UNIVERSITY *of* MISSOURI

RESEARCH REACTOR CENTER

December 23, 2019

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 and 3.2.f.8.

The attached document provides the University of Missouri-Columbia Research Reactor (MURR) Licensee Event Report (LER) for an event that occurred on December 19, 2019, that resulted in a deviation from MURR Technical Specifications 3.2.a and 3.2.f.8.

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. Mark McIntosh, Vice Chancellor for Research, Graduate Studies and Economic Development
Mr. Geoffrey Wertz, U.S. Nuclear Regulatory Commission
Mr. William Schuster, U.S. Nuclear Regulatory Commission

A020
NRR

1513 Research Park Drive Columbia, MO 65211 Phone: 573-882-4211 Fax: 573-882-6360 Web: www.murr.missouri.edu

Licensee Event Report No. 19-07 – December 19, 2019
University of Missouri Research Reactor

Introduction

On December 9, 2019, with the reactor operating at 10 MW in the automatic control mode, a "Channel 4, 5 or 6 Downscale" annunciation was received. This alarm is initiated when any one (1) of the three (3) Nuclear Instrumentation (NI) Power Range Monitor (PRM) channels decreases below a power level set point of 95%. Additionally, the control room operators noted that reactor power level was decreasing even though the reactor was in the automatic control mode – which should have been maintaining reactor power level at 10 MW automatically without any operator involvement. The reactor operator placed the reactor in the manual control mode and attempted to shim the regulating blade in the inward direction to verify operation. When the regulating blade did not respond, the reactor operator immediately initiated a manual scram and all immediate and subsequent actions of reactor emergency procedures REP-2, "Reactor Scram," and REP-7, "Rod Position Indication System Failure," were completed. A reactor operator was then directed to the reactor bridge to inspect the regulating blade drive mechanism. Visual inspection revealed no abnormalities – the rod position indication (RPI) encoder and rotatory limit switch drive chains were still properly attached.

Failure of the regulating blade to be operable during reactor operation resulted in a deviation from Technical Specification (TS) 3.2.a, which states, *"All control blades, including the regulating blade, shall be operable during reactor operation."* Additionally, the regulating blade failure prevented the "≤ 10% withdrawn" rod run-in function from being operable. Therefore, a deviation from TS 3.2.f.8 had also occurred. TS 3.2.f.8 specifies that *"The 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 (2) rod run-in functions, "≤ 10% withdrawn" or "bottomed," associated with the regulating blade must be operable when the reactor is in operation.

Description of the Regulating Blade and Drive Mechanism

The reactivity of the reactor is controlled by five (5) neutron-absorbing control blades. Four (4) of the control blades, referred to as the shim blades, are used for coarse adjustments to the neutron density of the reactor core. The fifth control blade is the 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 regulating blade is constructed of stainless steel with an overall length of approximately 30 inches, occupying about 18° of the circular arc around the outer reactor pressure vessel. The blade is driven at 40 inches per minute in both the inward and outward directions by its associated drive mechanism. The regulating blade drive mechanism consists of a servomotor, a reduction gearbox, and a lead screw assembly. The lead screw assembly converts the rotating motion of the servomotor to the linear motion of the regulating blade. The drive mechanism, through a connected sprocket and chain arrangement, also drives an RPI encoder transducer and a rotary limit switch assembly. The encoder transducer provides an

analog signal to the RPI chassis, which converts the analog signal to a digital readout that is displayed on the control room instrument panel and control console. The rotary limit switch assembly actuates two (2) regulating blade position alarm functions (20% and 60% withdrawn) and a rod run-in (≤ 10% withdrawn). A second rod run-in is initiated by a limit switch, which is independent of the rotary limit switch assembly, when the regulating blade is fully inserted or "bottomed."

