

November 4, 2016

MEMORANDUM TO: Mark Tonacci, Chief  
Licensing Branch 1  
Division of New Reactor Licensing  
Office of New Reactors

FROM: Prosanta Chowdhury, Project Manager /RA/  
Licensing Branch 1  
Division of New Reactor Licensing  
Office of New Reactors

SUBJECT: U. S. NUCLEAR REGULATORY COMMISSION STAFF AUDIT  
REPORT FOR NUSCALE POWER, LLC PRE-APPLICATION  
ACTIVITIES ASSOCIATED WITH NUSCALE EMERGENCY CORE  
COOLING SYSTEM/CONTAINMENT PERFORMANCE TESTING AT  
NUSCALE INTEGRAL SYSTEM TEST FACILITY (PROJ0769)

As part of its pre-application activities pertaining to the anticipated design certification (DC) application from NuScale Power, LLC (NuScale), the U.S. Nuclear Regulatory Commission (NRC) staff performed an audit of the NuScale Emergency Core Cooling System (ECCS)/ Containment Performance Testing at NuScale Integral System Test (NIST-1) facilities. The audit was conducted on June 27 – 30, 2016, in accordance with the audit plan (Agencywide Document Access and Management System (ADAMS) Accession No. ML16168A118). The pre-application audit was performed to observe the test facility, and audit the documents supporting the testing of containment heat transfer performance and Chemical Volume and Control System (CVCS) line break, prior to the NuScale submission of a DC application. Specifically, the NRC staff's objective in conducting this audit was to review documentation associated with the High Pressure Condensation Test (HP-02) and Cooling Pool Characterization Test (HP-04). These tests were performed on October 7 - 8, 2015, and November 11 - 12, 2015, respectively, which the NRC staff could not observe. However, the NRC staff's plan included an audit of the test facility, instrumentation, test procedure, and the test data to make sure that the test results can be used in the full-scale reactor design safety analyses. Another objective of this audit was to collect maximum information and assess the separate-effect containment heat transfer performance tests. In addition, the NRC staff planned to observe the CVCS Discharge Pipe Break Failure Test (HP-28) and audit the related information.

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The NRC staff conducted the audit at the NIST-1 Facilities, Oregon State University, Corvallis, Oregon 97331. 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. The NRC staff's detailed findings and observations resulting from this audit contain significant amount of proprietary information, and therefore, cannot be released publicly. The non-public (proprietary) version of the audit report (ADAMS Accession No. ML16272A136) is transmitted to NuScale under separate cover.

Project No.: PROJ0769

Enclosures:

1. Audit Report
2. Attendee List

cc: NuScale DC ListServ

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**ADAMS Accession Nos.:**

**ML16168A277– Pkg**

**ML16270A020– Audit Summary Report (Public)**

**ML16272A136– Audit Summary Report (Proprietary; Non-Public) – not enclosed**

**\*via email**

**NRO-002**

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DATE	11/04/2016	9/27/2016	11/04/2016	11/04/2016

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**NUSCALE POWER, LLC**  
**SUMMARY REPORT OF AUDIT REGARDING**  
**NUSCALE EMERGENCY CORE COOLING SYSTEM/ CONTAINMENT PERFORMANCE**  
**TESTING AT NUSCALE INTEGRAL SYSTEM TEST (NIST-1) FACILITIES**

**Introduction and Background**

On January 26, 2015, NuScale Power, LLC (NuScale) provided an initial test matrix [Reference 1] for the NuScale Integral System Test Facilities (NIST-1) located at the Oregon State University (OSU) in Corvallis, Oregon. This test matrix has been updated since then and forms an integral part of validating the code models and scaling arguments used by NuScale. The test series is intended to qualify a number of safety-significant phenomena relevant to the loss of coolant accident (LOCA) and non-LOCA Phenomena Identification and Ranking Tables (PIRTs) for the NuScale design.

The Containment and Ventilation Branch (SCVB) and the Reactor Systems, Nuclear Performance and Code Review Branch (SRSB) staff of the U.S. Nuclear Regulatory Commission (NRC) conducted a pre-application audit of the NIST-1 test facility and the documents supporting the testing of containment heat transfer performance, steam generators (SG) and DHRS operations, and decay heat under design basis (DB) LOCA conditions. The purpose of the audit was to examine NuScale test facility as well as the testing conducted to characterize the heat transfer performance of the NuScale containment and the cooling pool, in-vessel water inventory, two-phase water level transient behavior, and reactor core temperature history under LOCA conditions. The NRC staff performed an assessment of the test facility's configuration, test scaling, instrumentation (on both the containment and cooling pool sides), test specifications/procedures, data acquisition and reduction, and test results. The NRC staff examined the supporting documentation describing the calculations, assumptions, and uncertainties, to gain in-depth understanding of the NIST-1 testing and the application of test data for computer code validation. In this regard, the NRC staff interacted with NuScale staff on the overall heat balance, instrumentation grid, experimental uncertainties, acceptance criteria, flow patterns being representative of the full-scale reactor transient, and distortions in the test data.

