PROGRESS REPORT

FOR THE

MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

NUCLEAR REACTOR FACILITY

April 1, 2021 to March 31, 2022

Submitted to

The United States Nuclear Regulatory Commission

And

Missouri University of Science and Technology

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

REVISION HISTORY

Revision	Date	Notes
0	May 29, 2022	Initial issuance

ACKNOWLEDGEMENTS

I would like to recognize current members of the Missouri S&T Reactor staff who contributed heavily to the development of this document. Alice Skye, Narrie Loftus, Ethan Mullane, Colin Zerfass, and Nathan Jackson especially contributed to the areas of data collection, document generation, and document review. They have my sincerest thanks.

Ethan Taber
Reactor Manager, MSTR

SUMMARY

During the 2021-2022 reporting period, the Missouri University of Science and Technology Reactor (MSTR) was in use for 1,122.4 hours, including 228.4 hours while operating. The majority of this time was used for class instruction, research, and training purposes. The staff turnover and hindered operations as a result of COVID-19 have largely been overcome and the facility is set to make several significant upgrades over the next year.

The MSTR operated safely and efficiently over the past year. No significant safety-related incidents or personnel exposures occurred.

The reactor facility supported several Missouri University of Science and Technology (S&T) courses and operator training over the year for a total of 1,710 student-hours. The reactor was visited by 549 visitors during the past year.

The reactor produced 13,563.19 kilowatt-hours of thermal energy using approximately 0.701 grams of uranium. A total of 75 samples were neutron irradiated in the reactor with the majority being analyzed in the reactor counting laboratory.

1.0 INTRODUCTION

This progress report covers activities at the Missouri University of Science and Technology Reactor (MSTR) Facility for the period April 1, 2021 to March 31, 2022.

The reactor operates as a Missouri University of Science and Technology (S&T) facility. It is available to the faculty and students from various departments of the University for their educational and research programs. Several other college and pre-college institutions also make use of the facility. The reactor is also available for the training of personnel from commercial concerns with legitimate interest in our facility use.

1.1 Background Information

The MSTR attained initial criticality on December 9, 1961 and was the first operating nuclear reactor in the State of Missouri. The Bulk Shielding Reactor at Oak Ridge National Laboratory is the basis for the reactor's design, as the MSTR is a light water, open pool reactor cooled by natural convective flow. The initial licensed power was 10 kW, which was up-rated to 200 kW in 1966. The MSTR utilizes Materials Testing Reactor (MTR) plate-type fuel and was converted from an original high-enriched uranium to low-enriched uranium fuel loading during the summer of 1992. The MSTR license was renewed for another 20 years in March of 2009.

The facility is equipped with several experimental facilities including a beam port, thermal column, three pneumatic transfer (rabbit) systems, and several manual sample irradiation containers and systems. The facility also contains a counting laboratory that has gamma spectroscopy capabilities. The gamma spectroscopy systems include germanium and sodium-iodide detectors, associated electronics, and state-of-the-art data acquisition and spectrum analysis equipment. Additionally, there is a liquid scintillation counter, thermoluminescent dosimeter reader, and x-ray and neutron imaging equipment for student and faculty use.

1.2 General Facility Status

The MSTR operated safely and efficiently over the past year. No significant safety related incidents or personnel exposures occurred.

During the reporting period, several major changes were made to the reactor facility. On 6/15/2021 an AMS-4 Continuous Air Monitor (CAM) and AMS-4 Noble Gas Monitor were installed to replace the old CAM system. In June 2021 a crane was installed in the facility. In February 2022, the old Leeds & Northrup Speedomax-H strip chart recorder used for the startup channel was replaced with a Yokogawa DX-2000 digital recorder.

From May 17-19, 2021, the Nuclear Regulatory Commission (NRC) conducted a routine, announced inspection of MSTR. The inspection included review of the following areas: organization and staffing; procedures; experiments; health physics; committees, audits, and reviews; and transportation of radioactive materials since the last NRC inspection. A severity level IV violation was noted in the experimental verification of calculated releases of Argon-41. Due to errors in the performance of this verification, no valid tests had been performed since 2007; recorded values were found to have significantly underestimated the amount of released radioactivity. Despite these inaccuracies, corrections to the data make it reasonable to assume that effluents for that period were within release limits. Otherwise, MSTR was found to be compliant with current NRC requirements and MSTR Technical Specifications.

