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Tech Specs, Docket 50-156

August 18, 1993

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Dear Sir:

Enclosed herewith is a copy of the Annual Report for the fiscal year 1992-93 for the University of Wisconsin Nuclear Reactor Laboratory as required by our Technical Specifications.

Very truly yours,

R. J. Cashwell

R. J. Cashwell
Reactor Director

Enc. (Annual Report)

XC: Region III Administrator

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University of Wisconsi.

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August 16, 1993

UWNR Annual Report Distribution

Dear Sir or Madam:

Enclosed herewith is a copy of the Annual Report for the fiscal year 1992-93 for the University of Wisconsin Nuclear Reactor Laboratory. Although the report is prepared primarily to meet contractual and license obligations, much of the material contained is of interest to others. In particular, the use of the reactor for both teaching and research is described.

If you have little time, page 1 contains a succinct description of reactor use. Greater detail can be found in succeeding pages.

Very truly yours,

R. J. Cashwell
Reactor Director

Enc. (Annual Report)

THE UNIVERSITY OF WISCONSIN
NUCLEAR REACTOR LABORATORY

1992-1993 ANNUAL OPERATING REPORT

Prepared to meet reporting requirements of:
U. S. Department of Energy
SPECIAL MASTER TASK RESEARCH SUBCONTRACT NO. C87-101251
and
U. S. Nuclear Regulatory Commission
(Docket 50-156, License R-74)

PREPARED BY:

R. J. CASHWELL
DEPARTMENT OF NUCLEAR ENGINEERING AND ENGINEERING PHYSICS

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TABLE OF CONTENTS

EXECUTIVE SUMMARY OF REACTOR UTILIZATION

Teaching: Teaching usage of the reactor during the year included:

- 59 NEEP students in laboratory courses.
- 22 students in lecture courses which included demonstrations in the reactor laboratory.
- Numerous instructors and students from area school systems were given demonstrations in reactor operations and use.
- Students and staff from Colorado College, Lakeshore Technical Institute, Milwaukee School of Engineering, University of Wisconsin - Milwaukee, University of Wisconsin - Platteville, and University of Southern Mississippi used the facilities for formal instruction or research.

Research: Neutrons from the reactor were used primarily for neutron activation analysis.

- 156 samples were irradiated for research programs in other departments of the UW-Madison; Enzyme Institute, Chemistry, Electrical and Computer Engineering, School of Pharmacy, Material Science and Engineering and Soil Science.
- 1175 samples were irradiated for other educational institution research programs; Colorado College, University of Wisconsin - Milwaukee, University of Minnesota - Duluth, University of Southern Mississippi, and Lakeshore Technical Institute.

Industrial Use: No NAA services were requested or provided.

Federal Government Agencies: No services were requested or provided.

A. SUMMARY OF OPERATIONS

1. INSTRUCTIONAL USE --UW-Madison Classes and Activities

31 students enrolled in NEEP 231 participated in a laboratory session introducing students to reactor behavior characteristics. 8 hours of reactor operating time were devoted to this session.

NEEP 427 was offered in the fall and spring semesters with a total enrollment of 26. Several NEEP 427 experiments use materials that are activated in the reactor. One experiment entitled "Radiation Survey" requires that students make measurements of radiation levels in and around the reactor laboratory. All of these reactor uses take place during normal isotope production runs, so no reactor time is specifically devoted to NEEP 427.

The enrollment in NEEP 428 was 22 as it was offered in both semesters. Three experiments in NEEP 428 require exclusive use of the reactor. Each of these experiments ("Critical Experiment," "Control Element Calibration," and "Pulsing") was repeated four times during the year, requiring a total of 36 hours of exclusive reactor use. Other NEEP 428 laboratory sessions use material that has been irradiated in the reactor ("Fast Neutron Flux Measurements by Threshold Foil Techniques" and "Resonance Absorption"). These two experiments were repeated 8 times during the year.

Eighteen NEEP 305 students used the reactor for an experiment to measure the half-lives of the longer-lived delayed neutron emitters.

Eleven students completed NEEP 602/699, "Principles and Practice of Nuclear Reactor Operation" during the spring semester. This course uses the reactor extensively, as each student performed at least 20 significant reactivity changes. Although an effort was made to use students as operators for other scheduled operations, 209 hours of exclusive reactor use specifically for training were required to provide this operating experience. Eight of these students applied for NRC Operator Licenses.

