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Tech Specs, Docket 50-156

July 22, 1991

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 1990-91 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

IE47
1/1

THE UNIVERSITY OF WISCONSIN
NUCLEAR REACTOR LABORATORY

1990-1991 ANNUAL OPERATING REPORT

PREPARED TO MEET REPORTING REQUIREMENTS OF:

U. S. DEPARTMENT OF ENERGY

(REPORT DOE/ER/1560-25)

AND

U. S. NUCLEAR REGULATORY COMMISSION

(DOCKET 50-156, LICENSE R-74)

PREPARED BY:

R. J. CASHWELL
DEPARTMENT OF
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Overview:

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

62 NEEP students in laboratory courses

55 students in lecture courses which included demonstrations in the reactor laboratory.

Numerous instructors and students from area school systems were given demonstrations in reactor operations and use.

Students and staff from Colorado College, Colorado School of Mines, Edgewood College, Madison Area Technical College, Lakeshore Technical Institute, University of Colorado, University of Minnesota-Duluth, and University of Wisconsin- Eau Claire, used the facilities for formal instruction or research

Research: Neutrons from the reactor were used primarily for two activities: Neutron activation analysis and neutron radiography.

50 hours of use were devoted to further development of a neutron radiography experiment capable of real-time imaging of operating systems at high framing rates

683 samples were irradiated for research programs in other departments of the UW-Madison (Chemistry, Civil and Environmental Engineering, Material Science and Engineering, Ophthalmology, Pharmacy, and Soil Science).

129 samples were irradiated for other educational institution research programs (Colorado College, Colorado School of Mines, University of Colorado, University of Minnesota, and UW-Eau Claire).

Industrial Use: NAA services were provided to Consolidated Paper Company (measurement of thickness of paper coatings) and RMT, Inc (identification of waste material in the environment).

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A. SUMMARY OF OPERATIONS

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

Thirty-five students enrolled in NEEP 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.

NEEP 427 was offered in the fall and spring semesters with a total enrollment of 23. 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 32 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 77 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 six times during the year.

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

Seven students, one of whom was from outside the NEEP department, completed the NEEP 602/699 course entitled Principles and Practice of Nuclear Reactor Operation. This course covers knowledge areas required for a reactor operator at our facility, and includes extensive operation practice. The six NEEP students all indicated they wished to become licensed operators at this facility, and will take the NRC examination in September 1991.

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

During Engineering Exposition, a student-run open-house held in the spring of odd-numbered years, the laboratory was again made available for public tours. Approximately 12, 000 visitors toured the facility.

2. REACTOR SHARING PROGRAM

User institutions participated in the program as detailed below.

Participating Institution	Principal Investigator	Number of Faculty/Students Involved
Academic/Industrial Teacher Internship Program	D. Woolston	1/28
Reactor tour and nuclear power discussion for high school teachers.		
Albany High School	W. Martin	2/45
Reactor tour and nuclear power discussion for high school science students.		
Badger High School Lake Geneva, WI	M. Lewendowski	1/37
Reactor tour and nuclear power discussion.		
Colorado College	E. Henrickson	1/3
NAA of geological samples for student thesis projects.		
Colorado School of Mines	F. Cecil	1/2
NAA of Ti/Al alloys in study of emission of charged particles from thin foils.		
Univ. of Colorado	N. Auerbach	1/1
NAA of road materials for study of road dust on soil and vegetation in the Arctic.		
Edgewood College Madison, WI	P. Weldy	1/7
NAA demonstration/lecture for Advanced Chemistry Class.		
Elkhorn State College	B. Wad	1/9
Reactor Laboratory tour and nuclear power discussion		

Lakeshore Technical
Institute — P. Gossen — 1/4

Reactor operation demonstration showing subcritical, critical, supercritical, and prompt supercritical modes for students in a health physics technician training program.

Madison Plan — J. Thompson — 1/14

Reactor tour and nuclear power discussion as part of an enrichment program for minority students from inner city schools.

Madison Area Technical
College — N. Powell — 1/16

Reactor operation demonstration as above, for steamfitter apprentice program.

Middleton High School — J. Jensen — 1/25

Nuclear Power Plant operations presentations.

University of
Minnesota-Duluth — R. Rapp — 2/4

Continuation of project using NAA of artifacts to determine provenance. Serpentine samples were analyzed.

Pittsville (WI) High School

S. Schultz — 1/5

Reactor tour and nuclear power discussion.

Reedsville High School

M. Brooks — 1/72

Presentation on how nuclear power plants operate and comparison of electrical power production methods.

Williamsville (IL)
High School — M. Stier — 1/70

Presentation on radiation sources and concerns, and the U. S. Energy future.

University of Wisconsin-Eau Claire
Eau Claire, WI — M. Bishop — 1/2

NAA of sediment samples in attempt to correlate satellite surveillance data with actual sample content.

