

January 24, 1997

Dr. Lee H. Bettenhausen
Reactor Supervisor
Radiation Laboratory
University of Massachusetts Lowell
One University Avenue
Lowell, Massachusetts 01854

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION REGARDING HEU TO LEU CONVERSION

Dear Dr. Bettenhausen:

In order to complete our review of your application to convert the University of Massachusetts Lowell Research Reactor from high-to low-enriched uranium fuel, we need additional information. The information that needs to be developed is outlined in NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Format and Content", Appendix 18.1, Chapter 12. All sections of Chapter 12 should be addressed, where applicable, but, in particular, Section 12.6, "Reactor Reload and Startup Plan", should be fully developed.

Also, you could refer to Part 2 of NUREG-1537, "Standard Review Plan and Acceptance Criteria", same Appendix and Chapter, to gain further insight into the review process the staff will use for finding this aspect of the application acceptable.

Enclosed for your information are both parts of the documents mentioned above. Please provide a response to this request within 30 days of the date of this letter. If you have any questions, please contact me at 301-415-1102.

This requirement affects nine or fewer respondents and, therefore, is not subject to Office of Management and Budget review under P.L. 96-511.

Sincerely,

Original signed by:
Theodore S. Michaels, Senior Project Manager
Non-Power Reactors and Decommissioning
Project Directorate
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Docket No. 50-223

Enclosures: As stated

cc w/enclosures: See next page

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20585-0601

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University of Massachusetts Lowell

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cc:

Mayor of Lowell
City Hall
Lowell, Massachusetts 08152

Mr. Lee H. Bettenhausen
Nuclear Reactor Supervisor
University of Massachusetts Lowell
One University Avenue
Lowell, Massachusetts 01854

Office of the Attorney General
Environmental Protection Division
19th Floor
One Ashburton Place
Boston, Massachusetts 02108

- commitment to an ALARA program for potential exposures
- assessment of the effectiveness of the dose control programs
- methods to detect potential inadvertent criticality

11.2 Radioactive Waste Management

The following items should be addressed if affected by the conversion to LEU fuel:

- the capabilities of the reactor facility to control, collect, handle, process, store, and dispose of liquid, gaseous, and solid wastes that may contain radioactive materials
- the instrumentation and methods used to measure the quantities of radioactivity and to monitor the release of radioactive wastes outside of the restricted area

All types of radioactive wastes that are generated (solid, liquid, and gaseous) in the operation and maintenance of the reactor facilities and in the experimental programs should be considered. How the conversion of the fuel would change the formation, control, release, or disposition of radioactive waste materials associated with the reactor should be analyzed. Any changes to the facility or procedures should be analyzed and their effects evaluated. Any changes in methods used to store and dispose of radioactive wastes should be described. Any changes in the methods used to assess the source strengths and predict potential radiation exposures to personnel due to radioactive waste in both restricted and unrestricted areas should also be described.

For many non-power reactors, argon-41 is a significant radioactive waste that is produced by operations. All changes in the sources of argon-41 and all potential exposure pathways should be addressed. Changes in the sources of argon-41 may be related to changes in fuel geometry and neutron spectra.

The handling or release of all radioactive wastes should be verified to remain consistent with the facility program, applicable regulations, and the facility guidelines with regard to ALARA.

12 CONDUCT OF OPERATIONS

This section provides information on planning and implementing the activities for reactor facility operation during conversion from HEU to LEU fuel.

12.1 Organization and Staff Qualifications

It is not expected that reactor conversion from HEU fuel will require changes in the licensee organization. Note that significant organization changes would have already been reviewed and accepted by NRC in technical specifications and in the license revisions.

12.2 Procedures

Any procedural changes necessary for the conversion from HEU fuel should be described. Procedural changes to account for LEU-fueled core and fuel configuration may include such issues as location of fuel elements and control rods, conduct of critical experiments, storage and shipment of fuel elements as well as procedural changes to account for needed technical specifications changes.

The licensee should consider specific changes in shipping requirements and procedures (e.g., type B material, and associated quality assurance program and cask user registration requirements). ANSI/ANS 15.19-1991 provides guidance.

