

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

FOR
FISCAL YEAR 1987-1988

Prepared by:

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UNIVERSITY OF WISCONSIN
NUCLEAR REACTOR LABORATORY

ANNUAL REPORT

Fiscal Year 1987-1988

A. SUMMARY OF OPERATIONS

1. INSTRUCTIONAL USE - UW-MADISON FORMAL CLASSES

Five Nuclear Engineering and Engineering Physics Department classes made use of the reactor. Fifty-three 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 and had an enrollment of thirteen. 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. The irradiations in support of NEEP 427 and the radiation survey take place during normal isotope production runs, so no reactor time is specifically devoted to NEEP 427. The enrollment in NEEP 428 was nineteen, 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 three times during the year requiring a total of fifty-eight 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-five NEEP 305 students used the reactor to irradiate samples for a half-life measurement and for an experiment to measure the half-life of the longer-lived delayed neutron emitters. A class of five students completed the facility Reactor Operator Training program, which was taught during the spring semester as a four semester-hour formal course (NEEP 699/602). Each student performed reactor startups (11 each), shutdowns (11 each), and other significant reactivity changes. Two of these students have taken and passed the NRC examination and are currently serving as Reactor Operators. The other three students could not be certified as needing a NRC license, since their expected tenure at the University was not long enough. Individual one- to two-hour sessions in the reactor laboratory were also held for other classes.

2. REACTOR SHARING PROGRAM

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

| Participating Institution | Principal Investigator | Number of Staff/ Students Involved |
|---------------------------|------------------------|---------------------------------------|
|---------------------------|------------------------|---------------------------------------|

| | | |
|----------------|--------------------------------------|------|
| Beloit College | Prof. Viswanathan/ Prof. Senstrom | 49/3 |
|----------------|--------------------------------------|------|

A course entitled "Artifact and Site Examination: Analytical Techniques" accounted for much of the use by the institution. Multidisciplinary student teams undertook practical projects involving use of the neutron activation analysis capability of the Reactor Laboratory.

| | | |
|-----------------|-------------|-----|
| Carroll College | Prof. Welch | 6/1 |
|-----------------|-------------|-----|

Reactor facility tour and laboratory session on neutron activation analysis for students in an advanced Chemistry course.

| | | |
|----------------------|---------------|------|
| DeForest High School | Mr. Klingbeil | 10/1 |
|----------------------|---------------|------|

Reactor Laboratory tour and nuclear power explanation.

| | | |
|------------------|--------------|-----|
| Edgewood College | Prof Swanson | 6/1 |
|------------------|--------------|-----|

Laboratory session on neutron activation analysis.

| | | |
|-------------------------------|--------------|-----|
| Lakeshore Technical Institute | Prof. Gossen | 7/1 |
|-------------------------------|--------------|-----|

Reactor Laboratory tour; neutron survey instrument familiarization and use; shielding demonstration/laboratory; radiation survey instrument calibration.

| | | |
|---------------------|------------|-----|
| Lawrence University | Prof. Pope | 0/1 |
|---------------------|------------|-----|

NAA of prehistoric pottery samples from a Middle Woodland Wisconsin site.

| | | |
|----------------|---------------|------|
| Luther College | Prof. Kellogg | 16/1 |
|----------------|---------------|------|

Reactor operation demonstration and tour; neutron activation analysis familiarization.

| | | |
|--------------------------------|---------------|------|
| Madison Area Technical College | Prof. Seidman | 13/1 |
|--------------------------------|---------------|------|

Reactor familiarization; neutron activation analysis demonstration; instruction in use of radiation survey instruments.

