UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

July 26, 2017

Mr. Victor M. McCree
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: SAFETY EVALUATION OF THE NUSCALE POWER, LLC TOPICAL REPORT TR-0815-16497-P, "SAFETY CLASSIFICATION OF PASSIVE NUCLEAR POWER PLANT ELECTRICAL SYSTEMS," REVISION 1

Dear Mr. McCree:

During the 645th meeting of the Advisory Committee on Reactor Safeguards, July 12-14, 2017, we reviewed the NRC staff's safety evaluation report (SER) for the NuScale Power, LLC (NuScale) topical report TR-0815-16497-P, Revision 1, "Safety Classification of Passive Nuclear Power Plant Electrical Systems." Our NuScale Subcommittee also reviewed this matter during a meeting on March 24, 2017. During these meetings, we had the benefit of discussions with the staff and representatives of NuScale. We also had the benefit of the referenced documents.

CONCLUSION and RECOMMENDATIONS

1. NuScale topical report TR-0815-16497-P, Revision 1, is acceptable for use only as a reference document for the NuScale plant electrical systems design subject to the staff limitations and conditions. The staff SER on this topical report should be amended accordingly.

2. The staff should include an additional condition that the design, qualification, and quality assurance provisions described in Table 3-2 should be applied to any non-safety AC or DC power supplies that support (1) operation of risk-significant systems or components or (2) performance of risk-significant human actions that are identified in the site-specific probabilistic risk assessment.

BACKGROUND

Electrical power systems in a nuclear power plant do not establish classification requirements on other systems. Rather, the electrical loads determine the classification requirements for the electrical power system. Thus, given a reactor plant design with no safety-related equipment dependent on electrical power to perform its safety function, such a design would not require the use of Class 1E alternating current (AC) or direct current (DC) power systems.

In October 2015, NuScale submitted the topical report TR-0815-16497-P, Revision 0 to the staff for review. Revision 1 of the topical report was issued in February 2017. The topical report was submitted to the staff for review with the objective of obtaining approval of a set of passive reactor plant design and operational attributes (referred to as "conditions of applicability"), that if met, would justify that no plant electrical systems would require a Class 1E classification.

The topical report also specifies a set of augmented design, qualification, and quality assurance (QA) provisions as minimum requirements for electrical systems determined to be non-safety-related yet essential to post accident monitoring of certain parameters. These augmented provisions would be an acceptable alternative to the Class 1E power supply classification specified in Regulatory Guide 1.97. They are intended to be consistent with the process established in the regulations for treatment of non-safety-related structures, systems, and components that are determined to have risk significance, as discussed in SECY-94-084 and SECY-95-132.

DISCUSSION

The topical report only addresses plant electrical systems for which the conditions of applicability and augmented provisions apply, i.e., offsite and onsite AC and onsite DC electrical power systems. The scope of the topical report does not include safety-related instrumentation and control equipment and circuits.

The topical report includes four appendices that provide examples of how future applicants, such as NuScale, could meet the conditions of applicability. NuScale did not seek staff approval of the information contained in the appendices and states that its design certification application (DCA) will present the appropriate final design information.

The staff stated that their review was limited to only the main body of the topical report and focused on the design criteria considered in the conditions of applicability and augmented provisions. Nonetheless, in a number of circumstances the staff used examples from the appendices to develop and justify their findings. Staff concluded that if an application with a passive plant design references the topical report, it must demonstrate that it meets all the conditions of applicability, the augmented design, qualification, and QA provisions, plus meet the additional limitations and conditions that were imposed by the staff.

The staff review covered several technical areas:

Concept of Highly Reliable Non-Class 1E DC Power System

The topical report requires either the use of Class 1E vented lead-acid batteries or commercial grade valve regulated lead-acid (VRLA) batteries. If VRLA batteries are used, it specifies twice the full-load capacity redundancy of a typical Class 1E DC power system. While VRLA battery technology is widely used in other industries, it is not used in conventional light water reactors for onsite DC power. The topical report specifies adherence to IEEE standards for VRLA batteries. The staff found that there was reasonable assurance that a DC power system provided by VRLA battery technology will be monitored and meet its intended function with sufficient reliability.

