University of Missouri

Research Reactor Center
1513 Research Park Drive
Columbia, MO 65211
PHONE 573-882-4211
WEB murr.missouri.edu

August 9, 2021

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

REFERENCE: Docket No. 50-186
University of Missouri-Columbia Research Reactor
Renewed Facility Operating License No. R-103

SUBJECT: Written communication as required by University of Missouri Research Reactor Technical Specification 6.6.c(3) regarding a deviation from Technical Specifications 3.2.a

The enclosed document provides the University of Missouri-Columbia Research Reactor (MURR) Licensee Event Report (LER) for an event that occurred on July 26, 2021, that resulted in a deviation from MURR Technical Specifications 3.2.a.

If you have any questions regarding this report, please contact Bruce A. Meffert, the facility Reactor Manager, at (573) 882-5118.

Sincerely,

J. David Robertson, PhD
Reactor Facility Director

JDR:jlm

Enclosure

xc: Reactor Advisory Committee
Reactor Safety Subcommittee
Dr. Thomas Spencer, Interim Vice Chancellor for Research and Economic Development
Mr. Geoffrey Wertz, U.S. Nuclear Regulatory Commission
Mr. Craig Bassett, U.S. Nuclear Regulatory Commission

Enclosure
U.S. Nuclear Regulatory Commission
August 9, 2021

Licensee Event Report No. 21-01 – July 26, 2021
University of Missouri Research Reactor

Introduction

On July 26, 2021, during a normal reactor startup with the reactor operating in a subcritical condition in the manual control mode, the 'Blade Full In' light illuminated for shim control blade 'B.' Although rod position indication for control rod drive mechanism (CRDM) 'B' indicated a control blade height of approximately 10.30 inches, inspection revealed that the ball screw for CRDM 'B' had detached from the top of the drive mechanism allowing the ball screw, electromagnet, and shim control blade 'B' to fall to the fully inserted position. The Lead Senior Reactor Operator (LSRO) directed another operator to shut down the reactor by initiating a manual scram by placing Master Control Switch 1S1 to the "TEST" position. The LSRO completed all immediate and applicable subsequent actions of reactor emergency procedure REP-8, "Control Rod Drive Mechanism Failure or Stuck Rod," and verified all shim control blades were fully inserted.

With the ball screw detached from the top of CRDM 'B,' CRDM 'B' was considered not operable. This resulted in a deviation from TS 3.2.a, which states, "*All control blades, including the regulating blade, shall be operable during reactor operation.*" Additionally, TS 1.15 states, "*Operable means a component or system is capable of performing its intended function.*" The basis for TS 3.2.a is to ensure that the normal method of reactivity control is used during reactor operation. All reactor safety system scram functions for shim control blades 'A,' 'C,', and 'D' were unaffected and remained operable during this event. Shim control blade 'B' failed in a safe condition due to gravity and downward pool coolant flow fully inserting the control blade.

Description of the Rod Control System

As described in Section 7.5, Rod Control System, of the MURR Safety Analysis Report (SAR), the reactivity of the reactor is controlled by five (5) neutron absorbing control blades. Each control blade is attached to a CRDM by means of a support and guide extension (offset mechanism). Four (4) of the control blades, referred to as the shim control blades, are used for coarse adjustments to the neutron density of the reactor core. The fifth control blade is a regulating blade. The low reactivity worth of this blade allows for very fine adjustments in the neutron density in order to maintain the reactor at the desired power level. The nominal speed of the shim control blades is one (1) inch per minute in the outward direction and two (2) inches per minute in the inward direction. Nominal speed of the regulating blade is 40 inches per minute in both the inward and outward directions.

The reactor is operated from the control console in either of two control modes: manual or automatic. Manual control is used for reactor start-up, changes in power level, and steady-state operation for short periods of time. Automatic control is selected only after a minimum power level has been attained and is used for long term steady-state operation.

The four (4) shim control blades are actuated by electromechanical CRDMs that position, hold, and scram each shim control blade. Each CRDM consists of a 0.02-HP, 115-volt, one-amp, single-phase, 60-cycle motor with a reduction gearbox connected to a ball screw assembly. The ball screw assembly converts the rotation of the worm gear reducer in the drive motor to the linear motion of the control blades. The drive motor rotates a brass adapter that is pinned to the ball screw. A ball nut coupled directly to the drive tube is driven inward or outward by the ball screw. At a point above the reactor pool water level, an electromagnet, connected to the bottom end of the drive tube, engages a cadmium-plated carbon steel anvil that is attached to the end of the lift-rod assembly. The lift-rod assembly positions a shim blade through a support and guiding (offset) mechanism mounted on a bracket attached to the reflector tank. Cam-operated micro switches mounted on each CRDM stop the drive motor at the upper and lower limits of travel.