| | Principal Investigator | Number of Staff/ Students Involved |
|---|-----------------------------------|---------------------------------------|
| Marquette University High School | | 3/1 |
| Videotaping of laboratory tour and discussion of nuclear power for presentation to other students from the school. | | |
| Middleton High School School | Mr. Leutswager | 10/1 |
| Production of license exempt short-lived sources for laboratory demonstrations and half-life measurement. | | |
| Milwaukee School of Engineering | Prof. Butterfield/ Prof. Mayer | 19/2 |
| Reactor operation observation and tour. | | |
| New Glarus High School | Mr. Wehrley | 26/1 |
| Tour and explanation of facility operation for physics class. | | |
| Univ. of Minnesota-Duluth | Prof. Rapp | 3/3 |
| NAA of native copper samples of U.S. origin to establish a data base for determining provenance of copper artifacts. | | |
| Univ. of Wisconsin- Platteville | Prof. Fenrich | 4/1 |
| Reactor tour, nuclear power discussion and neutron activation analysis laboratory for students from Physical Chemistry and Instrumental Analysis classes. | | |
| Univ. of Wisconsin- River Falls | Prof. Lewendowski | 15/1 |
| Reactor tour and neutron activation analysis laboratory/demonstration. | | |
| Waunakee High School | Mr. Arbeitlinger | 43/1 |
| Tour and explanations of reactor operating theory for physics class. | | |
| Wisconsin Heights High School | Ms. Sadowski | 39/2 |
| Reactor tour and operating demonstration. Discussion of reactor operator training and knowledge areas. | | |

3. SAMPLE IRRADIATIONS AND NEUTRON ACTIVATION ANALYSIS SERVICES

There were 2168 individual samples irradiated during the year. 864 of these samples were irradiated for 15 minutes or less. The remaining samples accumulated 218.67 irradiation space hours and 2576.74 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 indicates work done under the DOE Reactor Sharing Program.

Biochemistry Department, UW-Madison (NAA)

28 samples, all less than 15 minutes, 8.5 sample hours, 2.08 irradiation space hours.

Professor John L. Markey, one visiting professor and 1 graduate student used NAA to determine metal content of proteins. Supported by USDA-SEA, NIH, and NSF.

Chemistry Department, UW-Madison (NAA)

16 samples, all less than 15 minutes, 4 sample hours, 0.5 irradiation space hours.

Professor Thomas Record and one graduate student used the NAA service to measure sodium concentrations in DNA solutions in order to quantify ion/DNA reactions. Supported by NIH and NSF.

Chemical Engineering Department-UW-Madison (NAA)

5 samples, all less than 15 minutes, 0.67 sample hours, 0.67 irradiation space hours.

Professor Stanley H. Langer and one graduate student used NAA to determine composition of deposits building up on heat exchange surfaces of a milk product heat exchanger. Supported by an industrial grant.

Engelhard Corp., N.J. (NAA)

18 samples, 14 less than 15 minutes, 19.25 sample hours, 3.85 irradiation space hours.

Measurements of trace element composition in various materials. Industrial support.

Environmental Textiles and Design Department-UW-Madison (NAA)

33 samples 2 less than 15 minutes, 60 sample hours, 2 irradiation space hours.

Professor Ray Young and 1 graduate student. NAA of museum specimen weighted silk costume material to determine materials used. Supported by department and a museum.

Johnson Controls Corp., Milwaukee (NAA)

23 samples, 11 less than 15 minutes, 24 sample hours, 2.92 irradiation space hours. Analysis of trace element concentrations in polypropylene. Industrial support.

Medical Physics Department, UW-Madison

20 samples, 18.3 samples hours, 6.31 irradiation space hours.
Associate Scientist Dave Pearson, a physician collaborator from the State Laboratory of Hygiene, and one graduate student exposed human blood cells to low-gamma-contamination fast-neutron fields in order to check for chromosomal damage. Supported by DOE.

Metallurgical and Mineral Engineering Dept., UW-Madison

251 samples, 251 less than 15 minutes, 1.19 samples hours, 1.19 irradiation space hours.
Prof. Eric Helstrom and one graduate student used NAA to determine the extent and the kinetics of ion exchange in ionic compounds. Supported by Sandia National Laboratory and UW-Madison Graduate School.

50 samples, 25 less than 15 minutes, 12.5 sample hours, 3.27 irradiation space hours.
Prof. John H. Perepezko, 3 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 the Office of Naval Research, DARPA, and ARO.

Milwaukee School of Engineering (NAA)

24 samples, 11 less than 15 minutes, 26 sample hours, 3 irradiation space hours.
Prof. Carol Diggelman used NAA for a preliminary investigation of the leachability of municipal solid waste incinerator ash. Supported by the Mich A. Naulin Foundation.

Nuclear Engineering and Engineering Physics-UW-Madison**NEEP 305**

11 samples, all less than 15 minutes, 1.92 sample hours, 1.92 irradiation space hours.
Development and performance of a demonstration/experiment on half-life measurements.

