuel element dimensions are approximately 3"x 3"x 24".

Fuel elements are retired after burnup levels of approximately 35-40% are reached. Fuel burnup rate is approximately 2.46 gm U235/day at two megawatts.

1.1 Facility Design Changes

The I-beamport collimator was replaced with a new convergent-divergent collimator to support neutron radiography. The new collimator incorporates an aluminum end window. The end window in the new design adds a second barrier against loss-of-coolant at I-beamport that did not exist with the old collimator. The old collimator was a pass-through design without end windows.

A solid aluminum filler piece with triangular cross section was inserted into the gap between the heavy water tank and the aluminum angle that makes up the northeast vertical bridge. The purpose of this was to displace the water to provide a more spatially uniform neutron flux at the I-beamport neutron radiography imaging plane. After insertion of the filler piece, tests were conducted at the imaging plane and the neutron flux was much more uniform.

1.2 Equipment and Fuel Performance Characteristics

The reactor was refueled on March 04-05, 2002 in Cycle 469. Three new regular fuel assemblies and one new control fuel assembly were installed. Three regular fuel assemblies and one control fuel assembly were retired. The core excess reactivity, after refueling and performing rod calibrations, was 3.29% Δ k/k.

Four new regular fuel assemblies were received on May 01, 2002 (ZBF-ZMZ-22)

The reactor was refueled on August 19-20, 2002 in Cycle 475. Three new regular fuel assemblies and one new control fuel assembly were installed. Three regular fuel assemblies and one control fuel assembly were retired. The core excess reactivity, after refueling and performing rod calibrations, was 3.79% Δ k/k.

No irradiated fuel shipments were made in 2002.

1.3 Safety-Related Procedure Changes

Safety-related procedures are those associated with operation, calibration, and maintenance of the primary coolant, the reactor safety system, the shim-safety rods, all scram functions, the high temperature auto rundown function, and the pool level rundown.

Calibration and Maintenance Procedures

1. CP-208 *Log Count Rate System*, Rev 10 dated 05 Jul 02.
   Provide a clear and consistent method for maintaining the Log Count Rate System.
   No substantial changes were made.
   The notable changes were: 1) Rewrite of procedure in MP-302 format, 2) revision of procedure to use the Ludlum 500 pulser, and 3) Incorporation of the Fission Chamber Replacement procedure CP-303, Revision 3.

2. CP-303 *Fission Chamber Replacement,* Rev 4 dated 05 Jul 02.
   Provide a clear and consistent method for replacing the fission chamber(s) in the Log Count Rate System
   Procedure was deleted due to full incorporation in CP-208.

1.4 Maintenance, Surveillance Tests, and Inspection Results as Required by Technical Specifications.

Maintenance, surveillance tests, and inspections required by Technical Specifications were completed at the prescribed intervals. Procedures, data sheets, and a maintenance schedule/record provide documentation.

1.5 Summary of Changes, Tests, and Experiments for Which NRC Authorization was Required.

Ford Nuclear Reactor submitted Amendment 46 to Technical Specifications. *Elimination of the Requirement for the Pool Gate to be in the Storage Location during Reactor Operation* to the Nuclear Regulatory Commission for review and approval on December 20, 2002. No changes to facility operation will be made until Amendment 46 is approved.

1.6 Operating Staff Changes

The following reactor operations staff changes occurred:

New Hire	Position	Date
Daniel Greve	Reactor Operator II	28 Oct 02

Terminated	Position	Date
Eric Touchberry	Administrative Associate II	08 Sep 02
Heath Downey	Health Physicist	06 Jun 02
Michael Dupree	Engineering Tech II	13 Sep 02

Safety Review Committee Changes

None

2. POWER GENERATION SUMMARY

The following table summarizes reactor annual power generation.

