UNIVERSITY *of* MISSOURI

RESEARCH REACTOR CENTER

April 15, 2015

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Station P1-37
Washington, DC 20555-0001

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

SUBJECT: Written communication as required by University of Missouri Research Reactor Technical Specification 6.1.h(2) regarding a deviation from Technical Specifications 3.2.a and 3.4.c

The attached document provides the University of Missouri-Columbia Research Reactor (MURR) Licensee Event Report (LER) for an event that occurred on March 21, 2015, that resulted in a deviation from MURR Technical Specifications 3.2.a and 3.4.c.

If you have any questions regarding this report, please contact John L. Fruits, the facility Reactor Manager, at (573) 882-5319.

Sincerely,

Ralph A. Butler, P.E.
Director

RAB:jlb

Enclosure

xc: Reactor Advisory Committee
Reactor Safety Subcommittee
Dr. Kenneth Dean, Deputy Provost
Dr. Robert Hall, Associate Vice Chancellor for Research
Mr. Geoffrey Wertz, U.S. NRC
Mr. Johnny Eads, U.S. NRC

IE22
NRR

Attachment
U.S. Nuclear Regulatory Commission
April 15, 2015

Licensee Event Report No. 15-01 – March 21, 2015
University of Missouri Research Reactor

Introduction

On March 21, 2015, 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 of the three Nuclear Instrumentation (NI) Power Range Monitor (PRM) channels decrease below a power level set point of 95%. All PRM channels indicated a decreasing reactor power level. All primary and pool coolant system pressure, temperature and flow indications were normal. Investigation revealed that the drive chain for the Rod Position Indication (RPI) encoder on the regulating blade drive mechanism had disengaged from the RPI encoder slave sprocket and became bound in the lead screw adapter drive sprocket. Upon discovery of this failure, the reactor was immediately shut down by manual scram and all action of reactor emergency procedures REP-2, "Manual Scram," and REP-7, "Rod Position Indication System Failure," were completed. 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, with the regulating blade in an inoperable state, a deviation from TS 3.4.c had also occurred. TS 3.4.c 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.*" This specification requires that the two rod run-in functions, < 10% withdrawn and 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 neutron-absorbing control blades. Four 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, a lead screw assembly and an overload clutch. The lead screw assembly

converts the rotating motion of the servomotor to the linear motion of the regulating blade. The overload clutch allows slippage of the lead screw should the regulating blade become bound within the blade gap. The drive mechanism, through a slave sprocket and chain arrangement, also drives a 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 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 shims to make minor adjustments to maintain power at the desired level.

Detailed Event Description

At 10:06 on March 21, 2015, 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 of the three NI PRM channels decrease below a power level set point of 95%. All PRM channels indicated a decreasing reactor power level. All primary and pool coolant system pressure, temperature and flow indications were normal. No additional annunciations were received and no rod motion was in progress. The Lead Senior Reactor Operator (LSRO) directed a second operator to the reactor bridge to inspect conditions near the control and regulating blade drive mechanisms. At 10:08, the operator discovered the drive chain for the regulating blade drive mechanism RPI encoder had disengaged from the slave sprocket for the regulating blade rotary limit switch assembly and was bound in the drive sprocket preventing movement of the regulating blade in either the inward or outward direction. The LSRO immediately initiated a manual reactor scram and all actions of reactor emergency procedures REP-2, "Reactor Scram," and REP-7, "Rod Position Indication System Failure" were completed. 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 regulating blade in an inoperable state, a deviation from TS 3.4.c had also occurred. TS 3.4.c

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.*" This specification requires that the two rod run-in functions, < 10% withdrawn and bottomed, associated with the regulating blade must be operable when the reactor is in operation.

After the reactor was shut down and secured, the regulating blade drive mechanism was removed for inspection and troubleshooting. It was determined that a sufficient minor misalignment had occurred over an extended period of time to allow the chain tension to vary slightly with the rotational motion of the RPI encoder sprockets. This lack of a correct, consistent tension allowed the drive chain to disengage from the RPI encoder sprocket.

Safety Analysis

Preceding the failure, the reactor had been at continuous full power operation with the regulating blade properly maintaining power level in the automatic control mode for a period of 88 hours and 51 minutes since the last scheduled startup on March 16, 2015. The regulating blade had been fully operational during that period. A review of the NI Wide Range Monitor (WRM) and PRM strip-chart recorders indicated an actual power level decrease starting about three minutes prior to receiving the "Channel 4, 5 or 6 Downscale" annunciator alarm; therefore, it appears that the regulating blade could have been inoperable for a period of approximately five minutes 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 1.18, which states, "*The safety system is that combination of sensing devices, circuits, signal conditioning equipment electronic equipment and electro-mechanical devices that serves to effect a reactor scram, initiate a containment building isolation or activate the primary coolant siphon break system.*" When a reactor scram or rod run-in occurs, the regulating blade is automatically shifted to manual control mode to prevent it from operating 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. After the reactor was shut down and secured, the regulating blade drive mechanism was removed for inspection and repairs. A complete alignment was performed on the chain drives and sprocket assemblies for the regulating blade RPI encoder, rotary limit switch assembly, regulating blade drive assembly, and idler arms. Chain tension was adjusted on all drive chains after the alignments were completed. The shaft bushings supporting the RPI encoder sprockets were also replaced. The "Regulating Blade Operation And Rod Run-In Function Test" portion of form FM-57, "Long Form Startup Checksheet," were completed satisfactorily to verify proper operation of the regulating blade rotary limit switch assembly and regulating blade RPI.

To prevent further failures of this type, more detailed instruction will be provided during the performance of FM-57, "Long Form Startup Checksheet," as to the type of inspections required. This will ensure that a check of regulating blade chain tension is performed at least weekly.

Additionally, this event has been entered into the MURR Corrective Action Program as CAP entry No. 15-0021, and any additional improvements or corrective actions will be considered. One of the possible long term corrective actions would be to relocate regulating blade rod run-in functions directly to the drive mechanism lead screw assembly similar to that of the current limit switches which provide the drive mechanism full-in and full-out stop functions. This would eliminate the need for a drive chain and the difficulties associated with aligning and providing the correct tension for multiple drive chains, sprocket assemblies and idler arms on the same component.

If there are any questions regarding this LER, please contact me at (573) 882-5319. I declare under penalty of perjury that the foregoing is true and correct.

Sincerely,

John L. Fruits
Reactor Manager

ENDORSEMENT:
Reviewed and Approved,

Ralph A. Butler, P.E.
Director

Signed before me, 4/15/15

NOTARY PUBLIC
NOTARY SEAL
STATE OF MISSOURI

MARGEE P. STOUT
My Commission Expires
March 24, 2016
Montgomery County
Commission #12511436

Margee P. Stout

Regulating Blade Drive Assembly