



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D.C. 20555-0001

March 12, 2021

Dr. J. David Robertson  
Reactor Facility Director  
University of Missouri-Columbia  
Research Reactor Center  
1513 Research Park Drive  
Columbia, MO 65211

SUBJECT: UNIVERSITY OF MISSOURI-COLUMBIA – U.S. NUCLEAR REGULATORY  
COMMISSION ROUTINE INSPECTION REPORT NO. 05000186/2020202

Dear Dr. Robertson:

From November 2-6, 2020, the U.S. Nuclear Regulatory Commission (NRC) staff conducted a routine announced safety inspection at the University of Missouri-Columbia Research Reactor facility. The enclosed report presents the results of that inspection.

During the inspection, the NRC staff examined activities conducted under your license as they relate to public health and safety to ensure compliance with the Commission's rules and regulations and with the conditions of your license. Within these areas, the inspection consisted of selected examination of procedures and representative records, observations of activities, and interviews with personnel.

Based on the results of this inspection, the NRC has determined that one Severity Level IV violation of NRC requirements, with four examples, occurred. The violation is being treated as a non-cited violation (NCV), consistent with Section 2.3.2.a of the Enforcement Policy. The four examples of the NCV are described in the subject inspection report. If you contest the violation or significance of the NCV, you should provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington DC 20555-0001, with copies to the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001.

In accordance with Title 10 of the *Code of Federal Regulations*, Section 2.390, "Public inspections, exemptions, requests for withholding," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the NRC's document system (Agencywide Documents Access and Management System (ADAMS)). ADAMS is accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html> (the Public Electronic Reading Room).

J. Robertson

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If you have any questions concerning this inspection, please contact Craig Bassett at (240) 535-1842, or by electronic mail at [Craig.Bassett@nrc.gov](mailto:Craig.Bassett@nrc.gov).

Sincerely,

Travis L. Tate, Chief  
Non-Power Production and Utilization Facility  
Oversight Branch  
Division of Advanced Reactors and Non-Power  
Production and Utilization Facilities  
Office of Nuclear Reactor Regulation

Docket No. 50-186  
License No. R-103

Enclosure:  
As stated

cc: See next page

University of Missouri-Columbia

Docket No. 50-186

cc:

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College Park, MD 20742-2115

SUBJECT: UNIVERSITY OF MISSOURI-COLUMBIA – U.S. NUCLEAR REGULATORY  
COMMISSION ROUTINE INSPECTION REPORT NO. 05000186/2020202  
DATED: MARCH 12, 2021

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**U.S. NUCLEAR REGULATORY COMMISSION**  
**OFFICE OF NUCLEAR REACTOR REGULATION**

Docket No. 50-186

License No. R-103

Report No. 05000186/2020202

Licensee: The Curators of the University of Missouri

Facility: University of Missouri-Columbia Research Reactor

Location: Columbia, Missouri

Dates: November 2-6, 2020

Inspector: Craig Bassett

Accompanied by: Travis Tate, Chief

Approved by: Travis L. Tate Chief  
Non-Power Production and Utilization Facility  
Oversight Branch  
Division of Advanced Reactors and Non-Power  
Production and Utilization Facilities  
Office of Nuclear Reactor Regulation

Enclosure

## EXECUTIVE SUMMARY

The Curators of the University of Missouri  
University of Missouri-Columbia Research Reactor  
Inspection Report No. 05000186/2020202

The primary focus of this routine, announced safety inspection included the onsite review of selected aspects of the Missouri University Research Reactor (MURR) facility safety program, including: (1) operator licenses, requalification, and medical examinations; (2) experiments; (3) organization and operations and maintenance activities; (4) review and audit and design change functions; (5) procedures; (6) fuel movement; (7) surveillance; (8) emergency preparedness; and, (9) event follow-up. The U.S. Nuclear Regulatory Commission (NRC) staff determined the licensee's program was acceptably directed toward the protection of public health and safety, and in compliance with the NRC requirements.

### Operator Licenses, Requalification, and Medical Examinations

- Operator licenses and requalification was completed as required by regulations and the requalification program and the program was maintained up to date.

### Experiments

- The program for reviewing and conducting experiments satisfied technical specifications (TSs) and current procedural requirements.
- Changes/amendments to existing experiments were reviewed and approved as required by TSs.

### Organization and Operations and Maintenance Activities

- Organization and staffing were in compliance with the TS requirements.
- Operations were conducted in accordance with procedures, appropriate logs were maintained, and the work control program was used for timely and effective completion of maintenance activities.

### Review and Audit and Design Change Functions

- Review, audit, and oversight functions required by the TS were acceptably completed.
- Changes to the facility were evaluated using the criteria specified in Title 10 of the *Code of Federal Regulations* (10 CFR) 50.59, "Changes, tests and experiments," and were reviewed and approved when required.

