Nuclear Reactor Laboratory
UWNR University of Wisconsin-Madison
1513 University Avenue, Room 1215 ME, Madison, WI 53706-1687, Tel: (608) 262-3392, FAX: (608) 262-8590
email: reactor@engr.wisc.edu, http://reactor.engr.wisc.edu

License R-74
Docket 50-156

September 25, 2020

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

Dear Sir:

Enclosed is a copy of the 2019-2020 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, William Kennedy
Reactor Safety Committee, RSC 1418

A020
NRR

THE UNIVERSITY OF WISCONSIN
NUCLEAR REACTOR LABORATORY

FISCAL YEAR 2019-2020 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
College of Engineering

THE UNIVERSITY of WISCONSIN
MADISON

TABLE OF CONTENTS

A. SUMMARY OF OPERATIONS

1. INSTRUCTIONAL USE

Fourteen 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.

Three sections of NE 427 were offered during the academic calendar year with a total enrollment of 23 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 18 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 continues its commitment to educational outreach program and community service. 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
Beloit College	0

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

International Visitor Leadership Program
U.S. Department of State 8

A reactor tour with a discussion of current nuclear engineering research being conducted at the facility. The U. S. Department of State's International Visitor Leadership Program invited Japanese regulators and representatives of Tokyo Electric Power Company (TEPC) to explore the U.S. industrial/commercial culture surrounding risk management and safety; learn how U.S. industrial safety practices have evolved in response to accidents and challenges; see industrial safety practices in action in the U.S. energy industry; and compare U.S. and Japanese industrial culture to evaluate whether some U.S. practices could make a positive impact in Japan.

U.S. Nuclear Regulatory Commission 6

A reactor tour with a discussion of current nuclear engineering research being conducted at the facility for Commissioner and UW alumnus Annie Caputo.

UW-Whitewater
Department of Physics 0

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

Wisconsin Public Utility Institute (WPUI) 19

A reactor tour with a discussion of current nuclear engineering research being conducted at the facility. WPUI's mission is to advance understanding and discussion of relevant industry topics and emerging trends in the utility industries through engaging programming and access to experts and current research to create opportunities for discussion and debate in non-partisan program formats.

3. IRRADIATION SERVICES

There were 166 individual samples irradiated during the year. Samples accumulated 93.1 irradiation space hours and 371.3 sample hours. Neutron beam irradiation experiments accumulated 3.7 hours of beam time.

Department of Engineering Physics, UW-Madison
Inertial Electrostatic Confinement Fusion Group
3 samples, 1.25 sample hours &
3.0 hours of neutron beam time
Prompt gamma neutron activation analysis of melamine and sand as surrogates for explosive detection.

Department of Engineering Physics, UW-Madison
NE 427
75 samples, 58.3 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, 26.0 sample hours
Irradiation of foils for resonance absorption measurements and fast neutron flux measurements.

Department of Engineering Physics, UW-Madison
UW Nuclear Reactor Laboratory
34 samples, 91.9 sample hours
Production of calibration sources for required reactor measurements, flux measurements and development of methods for instrumental neutron activation analysis.

NorthStar Medical Radioisotopes, LLC
30 samples, 193.9 sample hours
Irradiation of molybdenum samples to refine production techniques.

Sandia National Laboratory
Hi-Rel Commercial Technologies Department
0.7 hour of neutron beam time
Irradiation of integrated circuits to measure the frequency of single event upset or latch up failures.

4. OTHER MAJOR EDUCATIONAL, RESEARCH, & OPERATIONAL ACTIVITIES

In September 2018, the University of Wisconsin voluntarily chose to suspend experimental and teaching operations at the reactor to develop an action plan to resolve a reoccurring pool leak. Since 1986, the facility has experienced a small but recurring reactor pool leak. In the past, in-house testing identified the location of cracks in various welds around the thermal column. These were subsequently repaired in-house following partial draining of the pool on two occasions. Following the most recent leak in early 2018 an underwater camera was used to conduct a visual inspection of the weld areas and the pool liner plate near the thermal column. A potential crack was observed in this area. Subsequently the university created a committee composed of the College of Engineering Associate Dean for Research, the Assistant Director of Environmental Health and Safety (who is also the UW-Madison Radiation Safety Officer), the College of Engineering Director for Safety, and the UWNR Reactor Director. The committee developed an action plan to resolve the pool leak problem. The plan called for the application of epoxy coating by commercial diving services to the welds surrounding the thermal column penetration through the plates comprising the reactor pool liner wall.

