March 13, 2007

Mr. Jere H. Jenkins
Director of Radiation Laboratories
Purdue University
School of Nuclear Engineering
Nuclear Engineering Building
400 Central Drive
West Lafayette, IN 47907-2017

SUBJECT: PURDUE UNIVERSITY—REQUEST FOR ADDITIONAL INFORMATION RE: HIGH ENRICHED TO LOW ENRICHED URANIUM CONVERSION FOR THE PURDUE UNIVERSITY RESEARCH REACTOR (TAC NO. MC2877)

Dear Mr. Jenkins:

We are continuing our review of your request for high-enriched uranium (HEU) to low-enriched uranium (LEU) fuel conversion for the Purdue University Research Reactor which you submitted on August 13, 2006. During our review of your request, questions have arisen for which we require additional information and clarification. Please provide responses to the enclosed request for additional information within 45 days of the date of this letter. In accordance with 10 CFR 50.30(b), your response must be executed in a signed original under oath or affirmation. Following receipt of the additional information, we will continue our evaluation of your amendment request.

If you have any questions regarding this review, please contact me at (301) 415-1127.

Sincerely,

/RA/

Alexander Adams, Jr., Senior Project Manager
Research and Test Reactors Branch A
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-182

Enclosure:
As stated

cc:
See next page

March 13, 2007

Mr. Jere H. Jenkins
Director of Radiation Laboratories
Purdue University
School of Nuclear Engineering
Nuclear Engineering Building
400 Central Drive
West Lafayette, IN 47907-2017

SUBJECT: PURDUE UNIVERSITY—REQUEST FOR ADDITIONAL INFORMATION RE: HIGH ENRICHED TO LOW ENRICHED URANIUM CONVERSION FOR THE PURDUE UNIVERSITY RESEARCH REACTOR (TAC NO. MC2877)

Dear Mr. Jenkins:

We are continuing our review of your request for high-enriched uranium (HEU) to low-enriched uranium (LEU) fuel conversion for the Purdue University Research Reactor which you submitted on August 13, 2006. During our review of your request, questions have arisen for which we require additional information and clarification. Please provide responses to the enclosed request for additional information within 45 days of the date of this letter. In accordance with 10 CFR 50.30(b), your response must be executed in a signed original under oath or affirmation. Following receipt of the additional information, we will continue our evaluation of your amendment request.

If you have any questions regarding this review, please contact me at (301) 415-1127.

Sincerely,

/RA/

Alexander Adams, Jr., Senior Project Manager
Research and Test Reactors Branch A
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-182

Enclosure:
As stated

cc:
See next page

<u>DISTRIBUTION</u>:

Public	RidsNrrDpr	RidsNrrDprPrta
RTR r/f	RidsNrrDprPrtb	

ADAMS Accession Number: ML070680273

OFFICE	PRTA:DPR	PRTA:DPR	PRTA:DPR	PRTA:DPR:BC	PRTA:DPR
NAME	WSchuster:cah	EHylton	AAdams	DCollins	AAdams
DATE	3/08/07	3/12 /07	3/13 /07	3/13 /07	3/13/07

OFFICIAL RECORD COPY

REQUEST FOR ADDITIONAL INFORMATION
PURDUE UNIVERSITY RESEARCH REACTOR
DOCKET NO. 50-182

1. The regulations in 10 CFR 50.30(b) require applications, such as your application for conversion, to be made under oath or affirmation. Please provide a statement that your application of August 13, 2006, is made under oath or affirmation.

The following questions apply to the area of neutronics, which are necessary to verify compliance with 10 CFR 50.36, Technical Specifications, 10 CFR Part 20 Subpart C, Occupational Dose Limits, and 10 CFR Part 20 Subpart D, Radiation Dose Limits for Individual Members of the Public:

2. Table 4-1 and Figure 4-35. The figure shows the plate locations with a single dummy plate and 13 fueled plates. What is the distribution within the fuel assembly when two dummy plates are used? The figure shows nine standard fuel assemblies with 13 plates and four with 12 plates. This brings the total of plates to 189, not 190 as stated in Table 4-1 and on page 22. Please explain.

