



Missouri S & T Reactor

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May 29, 2019

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: 2018-2019 ANNUAL PROGRESS REPORT FOR MISSOURI UNIVERSITY OF
SCIENCE AND TECHNOLOGY REACTOR

Dear Sirs:

Please find enclosed the 2018-2019 Annual Progress Report for the Missouri University of Science and Technology Reactor (License R-79, Docket No. 50-123). This report is being filed under the reporting requirements of MSTR Technical Specification 6.7.1. A copy of this report is also being sent to our NRC Project Manager, Mr. William Kennedy, and our NRC Backup Project Manager, Mr. Xiaosong Yin.

Should you have any questions, please contact me at (573) 341-4291 or etaber@mst.edu.

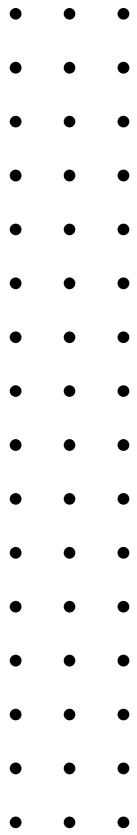
Sincerely,

A handwritten signature in black ink, appearing to read "Ethan Taber".

Ethan Taber
Reactor Manager, MSTR

Enclosure

Cc: Mr. William Kennedy, Project Manager (NRC)
Mr. Xiaosong Yin, Backup Project Manager (NRC)
Dr. Joseph Graham, Reactor Director (S&T)
Dr. Christopher Maples, Interim Chancellor (S&T)
Ms. Cuba Plain, Interim Vice Chancellor for Finance and Operations (S&T)
Mr. Ted Ruth, Asst. Vice Chancellor for Facilities Services (S&T)
Dr. Richard Wlezein, Vice Provost and Dean, CEC (S&T)
Dr. Hyoungh Lee, Associate Professor and Program Chair of Nuclear Eng. (S&T)
Dr. Mark Fitch, Chairman, Radiation Safety Committee (S&T)
Ms. Michelle Bresnahan, Radiation Safety Officer and Director of EHS (S&T)
Mr. Andrew Careaga, Executive Director of Marketing and Communications (S&T)



MSTR PROGRESS REPORT

FOR THE MISSOURI UNIVERSITY OF
SCIENCE AND TECHNOLOGY REACTOR

May 29, 2019

MISSOURI
S&T

PROGRESS REPORT
FOR THE
MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY
NUCLEAR REACTOR FACILITY

April 1, 2018 to March 31, 2019

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

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ACKNOWLEDGEMENTS

I would like to recognize current and former members of the Missouri S&T Reactor staff who contributed heavily to the development of this document. Mr. Craig Reisner, Ms. Laura Pirrone, Ms. Nhi (Lily) Ma, and Ms. Alice Skye 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 2018-2019 reporting period, the Missouri University of Science and Technology Reactor (MSTR) was in use for 2155 hours. The majority of this time (~92%) was used for class instruction, research, and training purposes.

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 1452 student-hours. The reactor was visited by 531 visitors during the past year. There were 305 of these visitors that participated in labs at the reactor.

The reactor produced 17450.27 kilowatt-hours of thermal energy using approximately 0.902 grams of uranium. A total of 162 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, 2018 to March 31, 2019.

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 imager 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.

No major upgrades or changes to the facility were performed over the past year. However, new electronic dosimeters were procured and put into service to replace the existing units.

The updated MSTR Emergency Plan from 2017 remains in effect. Training under this plan was completed in January 2019. Efforts are underway between S&T Police, campus Environmental Health and Safety, and MSTR staff to conduct a large-scale injured person contamination drill.

On August 6-9, 2018, the Nuclear Regulatory Commission (NRC) conducted an inspection at the MSTR. The inspection covered the following areas: procedures; experiments; health physics; design changes; committees, audits and reviews; and transportation. The MSTR was notified during the inspection and by subsequent letter (dated August 30, 2018), that a Severity Level IV violation of NRC requirements had occurred. It was determined that contrary to MSTR Emergency Plan requirements, “the NRC inspector found that, during calendar year 2017, no evacuation drills were held at the facility during either regular semester.” In response (letter dated September 14, 2018), it was noted that evacuation drills have been performed in accordance with the MSTR Emergency Plan prior to and after the violation time frame, and that the drills have been incorporated into the MSTR Operator Training Program as of Spring 2018. The MSTR was otherwise found to be compliant with current NRC requirements and MSTR Technical Specifications.