Cycle	Inclusive Dates	Operating Hours	Full Power Operating Hours	Megawatt Hours	Percent Availability
467	01/06/02 - 02/02/02	465.0	449.5	903.6	66.9
468	02/03/02 - 03/02/02	467.8	381.6	766.9	56.8
469	03/03/02 - 03/30/02	45.8	13.1	27.7	1.9
470	03/31/02 - 04/27/02	396.7	336.4	641.8	50.1
471	04/28/02 - 05/25/02	489.2	470.6	946.8	70.0
472	05/26/02 - 06/22/02	323.8	279.4	565.5	41.6
473	06/23/02 - 07/20/02	448.4	436.2	876.7	64.9
474	07/21/02 - 08/17/02	485.6	474.2	951.8	70.6
475	08/18/02 - 09/14/02	459.9	417.2	838.4	62.1
476	09/15/02 - 10/12/02	440.1	429.3	862.9	63.9
477	10/13/02 - 11/09/02	465.1	453.2	909.9	67.4
478	11/10/02 - 12/07/02	379.5	371.4	746.3	55.3
479	12/08/02 - 01/04/03	246.9	231.6	465.1	34.5
	Total:	5113.9	4743.9	9503.5	58.8

3. UNSCHEDULED REACTOR SHUTDOWN SUMMARY

The following summarizes unscheduled reactor shutdowns.

3.1 Shutdown Type Definitions

Single Rod Drop and Multiple Rod Drop (NAR) - An unscheduled shutdown caused by the release of one or more of the reactor shim-safety rods from its electromagnet, and for which at the time of the rod release, no specific component malfunction and no apparent reason (NAR) can be identified as having caused the release.

Operator Action - A condition exists (usually some minor difficulty with an experiment) for which the operator on duty judges that shutdown of the reactor is required until the difficulty is corrected.

Operator Error - The operator on duty makes a judgment or manipulative error that results in shutdown of the reactor.

Process Equipment Failure - Shutdown caused by a malfunction in the process equipment interlocks of the reactor control system.

Reactor Controls - Shutdown initiated by malfunction of the control and detection equipment directly associated with the reactor safety and control system.

Electrical Power Failure - Shutdown caused by interruption in the reactor facility electric power supply.

3.2 Summary of Unscheduled Shutdowns

07 Mar 02 The reactor was shut down due to a misloaded fuel element on the west core face. The reactor was shut down for approximately two weeks. For further details, see Reportable Occurrence #23. **Operator Action**

07 Apr 02 The reactor was shut down due to a Safety Rod "B" drop. The rods were relatched and the reactor was restarted without difficulty. **Single Rod Drop**

14 May 02 The reactor was shut down due to a greater than 25% blockage of a coolant channel by debris. The debris was removed and the reactor was restarted without difficulty. **Operator Action**

16 May 02 The reactor was shut down due to a greater than 25% blockage of a coolant channel by debris. The debris was removed and the reactor was restarted without difficulty. **Operator Action**

20 May 02 The reactor was shut down due to "water hammer" in the fire system piping. It was later determined that the city was flushing fire hydrants and there were no adverse effects on the reactor. The reactor was restarted without difficulty. **Operator Action**

24 Aug 02 The reactor was shut down due to a greater than 25% blockage of a coolant channel by debris. The debris was removed and the reactor was restarted, but the debris reappeared within a few hours (see below). **Operator Action**

24 Aug 02 The reactor was shut down due to a greater than 25% blockage of a coolant channel by debris. The debris was removed and the reactor was restarted without difficulty. **Operator Action**

25 Aug 02 The reactor was shut down due to a wing nut from the sample rotator motors being found on the core. The nut was removed and the reactor was restarted without difficulty. **Operator Action**

06 Nov 02 The reactor was shut down to allow repairs to a leaking RTD well in the primary cooling system. The well was capped and the reactor was restarted without difficulty. **Operator Action**

13 Nov 02 The reactor was shut down due to a greater than 25% blockage of a coolant channel by debris. The debris was removed and the reactor was restarted without difficulty. **Operator Action**

12 Dec 02 The reactor was shut down due to a failure of the Linear Level Servo Controller Unit. The unit was replaced and recalibrated and the reactor was restarted without difficulty. **Operator Action**