The regulating blade may be operated from the control console in either one of two modes: manual or automatic. In the automatic control mode, the regulating blade controls reactor power by comparing the output signal from the NI WRM with the setting of the power schedule potentiometer as determined by the reactor operator. If a mismatch does exist, a positive or negative output signal is generated and sent to the servomotor of the regulating blade drive mechanism, which repositions the regulating blade, stepwise, in a direction which minimizes the discrepancy between the power schedule setting and the actual power level. Over the course of the week, while in the automatic control mode, the regulating blade frequently repositions to make minor adjustments to maintain power at the desired level.

Detailed Event Description

At 21:20 on December 19, 2019, with the reactor operating in the automatic control mode, a "Channel 4, 5 or 6 Downscale" annunciation was received. This alarm is initiated when any one (1) of the three (3) NI PRM channels decreases below a power level set point of 95%. Additionally, the control room operators noted that reactor power level was decreasing even though the reactor was in the automatic control mode – which should have been maintaining reactor power level at 10 MW automatically without any operator involvement. The reactor operator placed the reactor in the manual control mode and attempted to shim the regulating blade in the inward direction to verify operation. When the regulating blade did not respond, the reactor operator immediately initiated a manual scram and all immediate and subsequent actions of reactor emergency procedures REP-2, "Reactor Scram," and REP-7, "Rod Position Indication System Failure," were completed.

After the manual scram was initiated, a reactor operator was then directed to the reactor bridge to inspect the regulating blade drive mechanism. Visual inspection revealed no abnormalities – the rod position indication (RPI) encoder and rotatory limit switch drive chains were still properly attached. The regulating blade drive mechanism was removed and transferred to the Instrumentation Support shop for inspection and troubleshooting. It was determined that the regulating blade drive mechanism servomotor had seized.

Failure of the regulating blade to be operable 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, with the RPI encoder drive chain disengaged, the regulating blade drive mechanism cannot move the rotary limit switch sprockets. Therefore, a deviation from TS 3.2.f.8 had also occurred. TS 3.2.f.8 specifies that "*The 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 (2) rod run-in functions, "≤ 10% withdrawn" or "bottomed," associated

with the regulating blade must be operable when the reactor is in operation. The "≤ 10% withdrawn" rod run-in function was not operable during this event.

Safety Analysis

Preceding the failure, the reactor had been at full power operation with the regulating blade properly maintaining reactor power level at 10 MW in the automatic control mode for a period of 75 hours and 49 minutes. A review of the NI WRM and PRMs reactor power data confirms that the regulating blade was operational and maintaining reactor power level between 17:31 on December 16 and 21:20 on December 19. At 21:20 on December 19, reactor power level on all NI channels started to decrease; therefore, it appears that the regulating blade was inoperable for a period of approximately one (1) minute before the reactor was shut down.

The regulating blade and its associated rod run-in features are not part of the reactor safety system as defined by TS 1.24, which states, "*The reactor safety system is that combination of sensing devices, electronic circuits and equipment, signal conditioning equipment, and electro-mechanical devices that serves to either effect a reactor scram, or activates the engineered safety features.*" When a reactor scram or rod run-in occurs, the regulating blade is automatically shifted to manual control to prevent it from attempting to maintain power.

The basis for the rod run-in features associated with the regulating blade is to assure termination of a transient which, in automatic operation, is causing a rapid insertion of the regulating blade. The regulating blade "≤ 10% withdrawn" rod run-in is not required to prevent reaching a Limiting Safety System Setting (LSSS). The redundant regulating blade "bottomed" rod run-in was operable during the time the "≤ 10% withdrawn" rod run-in was inoperable.

Corrective Action

The reactor was shut down by manual scram when it was determined that the regulating blade was inoperable. The regulating blade drive mechanism was removed and transferred to the Instrumentation Support shop for inspection and troubleshooting. It was determined that the regulating blade drive mechanism servomotor had seized – see photos on pages 6 and 7. The lower rotor bearing would not rotate and there were circular rub marks on the lower 1/3rd of the rotor which were caused by the stator as the bearing failed. The last photo shows damage to the servomotor stator from the rotor. The current servomotor is a Diehl Manufacturing Company Model No. F 12004, 115V, 60 Hz, 25 Watts.

