

**NUSCALE POWER, LLC**  
**HUMAN FACTORS ENGINEERING**  
**AUDIT SUMMARY REPORT**

**NRC Audit Team:**

- Paul Pieringer, Technical Reviewer, Audit Lead (NRO/DCIP/HOIB)
- Lauren Kent, Technical Reviewer, (NRO/DCIP/HOIB)
- Amy D'Agostino, Human Factors Analyst, (RES/DRA/HFRB)
- Rocky Foster, Project Manager (NRO/DNRL/LB1)

**I. Purpose**

Members of the U.S. Nuclear Regulatory Commission (NRC) staff <sup>1</sup> conducted an audit of human factors engineering (HFE) activities beginning March 29, 2016, and ending April 15, 2016. The NRC staff conducted the first part of the audit at NuScale Power, LLC (NuScale) Headquarters located in Corvallis, Oregon, and the second part of the audit at the NRC Headquarters located in Rockville, Maryland.

The purpose of the audit was to review the pre-engagement process that NuScale will use to validate its proposed control room staffing level and to determine the scope of HFE information that NuScale plans to submit with its application for a design certification (DC). During the audit, the NRC staff observed simulator scenarios and reviewed NuScale's procedures for validating its proposed staffing level.

The NRC staff conducted the audit in accordance with the guidelines in Office of New Reactors (NRO) Office Instruction NRO-REG-108 (Revision 0), "Regulatory Audits."

**II. Background and Audit Bases**

NUREG-0711, "Human Factors Engineering Program Review Model," states,

An implementation plan (IP) describes the applicant's proposed methodology for conducting an HFE element. The NRC staff reviews an IP methodology using the review criteria for the element provided in this document (NUREG-0711). The focus of the staff's review is to reasonably assure that the applicant's methodology will generate acceptable results that satisfy the NRC staff's review criteria.

In accordance with this guidance, NuScale submitted the following letters and HFE implementation plans to the NRC staff for review as part of pre-application activities:

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<sup>1</sup> NRC staff members Paul Pieringer, Lauren Kent and Amy D'Agostino conducted the audit.

1. A letter dated May 6, 2015, Mr. Zackary Rad, Manager, Licensing Support, NuScale submitted to the NRC, titled, "NuScale Power, LLC Submittal of Human Factors Engineering (HFE) Implementation Plans" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15139A214);
2. A letter dated August 6, 2015, Mr. Steven Mirsky, Manager, Licensing Washington, D.C., NuScale, submitted to the NRC, titled, "NuScale Power, LLC Submittal of a Second Set of Human Factors Engineering (HFE) Implementation Plans" (ADAMS Accession No. ML15223A042);
3. A letter dated September 15, 2015, Mr. Steven Mirsky, Manager, Licensing Washington, D.C., NuScale, submitted to the NRC, titled, "NuScale Power, LLC Submittal of NuScale Preliminary Concept of Operations Summary and Response to NRC Questions on Control Room Activities" (ADAMS Accession No. ML15258A846); and
4. A letter dated November 19, 2015, Mr. Steven Mirsky, Manager, Licensing Washington, D.C., NuScale, submitted to the NRC, titled, "NuScale Power, LLC Submittal of Human Factors Engineering Verification and Validation Implementation Plans, Revision 0" (ADAMS Accession No. ML15323A504).

As stated in NuScale's preliminary concept of operations summary listed above (No. 3), NuScale has assumed an initial control room staffing level of six licensed operators for a plant consisting of up to 12 reactor modules. This staffing level does not comply with the requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) 50.54(m). In accordance with Review Criteria 6.4(2) in NUREG-0711, the NRC staff uses the guidance in NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," and NUREG/CR 6838, "Technical Basis for Regulatory Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," to determine whether staffing levels that do not comply with 10 CFR 50.54(m) provide adequate assurance that public health and safety will be maintained at a level that is comparable to that afforded by compliance with 10 CFR 50.54(m). The method described in NUREG-1791, includes a staffing plan validation, which is an evaluation using performance-based tests to determine whether the staffing plan meets performance requirements and acceptably supports safe operation of the plant.