3. SAMPLE IRRADIATIONS AND NEUTRON ACTIVATION ANALYSIS SERVICES

There were 1,077 individual samples irradiated during the year. Of these samples, 697 were irradiated for 15 minutes or less. Samples accumulated 256.8 irradiation space hours and 782 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, while RSP listed as source of support indicates work done under the DOE Reactor Sharing Program.

Chemistry Department, UW-Madison (NAA)
8 samples, 4 sample hours, 0.5 irradiation space hours. Professor Thomas Record, one additional staff member, and two graduate students used the NAA service to measure sodium concentrations in DNA solutions in order to quantify ion/DNA reactions. Supported by NIH and NSF.

Civil and Environmental Engineering Department, UW-Madison (NAA)
77 samples, 41 less than 15 minutes, 82.25 sample hours, 12.25 irradiation space hours. Professor R. Hamm, one additional staff member, and 1 graduate student used NAA to measure metal content of garbage in a reclamation project using material that would otherwise go into sanitary landfills. Supported by industrial grant.

Colorado College (NAA)
32 samples, 64 sample hours, 2 irradiation space hour. Professor Henrickson and 6 students used the NAA service for investigation of trace element concentrations in rocks and rock systems. Supported by DOE Reactor Sharing Program.

Colorado School of Mines (NAA)
8 samples, 4 less than 15 minutes, 9 sample hours, 3 irradiation space hours. Professor F. E. Cecil and 2 students used the NAA service to determine variations in materials used in an experiment concerning production of energetic charged particles from thin dueterated titanium foils. Supported by EPRI, DOE, and DOE Reactor Sharing Program.

Colorado, University of (NAA)
18 samples, 9 less than 15 minutes, 20.25 sample hours, 4.25 irradiation space hours. Staff member N. Auerbach of the Institute of Arctic and Alpine Research,

used the NAA service to determine elemental constituency of road materials at two research sites. Part of a study of the effects of road dust settling on soil and vegetation in the Arctic. Supported by University of Colorado and DOE Reactor Sharing Program.

Consolidated Paper Company (NAA)
13 samples, all less than 15 minutes, 3.25 sample hours, 3.25 irradiation space hours. The NAA service was used to measure the coating thickness on paper samples, for cross-calibration of in-plant measurements. Supported by industrial funds.

Edgewood College, Madison, WI (NAA)
1 less than 15 minute sample, 0.25 sample hours, 0.25 irradiation space hours. Professor Olson and seven students participated in a laboratory session on neutron activation analysis. Supported by DOE Reactor Sharing Program.

Material Science and Engineering Department, UW-Madison (NAA)
109 samples, all less than 15 minutes, 27.25 sample hours, 27.25 irradiation space hours. Professor John H. Perepezko, three additional staff members and 5 students are using the NAA service for analysis of Nb-Ti-Al alloys. The analyses are then used to accurately determine the phase diagram of the alloy system. Supported by DARPA through the Office of Naval Research.

Nuclear Engineering and Engineering Physics, UW-Madison
NEEP 427 Laboratory
102 samples, 76 less than 15 minutes, 85 sample hours, 27.25 irradiation space hours. Irradiations in support of teaching laboratory.

NEEP 428 Laboratory
115 samples, 46 less than 15 minutes, 142.25 sample hours, 77 irradiation space hours. Irradiations in support of teaching laboratory.

NEEP 602/699, Principles and Practice of Reactor Operations
6 samples, all less than 15 minutes, 1.5 sample hours, 1.5 irradiation space hours. Production of samples for instruction and demonstration.

Reactor Laboratory
15 samples, 14 less than 15 minutes, 4 sample hours, 4 irradiation space hours. Irradiations for flux measurements and instrument calibrations.

Department of Ophthalmology, UW-Madison
8 samples, all less than 15 minutes, 2 sample hours, 2 irradiation space hours. Dr. J. Robinson, a research fellow, is using Na-24 to study the movement of the sodium ion into the posterior of the eye in the monkey. Supported by National Eye Institute.

Pharmacy Department, UW-Madison (NAA)
157 samples, all less than 15 minutes, 33.25 sample hours, 31.25 irradiation space hours. Professor P. Bass and 2 students are using the NAA service to determine sodium and chloride content of aqueous samples, as part of a study of absorption and secretion in the perfused rat intestine. Supported by NIH.

RMT Inc. (NAA)
14 samples, all less than 15 minutes, 3.5 sample hours, 3.5 irradiation space hours. Measurement of composition of soil and waste material to determine if such analysis could be used to trace the extent of areas containing industrial waste materials. Industrial support.

Department of Soil Science, UW-Madison

36 samples, 18 sample hours, 0.5 irradiation space hours. (NAA) Professor E. J. Tyler and one student. NAA and tracer production to study element behavior in soil-water-plant systems. Support institutional grant.

