February 24, 2017

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

FROM: Omid Tabatabai, Senior 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 THE FACTORY ACCEPTANCE TESTING OF NUSCALE POWER, LLC, PROTOTYPE HIGHLY INTEGRATED PROTECTION SYSTEM (PROJ0769)

From January 30, 2017 to February 3, 2017, the U.S. Nuclear Regulatory Commission (NRC) staff conducted an audit of the NuScale Power, LLC (NuScale) prototype Highly Integrated Protection System (HIPS) platform, or prototype module protection system (pMPS), factory acceptance testing (FAT).

The objective of this audit was to witness the FAT of the pMPS. The NRC staff observed the hardware configuration of the prototype HIPS test specimen, and key performance characteristics of the pMPS. Observing the FAT assisted the NRC staff in confirming that the safety and key design requirements and features described in HIPS topical report, TR-1015-18653-P, "Design of the Highly Integrated Protection System Platform" Rev. 1.

This audit was conducted at the Ultra Electronics – Nuclear Control Systems facilities located at Innovation House, Lancaster Road, Ferndown Industrial Estate, Wimborne BH21 7SQ, United Kingdom. The NRC staff conducted the audit in accordance with the Audit Plan for FAT of NuScale's Prototype HIPS Platform (Reference (Ref.) 1), which is based on the Office of New Reactors (NRO) Office Instruction NRO-REG-108, "Regulatory Audits" (Ref. 2).

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The publically available version of the audit report and the attendee list is documented as Enclosures 1 and 2 (Agencywide Document Access and Management System (ADAMS) Accession No. ML17053B498), and the non-public (proprietary) version of the audit report is documented in Enclosure 3 (ADAMS Accession No. ML17053B497).

Project No.: PROJ0769

Enclosures:
As stated

cc: NuScale DC ListServ

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ADAMS Accession Nos.:
ML17053B495 – Pkg.
ML17053B498 – Audit Summary Report (Public)
ML17053B497 – Audit Summary Report (Non-Public) *via email* NRO-002

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NUSCALE POWER, LLC
FACTORY ACCEPTANCE TESTING OF NUSCALE PROTOTYPE
HIGHLY INTEGRATED PROTECTION SYSTEM PLATFORM
AUDIT SUMMARY REPORT

NRC Audit Team:

- Luis Betancourt, Electronics Engineer, Audit Lead (NRO/DEIA/ICE)
- Dinesh Taneja, Senior Electronics Engineer (NRO/DEIA/ICE)

I. Purpose

From January 30, 2017 to February 3, 2017, the U.S. Nuclear Regulatory Commission (NRC) staff conducted an audit of the NuScale Power, LLC (NuScale) prototype Highly Integrated Protection System (HIPS) platform factory acceptance testing (FAT). The HIPS prototype being tested is also designated as the prototype Module Protection System (pMPS)

This audit was conducted at the Ultra Electronics – Nuclear Control Systems facilities located at Innovation House, Lancaster Road, Ferndown Industrial Estate, Wimborne BH21 7SQ, United Kingdom. The NRC staff conducted the audit in accordance with the Audit Plan for FAT of NuScale's Prototype HIPS Platform (Reference (Ref.) 1), which is based on the Office of New Reactors' (NRO) Office Instruction NRO-REG-108, "Regulatory Audits," (Ref. 2).

II. Background and Audit Bases

In December 2015, NuScale submitted a topical report (TR) titled, "Highly Integrated Protection System (HIPS) Platform," for the NRC staff's review and approval (Ref. 3). NuScale requested that the NRC staff review the HIPS TR and approve the assertion that generic key design concepts of the HIPS platform meet the applicable regulatory requirements. The NRC staff accepted the HIPS TR for review by letter dated February 19, 2016 (Ref. 4).

The NRC staff conducted a regulatory audit of NuScale's design documents from July 6, 2016 to July 7, 2016, at the NuScale offices located in Rockville, Maryland (Ref. 4). The purpose of the audit was to: (1) deepen understanding of the HIPS platform and associated design documents; (2) review non-docketed information related to the HIPS platform; and (3) confirm whether or not fundamental instrumentation and control (I&C) design principles and regulatory requirements are being met. During this audit, NuScale I&C staff informed the NRC staff of the FAT of the pMPS and offered that the NRC staff observe the testing. The NRC staff agreed that witnessing the FAT of the pMPS would facilitate the effective and efficient means for verifying some of the key design features and claims contained in the HIPS TR.

