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Tech Specs, Docket 50-156

July 26, 1995

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 1994-95 for the University of Wisconsin Nuclear Reactor Laboratory as required by our Technical Specifications.

Very truly yours,

R. J. Cashwell
Reactor Director

Enc. (Annual Report)

XC: Region III Administrator

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THE UNIVERSITY OF WISCONSIN
NUCLEAR REACTOR LABORATORY

1994-1995 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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EXECUTIVE SUMMARY OF REACTOR UTILIZATION

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

- 38 NEEP students in laboratory courses.
- 60 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 seven additional college-level educational institutions used the facilities for formal instruction or research.

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

- 379 samples were irradiated for departments at UW-Madison.
- 290 samples were irradiated for other educational institution research programs.

Industrial Use:

NAA services were provided to Hazelton Laboratories, Johnson Controls, Molten Metal Technology, and Rexnord Corp. Irradiations were performed for Green Park Gems and the Point Beach Nuclear Power Station.

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A. SUMMARY OF OPERATIONS

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

18 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 19. 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 13 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 15 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.

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

Six students completed NEEP 234, "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 normal scheduled reactor runs for training the students in this course, 138.65 hours of exclusive reactor use specifically for training were required to provide this operating experience. All 6 students applied for NRC Operator Licenses.

Individual class sessions for NEEP 565, EPD 275, and Naval Science were held in the Reactor Laboratory, with 17 students participating.

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, senior citizens, 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 Involved
Colorado College	Prof. Henrickson	2/10
	Provide containers for samples to be submitted for neutron activation analysis of rock and soil samples (for undergraduate thesis experiments).	
Edgewood College Madison, WI	P. Weldy	1/15
	NAA demonstration/Reactor tour for chemistry class.	
Lakeshore Technical Institute	D. Gossett	1/8
	Reactor operation demonstration, Neutron survey instrument use , NAA demonstration	
Milwaukee School of Engineering	Prof. Mayer	1/6
	Reactor Tour and Reactor Operation demonstration	
University of Minnesota-Duluth	Prof. Rapp	2/2
	NAA of rock (chert, quartzite, and other quartz-based) for provenance studies.	
Purdue University	Prof. Kolteck	1/1
	Fast neutron irradiation of insulating materials to determine sensitivity to radiation damage of base material and adhesives.	
University of Wisconsin-Whitewater	Prof. Helwig	2/*
	Provide neutron survey meter for required local surveys; assist with leak tests of gamma and neutron sources; repair and calibrate survey meters. *Number of students benefited is cannot be accurately stated, since the support to the program in the physics department indirectly benefits all students in their instructional units which involve radiation and radioactivity.	

Pre-College Groups: 22/397

Bootstrap

1/5

Reactor tour and nuclear power discussion for a program to enrich the experience of disadvantaged students.

Boy Scouts Blackhawk Council

5/54

Reactor tour, nuclear power discussion, shielding experiment, and neutron activation analysis demonstration for scouting merit badge credit.

Cambridge (WI) Middle School

4/82

Reactor tour, nuclear power discussion, shielding experiment, and neutron activation analysis demonstration to supplement academic unit on nuclear power.

Edgewood Campus School

1/51

Reactor tour, nuclear power discussion, shielding experiment, and neutron activation analysis demonstration to supplement academic unit on nuclear power.

Engineering Tomorrows Careers

1/64

Reactor tour and nuclear power discussion with High School junior and senior women. This program introduces women to career possibilities in engineering disciplines.

ESTEAM

3/33

Reactor tour and nuclear power discussion for minority high school students. Part of a program to interest minority students in technical education.

Four Lakes Girl Scouts

1/9

Reactor tour, nuclear power discussion, shielding experiment, and neutron activation analysis demonstration to satisfy requirements for completing an "interest area".

Institute For Chemical Education

1/25

Reactor tour, nuclear power discussion, shielding experiment, and neutron activation analysis demonstration for high school chemistry teachers. The program is part of a continuing education effort to keep those who teach sciences in the high schools abreast of current research.

Park Middle School, Cross Plains, WI

4/64

Reactor tour, nuclear power discussion, shielding experiment, and neutron activation analysis demonstration to supplement academic instructional unit on nuclear power.

Parkside Precollege

1/10

Reactor tour, nuclear power discussion, shielding experiment, and neutron activation analysis demonstration for a student group at Parkside school.

