ANNUAL OPERATING REPORT FOR LICENSE R-74

TO THE UNITED STATES NUCLEAR REGULATORY COMMISSION

FOR

FISCAL YEAR 1981-1982

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NUCLEAR REACTOR LABORATORY

ANNUAL REPORT

A. SUMMARY OF OPERATIONS

1. Instructional Use - UW-Madison Formal Classes

Three Nuclear Engineering Department classes make use of the reactor. Fifty students enrolled in NE 231 participated in a two-hour laboratory session introducing students to reactor behavior characteristics. Sixteen hours of reactor operating time were devoted to this session. NE 427 had an enrollment of 33 during the two semesters it was offered. Several NE 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 NE 427 and the radiation survey take place during normal isotope production runs, so no reactor time is specifically devoted to NE 427. The enrollment in NE 428 was 22, as it was also offered in both semesters. Three experiments in NE 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 eighty hours of exclusive reactor use. Other NE 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 eight times during the year. (Individual one to two-hour sessions in the Reactor Laboratory were also held for other departments on campus.)

2. Reactor Sharing Program

Participation by outside users in the Reactor Sharing Program showed a considerable decline during the year because of uncertainties in the funding of the program. The group from the University of Minnesota-Duluth, which has over several years used neutron activation analysis to determine common origin of archaeological artifacts, continued their work. Trace element compositions were determined in samples of copper, bronze, and pottery. A class from Carroll College (1 professor and 6 students) visited our facility for a three-hour laboratory session on neutron activation analysis.

3. Utility Personnel Training

Two groups of trainees from the Kewaunee Nuclear Plant attended our two-week Research Reactor Training Program. This program reinforces training in reactor physics and operation, and gives laboratory experience in health physics and instrumentation. There were a total of 17 trainees in the two groups.

4. Sample Irradiations and Neutron Activation Analysis Services

There were 6,382 samples irradiated during the year. 485 separate irradiations were involved, accumulating 372.5 irradiation-space-hours. Although 54% of the samples irradiated were irradiated for 15 minutes or less, the remaining samples accumulated 15,694 sample hours of irradiation. Most of these samples were irradiated, and subsequently counted, at the laboratory as part of our neutron activation analysis service. In the listing below, the notation (NAA) indicates that the samples were done as part of our neutron activation analysis service.

Biochemistry Department. (NAA) 92 samples, 76 less than 15 minutes, 28 sample hours.

Professor Adler, 1 post doctoral fellow, and 1 undergraduate student used the NAA service to investigate the ionic requirement for motility in bacteria. This work was supported by a Knapp Fellowship.

Professor Cleland, 1 post doctoral fellow, and 2 graduate students used the service for determining aluminum and other trace metals in ATP samples and for determination of how aluminum can be removed from ATP by different chelating column meterials. This research was supported by NIH.

Canada Certified Reference Materials Project. (NAA) 72 samples, 36 less than 15 minutes, 72 sample hours.

Our laboratory analyzed a number of rock and ore samples as part of the project to certify the composition of the samples for use in standards.

Carroll College. (NAA) 5 samples, all less than 15-minute irradiations.

Professor Auchter and his undergraduate class analyzed water samples. Supported by Reactor Sharing Program.

Chemistry Department. (NAA) 115 samples, 63 less than 15 minutes, 26 sample hours.

Professor Record, 2 graduate students for the measurement of cation concentrations in solutions at dialysis equilibrium or donnan equilibrium. Research on cation effects on DNA and its interactions. Supported by NSF.

Chemical Engineering Department. (NAA) 8 samples, 16 sample hours.

J. Welch -- measurement of heavy metal content of burned filter material. Industrial support.

Consolidated Cigar Corporation. (NAA) 108 samples, 108 sample hours.

Measurement of bromine levels in tobacco samples. Industrial support.

Dairy Science Department. 3,645 samples, 10,935 sample hours.

