

December 5, 2017

MEMORANDUM TO: Samuel S. Lee, Chief  
Licensing Branch 1  
Division of New Reactor Licensing  
Office of New Reactors

FROM: Bruce M. Bavol, Project Manager */RA/*  
Licensing Branch 1  
Division of New Reactor Licensing  
Office of New Reactors

SUBJECT: AUDIT SUMMARY FOR THE NUSCALE POWER, LLC  
STANDARD PLANT DESIGN CERTIFICATION, TIER 2,  
SECTION 5.3.2, "PRESSURE-TEMPERATURE LIMITS,  
PRESSURIZED THERMAL SHOCK, AND CHARPY UPPER-  
SHELF ENERGY DATA AND ANALYSES"

The U.S. Nuclear Regulatory Commission staff conducted an audit July 24, 2017 – September 13, 2017, to review Design Control Document, Chapter 5.3.2, "Pressure-Temperature Limits, Pressurized Thermal Shock, and Charpy Upper-Shelf Energy Data and Analyses," and technical report, TR-1015-18177, "Pressure and Temperature Limits Methodology." The purpose was to audit information supporting the adequacy of the methodology and results.

The enclosed audit summary describes the content of the review, identifies the audit participants, and audit exit observations.

Docket No. 52-048

Enclosure:  
Audit Summary

CONTACT: Bruce M. Bavol, NRO/DNRL  
301-415-6715

cc w/encl.: DC NuScale Power, LLC Listserv

SUBJECT: AUDIT SUMMARY FOR THE NUSCALE POWER, LLC STANDARD PLANT DESIGN CERTIFICATION, TIER 2, SECTION 5.3.2, "PRESSURE-TEMPERATURE LIMITS, PRESSURIZED THERMAL SHOCK, AND CHARPY UPPER-SHELF ENERGY DATA AND ANALYSES"

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NRO-002

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DATE	11/28/2017	11/21/2017	11/30/2017	12/05/2017

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**U.S. NUCLEAR REGULATORY COMMISSION**  
**AUDIT SUMMARY FOR THE REGULATORY AUDIT OF THE NUSCALE POWER, LLC**  
**STANDARD PLANT DESIGN CERTIFICATION, TIER 2, SECTION 5.3.2, “PRESSURE-TEMPERATURE LIMITS, PRESSURIZED THERMAL SHOCK, AND CHARPY UPPER-SHELF ENERGY DATA AND ANALYSES”**

**1.0 BACKGROUND**

NuScale Power, LLC (NuScale) submitted by letter dated December 31, 2016, to the U.S. Nuclear Regulatory Commission (NRC) a Design Control Document (DCD) for its Design Certification (DC) application of the NuScale reactor design (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17013A229). The NRC staff initiated its DC review on March 27, 2017.

The basis for setting operational limits on pressure and temperature for the reactor coolant pressure boundary (RCPB) is presented in DCD Tier 2, Chapter 5.3.2, “Pressure-Temperature Limits, Pressurized Thermal Shock, and Charpy Upper-Shelf Energy Data and Analyses.” These limits ensure adequate safety margins against non-ductile fracture during normal operation, heat-up, cooldown, anticipated operational occurrences; and system hydrostatic, pre-service, and inservice leakage tests.

The DCD and referenced technical report (TR), TR-1015-18177, “Pressure and Temperature Limits Methodology” (henceforth the TR; Ref. 1) did not contain sufficient information for the NRC staff to conduct adequate independent verification of the methodology or results.

The NRC staff determined it would be advantageous to audit information supporting the adequacy of the methodology and results. The audit plan is available as Reference 2. Specifically, the NRC staff planned to audit the following:

- Finite element meshes used for stress and temperature calculations (including boundary conditions) – to help assess TR Tables 4-8 and 4-9;
- Finite element meshes used for K calculations (in particular ensuring that the focused crack tip meshes are fine enough) – to help assess TR Tables 4-8 and 4-9;
- K values extracted from the successive contours for the cracks analyzed, to ensure that the values finally used are accurate or conservative, and to understand the choice of contour used in TR Table 5-1;
- Stress profiles extracted from the finite element models to calculate K at the crack tips: need to ensure a 3<sup>rd</sup> order polynomial fit is an acceptable representation of the stress, particularly for the cracks located at geometric discontinuities to support Tier 2, DCD Section 5.0 results.

Enclosure

## **2.0 REGULATORY AUDIT BASES**

Title 10 of the *Code of Federal Regulations* (CFR), Section 52.47(a)(3)(i) states:

*A DC application must contain a final safety analysis report (FSAR) that includes a description of principle design criteria for the facility.*

An audit is required to examine detailed information related to the applicant's principle design criteria, and reach a safety conclusion on the NuScale application sections in the scope of this audit plan. The NRC staff must have sufficient information to ensure that acceptable risk and reasonable assurance of safety can be documented in the NRC staff's safety evaluation.

This regulatory audit was based on the following regulations:

- 10 CFR 52.47, "Contents of applications; technical information in final safety analysis report."
- General Design Criteria (GDC) 1, "Quality Standards and Records," and GDC 30, "Quality of Reactor Coolant Pressure Boundary," found in Appendix A to 10 CFR Part 50, as they relate to quality standards for design, fabrication, erection, and testing of structures, systems, and components.
- GDC 4, "Environmental and Dynamic Effects Design Bases," as it relates to the environmental compatibility of components.
- GDC 14, "Reactor Coolant Pressure Boundary," as it relates to prevention of rapidly propagating failures of the RCPB.
- GDC 31, "Fracture Prevention of Reactor Coolant Pressure Boundary," as it relates to material fracture toughness.

