Nuclear Reactor Laboratory

UWNR University of Wisconsin-Madison

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License R-74
Docket 50-156

July 17, 2017

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

Dear Sir:

Enclosed is a copy of the 2016-2017 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 1307

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NRR

THE UNIVERSITY OF WISCONSIN
NUCLEAR REACTOR LABORATORY

FISCAL YEAR 2016-2017 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:

- 82 Nuclear Engineering students in laboratory and lecture courses.
- 636 individuals from 18 organizations as part of the UW Nuclear Reactor Outreach and Community Service Program.

Research: Neutron irradiations during the year included:

- 275 samples irradiated for departments at UW-Madison.
- 12.21 MW-hr of irradiation time of ion chambers for nuclear heating measurements

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A. SUMMARY OF OPERATIONS

1. INSTRUCTIONAL USE

Four sections of NE 427 were offered during the academic calendar year with a total enrollment of 37 students. 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.

Four sections of NE 428 were offered during the academic calendar year with a total enrollment of 45 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	18

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

American Nuclear Society	23
UW-Madison Student Branch	

Reactor tour with a discussion on the capabilities and uses of the UW nuclear reactor (UWNR). A joint outreach effort between the UW-Madison Student Branch of the American Nuclear Society (ANS) and the UWNR to promote the UW Nuclear Engineering program to the State of Wisconsin Legislature.

Participating Institution	Number of Participants

Beloit College 0

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

Boy Scouts of America 301

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.

Davis-Bahcall Scholars
Black Hills State University 11

Reactor tour with a discussion of the nuclear processes during fission. The Davis-Bahcall Scholars Program is a program for South Dakota high school seniors or college freshmen exploring the world of modern scientific research at the Sanford Underground Research Facility. The program includes a road trip to the Soudan Underground Laboratory and NOVA facility in Minnesota, UW-Madison, Argonne National Laboratory and Fermilab in Illinois.

Engineering Summer Program 65

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor. The Engineering Summer Program (ESP) is targeted to high school students from groups traditionally under-represented in the STEM (science, technology, engineering, mathematics) field.

International Atomic Energy Agency 9

Reactor tour and discussion of research capabilities of the UW nuclear reactor. Participants were representatives from 7 different member countries of the International Atomic Energy Agency (IAEA) collaborating on supercritical water reactors research to advance nuclear energy generation in their respective countries.

Madison Fire Department 48

Radiation safety training program for the Madison Fire Department's Hazardous Incident Response Team. See section A.4 of this report for more information.

Participating Institution	Number of Participants

McFarland Indian Mound Middle School 24

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

Mount Horeb High School 31

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

Outrider Foundation 9

Reactor tour with a discussion on the benefits of nuclear energy. Outrider is an educational media organization focused on increasing public understanding of global existential risks that threaten the health and safety of humankind.

UW College of Engineering
Computer Aided Engineering Department 20

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

UW Engineering Physics Department 4

Facility familiarization for building occupants including a reactor tour and a discussion on applications of nuclear energy and uses of the UW nuclear reactor.

UW Engineering Physics Department
Graduate Student Recruitment Program 27

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

UW PEOPLE 43

Reactor tour with a discussion on applications of nuclear energy and uses of the UW nuclear reactor. The Pre-College Enrichment Opportunity Program for Learning Excellence, or PEOPLE, is a pre-college pipeline for students of color and low-income students. The program prepares the students to apply, be successfully admitted and enroll at the University of Wisconsin-Madison. It is the UW's most successful venture in creating such opportunities and thereby improving campus diversity.

Participating Institution	Number of Participants
UW Police Department	3
Awareness training including a discussion on reactor emergency preparedness and response procedures.	
UW Radiation Safety Department	0
Performed neutron detector calibrations.	
UW-Whitewater Department of Physics	0
Analyzed swipe tests to leak check radioactive sources and performed detector calibrations.	

OUTREACH AND COMMUNITY SERVICE USER SUMMARY:

Organizations: 18

Participants: 636

3. SAMPLE IRRADIATIONS AND NEUTRON ACTIVATION ANALYSIS SERVICES

There were 275 individual samples irradiated during the year. Samples accumulated 54.4 irradiation space hours and 176.4 sample hours. Samples irradiated and then counted at the Reactor Laboratory as part of our neutron activation analysis program are listing below with the notation (NAA).

Department of Anthropology, UW-Madison (NAA)
76 samples, 76.0 sample hours
NAA to characterize fragments of steatite manufacturing debris excavated from the archaeological site of Harappa, Pakistan.

