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THE UNIVERSITY OF WISCONSIN
NUCLEAR REACTOR LABORATORY
MADISON, WISCONSIN

ANNUAL REPORT
FISCAL YEAR 1977-1978

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DEPARTMENT OF NUCLEAR
ENGINEERING

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ANNUAL REPORT

A. SUMMARY OF OPERATIONS

1. Instructional Use - UW-Madison Formal Classes

NE 427 had a total enrollment of 36 students during the fiscal year. Experiments in NE 427 used foils which had been activated in the reactor for counting experiments, and one experiment entitled, "Radiation Survey" involves measurements of radiation levels in and around the Reactor Laboratory by the use of portable instrumentation.

NE 428 had an enrollment of 34 students as it was offered both semesters and during summer school. Extensive exclusive use of the reactor is made in several of the experiments in NE 428. "Critical Experiment", "Control Element Calibration", and "Pulsing" experiments were repeated five times for 428 students. Two 428 experiments, "Fast Neutron Flux Measurements by Threshold Foil Techniques" and "Resonance Absorption" were repeated ten times each during the year.

Enrollment in NE 231 was 41. The "Reactor Operation Demonstration" experiment was performed four times for this class as a two-hour experiment in order to acquaint the students with basic reactor kinetic behavior.

At least one session in the reactor laboratory was included in courses of the Departments of Biochemistry (70 students), Chemistry (120 students), and Physics (15 students).

2. Reactor Sharing Program

Use of the reactor by other institutions under this program declined considerably during the year. Personnel from the University of Minnesota-Duluth (3 staff members and 2 graduate students) continued work on identification of copper artifacts, ores, and tin ores by multielement Instrumental Neutron Activation Analysis. This program is in pursuit of archaeological objectives based on the metallurgy of artifacts. In addition, the University of Wisconsin-Stevens Point brought a group to the reactor laboratory (2 staff members and 25 students) for a reactor operation demonstration.

3. Utility Operating Personnel Training. A two-week research reactor familiarization course was performed for personnel from Public Service Indiana. These three personnel will be associated with the operation of the Marble Hill Plant in Southern Indiana. The program acquainted the students with reactor kinetics and operation, and provided laboratory experience for the students in areas that had been covered in an academic program at their own site.

4. Sample Irradiation and Neutron Activation Analysis Services. During the year, 3,847 samples were irradiated. Irradiations of 15 minutes or less were performed on 765 of these samples, while the remainder accumulated 9,265 sample hours of irradiation. The irradiation work could be further classified into 525 individual irradiations of 15 minutes or less plus 398.7 irradiation space hours for samples run longer than 15 minutes.

A listing of individual groups for whom irradiations were performed follows. In this listing, information is supplied on object of the research effort, personnel involved, and sponsoring organization, where known. The parenthetical expression (NAA) with an entry indicates the work was performed by the UUNR Neutron Activation Analysis Service.

Canada Certified Reference Material Project. (NAA) 84 samples, 38 less than 15 minutes, 92 sample hours. Dr. J. A. McKeague is directing an effort which has prepared samples of four soil types. These samples are being analyzed by a number of laboratories in order to use the samples as standards for chemical and physical analyses of various types of soils. Supported by Department of Agriculture and Energy, Mines & Resources, Canada.

Civil and Environmental Engineering (Water Chemistry). (NAA) 72 samples, 12 less than 15 minutes, 120 sample hours, Professor A. Andren, 1 graduate student. NAA of sediments for metals introduced as pollutants.

Dairy Science. (NAA) 1437 samples, 3,996 sample hours. Professors L. Satter and N. Jorgensen, 3 graduate students. These are rare earth stable tracers in a study of feed constituent utilization in dairy cattle. Supported by an Industrial Grant.

Electrical & Computer Engineering. 9 samples, 2 less than 15 minutes, 27.33 sample hours. Professor Wiley and 1 graduate student. Attempt to dope silicone by transmutation with thermal neutrons. Performed as a course project for ECE 745.

Globe Union, Inc. (NAA) 141 samples, 34 less than 15 minutes, 156.5 sample hours. NAA of various materials for quality control purposes and developmental purposes.

University Hospitals, Radiotherapy Department. (NAA) 41 samples, 28 less than 15 minutes, 32.5 sample hours. Professor Wiley, 3 additional staff members, 1 graduate student. NAA service to establish correlations between multiple energy computerized axial tomographic scanning and the elemental composition of human neoplasms. Research effort is presently supported by University funds and a Grant for continued work is being submitted.