## **3.0 AUDIT LOCATION AND DATES**

Date: July 24, 2017 – September 13, 2017

Location: NuScale Power Rockville Office  
11333 Woodglen Ave., Suite 205  
Rockville, MD 20852

Electronic Reading Room (eRR)

## **4.0 AUDIT TEAM MEMBERS**

Daniel S. Widrevitz (NRO/MCB Materials Engineer, Audit Lead)  
Patrick A. Raynaud (RES/CIB Materials Engineer)  
Mark T. Kirk (RES/CIB Materials Engineer)  
Matthew Gordon (RES/CIB Materials Engineer)

Matthew A. Mitchell (NRO/MCB Branch Chief)  
Bruce M. Bavol (NRO, Project Manager)

## **5.0 APPLICANT AND INDUSTRY STAFF PARTICIPANTS**

### NuScale

Larry Losh, Manager of Nuclear Fuel  
Greg Meyers, Licensing Engineer  
Wendell Wagner, Supervisor, Core Thermal-Hydraulics  
Azat Galimov, Engineer, Core Thermal-Hydraulics  
Brandon Blackburn, Engineer, Core Thermal-Hydraulics  
Ken Rooks, Engineer, Core Thermal-Hydraulics  
Darrel Gartner, Manager, Licensing  
Robert Gamble, Vice President, Engineering

### Information Systems Laboratories

Michael Bradbury, Engineer, Information Systems Laboratories

## **6.0 DOCUMENTS AUDITED**

1. EC-A011-3215, "Pressure-Temperature Limits Calculation for RPV at 57-EFPY Fluence," Rev. 1, 11/18/2016
2. NP-12-01-A011-M-SA-2639-S01, "Lower RPV Section," Rev. 2, 3/15/2017

## **7.0 DESCRIPTION OF AUDIT ACTIVITIES AND SUMMARY OF OBSERVATIONS**

### Finite Element Mesh Implementation

The NRC staff reviewed the meshes used to calculate the thermal stresses and the stress intensity factors in EC-A011-3215. This supported the NRC staff goal of determining whether the meshes employed were accurate representations of the components modeled, and whether the meshing was fine enough to ensure good results.

### K Values Surrounding Postulated Cracks

The NRC staff requested that the applicant provide K values extracted from the successive contours for the cracks analyzed, to ensure that the values finally used are accurate or conservative, and to understand the choice of contour used in TR Table 5-1. The applicant was unable to provide these details within the span of the audit. The NRC staff concluded that this information would be necessary to complete its review of this area (see Request for Additional Information (RAI) 9118, Question 30677).

### Stress Profiles at Crack Tips

The NRC staff requested that the applicant provide stress profiles extracted from the finite element models to calculate K at the crack tips. This was necessary for the NRC staff to

confirm that the 3rd order polynomial fit used by the applicant was an acceptable representation of the stress at this location. The applicant provided details concerning the macro used to fit the 3<sup>rd</sup> order polynomials in Appendix C of EC-A011-3215 but did not provide the corresponding stress profiles and fits. The NRC staff concluded that this information would be necessary to complete its review of this area (see RAI 9118, Question 30678).

## **8.0 EXIT BRIEFING**

The NRC staff conducted an audit exit meeting on September 13, 2017. At the exit briefing NRC staff reiterated the purpose of the audit and discussed their activities. NRC stated that they obtained a clearer understanding of the applicant's analyses supporting the pressure and temperature limits methodology. Additionally, NRC staff stated that they had identified areas where additional information is being requested to support the review, and briefly discussed the scope of these information requests. References to the detailed questions are provided in Section 9.0 of this audit summary.

## **9.0 REQUESTS FOR ADDITIONAL INFORMATION RESULTING FROM AUDIT**

The NRC staff issued one RAI with five questions based on information observations made during the audit. This RAI is available in ADAMS (Reference 3).

**Table 1. RAI Resulting from Audit**

<b>RAI Number</b>	<b>Reference</b>
9118, Question 30674	3
9118, Question 30675	3
9118, Question 30676	3
9118, Question 30677	3
9118, Question 30678	3

## **10.0 OPEN ITEMS AND PROPOSED CLOSURE PATHS**

Not applicable.

## **11.0 DEVIATIONS FROM THE AUDIT PLAN**

Not applicable.

## **12.0 REFERENCES**

1. NuScale Topical Report TR-1015-18177, "Pressure and Temperature Limits Methodology," Rev. 0, December 31, 2016 (ADAMS Accession No. ML17005A130).
2. Audit Plan for the Regulatory Audit of DCD Section 5.3.2, "Audit Plan for the Regulatory Audit of NuScale Power, LLC Design Certification Application, Design Control Document, Tier 2, Chapter 5, Section 5.3.2, "Pressure-Temperature Limits, Pressurized Thermal Shock, and Charpy Uppershelf Energy Data and Analyses," Revision 0, July 25, 2017 (ADAMS Accession No. ML17202G482).
3. RAI-9118 (ADAMS Accession No. ML17265A773).