From March 28-30, 2022, the NRC conducted a routine, announced inspection of MSTR. The inspection included a review of the MSTR's physical security program implementation, material control and accounting for special nuclear material, and site-specfic security measures. NRC staff determined that the "[sic, MSTR's] programs were in compliance with NRC requirements."

Independent auditors from the University of Missouri Research Reactor (MURR) audited the reactor facility on November 30, 2021. The auditors recommended replacing instances of "should" or "must" in old procedures with "shall" to denote required actions more consistently. It was also suggested that quarterly statuses under the requalification program be updated as early as possible in order to aid in compliance tracking.

In July 2021, five personnel (including four students) who underwent their licensing examinations (RO-instant) in March 2021 received their licenses. In December 2021, three students underwent their licensing examinations (One SRO-upgrade, two RO-instant) and were licensed as of February 2022.

Several chapters of the SAR are currently under revision in accordance with amendment 23 to the technical specifications and changes to the facility

Table 1-1 lists revised SOPs and Table 1-2 lists emergency plan chapters revised during the reporting period.

Table 1-1 List of Revised MSTR SOPs

SOP	Title	Date	Notes
102	Pre-Startup Checklist Procedure	02/22/2022	Completely Revised
105	Reactor Shutdown and Shutdown Checklist	02/28/2022	Updated
106	Restart of Reactor	02/28/2022	Updated
108	Weekly Check	02/28/2022	Updated
150	Response to Alarms	02/28/2022	Updated
507	Emergency Procedures – Administrative Responsibilities	03/08/2022	Updated
654	Measurement of Ar-41 Concentration in the Reactor Building Air	09/17/2021	Completely Revised
806	Temperature Channel	11/05/2021	Updated
818	Function Test of the Building Security	03/29/2022	Updated
819	Spectroscopy Detector Calibration	09/17/2021	Created
Index (800)	Index – Reactor Instrumentation	09/17/2021	Updated

Table 1-2 List of MSTR Emergency Plan Chapters Revised

Ch.	Title	Date	Notes
-	Table of Contents, List of Figures, List of Tables	03/02/2022	Minor edits
2	Definitions	03/02/2022	Minor edits
3	Organization and Responsibilities	03/02/2022	Minor edits and updates to organizational titles
7	Emergency Response	03/02/2022	Updates to organizational titles

2.0 REACTOR STAFF AND PERSONNEL

2.1 Reactor Staff

Table 2-1 MSTR Staff

Name	Title
Dr. Joseph Graham	Reactor Director
Mr. Ethan Taber	Reactor Manager
Mr. Cole Kostelac	Senior Reactor Operator (Part-Time)
Ms. Alice Skye	Senior Reactor Operator (Part-Time)
Mr. Eli Boland	Reactor Operator (Part-Time)
Mr. John Talley	Reactor Operator (Part-Time)
Ms. Narrie Loftus	Reactor Operator (Part-Time)
Mr. Nathan Jackson	Reactor Operator (Part-Time)
Mr. Caleb Porter	Reactor Operator (Part-Time)
Mr. Colin Zerfass	Reactor Operator (Part-Time)
Mr. Ethan Mullane	Student Assistant (Part-Time)

2.2 Licensed Operators

Table 2-2 MSTR Operators

Name	License Type
Ethan Taber	Senior Reactor Operator
Cole Kostelac	Senior Reactor Operator
Alice Skye	Senior Reactor Operator
Joseph Graham	Reactor Operator
Eli Boland	Reactor Operator
John Talley	Reactor Operator
Narrie Loftus	Reactor Operator
Alexandra Lindsay	Reactor Operator
Nathan Jackson	Reactor Operator
Kelsey Shannon	Reactor Operator
Colin Zerfass	Reactor Operator

2.3 Radiation Safety Committee

The Missouri S&T Radiation Safety Committee performs on-campus oversight of the MSTR operations and meets quarterly. The committee met on 05/12/2021, 09/16/2021, 12/14/2021, and 3/15/2022. The committee members are listed on Table 2-3.

