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License R-74
Docket 50-156

July 16, 2018

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

Dear Sir:

Enclosed is a copy of the 2017-2018 Annual Report for the University of Wisconsin Nuclear Reactor Laboratory as required by Technical Specification 6.7.1(1).

Sincerely,

Robert J. Agasie
Reactor Director

Enc. (Annual Report)

cc: Compliance Inspector, Craig Bassett
Facility Project Manager, Spyros Traiforos
Reactor Safety Committee, RSC 1337

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NRR

THE UNIVERSITY OF WISCONSIN
NUCLEAR REACTOR LABORATORY

FISCAL YEAR 2017-2018 ANNUAL OPERATING REPORT

Prepared to meet reporting requirements of:

U. S. Nuclear Regulatory Commission
License R-74
Docket 50-156
Technical Specification 6.7.1(1)

Prepared by:

Robert J. Agasie
Department of Engineering Physics

EXECUTIVE SUMMARY OF REACTOR UTILIZATION

Instruction: Instructional usage of the reactor during the year included:

- 74 Nuclear Engineering students in laboratory and lecture courses.
- 485 individuals from 17 organizations as part of the UW Nuclear Reactor Outreach and Community Service Program.

Research: Neutron irradiations during the year included:

- 327 samples irradiated for departments at UW-Madison.
- 1.99 MW-hr of irradiation time of ion chambers for nuclear heating measurements
- 2.29 MW-hr of irradiation time for real-time, in-situ temperature monitoring in support of transient reactor testing

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A. SUMMARY OF OPERATIONS

1. INSTRUCTIONAL USE

Nuclear Engineering (NE) 231, "Survey of Nuclear Engineering" was offered in the spring semester. The course is designed for freshmen students interested in nuclear engineering and consists of three lecture modules surveying fission, fusion and radiation science technologies. The fission module concludes with an optional reactor tour, which 3 students attended.

Sixteen students completed NE 234, "Principles and Practice of Nuclear Reactor Operation" during the fall semester. This course uses the reactor extensively, over 100 hours of exclusive reactor use specifically for training were required to provide this operating experience.

Four sections of NE 427 were offered during the academic calendar year with a total enrollment of 36 students. Several NE 427 experiments use materials that are activated in the reactor. One experiment entitled "Radiation Survey" requires students to make measurements of radiation levels in and around the Reactor Laboratory.

Two sections of NE 428 were offered during the academic calendar year with a total enrollment of 19 students. Three experiments in NE 428 require exclusive use of the reactor. These experiments ("Critical Experiment", "Control Element Calibration", and "Pulsing") required a total of 36 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").

The Reactor Laboratory's continued commitment to its educational outreach program and community service attracts large numbers of community organizations who visit the reactor. A listing of individual schools and educational programs that have visited or received services is provided below in section A.2 of this report.

2. OUTREACH AND COMMUNITY SERVICE

Participating Institution	Number of Participants

Abundant Life Christian High School 21

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor.

Beloit College 0

Analyzed swipe tests to leak check radioactive sources and performed detector calibrations.

Boy Scouts of America 260

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor. Program included hands on demonstrations of radiation detection and shielding. Program co-sponsored by the UW Student Branch of the American Nuclear Society in support of the Scouts Atomic Energy Merit Badge program.

BRIDGE 7

Building Relationships in Diverse Global Environments Program

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor. The UW BRIDGE international friendship program connects students from different countries with U.S. students to assist with the initial adjustment to the university, to the new culture, and to build meaningful friendships.

Cryogenic Engineering Conference 13

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor.

Girl Scouts of USA 37

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor. Program included hands on demonstrations of radiation detection and shielding. Program co-sponsored by the UW Student Branch of the American Nuclear Society.

Madison College 33

Radiation safety training program for Madison College's Hazardous Materials Chemistry course. See section A.4 of this report for more information.

Participating Institution	Number of Participants

McFarland Indian Mound Middle School 20

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor.

Madison Academic Staff Association Tour 30

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor. The Madison Academic Staff Association (MASA) is a professional organization that serves the community of academic staff at the University of Wisconsin. MASA highlights the important contributions made by academic staff on campus.

Mount Horeb High School 40

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor.

State of Wisconsin Department of Health & Family Services
Radiation Protection Division 5

Reactor tour with a discussion on emergency planning for the UW nuclear reactor.

UW College of Engineering
Civil and Environmental Engineering Department 8

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor.

UW Engineering Physics Department
Graduate Student Recruitment Program 16

Reactor tour with a discussion on the capabilities and uses of the UW nuclear reactor in support of graduate research recruitment program.

UW Naval Reserve Officer Training Corps 21

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor.

UW Radiation Safety Department 10

Awareness training including a discussion on reactor emergency preparedness and response procedures.

