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

October 19, 2022

Mr. Daniel H. Dorman
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: SAFETY EVALUATION FOR NUSCALE TOPICAL REPORT, TR-0915-17772, "METHODOLOGY FOR ESTABLISHING THE TECHNICAL BASIS FOR PLUME EXPOSURE EMERGENCY PLANNING ZONES AT NUSCALE SMALL MODULAR REACTOR PLANT SITES," REVISION 3

Dear Mr. Dorman:

During the 698th and 699th meetings of the Advisory Committee on Reactor Safeguards (ACRS), September 7-9, and October 5-7, 2022, we reviewed the NuScale Topical Report (TR), TR-0915-17772, "Methodology for Establishing the Technical Basis for Plume Exposure Emergency Planning Zones at NuScale Small Modular Reactor (SMR) Plant Sites," Revision 3, and the Nuclear Regulatory Commission (NRC) staff's associated safety evaluation (SE). During these meetings, we had the benefit of discussions with representatives of the NRC staff and NuScale Power, LLC (NuScale or the Applicant). We also benefited from the referenced documents.

CONCLUSIONS AND RECOMMENDATION

1. TR-0915-17772, Revision 3, provides a technically adequate method for assessing plume exposure pathway emergency planning zone (EPZ) size for a NuScale SMR plant design.

2. The staff's SE approves this NuScale methodology subject to several conditions of use.

3. The SE report should be issued.

BACKGROUND

Nuclear power plant emergency planning regulatory requirements were developed to provide reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. These are codified under "Emergency Plans," Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.47, and "Emergency Planning and Preparedness for Production and Utilization Facilities," 10 CFR Part 50, Appendix E. Generally, the size of the EPZs for nuclear power plants is defined by 1) a plume exposure pathway EPZ area of about 10

miles in radius and 2) an ingestion pathway EPZ area of about 50 miles in radius. The size of EPZs surrounding a particular nuclear power plant may also be affected by such conditions as demographics, topography, land characteristics, access routes, and jurisdictional boundaries. However, there is an existing provision for a determination of the size of EPZs on a case-by-case basis for gas-cooled nuclear reactors and for reactors with a power level of 250 megawatts thermal or less.

The basis for current emergency planning (and sizing of EPZs) was developed in NUREG-0396, "Planning Basis for the Development of State and Local Government Emergency Response Plans in Support of Light Water Reactor Power Plants." It concludes the objective of emergency plans should be to provide dose savings for a spectrum of accidents, including beyond design basis accidents, that could produce offsite doses in excess of protective action guides. The most important element is determining the distance from a nuclear power plant that defines the area over which planning for predetermined protective actions is required. Appendix I to NUREG-0396 provides the rationale for the recommended generic plume exposure pathway EPZ radius of 10 miles. Recognizing the need for defense in depth, the task force developed this recommendation based on a review of consequences of design basis accidents from operating light water reactors and a spectrum of beyond design basis (or severe) accident sequences from WASH-1400 (the "Reactor Safety Study" in 1975). These accident scenarios included core melt, containment failure, and large fission product releases.

At the time NUREG-0396 was issued in 1978, prior to the severe accidents at Three Mile Island Unit 2 and Fukushima Daiichi Units 1, 2, and 3, there was little information available regarding severe accident progression in operating light water reactors. Since then, the knowledge base and analytical tools have advanced considerably, allowing for a more mechanistic, systematic approach to sizing the plume exposure pathway EPZ rather than using a bounding generic EPZ radius.

In 2013, the Nuclear Energy Institute developed a white paper presenting an industry approach to allow applicants to pursue reduced plume exposure pathway EPZ distance requirements for light-water SMRs using engineering insights gained from plant-specific probabilistic risk assessments (PRAs). Their paper emphasizes the importance of considering a spectrum of accidents in determining EPZ boundaries. The Nuclear Energy Institute approach also emphasizes several prudent measures, such as the need for onsite and offsite emergency plans and a certified offsite all hazards plan. To address any potential lack of completeness and uncertainties within the underlying PRA and associated accident analyses, the Nuclear Energy Institute white paper stresses that the user should show how detailed planning within an SMR's emergency plan also provides for expansion of emergency response efforts beyond the EPZ boundary.

DISCUSSION

NuScale EPZ Methodology

NuScale's TR describes a methodology to determine the size of the plume exposure pathway EPZ for NuScale SMR plant sites. The ingestion pathway EPZ is not addressed in this methodology, as the determination of this distance is largely site-specific. The methodology, which is applicable only to a NuScale SMR plant design, is consistent with the technical basis in NUREG-0396 and WASH-1400.