Classes from UW-Madison Physics and Materials Science and Engineering brought an additional 35 students into the laboratory for tours/demonstrations.

The Reactor Laboratory continues to attract large numbers of tours, with groups from public schools, day cares, scout troops, Kollege for Kids, trades apprentice programs, teacher groups, and service organizations visiting for tours and nuclear power information.

2. REACTOR SHARING PROGRAM

User institutions participated in the program as detailed below.

Participating Institution	Principal Investigator	Number of Faculty\Students
Colorado College NAA of sand samples NAA of Rock for studies	E. Henrickson	1/3
Edgewood College Madison, WI NAA demonstration/Reactor operation demo	P. Weldy	1/14
ESTEEM General information about reactor laboratory and nuclear power	High School Students	2/69
Lakeshore Technical Institute Reactor operation demonstration, neutron survey instruments for health physics technician training	D. Gossett	1/9
Milwaukee School of Engineering Reactor Tour and Reactor Operation demonstration	S. Mayer	1/8
Northside Elementary How a Nuclear Power Plant Works	Teachers	3/75
Orchard Ridge Middle School How a Nuclear Power Plant Works	Teachers	6/264
Sennet Middle School How a Nuclear Power plant works	V. Laufenberg	3/85
Society of Women Engineers Tours and explanation of reactor and department	K. Vrubley	1/13
University of Minnesota Duluth NAA of Silts and Clays. Overview of NAA sequence and procedures. NAA of ceramics - short and long. NAA of Native Copper Samples.	R. Rapp	2/2
University of Wisconsin - Eau Claire Tour of the Nuclear Reactor Lab	J. Reeves	1/20

University of Wisconsin - Milwaukee
T. Naik 1/2
NAA service for project investigation using foundry sands as construction material.

University of Wisconsin - Platteville
H. Fenrick 1/7
Reactor Operation and NAA demonstration

University of Wisconsin - Whitewater
R. Bergsten 2/0
Repair and calibrate neutron survey meter

University of Southern - Mississippi
D. McCain 1/0
Study of trace elements in plant leaves in relation to drought stress.

USER SUMMARY:

Educational Institutions:	15
Students:	571
Faculty/Instructors:	27

3. SAMPLE IRRADIATIONS AND NEUTRON ACTIVATION ANALYSIS SERVICES

There were 1,544 individual samples irradiated during the year. Of these samples, 727 were irradiated for 15 minutes or less. Samples accumulated 1,646 irradiation space hours and 574.5 sample hours. Many samples were irradiated and then counted at the Reactor Laboratory as part of our neutron activation analysis service. In the listing below the notation (NAA) indicates that the samples were processed by our neutron activation analysis service.

Chemistry Department (NAA)
60 samples, 27.4 sample hours, 40.5 irradiation space hours. Prof Lerner and 2 graduate students used the NAA service to determine Na in DNA - aqueous solutions. Supported by Whitaker Foundation and NIH.

Colorado College (NAA)
215 samples, 109 less than 15 minutes, 205.8 sample hours, 24.5 irradiation space hours. Professor Henrickson and 1 student used the NAA service to determine the origin of contrasting felsic and amorfic igneous bodies. Supported by DOE Reactor Sharing Program.

Electrical and Computer Engineering (NAA)
35 Samples, 25.3 sample hour, 2.7 irradiation space hours. Professor McCaughn and 2 students used the NAA service to determine erbium content of crystals.

Enzyme Institute (NAA)
5 samples, 10 sample hours, and 2 irradiation space hours. Professor Lardy used NAA to determine if 7-oxodehydroepiandrostone contained Chromium, which was used in preparation of the steroid. UW support.

Lakeshore Technical Institute (NAA)
2 samples, 0.5 sample hours, 0.5 irradiation space hours. Doug Gossett used the NAA service for demonstration purposes. Supported by DOE Reactor Sharing Program.

Nuclear Engineering and Engineering Physics, UW-Madison

Ion Implantation Research Group (NAA)
10 samples, 120 sample hours, 12 irradiation space hours Prof. Conrad, one additional staff member, and 1 graduate student used the NAA service to determine material implanted on pure silicon wafers. UW support.

