December 17, 2020 Project No. 99902078

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

**SUBJECT:** NuScale Power, LLC Submittal of "Revised Staffing Plan Validation Test Report," RP-0419-65209, Revision 2

NuScale Power, LLC (NuScale) hereby submits Revision 2 of the “Revised Staffing Plan Validation Test Report,” (RP-0419-65209).

Enclosure 1 contains the proprietary version of the report entitled “Revised Staffing Plan Validation Test Report," Revision 2. NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The enclosed affidavit (Enclosure 3) supports this request. Enclosure 2 contains the nonproprietary version of the report entitled “Revised Staffing Plan Validation Test Report.”

This letter makes no regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions, please feel free to contact Jim Osborn at 541-360-0693 or at JOsborn@nuscalepower.com.

Sincerely,

Director, Regulatory Affairs
NuScale Power, LLC

Distribution: Michael Dudek, NRC
Bruce Bavol, NRC
Getachew Tesfaye, NRC

Enclosure 1: “Revised Staffing Plan Validation Test Report," RP-0419-65209-P, Revision 2, (proprietary version)
Enclosure 2: “Revised Staffing Plan Validation Test Report," RP-0419-65209-NP, Revision 2, (nonproprietary version)
Enclosure 3: Affidavit of Carrie Fosaaen, AF-1220-73412

**Enclosure 1:**

“Revised Staffing Plan Validation Test Report" RP-0419-65209-P, Revision 2, (proprietary version)

**NuScale Power, LLC**
1100 NE Circle Blvd., Suite 200 Corvallis, Oregon 97330 Office 541.360-0500 Fax 541.207.3928
www.nuscalepower.com

**Enclosure 2:**

“Revised Staffing Plan Validation Test Report" RP-0419-65209-NP, Revision 2, (nonproprietary version)

# Revised Staffing Plan Validation Test Report

November 2020

Revision 2

Docket No. 99902078

**NuScale Power, LLC**

1100 NE Circle Blvd., Suite 200

Corvallis, Oregon  97330

www.nuscalepower.com

## Department of Energy Acknowledgement and Disclaimer

This material is based upon work supported by the Department of Energy under Award Number DE-NE0008928.

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

**CONTENTS**

## TABLES

## Abstract

This report describes the results of revised staffing plan validation (RSPV) testing performed to evaluate licensed operator workload in challenging, high-workload situations within a NuScale 12-module control room environment. Testing was performed to validate with a high level of confidence that the cognitive workload, situational awareness, and task completion times associated with safely operating a 12-module facility remained acceptable for a three-person licensed operator crew.

An RSPV was conducted using guidance in NUREG-0800 Chapter 18, NUREG-0711, SECY-11-0098, NUREG-1791, NUREG/CR-6838 and methodology used for the staffing plan validation. The validation included performance-based tests, using test operators in a simulator. Validation focused on operator performance, workload, and situational awareness during challenging plant operating conditions, such as design-basis events, beyond-design-basis events, and multi-NuScale Power Module events. This analysis employed an alternative approach to control room staffing in lieu of 10 CFR 50.54(m).

The results of the analysis confirm that up to 12 NuScale Power Modules and the associated plant facilities may be operated safely and reliably by a minimum staffing contingent of two licensed reactor operators and one licensed senior reactor operator from a single control room during high-workload conditions.

## Executive Summary

- NuScale conducted a high-workload, performance-based, revised staffing plan validation (RSPV) to provide assurance that a three-person, licensed operator control room staff is sufficient to safely operate a multi-unit NuScale Power Plant. The testing was performed in the simulator in Corvallis, Oregon.
- Validation testing was performed from May 20-24, 2019.
- Two independent, three-person crews were assembled. Information on validation scenarios was not shared with the crew participants before the testing.

The crew members were all previous participants in the integrated system validation (ISV) testing. Through the ISV training program, they were trained in basic, fundamental operation of the safety systems and applicable support systems. The participants also received training on human-system interface (HSI) navigation, conduct of operations, and administrative tasks. Each participant had completed ISV testing and drew on their operating experience with nuclear power plant fundamentals and control room etiquette. Participants were trained on the specific changes made to the HSI following ISV and were allowed time to regain proficiency in plant operations through simulator practice.