NEEP 427 Laboratory

98 samples, 56 less than 15 minutes, 127.4 sample hours, 38.13 irradiation space hours.
Irradiations in support of teaching laboratory.

NEEP 428 Laboratory

61 samples, 20 less than 15 minutes, 77.3 sample hours, 40.63 irradiation space hours.
Irradiations in support of teaching laboratory.

Reactor Laboratory

41 samples, 36 less than 15 minutes, 12.33 sample hours, 4.81 irradiation space hours.
Irradiations for measurements and instrument calibrations.

Nuclear Medicine Department-UW-Madison

2 samples, 2 sample hours, 1 irradiation space hour.
Professor James E. Holden, one additional staff member, and three graduate students used Fluorine-18 produced in the reactor in a study of metabolic processes. The study centers on energy production of the myocardium, and the F-18 is used to produce metabolic analogs labeled with positron emitters. Supported by NIH, National Heart, Lung, and Blood Institute.

Oak Ridge National Laboratories (NAA)

4 samples, 2 sample hours, 0.5 irradiation space hour.
Analysis of Co content (and other impurities) in Inconel samples. ORNL support (Martin Marietta Energy Systems, Inc.)

Ohio State University (NAA)

36 samples, 72 sample hours, 2 irradiation space hours.
NAA of sediment samples to determine impact of mining operations and runoff. Support unknown.

Reactor Sharing Program (NAA)**Beloit College**

633 samples, 279 less than 15 minutes, 689.85 sample hours, 47.34 irradiation space hours.

NAA of water samples to determine impact of sewage treatment plant effluents on quality of water in the Rock River; a study of zeolites in K-feldspars; NAA of mixed horizon rock samples including andesites, diorites, basalts, rhyolites, calcites, and galena; trace elements in pottery artifacts and attempts to match to associated sources of clays; copper and soil analyses.

Carroll College, Waukesha

1 sample less than 15 minutes, .08 sample hour, .08 irradiation space hour.

NAA session for students in an advanced Chemistry course.

Lawrence University, Appleton

72 samples, 36 less than 15 minutes, 37.52 sample hours, 3.27 irradiation space hours.

NAA of prehistoric pottery samples from a Middle Woodland Wisconsin site.

Madison Area Technical College

1 sample less than 15 minutes, .08 sample hour, .08 irradiation space hour.

Neutron activation analysis demonstration.

Middleton High School

1 sample less than 15 minutes, .08 sample hour, .08 irradiation space hour.
Production of license exempt short-lived sources for laboratory demonstrations and half-life measurement.

University of Minnesota-Duluth

531 samples, 1062 sample hours, 32 irradiation space hours.
Professor Rapp and associates continued their research of native copper samples of U.S. origin to establish a data base for determining provenance of copper artifacts.

University of Wisconsin-Platteville

1 sample less than 15 min., .08 sample hour, .08 irradiation space hour.
Neutron Activation Analysis laboratory for students from Physical Chemistry and Instrumental Analysis classes.

University of Wisconsin-Milwaukee, Dept. of Geosciences (NAA)

32 samples, 64 sample hours, 2 irradiation space hours.
Prof. Mursky, one additional staff member, and 2 students are using NAA of well log samples to attempt to predict high radium concentrations in water. Supported by Wisconsin DNR.

Department of Soil Science - UW-Madison

33 samples all less than 15 minutes, 2.7 sample hours, 1.74 irradiation space hours.
Prof. Helmke and three graduate students. NAA and tracer production to study element behavior in soil-water-plant systems. Support by Hatch Act and EPA.

State Laboratory of Hygiene (Wisconsin) (NAA)

24 samples, all less than 15 minutes, 0.5 irradiation space hours.
Monitoring and surveillance of total organic halide content of groundwater. State support.

Veterinary Science - UW-Madison (NAA)

98 samples, 236 sample hours, 7 irradiation space hours.
Prof. O. J. Ginther and one graduate student are using gold as a stable tracer to trace the fate of follicular fluid after ovulation. Supported by USDA-SEA.

Wisconsin Dairy Cooperative (NAA)

4 samples, 2 less than 15 minutes, 4.17 sample hours, 2.17 irradiation space hours.
NAA of metallic impurities found in whey and other products produced from whey to determine common origin and to determine source of impurity. Industrial support.