NEEP 427, 428, and 602/699 Laboratory Course
184 samples, 109 less than 15 minutes, 143.78 sample hours, 84.45 irradiation space hours. Irradiations in support of teaching laboratory.

Reactor Laboratory
7 samples, 6 less than 15 minutes, 2.25 sample hours, 3.25 irradiation space hours. Irradiations for flux measurements and instrument calibrations.

University of Wisconsin-Milwaukee (NAA)
79 Samples, 2 sample hours, 158 irradiation space hours. Professor Krezoski and 1 undergraduate student used the NAA service to determine composition of sediment samples.

20 samples, 11 less than 15 minutes, 20.55 sample hours, 2.55 irradiation space hours. Professors Naik and Patel and two graduate students used the NAA service for analysis of construction materials which use reclaimed foundry sands. Support by DOE Reactor Sharing Program.

University of Minnesota-Duluth (NAA)
798 samples, 380 less than 15 minutes, 804.7 sample hours, 32.7 irradiation space hours. Prof. George Rapp, two additional staff members, and one graduate student continue their use of NAA for characterization of copper artifacts, primarily to determine provenance. Supported by DOE Reactor Sharing Program.

University of Southern Mississippi (NAA)
61 samples, 61 less than 15 minutes, 15.25 sample hours, 1 irradiation space hour. Prof. D. McCain used NAA to study trace elements in plant leaves in relation to drought stress. Supported by NSF and DOE RSP.

School of Pharmacy (NAA)
3 samples, 2 less than 15 minutes, 6.5 sample hours, 2.5 irradiation space hours. Prof. Hutchinson, four additional staff members, and 1 graduate student used NAA to determine metal content in metabolitic enzyme for research in biosynthesis of antibiotics.

Material Science and Engineering (NAA)
46 samples, 46 less than 15 minutes, 10.5 sample hours, 1 irradiation space hour. Prof. Perepezko and 1 graduate student used NAA service to study Titanium, Aluminum and Niobium alloys. Support unknown.

Soil Science
7 samples, 7 sample hours, 1 irradiation space hours. Prof. Helmke used isotope production irradiation.

4. OTHER MAJOR RESEARCH USE

The neutron radiography facility was inactive during the year.

5. CHANGES IN PERSONNEL, FACILITY AND PROCEDURES

Changes reportable under 10 CFR 50.59 are indicated in section E of this report.

Personnel changes during the year were as follows:

Ronald R. Bresell was appointed Radiation Safety Officer for the university, and thus replaces Abdul Ben-Zikri, who was previously reported as acting RSO.

John G. Murphy, previously an operator, was appointed as a Senior Reactor Operator upon licensing by NRC as a SRO.

Robert J. Agasie, Carin A. Flint, William J. Keller, Geoffry W. Patterson, and Robert Ulfig were appointed as Reactor Operators upon licensing by NRC.

Operator Doug Bishop completed his degree requirements and left the university.

6. RESULTS OF SURVEILLANCE TESTS

The program of inspection and testing of reactor components continues. Inspection of underwater components showed no deterioration or wear. However, the transient control rod was found to have decreased in reactivity worth by observation of pulsing performance. This event was reported to NRC on December 28, 1992.

B. OPERATING STATISTICS AND FUEL EXPOSURE

Operating Period	Startups	Critical Hrs	MW Hrs	Pulses
FY 1992-93	285	719.84	552.77	49
Total Present Core	2715	9711.58	8028.36	619
Total TRIGA Cores	4750	16976.57	13016.54	1930

Core I23-R12 was operated until April 1, 1993, when changes were made in reflector configuration for experimental purposes. The resulting core, I23-R10, is a configuration in which two reflector elements are replaced with radiation baskets. Core I23-R10 had been used extensively in the past.

The excess reactivity of core I23-R12 (as expected) increased 0.11% ρ to 4.62 % ρ during the 9 months it was operated. The excess reactivity of I23-R10, when installed, was 3.89% ρ with both radiation baskets empty and 2.41% ρ with both radiation baskets filled. No change in core excess reactivity was observed during the remainder of the year.