Participating Institution	Number of Participants

UW-Whitewater
Department of Physics 0

Analyzed swipe tests to leak check radioactive sources and performed detector calibrations.

Women in Science and Engineering (WISE) 4

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor. WISE is a learning community where women interested in science, technology, engineering, or math build strong connections with each other and UW-Madison staff and faculty who share their interests.

OUTREACH AND COMMUNITY SERVICE USER SUMMARY:

Organizations: 17

Participants: 485

3. SAMPLE IRRADIATIONS AND NEUTRON ACTIVATION ANALYSIS SERVICES

There were 327 individual samples irradiated during the year. Samples accumulated 53.1 irradiation space hours and 274.1 sample hours. Samples irradiated and then counted at the Reactor Laboratory as part of our neutron activation analysis program are listed below with the notation (NAA).

Department of Anthropology, UW-Madison (NAA)

144 samples, 151.2 sample hours

NAA to characterize fragments of steatite manufacturing debris excavated from the archaeological site of Harappa, Pakistan.

Department of Engineering Physics, UW-Madison
NE 427

157 samples, 96.9 sample hours

Production of foil sources for radiation detector experiments and activation of samples for the neutron activation analysis experiment.

Department of Engineering Physics, UW-Madison
NE 428

24 samples, 24.0 sample hours
Irradiation of foils for resonance absorption measurements and fast neutron flux measurements.

Department of Engineering Physics, UW-Madison
UW Nuclear Reactor Laboratory

2 samples, 2.0 sample hours
Production of calibration sources for required reactor measurements and development of methods for instrumental neutron activation analysis.

4. OTHER MAJOR EDUCATIONAL, RESEARCH, & OPERATIONAL ACTIVITIES

The University of Wisconsin Nuclear Reactor (UWNR) continued to partner with Knolls Atomic Power Laboratory (KAPL) to measure energy deposition in various materials important in the design of reactor systems to validate their MC21 Monte Carlo (MC) modeling code. Previous work used differential calorimeters to measure the total heating rate in the various materials. This year, custom manufactured ion chambers of the various materials measured kerma rates directly and measured the neutron to gamma ratio. In July 2017 the reactor dedicated 1.99 MW-hr to the experiment.

The UWNR also participated in the Department of Energy's (DOE) Integrated Research Project (IRP-NE) in the area of Advanced Instrumentation for Transient Reactor Testing to support the TREAT restart program. Specifically the program developed innovative measurement diagnostics for real-time, in-situ monitoring in support of transient reactor testing. These novel instrumentation measurement methods were tested in the reactor environment using the UWNR. In August 2017 the reactor dedicated 2.29 MW-hr to the experiment.

This year, the UWNR partnered with Madison College to conduct a radiation safety training program. This program was a hands-on laboratory experience where the 33 students in the Hazardous Materials Chemistry course used health physics instruments to investigate the nature of radiation and radioactivity. The program covered topics including:

use of radiological detection equipment, the nature of alpha, beta and gamma radiation, investigation of various shielding material, demonstration of the $1/r^2$ nature of radiation point sources, and how to conduct a contamination survey.

5. CHANGES IN PERSONNEL, FACILITY AND PROCEDURES

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

All procedures were reviewed with proposed revision approved by the Reactor Safety Committee. No changes to operating procedures related to reactor safety occurred during the year.

Changes, not reportable under 10 CFR 50.59, to the facility included a replacement of the control element drop time measurement timer.

Personnel changes during the year were as follows:

The following Reactor Operator Licenses were terminated:

Name	License	Effective Date
Andrew D. Maile	OP-71215	September 1, 2017
Ryan A. Deyoe	OP-500513	March 7, 2018
Alexander J. Gross	OP-71214	June 25, 2018
Kenneth R. Zander	OP-500510	June 25, 2018

The following individuals were appointed as Reactor Operators effective June 25, 2018:

John D. Masse	OP-502592
Tomas A. Montenegro	OP-502593
Thomas L. Adams, III	OP-502594
Thomas D. DeGuire	OP-502595

6. RESULTS OF SURVEILLANCE TESTS AND INSPECTIONS

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

The pool leak surveillance program continues to monitor the pool evaporation rate, the pool make-up volume, and pool water radioactivity. The pool leak surveillance program indicated that approximately 3375 gallons of water effluent has been released to the environment as detailed in section H.1 of this report.

B. OPERATING STATISTICS AND FUEL EXPOSURE

Operating Period	Critical Hours	MW-Hours	Runs	Pulses
Fiscal Year 2017-2018	294.15	171.59	208	39
Cumulative TRIGA 30/20 LEU	2,743.53	1,732.59	1311	326

Core K21-R6 was operated throughout the year. The excess reactivity of this core was determined to be 4.035%ρ.

