

University of Wisconsin

NUCLEAR REACTOR LABORATORY
NUCLEAR ENGINEERING DEPARTMENT
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July 22, 1985

James R. Miller Chief
Standardization and Special Projects Branch
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Sir:

Enclosed herewith is a copy of the Annual Report for the fiscal year 1984-85 for the University of Wisconsin Nuclear Reactor Laboratory as required by our Technical Specifications.

Very truly yours,


R. J. Cashwell
Reactor Director

RJC:mld
Enc. (Annual Report 84-85)

XC: U. S. Nuclear Regulatory Commission
Region III
Office of Inspection and Enforcement
Glen Ellyn, IL 60137

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ANNUAL OPERATING REPORT FOR LICENSE R-74
THE UNITED STATES NUCLEAR REGULATORY COMMISSION

FOR
FISCAL YEAR 1984-1985

PREPARED BY: R. J. CASHWELL
DEPARTMENT OF NUCLEAR ENGINEERING

UNIVERSITY OF WISCONSIN
NUCLEAR REACTOR LABORATORY

ANNUAL REPORT
FISCAL YEAR 1984-1985

A. SUMMARY OF OPERATIONS
1. INSTRUCTIONAL USE - UW-MADISON FORMAL CLASSES

Three Nuclear Engineering Department classes make use of the reactor. Fifty-one students enrolled in NE 231 participated in a two-hour laboratory session introducing students to reactor behavior characteristics. Twelve hours of reactor operating time were devoted to this session. NE 427 was offered in the fall and spring semesters and had an enrollment of 28. Several NE 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. The irradiations in support of NE 427 and the radiation survey take place during normal isotope production runs, so no reactor time is specifically devoted to NE 427. The enrollment in NE 428 was 25, as it was offered in both semesters. Three experiments in NE 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 seventy-eight hours of exclusive reactor use. Other NE 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 eight times during the year. Individual one- to two-hour sessions in the reactor laboratory were also held for other departments on campus.

2. REACTOR SHARING PROGRAM

User institutions participated in the program as detailed in the following paragraphs:

Beloit College (Wisconsin)--Professor Dobson and 14 undergraduate students came to the laboratory to participate in the "Reactor Operation Demonstration" laboratory session, which familiarizes the students with reactor behavior while subcritical, critical, supercritical, and prompt supercritical.

Carleton College (Minnesota)--Professor Hennrickson and 12 undergraduate students used the NAA service to analyze rocks, pottery, and sediments for senior theses projects.

Carroll College (Wisconsin)--Professor Auchter and 6 of his advanced chemistry students came to the laboratory for a 4-hour NAA laboratory session.

Edgewood College (Wisconsin)--Professor Wilte and 5 students attended a neutron activation analysis laboratory session.

Lakeshore Technical Institute

(Wisconsin)--Professor Reindl and 15 of his students in a Health Physics Technician Training Program visited the laboratory for a reactor operating characteristics demonstration and familiarization with instruments and to detect radioactive effluents.

University of Minnesota-Duluth--Professor Rapp and his research group continued their work using NAA of artifacts to determine provenance of metals and pottery.

University of Wisconsin-Eau Claire--Professor Gleiter and 12 of his undergraduate students visited the laboratory for formal experiments on Neutron Activation Analysis and reactor startup.

University of Wisconsin-Parkside--Professor Firebaugh and 6 undergraduate students visited the laboratory for an experiment entitled "Control Element Calibrations".

University of Wisconsin-Stevens Point--Professor Lokken and 9 undergraduate students visited the laboratory for a reactor operation demonstration experiment and tour.

3. UTILITY PERSONNEL TRAINING

One group of four STA candidates from Northern States Power Company attended a one-week Research Reactor Training Program. This program gives operating practice while it reinforces previous training in reactor physics and operation and gives laboratory experience in health physics and instrumentation.

