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July 18, 2000

US Nuclear Regulatory Commission
ATTN: Document Control Desk
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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 the June 12, 2000 occurrence. On July 6, 2000, Mr. Tad Marsh of the NRC was verbally contacted to extend the due date for this report. Mr. Marsh granted a one-week extension.

Please contact Charlie McKibben at 573-882-5204 if you have any questions regarding this document.

Sincerely,

Edward A. Deutsch
Director

c: Mr. Alexander Adams, Jr., US NRC
Mr. Craig Bassett, NRC Region II
Dr. Jack O. Burns, MU Vice-Provost
Reactor Advisory Committee
Reactor Safety Subcommittee

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My Commission Expires 04/14/2003

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Event Report - June 12, 2000
University of Missouri Research Reactor

Introduction

On June 12, 2000, the University of Missouri Research Reactor (MURR) was shut down at 0300 and was subsequently refueled as part of normal maintenance day activities. At approximately 1100, control blade B was removed from the reactor as part of a plant maintenance procedure. Prerequisites in this procedure stated that the core shall have two less fuel elements (six compared to the normal eight) if the control blade is to be removed. However, at 1210 the Lead Senior Reactor Operator realized that the control blade had been removed without having two fuel elements removed from the core. Notwithstanding this discovery, it was confirmed that the requirement for a minimum shut down margin of 0.02 $\Delta k/k$ was met at all times. In fact, the reactor was subcritical by 0.083 $\Delta k/k$ with control blade B removed from the reactor.

Upon discovery of the error, a fuel movement procedure, which allowed the removal of the requisite fuel elements, was promptly developed and approved. In accordance with this procedure, the reactor pressure vessel head was removed and two fuel elements were removed from the core. Fuel element removal was accomplished at 1352. The as-found condition of the reactor did not pose an actual adverse impact to public health and safety, although the margin of safety for this evolution clearly was decreased.

MURR subsequently evaluated the impact of this deficiency and concludes that with eight fuel elements in the reactor core and one control blade not fully inserted, the reactor did not meet the Technical Specification definition to be considered either shutdown or secured. Therefore the reactor was technically in operation as is stated in Technical Specification Definition 1.17 Reactor in Operation, " The reactor shall be considered in operation unless it is either shutdown or secured." The reactor being in operation with a control blade inoperable is not in compliance with the Limiting Condition for Operation (Technical Specification 3.2.a), which requires all control blades shall be operable during reactor operation.

Description of Reactor and Control Blades

The reactor core consists of 8 fuel elements each occupying a 45-degree segment of a cylindrical annulus that is nominally 12 inches O.D. and 6 inches I.D. The fuel region is 24 inches long and each element has a total length of 32.5 inches. The core is inside the pressure vessel. Immediately outside the pressure vessel is the control rod gap, between the core and the beryllium reflector. Outside the beryllium reflector is a graphite reflector. (See attached drawings—perspective and horizontal cross section.)

Event Description

For the June 12 maintenance day, replacement of the offset mechanism for control blade B was the primary task that had been scheduled and planned. The reactor was shutdown at 0300 and was refueled as per procedure approved the previous week. The refueling sequence for an offset replacement would normally leave two elements out of the core adjacent to the location of the offset to be replaced. The Senior Operators on the night shift performing the refueling activity were aware of the plans to replace the offset mechanism but overlooked the preconditions necessary to perform the replacement; two adjacent fuel elements to be left out of the core. The oncoming dayshift operators and Operations management presumed the refueling had been done as required for the mechanism replacement but no one verified this to be true.

A concurrent unrelated, but impacting event occurred shortly after reactor shutdown when reactor operators discovered a leak in the shaft seal for primary pump 501A. Investigation of the leakage revealed a failed mechanical seal on the pump. A decision was made by Operations management to conduct this maintenance activity concurrent with the previously planned offset changeout. The Interim Operations Engineer elected to monitor the pump seal removal and rebuilding, to allow the Reactor Operators to focus on the offset mechanism replacement.

The two maintenance activities proceeded concurrently, with the offset being removed and the shim blade inspected at 1100. The pump seal replacement was completed shortly thereafter and a request was made to reactor operations staff to refill the pump leg to check for leaks. At this point in time, about 1210, the Lead Senior Reactor Operator, while considering the conditions necessary to refill the primary pump 501A piping, realized that the refueling had not left the reactor in the required precondition (i.e., with two elements removed from the core) for the offset removal.