The TR identifies and evaluates a spectrum of accident sequences and potential releases; it uses the same dose criteria (at and beyond the calculated EPZ boundary) to demonstrate an equivalent level of protection of the health and safety of the public; and it is risk-informed and consequence-based (combining quantitative evaluation and qualitative engineering judgement). Implementation requires a full-scope PRA (addressing both internal and external hazards and all operating modes) that is technically acceptable for this purpose (as per guidance in Regulatory Guide 1.200). The methodology recommends the use of codes such as RELAP and MELCOR to develop design-specific source terms and requires the use of the MACCS code to perform radiological consequence analysis.

The quantitative evaluation involves identifying a spectrum of accident sequences that form the basis for determining EPZ size. These sequences include: events from the Final Safety Analysis Report Chapter 15; severe accidents from the site and design-specific PRA; and other release events (e.g., loss of spent fuel cooling). Non-seismic single and multi-module sequences with core damage frequency >1E-07 per year are identified to capture a spectrum of accidents with similar frequencies to those considered in NUREG-0396. To evaluate non-seismic sequence uncertainties, the guidance in NUREG-1855 is used to ensure that cliff edge sequences are considered in the spectrum of accident sequences. Seismic hazards are also considered.

The final EPZ size is the smallest distance at which the dose criteria, chosen to provide a level of protection that meets or exceeds the basis in NUREG-0396, are satisfied. These criteria essentially are a) total effective dose equivalent from the design basis source term is less than or equal to 1 rem; b) the total effective dose equivalent from less severe accidents (containment intact) is less than or equal to 1 rem; or c) a substantial reduction in early health effects from more severe accidents (containment failure or bypass), i.e., an acute whole body dose less than 200 rem.

The modeling of dose receptors is consistent with that of NUREG-0396, including a parametric evaluation of uncertainty in source term and dose calculations. This quantitative evaluation is then supplemented by a qualitative defense-in-depth evaluation (RG 1.174 and INSAG-10) and a review of PRA uncertainties. NuScale design certification information was used in the TR to illustrate how the proposed methodology would be applied.

Staff's Evaluation

The staff determined that the NuScale EPZ sizing methodology is generally consistent with the technical basis of the current 10-mile EPZ prescribed in 10 CFR 50.47 (i.e., NUREG-0396), and there is reasonable assurance the methodology is adequate for sizing of the EPZ. Applicants using the NuScale methodology need to meet the scope of applicability in the TR (Section 2.5, i.e., for a NuScale SMR plant design) and adhere to the eight conditions of use in Section 5.0 of the staff's SE. The staff concluded that the NuScale EPZ TR is risk-informed and reflective of the NUREG-0396 approach.

Of note are the staff's seismic-related conditions of use. Revision 2 of the NuScale EPZ TR proposed a seismic screening threshold of 1E-5 per year for initiating event frequency. The staff found that this did not provide a spectrum of accidents for EPZ sizing consistent with the technical basis of NUREG-0396 and the consideration of seismic events in WASH-1400 (i.e., including key characteristics of more severe accidents with large releases to ensure capability to reduce early severe health effects). The revised TR, Revision 3, contains a proprietary

screening threshold for seismic hazards. Because seismic events are likely to dominate the NuScale risk profile, the staff developed a “risk gap” approach to assess the adequacy of the proprietary screening value when considering and evaluating seismic hazards.

The staff’s seismic-related conditions of use for the NuScale EPZ methodology limit the seismic event screening threshold to sites with a ground motion response spectrum (GMRS) bounded by NuScale’s certified seismic design response spectrum; limit the seismic event screening threshold to NuScale’s high confidence of low probability of failure (HCLPF) plant-level fragility; and require a demonstration of the GMRS and HCLPF plant-level fragility at application and prior to fuel loading for the as-built plant.

SUMMARY

TR-0915-17772, Revision 3, provides an adequate methodology for assessing plume exposure pathway EPZ sizing for a NuScale SMR plant design. The NuScale EPZ methodology is risk-informed, provides a technically consistent approach (with NUREG-0396) for EPZ sizing, and adequately considers seismic and multi-module impacts. The staff’s safety evaluation approves this NuScale methodology with several conditions of use. The SE report should be issued.

The staff’s evaluation is an example of how to use risk information, consequence analyses, and considerations of uncertainty and defense in depth in justifying the adequacy of their safety finding. The staff should preserve the insights gained from this review in guidance that can be used in future applications (consistent with the recommendations from our October 7, 2019, letter report on “Population-Related Siting Considerations for Advanced Reactors”).

