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

February 21, 2018

The Honorable Kristine L. Svinicki
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: NUSCALE POWER EXEMPTION REQUEST FROM 10 CFR PART 50, APPENDIX A, GENERAL DESIGN CRITERION 27, "COMBINED REACTIVITY CONTROL SYSTEMS CAPABILITY"

Dear Chairman Svinicki:

During the 650th meeting of the Advisory Committee on Reactor Safeguards, February 8-9, 2018, we reviewed the NRC staff's publicly available draft Commission Paper SECY-18-XXX, "NuScale Power Exemption Request from 10 CFR PART 50, Appendix A, General Design Criterion [GDC] 27, 'Combined Reactivity Control Systems Capability'." Our NuScale Subcommittee reviewed this matter on, January 23, 2018. During these meetings, we had the benefit of discussions with the staff and representatives of NuScale Power, LLC (NuScale). We also had the benefit of the referenced documents.

CONCLUSION AND RECOMMENDATION

The proposed criteria, which the staff will use to determine the acceptability of NuScale's GDC 27 exemption request, are reasonable provided the following recommendations and enhancements outlined in this letter report are addressed:

1. Evaluate the overall risk and not just the frequency of the challenge

2. Risk considerations should be based on the facility rather than an individual module

BACKGROUND

The GDC of 10 CFR Part 50, "Licenses, Certifications, and Approvals for Nuclear Power Plants," are the minimum requirements for the principle design criteria for water-cooled nuclear plants to provide reasonable assurance that the facilities can be operated without undue risk to the health and safety of the public. The GDC were developed based on the licensing of early commercial water-cooled reactor plant designs. The staff has acknowledged that fulfillment of some of the GDC may not be necessary or appropriate for some designs. The NuScale reactor is a modular, passive, water-cooled reactor design with innovative design features. The staff expects any reactor design to meet or justify departures from the GDC 27, which states:

> *Combined reactivity control systems capability.* The reactivity control systems shall be designed to have a combined capability, in conjunction with poison addition by the emergency core cooling system, of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained.

Based on historical practice and from documentation related to the development of GDC 27, the staff has implemented this criterion through design basis analyses demonstrating safe shutdown is achieved and maintained in the long-term following postulated accidents. The NRC has not licensed a power reactor that does not remain subcritical beyond the short-term under such conditions.

Following certain design basis event (DBE) scenarios, the NuScale reactor may return to critical at a thermal power above decay heat levels. These DBE scenarios assume that one of the sixteen control rods fails to insert, that there is a loss of offsite AC power, and that the non-safety boron injection system is unavailable. If the moderator temperature coefficient is sufficiently negative then recriticality would occur due to decreases in reactor coolant temperature. Based on these conditions and assumptions, the reactor would remain critical until an alternate means of reactivity control is actuated. Even though recovery actions may be realistic responses to such an event, the DBE analyses in the NuScale design and licensing basis assume no operator actions to mitigate the consequences of the event.

The staff has historically interpreted the intent of GDC 27 to require that the reactor be reliably controlled and achieve and maintain a safe, stable condition, including subcriticality beyond the short-term, using only safety-related equipment following a DBE with margin for stuck rods. The staff informed NuScale that an exemption to GDC 27 would be required and that consideration of such an exemption entails policy issues under the purview of the Commission. NuScale has stated their belief that the design is consistent with the intent of GDC 27.

DISCUSSION

NuScale requested an exemption from GDC 27 and proposed a design-specific principal design criterion to allow for the condition that the reactor could return to power, given these DBE assumptions, if adequate passive heat removal capability exists to maintain long-term core cooling.

It has been recognized for some time now that exemptions to the current GDC may be needed as design innovations are proposed, based on improved knowledge and decades of reactor operating experience. Such exemptions must be possible if reactor technology is to advance. Still, some caution is warranted when deviations are made from long-held design philosophies that have served well in the protection of public health and safety. Caution is certainly warranted when exemptions are taken to GDC 27 to accommodate a design that could involve recriticality and return to power that occurs at an uncertain time to an uncertain core power.

The staff plans to evaluate whether the NuScale design meets the underlying purpose of GDC 27 by assessing the results of NuScale's safety analyses of the assumed DBE scenarios against the established specified acceptable fuel design limits (SAFDLs). In accordance with the design certification process in 10 CFR Part 52, the Commission will make a final determination on the acceptability of NuScale's proposed exemption to GDC 27 and the safety of the design based on NuScale's analysis and staff review.

In DBE analyses performed for currently operating reactors, only safety-related structures, systems, and components (SSCs) are typically credited to show compliance with the regulations. However, the staff has stated that the NuScale exemption could be supported provided public health and safety are maintained by sufficient core cooling during the scenario to maintain fuel cladding integrity (i.e., SAFDLs are met), and provided the DBE sequence of events is not actually expected to occur during the lifetime of a module.

The following sections discuss our comments on the staff's criteria.

Maintain Long-Term Core Cooling

Given its passive design, NuScale should demonstrate that its reactor design can maintain adequate long-term core cooling using natural circulation without any operator action, under assumed DBE conditions, in which the core returns to a low power level. For this situation the SAFDLS need to be satisfied by showing that there is sufficient margin below critical heat flux in the core and that there is adequate capacity for core heat removal. These passive heat removal capabilities do not exist in the current fleet of operating power reactors. Thus, it seems reasonable to consider the NuScale request and whether its approach can depart from past precedent.