Each of the two crews performed three challenging, high-workload scenarios. The two crews completed a total of six tests. The scenarios required meeting pass/fail acceptance criteria to ensure safe plant operation and to meet operator assumptions within the plant design. Additionally, diagnostic criteria were used to identify potential lower level issues. All acceptance criteria were met during scenario testing, therefore no additional retesting or validation was required and no additional validation was necessary.

The required tasks were performed within the times established by the scenario acceptance criteria with margin. Diagnostic criteria were used to identify potentially high-workload tasks with a holistic approach using convergence of measured results. For example, the task load index (TLX) data collection methodology and the data analysis approach used were designed to identify potential high workload by examining deviations in data with less emphasis on absolute value. This was done so even small deviations at low workload levels would be identified. When workload met predetermined criteria, other tools such as direct questioning, observations, and self-critiques were used to validate or gather further evidentiary information. Actual or perceived level of workload and stress were related to the impact on performance. Testing analysis concluded that a three-person crew could safety operate up to 12 NuScale Power Modules and meet all required acceptance criteria with margin. The results demonstrated in this report were obtained using the methodology described in the Control Room Staffing Plan Validation Methodology (Reference 12.1.14) used in the previous staffing plan validation.

The RSPV demonstrated that three licensed operators, one control room supervisor (CRS) and two reactor operators (ROs), are sufficient to protect public health and safety while operating a 12–module NuScale Power Plant from a single control room.

The remaining on-shift operations crew consisted of four non-licensed operators (NLOs). The NLOs and support staff were not evaluated by this process, although the number of NLOs and their use was tracked during scenarios to include the workload of managing those resources. The results from this testing would not preclude one or both ROs being qualified at a senior reactor operator level.

Testing concluded that three licensed operators can safety operate a NuScale Power Plant while maintaining public health and safety during very high-workload, beyond-design-basis events. No discrepancies were identified that warranted being entered into the NuScale corrective action program. No Priority 1 human engineering discrepancies (HEDs) were identified. Some discrepancies were identified and categorized as improvements to the process, HSI, procedures, or conduct of operations (category priority 2 or 3). The identified HEDs were documented within the human factors engineering issue tracking system (HFEITS).

# 1.0 Introduction

## 1.1 Purpose

This report describes the results of revised staffing plan validation (RSPV) testing performed to evaluate licensed operator workload in challenging high-workload situations within a NuScale Power, LLC (NuScale) 12-module main control room (MCR) environment. Testing was performed to provide a high level of confidence that the cognitive workload, situational awareness, and task completion time demands associated with operating a 12-module NuScale Power Plant (NPP) were not excessive for a three-person licensed operator control room crew.

Testing was conducted in accordance with Control Room Staffing Plan Validation Methodology, (Reference 12.1.14). This report provides empirical evidence that the tested control room staffing levels are acceptable.

## 1.2 Scope

This document provides the results from testing to validate that a minimum control room staffing of three licensed operators can safely operate a 12-module NPP. The testing shows that the anticipated highest-workload conditions of a NPP are represented by the selected high-workload scenarios and by using participants representative of operators that would complete initial license training. The testing was limited to licensed control room operator staff positions and did not evaluate non-licensed operators (NLOs) or support staff.

## 1.3 Abbreviations and Definitions

Table 1-1 Abbreviations

| Term | Definition |
|---|---|
| ATWS | anticipated transient without scram |
| CFDS | containment flooding and drain system |
| CFR | Code of Federal Regulations |
| CIS | containment isolation system |
| CNV | containment vessel |
| CRS | control room supervisor |
| CVCS | chemical and volume control system |
| DCRM | Document Control and Records Management |
| DHRS | decay heat removal system |
| EAL | Emergency Action Level |
| ECCS | emergency core cooling system |
| EDSS | highly reliable DC power system |
| FSAR | Final Safety Analysis Report |
| HED | human engineering discrepancy |
| HFE | human factors engineering |
| HFEITS | human factors engineering issue tracking system |

| Term | Definition |
|---|---|
| HSI | human-system interface |
| IHA | important human action |
| ISV | integrated system validation |
| LOCA | loss-of-coolant accident |
| LTOP | low temperature overpressure system |
| MCR | main control room |
| MCS | module control system |
| MPS | module protection system |
| MSLB | main steam line break |
| NLO | Non-licensed operator |
| NRC | Nuclear Regulatory Commission |
| OE | operating experience |
| PRA | probabilistic risk assessment |
| RCS | reactor coolant system |
| RO | reactor operator |
| RSPV | revised staffing plan validation |
| RTS | reactor trip system |
| RXB | Reactor Building |
| SBT | scenario-based testing |
| SGTF | steam generator tube failure |
| SM | shift manager |
| SME | subject matter expert |
| SRO | senior reactor operator |
| STA | shift technical advisor |
| TLX | task load index (NASA) |
| UHS | ultimate heat sink |
| WCC | work control center |