Professor Jorgensen, 1 post doctoral fellow, 2 graduate students and 2 undergraduates. Determination of rate of passage of undigested feed particles and digestibility of neutrients in various sections of ruminant digestive tracts. Supported by Hatch Act, State Funds, and research gift funds from industry.

Professor Satter, 1 post doctoral fellow, and 4 graduate students measure rare earth elements used as indigestible markers in cattle to follow the progress of digestion in the animals. Supported by industry research funds, Federal Hatch Funds.

Engineering Experiment Station-Applied Superconductivity Center. (NAA) 334 samples, 452 sample hours.

Professor Boom and 1 graduate student used neutron activation analysis to test the performance of a superconducting ore separator. Supported by U. S. Department of Interior--Bureau of Mines.

Globe-Union (Division of Johnson Control Corporation). (NAA) 80 samples, 217.6 sample hours. Measurement of impurity levels of lead samples to be used in batteries. Industrial support.

Human Oncology Department. 1 irradiation, 1 sample hour.

Professor Yatvin, 1 post doctoral fellow produced platinum radioisotopes for tracer use.

Kewaunee Nuclear Plant. 8 samples, all less than 15 minutes.

Samples irradiated for use in training program.

Michigan State University. (NAA) 278 samples 849.3 sample hours.

Professor Boggs, 1 graduate student for determination of digesta flow in ruminants using ytterbium and chromium as digesta markers. Support unknown.

University of Minnesota-Duluth. (NAA) 59 samples, 118 sample hours.

Professor Rapp, 2 staff members, 2 graduate students. Analysis of archaeological artifacts. Supported by Reactor Sharing Program.

University of Minnesota-St. Paul. (NAA) 593 samples, 1779 sample hours.

Professor Donker and 2 graduate students using stable tracer techniques to study digestion process in cattle. Supported by USDA grant.

Nuclear Engineering. 33 samples, 20 less than 15 minutes, 33.1 sample hours.

Professor Vogelsang, 1 graduate student. Measurement of the diffusion of tritium in Li_2O. Research supported by Wisconsin Electric Utilities Research Foundation.

N.E. 427. 193 samples, 100 less than 15 minutes, 126.41 sample hours. Irradiations in support of teaching effort in the N.E. 427 laboratory.

N.E. 428. 88 samples, 34 less than 15 minutes, 105.2 sample hours. Irradiations in support of teaching effort in the N.E. 428 laboratory.

Nuclear Medicine. 116 samples, 28 less than 15 minutes, 53.5 sample hours.

Professor Gatley, 1 additional staff member, 4 students. Use of fluorine-18 compounds for positron-emission tomography. Supported by National Cancer Institute, UW Medical School, and Graduate School.

Physiology Department. (NAA) 5 samples, 2.5 sample hours.

Professor Lipton and 1 graduate student. Study of potassium and sodium levels in brain tissue samples. Support unknown.

Reactor Laboratory. 20 samples, 15 less than 15 minutes, 9.16 sample hours.

Irradiations for production of calibration material for flux measurement in support of laboratory programs.

Safety Department. (NAA) 47 samples, 38 less than 15 minutes, 18 sample hours.

One staff member. Determination of heavy metal and halogen content in waste materials. University support.

Serco, Inc. (NAA) 5 samples, 10 sample hours.

Analysis for thorium, zirconium, and cerium in samples of unknown origin. Industrial support.

Soils Department. 266 samples, 100 less than 15 minutes, 271 sample hours.

Professor Helmke and 2 students. Analysis of soils and rocks to understand the behavior of elements in natural systems. Supported by EPA, College of Agriculture and Life Sciences.

U. S. Department of Agriculture. (NAA) 108 samples, 215 sample hours. 2 staff members. Use of stable tracer techniques to determine animal digestive functions. Supported by U.S.D.A.

University of Wisconsin-Milwaukee. (NAA) 103 samples, 206 sample hours.

Professor Mursky and 1 graduate student. Determination of sodium, potassium, thorium, and uranium content of rock samples. Supported by Graduate School.

