UNITED STATES
NUCLEAR REGULATORY COMMISSION
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November 22, 2022

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SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION STAFF OBSERVATIONS REGARDING UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN WHITE PAPER – PROPOSED CONTENTS OF PRELIMINARY SAFETY ANALYSIS REPORT USING NUREG-1537 GUIDANCE FOR THE MICRO MODULAR REACTOR (EPID NO.: L-2022-NFO-0006)

Dear Dr. Brooks:

By letter dated August 5, 2022 (Agencywide Documents Access and Management System (ADAMS) Package Accession No. ML22220A252), the University of Illinois at Urbana-Champaign (UIUC), submitted the white paper titled "Proposed Contents of PSAR [Preliminary Safety Analysis Report] Using NUREG-1537 Guidance for the Micro Modular Reactor (MMR®)," to the U.S. Nuclear Regulatory Commission (NRC) staff for review.

The NRC staff's observations are provided in the enclosure to this letter. If you have any questions regarding this matter, please contact Adrian Muñiz at Adrian.Muniz@nrc.gov.

Sincerely,

Signed by Wentzel, Michael
on 11/22/22

Michael Wentzel, Chief
Advanced Reactor Licensing Branch 2
Division of Advanced Reactors and Non-Power
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Office of Nuclear Reactor Regulation

Project No.: 99902094

Enclosure:
As stated

cc: csbrooks@illinois.edu
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SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION STAFF OBSERVATIONS REGARDING UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN WHITE PAPER – PROPOSED CONTENTS OF PRELIMINARY SAFETY ANALYSIS REPORT USING NUREG-1537 GUIDANCE FOR THE MICRO MODULAR REACTOR (EPID NO.: L-2022-NFO-0006) DATED: NOVEMBER 22, 2022

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The U.S. Nuclear Regulatory Commission Staff's Observations on UIUC White Paper Submission, "Proposed Contents of PSAR using NUREG-1537 guidance for the Micro Modular Reactor (MMR®)"

By letter dated August 5, 2022, (Agencywide Documents Access and Management System (ADAMS) Package Accession No. ML22220A252), the University of Illinois Urbana-Champaign (UIUC) submitted a white paper titled, "Proposed Contents of PSAR [preliminary safety analysis report] using NUREG-1537 guidance for the Micro Modular Reactor (MMR®)". This paper summarizes UIUC's proposed contents to be included in the PSAR and identifies differences from the content recommended in NUREG-1537.

The NRC staff has reviewed the UIUC white paper. The NRC staff's observations are provided below. These observations do not constitute final agency positions. The NRC staff observations in this response are not intended as comprehensive feedback. Lack of comment or observations regarding a certain aspect of the white paper should not be interpreted as NRC agreement with UIUC's position.

General Observations:

1. Regulatory Guide (RG) 1.232 provides guidance on how the general design criteria (GDC) in Appendix A, "General Design Criteria for Nuclear Power Plants," of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," may be adapted for non-light-water reactor (non-LWR) designs. Appendix C of the RG describes the NRC's guidance for modifying and supplementing the GDC to develop PDC that address high temperature gas-cooled reactors (HTGR). UIUC should consider this reference for guidance when developing its application.

2. Section 10 CFR 50.35 has specific requirements for a construction permit (CP). A CP will only be issued if the technical or design information to complete the safety analysis is included in the PSAR or can reasonably be left for later consideration and will be in the FSAR. The NRC staff notes that, safety features or components, if any, which require research and development (R&D) should be described by the applicant including the associated R&D program designed to resolve any safety questions. Therefore, any information that UIUC intends to defer to the FSAR should be discussed in the PSAR as to why it is not expected to be present and why it can be reasonably left for later consideration.

Specific Observations:

Throughout the UIUC whitepaper construction of the Ultra Safe Nuclear Corporation (USNC) MMR is proposed as a "Research and Test reactor." {*emphasis added*} The MMR cannot be licensed as both. In this case, at 15 MW, the application should clearly articulate "testing facility." Note: reference to being a "non-power reactor" is correct because the MMR meets the definition as a research or test reactor licensed under §§ 50.21(c) or 50.22.

