July 26, 2000

EA-00-154

Dr. Edward A. Deutsch, Director
Research Reactor Facility
University of Missouri
Columbia, MO 65211

SUBJECT: NRC SPECIAL INSPECTION REPORT NO. 50-186/2000-202, UNIVERSITY OF MISSOURI-COLUMBIA RESEARCH REACTOR

Dear Dr. Deutsch:

This letter refers to a special inspection conducted on April 14, June 15-16, and July 13, 2000, at the University of Missouri-Columbia Research Reactor (MURR). The purpose of the inspection was to follow up on an unplanned radiation field event that occurred on April 12, 2000. The enclosed report presents the results of this inspection.

Based on the results of this inspection, one apparent violation was identified and is being considered for escalated enforcement action in accordance with the "General Statement of Policy and Procedure for NRC Enforcement Actions" (Enforcement Policy), NUREG-1600. On April 6, 2000, MURR removed shielding from the Spent Fuel Element Irradiation Facility. Removal of the shielding from the Spent Fuel Element Irradiation Facility increased the possibility and potential consequence of a radiation exposure event. The fact that MURR did not evaluate this condition to determine if prior NRC review and approval was required is an apparent violation of 10 CFR 50.59. No Notice of Violation is presently being issued for the inspection findings. In addition, please be advised that the number and characterization of apparent violations described in the enclosed inspection report may change as a result of further NRC staff review.

An open predecisional enforcement conference to discuss these apparent violations is being planned as discussed in the following paragraph. The decision to hold a predecisonal enforcement conference does not mean that the NRC staff has determined that a violation has occurred or that enforcement action will be taken. This conference is being held to obtain information to enable the NRC staff to make an enforcement decision, such as a common understanding of facts, root causes, missed opportunities to identify the apparent violations sooner, corrective actions, the significance of the issues, and the need for lasting and effective corrective actions. In addition, this is an opportunity for you to point out any errors in our inspection report and for you to provide any information concerning your perspectives on 1) the severity of the apparent violations, 2) the application of the factors that the NRC considers when it determines the amount of a civil penalty that may be assessed in accordance with Section VI.B.2 of the Enforcement Policy, and 3) any other application of the Enforcement Policy to this case, including the exercise of discretion in accordance with Section VII.

This inspection does not cover the June 12, 2000, event. However, from our inspection to date of the June 12 event and the commonalities with the subject April 12 event, you should plan to include an assessment of the June 12 event in the predecisional enforcement conference. In the very near future you should receive our inspection report on the June 12 event. If the NRC staff identifies apparent violations related to the June 12 event, we plan to include consideration of those apparent violations during the same predecisional enforcement conference. Prior to issuing the inspection report on the June 12 event, Mr. Alexander Adams or Mr. Marvin Mendonca of my staff will contact you to establish a mutually agreeable time and location for the enforcement conference. In addition to discussing these enforcement matters, we expect MURR to address organizational function and structure to ensure that management expectations are clear; resources, training, and feedback are acceptable to assure safety; and the command and control function of all regulated activities is maintained.

After the enforcement conference, you will be advised by separate correspondence of the results of our deliberations on this matter. No response regarding the apparent violations is required at this time.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter and its enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/NRC/ADAMS/index.html (the Public Electronic Reading Room).

Should you have any questions concerning this inspection, please contact Mr. Alexander Adams at 301-415-1127, or Mr. Marvin Mendonca at 301-415-1128.

Sincerely,

/RA by Charles E. Ader Acting for/

David B. Matthews, Director
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-186
License No. R-103

Enclosure: NRC Inspection Report No. 50-186/2000-202
cc w/enc: Please see next page

cc:

University of Missouri
Associate Director
Research Reactor Facility
Columbia, MO 65201

A-95 Coordinator
Division of Planning
Office of Administration
P.O. Box 809, State Capitol Building
Jefferson City, MO 65101

Mr. Ron Kucera, Director
Intergovernmental Cooperation
and Special Projects
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102

The National Organization of Test, Research,
and Training Reactors Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

This inspection does not cover the June 12, 2000, event. However, from our inspection to date of the June 12 event and the commonalities with the subject April 12 event, you should plan to include an assessment of the June 12 event in the predecisional enforcement conference. In the very near future you should receive our inspection report on the June 12 event. If the NRC staff identifies apparent violations related to the June 12 event, we plan to include consideration of those apparent violations during the same predecisional enforcement conference. Prior to issuing the inspection report on the June 12 event, Mr. Alexander Adams or Mr. Marvin Mendonca of my staff will contact you to establish a mutually agreeable time and location for the enforcement conference. In addition to discussing these enforcement matters, we expect MURR to address organizational function and structure to ensure that management expectations are clear; resources, training, and feedback are acceptable to assure safety; and the command and control function of all regulated activities is maintained.

After the enforcement conference, you will be advised by separate correspondence of the results of our deliberations on this matter. No response regarding the apparent violations is required at this time.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter and its enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/NRC/ADAMS/index.html (the Public Electronic Reading Room).

Should you have any questions concerning this inspection, please contact Mr. Alexander Adams at 301-415-1127, or Mr. Marvin Mendonca at 301-415-1128.