III. Audit Objective

The objective of this audit was to witness the FAT of the pMPS. The NRC staff observed the hardware configuration of the prototype HIPS test specimen, and key performance characteristics of the pMPS. Observing the FAT assisted the NRC staff in confirming that the safety and key design requirements and features described in HIPS TR-1015-18653-P, Rev. 1.

IV. Scope of the Audit

The NRC staff witnessed the FAT of the pMPS. The FAT scope of the pMPS was limited to:

- Subset of hardware for a single separation group of the full MPS architecture.
- Subset of hardware for a single division of the full MPS architecture.
- Prototype Maintenance Workstation (MWS).
- Prototype Diagnostic Computer.
- Simulation of the MPS architecture and interfaces not covered above.

The NRC staff observed the following test cases:

- Demonstration of the operation of the internal and external serial communications for data exchange.
- Demonstration of the architecture operation in the maintenance modes.
- Demonstration of the architecture performance in terms of response time for the given functionality.
- Demonstration of the expected operation of the system under a specific sub-set of fault conditions.
- Demonstration of features of the diagnostic capability of the system.
- Demonstration that the system will limit fault propagation to one board, i.e., a fault on one board will not cause damage to another board.

The prototype MPS was built using one type of field-programmable gate array (FPGA) (i.e., flash-based FPGA). Thus, the scope of the FAT excluded the diversity capability of the HIPS platform.

V. Audit Activities and Summary of Findings

The regulatory audit began with an entrance meeting at 9:00 a.m. on Monday, January 30, 2017. At the entrance meeting, the NRC staff discussed the schedule of activities for the audit and the agenda. A number of Ultra Electronics staff members were introduced at the meeting, including Mr. Nick Gaines, who is the Managing Director for the Nuclear Controls Systems Group. Mr. Gaines provided a concise overview of Ultra Electronics' business sectors, with particular focus on their nuclear instrumentation and controls business. As part of the audit activities, Ultra Electronics representatives scheduled several facility tours for the NRC staff. The audit team was able to view multiple instrumentation and control components that have been used for nuclear plants and are still actively supported by Ultra Electronics.

Throughout the audit, the NRC staff held question-and-answer sessions with representatives of NuScale and Ultra Electronics to address NRC staff's questions while observing the test cases (see Section IV of this report). At the end of each day, the NRC staff provided interim status briefings for each day's activities and observations. On the last day of the audit, February 2, 2017, the NRC staff summarized all the audit activities and acknowledged that each objective in the audit plan had been addressed. In addition, the NRC staff communicated that there were no observations or new requests for additional information identified during this audit.

Below is a summary of the audit activities and results:

1. Design Goals: The design goals for the HIPS platform are to achieve 99-percent diagnostic coverage in accordance with International Electrotechnical Commission 61508, "Functional Safety"; and the NuScale MPS architecture to attain Safety Integrity Level (SIL) 4 certification. The external diagnostic capabilities of the MPS architecture will achieve SIL-2 certification.

2. System State Validation: This test case demonstrated the basic system state configuration of the pMPS. Rated accuracy of the simulation tool used in the FAT is 2-percent. Simulated input of 16.464 milliamps (mA) (77.9-percent of full span) indicated 78-percent of full span (16.48 mA) on the pMPS, whereas, simulated input pf 4.0 mA (0-percent of full span) indicated 0-percent of full span (4 mA) on the pMPS.

3. Manual Trip Validation: This test case demonstrated the manual trip capability of the pMPS.

4. Automatic Trip and EIM Voting Validation: This test case demonstrated the automatic trip capability of the pMPS.

5. Automatic Trip Determinism: This test case demonstrated the predictability and repeatability capability of the pMPS. This included a demonstration of the pMPS performance in terms of response time for the given functionality. The calculated response time of the pMPS configuration based on the methods described in HIPS TR is

51 milliseconds (ms). All of the test cases were successfully executed within the calculated response time of 51 ms. The tested response times of various test cases varied from 17 to 48 ms.

