



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 25, 2018

MEMORANDUM TO: Samuel S. Lee, Chief
Licensing Branch 1
Division of Licensing, Siting,
and Environment Analysis
Office of New Reactors

FROM: Marieliz Vera Amadiz, Project Manager */RA/*
Licensing Branch 1
Division of Licensing, Siting,
and Environment Analysis
Office of New Reactors

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION
STAFF REPORT OF REGULATORY AUDIT FOR
NUSCALE POWER, LLC: SEISMIC CATEGORY I EQUIPMENT
AND ENVIRONMENT QUALIFICATION OF ELECTRICAL
EQUIPMENT SPECIFICATIONS

On January 6, 2017, NuScale Power, LLC (NuScale) submitted a design certification (DC) application for a small modular reactor (SMR) to the U.S. Nuclear Regulatory Commission (NRC) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17013A229). In a letter dated March 23, 2017, the NRC accepted for docketing the DC application for the SMR design submitted by NuScale (ADAMS Accession No. ML17074A087).

The NRC staff has conducted an initial audit of design specifications for Seismic Category I equipment described in the NuScale DC application, Final Safety Analysis Report (FSAR), Section 3.9.6, "Functional Design, Qualification, and In-service Testing Programs for Pumps, Valves, and Dynamic Restraints," Section 3.10, "Seismic and Dynamic Qualification of Mechanical and Electrical Equipment," and Section 3.11, "Environmental Qualification of Mechanical and Electrical Equipment. The audit was conducted from November 8, 2017 - January 31, 2018, in accordance with the audit plan (ADAMS Accession No. ML17307A382).

The purpose of the audit was to: (1) gain a better understanding of the NuScale design; (2) verify FSAR information; (3) identify information that may require docketing to support the basis of the licensing or regulatory decision; and (4) review related documentation and non-docketed information to evaluate conformance with regulatory guidance and compliance with NRC regulations.

NuScale provided acceptable corrective course of action to the observations and the NRC will track the items as confirmatory items, which will need to be completed before the safety evaluation can be advanced beyond phase 6.

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The NRC staff conducted the audit via access to NuScale's electronic reading room and telephone conferences with the applicant. The audit was conducted in accordance with the NRC Office of New Reactors (NRO) Office Instruction, NRO-REG-108, "Regulatory Audits" (ADAMS Accession No. ML081910260).

The audit report, audit attendee list, and follow-up item list are enclosed with this memorandum.

Docket No. 52-048

Enclosures:

1. Audit Report
2. List of Audit Attendees
3. Follow-Up Items List

cc: NuScale DC ListServ

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION STAFF REPORT OF REGULATORY
AUDIT FOR NUSCALE POWER, LLC: SEISMIC CATEGORY I EQUIPMENT AND
ENVIRONMENT QUALIFICATION OF ELECTRICAL EQUIPMENT
SPECIFICATIONS

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U.S. NUCLEAR REGULATORY COMMISSION
STAFF REPORT OF REGULATORY AUDIT FOR
NUSCALE POWER, LLC; SEISMIC CATEGORY I EQUIPMENT AND ENVIRONMENT
QUALIFICATION OF ELECTRICAL EQUIPMENT SPECIFICATIONS

NRC AUDIT TEAM:

Tuan Le, Office of New Reactors (NRO) Mechanical Engineer
Thomas G. Scarbrough, Sr. Mechanical Engineer
Michael Breach, Mechanical Engineer
Marieliz Vera Amadiz, Project Manager
Sheila Ray, Sr. Electrical Engineer
Jorge, Cintron-Rivera, Electrical Engineer

1.0 BACKGROUND

Title 10 of the *Code of Federal Regulations* (10 CFR), Part 52, Section 47, “Contents of applications; technical information,” states that:

The application must contain a level of design information sufficient to enable the Commission to judge the applicant's proposed means of assuring that construction conforms to the design and to reach a final conclusion on all safety questions associated with the design before the certification is granted. The information submitted for a design certification must include performance requirements and design information sufficiently detailed to permit the preparation of acceptance and inspection requirements by the [U.S. Nuclear Regulatory Commission] NRC, and procurement specifications and construction and installation specifications by an applicant. The Commission will require, before design certification, that information normally contained in certain procurement specifications and construction and installation specifications be completed and available for audit if the information is necessary for the Commission to make its safety determination.