1. Section 3.1 – The Facility

a) PSAR, Section 3.1.4 - The low safety significance and non-safety related systems should be described as to why they are acceptable for sharing, for example why a loss of shared power or water will not impact operations or safety (emergency power, backup

b) supply of make-up water). For example, potential habitability issues if the facility loses the HVAC, and potential effects on emergency response and access to the facility using. shared roads. All systems should be evaluated as to their impact on safe reactor operation and maintaining safe shutdown. In addition, the NRC staff notes that "High" is not part of the criteria for determining safety significance.

c) PSAR, Section 3.1.5 - Comparisons with the identified facilities is unclear. Per NUREG-1537, the comparison should show that the proposed facility would not exceed the safety envelope of the similar facilities. UIUC should describe how the design features for facilities used for comparison purposes do not differ in any substantive way from the UIUC facility. Furthermore, if the facilities that are being used for comparison purposes have not been previously found acceptable by the NRC staff, additional justification should be provided for using them for comparison purposes.

d) PSAR Section 3.1.6 - Fission product decay heat should be part of the summary discussion, as well as, assumed releases of radioactive effluents to the unrestricted environment.

e) PSAR, Section 3.1.7 should describe how UUIC will meet the requirements of Section 302(b)(1)(B) of the Nuclear Waste Policy Act of 1982 for disposal of high-level radioactive wastes and spent nuclear fuel.

2. Section 3.2 – Site Characteristics

a) PSAR, Section 3.2.1 - The information described is necessary, but not sufficient. Consult 10 CFR Part 100 and NUREG-1537 for geographic or demographic features that could render the site unsuitable for operation of the proposed reactor.

b) PSAR, Section 3.2.2 or another applicable area of the PSAR should include principal design criteria (PDC) and discussion and preliminary evaluation of on-site chemical storage and related hazards in the PSAR, that will be expanded upon in the FSAR.

c) PSAR, Section 3.2.3 - The list of Meteorological phenomena is not all inclusive of general climate; consult NUREG-1537, Section 2.3. The PSAR input of meteorological data for the proposed site should include meteorology information such as air flow, temperature, water vapor, fog, atmospheric stability and air quality to aid the staff in assessing meteorological impacts on reactor safety and operation or that could render the site unsuitable.

d) PSAR, Section 3.2.4 - The hydrology discussion needs to include the potential for radioactive contamination of ground and surface waters and discuss provisions to mitigate leakage or loss of radioactive material and consider neutron activation of ground water and deposition of released airborne material in surface water.

3. Section 3.3 – Design of Structures, Systems, and Components

a) PSAR, Section 3.3.1 - The NRC staff notes that while the information in Section 3.3.1 is accurate, principal design criteria (PDCs) are then only referenced once (in Section 3.4.3). The PSAR should provide information in the relevant sections how the design satisfies the PDCs applicable to that technical area, as the NRC staff will make findings

against the PDC when evaluating the actual design in each section or chapter that corresponds to the specific structure, system, or component (SSC).

4. Section 3.4 – Reactor Description

a) PSAR Section 3.4.2 - At a high level, the information provided in Section 3.4.2 appears to cover much of the information expected at the PSAR level in this technical area, though the level of detail is not yet sufficient to draw any conclusions. However, while Section 3.4.2 states that "[o]perating limits (i.e., temperature, pressure) for the fuel and moderator will also be provided in the PSAR," it is not clear to what extent specifications for SSCs discussed in this section will be provided. In particular, the NRC staff would expect a tie between the SSC limits and specifications and the operational envelope, including under accident conditions to the extent identified at the PSAR stage (e.g., bounding values that could be refined at the FSAR stage).

b) PSAR Section 3.4.5 appears to provide appropriate scope related to nuclear design, with the exception of the phrase "consider core operating limits." It is not clear to the NRC staff what this would entail. The high-level description associated with Section 3.4.6 is in line with the expected level of detail at the PSAR stage, but additional detail beyond the "design bases will be presented" would be expected (i.e., a sample or bounding calculation to validate the stated design bases).

5. Section 3.5 – Reactor Coolant Systems

a) PSAR Section 3.5.2 - The general description in Section 3.5.2 appears reasonable, but details regarding specific elements of the primary coolant system not discussed raise questions. Specifically, any details how the coolant system plays into the functional containment strategy or whether there are activity limits related to specified acceptable radionuclide release design limits for the fuel that are confirmed using the coolant system would also be relevant to discuss in this section of the PSAR.