### Procedures

- The procedure review, revision, control, and implementation program satisfied TS requirements.

### Fuel Movement

- Fuel movements and inspections were conducted in accordance with TS and procedural requirements.

### Surveillance

- Surveillance activities at the facility were completed within the TS-prescribed time frames.

### Emergency Preparedness

- The emergency preparedness program was conducted in accordance with the emergency plan (E-Plan).
- Emergency response equipment was maintained as required by the E-Plan.
- Memoranda of understanding (MOU) between the licensee and various support agencies were maintained by the E-Plan.
- Emergency drills were conducted annually as required by the E-Plan.
- Emergency preparedness training for personnel was conducted as required by the E-Plan.

### Event Follow-up

- One Severity Level IV non-cited violation (NCV) with four examples documented in Licensee Event Reports (LERs), were reviewed and are considered closed. One previously identified Inspector Follow-up Item (IFI) was closed and one new IFI was opened.

## REPORT DETAILS

### Summary of Facility Status

The University of Missouri-Columbia continued to operate the 10 megawatt (MW) research reactor in support of isotope production, irradiation services, research, education, and training.

#### 1. Operator Licenses, Requalification, and Medical Examinations

##### a. Inspection Scope (Inspection Procedure (IP) 69003)

The inspector reviewed the following to verify that the requirements of 10 CFR Part 55, "Operators' Licenses," were met:

- "Operator Requalification Program, University of Missouri Research Reactor (MURR)" dated January 7, 1997
- MURR administrative procedure (AP), AP-RO-105, "MURR Operator Requalification Process," Revision 1 dated October 4, 2019
- the on-the-job progress report for 2019 dated January 2, 2020, and the on-the-job progress report for 2020 as of November 2, 2020, providing the status of the senior reactor operator (SRO) and reactor operator (RO) annual on-the-job training progress
- a two-year physical and license expiration schedule spreadsheet for ROs and SROs as of November 2, 2020, containing the dates of the physical exams, next physical due, license effective, and license expiration; as well as, license and docket numbers, title, and license restrictions for each licensed operator
- the 2020 on-the-job training requirement/checklist for individual licensed operators
- the 2020 operator active status log for individual licensed operators
- the 2020 annual operating test record for individual licensed operators
- the 2019 operator license – requalification exam results for individual licensed operators
- MURR letter to the NRC dated November 2, 2020, providing written communication as specified by 10 CFR 50.74, "Notification of change in operator or senior operator status," requesting termination of operator license
- NRC Form 396, "Certification of Medical Examination by Facility Licensee," for two licensed operators

##### b. Observations and Findings

The inspector reviewed the list of the NRC licensed operators and determined that there are 9 SROs and 13 ROs currently licensed at MURR. Additionally, MURR has 3 individuals undergoing operator training. The inspector's review of the documents listed above found that the licensee implemented the operator requalification program as approved by the NRC. The inspector observed that the RO and SRO requalification examinations with the questions and individual answers were maintained by the licensee. The inspector determined the requalification examination records provide sufficient documentation to verify the technical adequacy of licensee administered examinations.



The inspector also reviewed the records for 6 licensed operators. The inspector noted that the MURR Requalification Program requires each operator to actively perform the functions of a RO or SRO for a minimum of 8 hours per calendar quarter. This requirement exceeds the minimum of 4 hours per calendar quarter required by 10 CFR 55.53, "Conditions of licenses," paragraph (e). The inspector review found that licensed ROs and SROs met the requalification program requirements for maintaining operator active status. The inspector also reviewed the license expiration dates and verified that operator licenses are current and/or was renewed as required by 10 CFR 55.57, "Renewal of licenses." The inspector noted one change in operator status for termination of an SRO license submitted to the NRC on November 2, 2020. Based upon discussion with the licensee's staff, the inspector found that the submittal was in accordance with the requirements of 10 CFR 50.74.

The inspector reviewed the medical records for two licensed operators. The inspector verified that the operators received biennial medical examinations as required.

c. Conclusion

Based upon review of the documents and operator records, as well as, the observations and findings described above, the inspector concluded that the operator licenses and requalification was conducted as required by the MURR Requalification Program and NRC regulations.