Limnology. (NAA) 179 samples, 433.5 sample hours. 2 staff members, 2 grad students. NAA of fish and crayfish to determine the uptake of trace metals from the environment. Supported by U. S. Environmental Protection Agency.

Metallurgical and Mineral Engineering. (NAA) 27 samples and 54 sample hours. Professor C. Loper, 7 students. NAA of aluminum weld material to determine the amount of tungsten deposited in the weld from tungsten inert gas welding of aluminum. Research sponsored by DOE.

Metallurgical and Mineral Engineering--Carnegie-Mellon University.(NAA) 65 samples, 79.50 sample hours. 1 Post Doctoral fellow. Alloy uniformity in production of superconducting alloys. Supported by DOE.

State of Minnesota-Regional Copper-Nickel Project. (NAA) 34 samples, 16 less than 15 minutes, 18 sample hours. NAA of rock, soil, and leaves to determine effect of mining operations on environmental quality. Supported by State of Minnesota.

University of Minnesota-Duluth. (NAA) 79 samples, 118.5 sample hours. Professor Rapp, 2 additional staff members, 2 students continue in their study of trace element composition of metallic artifacts and ores for archaeological investigations. Funded by private philanthropy.

Nuclear Engineering Department. 249 samples, 161 less than 15 minutes, 303 sample hours. Irradiations for NE 427 and NE 428 laboratories, plus neutron activation analysis to determine source of flaking aluminum in plasma device.

Physics Department. (NAA) 29 samples, 35 sample hours. Professor Yen and 2 graduate students. Correlation of physical properties of antiferromagnetic insulators with elemental composition of insulators as determined by NAA. Research supported by NSF.

Soils Department. 803 samples, 231 less than 15 minutes, 3,113 sample hours. Professor Helmke and 9 graduate students. This group performs neutron activation analysis of rocks, soil, and biological material, and also produces tracers for use in laboratory experiments studying behavior of elements in soils. Research is supported by Environmental Protection Agency, Cooperative State

Research Service (Hatch Act), Wisconsin Power & Light, Madison Gas & Electric, Wisconsin Public Service Corporation, and DOE.

Soils Department. (NAA) 36 samples, 36 sample hours. Professor J. Iyer. NAA of soil for arsenic content. Supported by Industrial Grant.

Reactor Laboratory. 158 samples, 29 less than 15 minutes, 71.6 sample hours. These irradiations include measurements of neutron fluxes and production of radioactive materials needed in instrument calibrations for the laboratory.

U. S. Army Cold Regions Research Laboratory. (NAA) 237 samples, 140 less than 15 minutes, 177 sample hours. Analysis of plant materials, sediments, and rocks for trace element composition. Supported by the United States Army Cold Regions Research Laboratory.

Wisconsin Department of Natural Resources. (NAA) 36 samples, 144 sample hours. Determination of mercury levels in fish.

University of Wisconsin-Green Bay. (NAA) 46 samples, 184 sample hours. Professor Norman. Analysis of soil samples for silver to determine effects on soils of cloud seeding experiments. Supported by Industrial Grant.

University of Wisconsin-Oshkosh. (NAA) 73 samples, 36 less than 15 minutes, 74 sample hours. Professor Propp and 1 student. NAA of sewage treatment plant effluents to determine efficiency of secondary and tertiary treatment.

5. Changes in Personnel, Facility, and Procedures

Two licensed operators, Gerald R. Danks and Larry D. Lukens, terminated their employment with the University during the year. Daniel L. LeGare joined the staff in January and is presently a licensed operator. Daniel E. Range will join the staff in July of 1978 and will be trained as an operator. Both Mr. LeGare and Mr. Range are former Navy electronic technicians who have been trained as Reactor Operators while on active duty. In addition, Herbert Nelson (a part-time employee of the department for two years) is presently in training to become a licensed operator. Finally, two additional former Navy personnel, who will be employed on a part-time basis, will be trained as Reactor Operators during the Fall Semester.

Stephen M. Matusewic has been issued a Senior Reactor Operator license.

The inspection function of the University Health Physics groups has been modified and the Reactor Safety Committee Charter modified to allow inspections of the Reactor Laboratory to be conducted by either Mr. Robert Radtke or Mr. Michael Baumann. This change results from Mr. Radtke's additional duties as head of the Safety Department on campus. Mr. Radtke currently remains a member of the Reactor Safety Committee, but Mr. Baumann conducts the monthly inspections.

