# THE UNIVERSITY OF WISCONSIN
# NUCLEAR REACTOR LABORATORY

## 1991-1992 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
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## EXECUTIVE SUMMARY OF REACTOR UTILIZATION

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

- 39 NEEP students in laboratory courses.
- 66 student 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, Edgewood College, Lakeshore Technical Institute, Milwaukee School of Engineering, and University of Wisconsin- Platteville, used the facilities for formal instruction or research.

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

- 36 samples were irradiated for research programs in other departments of the UW-Madison (Chemistry, Electrical and Computer Engineering, Material Science and Engineering).
- 194 samples were irradiated for other educational institution research programs (Colorado College, U.W. Milwaukee, U.W. Platteville, and Verona High School).

**Industrial Use:** NAA services were provided to Hazelton Laboratories (to determine La and Sn levels in ethanol-water mixtures) and Johnson Controls, Inc. (to determine composition of dross samples).

**Federal Government Agencies:** NAA services were provided to the National Institute of Standards and Technology (to determine Fe levels in hydroxide solutions and ion-exchange resins).

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## A. SUMMARY OF OPERATIONS

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

Thirty-two 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 22. 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 426 was 17 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.

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

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, 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 |
|---|---|---|
| Academic/Industrial Teacher/Internship Program<br>Reactor Tour; Discussion of Nuclear Power | D. Woolston | 1/20 |
| Blackhawk High School<br>Reactor Tour | S. O'Brien | 1/30 |
| Calvery Gospel School<br>Science Careers and Nuclear Power for 5-12th grades | L. Anderson | 3/60 |
| Cherokee Middle School<br>Reactor tour and nuclear power discussion for middle school students | N. Contrucci | 2/25 |
| Colorado College<br>NAA of sand samples<br>NAA, short and long and andesites for tracing origin<br>NAA of Rock for studies | E. Henrickson | 1/3 |
| Edgewood College Madison, WI<br>NAA demonstration/Reactor operation demo | P. Weldy | 1/7 |
| Lakeshore Technical Institute<br>Reactor operation demonstration, Neutron Monitor Operation | D. Gossett | 1/9 |
| Milwaukee School of Engineering<br>Reactor Tour and Reactor Operation demonstration | Prof. Dieball | 1/16 |
| Monona Grove High School<br>Tour of Reactor Laboratory | R. Zebell | 2/22 |

| | | |
|---|---|---|
| New Glarus High School | S. Wehrley | 1/19 |
| Tour of Reactor Lab and Facilities | | |
| St. Joseph's Middle School | J. Dwyer | 1/9 |
| Tour of Reactor Lab as part of science curriculum | | |
| Senate Middle School | V. Laufenberg | 2/34 |
| How a Nuclear Power plant works | | |
| University of Wisconsin - Platteville | H. Fenrick | 1/7 |
| Reactor Operation and NAA demonstration | | |
| Van Hise Middle School | D. Dubielzig | 8/250 |
| Subject: Nuclear Waste | | |
| Verona High School | | |
| Chemistry Class | R. Marks | 4/100 |
| Atomic Physics | | |
| Chemistry Class II | S. Moore | 1/1 |
| NAA of Rocks | | |

**USER SUMMARY:**

| | |
|---|---|
| Educational Institutions: | 15 |
| Students: | 612 |
| Faculty/Instructors: | 31 |

## 3. SAMPLE IRRADIATIONS AND NEUTRON ACTIVATION ANALYSIS SERVICES

There were 700 individual samples irradiated during the year. Of these samples, 411 were irradiated for 15 minutes or less. Samples accumulated 129.9 irradiation space hours and 583.8 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.

**Chemistry Department** (NAA)
7 samples, 2 less than 15 minutes, 5.5 sample hours, 1.5 irradiation space hour. Prof Lerner and 2 students used the NAA service to determine Na and Mg content in a determination of effect of cations on carbohydrate conformation. Supported by Whitaker Foundation and NIH.

**Colorado College** (NAA)
170 samples, 100.95 sample hours, 8.1 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.

**Electrical and Computer Engineering** (NAA)
10 Samples, 1 sample hr, 0.1 irradiation space hours. Professor McCaughn and 2 students used the NAA service to determine erbium content of crystals.

**Hazelton Laboratories** (NAA)
139 Samples, all less than 15 minutes, 37.25 sample hours, 1.75 irradiation space hours. A researcher used the NAA service to determine La and Sn levels in ethanol-water mixtures. Industrial support.

**Johnson Controls, Inc.** (NAA)
21 samples, 12 less than 15 minutes, 21 sample hours,2.5 irradiation space hours. Staff members used the NAA service to determine composition of dross samples. Industrial support

**Material Science and Engineering Department, UW-Madison** (NAA)
19 samples, all less than 15 minutes, 4.75 sample hours, 0.5 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.

**National Institute of Standards and Technology** (NAA)
70 samples, 128 sample hours, 22 irradiation space hours. A staff member used the NAA service to determine Fe levels in hydroxide solutions and ion-exchange resins.