Sincerely,

/RA by Charles E. Ader Acting for/
David B. Matthews, Director
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-186
License No. R-103
Enclosure: NRC Inspection Report No. 50-186/2000-202
cc w/enc: Please see next page

Distribution: w/enclosure

PUBLIC	REXB r/f	SCollins	DMatthews	BBoger
BDavis	TDragoun	SNewberry	LMarsh	TQuay
PDoyle	TMichaels	WEresian	PIsaac	JPetrosino
EHylton	AAdams	SHolmes	CBassett	VOrdaz
MMendonca	LHowell	MSatorius, OEDO (O16-E15)		

CITF

DOCUMENT NAME: ML003733222 **TEMPLATE #: NRR-056**
***Please see previous concurrences**

OFC	REXB:RI		TechEd		REXB:PM		IOLB		IQMB	
NAME	*CBassett:rdr		*BCalure		*MMendonca		*RPedersen		*JPetrosino	
DATE	07/14/00		06/ 23 /00		07/ 13 /00		07/ 14 /00		07/ 14 /00	

OFC	REXB:LA		REXB:BC		OE		DRIP	
NAME	*EHylton		*LMarsh				DMatthews	
DATE	07/ 19 /00		07/ 14 /00		*07/ 18 /00		07/ 26 /00	

C = COVER **E = COVER & ENCLOSURE** **N = NO COPY**
OFFICIAL RECORD COPY

U. S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION

Docket No:	50-186
License No:	R-103
Report No:	50-186/2000-202
Licensee:	University of Missouri
Facility:	University of Missouri Research Reactor
Location:	Columbia, Missouri
Dates:	April 14, June 15-16, and July 13, 2000
Inspectors:	Craig Bassett, NRR Marvin Mendonca, NRR Roger Pedersen, NRR Joseph Petrosino, NRR
Approved by:	Ledyard B. Marsh, Chief Events Assessment, Generic Communications, and Non-Power Reactors Branch Division of Regulatory Improvement Programs Office of Nuclear Reactor Regulation

EXECUTIVE SUMMARY

This was a special, announced inspection. It included onsite review of the licensee's programs concerning an event on April 12, 2000, at the University of Missouri-Columbia Research Reactor (MURR). The event involved an unplanned radiation field from the Spent Fuel Element Irradiation Facility. MURR sent the NRC a written report dated May 11, 2000, on the event. The following summarizes the conclusions of the inspection.

ORGANIZATIONAL STRUCTURE AND FUNCTIONS

Organizational structure and staffing were consistent with Technical Specification requirements. However, the NRC inspectors noted that the licensee's organizational functions and structure contributed to the event. Therefore, an inspection follow-up item was opened to evaluate the effectiveness of MURR's organizational function.

OPERATIONS

The operations program satisfied Technical Specification requirements. However, concerns were raised on the effectiveness of MURR's shift turnovers and communication, and operator cognizance of facility conditions. Therefore, an inspection follow-up item was opened to evaluate operator understanding and communication of facility conditions.

DESIGN CONTROL

The inspection identified one apparent violation.

RADIATION PROTECTION

No violation of NRC requirements was identified.

FUEL HANDLING

The fuel-handling activities met licensee procedural requirements. However, one inspection follow-up item was opened to assess the effectiveness of the licensee corrective actions.

PROCEDURES

The procedural control and implementation program satisfied Technical Specification requirements. However, an inspection follow-up item on acceptable procedural implementation was opened.

EMERGENCY PREPAREDNESS

The NRC inspectors identified an inspection follow-up item on the effectiveness of the licensee's emergency preparedness training program.

Report Details

Summary of Event

The licensee had been examining the reactor's pool liner to evaluate its condition. Part of the biological shielding consists of removable magnetite concrete blocks for the Spent Fuel Irradiation Facility. The licensee removed these blocks on April 6, 2000, to allow an examination of the outer side of the pool liner, which was completed on April 12, 2000. The area inside the pool at this location is a fuel storage area containing a storage structure known as the Z-basket. The licensee had removed all fuel from the Z-basket area before removal of the shielding blocks. MURR personnel had moved the fuel to the main part of the pool.

The reactor experienced an unscheduled shutdown on April 12, 2000, that required reactor refueling. All fuel storage locations in the main part of the pool near the reactor were filled with fuel. To limit the fuel movements necessary to replace the core, the licensee made a change to the refueling sequence. The change put a fuel element in a rack in the Z-basket rather than in the fuel inspection rig. When the element was placed in the Z-basket, an area radiation monitor alarmed (because of the lack of shield blocks in the Spent Fuel Element Irradiation Facility). A Heath Physicist investigated and found elevated radiation levels as she approached the beam floor (an area administratively controlled as a locked High-Radiation area). The Health Physicist apparently realized that the fuel element in the Z-basket was the cause of the elevated radiation levels and alerted the operating crew. The operating crew had recognized the cause independently and had already moved the fuel element from the Z-6 position to the Z-2 position in the Z-basket. The Health Physicist following administrative controls then returned to the beam port floor to assess the situation. The Health Physicist measured a 200-rem/hour radiation field at the edge of the area from which the licensee had removed the shielding. The operators then moved the fuel from the Z-basket back to its original location, which ended the event. The licensee estimates that the elevated radiation field existed for about 3 minutes. No one was on the beam floor when this event happened and no uncontrolled radiation exposures occurred.

Reactor operations were placed on hold from about 2:30 p.m. until 8:30 p.m. to evaluate and understand the event. The Reactor Manager discussed the incident with reactor operations crews and others who were involved. The licensee replaced the shielding and tagged out the Z-basket area to prevent fuel from being placed in the area. The licensee also suspended all non-routine maintenance work at the facility. Additionally, the licensee established a team of managers to determine the root causes of the event. These were the short-term corrective actions.

A more detailed description of the event and the licensee's identified root causes are presented in the licensee's report dated May 11, 2000. On the basis of the findings and observation, the inspectors found this May 11, report acceptably accurate and complete. Interim and long-term corrective actions, as specified in the licensee’s report, included the following:

Interim:

- Specified that both the Reactor Manager and Health Physics Manager shall authorize all non-routine activity and shall approve all new procedures and all changes to procedures associated with these non-routine activities.
- Issued a Standing Order requiring that the step-by-step fuel movement procedure approved by the Reactor Physicist, or his approved designee,

be reviewed and countersigned by a second individual who is licensed as a Senior Reactor Operator.