On November 26-29, 2018, the NRC conducted an inspection of the MSTR with regards to security. No significant security concerns or findings of non-compliance with NRC requirements were identified.

Independent auditors from the University of Missouri Research Reactor (MURR) audited the reactor facility on November 28, 2018. The audit cited an improvement in the written entries in to the Control Room Permanent Log Book, posting the current Health Physics surveys, and upgrading the dosimetry for visitors. It is noted that there is an agreement between MSTR and MURR to audit each other on an annual basis, which has been a very beneficial arrangement for both facilities.

In October, 2018, three students underwent NRC licensing examinations. The SRO license upgrade candidate and an operator trainee passed their respective exams. The remaining operator trainee failed a single exam section and is expected to retake the section in the following months.

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. The reactor is used mainly by the Nuclear Engineering Department for classes and research. The Reactor Lab II class reaches out to other departments on campus for collaboration projects. The reactor is working on resurrecting the reactor “outreach” program that was started in 1990 but has declined over past years.

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. Note that these SOPs are provided in the appendices.

Table 1-1 List of MSTR SOP Revised

SOP	Title
Index	Index
SOP 100	Preamble
SOP 101	General Operational Procedures
SOP 501	Emergency Procedures for Reactor Building Evacuation

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 ¹
Mr. Craig Reisner	Senior Reactor Operator ² / Interim Reactor Manager ³
Mr. Anthony Alchin	Electronic Technician II & Senior Reactor Operator
Ms. Laura Pirrone	Senior Reactor Operator (Part-Time)
Mr. Keith Kellett	Reactor Operator (Part-Time)
Mr. Isaac Mulhern	Reactor Operator (Part-Time)
Ms. Nhi Ma	Reactor Staff (Part-Time)
Ms. Alice Skye	Reactor Staff (Part-Time)

2.2 Licensed Operators

Table 2-2 MSTR Operators

Name	License Type
Craig Reisner	Senior Operator
William Bonzer	Senior Operator ⁴
Anthony Alchin	Senior Operator
Laura Pirrone	Senior Operator ⁵ , Reactor Operator
Nicholas Allen	Reactor Operator ⁶
Andrew Bingham	Reactor Operator ⁶
Keith Kellett	Reactor Operator
Isaac Mulhern	Reactor Operator ⁵
Jonathan Scott	Reactor Operator ⁶
Steve Wagstaff	Reactor Operator ⁶

¹ Effective Date: January 2019

² Termination Date: March 2019

³ Termination Date: January 2019

⁴ Termination Date: May 2018

⁵ Effective Date: December 2018

⁶ Termination Date: September 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 6/4/2018, 9/20/2018, 12/6/2018 and 3/12/2019 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 Services
Dr. David Wronkiewicz	Geosciences and Geological Engineering
Dr. Shoaib Usman	Mining and Nuclear Engineering
Dr. Fadha Al Falahi	Environmental Health and Safety Services
Dr. Yue-Wern Huang	Biological Sciences
Dr. Carlos Castaño	Mining and Nuclear Engineering
Dr. Amitava Choudhury	Chemistry
Mr. Tony Hunt	Environmental Health and Safety Services
Dr. Muthanna Al-Dahhan	Chemical and Biological Engineering
Dr. Joseph Graham	Mining and Nuclear Engineering
Mr. Ethan Taber ⁷	Missouri S&T Reactor
Mr. Craig Reisner ⁷	Missouri S&T Reactor
Mr. Anas Massri	Assistant Vice Chancellor, Fiscal Services

⁷ Mr. Taber replaced Mr. Reisner on the committee effective January 2019

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 ($\% \Delta k/k$)				Shutdown Margin ($\% \Delta k/k$)	Excess Reactivity ($\% \Delta k/k$)
		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