5. Changes in Personnel, Facility, and Procedures

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

Licensed operators Daniel E. Range and Jeffrey P. Ladewig are no longer employed by the department. Previously licensed operators Michael C. Jensen and Daniel L. LeGare were licensed as senior operators. A group of four new operators was trained and licensed during the year. These individuals are Jeffery A. Franzen, Robert M. Jones, II, John A. Mulvenna, and George C. Penn.

6. Results of Surveillance Tests

Surveillance tests and inspections during the year revealed no safety-related defects. Operating personnel performance evaluations under the Operator Proficiency Maintenance Program showed no dificiencies on written or oral examinations.

B. OPERATING STATISTICS AND FUEL EXPOSURE

Operating Period	Startups	Critical Hours	MW Hours	Pulses
FY 81-82	157	776.72	603.11	38
Total Present				
I-23-R12 FLIP Core	---	2407.60	1764.99	145
Total - TRIGA Cores	2740	9590.38	6904.77	1506

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

There were no emergency shutdowns during the year. There were 23 inadvertent scrams distributed as indicated below:

9 trainee operator error trips:

8/6/81, 8/7/81, 10/9/81, 10/13/81, 10/14/81, 10/23/81, 10/30/81

Trainee failed to uprange picoammeter in a timely fashion or turned the range switch in the wrong direction. The linear power channels on this reactor give a trip at 125% of any range, and errors in range switching almost always will result in a reactor trip.

10/29/81.
Trainee attempting to place the reactor on a 13 second period failed to consider prompt jump effects and received a period trip.

3/8/82.
Period trip. Trainee placed the reactor on a power increase before the Log-N Period Channel was on scale and received a period trip as the instrument came on scale.

4 trips from fuel temperature indicating meter.

The fuel temperature meter used at the facility is equipped with upscale burnout so that an intermittent open to the thermocouple lead will give a quick upscale deflection.

8/13/81.
The fuel temperature meter caused a trip while the reactor was at full power. The connections on the thermocouple connector were resoldered.

8/18/81.
The same instrument caused a trip again. The connectors on the back of the meter itself were cleaned up and reconnected.

11/17/81.
An additional trip from the same instrument occurred coincident with a blown fuse due to an electrical short in an unrelated system.

In all of the above cases, there was no change in reactor power level, and the instrument read normally after the trip. Since the thermocouple connected to the meter was the last operating thermocouple in the element, the instrumented element was not replaced until it could be definitely assured that the intermittent open was occurring due to thermocouple failure rather than to vibration or oxidation of contacts outside the instrumented element assembly. After the annual maintenance shutdown in December of 1981, upon reassembling the core, it was discovered that the thermocouple had permanently failed open, and the instrumented element was replaced.

6/24/82.
Another fuel temperature trip was received while the reactor was operating at constant power. The thermocouple indicators showed an intermittent open even after the trip. The meter was connected to a different thermocouple within the same instrumented element and observation during full power operation of the output signal from the thermocouple that had shown a failure has not shown similar behavior during the last 24 hours of full power operation.

2 period trips.

12/1/81.
Period trip received during a startup after prestartup checkout which included preparation for pulse mode operation. Pulse mode operation involves

removing the signal from the Log-N amplifier and turning off the high voltage power supply to the detector during the period of the pulse. Upon restoration of the power and signal cable while at zero power, it requires a long period of time for the signal cable to charge back up to its normal operating level. On this particular occasion, the startup was in progress and the spurious period from cable charging tripped the reactor.

5/13/82.
A period trip occurred when the control rod drive manual rundown switch was switched to rundown due to a ground loop into the input of the instrument. This behavior could not be reproduced during numerous attempts while diagnostic equipment was attached to the instrument, so no repairs were made.

1 trip from high voltage power supply high voltage monitor.