In a letter dated January 14, 2016, Mr. Frank Akstulewicz, Director, Division of New Reactors Licensing, NRC, to Mr. Thomas Bergman, Vice President, Regulatory Affairs, NuScale, titled, "NuScale Control Room Configuration and Staffing Levels," (ADAMS Accession No. ML15302A516) (i.e., the January 14<sup>th</sup> letter), the NRC staff stated that NuScale must submit an adequate technical basis for its proposed control room staffing as part of the DC application and that the NRC staff will use the guidance in NUREG-1791 to review it. The NRC staff reviewed the HFE implementation plans transmitted by the letters listed above (Nos. 1, 2, and 4) and determined that the staffing and qualifications (S&Q) IP did not contain sufficient detail to determine whether the method to validate NuScale's proposed staffing level conformed to guidance in NUREG-1791 or proposed an alternate method that would be comparable.

Additionally, NuScale submitted a letter dated June 30, 2015, Mr. Steven Mirsky, Manager, Licensing Washington, D.C., NuScale, submitted to the NRC, titled, "NuScale Power, LLC

Submittal of Proposed Scope of Human Factors Engineering Information in Design Certification Application” (ADAMS Accession No. ML15181A475). In the letter, NuScale stated that it would submit a technical report for the basic human-system interface (HSI) design element as well as an HSI design IP. In the January 14<sup>th</sup> letter, the NRC staff reiterated its expectation that NuScale submit a results summary report for the HSI design element with the DC application.

On February 8, 2016, the NRC staff held a public meeting with NuScale staff (the meeting summary is available at ADAMS Accession No. ML16060A221) to discuss the January 14<sup>th</sup> letter. During the meeting, NuScale discussed in greater detail the method that it will use to validate the proposed control room staffing levels. Specifically, NuScale discussed that it developed high-workload scenarios and that it will use test personnel to perform those scenarios in NuScale’s control room simulator to conduct the staffing plan validation. The NRC staff determined that it would be necessary to audit NuScale’s procedures for conducting the staffing plan validation and the scenarios to gain reasonable assurance that NuScale’s methodology will generate acceptable results that will satisfy the NRC staff’s review criteria. The NRC staff also determined that it would be necessary to verify that the NuScale control room simulator will be able to sufficiently model the scenarios for the staffing plan validation. Additionally, it was not clear to the NRC staff following the meeting whether NuScale intended to take credit for performing the scenarios used for the staffing plan validation in the verification and validation (V&V) HFE program element (i.e., whether NuScale intended to perform a phased validation).

During this public meeting, NuScale also provided more detail on the scope of information about the HSI design that will be submitted with the DC application; however, it was not clear to the NRC staff following the meeting what aspects of the HSI design would not be described in the DC application.

Accordingly, the NRC staff conducted the audit to resolve these technical issues.

### **III. Audit Objectives**

The audit objectives were as follows:

1. Verify the staffing plan validation methodology addresses guidance from NUREG-1791 or describes an alternate method that is comparable.
2. Verify scenarios effectively challenge workload for the proposed staffing configuration using guidance in Brookhaven National Laboratory (BNL) Technical Report 20918-1-2015, “Methodology to Assess the Workload of Challenging Operational Conditions In Support of Minimum Staffing Level Reviews” (i.e., the BNL Technical Report).
3. Verify through observing simulator scenarios that the simulator can effectively model the scenarios needed for the staffing plan validation.
4. Determine if and how phased validation is being used. Compare finding with what is in the V&V implementation plan for consistency.

5. Evaluate intended scope for the HSI design element. Will it be sufficient to satisfy a results summary report? If not, identify the deltas.

#### **IV. Scope of the Audit**

At NuScale's headquarters, NRC staff observed a demonstration of plant normal and abnormal evolutions and the application of NuScale's concept of operations in the control room simulator. Also, the NRC staff held discussions with NuScale operations and HFE staff<sup>2</sup> about the staffing plan validation method and the scope of information to be included in the HSI design element. Following this portion of the audit, the NRC staff performed a review at the NRC Headquarters of the following proprietary documents that NuScale provided for review in its electronic reading room:

- RP-1215-20253, "Control Room Staffing Plan Workload Analysis," Revision 0 (i.e., the Workload Analysis), and
- RP-0316-48456, "Control Room Staffing Plan Workload Scenario Overview," Revision 0 (i.e., the Scenario Overview).