Table 2-3 Radiation Safety Committee Members

Name	Department
Dr. Mark Fitch	Civil, Architectural, and Environmental Engineering
Ms. Michelle Bresnahan	Environment Health and Safety
Dr. David Wronkiewicz	Geosciences and Geological Engineering
Dr. Shoaib Usman	Nuclear Engineering and Radiation Science
Dr. Yue-Wern Huang	Biological Sciences
Dr. Carlos Castaño	Nuclear Engineering and Radiation Science
Dr. Amitava Choudhury	Chemistry
Mr. Tony Hunt	Environmental Health and Safety
Dr. Muthanna Al-Dahhan	Chemical and Biological Engineering
Dr. Joseph Graham	Nuclear Engineering and Radiation Science
Mr. Ethan Taber	Missouri S&T Reactor
Ms. Lisa Cerney	Fiscal Services

2.4 Health Physics

The Environmental Health and Safety (EHS) Department provides the health physics support for the Missouri S&T Reactor. The EHS Department is organizationally independent of the Reactor Facility operations group. Health Physics personnel are listed in Table 2-4. It is noted that the Radiation Safety Officer (RSO) continues to serve in a dual-capacity as the Health Physicist.

Table 2-4 Health Physics and EHS Staff

Name	Title
Ms. Michelle Bresnahan	Director of EHS, Radiation Safety Officer
Mr. Tony Hunt	Assistant Director of EHS
Mr. Ryan Siggins	Health Physics Technician (Part-time)
Ms. Kassandra Hayes	Health Physics Technician (Part-time)

3.0 REACTOR OPERATIONS

Core designation 130T is presently in use. The “W” mode core is completely water reflected and used for normal operations and beam port operations. The “T” mode (core positioned near graphite thermal column) may be used for various experiments and thermal column usage.

Three new core configurations were used in the past year: core designation 129, 130, and 131. Additionally, the 128 configuration was utilized. Table 3-1 presents pertinent core data for these three designations, both in W mode and T mode. The excess reactivity, shutdown margins, and rod worths were measured as required by TS 4.1.1 and under reference core conditions. Figures 3-1, 3-2, and 3-3 depict the core maps for designations 129, 130, and 131 respectively.

Table 3-1 MSTR Core Technical Data

Core	Mode	Rod Worth (%Δk/k)				Shutdown Margin (%Δk/k)	Excess Reactivity (%Δk/k)
		Rod #1	Rod #2	Rod #3	Reg. Rod		
128	W	2.614	2.209	2.144	0.469	3.820	0.532
	T	2.649	2.151	2.144	0.520	3.656	0.638
129	W	2.361	2.383	2.272	0.513	3.953	0.711
	T	2.264	2.457	2.310	0.495	3.904	0.863
130	W	2.280	2.567	2.139	0.544	4.521	0.184
	T	2.237	2.586	2.164	0.528	4.408	0.342
131	W	2.507	2.453	2.173	0.508	3.871	0.755
	T	2.443	2.459	2.098	0.506	3.699	0.858

Key to Prefixes for Core Configuration

F	Full Element	C	Control Element	HF	Half Front Element
HR	Half Rear Element	IF	Irradiation Fuel Element	BRT	Bare Rabbit
CRT	Cadmium Rabbit	HC	Hot Cell Rabbit	S	Source

	1	2	3	4	5	6	7	8	9
A									
B					HR1		F2		
C				F4	C4	F17	C1	F5	
D				F16	F13	F11	F14	F18	
E				F8	C5	F15	C2	F9	
F				CRT	HF1	HC	HF2	BRT	

Figure 3-1 MSTR Core 128 Configuration

	1	2	3	4	5	6	7	8	9
A									
B				S	F1		F9		
C				F2	C5	F18	C3	F13	
D				F14	F16	IF1	F11	F15	
E				F8	C2	F17	C1	F12	
F				CRT	F7	HC	F10	BRT	

Figure 3-2 MSTR Core 129 Configuration

	1	2	3	4	5	6	7	8	9
A									
B				S	HR1	CA	F9		
C				F2	C5	F18	C3	F13	
D				F14	F16	IF1	F11	F15	
E				F8	C2	F17	C1	F12	
F				CRT	F7	HC	F10	BRT	

Figure 3-3 MSTR Core 130 Configuration

	1	2	3	4	5	6	7	8	9
A									
B				S	HR1	CA	F9	HR2	
C				F2	C5	F18	C3	F13	
D				F14	F16	IF1	F11	F15	
E				F8	C2	F17	C1	F12	
F				CRT	F7	HC	F10	BRT	

Figure 3-4 MSTR Core 131 Configuration

Table 3-2 shows reactor utilization, while Table 3-3 shows specific irradiation facility usage.