USER SUMMARY:

Educational Institutions:	17
Students:	439
Faculty/Instructors:	32

3. SAMPLE IRRADIATIONS AND NEUTRON ACTIVATION ANALYSIS SERVICES

There were 983 individual samples irradiated during the year. Of these samples, 428 were irradiated for 15 minutes or less. Samples accumulated 692.5 irradiation space hours and 1829 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.

Chemical Engineering, UW-Madison (NAA)
62 samples, all less than 15 minutes, 15.5 sample hours, 6 irradiation space hours. Prof. Ray and 1 graduate student used the NAA service to determine trace element Al and Ti in polystyrene samples. Industrial support.

Edgewood College, Madison, WI (NAA)
2 samples, both less than 15 minutes. 0.5 sample hours, 0.25 irradiation-space hours. Prof. P. Welti and 15 undergraduate students. Activation of materials for an instrumental neutron activation analysis demonstration. Supported by USDOE Reactor Sharing Program.

Green Park Gems, NY
24 samples, 576 irradiation space hours, 576 sample hours. Irradiation of topaz to induce color change. Industrial support.

Hazelton Laboratories, Madison, WI (NAA)
16 samples, all less than 15 minute irradiations, 4 sample hours, 0.5 irradiation space hours. Determination of F content of oils; determination of leaching of impurities from food packaging materials. Industrial support.

Johnson Controls, Milwaukee, WI (NAA)
102 samples, 61 less than 15 minute irradiation, 103 sample hours, 3.35 irradiation space hours. Trace element analysis of plastic materials. Industrial support.

Lakeshore Technical Institute (NAA)
2 samples, both less than 15 minute irradiation, 0.5 sample hours, 0.25 irradiation space hours. Prof. D. Gossen and 8 undergraduate students. Irradiations for instrumental neutron activation analysis demonstration. Supported by DOE Reactor Sharing Program

Molten Metal Technology, MA and TN (NAA)
161 samples, 36 less than 15 minutes, 242 sample hours, 8 irradiation space hours. Three staff members used the neutron activation analysis service in three distinct projects. One project measured the amount of Hf and Ce in purified waste metals. A second project measured the long-lived activities produced in off-gas from a reclamation process. The third project measured the Na content in materials. Industrial support.

Nuclear Engineering and Engineering Physics, UW-Madison

NEEP 234, 427, and 428 Laboratory Courses
188 samples, 114 less than 15 minutes, 167.33 sample hours, 62.23 irradiation space hours. Irradiations in support of teaching laboratory.

Reactor Laboratory
44 samples, 5 less than 15 minutes, 32.24 sample hours, 4.33 irradiation space hours. Irradiations for flux measurements and instrument calibrations.

Neutron Radiography
24 samples, 204 sample hours, 12 irradiation space hours. Prof. Corradini and one additional staff member made flux measurements using activation foils.

Point Beach Nuclear Power Station, WI
1 sample, 4.3 sample hours, 4.3 irradiation space hours. Production of Na^{24} for steam generator carryover studies. Industrial support.

Rexnord Technical Services, Milwaukee, WI (NAA)
10 samples, all less than 15 minute irradiation, 2.5 sample hours, 0.25 irradiation space hours. Measurement of Mg in cured elastomers. Industrial support.

Purdue University, IN
7 samples, 5 less than 15 minutes, 1.91 sample hours, 0.58 irradiation space hours. Prof. Koltech and 1 graduate student irradiated insulating materials to determine the amount of fast neutron damage at different exposures. Supported by DOE Reactor Sharing Program.

University of Minnesota-Duluth (NAA)
279 samples, 108 less than 15 minutes, 429 sample hours, 11 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.

School of Veterinary Medicine, UW-Madison (NAA)
18 samples, 18 sample hours, 1 irradiation space hour. Prof. Kruse-Eliott used the NAA service to study transport of compounds in animals. Supported by University of Wisconsin.

4. OTHER MAJOR RESEARCH USE

Development of the neutron radiography facility continued. Two different collimator modifications were installed, and neutron flux measurements and resolution measurements were made using the modified collimators. A graduate student has been recruited to continue the work, while an industrial sponsor is being sought (in conjunction with the department of Mechanical Engineering) from an injection moulding group.

5. CHANGES IN PERSONNEL, FACILITY AND PROCEDURES

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

Additional upgrading of the facility, not reportable under 10CRF 50.59, was completed during the year.

The coaxial relays which interrupt signals to neutron instruments during pulsing operation were replaced with sealed reed relays on 3 January 1995. The original relays were high-current open-contact units which developed "dirty" contacts that had to be cleaned from time to time.

