

ANNUAL PROGRESS REPORT

FOR THE MISSOURI
UNIVERSITY OF SCIENCE AND
TECHNOLOGY REACTOR

June 16, 2020 – Revision 1



PROGRESS REPORT
FOR THE
MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

NUCLEAR REACTOR FACILITY

April 1, 2019 to March 31, 2020

Revision 1

Submitted to
The United States Nuclear Regulatory Commission
And
Missouri University of Science and Technology

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REVISION HISTORY

Revision	Date	Notes
0	May 29, 2020	Initial issuance
1	June 16, 2020	Added revision tracking information Correction pp. 22 (dates corresponding to water sampling)

ACKNOWLEDGEMENTS

I would like to recognize current members of the Missouri S&T Reactor staff who contributed heavily to the development of this document. Ms. Alice Skye, Mr. Riley Cavin, and Mr. Ethan Mullane contributed in the areas of data collection, document generation, and document review. They have my sincerest thanks.

Ethan Taber
Reactor Manager, MSTR

SUMMARY

During the 2019-2020 reporting period, the Missouri University of Science and Technology Reactor (MSTR) was in use for 2155 hours. A significant portion of this time (~40%) was used for class instruction, research, and training purposes. Operations were significantly hindered by a licensed staff shortage.

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 552 student-hours. The reactor was visited by 566 visitors during the past year. There were 223 of these visitors that participated in labs at the reactor.

The reactor produced 6,473.77 kilowatt-hours of thermal energy using approximately 0.334 grams of uranium. A total of 16 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, 2019 to March 31, 2020.

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. Operations were significantly reduced compared to previous years due to licensed staff shortages, with no full-time licensed operators on staff from June 14 to December 18, 2019. Operations were further suppressed by COVID-19 starting in early March 2020. Usage figures (excluding tours) presented herein reflect the three effective months (January 2020-March 2020) of operation.

No major upgrades or changes to the facility were performed over the past year. However, several long-standing maintenance items including degraded components on the Radiation Area Monitoring (RAM) system were resolved.

The updated MSTR Emergency Plan from 2017 remains in effect. Training under this plan was predominantly completed in December 2019. A joint, full-scale drill for an injured/contaminated student was coordinated and conducted by Rolla City Fire and Rescue, Phelps Health and Ambulance Service, the local Federal Bureau of Investigation field office, S&T Police, S&T Environmental Health and Safety, S&T Finance and Operations, S&T Marketing and Communications, and MSTR staff on June 18, 2019. The drill included a pre-exercise meeting and a post-exercise review. The drill and lessons learned were discussed in depth at the following Radiation Safety Committee meeting.

On June 3-5, 2019, the Nuclear Regulatory Commission (NRC) conducted a routine, announced inspection of the MSTR. The inspection included review of the following areas: organization and staffing; procedures; health physics; design changes; committees, audits, and review; and transportation of radioactive material since the last NRC inspection (of those areas). The MSTR was found to be compliant with current NRC requirements and MSTR Technical

Specifications. However, an Inspector Follow-up Item (IFI) was generated regarding the non-use of the Environmental Protection Agency's COMPLY code in calculating offsite releases to determine compliance. It is noted that per D. Freeman's memorandum dated 5/25/1995, the MSTR would remain below the reporting requirements (and therefore not require the use of COMPLY or CAP-88) so long as the facility released less than 16.85 Ci of Ar-41 per year. As compliance is demonstrated by the MSTR release, the use of COMPLY is not required. The inspector also specifically noted the "Staffing was at a minimum level," in response to the personnel turnover and lack of replacement.

Independent auditors from the University of Missouri Research Reactor (MURR) audited the reactor facility on December 4, 2019. The auditors recommended improving the methods used to document staff on duty (such as how/when the Senior Reactor Operator on Duty signs into the permanent log book), especially from the standpoint of consistency. The auditors also noted that older versions of forms (i.e. forms from an SOP revision prior to current) appeared to be in use and recommended replacing the blank stock with the most recent revision. Other minor areas were also identified as "suggested opportunities for improvement." MSTR and MURR audit each other on an annual basis, which has been a very beneficial arrangement for both facilities.