A				S				
B				HR2		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	
	1	2	3	4	5	6	7	8

Figure 3-1 MSTR Core 128 Configuration

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

Table 3-2 Reactor Utilization

Reactor use	327.9 hr.
Time at power	231.2 hr.
Energy generated	17450.3 kW-hr.
Total number of samples, neutron irradiated	162
U-235 burned	0.763 g
U-235 burned and converted	0.902 g

Table 3-3 Experimental Facility Usage

Facility	Hours
Bare Rabbit Tube	32.9
Cadmium Rabbit Tube	0.0
Beam port	4.2
Thermal Column	0.0
Other Core Positions	12.1
Hot Cell	0.0
Gamma Exposures	766.4
Total	815.5

Table 3-4 and Table 3-5 present a listing of unscheduled shutdowns (scrams, rundowns, and unplanned normal shutdowns) along with their causes and corrective actions. Maintenance activities are listed in Table 3-6. 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
2018-08-29T15:19-05:00	Reg Rod Insert Limit on Auto	Operator forgot Reg Rod was fully inserted	None	Yes
2018-10-17T14:18-05:00	120% Demand	Operator was not watching console and missed upscale	Operator had someone else complete paperwork so they could watch the upscale	Yes
2018-10-19T14:34-05:00	120% Demand	Operator downscaled after upscaling	Operator returned to the appropriate scale, instructed to remember the scale that is being stabilized on	Yes
2019-03-26T10:31-05:00	120% Demand	Operator neglected to upscale	Operator instructed to be more diligent in future	Yes

Table 3-5 Unplanned Shutdowns (Scrams)

Date/Time	Type	Cause	Corrective Action	SRO on Duty Permission to Restart
2018-08-01T15:17-05:00	5 Second Period Scram	Moving fuel too close to the Log and Linear CIC detector	None, as trip occurred during fuel movement. Operations were concluded for the day.	No
2019-01-31T11:28-06:00	Unplanned shutdown	Lost magnet power to magnets 2 and 3	None.	Yes
2019-03-05T09:19-06:00	Unplanned shutdown	Loss of electric	None	Yes

Table 3-6 Maintenance

<u>Date/Time</u>	<u>Issue or Basis</u>	<u>Action or Corrective Action</u>
2018-07-06	Channel calibration	Log count rate channel calibration was completed.
2018-07-20T13:23-05:00	Channel calibration	Linear channel calibration was completed.
2018-07-20T14:00-05:00	Rod visual inspection	All three rod drives and magnet assemblies were removed from core for rod visuals.
2018-07-30	Rod visual inspection	Rods 1, 2, and 3 were individually removed, inspected, and reinserted. Rod drives and magnet assemblies were reinstalled. Rod drop time test and rod indicator calibrations were completed. All work was completed by 2018-07-30T15:54-05:00.
2018-08-31T12:10-05:00	Channel calibration	Log & Linear and Safety channel calibrations were completed
2018-09-21	Thermocouple calibration	Thermocouples 1 and 2 were removed for annual calibration and reinstalled 2018-09-24T10:33-05:00.
2019-02-11T09:51-06:00	Magnet current adjustment screw unseated	Magnet power supply was removed for minor maintenance and returned to service. Rod drop current test was performed and results were satisfactory.
2019-02-11T02:31-06:00	Primary CAM housing stripped	Primary CAM removed from service for maintenance. Auxiliary CAM activated.
2019-02-14T02:34-06:00	Primary CAM housing stripped	Repaired primary CAM and placed back into service.
2019-03-01	Power calibration	13:15-06:00 Linear detector adjusted from 40 kW to 43 kW. 13:29-06:00 Log & Linear detector inserted to read 50.0% Power Range from 49.4% Power Range. 13:58-06:00 Log & Linear and Safety Channels adjusted to match Linear channel, detectors moved in.
2019-03-28T15:40-05:00	Startup channel exhibiting signal noise	Fission chamber was removed and reinstalled to accommodate maintenance. Coax cable was replaced.