3. Table 4-3. What is the basis for picking the width of the fuel meat for the LEU fuel plates (59.6 mm with a range between 58.9 mm and 62.7 mm)?

4. Section 4.2. Proposed Technical Specification (TS) 5.2.2 says that the LEU assembly will have up to 185 g of U-235. Please explain why that is different than 12.5 g/plate times a maximum of 14 plates/assembly as specified in Section 4.2.

5. Section 4.2.1. Please provide a copy of Reference 5. Our understanding is that the final design of the Purdue fuel elements was still underway when the conversion Safety Analysis Report (SAR) was submitted to NRC. Please verify that the description of the fuel in the SAR is accurate or discuss any fuel design changes made since the SAR was written. Our understanding is that the fuel plates and fuel boxes are being fabricated by different vendors and that final assembly of the fuel elements will be performed at Purdue. Please describe the quality assurance requirements the Department of Energy employs at the fuel component vendors to ensure that the fuel element components are consistent with the SAR. Please verify that approved procedures will be used at Purdue to assemble the fuel elements. Please describe the quality assurance requirements to be employed at Purdue to ensure that the assembled fuel elements are consistent with the SAR. Please discuss how the fresh fuel plates will be stored and handled during fuel element assembly such that the requirements of TS 5.3 are met.

6. Section 4.2.5. What is the effect on reactivity and power distribution of replacing graphite in the reflector with an aluminum sample holder?

7. Table 4-6. The measured to calculated eigenvalues for the excess reactivity of a fresh HEU core are compared. This difference establishes the claim that the model introduces a 0.32% bias to the calculation of the eigenvalue. What are the uncertainties for the measured and calculated eigenvalues? What is the justification to use this 0.32% bias for the LEU core? Note that if the bias for the LEU core is not used (or is significantly less than 0.32%) the excess reactivity exceeds the TS limit of 0.6%.

8. Table 4-7. The title of Table 4-7 does not reflect the contents of the table. The table is a tabulation of calculated eigenvalues at five measured critical rod positions. It does not contain any calculated critical rod positions. Please correct.

9. Table 4-8. In order to understand the differences between calculation and measurement quoted in the table, provide the uncertainties for both the measured and calculated control rod worths, if available. This will also clarify whether the last column in the table is really an “error” or more appropriately a “relative difference.”

10. Section 4.5, page 17. It is stated that in the LEU model there was an addition of 20 ppm of boron-equivalent to the 6061 cladding material. This section also states that the 6061 aluminum assembly cans had a 10 ppm boron content. Why were different boron contents assumed for the same aluminum alloy? Does this difference impact the calculated results, i.e., what is the reactivity worth of 10 ppm boron?

11. Section 4.5. What is the nominal thermal neutron flux for the PUR-1 core either on average or at experimental locations?

12. What is the expected reactivity lifetime of the shim-safety and regulating rods?

13. Figures 4-21, 4-22, and 4-23. These figures show calculated and measured calibration curves for SS-1, SS-2, and RR, respectively, with an HEU core, but only for rod position where there are measurements. Figures 4-24, 4-25 and 4-26 show the calculated curves for an LEU core for the full range of control rod travel. Please provide calculated curves for the HEU core with a full range of travel so they can be compared with the full-range curves for the LEU core.

14. Table 4-10. The text in Section 4.5.1 indicates that Table 4-10 contains calculated and measured control rod worths while the headings in the table only refer to calculated values. Please clarify.

15. Table 4-11. Comparing Tables 4-2 and 4-11 there is a discrepancy in the maximum insertion rate for the shim-safety rods and the regulating rod. The insertion rates for the LEU core are exactly the same while for the HEU core there is a factor of 100 in the SS-1 and SS-2 values and a factor of 1000 for the RR. What are the correct values?

16. Table 4-11. According to Figure 4-23 the slope of the calculated and measured reactivity curve as a function of rod position for the regulating rod are approximately the same. Why is there a factor of ten difference between the measured and calculated maximum reactivity insertion rate for the regulating rod in the HEU core in Table 4-11?