In November 2019, the reactor manager underwent Senior Reactor Operator licensing examination under the NRC. In February 2020, four students underwent licensing in the following categories, with one SRO-Instant, one RO retake, and two initial RO candidates. The reactor manager passed his exam and was licensed as of late December 2019. The status of the remaining exams has not been reported to the MSTR as of the writing of this report.

The reactor staff have continued to review the operation of the reactor facility in an effort to improve the safety and efficiency of its operation and to provide conditions conducive to its utilization by students and faculty.

Substantial efforts have continued to be invested in revising MSTR documentation, such as the SOPs, SAR, and other materials. Table 1-1 lists SOPs revised during the reporting period.

Table 1-1 List of MSTR SOP Revised

SOP	Title	Date	Notes
501	Emergency Procedures for Reactor Building Evacuation	09/20/2019	Page revision
501	Emergency Procedures for Reactor Building Evacuation	10/02/2019	Minor editorial

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. Craig Reisner	Senior Reactor Operator (Part-Time) ¹
Mr. Anthony Alchin	Electronic Technician II ²
Ms. Alice Skye	Student Assistant (Part-Time)
Mr. Riley Cavin	Student Assistant (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 ³
Craig Reisner	Senior Reactor Operator
Anthony Alchin	Senior Reactor Operator ⁴
Laura Pirrone	Senior Reactor Operator ⁴
Keith Kellett	Reactor Operator ⁴
Isaac Mulhern	Reactor Operator ⁴

¹ Effective Date: June 25, 2019

² Termination Date: June 14, 2019

³ Effective Date: December 18, 2019

⁴ Termination Date: June 20, 2018

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 6/20/2019, 9/19/2019, 12/13/2019, and 3/3/2020 during the reporting period. The committee members are listed in 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	Mining and Nuclear Engineering
Dr. Fadha Al Falahi	Environmental Health and Safety
Dr. Yue-Wern Huang	Biological Sciences
Dr. Carlos Castaño	Mining and Nuclear Engineering
Dr. Amitava Choudhury	Chemistry
Mr. Tony Hunt	Environmental Health and Safety
Dr. Muthanna Al-Dahhan	Chemical and Biological Engineering
Dr. Joseph Graham	Mining and Nuclear Engineering
Mr. Ethan Taber	Missouri S&T Reactor
Mr. Anas Massri ⁵	Fiscal Services
Ms. Lisa Cerney ⁵	Fiscal Services

⁵ Ms. Cerney replaced Mr. Massri on the committee effective February 12, 2020.

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.

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
Dr. Fadha Al Falahi	Health Physicist, Laser Safety Officer
Mr. Reagan Dugan	Health Physics Technician (Part-time)
Ms. Jenna Slocum	Health Physics Technician (Part-time)
Mr. Brandon Ochterbeck	Health Physics Technician (Part-time)
Mr. Bradley Faison	Health Physics Technician (Part-time)
Mr. Friedrich May	Health Physics Technician (Part-time)

3.0 REACTOR OPERATIONS

Core designation 128W 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.

Table 3-1 presents pertinent core data for core designation 128, while Figure 3-1 shows the core configuration. The excess reactivity, shutdown margin, and rod worths were previously measured in February 2018. The measurements were taken in both T and W mode with reference core conditions.