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

There were six automatic SCRAMS or manual emergency shutdowns during the year. Each is described below in chronological sequence.

November 10, 2017; SCRAM from picoammeter number 1. While performing a normal reactor startup, a reactor operator trainee inadvertently downranged the picoammeter instead of upranging. As a result, a reactor SCRAM from a neutron high flux trip at 125% occurred.

December 1, 2017; SCRAM from picoammeter number 2. While performing a normal reactor startup, a reactor operator trainee did not appreciate the differential worth of the

transient rod and inserted sufficient reactivity to result in a short period alarm. The trainee became distracted by the period alarm and failed to uprange the picoammeter to the next higher range. As a result, a reactor SCRAM from a neutron high flux trip at 125% occurred.

January 25, 2018; manual emergency shutdown. During steady state operations at full power the ventilation system exhaust fan failed. The on duty reactor operator observed decreasing exhaust flow and immediately initiated corrective actions by inserting a manual SCRAM.

March 9, 2018; SCRAM from picoammeter number 2. While performing a normal reactor startup, a reactor operator trainee inadvertently upranged two ranges on the picoammeter and rapidly downranged one range to correct the mistake. The subsequent electronic noise of the rapid range switch adjustments resulted in a SCRAM from a neutron high flux trip.

March 9, 2018; SCRAM from picoammeters number 1 and 2. While performing a normal reactor startup, another reactor operator trainee leveled the reactor at 100% on the appropriate range with the transient rod fully inserted. When instructed to level the reactor with all control elements banked at the same position, the trainee withdrew the transient rod without inserting an appropriate amount of negative reactivity to offset the positive reactivity insertion. As a result, a reactor SCRAM from a neutron high flux trip at 125% occurred.

May 21, 2018; SCRAM from picoammeter number 1. While performing a normal reactor startup, a reactor operator trainee inadvertently upranged two ranges on the picoammeter and rapidly downranged one range to correct the mistake. The subsequent electronic noise of the rapid range switch adjustments resulted in a SCRAM from a neutron high flux trip.

D. MAINTENANCE

The Preventive Maintenance Program continues to maintain equipment and systems in good condition. Routine demineralizer resin replacement occurred on February 28, 2018.

Corrective maintenance performed as a follow up action necessary for reactor restart following an automatic SCRAM is covered in section C of this report. Additional corrective maintenance was performed on the following installed systems, structures and components (SSC) as described in the Safety Analysis Report (SAR):

In December 2017 during weekly checks the bridge area radiation monitor (ARM) would not reach the alert or alarm set points and responded sluggishly. The GM tube was replaced and the unit recalibrated. The bridge ARM was returned to service.

In February 2018 the hydraulic irradiation experimental facility (Whale Tube) pump discharge tubing was discovered to have a crack. The tubing was replaced and the system returned to service. Subsequently in June the tubing slipped off the pipe nipple to the discharge manifold and the repairs were not completed until after the turn of the fiscal year.

On March 20, 2018 the Stack Air Monitor (SAM) vacuum pump failed. It was replaced with a spare and the system was restored to service.

On April 20, 2018 during a normal reactor start up and approach to full power the nitrogen 16 suppression system (diffuser) pump failed to automatically turn on at the trip set point. It was discovered that the solder joint on the plug to the NLI-1000 (LOGN) had failed. The plug was repaired and the system tested satisfactorily.

On May 18, 2018 during a normal reactor shutdown it was discovered that the roll pin coupling control blade drive #2 lead screw to the slip clutch failed. The roll pin was replaced. The drive was tested and returned to service.

During the completion of the pre-startup checklist on June 25, 2018 it was observed the transient rod interlock failed. Troubleshooting revealed the wire connection to the drive connector had failed. The wire was re-soldered and the drive was tested and returned to service.

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

There were no changes to the facility reportable pursuant to 10 CFR 50.59 completed during the year.

There were no changes to procedures reportable pursuant to 10 CFR 50.59 completed during the year.

There was one experiment approved pursuant to 10 CFR 50.59 during the year. The safety evaluation of the experiment concluded a license amendment pursuant to 10 CFR 50.90 was not required. The experiment is summarized below.

The experiment consists of seven arrays with 4 Micro-Pocket Fission Detectors (MPFDs) in each array. The MPFDs are a small, robust neutron sensor capable of real-time, in-core neutron-flux measurement. The MPFDs utilize a multi-wire design where a thin (< 1μm-thick) fissile layer is situated within an ionization chamber, bordered by two parallel wires. The parallel wires act as anode and cathode for the ionization chamber. An applied bias between the anode and cathode wires causes charge motion within the ionization chamber which is measured using a charge-sensitive pre-amplifier. The sensors will be subjected to various steady state power conditions for the ultimate goal of benchmarking neutronic computational codes.