17. Table 4-12. Some of the values in Table 4-2 do not agree with values in Table 4-12.

    Agreement: k_{excess}; SS-2 worth calculations; shutdown margin calculations
    Disagreement: Measured SS-2 worth; measured shutdown margin

    Please verify all values in these two tables.

18. Table 4-12. In Table 4-12 and Table 4-2 the calculated shutdown margin for the LEU core, taking into account the -0.32% systematic bias, is -1.53%. A footnote for Table 4-2 gives the calculated shutdown margin (without bias) as -1.31%. Should the value of the calculated unbiased shutdown margin be -1.21% (-1.53%+0.32% = 0.79-2.00 = -1.21%)?

19. Section 4.5.3. In calculating β_{eff} from k_{eff} with and without prompt neutrons, was any bias applied to the eigenvalues?

20. Please clarify the derivation of the temperature and void coefficients of reactivity by providing the following information:

    A. Is the water density perturbation used in the water temperature coefficient and for the void coefficient?

    B. What is the meaning of the void coefficient expressed in the unit of Δρ/°C? Why is the void coefficient expressed in Δρ/°C in Tables 4-14 and 4-15?

    C. How was the temperature coefficient calculated and what components were included?

    D. What scattering kernel data were used for these calculations?

    E. What are the uncertainties of these calculations?

    F. For both the HEU and LEU cores, the temperature coefficient is negative if the temperature of the water between the fuel plates and between the fuel cans is increased but is slightly positive if there is a simultaneous increase in the temperature of the water outside the core, that is if the entire inventory of water in the system is included. This might imply that if heating of the water occurs external to the core, there would be a positive change in reactivity. Are there any scenarios where the temperature of the water can be increased external to the core without increasing the water temperature within the core? Is there any physical scenario where temperature of the water exterior to the core can be simultaneously increased along with the temperature of the water in the interior of the core?

21. Section 4.5.3. What is the expected lifetime of the proposed LEU core and how does that translate into burnup? Explain if burnup over core life will have any significant impact on the reactor neutronic parameters.

22. Section 4.5.3. Once the LEU core is loaded, is there any anticipated reloading or rearrangement of the fuel? If yes, how would this change the nuclear design parameters?

23. Table 4-13. The fuel temperature reactivity coefficient shown in Table 4-13 for the LEU fuel is not the most conservative value as compared to the values shown in Table 4-15. Explain the basis for selecting the representative value for the fuel temperature coefficient.

24. Section 4.5.4.1. In Section 4.5.4.1 it says that the peak power in plate 89 of bundle 3-3 is about 13% lower than that of plate 262. Please explain how the 13% value was calculated.

25. Section 4.5.4.2. The hottest fuel plate for the proposed LEU core was calculated considering two different critical control rod configurations while the hottest fuel plate for the HEU core was calculated considering five different critical control rod configurations. The critical control rod configuration used to determine the hottest fuel plate in the LEU and HEU cores differ. Why were different critical control rod configurations used for the two cores? Which configuration is closest to the control rod configuration used during reactor operation? Does the calculation for the HEU core represent the limiting case? If not, what is the limiting case for the hottest fuel plate?

26. Figure 4-37. Figure 4-37 shows the radial power profile in LEU plates 1215 and 1348. According to Figure 4-35, the "bottom" edge of plate 1348 is closer to the core centerline and hence is expected to have a higher power density than the "upper" edge. However the text of the conversion SAR says that the radial segments (as shown in Figure 4-37) for plate 1348 are numbered from top-to-bottom. Figure 4-27 has radial segment 1 showing a higher power density than radial segment 11. Should the radial segments be numbered from bottom-to-top instead?