To assure long-term core cooling, we expect that NuScale will perform an evaluation to ensure SAFDLs are not exceeded for any of the DBE scenarios considered. The requisite analyses would include:

- Consideration of operator actions that may ameliorate or exacerbate the accident progression;
- Estimates of the magnitude and duration of the return to power and associated strategies to return to a subcritical condition; and
- Assurance that sufficient resources (e.g., available ultimate heat sink) exist so that the margin to the SAFDLs does not degrade over the duration of the event.

Low Probability of Return to Power

Modern probabilistic risk assessment tools can help the staff in their evaluation of the requested exemption. The staff evaluation criteria should be augmented to include an assessment of the incremental risk to public health and safety from the hypothesized situation. The staff should determine whether that risk increase is acceptable, considering the entire NuScale facility, rather than limiting the assessment to only a single reactor module. Inclusion of this risk evaluation and these risk acceptance criteria would be consistent with the Commission policy on the use of risk information and the integrated decision process of Regulatory Guide 1.174.

The staff's criteria also suggest that non-safety SSCs that provide boron addition (e.g., chemical and volume control system, containment flood and drain system) should have certain characteristics. These systems should not degrade during plant operations and they should function reliably when called upon, including operator actions needed for their startup and alignment.

Other Considerations

Some ACRS members have serious reservations about granting NuScale an exemption to GDC 27. Their view is that a key principle in any reactor design is to maintain subcriticality for DBEs according to the assumptions that have been applied for currently licensed reactors. While a short-term recriticality is currently tolerated for certain events, the long-term reactivity status is well controlled and the operator's procedures account for that control. In those cases, the duration of that criticality is short, not hours or days. Their view is that criticality beyond that short time span should not be tolerated under any circumstances and that approval of an exemption from GDC 27 that would permit recriticality and a return to power establishes an undesirable precedent from a fundamental safety-by-design perspective (i.e., defense in depth).

SUMMARY

The staff proposes to evaluate the NuScale GDC 27 exemption request based on criteria that the SAFDLs are met, and that the probability of a return to power is sufficiently low that it is not expected to occur during the lifetime of a NuScale module. These proposed criteria are reasonable provided the recommendations and enhancements outlined in this letter report are addressed.

Additional comments by ACRS Member Vesna B. Dimitrijevic are presented below.

Sincerely,

/RA/

Michael L. Corradini
Chairman

Additional Comments by ACRS Member Vesna B. Dimitrijevic

I agree with the conclusion and recommendation of my colleagues in this letter. However, I disagree with proposed criteria enhancements that might be inferred from the following statement in the letter: “Inclusion of this risk evaluation and these risk acceptance criteria would be consistent with the Commission policy on the use of risk information and the integrated decision process of Regulatory Guide [RG] 1.174.” I believe that this reference to RG 1.174 implies that this exemption to GDC 27 could be considered a risk-informed application, which I would not recommend because it may lead to unnecessary and difficult-to-meet requirements. The bases for my disagreement are presented below.

Classifying “exemptions to GDC” as risk-informed applications (1), could raise multiple issues associated with the application of the current regulatory guides (including RG 1.174), which are primarily developed for the current fleet of operating reactors, to new reactors. If the risk-informed applications are to be used for new and advanced reactors, new reactor considerations should be adequately addressed, including adjustment of the acceptance criteria, addition of large release frequency (in addition to large early release frequency (LERF)), and consideration of multiple modules. One of the biggest issues is the technical adequacy of the PRA; as defined in RG 1.200, Category 2 PRA quality is required for risk informed applications, and it is not achievable in the application stage, simply because of the limited level of design and operational details for new reactors, the lack of data to derive a plant-specific PRA database, and, for some designs, the lack of industry operating experience for new passive systems.

I also do not agree that a RG 1.174 delta risk evaluation should be required to support the GDC 27 exemption. This delta risk calculation, as defined in RG 1.174, would require comparing the existing design to a non-existing design (which meets GDC 27 requirements); the plant would need to be redesigned, to a level of detail to accommodate risk calculation (including changes in the electrical system, containment isolation, etc.). The core damage frequency (CDF)/L(E)RF comparison, for this specific example, may also require stepping outside the established PRA practices, for example, extending the PRA mission time from 24 hours to approximately 30 days, or using NUREG-0800, Chapter 15 thermal-hydraulic analyses to define the PRA success criteria.

In my opinion, a simpler approach could be used to show that incremental risk associated with the exemption is low. If a PRA evaluation shows (a) a very low challenge frequency and/or (b) very low risk CDF associated with the occurrence of recriticality, these insights should be enough to support the exemption. Such results would also guarantee that the risk to public health and safety from the analyzed situation is negligible.

(1) Three “categories” of the PRA uses are defined in RG 1.206, as referenced in the Standard Review Plan. Licensees are required to report in the Final Safety Analysis Report, Chapter 19: (i) use of the PRA in design to select among operational strategies and design options, (ii) use of PRA in support of licensee programs during the combined license application phase, (iii) risk-informed applications during the combined license application phase.

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3. NuScale Power, LLC, "NuScale Power, LLC Submittal of White Paper Entitled 'NuScale Reactivity Control Regulatory Compliance and Safety', Revision 0 (NRC Project No. 0769)," November 2, 2016 (ML16307A449).
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8. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," Revision 2, March 2009 (ML090410014).
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11. U.S. Nuclear Regulatory Commission, NUREG-0800, "Standard Review Plan: Chapter 19, 'Probabilistic Risk Assessment and Severe Accident Evaluation for New Reactors'," Revision 3, December 2015 (ML15098A068).

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