Table 3-2 Reactor Utilization

Reactor Use	362.6 hr.
Time at Power	228.4 hr.
Energy Generated	13563.2 kW-hr.
Total Number of Samples, Neutron Irradiated	75
U-235 Burned	0.593 g
U-235 Burned and Converted	0.701 g

Table 3-3 Experimental Facility Usage

Facility	**Minutes**
Neutron Irradiation	
Bare Rabbit Tube	380.5
Cadmium Rabbit Tube	10.0
Beam Port	662.0
Thermal Column	0.0
Core Access Element	0.0
Isotope Production Element	25.0
Irradiation Fuel Element	20.0
Hot Cell	0.0
Other Facility	0.0
Total	1089.5
Gamma Irradiation	
Void Tube	70.0
Total	70.0

Two unscheduled shutdowns (scrams, rundowns, and unplanned normal shutdowns) occurred during the reporting period, which are documented in Table 3-4. Maintenance activities are listed in Table 3-5.

Table 3-4 Unplanned Shutdowns (Rundowns)

Date/Time	Type	Cause	Corrective Action	SRO on Duty Permission to Restart
08/25/21 - 1335	<15 sec	Fuel element was positioned too close to log and linear detector during fuel move	Informed fuel handler to be mindful of detector position	Yes
12/03/21 – 1346	120% Demand	Trainee adjustment of compensating voltage	No corrective action	Yes

Table 3-5 Maintenance

Date/Time	Issue or Basis	Action or Corrective Action
4/6/21 1145-1606 to 4/26/21 1012	High background noise. Low resistance on detector signal terminal.	Detector and housing removed for troubleshooting. Signal cable disconnected and replaced. Detector replaced with WL-6937A.
4/6/21 1417-1437 to 4/26/21 1534	Startup channel noise troubleshooting	Startup channel HV disconnected
4/30/21 1313	Vent fan 3 determined to be inoperable during confinement check	Fan belt replaced
6/11/21 0922 to 7/02/21 1454	Vent fan 2 intake louvers failed to close.	OEM Actuator replaced with universal mounting frame and Bellimo Model AFBUP Actuator
6/14/21 0950 to 6/15/21 1114	CAM air flow calibration	CAM connected for air flow calibration, disconnected for further calibration, and finally returned to service following calibration
6/20/21 0952 to 6/20/21 1118	Crane installation	CAM removed and reconnected
6/21/21 1725-1735	New safety channel detector	Safety channel 1 calibrated, gain adjusted
6/22/21 1002 to 8/19/21 1938	Control rod inspections and fuel movement	Rods disassembled and removed. Upon inspection, returned to control elements. Magnets, shrouds, and rods reassembled. Magnet 1 replaced. Rod drop times determined to be acceptable.
8/20/21 1551	Safety channels annual calibration	Safety channels 1 and 2 calibrated
8/23/21 0854	Linear channel calibration	Linear channel calibrated and reconnected
8/24/21 1443	Log & linear channel annual calibration	Log & linear channel calibrated
8/24/21 1443	Startup channel calibration	Startup channel calibrated
6/21/2021 1800 to 8/27/21 0856	Core configuration change	TC 2 and core access element removed. TC 2 reinstalled upon completion of core change.
09/13/21 1049	SC1 reading lower than SC2	SC1 gain adjusted from 94.0 to 98.6

