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October 14, 2002

US Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Subject: Docket No. 50-186
The Curators of the University of Missouri
License No. R-103

The attached document provides the University of Missouri Research Reactor event report for a mis-positioned fuel element that was discovered on September 18, 2002. The mis-positioned element resulted in a deviation from Technical Specification 3.8.c. This report is submitted in accordance with Technical Specification 6.1.h (2).

Please contact Paul Hobbs, Reactor Manager at 573-882-5264 if you have questions regarding this report.

Sincerely,

Ralph A. Butler, P.E.
Interim Director

RAB:dcp

Enc.

cc: Mr. Alexander Adams, Jr., US NRC
Mr. Craig Bassett, NRC Region II
Dr. Robert Hall, Interim Vice-Provost
Reactor Advisory Committee
Reactor Safety Committee

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A020

Subscribed and Sworn to before me this 14th October 2002
Notary Public
MCE: 3-25-04

Event Report 02-03 – October 14, 2002
University of Missouri Research Reactor

Introduction

At approximately 1600, September 18, 2002, during a reactor startup following a refuel, Control Room Operators observed that there was a difference in the predicted control rod height at criticality between the calculated Estimated Critical Position (ECP) and the 1/M Plot. The ECP was 16.48 inches banked rod position, and the 1/M plot was indicating criticality at 20.95 inches. This difference in predicted rod height at criticality was indicative of a significant difference between the calculated and actual reactivity of the core.

The ECP for a given core is based upon the amount of fuel loaded, the operating history of the fuel, pool and reactor coolant temperatures and control rod reactivity worths. The 1/M plot is based upon the change in Source Range nuclear instrument count rate as positive reactivity is inserted by control rod withdrawal during a reactor startup. The ECP is a calculated value that predicts core behavior, and the 1/M plot is representative of actual core behavior during a reactor startup. At MURR a 1/M plot is performed for all startups following refuel of the reactor. During a startup, the rods are stopped at 5-inch increments to collect count rate data for the 1/M plot. This plot provides assurance that the reactor core is behaving as expected.

Having a significant difference between the ECP and the 1/M plot, operators terminated the startup and initiated an investigation. At that time, the rods were at 14.48 inches, 2 inches below the ECP. This 2 inches below predicted ECP data point for the 1/M plot is required by the reactor SOP. The reactor did not attain criticality. During the initial investigation, the rods were maintained at 14.48 inches. By procedure, it would have been permissible to continue the rod withdrawal to 17.18 inches, the upper limit of the ECP tolerance band. Control Room personnel made the decision to terminate the startup at 14.48 inches rather than approach the administrative barrier of 17.18 inches.

The investigation focused on the Source Range instrument that was providing the count rate data for the 1/M plot, recalculating the ECP, verifying the fuel data used in the ECP calculation was correct and visually inspecting the control rods and their drive mechanisms. It was noted that the Source Range count rate was somewhat lower than it was for the previous startup. Finding no abnormalities external to the reactor core during this phase of the investigation, at 1712 the control rods were inserted to the full in position. The Rod Run-In feature was used to insert the rods to allow further visual inspection of the rod drive mechanisms while the rods were in motion.

Preparations were then made to remove the reactor pressure vessel head to inspect the core itself. Upon head removal, it was noted that the fuel element in position F5 did not appear to be fully seated. Physical measurement verified that this element was several inches above its core position. Using the fuel handling tool, the element was withdrawn for inspection, and finding no abnormalities was inserted correctly into core position F5 as directed by the fuel movement sheet.

The core configuration that existed was a noncompliance with Technical Specification 3.8.c that states, **"The reactor core shall consist of eight fuel assemblies. Exception: The reactor may be operated to 100 watts above shutdown power on less than eight assemblies for purposes of reactor calibration or multiplication studies."**

The reactor startup was terminated below criticality and therefore the core, containing 7 fuel elements, was never operated above shutdown power.

Following the inspection of the fuel element and placing it in its correct position, the Reactor Manager directed that all startup activities be suspended and an Event Review Team meeting was convened to review the event. The Event Review Team determined probable causes and corrective actions. Several corrective actions were implemented prior to resuming reactor operating activities.

Description of the reactor core and fuel movement

The annular MURR core is typically made up of 8 fuel elements. During refuel the elements are changed out one at a time using a manual tool that has a buoyancy assist tank and an air operated mechanical gripper assembly. When a fuel element is unlatched, it is important that the tool be permitted to float up off of the element, on its own with no assistance from the operator. This is to ensure that the fuel element has fully disengaged from the tool. When set up and used correctly, the tool cannot float on its own if a fuel element is attached.

Considering the weight of the tool with a fuel element attached and the buoyancy effects of the pool water, the overall weight sensed by the operator handling the tool is only about 5 lb. Upon releasing the fuel element, the assembly loses approximately 9 lb. and the tool will float.

Event description

On Wednesday, September 18, 2002, at 0617, an unscheduled reactor shutdown was performed as a result of a malfunction of the containment airlock doors. Refueling, made necessary by the shutdown, was performed following the repair and testing of the doors. All aspects of the refueling activity appeared to have been accomplished successfully with no abnormalities noted.