The control element release and drop time measurement device was upgraded from mechanical timers with electric clutches to electronic timers. Some wiring changes that facilitate the release time measurements were included in this modification. The mechanical timers had performed well, but our calibration facility expressed concern that performance was degrading, primarily due to hardening of lubricants and mechanical wear.

A new pump and filtration capability for the liquid waste disposal facility was procured during the year, but installation was not completed during the report period. The system is expected to be completed in early July, 1995.

Personnel changes during the year were as follows:

The following individuals were appointed as Reactor Operators upon licensing by NRC.

Lonny Joe Kress
Heather Jean MacLean
Dirk Ernst Raebel
William Roger Wood

The following individual as appointed as Senior Reactor Operator upon licensing by NRC (upgrade from RO to SRO)

Robert J. Agasie

The following operator completed degree requirements and left the university.

Daniel James Dettmers

The following operators were removed from licensed status due to inability to meet the requirements of the Operator Proficiency Maintenance Program of the facility.

Geoff Patterson
David Pearson

6. RESULTS OF SURVEILLANCE TESTS

The program of inspection and testing of reactor components continues. Inspection of underwater components showed no deterioration or wear.

B. OPERATING STATISTICS AND FUEL EXPOSURE

Operating Period	Startups	Critical Hrs	MW Hrs	Pulses
FY 1994-95	242	544.95	529.48	49
Total Present Core	3115	10,852.49	9,090.92	695
Total TRIGA Cores	5105	18,117.48	14,079.10	2006

Core I23-R10 was operated throughout the year. The excess reactivity of this core with cadmium-lined irradiation positions loaded decreased 0.023%ρ to 2.385 %ρ during the year.

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

There were 16 automatic scrams or inadvertent shutdowns during the year. Each is described below in chronological sequence, but the events can be grouped as follows:

- 4 drops of a single control element due to misalignment of magnet and armature
- 2 building electrical power interruptions
- 2 failure of picoammeter switch make-before-break feature
- 4 operator errors (3 range switch errors, 1 short period) by students learning to operate the reactor
- 1 range switch operating error by licensed operator
- 1 short period from operating error by licensed operator
- 1 high pool level due to water temperature increase
- 1 power trip due to shift in square wave calibration curve

On July 7, 1994, relay and electronic scrams on both picoammeters resulted from a square wave to 100% power. The calibration curve for square wave operation had shifted enough that the indicated insertion for 100% power was enough that transient power reached the scram point.

On August 11, 1994 a building power disturbance caused automatic drop of all scrammable control elements.

On August 25, 1994, a relay scram occurred from high pool level. The reactor was at full power, and a high wet-bulb temperature resulted in higher than usual pool temperatures; the higher temperature caused enough expansion to actuate the high level scram setting. (The pool level scram is provided for early indication of leaks. Since a heat exchanger leak will cause secondary water leakage into the pool, the level scram and alarm actuate on both high and low level.) The run was terminated to allow the cooling system to reduce pool temperature.

On November 1, 1994, a relay and electronic scram from both picoammeters resulted from an operator failing to uprange in a timely manner. The operator was instructed on proper instrument coverage.

On February 6, 1995, a relay and electronic scram from #1 picoammeter resulted from a trainee error in down-ranging one range too many.

On February 9, 1995, a period relay scram (5 second setpoint) occurred when an operator trainee inserted too much reactivity while increasing power. The trainee was told to expect faster reactivity changes near the center of travel of a control element, and that he should not try to respond to oral questioning while his attention should be on instrument response.

On February 17, 1995, a relay and electronic scram from picoammeter #1 occurred when changing range from 300 kW to 100 kW. The trip occurred again when tested. The picoammeter was replaced with the spare, and the range switch was replaced in the unit that had exhibited failure. That unit was made the spare after repair and testing.

On March 28, 1995, control blade #3 dropped. Magnet current was normal before and after the drop. The drive picked up the armature with no problem, so operation continued.

On 12 May, 1995, electronic and relay scram occurred when picoammeter #2 was switched from the 300 kW range to the 100 kW range. This was the result of a failure of the make-before-break feature of the range switch. The problem repeated upon testing, so the installed picoammeter was replaced with the spare unit and the defective unit was declared a working spare after the defective switch was replaced.

On 16 May, 1995, the reactor scrammed due to loss of electrical power to the building. Power was restored within a few minutes, but operation did not continue until the next scheduled operation day.

On 23 May, 1995 <u>two</u> electronic and relay scrams occurred when an operator trainee failed to uprange picoammeter #2 while increasing power. The trainee was undergoing a NRC operator license exam at the time, and exam stress significantly affected the candidate's performance.

