The University of Michigan

MICHIGAN MEMORIAL – PHOENIX PROJECT
PHOENIX MEMORIAL LABORATORY   FORD NUCLEAR REACTOR
ANN ARBOR, MICHIGAN 48109-2100

May 31, 2001

Document Control Desk
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Re: License R-28
Docket 50-2

Dear Sir:

The enclosed REPORT ON REACTOR OPERATIONS, is for the period of January 1, 2000 to December 31, 2000 as required by Technical Specification 6.6.1 *Annual Operating Report.*

Sincerely,

Christopher W. Becker

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Reactor Laboratory Manager

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REPORT OF REACTOR OPERATIONS

January 1, 2000 - December 31, 2000

FORD NUCLEAR REACTOR

MICHIGAN MEMORIAL - PHOENIX PROJECT

THE UNIVERSITY OF MICHIGAN

ANN ARBOR

March 2001

Prepared For

The U.S. Nuclear Regulatory Commission

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, 2000. 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.

Tours are provided for school children, university students, and the public at large as part of a public education program. During the year 2011 people participated in 127 tours.

The operating schedule of the reactor enables a sustained high level of participation by research groups. Continued support by the Department of Energy through the University Research Reactor Assistance Program (Contract No. J-AF-4000-000 (DE-AC02-76ER00385)) and the Reactor Facility Cost Sharing Program (Contract No. DE-FG07-80ER10724) has been essential to maintaining operation of the reactor facility.

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 428 and ended with cycle 440. 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

Modification 140. *Addition of an External Voltage Divider Circuit to the Linear Level Instrument Compensating Voltage Power Supply.* This modification provided continuous adjustment to the ion chamber compensation voltage below the minimum 5 Vdc increments that are allowed by the NMP-1000 Linear Power Channel. The 10 CFR 50.59 evaluation showed that this was a refinement to a preexisting system described in the Safety Analysis Report that will improve the linear level instrument channel sensitivity at low power levels without affecting its performance or linearity at intermediate or high power levels. This will provide operators with better power level information at low power levels. A review of the Safety Analysis Report and Technical Specifications concluded that making the linear level compensating voltage continuously adjustable could be implemented under 10 CFR 50.59.

1.2 Equipment and Fuel Performance Characteristics

None

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-101, *Reactor Maintenance Schedule*, Rev 20 dated 25 Jan 00.
Identifies frequency requirements for routine maintenance items, and sets guidelines for scheduling routine and non-routine maintenance for shutdown periods.
No substantial changes were made.
The notable changes were 1) deletion of Emergency Generator Test, 2) deletion of Emergency Generator Test (Honda), 3) addition of monthly emergency generator maintenance and 4) update of activities from the changes to the CP's during the past year.

2. CP-205, *Safety Channel A and B Calibration*, Rev 9 dated 18 Feb 00.
Provides a safe and consistent method for calibrating the Safety Channels A and B.
No substantial changes were made.
The notable changes were 1) changed "TP" to "E" to match the schematic, 2) delete references to resister string which is not used, 3) delete references to a specific picoammeter source, 4) acknowledge J4 connector in module removal, 5) step to verify meter indication has not changed, 5) change the voltage to 440 volts after setting the low voltage trip, 6) new schematic and 7) editing changes.

3. CP-218, *Magnet Power Supply Calibration*, Rev 2 dated Apr 12 00.
Provides a safe and consistent method for calibrating the safety system magnet power supply.
No substantial changes were made.
The notable changes were 1) addition of a mounted 150Ω resistor inside the module was incorporated into the procedure and 2) step for that if the module is installed for use, then Rod Drop and Release times must be measured.

4. CP-206, *Safety System Period Channel C Calibration*, Rev 17 dated Sep 28 00.
Provides a consolidated standardized procedure for calibration of the Log Power Channel including the recorders, using a calibrated current source.
No substantial changes were made.
The only change was widening the band on the console period meter due to lag time.

Administrative Procedures

1. AP-301, *Reactor Fuel*, Rev 22 dated 25 Jan 00.
Prescribe techniques for handling reactor fuel and for keeping fuel records.
No substantial changes were made.
The notable changes were 1) ensuring a Full Building Check and Operations Check is complete for the current shift, by adding an additional step to the procedure and 2) ensuring a Full Building Check and Operations Check is complete for the current shift, by adding an additional check to the Fuel Movement Checklist.

