Nuclear Reactor Laboratory

University of Wisconsin-Madison

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Docket 50-156

July 29, 2002

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

Dear Sir:

Enclosed is a copy of the 2001-2002 Annual Report for the University of Wisconsin Nuclear Reactor Laboratory as required by our Technical Specifications.

Sincerely,

Robert J. Agasie
Reactor Director

Enc. (Annual Report)

cc: Region III Administrator
Compliance Inspector, Region II, Craig Bassett
Facility Project Manager, Alexander Adams
Reactor Safety Committee, RSC 753

A020

THE UNIVERSITY OF WISCONSIN

NUCLEAR REACTOR LABORATORY

Fiscal Year 2001-2002 ANNUAL OPERATING REPORT

Prepared to meet reporting requirements of:
U. S. Department of Energy
SPECIAL MASTER TASK RESEARCH SUBCONTRACT NO. C96-175937
and
U. S. Nuclear Regulatory Commission
(Docket 50-156, License R-74)

Prepared by:

Robert J. Agasie
Department of Engineering Physics

EXECUTIVE SUMMARY OF REACTOR UTILIZATION

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

- 27 NEEP students in laboratory courses.
- 40 students in lecture courses which included demonstrations in the reactor laboratory.
- 308 instructors and students from area school systems were given demonstrations in reactor operations and use.
- 21 students and staff from 6 additional college-level educational organizations used the facilities for formal instruction or research.

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

- 808 samples were irradiated for departments at UW-Madison.
- 515 samples were irradiated for other educational institution research programs.

Industrial Use:

- Irradiation of 31 samples, provided to 4 different organizations, were performed for NAA or isotope production services.

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A. SUMMARY OF OPERATIONS

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

Nuclear Engineering & Engineering Physics (NEEP) 427 was offered in the fall and spring semesters with a total enrollment of 16 students. 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.

Seven students were enrolled in NEEP 428 which was offered in the spring semester. Three experiments in NEEP 428 require exclusive use of the reactor. These experiments ("Critical Experiment", "Control Element Calibration", and "Pulsing") required a total of 9 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").

Four students completed NEEP 234, "Principles and Practice of Nuclear Reactor Operation" during the summer session, 2001. The course was offered during the summer session as part of the unique dual-degree exchange program between the University of Wisconsin and South Carolina State University. The program is a U.S. Department of Energy funded pilot program designed to encourage students from historically black colleges and universities to pursue degrees in nuclear engineering. This course uses the reactor extensively. Each student performed at least 16 significant reactivity changes requiring over 30 hours of exclusive reactor use to provide this operating experience.

NEEP 231, "Survey of Nuclear Engineering" was offered in the spring semester with an enrollment of 30 students. The course is designed for freshmen students interested in nuclear engineering and consists of three lecture modules surveying fission, fusion and radiation science technologies. The fission module concludes with a reactor operation demonstration.

An individual class lecture for Geology 875, "Techniques in Geochronology", was held at the Reactor Laboratory, with 10 students participating. The lecture covered the techniques of neutron activation of ^{39}Ar for the $^{40}Ar/^{39}Ar$ methodology of geological dating. The lecturing professor is currently engaged in this research and is working with reactor staff to develop a permanent facility to date geological specimens using this technique.

The Reactor Laboratory's continued commitment to its educational outreach program attracts large numbers of community organizations who visit the reactor for tours and information on nuclear energy. A listing of individual schools and educational programs who have visited is provided below in section A.2 of this report.

2. REACTOR SHARING PROGRAM

The University of Wisconsin Nuclear Reactor was again funded this year by the U.S. Department of Energy, Office of Nuclear Energy, Science and Technology to offer reactor services in accordance with the University Reactor Sharing Program. The purpose of the program is to make available university nuclear reactor facilities to non-reactor owning colleges, universities, and other educational institutions. User groups affiliated with the host institution (UW-Madison) are also eligible for assistance, up to 35% of the awarded funds. This year, the Reactor Laboratory provided over $25,000 of reactor services free of charge to the user institutions under the University Reactor Sharing Program, of which $13,000 was reimbursed by the U.S. Department of Energy. User institutions participation in this year's program are detailed below.