F. SUMMARY OF RADIATION EXPOSURE OF PERSONNEL (01/01/17 - 12/31/17)

The personnel radiation monitoring program at the University of Wisconsin for the past calendar year used Landauer Luxel brand monitors for whole body and extremity exposure. No personnel received any significant radiation exposure for the above period. The highest annual whole body doses recorded were 12 mrem deep dose equivalent (DDE)

and 12 mrem shallow dose equivalent (SDE). The highest annual extremity dose was 50 mrem and the highest annual dose to the lens of the eye was 12 mrem.

The highest dose received by a member of the public visiting the reactor lab was 0.27 mrem, as measured by Mirion brand, model DMC 3000 electronic personal dosimeters.

Monthly radiation surveys continue to demonstrate acceptable radiation dose rates within the reactor laboratory and no contamination.

G. RESULTS OF ENVIRONMENTAL SURVEYS (01/01/17 - 12/31/17)

The environmental monitoring program at the University uses Landauer Luxel brand area monitors located in areas surrounding the reactor laboratory. Table 1 indicates the dose a person would have received if continuously present in the indicated area for the entire 2017 calendar year.

H. RADIOACTIVE EFFLUENTS

1. LIQUID EFFLUENTS

No liquid waste was discharged to the sanitary sewer from the facility during the year.

Liquid effluents released to the environment during the year are detailed in Table 2.

2. EXHAUST EFFLUENTS

Table 3 presents information on stack discharges during the year.

3. SOLID WASTE

Solid waste transferred from the facility during the year are detailed in Table 4.

TABLE 1 ANNUAL ENVIRONMENTAL MONITORING DOSE DATA
(01/01/17 - 12/31/17)

Location	Annual Dose (mrem)
Dose Inside Reactor Laboratory Stack	<1
Highest Dose in Non-restricted Area	26
Highest Dose in Occupied* Non-restricted Area	20
Average Dose in all Non-restricted Areas (26 Monitor Points)	5.52

*Occupied areas include classrooms, offices, and lobbies/meeting areas where an individual might reasonably spend in excess of 2 hours per day

TABLE 2 LIQUID EFFLUENT FROM POOL

Liquid Release to the Environment - All Activity H-3

Month	Water Released (Gallons)	Average Concentration (µCi/ml)	Activity Released (mCi)	Fraction of MPC
July 2017	0	2.459E-05	0.000	-
August	0	1.595E-05	0.000	-
September	0	2.432E-05	0.000	-
October	0	2.649E-05	0.000	-
November	0	3.000E-05	0.000	-
December	0	3.000E-05	0.000	-
January 2018	0	2.919E-05	0.000	-
February	0	2.865E-05	0.000	-
March	460	2.784E-05	0.048	0.028
April	1214	2.514E-05	0.115	0.025
May	1701	2.432E-05	0.157	0.024
June	0	2.351E-05	0.000	-
	Total	Average	Total	Average
	3375	2.583E-5	0.320	0.026

TABLE 3 EFFLUENT FROM STACK

1. Particulate Activity

There was no discharge of particulate activity above background levels.

2. Gaseous Activity - All Argon-41

Month	Activity Discharged (Curies)	Maximum Concentration (µCi/ml)	Average Concentration (µCi/ml)
July 2017	0.007	2.265E-07	4.031E-10
August	0.013	2.018E-07	8.001E-10
September	0.035	2.920E-07	2.172E-09
October	0.063	3.510E-07	3.826E-09
November	0.071	3.670E-07	4.441E-09
December	0.018	2.990E-07	1.081E-09
January 2018	0.040	3.200E-07	2.451E-09
February	0.144	8.220E-06	9.604E-09
March	0.048	4.420E-07	2.901E-09
April	0.030	3.200E-07	1.826E-09
May	0.029	5.070E-07	1.776E-09
June	0.002	1.680E-07	1.366E-10
	Total	Maximum	Average
	0.502	8.220E-6	2.618E-9

Using the Gaussian Plume model, as described in section 13.1.7.2 of the "Safety Analysis Report for the University of Wisconsin Nuclear Reactor", a concentration of 6E-5 µCi/ml at the stack discharge would result in a maximum air concentration of 1E-8 µCi/ml at any point downwind.

TABLE 4 SOLID WASTE

Date:	01/10/18	TOTAL VOLUME
Volume:	5.9 ft^3	5.9 ft^3
Constituents:	Resins	
Isotope	Activity (mCi)	Total Activity by Isotope (mCi)
Co-60	0.02975	0.02975
Mn-54	0.00960	0.00960
Total Activity per Transfer	0.03935 mCi	**TOTAL ACTIVITY** 0.03935 mCi

All activity transferred from the facility to the University of Wisconsin Broadscope License, license number WI-1323-1.