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

There were 8 automatic scrams during the year distributed as follows:

6 -Trainee picoammeter switching errors resulting in reactor scrams. The picoammeters trip at 125% on any range, so inexperienced operators often cause reactor scrams.
- Trainee turned switch downscale while intending to switch upscale; 3/4 and 3/17
- Trainee moved switch too far downscale while reducing power; 2/15, 2/15, 3/4, 4/28

1 -On 2/8, Picoammeter 1 tripped while upranging when it should not have tripped based on power level. Although a trainee was operating at the time it was assumed that the make-before-break feature of the switch did not operate properly because of the tentative manner in which the switch was operated. The switch was exercised and operation continued without incident.

1 -On 3/30, Picoammeter 1 tripped while the reactor was being returned to critical following a pulse. The (trainee) operator noted that picoammeter 2 was reading higher than picoammeter 1 (30% vs. 15% on 1 watt range). Picoammeter 1 then deflected full-scale and caused the trip. Although the event could not be reproduced, the behavior indicates that the coaxial relay which removes the signal from picoammeter 1

during a pulse did not restore a clean signal path immediately after the pulse was over, and when a vibration allowed the contacts to make a low-resistance signal path the charge on the cable discharged into the picoammeter, causing a full scale reading. The relay was inspected and the contacts were burnished.

The following event was not a scram, since no trips occurred and magnet current remained normal. It is included, however, as an unintentional drop of a safety blade.

1 -On 11/20, control blade #3 disengaged while being withdrawn at a position of 9.82 inches. Magnet current was normal before and after the blade dropped. Alignment between the magnet and the armature was checked when the drive was lowered to pick up the blade again, with no more than the usual misalignment noted. The blade withdrew satisfactorily. The magnets do not always align centered on the armatures, due to leadscrew "whip" as the drive is operated. Failure to lift a blade upon initial withdrawal is fairly common, and not noted as a scram or unintentional drop. Since the magnet current is adjusted to only 1.5 times dropout current such behavior is expected.

D. MAINTENANCE

Routine preventive maintenance continued to maintain most equipment operability. Two significant maintenance problems occurred during the year.

In December 1992, the transient control rod worth was determined (by observation of smaller pulses than expected) to have decreased. Upon inspection, it was determined that there were clad penetrations caused by corrosion, resulting in loss of boron from the borated graphite control rod. A new B_4C transient rod was ordered, while a spare was installed to allow operation while waiting for the new rod. The new rod was received and installed by February 20, 1993. Although this event was not reportable per technical specifications, it was reported to NRC on December 28, 1992.

On June 1, 1993 the +500 volt power supply appeared to have failed to 29 volts. Investigation revealed that the gamma ionization chamber used for pulse readout had failed by internal insulation breakdown at high voltage. This detector had been in place since 1967, so the failure is considered to be a normal ageing effect. A spare gamma ionization chamber was installed. During the installation, coaxial cables connecting to the ionization chamber and the plastic insulators which isolate the chamber from ground were also replaced because of radiation damage.

E. CHANGES IN THE FACILITY OR PROCEDURES REPORTABLE UNDER 10CFR 50.59

The Area Radiation Monitoring system described in the SAR, pages 2-45 and 2-53-55 was replaced with a new system on August 5, 1992. The new equipment is a GM-tube based Eberline radiation monitoring system that replaces the previous radiation monitoring system and the beam port monitor system. A complete description of the system is attached as updates to the referenced pages of the SAR (the updates also include changes reported in the 1983-84, 1979-80, and 1991-92 annual reports). The analysis done before system replacement concluded the system was functionally equivalent to the SAR description, but with increased reliability and redundancy. In addition, the range of the new system covers two additional decades of dose rate.

The fast recorder previously used for pulse power and temperature readout was replaced with a Tektronic Testlab data acquisition device effective September 15, 1992. The safety analysis for this equipment concluded there was no effect on reactor safety, since the instrument is a readout only. The new device provides enhanced data collection capabilities, and is controlled by the pulsing control system as was the fast recorder. This equipment was described on pages 2-45 and page 2-47 of the SAR. The revised pages are attached.

F. RADIOACTIVE WASTE DISPOSAL

1. SOLID WASTE

No solid radioactive waste was transferred during the year.

2. LIQUID WASTE

There were 3 discharges of liquid radioactive waste to the sewer system during the year. Concentrations discharged were below MPC without considering dilution by the sewage discharge flow. Table 1 details the discharges to the sewer system.