Wisconsin Electric Power Company

6 samples, 7.82 sample hours, 7.82 irradiation space hours.
Production of Na^{24} tracer for steam generator carry-over measurements at the Point Beach Nuclear Power Plant. Industrial support.

4. CHANGES IN PERSONNEL, FACILITY AND PROCEDURES

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

Operator Michael Rothenbuehler completed the requirements for his degree and left the university for employment elsewhere. Two students, Joseph Giebel and Michelle Parker, were trained and licensed during the year.

There were no significant changes to the facility or procedures during the year.

5. RESULTS OF SURVEILLANCE TESTS

The only significant deviation from expected performance during surveillance testing was continued leakage from the reactor pool. Efforts to control this leakage are detailed in Section D of this report.

Inspection of underwater components showed no deterioration or wear.

B. OPERATING STATISTICS AND FUEL EXPOSURE

| <u>Operating Period</u> | <u>Startups</u> | <u>Critical Hours</u> | <u>MW Hours</u> | <u>Pulses</u> |
|-------------------------|-----------------|-----------------------|-----------------|---------------|
| FY 87-88 | 170 | 644.96 | 543.28 | 29 |
| Total Present Core | 1707 | 6460.66 | 5133.38 | 370 |
| Total TRIGA Cores | 3741 | 13643.44 | 10203.16 | 1731 |

Excess reactivity of core I23-R12 increased by 0.157% reactivity over the year to 4.317%.

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

There were no emergency shutdowns during the year.

There were 11 inadvertent scrams or shutdowns during the year distributed as follows:

2 Relay Scrams - 11/17/87, 12/04/87 --
with no changes in any measured parameter. These scrams are attributed to noise sensitivity of the period scram circuitry. The bistable that controls the relay scram does not trip in these scrams, but the solid-state relay controlled by the bistable picks up noise and drops out momentarily. Since the original solid-state relays employ zero-crossing circuitry, the relay cannot pick up until the AC voltage drops to zero again. Since there was no need for the zero-crossing feature in this application, the relays were replaced on 12/22/87 with electrically equivalent solid-state relays that did not have the zero-crossing turn-on feature.

3 Electronic Scrams - 03/23/88, 03/23/88, 04/27/88 -- #2 picoammeter range switch make-before-break feature malfunctioned, giving an instantaneous high output during upranging of the switch. Exercising the switch after the first occurrences had seemed to fix the problem, but the picoammeter was replaced with a spare after the third occurrence. The range switch in the original unit will be replaced.

1 - Loss of all AC power to building - 05/23/88

3 - Drop of #3 control blade without scram - 3/23/88, 05/02/88/, 05/16/88 -- After reassembly of blade to its shaft following the December maintenance shutdown the alignment of the armature with the magnet that picks up the blade assembly was not optimum. Since the core must be unloaded to realign the components of the blade, this was not repaired until the scheduled maintenance in June for pool repairs.

1 Relay Scram - 05/23/88 -- period scram due to period amplifier sensing a faster than actual period during a startup. Checkout of the transient rod square wave and pulse interlock often introduces negative spikes into the log N-Period Amplifier input circuits. This can cause short period indications when the negative charge is finally dissipated.

1 Relay Scram - 07/16/87 -- core inlet temperature recorder slidewire cover fell off when recorder was closed, shorting out slidewire and causing an upscale deflection.

It should be noted that six of the eight scrams were due to scram conditions not required by Technical Specifications (period scram and electronic scram), and none of the scrams excepting the AC power loss was due to any parameter being outside its normal operating range.

D.

MAINTENANCE

The rate of water loss is detailed in Table 2 of Section F of this report. The levels of radioactivity in the pool water continued to be far below MPC for release to the environment. All leakage in Table 2 was assumed to be released to the environment, although a large portion of the water leaked into the thermal column door tracks and was evaporated into the Reactor Laboratory.

During the annual maintenance shutdown in December, 1987, the core was unloaded to the storage pit in the pool floor and radiation surveys were conducted within the pool. Dose rates were low enough that an operator with SCUBA diving experience was able to inspect the liner in the thermal column region. (Dosimetry worn by the diver indicated a total dose of 10 mrem.) As detailed in RSC document #424, the liner and weld appearance was excellent.