## 2. Experiments

a. Inspection Scope (IP 69005)

The inspector reviewed the licensee's program for conducting experiments and selected aspects of the following to verify compliance with TSs 3.8 and 6.5:

- listing of current experiments
- selected reactor utilization request (RUR) proposal and evaluation packages
- "RUR Summary Sheets Manual" binder listing summaries of experiments that can be performed in the "Flux Trap or All Positions" and those that can be performed in the "Reflector Only"
- "University of Missouri-Columbia Research Reactor, Reactor Operations Annual Report, January 1, 2018, through December 31, 2018"
- "University of Missouri-Columbia Research Reactor, Reactor Operations Annual Report, January 1, 2019, through December 31, 2019"

b. Observations and Findings

The inspector found that experiments conducted at the facility were required to be evaluated and reviewed using MURR AP-RO-135, "Reactor Utilization Requests." The procedure required that experiments which did not involve a new class of experiments or a question pursuant to 10 CFR 50.59 be reviewed and approved by the Reactor Manager and the Reactor Health Physics Manager. The inspector found the associated RURs were also approved in accordance

with AP-RO-135. Any RURs involving a new class of experiment or a safety question were required by TSs to be reviewed by the Reactor Safety Subcommittee. Following this review and analysis, these RURs were then required to be reviewed and approved by the full Reactor Advisory Committee (RAC).

The inspector noted that the RURs most commonly used at the facility were for product or sample irradiation. The inspector reviewed various recently approved RURs or amendments to previously approved RURs that were submitted for review and approval. The inspector found that experiments were evaluated in accordance with TS requirements and the accompanying data sheets indicated that they were within reactivity limits. The safety analysis for each were performed by the licensee and the appropriate reviews and approvals were completed.

The inspector noted that the experiments in progress during the inspection were conducted under the cognizance of the reactor manager and the licensed SRO, and in accordance with TS requirements (e.g., reactivity limitations). The experiments reviewed by the inspector were found to be conducted in accordance with procedure and the materials produced were handled and transferred as required by TSs and regulations.

c. Conclusion

The inspector determined that the program for reviewing, amending, and conducting experiments satisfied TS and procedural requirements.

**3. Organization and Operations and Maintenance Activities**

a. Inspection Scope (IP 69006)

To verify compliance with the licensee's TS requirements, the inspector reviewed selected aspects of the licensee's organization, operations, and preventative maintenance program, including:

- current TSs for the facility
- select compliance check procedures
- facility annual reports for the past two years
- select preventive and special maintenance procedures
- select MURR procedures including: MURR AP-RR-001, "Corrective Action Program [CAP]," Revision 14; MURR Operating Procedure, AP-RO-110, "Conduct of Operations," Revision 29; and, MURR Operating Procedure, OP-RO-220, "Reactor Shutdown or Power Reduction," Revision 14
- "Research Reactor Center Year 2020 Organization Chart," dated July 1, 2019
- MURR control room logbooks from 2019-2020
- select records for maintenance and surveillance activities performed in 2019 and to date in 2020

- CAP overview list, dated October 31, 2020
- select records, "CAP Summary Reports," issued quarterly for October – December 2019 and January – March, April – June, and July – September 2020

b. Observations and Findings

(1) Organization and Staffing

The inspector reviewed the organizational structure at the facility and found that it remained unchanged since the last inspection. The subject of facility staffing was reviewed by the inspector. Through a review of selected reactor operation logs for periods in 2019-2020 and observation of operating shifts, the inspector determined that the licensee operates with rotating crews, staffed with three to four licensed reactor operators. Several crews were also staffed with an operator trainee. The inspector verified that staffing during reactor operations consisted of at least two facility staff personnel (one SRO/RO and one knowledgeable individual) in accordance with TS 6.1.c.

(2) Operations and Maintenance

During the inspection, the inspector observed various activities, including a reactor start-up on Monday evening following a routine shutdown. The inspector observed that written procedures and checklists were used for other operations activities as required by TSs. The inspector also attended an evening operations crew shift turnover meeting. (Turnover briefings are held at 6:30 a.m. and 6:30 p.m. each day.) The status of the reactor and the facility was discussed in detail during crew turnover. The inspector observed that all operators of the relief crew reviewed the appropriate logs and records and were briefed on the upcoming shift activities and scheduled events before assuming the operations duty. The inspector noted staff members were knowledgeable, adhered to procedures, and professional in the conduct of their duties.

(3) Maintenance

The inspector reviewed various logs and records documenting maintenance activities at the facility. The records indicated that equipment was monitored and maintained as required by TSs. Specific maintenance and compliance check procedures were used by the licensee to outline the required work done and document the results.

(4) Corrective Action Program

The inspector reviewed the licensee's CAP, which was developed to provide staff members with a formal process to identify deficiencies and bring safety issues, as well as other issues of concern, to management's attention for resolution. When issues were identified, each one was screened for safety significance, evaluated to determine the cause and its contributing factors, and assigned to a responsible manager for resolution. Corrective actions were developed and implemented consistent with the significance of the

issue and according to an established schedule. Based on a review of a sample of CAP documents, the inspector determined that the licensee's program to identify and record issues and corrective actions was an effective method to resolve deficiencies and safety concerns.

c. Conclusion

The inspector confirmed that organization and staffing were in compliance with the TS requirements; operations were conducted in accordance with procedures; maintenance was conducted as required by TSs; and, the licensee's CAP assisted in resolving safety concerns.

