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

29 March 2003

American Nuclear Insurers
Attn: Mark Poirier
95 Glastonbury Blvd.
Galstonbury, Connecticut 06033

Insuree: Ford Nuclear Reactor, Docket 50-2, License R-28

Dear Mr. Poirier;

Enclosed is the written annual report required by Technical Specifications for the period of 01 January through 31 December 2003.

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, 2003

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Annual Report
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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, 2003. 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 operated 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

See Section 5, *Changes, Tests, and Experiments Carried Out without Prior NRC Approval Pursuant to 10 CFR 50.59(a)*.

1.2 Equipment and Fuel Performance Characteristics

Performance Characteristics. The reactor was refueled on February 3-4, 2003. 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 rod calibrations, was 3.6176 % Delta-K/K.

The reactor was shutdown permanently and ceased further operation on July 3, 2003 at 15:34 hours.

No new fuel assemblies were received.

Four remaining new fuel assemblies (one control and three regulars) were shipped back to the supplier, BWXT (ZMZ-ZBF-01) on 19 August 2003.

Seven irradiated fuel shipments were made in October, November and December 2003 (ZMZ-DZA-34, ZMZ-DZA-35, ZMZ-DZA-36, ZMZ-DZA-37, ZMZ-DZA-38, ZMZ-DZA-39, and ZMZ-DZA-40). This campaign shipped all of Ford Nuclear Reactor's irradiated fuel to Westinghouse Savannah River Site.

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.

Operating Procedures

1. OP-109, *Response to Scrams, Alarms and Abnormal Conditions,* Rev 8 dated 21 Feb 03
   Provide the proper response for the console operator to scrams, alarms and abnormal conditions in the facility.
   No substantial changes were made.
   The procedure was reformatted and the responses to emergency conditions were updated or added to support the rewrite of the Emergency Plan.

2. OP-110, *Movement of Reactor Fuel and Reactor Refueling,* Rev 2 dated 31 Jan 03
   Provides the techniques, inspections, control, and methods involved in the movement of reactor fuel and refueling and maintaining the reactor core.
   No substantial changes were made.
   The procedure was rewritten and fully incorporated a variety of administrative and maintenance procedures to provide for one procedure to address refueling of the reactor and all associated maintenance. Proceduralized the inspections and handling techniques previously provided through training on the proper handling of reactor fuel and refueling of the reactor. Incorporated the recommendations and root causes from Reportable Occurrence No. 23.

3. OP-110, *Movement of Reactor Fuel and Reactor Refueling,* Rev 3 dated 29 Sep 03
   Provides the techniques, inspections, control, and methods involved in the movement of reactor fuel and refueling and maintaining the reactor core.
   No substantial changes were made.
   Approved the use of a shortened checklist for fuel movement. Added steps to the Pre-Fuel Movement Checklist to better verify confinement. Modified the checks of the fuel vault criticality monitors and the Log Count Rate system only when conditions required. Added steps for the loading of control fuel elements into the irradiated fuel shipping cask.

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.

Amendment 46 – Pool Gate: Allowed for reactor operation with the reactor pool gate. Installed the pool gate separates the main area of the pool (where the reactor is located) from the southern area.

Amendment 47 – Possession Only License Amendment Request: Removed the authority to operate the reactor, eliminated the possession of special nuclear material, eliminated the Physical Security Plan, and maintained the authority to make changes and conduct tests and experiments.

1.6 Operating Staff Changes

The following reactor operations staff changes occurred:

New Hire	Position	Date
Anthony H. Francis, Ph.D.	Director	20 Jun 03
Eric Touchberry	Administrative Associate II	17 Feb 03
Thomas O'Donnell, Ph.D	Health Physicist (50%)	11 Feb 03

Terminated	Position	Date
David Wehe, Ph.D.	Director	20 Jun 03
William Snyder	Engineering Tech	12 May 03
Christopher Berg	Reactor Operator	15 Aug 03
Andrew Cook	Reactor Engineer	22 Aug 03

Safety Review Committee Changes

John C. Lee, Chairman resigned 01 Jul 03
William R. Martin became Chairman on 01 Jul 03