Table 2 shows that the leak again decreased markedly during the shutdown period and increased again as the weather warmed.

The underwater surveys indicated that, except for the regulating blade and fuel, radiation levels were low enough that the pool could be drained to permit finding and repairing the leak. A plan for the repair was approved by the Reactor Safety Committee at the May, 1988 meeting

(RSC document #432) and was carried out in June, 1988. Fuel, the regulating blade, and neutron sources were transferred into the storage pit and covered with the shielded cover.

Instrumented fuel elements, whose conduit extensions were too long to fit into the pit, were stored in a shielded single-bundle transfer cask (which was itself stored on the pool bottom). Hydraulic irradiation facilities were unloaded from the grid box and placed at the pool bottom on the NE side of the pool.

Pool water was incrementally drained into the 2000 gallon waste water hold tank and into a 27 foot diameter above ground swimming pool erected on the floor of the laboratory.

Pool water level was lowered in 4-5 foot increments and the liner tested for leakage by applying 2-2.5 psi air pressure between the concrete pool walls and the pool liner. In addition, the water level was carefully monitored overnight at each level. Finally, dye injection between the liner and the pool wall was planned if the leak could not be located by the other methods.

Level change could not be used for leakage indication, since the lowered water level allowed the pool liner to relax away from the concrete walls, usually resulting in a level increase overnight.

Air pressure checking revealed a single leak -- a crack in the pool wall in the form of an arc (0.5 inches long) about 9/32 of an inch above the top west corner of the thermal column. There was no evidence of corrosion, and no further leak indication as the pool level was drained to within three feet of the pool bottom.

With water at the lowest level the dose rate at the top of the pool was 10 mrem/hour, while at contact with the grid box the dose was 1000 mrem/hour.

Water level was increased to about 6 inches below the leak in order to minimize dose during repairs. Dose rate in the area where the repair had to be made was 20-100 mrem/hour under these conditions. The dosimeter of the person performing the repair indicated a total dose of 60 mrem. Total dose during the entire drain/input/repair/refill was 100 mrem (per dosimeter) for each of the two SRO personnel who performed the work.

Quarter inch diameter holes were drilled at each end of the crack and the cracked region was ground out. MIG welding was used to fill the ground out area and to overlay that weld with three additional welds. The water level was raised and air pressure testing indicated the leak was sealed.

The pool was filled and operation resumed on 30 June 1988. There has been no further indication of leakage since the repair.

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

There were no reportable changes to the facility or procedures.

F. RADIOACTIVE WASTE DISPOSAL**1. SOLID WASTE**

There was no solid waste disposal during the year.

2. LIQUID WASTE

a. 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.

b. Releases due to pool leakage are detailed in Table 2. The concentrations released are all less than the 5×10^{-5} $\mu\text{Ci/ml}$ limit on pool water activity from the Safety Analysis Report, but the total release figure is based on the pool water being at this limit. The measured pool water activity from monthly surveillance tests is also indicated in the table.

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

| DATE | 04-25-88 | 06-10-88 | TOTAL μCi |
|--------------------------|----------|----------|----------------------|
| Total μCi | 27.4 | 332.4 | 359.4 |
| Gallons | 1900 | 800 | 2700 |
| Co-57 MPC Used | 2E-2 | | |
| μCi | 0.78 | -- | 0.78 |
| $\mu\text{Ci}/\text{ml}$ | 1.08E-8 | -- | |
| Co-58 MPC Used | 4E-3 | | |
| μCi | 1.97 | 26.88 | 28.85 |
| $\mu\text{Ci}/\text{ml}$ | 2.74E-7 | 8.89E-6 | |
| Co-60 MPC Used | 1E-3 | | |
| μCi | 5.23 | 16.64 | 21.87 |
| $\mu\text{Ci}/\text{ml}$ | 7.28E-7 | 5.50E-6 | |
| Cr-51 MPC Used | 5E-2 | | |
| μCi | -- | 73.48 | 73.48 |
| $\mu\text{Ci}/\text{ml}$ | -- | 2.43E-5 | |
| Na-24 MPC Used | 6E-3 | | |
| μCi | -- | -- | -- |
| $\mu\text{Ci}/\text{ml}$ | -- | -- | |
| Mn-54 MPC Used | 4E-3 | | |
| μCi | 4.72 | 35.07 | 39.79 |
| $\mu\text{Ci}/\text{ml}$ | 6.58E-7 | 1.16E-5 | |
| Zn-65 MPC Used | 3E-3 | | |
| μCi | 15.4 | 134.5 | 149.9 |
| $\mu\text{Ci}/\text{ml}$ | 2.14E-6 | 4.45E-5 | |
| Fe-59 MPC Used | 2E-3 | | |
| μCi | -- | 0.82 | 0.82 |
| $\mu\text{Ci}/\text{ml}$ | -- | 5.44E-7 | |
| Fe-55 MPC Used | 2E-2 | | |
| μCi | -- | 44.1 | 44.1 |
| $\mu\text{Ci}/\text{ml}$ | -- | 2.93E-5 | |