The regulatory audit gave the NRC staff an opportunity to identify the information needed from NuScale to establish the capability of the NIST-1 facilities to support the the NuScale design certification application. The audit activities were planned around two coupled figures of merit in the full-scale NuScale power module (NPM) under a design-basis accident (DBA) scenario, as identified in the LOCA PIRT: (1) Peak containment pressure to ensure the containment integrity, and (2) Collapsed liquid level within reactor pressure vessel (RPV), e.g., during the LOCA that would protect against any core uncover and Peak Cladding temperature (PCT) occurrence. Since the containment pressure and liquid level within the Reactor Pressure Vessel (RPV) are tied to the condensation rate and heat rejection to the cooling pool, the NRC staff needed to understand how the NuScale testing captures the associated safety-significant phenomena associated with the emergency core cooling system (ECCS) and containment. The NRC staff also needed to understand any scaling distortions on the two figures of merit at NIST-1.

Having access to the test setup, observing the LOCA testing in the control room, and reviewing the associated documentation familiarized the NRC staff with the NuScale NIST-1 test facility and the applicability of the test results to the full-scale reactor design safety analyses. This also allowed the NRC staff to make informed observations about the completeness and validity of the thermal-hydraulic testing performance, and prepared them to perform confirmatory analyses of their own. This audit is intended to reduce the need for issuing requests for additional information (RAIs) during the NRC staff's safety review of the design certification application (DCA), when submitted. Summarily, the audit has better prepared the NRC staff for a more efficient and timely review of the NuScale design certification documents (DCD) and topical reports referencing the test data.

### **Regulatory Audit Bases**

This technical audit was based on the following regulatory requirements:

- General Design Criteria (GDC) 38, "Containment heat removal," of Appendix A to Title 10 *Code of Federal Regulations* (10 CFR) Part 50
- GDC 50, "Containment design basis," of Appendix A to 10 CFR, Part 50
- 10 CFR 52.157, "Contents of applications; technical information in final safety analysis report."
- 10 CFR 50.43(e), concerning testing to qualify and assess the capability of submitted designs to meet safety criteria
- 10 CFR 50.46, "Acceptance criteria for ECCS for Light-Water Nuclear Power Reactors."

The audit followed the guidelines in the Office of New Reactors (NRO) Office Instruction NRO-REG-108 (Revision 0), "Regulatory Audits" [Reference 2].

### **NRC Audit Team**

Syed I. Haider:	Reactor Systems Engineer	(NRO/DSRA/SCVB)
Shanlai Lu:	Sr. Reactor Systems Engineer	(NRO/DSRA/SRSB)
Carl Thurston:	Reactor Systems Engineer	(NRO/DSRA/SRSB)

### **Audit Preparation**

The NRC staff issued a detailed audit plan [Reference 3] that identified the information needed for the audit of the NIST-1 test facility. The audit plan also communicated a detailed list of questions and concerns to NuScale to convey the kind of technical aspects of the test facility the NRC staff planned to audit. The questions were proprietary in nature. The NRC staff requested NuScale to either address those questions and concerns during the audit or justify their lack of relevance to the test results usage. The NRC staff expected NuScale to furnish the proprietary versions of all the documents, if applicable, that would support the resolution of these questions and concerns during the audit. The NRC staff accepted the interactive presentation format proposed by NuScale to address the written questions posed by the NRC staff while minimizing the impact on test facility operation. The NIST-1 tests HP-02, HP-04, and HP-28, as described later, were identified for special containment/ECCS audit interest.

### **Documents Provided by NuScale for the Audit**

Below is a list of the NIST-1 facility and design documents that were made available to the audit team to support the requests made in the audit plan [Reference 3]. The NRC staff examined these documents, as needed.

