OFFICE OF NUCLEAR REACTOR REGULATION

REGULATORY AUDIT TOPICS

REGARDING LOSS-OF-COOLANT ACCIDENT DESCRIBED IN

THE APPLICATION FOR LICENSE RENEWAL

LICENSE NO. R-120

NORTH CAROLINA STATE UNIVERSITY

DOCKET NO. 50-297

By letter dated February 24, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17088A819), as supplemented by letter(s) dated July 17, 2018, November 1, 2018, February 14, 2019, June 21, 2019, September 25, 2019, March 24, 2020, and May 26, 2020 (ADAMS Accession Nos. ML18201A200, ML18312A303, ML19046A031, ML19221B602, ML19269B706, ML20084K704, and ML20149K759, respectively) North Carolina State University (NCSU) submitted an application to renew the Facility Operating License No. R-120 for the NCSU PULSTAR Nuclear Research Reactor in accordance with the requirements contained in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities." The requested licensing action would renew the facility operating license for a period of 20 years.

The U.S. Nuclear Regulatory Commission (NRC) staff identified additional information needed to continue its review of the loss-of-coolant accident (LOCA) analysis, as described in the NCSU final safety analysis report (FSAR). The NCSU FSAR and supplemental information identified above, concludes that the limiting LOCA results are not beyond the maximum allowable value for cladding temperature.

To support the review of the NCSU license renewal application, the NRC staff will conduct a virtual regulatory audit on June 16, 2021, as a continuation of the license renewal audit to confirm that the LOCA analysis will not exceed maximum allowable values. The specific topics below identify areas where additional information is needed for the NRC staff to continue its review of the NCSU LOCA topics and may become formal requests for additional information following the June 2021 regulatory audit.

Regulatory Basis and Applicable Guidance Documents

PULSTAR LOCA topics, as described in the NCSU license renewal application, is being evaluated using the following regulations and guidance:

- Section 50.34, "Contents of applications; technical information," paragraph (b)(2) of 10 CFR requires, in part, that an FSAR include a description and analysis of the structures, systems, and components of the facility, with emphasis upon performance requirements, the bases, and the evaluations required to show that safety functions will be accomplished. The description shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations.

- Section 50.9, “Completeness and accuracy of information,” of 10 CFR require that information provided to the Commission by a licensee shall be complete and accurate in all material respects.

- Part 20, “Standards for Protection against Radiation,” of 10 CFR require that doses to workers and members of the public be limited.

The NRC staff’s review of the NCSU PULSTAR LOCA topics is also based on the following:

- NUREG-1537, Part 1, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content,” issued February 1996 (ADAMS Accession No. ML042430055)

- NUREG-1537, Part 2, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria,” issued February 1996 (ADAMS Accession No. ML042430048)

In particular, the requested information in this regulatory audit is intended to support the NRC staff in making appropriate evaluation findings based on the following:

- Section 10.2, “Experimental Facilities,” of NUREG-1537, Part 2, states:

  The applicant should show that the design of experimental facilities does not introduce new mechanisms to initiate a LOCA or that the potential consequences of a LOCA caused by the failure of experimental facilities are considered acceptable by the Chapter 13 analysis. The applicant should show that fuel integrity would not be lost as a result of a LOCA initiated or affected by the design of an experimental facility or by the malfunction of an experiment or experimental facility.

- Chapter 13, “Accident Analyses,” of NUREG-1537, Part 1, states, in part:

  The applicant should submit information and analyses that show that the health and safety of the public and workers are protected and that the applicant has considered potential radiological consequences in the event of malfunctions and the capability of the facility to accommodate such disturbances [and] that the facility, design features, safety limits, limiting safety system settings; and limiting conditions for operation have been selected to ensure that no credible accident could lead to unacceptable radiological consequences to people or the environment.

- Chapter 13, “Accident Analyses,” of NUREG 1537, Part 2, states:

  The reviewer should confirm that the facility design prevents loss of fuel integrity in the event of a credible loss-of-coolant accident (LOCA) or loss-of-flow accident. Emergency core cooling may be required for some non-power reactors to satisfy this condition.

- Section 3.1, “Design Criteria” of NUREG 1537, Part 2, states, in part:

  Areas of review should include the criteria for the design and construction of the structures, systems, and components that are required to ensure … safe reactor

operation, safe reactor shutdown and continued safe conditions, and response to potential accidents analyzed in Chapter 13, “Accident Analyses,” of the SAR.

Audit Topics

The NRC staff seeks to confirm NCSU’s conclusion that the LOCA results for the PULSTAR are not beyond the maximum allowable value for cladding temperature or other limiting conditions, and consistent with the assumptions used in the maximum hypothetical accident. The limiting break in the FSAR is the Pool Inlet Break. The pool inlet break is more limiting because the pool drains faster and the core is uncovered earlier so the heat up starts when the decay heat is higher. An area of focus for the NRC staff will be on the potential for breakaway reactions with the zircaloy cladding and atmospheric oxygen and nitrogen. The NRC staff performed confirmatory studies at the current power level and using the conservative assumptions in the NRC staff’s model, the time and temperature of the cladding show that there is a potential for these types of reactions to occur.

The NRC staff requests the following information to support its review:

1. Analysis and/or calculation of results with details of model and parameters used and justifications under conditions of the limiting LOCA, including consideration of the peak clad temperature compared with the allowable cladding limit temperature under conditions of complete core uncovery with the potential for zircaloy reaction with atmospheric oxygen and nitrogen.

2. Analysis and/or calculation of maximum power history, design peaking factors, power density, and fuel burnup with details of model and parameters used and justifications based on the current licensed operating power of 1 megawatt-thermal.

3. Details on the design parameters of the pool cooling loop, such as:
   - length of the complete piping run,
   - number and location of any isolation valves,
   - details on any piping inspections of the cooling loop, including periodicity, and
   - design code(s) used for cooling loop piping.

4. Details regarding the source of the 10 gallon per minute pool makeup water, including time to initiate, volume of water available, and operator training/procedures.

5. Details on any other plausible sources of makeup water to the pool in the event of a LOCA, including time to initiate, volume of water available, and operator training/procedure.

6. Details on recent and upcoming reactor operation campaigns, including power level and duration.

7. Details on analyzed radiological dose consequence analyses for the limiting LOCA and fuel cladding failure/accident using the clad temperature limit and oxidation reactions with the zircaloy cladding and atmospheric oxygen and nitrogen (i.e., in air).