Average concentration at point of release to sewer = $3.52\text{E-}5 \mu\text{Ci}/\text{ml}$.

Average daily sewage flow for dilution = $2.37\text{E}4$ gallons.

Average yearly concentration = $1.1\text{E-}8 \mu\text{Ci}/\text{ml}$.

TABLE 2

LIQUID EFFLUENT TO ENVIRONMENT

(Pool Leakage)*

| MONTH | GALLONS | μCi | ASSUMED $\mu\text{Ci/ml}$ | MPC(Na-24) | MEASURED ACTIVITY/ml |
|-----------|------------|----------------|---------------------------|------------|----------------------|
| July 87 | 432 | 82 | 5E-5 | 2E-4 | 7.4E-7 |
| August | 562 | 106 | " | " | 2.9E-7 |
| September | 850 | 160 | " | " | <5.4E-8(MDA) |
| October | 917 | 173 | " | " | <5.4E-8 |
| November | 897 | 170 | " | " | <5.4E-8 |
| December | 832 | 157 | " | " | 4.3E-7 |
| Jan. 88 | 202 | 41 | " | " | 4.2E-7 |
| February | 337 | 64 | " | " | 1.7E-7 |
| March | 967 | 183 | " | " | 7.5E-6 |
| April | 782 | 148 | " | " | 2.6E-7 |
| May | 642 | 121 | " | " | 1.3E-7 |
| June | <u>202</u> | <u>38</u> | " | " | 1.1E-7 |
| | 7,622 | 1,443 | | | |

* Although much of the water lost from the pool leaked into the thermal column down tracks and evaporated, all water loss is assumed to have soaked into the concrete below the reactor shield.

TABLE 3

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 $\mu\text{Ci/ml} \times 10^{-6}$ | Average Stack Concentration $\mu\text{Ci/m}^3 \times 10^{-6}$ |
|------------|------------------------------|--|---|
| July 87 | .12274 | 1.5 | .068 |
| August | .15971 | 2.0 | .089 |
| September | .20983 | 2.0 | .121 |
| October | .13860 | 1.1 | .083 |
| November | .11038 | 1.2 | .069 |
| December | .13293 | 2.0 | .076 |
| January 87 | .45534 | 2.8 | .251 |
| February | .14087 | 3.1 | .084 |
| March | .24903 | 2.3 | .164 |
| April | .18445 | 5.0 | .100 |
| May | .21501 | 2.1 | .124 |
| June | <u>.14580</u> | 2.5 | .074 |
| TOTAL | 2.2736 | 5.0E-6 (maximum) | 0.160 |

Maximum Instantaneous Concentration = 0.21 of MPC

Average Concentration = 0.16 of MPC

G. **SUMMARY OF RADIATION EXPOSURE OF PERSONNEL**
(15 June 1987 -- 14 June 1988)

No personnel received any significant radiation dose during the year. The highest doses recorded were 20 mrem whole body, 70 mrem skin dose, and 710 mrem extremity dose. Radiation doses continue to be low enough that 10 CFR Part 20 does not require wearing of dosimetry even though facility policy requires dosimetry.

Routine radiation and contamination surveys of the facility revealed no problem areas, consistent with personnel exposure data cited above.

H. **RESULTS OF ENVIRONMENTAL SURVEYS**

The environmental monitoring program at Wisconsin uses Eberline TLD area monitors located in areas surrounding the reactor laboratory.