The servomotor for the regulating blade drive mechanism was replaced with a brand new one and the drive mechanism was cycled across its full range 10 times in a test stand prior to re-installation. The regulating blade drive mechanism was then reinstalled and connected to the regulating blade. The regulating blade was cycled across its full range two (2) times prior to pre-startup checks. No visual or audible abnormalities with the chain, sprockets, shafts, RPI, or rotary switch assembly operation were noted during these cycle tests.

The "Regulating Blade Operation And Rod Run-In Function Test" portion of form FM-57, "Long Form Startup Checksheet," was completed satisfactorily as a pre-startup final test of proper operation of the regulating blade drive mechanism and its rotary limit switch assembly. Permission to restart the reactor was obtained from the Reactor Facility Director in accordance with TS 6.6.c.

It should be noted that in over 53 years of operation, this is the first failure of the regulating blade drive mechanism servomotor during reactor operation. As discussed in LER No. 19-06, significant progress has been made in the long-term corrective action of designing and fabricating a new regulating blade drive mechanism. The design has been finalized, the new drive mechanism has been fabricated and initial testing was satisfactorily completed. The new regulating blade drive mechanism was then disassembled so certain components could be anodized and powder coated for final assembly. Reassembly should occur within a week after the anodized and powder coated parts are received with final testing completed approximately two (2) months afterwards. Installation is tentatively scheduled for late March/early April. The new servomotor is a Groschopp Model No. A C8040FC-RA2605T, 115V, 60 Hz, 74 Watts. It is a much more robust motor than the current servomotor.

Additionally, this event has been entered into the MURR Corrective Action Program as CAP entry No. 19-0140, and any additional improvements or corrective actions will be considered.