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
480	01/05/03 - 02/01/03	493.6	466.1	937.3	69.4
481	02/02/03 - 03/01/03	489.9	446.8	895.4	66.5
482	03/02/03 - 03/29/03	492.6	449.7	903.3	66.9
483	03/30/03 - 04/26/03	345.1	313.5	633.7	46.7
484	04/27/03 - 05/24/03	469.1	455.5	913.8	67.8
485	05/25/03 - 06/21/03	468.4	461.6	925.8	68.7
486*	06/22/03 - 07/19/03	221.4	215.4	432.8	32.1
	Total:	2980.1	2808.6	5642.1	59.7

* Final Reactor Shutdown 07/03/2003

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

06 Feb 03 The reactor was shutdown due to an electrical power failure. Electrical power was restored and the reactor was restarted without difficulty. **Electrical Power Failure**

10 Feb 03 The reactor was shutdown due to no watch relief. The control room was restaffed and the reactor was restarted without difficulty. **Operator Action**

12 Feb 03 The reactor was shutdown 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**

18 Feb 03 The reactor was shutdown 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**

19 Feb 03 The reactor was shutdown 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**

22 Feb 03 The reactor was shutdown 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 Feb 03 The reactor was shutdown 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**

04 Mar 03 The reactor was shutdown 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**

05 Mar 03 The reactor was shutdown due to no watch relief. The control room was remanned and the reactor was restarted without difficulty. **Operator Action**

06 Mar 03 The reactor was shutdown 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**

07 Mar 03 The reactor was shutdown three times during the day due to a greater than 25% blockage of a coolant channel by debris. During each of the three occurrences the debris was removed and the reactor was restarted without difficulty. **Operator Action**

27 Mar 03 The reactor was shutdown 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**

02 May 03 The reactor was shutdown 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**

03 May 03 The reactor was shutdown 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**

05 May 03 The reactor was shutdown due to a Tornado Warning. The warning cleared and the reactor was restarted without difficulty. **Operator Action**

17 May 03 The reactor was shutdown twice during the day due to a greater than 25% blockage of a coolant channel by debris. During both occurrences the debris was removed and the reactor was restarted without difficulty. **Operator Action**

3.3 Characterization of Unscheduled Shutdowns

Single Rod Drop (NAR)	0
Multiple Rod Drop (NAR)	0
Operator Action	15
Operator Error	0
Process Equipment Failure	0
Reactor Controls	0
Electric Power Failure	1
Total Unscheduled Shutdowns	16

4. CORRECTIVE MAINTENANCE ON SAFETY RELATED SYSTEMS AND COMPONENTS

10 January 2003 - Stack #2 Mobile Air Particulate system detector end window failure. The detector was replaced, the unit was recalibrated, and Conditions Checks were performed prior to returning the unit to operability.

21 March 2003 - Stack #2 Mobile Air Particulate system output to the Control Room Radiation Recorder failed. A loose wire on the output connector was re-attached, and Condition Checks were performed prior to returning the unit to operability.

27 June 2003 - The Annunciator System Reset switch failed to open (to reset the annunciator) during routine pre-startup checks. A duplicate reset switch was wired in series to perform the same function.

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

Holes in the Beamport Floor – to support the site characterization of the FNR, soil samples were collected through the floor of the reactor building to a depth of 25 feet. These samples were taken to assess the potential impact from pool leakage and a known loss of approximately 7,500 gallons of radioactive water from backflow from the cold sump in 1993 (Reportable Occurrence No. 18). The activity was conservatively evaluated as a "test or experiment" because of uncertainty as to whether the floor was being utilized or controlled in a manner outside or inconsistent with the current licensing basis. This review determined that prior approval of the NRC was not required.

Pool Filtration System – the pool filtration system was changed from a sand filter to a bag filter system which included a heater and demineralizer column for maintaining the reactor pool following the permanent shutdown of the FNR.

Gaseous Nitrogen Supply Removal – the supply of gaseous nitrogen to the reactor building was cut and capped to facilitate the removal of the bulk liquid nitrogen tank.