Information described in Section 3.5.3 appears to provide the scope expected of secondary coolant systems in the FSAR. In this Section, UIUC states that:

> ".... the primary coolant loop will be demonstrated to be adequately isolated from the secondary coolant loop to preclude an abrupt event that could cause substantial primary-to-secondary leakage (e.g., tube rupture). Therefore, a transfer of primary coolant to secondary coolant system accident does not need to be explicitly evaluated in Section 13 as it is not a credible accident propagation pathway."

The above statement will require additional context in the PSAR. Provided an event class can be demonstrated to be precluded, the NRC staff believes not performing an evaluation can be justified. However, from a practical perspective, demonstrating such an event can be precluded (in this case, an event with an operational history of occurrences under comparable operational conditions) may prove challenging.

The NRC staff does not have sufficient information to draw conclusions at this stage. Therefore, engaging on this topic with additional technical detail regarding the system(s) in question prior to submission of the application might prove beneficial.

6. Section 3.6 – Engineered Safety Features

a) PSAR Section 3.6.2 provides context on two areas of detail: “Confinement and Containment” and the “Emergency Core Cooling System.” For confinement and containment, NRC staff recognizes this document provides only a high-level description of the information expected in the PSAR. In this Section, UIUC states that:

> “Therefore, the fuel provides confinement and containment of radionuclides for the MMR. Pressure zones in the reactor building provide additional containment of radionuclides. Radionuclide release design limits will be specified in the FSAR.”

The NRC staff expects these statements will be adequately justified with supporting information in the PSAR. This concept is relatively novel in implementation and the NRC staff is not aware of a wholly similar implementation of functional containment, so additional information regarding these statements will be important to establish the role and design bases of the functional containment.

UIUC further states that:

> “The MMR does not rely on active safety systems and can maintain core cooling through natural circulation of ambient air in the event of a loss of primary coolant. Therefore, there is no safety-related emergency core cooling system (ECCS).”

Based on the context in the section, staff understands the RCCS performs the role associated with the traditional scope of the ECCS. It is not clear whether the RCCS will be safety-related, though NRC staff expects there will be at least one system performing the heat removal function of the design. The RCCS is stated to “[facilitate] air-cooled natural convection,” which may benefit from additional context. As such, it appears to the NRC staff that UIUC will provide the appropriate scope for this section of the PSAR, and the PSAR should provide a complete preliminary framework for the role of systems removing heat under off-normal conditions in this section.

7. Section 3.7 – Instrumentation and Control Systems

a) PSAR Section 3.7.2 of the proposed PSAR contents states that the information does not need to be included in the license application. Staff disagrees with this statement. All of the information referenced in NUREG-1537, Section 7.2 for instrumentation and control (I&C) should be included. PSAR, Section 3.7.2 should include summary details related to the information provided in the later sections for the specific equipment, as a high-level summary that discusses the applicable design criteria from section 3.3 of the PSAR and should describe how the equipment meets the design criteria and how the design criteria is satisfied by the design bases at the system level. This includes clearly stating how the system architecture provides the appropriate level of diversity, redundancy, reliability, independence, quality, defense-in-depth, fail-safe capability, prioritization, and

performance capabilities. Section 3.7.2 should also include the description of how generally applicable design criteria are met for the I&C systems, such as natural phenomenon, building codes, fire/explosion, chemical hazards, and environmental qualification. Other details that should be in PSAR Section 3.7.2 include a high-level summary of the below listed design attributes as they relate to the I&C systems:

- PSAR Section 3.7.2.1 - Design criteria derived from the analyses of normal operating conditions and of accidents and transients that could occur at the facility [see 10 CFR 50.34(a)(3)(i)]
- PSAR 3.7.2.2 - Design bases and the relation of the design bases to the principal design criteria [see 10 CFR 50.34(a)(3)(ii)]
- PSAR 3.7.2.3, “System Description” – Section 10 CFR 50.34(a)(2) requires the preliminary safety analysis report (PSAR) include a summary description and discussion of the facility, with special attention to design and operating characteristics, unusual or novel design features, and principal safety considerations
- PSAR 3.7.2.4, “System Performance Analysis” – PSAR should include a high-level description with full details to be provided in FSAR
- PSAR 3.7.2.5, “Design and Development Process” - PSAR should include a high-level description with full details to be provided in FSAR. Quality assurance should be described as relevant to the I&C systems. This should include a description of the software development activities if the system(s) will contain specifically developed software. This includes configuration management and verification and validation activities to provide an objective assessment of software products and processes throughout the software life cycle.
- PSAR 3.7.2.6, “Access Control and Cyber Security” - Nonpower reactor licensees have an obligation to meet specific physical security requirements in accordance with 10 CFR 73.60 and 73.67. Access control and cyber security is a part of physical security.