**Nuclear Engineering and Engineering Physics, UW-Madison**
**NEEP 427 and 428 Laboratory Courses**
194 samples, 120 less than 15 minutes, 242.88 sample hours, 73.54 irradiation space hours. Irradiations in support of teaching laboratory.

**Reactor Laboratory**
56 samples, 4 less than 15 minutes, 16 sample hours, 8.75 irradiation space hours. Irradiations for flux measurements and instrument calibrations.

**University of Wisconsin-Milwaukee** (NAA)
12 Samples, 3 less than 15 minutes, 7.5 sample hours, 1.25 irradiation space hours. Professor Conrad and 1 undergraduate student used the NAA service to determine impurities in coatings. Supported by DOE Reactor Sharing Program.

**University of Wisconsin-Platteville**
2 samples, 4 sample hours, 2 irradiation space hours. Professor and 7 students in a neutron activation analysis laboratory. Supported by USDOE Reactor Sharing Program.

**Verona High School**
10 samples, 15 sample hours, 1.5 irradiation space hours Activations for demonstrations. Supported by DOE Reactor Sharing Program.

4. OTHER MAJOR RESEARCH USE

The neutron radiography facility was inactive 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.

Personnel changes during the year were as follows:

Professor George M. Maxwell replaced Professor VanSciver on the Reactor Safety Committee.

Susan Englehardt resigned as Health Physics supervisor for the University. She was replaced on the Reactor Safety Committee by the acting Radiation Safety Officer, Abdul BenZikri. A search for a permanent replacement is continuing..

Reactor Operators Joe W. Kettner and Eric P. Loewen were appointed as Senior Reactor Operators upon licensing by NRC.

Douglas A. Bishop, Jody I. Helland, John G. Murphy, and Michael T. Trubenbach were appointed as Reactor Operators upon licensing by NRC.

The Safety Department, parent organization of the University Radiation Safety Office has been transferred from the administrative control of the Department of Physical Plant to report directly to the Assistant Vice Chancellor for Facilities Planning and Management. The Radiation Safety Office continues to be operationally controlled by the University Radiation Safety Committee, and the relationships with the Reactor Laboratory are unchanged.

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 1991-92 | 138 | 556.06 | 637.67 | 36 |
| Total Present Core | 2430 | 8991.74 | 7475.59 | 570 |
| Total TRIGA Cores | 4465 | 16256.73 | 12463.77 | 1881 |

The excess reactivity of core I23-R12 increased slightly during the year to 4.51 percent.

## C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

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

7/25/91 High pool level alarm due to thermal expansion plus currents due to leak in polyethylene tube conveying water to whale tube C2. The currents caused actuation of the float switch while the pool level was below the actual setpoint. The polyethylene tubing was replaced.

The following 6 scrams are retrospectively classified as range switch problems on the picoammeters. The picoammeters provide an electronic scram function, as well as the technical specification required electronic scram. This electronic scram sometimes actuates even though the bistable (which produces both electronic and relay scrams) does not change state.

8/1/91 & 8/1/91 (2 scrams)

Electronic scrams in one case while reducing power, in the other case during steady-state operation with no control manipulations taking place. No upscale movements on any instruments, and no bistable operation. After investigation, solder joints in the logic element were resoldered, and the contacts of the logic element connector were burnished.

9/24/91 Another electronic scram with no upscale indication on any instrument. Since this appeared to be a recurrence of the electronic scrams on 8/1/91, it was decided to replace one of the three instruments (logN-period amplifier and the two

(picoammeters) that can cause electronic scram. The logN-Period amplifier was replaced with the spare, since this instrument had previously caused electronic scrams without bistable actuation.

9/24/91 Electronic scram coincident with upranging #1 picoammeter to 1000 kW range. Could not cause to recur with testing. Replaced picoammeter with spare, and reheated solder joints on range switch for unit that was removed.

9/26/91 Electronic and relay scram from #1 picoammeter when changing range switch to 30 watt range. Found and repaired intermittent solder joint in range resistor on spare (switch had been replaced in 1988, and tested satisfactorily at that time).

9/27/91 Electronic scram from #1 picoammeter when switched to 300 W range. Restarted and continued full power run with #1 picoammeter on full power range in order to complete run required to maintain fuel gamma ray dose at self-protection levels. Switched back to original picoammeter.

## D. MAINTENANCE

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

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

The air monitor which monitors the radioactivity in air discharged from the stack was replaced in January 1992. The new system description matches that in the Safety Analysis Report (pages 2-54 and 2-55) except for the quoted sensitivities. The values in the SAR were calculated sensitivities without consideration of normal background variations. The equipment currently in service will detect a particulate activity of about 5E-10 Ci/ml and a gaseous activity of about 1E-7 Ci/ml with normal background. In addition, the Continuous Air Monitor system (not described in the SAR, but reported as an additional instrument in our 1979-80 annual report) has been replaced with a system identical to the stack air monitor. The CAM includes gaseous detection capability and can be used as a spare for the stack monitor.