Participating Institution	Principal Investigator	Number of Faculty/ Students Involved
Department of Agronomy, UW-Madison	L. Lukens	1/0
Fast neutron irradiation to induce DNA double-ended breaks in plant chromosome to investigate gene characteristics.		
Department of Anthropology, UW-Madison	R. Law	1/1
NAA to characterize steatite excavated from the archaeological site of Harappa, Pakistan, to determine the provenance of Harappan steatite on a regional scale.		

Department of Engineering Physics, UW-Madison
D. Henderson 3/1
Thermal neutron irradiation to produce ^{3}H from enriched ^{6}Li, Li_2O microspheres to produce microsphere sources used in prototype nuclear powered MEMS devices.

Department of Soil Sciences, UW-Madison
P. Helmke 1/1
NAA to determine Fe, K/Na ratios, and trace element concentrations of samples from a soil-stoneline-ironstone complex in Uganda.

School of Veterinary Medicine, UW-Madison
C. Czuprynski 2/0
NAA to assess iron concentrations in yeast.

Beloit College
B. Dobson 1/0
Analyzed swipe tests performed by Professor Dobson to leak check radioactive sources.

Temple University
D. Terry 1/1
NAA to characterize sediment across the cretaceous-tertiary boundary in South Dakota. This boundary marks the extinction of the dinosaurs. Geochemical characterization may establish a link to the hypothesis that an asteroid impact lead to the extinction of the dinosaurs.

Luther College
S. Roland 1/8
Visit and tour of the reactor with discussion of the research capabilities of the reactor.

Vanderbilt University
Department of Civil and Environmental Engineering
S. Lopez 1/0
NAA to determine trace elements in recycled aluminum.

University of Wisconsin-Milwaukee
T. Naik 3/3
Professor Naik and research associates from the Center for Byproduct Utilization used NAA to investigate the use of waste products in construction materials.

Non-College Groups:

Advanced Topics in Nuclear Physics and Energy Issues 26/14
Day-long workshop designed for middle and high school teachers and students interested in exploring nuclear and radiation sciences. Topics included nuclear energy and power fundamentals and the role of nuclear power in the future. Further detail of this program can be found in section A.4 of this report.

Argonne National Lab/International Atomic Energy Agency 22/0
Members from six Asian nuclear regulatory agencies participated in lectures and a reactor operation demonstration as part of a program to help participating nations develop nuclear training programs. Further detail of this program can be found in section A.4 of this report.

College for Kids 2/9
Lecture on nuclear energy and radiation sciences with a reactor tour and a discussion on the uses of the UW nuclear reactor. Summer program to enrich gifted and talented students during the transition from elementary to middle school.

Engineering Summer Program 1/23
Reactor tour and nuclear energy discussion for minority high school students. Summer program to interest minority students in technical education.

ESTEAM 4/85
Reactor tour and nuclear energy discussion for minority high school students. Part of a program to interest minority students in technical education.

Marathon High School 1/15
Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor.

Nuclear Physics in the Science Curriculum 43/0
Day-long workshop designed for teachers interested in understanding radiation, applications of radiation, nuclear power for electricity production and issues in these fields. Further detail of this program can be found in section A.4 of this report.

Snake River Montessori School 2/17
NAA services provided to investigate elemental composition of finger nail clippings as part of an elementary school science curriculum enrichment program.

Verona High School 6/79
Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor.

USER SUMMARY:

Educational Institutions:	55
Students:	257
Faculty/Instructors:	122

3. SAMPLE IRRADIATIONS AND NEUTRON ACTIVATION ANALYSIS SERVICES

There were 1354 individual samples irradiated during the year. Of these samples, 669 were irradiated for 15 minutes or less. Samples accumulated 197.06 irradiation space hours and 1365.03 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.