6. Hot Swap Capability: This test case demonstrated that all HIPS modules can be hot swapped from a powered chassis without damaging the module or the chassis. Each of the modules is physical and electronic key coded for a designated slot in the 19" rack chassis. An inadvertent plugging in of a HIPS module in a wrong chassis slot would result in a fault alarm.

7. Independence and Redundancy Capability: This test case demonstrated how the design concepts of independence and redundancy were applied to the pMPS. Furthermore, the NRC staff observed the communications independence interfaces within and outside the HIPS platform.

8. Diagnostic Comparison Capability: This test case demonstrated the diagnostics features of the pMPS. This included a demonstration of the automation sensor cross-check between the four separation groups of the measured sensor value.

9. Fault Condition Diagnostics: This test case demonstrated the diagnostic capability of the system by introducing fault conditions into the pMPS and demonstrating how the system correctly responds to the faults, reporting to the MWS, and for certain faults, failing over to a reversionary mode of operation. The communication module performs five different types of diagnostics: [

] All of these diagnostic capabilities were successfully demonstrated during this test.

VI. CONCLUSION

Based on the review of the test procedures and the observance of the test cases, the NRC staff concludes that the prototype test results provide reasonable assurance that the HIPS platform's design requirements and features described in HIPS TR-1015-18653-P, Rev. 1 conform to the claims made in the HIPS TR, which the NRC staff found in conformance with the applicable regulations and standards. The NRC staff will use the results of this audit to support staff's efforts to complete their safety evaluation report for the HIPS TR.

There were no open items or new RAIs identified during this audit.

VII. REFERENCES

1. Audit Plan for Factory Acceptance Testing of NuScale Prototype Highly Integrated Protection System Platform (ADAMS Accession No. ML16351A128).

2. NRO Office Instruction, NRO-REG-108, “Regulatory Audits,” Revision 0, April 2009.

3. NuScale Power, LLC, Ltd., Topical Report 1015-18653, "Highly Integrated Protection System Platform," December 2015 (ADAMS Accession No. ML15363A114).

4. NRC letter to NuScale, “Acceptance Letter for the Review of Topical Report 1015-18653, "Highly Integrated Protection System Platform" Revision 0, (PROJ. 0769),” February 19, 2016 (ADAMS Accession No. ML16048A135).

5. NRC letter to NuScale, “NRC Staff’s Report for the July 2016 Audit of NuScale’s Highly Integrated Protection System (HIPS) Platform (Project 0769),” August 1, 2016 (ADAMS Accession No. ML16208A427).

6. NRC, “Draft Safety Evaluation Report of NuScale Power, LLC Topical Report, entitled, Design of the Highly Integrated Protection System Platform (Project 0769),” January 6, 2017 (ADAMS Accession No. ML17006A131).

LIST OF ATTENDEES

Name	Title	Organization
Luis Betancourt	Electronics Engineer	U.S. Nuclear Regulatory Commission
Dinesh Taneja	Senior Electronics Engineer	U.S. Nuclear Regulatory Commission
Gregg Clarkson	Principle HIPS Designer	Rock Creek Innovations
Jason Porttof	Lead I&C Engineer	NuScale
Rufino Ayala	I&C Engineer	NuScale
Steven Pope	Licensing Project Manager	NuScale
Ashraf Sharaf	Independent Verification and Validation Engineer	NuScale
Nick Gaines	Managing Director, Nuclear Control Systems	Ultra Electronics
Gary Hawkins	Engineering Director, NCS	Ultra Electronics
Frank Charlesworth	Nuclear Safety Director, NCS	Ultra Electronics
Ben Cannon	pMPS Project Manager	Ultra Electronics
Martin Harrison	Chief Systems Engineer, NCS	Ultra Electronics
Alex Eichorn	Principal Systems, NCS	Ultra Electronics
Ian Chuter	Electronics Engineer	Ultra Electronics
Gary Meakin	Field Programmable Gate Array Designer	Ultra Electronics
Paul McKnight	Software Engineer – Management Workstation	Ultra Electronics
Sam Stacey	Systems Engineer – Simulator	Ultra Electronics
Tim Moul	Head of Quality	Ultra Electronics
Chris Wallace	Lead NQA-1 Auditor	Ultra Electronics