The University of Michigan

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

March 31, 2000

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 for the period January 1, 1999 to December 31, 1999 as required by Technical Specification 6.6.1 *Annual Operating Report*.

Sincerely,

Christopher W. Becker

Christopher W. Becker
Reactor Laboratory Manager

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Enclosure (1)

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REPORT OF REACTOR OPERATIONS

January 1, 1999 - December 31, 1999

FORD NUCLEAR REACTOR

MICHIGAN MEMORIAL - PHOENIX PROJECT

THE UNIVERSITY OF MICHIGAN

ANN ARBOR

March 2000

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, 1999. 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 1142 people participated in 69 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 Request 133, *Addition of Nitrogen Purge to the Vertical Beam Tube.* During Cycle 432 the Vertical Beam Tube (VBT) was found to have a leak allowing the bottom of the tube to collect water which degraded the neutron flux. The VBT was constructed with a "drain" and "purge" line such that when nitrogen is forced into the tube, the water comes out of the drain. A permanent purge rig was added to these connections as a means of providing a continuous flow of nitrogen to remove moisture and provide a positive pressure to minimize in-leakage. This arrangement will remain until the VBT can be repaired or replaced. A review of the Safety Analysis report and Technical Specifications concluded that this nitrogen purge could be implemented under the rules contained in 10 CFR 50.59.

Modification Request 134, *Temperature System Upgrade – RTDs, Current Loops, Testable, and Buffered.* The temperature system was upgraded to provide 1) ability to individually test required channels prior to startup, 2) ability to calibrate system in accordance with industry standards, 3) relocation of resistance-to-current converters closer to the detectors to reduce signal noise, 4) upgrading of RTDs and wiring runs to facilitate shielding and appearance, 5) addition of low temperature rundowns and alarms to guard against a failure of the 15 Vdc power supply, 6) addition of precision current to voltage converters to ensure signal stability, prevention of fault transfer and provide future expansion and 7) redesign of the in pool temperature well to facilitate better and more responsive measurement. A review of the Safety Analysis report and Technical Specifications concluded that these improvements to the Temperature System could be implemented under the rules contained in 10 CFR 50.59.

Modification No. 135, *Irradiated Fuel Shipments: Control Element Handling Tool for Loading Into Shipping Cask Underwater.* The element described in the Safety Analysis Report to handle control elements, hooks the control elements through a slot in the top of the assembly. This tool cannot be used to load control elements into the BMI-1 cask as the elements are fully contained within the basket when seated. As a result a tool that could handle a control element from inside had to be developed specifically for the loading of control assemblies into the BMI-1 cask. This tool has a shouldered key which can be fully inserted into the slot of a control assembly. Once through the assembly the key can be turned 90 degrees in the nozzle area of the assembly and used to lift the fuel assembly. The shoulder prevents the fuel assembly from twisting and falling off the key. A review of the Safety Analysis Report and Technical Specifications concluded that the use of this new tool could be implemented under the rules contained in 10 CFR 50.59.

Modification 138, *Replacement of the Door Security System.* The card swipe security system was replaced with a proximity card system with similar functionality. A review of the Security Plan and the Safety Analysis Report concluded that the new proximity card system met the requirements for an access control system.

Modification 139, *Replace Secondary Flow Indicator with Newport Display Unit.* The flow display unit, digital readout, for the secondary flow measurement system was replaced with a programmable display unit. The new unit can be programmed to indicate engineering units for any linear voltage signal. A review of the Safety Analysis Report and the Technical Specifications concluded that the new display unit met the requirements of these documents.

1.2 Equipment and Fuel Performance Characteristics

12 Jan 99 Two fuel assemblies were inserted into the core at locations L6 and L80 to raise excess reactivity. Core Load No. 934

25 Jan 99 A major core shuffle inserted three new regular assemblies into locations L37, L36, and L35. Following this activity the core excess reactivity was 3.48 %Δk/k (Tech Spec limit of 4.36 %Δk/k). Following the core reload, rod drop times were measured and rod calibrations performed as required.

17 Mar 99 Received five regular fuel elements in satisfactory condition.

05 Apr 99 The core was partially unloaded to support the Critical Experiment for the NE445 class.

06 Apr 99 The core was altered to support the Critical Experiment for the NE445 class and reloaded after the Critical Experiment completed.