60 samples, 25 less than 15 minutes, 41.25 sample hours, 8.25 irradiation space hours. Professor P. Helmke, and 3 graduate students. Production of tracers and analysis of rocks and soils. Supported by Cooperative State Research Service, Hatch, and Center for Integrated Agriculture Systems.

University of Minnesota-Duluth (NAA)
70 samples, 140 sample hours, 4 irradiation space hours. Professor Rapp and associates continued their research of establish a data base for determining provenance of serpentine samples. Supported by DOE Reactor Sharing Program.

4. OTHER MAJOR RESEARCH USE

The neutron radiography facility was used for 50.44 hours during the year.

5. CHANGES IN PERSONNEL, FACILITY AND PROCEDURES

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

During the year licensed operators Dave Deuno and Michelle Parker left the university for employment elsewhere.

Several improvements made possible by a U. S. Department Of Energy grant have been completed.

A new instrument has been procured and installed to continuously monitor resistivity at the inlet and outlet of the demineralizer.

The vacuum-tube high voltage and compensating power supplies for the reactor instrumentation have been replaced with solid-state electronics equivalents.

Additional replacements are in progress, with all equipment on hand, awaiting completion of modification checklists and approval of modifications by the Reactor Safety Committee. These include replacement of vacuum-tube strip-chart recorders, the oscillographic recorder used for pulse readout, and the stack and continuous air radioactivity monitoring system. These will be completed during the 91-92 fiscal year, along with purchase of a replacement area radiation monitoring system.

6. RESULTS OF SURVEILLANCE TESTS

The program of inspection and testing of reactor components continues. Inspection of underwater components showed no deterioration or wear. The purification demineralizer resins are no longer regenerating satisfactorily and will be replaced.

B. OPERATING STATISTICS AND FUEL EXPOSURE

Operating Period	Startups	Critical Hrs	MW Hrs	Pulses
FY 1990-91	171	674.09	573.30	97
Total Present Core	2292	8435.68	6837.92	534
Total TRIGA Cores	4327	15,619.06	11,907.70	1895

Excess reactivity of core I23-R12 remained constant during the year at 4.30 percent.

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

There were 7 automatic scrams during the year distributed as follows:

7/17/90 Period channel relay and electronic scrams due to noisy period from suspected high voltage power supply breakdown during high humidity conditions.

7/26/90 High Voltage Monitor and Period channel scrams when off-duty operator brushed against leads of voltmeter attached to monitor power supply fluctuations causing noisy period.

2/22/91 Picoammeter #2 relay and electronic scram when trainee downranged two ranges when intending to downrange one range.

3/7/91 Picoammeter #2 relay and electronic scram when trainee downranged when he intended to uprange the instrument while increasing power.

3/12/91 Picoammeter #1 relay and electronic scram when trainee downranged when he intended to uprange instrument while increasing power.

3/12/91 Scram from momentary loss of AC power due to ice storm impact on transmission lines.

4/11/91 Log N period trip from high voltage power supply disturbance caused by a pendant switch (used for measurements of rod-drop reactivity) hitting the front panel of the power supply distribution box. Both relay and electronic scrams actuated

In addition to the scrams indicated above, on 4/30/91 a manual scram was

performed due to failure of shim-safety blades to insert on a manual rundown signal. The usual method of shutdown at this facility is to perform a manual rundown using the manual rundown switch. This switch causes all control element drives to run down to the "in" limit switch without interrupting current to magnets or removing power from the air solenoid valve for the transient control rod. At the end of this full power run the operator placed the manual rundown switch into the rundown position. He noted that the regulating blade ran in normally, but that the shim safety blades did not. In addition, the transient rod dropped. The transient rod drop and regulating blade motion placed the reactor in shutdown condition but the operator used manual scram to place the shim-safety blades in shutdown position. Subsequent investigation indicated that fuse F4 opened when the switch was placed in rundown position. This caused the transient rod to drop, since the solenoid valve that supplies air to hold the rod out was de-energized when the fuse blew. The regulating blade motor circuits are supplied from a separate fuse, so it operated normally. Further investigation revealed that the automatic control (servo) channel was responsible for the blown fuse. One of the two solid-state relays that control motion of selected control elements during automatic control had shorted to ground. The relay and fuse were replaced.

D. MAINTENANCE

Routine preventive maintenance continued to maintain equipment operability, except for the event discussed immediately above.

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

The porpoise tube, a small hydraulic irradiation facility described in the third paragraph of section 2.4.5, page 2-42, of the SAR had not been used for several years. The hydraulic portions connected to the N^{16} diffuser system were removed, and the incore irradiation device was converted to a radiation basket to be used for small samples.