Table 3-1 MSTR Core 128 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	2.6066	2.2023	2.1376	0.5159	3.7455	0.5944
	T	2.6416	2.1444	2.1374	0.5630	3.6296	0.6522

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

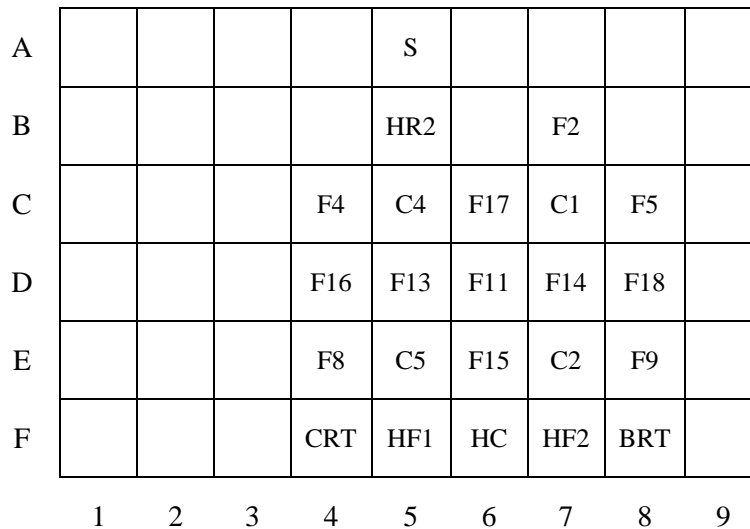


Figure 3-1 MSTR Core 128 Configuration

Table 3-2 shows reactor utilization, while Table 3-3 shows facility use other than the reactor.

Table 3-2 Reactor Utilization

Reactor use	119.9 hr.
Time at power	76.8 hr.
Energy generated	6473.8 kW-hr.
Total number of samples, neutron irradiated	16
U-235 burned	0.283 g
U-235 burned and converted	0.334 g

Table 3-3 Experimental Facility Usage

Facility	Hours
Bare Rabbit Tube	2.7
Cadmium Rabbit Tube	0.0
Beam Port	0.0
Thermal Column	0.0
Other Core Positions	0.5
Hot Cell	0.0
Gamma Exposures	0.0
Total	3.3

Only a single unscheduled shutdown (scrams, rundowns, and unplanned normal shutdowns) occurred during the reporting period, which is documented in Table 3-4.

Maintenance activities are listed in Table 3-5. Note that all date and time entries in these tables utilize the ISO 8601 standard.

Table 3-4 Unplanned Shutdowns (Rundowns)

Date/Time	Type	Cause	Corrective Action	SRO on Duty Permission to Restart
2019-11-12T12:03-06:00	120% Demand	Trainee upscaled incorrectly	SRO instructed Trainee to be aware of which buttons to push while operating	Yes

Table 3-5 Maintenance

<u>Date/Time</u>	<u>Issue or Basis</u>	<u>Action or Corrective Action</u>
2019-05-28T10:00-05:00	Channel calibration	Annual checklist started (Log&Linear, Linear, Safety Channels Complete)
2019-05-30T06:00-05:00	Electrical service	Power to building shut off due to substation replacement. Battery backup found to be insufficient. New batteries ordered.
2019-05-31	Channel calibration	10:00-05:00 Annual checklist startup channel started. 11:10-05:00 Startup calibration complete. 14:30-05:00 Rod indicator calibration started. 15:31-05:00 Rod indicator calibration complete.
2019-06-06	Channel calibration	10:25-05:00 RAM calibrations started 13:51-05:00 Lower Level basement RAM enters continuous discharge above 20 mrem/hr. Alarm setpoints still usable within working range. Queries to find spare parts to fix RAM have been sent out. Otherwise HRA for LL Basement still within TS requirements. All other RAMs completed satisfactorily.

Table 3-5 (Cont.)