**4. Review and Audit and Design Change Functions**

a. Inspection Scope (IP 69007)

To verify compliance with (1) the licensee's TS requirements for the conduct of reviews and audits; and, (2) 10 CFR 50.59, the inspector reviewed selected aspects of the licensee's program, including:

- current TSs for the facility
- facility annual reports for the past two years
- committee/subcommittee meeting minutes from July 2019 through July 2020 for the RAC; Reactor Safety Subcommittee; Reactor Safety Procedure Review Subcommittee; and Isotope Use Subcommittee
- "50.59 Screens," for 2019 and to date in 2020
- modification record 19-03, "Replacement of 2PS1 and 2PS2 Power Supplies"
- modification record 19-05, "Replacement of DPS-930 Transmitters and Indication"
- modification record 20-01, "Installation of Additional Isolation Valves to the Pneumatic Tube System"

b. Observations and Findings

(1) Review and Audit Functions

The inspector reviewed the meeting minutes of the RAC and subcommittees. The inspector found that composition of the RAC was as specified in TS 6.2.a. The inspector also found that meeting minutes demonstrated that the committee (or subcommittees) met as required by TS 6.2.b, and, provided the reviews as specified in TS 6.2.a. Topics of the reviews were as required by TS and provided independent oversight to ensure safe operations of the reactor. Based on records review and interviews, the inspector verified the 2019 audits pertaining to Facility Operations, Operator Requalification Program, Corrective Action items, and E-Plan were completed as required by TS 6.2.e(1)i-iv.

(2) Design Change Function

To satisfy the regulatory requirements stipulated in 10 CFR 50.59, the licensee established a design change review program which was implemented through MURR procedures AP-RR-003 and AP-RO-115. The program included the screening and safety review of changes, tests, or experiments to determine if, pursuant to 10 CFR 50.59, a change required the NRC's approval prior to implementation. The inspector found evidence of the licensees' adherence to the procedures which appropriately guided the review process.

c. Conclusion

The inspector determined that review, audit, and oversight functions required by the TS were appropriately completed. The also inspector determined that changes to the facility were evaluated using the criteria specified in 10 CFR 50.59, and were reviewed and approved when required.

**5. Procedures**

a. Inspection Scope (IP 69008)

To verify compliance with the licensee's TS requirements for procedures, the inspector reviewed selected aspects of the licensee's program, including:

- current TSs for the facility
- facility annual reports for the past two years
- status of completed FM-5 reviews for operations procedures
- FM-5, "Facility-Controlled Document Revision and Annual Review Form," Revision 21

b. Observations and Findings

The inspector reviewed the facility procedures and the processes to review, approve, change, and deviate from procedures. The inspector noted that facility procedures were developed for the operation of the reactor, as required by TS 6.4.a. The inspector found that all operation procedures were approved and annually reviewed by the Reactor Manager as required by TS 6.4.c.

c. Conclusion

The inspector confirmed that the procedure review, revision, control, and implementation program satisfied TS requirements.

**6. Fuel Movement**

a. Inspection Scope (IP 69009)

To verify compliance with the licensee's TS requirements for the MURR fuel, the inspector reviewed selected aspects of the licensee's program, including:

- current TSs for the facility
- MURR control room logbooks for 2020
- “Fuel Location Maps,” for Cores 20-01 through 20-49
- completed FM-08, “Fuel Movement Sheet,” for Cores 20-01 through 20-49

b. Observations and Findings

The inspector reviewed the fuel movement process used by the licensee and verified that fuel was moved according to established procedures and in conjunction with the selected fuel movement sheets. Fuel movement sheets were specifically prepared for each of the different types of fuel handling operations. Review of the fuel movement sheets by the inspector indicated that the licensee followed the approved procedural process. The inspector verified that fuel handling tools were properly maintained and were adequately controlled when not in use. The inspector compared the current location of selected fuel elements in the reactor core (as illustrated by a printed core configuration or map) with the information maintained on the fuel status boards in the Control Room and on the fuel movement sheets. The inspector determined that fuel was used and stored in the required and approved locations. As part of this inspection, the inspector conducted a review of a fuel handling incident that occurred prior to the inspection. It is discussed below in Section 9.

c. Conclusion

The inspector verified that fuel movements and inspections were conducted in accordance with TS and procedural requirements.

**7. Surveillance**

a. Inspection Scope (IP 69010)

To verify compliance with the licensee’s TS requirements for surveillances, the inspector reviewed selected aspects of the licensee’s program, including:

- current TSs for the facility
- MURR control room logbooks for 2020
- facility annual reports for the past two years
- select records documenting completed compliance check procedures (CPs) for 2020

b. Observations and Findings

Routine maintenance and surveillance activities, including: verifications, calibrations, and testing of various reactor systems, instrumentation, auxiliary systems, and security systems and alarms, were completed by the licensee during routine shutdowns for reactor refueling. The inspector reviewed completed CPs, associated data sheets, and reactor console logbooks. The records indicated that the required tests, checks, verifications, and calibrations were completed on schedule and in accordance with licensee procedures. The

results of the completed CPs reviewed by the inspector were found to be within the TS and procedurally prescribed parameters.

c. Conclusion

The inspector determined that surveillance activities at the facility were completed within the TS-prescribed time frames and parameters.