Additionally, on April 1, 2016, NuScale submitted Revision 2 of the RP-0914-8538-P, "Human Factors Engineering Staffing and Qualifications Implementation Plan" (ADAMS Accession No. ML16092A286), which the NRC staff also reviewed during the audit period.

#### **V. Audit Activities and Summary of Findings**

To address audit objectives Nos. 1 and 2, the NRC staff compared the Workload Analysis and the Scenario Overview to the guidance in NUREG-1791, NUREG/CR-6838, and the BNL Technical Report. The NRC staff provided written comments to NuScale about the conformance of these documents to the guidance, and these comments are summarized below.

- The NRC staff provided some comments related to the method for sampling challenging operational conditions for the staffing plan validation. In general, the NRC staff found that the Workload Analysis described a method for sampling challenging operational conditions that is an alternative and comparable method to the method described in Section 3, "Review the Operational Conditions," of NUREG-1791. The NRC staff observed that this alternative method adds rigor to the sampling process. The NRC staff also noted that the sampling process provides for identification of licensed operator tasks that are associated with factors that are most likely to contribute to high workload as described in Section 1.2.2 of NUREG/CR-7190, "Workload, Situation Awareness, and Teamwork." The NRC staff also noted that in accordance with Section 3.2, "Applicant Submittals," of NUREG-1791, NuScale's DC application should provide a rationale for excluding operational conditions that could have been analyzed.

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<sup>2</sup> The NuScale staff members who participated in substantive discussions include the following: Timothy Tovar, Manager, Plant Operations; Shawn Jerrow, Supervisor, Plant Operations; Doug Bowman, Operations Engineer; Ross Snuggerud, Operations Engineer; Ryan Flamand, Operations Engineer; Jessica Stevens, Human Factors Engineer; and Kevin LaFerriere, Human Factors Engineer.

- NUREG/CR-6838 provides guidance on test controls, which includes ensuring that the personnel selected to perform the staffing plan validation do not know content of the scenarios before the test. The NRC staff provided comments related to this guidance.
- NUREG/CR-6838 provides guidance on the fidelity of a simulator that is used to perform a staffing plan validation. The NRC staff noted that NuScale's DC application should describe the fidelity of the simulator used to perform the staffing plan validation.
- The NRC staff noted that some of the data collection tools seemed to be more focused on assessing operator performance rather than on assessing workload.
- The NRC staff observed that the Workload Analysis and the Scenario Overview contained more detail than the S&Q IP. The NRC staff stated that the DC application will need to contain enough detail for the NRC staff to evaluate the results of the design work and make safety findings. The NRC staff will most likely need to review the results of the testing performed in accordance with NuScale's procedure RP-1215-20253, "Control Room Staffing Plan Workload Analysis" (i.e., the test reports described in Section 9.0, "Results/Conclusions").

To assess audit objective No. 3, the NRC staff observed a demonstration of the concept of operations, conduct of operations, and plant operation on the NuScale control room simulator. The NRC staff observed that the simulator modeled important plant indications and simulated a variety of normal and abnormal operations. The NRC staff observed that the module overview screens indicated changes in plant status; however, the displays on the operator consoles did not consistently provide the same indications. The NuScale staff stated that additional work must be done to develop the simulator for the staffing plan validation. Also, the NuScale staff stated that the control room simulator did not yet incorporate all applicable HFE guidelines (e.g., guidelines in NUREG-0700, "Human-System Interface Design Review Guidelines" for console dimensions).

With respect to audit objective No. 4, the NRC staff determined that the simulator is being used as an integral part of Control Room design development and testing. Simulator scenarios are used to validate proposed HFE design features, and this validation is more closely associated with a design testing program, as defined by NUREG-0711. Phased validation is a relatively new concept being developed by the HFE community as an alternate method for the integrated system validation (ISV). The NRC staff determined that a phased validation was not developed at this point in time to serve as an alternate method for the ISV.

The staff observed that using the simulator provided for a robust means of testing the HFE design.