<b>Document Number</b>	<b>Document Title</b>
ER-T080-3193	NIST-1 Upgrade and Testing Needs Statements
EE-T080-13757	NuScale Integral System Test (NIST-1) Facility Scaling Analysis
SDR-0815-16916	OSU NIST-1 Data Acquisition and Control System Configuration Report
TSD-1014-9271	Test Specification – NIST-1 Facility
TSD-T080-10667	NIST-1 HP-02 High Pressure Condensation Test Specification
TSD-T080-10669	NIST-1 HP-04 Cooling Pool Characterization Test Specification
TSD-A010-48666	NIST-1 HP-28 CVCS Discharge Pipe Break w/RVV Failure Test Specification
TP-0715-15853	HP-02 High Pressure Condensation Test Procedure
TP-0715-15834	HP-04 Cooling Pool Characterization Test Procedure
TP-0616-49787	HP-28 CVCS Discharge Pipe Break w/RVV Failure Test Procedure
EE-T110-3030	Pre-Test Predictions for the 2015 NIST-1 High Pressure Condensation (HPC) Tests
EE-T080-3135	Pre-Test Predictions for the NIST-1 Full Length DHRS Condensation Tests
EE-T080-4074	Pre-Test Predictions for the NIST-1 HP-28 CVCS Discharge Pipe Break w/RVV Failure Test
ER-A010-4065	HP-02 High Pressure Condensation Test Final Test Report
ER-A010-4063	HP-04 Cooling Pool Characterization Test Final Test Report
EC-T080-3822	NRELAP5 Assessment Against NuScale Separate Effects High Pressure Condensation Test Series NIST-HP-02
EC-T080-4163	NRELAP5 Assessment Against NIST-1 HP-04 NuScale Cooling Pool Characterization Test
ER-0000-3095	NuScale Module Loss-of-Coolant Accident Phenomena Identification and Ranking
SwUM-0304-17023	NRELAP5 Version 1.1 Theory Manual

Additional NuScale documents that were requested by the NRC staff to meet the audit needs that emerged:

<b>Document Number</b>	<b>Document Title</b>
NCI-0315-12869	NRELAP5 – Helical Coil Component
EC-T080-4161	NRELAP5 Assessment Against NuScale Separate Effects High Pressure Condensation Test Series NIST HP-03
EC-T050-3638	Assessment of NRELAP5 Using SIET Fluid Heated Test Facility (TF-2) Data
EC-B030-2121, Rev B	DHRS Thermal Hydraulic Analysis
EC-T080-3828	NRELAP5 Assessment Against NuScale Integral System CVCS Discharge Line Break Test NIST-HP-06-0926

EC-0000-3155	Assessment of NRELAP5 with KAIST Condensation Experiments
EC-T050-3234	NRELAP5 Model for the SIET Fluid Heated Test Facility
EC-T080-3468, Rev 2	Appendix E, NIST-1 Powered Natural Circulation Test; Pages 645-669
EC-0000-3853, Rev 0	Calculations to support NIST-1 Distortion Analysis and Modeling of Containment and Pool Heat Transfer

## **Conclusions**

The NRC staff concludes that overall the audit was productive and the NRC staff was able to gain good understanding of the test facility; the documents supporting the testing of containment heat transfer performance and CVCS line break (HP-28); the documentation associated with the High Pressure Condensation Test (HP-02) and Cooling Pool Characterization Test (HP-04); and the information on the separate-effect containment heat transfer performance tests. The NRC staff's detailed findings and observations resulting from the audit of the NIST-1 facilities, test procedures and related documentation contain significant amount of proprietary information, and therefore, are not released publicly. The proprietary version of the audit summary report includes several audit close-out observations made by the NRC staff and conveyed to NuScale during the audit exit meeting. NuScale agreed to provide the NRC staff's requested additional information necessary to address the close-out observations.

## **References**

1. "NuScale Power, LLC Submittal of the Preliminary NuScale Integral System Test Facilities (NIST) Test Identifier List", January 26, 2015 (ADAMS Accession No. ML15026A755).
2. NRO-REG-108, "Regulatory Audits", April 2, 2009 (ADAMS Accession No. ML081910260).
3. "Audit Plan for NuScale Power, LLC Pre-Application Activities Associated with NuScale Emergency Core Cooling System/Containment Performance Testing at NIST-1 Test Facility (PROJ0769)," June 20, 2016 (ADAMS Accession No. ML16168A118).

## **LIST OF ATTENDEES**

### **U.S. Nuclear Regulatory Commission Audit of NuScale Power, LLC Pre-Application Activities Associated with NuScale Emergency Core Cooling System/ Containment Performance Testing at NuScale Integral System Test (NIST-1) Facilities**

**June 27 – 30, 2016**

#### NRC staff participants:

Syed I. Haider, Nuclear Regulatory Commission (NRC)  
Shanlai Lu, (NRC)  
Carl Thurston, (NRC)

#### NuScale and OSU Staff Participants:

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Robert Houser, Manager Testing and Code Development  
John Hardy, P.E., NIST-1 Facility Manager  
Eric Young, Ph.D., Supervisor Testing  
Brian Wolf, Ph.D., Supervisor (Acting) Code Development  
Pravin Sawant, Ph.D., Lead Methodology Development  
Bradyn Wuth, NIST-1 Test Engineer  
Qiao Wu, Ph.D., OSU Professor and NIST-1 Program Manager  
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Patrick Byfield, Code Development Engineer  
Kevin Stovall, OSU Deputy NIST-1 Program Manager  
David Brown, NIST-1 Quality Assurance Manager  
Zackary Rad, Director Regulatory Affairs  
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