4. SAMPLE IRRADIATIONS AND NEUTRON ACTIVATION ANALYSIS SERVICES

There were 2,322 samples irradiated during the year. There were 1,103 samples which received short (15 minutes or less) irradiations. Other samples accumulated 282.05 irradiation space hours and 2568.11 sample hours. Most of the samples were irradiated and subsequently counted at the 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) 70 samples, 68 less than 15 minutes, 7.58 irradiation space hours, 20 sample hours.

Professor Record, 1 post doctoral fellow, and 1 graduate student used the neutron activation analysis service in a study of sodium and rubidium interactions with DNA. Research is supported by NSF and NIH.

Chemistry Department. (NAA) 15 samples, 1 irradiation space hour, 15 sample hours.

Professor Wright and 4 graduate students used the neutron activation analysis service to determine absorption coefficients of various Eu sites in PbF matrixes. Supported by NSF.

Enzyme Institute (University of Wisconsin-Madison)
(NAA) 7 samples, 7 less than 15 minutes, 0.58 irradiation space hours.

Professor Frey and 1 graduate student measured metals present in an enzyme to determine mechanism of action. Supported by National Institute of General Medical Sciences.

Globe Battery Division of Johnson Controls. (NAA)
231 samples, 230 less than 15 minutes, 26.65 irradiation space hours, 45 sample hours.

Measurement of impurity levels of lead samples to be used in batteries. Industrial support.

Human Oncology Department. 12.91 hours of beam port use.

Professor Clifton and his research group of 4 faculty and academic staff, 2 post doctoral fellows, 2 graduate students and 1 other staff member are preparing for a study of radiation induced carcinogenesis. Work done thus far has consisted of building the facilities on beam ports 1 and 2 and dosimetry and beam tailoring to establish the optimum fast neutron to gamma dose ratios. Supported by DOE and USDHHS National Cancer Institute.

Mechanical Engineering Department. (NAA) 49 samples, 39 less than 15 minutes, 4.24 irradiation space hours, 10 sample hours.

Professor Ragland and 1 graduate student used the neutron activation analysis service to determine the halogen content of residues from combustion of refuse derived fuels. Support unknown.

Medical Physics Department. 6 samples, 6 less than 15 minutes, 0.5 irradiation space hours.

Professor Deluca and one undergraduate student activated standards for use in detector calibrations. Instructional funds.

Nuclear Medicine Department. 68 samples, 2 less than 15 minutes, 37.25 irradiation space hours, 64 sample hours.

Professor Gatley, 2 additional staff member, 3 graduate students and 1 undergraduate student. Production of fluorine-18 to produce compounds for positron emission tomography. Supported by NIH.

Nuclear Engineering Department

NE 427 and NE 428 instructional use. 151 samples, 89 less than 15 minutes, 81.22 irradiation space hours, 170.71 sample hours. Irradiation of foils and NAA unknowns in support of laboratory instruction.

Reactor Laboratory and Utility Training. 25 samples, 13 less than 15 minutes, 13.06 irradiation space hours, 72 sample hours. Tests of neutron activation analysis techniques and preparation of samples used in calibration of reactor instrumentation.

Radiation damage studies.-- 74.7 hours of beam port irradiation.

Professor Wolfer and 2 graduate students have performed neutron irradiations of static RAM semiconductor chips to determine failure

rates under radiation exposure. This work was done inside beam port #3. Departmental support.

Orthopedic Surgery Department. (NAA) 24 samples, 6.3 irradiation space hours, 74.4 sample hours.

Professor Lindgren and 2 staff members. Determination of possible toxic effects of degraded artificial hip joint materials on heart of heart transplant patient. Supported by Department of Surgery.

Physics Department. (NAA) 8 samples, 0.5 irradiation space hours, 4 sample hours.

Professor Knutson and 1 student. Determination of ytterbium concentrations in samples of yttrium ethyl sulfate. Analysis of samples for the presence of other contaminants and analysis of synthesized crystals. Supported by the Department of Energy.

Radiology Department. 2 hours of beam port use.

Professor Wiley and 1 staff member have begun studies of use of epithermal neutron beams for boron capture therapy. Initial work has been on construction and evaluation of appropriate filter systems. Supported by Graduate School.