The following indications are displayed on the reactor control console for each shim control blade:

1. 'Power On' - Power is available to the electromagnets;
2. 'Drive Full In' - Control rod drive mechanism is fully inserted;
3. 'Drive Full Out' - Control rod drive mechanism is fully withdrawn;
4. 'Magnet Engaged' - Electromagnet engaged to the anvil; and
5. 'Blade Full In' - Shim blade is fully inserted.

Detailed Event Description

On July 26, 2021, during a normal reactor startup with the reactor operating in a subcritical condition in the manual control mode, the 'Blade Full In' light illuminated for shim control blade 'B' while the rod position indication for CRDM 'B' indicated a control blade height of approximately 10.30 inches. The LSRO immediately stopped all rod motion to investigate the cause of the 'Blade Full In' indication. At that time, all four (4) shim blades were several inches below the estimated critical position of 16.75 inches for four-banked shim control blades.

The LSRO had another SRO go to the reactor pool to investigate the abnormal indication. The SRO visually verified that shim control blade 'B' was fully inserted. The SRO then investigated the cause for the control blade to be fully inserted even though the 'Magnet Engaged' indication was illuminated. The SRO determined that the ball screw for CRDM 'B' had detached from the top of the drive mechanism allowing the ball screw, electromagnet, and shim control blade 'B' to fall to the fully inserted blade position without the electromagnet separating from the anvil. At 17:31 CDT, the LSRO directed another operator to shut down the reactor by initiating a manual scram by placing Master Control Switch 1S1 to the "TEST" position. The LSRO completed all immediate and applicable subsequent actions of reactor emergency procedure REP-8, "Control Rod Drive Mechanism Failure or Stuck Rod," and verified all shim control blades were fully inserted.

After the reactor was secured, CRDM 'B' was removed for further investigation and a spare CRDM was installed into position 'B.' A restart plan was discussed and compliance procedure CP-10, "Rod Drop

Times," for shim control blade 'B' was performed satisfactorily. Performing CP-10 operated the CRDM and its associated offset mechanism with the control blade through its entire range of motion while staff members could observe the CRDM and offset mechanism for binding or other abnormalities. Permission from the Reactor Facility Director to resume reactor operation per TS 6.6.c(4) was obtained prior to reactor operation for CP-10. During CP-10, two staff members performed a careful visual and audible inspection to the entire assembly as it moved through its full range of travel. No abnormalities were discovered during this inspection, and the Reactor Manager deemed the spare CRDM operable. A normal reactor startup was performed, and the reactor returned to 10 MW operation at 20:24 CDT on July 26, 2021.

Safety Analysis

The basis for TS 3.2.a is to ensure that the normal method of reactivity control is used during reactor operation. The reactor operated in a subcritical condition in deviation of TS 3.2.a for a short time while an initial investigation was performed to discover the cause of the abnormal indications. During this time, the source range nuclear instrumentation power level data recorder indicated an average count rate of 76 counts per minute, consistent with a subcritical reactor condition. The full insertion of shim control blade 'B' into the core had no safety implications to the reactor.

At no time was the ability to scram the other shim blades, either through automatic initiation or manually by the control room operator, affected by this failure.

Corrective Actions

The LSRO completed all immediate and applicable subsequent actions of reactor emergency procedure REP-8, "Control Rod Drive Mechanism Failure or Stuck Rod," and verified all shim control blades were fully inserted. After the reactor was secured, the CRDM for shim control blade 'B' was removed for further investigation. A spare CRDM was installed into position 'B' and retested satisfactorily.

Troubleshooting of the failed CRDM revealed that the 3/32-inch roll pin, which connects the ball screw to the support and drive assembly at the top of the CRDM, was sheared (see Attachment 1). The 3/32-inch roll pin supports the approximately 50 pounds of weight of the lift-rod assembly and shim control blade. In addition, it transfers the rotational torque of the drive motor to the ball screw during normal control blade withdrawal and insertion.

The design of the shim CRDM and offset mechanism has basically been unchanged in MURR's 54+ years of operation. This is the first occurrence of a CRDM roll pin failure in MURR history.