Although full I&C system details may not be available at PSAR submittal, the design criteria and how UIUC intends to meet the above attributes should be addressed. The principal design criteria for the facility can be understood to be technology-neutral and performance-based since they predominately state what must be achieved, not how it is to be achieved. Once the principal design criteria for a facility is established, the remainder of the SAR demonstrates (or explains) how the principal design criteria for a facility is achieved. The design bases, as defined in 10 CFR 50.2, can also be understood to be technology-neutral and performance-based since the design bases predominately include the specific functions to be performed by SSCs and the specific values or ranges of values chosen for controlling parameters as reference bounds for design (i.e., the design bases of the facility is not the engineering design bases for the SSCs)

b) PSAR Sections 3.7.3 through 3.7.7 - The NRC staff expects that sections 3.7.3 through 3.7.7 of the PSAR to describe the specific information for each subsystem as applicable to each of the I&C subsystems related to 3.7.2.1 through 3.7.2.5 above. For Section 3.7.5 of the PSAR, the information on actuation systems for ESFs should be consistent with the information provided in Section 3.6.

8. Section 3.8 – Electrical Power Systems

a) PSAR Section 3.8.1 - UIUC states the PSAR will discuss any impacts of a loss of electrical power on safe shutdown. The PSAR discussion should also include the full effects of a loss of all offsite power in both the short- and long-term scenario. Also, the PSAR should discuss If the offsite supply comes from more than one different substation for reliability. The detailed schematics or description of the PSAR should also include any specific components for suppression, filtering, noise limiters, and/or lightning arrestors, if applicable

b) PSAR Section 3.8.2 - UIUC states the PSAR will contain departures from the guidance in NUREG-1537 due to the design of the MMR. Regardless of the UIUC design, information related to uses / needs for backup electrical power and uses of emergency electrical power to monitor and maintain the reactor in a safe shutdown condition should follow the guidance in NUREG 1537, Section 8.2. This includes (based on the whitepaper description of the UIUC design):
    - Power for reactor power level monitors, recorders, and necessary safety-related instruments (e.g., those instrument and control systems necessary to monitor reactor shutdown).
    - Power for effluent, process and area radiation monitors, including recorders.
    - Power for physical security control systems, information systems, or communications. (references only, with safeguards information left to physical security plan)
    - Power for the active confinement strategy equipment and control systems described in Section 3.6 of the UIUC whitepaper.
    - Power for emergency area lighting and communication equipment.

9. Section 3.9 – Auxiliary Systems

a) For each auxiliary system, the applicant should discuss the capability to 'function as designed without compromising reactor operation or the capability to shut down the reactor. Operating parameter limits (i.e., air temperature, quality, humidity, pressure) should be part of the proposed design and presented to the extent necessary to establish the related PDC (see 10 CFR Part 50, Appendix A, Criterion 4). SSCs important to safety must be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.

b) PSAR 3.9.2 should address PDCs related to Fuel storage and handling and radioactivity control (see Criterion 61 through 64 of 10 CFR Part 50, Appendix A).

10. Section 3.10 – Experimental Facilities and Utilization

a) 3.10 UIUC states that it intends to depart from the NUREG-1537 guidance in this section. The information in this section is not clear as to what would be considered deviations from the guidance as it pertains to experimental facilities and utilization.

11. Section 3.11 – Radiation Protection Program and Waste Management

a) PSAR 3.11.1 should address PDC for control of releases of radioactive materials to the environment.

b) In addition to the listed UIUC references, ANSI/ANS 15.1, Section 6.3 should be consulted to indicate reporting level and assigned responsibility for implementing the UIUC radiation protection program, including any interfaces to the university's radiation protection program and environmental monitoring.