Department of Engineering Physics, UW-Madison
27 samples, 17.5 sample hours
Irradiation of fiber optic temperature sensors as part of the Advanced Instrumentation for Transient Reactor Testing program at the UW-Madison in support of the DOE TREAT transient reactor restart initiative.

Department of Engineering Physics, UW-Madison
NE 427

116 samples, 55.2 sample hours
Irradiation of foil sources for radiation detector experiments, including absolute counting for neutron flux measurements and activation of samples for neutron activation analysis experiment.

Department of Engineering Physics, UW-Madison
NE 428

24 samples, 14.47 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.

Department of Medical Physics, UW-Madison

30 samples, 11.2 sample hours
Irradiation of flux foils in support of the Knolls Atomic Power Laboratory (KAPL) project to measure energy deposition in various materials. See section A.4 for more detail.

4. OTHER MAJOR EDUCATIONAL, RESEARCH, & OPERATIONAL ACTIVITIES

The University of Wisconsin Nuclear Reactor (UWNR) continues 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 material measured kerma rates directly and measured the neutron to gamma ratio. From July 2016 through May 2017 the reactor dedicated 12.21 MW-hr to the experiment.

This year, the UWNR partnered with the Madison Fire Department's (MFD) Hazardous Incident Response Team (HIT) to conduct a radiation safety training program. This program was a hands-on laboratory experience where MFD participants used their own equipment to increase familiarity. The program covered topics including: use of radiological detection equipment, the nature of alpha, beta and gamma radiation, investigation of activity versus dose, demonstration of the $1/r^2$ nature of radiation point sources, how to conduct a contamination survey, and general awareness of the hazard communicated by regulatory signs and placards.

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.

Other changes to the facility included a modification to the UWNR designed and built period amplifier.

Personnel changes during the year were as follows:

The following individuals were appointed as Reactor Operators effective July 25, 2016:

Kenneth R. Zander	OP-500510
Jake R. Quincey	OP-500511
Zachary D. Fiscus	OP-500512
Ryan A. Deyoe	OP-500513

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 no water effluent has been released to the environment.

B. OPERATING STATISTICS AND FUEL EXPOSURE

Operating Period	Critical Hours	MW-Hours	Runs	Pulses
Fiscal Year 2016-2017	202.37	143.48	70	22
Cumulative TRIGA 30/20 LEU	2,449.38	1,561.00	1103	287

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 was only one automatic SCRAM during the year.

On May 11, 2017 a SCRAM from a loss of alternating current occurred. While performing a normal reactor startup the Mechanical Engineering Building suffered a building wide power failure. As a result the SCRAM relays de-energized.

D. MAINTENANCE

The Preventive Maintenance Program continues to maintain equipment and systems in good condition. Routine regeneration of demineralizer resins occurred on November 9, 2016 and June 23, 2017.

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 July 2016 the mechanical shaft seal on the chilled water cooling system pump was replaced after the existing seal failed and began to leak chilled water.

On November 1, 2016 during a normal reactor shutdown the regulating blade was found to be in a non-moving state. Troubleshooting had revealed the clutch was worn out. A new clutch was machined based on the regulating blade drive drawings. The motor was reattached to the drive and tested through its full motion.

On December 1, 2016 while recovering from a reactor pulse, control blade drive number 2 appeared to stick during rod withdrawal. During troubleshooting it was impossible to recreate the symptoms. Subsequently on February 9, 2017 the rod drive again appeared to stick. This time troubleshooting revealed that the slip clutch had disengaged. It was concluded that the ball plunger needed to be replaced.

During weekly checks of the stack air monitor (SAM) on December 6, 2016, it was observed that the gaseous channel DAC-hours was reading zero. Troubleshooting revealed that the detector window was torn. The detector was replaced and the system recalibrated before being returned to service.

During annual calibration of the Area Radiation Monitoring (ARM) system, the demineralizer ARM was acting erratic and would not calibrate. The GM tube was replaced and was subsequently able to be calibrated.

On May 17, 2017 during a normal reactor shutdown, control blade drive number 1 would not drive in. Troubleshooting revealed the drive motor was binding at the right angle gear reducer. The gear reducer was opened and the old grease was cleaned out and repacked with fresh grease. The motor was verified to freely turn and reinstalled on the drive mechanism. Since this appeared to be a possible common mode failure for all the shim safety blade drive mechanisms, it was decided to preemptively clean and repack the right angle gear reducers on the remaining shim safety blade drive mechanisms during annual maintenance activities in June 2017.