On August 1, 2019 the University contracted with Underwater Engineering Services, Inc. (UESI) to apply UT-15 epoxy coating on the fillet weld bead around the entire circumference of the thermal column penetration through the pool liner and approximately 2 inches on either side of the weld to include the heat affected zone.

From August 12, 2019 through September 6, 2019 extensive radiation surveys were conducted and a Radiation Work Permit (RWP) was prepared with direct consultation with the Office of Radiation Safety (ORS).

The diving company employees were issued a whole-body dosimeter and a DMC 3000 self-reading electronic personal dosimeter (EPD). During dive operations, divers were outfitted with additional dosimetry including a whole-body monitor and EPD on front and back of the torso and extremity monitors on both wrists and ankles.

On September 9, 2019 UESI employees arrived on site and were provided facility familiarization and radiation worker training. The UESI employees were subsequently trained on the requirements of the RWP.

Diving operations commenced on September 10, 2019 at 14:24 CDT. The dive lasted 1 hour and 32 minutes. An initial inspection of the thermal column was conducted. The diver confirmed the presence of a crack in the lower right-hand corner (southwest corner) although he did not observe any water flowing in, which was consistent with the pool leak surveillance data. The diver and superintendent inspected the 1986 and 1996 weld repairs and determined that the old weld build up did not make it suitable for applying the UT-15 epoxy directly. The rounded edges of the weld buildup were likely to cause the UT-15 to not adhere to the surrounding aluminum. They recommended application of Carboline A-788, which is a putty type epoxy to seal over the weld build up and allow the creation of a smooth surface that could then be coated with UT-15. No other cracks were observed during the inspection. After the inspection, the diver performed surface preparations and applied UT-15 to the top weld, excluding the corners where the weld buildup prevented the application. The dive ended at 15:56 CDT. The diver's exposure, as monitored with the EPD, was 1.0 mrem to his back and 3.4 mrem to his chest.

Two dives occurred on September 11, 2019. The first dive commenced at 09:48 CDT and lasted 1 hour and 39 minutes. The upper patch, from the day before, was visually inspected and found to be satisfactory. The right-hand vertical side and lower underside weld surfaces were prepared. Carboline A-788 was placed on the existing repairs on the upper right and left corners as well as the observed crack in the lower right-hand corner. UT-15 was applied to the right vertical weld and to 75% of the bottom weld. The dive ended at 11:27 CDT. The diver's exposure, as monitored with the EPD, was 1.9 mrem to his back and 2.5 mrem to his chest.

The second dive commenced at 13:47 CDT and lasted 1 hour and 26 minutes. A second coat of UT-15 was applied to the right vertical weld to bring the coating thickness to specification and the bottom weld was finished. The dive was terminated early, at 15:13 CDT due to the diver's

helmet seal developing a small leak. Surveys of the diver showed no contamination and a baseline urinalysis was conducted with a second performed 24 hours later to monitor any possible tritium uptake. The diver's exposure, as monitored with the EPD, was 1.6 mrem to his back and 1.5 mrem to his chest.

On September 12, 2019 one dive operation was completed commencing at 09:21 CDT and lasting 2 hours and 3 minutes. The left-hand vertical side weld surface was prepared, and UT-15 was applied to the left-hand vertical weld. The Carboline A-788 patches had been allowed to cure for 24 hours and UT-15 was applied to the upper right, upper left and lower right corners. With all surfaces coated a preliminary inspection was conducted and found to be satisfactory before terminating the dive at 11:24 CDT. The diver's exposure, as monitored with the EPD, was 12.9 mrem to his back and 10.5 mrem to his chest. The UT-15 was required to cure to a minimum of 24 hours before the final inspection, so no further diving operations were conducted.