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,

Bruce A. Meffert
Reactor Manager

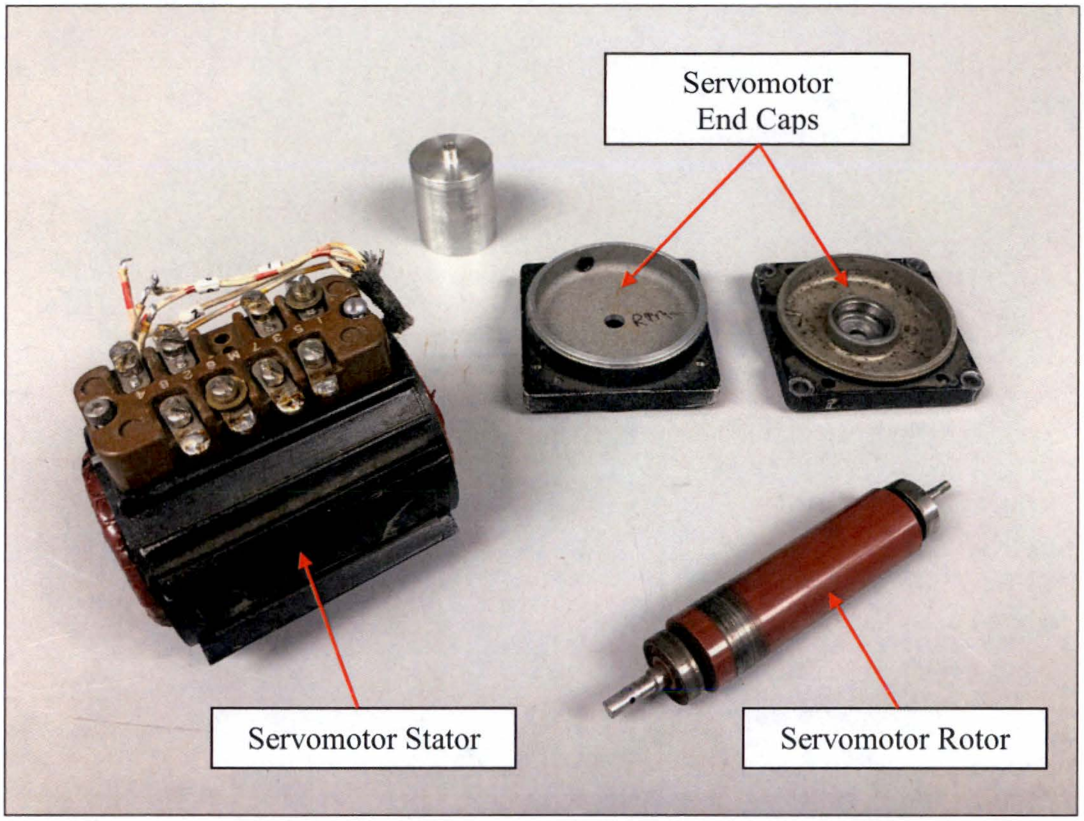
ENDORSEMENT:
Reviewed and Approved,

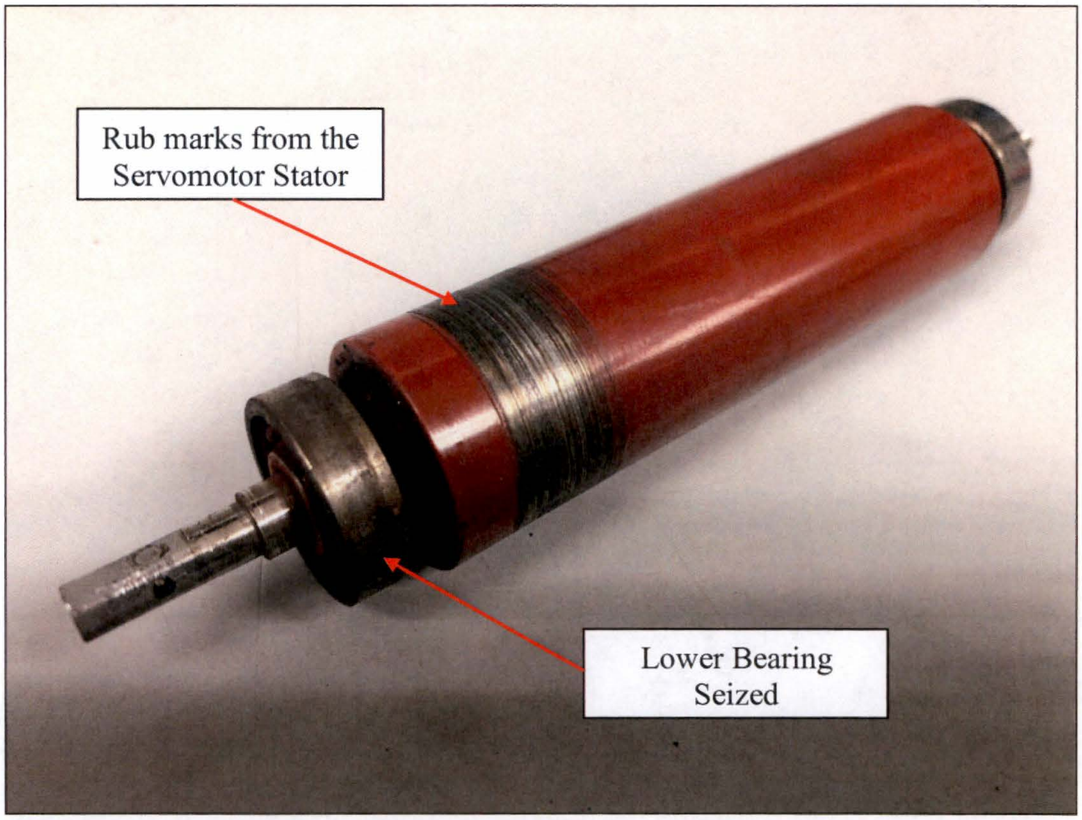
J. David Robertson, PhD
Reactor Facility Director