**8. Emergency Preparedness**

a. Inspection Scope (IP 69011)

To verify compliance with Appendix E, "Emergency Planning and Preparedness for Production and Utilization Facilities," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," and the licensee's E-Plan, the inspector reviewed selected aspects of the licensee's program, including:

- select emergency procedures (EPs)
- EP-RO-020, Attachment 2.1, "Emergency Locker Inventory"
- current FM-104, "MURR Emergency Call List"
- MURR annual on-site emergency drill scenarios for 2019 and 2020
- presentation, "Emergency Preparedness Drill, All-Staff Review," for 2019 and 2020
- "Emergency Plan, University of Missouri Research Reactor," Revision 20, dated January 3, 2019
- letter from, "Office of City Manager, RE: City of Columbia Fire Department Response," dated December 19, 2018

b. Observations and Findings

(1) Emergency Plan and Implementing Procedures

The inspector reviewed the E-Plan in use at the facility. The inspector verified that the latest update on January 3, 2019, was made in accordance with the requirements of 10 CFR 50.54, "Conditions of licenses," paragraph (q). The inspector noted that the E-Plan, as revised, continued to meet the requirements in Appendix E to 10 CFR Part 50. The inspector reviewed the E-Plan implementing procedures in use at the facility and verified updates were made using the MURR procedure review, revision, control, and implementation program. The inspector verified that the E-Plan and emergency procedures were reviewed annually as required.

(2) Emergency Equipment and Inventories

The inspector verified that emergency equipment lockers were maintained at the University of Missouri (MU) Police Department Headquarters and in the MURR Lobby Storage Room. The lockers were properly maintained and inventoried on a quarterly basis as required by the E-Plan. The inspector determined that emergency call lists was

revised and updated as needed and were available in the control room, the front lobby, and in the various controlled copies of MURR EPs manuals as required by the E-Plan.

(3) Drills

Through record reviews, the inspector determined that emergency drills were conducted annually and included the participation of off-site support groups on a biennial basis. The inspector found that scenarios written for the drills were challenging and critiques were held by the participants following the drills. The inspector observed that the drills were well documented and noted strengths and areas for improvement.

(4) Training

Through records review, the inspector determined that emergency training for operators were completed and tracked through the operator requalification program. The inspector verified that facility emergency organization personnel participated in annual training as required by the E-Plan. Emergency preparedness and response training for emergency support organizations were completed biennially, as required.

(5) Offsite Support

The inspector, accompanied by the Reactor Manager, visited the MU hospital and met with the Coordinator for Safety and Emergency Management. The inspector toured the emergency receiving and decontamination area and discussed equipment, capabilities, staffing, training, and response. The hospital would provide response to the facility in case of emergency and participated in larger emergency drills organized by MURR. The inspector also verified that MOUs between the licensee and various support agencies were maintained as required by the E-Plan.

c. Conclusion

The inspector verified that the emergency preparedness program was conducted in accordance with the E-Plan.

**9. Follow-up**

a. Inspection Scope (IP 69006, IP 92701)

The inspector reviewed licensee-submitted reports and associated documentation, including:

- letter from the licensee to the NRC regarding a deviation from TS 3.2.a and TS 3.2.f.8, dated December 17, 2019 (LER 19-06), and the associated CAP Report No. 19-0136



- letter from the licensee to the NRC regarding a deviation from TS 3.2.a and TS 3.2.f.8, dated December 23, 2019 (LER 19-07), and the associated CAP Report No. 19-0140
- letter from the licensee to the NRC regarding a deviation from TS 3.2.a and TS 3.2.f.8, dated April 20, 2020 (LER 20-01), and the associated CAP Report No. 20-0042
- letter from the licensee to the NRC regarding a deviation from TS 3.2.f.8, dated April 20, 2020 (LER 20-02), and the associated CAP Report No. 20-0043
- electronic mail from the licensee to the Idaho National Laboratory representative handling Department of Energy (DOE) fuel matters, dated September 14, 2020, which contained information regarding damage to a new fuel element
- NRC IFI 05000186/2019-202-01 concerning the need for enhanced work control training for licensee personnel

b. Observations and Findings

The inspector reviewed the licensee's actions taken in response to four self-identified deviations from TS 3.2.a and TS 3.2.f.8, a new fuel damage event, and a previously identified IFI.