4.0 EDUCATIONAL UTILIZATION

The reactor facility supported 11 Nuclear Engineering courses in the past year for a total of 300 students and 1920.6 student-hours. The reactor supported 14 graduate students for total of 718.1 hours and Reactor Operator Training for 6-10 students for 213 hours. The MSTR was able to provide financial support for two student workers with hourly wages and have two students from the S&T work study program. The reactor supported tours from six teaching institutions, four camps, and three non-Nuclear tours for total of 692 tour-hours.

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 2018	NE 1105: Nuclear Technology Applications	19	1.0	19.0
SP 2018	NE 2406: Reactor Operations I	28	17.0	476.0
SP 2018	NE 4312: Nuclear Radiation Measurements and Spectroscopy	40	6.3	250.0
SP 2018	NE 4438: Reactor Laboratory II	20	17.2	343.2
FS 2018	NE 1105: Nuclear Technology Applications	36	4.5	162.0
FS 2018	NE 2406: Reactor Operations I	9	39.5	355.5
FS 2018	NE 4428: Reactor Laboratory I	31	19.7	611.3
SP 2019	NE 1105: Nuclear Technology Applications	8	1.9	14.8
SP 2019	NE 2406: Reactor Operations I	11	23.0	253.0
SP 2019	NE 3406: Reactor Operations II	1	1.0	1.0
SP 2019	NE 4312: Nuclear Radiation Measurements and Spectroscopy	34	2.5	85.0
SP 2019	NE 4438: Reactor Laboratory II	21	34.8	723.0

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, 531 students, instructors and public guests visited the MSTR facility for total of 536 hours. Of these 531 individuals, 305 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

Date	Event/Group	# of Visitors	Time at Reactor (hrs.)	Visitor-Hours
04/04/2018	East Central College	20	1.33	26.7
04/18/2018	MST MSE 5230/6220	23	0.75	17.3
05/02/2018	Dr. Gellis Energy class	13	0.75	9.8
05/14/2018	Fort Leonard Wood CBRN	17	1.00	17.0
06/04/2018	Jackling Camp	19	1.77	33.6
06/06/2018	Nuclear Engineering Camp	18	1.07	19.2
06/12/2018	Jackling Camp	6	1.83	11.0
06/14/2018	Jackling Camp	30	1.00	30.0
06/26/2018	Jackling Camp	18	1.00	18.0
06/27/2018	Dr. Schlegel Student Tour	2	1.17	2.3
06/28/2018	Jackling Camp	17	1.33	22.7
07/06/2018	Discovery Days	3	0.25	0.8

Table 4-2 (Cont.)

Date	Event/Group	# of Visitors	Time at Reactor (hrs.)	Visitor-Hours
07/09/2018	Jackling Camp	20	0.48	9.7
07/12/2018	Jackling Camp	14	1.27	17.7
07/12/2018	Jackling Camp	18	1.22	21.9
07/23/2018	WU Tour	5	0.45	2.3
07/24/2018	Fort Leonard Wood CBRN	15	1.83	27.5
07/24/2018	Admissions Tour	11	2.05	22.6
07/27/2018	Discovery Days	7	1.18	8.3
08/10/2018	University of Tennessee Knoxville	2	1.12	2.2
08/24/2018	MCHS	3	0.22	0.7
09/15/2018	University of Illinois	10	4.05	40.5
10/01/2018	NCSU	1	0.37	0.4
10/08/2018	HLC	4	0.25	1.0
10/18/2018	American Nuclear Society	50	0.50	25.0
10/19/2018	Eldon High School	5	1.50	7.5
10/26/2018	Discovery Days	2	0.28	0.6
11/02/2018	Reactor Tours	20	0.77	15.3
11/03/2018	Reactor Tours	20	0.65	13.0
11/14/2018	East Central College	13	1.77	23.0
02/02/2019	Boy Scouts	19	0.50	9.5
02/02/2019	Boy Scouts	25	0.37	9.2
02/15/2019	Discovery Days	11	0.50	5.5
02/15/2019	Discovery Days	3	0.80	2.4
02/18/2019	Admissions Tour	4	1.00	4.0
02/23/2019	AUC Facility Tour	13	0.72	9.3
02/26/2019	JSHS	27	0.67	18.0
03/08/2019	Fort Leonard Wood CBRN	23	1.33	30.7

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. A total of 11.4 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 30 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 were procured in late 2018 to replace existing, aging digital dosimeters and 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 monitors (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 2018 through March 2019 sample concentrations averaged $9.1 \times 10^{-6} \mu\text{Ci/mL}$.

