UNIVERSITY *of* MISSOURI

RESEARCH REACTOR CENTER

May 16, 2014

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
Amended Facility 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

The attached document provides the University of Missouri-Columbia Research Reactor (MURR) Licensee Event Report (LER) for an event that occurred on April 23, 2014, that resulted in a deviation from MURR Technical Specification 3.2.a.

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
Mr. Alexander Adams, Jr., U.S. NRC
Mr. Johnny Eads, U.S. NRC

IE22

NRR

Licensee Event Report No. 14-02 – April 23, 2014
University of Missouri Research Reactor

Introduction

On April 23, 2014, with the reactor operating at 10 MW in the automatic control mode, the control room operator attempted to shim control blade 'B' in the inward direction during a routine shimming evolution. No movement of the control blade was noted; therefore, the reactor was immediately shut down by placing Master Control Switch 1S1 in the "Test" position in accordance with reactor emergency procedure REP-8, "Control Rod Drive Mechanism Failure or Stuck Rod." Operation of Master Control Switch 1S1 removed the holding current from the four control rod drive mechanism (CRDM) electromagnets, thus allowing all control blades to drop to the fully inserted position without inward movement of the CRDMs. Failure of the CRDM to move control blade 'B' in the inward direction 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."* The basis for this Specification is to ensure that the normal method of reactivity control is used during reactor operation.

Description of the Rod Control System

The reactivity of the reactor is controlled by five neutron absorbing control blades. Each control blade is attached to a CRDM by means of a support and guide extension (offset mechanism). 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 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 blades is one inch per minute in the outward direction and two 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 speed of the control blades cannot be adjusted without physically altering the system. The four shim blades are actuated by electro mechanical CRDMs that position, hold, and scram each shim blade. Each CRDM consists of a 0.02-HP, 115-volt, one-amp, single-phase, 60-cycle motor connected to a lead screw assembly through a reduction gearbox and overload clutch. The reactivity worth and speed of travel for the control blades are sufficient to allow complete control of the reactor system from a shutdown condition to full power operation. The insertion rate of the control blades is adequate to ensure prompt shutdown of the reactor in the event a scram signal is received.

Control blade movements, interlocks and bypasses, and control modes are managed by the Rod Control System. The Rod Control System is a relay and switch logic system used to prohibit accidental or incorrect operation which could result in an unsafe condition. During normal operation, Master Control Switch 1S1 allows the shim blades to be withdrawn or inserted manually by three-position ("In-Normal-Out") switch (1S4) located on the reactor control console. The switch is spring return to the mid-position ("Normal") when released. A five-position ("A-B-C-D-Gang") selector switch (1S3) enables the reactor operator to select the shim blades individually or as a group. 115 V a-c power is supplied to the CRDM motor windings through the CRDM motor relays (see Attachment 1); K1 for shim blade insertion and K2 for shim blade withdrawal.

Detailed Event Description

On April 23, 2014, at approximately 07:38, with the reactor operating at 10 MW in the automatic control mode, all control blades were individually shimmed as part of a routine sample handling evolution. Shortly after completion of the first evolution, the control room operator was preparing for the second sample loading and noted that control blade 'B' would not shim in the inward direction. At 07:42 the reactor was immediately shut down by placing Master Control Switch 1S1 in the "Test" position in accordance with reactor emergency procedure REP-8, "Control Rod Drive Mechanism Failure or Stuck Rod." Operation of Master Control Switch 1S1 removed the holding current from the four CRDM electromagnets, thus allowing all control blades to drop to the fully inserted position without inward movement of the CRDMs. All control blades were visually verified to be inserted. All immediate and subsequent actions of REP-8 were completed. Failure of the CRDM to move control blade 'B' in the inward direction resulted in a deviation from TS 3.2.a, which states, *"All control blades, including the regulating blade, shall be operable during reactor operation."*

After the reactor was secured, the CRDM was removed for inspection. Extensive troubleshooting efforts revealed a failure of CRDM 'B' motor inward relay K1. Relay contacts 6 and 10 failed to make sufficient contact to allow current flow with the relay coil energized and prevented the motor inward direction windings from energizing.