Table 1-2 Definitions

| Term | Definition |
|---|---|
| Observer | A person who has experience in critical observations and has completed specific observation training. Observers as a group applied their human factors engineering (HFE) and operations expertise to the assessment of validation activities. |
| Independent observer | A person who has completed the NuScale HFE/Operations initial company training program and has had no involvement in NuScale control room design decisions. |

| Term | Definition |
|---|---|
| Operations subject matter expert (SME) | A person who has completed the NuScale HFE/Operations initial company training program, has previous licensed operating nuclear plant experience, and has performed task analysis or NuScale system reviews such that they are familiar with the NuScale plant design. |
| Participant | A person who has been selected as a control room operator to perform validation exams. This person has not been involved in the plant design and has no knowledge of the validation scenarios prior to test performance. |
| Scenario guide | A document that describes the initial conditions, sequence of events, and evaluation criteria that are used in simulator testing of participants. |
| Simulator | A facility constructed to model as close as practical the actual NuScale design control room. NUREG-0711 uses the term “validation testbed” to describe the area in which the human-system interface (HSI) is displayed for performance evaluations. Within this document the testbed is referred to as the simulator. |
| Simulator operator (booth operator) | A person assigned to operate the simulator or to provide outside support to the performance of validation testing. Simulator operators may act as plant personnel to role-play interactions or to inject and control the scenario inputs as directed by the scenario guides. |
| Validation Team | A team consisting of test administrators, Operations observers, HFE observers, and simulator operators. The Validation Team does not include test participants. |

# 2.0 Revised Staffing Plan Validation Results Overview

## 2.1 General

The RSPV testing was conducted during May 20-24, 2019. The overall conclusion of the testing is the NuScale control room design and staffing plan of three licensed MCR operators supports safe operation of the NPP. Performance measures with a low threshold were used to ensure low plant safety risk issues were identified and addressed before becoming potential nuclear safety issues. Individual performance measures were analyzed and categorized into human engineering discrepancies (HEDs). {{ }}$^{2(a),(c)}$ HEDs were identified, but none had a direct or indirect adverse impact on plant safety or resulted in a cross-cutting issue that adversely affected plant safety.

A shift staffing level of three licensed operators is appropriate and demonstrates that all tasks observed in a comprehensive sample of high-workload operational conditions can be performed. The tested validation crew compliment was three control room personnel acting as a combined control room supervisor (CRS)/shift manager (SM) and two reactor operators (ROs). The ROs could be licensed at either the RO or SRO qualification level.

The HSI design is adequate in alerting, informing, and controlling evolutions as demonstrated by the high-workload sample of operational conditions. The primary method for operators to monitor and perform actions for safe plant operation is through the use of safety functions. The safety functions are monitored automatically, and operators confirm indications and perform actions based on safety function indications. The ability to use and understand safety function indications and emergency procedures resulted in the crew being able to prioritize and to take appropriate actions in high-workload situations.

Personnel tasks that are credited by probabilistic risk assessment (PRA) in the NuScale design to mitigate core damage or large releases were completed within {{ }}$^{2(a),(c)}$ of the time allowed. This provides a large margin {{ }}$^{2(a),(c)}$ of being successful. Other tasks performed for plant safety, personnel protection, or equipment protection were completed in all cases within the time allowed through analysis. Overall average workload was very low with a rating of {{ }}$^{2(a),(c)}$ on a 0-100 scale, and overall average situational awareness was very high at {{ }}$^{2(a),(c)}$ percent.

Occasionally, minor human performance errors were observed during validation testing, but not one occurrence was observed of an incorrect component actually being manipulated. Errors were concentrated in communication and administrative issues with minor lapses in conduct of operations standards. This demonstrates that the HSI helps prevent errors, and when they occur it is easy to detect and recover.

Important human actions (IHAs) were performed within {{ }}$^{2(a),(c)}$ percent of the allowed time.