2. AP-301 *Reactor Fuel*, Rev 23 dated 28 Jun 00.
Prescribe techniques for handling reactor fuel and for keeping fuel records.
No substantial changes were made.
The notable change was deletion of Fuel Racks from Fuel Location Data Sheet, due to removal from pool.

Operating Procedures

1. OP-102, *Reactor Shutdown*, Rev 16 dated 17 Jan 00.
   Provide consistent manipulation of controls and sequence of operations for routine reactor shutdown at the conclusion of an operating cycle or for a holiday.
   No substantial changes were made.
   The notable change was re-wording of various steps.

2. OP-101, *Reactor Startup*, Rev 38 dated 25 Jan 00.
   Promote consistent manipulation of controls and sequence of operations for reactor startup in natural and forced circulation though the use of three independent startup sequences, including excess reactivity determination and calorimeter calibration of nuclear instruments.
   Substantial changes were made to this procedure by a comprehensive rewrite. The changes were, 1) splitting the procedure into three separate startups, Forced Circulation (Shutdown > 24 Hours), Forced Circulation (Shutdown < 24 Hours), Natural Circulation, 2) incorporation of calorimeter into this procedure, then deletion of calorimeter procedure, 3) incorporation of core excess reactivity into this procedure, then deletion of core excess reactivity procedure, 4) requirement of two initials for certain startup checklist steps, 5) acceptance criteria for certain numerical values on the startup checklist, 6) addition of a Reactor Startup Data Sheet 7) addition of various notes and bases.
   Notable change was removal of Cycle Operation Checklist and Operating Schedule from startup procedure.

3. OP-103, *Reactor Operation, Maintenance, Systems and Components*, Rev 36 dated 3 Feb 00.
   Provide consistent procedures for operation of the reactor and its associated equipment at power and during shutdown for maintenance.
   No substantial changes were made.
   Notable changes were 1) addition of Cycle Operation Checklist and Operating Schedule, 2) establishing rod heights between 6" and 22" when at power, 3) allows for removal of items > 100 mrem/hr from pool if properly posted and 4) various editing changes.

4. OP-103, *Reactor Operation, Maintenance, Systems and Components*, Rev 37 dated 7 Feb 00.
   Provide consistent procedures for operation of the reactor and its associated equipment at power and during shutdown for maintenance.
   No substantial changes were made.
   Notable change was removal of Primary Pump Alignment from Cycle Operation Checklist.

5. OP-201 *Building Checklist*, Rev 41 dated 28 June 00.
   Provide specific requirements for items on the Building Checklist.
   No substantial changes were made.
   Notable changes were 1) additions of ISTC data and 2) Combo-only keypad: Enabled or Off.

6. OP-103, *Reactor Operation, Maintenance, Systems and Components,* Rev 38 dated 12 Sep 00.
   Provide consistent procedures for operation of the reactor and its associated equipment at power and during shutdown for maintenance.
   No substantial changes were made.
   The only notable change was to delineate each system to have a separate check on the Cycle operation Checklist.

7. OP-101 *Reactor Startup*, Rev 39 dated 29 Sep 00.
   Promote consistent manipulation of controls and sequence of operations for reactor startup in natural and forced circulation though the use of three independent startup sequences, including excess reactivity determination and calorimeter calibration of nuclear instruments.
   No substantial changes were made.
   The only notable change to the procedure was editing changes.

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.

None

1.6 Operating Staff Changes

The following reactor operations staff changes occurred:

New Hire	Position	Date
Andrew Cook	Engineering Tech. II	April 03, 2000
Robb Thomas	Engineering Tech. II	June 05, 2000
Michael Dupree	Engineering Tech. II	Nov. 13, 2000

Terminated	Position	Date
Michael Landis	Reactor Operator	February 25, 2000
Richard McCue	Reactor Operator	June 30, 2000

Safety Review Committee Changes

The following Safety Review Committee Changes occurred:

New Appointees	Position	Date
William Lipton	Outside Member	Nov. 02, 2000

Removed Appointees	Position	Date
William Martin	Faculty Member	Nov. 02, 2000

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
441	01/09/00 - 02/06/00	273.0	228.9	462.6	34.0
442	02/06/00 - 03/04/00	495.5	472.9	950.0	70.4
443	03/05/00 - 04/01/00	461.0	385.2	778.2	57.3
444	04/02/00 - 04/29/00	463.8	427.7	859.1	63.6
445	04/30/00 - 05/26/00	475.1	458.2	923.0	68.2
446	05/27/00 - 06/24/00	473.7	435.2	877.2	64.8
447	06/25/00 - 07/22/00	463.8	446.8	900.5	66.5
448	07/23/00 - 08/19/00	280.3	230.2	472.4	34.3
449	08/20/00 - 09/16/00	440.2	404.4	813.7	60.2
450	09/17/00 - 10/14/00	493.9	475.9	957.4	70.8
451	10/15/00 - 11/11/00	492.1	481.1	966.4	71.6
452	11/12/00 - 12/09/00	440.8	401.9	808.2	59.8
453	12/10/00 - 01/06/01	244.1	236.3	474.6	35.2
	Totals:	5497.3	5084.7	10243.3	58.2

3. UNSCHEDULED REACTOR SHUTDOWN SUMMARY

The following table 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 which 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

25 Jan 00 The reactor was shut down due to a small piece of debris on the elements in location L45, L65, and L68, source unknown. The fuel element was removed from the core in accordance with AP-301, *Reactor Fuel* and shaken to dislodge the debris. The fuel element was then returned to its original location in the core. **Operator Action.**

03 Feb 00 The reactor scrammed following a loss of electrical power to PML. The On-call Supervisor gave permission for an immediate restart upon restoration of electrical service. The reactor restarted 10 minutes after the loss. **Electrical Power Failure.**

22 Feb 00 The reactor scrammed during 2 MW operation from a "Percent Power" trip on Safety Channel B. Inspection of module revealed a loose/broken signal connector. The connector was replaced and all connectors were checked in satisfactory condition. **Reactor Controls.**

09 May 00 The reactor was shut down because of a tornado warning for Washtenaw county. The reactor was restarted after the warning was lifted. **Operator Action.**

15 May 00 The reactor was shutdown due o less than expected on temperature reading on Core Exit Temperature Channel (T1) following RTD replacement. The original RTD was reinstalled, the channel calibrated, and reactor restarted. The original RTD was replaced later without incident. **Reactor Controls.**

02 Jun 00 The reactor was shut down following an auto rundown from the linear level system. While operating at 2MW a "High Power" auto rundown (set point of 103%) was received while the Shift Supervisor was performing a shim operation at a linear level setpoint of 102.3%. **Operator Error.**

15 Aug 00 The reactor was shut down for calibration test of Safety Channel B due to a step indication change between operation checks. CP-205, *Safety Channel A and B Calibration* and CP-209, *Calibration Check of Linear Level, Log N, Period and Log Count Rate (LCR) Systems* were performed on Safety Channel B satisfactorily and restart authorized. **Reactor Controls.**

09 Sep 00 Reactor shutdown by operator due to loss of recorder indications from a power interruption caused by a short circuit in the annunciator circuit. The short circuit was repaired, fuses replaced and restart authorized. **Reactor Controls.**

30 Nov 00 The reactor scrammed on H-Port door open interlock due to a technician moving electrical wire while cleaning near H-Port. The interlock was placed in "defeated" and restart authorized. The material deficiency will be corrected when the beamport is put into service. **Process Equipment Failure.**

08 Dec 00 The reactor was shut down due to the Shift Supervisor not being able to contact plant operator via announcing system. The Shift Supervisor removed the magnet power key and left the control room to find the plant operator. The plant operator was filling the liquid nitrogen dewar and could not hear the announcements due to the hearing protection equipment he was using. An OP-101, *Reactor Startup* checklist was performed, and a restart was authorized. Permanent corrective actions are pending. **Operator Action.**

3.3 Characterization of Unscheduled Shutdowns

Single Rod Drop (NAR)	0
Multiple Rod Drop (NAR)	0
Operator Action	3
Operator Error	1
Process Equipment Failure	1
Reactor Controls	4
Electric Power Failure	1
Total Unscheduled Shutdowns	10

4. CORRECTIVE MAINTENANCE ON SAFETY RELATED SYSTEMS AND COMPONENTS

10 Jan 00 Log N High voltage was found improperly connected to compensation voltage after routine maintenance had been conducted. The connections were switched to the proper locations. Reutor-Stokes was contacted to verify no internal damage was likely to have occurred. All NI's were color-coded and tethered to prevent further occurrences.