Any new procedures that are needed for the conversion should similarly be addressed. For example, changes to the reactor coolant system to ensure adequate flow may require modified operational procedures.

12.3 Operator Training and Requalification

Certain operating characteristics, license conditions, operating procedures, and technical specifications requirements may change as a result of the fuel conversion. The implications of these changes should be incorporated into the operator training and requalification program. The operator training and requalification program should clearly establish the procedures, techniques, and on-the-job training which ensures that the licensed operators are instructed on all changes to the reactor, its operating characteristics, written procedures, license conditions, and technical specifications. Additional general guidance can be found in ANSI/ANS 15.4-1988.

12.4 Emergency Plan

The conversion to LEU fuel should not significantly affect the emergency action level guidelines or potential reactor emergency event consequences. Although changes are not expected, any changes to the emergency plan that might occur should be submitted as part of the conversion application in accordance with applicable regulatory requirements. Additional general guidance may be found in ANSI/ANS 15.16-1982 and RG 2.6.

12.5 Physical Security Plan

A less demanding physical security plan could result from the conversion to LEU fuel if the conversion affects the category for possession of special nuclear material as discussed contain 10 CFR 73.2, 73.6, and 73.67. Any proposed changes in the physical security plan and implementing procedures should demonstrate that the applicable requirements of the regulations are still met when either irradiated or unirradiated fuel is at the facility and in transit. These changes should allow possession of LEU and HEU fuel for as long as necessary. Additionally, if the licensee has relied on the exemption of 10 CFR 73.6(b) for self-protection of the HEU fuel, the licensee should demonstrate that the exemption will continue to be applicable while the HEU is still on site or should discuss the options to the self-protecting exemption. Applicable alternatives and changes to the security plan and related, license conditions should be proposed in accordance with regulatory requirements.

12.6 Reactor Reload and Startup Plan

Reloading with LEU fuel and implementing a startup plan are very similar to the initial loading and startup as part of the original licensing action. Many of the same concerns and precautions should be considered in the conversion reload. A reload and startup plan should be submitted as part of the proposal for authorization to convert the reactor from the use of HEU fuel to make sure that the operating characteristics are well understood and to validate the predicted behavior. Therefore, if practical, measurements of selected parameters of the HEU-fueled core should be compared to calculated values to verify analytical methods and ensure that meaningful acceptance criteria for the LEU-fueled core have been established from the calculational methods. The plan should provide that the measurements for the LEU reactor are compared to acceptance criteria as established in this conversion proposal. The acceptance criteria should ensure that the LEU reactor is functioning as it was designed and analyzed and that the license and technical specifications will be satisfied.

The plan should contain the following items:

- a well-planned systematic set of subcritical multiplication measurements or an inverse multiplication approach to critical measurement during new fuel loading, and confirmation that analysis subcritical multiplication or critical fuel loading are within preestablished acceptable limits
- an experimental measurement plan to determine the important operational reactor physics parameters (such as control rod worth, excess reactivity, reactor thermal power, coefficients of reactivity, and power peaking factors)

and thermal-hydraulic parameters (such as fuel, cladding, and coolant temperatures, reactor coolant system flow rates, and pressure drops, if appropriate), comparisons with predictions and acceptance criteria established in the applicable section of this conversion proposal, and discussions of any discrepancies that may have arisen

- measurements of magnitudes of area radiation fields and radioactive effluents, and comparisons with the same parameters for operation of the HEU-fueled reactor and preestablished acceptance criteria from the applicable sections of this conversion proposal for the LEU-fueled reactor

A startup report should be submitted to the NRC, in accordance with the time frame required in the technical specifications or within 6 months after the LEU fuel is loaded. An example of an outline for a startup report is given below:

- (1) critical mass and final criticality conditions for this first LEU core
 - measurement with HEU cores
 - measurement with LEU cores
 - comparisons with acceptance criteria established earlier in conversion proposal calculations and analyses
- (2) measurements and comparison to prediction of subcritical multiplication for initial core fuel loading
- (3) excess (operational) reactivity
 - measurement with HEU cores
 - measurement with LEU cores
 - comparisons with acceptance criteria established earlier in conversion proposal calculations and analyses
- (4) control and regulating rod calibration
 - measurement of differential and integral rod worth for HEU core
 - measurement of differential and integral rod worth for LEU core
 - comparisons with acceptance criteria established earlier in conversion proposal calculations and analyses

(5) reactor power calibration

- methods and measurements that ensure operation within the license limit
- comparison between HEU and LEU nuclear instrumentation setpoints, detector positions, and detector output
- comparisons with acceptance criteria established earlier in conversion proposal calculations and analyses

(6) shutdown margin

- measurement with HEU
- measurement with LEU
- comparisons with acceptance criteria established earlier in conversion proposal calculations and analyses

(7) partial fuel element worth

- measurements of the worth for HEU-fueled core
- measurements of the worth for LEU-fueled core
- comparisons with acceptance criteria established earlier in conversion proposal calculations and analyses

(8) thermal neutron flux distributions

- measurements of core and experimental facilities with HEU
- measurements of core and experimental facilities with LEU
- comparisons with acceptance criteria established earlier in conversion proposal calculations and analyses

(9) enhanced radiation measurements of reactor coolant fission product inventory or release during startup test program to detect potential fuel fission product barrier degradation or contamination from other sources

- measurements of core and experimental facilities with HEU

- measurements of core and experimental facilities with LEU
 - comparisons with acceptance criteria established earlier in conversion proposal calculations and analyses
- (10) results of determination of LEU effective delayed neutron fraction, temperature coefficients, and void coefficients for LEU- and HEU-fueled cores and comparison with acceptance criteria established earlier in conversion proposal calculations and analyses
- (11) comparison of the various results with the two fuel types, and discussion of the comparison, including an explanation of any significant differences that could affect operation and possible accidents with the reactor
- (12) thermal-hydraulic characteristics such as fuel, cladding, and coolant temperatures, and reactor coolant system flow rates and pressure drops

13 ACCIDENT ANALYSES

In this section, the licensee should demonstrate that the accident analyses results for the LEU reactor do not significantly exceed acceptance criteria of the accidents previously postulated and analyzed in the safety analyses or evaluated in staff safety evaluation reports. In the accident analyses, the licensee also should consider if any new accidents may be introduced by the conversion.

This discussion should summarize the comparison of the HEU and LEU accident analyses. This comparison should demonstrate that the conclusions previously reached in the safety analyses and staff safety evaluation reports remain valid for the LEU-fueled core. For example, a maximum hypothetical accident that assumes a fission product release scenario for an HEU fuel element may be used for the LEU fuel if the licensee demonstrates that the two fuels have sufficiently similar physical characteristics and fission product inventories. If these conditions can be verified, a largely qualitative analysis with check calculations should be sufficient. This process involves a comparison of the scenarios and conclusions for the HEU-fueled reactor accidents considering the physical characteristics of the LEU-fueled reactor.

New or revised accident analyses for the LEU fuel should be performed if the techniques used for the current HEU analyses are no longer available or appropriate, or if the conversion creates the possibility of a new, previously unanalyzed accident scenario or significantly changes the potential consequences of a previously accepted HEU accident scenario. (If this approach is adopted, the licensee may need to reanalyze some HEU data with the new methods to provide a

reviewer should verify the licensee's ALARA considerations and proposed methods for compliance with other applicable regulations, such as 10 CFR Part 71.

Evaluation Findings

This section of the SAR should contain sufficient information to support the following types of conclusions, which will be included in the staff's safety evaluation report:

- The licensee's proposed modifications to the facility or changes in reactor operating conditions or procedures are required by the HEU to LEU conversion.
- The licensee has analyzed any changes in the production or control of radioactive wastes and demonstrated that any radiological effects from these changes are not significantly larger than for the HEU-fueled reactor.
- The evaluation confirms that the licensee's ALARA considerations are consistent with applicable program requirements and guidelines and that potential radiation exposures to facility personnel, the public, and the environment from these wastes remain consistent with all applicable regulations.