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 70,100 μCi of Ar-41 was released into the air.

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. Water is analyzed for radioactive contamination and approval is required before the water is released. No waste was transported offsite during the reporting period.

5.5 **Instrument Calibrations**

Portable survey instruments and meters are calibrated annually. Thirteen meters were calibrated on 9/21/2018, with the next calibration due in September 2019. Eight meters were calibrated on 3/14/2019, with the next calibration due in March 2020. Portable ion chambers were calibrated by an offsite vendor (Ludlum Instruments) on a rotating schedule of 6/18/2018, 8/6/2018, and 1/11/2019.

The previous digital dosimeters were calibrated 4/26/2018 and were replaced in October 2018. Half of the replacement dosimeters were calibrated (offsite) on 8/19/2018, with the remaining half calibrated on 3/5/2018 (also offsite).

The radiation area monitors were calibrated on 7/31/2018, with the next calibration due August 2019.

6.0 PLANS

The reactor staff will continue to be involved in four major undertakings during the next reporting period: 1) updating the reactor documentation, specifically the SAR and SOPs, 2) replacing control room equipment, 3) expanding research to outside companies and other departments and 4) continuation of the reactor operator training program.

6.1 Reactor Documentation

The SAR remains in need of updates. In the past 7 years the reactor has undergone several changes that have not been corrected or fully-documented in the SAR. The control room upgrades and chiller upgrades are among those projects.

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.

6.2 Replacing Control Room Equipment

A process of modernizing control room instrumentation started in 2017 with the Temperature and CAM recorder. Equipment to be replaced will be selected on a priority basis of what needs replaced and scope of project. Control room equipment replacement will have a thorough analysis of a 10 CFR 50.59 screening and evaluation/review process. The reactor staff will present the completed 10 CFR 50.59 review to the Radiation Safety Committee as required by MSTR Technical Specifications. The initial focus will be for converting the remaining paper recorders to paperless systems.

6.3 Reactor Operator Training

The MSTR had two students obtain their license of Reactor Operator. 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 for an operator's license to take in the fall of 2019. The Reactor Manager, Reactor Director, and an additional faculty member are all also preparing for Reactor Operator and Senior Reactor Operator examinations in fall 2019.

Appendices and Attachments

SOP 100-199 Routine Reactor Operation

SOP 100	Preamble
SOP 101	General Operational Procedures
SOP 102	Pre-Startup Checklist Procedures
SOP 103	Reactor Startup to Low Power
SOP 104	Reactor Power Changes and Stable Operations
SOP 105	Reactor Shutdown & Reactor Securing Procedures
SOP 106	Restart of Reactor When It Is Not Secured
SOP 107	Permanent Log, Hourly Log, and Operational Data
SOP 109	Determination of Control Rod Worths by the Rod Drop Method
SOP 110	Calibration of Control Rods by Positive Period Method
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SOP 112	Fuel Management
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SOP 306	Estimation of Activity and Reactivity Worth of a Sample	Rev.
SOP 308	Restoration of AC Power Following a Power Outage	
SOP 309	Response to a Coolant System Leak	
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*** MISSOURI S&T REACTOR STANDARD OPERATING PROCEDURES ***

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Revised By: Ethan Taber

Approved By: Ethan Taber

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SOP 818	Function Test of Building Security System

| Rev.

Revised By: Ethan Taber

Approved By: Ethan Taber

A. PURPOSE

The purpose of this document is to set forth the procedures for routine and emergency operations of the Missouri University of Science and Technology Reactor (MSTR). The goal of these procedures is to assure that the MSTR will be operated safely; presenting no hazard to the public or to the operating staff, and secondarily, that reactor equipment will be safeguarded. It is mandatory that all personnel involved with reactor operations be completely familiar with these procedures and that these procedures be followed.

