NuScale Power

November 3, 2016 Docket: PROJ0769

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Submittal of Discussion Topics Regarding NuScale Power LLC's Planned Request for Exemption from 10 CFR 50 Appendix A, Criterion 52, Capability for Containment Leakage Rate Testing (NRC Project No. 0769).

REFERENCES:

1. NRC Letter to NuScale, "Summary of April 14, 2016, Public meeting with NuScale Power, LLC to Discuss NuScale's Approach to Containment Integrated Leakage Rate Testing." Dated June 27, 2016 (ML16146A659).
2. NRC Letter to NuScale, "Summary of Observations Related to a Staff Preapplication Readiness Assessment of a Potential NuScale Power, LLC Design Certification Application," dated October 7, 2016 (ML16277A515).
3. NRC Bulletin 78-09, "BWR Drywell Leakage Paths Associated with Inadequate Drywell Closures," dated June 14, 1978.

On April 14, 2016, a public meeting was held between representatives of the U. S. Nuclear Regulatory Commission (NRC) staff and NuScale Power, LLC (NuScale). The purpose of the meeting was to discuss topics related to how NuScale's small modular reactor containment integrity will be verified and leakage rate tested including the basis for NuScale's planned request for exemption from 10 CFR 50 Appendix A, Criterion 52 (GDC 52), capability for containment leakage rate testing at design pressure. The NRC summarized the meeting in a letter to NuScale dated June 27, 2016 (Reference 1). The NRC provided additional feedback in a letter dated October 7, 2016 (Reference 2) following the NRC's preapplication readiness assessment of the NuScale draft Design Certification Application (DCA).

The purpose of this correspondence is to facilitate discussion during the forthcoming meeting between the NRC and NuScale scheduled for November 10, 2016. NuScale intends to provide updated information regarding design, analysis, and testing programs associated with NuScale's approach to ensure an essentially leak tight containment and planned exemption request. This correspondence also provides feedback on insights and comments received through NRC interactions. The final objective is to establish alignment on the specific, additional technical information necessary to support affirmative docketing determination for the NuScale DCA with respect to GDC 52.

This letter makes no regulatory commitments and no revisions to any existing regulatory commitments.

Please feel free to contact Zackary Rad at 980-349-4831 or at zrad@nuscalepower.com if you have any questions.

Sincerely,

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Attachment: Discussion Topics Regarding NuScale Power LLC's Planned Request for Exemption from 10 CFR 50 Appendix A, Criterion 52, Capability for Containment Leakage Rate Testing

Discussion Topics Regarding NuScale Power LLC's Planned Request for Exemption from 10 CFR 50 Appendix A, Criterion 52, Capability for Containment Leakage Rate Testing

Purpose

The purpose of this correspondence is to facilitate discussion regarding NuScale's updated approach to ensure an essentially leak tight containment as a result of further development of the associated design, analysis, and testing programs. This correspondence also provides feedback on insights and comments received through NRC interactions. The final objective is to establish alignment on the specific, additional technical information necessary to support an affirmative docketing determination with respect to GDC 52 for the NuScale Design Certification Application (DCA).

Background

Pursuant to 10 CFR 52.7, NuScale is planning to request an exemption from 10 CFR 50 Appendix A, Criterion 52 (GDC 52), capability for containment leakage rate testing.

10 CFR 50 Appendix J specifies Type A testing directly related to GDC 52. While Appendix J is not applicable to a design certification applicant, NuScale is also planning to request that the approval of the GDC 52 exemption within the NuScale Power Plant design certification include exemption from the requirements of 10 CFR 50 Appendix J Type A tests for plants referencing the NuScale design.

On April 14, 2016, a public meeting was held at the NRC Headquarters Office, and a closed portion at NuScale Power, LLC's (NuScale), Rockville, Maryland office, between representatives of the U.S. Nuclear Regulatory Commission (NRC) staff and NuScale. The purpose of the meeting was to discuss topics related to how NuScale's small modular reactor containment integrity will be verified and leakage rate tested to quantify potential leakage from the containment subsequent to a design basis loss of coolant accident.

The NRC summarized the meeting in a letter to NuScale dated June 27, 2016 (Reference 1). The summary included feedback regarding NuScale's reliance on design and analysis, activity-based failure mechanisms and local leak rate testing (LLRT), and the capability to perform Type A testing on the NuScale Containment Vessel (CNV) as designed.