The table below indicates dose rates a person would have received if continuously present in the indicated area for the full year.

Annual Dose Data -- Environmental Monitors

| <u>Location</u> | <u>Average Dose Rate-mrem/week</u> |
|---|------------------------------------|
| Inside Wall of Reactor Laboratory | 8.86 |
| Inside Reactor Laboratory Stack | 2.56 |
| Highest Dose Outside Reactor Laboratory (Reactor Lab roof entrance window: monitor adjacent to stone surface) | 3.49 |
| Highest Dose in Occupied Nonrestricted Area (third floor classroom) Room #323 | 1.81 |
| Average Dose in all Nonrestricted Areas (27 Monitor Points) | 1.71 |
| Lowest Dose Reported in Nonrestricted Area | 1.44 |

I. PUBLICATIONS AND PRESENTATIONS ON WORK BASED ON REACTOR USE

Beloit College

Venzke, Edward A., "The Geology of the Guffey Volcanic Center North of Guffey, Park County, Colorado". Bachelor's Thesis.

Randy Schon, Kim Roehl, Shao-Chyi-Lee, "Analytical Examination of Eighteenth and Early Nineteenth Century Lead Musket Balls and Shot". Student Research Project Report.

E. A. Venzki and Amy Rogel, "An Examination and Interpretation of Calcite and Galena from the Gottschall Rock Shelter, Muscoda, WI". Student Research Project Report.

S. Everse and P. Kraemer, "Pottery at the Gottschall Site: Was it Home Made?". Student Research Project Report.

S. O'Dell and J. Hawthorn, "Copper Artifact Analysis from the Squirrel Dam Site, WI". Student Research Project Report.

Departments of Chemistry and Biochemistry

Bleam, M.L., Anderson, C.F. & Record, M.T., Jr., "Relative Binding Affinities of Monovalent Cations for Double Stranded DNA". Proc. Natl. Acad. Sci USA 77 pp3085-3091 (1980).

Bleam, M.L., Anderson, C.F., & Record, M.T., Jr., "²³Na NMR Studies of Cation-DNA Interaction". Biochemistry 22, pp 5418-5424 (1983).

Braunlin, W.H., Anderson, C.F., & Record, M.T., Jr. "²³Na NMR Investigation of Counterion Exchange Reactions of Helical DNA". Biopolymers 25 pp 205-214 (1986).

Braunlin, W.H., Anderson, C.F. & Record, M.T., Jr. "Competitive Interactions of Co (NH₃)₆³⁺ & Na⁺ with Helical B-DNA Probed by ⁵⁹Co and ²³Na NMR". Biochemistry 26 pp 7724-7731 (1987).

Nordenskiöld, L., Chang, D.K., Anderson, C.F. & Record, M.T., Jr. "²³Na NMR Relaxation Study of the Effect of Conformation and Base Composition on the Interactions of Counterions with Helical DNA". Biochemistry 23 pp 4309-4317 (1984).

Padmanabhan, S., Rickey, B., Anderson, C.T. & Record, M.T., Jr., "The Interaction of a N-Methylated Polyamine Analog, Hexamethonium (+2) with Ha DNA: Quantitative ¹⁴N ²³Na NMR Relaxation Rate Studies of the Cation Exchange Process". Biochemistry 27 pp 4367-4376 (1988).

Lawrence University

Pope, Robert A. "Exploring Cultural Associations of Ceramics through Petrographic and Instrumental Analysis: A Viable Supplement When Conventional Methods Alone are Insufficient". To be published. (1988)

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Metallurgical and Mineral Engineering

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University of Wisconsin

NUCLEAR REACTOR LABORATORY
NUCLEAR ENGINEERING DEPARTMENT
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ADDRESS:
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MADISON, WISCONSIN 53706

Tech Specs

50-156

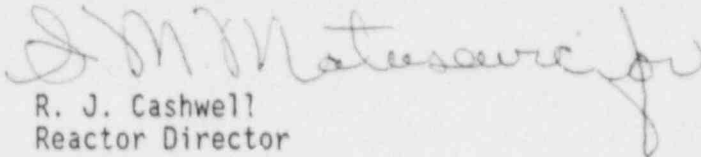
August 15, 1988

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 1987-88 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

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