Engineering Physics Department, UW-Madison
UW Nuclear Reactor Laboratory
31 samples, 104.9 sample hours
Production of calibration sources for required reactor measurements and development of methods for instrumental neutron activation analysis. UW support.

Engineering Physics Department, UW-Madison
Undergraduate Research Projects
4 samples, 4.0 sample hours
Production of radioactive gadolinium sources to conduct HPGe gamma spectroscopy system dead-time measurements for developing dead-time correction factors. Supported by the DOE/Industry Matching Grant Program.

Engineering Physics Department, UW-Madison
NEEP 427

151 samples, 166.5 sample hours
Irradiation of foil sources for radiation detector experiments, including absolute counting for neutron flux measurements; activation of samples for neutron activation analysis experiment. UW support.

Engineering Physics Department, UW-Madison
NEEP 428

36 samples, 41.8 sample hours
Irradiation of foils for resonance integral measurement and fast neutron flux measurement. UW support.

Engineering Physics Department, UW-Madison

2 samples, 8.4 sample hours
Professors D. Henderson, J. Blanchard, and A. Lal requested thermal neutron irradiation to produce ^{3}H in ^{6}Li enriched Li_2O microspheres to produce microsphere sources used in prototype nuclear powered MEMS devices. Supported by DOE NEER and Reactor Sharing Program.

Engineering Physics Department, UW-Madison (NAA)

1 sample, 0.1 sample hours
Dr. M. Anderson used NAA in order to determine the composition of oxide material discovered in a liquid metal test loop. Supported by DOE NERI.

Department of Anthropology, UW-Madison (NAA)

387 samples, 365.5 sample hours
Dr. M. Kenoyer and R. Law used NAA to characterize fragments of steatite manufacturing debris excavated from the archaeological site of Harappa, Pakistan. Analyses of the rare earth element and transition metal concentrations in source samples indicated that source regions could be differentiated from one another with a high degree of confidence. Based on these characterizations, the archaeological steatite analyzed in this study appears to have originated from source regions in the Northwest Frontier Province and Baluchistan Province of Pakistan. Supported by DOE Reactor Sharing Program.

Department of Agronomy, UW-Madison

85 samples, 12.3 sample hours

Dr. L. Lukens and 1 additional staff member used reactor services to induce DNA double-ended breaks in plant chromosome by fast neutron irradiation to investigate gene characteristics. Supported by DOE Reactor Sharing Program.

Department of Soil Sciences, UW-Madison (NAA)

105 samples, 37.5 sample hours

Professors J. Norman, V. Holliday, K. McSweeny, and P. Helmke and 1 graduate student used NAA to determine Fe, K/Na ratios, and trace element concentrations of samples from a soil-stoneline-ironstone complex in Uganda. This information determines the degree and type of weathering, geochemistry and hydrology which control formation of these types of complexes throughout much of the tropics. Supported by DOE Reactor Sharing Program.

School of Veterinary Medicine, UW-Madison (NAA)

6 samples, 12.0 sample hours

Professor C. Czuprynski and S. Giles used NAA to assess iron concentrations in yeast.

University of Wisconsin- Milwaukee (NAA)
Center for Byproduct Utilization

54 samples, 56.7 sample hours

Professor T. Naik and one additional staff member used NAA to measure levels of various elements in concretes prepared using various byproduct materials, such as paper mill sludge, fly ash, and bottom ash. Supported by DOE Reactor Sharing Program.

University of Arkansas - Fayetteville (NAA)

110 samples, 172.0 sample hours

Professor R. Davis and one graduate student used NAA to measure stable environmental tracers. The purpose of the investigation is to understand the transport and storage mechanism of E.coli in ground water systems. Private support.