01 June 99 A major core shuffle inserted a new control assembly into location L26 with 'C' Shim-safety and three regular assemblies in locations L35, L36, and L37. Following this activity the core excess reactivity was 3.55 %Δk/k (Tech Spec limit of 4.36 %Δk/k).

02 June 99 Pool Floor MAP indication in the control room was erratic. The 24 hour limiting condition for an inoperable Pool Floor MAP was entered at 1700. The reactor was shutdown on 03 Jun 99 at 0128 due to an electrical short which caused a partial loss of essential 120 Vac power. The signal lead

from the detector to the Radiation Recorder was repaired. MAP checks were completed to verify proper operation.

27 Sep 99 Shipped eleven irradiated, control fuel elements to Savannah River Site.

07 Oct 99 Receive three new control elements in good condition.

11 Oct 99 Shipped twelve irradiated, regular fuel elements to Savannah River Site.

25 Oct 99 Shipped twelve irradiated, regular fuel assemblies to Savanna River Site.

08 Nov 99 A major core shuffle inserted new regular fuel assemblies in locations L26, L35, and L36. Following this activity the core excess reactivity was 3.75%Δk/k (Tech Spec limit of 4.36%Δk/k).

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 19 dated 26 Feb 99.
   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) allowance for the Assistant Manager for Operations to delegate scheduling activities and 2) update of activities from the changes to the CP's during the past year.

2. CP-211, *Temperature System Calibration,* Rev 11 dated 15 Jul 99.
   Provides means for calibrating the temperature system by calibrating the decade box to each of the RTDs and using the decade box to simulate the RTDs for calibration of the temperature transmitters (temperature-to-current converters). Also provides for a channel check and a channel test of each temperature channel.
   Substantial change in that the methodology was changed to reflect industry guidance. The changes are 1) follow ASTM E-644 methodology for calibration of Industrial RTDs to the decade box using a liquid in glass thermometer, 2) the calibrated decade box is then used to calibrate, test, and check each channel of the system, and 3) added a channel test to quantitatively verify the Autorundowns.
   Complete rewrite.

Operating Procedures

1. OP-101, *Reactor Startup,* Rev 35 dated 3 May 99.
   Provides steps to promote consistent manipulation of reactor controls by providing the sequence of operation for a reactor startup.
   No substantial changes were made.
   The only notable changes were 1) change of prerequisite for building check from within 8 hours to current shift, 2) detailed linear level minimum power indication

prerequisite, 3) specified specific power level settings in response to NRC concerns, 4) identified the on-call supervisor as the point of notification if NI checks at 2 MW identify an out of spec channel, and 5) addition of step to place secondary cooling in operation for startups w/o a calorimeter.

2. OP-106, *Power Level Determination,* Rev 19 dated 3 May 99.
Provides a standard method for conducting a calorimetric determination of power level and for adjusting indicated power to match thermal power.
No substantial changes were made.
The only notable changes were 1) addition of steps to place the secondary cooling system into operation when the calorimeter is completed, 2) specification that Linear Level be adjusted to 49% indication at 1 MW_{true} in response to NRC concerns.

3. OP-107, *Ion Chamber Position and Signal Adjustment Procedure,* Rev. 8 dated 3 May 99.
Provides a safe and consistent method for adjusting ion chamber positions and signals.
No substantial changes were made.
The only notable changes was the removal of the steps for beginning of cycle chamber adjustment. These steps were removed as they are the same as for a regular chamber adjustment.

4. OP-101, *Reactor Startup,* Rev 36 dated 14 Jun 99.
Provides a consistent manipulation of controls and sequence of operations for a reactor startup.
No substantial changes were made.
The only notable changes were 1) identification that the Assistant Manager for Operations is responsible for implementation and maintenance of the procedure, 2) specification that only the Nuclear Reactor Laboratory Manager could approve this procedure and authorize deviations from the procedure, 3) added note that for reactor startups without a calorimeter, that the On-call supervisor should be contacted to determine power level.

5. OP-101, *Reactor Startup,* Rev 44 dated 14 Jul 99.
Provides a consistent manipulation of controls and sequence of operations for a reactor startup.
Substantial change to upgrade the process for channel testing of the Temperature channels providing auto rundowns by quantitatively verifying setpoint and rundown.
Other changes were formatting and correction of the several steps involving acknowledging and resetting annunciators during the startup checklist to match how they are actually performed.

