

July 14, 2016

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

FROM: Rocky D. Foster, Project Manager */RA/*  
Licensing Branch 1  
Division of New Reactor Licensing  
Office of New Reactors

SUBJECT: AUDIT PLAN FOR NUSCALE POWER, LLC PRE-APPLICATION  
ACTIVITIES HUMAN FACTORS ENGINEERING TOPICS (PROJ0769)

In an April 8, 2016, letter, Mr. Thomas A. Bergman, Vice President, Regulatory Affairs, NuScale Power, LLC (NuScale) submitted to the U.S. Nuclear Regulatory Commission (NRC), titled, "NuScale Power, LLC Submittal of Response to NRC's letter, 'NuScale Control Room Configuration and Staffing Levels,' January 14, 2016" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16099A270). In response to the April 8, 2016, letter, NRC staff issued audit report memorandum dated May 26, 2016, from Mr. Rocky D. Foster, Project Manager, NRC, titled, "U.S. Nuclear Regulatory Commission Audit Report To Review NuScale Power, LLC Pre-Application Activities Human Factors Engineering Topics (PROJ0769)" (ADAMS Accession No. ML16137A552) in support of NuScale pre-application activities.

The NRC will audit activities associated with the staffing plan validation in support of staff's review of the reduced staffing levels NuScale is proposing for the NuScale Small Modular Reactor Design. The audit will take place at the NuScale Power, LLC facility in Corvallis, Oregon, on August 16, 2016, through August 19, 2016. The audit plan is provided as Enclosure 1 and the audit plan detailed objectives information is provided as Enclosure 2.

CONTACT: Rocky D. Foster, NRO/DNRL  
301-415-5787

Project No.: PROJ0769

Enclosures:  
As stated

cc: DC NuScale Power LLC Listserv

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**ADAMS Accession No: ML16195A178**

**\*via email**

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**NuScale Power, LLC  
Human Factors Engineering Submittals  
Pre-Application Activities  
"Human Factors Engineering Topics" Audit Plan**

APPLICANT: NuScale Power, LLC

APPLICANT CONTACT: Steve Mirsky  
Steve Pope  
Tim Tovar, et al.

DATE: August 16, 2016, to August 19, 2016

LOCATION: NuScale Power, LLC Office  
1100 Circle Boulevard  
Corvallis, OR 97330

REVIEWERS: Paul Pieringer (NRO/DCIP/HOIB)  
Lauren Kent (NRO/DCIP/HOIB)  
Amy D'Agostino (RES/DRA/HFRB)  
Joe DeMarshall (NRO/DCIP/HOIB)  
Dinesh Taneja (NRO/DEIA/ICE)

PROJECT MANAGER: Rocky D. Foster (NRO/DNRL/LB1)

AUDIT OBJECTIVE:

The objective of the planned audit is to review detailed documents and simulator operations to:

1. Verify that the simulator configuration supports validation testing:
  - Review simulator testing results.
  - Review simulator deficiency list.

Regulatory Reference: NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," Part II, "Evaluation of Exemption Requests," Section 1.2, "Application Submittals," and NUREG-0711, "Human Factors Engineering Program Review Model," Section 11.4.3.3, "Validation Testbeds," Criteria 1-9.

2. Verify that the scenarios adequately address high workload conditions.

Regulatory Reference: NUREG-0711, "Human Factors Engineering Program Review Model," Section 11.4.1.2, "Identification of Scenarios."

3. Verify that the number of scenarios used sufficiently addresses workload scope.

Regulatory Reference: NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," Part II, "Evaluation of Exemption Requests," Section 3.3.1, "Operational Conditions Sampling for an Advanced Reactor Design," and NUREG-0711, "Human Factors Engineering Program Review Model," Section 11.4.1.1, "Sampling Dimensions."

4. Verify that the concept/conduct of operations is sufficiently defined. The U.S. Nuclear Regulatory staff (NRC) should understand the expected concept/conduct of operations prior to beginning validation observations.

Regulatory Reference: NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," Part II, "Evaluation of Exemption Requests," Section 2.2, "Applicant Submittals," and Section 8.3, "Review Criteria."