Temple University (NAA)

318 sample, 168.0 sample hours

Professor D. Terry used NAA to characterize sediment across the cretaceous-tertiary boundary in South Dakota. This boundary marks the extinction of the dinosaurs. Geochemical characterization may establish a link to the hypothesis that an asteroid impact lead to the extinction of the dinosaurs. Supported by DOE Reactor Sharing Program.

Vanderbilt University (NAA)

12 samples, 8.8 sample hours

S. Lopez of the Department of Civil and Environmental Engineering used NAA to determine trace elements in recycled aluminum. Supported by DOE Reactor Sharing Program.

Snake River Montessori School (NAA)

21 samples, 21.0 sample hours

Program sponsored by the Idaho National Engineering and Environmental Laboratory Outreach Program to enrich the science curriculum in local elementary schools. NAA services provided to investigate elemental composition of finger nail clippings. Supported by DOE Reactor Sharing Program.

Albchem Industries LTD. (NAA)

4 samples, 4.0 sample hours

Use of NAA service to measure bromine content in sodium chlorate from several sodium chlorate manufacturing plants. Industrial support.

BC Research Inc. (NAA)

24 samples, 24.0 sample hours

Use of NAA service to measure bromine content in sodium chlorate from several sodium chlorate manufacturing plants. Industrial support.

NWT Corporation

2 samples, 5.4 sample hours

Irradiation of sodium to produce ^{24}Na for use as a radioactive tracer in moisture carry over tests performed at regional utilities nuclear generating stations. Industrial support.

Wisconsin Public Service

1 sample, 3.5 sample hours

Irradiation of sodium to produce ^{24}Na for use as a radioactive tracer in steam generator moisture carry over tests performed at the Kewaunee Nuclear Power Plant. Industrial support.

4. OTHER MAJOR EDUCATIONAL AND RESEARCH USE

In the fall of 2001, the Reactor facility hosted a series of workshops in nuclear physics. Two workshops, entitled "Nuclear Physics in the Science Curriculum: A Primer for Middle and High School Teachers", were reproductions of similar workshops offered by the Reactor Laboratory the previous year. However, due to the popularity of the these workshops, a second, new workshop entitled, "Advanced Topics in Nuclear Physics and Energy Issues" was offered this year. The workshops were attended by 83 participants representing middle and high school math and science teachers from 40 school districts in Wisconsin. The participating teachers attending the Advanced Topics workshop were allowed to bring up to 3 students from their classes to also attend. The day-long workshops were designed for teachers and students interested in understanding radiation and nuclear processes, applications of radiation and nuclear energy, nuclear power for electricity production and issues in these fields. Each workshop consisted of several lectures and laboratory sessions with substantial hands-on activities.

In June 2002, the Nuclear Reactor Laboratory hosted a group of 22 visitors from nuclear regulatory agencies from several Asian countries including China, Indonesia, Malaysia, Philippines, Thailand and Vietnam. The visit was part of a six-week course sponsored by the International Atomic Energy Agency (IAEA) and Argonne National Laboratory (ANL). The objective of the program was to help participating nations' regulatory agencies to develop comprehensive training programs in the areas of nuclear reactor operations and radiation safety. The Reactor Laboratory served as an example of a training program at a major U.S. university equipped with a training and research reactor. The participants attended a lecture that outlined the various training programs offered by the Reactor Laboratory and were given an opportunity to see, first hand, how the reactor is utilized in these training programs, by participating in a reactor demonstration.

5. CHANGES IN PERSONNEL, FACILITY AND PROCEDURES

Any changes reportable under 10 CFR 50.59 are indicated in section E of this report. No other upgrades to the facility were completed during the year.

Personnel changes during the year were as follows:

Reactor operator Donald R. Williamson, OP-70268, was removed from licensed operator status. Mr. Williamson's license was terminated April 5, 2002.