12 CONDUCT OF OPERATIONS

Areas of Review

The reviewer should assess the planning and implementation of facility staff activities that are subject to regulation and relate to the conformance, quality, and effectiveness of operations. Although major changes are not expected, some of the following areas could be affected by the conversion of the reactor from the HEU to LEU fuel:

- Organization and staff qualifications—These factors should not change as a result of fuel conversion.
- Procedures—Changes may be needed to specify new core configurations or loading techniques. Also other system changes for the conversion may require procedure changes.
- Operator training and requalification—If conversion of a reactor results in different systems, different operating characteristics and procedures, different administrative or operating limits, or different technical

specifications, associated retraining of licensed operators should be considered.

- Emergency plan—If the conversion changes facility characteristics or systems for emergency response, associated changes in the emergency plan and implementing procedures should be considered.
- Physical security plan—If the conversion results in changed requirements for physical control of the special nuclear material, a modification of the physical security plan and related procedures should be considered. Both interim (i.e., while the HEU fuel is still at the facility) and permanent changes should be evaluated.
- Reactor reload and startup plan—The conversion of a reactor from HEU to LEU fuel could be implemented all at once or LEU fuel elements could replace HEU fuel elements a few at a time according to a detailed plan and schedule. In either case, to ensure that the licensee has sufficient information to operate the reactor safely, a reload and startup plan should be included with the licensee's submittal. The plan should provide for testing any newly installed equipment; a proposed fuel loading procedure and schedule; radiation surveys; a systematic set of subcritical measurements in the approach to critical with the new fuel; experiments and measurements that compare predicted and calculated reactor parameters; and verification of compliance with license conditions, including technical specifications, of the LEU-fueled reactor.

Acceptance Criteria

Acceptance criteria should be based on the following considerations:

- Organization and staff qualifications—No direct relationship is expected between the organization and staff qualifications and the enrichment of the fuel in the reactor. Therefore, the licensee should not propose any changes in these functions as a result of fuel conversion. Any proposed changes should be submitted to NRC as a license amendment request.
- Procedures—Procedural changes should account for LEU-fueled core and fuel configuration may include such issues as location of fuel elements and control, conduct of critical experiments, storage and shipment of fuel elements, as well as procedural changes to account for needed technical specifications changes. Specific changes in shipping requirements and procedures should be considered by the licensee (e.g., type B material, and associated quality assurance program and cask user registration

requirements). Also, if changes to other systems are required, appropriate changes to facility procedures should be incorporated.

- Operator training and requalification—The retraining of licensed operators could be a one-time supplement to the existing operator requalification plan. This supplement would be acceptable if it specifies the procedures, techniques, and on-the-job training that will be used to instruct licensed operators on all changes made to the reactor, its operating characteristics, written procedures, and license conditions related to the conversion. Changes to the operator training program should be acceptable if the new reactor operating characteristics are consistent with the existing program, 10 CFR 50.54, 10 CFR Part 55, NUREG-1478, and ANSI/ANS 15.4.
- Emergency plan—Changes in operating characteristics or procedures resulting from fuel conversion generally will not significantly affect emergency events or emergency planning. However, if significant reactor changes are required by the conversion, they could affect emergency planning. In such cases, the licensee should submit a revised emergency plan, whose content is consistent with 10 CFR 50.54, Regulatory Guide 2.6, ANSI/ANS 15.16, and NUREG-0849.
- Physical security plan—Removal of the HEU fuel from the facility and replacement with LEU fuel could change the category for possession of special nuclear material, as defined in 10 CFR 73.2, 73.6, and 73.67. Changes in the physical security plan and its implementing procedures should be acceptable if the requirements of the regulations are met for irradiated and unirradiated fuel at the facility and in transit. If it is anticipated that HEU fuel radiation levels will decrease so that "self-protection" would be lost, the licensee must propose actions to preclude violations of license and applicable regulations. Guidance is available in NUREG/CR-4203.