5. Verify that the concept/conduct of operations is consistently and appropriately exercised during the scenarios:

- Communications.
- Supervisory direction.
- Teamwork.

Regulatory Reference: NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," Part II, "Evaluation of Exemption Requests," Section 2.2, "Applicant Submittals," and Section 8.3, "Review Criteria."

6. Observe that the impact on human performance of operators having the ability to control multiple modules from a single operating console. Specifically, observe how the Human-System Interface (HSI) design minimizes personnel errors and supports error detection and recovery capability:

- Impact on workload of mouse-click vs touch screen to interface with the controls.

Regulatory Reference: NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," Part II, "Evaluation of Exemption Requests," Section 2.2, "Applicant Submittals," and Section 8.3, "Review Criteria."

7. Verify that the testing is conducted under appropriate controls (similar to the Integrated System Validation).

Regulatory Reference: NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," Part II, "Evaluation of Exemption Requests," Section 10, "Review the Staffing Plan Validation."

8. Verify that observers are used and are actively engaged in assessing the Control Room Design's capability to support operators in high work load conditions.

Regulatory Reference: NUREG-0711, "Human Factors Engineering Program Review Model," Section 11.4.3.6.3, "Training Test Personnel."

9. If possible, verify that problems identified are not inappropriately relegated to training or procedure improvements.

Regulatory Reference: NUREG-0711, "Human Factors Engineering Program Review Model," Section 11.4.4, "Human Engineering Discrepancy Resolution Review Criteria."

10. Verify that the data collection tools (e.g., surveys) conform to 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-7190, "Workload, Situation Awareness, and Teamwork."

Regulatory Reference: NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," Part II, "Evaluation of Exemption Requests," Section 10, "Review the Staffing Plan Validation."

11. Observe that the displays and control room layout in the simulator and compare to guidance in NUREG-0700, "Human-System Interface Design Review Guidelines," about font size, accessibility of displays, and spatially dedicated & continuously visible indications.

Regulatory Reference: NUREG-0700, "Human-System Interface Design Review Guidelines," Various Sections.

12. Observe that the use of unique HSI design features (e.g., features associated with the alarm response system) and any impacts on human performance.

Regulatory Reference: NUREG-0711, "Human Factors Engineering Program Review Model," Section 8.4.4, "HSI Detailed Design and Integration," and NUREG-0700, "Human-System Interface Design Review Guidelines," Various Sections.

13. Determine that the extent to which automation is used and observe impacts on human performance.

Regulatory Reference: NUREG-0711, "Human Factors Engineering Program Review Model," Section 8.4.5, "Degraded I&C and HSI Conditions," and Section 4, "Functional Requirements Analysis and Functional Allocation."

14. Observe how the lead operator turns over responsibility for a module to other operators and determine whether he/she is "directing" the activities of the other operators, which requires a Senior Reactor Operator license, or informing the other operators. If the latter, determine the role of the control room supervisor in this process.

Regulatory Reference: 10 CFR 55.4, "Operator Licenses; Definitions."

15. Observe that the extent and nature of the interconnection of the protection and control systems to ensure that this interconnection supports or enhances plant operations as related to operator interface.

Regulatory Reference: 10 CFR 50, Appendix A, General Design Criteria 24, "Domestic Licensing of Production and Utilization Facilities; General Design Criteria for Nuclear Power Plants; Separation of Protection and Control Systems."

#### REQUESTED MATERIAL FOR AUDIT:

Based on the proposed implementation plans and the preliminary concept of operations summary, staff plans to request that the following documentation be made available during the audit:

- Material associated with the performance of the staffing plan validation activity including forms used to collect information
- Scenario descriptions
- Style Guide
- Material associated with the concept and conduct of operations
- Material associated with simulator testing particularly the tests performed and the results of those tests
- List of current simulator deficiencies
- Summary level descriptions of the test participants' experience

**NuScale Power, LLC**  
**Human Factors Engineering Submittals**  
**Pre-Application Activities**  
**“Human Factors Engineering Topics” Audit Plan**  
**Detailed Objectives Information**