Reactor Sharing Program.

Carroll College. (NAA) 2 samples less than 15 minutes, .5 irradiation space hours. Professor Auchter and 6 students. Activation for neutron activation analysis laboratory session.

Carleton College. (NAA) 101 samples, 14 irradiation space hours, 206 sample hours. Prof. E. Henrickson of the Geology Department, 1 additional staff member and 6 undergraduate students use the NAA service for senior theses on effects of geological processes as indicated by trace element patterns.

Edgewood College. (NAA) 1 sample, 1 less than 15 minutes, 0.08 irradiation space hours. Professor and 5 students. Samples irradiated for NAA laboratory exercise.

University of Minnesota-Duluth. (NAA) 478 samples, 4 irradiation space hours, 992 sample hours. Prof. Rapp, 2 staff members, and 2 students continued work on determining common origin of copper and pottery artifacts.

University of Wisconsin-Eau Claire. (NAA) 46 samples, 46 less than 15 minutes, 3.4 sample hours. Professor Gleiter and 12 undergraduate students. Irradiations in support of neutron activation analysis session and NAA of lake core samples for unsponsored research.

All of these instructional and research uses were supported by the United States Department of Energy's Reactor Sharing Program.

Safety Department. (NAA) 6 samples, 2 irradiation space hours, 12 sample hours.

Measurement of halogen content of organic waste samples. Supported by the University of Wisconsin.

Soils Department. 36 samples, 4.5 irradiation space hours, 79 sample hours.

Professor Helmke, 1 post doctoral fellow, 1 graduate student. Development of rare earth tracer techniques to measure in-situ

biogenic sediment redistribution by deposit feeding benthic microinvertebrates. Supported by the Environmental Protection Agency.

Tracer studies of elemental behavior in environmental systems. Supported by federal Hatch Act and EPA.

University of Maryland. (NAA) 141 samples, 9 irradiation space hours, 729 sample hours.

Professor Erdman of the Department of Animal Science and his graduate students used stable tracer techniques for measuring feedstuff utilization in cattle. Support unknown.

University of Minnesota. (NAA) 45 samples, 2.75 irradiation space hours, 72 sample hours.

Professor Gorham of the Department of Ecology and Behavioral Biology with 1 post doctoral and 1 graduate student is using the neutron activation analysis service to analyze plants and peat cores from bogs ranging from Minnesota to Newfoundland. Research supported by the National Science Foundation.

Warzyn Engineering, Inc. (NAA) 466 samples, all less than 15 minutes, 39.74 irradiation space hours, 3 sample hours.

Determination of halogen content of groundwater using EPA standard method. Industrial support.

5. CHANGES IN PERSONNEL, FACILITY, AND PROCEDURES

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

Two student employees, David Skulina and Tim Tautges, were licensed by the Nuclear Regulatory Commission during the year and appointed as reactor operators.

Fast neutron beam experiments for biological irradiations were installed on beam ports 1 and 2 during the year. These facilities will be used in support of Professor Kelly Clifton (Human Oncology Department) and his research group who are investigating the effect of low dose high LET radiation under a DOE grant. Preliminary work has begun on development of an epithermal beam experiment for boron/epithermal neutron therapy evaluation.

There were no significant changes in facility procedures during the year.

6. RESULTS OF SURVEILLANCE TESTS

Surveillance tests and inspections during the year revealed no safety-related defects.

B. OPERATING STATISTICS AND FUEL EXPOSURE

Operating Period	Startups	Critical Hours	MW Hours	Pulses
FY 84-85	142	647.11	535.59	39
Total Present Core	1281	4467.49	3457.07	260
Total TRIGA Cores	3256	11650.27	8596.85	1621

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

There was one shutdown initiated for emergency reasons during the year. On 10/18/84, while the reactor was being brought to critical during the final control element pull concluding a NE 428 laboratory session on loading to critical smoke was observed coming from the vicinity of the area radiation monitor chassis. The reactor was shut down by a manual scram, the AC power was removed from the chassis, and a fire extinguisher was used to suppress the suspected fire. Upon examination it was discovered that a large oil-filled capacitor in the Sola regulating transformer for the Victoreen area radiation monitor power supply had failed by leaking oil and the smoke resulted from the oil being evaporated from the transformer coil where it had dripped. There was no actual fire, and the instrument was still operating until the power was removed after the shutdown. The capacitor was replaced and the instrument was returned to service.