The following questions apply to the area of thermal hydraulics, which are necessary to verify compliance with 10 CFR 50.36, Technical Specifications, 10 CFR Part 20 Subpart C, Occupational Dose Limits, 10 CFR Part 20 Subpart D, Radiation Dose Limits for Individual Members of the Public and ensure that safety limits are not exceeded:

27. Section 4.5.4.2. In Section 4.5.4.2 it states that radial power profiles shown in Tables 4-21 and 4-22 for plates 1348 and 1215 are used for the thermal-hydraulic analysis of the plates. Where is the radial power profile incorporated in the thermal-hydraulic analysis? If the radial power profile is not explicitly included in the analysis, explain the impact on the thermal-hydraulic analysis.

28. Appendix 1. From the information in Appendix 1 it is not clear how insignificant are the channel inlet and outlet losses when compared to the wall shear. Please clarify.

29. Appendix 1. From the information in Appendix 1 it is not clear what is the functional dependency of the laminar friction parameter C to the channel cross-section dimensions. Provide a reference for the evaluation of C.

30. Appendix 1. From the information in Appendix 1 in both the calculation of the channel flow and the calculation of the bulk coolant temperature rise the ratio of the coolant kinematic viscosity to density (μ/ρ) was assumed to be insensitive to temperature. Please demonstrate the validity of this assumption.

31. Table 4-24. A pool temperature (coolant inlet temperature) of 27°C is used in the LEU thermal-hydraulic analyses. The TSs contain no limits on pool temperature. Please explain why a limit on pool temperature should not be added to the TSs or propose a limit on pool temperature.

32. Appendix 1. Equation (30) has two terms and the conversion SAR states that the expression within the parenthesis on the right hand side of the equation varies slowly compared to the heat flux $t_{fuel}\, q'''/2$. Demonstrate the validity of the statement with reference to the PUR-1 fuel plate.

33. Section 4.7.2. According to Appendix 1 the systematic uncertainty in flow rate is accounted for by applying the hot channel factor F_w to the laminar friction factor C. Explain the reason for the value of the flow friction factor F_w being unity in Tables 4-25 and 4-26.

34. Section 4.7.2. In Table 4-25 a random tolerance fraction of 0.05 was specified for the fuel meat of the HEU core. Explain why the corresponding tolerance fraction was given as 0.0 in Table 4-26 for the LEU core.

35. Section 4.7.3.1. It is not clear if the hot channel factors were used in the determination of the ONB power. Please clarify.

36. Table 4-28. Define the parameter “margin to incipient boiling.”

37. Section 9.4. Please provide an analysis of storage of LEU fuel in the in-pool storage racks that shows that TS 5.3 will be met.

38. Please propose license possession limits for the reactor conversion. Please provide the following possession limits and any other changes needed:

    amount of U-235 of enrichment less than 20 % possessed in the form of LEU fuel elements;

    amount of U-235 of any enrichment needed in connection with operation of the facility and the form of the material (e.g., fission chambers, flux foils, fueled experiments);

    amount of U-235 of any enrichment in the form of the existing HEU fuel elements until that core is removed from site.

39. Sections 13.2 and 13.4. What is the maximum amount of positive rapid reactivity and slow insertion (up to a maximum of the allowed excess reactivity) that can be added to the LEU fueled reactor without exceeding the proposed safety limit?

40. Section 13.4. Was reactivity introduced by the flooding or voiding of an experiment located in the irradiation facility considered? Is that a viable accident (it was evaluated in NUREG-1283 for the 1988 license renewal)? If not, please explain. If so, please provide an analysis.

The following questions are related to technical specifications, compliance is required by regulations contained in 10 CFR 50.36:

41. TS 4.4.d. There are proposed modifications to TS 4.4.d to change fuel inspection requirements from periodic inspection of representative fuel plates to representative fuel assemblies. What will the fuel assembly inspection consist of and how will this inspection help ensure fuel cladding integrity? TS 4.3.d requires monthly analysis of primary coolant. Is this analysis used as an indicator of fuel cladding integrity? If not, can the analysis be adapted for such purpose?

42. Section 14, TS 4.4. Section 4.1 footnotes and Table 4-1 indicate a change in the alloy of aluminum to 6061. Please clarify the following sentence: "No new alloys will be introduced into the reactor as a result of conversion from HEU to LEU fuel."