Operating procedures are incorporated within the HSI and seamlessly allow operators to transition between procedures and controls. Improvement opportunities were identified and captured as HED-proposed resolutions.

Additional overview information of validation testing included:

- {{

  }}2(a),(c)

## 2.2 Acceptance Criteria

- Meet {{ }}2(a),(c) listed acceptance criteria within the times specified in the scenario guides.
- Complete credited IHAs within {{ }}2(a),(c) percent of the time allowed.

## 2.3 Diagnostic Measures

- Overall workload as measured by NASA task load index (TLX) was reported to be moderate to low in every scenario. All crew members had comparable workload scores.
- {{ }}2(a),(c) discrete NASA TLX workload data points were collected. The average rating of all crew members over the testing period was {{ }}2(a),(c) on a 0-100 scale.
- {{ }}2(a),(c) individual situational awareness questions were asked of each participant which resulted in {{ }}2(a),(c) collected responses. All individuals scored {{ }}2(a),(c) percent or higher.
- {{ }}2(a),(c) participant comments were recorded from post scenario critiques.
- {{ }}2(a),(c) observer comments were recorded from post scenario critiques.

## 3.0 Scenario Development

High-workload scenarios were developed to test and evaluate the revised staffing plan to determine if plant personnel could successfully meet plant safety and operational goals. The scenarios were developed using the following inputs:

- {{

}}2(a),(c)

## 3.1 Scenario Construction

{{

}}2(a),(c)

The scenarios were then developed being informed by the {{ }}2(a),(c) Details were added to support scenario tasks and acceptance criteria was applied based on timing criteria used during integrated system validation (ISV) testing. NUREG-0711 provides a list of sample conditions that were referenced with the goal of including {{ }}2(a),(c) percent of the listed conditions within all {{ }}2(a),(c) scenarios in total.

Table 3-1 illustrates how the test scenarios compare to the test plan development goals.

Table 3-1 {{ }}2(a),(c)

{{

}}2(a),(c)

Table 3-2 illustrates how each of the test scenarios contain an event that correlates to operating conditions listed in NUREG-0711.

Table 3-2 {{ }}2(a),(c)

{{

}}2(a),(c)

In addition to the test plan and sample conditions, NUREG-0711 contains other guidance on scenario development that was incorporated into the test scenarios:

- Scenarios should not always result in positive outcomes.
- Scenarios should not be avoided because they are demanding to set up and run on a simulator.

- Scenarios should not all be familiar and well-structured to be highly compatible with plant procedures (e.g., textbook response to DBAs).
- Outside the control room, actions should be simulated to real time (e.g., time to don protective clothing, obtain sample, etc.).

## 3.2 Scenario Descriptions

The test scenarios were implemented through the use of detailed scenario guides. These guides not only describe the scenario, but also provide the following information used by the test lead and simulator operators:

- Pass/fail acceptance criteria
- Simulator initial conditions
- Turnover information to the crew members
- List of cues that are provided during the scenario
- Expected plant responses
- Specific individual event evaluation criteria
- Event continuation criteria

In some instances events occur concurrently, and in others events are in sequence. The event continuation criteria lists what conditions must occur for the next event to proceed.

The following lists the scenarios, a brief description, the events, and the acceptance criteria for each:

### 3.2.1 {{ }}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

### 3.2.2 {{ }}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

### 3.2.3 {{ }}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

### 3.3 Scenario Assumptions

Many administrative programs that fall under the responsibility of the licensee, such as those to develop and control work orders and clearance orders, were simulated for the validation scenarios. Additionally, this RSPV was limited to licensed operator tasks in the MCR. Certain assumptions were incorporated into testing scenarios. The following major assumptions were incorporated:

- {{

}}2(a),(c)

{{

}}2(a),(c)

### 3.4 Scenario-Based Testing

This testing is done to confirm the simulator performs acceptably prior to administering a performance-based simulator scenario test. Scenario-based testing (SBT) is an integrated test methodology used to collect and analyze data to ensure the simulator adequately models the NPP design. Scenario-based testing was performed in accordance with OP-0504-50019, Simulator Scenario-Based Testing Procedure (Reference 12.1.10).

Individual SBT packages were assembled for each scenario following many iterative rounds of testing. Each scenario was pilot tested in real time with staff crews that had no knowledge of the scenario. Feedback from pilot testing was incorporated before performing the final, documented SBT. The SBT was performed using the final version of procedures, the final version of the scenario, and the simulator configuration that was used to conduct validation testing.