6. RADIOACTIVE EFFLUENT RELEASE

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.	$1.59 \times 10^{+7}$	µCi
b. Average concentration released.	4.46×10^{-8}	µCi/ml
c. Average release rate.	0.48	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.	445.57	Percent
f. Percent of ^{41}Ar ERL with a dilution factor of 400.	1.11	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.	7.23	µCi
2. Average concentration released.	3.53×10^{-14}	µCi/ml
3. Percent of ^{131}I ERL (2.0×10^{-10} µCi/ml) without dilution factor.	0.0176	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	1,151	µCi
Br-82	367	µCi
I-131	84.8	µCi
Hg-203	2.8	µCi

2. Average concentration released.

Br-80m	9.49×10^{-12}	µCi/ml
Br-82	3.03×10^{-11}	µCi/ml
I-131	7.00×10^{-13}	µCi/ml
Hg-203	2.33×10^{-14}	µCi/ml

3. Percent of ERL without the dilution factor.

Br-80m	4.75×10^{-2}	Percent
Br-82	6.05×10^{-2}	Percent
I-131	3.50×10^{-1}	Percent
Hg-203	3.22×10^{-3}	Percent

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

Br-80m	1.19×10^{-4}	Percent
Br-82	1.51×10^{-4}	Percent
I-131	8.74×10^{-4}	Percent
Hg-203	5.83×10^{-6}	Percent

d. Total Facility Release of Radiohalogens.

1. Total facility radiohalogen releases.

Br-80m	47,120	µCi
Br-82	590	µCi
I-125	557	µCi
I-131	12,269	µCi
Hg-203	52	µCi

2. Average concentration released.

Br-80m	4.86×10^{-11}	µCi/ml
Br-82	6.09×10^{-13}	µCi/ml
I-125	5.74×10^{-13}	µCi/ml
I-131	1.27×10^{-11}	µCi/ml
Hg-203	5.35×10^{-14}	µCi/ml

3. Percent of ERL without the dilution factor.

	Quantity	Unit
Br-80m	0.243	Percent
Br-82	0.012	Percent
I-125	0.191	Percent
I-131	6.328	Percent
Hg-203	0.005	Percent
TOTAL	6.780	Percent

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

Br-80m	0.001	Percent
Br-82	0.000	Percent
I-125	0.000	Percent
I-131	0.016	Percent
Hg-203	0.000	Percent
TOTAL	0.017	Percent

6.3 Particulate Releases

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

	Quantity	Unit
a. Total gross radioactivity.	118.41	µCi
b. Average concentration.	2.38×10^{-13}	µCi/ml
c. Percent of ERL (1.0×10^{-12} µCi/ml) without dilution factor.	23.80	Percent
d. Percent of ERL with a dilution factor of 400.	0.06	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 2003.

6.5 **Environmental 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)	39.7
Glazier Way (S)	32.7
FNR Lawn (N)	41.2
Beal (E)	38.8
School Of Music (W)	27.6
Environmental Control	33.1

b. **Air Particulate 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)	3.68×10^{-14}	µCi/ml
Industrial and Operations Engineering (E)	3.54×10^{-14}	µCi/ml
Media Union (W)	3.13×10^{-14}	µCi/ml
Institute of Science and Technology (S)	3.24×10^{-14}	µCi/ml
Environmental Control (Background)	2.47×10^{-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)	3.68	Percent
Industrial and Operations Engineering (E)	3.54	Percent
Media Union (W)	3.13	Percent
Institute of Science and Technology (S)	3.24	Percent
Environmental Control (Background)	2.47	Percent

c. **Water Samples**

No radioactive liquid effluents were released from the facility in 2003.

d. **Sewage Samples**

No radioactive liquid effluents were released from the facility in 2003.

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	$1.59 \times 10^{+7}$	4.46×10^{-08}	446	1.11
Br-80m	$4.72 \times 10^{+4}$	4.86×10^{-11}	0.243	0.001
Br-82	$5.90 \times 10^{+2}$	6.09×10^{-13}	0.012	0.000
Hg-203	$5.18 \times 10^{+1}$	5.35×10^{-14}	0.005	0.000
I-125	$5.57 \times 10^{+2}$	5.74×10^{-13}	0.191	0.000
I-131	$1.23 \times 10^{+4}$	1.27×10^{-11}	6.328	0.016
Gross Particulate	$1.18 \times 10^{+2}$	2.38×10^{-13}	23.80	0.061
TOTAL			476.579	1.171
Equivalent Radiation Dose (mrem)				0.56

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 2003.

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 1.17% ERL is 0.56 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 2003 revealed that one staff member received an annual whole body dose greater than 500 mrem. The staff member received 638 mrem.