If the logistics of conversion require both the HEU fuel and LEU fuel to be at the facility simultaneously, the licensee must propose appropriate license conditions to allow that.

Additional guidance may be found in Chapter 12 of this document.

- Reactor reload and startup plan—The plan would be acceptable if it clearly provides for the following: (1) the licensee receives, handles and loads the LEU fuel as though the reactor is being fueled for the first time (e.g. monitoring, examinations and cleaning); (2) the critical mass (number of fuel elements) is approximately known and will be exactly determined by a systematic approach to critical; (3) neutron detectors of high sensitivity and

reliability supplement the operational instrumentation during subcritical neutron multiplication measurements; (4) measurements are planned to measure operational reactor parameters, such as shutdown reactivity (to confirm shutdown margin), reactivity feedback coefficients, differential and integral control rod worths, power level monitors, scram and interlock functions, fuel heat removal, and related thermal-hydraulic parameters; (5) measured and predicted LEU parameters should be compared and the results of the comparisons should be evaluated against preestablished acceptance criteria; (6) the control rods will be calibrated and excess reactivity will be loaded systematically, resulting in accurate values; (7) thermal power of the reactor will be calibrated acceptably and accurately to ensure compliance with the licensed power level limits and any other license conditions, such as pulse characteristics; (8) area and effluent radiation surveys will be performed to confirm status; and (9) all new, recalibrated, refurbished, or modified instruments and components will be tested before routine operations begin.

Review Procedures

The reviewer should verify the following:

- Organization and staff qualifications—The reviewer should verify that no changes to organization and staff qualifications would be required by the fuel conversion and none are proposed.
- Procedures—The reviewer should verify that applicable procedures were appropriately considered and changed to accommodate the new LEU facility.
- Operator training and requalification—The reviewer should verify that the licensee plans to train all operators in the significant changes in design, operational characteristics, and technical specifications for the LEU facility.
- Emergency plan—The reviewer should determine if changes proposed by the licensee in the emergency plan for the LEU facility are consistent with the changes required for conversion and with the provisions of NUREG-0849, Regulatory Guide 2.6, and ANSI/ANS 15.16.
- Physical security plan—Review procedures should verify if the changes in the security plan are consistent with the change to LEU fuel and the requirements of 10 CFR Part 73.

- **Reactor reload and startup plan**—Comparisons should be made with the initial HEU-fueled reactor load and startup reports, technical specifications, other license conditions, reload and startup plans, and final reports from other similar reactor facilities that have been converted from HEU to LEU fuel. The reviewer should verify that key facility parameters and conditions which are calculated and used in the licensee's safety analysis are to be measured and that acceptance criteria are specified for the tests.

Evaluation Findings

This section of the SAR should contain sufficient information to support the following types of conclusions, which will be included in the staff's safety evaluation report:

- Sufficient information and discussion have been provided in each of the topics of this section and the submitted plans comply with all applicable regulations and guides.
- Implementation of the proposed reactor reload and startup plan will provide reasonable assurance that the LEU-fueled reactor is operating as described and analyzed in the SAR.
- Any changes in the facility or its operating procedures resulting from the fuel conversion and all proposed changes in the conduct of operations will afford acceptable security and protection of the health and safety of the public.

13 ACCIDENT ANALYSIS

Accident evaluations are an important aspect of the conversion from HEU to LEU fuel. In this section, the licensee should compare the consequences of all accident scenarios postulated and analyzed for the existing HEU-fueled reactor with similar accidents for the proposed LEU-fueled reactor. Additionally, the discussions should analyze any new accidents not previously evaluated that could be introduced by the conversion.

The information should summarize the postulated initiating event and the scenario of each accident in the HEU-fueled reactor, showing how the course of the accident and the consequences depend on the physical parameters and geometry of the reactor core, operating characteristics, and license and technical specification requirements for the reactor. The discussions should compare the parameters of the HEU-fueled reactor that have a significant effect on the progression and the consequences of the accident with the comparable parameters of the proposed LEU-fueled reactor. The comparison of the consequences should show that the