3. PARTICULATE AND GASEOUS ACTIVITY RELEASED TO THE ATMOSPHERE

Table 2 presents information on stack discharges during the year.

TABLE 1

LIQUID WASTE TO SANITARY SEWER

		DATE	7/6/92	9/16/92	5/25/93	Total
		Total μCi	7.18	18.75	1.19	27.12
		GALLONS	875	1000	1100	2975
Co-60	MPC Used	1E-3				
		μCi	1.1	1.09	1.19	3.38
		μCi/ml	3.3E-7	2.9E-7	2.9E-7	3.0E-7
	Fraction of MPC		1.22E-5	1.2E-5	1.3E-5	3.01E-4
Mn-54	MPC Used	4E-3				
		μCi	0.92	1.58	0	2.50
		μCi/ml	2.7E-7	4.2E-7	0	2.2E-7
	Fraction of MPC		2.5E-6	4.4E-6	0	5.6E-5
Zn-65	MPC Used	3E-3				
		μCi	5.16	16.08	0	21.24
		μCi/ml	1.56E-6	4.25E-6	0	1.9E-6
	Fraction of MPC		1.9E-5	5.96E-5	0	6.3E-4

Average concentration at point of release to sewer = 2.41E-6 μCi/ml.
Fraction of release limit without dilution= 9.86E-4
Average daily sewage flow for dilution = 2.37E4 gallons.
Fraction of daily release limit including dilution= 1.10E-4
Average yearly concentration = 8.29E-10 μCi/ml.

TABLE 2
EFFLUENT FROM STACK

1. Particulate Activity

There was no discharge of particulate radioactivity above background levels.

2. Gaseous Activity -- All Argon 41

Month $\mu Ci/ml x 10^{-6}$	Activity Discharged	Maximum Instantaneous Concentration (Curies)	Average Concentration $\mu Ci/ml \times 10^{-6}$
July 92	0.05788	1.8	0.0323
August	0.05453	2.1	0.0304
September	0.11978	2.1	0.0690
October	0.01970	1.6	0.0110
November	0.07204	1.6	0.0415
December	0.02995	1.2	0.0167
January 93	0.17520	1.2	0.0977
February	0.44776	1.2	0.2760
March	0.10407	4.2	0.0580
April	0.17424	4.4	0.0100
May	0.09498	1.8	0.0530
June	0.05015	1.7	0.0289
TOTAL	1.40028	4.4 (Max)	0.0663 (Avg.)

Maximum Instantaneous Concentration = 0.183 of MPC

Average Concentration = 0.0028 of MPC

MPC used 2.4E-5 µCi/ml; calculated in SAR to yield 3E-8 µCi/ml in non-restricted area.

G. SUMMARY OF RADIATION EXPOSURE OF PERSONNEL (1 July 92 - 30 June 93)

No personnel received any significant radiation exposure for the above period. The highest doses recorded were 60 mrem to the whole body and 110 mrem to extremities, and most of this dose was a result of the replacement of the transient control rod described elsewhere in this report.

H. RESULTS OF ENVIRONMENTAL SURVEYS

The environmental monitoring program at Wisconsin uses Eberline TLD area monitors located in areas surrounding the reactor laboratory. The following table indicates dose rates a person would have received if continuously present in the indicated area for the full year.

Annual Dose Data -- Environmental Monitors
(Time period is from 6/1/92 through 5/30/93)

Location	Average Dose Rate mrem/week 1992-93
Inside Wall of Reactor Laboratory	5.62
Inside Reactor Laboratory Stack	1.38
Highest Dose Outside Reactor Laboratory (Reactor Lab roof entrance window: monitor adjacent to stone surface)	1.93
Highest Dose in Occupied Nonrestricted Area (second floor classroom) Room 247	1.32
Average Dose in all Nonrestricted Areas (27 Monitor Points)	1.14
Lowest Dose Reported in Non-restricted Area	0.87
Average control dosimeter reading	0.86

I. PUBLICATIONS ON WORK BASED ON REACTOR USE

Geology Department, University of Minnesota - Duluth
Skokan, E. "Neutron Activation Analysis of Ancient Indian Pottery in Northern Minnesota" Master's Paper, UW-Minnesota - Duluth (July 1993).

