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

December 6, 2018

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

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

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION STAFF REPORT OF FOLLOW-UP REGULATORY AUDIT FOR NUSCALE POWER, LLC DESIGN CERTIFICATION APPLICATION FINAL SAFETY ANALYSIS REPORT SECTIONS 3.9.4 AND 4.6

On January 6, 2017, NuScale Power, LLC (NuScale) submitted a design certification (DC) application, for a Small Modular Reactor, to the U.S. Nuclear Regulatory Commission (NRC) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17013A229). The NRC staff started its detailed technical review of NuScale's DC application on March 15, 2017.

The NRC staff conducted a follow-up audit of the design and testing methods of the control rod drive system (CRDS) associated with the NuScale DC application, Final Safety Analysis Report, Sections 3.9.4 and 4.6. The audit was initiated on September 4, 2018, and continued through October 25, 2018, in accordance with an approved audit plan (ADAMS Accession No. ML18235A509).

The purpose of the audit was to review the testing methods and results of the control rod assembly drop and control rod drive shaft alignment testing for the NuScale design, as well as review the supporting design documents for the CRDS testing program.

The audit was performed to gain a better understanding of the design and testing methods of the CRDS and to confirm the adequacy of the testing methods used by NuScale.

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The NRC staff conducted the audit via access to NuScale's electronic reading room. The audit was conducted in accordance with the NRC Office of New Reactors (NRO) Office Instruction NRO-REG-108, "Regulatory Audits."

The publicly available version of the audit report and the audit attendee list are enclosed with this memorandum.

Docket No. 52-048

Enclosures:
1. Audit Report
2. Attendee List

cc: NuScale DC ListServ

SUBJECT: U. S. NUCLEAR REGULATORY COMMISSION STAFF REPORT OF FOLLOW-UP REGULATORY AUDIT FOR NUSCALE POWER, LLC DESIGN CERTIFICATION APPLICATION FINAL SAFETY ANALYSIS REPORT SECTIONS 3.9.4 AND 4.6 DATED: December 6, 2018

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U.S. NUCLEAR REGULATORY COMMISSION

NUSCALE POWER, LLC

SUMMARY FOLLOW-UP AUDIT REPORT OF DESIGN CONTROL

DOCUMENT SECTIONS 3.9.4 AND 4.6

1.0 BACKGROUND

On January 6, 2017, NuScale Power, LLC (NuScale) submitted a design certification (DC) application for a small modular reactor to the U.S. Nuclear Regulatory Commission (NRC) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17013A229). The NRC staff started its detailed technical review of NuScale's DC application on March 15, 2017. The NRC staff sought to understand and confirm the adequacy of the functional testing program for the control rod drive mechanism (CRDM) design and to review the results of the control rod assembly drop and control rod drive shaft alignment testing. The NRC staff audited the design and testing documentation for the control rod drive system (CRDS) to help achieve these outcomes.

The NRC staff provided NuScale with the audit plan (ADAMS Accession No. XXX) to facilitate the audit.

During this audit, which ran from September 4, 2018 to October 25, 2018, the NRC staff reviewed the documentation provided at the end of this report and asked questions of NuScale personnel.

NRC Audit Team:

Nicholas J. Hansing, Mechanical Engineering
Yiu Law, Mechanical Engineering
Marieliz Vera Amadiz, Project Manager

2.0 AUDIT RESULTS

The NRC staff gained a better understanding of the material presented in the design control document (DCD) through a review of detailed supporting documents and discussion with NuScale personnel. This section of the report provides a discussion of the audit findings and planned resolution by the NuScale DC applicant.

The applicant's personnel provided a presentation during the first audit status meeting, which provided a general overview of the test objectives, facility, procedures, and results. No request for additional information (RAIs) were generated as a result of the audit and there are no open items associated with the audit.