In addition, the staff placed a condition (4.1) in the SER to ensure that an applicant referencing the topical report address the guidance in Regulatory Guide 1.155, Appendix A, in sufficient detail to verify that the relevant QA program would meet or exceed that guidance. The staff also

added a condition (4.2) in the SER to confirm that the VRLA batteries and their support structures are Seismic Category I. A qualification test plan would include environmental and seismic qualification and functional requirements for VRLA batteries to show they can perform as intended.

Finally, the staff required that the topical report include a methodology for comparing the relative reliability of a non-Class 1E system with that of an analogous Class 1E system. This comparison is of limited use and could be misleading. Even if the reliabilities are the same, experience has shown that elements of the specific proposed plant design, including possible asymmetries in the DC bus loads, can have an important effect on the risk significance of each power supply. The integrated, design-specific probabilistic risk assessment (PRA) will evaluate whether the DC power system has adequate reliability, considering both the frequency of event scenarios that need DC power and the consequences if DC power is not available.

Post-accident Monitoring

Regulatory Guide 1.97 specifies that a Class 1E electrical system should be provided to supply the instrumentation that monitors a range of parameters under post-accident conditions. The topical report only applies to a design in which no parameters are needed for operator actions to provide a safety-related function during any design basis event (DBE). Rather, such instrumentation would be used only for safety status indication. The staff determined that even if the regulatory requirements for post-accident monitoring do not require a Class 1E electrical system, the reliability of the electrical power supply for these instruments should be substantially similar to that of a Class 1E electrical system. This would have to be confirmed in the DCA review and the associated reliability program previously discussed. In addition, the staff has established a condition (4.3) in the SER to confirm that operator actions are not necessary to ensure the performance of safety-related functions for any postulated DBE.

Safe Shutdown, Core Cooling, Reactor Coolant Pressure Boundary Integrity

The general design criteria (GDC) in 10 CFR Part 50, Appendix A, are applicable to all types of nuclear power plants and provide guidance to establish the principal design criteria for specific plant designs. The staff established a condition (4.4) in the SER to confirm that a passive reactor design demonstrate that the conditions of applicability given in topical report Table 3-1 are consistent with the functional requirements contained in its principal design criteria.

SECY-94-084 states that appropriate evaluations can be used to demonstrate passive system capabilities to bring the plant to a safe, stable condition and to maintain this condition. The topical report contained examples in Appendix B and Appendix D to illustrate how the conditions of applicability for safe shutdown can be demonstrated. The examples provided did not include a quantitative safety analysis to demonstrate the ability to insert sufficient negative reactivity during and following a DBE to achieve and maintain safe shutdown. The staff requested additional information, asking the applicant to specify the criteria that constitute a safe shutdown state as applied to this condition of applicability, and to describe how a passive plant design will demonstrate that electrical power is not necessary to achieve and maintain a safe shutdown for a minimum of 72 hours. The applicant stated that the safe shutdown criteria are subcriticality and decay heat removal in order to maintain fuel cladding integrity. While the staff found this generally acceptable, reactor shutdown and maintaining a subcritical reactor are safety functions considered in GDC 26 and GDC 27, both of which require margin for malfunctions,

such as stuck control rods. Thus, the NRC staff established a condition (4.6) to require a demonstration or appropriate justification of shutdown margin consistent with GDC 26 and GDC 27.

To demonstrate that the reactor coolant pressure boundary overpressure protection is maintained without the need of Class 1E power, the topical report contained examples in Appendices B and D to illustrate how this specific condition of applicability can be demonstrated. The staff noted that the example safety analysis in Appendix D showed that the example passive plant response to an anticipated operational occurrence (AOO) includes establishing a direct coolant flow path between the reactor core and the containment, thereby removing a fission product barrier. This caused the staff to ask whether the condition of applicability is sufficient for demonstrating reactor coolant pressure boundary integrity. The AOO scenario, provided in Appendix D to the topical report, relies on the containment to retain the reactor coolant necessary to ensure fuel cladding integrity. An AOO, by definition, is expected to occur one or more times during the life of the nuclear power plant. The staff was concerned that too much reliance is placed on the containment and this may not be consistent with the underlying defense-in-depth purpose of GDC 15. Accordingly, the staff established a condition (4.5) in the SER to address reliability requirements for systems necessary to retain the reactor coolant and assure overpressure protection of the reactor coolant pressure boundary. This condition was added to require the design demonstrate that system(s) necessary to retain the reactor coolant within the reactor coolant pressure boundary are designed with sufficient reliability such that a design-basis event that removes the reactor coolant pressure boundary as a fission product barrier does not occur with the frequency of an AOO.