The Reactor Manager was immediately contacted. He determined that the quickest way to restore Technical Specifications compliance while protecting public health and safety was to remove two elements from the core. The Reactor Manager and Lead Senior Reactor Operator knew from the Hazards Summary Report that criticality was not a possibility. The Reactor Manager estimated the shutdown margin of the existing core configuration to be approximately 0.08 $\Delta k/k$, which confirmed meeting Technical Specification 3.1e, which requires the reactor be subcritical by a margin of at least 0.02 $\Delta k/k$ with one control blade fully withdrawn. A new refuel procedure was written, approved and completed at 1352.

After the appropriate prerequisites were met, the installation of the offset mechanism B continued in an effort to place the plant in its safest configuration. The Reactor Manager declared the reactor "in standdown" and scheduled a meeting of all Reactor Operations staff for the following morning, June 13 at 0630 to discuss the event, contributing causes and to solicit information for the root cause determination. The offset B installation was completed at 0215 on June 13.

Safety Analysis

The Original Hazards Summary Report (HSR), Section 4.6 indicates the reactor was designed to provide enough control blade worth to enable reactor shutdown with the most reactive control blade stuck full out. HSR Addendum 2, states the reactor design is such that with the core in cold clean condition (maximum k excess), it will be subcritical with one blade fully withdrawn.

On June 12, when the Control Blade-B was removed from the core for maintenance, the reactor was in a safe shutdown mode. The following reactivity ($\Delta k/k$) values were estimated for the core with Blade B removed from the core:

Total worth of all 4 Blades (A, B, C, & D) (R_T):	0.1411
Total worth of Blade B (R_B):	0.0357
Core Excess Reactivity (R_{EX}):	0.0220
Core Shutdown Margin (R_T-R_B-R_{EX}):	0.0834

The Estimated Critical Position (ECP) for the core and the corresponding Core Excess Reactivity were confirmed by a subsequent reactor startup performed on June 15.

Initial Root cause determination

On the day following the oversight, the licensed operators were assembled for a safety stand down. During this stand down, the activities leading up to and during the event were pointed out and discussed.

1. Operations instructions and steps directly related to the offset mechanism removal are contained in two procedures. One is a Maintenance procedure, and the other is an Operations procedure SOP II, *Reactor Operating Procedure.*

2. The Maintenance procedure step IX.D states: "Remove required mechanism as per SOP II.3.3." This reference bypasses the Operations procedure section II.3.1 "Conditions Prior To Removal".

3. Step II.3.1.C.1 under Conditions Prior To Removal, which was bypassed by the reference to SOP II.3.3, states: "The core will be defueled of two fuel elements corresponding to the offset mechanism being removed."

4. There was not a sign off step requiring that the two fuel elements be removed.

5. Normal practice for performing this activity is to write the refueling procedure to leave two fuel elements out of the reactor until the offset mechanism work is completed.

6. Historically, the instructions to the Reactor Physicist to write the refueling procedure to leave two fuel elements out have been informal and usually verbal.

7. Personnel on the night shift had completed the refueling and had made preparations for the offset mechanism changeout. The actual changout was turned over to the day shift.

8. A leaking primary pump mechanical seal became a "jump up" maintenance activity that distracted key personnel on both the night and day shift.

9. The day shift Lead Senior Reactor Operator was directly and actively involved in the mechanism changout.

10. A number of personnel were aware that two fuel elements had to be removed from the reactor or left out during the refueling. Each thought or assumed that it had been done.

11. The position of Reactor Engineer had been vacant. Other individuals had been fulfilling the Reactor Engineer responsibilities on an "Acting" basis. This work was in addition to their regular duties. A senior staff member was assigned to this position on an interim basis until a permanent replacement is trained.

Based upon these facts, the root cause of this oversight has been determined to be a synergistic combination of inadequate procedure guidance, complacency with regard to performing infrequent activities, and inadequate reinforcement of management expectations regarding these two factors.