17 Jan 00 While performing a startup checklist, C rod magnet current loss was noted. The cable between the bridge terminals and C magnet plug was replaced. The problem returned on 18 Jan 00 and the magnet power supply was replaced with the spare module.

22 Mar 00 While performing a startup checklist, Linear Level channel indication failed to a zero signal. The CIC was replaced with a spare CIC. The bridge terminal box connectors for Linear Level were replaced. Meggar and continuity checks were also performed.

30 Jun 00 Magnet power supply failed to calibrate during routine maintenance. Investigation revealed a TISV regulator had failed, due to a short in a capacitor. The TISV regulator and capacitor were replaced. In addition all IC's that are socket type were also replaced.

10 Jul 00 The Core Exit (T1) RTD well was replaced to be consistent with other RTD's in the temperature system. A new longer and larger I.D. well (1/4 ") was installed in the holdup tank.

03 Aug 00 Loss of Linear Level was noted during a startup checklist. Trouble-shooting indicated a loss of compensating voltage. Cables were replaced from the bridge to the control room. In addition a compensating voltage adjustment and indication panel was added in the control room. Subsequent reactor experiments indicated compensation voltage should be set at –7.5 volts.

15 Aug 00 The reactor was shutdown when a step change was noted on "B" Safety from 2.06 to 2.01. CP-205, *Safety Channel A and B Calibration* was performed. Resistors R120 (zero set) and R123 (scale trim) were adjusted.

06 Sep 00 Channel B on the Magnet Power Supply was noticed to be slowly oscillating between 72 and 65 ma. The magnet power supply was replaced with the spare.

09 Sep 00 The reactor was manually shut down due to a loss of recorders. A short, resulting in an over current condition, caused a blown fuse in circuit #5. Repairs performed were replacement of the red light socket for the bridge not clamped alarm, replacement of the manual push button for the building alarm in the control console and replacement of the annunciater flasher alarm.

10 Sep 00 While performing a startup checklist, sluggish indication on Channel "C" Magnet Power Supply Channel was observed. Both Channel "C" op amps were replaced.

17 Oct 00 While performing a startup checklist, the failure of the flow system was noted. Investigation revealed an internal fault in the 24-volt dc power supply. A replacement 24-volt dc power supply with equivalent or greater capacity was installed.

27 Nov 00 While performing a channel check of Log N, the recorder was noted to be reading low (0.0). Investigation led to a bad op amp which was replaced on NLI-1000 Log Current amplifier board.

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

Modification 140. *Addition of an External Voltage Divider Circuit to the Linear Level Instrument Compensating Voltage Power Supply.* This modification provided continuous adjustment to the ion chamber compensation voltage below the minimum 5 Vdc increments that are allowed by the NMP-1000 Linear Power Channel. The 10 CFR 50.59 evaluation showed that this was a refinement to a preexisting system described in the Safety Analysis Report that will improve the linear level instrument channel sensitivity at low power levels without affecting its performance or linearity at intermediate or high power levels. This will provide operators with better power level information at low power levels. A review of the Safety Analysis Report and Technical Specifications concluded that making the linear level compensating voltage continuously adjustable could be implemented under 10 CFR 50.59.

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.	5.85×10^{7}	µCi
b. Average concentration released.	1.72×10^{-7}	µCi/ml
c. Average release rate.	1.84	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.	1719	Percent
f. Percent of ^{41}Ar ERL with 400 dilution factor.	4.30	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.

Iodine-131 was not identified in the one week count of the primary coolant samples.

Xenon-133 was not identified in the one week count of the primary coolant samples.

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.	14	µCi
2. Average concentration released.	6.54×10^{-14}	µCi/ml
3. Percent of ^{131}I ERL (2.0×10^{-10} µCi/ml) without dilution factor.	0.03	Percent
4. Percent of ^{131}I ERL with 400 dilution factor.	0.00008	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	785	µCi
Br-82	227	µCi
I-131	90	µCi
Hg-203	12	µCi

2. Average concentration released.

Br-80m	6.51×10^{-12}	µCi/ml
Br-82	1.88×10^{-12}	µCi/ml
I-131	7.48×10^{-13}	µCi/ml
Hg-203	9.57×10^{-14}	µCi/ml

3. Percent of ERL without the dilution factor.

Br-80m	0.03	Percent
Br-82	0.04	Percent
I-131	0.37	Percent
Hg-203	0.01	Percent

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

Br-80m	0.00008	Percent
Br-82	0.00010	Percent
I-131	0.00093	Percent
Hg-203	0.00003	Percent

d. Total Facility Release of Radiohalogens.