Mr. Baumann has been employed as a Health Physicist by the Safety Department for two years. He received his Bachelor's Degree in Nuclear Engineering from the University of Wisconsin in 1976.

Facility Changes

No reportable changes in the facility, as described in the Safety Analysis Report, were made during the year. A partial refueling was completed during January, 1978, in which an additional six FLIP fuel bundles were added to the core to give a total of fifteen bundles of FLIP fuel in the present core. A document entitled, "Core Test Program-UWNR Mixed TRIGA-FLIP Core" dated February, 1978 is appended to this report. The report describes the loading and performance characteristics of the current operational core. This report also includes information on the variation in excess reactivity vs. core exposure since the initial TRIGA core was loaded at our facility, which shows the effect of the additional fuel lifetime of FLIP fuel.

The last of the three thermocouples in the original TRIGA instrumented element failed during the year. At the refueling step, a new instrumented TRIGA element was installed in the core to replace the one which had failed.

Procedure Changes

Only minor changes in procedures were made during the year in order to update procedures for current conditions. No procedure changes of the type which are considered reportable occurred.

6. Results of Surveillance Tests

Surveillance tests and inspections during the year revealed no problems in safety-related systems. Surface roughness previously noted on one FLIP fuel element was again inspected and, again, an apparent decrease in surface roughening with additional time of exposure to pool water was noted.

Surveillance of licensed operators performance under the Operator Proficiency Maintenance Program showed no deficiencies.

B. OPERATING STATISTICS AND FUEL EXPOSURE

	<u>Startups</u>	<u>Critical Hours</u>	<u>MW Hours</u>	<u>Pulses</u>
FY 77-78	120	376.76	196.44	97
Total on TRIGA Cores 1970		6631.60	4767.90	1306

Total energy output during the year was 8.19 MW days, and the total exposure since converting to TRIGA fuel is 198.66 MW days.

The fuel exposure since loading a mixed TRIGA-FLIP core is 1199.22 MW hours or 49.97 MW days.

C. EMERGENCY SHUTDOWN AND INADVERTENT SCRAMS

There were no emergency shutdowns during the year. There were, however, nine inadvertent scrams. Four scrams were due to instrument malfunctions, and the remaining five were due to operating errors by trainees.

On 27 September 1977, fuel temperature indicator 19M1 caused a relay scram to be initiated when its associated thermocouple opened. There was no increase in power level or temperature as indicated by associated instrumentation. TC41T was disconnected from 19M1 and TC41C was connected to 19M1. TC41T was connected to 19M2 where it could be observed without causing a scram. Observation of TC41T has shown that it is failing due to an intermittent open at high power levels. On 21 October 1977, the Log N-Period Channel initiated a scram due to failure of tubes in the amplifier. On 12 January 1978, a scram occurred when a trainee incorrectly downranged #1 pa range switch. On 16 January 1978, the Log N-Period Channel initiated a trip which was caused by a noise spike. On 2 March 1978, during a restart from a planned shutdown, the Log N-Period Channel initiated a trip. The trip was due to poor compensation. The compensation voltage was adjusted and a restart made successfully. In May of 1978, four scrams occurred. On 17 May 1978, #1 pa initiated a scram due to a switching error. On 22 May 1978, a trainee tripped the Reactor Control Power Breaker inadvertently causing a scram. On 23 May 1978, the Log N-Period Channel initiated a trip while a trainee was recovering from a planned shutdown. The trainee achieved too short a period during the restart. On 25 May 1978, #1 pa initiated a trip when the trainee on watch failed to uprange #1 pa during startup.

D. MAINTENANCE OPERATIONS

Ordinary preventative maintenance performed on the equipment throughout the period resulted in acceptable performance except for the one trip in the Log N-Period Channel due to tube failure. There were no major reportable maintenance operations except for replacement of the instrumented element in a standard fuel bundle, which was mentioned earlier in the report.

F. RADIOACTIVE WASTE DISPOSAL

1. Solid Waste

During the year, 13.4 cubic feet of solid radioactive waste was transferred to the University Health Physicist. This contained total activity of 141 microcuries, primarily cobalt-60 and cobalt-58. This material was transferred offsite by University Health Physics. On 25 May 1978, it was sent to Nuclear Engineering Company, Inc. at Beatty, Nevada.

2. Liquid Waste

Table 1 shows the record of liquid waste disposal during the fiscal year.