- Require any revision to the step-by-step fuel movement procedure to be approved by two individuals comprised of any combination of the Reactor Physicist or licensed Senior Reactor Operators.
- Devised a more formal shift turnover status sheet to heighten communication at shift turnover, including unusual plant conditions.
- Assigned an experienced senior staff member to the Operations Engineer position until a permanent replacement can be recruited.

Long-Term:

- Developing procedure screening guidelines for delineating the types and methods of review for procedures prior to being implemented.
- Having external peer review. (At the end of this inspection, the licensee was reviewing a National Organization of Test, Research and Training Reactors (TRTR) report on this event and will inform the NRC of their plan for this external peer review. This NRC inspection did not include any review of that peer review.)
- Evaluating oversight and control of non-routine maintenance activities.

A discussion of the inspection findings in the individual functional areas follows.

1. ORGANIZATIONAL STRUCTURE AND FUNCTIONS (39745)

a. Scope

The inspectors reviewed selected aspects of the following:

- organization and staffing
- management responsibilities

b. Observations and Findings

The Acting Facility Director knew about the liner examination and took ultimate responsibility for its authorization. The Reactor Manager said he authorized the activity and had responsibility for the actual authorization of the liner examination. The inspectors concluded that these managers showed a sense of responsibility for the event and reactor safety.

The licensee informed the inspectors that it had established an incident response team of senior licensee managers to address the event. The inspectors found that although the team included experienced operations and radiation safety personnel (i.e., the Associate Director responsible for Operations, the Associate Director responsible for Reactor Income Generating Operations, and the Health Physics Manager), some members of this group had little nuclear safety experience. However, the inspectors concluded that this group provided a facility management perspective with acceptable nuclear safety experience to address the issue.

This team of MURR managers included members from most functional areas. It did not include a member from MURR's Reactor Research and Development Program. The licensee said that individuals from the Reactor Research and Development Program, the Operations organization, and the Health Physics organization are involved together in the research approval process. This process ensures coordination on many MURR activities but not necessarily all that may affect radiation safety. As part of the follow-up, the inspectors will assess if the licensee's consideration of the event is comprehensive. This follow-up will include ensuring that the licensee informs and acceptably involves all potentially affected individuals of facility, procedure, experimental or other changes.

The licensee contacted the Reactor Advisory Safety Committee to review the event. This review was comprehensive and issues raised by the committee were acceptably resolved as evidenced by the minutes of April 18, 2000.

The licensee requested a peer review from TRTR. The licensee was reviewing the draft report to ensure it is factually correct in accordance with TRTR policy on peer reviews. The licensee plans to inform the NRC staff of the disposition of the report when the report is completed.

An unusual feature of the licensee’s organization was the use of a lead Senior Reactor Operator position rather than the more traditional shift supervisor. The inspectors raised this issue with the licensee on April 14. In the May 11 report, the licensee "concluded ‘shift oversight and control' meets license and technical specification requirements." The inspectors concur in that assessment. Although the licensee’s use of a lead Senior Reactor Operator versus the more traditional shift supervisor meets NRC requirements, it introduces additional operational challenges. The inspectors could not establish that the elimination of shift supervisors was advantageous to reactor operation and shift turnover activities. However, neither the licensee nor the NRC inspectors could definitively establish that this unusual feature contributed to the unplanned radiation field.

At the time of the event, the Reactor Physicist was acting as the Operations Engineer and the Reactor Physicist. Both positions have some supervisory responsibility for operations. The Reactor Physicist prepared the fuel movement sequences for the reactor. As the Operations Engineer, he provided oversight and engineering support to operations. Just before the April 12 fuel movement, the Reactor Physicist was on his way to his office on another task. In passing, he noted the operators installing the fuel inspection rig. The Reactor Physicist suggested using the Z-basket instead. The operators assumed this was an acceptable alternative and did not question it. The inspectors concluded that allowing one person to function in two positions was a contributor to the event. This “dual position” situation was also considered a contributor to the event from the viewpoint that the operators did not question the change.

In the report of May 11, 2000, the licensee indicated that the lack of a full-time Operations Engineer created some inefficiencies in communications between shifts. As corrective action, the licensee assigned an experienced senior staff member as Operations Engineer. During subsequent conversations, the Reactor Manager said that MURR had recruited an Operations Engineer. The licensee also said that the senior

staff member would phase out of the Operations Engineer's duties when the new Operations Engineer can assume the responsibilities.

The inspectors considered the fact that the licensee was using an interim Reactor Manager in addition to the interim Operations Engineer previously discussed. The inspectors noted that two senior staff members had recently left. The licensee has filled the Operations Engineer position and is continuing to try to fill the Reactor Manager and other positions. The inspectors found that management and staff levels were contributors to the April 12 event.

As previously noted, one of the licensee's interim corrective actions from the May 11 report specifies that MURR requires authorization from both the Reactor Manager and the Health Physics Manager on all non-routine activities. In the long term, the licensee is planning to evaluate the oversight and control of non-routine maintenance activities. This evaluation should provide additional assurance that the licensee will control similar events. However, the inspectors note that the licensee's evaluations should not be limited to only non-routine maintenance, and the inspectors follow-up will ensure that the corrective actions were acceptably comprehensive.

The inspectors reviewed the licensee's organizational function and structure as related to the event and found that certain elements were potential contributors or contributors to the event. The previously mentioned lead Senior Reactor Operator structure, and the vacant Operations Engineer and Reactor Manager positions were examples. Many different parts of the organization had opportunities to see or hear about the removed shielding. Facility management, reactor management and staff, health physics management and staff, group leaders, and other licensee staff and researchers did not recognize the potential for the event. They did not raise questions on it in meetings or other work-related activities. Neither did licensee management formally inform many MURR staff of the removed shielding. Therefore, several opportunities to address the issue were missed by MURR management and staff.