19 Dec 02 The reactor was shut down due to a greater than 25% blockage of a coolant channel by debris. The debris was removed and the reactor was restarted, but the debris reappeared within a few hours (see below). **Operator Action**

19 Dec 02 The reactor was shut down due to a greater than 25% blockage of a coolant channel by debris. The debris was removed and the reactor was restarted without difficulty. **Operator Action**

3.3 Characterization of Unscheduled Shutdowns

Single Rod Drop (NAR)	1
Multiple Rod Drop (NAR)	0
Operator Action	12
Operator Error	0
Process Equipment Failure	0
Reactor Controls	0
Electric Power Failure	0
Total Unscheduled Shutdowns	13

4. CORRECTIVE MAINTENANCE ON SAFETY RELATED SYSTEMS AND COMPONENTS

06 Feb 02 Log Count Rate #1 chamber housing was flooded. Installed Swagelock fitting to provide a 3/8 inch tube adapter barb.

01 Apr 02 Temperature Recorder was non-functional after replacing thermal print head. Repaired and Calibrated by outside repair firm specializing in Leeds and Northrup recorders.

03 Apr 02 Log N Period recorder Failed. Drive motor replaced. Chain and gears oiled.

02 Jun 02 Position #5 on the Temperature Recorder was not indicating correctly. Replaced AC1362 a 20-ohm resistor and calibrated position #5.

03 Jun 02 Failure of the Annunciator Flasher Relay. Replaced Flasher Relay and refurbished a number of alarm and acknowledge relays.

22 Jul 02 Log Count Rate #1 noise. Complete overhaul of #1 LCR. New fission chamber, signal cable, hose hardware and connections.

22 Jul 02 The analog input card for the radiation recorder was sending voltage noise back to the input instruments. Due to the low signal level of the airborne particulate detectors (0-5mV) erratic readings for the airborne monitors resulted. Isolating amplifiers were installed between the rate meters and radiation recorder inputs. These isolating amplifies provide 5 times amplification so the radiation recorder for the affected channels was re-programmed radiation recorder channels 9, 10 and 11 for a times 5 input. The radiation recorder was calibrated by applying an external source to the affected instruments.

27 Jul 02 Radiation Recorder slide wire for printhead broke. Replaced slide wire.

12 Aug 02 Emergency Generator gas supply line broke. Replaced supply line.

25 Sep 02 FNR GAD failed. Replaced detector and completed GAD checks.

06 Nov 02 The T-ATV sensor well on the primary coolant system developed a small leak. Removed well and associated T-ATV sensor and installed cap. This sensor was taken out of service in the late 1970's.

12 Dec 02 Linear Level Servo Control Unit failed. Replaced with spare.

5. CHANGES, TESTS, AND EXPERIMENTS CARRIED OUT WITHOUT PRIOR NRC APPROVAL PURSUANT TO 10CFR50.59(a)

None

6. RADIOACTIVE EFFLUENT RELEASE (2002)

Quantities and types of radioactive effluent releases, environmental monitoring locations and data, and occupational personnel radiation exposures are provided in this section.

6.1 Gaseous Effluents - ^{41}Ar Releases
Gaseous effluent concentrations are averaged over a period of one year.

	Quantity	Unit
a. Total gross radioactivity.	3.21×10^{6}	µCi
b. Average concentration released.	9.32×10^{-9}	µCi/ml
c. Average release rate.	0.10	µCi/sec
d. Maximum instantaneous concentration during special operations, tests, and experiments.	Not Applicable	µCi/ml
e. Percent of ^{41}Ar ERL (Effluent Release Limits) (1.0×10^{-8} µCi/ml) without dilution factor.	93	Percent
f. Percent of ^{41}Ar ERL with a dilution factor of 400.	0.23	Percent

6.2 Radiohalogen Releases

a. Total iodine radioactivity by nuclide based upon a representative isotopic analysis. (Required if iodine is identified in primary coolant samples or if fueled experiments are conducted at the facility). Based on this criteria, this section of the report is not required. The analysis is based on primary coolant activity following one week of decay.