After the failed roll pin was removed from the CRDM, MURR engineers and management analyzed the pin under microscopes. The images indicate a downward force on the ball screw sheared the roll pin. (see Attachment 2). No signs of repetitive fatigue force were apparent. Therefore, the focus of the cause is centered on a significant, one-time, downward force applied to the ball screw that left the roll pin in a very weakened condition. Since the most probable time for such a force to be applied is prior to CRDM

installation into the reactor, CRDM handling and testing outside of the installed reactor position is being examined for potential improvement opportunities.

During the next scheduled CRDM preventive maintenance, the roll pin will be inspected in each of the other CRDMs. In addition, MURR electronic maintenance procedure EMP-12C, "Control Rod Drive Mechanism (CRDM) Relay Renewal and Magnet Pull Tests," will be revised to add an inspection of the roll pin for deformation or damage.

Additionally, this event has been entered into the MURR Corrective Action Program as CAP No. 21-0066, and any additional information or corrective actions will be considered and documented in that CAP entry.

If there are any questions regarding this LER, please contact me at (573) 882-5118. I declare under penalty of perjury that the foregoing is true and correct.

Sincerely,

Sean Schaefer Acting Reactor Manager

Bruce A. Meffert
Reactor Manager

ENDORSEMENT:
Reviewed and Approved,

J. David Robertson, PhD
Reactor Facility Director

Attachments:

1. As-Found Condition of the Broken Roll Pin in the Ball Screw and Brass Adapter
2. Magnified Picture of the Three (3) Parts of the CRDM Broken Roll Pin

State of Missouri
County of Boone

Subscribed and sworn before me this
9th day of August, 2021.