In conducting the review of the NuScale Power, LLC (NuScale) design certification (DC) application, the NRC staff requested that the applicant make available design specifications for seismic category I equipment. This audit confirms that the provisions of NuScale design control document (DCD) will be properly implemented into the design qualification specifications of these components.

The NRC staff audited the equipment design specifications for active mechanical and electrical equipment in support of its review against SRP section:

- Section 3.10, “Seismic and Dynamic Qualification of Mechanical and Electrical Equipment.”

Additionally, the NRC staff performed an audit of the electrical equipment qualification in support of its review against the following SRP section:

- Section 3.11, “Environmental Qualification of Mechanical and Electrical Equipment.”

The NRC staff focused the review on the environmental qualification information for containment electrical penetration assemblies (EPAs), pressurizer heater bundles, and containment isolation valves and actuated valves.

The NRC staff provided NuScale with the audit plan documented in the Agencywide Documents Access and Management System (ADAMS) under Accession No. ML17307A382. The NRC staff followed the NRO Office Instruction, NRO-REG-108 (Revision 0), “Regulatory Audits,” in performing the audit of the NuScale design specifications.

The staff conducted that audit at the NRC office in Rockville, Maryland, from November 8, 2017, through January 31, 2017. Staff members were from the Mechanical Engineering Branch (MEB) of the Division of Engineering and Infrastructure in NRO and the Mechanical Engineering and Inservice Testing Branch, the Electrical Engineering New Reactor and License Renewal Branch, and the Electrical Engineering Operating Reactor and License Renewal Branch of the Division of Engineering in the Office of Nuclear Reactor Regulation (NRR).

2.0 AUDIT RESULTS

During this audit, the NRC staff reviewed the design qualification specifications to determine whether they incorporated the provisions specified in the NuScale Final Safety Analysis Report (FSAR).

The NRC staff found that seismic testing provisions specified in the NuScale DCD have not been completely and consistently incorporated into the design specifications. The NRC staff found that design specification EQ-A012-2041 “ASME Design Specification for Pressurizer Heater Bundles” and DCD Tier 2 Section 3.10 “Seismic and Dynamic Qualifications of Mechanical and Electrical Equipment” do not address the seismically induced shock loads for the seismic qualifications of reactor pressure vessel (RPV) and pressurizer (PZR), as identified in the question number 15 of the enclosure. The additional design information would need to be included in the design documents and made available for audit, such that the NRC staff can reach a conclusion regarding the specification-related provision in 10 CFR 52.47, “Contents of applications; technical information.”

Below are the provisions of the DCD that have not been incorporated into the affected design specifications. The provisions are:

1. Application of input motion

In accordance with FSAR Tier 2, Section 3.10.2.1:

Intended for the seismic and dynamic portion of the loads, the test input motion should be applied to one vertical axis and one principal horizontal axis (or two orthogonal horizontal axes) simultaneously, unless it can be demonstrated that the equipment response in the vertical direction is not sensitive to the vibratory motion in the horizontal direction, and vice versa. The time phasing of the inputs in the vertical and horizontal directions must be such that a purely rectilinear

resultant input is avoided. An acceptable alternative is to test with vertical and horizontal inputs in-phase, and then repeat the test with inputs 180 degrees out-of phase. In addition, the test must be repeated with the equipment rotated 90 degrees horizontally.

2. Test Response Spectra

In accordance with FSAR Tier 2, Section 3.10.1.2:

The test response spectrum (TRS) and required response spectrum (RRS) for the seismic qualification are also identified in the equipment qualification record file (EQRf). The RRS is bounded by the TRS to demonstrate the conservative qualification of equipment.

3. 5(OBE) +1 SSE or 2 SSE Requirement

In accordance with FSAR Tier 2, Section 3.10.2.1:

The testing also simulates the effects of aging, such as the fatigue effects of five OBEs plus the loadings associated with normal operation for the design life of the equipment prior to simulating the effects of an SSE, which is equivalent to two SSEs, with 10 stress cycles each, per Section 3.10.1.1.