B. PRECAUTIONS, PREREQUISITES, OR LIMITATIONS

1. These procedures are intended to reflect and implement Facility License Number R-79, as amended, and Title 10 of the Code of Federal Regulations.
2. Only two copies of the SOPs are to be considered controlled copies. The controlled copies shall contain all of the approved procedures and will incorporate new or revised procedures as they are approved. The controlled copies should be retained in the office reception area (Reactor Manager's Copy) and in the Control Room (Control Room Copy). All other copies of SOPs are to be considered complimentary only and shall not be used for facility evolutions.
3. The SOPs shall be reviewed annually by either the Reactor Manager, Reactor Director, or a licensed operator. Identified weaknesses, inadequacies, or recommendations for improvements should be discussed with the Reactor Manager to determine if revision to the SOPs is required.
4. Each SOP revision shall be listed on the revision form located in front of the Reactor Manager's Controlled Copy of the SOPs. Each licensed operator shall acknowledge the revision by initialing the revision form prior to conducting reactor operations. Approval authority for revisions shall meet the following requirements:
 - a) Changes that do not modify the original intent of the procedures may be made by the Reactor Manager (or higher level personnel), with the approval of the Reactor Director or designated alternate within 14 days. | Rev.
 - b) Substantive changes to the approved procedures and new procedures shall be made only with the additional approval of the Radiation Safety Committee. | Rev.

*** MISSOURI S&T REACTOR STANDARD OPERATING PROCEDURES ***

SOP: 100

TITLE: **PREAMBLE**

Revised: February 20, 2019

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5. Handwritten revisions to the Controlled SOPs may be made provided the following conditions are satisfied:

- a) Handwritten revisions are clearly legible and neatly made in red ink in both Controlled SOP copies.
- b) Handwritten revisions are reviewed and approved by both a SRO and the Reactor Director or designated alternate. Review and approval shall be documented by initialing and dating the revision.
- c) Handwritten revisions should be listed on the revision form located in the front of the Reactor Manager's controlled copy of SOPs in red ink.

In the absence of the Reactor Director, the Reactor Manager may review and temporarily approve handwritten revisions provided the Reactor Director or designated alternate reviews the revision as soon as practical upon their return.

Revised By: Ethan Taber

Approved By: Ethan Taber

A. PURPOSE

To provide written general operational procedures for routine operations.

B. PROCEDURE

1. Reactor operations must at all times meet the requirements of the Facility License R-79, Technical Specifications, and security in accordance with the provisions of 10 CFR 73.67(f).
2. At least two persons, as per Technical Specification 6.1.3 “Staffing”, shall be present in the Reactor Building when the reactor is operating.
3. The following additional staffing requirements shall be met:
 - a) A licensed operator who is responsible for reactor operation shall be present in the control room at all times when the reactor is operating.
 - b) Students and trainees may operate the reactor controls subject to the following conditions. In such cases the licensed operator maintains complete and total responsibility for all aspects of reactor operations.
 - i) Students and trainees may operate the reactor controls under the direct supervision of a licensed operator provided the excess reactivity is less than 0.7% delta k/k.
 - ii) Trainees may operate the reactor controls under the direct supervision of a Senior Reactor Operator when the excess reactivity is greater than 0.7% delta k/k and less than 1.5% delta k/k.
4. The reactor will be operated with the minimum amount of excess reactivity necessary to fulfill operational requirements as determined by the Reactor Director.
5. Read backs should be performed when verbally communicating without direct visual contact. This requirement is especially critical when handling fuel or radioactive samples. The NATO phonetic alphabet or jointly-agreed-upon system should be used for letters and numbers in the read back for brevity and clarity.
6. All reactor operational personnel are responsible for entering in the appropriate log book any work on or around the reactor or reactor components important enough to justify a record for future reference.