Corrective Actions

Prompt Post-Event Actions

1. On June 13 the Reactor Manager contacted the NRC to report the June 12 event and our initial corrective actions.

2. A meeting was held the morning of June 13, 2000; of the licensed operators, all except one who was on vacation and one who was on watch in the control room, were assembled for a safety stand down. During this stand down, the activities leading up to and during the event were pointed out and discussed.

3. Standing Order 00-09 was issued. This Order requires A Control Room Briefing prior to performing infrequent operations and activities, or whenever desired by the Lead Senior Reactor Operator.

4. At 0630 on June 14, a second Reactor Operations meeting was held with all operators except one on vacation. The purpose of this meeting was to provide training regarding the root cause determination, corrective actions, and expectations for the LSRO position and other licensed operators. This training addressed attention to detail, questioning attitude, complacency, performance of infrequent activities and other corrective actions to be implemented.

5. At 0800 on June 14, the Action Subcommittee (subset of the MURR Safety Subcommittee) was convened to review the event, Root Cause, and Corrective Actions. It was commented that since complacency apparently was a central issue in both events, the corrective actions should be designed to protect against this factor. It was also

recommended that criticality safety training be provided. Reactivity manipulation tasks should be viewed in respect to safety and not performed as dissociated tasks. It was recommended that those who actually perform the task should be requested to provide feedback on whether the procedure was adequate. A lack of awareness was cited as at lease one of the similarities between the April 12, 2000 and June 12, 2000 events As a further corrective measure, it was recommended that managerial staff could limit the number of additional tasks performed during a scheduled shutdown, or increase the number of operational staff on days when multiple tasks or activities are being performed.

6. Management attendance at shift turnovers is required to highlight management responsibility for safety and oversight. Management is providing this oversight to verify that policies, procedures and practices in place are adequate to ensure that pertinent information is transferred, and to emphasize maintaining the status board to include significant conditions and activities within the facility that could impact control room activities. The need for this corrective action will be reassessed at a later time after it is determined that shift turnover briefings are consistently satisfying management expectation. However, emphasis on management responsibility for safety will not decrease.

7. Re-emphasized to licensed operators the need for heightened awareness and attention to detail regarding reactivity manipulations.

8. Standard Operating Procedures Sections I through VI were reviewed to determine if there were misstatements or omissions, which would have safety implications in regard to operating the reactor. Based on this review it was noted that the SOP step addressing shift turnover required only the Lead Senior Reactor Operator to review the logbook and be briefed on current operations by the departing shift. It was decided that this step must be promptly revised. The actual practice has been the oncoming crewmembers, not just the Lead Senior Reactor Operator, would review the logbook and are briefed. Accordingly, a Standing Order was issued that revised the procedure to make the actual practice a requirement.

9. At 1800 on June 14, the Safety Subcommittee was convened to review the Root Cause, Corrective Actions and discuss plans for restart of the reactor. A concern was expressed that Lead Senior Reactor Operators may be focusing on the tasks they are faced with on a particular shift rather than operating with the big picture or the entire procedure in mind. It was also stated proper communication appears to be lacking.

10. The Reactor Manager authorized the reactor for restart on June 14 at 2200 after verifying all pre-startup corrective actions had been taken. The Reactor Manager completed a briefing of the Operating crew for the performance of startup and control blade worth measurement at 2230. The reactor returned to full power at 0505 on June 15.

Additional Corrective Actions

1. In the future, after the maintenance day activities are planned, a briefing with the licensed personnel that will be involved with performing/overseeing the maintenance

activities will be conducted. This briefing, coupled with the requirement for Control Room briefings for infrequent activities, will better ensure that those involved will be aware of the prerequisites, their responsibilities, and be prepared to maintain a situational awareness.

2. Offset change-out steps from the maintenance procedure have been relocated to control blade inspection Compliance Procedure (CP-25), which addresses removal of a control blade offset mechanism. This procedure has a signoff step, which requires verifying that the core is defueled of two fuel elements and to log this verification in the console log before removing the control blade offset mechanism.