6. OP-106, *Power Level Determination* Rev 20 dated 14 Oct 99.
Provides standard method for conducting a calorimetric determination of power level and for adjusting indicated power to match thermal power.
No substantial changes were made.
The notable change was the elimination of cricket graph to plot the data. Now Excel is used to analyze and plot the results on a single graph.

Management Procedures

None

Health Physics Procedures

None

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
Christopher W. Becker	Reactor Laboratory Manager	Feb. 15, 1999
William Clayton Snyder	Reactor Operator II	Oct. 4, 1999
Michael Hartman	Engineer II	July 6, 1999

Terminated	Position	Date
Steve Nowack	Engineering Technician III	May 7, 1999
Eric Sharp	Reactor Operator II	Sept. 12, 1999
Michael Hartman	Engineering Technician III	March 3, 1999

Safety Review Committee Changes

The following Safety Review Committee Changes occurred:

New Appointees	Position	Date
Christopher W. Becker	Ex-Officio Member	June 21, 1999
Richard Robertson	Faculty Member	June 21, 1999
Fawwaz Ulaby	Ex-Officio Member	June 21, 1999
William R. Martin	Faculty Member	September 23, 1999

Removed Appointees	Position	Date
Dale E. Briggs	Faculty Member	June 21, 1999
Philip A. Simpson	Ex-Officio Member	June 21, 1999
Fredrick C. Neidhardt	Ex-Officio Member	June 21, 1999
David K. Wehe	Faculty Member	September 23, 1999

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
428	01/10/99 - 02/06/99	491.5	457.5	919.4	70.8
429	02/07/99 - 03/06/99	495.8	482.0	967.8	71.7
430	03/07/99 - 04/03/99	472.4	434.0	873.1	64.6
431	04/04/99 - 05/01/99	483.3	466.6	936.7	69.4
432	05/02/99 - 05/29/99	486.4	479.7	959.8	71.4
433	05/30/99 - 06/26/99	406.3	353.5	682	52.6
434	06/27/99 - 07/24/99	190.3	176.3	349.4	26.2
435	07/25/99 - 08/21/99	493.3	474.1	958.2	70.7
436	08/22/99 - 09/08/99	487.2	472.8	901.2	70.4
437	09/19/99 - 01/16/99	438.4	416.9	836.5	62.0
438	10/17/99 - 1/13/99	335.3	297.2	596.8	44.0
439	11/14/99 - 12/11/99	342.1	326.8	655.8	48.6
440	11/14/99 - 12/11/99	4.0	0.0	1.85	0.0
	Totals:	5126.3	4837.4	9638.6	56.0

2. 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

27 Jan 99 The reactor was shut down due to a small piece of debris on the element in location L36, source unknown. The fuel element was removed from the core in accordance with AP-301 and shaken to dislodge the debris. The fuel element was then returned to its original location in the core. **Operator Action.**

23 Mar 99 The reactor scrammed on low reactor period due to the failure of the reset circuit in the Log N instrument. The trips circuit board and several solid state logic chips were replaced. The applicable portions of CP-206, *Safety System C Period Channel C Calibration,* were performed to verify proper operation of the instrument. **Reactor Controls.**

24 April 99 The reactor was shut down due to a small piece of debris on the fuel element in location L40. The material was probably disturbed by the pool vacuuming maintenance conducted during the shutdown period. The source of the material is unknown. The debris covered >25% of one channel and >10% of the element in location L40. Two fuel elements (location L40 and L69) were removed from the core in accordance with procedure AP-301 and shaken to dislodge debris. The fuel elements were then returned to their former location in the core. The reactor was restarted without difficulty. **Operator Action.**

18 May 99 An Automatic rundown occurred due to reactor core inlet temperature exceeding 114 °F at a power level of greater than 1.6 MW (80%). The Safety Limit of 116 °F was not exceeded due to this automatic protective action. The rundown lowered reactor power below 1.6 MW (80%), where it cleared. The operators believed that the high core inlet temperature was due to insufficient cooling tower fans operating (only two were operating at the time of the rundown) and started a third fan. This did not lower temperatures and the crew continued its investigation and found local disconnects at the cooling tower fans open. During preventative maintenance the disconnects were open for maintenance, but the operators failed to close them at the conclusion of the maintenance. Additionally, the practice of listening to the cooling tower fans start had been abandoned and the operators trusted their single indication of the running light. The disconnects were closed and with the permission of the On-Call supervisor, reactor power was restored to 2 MW. **Operator Error.**