On September 29, 2016, NRC staff completed a preapplication readiness assessment (readiness assessment) of the draft application and supporting documents that NuScale intends to submit as part of the NuScale DCA. The NRC provided observations related to the readiness assessment, including the subject exemption request, in a letter dated October 7, 2016 (Reference 2).These observations were consistent with comments received in previous interactions and correspondence. The NRC stated, in summary, that the technical basis provided for the GDC 52 exemption request is not sufficient to support docketing the application.

Since the initial interaction with the NRC on April 14, 2016, NuScale has performed additional planning, engineering design, and analysis with specific regard to the insights gained through this interaction. These activities included the completion of analyses of degradation mechanisms with the potential to affect the CNV, the finalization of CNV testing specifications, and the CNV ASME Section XI In-Service Inspection (ISI) plan. During this time NuScale also re-visited the feasibility of performing Type A testing on the current CNV design in order to evaluate potential options to address Type A testing in future operating license applications.

During this interim period NuScale also finalized the request for exemption from General Design Criterion (GDC) 52. This activity included a review of the history and regulatory basis of information related to NRC comments and observations to verify that, in addition to ensuring safety, NuScale's approach was consistent with the intent of the applicable regulations and established precedents.

Insights from the NRC Interactions and Correspondence

Reliance on Design and Analysis

During several interactions, the NRC has indicated their understanding that the NuScale CNV will not be tested for leak tightness prior to being put into service. On page 3 of the referenced letter dated June 27, 2016, the NRC commented on NuScale's basis to justify an exemption. The NRC staff stated that "relying on design and analysis without any testing or operational experience on the new, unique NuScale CNV design does not currently provide a convincing basis to justify an exemption from the 10 CFR Part 50, Appendix J, containment Type A testing requirement" (emphasis added).

To clarify, while design and analysis are key components in NuScale's approach to ensuring an essentially leak tight CNV and to the basis for the subject exemption, NuScale is not relying solely on design and analysis to justify this exemption. Rather, NuScale proposes to rely on a rigorous design and analysis process, preservice inspection and leakage testing, post-repair inspection and testing, inservice examination, and Type B and C testing as the basis for the exemption. Each of these is addressed further below.

As the NRC's letter acknowledges, the NuScale CNV will be designed and constructed in accordance with ASME Code, Section III, Class 1 pressure vessels (material, design, and fabrication). The NuScale CNV will also be tested and inspected, in accordance with ASME Code, Section III, Class 1 pressure vessels (inspection, examination, and testing), and ASME Code, Section XI (inservice testing and inspection, repair and replacement, scheduled examinations, NDE methods, and flaw size characterization) and 10 CFR 50, Appendix J, Type B and C testing requirements.

Consistent with reactor coolant systems, pre-service structural integrity and leak tightness will be verified by hydrostatic testing in accordance with ASME Section III. Following certain repairs or modifications to the CNV pressure boundary, leak tightness and structural integrity will be verified by hydrostatic testing as required by ASME Section XI. The test specification for the NuScale CNV requires that all joints, connections, and regions of high stress, such as regions around openings and thickness transition sections, be examined for leakage; no leakage indications at the examination pressure are acceptable.

During service, the integrity of the CNV is potentially subject to two (2) types of failure mechanisms which can be categorized as (1) activity-based and (2) time-based (i.e., age-related degradation).

For the current fleet of large light water reactors (LLWR), the purpose of Type A testing is to verify the leakage integrity of the containment structure by detecting leakage from unidentified, age-related degradation mechanisms. The focus of Section XI program for the NuScale CNV (in-service testing and inspection, repair and replacement, scheduled examinations, NDE methods, and flaw size characterization) is also the detection of age-related failure mechanisms. This approach is consistent with Section XI programs for operating reactor vessels in that the design, construction, inspection, and examination of the CNV will detect and preempt leakage from such mechanisms.

Activity-based failure mechanisms are generally defined as degradation due to system and/or component modifications or maintenance. Consistent with the operating fleet of large light water reactors, local leak rate test requirements and administrative controls, such as configuration management and procedural requirements for system restoration, will ensure that the reactor CNV integrity is not degraded by plant modifications or maintenance activities.

Type B pneumatic tests (local penetration leak tests) will detect and measure leakage across the pressure retaining, leakage limiting boundaries in the CNV. Preoperational and periodic Type B leakage rate testing will be performed in accordance with 10 CFR 50 Appendix J, NEI 94-01, ANSI-56.8, and the owner's Technical Specifications.