2.1 Comparison of Test Facility to Design Conditions

As part of their review, the NRC staff sought to compare the specifications provided for the test facility to the specifications for the NuScale design in order to confirm that the test facility reflected the configuration expected for the NuScale design. NuScale personnel prepared a presentation for the September 20, 2018, status meeting which provided a discussion of the major differences between the test facility and the NuScale design. The NRC staff performed an independent verification by comparing the NuScale design documents in the electronic reading room (eRR) to the as-built dimensions of the test facility provided by the test vendor. The NRC staff observed that while certain dimensions were not identical, such as the diameter of the control rod drive shaft, the diametrical gap between the shaft and the interfacing supports was kept consistent between the design and test facility. Some conditions were not reasonably achievable for this testing, such as enveloping the entire support configuration in borated water at 590 degrees Fahrenheit (°F) and 1850 pounds per square inch (psia), but the impact was evaluated by NuScale staff and considered negligible or even conservative in some cases. The test facility utilized sprays to provide lubrication to the CRDS supports and to provide an interface between the shafts and supports that is more representative of the actual design conditions.

The test facility utilized a shaft composed of 304/304L austenitic stainless steel sliding on 410 stainless steel supports to represent the motion of the control rod drive shaft sliding on the various supports within NuScale Power Module. In the design documentation, this configuration is described as a 410 stainless steel shaft sliding on 304/304L supports. While this configuration is reversed, the test still contains a sliding interface between 304/304L austenitic stainless steel and 410 stainless steel. The staff inquired as to why the materials were reversed, and NuScale personnel indicated that the original test facility was composed of a 304/304L shaft sliding over 304/304L supports, but it was later determined that a more accurate test would include the interaction of dissimilar materials (i.e. 410 and 304/304L). Because the shaft required significant fabrication operations in order to embed the instrumentation components, it was ultimately decided that the shaft would be retained, but the supports would be changed to 410 stainless steel. NuScale personnel determined that differences introduced by the reverse pairing of these materials would be negligible on the overall results of the testing.

2.2 Comparison of Test Displacements to Calculated Values

Revision 2 of NuScale's Reactor Module Seismic Calculation (EC-A010-3559) was used to extract the values used for comparison to the test displacements, but NuScale personnel noted that the most recent revision (Revision 4) has much smaller calculated displacements. The larger values were used in order to ensure a bounding case. In the seismic calculation, a model of the entire reactor module was created and various seismic scenarios were simulated. The model contains multiple nodes that correspond to the locations of control rod drive shaft supports. The post processing displacement results of these nodes were extracted and the results were provided to the NRC staff. A reference axis was established between the nodes representing the control rod drive shaft supports, and the maximum displacement of the nodes from this reference axis was determined under seismic conditions through a square root sum of squares of the x and z direction displacements (the y direction displacements were excluded due to their small values). The maximum seismic displacement from this reference axis was calculated by NuScale and provided to the NRC staff.

This seismic displacement, combined with the manufacturing tolerances provided in the reference drawings for the NuScale design, are below the maximum tested displacement. The maximum values of the seismic displacement and manufacturing tolerance provided remain more than a factor of two below the maximum displacement used in the testing and are therefore bounded. A total of 14 test configurations were used, with some of the configurations utilizing extreme displacements in order to determine the physical limitations of the control rod drive shaft misalignments. The NRC staff considered this approach to be reasonable in determining the limiting displacements for the control rod drive shaft supports.

2.3 Test Synopsis

Section 1.5.1.7 in the DCD discusses the control rod assembly drop and control rod drive shaft alignment test. This testing was conducted by Framatome GmbH under their existing Appendix B compliant Quality Assurance program. It utilized prototypical fuel (with tungsten pellets), a prototypical control rod assembly, and prototypical control rod assembly guide cards. The testing configuration consisted of an integrated steam plenum, five upper riser control rod drive shaft supports, and four control rod assemblies CRA guide cards, which are independently adjustable to introduce up to +/- 1 inch of misalignment. The configuration was also capable of introducing mid-span lateral deflection at the fuel assembly. The fluid conditions for the test configuration had two temperature setpoints: ambient and 180°F, with ambient pressure and minimum flow rate for all cases.

The procedure for conducting the test consisted of:

- Setting and recording the displacements of the adjustable components;
- Setting the water temperature;
- Lifting the control rod drive shaft;
- Initiating the water spray system;
- Initiating the data acquisition system;
- Dropping the shaft;
- Recording and reviewing the data;
- Repeating the above process five times, if acceptance criteria is met; and
- Recording the post-test position of the components.