09/13/21 1144 to 10/13/21 0926	Demineralizer reading <0.2MΩ	Demineralizer removed from service; resins replaced.
10/19/2021 0831	Startup channel disconnected	Due to abnormal readings, reconnected and tested afterwards. Connections visually verified.
10/20/21 1509 to 10/22/21 1657	Linear channel noise troubleshooting and connection testing	Signal wires from picoamp, recorder, and detector disconnected, tested, then reconnected. Disconnected, tested, and reconnected again.
10/28/21 0942 to 12/07/21 0840	TC 3 housing broken upon removal for calibration	TC 3 >135F trip temporarily deactivated until replacement. TC 3 replaced and calibrated. Trip reactivated.
10/28/21 0942 to 11/05/21 1628	TC 1 calibration	TC 1 calibrated and reinstalled.
11/02/21 1045 to 11/02/21 1211	TC 2 calibration	TC 2 calibrated and reinstalled
11/22/21 1257 11/22/21 1350	Bridge motion sensor reliability	Sensor arm removed. Bridge rail and rubber sensor tip sanded.
1/25/2022 1151	Demineralizer restored following leak repair	Pipe thread sealant used to lubricate threads on coupling, allowing full seating. System returned to operability.
2/14/2021 1606 to 2/22/2022 0028	Startup recorder replacement	Strip-chart recorder was replaced with a digital recorder.
2/21/2022 2111	Rod heights/drive speed calibrated	Rod height was measured with a tape measure and set on PLC until the measured difference was minimal.

4.0 EDUCATIONAL UTILIZATION

The reactor facility supported 12 Nuclear Engineering courses in the past year for approximately 202 students and 630.8 student-hours. The reactor supported 3 graduate students for 19.7 hours and Reactor Operator Training for 38 students (7 exam-track senior trainees and 31 junior trainees) for 732.85 student-hours. Approximately 490 hours of supporting operations (including experiment preparation and spectroscopy) were involved for these educational (non-training) uses.

Table 4-1 lists Missouri S&T classes taught at the facility along with associated reactor usage for this reporting period.

Table 4-1 S&T Classes at MSTR

Semester	Class Number/Title	# of Students	Time at Reactor (hrs.)	Student Hours
SP 2021	NE 1105: Nuclear Technology Applications	10	0.90	5.40
SP 2021	NE 2406: Reactor Operations I	13	10.29	32.71
SP 2021	NE 4312: Nuclear Radiation Measurements and Spectroscopy	18	7.60	51.32
SP 2021	NE 4428: Reactor Laboratory I	5	12.44	25.09
SP 2021	NE 4438: Reactor Laboratory II	25	29.88	67.06
FS 2021	NE 1105: Nuclear Technology Applications	38	7.90	77.95
FS 2021	NE 2406: Reactor Operations I	16	59.54	165.75
FS 2021	NE 4428: Reactor Laboratory I	17	10.82	50.68
SP 2022	NE 1105: Nuclear Technology Applications	4	2.52	11.58
SP 2022	NE 2406: Reactor Operations I	15	52.33	140.91
SP 2022	NE 4312: Nuclear Radiation Measurements and Spectroscopy	30	0.00	0.00
SP 2022	NE 4438: Reactor Laboratory II	16	1.20	2.40
SP 2022	NE 4456: Reactor Operations II	1	5.00	5.00

The Reactor Sharing Program was a U.S. Department of Energy (DOE) project intended to establish awareness and share education about the nuclear field beyond the campus. The MSTR established a corresponding program in 1990 and, while no longer DOE funded, is still active at the MSTR. As a related component, future nuclear engineering students are also brought to the facility for departmental tours.

MSTR still provides outreach opportunities for local schools. During the reporting period, 275 students, instructors, and public guests visited the MSTR facility for a total of 142.24 visitor-hours. Table 4-2 lists those individuals and groups that were involved that are not a part of the S&T Nuclear Engineering Department. MSTR serves as a strong campus-wide recruiting tool by attracting students to the university and generating interest in nuclear engineering, science, and technology.

Table 4-2 Reactor Sharing Program and Tours

Date	Event/Group	# of Visitors	Time at Reactor (hrs.)	Visitor-Hours
4/8/2021	Tour	2	0.27	0.54
4/8/2021	Tour	3	0.98	2.94
4/12/2021	Tour	2	1.23	2.47
4/13/2021	Tour	1	1.33	1.33
5/4/2021	Tour	3	0.68	2.05
5/14/2021	Tour	2	0.50	1.00
5/21/2021	Tour	4	0.73	2.93
7/13/2021	Jackling Camp	6	0.32	1.90
7/13/2021	Jackling Camp	6	0.42	2.50
7/15/2021	Jackling Camp	8	0.47	3.74
7/15/2021	Jackling Camp	7	0.27	1.87
7/23/2021	Tour	2	1.07	2.13
7/31/2021	Tour	4	0.58	2.33
9/2/2021	Tour	2	0.43	0.87
9/13/2021	Tour	6	0.77	4.60
9/17/2021	Tour	3	0.85	2.55
9/24/2021	Tour	3	1.15	3.45
9/24/2021	Tour	3	0.33	0.99
9/24/2021	Tour	1	1.93	1.93
9/29/2021	Tour	1	0.12	0.12
10/15/2021	Tour	4	0.30	1.20
10/15/2021	Tour	3	0.53	1.60