The CNV and containment isolation valves (CIVs) are designed to support Type C (containment isolation valve leak tests) pneumatic tests. Preoperational and periodic Type C leakage rate testing of CIVs will be performed in accordance with the 10 CFR 50 Appendix J requirements, ANSI-56.8, and the owner's Technical Specifications.

The reliability of the NuScale LLRT program is improved and its performance simplified by the design of the NuScale CNV. The CNV has a low number of penetrations (40), all of which are either ASME Class 1 flanged joints capable of Type B testing or ASME Class 1 welded nozzles with isolation valves capable of Type C testing. The CNV has no penetrations equipped with resilient seals. No instrument lines penetrate containment; therefore, there are no small diameter fluid lines without isolation capability that are not subject to Type B or C LLRT. There are no air locks, flexible sleeves, or nonmetallic boundaries.

The NuScale CNV is an advanced design; however, it utilizes proven design solutions for Type B and C pressure boundaries. By developing the NuScale testing, inspection, and assessment programs in accordance with established codes and standards, NuScale will leverage the full breadth of the extensive collection of operating experience that is the foundation for the ASME BPV code as well as the extensive body of operating experience specific to Type B and C local leak rate testing.

Activity-Based Failure Mechanisms and Local Leak Rate Testing

Industry operating experience referenced by the NRC is an activity-based failure mechanism potentially affecting the integrity of the primary containment of boiling water reactors. This example, described in NRC Bulletin 78-09, is of a test at one nuclear plant where the flanged connection between the containment head and lower containment vessel was tested by LLRT after being reassembled, and passed. When the containment was pressurized to design pressure to conduct the Type A the flange connection leaked through the double O-ring seals.

In Reference 1 the NRC states that Appendix J initial and periodic Type A tests "not only verify that analytical methods are correct but verify that procedures associated with maintaining containment integrity at flanged fittings (containment flange and access flange face seals, for example), or elsewhere, are correct and administered correctly" (emphasis added).

NuScale agrees that LLRT should not be the sole basis for assuring a suitable degree of leak tightness for bolted containment closures that would tend to unseat on positive internal pressure. Consistent with industry actions taken in response to the bulletin, NuScale procedural controls will ensure that the reinstallation of such bolted containment closures are made in a reproducible manner. Further, the metal containment structures of operating nuclear power plants were designed in accordance with either Section III, Subsection NE, "Class MC Components," or Section VIII of the ASME Code. For the NuScale CNV, all Type B penetration seals, including those for flanged closures, have a similar double o-ring and test port design. Each penetration is designed and will be fabricated to ASME Code, Class 1 requirements. Bolting design for each flange meets ASME Code Class 1 design criteria. Class 1 bolted joints must meet NB-3230 which includes determination of the number of bolts and preload to maintain a tight joint (NB-3231). In addition detailed fatigue analyses are required per NB-3232.3. To determine the number of bolts and preload Nonmandatory Appendix E shall be used per NB-3231(a). This ensures each flange can maintain minimum required seal compression load at design pressure. This is the same bolting criteria required for the NuScale Reactor Pressure Vessel (RPV). The adequacy and proper administration of procedures associated with maintaining containment integrity at flanged fittings will be verified during system hydrostatic testing as required by the ASME code.

NuScale disagrees that a purpose of Type A testing is to "verify that procedures associated with maintaining containment integrity at flanged fittings …. are correct and administered correctly." This position is not supported by the NRC's response to the operating experience outlined in NRC Bulletin 78-09 (Reference 3) or the NRC's findings related to the extension of intervals for the performance of ILRT for operating reactors. In both examples the NRC does not emphasize the importance or adjust the frequency of ILRT performance relative to the performance of such activities. Rather, the NRC emphasizes the importance of administrative controls and maintenance practices. The frequency of ILRT performance for operating reactors is independent of the frequency of such activities (removal and replacement of bolted closures). The required frequency indicates the intent to detect age-related degradation, not to verify that procedures associated with maintaining containment integrity at flanged fittings are correct and administered correctly.

NuScale's approach is consistent with the NRC's previously documented position supporting the extension of ILRT intervals for operating reactors. Specifically, that activity-based failure mechanisms for containment are:

1) prevented by administrative controls such as configuration management and procedural requirements for system restoration which ensure that integrity is not degraded by plant modifications or maintenance activities (consistent with RCS and current LLWR containments) and;

2) detected by local leak rate test (consistent with current LLWR containments).