The refueling procedure requires the height of all of the fuel elements to be checked using a special template that fastens to the bottom of the fuel handling tool. This check was performed and all elements were considered to be properly seated. Additionally, the procedure requires that the core be visually inspected for "debris and abnormalities". This visual inspection is done through 26 feet of pool water using binoculars and/or the naked eye. Both of these checks were performed and no abnormalities were noted at that time. To complete the refueling, the reactor pressure vessel head was installed.

Following completion of the startup checks, at 1532 that afternoon, a reactor startup was commenced. The calculated Estimated Critical Position of the control rods was 16.48 inches. Per Reactor Startup procedure OP-RO-210, the control rods were withdrawn to 5 inches and the first 1/M point was established. The rods were then withdrawn to 10 inches and the second 1/M point was established. Due to the low count rate and fluctuations at this level, the first two 1/M points are generally not considered accurate. By procedure, the next required stopping point was 14.48 inches, 2 inches below the calculated ECP. The 1/M point at this rod height predicted criticality at 20.95 inches, well above the ECP of 16.48 inches. Upon noting the difference between the ECP and the 1/M prediction of critical rod height the operators halted the startup to evaluate the situation.

Initially the investigation focused on the source range nuclear instrument channel that was providing the count rate data for the 1/M plot. The Chief Electronics Technician was called in to support the evaluation of this instrument that was found to be operating normally in all respects. The fuel data that was used to calculate the ECP was also checked and verified to be correct. The control rods and their drive mechanisms were visually examined and no abnormalities were found.

Upon removal of the reactor pressure vessel head, it was noted that the fuel element in position F5 did not appear to be fully seated. Physical measurement verified that this element was several inches above its core position. It was subsequently determined that this element was resting on a ledge where the fuel guide narrows just above the top of the core.

Safety Analysis

Although the reactor startup was terminated at a control rod height of 14.48 inches, 2 inches below the Estimated Critical Position, by procedure, the rod withdrawal could have continued to 17.18 inches, the upper limit of the ECP tolerance band. The 1/M plot as well as calculations based on historic startups using 7 and 8 elements show that at this upper limit the reactor would not have attained criticality.

Prior to removing the element from this position, the handling tool was used to apply a light downward force on the element. It would not move downward.

Root Cause Determination

A team was assembled to perform a formal Root Cause Analysis of this event. Mr. Bruce Little, former NRC Inspector, was brought in to facilitate this analysis. The direct cause was determined to be lack of attention to detail during the fuel element unlatching operation at core position F5, specifically, failing to allow the fuel handling tool to float up off of the element.

The trace on the Source Range chart recorder shows that the fuel element was placed in the F5 position, then withdrawn indicating that when unlatched, the element was not fully disengaged and it was lifted up out of the core with the tool. It is apparent that the tool did not float, but was hand lifted following the initial placement of the element.

The Root Cause Analysis also identified a "workaround" that may have been a contributing factor. A "design/maintenance deficiency of the fuel handling tool floatation tank caused recurring water leakage into the tank. This deficiency resulted in a need for operators to periodically raise and drain the tool in order to achieve the specified tool floatation after unlatching from an element. This deficiency can result in a tendency, by an operator, to assist the tool removal by hand lifting after tool unlatching."

Barriers to detect this type of event, checking the height of each fuel element using a special tool, and visual inspection of the core, failed to identify the fact that the fuel element was not seated in the core.

Additionally, the relationship between several primary flow related parameters and the out of place element was not immediately made. Reactor core differential pressure was lower than normal but within specifications. Reactor coolant flow was higher than normal but still within specifications and core discharge pressure was slightly high but out of specifications. All three of these parameter trends were a result of the fuel element not being in its correct position.

Corrective actions

The root cause analysis team believes that a challenging visual working environment relating to fuel handling, measurements and inspections created by the depth of water, Cerenkov glow and heat waves, were factors in this event. This adverse environment shows a need for specific experience based instructions that require angles of view, alternate viewing with and without binoculars, and independent second checking at key activity points.

The following corrective actions were implemented prior to continuing the reactor startup on September 18:

1. Require an independent second visual inspection of the reactor core following fuel movement.

2. Require that the visual inspection of the reactor core be performed at various angles, with and without binoculars.

3. Require verification of correct response on the Source Range chart recorder following each fuel element movement.

4. Train all operators on the rationale and importance of allowing the fuel tool to float up on its own, with no assistance, when each element is unlatched.

5. Train all operators on the necessity of analyzing and understanding why a change has occurred in a logged parameter.

Follow up actions:

1. Design and build a new tool for checking the height of the fuel elements. This new tool must have no visual interference.

2. Correct the leakage of water into the fuel tool buoyancy tank.

This event is entered into the MURR Corrective Action Program as CAP 02-0068 and the analysis is continuing into the causes and additional corrective actions.

If additional information is desired please call me at 573-882-5264.

Paul S. Hobbs PE
Reactor Manager
University of Missouri Research Reactor