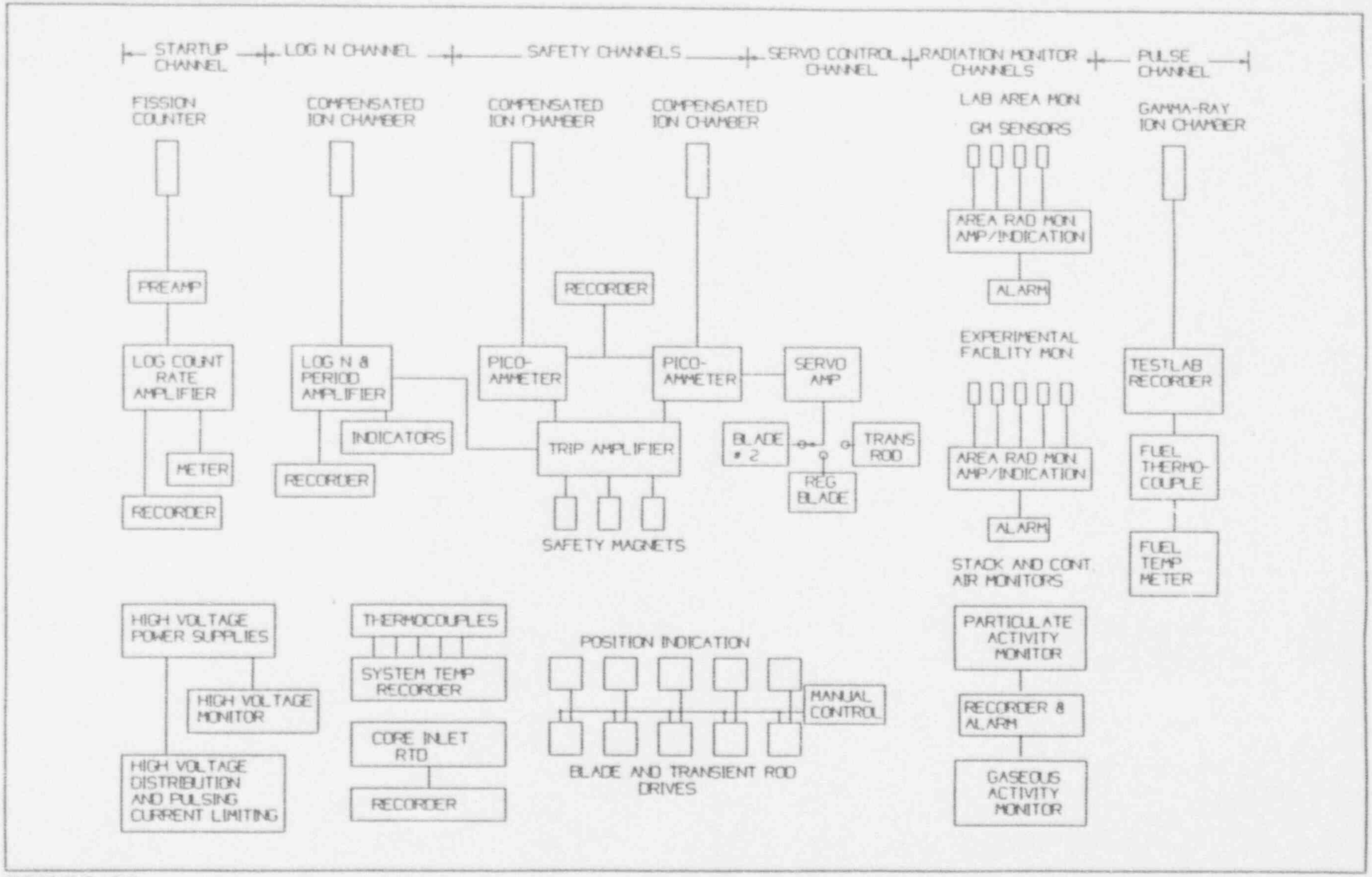

FIGURE 23
<u>NUCLEAR INSTRUMENTATION</u>

Safety Channels

Two safety channels monitor reactor power level from about 0.1 watt to full power. The signal from each channel originates in a compensated ionization chamber. the chamber signal is fed into a solid state picoammeter. The trip output signals from the picoammeters are fed to the logic element where they, along with the period signal from the Log N channel, determine whether power is supplied to the control blade magnets. Should any one scram signal or a combination of scram signals be present, the reactor shuts down. The power level scram trip point is set to 1.25 times the operating level.

