University of Missouri

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April 20, 2020

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 Specification 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 April 9, 2020, that resulted in a deviation from MURR Technical Specification 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

cc: 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. Craig Bassett, U.S. Nuclear Regulatory Commission

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Enclosure
U.S. Nuclear Regulatory Commission
April 20, 2020

Licensee Event Report No. 20-02 – April 9, 2020
University of Missouri Research Reactor

Introduction

On April 9, 2020, with the reactor operating at 10 MW in the automatic control mode, the Lead Senior Reactor Operator (LSRO), while conducting a routine patrol of the facility, noticed that the geared rotary limit switch assembly was not moving with corresponding regulating blade drive mechanism movement. The reactor was then immediately shut down by manual scram, and all immediate and subsequent actions of reactor emergency procedure REP-2, "Manual Scram," were completed. Failure of the geared rotary limit switch assembly to move prevented the "≤ 10% withdrawn" rod run-in function from being operable; therefore, a deviation from Technical Specification (TS) 3.2.f.8 occurred.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operation.*" Rod Run-In Function No. 8 under this specification requires that the two (2) rod run-in functions, "≤ 10% withdrawn" or "bottomed," associated with the regulating blade must be operable when the reactor is in operation.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 slave sprocket and chain arrangement, also drives a rod position indication (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 (1) of two (2) modes: manual or automatic. In the automatic control mode, the regulating blade controls reactor power by comparing the output signal from the Nuclear Instrument (NI) Wide Range Monitor (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 14:32 on April 9, 2020, the LSRO, while conducting a routine patrol of the facility, noticed that the geared rotary limit switch assembly was not moving with corresponding regulating blade drive mechanism movement. The reactor was then immediately shut down by manual scram, and all immediate and subsequent actions of reactor emergency procedure REP-2, "Manual Scram," were completed.

Failure of the geared rotary limit switch assembly to move prevented the "≤ 10% withdrawn" rod run-in function from being operable; therefore, a deviation from TS 3.2.f.8 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.

Initial investigation revealed that the upper RPI encoder sprocket, which drives the rotary limit switch slave sprocket, was not moving when its drive shaft was rotating. The regulating blade drive mechanism was removed and taken to the Instrumentation Support Shop for further inspection and troubleshooting. Examination revealed that the two (2) setscrews that couple the upper RPI encoder sprocket to the RPI encoder drive shaft were not tightened onto the two (2) flat areas of the encoder drive shaft. The as-found positions of the setscrews indicated the setscrews were tightened against the rounded portion of the RPI encoder drive shaft, not the flat areas, during recovery from LER 20-01 the previous day. Eventually, the rotary shaft drive force must have overcome the setscrews' friction and allowed slippage between the sprocket setscrews and the rounded portion of the shaft.

After replacing the RPI encoder drive shaft, all regulating blade drive setscrews had thread lock applied and were checked tight. In addition, both regulating blade drive mechanism chains were aligned and the chains' tensions evaluated to be normal and satisfactory.

Safety Analysis

It is not known exactly when the geared rotary limit switch assembly stopped moving with corresponding regulating blade drive mechanism movements. However, it is known that the rotary limit switch was operating correctly approximately four (4) hours prior to discovery of the failure when a control room operator conducted the previous routine patrol. Therefore, the maximum time the reactor possibly operated in deviation from TS 3.2.f.8 was about four (4) hours.

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 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 the geared rotary limit switch assembly was not moving with corresponding regulating blade drive mechanism movement. The regulating blade drive mechanism was removed for inspection and troubleshooting. After replacing the RPI encoder drive shaft, all regulating blade drive mechanism setscrews had thread lock applied and were checked tight. In addition, both regulating blade drive mechanism chains were aligned and the chains' tensions evaluated to be normal and satisfactory.

The regulating blade drive mechanism was cycled across its full range several times in a test stand in the Instrumentation Support Shop prior to re-installation. Then, the regulating blade drive mechanism was reinstalled and connected to the regulating blade. The regulating blade was cycled across its full range several times prior to pre-startup checks. No visual or audible abnormalities with the chain, sprockets, shafts, RPI, or rotary limit switch 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.

The long-term corrective action of relocating the regulating blade rotary limit switch functions directly to the drive mechanism lead screw assembly actuated by linear limit switches, as described in LER Nos. 15-01, 17-04, 19-05, and 19-06, was implemented on April 13, 2020. As explained in LER No. 20-01, this new, current regulating blade drive mechanism design incorporates flexible shaft couplings that allow for slight misalignments, industry standard linear microswitches that replace the antiquated rotary limit switch assembly, a more robust gearbox that is directly coupled to the servomotor, and no drive chains. The new design eliminates the difficulties associated with aligning and providing the correct tension for multiple drive chains, sprocket assemblies including setscrews, and idler arms on the same component. Additionally, this new regulating blade drive mechanism went through an extensive and thorough benchtop testing program, which simulated over six (6) months of hard service, prior to its implementation.

