UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

November 19, 2015

Dr. Ayman I. Hawari, Director
Nuclear reactor Program
North Carolina State University
Department of Nuclear Engineering
Campus Box 7909
Raleigh, NC 27695-7909

SUBJECT: NORTH CAROLINA STATE UNIVERSITY PULSTAR RESEARCH REACTOR – REQUEST FOR ADDITIONAL INFORMATION REGARDING THE LICENSE AMENDMENT RELATED TO THE USE OF SIX PERCENT ENRICHED FUEL (TAC NO. MF6088)

Dear Dr. Hawari:

The U.S. Nuclear Regulatory Commission (NRC) staff is reviewing your application to amend Facility Operating License No. R-120, dated March 13, 2015 (available on the NRC's public Web site at www.nrc.gov under (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15076A006), for the North Carolina State University (NCSU) Pulstar Research Reactor. During our review, questions have arisen for which additional information is needed. The enclosed request for additional information (RAI) identifies the additional information needed to complete our review. We request that you provide responses to the enclosed RAI within 45 days from the date of this letter.

In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 50.30(b), "Oath or affirmation," you must execute your response in a signed original document under oath or affirmation. Your response must be submitted in accordance with 10 CFR 50.4, "Written communications." Information included in your response that is considered sensitive or proprietary, that you seek to have withheld from the public, must be marked in accordance with 10 CFR 2.390, "Public inspections, exemptions, requests for withholding." Any information related to security should be submitted in accordance with 10 CFR 73.21, "Protection of Safeguards Information: Performance Requirements." Following receipt of the additional information, we will continue our review of your amendment request.

If you have any questions, or need additional time to respond to this request, please contact me at (301) 415-3724, or by electronic mail at Duane.Hardesty@nrc.gov.

Sincerely,

/RA/

Duane A. Hardesty, Senior Project Manager
Research and Test Reactors Licensing Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-297

Enclosure:
As stated

cc: See next page

cc:

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As stated

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ADAMS Accession No.: ML15316A581 * concurrence via email NRR-088

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REQUEST FOR ADDITIONAL INFORMATION

FOR AMENDMENT NO. 19 FOR

NORTH CAROLINA STATE UNIVERSITY

LICENSE NO. R-120; DOCKET NO. 50-297

The U.S. Nuclear Regulatory Commission (NRC) staff is reviewing your application to amend Facility Operating License No. R-120, dated March 13, 2015, available on the NRC's public web site at www.nrc.gov under (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15076A006), for the North Carolina State University (NCSU) Pulstar Research Reactor. During our review of the NCSU License Amendment Request (LAR), the following questions have arisen for which additional information is needed. Provide responses within 45 days from the date of this letter.

1. Appendix A, Section 1.2, of the NCSU LAR (ADAMS Accession No. ML15076A020) states, in part, "[t]he reactor has been operated under eight core configurations for 1541 MWd with a core average burn-up of less than 5 GWd/MTU and a corresponding maximum fuel burn-up and assembly average burn-up of no more than 15 GWd/MTU and 10 GWd/MTU, respectively." NCSU Technical Specification (TS) 5.1.b., states, "Total burn-up on the reactor fuel is limited to 20,000 MWD/MTU." Explain how the maximum burn-up of the six weight percent fuel will be managed and where and how this will be documented.

2. NCSU TSs 3.1.e., 3.1.f., and 3.2.b., express limits on maximum worth of a single fuel assembly, total nuclear peaking factor in any fuel assembly, and excess reactivity, respectively, such that the reactor can be shutdown at all times and that the Safety Limits will not be exceeded. Explain how the proposed allowable core configuration loadings will be controlled to prevent the insertion of a six weight percent fuel assembly into a grid plate location that is not allowed.