The licensee said that it had conducted facility-wide meetings about once a month. The licensee also said that a "safety moment" was always part of this meeting. The licensee said it discussed current safety issues and other ongoing MURR issues. The licensee estimated that a little over three-quarters of the staff participate in these meetings. The licensee also said that individual groups held meetings as well. The inspectors did not have an opportunity to observe any of these meetings and, therefore, could not evaluate the effectiveness of MURR staff meetings from a safety perspective.

An inspection follow-up item (IFI 50-186/2000202-01) will address potential concerns about organizational function and structure. Specifically, in subsequent inspections, the NRC staff will evaluate whether licensee management expectations on reactor safety are clearly established, understood, and implemented. The NRC staff will evaluate whether management provides resources, personnel, training, and feedback to ensure the safe conduct of licensed activities and compliance with regulatory requirements. Also, the NRC staff will evaluate the command and control function from the licensee management to the licensee staff. This evaluation is to ensure that MURR staff (1) have adequate information of facility conditions, (2) understand their responsibilities,

and (3) know how to carry out their responsibilities acceptably. Finally, the NRC staff will evaluate corrective actions, including the licensee's oversight and control of not only non-routine maintenance activities, but also other activities as well.

The organizational structure was consistent with the requirements of Technical Specifications Section 6.1.a and Figure 6.0. Staffing satisfied the requirements of Technical Specifications Section 6.1.i.

c. Conclusions

The organizational structure and staffing were consistent with Technical Specification requirements. However, the inspectors noted that the licensee's organizational functions and structure contributed to the event. Therefore, an inspection follow-up item to evaluate the effectiveness of MURR's organizational function was opened.

2. OPERATIONS (39745)

a. Scope

The inspectors reviewed selected aspects of the following:

- operational logs and records
- selected shutdown activities

b. Observations and Findings

The operating logs and records were clear and provided an indication of operational activities, including documentation of events. The logs and records showed that the licensee operated the reactor during the liner examination. The liner examination was remote from safety-related equipment. The reactor design is such that reactor safety functions are assured even with the most limiting single failure. Records showed the radiation exposures associated with operation of the reactor during the liner examination were within limits. No regulatory requirements prohibited operation of the reactor during the pool liner examination.

The inspectors assessed the licensee's 6-hour hold on reactor operations following the April 12 event. During this time, the individuals involved described the event to the licensee. Also, oncoming shift operators were briefed. The licensee replaced the shielding and tagged out the Z-basket area to prevent fuel from being placed in the area. The licensee suspended all similar work. Further, the licensee evaluated non-routine activities to ensure that it acceptably controlled activities (i.e., other informal activities were done under procedural or administrative controls).

Other non-routine activities that MURR had performed were beryllium replacement and pool heat exchanger replacement. These were conducted under special, reviewed and approved maintenance procedures. The licensee also pointed out that radiation work permits were prepared according to administrative procedure, and that Health Physics

personnel reviewed or approved these documents. The licensee reviewed all other non-routine maintenance activities for procedural requirements.

The inspectors reviewed logs and records to see whether the licensee had conducted other similar non-routine activities. Specifically, the inspectors looked for activities not controlled by a reviewed and approved procedure, or otherwise not following administrative controls or industry practice. Review of the logs found activities controlled by reviewed and approved procedures.

The licensee had removed the shielding approximately 1 week before the event. The licensee did not document this fact in logs or communicate this change in reactor condition in shift turnovers. Some operators said that they had passed on the information informally. However, operators generally had not recognized the potential significance of the removal of the shielding before the event. Discussions with operators after the event showed an understanding of the significance of the event and their responsibilities to operate the reactor and associated facilities safely. The licensee's report of May 11, 2000, indicated that MURR devised a more formal shift turnover status sheet to heighten communication at shift turnover, including unusual plant conditions. (The licensee also reported an event that occurred on June 12, 2000, in which shift turnover communications were a concern.)

Also, during the fuel movement, the licensee used a licensed Senior Reactor Operator, who is normally off shift. Use of this individual to help the remaining shift-assigned Senior Reactor Operator and Reactor Operator Trainee contributed to the event. The turnover did not communicate the removed shielding and the normally off-shift operator had no opportunity to understand the condition of the facility.

The inspectors questioned the movement of the fuel assembly from the Z-6 to the Z-2 position. Operators said that they considered the fuel assembly to be the cause of the alarm from the area radiation monitor. They said they moved the assembly to Z-2 so that it would be farther away from the center of the racks and thus provide more shielding and distance from the fuel assembly. Alternatively, operators could have moved the fuel assembly out of the Z-baskets back to the original storage location in the reactor pool. Although this move would not have allowed the radiological measurement of the exposure rate when the fuel was in the Z-2 position, it would have ended the unplanned radiation field in about one-half the time.

The inspectors have identified an inspection follow-up item (IFI 50-186/2000202-02) to assess operator cognizance of facility conditions. This item was opened because of the many opportunities the operators had to recognize that the shielding was removed. Examples of opportunities to identify this issue included routine operator rounds, operator observations, and the fact that some individuals knew of the activity in the Spent Fuel Element Irradiation Facility. Follow-up will also include consideration of the effectiveness of shift turnover corrective actions.