12. Section 3.12 – Conduct of Operations

a) PSAR Section 3.12.1 - UIUC states, "Detailed discussion of staffing and training considerations and final procedures will be provided in the FSAR, including details regarding the authority of the radiation safety staff in respect to other facility staff." In accordance with 10 CFR 50.34(a)(6) UIUC must provide a preliminary plan for the applicant's organization, training of personnel, and conduct of operations in the PSAR.

b) PSAR Section 3.12.7 - Consistent with 10 CFR Part 100, the application should identify physical characteristics unique to the proposed site that could pose a significant impediment to the development of emergency plans. This should include consideration for factors that determine acceptability of the proposed site in 10 CFR Part 100, Section 100.20 and 100.21.

c) PSAR Section 3.12.8 - The PSAR must address 10 CFR Part 100, Section 100.21 to describe that the site characteristics are such that adequate security plans and measures can be developed.

d) PSAR Section 3.12.9 - UIUC indicated that the PSAR will identify relevant regulations and guidelines regarding quality assurance (QA). This is not sufficient for the PSAR. UIUC should establish a PDC related to quality assurance consistent with the guidance of Appendix A of 10 CFR Part 50 Criterion 1, Quality standards and records. A quality assurance program must be established and implemented in order to provide adequate assurance that the structures, systems, and components will satisfactorily perform their safety functions.

13. Section 3.13 – Accident Analyses

a) As a testing facility, the NRC staff will evaluate and establish approval requirements for the proposed design based on 10 CFR Part 100 for the reactor site requirements and the doses to the public that could result from a serious accident. However, the doses given in 10 CFR Part 100 are reference values and are not intended to imply that the dose numbers constitute acceptable limits for emergency doses to the public under accident conditions. Rather, they are values that can be used for evaluating reactor sites with respect to potential reactor accidents of exceedingly low probability of occurrence and low risk of exposure of the public to radiation.

14. Section 3.14 – Technical Specifications

a) The use of ANSI/ANS 15.1 as guidance is acceptable to the NRC staff to the extent that ANSI/ANS 15.1 should be clarified to provide acceptable TSs, as modified by NUREG-

1537, Part 1, Appendix 14.1. The applicant must also comply with the regulations on technical specifications (TS), including 10 CFR 50.36.

b) Per 10 CFR 50.33(a)(5), applications for construction permits must identify and justify the selection of those variables, conditions, or other items which are determined as the result of preliminary safety analysis and evaluation to be probable subjects of technical specifications for the facility, with special attention given to those items which may significantly influence the final design. The applicant should be able to state conclusively that normal operation of the reactor within the limits of the technical specifications will not result in offsite radiation exposure in excess of established limits, and that the technical specifications limit the likelihood and consequences of malfunctions.

c) UIUC states that the MMR is not expected to contain experimental facilities and that experiments need not be discussed. The NRC staff notes that TS on experiments might be needed even if the experiments aren't performed in the core.

15. Section 3.15 – Financial Qualifications

a) In accordance with 10 CFR 50.33(f)(1), if the application is for a construction permit, the applicant must submit information that demonstrates that the applicant possesses or has reasonable assurance of obtaining the funds necessary to cover estimated construction costs and related fuel cycle costs. The applicant must submit estimates of the total construction costs of the facility and related fuel cycle costs and shall indicate the source(s) of funds to cover these costs.

The application for a CP must also include information showing:

> (i) The legal and financial relationships it has or proposes to have with its stockholders or owners;
> (ii) The stockholders' or owners' financial ability to meet any contractual obligation to the entity which they have incurred or proposed to incur; and
> (iii) Any other information considered necessary by the Commission to enable it to determine the applicant's financial qualification.

b) The application must indicate the class of license applied for, the use of facility, the period of time for which the license is sought, and a list of other licenses, except operator's licenses, issued or applied for in connection with the proposed facility. Accordingly, the application must include sufficient information to show compliance with 10 CFR 50.22 and the Nuclear Innovation and Modernization Act (NEIMA) [Public Law No: 115-439] to show that the facility is to be used primarily for research and development or education and training.

16. Section 3.16 – Other License Considerations

a) PSAR Section 3.16.1 should not be omitted as not applicable. As a new facility any components that are being used that came from other reactor facilities may have to consider prior use of those components. If no components are to be used, as stated by UIUC, then an affirmative statement that there are no prior use components should be made in the PSAR and the FSAR.