Temperature Measurements

Fuel element internal temperature is indicated at the console. It causes an alarm and scram at the limiting safety system setting.

The temperature of the bulk pool water is measured the core inlet by a resistance thermometer. This temperature is indicated on a recorder and causes an alarm and a scram on excessive temperature.

Primary and secondary cooling system inlet and outlet temperatures, and demineralizer inlet temperature are indicated on the system temperature recorder. An alarm on this recorder indicates excessive temperature at any of these points.

2.5.2 Square Wave Operation

This mode is provided for those applications which require that the power level be brought rapidly to some high level, held there for a period of time, and then reduced rapidly producing a square wave of power.

In the square wave mode the reactor is brought to a level of 1 to 1000 watts in the steady-state mode. The mode switch is then changed to the square wave position. A preadjusted step reactivity change is then made to bring the reactor to preset power levels between 300 and 1000 kW. The reactivity step change is made with the transient rod. Then the automatic control system inserts additional reactivity required to maintain the preset power level as the fuel heats up. The operator must manually augment the reactivity inserted by the servo. In this mode the period meter and scram are disconnected and the safety channel range switches must be set on their full power ranges. The linear power level scram is maintained at 1.25 P max. and an interlock prevents initiation of this mode if the range switch is not on the full power range setting.

2.5.3 Pulsing Operation

The reactor is brought to a power level of less than 1000 watts in steady state mode. The mode switch is then changed to pulsing mode. When the switch is in pulsing mode the normal neutron channels are disconnected and a high level pulsing chamber is connected to read out the peak power of the pulse on a Tektronix Testlab provided for that purpose. Changing of the mode switch to pulse removes an interlock that prevents application of air to the transient rod unless the transient rod is in the full "in" position. Only the transient rod is automatically reinserted after a preset time delay. Fuel temperature is recorded during pulsing operation. The pulse channels are also indicated on Figure 23.

2.5.4 Blade Control

The three safety blades are manually controlled by two switches: one selects the blade to be moved; the other, a pistol-grip switch with spring return to "off", has positions of "raise", "off",

and "lower" and controls the selected blade. Only one blade may be raised at a time. A separate switch is available which will lower all blades at the same time. The position of each safety blade is indicated by a digital read-out, and the indicator lights on the console show when each blade drive is at its "in" or "out" limit and when the blade magnets are engaged with the armatures.

The safety blades will scram from any position during withdrawal and run-down. In the event of a scram, the manual controls are over-ridden and the blade drives run in to their "in" limits. The following conditions must be met before the safety blades can be withdrawn:

1. No scram conditions present and scram relays reset;

2. Count-rate on startup channel greater than 2 counts per second;

3. Fission Counter not in motion;

4. Console key switch set to "on" position.

The regulating blade has identical position indication and "in" and "out" limit indication. It is manually controlled by a separate pistol-grip switch and may be driven concurrently with one other control element. The blade drives may be tested by use of a "test" position on the key switch. The scram relay must be de-energized before the drives can be moved while the key switch is in the test position.

2.5.9 Radiation Monitors

The radiation monitors are arranged into three systems; the primary area monitors, experimental facility area monitors, and air activity monitors.

The primary area monitors are located as follows:

1. Demineralizer area;
2. On the reactor bridge about one foot above the water surface;
3. Beside the thermal column door;
4. In the control console area.

All Area Radiation monitor units have ranges from 0.1 to 10000 mr/hr.

Unit 1 supplies information on radiation level from the demineralizer. It will be set at the beginning of a reactor run to alarm at a radiation level just above that reacted in a normal run. Unit 2 will be set to alarm at a radiation level just above that reached at full power operation. Unit 3 is located beside the thermal column. It too is set to alarm just above normal operating level. This unit will give an alarm if the thermal column door is left open when the reactor is operated at any substantial power. Unit 4 indicates the dose rate in the console area.