The inspectors gathered information on the licensee's overall operational compliance with the provisions of 10 CFR 50.21 to determine if the licensee operated the facility for industrial or commercial purposes. The regulation requires that for the MURR class of

license, no more than 50 percent of the annual cost of owning and operating the facility goes to the production of materials, products, or energy for sale or commercial distribution, or to the sale of services, other than research and development or education or training. On June 15, 2000, MURR's tabulation of expenditures for fiscal year 1999 (July 1, 1998, through June 30, 1999) showed 74 percent of the annual cost of owning and operating the facility was for research. MURR anticipated that 77 percent of the cost of owning and operating the research reactor in fiscal year 2000 will be for research. NRC's Generic Issues, Environmental, Financial and Rulemaking Branch from the Office of Nuclear Reactor Regulation reviewed this tabulation. Based on this review, MURR continues to meet the requirements as a noncommercial research reactor.

c. Conclusions

The operations program satisfied Technical Specification requirements. However, operational concerns were raised on the effectiveness of MURR's shift turnovers, communications and awareness of facility conditions. Therefore, an inspection follow-up item was opened to evaluate operator understanding and communication of facility conditions.

3. DESIGN CONTROL (40745)

a. Scope

The inspectors reviewed selected aspects of the following:

- facility changes and records
- facility configuration

b. Observations and Findings

The inspectors examined the records and the facility configuration related to the removal of shielding from the Spent Fuel Element Irradiation Facility. The licensee described the activity in a document dated March 29, 2000, "Pool Liner Inspection Tasks and Preparation." Discussions with personnel found that a senior staff person prepared this document, and the Reactor Manager, Health Physics Manager, and a licensed Senior Reactor Operator reviewed it. Additionally, operators, health physics personnel, other licensee staff, and contractor personnel said they used this document.

The licensee planned the removal of the shielding to be coincident with the lowest fuel inventory. MURR had also planned to leave the Spent Fuel Element Irradiation Facility open so that potential repairs could be made if necessary. The licensee said it was an integrated plan, such that, MURR needed 2 weeks to schedule the sequence of events taking into consideration equipment, personnel, and potential repair contingencies. Because the licensee concluded that the potential for introducing fuel in the Z-baskets was small, MURR did not assess the potential probability and consequences of the removed shielding. Specifically, the licensee did not consider replacing the shielding earlier, placing additional warning indications or monitors at the open Spent Fuel

Element Irradiation Facility, or tagging the Z-baskets to reduce the risk of exposure until after the event.

Through review of the records and discussions with selected staff, the inspectors found no consideration of 10 CFR 50.59 requirements by the licensee. Particularly, the inspectors found no assessment of the potential effects of removing the shielding. The licensee described the Spent Fuel Element Irradiation Facility in Section 6.5.3 of the University of Missouri Research Reactor Facility Hazards Summary Report dated July 1, 1965. The removal of shielding from the irradiation facility without a 10 CFR 50.59 evaluation is an apparent violation (VIO 50-186/2000202-03).

The inspectors also considered the design control on area radiation monitors. After the event of April 12, 2000, the licensee moved a monitor to the east wall from the nuclepore experimental facility area. The licensee controlled the design change in accordance with 10 CFR 50.59. The licensee moved the monitor away from the east wall in about 1968 and documented this change in Hazard Summary Report updates.

c. Conclusions

The inspectors identified one apparent violation.

4. RADIATION PROTECTION (83743)

a. Scope

The inspectors reviewed selected aspects of the following:

- radiological signs and posting
- routine surveys and monitoring
- dosimetry records
- maintenance and calibration of radiation monitoring equipment
- as low as reasonably achievable (ALARA) reviews

b. Observations and Findings

Caution signs, postings, and controls in radiation areas were as required in 10 CFR Part 20, Subpart J. Licensee personnel were observing the required precautions before entering the radiation areas. Use of dosimeters and exit frisking practices followed radiation protection requirements. Equipment for radiation monitoring and survey activities was calibrated. The event did not require a respiratory protection program or a planned special exposure program. Discussions with and observations of licensee personnel showed them acceptably trained in radiation protection practices.

The license conducted two re-creations of the event with the involved personnel. The first re-creation took about 180 seconds. The second re-creation simulated the activities in segments and added up to 187 seconds. These re-creations confirmed the potential exposure time and the licensee's report of activities during the event. Simulations by the inspectors also confirmed the timing.

The Health Physicist had been on the beam floor about 5 minutes before the event and was on the reactor bridge area when the event occurred. The licensee also interviewed personnel who might have been on the beam floor and found no one who had walked through the area during the event. The actions of the Health Physicist and the Reactor Operator Trainee resulted in assuring that no one was on the beam port floor. The inspectors determined through review of records and personnel interviews that no one had been on the beam floor during the event.

The Health Physics Manager calculated the maximum dose rate during the event at about 400-rem/hour. This calculation was based on the 200-rem/hour measurement by the Health Physicist when the fuel element was in the Z-2 position. The Health Physics Manager calculated this dose rate on the basis of the differences in shielding and the distances between the Z-6 and Z-2 positions. For an estimate of the shielding effect, the Health Physics Manager used "Figure 6.10, Transmission of fission product gamma radiation" from the "Health Physics and Radiological Health Handbook," compiled and edited by B. Shleien, et al., copyrighted 1984.

Although the Health Physicist was present, she was not monitoring radiation levels at the time of the liner examination in the Spent Fuel Element Irradiation Facility, because the licensee believed there was no radiation source or potential. In fact, no one was in the radiation field at the time of the event. However, if personnel were assumed in a radiation field of about 400 rem/hour, exposure for 45 seconds would exceed 10 CFR Part 20 occupational limits.

The inspectors did not identify any overexposure. Radiological exposure records of thermoluminescent devices for personnel and areas on the beam floor showed that doses were within 10 CFR Part 20 limits.

The inspectors examined the MURR personnel exposure records. No abnormal exposures were noted except the 500 millirem measurement from the Health Physicist finger ring dosimeter. Area dosimeters were also examined and the only abnormal indication was the 1260 millirem measurement on the east wall.