Safety Analysis

The basis for TS 3.2.a is to ensure that the normal method of reactivity control is used during reactor operation. Conservatively, it can be assumed that the reactor operated in violation of TS 3.2.a for the period of time from which the previous control rod shimming evolution concluded until discovery of the failure at 07:42 by the control room operator. During this period the reactor remained at a steady-state power level in automatic control. Additionally, a review of the nuclear instrumentation power strip-chart recorders indicated conditions consistent with steady-state operation. The maximum distance between any two shim blades during this period was 0.15 inches. While inward movement of control blade 'B' was compromised for a period of no greater than four (4) minutes, at no time was the ability to scram the reactor, either through automatic initiation or manually by the control room operator, affected by this failure. CRDM motor relays K1 and K2 are not a part of the reactor safety system.

Corrective Actions

When the control room operator discovered that CRDM 'B' would not move the control blade in the inward direction, he immediately initiated a reactor scram by placing Master Control Switch 1S1 in the "Test" position and completed the immediate actions of reactor emergency procedure REP-8, "Control Rod Drive Mechanism Failure or Stuck Rod," to ensure the reactor was in a safe shutdown condition. All four shim blades were visually verified to be fully inserted.

Troubleshooting efforts identified the failure of the CRDM motor inward relay K1. The relay was bench tested to identify the single component failure for contacts 6 and 10. The relay internals were visually inspected and no other signs of failure noted (Attachment 2). This relay type, Magnecraft 782HXDXH21-120A (Attachment 2), has been used at MURR for many years and previously proven to be very reliable. This specific relay had been replaced as part of regularly scheduled preventive maintenance two weeks prior to this event. In addition to replacing the failed relay, all relays of this lot number have been removed from the remaining CRDMs. MURR has contacted the supplier of these relays to obtain additional information to further investigate the failure of this component and the potential for any future failures of this type.

MURR electronic maintenance procedure EMP-12, "Drive Mechanism," was completed on CRDM 'B.' Additional post maintenance testing included bench testing to ensure correct operation of the CRDM relay contacts, monitoring run current of the CRDM over the full length of travel, monitoring CRDM speed over the full length of travel and performing multiple cycles of the CRDM motor relay to ensure proper operation. The CRDM was reinstalled and compliance procedure CP-10, "Rod Drop Times," was completed satisfactory. Identical post maintenance testing was performed and completed on CRDM 'A' which also contained relays from this lot number.

Additionally, this event was entered into the MURR Corrective Action Program as CAP entry No. 14-0028 and any additional information or corrective actions will be considered and documented.

If there are any questions regarding this Licensee Event Report, 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

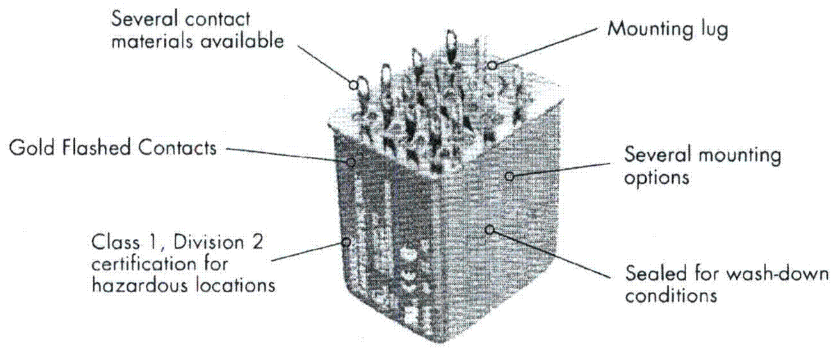
NOTARY PUBLIC
NOTARY SEAL
STATE OF MISSOURI

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

782H Hermetic Ice Cube Relays/DPDT, 4PDT, 1 - 5 Amp Rating (DC & AC)

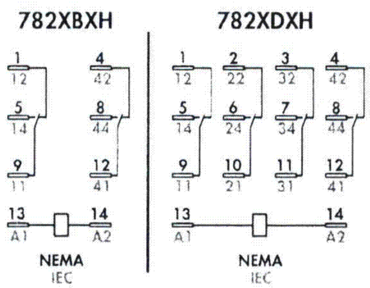
UL Listed When Used With Magnecraft Sockets.