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 were two experiments approved pursuant to 10 CFR 50.59 during the year. The safety evaluation of each experiment concluded a license amendment pursuant to 10 CFR 50.90 was not required. Each experiment is summarized below.

One experiment consists of several digital/optical camera systems mounted in a modified watertight aluminum housing. The watertight aluminum housing is of similar construction and design as previously approved. This experiment is designed to irradiate and test the survivability of a new generation of still and video digital cameras for use in ultra-high radiation dose and dose rate environments.

The second experiment consists of four temperature sensors mounted in a modified watertight aluminum housing. The watertight aluminum housing is of similar construction and design as previously approved. The temperature sensors reside in an alumina rod surrounded by a silicon carbide (SiC) heater which itself is surrounded with zirconia insulation. The sensors will be subjected to various steady state power conditions for the ultimate goal of determining suitability for insertion into the Transient Reactor Test Facility (TREAT) as part of the Department of Energy (DOE) advanced light water reactor (LWR) nuclear fuel initiative.

F. SUMMARY OF RADIATION EXPOSURE OF PERSONNEL (01/01/16 - 12/31/16)

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 40 mrem deep dose equivalent (DDE) and 89 mrem shallow dose equivalent (SDE). The highest annual extremity dose was 70 mrem and the highest annual dose to the lens of the eye was 57 mrem.

The highest dose received by a member of the public visiting the reactor lab was 0.214 mrem, as measured by Siemens brand 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 (01/01/16 - 12/31/16)

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 2016 calendar year.

H. RADIOACTIVE EFFLUENTS

1. LIQUID EFFLUENTS

Liquid waste discharges to the sanitary sewer from the facility during the year are detailed in Table 2.

No liquid effluents were released to the environment during the year.

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
(01/01/16 - 12/31/16)

Location	Annual Dose (mrem)
Dose Inside Reactor Laboratory Stack	<1
Highest Dose in Non-restricted Area	23
Highest Dose in Occupied* Non-restricted Area	19
Average Dose in all Non-restricted Areas (26 Monitor Points)	5.57

*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 RADIOACTIVE WASTE DISCHARGED TO SEWER

Release Date:	12/05/2016
Gallons Released:	1490
Total µCi:	72.71
Sum of Fraction of MPC w/o dilution:	0.1412
Sum of Fraction of MPC w/ daily dilution:	0.0089

Isotope	MPC (µCi/ml)	Released	
Co-58	2.00E-04	30.54	µCi
		5.43E-06	µCi/ml
		0.0272	Fraction of MPC
Co-60	3.00E-05	16.77	µCi
		2.97E-06	µCi/ml
		0.0991	Fraction of MPC
Mn-54	3.00E-4	25.30	µCi
		4.49E-06	µCi/ml
		0.0150	Fraction of MPC

Annual total volume of water released to the sanitary sewer (gallons)	=	1490
Annual total activity released to the sanitary sewer (µCi)	=	72.71
Average daily sewage flow for dilution (gallons)	=	2.37E+4
Annual sum of fraction of MONTHLY release limit with DAILY dilution	=	0.0089
Annual sum of fraction of MONTHLY release limit with MONTHLY dilution	=	2.91E-4

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 2016	0.012	2.320E-07	7.089E-10
August	0.006	1.245E-07	3.674E-10
September	0.026	4.220E-07	1.611E-09
October	0.177	8.410E-06	1.080E-08
November	0.037	8.810E-07	2.349E-09
December	0.002	1.330E-07	1.337E-10
January 2017	0.061	3.270E-07	3.783E-09
February	0.093	4.320E-07	6.251E-09
March	0.128	6.680E-07	7.629E-09
April	0.024	2.370E-07	1.473E-09
May	0.035	2.940E-08	2.082E-09
June	0.018	3.430E-07	1.079E-09
	Total	Maximum	Average
	0.618	8.410E-6	3.189E-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:	10/21/16	02/27/2017	TOTAL VOLUME
Volume:	14 ft^3	4 ft^3	18 ft^3
Constituents:	Routine Consumables	Resins	
Isotope	Activity (mCi)	Activity (mCi)	Total Activity by Isotope (mCi)
Be-7	0.31000		0.31000
Co-58	0.00007		0.00007
Co-60	0.01470	0.00543	0.02013
Eu-152		0.00022	0.00022
Mn-54	0.00047	0.00006	0.00053
Sb-124	0.00082		0.00082
Zn-65	0.00100		0.00100
Total Activity per Transfer	0.32706 mCi	0.00571 mCi	**TOTAL ACTIVITY** 0.33277 mCi

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