<u>Date/Time</u>	<u>Issue or Basis</u>	<u>Action or Corrective Action</u>
Ongoing	Startup channel offscale/inoperable	<p>2019-06-28T13:00-05:00 Fission chamber (startup channel) is reading offscale on "Operate" setting. Preamplifier and detector-side cable removed for testing and troubleshooting.</p> <p>2019-07-03T11:03-05:00 Startup channel preamplifier and cabling reinstalled. Reactor will not be taken critical until startup channel is calibrated.</p> <p>2019-07-11T14:21-05:00 Startup channel fission chamber removed and connections were checked. Additional maintenance and calibration was in progress and was completed. The channel appropriately responds to fission chamber and source movement. The discriminator circuit (R26) may need to be adjusted prior to the next startup due to the extremely clean core.</p> <p>2019-07-22T09:00-05:00 Startup channel connections and preamplifier checked due to no reading. The intermediate connector was insulated, which appeared to fix the issue.</p> <p>2019-09-04T16:30-05:00 Due to excessive noise on the startup channel, channel preamplifier was removed for testing.</p> <p>2019-09-10T10:15-05:00 Fission chamber removed.</p> <p>2019-09-14T16:00-05:00 Fission chamber was reinstalled with the preamplifier and a new detector-preamp signal cable.</p> <p>2019-10-23T11:57-05:00 Fission chamber was removed at 10:00-05:00. Fission chamber was reinstalled at 11:57, with connections independently verified.</p> <p>2020-01-08T14:45-06:00 Startup channel preamplifier removed to troubleshoot noise issues.</p>

Table 3-5 (Cont.)

<u>Date/Time</u>	<u>Issue or Basis</u>	<u>Action or Corrective Action</u>
Ongoing	Startup channel offscale/inoperable	<p>2020-01-13T14:45-06:00 Startup channel fission chamber removed. Corrosion noted on terminal at FC.</p> <p>2020-01-21T12:54-06:00 Startup channel fission chamber and preamplifier reinstalled. Connections independently verified. Channel tested (and determined to be operable) by inserting and removing (using motor) fission chamber and observing response.</p> <p>2020-02-26T10:40-06:00 Significant noise observed on startup channel. HV was power cycled, signal cables were adjusted, and discriminator (R26) was reset to 10 cps. Channel determined to be operable by observing response to FC insertion and removal.</p> <p>2020-03-17T14:53-05:00 Startup channel preamplifier connections were removed, checked, and reattached for troubleshooting noise issues. Connections were verified independently.</p>
Ongoing	Channel calibration	<p>2019-08-05T16:26-05:00 Thermocouple 2 removed from the core.</p> <p>2019-10-17T14:10-05:00 Thermocouples 1 and 3 removed from the core for calibration.</p> <p>2019-10-18T12:20-05:00 Thermocouples 1, 2, and 3 were installed following calibration.</p>
2019-08-12	Rod visual inspection	Rods 1, 2, and 3 were individually removed, inspected, and reinserted. Rod drives and magnet assemblies were reinstalled. All items were completed by 2019-08-14T14:10-05:00.
2019-10-23T13:35-05:00	Channel calibration	Annual checklist completed

Table 3-5 (Cont.)

<u>Date/Time</u>	<u>Issue or Basis</u>	<u>Action or Corrective Action</u>
2020-01-08T12:21-06:00	Magnet current drop	Magnet #1 current observed to drop and fluctuate. Current reset to 42 mA, but determined to be operable.
2020-01-08T14:45-06:00	Rod drop time test	Rod drop time test completed
2020-01-23T12:45-06:00	RAM battery	RAM battery replaced. Console clock reset. RAMs tested and determined to be operable.
Ongoing	Linear channel noise	<p>2020-01-28T08:51-06:00 Linear power supply HV and CV connection removed, checked, and reconnected. Connections independently verified. Determined to be operable by source spike during prestartup.</p> <p>2020-02-03T10:30-06:00 Linear PS HV cable inspected and reconnected. Connections independently verified. Channel determined to be operable.</p> <p>2020-02-06T08:40-06:00 Linear power supply HV connection removed, inspected, and reinstalled. Connections were independently verified. Operability will be determined as part of Prestartup Checklist.</p> <p>2020-03-17T14:53-05:00 Linear PS connections were removed, checked, and reattached for troubleshooting noise issues. Connections were verified independently</p> <p>2020-03-18T13:07-05:00 Linear PS HV cable connector resoldered and reattached. Connections were verified independently.</p>
2020-02-03T09:30-06:00	Vent fan preventative maintenance	Pulley belts and filters/outlets inspected on vent fans 1, 2, and 3. Pulleys replaced as necessary. Vent fans were tested and determined to be operable at 10:12-06:00.