UL Recognized File No. E209950

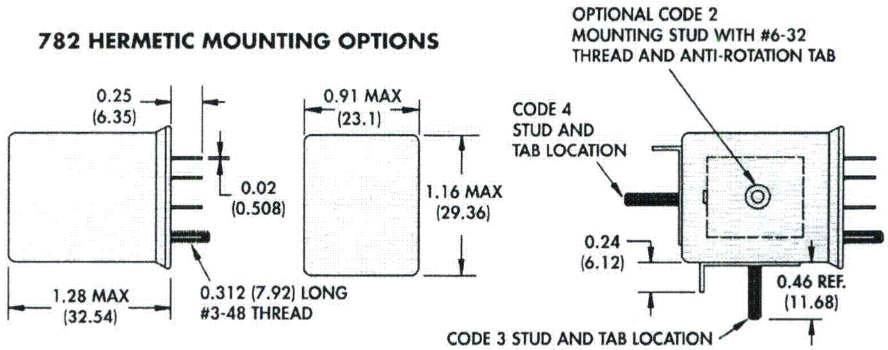


General Specifications

General Specifications	(UL 508)		Units	782XBXH21, 782XDXH21	782XBXH10, 782XDXH10	782XDXH32
Contact Characteristics				**Standard**	**Low Level**	**Low Level**
Number and type of Contacts				DPDT, 4PDT	DPDT, 4PDT	4PDT
Contact materials				Silver Alloy	Fine Silver	Bifurcated
Thermal (Carrying) Current			A	5	3	1
Maximum Switching Voltage			V	300	300	300
Switching Current @ Voltage		~	Resistive	5A @ 120V 50/60Hz	3A @ 120V 50/60Hz	1A @ 120V 50/60Hz
		~	Resistive	5A @ 240V 50/60Hz	3A @ 240V 50/60Hz	1A @ 240V 50/60Hz
		⎓	Resistive	5A @ 30V	3A @ 30V	1A @ 30V
			HP		1/16 @ 120VAC	
			HP		1/10 @ 240VAC	
Minimum Switching Requirement			mA	100 @ 5VDC (.5W)	10 @ 5VDC (.05W)	10 @ 5VDC (.05W)
Coil Characteristics						
Voltage Range		~	V	6....240, 50/60 Hz	6....240, 50/60 Hz	6....240, 50/60 Hz
		⎓	V	6....125	6....125	6....125
Operating Range	% of Nominal	~		85% to 110%	85% to 110%	85% to 110%
		⎓		80% to 110%	80% to 110%	80% to 110%
Average consumption		~	VA	1.2	1.2	1.2
		⎓	W	0.9	0.9	0.9
Drop-out voltage threshold		~		15%	15%	15%
		⎓		10%	10%	10%
Performance Characteristics						
Electrical Life (UL508)	Operations @ Rated Current			100,000	100,000	100,000
Mechanical Life	Unpowered			10,000,000	10,000,000	10,000,000
Operating time (response time)			ms	20	20	20
Dielectric strength	Between coil and contact	~	Vrms	1240	1240	1240
	Between poles	~	Vrms	1240	1240	1240
	Between contacts	~	Vrms	500	500	500
Environment						
Product certifications	Standard version			UL, CSA, CE	UL, CSA, CE	UL, CSA, CE
Ambient air temperature	Storage		°C	-40...+85	-40...+85	-40...+85
around the device	Operation		°C	-40...+70	-40...+70	-40...+70
Vibration resistance	Operational		g-n	3, 10 - 55 Hz	3, 10 - 55 Hz	3, 10 - 55 Hz
Shock resistance			g-n	10	10	10
Degree of protection				IP 67	IP 67	IP 67
Weight			grams	45	45	45