## F. RADIOACTIVE WASTE DISPOSAL

### 1. SOLID WASTE

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

### 2. LIQUID WASTE

There were 5 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 July 1991 - 30 June 1992)

No personnel received any significant radiation exposure for the above period. The highest doses recorded were 70 mrem to the whole body and 0 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 1991-92 |
|---|---|
| Inside Wall of Reactor Laboratory | 9.06 |
| Inside Reactor Laboratory Stack | 1.81 |
| Highest Dose Outside Reactor Laboratory (Reactor Lab roof entrance window: monitor adjacent to stone surface) | 2.80 |
| Highest Dose in Occupied Nonrestricted Area (second floor classroom) Room 247 | 1.46 |
| Average Dose in all Nonrestricted Areas (27 Monitor Points) | 1.43 |
| Lowest Dose Reported in Non-restricted Area | .95 |

TABLE 1 LIQUID WASTE TO SANITARY SEWER

| | Date | 7/3/91 | 7/23/91 | 2/3/92 | 2/26/92 | 4/15/92 | TOTAL |
|---|---|---|---|---|---|---|---|
| | Total µCi | 75.23 | 129.55 | 2.124 | 15.60 | 7.92 | 233.424 |
| | GALLONS | 1200 | 1450 | 1200 | 1400 | 1220 | 6470 |
| | % of MPC | 2.9E-2 | 4.4E-2 | 1.0E-3 | 7.0E-3 | 1.0E-3 | |
| Co-58 (MPC Used = 4E-3) | | | | | | | |
| | µCi | 1.96 | 4.73 | 0 | 0 | 0.26 | 6.95 |
| | µCi/ml | 2.2E-8 | 5.2E-8 | | | 2.9E-9 | |
| | Fraction of MPC | 5.4E-6 | 1.3E-5 | | | 7.3E-7 | |
| Co-60 (MPC Used = 1E-3) | | | | | | | |
| | µCi | 5.90 | 5.81 | 0.37 | 1.80 | 0 | 13.88 |
| | µCi/ml | 6.6E-8 | 6.4E-8 | 4.1E-9 | 2.0E-8 | | |
| | Fraction of MPC | 6.6E-5 | 6.4E-5 | 4.1E-6 | 2.0E-5 | | |
| Cr-51 (MPC Used = 5E-2) | | | | | | | |
| | µCi | 9.46 | 19.57 | 0 | 0 | 5.29 | 34.32 |
| | µCi/ml | 1.1E-7 | 2.2E-7 | | | 5.9E-8 | |
| Fraction of MPC | | 2.1E-6 | 4.3E-6 | | | 7.3E-7 | |
| Mn-54 (MPC Used = 4E-3) | | | | | | | |
| | µCi | 6.76 | 7.64 | 0.20 | 0.58 | 0.49 | 15.94 |
| | µCi/ml | 7.5E-8 | 8.5E-6 | 2.2E-9 | 9.4E-9 | 5.5E-9 | |
| | Fraction of MPC | 1.9E-5 | 2.1E-5 | 5.5E-7 | 2.3E-6 | 1.4E-6 | |
| Zn-65 (MPC Used = 3E-3)8 | | | | | | | |
| | µCi | 54.15 | 91.80 | 1.554 | 12.95 | 1.88 | 162.334 |
| | µCi/ml | 6.1E-7 | 1.0E-6 | 1.78E-8 | 1.4E-7 | 2.1E-8 | |
| | Fraction of MPC | 2.0E-4 | 3.4E-4 | 5.9E-6 | 4.8E-5 | 7.0E-6 | |

Average concentration at point of release to sewer = 9.5E-6 µCi/ml.
Average daily sewage flow for dilution = 2.37E4 gallons.
Largest daily release fraction of limit, including dilution = 4.4E-4 of MPC.
Average yearly concentration = 7.0E-9 µCi/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

| Concentration Month | Activity (Curies) | Maximum Instantaneous Discharged $\mu Ci/ml \times 10^{-6}$ | Average Concentration $\mu Ci/ml \times 10^{-6}$ |
|---|---|---|---|
| July 1991 | 0.092 | 2.0 | 0.0513 |
| August | 0.089 | 1.6 | 0.0500 |
| September | 0.086 | 1.6 | 0.0500 |
| October | 0.088 | 1.3 | 0.0492 |
| November | 0.108 | 1.5 | 0.0622 |
| December | 0.029 | 1.1 | 0.0162 |
| January 1992 | 0.202 | 1.0 | 0.1130 |
| February | 0.591 | 1.4 | 0.3520 |
| March | 0.838 | 1.4 | 0.4680 |
| April | 0.024 | 1.4 | 0.0140 |
| May | 0.072 | 1.7 | 0.0400 |
| June | 0.084 | 3.5 | 0.0486 |
| TOTAL | 2.303 | 3.5 (Maximum) | 0.1095 (Average) |

Maximum Instantaneous Concentration = 0.145 of MPC

Average Concentration = 4.6E-3 of MPC

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