3. Particulate and Gaseous Radioactivity Released to the Atmosphere

Table 2 presents information on stack activity discharged for the period.

TABLE 1.

LIQUID WASTE TO SANITARY SEWER

	<u>9 SEPT 1977</u>	<u>21 APRIL 1978</u>	<u>TOTAL</u>
TOTAL ACTIVITY DISCHARGED (Microcuries)	78.65	41.19	119.84
LIQUID QUANTITY (Gallons)	1650.	925.	2575.
Ra ²²⁶ - MPC USED - 4×10^{-7}			
AMOUNT (μ Ci)	2.37	0	2.37
CONC (μ Ci/ml)	2.63×10^{-8}	0	
Ru ¹⁰⁶ - MPC USED - 4×10^{-4}			
AMOUNT (μ Ci)	9.60	7.35	16.95
CONC (μ Ci/ml)	1.07×10^{-7}	8.17×10^{-8}	
Co ⁶⁰ - MPC USED - 1×10^{-3}			
AMOUNT (μ Ci)	5.71	12.9	18.61
CONC (μ Ci/ml)	6.34×10^{-8}	1.44×10^{-7}	
Zn ⁶⁵ - MPC USED - 3×10^{-3}			
AMOUNT (μ Ci)	38.9	19.5	58.4
CONC (μ Ci/ml)	4.36×10^{-7}	2.16×10^{-7}	
Mn ⁵⁴ - MPC USED - 4×10^{-3}			
AMOUNT (μ Ci)	12.72	0	12.72
CONC (μ Ci/ml)	1.41×10^{-7}	0	
Co ⁵⁸ - MPC USED - 4×10^{-3}			
AMOUNT (μ Ci)	7.55	1.44	8.99
CONC (μ Ci/ml)	8.38×10^{-8}	1.59×10^{-8}	

Average concentration at point of release to sewer = 1.23×10^{-5} μ Ci/ml (includes natural radioactivity).

Average daily sewage flow for dilution = 2.37×10^4 gallons.

Average concentration after dilution = 3.67×10^{-9} μ Ci/ml.

TABLE 2

EFFLUENT FROM STACK

1. Particulate Activity

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

3. Gaseous Activity -- All Argon 41

<u>Month</u>	<u>Activity Discharged (Curies)</u>	<u>Maximum Instantaneous Concentration $\mu\text{Ci/ml} \times 10^{-6}$</u>	<u>Average Stack Concentration $\mu\text{Ci/ml} \times 10^{-8}$</u>	<u>MPC Used $\mu\text{Ci/ml}$</u>
July 77	0.1975	3.5	11.38	2.4×10^{-5}
August	0.0005	0.12	0.03	
September	0.0897	5.0	6.39	
October	0.1258	3.5	6.87	
November	0.1093	1.9	6.29	
December	0.0469	1.8	2.45	
January 78	0.0545	0.9	3.26	
February	0.0653	1.3	4.05	
March	0.0777	1.3	4.44	
April	0.0720	1.0	4.05	
May	0.0998	1.4	5.53	
June	<u>0.0603</u>	<u>1.8</u>	<u>3.63</u>	
TOTAL	0.9993	3.5×10^{-6} Maximum	4.86×10^{-8} Yearly Average	

The MPC value above is that calculated in the SAR to be equivalent to $3 \times 10^{-8} \mu\text{Ci/ml}$ in the area surrounding the laboratory.

G. SUMMARY OF RADIATION EXPOSURES

No significant exposure of personnel occurred due to operation of the reactor. For occupationally exposed personnel, the highest annual whole body dose was 45 mrem, while the highest extremity dose for the entire year was only 60 mrem. No laboratory student or facility visitor received any measurable dose.

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

H. RESULTS OF ENVIRONMENTAL SURVEYS

The environmental monitoring program at Wisconsin consists of thermoluminescent dosimeters (LiF TLD service from Eberline) located in the area surrounding the Reactor Laboratory.