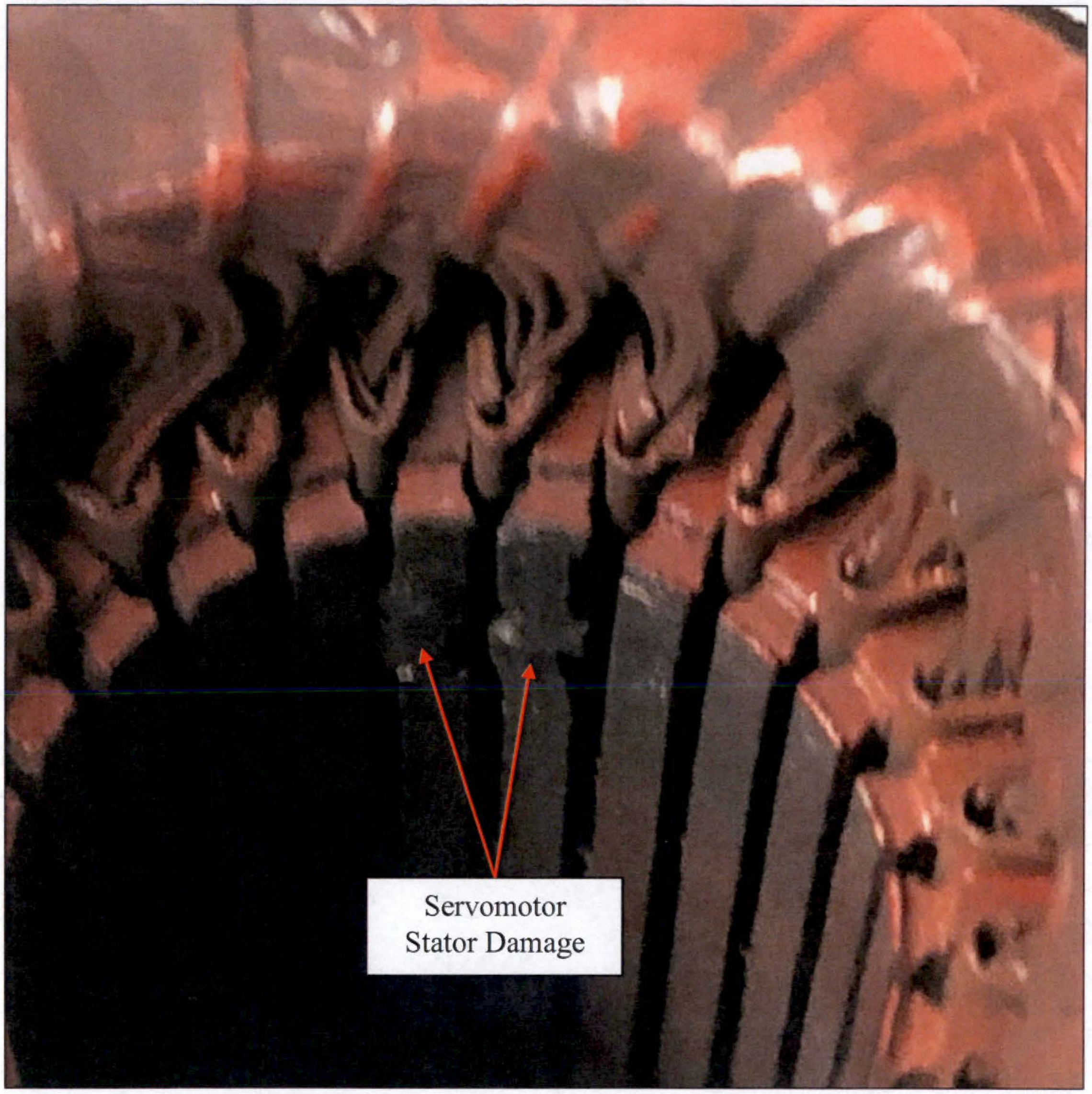
D Kristine Gorham
12/23/19

D KRISTINE GORHAM
Notary Public – Notary Seal
Boone County – State of Missouri
Commission Number 17403363
My Commission Expires Mar 5, 2021

Failed Regulating Blade Drive Mechanism Servomotor Disassembled






Servomotor
Stator Damage