7/29/81
A trip was received during firing of a pulse. A relay in the power supply which disconnects the high voltage from neutron detectors during the pulse failed so that when the pulse was fired, the current flow from the high voltage power supply caused the voltage to drop and the high voltage monitor to trip as though it had detected a loss of high voltage. The relay was replaced.

1 intentional manual scram.

6/10/82.
The protruding manual scram pushbutton was inadvertently hit when the operator was reaching for another switch immediately beside it.

1 scram from high pool level.

10/23/81.
The high pool level alarm and trip occurred while the reactor was operating at power without the cooling system in operation. The increase in the temperature of the water caused sufficient pool level increase to give a trip.

3 scrams with no instrument trips or indications.

4/22/82 - three occassions.
The scram relay dropped out with no indicated movement of any instrument nor any trip indication from any instrument. It was determined that this must be due to an intermittent opening in the scram string, so all solder joints in the Log-N period amplifier trip circuit and picoammeter trip circuits were resoldered. No further such trips occurred after the resoldering operation.

2 trips from electrical noise.

4/27/82.
No. 1 picoammeter tripped while at steady power level when the cooling tower fan speed was changed from high to low. Attempts to reproduce this be-

havior or to detect noise input to the instrument were unable to see any noise due to fan speed change.

5/6/82.

No. 1 picoammeter again gave a trip light while the power level was steady at 100% power. The instrument was removed from service, solder joints in the trip circuit were resoldered, and the instrument was replaced. No further such occurrences have been observed.

D. MAINTENANCE OPERATIONS

Instrumented element #7524TC, which was installed in fuel bundle #41, was found to be shorted when the core was reassembled after the annual maintenance shutdown. Since two of the three thermocouples in that element now had shorts and the other thermocouple had given intermittent open indications, that instrumented element was replaced with a new instrumented element #8889TC.

Inspection of the secondary side of the heat exchanger during the summer of 1981 revealed a large amount of lime buildup on the tube surfaces. The secondary side of the heat exchanger was chemically cleaned and the water treatment in use was changed over to use of HOH Chemical Company C-437 Cooling Tower Treatment. This is an acid-based solution containing appropriate corrosion inhibitors which has been selected as the campus-wide replacement for the old sulphamic acid treatment used in the past.

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

There were no changes reportable under this item.

F. RADIOACTIVE WASTE DISPOSAL

1. Solid Waste

There was no solid waste transferred offsite during the year.

2. Liquid Waste

There were two liquid waste discharges during the fiscal year. Table 1 shows the information on those discharges.

3. Particulate and Gaseous Activity Released to the Atmosphere

Table 2 presents information on stack discharges during the year.

G. SUMMARY OF RADIATION EXPOSURES (1 July 1981 - 30 June 1982)

No significant exposure of personnel occurred due to operation of the reactor. For occupationally-exposed personnel, the highest annual whole body dose was 90 mrem. For laboratory students, the highest annual whole body dose was indicated at 50 mrem although it should be pointed out that a number of unissued badges also indicated annual doses of 50 mrem. No facility visitor received any measurable dose.