The Health Physics Manager calculated the dose rate in the room immediately in line with the Spent Fuel Element Irradiation Facility. Based on the distances (about an additional 17 feet, plus another 3 feet to accessible areas in Room 111A) and the intervening material (the approximately 16-inch-thick concrete wall of the containment), the licensee calculated the radiation field in Room 111A. The result was about 140-millirem/hour, or for the approximate 3 minutes of the event, about 7 millirem if any individuals were present in the room. The licensee interviewed staff members and has not found anyone who was in Room 111A at the time of the event. The inspectors also found no one who was in Room 111A during the event.

The licensee said that ALARA reviews considered the fact that fuel was out of the Z-basket area with no plans to move it back until the shielding was replaced. The inspectors noted from document review that the licensee had monitored radiation conditions during shielding removal.

NRC Enforcement Policy specifies that the NRC staff should assume a single change in the circumstances of an event (i.e., timing, less radiation shielding in place, etc.) to assess if there was a substantial potential for overexposure. A substantial potential for overexposure would exist if this single change could have resulted in exposure of an individual to radiation in excess of the dose limits. The NRC staff considers program failures that pose a substantial potential for overexposure as seriously as an actual overexposure.

In accordance with this policy, the inspectors considered the scenario if the liner examination had been coincident with fuel movement to the Spent Fuel Element Irradiation Facility (e.g., the timing of the actual event only slightly altered). In this assumed scenario, the personnel on the pool liner examination could have shielded the alarming monitor and received additional direct radiation exposure from the fuel movement. That is, without the alarm actuation, timely evacuation would not have occurred and an overexposure of the liner examination team would likely have resulted. In this assumed scenario, these individuals could have provided shielding of the area radiation monitors for some time. A contractor to the licensee and a licensee staff member conducted the examination of the pool liner in the morning before the event so a change of a few hours could have established these conditions.

Personnel in the radiation field could have shielded the area radiation monitor from the field and thus prevented the alarm. To assess the shielding effect, the inspectors considered the geometry of the Spent Fuel Element Irradiation Facility with the two people performing the liner examination at the opening. Indications are that the liner examination personnel leaned into the cavity, and one examined the liner for about 5 minutes and the other for about 10 minutes. The inspectors estimated the sizes of the individuals. One individual's size was based on direct observation. The other individual's size was based on a description by licensee personnel. On the basis of the description of the liner examination process and these size evaluations, the inspectors conservatively calculated that the two people examining the liner would cover approximately two-thirds of the effective radiation field. The inspectors gave no consideration for the potential movement of the individuals during the examination. The inspectors conservatively estimated that with these individuals in the Spent Fuel Element Irradiation Facility, the shielding would be equivalent to about an additional 8 inches of water. This assumes no credit for contours of the body or for voids in the body, such as air in the lungs. It conservatively assumes that the individuals would completely cover the facility width of 32 inches to this depth over an equivalent of about 22 inches of the 32-inch opening. This would conservatively add about 8 inches of water to the shielding of 24 inches already in the Z-basket area. Using the above quoted "Figure 6.10, Transmission of fission product gamma radiation" the inspectors have calculated that the shielding reduces the effective radiation dose rate to the area radiation monitor. The result was greater than the 4-millirem/hour setpoint. The inspectors verified the 4-millirem/hour set point by observation of alarm testing. Thus, the inspectors could not determine that the alarm would not have activated if the liner examination was concurrent with the event. With the alarm, the inspectors concluded that the liner examination personnel would have likely evacuated within 45 seconds and therefore not exceeded the 5 rem limit.

Another potential overexposure scenario in accordance with NRC policy is to assume that the area radiation monitor was inoperable or that a less radioactive fuel element could have been placed in the Z-baskets, which would have resulted in no alarms. The Reactor Manager indicted that the longest refueling takes about 1 hour. Since the licensee would have returned the fuel element to normal storage to complete the fuel movements, the unplanned radiation field would have been in place for 1 hour. During the April 12 fuel movement, no personnel were near the Spent Fuel Element Irradiation Facility. Only personnel going through the beam or standing in the beam would have been exposed to the unplanned radiation field. On April 12, licensee personnel said that no one was observed attempting to get to the beam floor during the event and in the following hour. It would require 11 or more trips through the beam to be overexposed as previously discussed. Alternatively, to be overexposed, an individual would have to stay a relatively long time in the posted High-Radiation Area with no specific purpose. Given the one change of the monitor not working or being able to respond, the NRC policy for evaluation can assume no individuals were in the facility in assessing the potential for overexposure. Therefore, in accordance with the NRC's Enforcement Policy the NRC inspectors consider a substantial potential for overexposure did not exist given the alarm would not sound.

In the report of May 11, 2000, the licensee characterized the original notification to NRC staff as required for a potential exposure greater than 5 rem. The licensee's subsequent evaluation of the area radiation alarm has led to a determination that administrative controls would have limited personnel exposure time to less than 5 rem. In the May 11 report, the licensee asked to withdraw the original notification of the event.

The inspectors examined various work areas at the facility. Desks, experimental data gathering areas, and other work areas were observed on the same floor as the Spent Fuel Element Irradiation Facility. No work areas were in the direct line of the unplanned radiation field. The inspectors also considered the work areas on the beam floor from an ALARA perspective. The inspectors reviewed the licensee's measurements of the radiological exposures at the work areas inside the fenced, locked High-Radiation area of the beam floor. The measurements were in late April during full-power operations. The results were generally less than about 20-millirem/hour. The licensee measured the doses on the beam floor outside the fenced, locked area in September and November 1999. The results showed dose rates at less than 0.06-millirem/hour, which is not required to be controlled as a radiation area. For these areas, the inspectors determine that the configuration to reduce exposure and usage to limit times met the ALARA principles.