<p>1. Verify that the simulator configuration supports validation testing:</p> <ul style="list-style-type: none"> <li>• Review simulator testing results.</li> <li>• Review simulator deficiency list.</li> </ul>	<p><b>NUREG-1791, “Guidance for Assessing Exemptions Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m),” Part II, “Evaluation of Exemption Requests,” Section 1.2, “Application Submittals” and NUREG-0711, “Human Factors Engineering Program Review Model,” Section 11.4.3.3, “Validation Testbeds,” Criteria 1-9</b></p> <p>The request for exemption should include the following elements:</p> <ul style="list-style-type: none"> <li>▪ a description of the specific aspects of 10 CFR 50.54(m) from which an exemption is requested</li> <li>▪ a physical representation of the plant and systems involved</li> <li>▪ descriptions of plant/system responses to inputs and expected equipment response times</li> <li>▪ a detailed representation of the control room, control suites, and/or the Human-System Interface (HSI) to be used for monitoring and control actions</li> <li>▪ definitions of any new terms used or definitions of terms whose meanings are changed</li> <li>▪ information to meet the data requirements of subsequent review steps</li> </ul>
<p>2. Verify that the scenarios adequately address high workload conditions.</p>	<p><b>NUREG-0711, “Human Factors Engineering Program Review Model,” Section 11.4.1.2, “Identification of Scenarios”</b></p> <p>(1) The applicant should combine the results of the sampling to identify a set of V&amp;V scenarios to guide subsequent analyses.</p> <p><i>Additional Information:</i> A given scenario may combine many of the characteristics identified by sampling of operational conditions.</p>

<p>3. Verify that the number of scenarios used sufficiently addresses workload scope.</p>	<p><b>NUREG-1791, “Guidance for Assessing Exemptions Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m),” Part II, “Evaluation of Exemption Requests,” Section 3.3.1, “Operational Conditions Sampling for an Advanced Reactor Design”</b></p> <p>The reviewer should confirm that the following operational conditions were analyzed or that an adequate rationale for not analyzing the conditions was provided:</p> <ul style="list-style-type: none"> <li>▪ normal operational events, including plant startup, shutdown, or refueling, and significant changes in operating power</li> <li>▪ failure events, including instrument failures and HSI failures</li> <li>▪ transients and accidents</li> <li>▪ reasonable, risk-significant, and beyond-design-basis events, derived from the</li> <li>▪ plant-specific probabilistic risk assessment (PRA)</li> <li>▪ conditions that challenge plant safety functions as a result of interconnections and interactions among systems</li> </ul> <p>The reviewer should confirm that the following types of personnel tasks were included in the analysis:</p> <ul style="list-style-type: none"> <li>▪ risk-significant human actions</li> <li>▪ difficult tasks identified through the operating experience review</li> <li>▪ a range of procedure-guided tasks that are well defined by normal, abnormal, emergency, alarm response, and test procedures</li> <li>▪ a range of knowledge-based tasks that require greater reasoning about safety and operating goals and the various means of achieving them</li> <li>▪ a range of human cognitive activities, including decision-making</li> <li>▪ a range of human interactions, including tasks performed by individual control personnel and any tasks performed by personnel acting as a crew</li> <li>▪ tasks that are performed with high frequency</li> <li>▪ tasks that are important or difficult, but infrequently performed</li> </ul>
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	<p>The reviewer should confirm that the analysis included the following situational factors that are known to challenge human performance:</p> <ul style="list-style-type: none"> <li>▪ operationally difficult tasks</li> <li>▪ error-forcing contexts</li> <li>▪ high-workload conditions</li> <li>▪ varying-workload situations</li> <li>▪ fatigue and circadian factors</li> <li>▪ environmental factors</li> </ul> <p>Finally, the reviewer should confirm that the range and combination of operational conditions considered by the applicant are appropriate and adequate.</p> <p><b>NUREG-0711, “Human Factors Engineering Program Review Model,” Section 11.4.1.1, “Sampling Dimensions”</b></p> <p>(3) The applicant should include the following situational factors or error-forcing contexts known to challenge human performance. It also should include situations specifically designed to create human errors to assess the system’s error tolerance, and the ability of personnel to recover from any errors, should these occur, for example:</p> <ul style="list-style-type: none"> <li>• <i>High-Workload Situations</i> – The sample should include situations where variations in human performance due to high workload and multitasking situations can be assessed.</li> <li>• <i>Varying-Workload Situations</i> – The sample should include situations wherein variations in human performance due to workload transitions can be determined. These include conditions where there is <ul style="list-style-type: none"> <li>(1) a sudden increase in the number of signals that must be detected and processed after a period in which signals were infrequent, and (2) a rapid reduction in the need for detecting signals and processing demands following a time of high sustained task-demand.</li> </ul> </li> </ul>
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	<ul style="list-style-type: none"> <li>▪ <i>Fatigue Situations</i> – To the extent possible, the sample should include situations that may be associated with fatigue, such as work on backshifts and tasks performed frequently with repetitive actions, such as repeated inputs to a touch screen during plant operations or pulling rods.</li> <li>▪ <i>Environmental Factors</i> – To the extent possible, the sample should include environmental conditions that may cause human performance to vary, e.g., poor lighting, extreme temperatures, high noise, and simulated radiological contamination.</li> </ul>
<p>4. Verify that the concept/conduct of operations is sufficiently defined. Staff should understand the expected concept/conduct of operations prior to beginning validation observations.</p>	<p><b>NUREG-1791, “Guidance for Assessing Exemptions Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m),” Part II, “Evaluation of Exemption Requests,” Section 2.2, “Applicant Submittals” and Section 8.3, “Review Criteria”</b></p> <p>The concept of operations should describe the following elements:</p> <ul style="list-style-type: none"> <li>▪ the primary design and operating characteristics of the plant or system and the specific staffing goals and assumptions necessary to implement the concept of operations</li> </ul>