TABLE 1

LIQUID WASTE TO SANITARY SEWER

	27 Oct 81	9 June 82	TOTALS
TOTAL ACTIVITY DISCHARGED (Microcuries)	24.6	187.3	211.9
LIQUID QUANTITY (Gallons)	1850	1200	3050
Ra^{226} - MPC USED - $4x10^{-7}$			
AMOUNT (µCi)	--	--	
CONC (µCi/ml)			
Ru^{106} - MPC USED - $4x10^{-4}$			
AMOUNT (µCi)	8.3	25.9	34.2
CONC (µCi/ml)	$1.2x10^{-6}$	$5.7x10^{-6}$	
Co^{57} - MPC USED - $2x10^{-2}$			
AMOUNT (µCi)	--	--	
CONC (µCi/ml)			
Co^{58} - MPC USED - $4x10^{-3}$			
AMOUNT (µCi)	--	7.3	7.3
CONC (µCi/ml)		$1.6x10^{-6}$	
Co^{60} - MPC USED - $1x10^{-3}$			
AMOUNT (µCi)	1.2	10.2	11.4
CONC (µCi/ml)	$1.66x10^{-7}$	$2.2x10^{-6}$	
Zn^{65} - MPC USED - $3x10^{-3}$			
AMOUNT (µCi)	3.0	112.9	115.9
CONC (µCi/ml)	$4.3x10^{-7}$	$2.5x10^{-5}$	
Mn^{54} - MPC USED - $4x10^{-3}$			
AMOUNT (µCi)	1.9	19.5	21.4
CONC (µCi/ml)	$2.7x10^{-7}$	$4.3x10^{-6}$	
K^{40} - MPC USED - $9x10^{-5}$			
AMOUNT (µCi)	--	--	
CONC (µCi/ml)			
Fe^{55} - MPC USED - $2x10^{-2}$			
AMOUNT (µCi)	--	--	
CONC (µCi/ml)			
Fe^{59} - MPC USED - $2x10^{-3}$			
AMOUNT (µCi)	--	--	
CONC (µCi/ml)			
Cr^{51} - MPC USED - $5x10^{-2}$			
AMOUNT (µCi)	10.2	11.5	21.7
CONC (µCi/ml)	$1.5x10^{-6}$	$2.5x10^{-6}$	

Average concentration at point of release to sewer = $1.8x10^{-5}$ µCi/ml (includes natural radioactivity).

Average daily sewage flow for dilution = $2.37x10^{4}$ gallons

Average concentration after dilution = $2.09x10^{-6}$ µCi/ml

TABLE 2

EFFLUENT FROM STACK

1. Particulate Activity

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

2. Gaseous Activity - All Argon 41

Month	Activity Discharged (Curies)	Maximum Instantaneous Concentration $\mu Ci/ml \times 10^{-6}$	Average Stack Concentration $\mu Ci/ml \times 10^{-8}$	MPC Used $\mu Ci/ml$
July '81	.0799	1.2	4.19	2.4×10^{-5}
August	.0858	1.25	5.12	
September	.1359	1.3	7.84	
October	.0796	0.8	4.30	
November	.1398	1.2	8.3	
December	.1180	2.5	6.76	
January '82	.0847	1.0	4.60	
February	.1340	1.8	7.50	
March	.2450	1.2	15.1	
April	.2336	1.5	12.6	
May	.1825	2.0	10.9	
June	.2550	1.7	14.8	
TOTAL	1.7738	2.5×10^{-6} max	8.41×10^{-8}	

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

The maximum instantaneous concentration released was 0.104 of MPC, while the average concentration released was 0.0035 of MPC.

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

H. RESULTS OF ENVIRONMENTAL SURVEYS

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

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

Annual Dose Data-Environmental Monitors

Location	Average Dose Rate-mrem/week
Inside Wall of Reactor Laboratory (normal)	2.99 ± .15
(Beamport Open)	9.99 ± 1.47
Inside Reactor Laboratory Stack	.78 ± .20
Highest Dose Outside Reactor Laboratory (Reactor Lab roof entrance window: Monitor adjacent to stone surface)	1.93 ± .43
Highest Dose in Occupied Nonrestricted Area (third floor classroom facing away from Reactor Lab - Room 314)	.66 ± .07
Average Dose in Occupied Nonrestricted Area	.45 ± .20
Average Dose in All Unrestricted Areas (29 Monitor Points)	.54 ± .34

I. PUBLICATIONS AND PRESENTATIONS ON WORK BASED ON REACTOR USE

Biochemistry

John V. Schloss, Georgianna Smith, Ann Aulabaugh, and W. W. Cleland, "Synthesis of Various Chelating Celluloses and Their Application in Removing Al^{3+} from ATP," Analytical Biochemistry 120, 176-180 (1982).