03 Jun 99 During Rod Calibrations at a power level of 5 kW, a loss of lighting and a few alarms (Fuel Vault and Door Access Alarms) were received. The reactor was shutdown. Investigation showed that breaker 56lt on the Y panel was tripped free. The breaker was reset without problem. Later, a frayed power cable to an old outlet in a drawer of the console was found sparking and removed. **Electrical Power Failure.**

06 June 99 The C Shim Safety rod dropped during a reactor startup after a shutdown for a restroom break. The reactor was shut down and the alignment of the magnet and armature was adjusted. Rod Drop timing was performed as required by Technical Specifications and reactor operation resumed. **Single Rod Drop.**

09 Jun 99 The reactor was shut down when the Supply and Exhaust Damper failed to close. While looking for air leaks, the Assistant Manager for Operations found the damper cylinder stuck in the open position. Earlier that day, a check of the damper cylinder was satisfactory. During the rebuild of the damper cylinder, it was discovered that the piston had two seals, and that the bottom seal was not getting sufficient lubrication. Consultation with the manufacturers engineering representative led to the removal of the bottom piston seal. A trending program was implemented for the cylinder to predict future failures. **Process Equipment.**

15 Jun 99 The reactor was shut down when during the calorimeter, the Annuciator Reset switch failed. The switch was replaced and tested by performing step 43 of the Startup Checklist. **Process Equipment.**

20 Jun 99 The reactor was shut down when it appeared that debris was fouling greater than 25% of a channel. Upon removal of the fuel assembly to clear the debris, it was determined the north most fuel plate of the fuel element in L60 was bent outward. The fuel element in L60 (No. MI-283-L) was retired and replaced with an element of similar burnup. Reactor operation was resumed. Subsequent investigation reveals that the damage was probably caused by a hold down, fuel tool, or other hard, heavy object. The "V" in the north most fuel plate is estimated to be ¾ - 1 inch deep causing a protrusion of approximately 1/8 inch in the north direction. This is based upon hitting the dummy fuel elements with a dead weight to produce similar damage. **Operator Error.**

27 Jul 99 The Log N recorder failed requiring the reactor to be shutdown for repairs. The slide wire finger contacts were bent at different angles providing improper contact with the slide wires. The finger contacts were adjusted, followed by a test of the Reactor Core Inlet Rundown (>80%), High Power / Header Down (> 2%), and Header Up / No Flow (>2%). The reactor was restarted with permission of the On-call Supervisor. **Process Equipment.**

31 Jul 99 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.**

10 Aug 99 The reactor was shut down following an auto rundown from the temperature system. While operating at 2MW the Electrical Engineer was reconnecting the Data Acquisition System to the temperature system. A multi-pin connector shorted, providing a low temperature indication to the Temperature recorder and the rundown that would not clear until the connector was removed. The Console Operator was aware that the Electrical Engineer was working in the Instrument wall but never questioned what he was doing. The Shift Supervisor was not aware of the maintenance activity. The maintenance activity was not on the maintenance schedule. The reactor was shut down to allow for the completion of the maintenance activity. **Operator Error.**

21 Sep 99 The reactor scrammed on High Power / Low Flow when the primary coolant pump tripped. While operating at 2MW the shift operator was restoring the Hot DI system that had been secured for a irradiated fuel shipment. When

attempting to start the Hot DI pumps from the control room, the Programmable Logic Controller overloaded the circuit and tripped. This same controller controls the primary coolant pump and causes the primary coolant pump to trip resulting in a High Power / Low Flow condition. Investigation showed that it was supposedly common knowledge amongst the regular operators that the Hot DI pumps were to be operated locally only. The reactor was restarted following a tagout of the local control switches to prevent reoccurrence until repairs can be completed. **Operator Error.**

30 Sep 99 The reactor scrammed when electrical power was secured to Phoenix Memorial Laboratory due to a fire on North Campus. **Electrical Power Failure.**

09 Oct 99 The reactor was shut down twice due to debris on the core which covered >25% of one channel and >10% of the element in location L9 then L39. The debris was most likely disturbed during the removal of the "deep tray" from south pool for irradiated fuel shipments. During the clean off of the "deep tray" a near neutrally buoyant object was disturbed. Attempts to remove the object failed. The material appeared on the reactor core approximately three hours later. The reactor was shut down and the material floated from the core when the primary coolant pump was secured. The reactor was restarted and the material returned within 15 minutes. The reactor was shut down and the pool allowed to settle for 60 minutes before restart. **Operator Action.**