A concern was raised that not all personnel with beam floor access or with radiation worker status were informed of the event or the results of the event follow-up. The inspectors raised this concern with licensee management. The licensee had not ensured that all personnel with access to the beam floor were in the communication loop. However, on the basis of licensee follow-up previous to the inspectors raising the issue, the Health Physics Manager said that MURR had already made a change to the distribution of information by electronic mail to address this issue.

c. Conclusions

No violation of NRC requirements was identified.

5. FUEL HANDLING (60745)

a. Scope

The inspectors reviewed selected aspects of the following:

- fuel-handling procedures
- fuel-handling equipment and instrumentation
- fuel-handling and examination records

b. Observations and Findings

Fuel-handling procedures (SOP/II.2) and the "MURR Refueling Sequence" for the event provided a prescribed method for moving and handling fuel. The inspectors found this guidance consistent with the provisions of the Technical Specifications and the licensee safety analyses. The Reactor Physicist, who was also acting as the Reactor Engineer, was passing by during the refueling operation. He said that he had forgot that the Spent Fuel Element Irradiation Facility had been opened, and he indicated that the operators could use the Z-basket. The two Senior Reactor Operators and the Reactor Operator Trainee who were on duty either forgot or did not know that the shielding had been removed. The lead Senior Reactor Operator made the change to the refueling sequence procedure. Required administrative controls allowed the change. Procedures for refueling the reactor and handling hot fuel elements did not have any provisions for the condition in which the Spent Fuel Element Irradiation Facility shielding had been removed. The licensee put no controls, tags, or other indications on the Z-baskets.

The licensee's corrective actions included a Standing Order requiring that the step-by-step fuel movement procedure approved by the Reactor Physicist, or his approved designee, be reviewed and countersigned by a second individual who is licensed as a Senior Reactor Operator. The licensee also required any revision of the step-by-step fuel movement procedure be approved by two individuals comprising any combination of the Reactor Physicist or licensed Senior Reactor Operators. To evaluate the effectiveness of these corrective actions, an inspection follow-up item (IFI 50-186/2000202-04) was opened.

c. Conclusions

The fuel-handling activities met licensee procedural requirements. However, the inspectors identified one inspection follow-up item to monitor the effectiveness of the licensee's corrective actions.

6. PROCEDURES (42745)

a. Scope

The inspectors reviewed selected aspects of the following:

- administrative controls
- records for changes and temporary changes
- procedural implementation
- logs and records

b. Observations and Findings

The licensee did not make the "Pool Liner Inspection Tasks and Preparation," document of March 29, 2000, into a formal procedure. Therefore, the Reactor Advisory Committee did not review the document. Neither the Technical Specifications nor the Administrative Operating Policies (SOP-I) require a procedure for such activities. However, such an activity should have received an evaluation in accordance with 10 CFR 50.59 as discussed in the design control section. If the licensee performed an adequate 10 CFR 50.59 evaluation, a procedure would have, in all likelihood, been required.

The licensee did not conduct the activity following the guidance given in the document of March 29, 2000. Specifically, the document said to remove all Z-baskets, but the licensee could not remove all of them because some bolts could not be loosened. When MURR could not remove all the Z-baskets, the licensee made no change to provide tags to avoid use of the Z-basket. The licensee made no provisions for potential malfunctions.

Because of these potentially procedure-related concerns, an inspection follow-up item (IFI 50-186/2000202-05) was opened to ensure acceptable implementation of procedure documentation, review, training, conduct, changes, and precautions.

c. Conclusions

The procedural control and implementation program satisfied Technical Specification requirements. However, an inspection follow-up item on acceptable procedural implementation was opened.

7. EMERGENCY PREPAREDNESS (82745)

a. Scope

The inspectors reviewed selected aspects of the following:

- personnel emergency response
- training
- emergency drills and exercises

b. Observations and Findings

Training records and presentation material showed the actions to take if an area radiation monitor alarm occurred. Records showed that emergency preparedness and response training was being completed as required.

The Health Physicist, a Reactor Operator Trainee, and two licensed Senior Reactor Operators were on the reactor bridge when the event occurred. About 5 minutes before the event, the Health Physicist was on the beam port floor and had observed no one. Upon the area radiation monitor alarm, the Health Physicist went down the stairs, picked up an ion chamber, and measured 10-millirem/hour toward the bottom of the stairs. The Health Physicist realized the problem was the fuel element in the Z-basket. She returned upstairs, monitoring for radiation in the areas she passed. Operators informed the Health Physicist that she needed to perform an evaluation of the conditions in accordance with alarm response administrative controls. The Health Physicist then went down the stairs onto the beam port floor to more closely monitor the radiation field and got the 200-rem/hr reading. The Reactor Operator Trainee went down the back stairs to the platform area to observe the beam port floor and called out to alert anyone on the beam port floor. Together, the Health Physicist and the Reactor Operator Trainee confirmed visually and by voice that no one was on the beam floor. The inspectors confirmed the effectiveness of this process. The inspectors walked through the actions of these individuals and talked with each other where researchers or students might have been.

The inspectors have conducted discussions with witnesses as part of event follow-up. The inspectors conducted discussions with operators, researchers, staff members and students who were not present during the event although they could have been. These discussions showed that some personnel would leave an area if an area radiation alarm sounded. Operators regularly tested the area radiation monitor alarm as part of startup procedures and as demonstrated by the Reactor Operator Trainee's response and individuals' statements would evacuate on the alarm. Other personnel said they would seek a radiation meter and try to find the cause of the radiation. A radiation meter is available near the Spent Fuel Element Irradiation Facility. The inspectors examined the radiation meter and found it calibrated. From discussions, the individuals understood the use of such meters and would have identified the radiation field and protected themselves. Some personnel did not recall the training or instructions on response to area radiation monitor alarms.