As described above, the LLRT program for the NuScale CNV includes Type B pneumatic tests that will detect and measure leakage across the pressure retaining, leakage limiting boundaries in the CNV, including such flanges. Preoperational and periodic Type B leakage rate testing is performed in accordance with 10 CFR 50 Appendix J, NEI 94-01, and ANSI-56.8.

<u>Capability to Perform Type A Testing on the Current NuScale CNV Design</u>

Reference 1 notes that, during the subject meeting on April 14, "[t]he NRC staff asked NuScale if there are any reasons that NuScale cannot pressurize the CNV with air and conduct a leakage rate test at design pressure. Reference 1 also notes that NuScale stated that they have the capability to do a Type A CNV test at design pressure, if needed. However, NuScale also stated that they believe that a Type A test would not provide additional assurance beyond that provided by design and inspection."

Based on the completed design and analysis up to the date of the April 14th meeting, it was NuScale's position that performing Type A testing on the NuScale CNV would be challenging, costly, and impose unnecessary radiological and industrial safety risks but was likely technically feasible. Following the initial interactions with NRC on this matter, NuScale re-visited the feasibility of performing Type A testing in order to fully understand all potential approaches in seeking NRC approval of the NuScale DCA. NuScale performed an engineering evaluation to assess the value, practicality, impact, and alternatives for CILRT testing in accordance with NRC regulations. This evaluation documented additional challenges and risks that render the performance of traditional Type A testing on the NuScale CNV infeasible, even with the consideration of potential design changes. Moreover, such design changes would result in a greater number of penetrations in the CNV, increasing the probability of CNV leakage and potentially reduce the overall safety of the design. Examples of these challenges are summarized below.

Instrumentation with the necessary range and accuracy to support ILRT testing of the NuScale CNV is not currently available. The allowable leakage rates of large PWRs are mostly above 1 SCFM with many being around 5 SCFM. The acceptance criterion for traditional Type A testing for the NuScale CNV would be approximately 0.226 SCFM at 1000 psia. As a result, ILRT for a NuScale module would require a monitoring accuracy that is at least 27 times better than currently used for such testing.

Due to the accessibility constraints of the current design of the NuScale CNV, sensors would need to be permanently installed to support as-found testing. Including the additional sensors in the CNV design would result in approximately double the number of sensors in the CNV and add more signal leads to the number already required. More challenging, the sensors and wiring would need to be qualified to survive harsh CNV conditions during postulated events to avoid debris generation. Accessibility constraints and the permanent installation of the required instrumentation also make maintenance and calibration impractical. These changes would increase cost, complexity and radiation exposure without a safety benefit.

The RPV would necessarily be part of the pressurized volume during performance of traditional ILRT of the NuScale CNV, however, the RPV does not freely communicate with the CNV. Unlike the CNV, the RPV is compartmentalized. As a result, there will be regional variations in dry and wet bulk temperature. During the performance of ILRT, with a 0.1°F undetected temperature increase in the gas volume the pressure is calculated to rise 0.179 psi, which is three times the pressure change for the maximum allowable leak rate at 1000 psia. For this and other related reasons NuScale has determined that it is not feasible to account for all of the potential variations in temperature, humidity, and pressure at the accuracy required to satisfy the requirements of ANSI/ANS 56.8.

Summary

NuScale's approach to ensuring an essentially leak tight containment provides a high degree of assurance that containment leakage will be maintained within specified limits and meets the intent of 10 CFR 50 Appendix J and GDC 52. Continued leakage integrity is assured in the NuScale CNV design by the welded metal vessel design of the containment system, in contrast to existing PWRs with large containment building structures and inaccessible areas. The NuScale containment system is a small, high pressure, ASME Code Class 1 vessel with a significantly reduced number of penetrations (40) and no internal sub-compartments or concrete floors.

The NuScale CNV design, construction, maintenance, inspection and testing are more appropriately compared to a reactor vessel than to a conventional containment vessel, as the NuScale CNV is essentially a secondary pressure vessel. Table 1 summarizes the comparison between program elements for the NuScale CNV, NuScale and licensed facility reactor vessels and RCS, and conventional containments. Each programmatic element designed to ensure leak tightness of the NuScale CNV is consistent with a corresponding programmatic element for licensed reactor RCS or containment systems.

Preservice tests and inspections are similar to the RPV and are performed in a factory environment. Initial verification of structural integrity and leak tightness of the NuScale CNV will be verified by hydrostatic testing in accordance with ASME Section III (consistent with RCS) and LLRT of all penetrations..