24 Oct 99 The reactor scrammed during a reactor shut down when a static discharge jumped from an operator to the Log N instrument. The Log N channel was checked for satisfactory operation and reactor operation resumed following the completion of the irradiated fuel shipment. **Control Equipment.**

12 Nov 99 The reactor was ordered shutdown when it was discovered that the Radiation Recorder had been improperly tested following corrective maintenance. Reportable Occurrence 21. **Operator Action.**

13 Nov 99 The reactor was shut down due to the occurrence of a temperature inversion, Radon that was detected on the Pool Floor and Beam Hole Floor Moving Air Particulate (MAP) detectors. The Emergency Procedure requires reactor shutdown for continuos alarming of two or more radiation monitors until the source is identified. Reactor operation resumed when the portable air sample confirmed the inversion. **Operator Response.**

30 Nov 99 The reactor was shut down due to a failure of one of two of the digital displays for primary flow. The display was replaced, the channel calibrated and reactor operation resumed. **Process Equipment.**

14 Dec 99 The reactor was shut down due to the improper connection of the Log N ion chamber following preventative maintenance. Reportable Occurrence 22. **Operator Error.**

3.3 Characterization of Unscheduled Shutdowns

Single Rod Drop (NAR)	1
Multiple Rod Drop (NAR)	0
Operator Action	4
Operator Error	6
Process Equipment Failure	6
Reactor Controls	0
Electric Power Failure	3
Total Unscheduled Shutdowns	20

4. CORRECTIVE MAINTENANCE ON SAFETY RELATED SYSTEMS AND COMPONENTS

23 Mar 99 The reactor scrammed on low reactor period due to the failure of the reset circuit in the Log N instrument. The trips circuit board and several solid state logic chips were replaced. The applicable portions of CP-206, *Safety System C Period Channel C Calibration,* were performed to verify proper operation of the instrument.

15 July 99 Found the mechanical cam for 1.6 MW (80%) on the Log N recorder was set at 50%. The cam was adjusted and tested. This is a conservative setpoint so no Limiting Safety System Settings were violated.

27 Jul 99 The Log N recorder failed requiring the reactor to be shutdown for repairs. The slide wire finger contacts were bent at different angles providing improper contact with the slide wires. The finger contacts were adjusted, followed by a test of the Reactor Core Inlet Rundown (>80%), High Power / Header Down (> 2%), and Header Up / No Flow (>2%).

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

Modification Request 133, *Addition of Nitrogen Purge to the Vertical Beam Tube.* During Cycle 432 the Vertical Beam Tube (VBT) was found to have a leak allowing the bottom of the tube to collect water which degraded the neutron flux. The VBT was constructed with a "drain" and "purge" line such that when nitrogen is forced into the tube, the water comes out of the drain. A permanent purge rig was added to these connections as a means of providing a continuous flow of nitrogen to remove moisture and provide a positive pressure to minimize in-leakage. This arrangement will remain until the VBT can be repaired or replaced. A review of the Safety Analysis report and Technical Specifications concluded that this nitrogen purge could be implemented under the rules contained in 10 CFR 50.59.

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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.	3.21×10^{7}	μCi
b. Average concentration released.	1.26×10^{-7}	μCi/ml
c. Average release rate.	1.01	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.	1263	Percent
f. Percent of ^{41}Ar ERL with 400 dilution factor.	3.16	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.	105	μCi
2. Average concentration released.	4.81×10^{-13}	μCi/ml
3. Percent of ^{131}I ERL (2.0×10^{-16} μCi/ml) without dilution factor.	0.24	Percent
4. Percent of ^{131}I ERL with 400 dilution factor.	0.00060	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.

