October 17, 2016

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

FROM: Gregory Cranston, Senior Project Manager ***/RA/***
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Office of New Reactors

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION STAFF AUDIT REPORT FOR THE REVIEW OF NUSCALE POWER, LLC, PRE-APPLICATION ACTIVITIES ASSOCIATED WITH AREVA, INC., TESTS RELATED TO THE DESIGN OF FUEL ASSEMBLIES FOR NUSCALE (PROJ0769)

From May 24, 2016 to May 26, 2016, the U.S. Nuclear Regulatory Commission (NRC) staff conducted an audit of AREVA, Inc. (AREVA), test facility and documents for tests related to the design of AREVA fuel assemblies to be used for NuScale Power, LLC, (NuScale). The purpose of the audit was for the NRC staff to observe tests related to the new design of the proposed NuScale fuel assembly.

The NRC staff conducted the audit at the AREVA facility, 2101 Horn Rapids Road Richland, Washington 99354. The NRC staff conducted the audit in accordance with the Office of New Reactors (NRO) Office Instruction NRO-REG-108, "Regulatory Audits." The audit was conducted in accordance with "Audit Plan for NuScale Power, LLC, Pre-Application Activities Associated with AREVA Tests Related to the Design of Fuel Assemblies for NuScale," Agencywide Document Access and Management System Accession No. ML16144A431.

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The audit report and the attendee list is documented as Enclosures 1 and 2.

Project No.: PROJ0769

Enclosures:
As stated

cc: NuScale DC ListServ

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DATE	10/07/2016	10/12/2016	10/05/2016	10/17/2016

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TESTS RELATED TO DESIGN OF AREVA FUEL ASSEMBLIES FOR NUSCALE POWER AUDIT SUMMARY REPORT

NRC Audit Team:

- Jeffrey Schmidt
- Pravin Patel
- Nicholas Klymyshyn, PNNL (part time)

I. Purpose

From May 24, 2016 to May 26, 2016, the U.S. Nuclear Regulatory Commission (NRC) staff conducted an audit of AREVA, Inc. (AREVA), test facility and documents related to tests related to the design of AREVA fuel assemblies to be used for NuScale Power, LLC, (NuScale). The purpose of the audit was for the NRC staff to observe tests related to the new design of the proposed NuScale fuel assembly.

The NRC staff conducted the audit at the AREVA facility, 2101 Horn Rapids Road Richland, Washington 99354. The NRC staff conducted the audit in accordance with the Office of New Reactors (NRO) Office Instruction NRO-REG-108, "Regulatory Audits," (Reference 1).

II. Background and Audit Bases

Title 10, Part 50 of the *Code of Federal Regulations* (10 CFR 50), Appendix A, General Design Criterion (GDC) 2, "Design Bases for Protection Against Natural Phenomena," states that, "Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions." GDC 2 goes on to say that, "appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena," should also be considered. The NRC staff guidance, as they relate to meeting the requirements of GDC 2 for fuel and fuel structures, is reflected in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition, Standard Review Plan (SRP) 4.2," Appendix A, "Evaluation of Fuel Assembly Structural Response to Externally Applied Forces." Fuel behavior characterization related to externally applied forces such as loss of coolant accidents (LOCA) and safe shutdown earthquakes is necessary to ensure the fuel and fuel structure preform their safety function of allowing control rod insertion to control reactivity, preventing fuel fragmentation and maintaining a structural configuration such that the LOCA criteria of 10 CFR 50.46 is met.

III. Audit Objectives

Observe the forced vibration tests of a prototypical NuScale fuel assembly. The NRC staff reviewed test procedures, observed data collection and discussed how test data is used to inform the methodology which predicts fuel assembly behavior under externally applied forces.

IV. Scope of the Audit

The NRC staff observed the testing, reviewed test procedures, and preliminary results of the forced vibration testing.

Audit Activities and Summary of Findings

Below is a summary of the audit activities, findings, and follow-up actions:

The NRC staff observed the forced vibration tests of a prototypical NuScale design fuel assembly in the seismic test stand at the AREVA Richland facility. This testing was re-performed due to the seismic reanalysis and addition of a hold-down spring to the NuScale design. The forced vibration or modal testing is conducted by instrumenting the fuel assembly at various axial locations and then subjecting the assembly to a series of forced, random motions using the attached electrodynamic shaker. Data from the random motions is then analyzed to determine the approximate assembly natural frequencies. The excitation frequency range is then narrowed around the identified modal frequencies to accurately characterize the assembly's response. The forced vibration tests, in combination with the free vibration (pluck) tests, are used to determine the assembly's natural frequency and structural damping for use in the seismic response models. The use of forced vibration testing complements the free vibration tests by examining a range of excitation frequencies but over a smaller amplitude range than the free vibration tests. Forced vibration testing is especially useful in determining higher mode fuel assembly behavior (i.e., the relationship between first and higher mode frequencies).

The NRC staff reviewed the AREVA test procedure SOP-41093, Version 1.0, "RTF Procedure for Performing Modal Tests." The NRC staff review identified one issue associated with the use of a constant assembly hold-down force for both beginning of core life (BOC) and end of core life (EOC) fuel assembly testing. The test hold-down force was believed to correspond to a BOC condition. The test hold-down force was believed to correspond to a BOC condition. As the fuel assembly is irradiated the assembly growth compresses the spring at the same time the hold-down spring relaxes. These effects change hold-down spring force as a function of exposure and hence are not constant as in the test. AREVA addressed this issue by providing NRC staff data which demonstrated that a large range in hold-down forces do not substantially affect lateral stiffness and the assembly measured frequency responses. The range of hold-down forces in the previous test data bound the expected change in the NuScale assembly hold-down force with exposure. Therefore, the staff did not identify any further questions regarding this issue. Other minor testing questions were asked by the NRC staff with AREVA providing acceptable responses such that the staff did not identify any remaining issues.

No data from previous tests was available and no preliminary data for the tests being conducted was available for review.

V. CONCLUSION

During the audit, the NRC staff provided feedback to AREVA regarding the forced vibration testing of the prototypical NuScale fuel assembly design. An exit meeting was held on the last

day with AREVA presenting detailed responses to the NRC staff's questions. Based on review of the AREVA responses no findings, open items or issues were identified during this audit.

VI. REFERENCES

1. NRO Office Instruction, NRO-REG-108, "Regulatory Audits," Revision 0, April 2009.

LIST OF ATTENDEES

U.S. Nuclear Regulatory Commission Audit of Tests Related to Design of AREVA Fuel Assemblies for NuScale Power

May 24, 2016 to May 26, 2016

Name	Affiliation
Jeffrey Schmidt	NRC
Pravin Patel	NRC
Nicholas Klymyshyn	Pacific Northwest National Laboratory
Brett Matthews	AREVA
Corey Long	AREVA