Activity-based failure mechanisms, including those related to bolted closures, will be prevented by administrative controls such as configuration management and procedural requirements for system restoration (consistent with programs for licensed LLWR RCS and containments) and will be detected by local leak rate testing (consistent with programs for licensed LLWR containments). Preoperational and periodic Type B anc C leakage rate testing will be performed in accordance with 10 CFR 50 Appendix J, NEI 94-01, and ANSI-56.8.

Age-based failure mechanisms will be prevented and detected through design and construction requirements for CNV, inspections and examinations performed in accordance with ASME, Section XI, the maintenance rule and regulatory commitments (consistent with licensed LLWR RCS). As noted above, the NuScale CNV is a ASME Code Class 1 vessel. The CNV components are constructed of stainless steel or clad on interior and exterior surfaces with stainless steel and are fully inspectable. These factors preclude undetected, through-wall, age-related degradation as a credible mechanism for containment leakage.

NuScale's approach to preventing, detecting, and measuring potential leakage ensures CNV integrity in a manner consistent with the underlying intent of GDC 52 and 10 CFR 50 Appendix J Type A testing. NuScale's approach relies on design and inspection criteria that are impractical for a traditional LLWR containment, but appropriate for the NuScale CNV. As described herein, NuScale considered NRC Staff's feedback, and believes this approach addresses known concerns, in a manner consistent with established codes and standards. Upon further review, literal compliance with the requirements of GDC 52 and 10 CFR 50 Appendix J Type A testing is infeasible for the NuScale CNV, and would result in increased expense and risk with no corresponding increase in safety.

element of programs ensuring essentially leak tight CNV barrier	NuScale CNV	licensed facilities / NuScale RCS	traditional LLWR containment
initial verification of structural integrity	hydrostatic testing i.a.w. ASME Section III*	hydrostatic testing i.a.w. ASME Section III*	pre-service integrated leak rate testing
initial verification of leak tightness	factory hydrostatic testing i.a.w. ASME Section III * (zero allowable leakage)	hydrostatic testing i.a.w. ASME Section III*	pre-service integrated leak rate testing (leakage allowed < prescribed limit)
	pre-service local leak rate testing		pre-service local leak rate testing
prevention of leakage from activity-based failure mechanisms (degradation due to system and/or component modifications or maintenance)	administrative controls such as configuration management and procedural requirements for system restoration which ensure that integrity is not degraded by plant modifications or maintenance activities	administrative controls such as configuration management and procedural requirements for system restoration which ensure that integrity is not degraded by plant modifications or maintenance activities	administrative controls such as configuration management and procedural requirements for system restoration which ensure that integrity is not degraded by plant modifications or maintenance activities
detection of leakage from activity-based failure mechanisms	local leak rate testing	RCS leak test – operational pressure	local leak rate testing
prevention of leakage from age-based failure mechanisms (age-related degradation)	design and construction requirements for CNV, inspections / examinations performed in accordance with ASME, section XI*, the maintenance rule and regulatory commitments	design and construction requirements for RCS, inspections / examinations performed in accordance with ASME, section XI*, the maintenance rule and regulatory commitments	design and construction requirements, inspections / examinations performed in accordance with ASME, section XI, the maintenance rule and regulatory commitments
detection of leakage from age-based failure mechanisms (age-related degradation)			integrated leak rate testing / inspections / examinations performed in accordance with ASME, section XI, the maintenance rule and regulatory commitments
post repair / modification verification of leak tightness (pressure vessel)	inspection / NDE / hydrostatic testing i.a.w. ASME Section XI*	inspection / NDE / hydrostatic testing i.a.w. ASME Section XI*	inspection / NDE i.a.w. ASME Section XI
	local leak rate testing		local leak rate testing
post repair / modification verification of structural integrity (pressure vessel)	inspection / NDE / hydrostatic testing i.a.w. ASME Section XI*	inspection / NDE / hydrostatic testing i.a.w. ASME Section XI*	integrated leak rate testing

*designed, constructed, inspected, and tested in accordance with the specifications of ASME Code, Section III, Class 1 pressure vessels (requirements for the material, design, fabrication, examination, and testing), and ASME Code, Section XI, Class 1 pressure vessels (requirements for in service testing and inspection, repair and replacement, scheduled examinations, testing, inspections, NDE methods, and flaw size characterization