Subsequently on 23 May, 1995, control blade #3 dropped while being moved. Magnet current was normal both before and after the drop. The armature and magnet face were cleaned and the reactor was re-started. (Alignment between the magnet face and armature is variable due to "whip" of the magnet due to lead screw operation, so occasional drops of this type are not rare.)

On May 24, 1995, control blade #3 again dropped while being moved on two occasions. After the second drop, the armature and magnet face were cleaned with emery cloth and the thickness of the studs which provide a small air gap between the magnet face and the armature was slightly reduced. Magnet current was already at the maximum capacity of the magnet amplifier, so no other method of increasing holding force was available. After the modification, testing indicated no measurable increase in release and drop time for this blade, and operation resumed.

On June 5, 1995 a period relay scram (5 second setting) occurred during a transient rod pull for reactivity calibration. The operator on duty misjudged the amount of prompt jump that would occur. The reactor was restarted.

D. MAINTENANCE

Routine preventive maintenance continued to maintain most equipment operability. The only significant maintenance problems occurring during the year were the failures of the range switches on two picoammeters. The switches usually fail after five to seven years of operation, especially during semesters with much trainee operation.

Wiring and watertight tubing for the fuel measuring tool was replaced due to ageing and radiation damage. In addition, the "BlueRibbon" connector between the cable and the readout box was giving intermittent connections, so the connector was also replaced.

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

There were no changes in the facility of procedures reportable under 10CFR Part 50.59.

F. RADIOACTIVE WASTE DISPOSAL

1. SOLID WASTE

No solid waste was transferred from the facility during the year.

2. LIQUID WASTE

There were no discharges of liquid radioactive waste to the sewer system during the year.

3. PARTICULATE AND GASEOUS ACTIVITY RELEASED TO THE ATMOSPHERE

Table 1 presents information on stack discharges during the year.

G. SUMMARY OF RADIATION EXPOSURE OF PERSONNEL (1 June 1994 - 31 May 1995)

No personnel received any significant radiation exposure for the above period. The highest doses recorded were 160 mrem to the whole body and 90 mrem to extremities.

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 the dose a person would have received if continuously present in the indicated area for the full year.

I. PUBLICATIONS BASED ON REACTOR USE

1994 Chen, T., G. Rapp, Jr., Z. Jing, and N. He, "Provenance Study with Neutron Activation Analysis on the Ceramics from Jingnansi Bronze Age Site, Hubei, China", *Proceedings of the Symposium: Chinese Archaeology Enters the 21st Century,* Peking University (in press).

1994 Rothe, R. and G. Rapp, Jr., "Trace Element Analysis of Egyptian Eastern Desert Tin and Its Importance to Egyptian Archaeology", *Proceedings of the First Egyptian-Italian Conference on the Geosciences and Archaeology in the Mediterranean Countries* (in press).

TABLE 1
EFFLUENT FROM STACK

1. Particulate Activity

There was no discharge of particulate radioactivity above background levels.

2. Gaseous Activity -- All Argon 41

Month	Activity Discharged (Curies)	Maximum Instantaneous Concentration $\mu Ci/ml \times 10^{-6}$	Average Concentration $\mu Ci/ml \times 10^{-6}$
July 1994	0.05120	6.0	0.0253
August	0.01539	4.2	0.0085
September	0.04874	1.5	0.0281
October	0.04742	2.0	0.0265
November	0.02304	1.2	0.0133
December	0.00187	1.3	0.0001
January 1995	0.01844	1.0	0.0103
February	0.05292	1.5	0.0327
March	0.01974	0.8	0.0110
April	0.05310	1.5	0.0306
May	0.06108	1.7	0.0341
June	0.07697	1.9	0.0380
TOTAL (Average)	0.46991	6.0 (Maximum)	0.0224

Maximum Instantaneous Concentration = 0.25 of MPC

Average Concentration = 0.00093 of MPC

TABLE 2
ANNUAL DOSE DATA -- Environmental Monitors

Location	Annual Dose mrem 1994-1995
Control- kept in lead shield except for shipment from and to processor	82.6
Inside Wall of Reactor Laboratory	454.8
Inside Reactor Laboratory Stack	110.4
Highest Dose Outside Reactor Laboratory (Reactor Lab roof entrance window: monitor adjacent to stone surface)	155.2
Highest Dose in Occupied Nonrestricted Area (second floor classroom) Room 247	125.4
Average Dose in all Nonrestricted Areas (27 Monitor Points)	97.1