Scenario-based testing was performed on each scenario and included observing plant performance and operator response to ensure the plant behavior is consistent with design assumptions. The assembled SBT test results package includes the following sections:

- Scenario Overview Description
- Scenario Based Testing Checklist
- Notification Summary (lists alarms and cautions received during the scenario)
- Process Event Report (lists the procedures and automations started and completed)
- Monitored Parameter Summary (graphs of important parameters for units in transient conditions)
- Primary Procedures used in Scenario (actual procedures used by crew members during testing)
- Scenario Guide (used to conduct testing)

NuScale Document Control and Records Management (DCRM) maintains the SBT test results package.

Each SBT test package is a stand-alone, approved document. Table 3-3 lists the document number and title for reference.

Table 3-3 {{ }}2(a),(c)

{{

}}2(a),(c)

The results of the SBT determined that each scenario was acceptable for testing based on passing the following criteria:

- The simulator was able to perform all actions required to demonstrate task performance as described in the scenario guide.
- The simulator displayed the correct initial conditions as described in the scenario guide and conformed to plant design with respect to reactor status, plant configuration, and system operation.
- Plant maneuvers and automation sequences were performed in real time. Administrative tasks and communications were performed in real time during pilot testing, but condensed during SBT data collection when they did not result in an observable change to a key parameter (e.g., no time allotted for pre-job briefs or discussion that would be expected during test performance).
- The simulator demonstrated expected plant responses to operator input and to normal, transient, and accident conditions.
- The simulator permitted use of the plant procedures so that the scenario was completed without procedural exceptions, simulator performance exceptions, or deviation from the scenario sequence.
- The simulator did not fail to actuate an expected alarm or automatic action and did not cause an unexpected alarm or automatic action.
- The observable change in simulated parameters corresponded in trend and direction to those expected from best-estimate response of the reference plant.
- Plant design limitations were not exceeded.
- The simulator modeled the expected plant response for each scenario malfunction.
- Scenario-based testing conducted in a manner sufficient to ensure that simulator fidelity has been demonstrated for this scenario.
- Modeling and hardware discrepancies identified during the conduct of SBT were documented.

There were no discrepancies identified during the performance of SBT that required changes prior to the start of testing.

## 4.0 Operating Crew Overview

{{

}}2(a),(c)

The crew members demonstrated that they were appropriately critical and effectively used all methods of feedback. None of the crew participants demonstrated a bias that would impact the test results either positively or negatively.

## 4.1 Crew Biographies

### 4.1.1 {{ }}2(a),(c)

{{ }}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

### 4.1.2 {{ }}2(a),(c)

{{ }}2(a),(c)

{{

}}2(a),(c)

## 4.2 Operating Crew Participant Training

Operating crew participant training is required to ensure crew members have sufficient knowledge of the NuScale plant design, plant controls, and conduct of operations to interact with the HFE design in the same manner as experienced plant personnel. {{

}}2(a),(c)

### 4.2.1 Simulator Familiarization

The crew performed {{ }}2(a),(c) training scenarios {{

}}2(a),(c) The following training scenarios were used to allow the crews to become comfortable performing as a crew and regaining proficiency {{ }}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

### 4.2.2 Crew Readiness Assessment

{{

}}2(a),(c)

{{

}}2(a),(c) Crew competency was determined to be acceptable to continue with this RSPV testing at the conclusion of the crew readiness assessment based on observation of crew performance.

## 4.3 Scenario Security Overview

The following actions were taken to prevent compromising exam security.

- Electronic files associated with RSPV scenarios were only stored on one local computer hard drive and not placed in any shared network area. Only one individual and IT had access to this specific computer.
- Printed copies of scenario information were printed only on an as-needed basis. Printed copies were made the day before each validation test and were kept in a locked cabinet until used the next day. This minimized the time printed copies were available.
- Printed copies of RSPV scenario information were marked with a red watermark "RSPV EXAM – RESTRICTED" and a red border.
- The simulator and simulator control booth have electronically locked doors. The access to either of these two areas was restricted and not allowed to RSPV participants.
- Physical proximity also was used as a method of protecting exam security. Only the simulator and simulator control booth located adjacent to the simulator were used to view or store printed scenario material. The doors to these areas were closed with posted signs stating, "Testing in Progress – AUTHORIZED PERSONNEL ONLY" in red with a red border.
- The McKenzie conference room has one-way-mirrored glass to view the simulator. The shades to block this view were fully lowered at all times.
- Classroom training was provided to observers and participants on how to spot RSPV exam material and what actions to take if material was found unattended.
- The same scenario was performed by both crews on the same day with only a short interval between one crew completing and another crew performing the scenario.
- No issues of potential or actual scenario exam security were identified throughout the testing process.