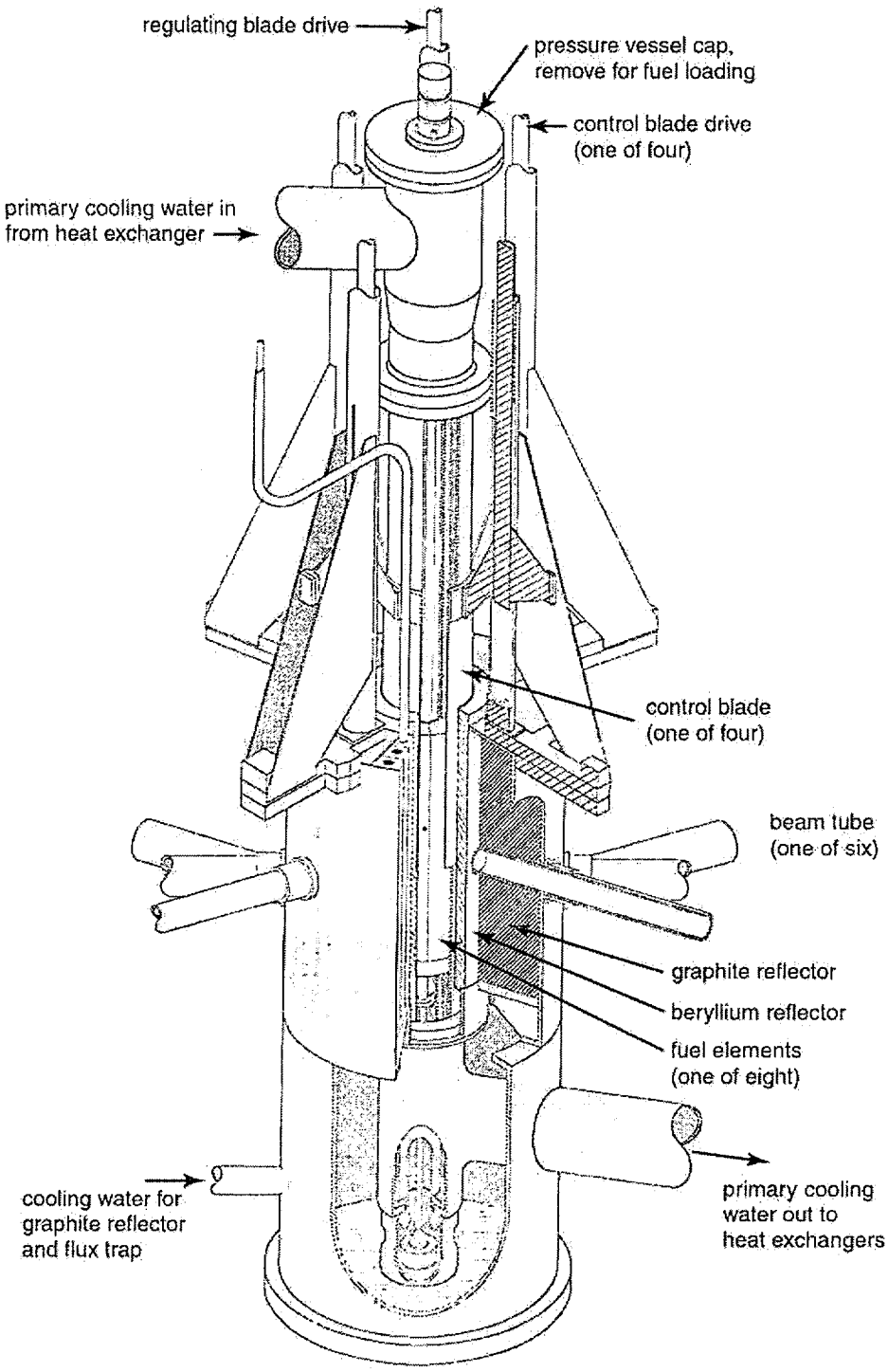
3. A procedure for writing specific refueling procedures has been issued. This procedure requires verification of the planned maintenance activities for the day the refueling will be used.

4. Vacancies in upper management are being filled. An Assistant Reactor Manager, with over 30 years nuclear experience, was hired and started June 12, 2000. A Chief Operating Officer, with 25 years of nuclear experience, has been hired and will start July 24, 2000. The selection of a Reactor Manager is in progress at this time. In the interim, a senior staff member with previous experience as Reactor Manager is acting in this capacity.