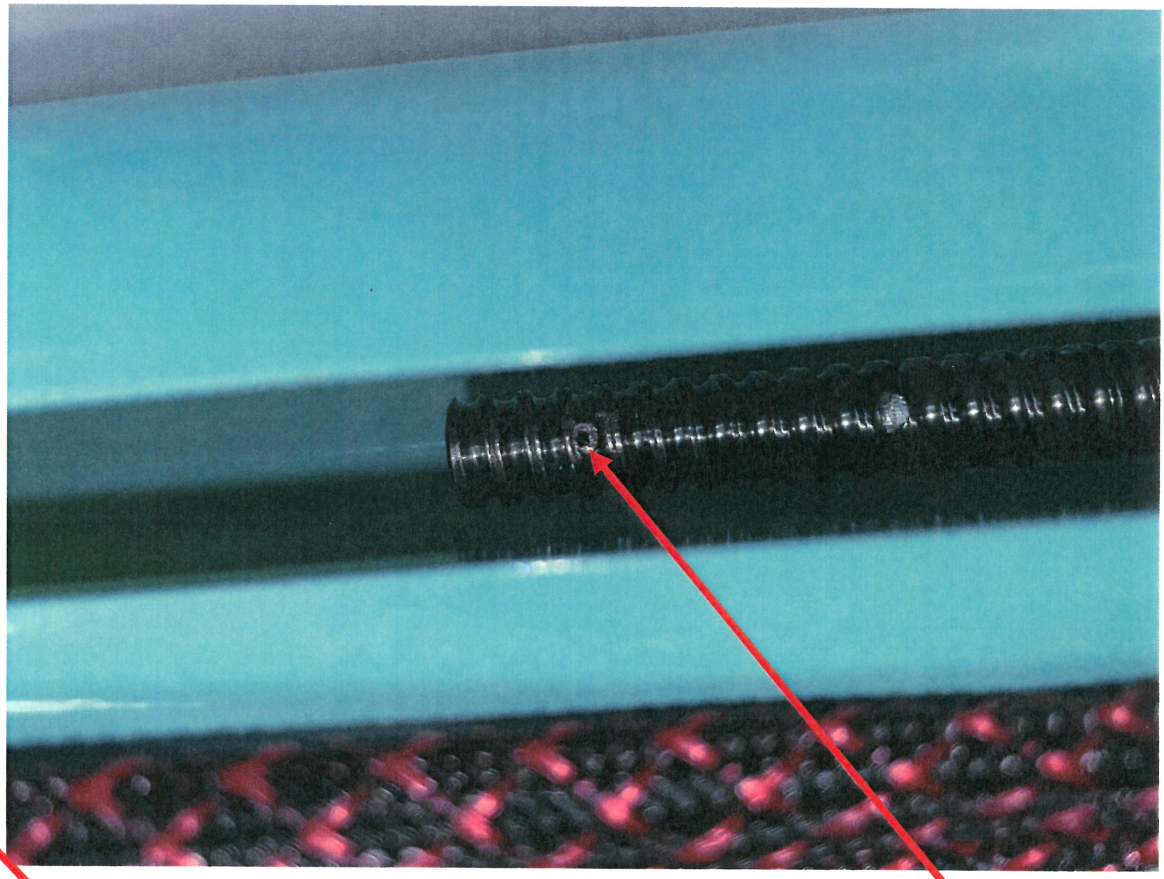
Jacqueline L Matyas

JACQUELINE L. MATYAS, Notary Public
My Commission Expires: March 26, 2023

NOTARY PUBLIC NOTARY SEAL STATE OF MISSOURI

JACQUELINE L. MATYAS
My Commission Expires
March 26, 2023
Howard County
Commission #15634308