4. Seismic Testing Requirement

In accordance with FSAR Tier 2, Section 3.10.2.1:

Seismic qualification of mechanical and electrical equipment by testing is performed in accordance with the requirements of IEEE 344-2004. For equipment qualified by testing, the test simulates normal loadings, such as thermal and flow induced loads, concurrently with the seismic and other dynamic loadings. The loads include forces imposed by piping onto the equipment. The survival and operability of the equipment is verified during and after the testing.

In general, the NRC staff found that the design specifications for the actuated valves are not complete. The design specifications did not completely incorporate the provisions specified in the FSAR. The NRC staff prepared questions on the design specifications for actuated valves missing some or all of the aforementioned provisions of the DCD and provided those questions to NuScale. In regard to the environmental qualification the NRC staff found discrepancies between design specification documentation and the FSAR Tier 2 information related to the environmental qualification of the Electrical Penetration Assemblies (EPAs). These discrepancies are enumerated in Enclosure 3 of this memorandum.

DOCUMENTS REVIEWED

1. NuScale Design Specification, EQ-A010-2224, "ASME Design Specification for Secondary Side Containment Isolation Valves," Revision 0.
2. NuScale Design Specification, EQ-A010-2235, "ASME Design Specification for Primary Systems Containment Isolation Valves," Revision 0.
3. NuScale Design Specification, EQ-B010-3227, "ASME Design Specification for CVCS

Class 3 Valves,” Revision 0, dated June 1, 2017.

4. NuScale Design Specification, EQ-B020-2140, “ASME Design Specification for Emergency Core Cooling System Valves,” Revision 2.
5. NuScale Design Specification, EQ-B030-2258, “ASME Design Specification for Decay Heat Removal System Actuation Valves,” Revision 0.
6. NuScale Design Specification, EQ-A012-2041, “ASME Design Specification for Pressurizer Heater Bundles,” Revision 0.
7. NuScale Design Specification, EQ-A013-5418, “ASME Design Specification for CNV Electrical Penetration Assemblies,” Revision 0.
8. NuScale Design Specification, EQ-C020-3263, “Condensate and Feedwater System Regulating Valve Equipment Requirement Specification,” Revision 0.
9. NuScale Design Specification, EQ-C020-3445, “Feedwater System Check Valve Equipment Requirement Specification,” Revision 0.
10. NuScale Design Specification, EQ-A014-4255, “ASME Design Specification for Thermal Relief Valves,” Revision 0.

LIST OF ATTENDEES

November 8, 2017 – January 31, 2017

NRC Staff Participants:

Tuan Le, NRO Mechanical Engineer
Thomas G. Scarbrough, Sr. Mechanical Engineer
Michael Breach, Mechanical Engineer
Marieliz Vera Amadiz, Project Manager
Sheila Ray, Sr. Electrical Engineer
Jorge, Cintron-Rivera, Electrical Engineer

NuScale (and other support organization) Participants:

Zack Houghton
Matt Mallet
Vern Pence
Wayne Massie
Marty Bryan

List of Questions and Responses from the Design Specifications Audit

1. The design specifications should be consistent for actuated valves. (General statement. Details in questions 2 through 6)

NuScale Power, LLC (NuScale) response: *The design specifications will be revised.*

The U.S. Nuclear Regulatory Commission (NRC) staff found the response acceptable.

2. The application of input motions and qualification by test are described in Design Control Document (DCD) Tier 2, 3.10.2.1. This description is omitted from the design specifications in regard to seismic testing; (EQ-A010-2224, Rev. 0, EQ-A010-2235, Rev. 1, EQ-A010-3227, Rev. 0, EQ-A010-2140, Rev. 0, EQ-A010-2258, Rev. 0)

NuScale response: *NuScale indicated that IEEE 344-2004 will be followed and referenced.*

The NRC staff found the response acceptable because the design specification will require testing in accordance with Institute of Electrical and Electronics Engineers (IEEE) 344-2004, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," which is the reference for the application of input motions in the DCD.