10/18/2021	Tour	2	0.85	1.70
10/18/2021	Tour	4	0.48	1.93
10/19/2021	Tour	5	0.33	1.67
10/19/2021	Tour	8	0.25	2.00
10/19/2021	Tour	8	0.33	2.66
10/19/2021	Tour	12	0.33	3.96
10/19/2021	Tour	17	0.37	6.22
10/19/2021	Tour	6	0.25	1.50
10/19/2021	Tour	12	0.33	4.00
10/19/2021	Tour	8	0.25	2.00
11/4/2021	Tour	3	2.08	6.25
11/5/2021	Tour	4	0.40	1.60
11/9/2021	Tour	1	0.35	0.35
11/12/2021	Tour	2	0.33	0.67
12/3/2021	Tour	4	0.75	3.00
12/8/2021	Tour	4	0.33	1.33
12/10/2021	Tour	1	1.13	1.13
1/01/2022	Tour	4	1.23	4.92
1/11/2022	Tour	3	0.20	0.60
1/28/2022	Tour	4	0.32	1.27
2/10/2022	Tour	1	0.35	0.35
2/11/2022	Rolla MBU	18	0.70	12.60
2/11/2022	Rolla MBU	13	0.72	9.31
2/15/2022	Tour	2	0.87	1.73
2/18/2022	Tour	4	0.43	1.73
2/18/2022	Tour	1	0.57	0.57
2/19/2022	Tour	4	0.65	2.60
2/16/2022	Tour	2	0.63	1.27
2/28/2022	Tour	4	0.15	0.60
2/28/2022	Tour	2	0.33	0.67
3/04/2022	Tour	2	0.20	0.40
3/14/2022	Tour	12	0.52	6.20
3/16/2022	Tour	13	0.43	5.63
3/17/2022	Tour	5	0.83	4.17

5.0 REACTOR HEALTH PHYSICS ACTIVITIES

The health physics activities at the Missouri S&T Reactor facility consist primarily of radiation and contamination surveys, monitoring of personnel exposures, airborne activity, pool water activity, and waste disposal. Releases of all by-product material to authorized, licensed recipients are surveyed and recorded. In addition, health physics activities include calibrations of portable and stationary radiation detection instruments, personnel training, special surveys and monitoring of non-routine procedures.

5.1 Routine Surveys

Monthly radiation exposure surveys of the facility consist of direct gamma and neutron measurements. No unusual exposure rates were identified. Monthly surface contamination surveys consist of 20 to 40 swipes counted separately for alpha and beta/gamma activity. No significant contamination outside of contained work areas were found.

5.2 By-Product Material Release Surveys

There were no shipments of by-product material released off campus under the MSTR license (R-79). A total of 3.94 nCi of by-product materials were transferred on-campus to S&T's materials license in accordance with SOP 603, "Release of By-Product Materials on Campus," and the Missouri S&T's "Handbook of Radiological Operations."

5.3 Routine Monitoring

Approximately 30-50 reactor facility personnel and students involved with the operations or regular experiments in the reactor facility are assigned Landauer Luxel+ optically stimulated luminescence dosimeters (OSLDs). Previously, Mirion Technologies Genesis Ultra Thermoluminescent Dosimeters (TLDs) were used. The quantity of OSLDs issued varies throughout the year due to class enrolment and personnel turnover, with reactor staff and

operator trainees issued OSLDs as soon as practical after their start. The reactor staff have beta, gamma, and neutron whole-body dosimeters along with individual TLD rings and five area dosimeters. Staff dosimetry is read either semi-monthly for full time staff or monthly for part time staff. There have been no significant personnel exposures during this reporting period.