The units indicated above are connected to the Reactor Laboratory evacuation alarm. An alarm from one of these units will sound the evacuation alarm if it is not acknowledged by the operator within 30 seconds. (See UWNR 150).

The Experimental Facility Area Radiation Monitor is an area radiation monitor installed to preclude the possibility of unknowingly generating high radiation levels by operating the reactor at high power levels with the beam ports open, or by return of an intensely radioactive pneumatic tube sample. The

sensors for this system are installed on the walls of the Reactor Laboratory in direct line with the beam ports and at the pneumatic tube send-receive station. The system gives visual and audible alarms at the console if the radiation level exceeds a preset value. The pneumatic tube monitor also provides local alarm and indication. The monitors are normally set to alarm at a radiation level equivalent to a dose rate of 50-100 mr/hr at the beam port flange. The setting varies from beam port to beam port due to different distances between the walls and the beam port openings. The pneumatic tube monitor alarm is normally set at 10 mrem/hour. It man be set to a higher level if calculated sample activity is expected to be higher.

The air monitor measures both particulate and gaseous activity of the air discharged from the stack. Particulate activity is collected on a filter tape and counted with a thin end-window GM tube and count-rate meter. Gaseous activity is measured with a large Kanne ionization chamber. The system therefore operates by detecting β activity. Both particulate and gaseous activity levels are recorded, and provide annunciation should preset levels be exceeded.

The sensitivity of the particulate activity monitor allows detection of concentrations of about 10^{-10} $\mu c/ml$ of a material with a single β particle emitted per disintegration. The efficiency is higher if more than one β particle is emitted per disintegration. The sensitivity of the gaseous activity monitor is such that a concentration of about 1×10^{-7} $\mu c/ml$ of A^{41} at the stack discharge can be detected by the instrument. The efficiency varies with the number of β particles emitted by the isotope being detected. The primary activity expected to be present in the stack discharge is A^{41} and the instrument is calibrated in terms of A^{41} activity. An identical instrument, provided as a backup for the Stack Air Monitor, is operated as

a Continuous Air Monitor. It samples the atmosphere immediately above the surface of the reactor pool, although it can be made to sample other locations when required. The backup Air monitor can be connected to the stack monitor flowpath, should the stack monitor fail.

2.6 SHIELDING AND EXPECTED RADIATION LEVELS

2.6.1 Basic Reactor Shield

The reactor is shielded by concrete and water. The core is covered by 20 feet of water. The shield at core level consists of about 3 feet of water plus 8 feet of ordinary concrete. Denser concrete is used in the thermal column door and beam port plugs. Calculations and measurements indicate radiation levels to be expected for 10000 kW operation are (excepting N^{16} activity which is discussed below:

Surface of shield, excepting beam port and thermal column openings - less than 1.5 mrem/hr.

Pool surface (leakage radiation - No N^{16} less than 15 mrem/hr.

"Hot spots" - measurements have shown that higher radiation levels exist around the beam ports and thermal column. Extrapolation from these measurements indicates the maximum radiation levels at these "hot spots" at 1000 kW will be about 10 mrem/hr around the beam ports and 40 mrem/hr at the hottest spot around the thermal column door. The dose one foot away from the hot spot will be about 5 mrem/hr.

2.6.2 Pool Surface Radiation Levels - N^{16} Activity

The expected radiation level due to N^{16} activity at the pool surface directly above the core when operating at 1000 kW is 120 mrem/hr. The diffuser jet system will normally be used, and the radiation level would normally be considerably less than the level indicated above. these radiation levels will be low enough that no hazard will exist to personnel outside the Reactor Laboratory or in normally occupied levels within the Reactor Laboratory. Radiation levels on the walkway surrounding the pool are expected to be around 20 mrem/hr while the reactor is operating at 1000 kW without the diffuser operating.

The entire Reactor Laboratory is posted as a radiation area. A chain and switch arrangement is position on the north stairway to the pool surface so that an alarm will be sounded should entry to that area by made while the reactor is operating, thus assuring that personnel will not enter the area without knowledge of the reactor operator.

The south stairway, leading from the console area to the pool surface does not have a chain and switch arrangement, as does the north stairway. Access to these stairs is gained only through the console area and is thus well monitored. No difficulty is expected in maintaining radiation doses to individuals below those doses permitted in 10 CFR 20.