The pool water analyses show no indication of leaking fuel.

b. ^{131}Iodine releases related to steady state reactor operation (Sample C-3, main reactor exhaust stack).

	Quantity	Unit
1. Total ^{131}I release.	6	µCi
2. Average concentration released.	2.80×10^{-14}	µCi/ml
3. Percent of ^{131}I ERL (2.0×10^{-10} µCi/ml) without dilution factor.	0.014	Percent
4. Percent of ^{131}I ERL with 400 dilution factor.	0.00004	Percent

c. Radiohalogen releases related to combined steady state reactor operation and radiation laboratory activities (Sample C-2; combined secondary reactor exhaust and partial radiation laboratory exhaust).

1. Total C-2 stack radiohalogen releases.

	Quantity	Unit
Br-80m	414	µCi
Br-82	3288	µCi
I-131	34	µCi
Hg-203	6	µCi

2. Average concentration released.

Br-80m	3.28×10^{-12}	µCi/ml
Br-82	2.60×10^{-11}	µCi/ml
I-131	2.71×10^{-13}	µCi/ml
Hg-203	5.09×10^{-14}	µCi/ml

3. Percent of ERL without the dilution factor.

Br-80m	0.02	Percent
Br-82	0.52	Percent
I-131	0.14	Percent
Hg-203	0.01	Percent

4. Percent of ERL with a dilution factor of 400.

Br-80m	0.00004	Percent
Br-82	0.00130	Percent
I-131	0.00034	Percent
Hg-203	0.00001	Percent

d. Total Facility Release of Radiohalogens.

1. Total facility radiohalogen releases.

Br-80m	257768	µCi
Br-82	1813	µCi
I-125	357	µCi
I-131	3650	µCi
Hg-203	26	µCi

2. Average concentration released.

Br-80m	3.96×10^{-10}	µCi/ml
Br-82	2.78×10^{-12}	µCi/ml
I-125	5.48×10^{-13}	µCi/ml
I-131	5.61×10^{-12}	µCi/ml
Hg-203	3.99×10^{-14}	µCi/ml

3. Percent of ERL without the dilution factor.

	Quantity	Unit
Br-80m	1.980	Percent
Br-82	0.0556	Percent
I-125	0.183	Percent
I-131	2.805	Percent
Hg-203	0.004	Percent
TOTAL	5.0276	Percent

4. Percent of ERL with a dilution factor of 400.

Br-80m	0.005	Percent
Br-82	0.00014	Percent
I-125	0.00046	Percent
I-131	0.007	Percent
Hg-203	0.00001	Percent
TOTAL	0.01675	Percent

6.3 Particulate Releases

Particulate activity for nuclides with half lives greater than eight days.

	Quantity	Unit
a. Total gross radioactivity.	148	μCi
b. Average concentration.	2.42×10^{-13}	μCi/ml
c. Percent of ERL (1.0×10^{-12} μCi/ml) without dilution factor.	24.2	Percent
d. Percent of ERL with a dilution factor of 400.	0.061	Percent

Gross alpha activity is required to be measured if the operational or experimental program could result in the release of alpha emitters.

e. Gross alpha radioactivity.	Not Required

6.4 Liquid Effluents

No radioactive liquid effluents were released from the facility in 2002.

6.5 Accident Evaluation Monitoring

The accident evaluation monitoring program for the Ford Nuclear Reactor facility consists of direct radiation monitors (TLD), air sampling stations located around the facility, and selected water and sewer sampling stations.

a. **TLD Monitors (Landauer X9 Aluminum Oxide)**

TLDs located at stations to the north (lawn adjacent to the reactor building), northeast (Fluids), east (Beal Avenue), south (Glazier Way), and west (School of Music) of the reactor facility are collected and sent to a commercial dosimetry company for analysis.