Table 3-5 (Cont.)

<u>Date/Time</u>	<u>Issue or Basis</u>	<u>Action or Corrective Action</u>
2020-03-09T09:15-05:00	Conductivity meter inoperable	Conductivity meter (demin) declared inoperable due to hardware reset. Prior to reset, cell #1 0.527, cell #2 0.764. Restored to operation by 11:30-05:00.
Ongoing	RMS Degradation	2020-03-18T13:07-05:00 RMS Unit #4 replaced with spare. 2020-04-02T15:34-05:00 Troubleshooting performed on RAM #4. Alternate remains in place.
2020-03-22T23:30-05:00	Fire alarm system component inoperable	Beam smoke detector declared inoperable. Remote surveillance fire watch enacted as CM. Detector restored to operable status by 2020-03-23T10:03-05:00

4.0 EDUCATIONAL UTILIZATION

The reactor facility supported 12 Nuclear Engineering courses in the past year for approximately 140 students and 350 student-hours. The reactor supported one graduate student for a total of 4 hours and Reactor Operator Training for 6-10 students for 202 hours. The MSTR was able to have three students from the S&T work study program assist in facility operations. Approximately 160 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 2019	NE 1105: Nuclear Technology Applications	10	-	-
SP 2019	NE 2406: Reactor Operations I	11	0.9	10.2
SP 2020	NE 4456: Reactor Operations II	1	5.0	5.0
SP 2019	NE 4312: Nuclear Radiation Measurements and Spectroscopy	35	1.2	41.9
SP 2019	NE 4438: Reactor Laboratory II	31	0.4	11.2
FS 2019	NE 1105: Nuclear Technology Applications	17	0.8	13.6
FS 2019	NE 4428: Reactor Laboratory I	28	2.4	66.0
SP 2020	NE 1105: Nuclear Technology Applications	6	1.9	11.3
SP 2020	NE 2406: Reactor Operations I	20	7.5	149.5
SP 2020	NE 4456: Reactor Operations II	2	0.5	1.1
SP 2020	NE 4312: Nuclear Radiation Measurements and Spectroscopy	30	0.7	20.5
SP 2020	NE 4438: Reactor Laboratory II	27	0.5	13.6

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.

During the reporting period, 566 students, instructors and public guests visited the MSTR facility for total of 585 hours. Of these individuals, 223 participated in some kind of lab in the facility. Table 4-2 lists those schools and groups that were involved in this year's program that are not part of S&T Nuclear Engineering Department. The majority of participants were high school students. The Reactor Sharing Program serves as a strong campus-wide recruiting tool by attracting high school 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
04/05/2019	Development Board	3	0.43	1.3
04/05/2019	Society of Women Engineers (SWE)	44	0.50	22.0
04/18/2019	Tour	2	0.82	1.6
04/19/2019	Tour	2	0.15	0.3
04/22/2019	Tour	6	1.05	6.3
04/26/2019	Dr. Gelles's Energy Economics Class	6	0.65	3.9
04/27/2020	Boy Scouts (Merit Badge Univ.)	15	0.53	8.0
04/30/2019	Tour	2	1.17	2.3
05/03/2019	Khalifa University	1	0.58	0.6
05/03/2019	Tour	1	1.03	1.0
05/19/2019	Tour	4	0.30	1.2
05/19/2019	Tour	15	0.77	11.5

Table 4-2 (Cont.)