Additionally, this event has been entered into the MURR Corrective Action Program as CAP No. 20-0043, and any additional improvements 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,

Bruce A. Meffert
Reactor Manager

ENDORSEMENT:
Reviewed and Approved,

J. David Robertson, PhD
Reactor Facility Director

Attachments:

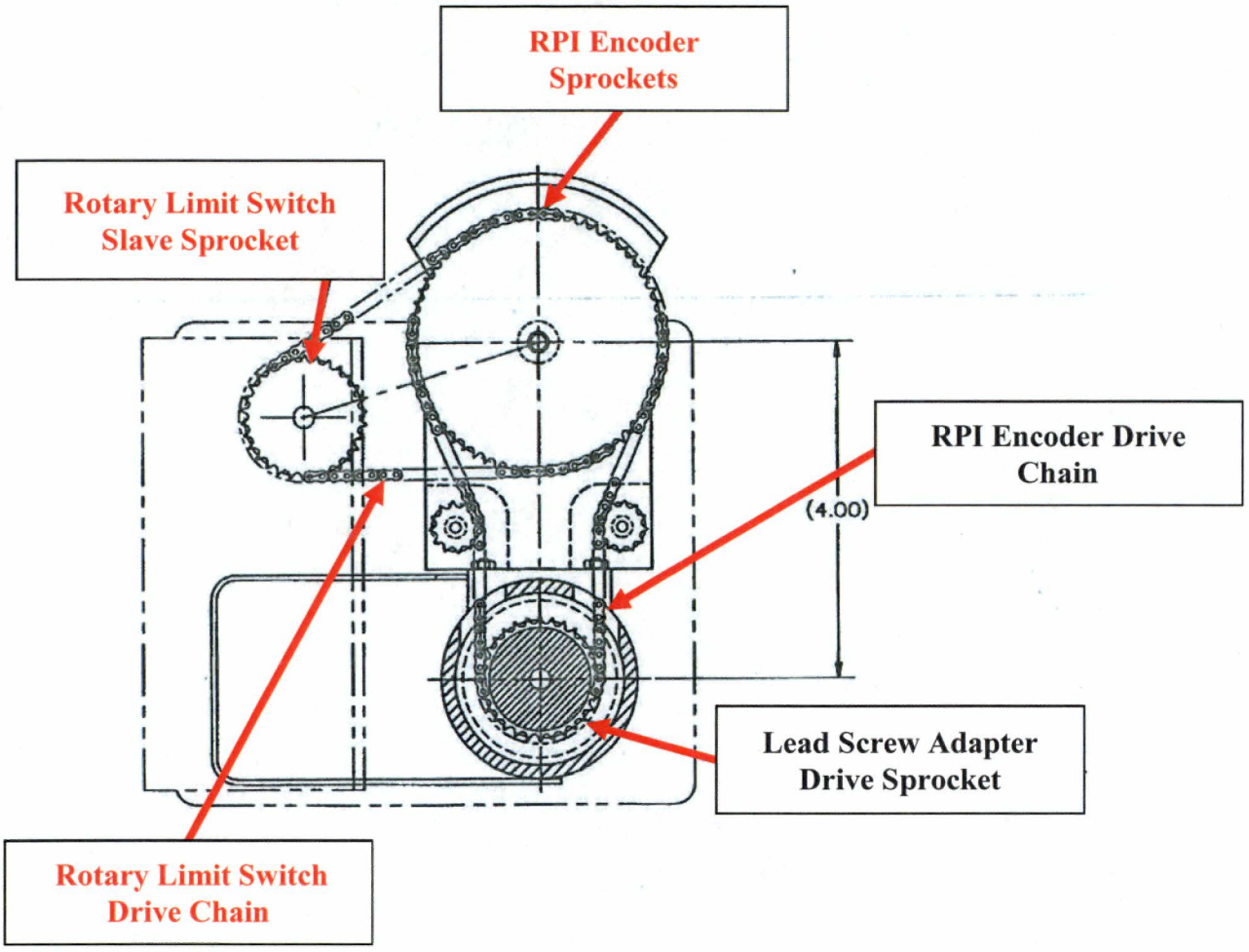
1. Regulating Blade Drive Assembly Diagram
2. Regulating Blade Drive Assembly