Depending on specific features of the proposed plant design, we are concerned that strict interpretation of the topical report conditions of applicability could inadvertently overlook other reasons for the need to apply enhanced controls to selected non-safety AC or DC power supplies. In particular, the PRA may identify power supplies that are important to overall plant risk, but do not satisfy the listed conditions for design-basis event response, post-accident monitoring instrumentation, or maintenance of specific functions for 72 hours after a plant transient or accident. The staff should include an additional condition that the design, qualification, and quality assurance provisions described in Table 3-2 should be applied to any non-safety AC or DC power supplies that support (1) operation of risk-significant systems or components or (2) performance of risk-significant human actions that are identified in the site-specific PRA.

SUMMARY

This topical report is acceptable for use as a reference document. However, considering the staff's extensive reference to the information in the appendices, use of the topical report should be limited to the NuScale plant electrical systems design, which will be reviewed as part of the DCA. The DCA should confirm that the final design meets the conditions of applicability in

topical report Table 3-1, the augmented design, qualification, and QA provisions in Table 3-2, and the staff limitations and conditions as well as the additional condition previously discussed.

Additional comments by ACRS Members Dennis Bley, John Stetkar, Walter Kirchner and Ronald Ballinger are presented below.

Sincerely,

/RA/

Dennis C. Bley
Chairman

Additional Comments by ACRS Members Dennis Bley, John Stetkar, Walter Kirchner and Ronald Ballinger

We agree with our colleagues that the topical report should be approved. The staff's safety evaluation report refers to Appendices A-D many times, despite the claim that the staff did not review the appendices. Because the example in the appendices has similarities with the NuScale design, the SER emphasis on the appendices does not justify use of the topical report by other applicants. Where we disagree is on the solution to this problem.

Our colleagues argue that the staff should revise the SER to say that the topical is acceptable for use only as a reference document for the NuScale plant electrical systems. In essence, the report would no longer be a topical report. In fact, the authors of the topical report were careful to craft it so that the appendices were completely separate from the main report. If an applicant can meet the criteria in Chapter 3 of the main report (including Tables 3-1 and 3-2), then they should be able to use it. Every issue the staff raised in their explicit references to the appendices is answered in Chapter 3 of the main report. If the staff were to revise the SER with the same care taken by the authors of the topical report, they could draw all their conclusions from the main report and never refer to the appendices. If another applicant meets all the criteria of the topical report, there is no reason the staff should need to revisit the same issues.

Our second concern with the topical report revolves around its central claim, that, for any passive plant that meets the criteria of the conditions of applicability in Chapter 3 of the topical, none of the plant electrical systems fulfill functions that would require a Class 1E designation. Nevertheless, for any specific, as-built design, specific scenarios under specific conditions would be different than simplified generic examples considered *a priori*. Those differences will need to be considered. The Committee's second recommendation about risk-significant scenarios gives us the confidence needed to support the topical report. It provides one solution for such situations. We would go further to note that, should risk-significant scenarios be identified, there are a range of approaches available to an applicant to address them: redesign the associated elements of the electric power system to reduce their risk significance; redesign elements of the plant or operations to reduce the risk by other means; improve the PRA, if the calculated risk is an artifice of PRA modeling assumptions; take exception to the topical report criteria, if the actual plant design or its total risk suggest special circumstances that justify acceptance of the calculated risks.

REFERENCES

1. U.S. Nuclear Regulatory Commission, “Safety Evaluation for Topical Report TR-0815-16497, ‘Safety Classification of Passive Nuclear Power Plant Electrical Systems’,” Revision 1, June 27, 2017 (ML17170A202).