3. Where is the test response spectra (TRS) included? (This applies to the following documents; (EQ-A010-2224, Rev. 0, EQ-A010-2235, Rev. 1, EQ-A010-3227, Rev. 0, Rev. 0, EQ-A010-2258, Rev. 0)

NuScale response: *Addressed in QME-1 section QR-A7222*

The NRC staff found the response acceptable, because following Qualification of Active Mechanical Equipment Used in Nuclear Facilities (QME-1) section QR-A7222 is required by the design specification. The TRS will be furnished from the design control documentation.

4. 5 OBE + 1 SSE and testing – (the requirement is missing from the following documents.; EQ-A010-2235, Rev. 1, EQ-A010-3227 EQ-A010-2258, Rev. 0)

NuScale response: *The design specifications will be revised.*

The NRC staff found the response acceptable, because all of the listed document will be revised.

5. Seismic testing required for actuated valves - (the requirement is missing from the following documents; EQ-A010-2224, Rev. 0, EQ-A010-2235, Rev. 1, EQ-A010-3227, Rev. 0, Rev. 0, EQ-A010-2258, Rev. 0)

NuScale response: *The design specifications will be revised.*

The NRC staff found the response acceptable, because all of the listed document will be revised.

6. Valve and actuator – The NRC staff stated that, it is unclear what is required for testing, i.e., if both valve and actuator or just the valve.

NuScale response: *The design specifications will be revised.*

The NRC staff found the response acceptable. (The valve with the actuator must be tested.)

7. Do the non-actuated valves required analysis? Among EQ-A010-4255, EQ-A010-3263 and EQ-A010-3445 only EQ-A010-4255 state that a seismic analysis is required? This appears to be an inconsistency.

NuScale response: *The design specifications will be revised.*

The NRC staff found the response acceptable. (All of the non-actuated valves will state that a seismic analysis is required)

8. The definition of qualified life in document EQ-A013-5418 R0, "ASME Design Specification for Containment EPAs," does not include the Design Basis Event (DBE). How is DBE addressed in the qualification of the EPAs?

NuScale response: *Used the 1974 version, will change the definition to make it consistent.*

The NRC staff found the response acceptable. (The definition in the design specification will be made consistent with the 1974 version.)

9. EQ-A013-5418 Rev. 0, "ASME Design Specification for Containment EPAs." FSAR Tier 2, Section 3.11 describes the applicant's approach for conformance to Title 10 of the *Code of Federal Regulations* (CFR), Section 50.49, "Environmental qualification of electric equipment important to safety for nuclear power plants." All equipment subject to the requirements of 10 CFR 50.49 will be qualified in accordance to IEEE 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations." In addition FSAR Tier 2, Table 1.9-2, "Conformance with Regulatory Guides," states that NuScale conforms to Regulatory Guide 1.63, "Electrical Penetration Assemblies in Containment Structures for Nuclear Power Plants," that endorses IEEE Standard (Std.) 317-1983, "IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations." During the audit the NRC staff found discrepancies between the design specification documentation and the FSAR Tier 2 information related to the environmental qualification of the EPAs. The following discrepancies were found during the review:

- The definition of qualified life in document EQ-A013-5418 Rev. 0 does not include Design Basis Event (DBE). This definition deviated from the definition of qualified life in IEEE Std. 323-1974. The staff requested the applicant to explain how DBE is addressed in the qualification of the EPAs. In addition, the definition of EPAs

does not include terminal/junction boxes, terminal blocks, or splices as defined in IEEE Std. 317-1983.

NuScale response: *NuScale will revise the definitions in the design specifications documents to ensure they are consistent with IEEE Std. 323-1974 and IEEE Std. 317-1983 definitions.*

The NRC staff found the response acceptable.

10. EQ-A013-5418 Rev. 0 states that “no radiation exposure testing is required.” The NRC staff requested the applicant to explain how this meets IEEE Std.317-1983, Section 6.3.2, “Preconditioning,” as it relates to radiation exposure simulation because the applicant does not apply radiation aging.

NuScale response: *NuScale stated that radiation is not a significant aging mechanism and that the standard allows the specimen not to be subjected to radiation if it can be demonstrated that radiation does not degrade the equipment. (NuScale found an incorrect reference to Section 3.6.1, instead to Section 3.7, which discusses why radiation aging is not needed. The applicant NuScale issued a condition report to correct this reference.)*

The NRC staff found the response acceptable.