Wiring Diagrams
Bottom View



Attachment 1

Standard Part Numbers

BOLD-FACED PART NUMBERS ARE NORMALLY STOCKED

782XBXH Nominal Voltage	Resistance	Part number (Standard) 5 Amp	Part Number (Low Level) 3 Amp
AC Operated			
24 VAC 50/60 Hz	180 Ohms	782XBXH21-24A	782XBXH10-24A
120 VAC 50/60 Hz	4430 Ohms	782XBXH21-120A	782XBXH10-120A
240 VAC 50/60 Hz	15720 Ohms	782XBXH21-240A	782XBXH10-240A
DC Operated			
12 VDC	160 Ohms	782XBXH21-12D	782XBXH10-12D
24 VDC	650 Ohms	782XBXH21-24D	782XBXH10-24D
110-125 VDC	13800 Ohms	782XBXH21-110/125D	782XBXH10-110/125D

782XDXH Nominal Voltage	Resistance	Part number (Standard) 5 Amp	Part Number (Low Level) 3 Amp	Part Number (Low Level) 1 Amp
AC Operated				
6 VAC 50/60 Hz	9.6 Ohms	782XDXH21-6A	782XDXH10-6A	782XDXH32-6A
12 VAC 50/60 Hz	46 Ohms	782XDXH21-12A	782XDXH10-12A	782XDXH32-12A
24 VAC 50/60 Hz	180 Ohms	**782XDXH21-24A**	**782XDXH10-24A**	782XDXH32-24A
120 VAC 50/60 Hz	4430 Ohms	**782XDXH21-120A**	**782XDXH10-120A**	782XDXH32-120A
220-240 VAC 50/60 Hz	15720 Ohms	782XDXH21-220/240A	782XDXH10-220/240A	782XDXH32-220/240A
DC Operated				
6 VDC	40 Ohms	782XDXH21-6D	782XDXH10-6D	782XDXH32-6D
12 VDC	160 Ohms	**782XDXH21-12D**	**782XDXH10-12D**	782XDXH32-12D
24 VDC	650 Ohms	**782XDXH21-24D**	**782XDXH10-24D**	782XDXH32-24D
48 VDC	2600 Ohms	782XDXH21-48D	782XDXH10-48D	782XDXH32-48D
110-125 VDC	13800 Ohms	**782XDXH21-110/125D**	**782XDXH10-110/125D**	782XDXH32-110/125D