Date	Event/Group	# of Visitors	Time at Reactor (hrs.)	Visitor-Hours
05/22/2020	Alumni Tour	3	0.43	1.3
05/31/2019	Tour	7	1.05	7.4
06/03/2019	NE Camp	18	0.83	15.0
06/03/2019	NE Camp	18	0.85	15.3
06/11/2019	Jackling Camp	14	1.58	22.2
06/13/2019	Jackling Camp	11	1.65	18.2
06/13/2019	Jackling Camp	3	0.23	0.7
06/13/2019	Jackling Camp	14	1.22	17.0
06/18/2019	Emergency Drill Volunteer	2	2.22	4.4
06/20/2019	Tour	1	0.63	0.6
06/25/2019	Jackling Camp	8	1.50	12.0
06/27/2019	Jackling Camp	17	1.17	19.8
06/27/2019	Jackling Camp	12	1.67	20.0
06/28/2019	Tour	4	0.68	2.7
07/05/2019	Discovery Day	4	0.83	3.3
07/08/2019	Mining and Nuclear	2	0.13	0.3
07/08/2019	Tour	6	1.00	6.0
07/09/2019	Jackling Camp	16	1.65	26.4
07/11/2019	Jackling Camp	14	1.57	21.9
07/11/2019	Jackling Camp	16	1.28	20.5
07/12/2019	Discovery Day	4	1.05	4.2
07/19/2019	Fort Leonard Wood CBRN	18	1.60	28.8
07/19/2019	Discovery Day	3	0.90	2.7
07/19/2019	Discovery Day	3	0.33	1.0
07/24/2019	Ghanaian Ambassador to US	7	0.57	4.0
07/25/2019	Materials Camp	14	0.82	11.4

Table 4-2 (Cont.)

Date	Event/Group	# of Visitors	Time at Reactor (hrs.)	Visitor-Hours
07/25/2019	Materials Camp	17	0.82	13.9
07/25/2019	Materials Camp	13	0.93	12.1
07/26/2019	Discovery Day	5	0.97	4.8
08/02/2019	Tour	1	0.55	0.6
08/02/2019	Discovery Day	4	1.03	4.1
09/16/2019	Tour	4	0.32	1.3
10/10/2019	ERDC-CERL	2	0.58	1.2
10/14/2019	Tour	2	0.13	0.3
10/15/2019	Blue Glow Tour	33	2.25	74.3
10/19/2019	SWE	35	1.73	60.7
10/21/2019	Tour	2	0.23	0.5
10/28/2019	Job Shadow	1	7.42	7.4
11/01/2019	NASA MSFC	1	0.45	0.5
11/07/2019	Tour	2	0.78	1.6
11/13/2019	Al Qadisyah University	7	0.32	2.2
12/04/2019	Tour	2	1.05	2.1
12/11/2019	Curtiss-Wright	2	0.38	0.8
12/14/2019	Tour	3	0.37	1.1
12/16/2019	Discovery Day	3	0.93	2.8
01/02/2020	Tour	2	0.37	0.7
01/24/2020	Tour	3	0.70	2.1
02/06/2020	Missouri State Highway Patrol	7	0.45	3.2
02/08/2020	Boy Scouts (Merit Badge Univ.)	13	0.75	9.8
02/08/2020	Boy Scouts (Merit Badge Univ.)	16	0.52	8.3
02/08/2020	Boy Scouts (Merit Badge Univ.)	15	0.47	7.0
02/17/2020	Open House	25	0.48	12.1

Table 4-2 (Cont.)

Date	Event/Group	# of Visitors	Time at Reactor (hrs.)	Visitor-Hours
02/17/2020	Open House	2	0.23	0.5
02/18/2020	Tour	2	0.38	0.8
02/21/2020	Tour	2	0.68	1.4

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 0.1 μCi 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 20 reactor facility personnel and students involved with the operations or regular experiments in the reactor facility are assigned Mirion Technologies Genesis Ultra Thermoluminescent Dosimeters (TLDs). The quantity of issued TLDs varies throughout the year due to class enrollment and personnel turnover, with reactor staff and operator trainees issued TLDs as soon as practical after their start. The full-time Reactor Staff have beta, gamma, and neutron whole-body TLDs along with individual TLD rings and five area dosimeters. This staff

dosimetry set is read twice monthly. 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). 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 2019 through March 2020 sample concentrations averaged $1.1 \times 10^{-5} \mu\text{Ci/mL}$.