3. The "fuel comparison" provided in the NCSU LAR states that the NCSU four weight percent fuel is physically and visually identical to the six weight percent fuel assemblies obtained from Buffalo Materials Research Center (BMRC) at the State University of New York at Buffalo. NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors," Part 2, Chapter 14 states, "All conditions that provide reasonable assurance that the facility will function as analyzed in the [safety analysis report] SAR should be in the technical specifications." Please provide a TS that will ensure proper placement of the fuel assemblies or explain how positive identification will be provided so the correct fuel assembly is handled and positioned within an allowable grid plate location.

4. Appendix A, Section 3.1, of the NCSU LAR describes the general purpose Monte Carlo N-Particle code (MCNP6) model used to evaluate the steady-state neutronic characteristics of the PULSTAR reactor. The guidance in NUREG-1537, Part 2, Section 4.2, "Reactor Core," and Section 4.5, "Nuclear Design," states, in part, that the applicant should present all design information and analyses necessary to

demonstrate that the core can be safely operated. Please provide the following information:

a) Discuss the details/assumptions made on how the fuel assembly was modeled. Explain how the fuel assembly cells (material/geometry) were treated and tracked during the depletion calculations.
b) Discuss whether the effects of manufacturing tolerances for the fuel assembly were considered in the analysis.
c) Address how the statistical variations were addressed in the calculations. (For example, was the average value of 10 runs with varying random number generator utilized?)
d) Discuss how the model statistics (e.g., minimizing the calculation uncertainty) were addressed and verification of fission occurring were checked for in each cell.
e) Explain how the MCNP6 calculated statistical uncertainty was applied to the core reactivity parameter and power peaking results.
f) Provide justification for why the 15 percent margin added to the calculated peaking factor for mixed enrichment cores provides sufficient confidence that the observed peaking factor will not exceed the limit in TS 3.1.f., given that the experimental margin was determined from uniform enrichment experiments only.
g) The uncertainty margin is the difference between the experimental measured results and the MCNP6 calculated result.
    1) Explain how the MCNP6 code utilizing the ENDF/B-VII cross-sections libraries was validated and the associated uncertainty margin was addressed.
    2) Explain whether other benchmark cores were utilized, other than the initial fresh fuel core, to validate the core model and to calculate the uncertainty margin. If so, was the use of other benchmark cores documented in a separate report as part of the Verification and Validation of the MCNP6 code?
h) In the summary of parameter comparison of measured vs. calculated historic core configurations, the measured vs calculated parameters are relatively in good agreement, except for core configuration 8. Explain whether there are any unaccounted measurement or calculation errors that could be affecting the results for core configuration 8.
i) Describe the predicted core reactivity parameters and power peaking behaviors for the core configuration using six weight percent fuel assemblies for the end of core burn-up calculations.
j) Discuss the verifications of model geometry definition and input data as well as configuration changes for specific core analyses (i.e., fuel shuffling locations) that were performed.
k) Discuss the extent computer scripts were used to shuffle fuel assembly locations vs. manual data entry.

5. The bases for NCSU TS 3.1.e., indicates that the single fuel assembly worth limit is set such that the safety limit is not exceeded during a postulated fuel loading accident as presented in Section 13.2.2.1, of the NCSU SAR, dated September 4, 1995. Provide an evaluation showing that the assumptions leading to this limit remain valid for a mixed core using six weight percent fuel assemblies.

6. The bases for TS 3.2.d., indicates that the limit on rate of reactivity insertion of the control rods is set such that the energy pulse from a postulated startup accident (as described in NCSU SAR, Section 13.2.2.2) is significantly less than the nominal original design pulse for the reactor core. Provide an evaluation showing that the assumptions leading to this limit remain valid for a mixed core using six weight percent fuel assemblies.

7. Provide updates to NCSU SAR Table 1-1, "Comparison of PULSTAR reactors," (NCSU and BMRC) to reflect the current NCSU core configuration and proposed six weight percent fuel.