With respect to audit objective No. 5, the NRC staff and NuScale staff discussed the scope of HSI design information to be provided with the DC application and the appropriate use of combined operating license (COL) information items as described in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Chapter 18, "Human Factors Engineering." NuScale documented the results of that discussion in a letter to the NRC dated April 8, 2016, titled, "NuScale Power, LLC Submittal of Response to NRC's letter, 'NuScale Control Room Configuration and Staffing Levels,'" January 14, 2016

(ADAMS Accession No. ML16099A270), which stated that it will submit a results summary report for the HSI design program element with the DC application.

The staff made the following additional observations:

- The NRC staff noted that the NuScale HFE and operations staff work together to develop the HSI and control room design. The NRC staff noted that the NuScale staff members have substantial HFE and operations experience.
- As described in the S&Q IP, NuScale uses a database program to track the results of its HFE design work. The NRC staff noted that the database program is a robust and comprehensive means for documenting HFE design work and for ensuring that the results of the HFE design work can be incorporated into training programs and procedures.
- The NRC staff observed that certain aspects of the HSI in the NuScale control room simulator provide for pattern recognition and will enable operators to readily identify trends in important plant parameters. The NRC staff observed that other aspects of the HSI may deviate from accepted HFE guidelines described in NUREG-0700. For example, the NRC staff noted that the font size for labels on the center overview screens were difficult to read from the operator consoles.
- It was not clear to the NRC staff following the audit which portions of the HSI were credited as the spatially dedicated and continuously available information (i.e., whether it is the information on the overview screens or the safety-related screens). The NRC staff noted that this should be clarified in NuScale's DC application.
- The NRC staff observed that the NuScale alarm response system includes a unique feature with respect to the audible portion of the alarm system. The NRC staff noted that it would be prudent to observe the use of this design feature during future site visits or to review the results of tests performed to evaluate this feature of the HSI.
- The NuScale design includes more automation than operating reactors. The NuScale staff had recently developed automation criteria and was in the process of applying that criteria in its HFE program.
- The NRC staff noted that because NuScale's design provides the ability to operate multiple modules from a single operating console, it will be important to describe in the DC application how the HSI will minimize personnel errors (e.g., performing the right action on the wrong module) and support error detection and recovery capability.
- The NRC staff noted that NuScale is in the process of finalizing some aspects of the concept of operations and conduct of operations that will be tested during the staffing plan validation. The following observations apply to the concept of operations and conduct of operations.
  - The NRC staff observed that the lead reactor operator, who is responsible for monitoring all units during steady state operations, may perform some tasks

before delegating responsibility for a module to another reactor operator during a transient. The NRC staff concluded that the set of tasks that the lead reactor operator is allowed to perform (i.e., tasks other than monitoring the modules) could be subject to his or her judgement and has not yet been defined.

- The NRC staff noted that if the lead reactor operator is not a licensed senior operator, then the responsibilities of the lead reactor operator should not require directing the licensed activities of the other licensed operators.

At the conclusion of the portion of the audit conducted at NuScale's Headquarters, the NRC staff conducted a closing briefing with NuScale's HFE and Operations staff that included a summary of the observations documented in this audit report. Following the NRC staff's review of the Workload Analysis, the Scenario Overview, and the S&Q IP, Revision 2, the NRC staff provided written comments to NuScale. NuScale did not request an additional closing briefing following its receipt of these comments.

## **VI. CONCLUSION**

In summary, by observing the NuScale control room simulator demonstration and reviewing the Workload Analysis and Scenario Overview with NuScale staff, the NRC staff completed the audit objectives. The NRC staff acknowledges that aspects of the concept of operations and HSI design were still evolving at the time of this audit. During the audit period, the NRC staff provided written comments to the NuScale staff on topics that should be clarified in the DC application to ensure that the acceptance criteria as listed in NUREG-1791 and NUREG-0711 are addressed.

## **VII. REFERENCES**

1. NRO Office Instruction NRO-REG-108, "Regulatory Audits," Revision 0, April 2009.
2. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Chapter 18, "Human Factors Engineering," Revision 2, March 2007.
3. NUREG-0711, "Human Factors Engineering Program Review Model," Revision 3, November 2012.
4. NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," July 2005.
5. NUREG/CR-6838, "Technical Basis for Regulatory Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," February 2004.
6. Brookhaven National Laboratory Technical Report 20918-1-2015, "Methodology to Assess the Workload of Challenging Operational Conditions In Support of Minimum Staffing Level Reviews," March 2015.