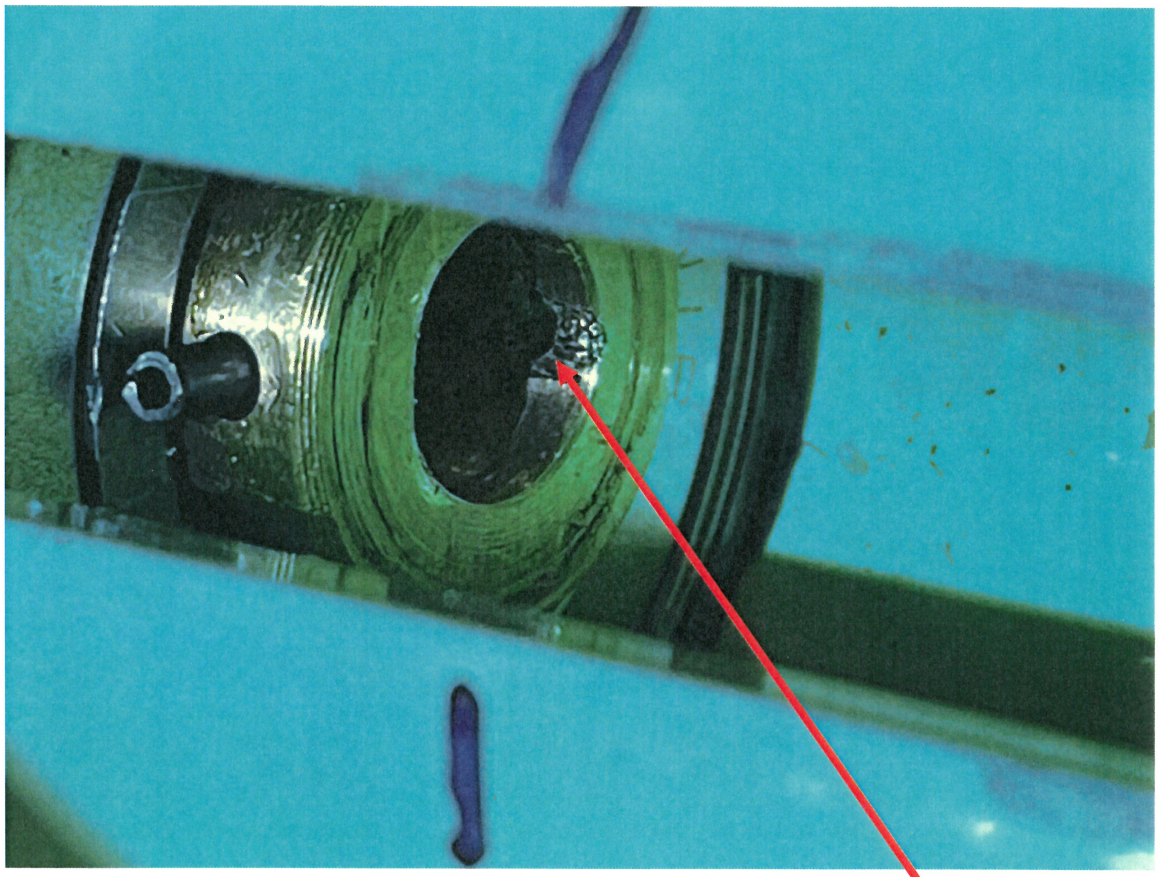
ATTACHMENT 1



Failed Roll Pin

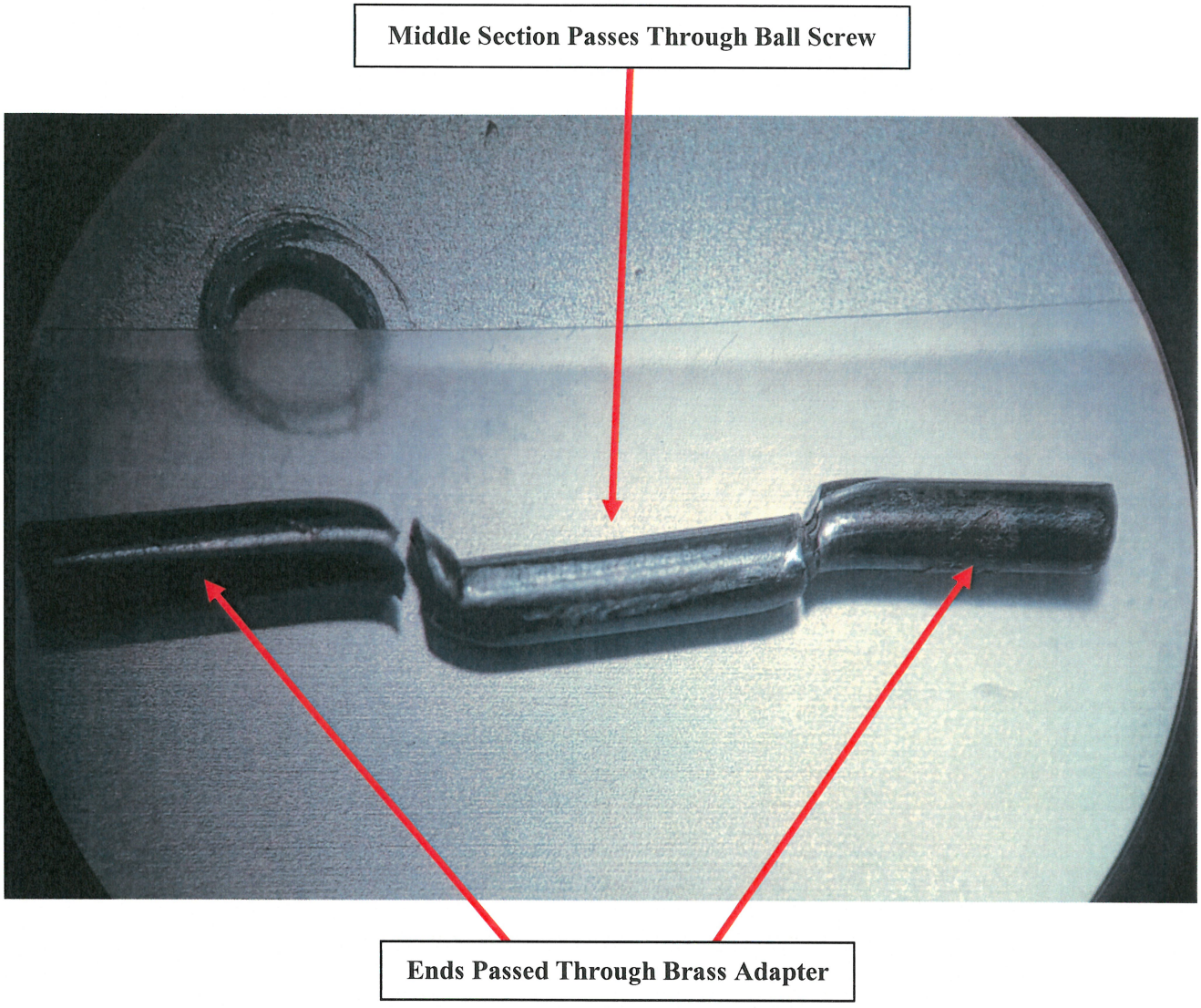
CRDM Ball Screw Connection Point to Brass Adapter is off of this picture to the left
(see Brass Adapter next page)

As-Found Condition of the Broken Roll Pin in the Ball Screw
(Normal CRDM Orientation: The Left Side of the Picture is UP)



As-Found Condition of the Broken Roll Pin in the Brass Adapter

ATTACHMENT 2



Magnified Picture of the Three (3) Parts of the CRDM Broken Roll Pin
(up is towards the top of this page)