There were 7 inadvertent scrams distributed as indicated below:

4 Trainee Operator Error Scrams

7/23/84--Trip from picoammeters 1 and 2 due to trainee failing to uprange in a timely fashion while increasing power level.

12/11/84--Period scram when trainee withdrew transient rod drive excessively because he thought the rod was not latched, when in reality it was latched.

5/30/85--Period scram when trainee failed to observe period attained upon control element motion and excessive control element motion occurred.

6/3/85--Period scram when trainee failed to allow sufficient time after pulsing operation for instrument recover before returning the mode switch to manual.

3 Spurious Scrams Attributed to Fuel Temperature Indicating Meter 19M1

7/3/84--Relay scram with no indication of initiating instrument while at steady full power and 98 deg. F pool temperature. There was no upscale deflection on any recorder chart, and the fuel temperature readings had been constant before and after the event.

3/12/85--Same as 7/3/84 event.

5/2/84-- Same as above two events, except it was suspected that the thermocouple leads at the bridge top had been bumped coincident with the scram.

The modifications of the fuel temperature monitor indicated in section 5. of the previous annual report have reduced

the number of spurious fuel temperature scrams to 3 during the fiscal year compared to 9 in the previous year. The problem is still under investigation.

D. MAINTENANCE

Normal preventive maintenance kept equipment in good operating condition. See Section A.5 for modifications and Section E for any changes reportable under 10 CFR 50.59.

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

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

F. RADIOACTIVE WASTE DISPOSAL

1. Solid Waste
No waste was transferred offsite during the year.

2. Liquid Waste
There were two liquid waste discharges during the year. The concentrations at discharge were below MPC levels 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

	9 Nov. 84	7 May 85	Annual Total
Total Activity Discharged (Microcuries)	31.17	93.85	125.02
Liquid Quantity Gallons	1300	1150	2450
Co-57 - MPC - 4E-4 Microcuries Microcuries/ml	0.07 8.03E-10	-- --	0.07
Co-58 - MPC - 4E-3 Microcuries Microcuries/ml	-- --	1.85 2.06E-8	1.85
Co-60 - MPC - 1E-3 Microcuries Microcuries/ml	0.29 3.22E-9	2.69 2.99E-8	2.98
Zn-65 - MPC - 3E-3 Microcuries Microcuries/ml	6.92 7.69E-8	30.5 3.39E-7	37.42
Mn-54 - MPC - 4E-3 Microcuries Microcuries/ml	1.05 1.17E-8	5.26 5.84E-8	6.31
Cr-51 - MPC - 5E-2 Microcuries Microcuries/ml	22.84 2.538E-7	12.5 1.36E-7	35.34
Fe-55 - MPC - 2E-2 Microcuries Microcuries/ml	-- --	40.3 4.47E-7	40.3
Fe-59 - MPC - 2E-3 Microcuries Microcuries/ml	-- --	0.746 8.28E-9	0.746

All concentrations discharged were below MPC without accounting for dilution by sewage flow.

Average concentration at point of release to sewer = 1.35E-5 microcuries/ml.

Average daily sewage flow for dilution = 2.37E4 gallons.

Average yearly concentration = 3.82E-9 microcuries/ml.

TABLE 2
EFFLUENT FROM STACK

1. Particulate Activity

There was no discharge of particulate activity in excess of background levels.