Chemistry

W. R. Braunlin, PhD Thesis. In preparation.

W. R. Braunlin, T. J. Strick and M. T. Record, Jr., "Biopolymers," in press.

Civil & Environmental Engineering

W. C. Boyle, R. K. Ham, J. Pastene, R. Stanforth, "Leachate Tests on Selected Foundry Cupola Dusts and Sludges," AFS Transactions 81-149, 767-786 (1982).

Dairy Science

N. A. Jorgensen - several publications in preparation.

Dairy Science (continued)

Prange, R. W., University of Wisconsin PhD Thesis, "Kinetics of digesta passage in lactating dairy cows." (1981).

Merchen, N.R., University of Wisconsin PhD Thesis, "Effect of conservation method on digestion of alfalfa by ruminants," (1981).

Merchen, N. R., D. C. Weakley, N. A. Jorgensen and L. D. Satter, "Sites of digestion of nutrients in alfalfa ensiled at different moisture levels," J. Dairy Sci. 64: Supplement 1, p. 105, (1981).

Rode, L. M. and L. D. Satter, "The effect of physical form on ruminal and post-ruminal digestion of alfalfa hay." Proceedings of the Joint Meeting of the Canadian Society of Animal Science (Western Branch) and the American Society of Animal Science (Western Section), p 80-81, 1981.

Rode, L. M., D. C. Weakley and L. D. Satter, "The effect of altering forage: grain ratios on digestibility and bacterial protein synthesis." Proceedings of the ASAS Annual Meeting, p. 426, (1981).

Santos, K. A. S., M. D. Stern and L. D. Satter, "Ruminal protein degradation and amino acid absorption in the small intestine of lactating cows fed various protein sources." Proceedings of the ASAS Annual Meeting, (1981).

Stern, M. D. and L. D. Satter, "Amino acid and fatty acid digestion in intestinally cannulated cows fed heat treated or raw soybeans." Proceedings of the Rumen Function Meetings, Chicago, (1981).

Tagari, H., N. S. Reddy and L. D. Satter, "Effect of magnesium oxide and sodium bicarbonate on the environment and digestion in the rumen of lactating cows." Proceedings of the Rumen Function Meetings, Chicago, (1981).

Engineering Experiment Station - Applied Suprconductivity Center

Agdelsalam, Mostafa, University of Wisconsin PhD Thesis, "A Centrifugal Channel-Straight Wire Superconducting Magnetic Ore Separator," (1981).

Mechanical Engineering

A. J. Jessel, G. L. Borman, "A Tracer Technique for Measuring Gas Motion in a Fired Diesel Engine Cylinder," Society of Automotive Engineers Convention, Detroit, (1980).

R. J. Vetter, M. L. Smith, K. W. Ragland, R. K. Ham and R. P. Madding, "Test Firing Refuse-Derived Fuel in an Industrial Coal Fired Boiler," ASME Journal of Engineering for Power," (1982).

Michigan State University - Animal Science Department

Boggs, D. L., Michigan State University PhD Dissertation, "Tallow supplementation and simultaneous protein withdrawal in finishing rations for large framed steers," (1982).

University of Minnesota - Animal Science Department

John D. Donker, "A comparison of grass and legume hays fed to yearling Holstein heifers." Submitted for presentation at Annual Meeting of the American Dairy Science Association, (1982).

Nuclear Engineering

Kevin R. Okula, University of Wisconsin PhD Thesis, "Aspects of Tritium Release from Neutron-Irradiated Lithium Oxide." In preparation.

Gary J. Russel, Samit K. Bhattacharyya and Wesley K. Foell, "A Hybrid Static/Dynamic Heating Technique for the Measurement of Nuclear Doppler Effects," Nuclear Instruments and Methods 148, pp. 99-111, (1978).

Soil Science

Hanson, G. D. and P. A. Helmke, "Pozzolanic stabilization of fly ash and flue gas desulfurization sludge," Environmental Science Technology, (accepted).

Vale, R. D., University of Wisconsin M.S. Thesis, "Comparison of four trace element extractants by isotope dilution analysis." (1982).