<p>5. Verify that the concept/conduct of operations is consistently and appropriately exercised during the scenarios:</p> <ul style="list-style-type: none"> <li>• Communications</li> <li>• Supervisory direction</li> <li>• Teamwork</li> </ul>	<ul style="list-style-type: none"> <li>▪ the number of personnel who will have plant monitoring and operational control responsibilities on each shift (i.e., “control personnel”) and staffing levels for these personnel across shifts</li> <li>▪ the roles and responsibilities of each individual designated as control personnel, if that individual is responsible for control and monitoring plant or unit operations</li> <li>▪ the training and qualifications required for control personnel.</li> <li>▪ the overall operating environment and primary HSIs to be used by control personnel</li> <li>▪ the interaction of control personnel with automated systems, including responsibilities for monitoring, operating, and overriding automated systems</li> </ul>
<p>6. Observe that the impact on human performance of operators having the ability to control multiple modules from a single operating console. Specifically, observe how the HSI design minimizes personnel errors and supports error detection and recovery capability:</p> <ul style="list-style-type: none"> <li>• Impact on workload of mouse-click vs touch screen to interface with the controls</li> </ul>	<ul style="list-style-type: none"> <li>▪ the interaction of control personnel with automated support systems and the role of these</li> <li>▪ systems in the overall management and control of the plant</li> <li>▪ other mechanisms that enable or support control personnel responsibilities for monitoring, disturbance detection, situation assessment, response planning, response execution, and the management of transitions between automatic and manual control</li> <li>▪ the interactions of control personnel with each other and with people not directly responsible for the control and safe operation of the plant</li> <li>▪ multi-unit operations</li> <li>▪ modular unit operations</li> <li>▪ operations during construction of additional units</li> </ul>
<p>7. Verify that the testing is conducted under appropriate controls (similar to the Integrated System Validation).</p>	<p><b>NUREG-1791, “Guidance for Assessing Exemptions Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m),” Part II, “Evaluation of Exemption Requests,” Section 10, “Review the Staffing Plan Validation”</b></p>
<p>8. Verify that observers are used and are actively engaged in assessing the Control Room Design’s capability to support operators in high work load conditions. Does the design really work?</p>	<p><b>NUREG-0711, “Human Factors Engineering Program Review Model,” Section 11.4.3.6.3, “Training Test Personnel”</b></p> <p>(1) The applicant should train test personnel (those who conduct or administer the validation tests) on the following:</p>