Mr. Robert J. Agasie was appointed as Reactor Director and Nuclear Materials Custodian effective August 10, 2001 upon the retirement of the incumbent director, Richard J. Cashwell.

6. RESULTS OF SURVEILLANCE TESTS

The program of inspection and testing of reactor components continues, satisfactorily meeting procedural acceptance criteria. Inspection of underwater components during the annual maintenance showed no deterioration or wear.

B. OPERATING STATISTICS AND FUEL EXPOSURE

Operating Period	Critical Hrs	MW Hrs	Runs	Pulses
Fiscal Year 2001-2002	549.77	492.53	127	20
FLIP Core	15,247.31	12,692.82	4,353	935
TRIGA	22,512.30	17,681.00	6,343	2,246

Core I23-R10 was operated throughout the year. The excess reactivity of this core was determined to be 4.179%ρ

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

There were four automatic scrams or emergency shutdowns during the year. Each is described below in chronological sequence.

October 2, 2001, Manual SCRAM. The reactor operator on duty manually scrammed the reactor from full power when the Continuous Air Monitor (CAM) particulate activity read high. The particulate filter tape was analyzed and the activity was determined to be a buildup of radon decay products due to excessive construction dust and high moisture content in the CAM suction line.

December 11, 2001, Relay SCRAM from Log-N Period Amplifier. While increasing power to 1000 kW, the reactor operator placed the mode switch into automatic. The servo channel, which controls the selected servo controlled control element while in automatic mode, has a control element withdraw inhibit to limit reactor period to 20 seconds. However, the reactor operator failed to anticipate the resulting prompt jump during the control element withdraw and the reactor scrammed as a result of a 5 second period.

June 4, 2002, Relay SCRAM from loss of power. During control element calibration operations, the Mechanical Engineering Building suffered from a complete loss of electrical power resulting in a reactor SCRAM.

June 5, 2002, Relay and electronic SCRAM from picoammeter #1. During control element calibration operations, the reactor operator inadvertently down ranged picoammeter number 1 during doubling time measurements following a rod pull. A reactor SCRAM resulted from a neutron flux high trip.

D. MAINTENANCE

Routine preventive maintenance continues to maintain equipment operability. Routine regeneration of the demineralizer resins was performed on August 22, 2001 and new resins were placed in service on February 14, 2002.

Corrective maintenance was performed on the following systems:

In mid July 2001, after determining greater than normal pool water make-up, the primary pump shaft mechanical seal was observed to be leaking. The pump was removed and the seal replaced.

On August 27, 2001 a nearby lightening strike caused the negative 15 V regulator on the power supply board to the Log-N channel to fail. The regulator was replaced.

The installed Eberline area radiation monitoring system is equipped with nine remote sensors. In February 2002, the GM tube in the sensor located near beam port number one experienced continuous discharge and indicated full scale. The GM tube was replaced.

On June 20, 2002 the Log Count Rate Monitor was indicating erratically. An investigation revealed that the pre-amplifier of the Log Count Rate Monitor had experienced extensive radiation damage to the insulating material. The pre-amplifier was replaced.

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

There were no changes in the facility or 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

   Liquid waste discharges are detailed in Table 1.

3. PARTICULATE AND GASEOUS ACTIVITY RELEASED TO THE ATMOSPHERE

   Table 2 presents information on stack discharges during the year.

G. SUMMARY OF RADIATION EXPOSURE OF PERSONNEL (01/01/01 - 12/31/01)

The personnel radiation monitoring program at Wisconsin for the past calendar year used Landauer Luxel brand monitors for whole body exposure. Commencing in May 2001, extremity dose was monitored using TLD ring badges processed by the University of Wisconsin Radiation Calibration Laboratory which is NVLAP certified. No personnel received any significant radiation exposure for the above period. The highest annual doses recorded were 107 mrem to the whole body and 148 mrem to the extremities.