Br-80m	1,815	μCi
Br-82	7,847	μCi
I-123	169	μCi
I-125	172	μCi
I-131	103	μCi
Hg-203	15	μCi

2. Average concentration released.

	Quantity	Unit
Br-80m	1.67×10^{-11}	μCi/ml
Br-82	5.55×10^{-11}	μCi/ml
I-123	1.19×10^{-12}	μCi/ml
I-125	1.22×10^{-12}	μCi/ml
I-131	7.28×10^{-13}	μCi/ml
Hg-203	1.06×10^{-13}	μCi/ml

3. Percent of ERL without the dilution factor.

Br-80m	0.08	Percent
Br-82	1.11	Percent
I-123	0.01	Percent
I-125	0.41	Percent
I-131	0.36	Percent
Hg-203	0.01	Percent

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

Br-80m	0.00021	Percent
Br-82	0.00277	Percent
I-123	0.00001	Percent
I-125	0.00101	Percent
I-131	0.00091	Percent
Hg-203	0.00003	Percent

d. Total Facility Release of Radiohalogens.

1. Total facility radiohalogen releases.

Br-80m	2,691	µCi
Br-82	7,847	µCi
I-123	33,976	µCi
I-125	2,118	µCi
I-131	3,870	µCi
Hg-203	4,421	µCi

2. Average concentration released.

Br-80m	8.58×10^{-12}	µCi/ml
Br-82	5.55×10^{-11}	µCi/ml
I-123	8.33×10^{-11}	µCi/ml
I-125	3.31×10^{-12}	µCi/ml
I-131	6.05×10^{-12}	µCi/ml
Hg-203	1.08×10^{-11}	µCi/ml

3. Percent of ERL without the dilution factor.

	Quantity	Unit
Br-80m	0.04	
Br-82	1.11	Percent
I-123	0.42	Percent
I-125	1.10	Percent
I-131	3.02	Percent
Hg-203	1.08	Percent
TOTAL	6.77	Percent

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

Br-80m	0.00011	Percent
Br-82	0.00277	Percent
I-123	0.00104	Percent
I-125	0.00276	Percent
I-131	0.00756	Percent
Hg-203	0.00271	Percent
TOTAL	0.01695	Percent

6.3 Particulate Releases

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

a. Total gross radioactivity.	299	μCi
b. Average concentration.	5.36×10^{-13}	μCi/ml
c. Percent of ERL (1.0×10^{-12} μCi/ml) without dilution factor.	53.61	Percent
d. Percent of ERL with 400 dilution factor.	0.134	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 1999.

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	31.0	7.8
Fluids	Northeast	29.2	7.3
Beal	East	32.1	8.0
Glazier Way	South	25.4	6.4
School of Music	West	21.7	5.4
Environmental Control (UM Botanical Gardens)		14.6	3.7

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 48 samples included in this report for each location except for Northwood which has 46 samples. 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)	1.46×10^{-14}	μCi/ml
Industrial and Operations Engineering (E)	2.44×10^{-14}	μCi/ml
Media Union (W)	2.13×10^{-14}	μCi/ml
Institute of Science and Technology (S)	2.07×10^{-14}	μCi/ml
Laundry (NE)	2.16×10^{-14}	μCi/ml
Environmental Control (Background)	2.45×10^{-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)	1.46	Percent
Industrial and Operations Engineering (E)	2.44	Percent
Media Union (W)	2.13	Percent
Institute of Science and Technology (S)	2.07	Percent
Laundry (NE)	2.16	Percent
Environmental Control (Background)	2.45	Percent

c. **Water Samples**

No Radioactive liquid effluents were released from the facility in 1999.

d. **Sewage Samples**

No Radioactive liquid effluents were released from the facility in 1999.

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	$3.21x10^{7}$	$1.26x10^{-07}$	1,263.24	3.16000
Br-80m	2,690.58	$8.58x10^{-12}$	0.04	0.00011
Br-82	7,847.40	$5.55x10^{-11}$	1.11	0.00277
Hg-203	4,421.40	$1.08x10^{-11}$	1.08	0.00271
I-123	33,975.60	$8.33x10^{-11}$	0.42	0.00104
I-125	2,117.68	$3.31x10^{-12}$	1.10	0.00276
I-131	3,870.34	$6.05x10^{-12}$	3.02	0.00756
Gross Particulate	299.34	$5.36x10^{-13}$	53.61	0.13400
TOTAL			1,323.62	3.31095
Equivalent Radiation Dose (mrem)				1.66

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 1999.

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 3.31% ERL is 1.66 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

Facility personnel were provided personal radiation dosimeters. Individuals for whom extremity monitoring was provided received TLD ring dosimeters for each hand.

Due to changes in the dosimetry program the occupational personnel radiation exposures for the last quarter of 1999 are not yet available. An update to this annual report will be submitted shortly after the data becomes available.