	<ul style="list-style-type: none"> <li>▪ the use and importance of test procedures</li> <li>▪ bias and errors that test personnel may introduce into the data through failures to follow test procedures accurately or to interact with participants properly</li> <li>▪ the importance of accurately documenting problems arising during testing, even if they were due to an oversight or error of those conducting the test</li> </ul>
<p>9. If possible, verify that problems identified are not inappropriately relegated to training or procedure improvements.</p>	<p><b>NUREG-0711, “Human Factors Engineering Program Review Model,” Section 11.4.4, “Human Engineering Discrepancy Resolution Review Criteria”</b></p>
<p>10. Verify that the data collection tools (e.g., surveys) conform to guidance in NUREG-1791, “Guidance for Assessing Exemptions Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m),” and NUREG/CR-7190, “Workload, Situation Awareness, and Teamwork.”</p>	<p><b>NUREG-1791, “Guidance for Assessing Exemptions Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m),” Part II, “Evaluation of Exemption Requests,” Section 10, “Review the Staffing Plan Validation”</b></p>
<p>11. Observe that the displays and control room layout in the simulator and compare to guidance in NUREG-0700, “Human-System Interface Design Review Guidelines,” about font size, accessibility of displays, and spatially dedicated &amp; continuously visible indications.</p>	<p><b>NUREG-0700, “Human-System Interface Design Review Guidelines,” Various Sections</b></p>
<p>12. Observe that the use of unique HSI design features (e.g., features associated with the alarm response system) and any impacts on human performance.</p>	<p><b>NUREG-0711, “Human Factors Engineering Program Review Model,” Section 8.4.4, “HSI Detailed Design and Integration”</b></p> <p>In particular, Section 8.4.4.2, “Main Control Room,” which contains required indications. SPDS guidance addresses unique design features.</p>

	<p><b>NUREG-0700, “Human-System Interface Design Review Guidelines,” Various Sections</b> contains general functional requirement for HSI (such as the alarm system) that should be used to assess unique design features.</p>
<p>13. Determine that the extent to which automation is used and observe impacts on human performance.</p>	<p><b>NUREG-0711, “Human Factors Engineering Program Review Model,” Section 8.4.5, “Degraded I&amp;C and HSI Conditions,” and Section 4, “Functional Requirements Analysis and Functional Allocation”</b></p> <p>Criteria 5:  (5) Applicants should allocate functions to a level of automation (e.g., from manual to fully automatic) and identify the technical bases for the allocations.</p> <p>Additional Information: The technical basis for the FA can be any one or combination of the factors (see Figure 4-2). For example:</p> <ul style="list-style-type: none"> <li>▪ Functions, or parts of them, may be allocated based on operating experience. Successful operating experience may suggest keeping allocations the same as in predecessor designs and operating experience issues may suggest changing the allocations to address the issues.</li> <li>▪ Functions, or parts of them, may be allocated to automation when their performance requirements exceed human capabilities and human error is likely. Conditions that establish a basis for automation (assuming the acceptability of other factors, such as technical feasibility or cost) include when the required response time is very short, when an action has to be performed repeatedly, or when very precise control is required.</li> <li>▪ Functions, or parts of them, should be allocated to personnel when human knowledge and judgment is needed to ensure reliable function performance, it is important to keep personnel involved in the actions so they have good situation awareness should they need to perform the function, or to preclude boredom.</li> </ul>

<p>14. Observe how the lead operator turns over responsibility for a module to other operators and determine whether he/she is “directing” the activities of the other operators, which requires a Senior Reactor Operator license, or informing the other operators. If the latter, determine the role of the control room supervisor in this process.</p>	<p><b>10 CFR 55.4, “Operator Licenses; Definitions”</b></p>
<p>15. Observe that the extent and nature of the interconnection of the protection and control systems to ensure that this interconnection supports or enhances plant operations as related to operator interface.</p>	<p><b>10 CFR 50, Appendix A, General Design Criteria 24, “Domestic Licensing of Production and Utilization Facilities; General Design Criteria for Nuclear Power Plants; Separation of Protection and Control Systems”</b></p> <p>DI&amp;C-ISG-04, “Highly-Integrated Control Room – Communication Issues,” Staff Position 1.3, “A safety channel should not receive any communication from outside its own safety division unless that communication supports or enhances the performance of the safety function.”</p>