(1) TS TS 3.2.a and TS 3.2.f.8 deviations:

Example 1 - LER 19-06. TS 1.15 states that a component or system is "Operable" when that component or system is capable of performing its intended function. TS 1.23, states that, "[t]he reactor shall be considered in operation unless it is either shutdown or secured." TS 3.2.a states that, "[a]ll control blades, including the regulating blade, shall be operable during reactor operation." Additionally, TS 3.2.f.8 specifies that, "[t]he reactor shall not be operated unless the following rod run-in functions are operable. Each of the rod run-in functions shall have 1/N logic where N is the number of instrument channels required for the corresponding mode of operation." Rod Run-In Function No. 8 under this Specification requires that the two rod run-in functions "≤ 10% withdrawn" or "bottomed," associated with the regulating blade must be operable when the reactor is in operation.

On December 10, 2019, with the reactor operating at 10 MW in the automatic control mode, a "Channel 4, 5, or 6 Downscale" annunciation was received. Additionally, the control room operators noted that reactor power was decreasing even though the reactor was in "automatic" which should have maintained reactor power at 10 MW automatically. About one minute later a "Reg. Blade Out of Auto" annunciation was received. The lead SRO (LSRO) immediately initiated a manual scram. Upon investigation it was discovered that the rod position indication (RPI) encoder drive chain fell off the regulating blade drive mechanism (RBDM) lead screw adapter drive sprocket. This caused a malfunction of the regulating blade.

The licensee took corrective actions as follows: 1) the reactor was shut down (as noted above), 2) the RBDM was removed for inspection and

troubleshooting, 3) the RPI encoder drive chain was placed back on its associated sprockets and the drive chain adjusted for proper alignment and tension, and, 4) the RBDM was cycled many times in the test stand in the instrumentation shop prior to re-installation. After installation in the reactor, the mechanism was again tested and permission to restart the reactor was obtained from the Acting Reactor Facility Director. The event was also placed into the MURR CAP system as CAP 19-0136. The inspector reviewed the actions taken and verified that the corrective actions were appropriate.

Example 2 - LER 19-07. All the TS Sections quoted in Example 1 above apply to Example 2.

On December 19, 2019, with the reactor operating at 10 MW in the automatic control mode, a “Channel 4, 5, or 6 Downscale” annunciation was received. As happened on December 10, 2019, the control room operators noted that reactor power was decreasing even though the reactor was in “automatic” which should have maintained reactor power at 10 MW automatically. The RO placed the reactor in the manual control mode and attempted to shim the regulating blade in the inward direction to verify operation. When the blade did not respond, the operator immediately initiated a manual scram and followed procedures for a reactor scram. Upon visual inspection of the RBDM, no abnormalities were found. The RPI encoder and rotary limit switch drive chains were still properly attached. The drive mechanism was removed and transferred to the instrumentation shop for inspection and troubleshooting. It was then determined that the drive mechanism servomotor seized. This caused a malfunction of the regulating blade.

The licensee took corrective actions as follows: 1) the reactor was shut down (as noted above), 2) the RBDM was removed for inspection and troubleshooting, and, 3) the servomotor for the RBDM was replaced with a new one and cycled many times in a test stand prior to re-installation. The mechanism was reinstalled in the reactor and tested again. Permission to restart the reactor was obtained from the Reactor Facility Director. The event was also placed into the MURR CAP system as CAP 19-0140. The inspector reviewed the actions taken and verified that the corrective actions were appropriate.

Example 3 - LER 20-01. All the TS Sections quoted in Example 1 above apply to Example 3.

On April 8, 2020, with the reactor operating at 10 MW in the automatic control mode, the control room operators noted that reactor power was decreasing even though the reactor was in “automatic” which should have maintained reactor power at 10 MW automatically. Approximately one minute later the regulating blade was deemed to be inoperable when the RPI encoder drive chain was found off its sprockets. The reactor was immediately shut down by manual scram and all emergency procedures were completed for a reactor scram. Initial investigation revealed that the RBDM RPI encoder drive chain disengaged. The drive mechanism was removed and taken to the instrumentation shop for inspection and troubleshooting. It was determined that a pin inside the drive mechanism, which holds the drive gear to the

gearbox output shaft, was broken. This caused a malfunction of the regulating blade.

The licensee took corrective actions as follows: 1) the reactor was shut down (as noted above), 2) the RBDM was removed for inspection and troubleshooting, and, 3) the RBDM gearbox was replaced, the RPI encoder drive chain was placed back on its associated sprockets, the drive chain aligned, and the rotary limit switch drive chain was aligned. The drive mechanism was then cycled many times in a test stand prior to re-installation. After the mechanism was installed in the reactor, it was again tested and permission to restart the reactor was obtained from the Reactor Facility Director. The event was also placed into the MURR CAP system as CAP 20-0042. The inspector reviewed the actions taken and verified that the that the corrective actions were appropriate.