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 80,630 μCi of Ar-41 was released into the air. It is noted that a bounding analysis performed in 1994 using COMPLY indicated that the MSTR is exempt from reporting this release to the Environmental Protection Agency so long as the annual release remains below 16.85 Ci and reactor power is limited to 200 kW.

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 waste was transported offsite during the reporting period.

Water is analyzed for radioactive contamination, and approval is required before the water is released. One release was made from the subcritical assembly (359.2 gal), with no detectable activity.

5.5 Instrument Calibrations

Portable survey instruments and meters are calibrated annually. Thirteen meters were calibrated on 9/20/2019, with the next calibration due in September 2020. Eight meters were calibrated on 3/14/2020, with the next calibration due in March 2021. Portable ion chambers were calibrated by an offsite vendor (Ludlum Instruments) on a rotating schedule of 6/28/2019, 8/16/2019, and 2/6/2020.

The digital dosimeters are calibrated by an offsite vendor. Half of the digital dosimeters were calibrated on 8/20/2019, with the remaining half calibrated on 3/5/2019 (vendor had not completed the current calibration by the end of the reporting period).

The radiation area monitors were calibrated on 6/6/2019 with the next calibration due June 2020.

6.0 PLANS

The reactor staff will continue to be involved in four major undertakings during the next reporting period: 1) mitigating staffing losses and financial considerations, 2) updating the reactor documentation, specifically the SAR and SOPs, 3) replacing control room equipment, and 4) continuation of the reactor operator training program.

6.1 Staffing and Financial Considerations

The MSTR was observed to be at low staffing levels during the most recent NRC inspection, and personnel loss has continued. To correct the severe staffing shortage at the MSTR, a broad-responsibility position of Reactor Engineer has been reinstated, with the initial hiring approval process underway. Student reactor operators and work studies will also be utilized where prudent to try and overcome the staffing shortage.

Final COVID-19 financial impacts were unknown as of the end of the reporting period. However, the facility may need to consider additional budget cuts with a corresponding reduction in facility capabilities.

6.2 Reactor Documentation

Updates to the SAR continue to be works in progress. Several changes have not been corrected or fully documented in the SAR in previous years, with instrumentation and auxiliary cooling being the primary areas of concern. The SAR updates are also intended to support future license renewal efforts (or NPUF SAR update requirements if the Commission approves the NPUF licensing rule).

The SOPs continue to be updated with the new university name in addition to minor changes and corrections. Any remaining non-digitalized checklists are also intended to be reformatted into fillable PDF files with electronic signatures. Maintenance, training, and administrative procedures are being heavily expanded upon.

6.3 Replacing Control Room Equipment

Efforts to modernize the control room instrumentation are ongoing. Digital recorders have been procured to replace the existing Nuclear Instrumentation (NI) strip chart recorders. Each modification package is being performed under 10 CFR 50.59 and requires RSC review and approval.

NI channels are also being considered for replacement. Replacement channels with mostly unused/not-installed 1990s systems (replacement startup and linear channels) are available in the facility in various states of testing and disrepair. The facility may consider pursuing new digital NI channels in the future as a longer term solution.

6.4 Reactor Operator Training

The MSTR had one staff member obtain their Senior Reactor Operator license. An additional four students underwent licensing in February 2020, with the results pending.

The reactor staff is limiting operator training to approximately ten students with a very strong desire to obtain the license and assist reactor staff with reactor operations. 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, six students were training to undergo operator licensing in Spring 2021. The Reactor Director, an additional faculty member, and the Radiation Safety Officer are all also preparing for Reactor Operator or Senior Reactor Operator examinations in Spring 2021.