2.4 Acceptability of Test Results

The test results showed that the most limiting drop was bounded by the performance assumed in the safety analysis for control rod drop time. NuScale has plans to update the DCD to reflect the completion of this testing program and to incorporate the testing results into the appropriate sections of the DCD. The NRC staff will be tracking this as NuScale submits further revisions to the DCD.

3.0 DOCUMENTS REVIEWED

- Engineering Drawing ED-A023-2303, “Reactor Vessel Internals – Upper Riser,” Revision 1, dated October 10, 2017

- Engineering Drawing ED-A011-1932, “Reactor Pressure Vessel Assembly,” Revision 2, dated August 8, 2018

- Engineering Drawing ED-A011-2658, “Upper RPV Section,” Revision 2, dated February 8, 2018

- Engineering Drawing ED-A023-2304, “Reactor Vessel Internals – Lower Riser,” Revision 1, dated September 7, 2018

- Engineering Drawing ED-A022-2684, “CRDM Assembly,” Revision 3, dated May 2, 2016

- Engineering Drawing ED-A022-3188, “CRDM Drive Rod Assembly,” Revision 1, dated January 29, 2016

- Document ER-A022-1376, “NuScale Control Rod Drive Mechanism Summary Report,” Revision 3, dated August 24, 2016

- Document ER-T020-6399, “TD.24 As-built Report – Drop Alignment Test – Cold Test,” Revision 0, dated April 26, 2018

- Document ER-T020-6617, “TD.24 Drop Alignment Test - Summary Test Report for the Cold Test,” Revision 0, dated August 2, 2018

- Document ER-T020-6624, “TD. 24 Drop Alignment Test – Final Test Report – Cold Test,” Revision 0, dated August 29, 2018

- Document PL-0202-13207, “TD.24 Drop Alignment Test – AREVA GmbH Project Quality Plan,” Revision 3, dated April 24, 2018

- Document SDR-0416-48702, “TD.24 Drop Alignment Test - Test Procedure and Test Plan,” Revision 4, dated April 18, 2018

- Document SDR-1015-18680, “Predesign of the CRD Shaft Support and CRAGT Alignment Testing – Cold Test," Revision 2, dated March 2, 2018

- Document SDR-1015-18681, “TD.24 Drop Alignment Test - Fabrication Drawing Package,” Revision 3, dated February 19, 2018

- Document TSD-020-56700, “Test Specification – CRD Shaft Support and CRAGT Alignment Testing - Cold Test,” Revision 1, dated February 9, 2018

- Document EC-A010-3559, “Reactor Module Seismic Calculation,” Revision 4, dated June 6, 2018

4.0 CONCLUSION

The NRC staff conducted an audit exit briefing with NuScale personnel on October 25, 2018. The NRC staff stated that they were able to accomplish the audit’s objectives through review of the available documentation and discussions with NuScale personnel. The NRC staff gained a better understanding of the CRDM design and the testing methods utilized by NuScale. As a result of this audit, the staff did not generate any RAIs to request changes to the DCD. Additionally, there are no open items associated with the audit and currently no plans for a follow-up audit. However, the NRC staff will be reviewing subsequent revisions to the DCD to confirm that the discussion of the testing results have been updated to reflect the completion of the testing program.

U.S. NUCLEAR REGULATORY COMMISSION

FOLLOW-UP AUDIT OF NUSCALE POWER, LLC

DESIGN CERTIFICATION APPLICATION, FINAL SAFETY ANALYSIS REPORT,

SECTIONS 3.9.4 AND 4.6

LIST OF ATTENDEES

September 4, 2018 – October 25, 2018

NRC Staff Participants:

Nicholas J. Hansing
Yiu Law
Marieliz Vera Amadiz
Tim Lupold

NuScale (and other support organization) Participants:

Marty Bryan
Greg Myers
Vern Pence
Derek Noel
Bob Hauser
Christian Galvez
Maggie Wang
Larry Linik

Enclosure 2