2. Gaseous Activity - All Argon 41

Month	Activity Discharged (Curies)	Maximum Instantaneous Concentration (Microcuries/ml $\times 10^{-6}$)	Average Stack Concentration (Microcuries/ml)
July '84	.22382	2.2	.1290
August	.17177	1.8	.0873
September	.22527	2.0	.1450
October	.16867	1.8	.0939
November	.27551	2.0	.1490
December	.19375	2.0	.1120
January '85	.22065	2.0	.1160
February	.11758	1.6	.0813
March	.13913	1.8	.0776
April	.15241	1.8	.0880
May	.16121	2.0	.0767
June	.16104	2.4	.0971
TOTAL	2.21081	2.4 (maximum)	.1047

The MPC used is 2.4×10^{-5} microcuries/ml.

This MPC is that calculated in the SAR to result in a concentration of 3×10^{-8} microcuries/ml in the area surrounding the laboratory. The maximum instantaneous concentration released was 0.100 of MPC, while the average concentration released was 0.00436 of MPC.

The approximately 20% increase in Argon 41 activity discharged was due to installation and use of two beam port experiments during the year.

G. SUMMARY OF RADIATION EXPOSURES (1 JULY 1984 - 30 JUNE 1985)

No excessive exposure of personnel to radiation occurred during the year. The highest exposure for any employee was 320 mrem whole body, 320 mrem skin, and 120 mrem extremities which may be compared to the federally-permissible doses of 5,000 mrem, 7,500 mrem, and 18,750 mrem respectively per year. The highest annual dose for any student was 50 mrem whole body and 140 mrem skin.

Routine radiation and contamination surveys of the facility revealed no areas of high exposure rates or high contamination levels due to operation of the facility.

H. RESULTS OF ENVIRONMENTAL SURVEYS

The environmental monitoring program at Wisconsin consists of thermoluminescent dosimeters (LiF TLD service from Eberline) located in areas surrounding the reactor laboratory.

The table below lists doses for persons continuously in the area for representative dosimeter readings.

Annual Dose Data--Environmental Monitors

Location	Average Dose Rate-mrem/week
Inside Wall of Reactor Laboratory	6.74 ± 1.30
Inside Reactor Laboratory Stack	1.68 ± 0.22
Highest Dose Outside Reactor Laboratory (Reactor Lab roof entrance window; Monitor adjacent to stone surface)	3.04 ± 0.63
Highest Dose in Occupied Nonrestricted Area (third floor classroom facing away from Reactor Lab - Room 314)	1.55 ± 0.21
Average Dose in Occupied Nonrestricted Area	1.33 ± 0.25
Average Dose in All Unrestricted Areas (29 Monitor Points)	1.43 ± 0.36

I. PUBLICATIONS AND PRESENTATIONS ON WORK
BASED ON REACTOR USE

Soils Department

J. R. Kawaas, PhD Thesis, "Significance of Fiber Level on Nutritive Value of Alfalfa Hay-based Diets for Ruminants", University of Wisconsin (1983).

J. R. Kawaas, R. D. Shaver, J. A. Woodford, N. A. Jorgensen, and D. A. Rohweder, "Forage Quality for Dairy Cattle", 44th Minn. Nutrition Conf. (1983).

Jose Danelon, M.S. Thesis, "Evaluation of Partial Substitution of Dietary Components with Dehydrated Alfalfa in Diets of Lactating Cows", University of Wisconsin (1983).

Nuclear Medicine

James R. Halama, S. John Gatley, Timothy R. DeGrado, Dana R. Bernstein, Chin K. Ng, and James E. Holden, "Validation of 3-deoxy-3-fluoro-D-glucose as a glucose transport analogue in rat heart", Amer. J. Physiology 247, pp H754-H759 (1984).

M. S. Rosenthal, Al Bosch, R. J. Nickles, S. J. Gatley, "Synthesis and some characteristics of no carrier added F-18 fluorotrimethylsilane", Int. J. Appl. Radiat. Isot. (in press)

L. G. Hutchins, Al Bosch, M. S. Rosenthal, R. J. Nickles, S. J. Gatley, "Synthesis of F-18 2-deoxy-2-fluoro-D-glucose from highly reactive F-18 tetraethylammonium fluoride prepared by hydrolysis of F-18 fluorotrimethylsilane", Int. J. Appl. Radiat. Isot. (in press)