Example 4 - LER 20-02. All the TS Sections quoted in Example 1 above apply to Example 4.

On April 9, 2020, with the reactor operating at 10 MW in the automatic control mode, the LSRO was conducting a routine patrol of the facility. The LSRO noticed that the geared rotary limit switch assembly was not moving with corresponding RBDM movement. The reactor was immediately shut down by manual scram. Upon investigation, it was discovered that the two setscrews that couple the upper RPI encoder sprocket to the RPI encoder drive shaft were not tightened onto the two flat areas of the encoder drive shaft. It was determined that the setscrews were tightened against the rounded portion of the RPI encoder drive shaft, not the flat areas, the previous day. Eventually the rotary shaft drive force overcame the setscrews' friction and allowed slippage between the sprocket setscrews and the rounded portion of the shaft. This caused a malfunction of the regulating blade.

The licensee took corrective actions as follows: 1) the reactor was shut down (as noted above), 2) the RBDM was removed for inspection and troubleshooting, 3) after replacing the RPI encoder drive shaft, all RBDM setscrews had thread lock applied and were checked to ensure that they were tight, and, 4) the RBDM was cycled many times in the test stand in the Instrumentation Shop prior to re-installation. Following installation of the mechanism in the reactor, it was tested again and found to be operational. Permission to restart the reactor was obtained from the Reactor Facility Director and the event was also placed into the MURR CAP system as CAP 20-0043. The inspector reviewed the actions taken and verified that the corrective actions were appropriate.

The licensee subsequently implemented a final long-term corrective action for this problem when a redesigned RBDM was installed in the reactor on April 13, 2020. The new design involved relocating the regulating blade rotary limit switch functions directly to the drive mechanism lead screw assembly actuated by linear limit switches. It also incorporated flexible shaft couplings that allow for slight misalignments, industry standard linear microswitches that replace the antiquated rotary limit switch assembly, a more robust gearbox, and no drive chains. The new drive mechanism was

installed in the reactor after extensive testing, which simulated approximately six months of actual operation. No RBDM malfunctions were noted since the newly designed model was installed.

The licensee was informed by the inspector that the aforementioned failures of the regulating blade to be operable during reactor operation were violations of TS 3.2.a and 3.2.f.8. As indicated above, the inspector determined that each failure was identified by the licensee, reported to the NRC, and entered into the CAP. Corrective actions were identified following each event and was completed as well. As a result, the inspector informed the licensee that these failures represented four examples of one non-willful, non-repetitive (because each was a different causal factor), licensee-identified, and licensee-corrected violation and would be treated as an NCV, consistent with Section 2.3.2.a of the NRC Enforcement Policy (NCV 05000186/2020-202-01).

The inspector determined that these LERs and the issue of regulating blade malfunctions are considered closed.

(2) Damage to a new fuel element designated as MO-993

By an electronic mail message from the MURR Associate Director, Reactor and Facilities Operations to the DOE representative at the Idaho National Laboratory for research reactor fuel program dated September 14, 2020, the representative was informed of an event involving damage to a new fuel element. DOE informed the NRC of the event approximately one week later.

On the evening of August 23, 2020, the MURR reactor operations crew transferred two fresh fuel elements from storage to the reactor pool area. While lowering one of the new fuel elements into the reactor pool storage location using a rope, the rope became caught in the fuel element roller gap. The operations crew latched onto the element with the facility fuel tool and moved it to the inspection rig. The rope interfered with the fuel tool so it could not be unlatched from the fuel element. The LSRO and crew decided to hand lift the fuel tool with the element latched onto it while also raising the inspection rig. When the operators tried to hold the 30-foot long fuel tool while removing it vertically from the pool, they lost control of the fuel tool with the fuel element attached. The fuel tool and element dropped until the rope tied between the top of the fuel tool and an overhead crane became taut. This caused the fuel tool and attached element to swing widely in the pool. The fuel element collided with the side of the pool and other equipment in the pool. The element sustained various scratches and one of the fuel plates was dented making the element unusable.

The licensee investigated the event and determined that there were several causes for what occurred. These included lack of procedural guidance, lack of management oversight, and a lack of safety focused decision-making by not stopping actions when the crew was unsure of how to correct the problem. The inspector found that corrective actions were taken to prevent reoccurrence including fabricating a new basket for lowering the new fuel into the reactor pool. The inspector was shown the new basket during the

inspection. After placing the new element in the basket, it could then be safely placed into the proper fuel storage position. The inspector found the fuel handling procedure was also revised to address all the problems identified with the process. The licensee also now requires that a Reactor Operations' manager be onsite during any fuel movement. In addition, training for all ROs and managers on this event and other lessons learned was scheduled. The licensee was informed by the inspector that the completion of all these corrective actions will be considered an IFI by the NRC and will be reviewed during subsequent inspections (IFI 05000186/2020202-02).