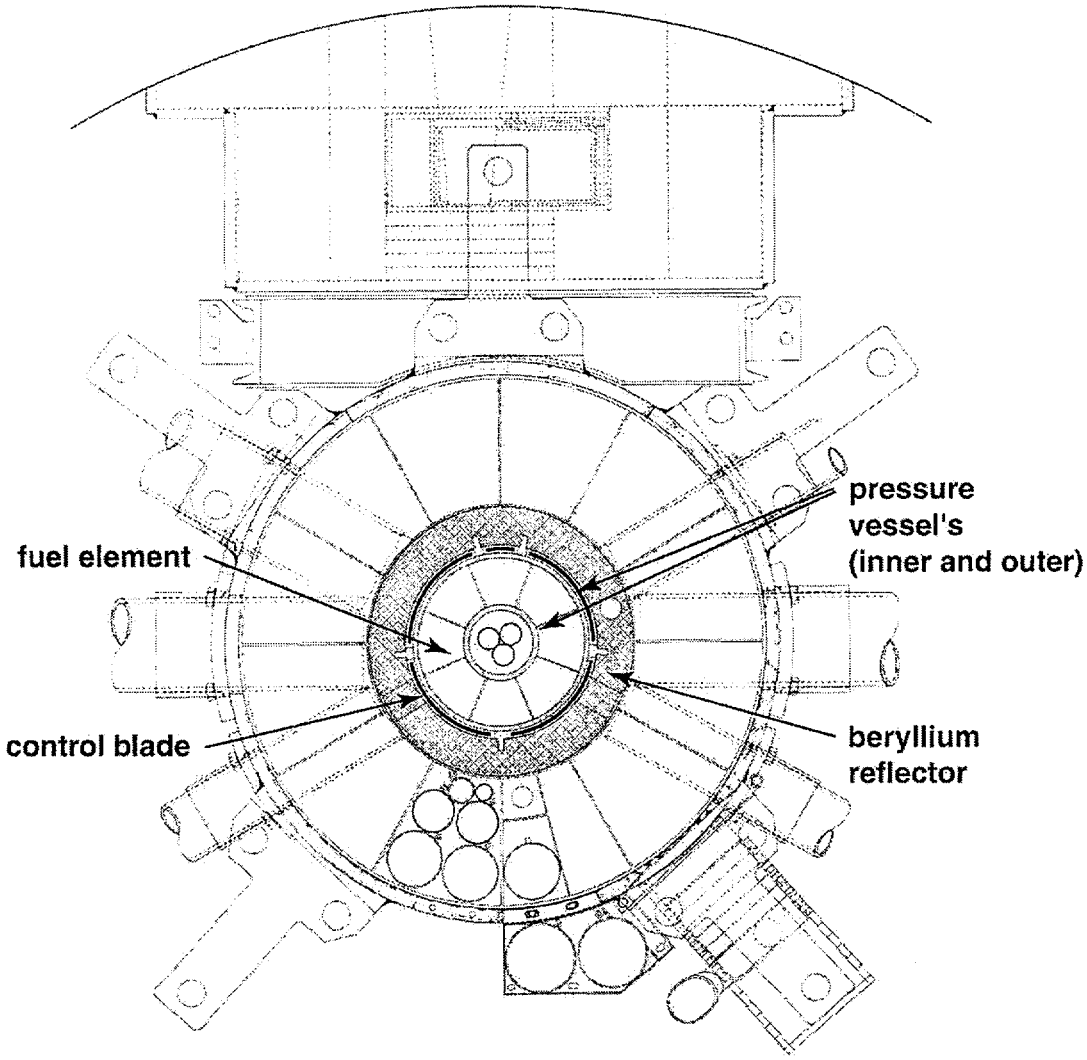
5. A review of operating procedure format is being performed and procedures are being revised as necessary for overall procedure upgrade.

6. An outside review team is performing a comprehensive review of the April 12 and June 12 events to confirm initial root cause conclusions. Their review report, when completed, will be reviewed to determine if additional corrective actions are necessary.

7. An independent peer review assessment of the April 12 event was performed by the Test, Research and Training Reactor National Organization (TRTR). The TRTR Chairman formally issued this report on July 12, 2000. MURR management is reviewing the report recommendations and corrective actions will be implemented as appropriate.



University of Missouri Research Reactor



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