There are three environmental TLDs outside the reactor building which are read quarterly. There are also five other beta, gamma, neutron dosimeters used by the health physics personnel and four other area beta, gamma neutron dosimeters that are read monthly. All remaining dosimeters are also read monthly. In addition, 10 digital, direct-reading dosimeters are used for non-TLD-issued students and visitors. These digital dosimeters are also used for high radiation work along with audible dosimeters. No students or visitors received any reportable or significant exposure.

Airborne activity in the reactor bay is monitored by a fixed filter, particulate continuous air monitor (CAM), as well as a noble gas monitor. Low levels of Argon-41 are routinely produced during operations.

Pool water activity is monitored monthly to ensure that no gross pool contamination or fuel cladding rupture has occurred. Gross counts and spectra of long-lived gamma activity are compared to previous monthly counts. From April 2021 through March 2022 monthly sample concentrations averaged 6.325×10^{-6} µCi/mL.

Release of gaseous Ar-41 activity through the building exhausts is determined by relating the operating times of the exhaust fans and reactor power during fan operation to previously measured air activity at maximum reactor power. During this period, an estimated 137 mCi of Ar-41 was released into the air.

As a corrective action for Notice of Violation (NOV) 2021-201-01, an Argon-41 release verification was performed on 9/22/2021. This measurement established a calendar year threshold of 50 MW-hr of operation for requiring further evaluation of Ar-41 releases to ensure compliance with 10 CFR 20.1101 (d).

5.4 Waste Disposal

Solid waste, including water filters, used resins, and contaminated paper/gloves is stored and/or transferred to the campus waste storage area for later shipment to a commercial burial site. No solid waste was transported offsite during the reporting period.

Liquid waste totaling an activity of 60.9 µCi was released to the sanitary sewer during this period.

5.5 Instrument Calibration

Portable survey instruments and meters are calibrated annually. Four portable survey meters were calibrated on 9/23/2021 by Missouri S&T Environmental Health and Safety (EHS), with the next calibration due in September 2021. For higher range instruments, four portable ion chambers and three 9DP detectors were calibrated by an offsite vendor (Ludlum Instruments) between 6/16/2021 and 3/9/2022. The Ludlum and PRESCILA portable neutron monitors were calibrated on 8/13/2021 and 6/21/2021 respectively. The Victoreen 488A was determined to be inoperable when sent out for calibration and has been removed from service.

The personal digital dosimeters are calibrated by Mirion Technologies. Five of the digital dosimeters were calibrated on 9/7/2021, with the remaining five due for calibration in April 2022.

The radiation area monitors (RAMs) were calibrated on 7/29/2021, with the next full calibration due July 2022.

6.0 PLANS

The reactor staff will continue to be involved in four major undertakings during the next reporting period: 1) installation of the wide range linear channel, 2) installation of digital recorders for the linear and period channels, 3) continuation of the reactor operator training program, and 4) hiring of new full-time staff.

6.1 Wide Range Linear Channel

A Gamma-Metrics wide range linear channel acquired in 1992 is being prepared for installation in the MSTR console. This unit offers automatic scaling, a larger number of intermediate scales (base-2 and base-6), and integrated testing/calibration functions.

6.2 Digital Recorder Installation

As part of an effort to modernize the MSTR console, the old Leeds & Northrup paper strip chart recorders are being replaced with newer Yokogawa DX2000 digital recorders. In addition to the increased flexibility of the new recorders, the facility will benefit from reduced operating costs and down time caused by the expensive paper rolls required by the old recorders. Installation of one of these recorders has already been completed for the startup channel, and plans are in place to install the other two in the summer of 2022.

6.3 Reactor Operator Training

In March 2021, four students and the Reactor Director underwent licensing as initial RO candidates. As of July 2021, all five of these individuals were licensed. In December 2021, three students underwent their licensing examinations (One SRO-upgrade, two RO-instant) and were licensed as of February 2022.

The new training program has proven to be effective in keeping the students that want the license and work with reactor staff. At the end of the reporting period, eight students were training to undergo operator licensing in April 2022, with approximately 15 candidatesa preparing for a later exam.

6.4 Hiring of New Full-Time Staff

To correct the severe staffing shortage at the MSTR, a broad-responsibility position of Reactor Engineer has been reinstated, with interviews for the position underway. Student reactor operators and Federal Work-Study Program students were utilized where prudent to try and overcome the staffing shortage.