### (3) Follow-up on Enhanced Work Control Training

LER 19-04. This LER dealt with an event that occurred on January 27, 2019. The LER reported the reactor containment building automatically-closing doors were found to be inoperable while scheduled maintenance was occurring on two shim control rod drive mechanisms. This was contrary to TS 3.4.b. The cause was subsequently determined by the licensee to be due to electrical breakers for the automatically-closing doors that were opened during unscheduled electrical preventative maintenance. Corrective actions were initiated and the event was entered into the MURR CAP as CAP 19-0097. The licensee's corrective actions included improvements to training on work authorization, procedural compliance, and TS-required system equipment identification. Because continued enhanced training was planned for a later date, the licensee was informed that the implementation of enhanced work control training would be tracked by the NRC as an IFI and would be reviewed during a future inspection (IFI 05000186/2019-202-01).

During this inspection, the inspector reviewed the issue of enhanced work control training. The inspector determined that, following the initial training which occurred at the time of the event, additional training was conducted on October 11, 2019. The issue was also added into the licensee's work control system (Maximo) to generate a recurring requirement for this training to be continued in the future. The inspector determined that additional enhanced training was conducted on July 10, 2020, concerning reactor-related electrical/electronic equipment recognition. This training was given to facility electrical technicians to assist them in recognizing what reactor related equipment would require permission from reactor operations personnel before work on the system(s) was initiated. The inspector determined that the recurring training requirement was established and the system is in place to ensure that ongoing training will occur. This issue is considered closed.

#### c. Conclusion

The inspector reviewed four examples of one Severity Level IV NCV and determined they are closed. One previously identified IFI was closed and one new IFI was opened.

**10. Exit Interview**

The inspection scope and results were reviewed with the licensee on November 6, 2020. The inspector discussed the findings for each area reviewed. The licensee acknowledged the findings.

## **PARTIAL LIST OF PERSONS CONTACTED**

### **Licensee Personnel**

C. Braun	Interim Assistant Reactor Manager – Engineering
R. Dobey	Technical Advisor
D. Doenges	Health Physics and Safety Manager
B. Fairchild	Assistant Health & Safety Manager - Training
L. Foyto	Associate Director, Reactor and Facilities Operations
K. Kutikkad	Assistant Reactor Manager – Physics
A. Luehbering	Lead Senior Reactor Operator
J. Matyas	Access Control Manager
B. Meffert	Reactor Operations Manager
L. Primmer	Electrical Technician
D. Rathke	Document Management Coordinator
D. Robertson	Executive Director
S. Schaefer	Assistant Reactor Manager

### **Other Personnel**

P. Van Hunnik      Safety and Emergency Preparedness Coordinator, MU Health

## **INSPECTION PROCEDURES USED**

IP 69003	Class I Research and Test Reactor Operator Licenses, Requalification, and Medical Examinations
IP 69005	Class I Research and Test Reactor Experiments
IP 69006	Class I Research and Test Reactor Organization and Operations, and Maintenance Activities
IP 69007	Class I Research and Test Reactor Review and Audit and Design Change Functions
IP 69008	Class I Research and Test Reactor Procedures
IP 69009	Class I Research and Test Reactor Fuel Movement
IP 69010	Class I Research and Test Reactor Surveillance
IP 69011	Class I Research and Test Reactor Emergency Preparedness
IP 97201	Followup

## **ITEMS OPENED, CLOSED, AND DISCUSSED**

### **Opened**

05000186/2020-202-01	NCV	Four examples of failure of the regulating blade to be operable during reactor operation as required by TS 3.2.a and 3.2.f.8.
05000186/2020-202-02	IFI	Follow-up on the completion of all the corrective actions identified following the new fuel damage event of August 23, 2020.

Closed

05000186/2019-202-01 IFI Follow-up on implementation of enhanced work control training

05000186/2020-202-01 NCV Four examples of failure of the regulating blade to be operable during reactor operation as required by TS 3.2.a and 3.2.f.8.

**LIST OF ACRONYMS USED**

10 CFR	Title 10 of the <i>Code of Federal Regulations</i>
CAP	Corrective Action Program
CP	Compliance Procedure
DOE	Department of Energy
EP	Emergency Procedure
E-Plan	Emergency Plan
IFI	Inspector Follow-Up Item
IP	Inspection Procedure
LER	Licensee Event Report
LSRO	Lead Senior Reactor Operator
MOU	Memoranda of Understanding
MU	University of Missouri
MURR	Missouri University Research Reactor
MW	Megawatt
NCV	Non-Cited Violation
NRC	U.S. Nuclear Regulatory Commission
RAC	Reactor Advisory Committee
RBDM	Regulating Blade Drive Mechanism
RO	Reactor Operator
RUR	Reactor Utilization Request
SRO	Senior Reactor Operator
TS	Technical Specification