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

Annual Dose Data-Environmental Monitors

<u>Location</u>	<u>Average Dose Rate-mrem/week</u>
Inside wall of Reactor Laboratory	3.00
Inside Reactor Laboratory Stack	0.93
Highest dose outside Reactor Laboratory (Loading Dock--Monitor adjacent to stone surface)	2.03
Highest Dose in Occupied Nonrestricted Area (third floor classroom facing away from Reactor Lab)	0.57
Average Dose in Occupied Nonrestricted Area	0.28
Average Dose in all Unrestricted Areas (29 Monitor Points)	0.61

I. PUBLICATIONS AND PRESENTATIONS ON WORK BASED ON REACTOR USE

Dairy Science

N. A. Jorgensen, M. F. Finner, and J. P. Marquardt (1978), "Effect of Forage Particle Size on Animal Performance", to be presented at the American Society of Agricultural Engineers' Summer Meetings, June 27-30 at Utah State University, Logan, Utah.

J. P. Marquardt, N. A. Jorgensen, J. W. Crowley, M. F. Finner, and G. P. Barrington (1976), "Effect of Forage Particle Size on Performance of High Producing Cows". Paper 1211, ADSA 71st Annual Meeting, Raleigh, North Carolina, June 20-23.

G. F. Hartnell, L. D. Satter (1978), "Extent of Particulate Marker (samarium, lanthanum, and cerium) Movement from One Digesta Particle to Another". Submitted to Journal of Animal Science.

G. F. Hartnell, L. D. Satter (1978), "Rumen Fill, Retention Time, and Ruminant Turnover Rates of Ingesta at Different Stages of Lactation in Dairy Cows". Submitted to Journal of Animal Science.

Geology, Chemistry

David Bratberg, J. I. Hoffman, J. Propp, C. W. Fetter, "Potential Heavy Metal Contamination of Groundwater from Land Disposal of Municipal Sewage Sludge", undergraduate research symposium paper, Marquette University, April 22, 1978.

Human Oncology

PhD Thesis Project (in progress), "Correlation of CT Numbers with Heavy Element Composition in Human Tumors".

Metallurgical and Mineral Engineering

R. C. Voight: M.S. Thesis (1978), "Gas, Tungsten-Arc Welding and Heat Treating of High Purity Aluminum".

Wisconsin Superconductive Energy Storage Project Annual Report (1978)
To be published 8/78.

Soil Science

P. A. Helmke, R. D. Koons, P. J. Schomberg, and I. K. Iskandar, "Determination of Trace Element Contamination of Sediments by Multielement Analysis of the Clay-Size Fraction", Environ. Sci. Technol. 11: pp 984-989 (1977).

R. D. Koons: PhD Thesis (1978), "Behavior of Trace and Major Elements and Minerals During Early Stages of Weathering of Diabase and Granite from Central Wisconsin".

R. J. Korda, T. E. Henzler, P. A. Helmke, M. M. Jimenez, and L. A. Haskin, "Trace Elements in Samples of Fish, Sediment, and Taconite from Lake Superior", J. Great Lakes Res. 3: pp 148-154, (1977).

Publications

Soil Science (continued)

H. M. May: PhD Thesis (1978) "Aluminum Determination, Aluminum Hydrolysis and the Solubilities of Some Common Aluminous Minerals in Near-Neutral Aqueous Solutions".

M. B. Schoenfield: M.S. Thesis (1978) "Trace Elements in Aquatic Organisms from the Environment of a Coal Burning Generating Station".

Zoology & Institute for Environmental Studies, EMDAG

D. Harrell: M.S. Thesis (1978) "The Effect of Ash Effluent on Crayfish". In preparation.

J. Magnuson, A. Forbes, D. Harrell, and J. Schwarzmeier (1978) "Responses of Stream Invertebrates to an Ash Pond Effluent", E.P.A. Ecological Research Series. In preparation.

J. Magnuson, M. Talbot, F. Rahel, A. Forbes, and P. Medvick (1978), "Responses of Fish Populations to Habitat Modifications Resulting from a Coal-Fired Generating Station", E.P.A. Ecological Research Series. In preparation.

Science & Environmental Change -- University of Wisconsin-Green Bay

Jack C. Norman, "Preliminary Report on the Silver Content of Soils in Northeastern Wisconsin--July-August, 1977", The Journal of Weather Modification, 40, pp 62-66 (April, 1978).

Archaeometry Laboratory -- University of Minnesota-Duluth

George Rapp, Jr., Richard E. Jones, S.R.B. Cooke, and Eiler Henrickson, (1978) "Analyses of Metal Artifacts", The Excavation at Nichoria in Southwestern Greece, Volume I, Site, Environs, Techniques, edited by George Rapp, Jr. and S. E. Aschenbrenner, Chapter 11, pp 166-181. In press.

Department of Agriculture, Canada

A bulletin giving certified elemental composition of samples will be prepared this year.