On September 13, 2019 one dive operation was planned for final inspection of all coated surfaces. The dive commenced at 12:48 CDT and lasting 9 minutes. All coated surfaces were inspected and found to be satisfactory. The dive terminated at 12:57 CDT. The diver's exposure, as monitored with the EPD, was 0.3 mrem to his back and 0.2 mrem to his chest.

Following dive operations UESI completed component breakdown allowing adequate time for reactor staff to complete contamination surveys of all equipment to be shipped off site. UESI departed the facility on September 16, 2019.

UESI employee's whole-body dosimetry was sent to the vendor (Landauer) for processing. In summary, the total whole-body deep dose equivalent (DDE) and shallow dose equivalent (SDE) for the project was 17 man-mrem and 18 man-mrem respectively. The total project dose to the lens of the eye and extremities were 18 man-mrem and 78 man-mrem respectively. The urinalysis indicated no tritium uptake had occurred.

From September 17-24, 2019, operational activities were dedicated to returning the reactor to an operable state. On September 26, 2019, the Dean of College of Engineering reported that the Vice Chancellor for Finance and Administration (VCFA) approved restart of the reactor.

5. CHANGES IN PERSONNEL, FACILITY AND PROCEDURES

Personnel changes during the year were as follows:

Effective, July 1, 2019, Dr. Paul P.H. Wilson became the chair of the department of Engineering Physics at the University of Wisconsin at Madison replacing Dr. Douglass L. Henderson.

The following Reactor Operator License was terminated:

Name	License	Effective Date
Thomas L. Adams III	OP-502594	June 3, 2020

Facility changes reportable under 10 CFR 50.59 are detailed in section E of this report. Two routine experiments were installed and/or conducted at the facility. These include the installation of a neutron collimator in beamport #1 to conduct prompt gamma neutron activation analysis of sand and melamine as described in section A.3 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.

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 make-up volume and pool water radioactivity. The pool leak surveillance program indicated that no water effluent had been released to the environment this year.

B. OPERATING STATISTICS AND FUEL EXPOSURE

Operating Period	Critical Hours	MW-Hours	Runs	Pulses
Fiscal Year 2019-2020	253.56	155.40	161	20
Cumulative TRIGA 30/20 LEU	3,099.43	1,918.02	1515	360

Core K21-R6 was operated throughout the year. The excess reactivity of this core was determined to be 3.956%ρ.

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

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

October 10, 2019; SCRAM from picoammeter number 2. While performing a normal reactor startup, a reactor operator failed to uprange the picoammeter to the next higher range. As a result, a reactor SCRAM from a neutron high flux trip at 125% on the 1W range occurred.

November 6, 2019; SCRAM from picoammeter number 2. While performing a normal reactor shutdown, a reactor operator trainee decided to watch power decrease and down ranged the picoammeter to the next lower range too soon. As a result, a reactor SCRAM from a neutron high flux trip at 125% on the 100kW range occurred.

November 13, 2019; SCRAM from picoammeter number 2. While performing a normal reactor startup, a reactor operator trainee failed to uprange the picoammeter to the next higher range. As a result, a reactor SCRAM from a neutron high flux trip at 125% on the 1W range occurred.

January 16, 2020; manual emergency shutdown. During a reactor start-up to low power, before the reactor achieved criticality, the ventilation system exhaust fan failed. The on-duty reactor operator observed decreasing exhaust flow and immediately initiated corrective actions by inserting all control elements to shut down the reactor. Troubleshooting of the fan revealed the wire lugs in the motor starter had become loose resulting in arcing and an eventual current overload trip. The lugs were tightened, and the fan returned to service.

D. MAINTENANCE

The Preventive Maintenance Program continues to maintain equipment and systems in good condition. Routine demineralizer regeneration occurred on December 26, 2019.

Corrective maintenance performed as a follow up action necessary for reactor restart following an emergency shutdown or 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):

As described in section A.4 of this report, in September, epoxy sealant was applied to the weld beam around the thermal column penetration through the pool liner.