State of Missouri
County of Boone
Subscribed and sworn to before me this 20 day of April, 2020
Jacqueline L Matyas
JACQUELINE L. MATYAS, Notary Public
My Commission Expires: March 26, 2023

NOTARY PUBLIC NOTARY SEAL STATE OF MISSOURI

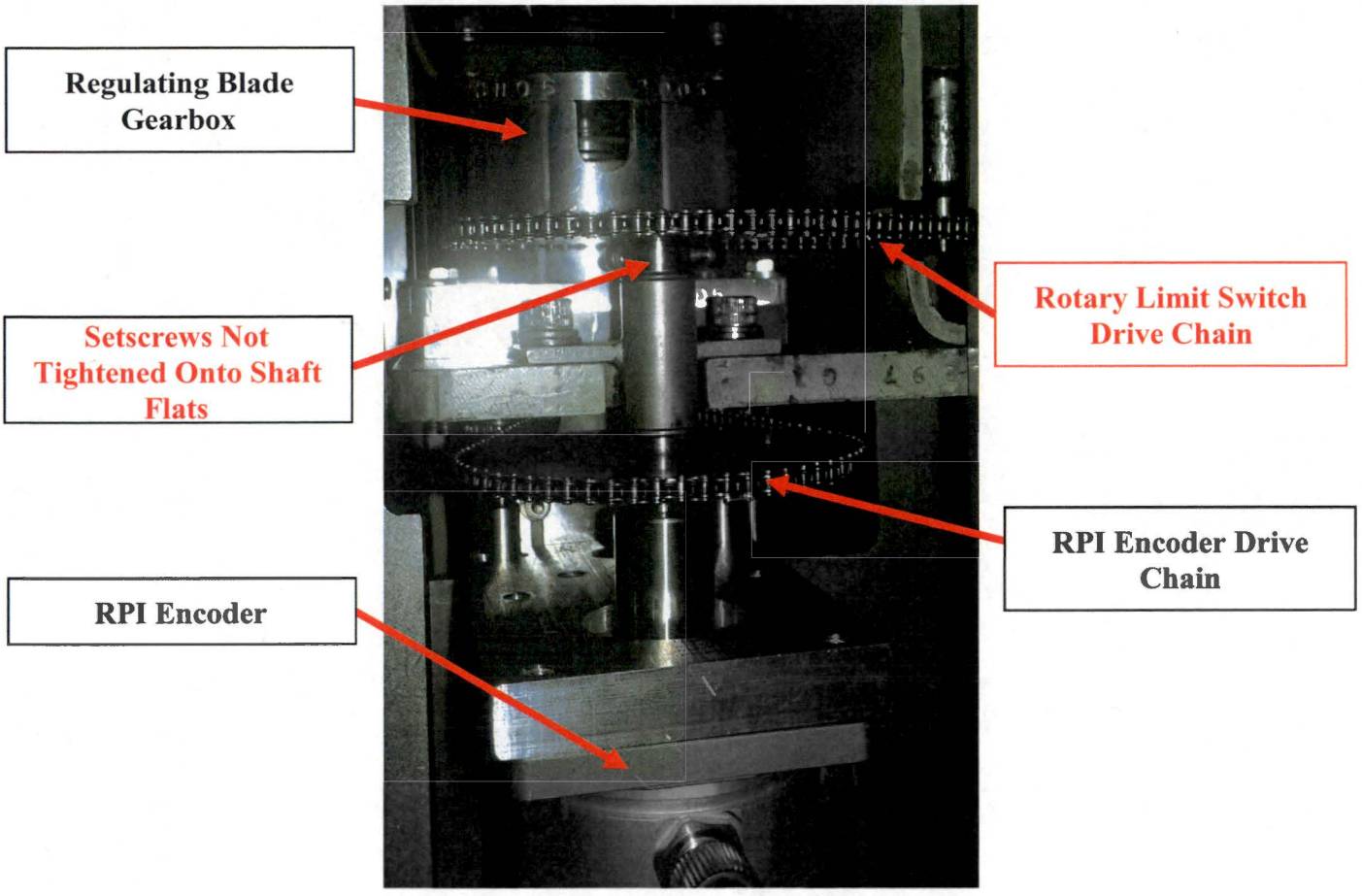
JACQUELINE L. MATYAS
My Commission Expires
March 26, 2023
Howard County
Commission #15634308

ATTACHMENT 1



Regulating Blade Drive Assembly Diagram

ATTACHMENT 2



Regulating Blade Drive Assembly