2. U.S. Nuclear Regulatory Commission, “Safety Evaluation for Topical Report TR-0815-16497, Revision 1, ‘Safety Classification of Passive Nuclear Power Plant Electrical Systems’,” June 27, 2017 (ML17170A201) [PUBLIC VERSION].

3. U.S. Nuclear Regulatory Commission, “Safety Evaluation for Topical Report TR-0815-16497, ‘Safety Classification of Passive Nuclear Power Plant Electrical Systems’,” Revision 0, February 6, 2017 (ML17037D274).

4. NuScale Power, LLC, TR-0815-16497-P, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," Revision 1, February 2017 (ML17048A460).

5. NuScale Power, LLC, TR-0815-16497-NP, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," Revision 1, February 28, 2016 (ML17048A459) [PUBLIC VERSION].

6. NuScale Power, LLC, TR-0815-16497-P, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," Revision 0, October 2015 (ML15306A128).

7. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.97, “Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants,” Revision 4, June 2006 (ML061580448).

8. U.S. Nuclear Regulatory Commission, SECY-94-084, “Policy and Technical Issues Associated With the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs,” March 28, 1994 (ML003708068).

9. U.S. Nuclear Regulatory Commission, SECY-95-132, “Policy and Technical Issues Associated With the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Designs (SECY-94-084),” May 22, 1995 (ML003708005).

10. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.155, “Station Blackout,” August 1988 (ML003740034).

11. NuScale Power, LLC, “Submittal of Response to Request for Additional Information Letter No. 8 for the review of Topical Report 0815-16497, ‘Safety Classification of Passive Nuclear Power Plant Electrical Systems,’ Revision 0, December 5, 2016 (ML16340D339).

REFERENCES

1. U.S. Nuclear Regulatory Commission, “Safety Evaluation for Topical Report TR-0815-16497, ‘Safety Classification of Passive Nuclear Power Plant Electrical Systems’,” Revision 1, June 27, 2017 (ML17170A202).

2. U.S. Nuclear Regulatory Commission, “Safety Evaluation for Topical Report TR-0815-16497, Revision 1, ‘Safety Classification of Passive Nuclear Power Plant Electrical Systems’,” June 27, 2017 (ML17170A201) [PUBLIC VERSION].

3. U.S. Nuclear Regulatory Commission, “Safety Evaluation for Topical Report TR-0815-16497, ‘Safety Classification of Passive Nuclear Power Plant Electrical Systems’,” Revision 0, February 6, 2017 (ML17037D274).

4. NuScale Power, LLC, TR-0815-16497-P, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," Revision 1, February 2017 (ML17048A460).

5. NuScale Power, LLC, TR-0815-16497-NP, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," Revision 1, February 28, 2016 (ML17048A459) [PUBLIC VERSION].

6. NuScale Power, LLC, TR-0815-16497-P, "Safety Classification of Passive Nuclear Power Plant Electrical Systems," Revision 0, October 2015 (ML15306A128).

7. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.97, “Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants,” Revision 4, June 2006 (ML061580448).

8. U.S. Nuclear Regulatory Commission, SECY-94-084, “Policy and Technical Issues Associated With the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs,” March 28, 1994 (ML003708068).

9. U.S. Nuclear Regulatory Commission, SECY-95-132, “Policy and Technical Issues Associated With the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Designs (SECY-94-084),” May 22, 1995 (ML003708005).

10. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.155, “Station Blackout,” August 1988 (ML003740034).

11. NuScale Power, LLC, “Submittal of Response to Request for Additional Information Letter No. 8 for the review of Topical Report 0815-16497, ‘Safety Classification of Passive Nuclear Power Plant Electrical Systems,’ Revision 0, December 5, 2016 (ML16340D339).

Accession No: ML17205A380 **Publicly Available Y** **Sensitive N**
Viewing Rights: ☒ NRC Users or ☐ ACRS Only or ☐ See Restricted distribution

OFFICE	ACRS/TSB	SUNSI Review	ACRS/TSB	ACRS	ACRS
NAME	MSnodderly *(MLB for)*	MSnodderly *(MLB for)*	MBanks	AVeil	DBley *(AV for)*
DATE	7/25/2017	7/25/2017	7/25/2017	7/26/2017	7/26/2017

OFFICIAL RECORD COPY