8. Section 3 of the NCSU SAR provides the current NCSU core configuration. Provide the proposed six weight percent fuel mixed core configuration information that:

    a) Updates the core history including the use of beryllium reflector elements and the planned introduction of six weight percent fuel in a mixed core configuration.
    b) Updates the operational reactivity requirements for the PULSTAR as shown in SAR Table 3-2.
    c) Updates NCSU SAR, Section 3.2.2.4, "Fuel," data for the six weight percent fuel elements planned for used in the proposed mix core configurations.
    d) Updates NCSU SAR, Section 3.2.3.3, "Core Configuration," to reflect use of beryllium reflectors.

9. NUREG-1537, Part 2, Chapter 13, "Accident Analyses," states, in part, the applicant should provide information and analyses demonstrating that all potential accidents at the reactor facility have been considered and their consequences adequately evaluated. Provide justification that the NCSU SAR analyses of transients, etc. are not significantly impacted by six weight percent fuel mixed core configuration.

10. NCSU currently has a license to possess, but not use the six weight percent fuel assemblies. NUREG-1537, Part 1, Section 9.2, "Handling and Storage of Reactor Fuel," states, in part, "[t]he applicant should discuss briefly the methods that ensure the prudent control of fuel." Describe the location and conditions under which six weight percent fuel assemblies will be handled and stored. Include discussions of fuel handling and storage, the bases of related technical specifications, including inspections, testing, and surveillance and applicable administrative controls and procedures. [*The discussion should not contain safeguards information or a separate response should be submitted in accordance with 10 CFR 73.21, "Protection of Safeguards Information: Performance Requirements."]*

11. NUREG-1537, Part 1, Section 9.2, states, in part, "[t]he applicant should provide an analysis and discuss how subcriticality is ensured." Provide an analysis that demonstrates the calculated effective neutron multiplication factor (k_{eff}) for the in-pool storage racks located in the PULSTAR pool containing un-irradiated and irradiated 6 weight percent fuel assemblies will remain subcritical (i.e., k_{eff} not to exceed 0.90).

12. NUREG-1537, Part 2, Section 7.4, "Reactor Protection System," states, in part, that the Reactor Protection System should place the reactor in a subcritical, safe shutdown condition when any of the monitored parameters exceeds the limit as defined in the SAR. Describe any changes to the instrumentation and control system that affect the reactor protection system for the PULSTAR reactor necessitated by the use of the mixed core using six weight percent fuel assemblies or explain why they were not required.

13. NUREG-1537, Part 2, Section 12.11, “Startup Plans,” states, in part, that the applicant should submit a startup plan whenever significant core modifications are being made. Describe the NCSU start-up procedure for the reactor core utilizing the mixed enrichment core configuration loadings that will provide confirmation of analysis predictions for the mixed enrichment core.

14. In regards to NCSU SAR, Section 13.2.1.4, “Fuel Pin Clad Failure,” explain whether the use of six weight percent fuel impacts the fission products released, and provide updates to Tables 13.1, and Tables 13.2, as appropriate.

15. NUREG-1537, Part 2, Chapter 10, “Experimental Facilities and Utilization,” and Section 13.1.6, “Experiment Malfunction,” states, in part, that the applicant should provide an analysis to demonstrate that the reactor and experimental facilities can be operated safely during normal and abnormal events. NCSU SAR, Section 13.2.2.4, analyzes the impacts of an experiment failure, but does not discuss the possibility of a beam tube flooding.
    a) Explain any impact the experimental facility imposes on the mixed core configuration and any impact the mixed core configuration imposes on the experimental facility.
    b) Describe the impact of a neutron beam tube flooding event on a mixed core utilizing six weight percent fuel.

16. NCSU SAR, Section 3.2.2.6, “Cold Primary Coolant Slug,” provides an analysis for the cold primary coolant slug event. The facility modifications made in 2013 to the primary and secondary system to increase cooling flow rates/capacities combined with the mixed core use of six weight percent enriched fuel may make the cold primary coolant slug event more severe. Discuss the potential impact of the use of six weight percent fuel on the cold primary coolant slug event described in the NCSU SAR.