During annual fume hood testing, the Pn Tube fume hood failed the face velocity test. Troubleshooting revealed one of the fire dampers inside the exhaust duct was closed due to a failed fusible link. The fusible link was replaced on the damper, the damper returned to open and the exhaust duct static pressure returned to normal.

On November 4, 2019, the main control panel annunciator was observed to be flashing at an unusually fast rate. Troubleshooting revealed the 100 μF electrolytic capacitor on the flasher card was found to have failed. Replaced the capacitor, tested the annunciator and returned to service.

On November 12, 2019, control blade drive number 1 failed to insert on demand. Adjustment of the drive motor brake alleviated the condition. Subsequently on November 21,

2019 the drive again failed to insert. Further troubleshooting revealed that the chain to the position indicator was too loose and the excess slack jammed on one of the sprocket teeth connected to the drive lead screw. The chain was realigned with the teeth and retensioned. The drive was then tested and returned to service.

On November 20, 2019 fission counter drive system failed. Troubleshooting revealed the set screw locking the reduction gear to the fission counter drive motor shaft became loose. The set screw was retightened and the drive put back in service.

In April the aspirating early warning fire detection system went into trouble. The gear tray was replaced with an identical spare and the system 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 consisted of fault testing of circuit boards undergoing active irradiation in the thermal column to ensure the circuit was only exposed to thermal neutrons and minimize the gamma photon component to the overall exposure to ionizing radiation.

F. SUMMARY OF RADIATION EXPOSURE OF PERSONNEL (01/01/19 - 12/31/19)

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 35 mrem deep dose equivalent (DDE) and 34 mrem shallow dose equivalent (SDE). The highest annual extremity dose was 26 mrem and the highest annual dose to the lens of the eye was 35 mrem.

The highest dose received by a member of the public visiting the reactor lab was 0.28 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 (01/01/19 - 12/31/19)

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 2019 calendar year.

H. RADIOACTIVE EFFLUENTS

1. LIQUID EFFLUENTS

   Liquid waste discharged 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

   No solid waste transferred from the facility during the year.

TABLE 1 ANNUAL ENVIRONMENTAL MONITORING DOSE DATA (01/01/19 - 12/31/19)

Location	Annual Dose (mrem)
Dose Inside Reactor Laboratory Stack	<1
Highest Dose in Non-restricted Area	23
Highest Dose in Occupied* Non-restricted Area	23
Average Dose in all Non-restricted Areas (26 Monitor Points)	4.96

*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:	12/17/2019
Gallons Released:	913
Total µCi:	2.251E+00
Sum of Fraction of MPC w/o dilution:	1.409E-02
Sum of Fraction of MPC w/ daily dilution:	5.411E-04

Isotope	MPC (µCi/ml)	Released	
Co-60	3.00E-05	1.373E-00	µCi
		3.973E-07	µCi/ml
		1.324E-02	Fraction of MPC
Mn-54	3.00E-04	8.780E-01	µCi
		2.541E-07	µCi/ml
		8.468E-04	Fraction of MPC

Annual total volume of water released to the sanitary sewer (gallons)	=	913
Annual total activity released to the sanitary sewer (µCi)	=	2.251
Average daily sewage flow for dilution (gallons)	=	2.370E+04
Annual sum of fraction of MONTHLY release limit with DAILY dilution	=	5.411E-04
Annual sum of fraction of MONTHLY release limit with MONTHLY dilution	=	1.778E-05

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 2019	0.000	0.000E+00	0.000E+00
August	0.000	0.000E+00	0.000E+00
September	0.024	3.130E-07	1.582E-09
October	0.367	7.850E-07	2.284E-08
November	0.256	4.120E-07	1.577E-08
December	0.120	3.590E-07	7.181E-09
January 2020	0.182	6.240E-07	1.119E-08
February	0.149	4.730E-07	9.648E-09
March	0.085	2.260E-07	5.157E-09
April	0.000	0.000E+00	0.000E+00
May	0.000	0.000E+00	0.000E+00
June	0.020	2.260E-07	1.224E-09
	Total	Maximum	Average
	1.203	7.850E-07	6.216E-09

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.