7. All personnel are responsible for notifying the SRO on Duty of any work being done that could either directly or indirectly affect reactor operations.
8. Log books will be kept in the permanent log book cabinet, except the one currently in use, which may be kept on the console. If the books are removed from the control room, permission must be granted by the Reactor Manager. Any books removed shall be returned as soon as possible.
9. Only the SRO on Duty may authorize the use of bypass keys for control channel automatic functions. The use of any interlock bypass key requires a permanent log entry for insertion and removal. This log entry shall include date and time. This requirement does not apply when the reactor is shut down (e.g. performance of the Weekly Checklist procedure).
10. Any abnormal behavior or abnormal change in core reactivity associated with reactor startup or operation should be reported to the SRO on Duty immediately if there is any doubt about reactor safety, the reactor shall be immediately shut down by the licensed operator in the control room. The cause should then be determined and corrective action taken. | Rev.
11. The Standard Operating Procedure (SOPs) should be followed to the extent practicable, especially whenever the Pre-Startup Checklist is being completed, when the reactor is being started, or when the reactor power is being changed.
12. The SRO on Duty has the authority to instruct the reactor operator to disregard certain SOPs provided that no safety requirements are violated (e.g., SOP 106 does not have to be performed following every shutdown while performing SOP 109). | Rev.
13. All surveillance time intervals referred to in the SOPs are as defined in Section 1 of the Technical Specifications.

14. The following procedures are to be performed by the Reactor Electronics Technician or other qualified individual as determined by the Reactor Manager. A licensed operator will participate when reactor operation is involved (e.g. Rod Drop Time Measurements). | Rev.
- SOP 655, "Radiation Area Monitor (RAM) Calibrations" |
- SOP 800, "Annual Checklist" | Rev.
- SOP 801, "Log and Linear Drawer Calibration" |
- SOP 802, "Linear Channel" |
- SOP 803, "Log Count Rate (LCR) Channel" |
- SOP 804, "Safety Amplifier System" | Rev.
- SOP 806, "Temperature Channel" |
- SOP 809, "Relay Test" |
- SOP 811, "Fire and Smoke Alarm System" |
- SOP 813, "Rod Drop Time Measurement" |
- SOP 818, "Functional Test of Building Security System" | Rev.

*** MISSOURI S&T REACTOR STANDARD OPERATING PROCEDURES ***

SOP: 501 TITLE: **EMERGENCY PROCEDURES FOR REACTOR BUILDING
EVACUATION**

Page Revision: March 26, 2019

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MISSOURI S&T EMERGENCY PHONE LIST

Reactor Staff	CELL	HOME	WORK
Staff On-Call	(573) 578-9463		
Ethan Taber, Reactor Manager	(512) 905-3671		341- 4291
Anthony Alchin, Electronics Technician III	(816) 274-1771		341- 6617

Rev.

University Administrative Staff

Michelle Bresnahan, EHS Director, RSO	(314) 239-7751		341- 4305
Doug Roberts, Director Missouri S&T Police	(573) 202-3689		341- 4300
Dr. Christopher Maples Interim Chancellor	(775) 741-1635	(573) 341-7141	341- 4114
Cuba Plain, Vice Chancellor, Finance & Operations	(573) 268-3208		341- 4122
Ted Ruth, Asst. Vice Chancellor, Facilities Services	(573) 647-6239		341- 7619
Dr. Goodman DO, Director Student Health Services			341- 4284
Dr. Hyoung Lee, Chair of Nuclear Eng	(573) 202-4665		341- 4585
Dr. Joseph Graham, Reactor Director	(719) 244-0042		341- 7759
Fadha Al Falahi, Health Physicist EHS-MS&T	(314) 960-9211	(636) 223-2054	341- 7014

Local

Missouri S&T Police			341- 4300
Rolla City Police			911
Rolla Fire Department			911
Phelps County Hospital			911
Rolla Emergency Management Agency			911

State Agencies

Missouri Highway Patrol		(573) 368-2345	
Missouri State Emergency Mgt. (24 hr.)		(573) 751-2748	
Missouri Dept. of Natural Resources (24 hr.)		(573) 634-2436	
Missouri Bureau of Environmental Epidemiology	(573) 751-6160	(24 hr.) (573) 751-4674	

Federal Agencies

NRC, Operations Center		(301) 951-0550	
NRC Duty Officer (24 hr.)		(301) 816-5100	

Other

Radiation Emergency Assistance Center	(865) 576-3131	(24 hr.) (865) 576-1005	
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Revised By: Anthony Alchin

Approved By: Ethan Taber