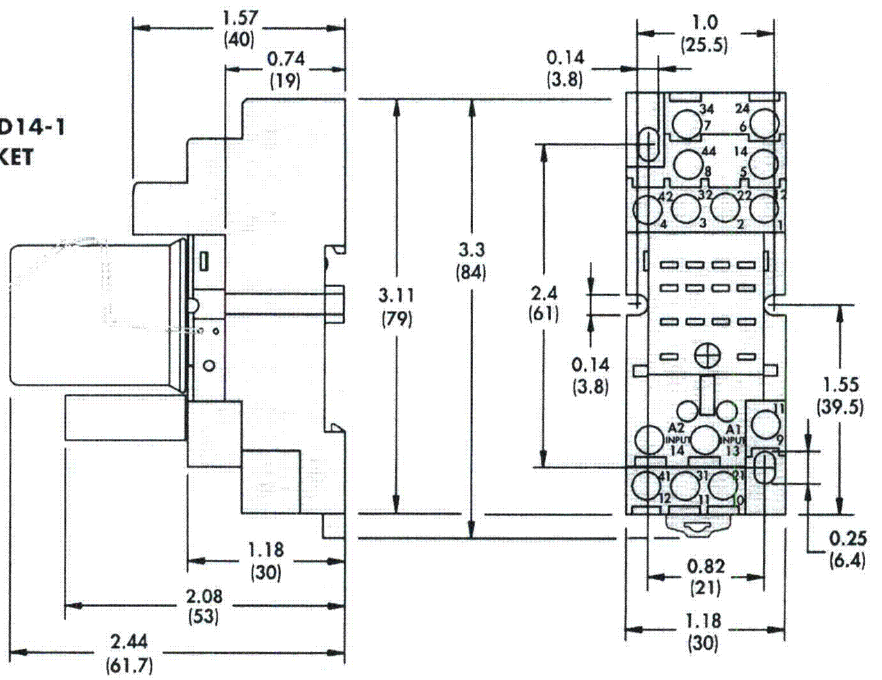
Custom Relay Part Number Builder

782	XBX	H	21	2	240A
Series	**Contact Configuration**	**Hermetic**	**Contact Code**	**Mounting Options**	**Coil Voltage**
782	XBX = DPDT		3 Amp Fine Silver, Gold Diffused = 10	Solder/Plug-In = No Code	VAC = 6 - 240A
	XDX = 4PDT		5 Amp Silver Alloy = 21	Stud on Broad Side = 2	VDC = 6 - 125D
			1 Amp Bifurcated = 32	Stud on Narrow Side = 3	
			3 Amp Silver Alloy = 37	Stud on Top Side = 4	

For other mating sockets, see Section 2: 70-782EL14-1, 70-782E14-1, 70-461-1, 70-378-1, 70-379-1

70-782D14-1 SOCKET

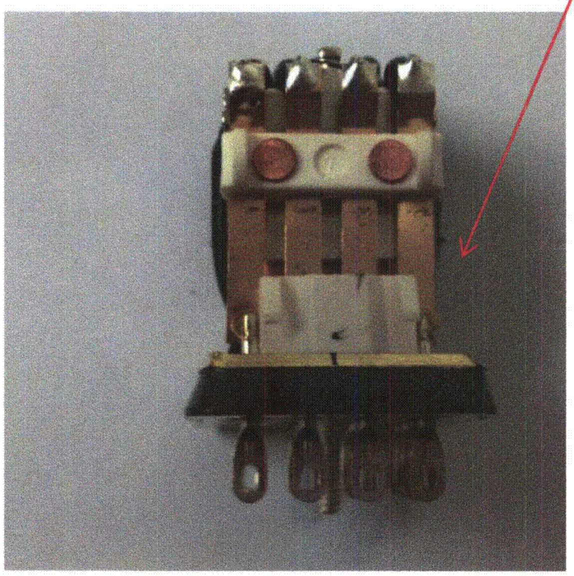
16-1342
Metal Hold-Down Clip
Section 3, p.8-11

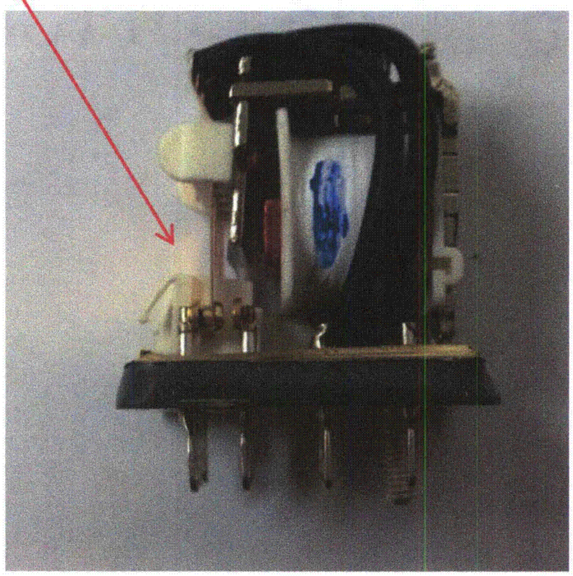


Attachment 1

Control Rod Drive Mechanism Motor Relay K1

Outer skin mechanically removed to illustrate internals of relay





Attachment 2