11. The NRC staff found that in Section 13.10.3 of EQ-A013-5418 Rev. 0, the document states that, “documentation of design qualification is in accordance with IEEE [Std.] 323-1983.” The NRC staff requested the applicant explain why the design specification documentation stated IEEE Std. 323-1983 instead of qualifying equipment to IEEE 323-1974.

NuScale response: *NuScale issued a condition report to correct the IEEE Std. 323 year from 1983 to 1974.*

In IEEE Std. 317-1983, the definition of EPAs did include terminal boxes, terminal blocks and splices. However, in EQ-A013-5418 Rev. 0, the NRC staff found that the definition of EPAs did not include terminal boxes, terminal blocks or splices. The applicant clarified that the NuScale design does not have terminal boxes, terminal blocks and splices in the EPAs. The NRC staff finds this acceptable because the definition is in conformance to IEEE Std. 317-1983. NuScale will provide the revised documentation to the staff to ensure the changes where completed.

The NRC staff found the response acceptable.

12. EQ-A012-2041, Rev 0, “ASME Design Specification for Pressurizer Heater Bundles”: The NRC staff audited document EQ-A012-2041, Rev. 0, “ASME Design Specification for Pressurizer Heater Bundles.” Reference 1.5.4.3 of the document lists IEEE Std. 323-2003 as the qualification standard. The NRC staff’s requested the applicant to provide justification why they are qualifying equipment to IEEE Std. 323-2003 instead of IEEE Std. 323-1974.

NuScale response: *NuScale will update the reference to change the year of the standard from 2003 to 1974. In addition, Section 5.3, “Wiring,” states that heater*

element wiring and power cables shall be qualified in accordance with IEEE Std. 323 for the design conditions.

The NRC staff found the response acceptable.

13. The NRC staff requested the applicant to explain whether the cables will also be qualified to IEEE Std. 383.

NuScale response: *NuScale stated that the Pressurizer Heater Bundles are not important to safety, therefore, the cables are not required to be qualified. NuScale will update the design documentation to remove the environmental qualification requirements since is not required for the Pressurizer Heater Bundles cables.*

The NRC staff found the response acceptable.

14. EQ-A010-2224, "ASME Design Specification for Secondary Side Containment Isolation Valves," Rev. 0 and EQ-A010-2235, "ASME Design Specification for Primary Systems Containment Isolation Valves," the design of valve mountings and supports for main steam isolation valves (MSIVs, feed water isolation valves (FWIVs) and primary system containment isolation valves (PSCIVs) should have been included in these design specifications. What (where) is the description of (the) seismic qualifications of the valve mounting and supports?

NuScale response: *Addressed in QME-1 section QR-A5600. Qualification plan and test plan developed by vendor.*

The NRC staff found the response acceptable because QME-1 section QR-A5600 is referenced and the description of the seismic qualifications of the valve mounting and supports is described.

15. EQ-A012-2041, "ASME Design Specification for Pressurizer Heater Bundle," Rev. 0. Section 3.10, "Seismic Load," states, "the RCPB of the PZR heater bundles shall be designed to withstand load due to seismic ground accelerations." The NRC staff noticed that Section 3.7, "Pressure Boundary," states, "RCPB of PZR heater bundle shall be qualified in accordance with the requirement of the ASME Code for the design conditions identified in Table 3-2." Both sections regarding loads and design conditions in Table 3-2 do not include the seismically induced shock loads. RPV and PZR are submerged in the reactor pool and there are seismically induced shock loads (due to sloshing effects) imposed on these components. The design specification EQ-A012-2041, (and DCD Tier 2 Section 3.10) is not clear on the seismic qualifications of RPV and PZR regarding seismically induced shock loads. The NRC staff requests that the applicant addresses this in DCD Tier 2, Section 3.10 and the design specification that the design of these submerged components are qualified for seismically induced shock loads.

NuScale response: *NuScale agreed to update DCD Tier 2 and the design specification.*

The NRC staff found the response acceptable. Updating the DCD Tier 2 to state that the RPV and PZR are qualified for seismically induced shock loads should be adequate.