A 50.59 analysis of the proposed replacement of console strip-chart recorders with a hybrid digital/analog multiple point recorder was performed and submitted to NRC for evaluation as an unreviewed safety question. Concurrence of NRC with our evaluation was obtained by a letter dated February 13, 1991. The replacement has not yet been completed because of the need to schedule reactor down-time for the changeover.

F. RADIOACTIVE WASTE DISPOSAL

1. SOLID WASTE

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

2. LIQUID WASTE

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

3. PARTICULATE AND GASEOUS ACTIVITY RELEASED TO THE ATMOSPHERE

Table 2 presents information on stack discharges during the year.

G. SUMMARY OF RADIATION EXPOSURE OF PERSONNEL (1 MAY 90 - 31 MAY 91)

The period of exposure reported here exceeds one year because dosimetry data for the previous report was not available from the vendor until long after the end of the report period. No personnel received any significant radiation exposure for the above period. The highest doses recorded were 60 mrem to the whole body and 100 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 dose rates a person would have received if continuously present in the indicated area for the full year.

Annual Dose Data -- Environmental Monitors

Location	Average Dose Rate mrem/week 1990-91
Inside Wall of Reactor Laboratory	9.36
Inside Reactor Laboratory Stack	2.40
Highest Dose Outside Reactor Laboratory (Reactor Lab roof entrance window: monitor adjacent to stone surface)	3.39
Highest Dose in Occupied Nonrestricted Area (third floor classroom) Room 314	1.83
Average Dose in all Nonrestricted Areas (27 Monitor Points)	1.64
Lowest Dose Reported in Non-restricted Area	1.17

TABLE 1 LIQUID WASTE TO SANITARY SEWER

		3/5/91	5/17/91	Total
Total Ci		12.72	234.0	246.72
GALLONS		1400	1100	2500
Co-57 (MPC Used = 2E-2)				
	Ci	0	0	0
	Ci/ml			
	Fraction of MPC	0	0	0
Co-58 (MPC Used = 4E-3)				
	Ci	0.72	1.02	1.74
	Ci/ml	9.7E-8	2.4E-7	1.8E-7
	Fraction of MPC	2.4E-5	6.0E-5	4.5E-5
Co-60 (MPC Used = 1E-3)				
	Ci	2.61	1.85	4.46
	Ci/ml	5.0E-7	4.4E-7	4.7E-7
	Fraction of MPC	5.1E-4	4.4E-4	4.7E-4
Cr-51 (MPC Used = 5E-2)				
	Ci	0	12.65	12.65
	Ci/ml		3.0E-6	1.3E-6
	Fraction of MPC	0	6.1E-5	2.7E-5
Fe-59 (MPC Used = 2E-3)				
	Ci		3.32	3.32
	Ci/ml		6.3E-6	3.5E-7
	Fraction of MPC		3.2E-3	1.8E-4
Fe-55 (MPC Used = 2E-2)				
	Ci		179.3	179.3
	Ci/ml		3.4E-4	1.9E-5
	Fraction of MPC		1.7E-2	9.5E-4
Mn-54 (MPC Used = 4E-3)				
	Ci	1.59	2.51	4.10
	Ci/ml	3.0E-7	6.0E-7	4.3E-7
	Fraction of MPC	7.6E-5	1.5E-4	1.1E-4
Zn-65 (MPC Used = 3E-3)				
	Ci	7.8	33.38	41.18
	Ci/ml	1.4E-6	8.0E-6	4.4E-6
	Fraction of MPC	4.9E-4	2.7E-3	2.0E-4

Average concentration at point of release to sewer = 2.61E-5 Ci/ml.
Fraction of release limit without dilution = 8.2E-4.
Average daily sewage flow for dilution = 2.37E4 gallons.
Largest daily release fraction of limit, including dilution = 1.0E-3 of MPC.
Average yearly concentration = 7.53E-9 Ci/ml.

TABLE 2 EFFLUENT FROM STACK

1. Particulate Activity

There was no discharge of particulate radioactivity above background levels.

2. Gaseous Activity -- All Argon 41

Month	Activity Discharged (Curies)	Maximum Instantaneous Concentration $\mu Ci/ml \times 10^{-6}$	Average Concentration $\mu Ci/ml \times 10^{-6}$
July 1990	0.170	2.2	0.0095
August	0.258	2.1	0.0144
September	0.231	3.0	0.0133
October	0.277	3.0	0.0154
November	0.160	2.3	0.0092
December	0.135	2.6	0.0075
January 1991	0.127	0.8	0.0071
February	0.035	0.7	0.0215
March	0.042	0.9	0.0236
April	0.026	0.9	0.0153
May	0.062	1.7	0.0034
June	0.054	1.0	0.0031
TOTAL	1.577	3.0 (Maximum)	0.0075 (Average)

Maximum Instantaneous Concentration = 0.125 of MPC

Average Concentration = 3.125E-4 of MPC

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