1. Total facility radiohalogen releases.

Br-80m	7,532	µCi
Br-82	433	µCi
I-125	4,438	µCi
I-131	12,970	µCi
Hg-203	314	µCi

2. Average concentration released.

Br-80m	1.17×10^{-11}	µCi/ml
Br-82	6.75×10^{-13}	µCi/ml
I-125	6.92×10^{-12}	µCi/ml
I-131	2.02×10^{-11}	µCi/ml
Hg-203	4.90×10^{-13}	µCi/ml

3. Percent of ERL without the dilution factor.

	Quantity	Unit
Br-80m	0.06	Percent
Br-82	0.01	Percent
I-125	2.31	Percent
I-131	10.12	Percent
Hg-203	0.05	Percent
TOTAL	12.54	Percent

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

Br-80m	0.00015	Percent
Br-82	0.00003	Percent
I-125	0.00577	Percent
I-131	0.02529	Percent
Hg-203	0.00012	Percent
TOTAL	0.03136	Percent

6.3 Particulate Releases

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

a. Total gross radioactivity.	500	μCi
b. Average concentration.	7.79×10^{-13}	μCi/ml
c. Percent of ERL (1.0×10^{-12} μCi/ml) without dilution factor.	77.92	Percent
d. Percent of ERL with 400 dilution factor.	0.195	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 2000.

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

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. The values reported have a deploy control TLD subtracted. Background (UM Botanical Gardens) has not been subtracted from the TLD values.

Location	**Direction**	**Annual Total (mrem)**	**Quarterly Mean (mrem)**
FNR Lawn	North	48.7	12.2
Fluids	Northeast	49.0	12.3
Beal	East	43.2	10.8
Glazier Way	South	31.1	7.8
School of Music	West	33.1	8.3
Environmental Control (UM Botanical Gardens)		40.5	10.1

Background is taken at a distance in excess of one mile from the reactor at The University of Michigan Botanical Gardens. None of the readings for the indicator locations were statistically distinguishable from the background readings (Student's T-Test).

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), northeast (Laundry), 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 52 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)	1.47×10^{-14}	μCi/ml
Industrial and Operations Engineering (E)	2.09×10^{-14}	μCi/ml
Media Union (W)	2.14×10^{-14}	μCi/ml
Institute of Science and Technology (S)	2.13×10^{-14}	μCi/ml
Laundry (NE)	1.94×10^{-14}	μCi/ml
Environmental Control (Background)	2.19×10^{-14}	μCi/ml

The result of air sampling expressed in percentages of the Effluent Release Limits are shown below.

Station Description	Percent ERL	Unit
Northwood (N)	1.47	Percent
Industrial and Operations Engineering (E)	2.09	Percent
Media Union (W)	2.14	Percent
Institute of Science and Technology (S)	2.13	Percent
Laundry (NE)	1.94	Percent
Environmental Control (Background)	2.19	Percent

c. **Water Samples**

No Radioactive liquid effluents were released from the facility in 2000.

d. **Sewage Samples**

No Radioactive liquid effluents were released from the facility in 2000.

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	5.85×10^{7}	1.72×10^{-07}	1,718.78	4.30000
Br-80m	7,531.58	1.17×10^{-11}	0.06	0.00015
Br-82	432.76	6.75×10^{-13}	0.01	0.00003
Hg-203	314.08	4.90×10^{-13}	0.05	0.00012
I-125	4,438.28	6.92×10^{-12}	2.31	0.00577
I-131	12,969.91	2.02×10^{-11}	10.12	0.02529
Gross Particulate	500.28	7.79×10^{-13}	77.92	0.19479
TOTAL			1,809.25	4.52615
Equivalent Radiation Dose (mrem)				2.26

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 2000.

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, 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 4.53% ERL is 2.26 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 2000 have not been received from the processor in time for this report. A revision to this report will be submitted shortly after the data is available.

This includes facility personnel including faculty, students, or experimenters.