A licensee researcher indicated to the Health Physics Manager that two students suggested they may not have evacuated promptly. A Health Physicist discussed this issue with the researcher and the students. The NRC inspectors also discussed the issue with the researcher, and one of the students. The researcher said he would have evacuated immediately based on his past research reactor experience. The student said that she might not have left the south side area immediately because the alarm was on the north side. The student would have called the control room. The operators said they would have told the student to evacuate. The student then would have evacuated through the area of the beam. The total time for the student to simulate these steps was less than 45 seconds as measured by the inspectors. The time in front of the

Spent Fuel Element Irradiation Facility was less than 4 seconds. The researcher said the other student responded similarly. Another student indicated that he was unaware of the response, would not have recognized the alarm, but would have evacuated when told to do so by the Health Physicist or the Reactor Operator Trainee.

The inspectors conclude that some of these responses are inconsistent with the training and the licensee-expected response. Therefore, an inspection follow-up item (IFI 50-186/2000202-06) was opened to determine the effectiveness of emergency response training.

Further, the actions of the Health Physicist and the Reactor Operator Trainee ensured that the response would have been to evacuate in the safest direction. That is, they said they would have directed personnel away from the unplanned radiation field. However, some individuals indicated if they were by themselves on the beam floor before the arrival of the Health Physicist or Reactor Operator Trainee, they would have evacuated through the shortest route. This evacuation route could have been through the unplanned radiation field. The operators said that they would have checked for personnel on the beam floor if the Health Physicist or the Reactor Operator Trainee were not there.

The inspectors found it unlikely that an individual would stand in front of the open Spent Fuel Element Irradiation Facility for any protracted time with an area radiation alarm sounding. Although it was around the corner from the open Spent Fuel Element Irradiation Facility, individuals would have been evacuated considering that the Operations and Health Physics personnel were ensuring evacuation. In view of radiation worker training on monitoring, evaluating, and responding to radiation meter readings or alarms, the inspectors concluded that personnel would protect themselves. That is, MURR personnel would have limited exposure to the radiation field to less than 45 seconds (the minimum time required to exceed occupational dose limits) for the event as it occurred.

The licensee estimated that "it would take on the order of 4 seconds for an individual to pass through the radiation field while leaving the area." The inspectors considered this a conservative estimate of the time to move through the beam once. The inspectors concluded that about 11 transits through the radiation field would result in exposures of 0.5 rem. On the basis of the discussions, training records, and observations, the inspectors conclude that this is a conservative assumption.

c. Conclusions

The inspectors opened an inspection follow-up item to monitor the effectiveness of the licensee's emergency preparedness training program.

8. Exit Interviews

The inspectors summarized the inspection scope and results on April 14, June 16, and July 13, 2000, with members of the licensee’s management. The inspectors described the areas inspected and discussed the inspection findings. No dissenting comments were received from the licensee. The licensee did not identify as proprietary any of the material provided to or reviewed by the inspector.

PARTIAL LIST OF PERSONS CONTACTED

Licensee Personnel

Chuck Anderson, Senior Reactor Operator
Jeff Attebery, Manager, Business and Fiscal Operations
Ron Berliner, Senior Research Scientist
Barry Bezenek, Senior Reactor Operator
Brian Brocker, Senior Reactor Operator
Ken Brooks, Acting Director
Tamara Crockett, Information Officer
Ed Deutsch, Facility Director
Chester Edward, Facilities Manager
John Ernst, Health Physics Manager
John Farmer, Senior Research Scientist and Adjunct Associate Professor of Physics
Rob Hudson, Senior Reactor Operator
Paul Hobbs, Assistant Reactor Manager
Das Kutikkad, Reactor Physicist
Charlie McKibben, Associate Director/Interim Reactor Manager
Walt Meyer, Associate Director
Jim Rhyne, Professor of Physics
Alex Saale, Reactor Operator
Andrea Shipp, Health Physicist
Laura Stumpe, Graduate Research Assistant
Rob Taylor, Reactor Operator Trainee
Tobu Tsuchiya, Graduate Research Assistant
Tim Warner, Senior Reactor Operator
Bill Yelon, Senior Research Scientist

INSPECTION PROCEDURES USED

IP 39745	CLASS I NON-POWER REACTORS ORGANIZATION AND OPERATIONS AND MAINTENANCE ACTIVITIES
IP 40745	NON-POWER REACTOR REVIEW AND AUDIT AND DESIGN CHANGE FUNCTIONS
IP 42745	NON-POWER REACTOR PROCEDURES
IP 60745	NON-POWER REACTOR FUEL MOVEMENT
IP 82745	NON-POWER REACTOR EMERGENCY PREPAREDNESS
IP 83743	NON-POWER REACTOR RADIATION PROTECTION

ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

50-186/2000202-01	IFI	Evaluate organizational function
50-186/2000202-02	IFI	Assess operator understanding of facility conditions
50-186/2000202-03	VIO	Failure to perform 10 CFR 50.59 for removal of shielding from the Spent Fuel Element Irradiation Facility
50-186/2000202-04	IFI	Review effectiveness of corrective actions in the fuel-handling area
50-186/2000202-05	IFI	Determine whether procedural implementation is acceptable
50-186/2000202-06	IFI	Evaluate effectiveness of emergency response training

LIST OF ACRONYMS USED

ALARA	as low as reasonably achievable
CFR	Code of Federal Regulations
IFI	inspection followup item
MURR	University of Missouri-Columbia Research Reactor
NRC	Nuclear Regulatory Commission, U.S.
TRTR	National Organization of Test, Research, and Training Reactors
VIO	violation