Location	Yearly Total (mRem)
Fluids (NE)	31.8
Glazier Way (S)	25.8
FNR Lawn (N)	35.2
Beal (E)	30.6
School Of Music (W)	22.6
Environmental Control	32.0

b. **Dust Samples**

Five air grab samples are collected weekly from continuously operating monitors located to the north (Northwood Apartments), east (Industrial and Operations Engineering), south (Institute of Science and Technology), and west (Media Union) of the reactor facility. Each filter sample is counted for net beta activity. There are 43 samples included in this report for each location. Gas proportional counter backgrounds have been subtracted from the concentrations reported. Environmental background (University of Michigan Botanical Gardens) has not been subtracted from the mean radioactivity concentrations shown below.

Station Description	Mean Concentration	Unit
Northwood (N)	2.15×10^{-14}	μCi/ml
Industrial and Operations Engineering (E)	2.57×10^{-14}	μCi/ml
Media Union (W)	2.53×10^{-14}	μCi/ml
Institute of Science and Technology (S)	2.49×10^{-14}	μCi/ml
Environmental Control (Background)	2.74×10^{-14}	μCi/ml

The results of air sampling expressed in percentages of the Effluent Release Limits (1.0×10^{-12} μCi/ml) are shown below.

Station Description	Percent ERL	Unit
Northwood (N)	2.15	Percent
Industrial and Operations Engineering (E)	2.57	Percent
Media Union (W)	2.53	Percent
Institute of Science and Technology (S)	2.49	Percent
Environmental Control (Background)	2.74	Percent

c. **Water Samples**

No radioactive liquid effluents were released from the facility in 2002.

d. **Sewage Samples**

No radioactive liquid effluents were released from the facility in 2002.

e. **Maximum Cumulative Radiation Dose**

The maximum cumulative radiation dose, which could have been received by an individual continuously present in an unrestricted area during reactor operations from direct radiation exposure, exposure to gaseous effluents, and exposure to liquid effluents:

1. Direct radiation exposure to such an individual is negligible since a survey of occupied areas around the reactor building shows insignificant radiation dose rates above background from the reactor.

2. Airborne Effluents

The airborne effluents from the reactor and the contiguous laboratory facility are as follows:

Isotope	Total Release (µCi)	Concentration (µCi/ml)	%ERL Undiluted	% ERL Diluted
Ar-41	3210000	9.32×10^{-9}	93	.23
Br-80m	257768	3.96×10^{-10}	1.980	.005
Br-82	1813	2.78×10^{-12}	.0556	.00014
Hg-203	26	3.99×10^{-14}	.004	.00001
I-125	357	5.48×10^{-13}	.183	.00046
I-131	3650	5.61×10^{-12}	2.805	.007
Gross Particulate	148	2.42×10^{-13}	24.2	.061
TOTAL			122.2276	0.30361
Equivalent Radiation Dose (mrem)				0.15

The total airborne effluent releases are well within the allowed release concentrations when the conservative dilution factor of 400 is applied.

The equivalent total dose from all airborne effluent releases is well below the 10 mrem per year constraint described in NRC Information Notice 97-04, "Implementation of a New Constraint on Radioactive Air Effluents."

3. Liquid Effluents

No radioactive liquid effluents were released from the reactor and the contiguous laboratory facility in 2002.

f. If levels of radioactive materials in environmental media, as determined by an environmental monitoring program, indicate the likelihood of public intake in excess of 1% of those that could result from continuous exposure to the concentration values listed in Appendix B, Table 2, 10CFR20, the facility is required to estimate the likely resultant exposure to individuals and to population groups and the assumptions upon which those estimates are based. Exposure of the general public to 1 ERL would result in a whole body dose of 50 mrem. The maximum public dose based on airborne and liquid effluent releases of 0.30% ERL is 0.15 mrem. This dose is based on a member of the public being continuously present at the point of minimum dilution near the reactor building.

6.6 Occupational Personnel Radiation Exposures

Individuals for whom the annual whole body radiation exposure exceeded 500 mrem (50 mrem for person under 18 years of age) during the reporting period:

The final dosimetry reports for calendar year 2002 revealed that two personnel have received annual whole body dose greater than 500 mrem. One user received 569 mrem and a second user received 690 mrem.