When the methodology is used for a NuScale application, we expect the staff to rigorously review the adequacy and completeness of the PRA, the results from MELCOR, and important underlying analysis assumptions related to accident phenomenology and system response. As noted in our final letter on the NuScale design certification application, there are several potentially risk-significant items that were not completed at the time of the design certification application approval. We expect an evaluation of the potential impact of these items to be included in any future staff review. We plan to review the first application of this TR.

We also draw attention to the staff’s conditions of use for the methodology in determining EPZ size. Practical applications of this methodology may produce a very small distance for the EPZ boundary. At close-in distances (less than one mile), timing and physical characteristics of the release (e.g., building wake effects, transport and deposition mechanisms, and/or chemical composition) may dominate rather than distance and dispersal.

We note that justifying a small EPZ will be different for non-light water reactors with little or no operating experience or sound estimates of the frequency of severe accidents. The uncertainty in severe accidents (e.g., external events) must be balanced against expected lower source terms and the passive and inherent safety features of the design. Engineering judgement may have to replace mechanistic analytic calculations in establishing the relevant accident phenomenology and system response.

We emphasize that prudent emergency planning, in the end, is a matter of applying the principle of defense in depth in protecting public health and safety.

We are not requesting a formal response from the staff to this letter.

Sincerely,

Signed by Rempe, Joy
on 10/19/22

Joy L. Rempe, Chairman

REFERENCES

1. U. S. Nuclear Regulatory Commission, “Safety Evaluation for NuScale Topical Report, TR-0915-17772, ‘Methodology for Establishing the Technical Basis for Plume Exposure Emergency Planning Zones’,” Revision 3, August 8, 2022 (ML22175A002).

2. NuScale Power, LLC, Topical Report, “Methodology for Establishing the Technical Basis for Plume Exposure Emergency Planning Zones at SMR Plant Sites,” TR-0915-17772, Revision 3, June 10, 2022 (ML22161B010).

3. U.S. Nuclear Regulatory Commission, Staff Requirements Memorandum for SECY-20-0045, “Population-Related Siting Considerations for Advanced Reactors,” July 13, 2022 (ML22194A885).

4. U. S. Nuclear Regulatory Commission, SECY-20-0045, “Population-Related Siting Considerations for Advanced Reactors,” May 8, 2020 (ML19143A194).

5. Advisory Committee on Reactor Safeguards, “Review of Draft SECY Paper, ‘Population-Related Siting Considerations for Advanced Reactors’,” October 7, 2019 (ML19277H031).

6. Advisory Committee on Reactor Safeguards, “Draft Final Rule, ‘Emergency Preparedness for Small Modular Reactors and Other New Technologies’,” November 16, 2021 (ML21316A252).

7. Nuclear Energy Institute, "Proposed Methodology and Criteria for Establishing the Technical Basis for Small Modular Reactor Emergency Planning Zone," December 23, 2013 (ML13364A345).

8. U. S. Nuclear Regulatory Commission, NUREG-0396, “Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants,” December 31, 1978 (ML051390356).

9. U. S. Nuclear Regulatory Commission, NUREG/KM-0010, “WASH-1400,’The Reactor Safety Study’,” August 31, 2016 (ML16225A002).

10. U. S. Nuclear Regulatory Commission, Regulatory Guide 1.200, “Acceptability of Probabilistic Risk Assessment Results for Risk-Informed Activities,” Revision 3, December 31, 2020 (ML20238B871).

11. NuScale Power, LLC, Final Safety Analysis Report, Chapter 15, “Transient and Accident Analyses,” Revision 5, July 29, 2020 (ML20224A504).

12. U. S. Nuclear Regulatory Commission, NUREG-1855, “Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decisionmaking,” Revision 1, March 31, 2017 (ML17062A466).

13. U. S. Nuclear Regulatory Commission, Regulatory Guide 1.174, “An Approach for Using PRA in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis,” Revision 3, January 31, 2018 (ML17317A256).

14. International Nuclear Safety Advisory Group, INSAG-10, “Defence in Depth in Nuclear Safety,” 1996 (not publicly available).

15. Advisory Committee on Reactor Safeguards, “Report on the Safety Aspects of the NuScale Small Modular Reactor,” July 29, 2020 (ML20211M386).

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Accession No: ML22287A155 **Publicly Available (Y/N):** Y **Sensitive (Y/N):** N
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