H. RESULTS OF ENVIRONMENTAL SURVEYS (01/01/01 - 12/31/01)

The environmental monitoring program at Wisconsin uses Landauer Luxel brand area monitors located in areas surrounding the reactor laboratory. Table 3 indicates the dose a person would have received if continuously present in the indicated area for the entire 2001 calendar year.

TABLE 1
LIQUID RADIOACTIVE WASTE DISCHARGED TO SEWER

		Release Date 02/06/2002	Total
	Gallons Released	1450	1450
	Total µCi	160.61	160.61
	Fraction of MPC w/o dilution	0.61	0.61
	Fraction of MPC with daily dilution	0.04	0.04
Isotope / MPC			
Co-58/	µCi	4.57	4.57
2.00E-04 µCi/ml	µCi/ml	8.33E-07	8.33E-07
	Fraction of MPC	4.17E-03	4.17E-03
Co-60/	µCi	15.46	15.46
3.00E-05 µCi/ml	µCi/ml	2.82E-06	2.82E-06
	Fraction of MPC	9.39E-02	9.39E-02
K-40/	µCi	18.95	18.95
4.00E-05 µCi/ml	µCi/ml	3.45E-06	3.45E-06
	Fraction of MPC	8.63E-02	8.63E-02
Mn-54/	µCi	18.63	18.63
3.00E-04 µCi/ml	µCi/ml	3.39E-06	3.39E-06
	Fraction of MPC	1.13E-02	1.13E-02
Zn-65/	µCi	86.46	86.46
5.00E-05 µCi/ml	µCi/ml	1.58E-05	1.58E-05
	Fraction of MPC	3.15E-01	3.15E-01
Ru-106/	µCi	16.53	16.53
3.00E-05 µCi/ml	µCi/ml	3.01E-06	3.01E-06
	Fraction of MPC	1.00E-01	1.00E-01

Average concentration (µCi/ml) at point of release to sewer =	2.93E-05
Avg. fraction of release limit w/o dilution =	0.61
Max. fraction of release limit w/o dilution =	0.61
Average daily sewage flow for dilution (gallons) =	2.37E+04
Max. fraction of MONTHLY release limit with DAILY dilution =	0.04
Max. fraction of MONTHLY release limit with MONTHLY dilution =	0.002

TABLE 2
EFFLUENT FROM STACK

1. Particulate Activity

There was no discharge of particulate activity above background levels.

2. Gaseous Activity - All Argon-41

Month	Activity Discharged (Curies)	Maximum Concentration µCi/ml x 1E-6	Average Concentration µCi/ml x 1E-6
July 2001	0.0353	2.60	0.0197
August	0.0871	2.45	0.0486
September	0.1174	2.60	0.0677
October	0.2771	3.50	0.1545
November	0.1319	2.50	0.0760
December	0.0520	1.75	0.0290
January 2002	0.1107	1.50	0.0632
February	0.0968	1.50	0.0598
March	0.1059	1.60	0.0591
April	0.2556	1.70	0.1473
May	0.1512	2.00	0.0843
June	0.0602	1.50	0.0347
	Total	Maximum	Average
	1.4812	3.50	0.0703

Using Gifford's model, as described in the appendix to the "Safety Analysis Report for the University of Wisconsin Nuclear Reactor", a concentration of 8E-6 µCi/ml at the stack discharge would result in an air concentration of 1E-8 µCi/ml.

TABLE 3
ANNUAL DOSE DATA -- Environmental Monitors
(01/01/01 - 12/31/01)

Location	Annual Dose mrem
Inside Wall of Reactor Laboratory	121.0
Inside Reactor Laboratory Stack	19.0
Highest Dose Outside Reactor Laboratory (Reactor Lab roof ladder: monitor adjacent to stone surface)	68.0
Highest Dose in Occupied Nonrestricted Area (third floor classroom, Room 314)	19.0
Average Dose in all Nonrestricted Areas (27 Monitor Points)	13.4

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