## 5.0 Observation Team Overview

An observation team of four individuals was assigned to each validation test. A total of {{ }}2(a),(c) were selected to act as the available observer group.

The observation team for each validation test consisted of

- {{

}}2(a),(c)

The purpose of two observers in the same functional area allows for collaboration and overlap of observations, and provides a degree of inter-rater reliability.

NUREG-0711 Section 11.4.3.1 states, "The applicant should describe how the team performing the validation has independence from the personnel responsible for the actual design." Independence is met by not having been involved in the design, development, or testing of the HFE program, HSI, or concept of operations prior to the start of RSPV testing.

{{

}}2(a),(c)

### 5.1 {{ }}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

## 5.2 Observation Team Training

Observer training was completed to ensure each observer specifically understood the goals of validation testing and the role each plays in providing insightful observations. Observers completed classroom training on April 30, 2019, covering the following topics:

- {{

}}2(a),(c)

Each HFE observer completed electronic reading of HFE-related documents through a NuScale core competencies course for HFE, which is documented within the NuScale Training Program within the OPS core curriculum.

{{

}}2(a),(c)

## 6.0 Simulator Overview

The NuScale simulator located in Corvallis, Oregon, was used for the NuScale RSPV testing. The purpose-built facility design, models, and software are based upon the NuScale 12-module, small modular reactor plant design as described in the design certification application. The simulation facility is modeled using {{ }}2(a),(c) such that indications described in the design are available to plant operators. The fidelity of the parameters is such that operators are provided, reliably and in real-time, a best-estimate response that represents the expected actual plant response. The simulation facility is referred to "as-designed" because a reference plant does not exist; hence, the ability to benchmark simulator plant performance against actual plant performance is not possible. NuScale RSPV simulator fidelity was validated using {{

}}2(a),(c) See Section 7.2, Simulator Certification Testing.

The simulator modeling and interface was acceptable to support the necessary tasks sampled per the operating conditions for RSPV as follows:

- Interface completeness – Interfaces supported all the tasks associated with the broad range of operational conditions tested. Design verification testing performed before the start of validation provided confidence of completeness. Improvements were identified in some of the interfaces, but, in general, operators could easily navigate to the correct controls and indications.
- Interface physical fidelity – The physical layout of the MCR is the same as the plant design with the exception of ceiling height, movable furniture, and two large columns that are part of the space used for the simulator. The presentation of alarms, displays, controls, embedded procedures, layout, and spatial relationships are modeled per the design of the NuScale MCR.
- Interface functional fidelity – Human-systems interface functions, automation, and procedures were developed directly from task analysis to support plant operation. Procedures were developed to support expected responses, as well as alternate paths not intended by the RSPV test design team.
- Environmental fidelity – The simulator is representative of the MCR design with regard to layout of screens, workstations, and controls. The environment reflects expected levels for noise, lighting, temperature, and humidity. Where necessary, approximations were provided based on best available information such as control room habitability ventilation noise level.
- Data completeness fidelity – Information and data provided to personnel represented the plant system information necessary to support the sampling of operational conditions and to demonstrate safe plant operation. Other systems are developed to a level of fidelity similar to existing commercial nuclear plant training simulators.
- Data content fidelity – 12 NPMs are {{ }}2(a),(c) modeled. Systems that interface with multiple NPMs are integrated into the plant

model such that impacts from one NPM through common systems are accurately conveyed to other NPMs. This underlying model information provides input to {{ }}2(a),(c) such that the information presented matches what would be expected during actual operation.

- Data dynamics fidelity – Each NPM is a combination of high-fidelity models working together to provide the most accurate results without sacrificing the ability to run in real-time. {{

  }}2(a),(c)

- Test bed conformance – The NuScale simulator is certified to perform RSPV testing. Detailed, individual SBT (Section 3.4) and a comprehensive certification test were performed to ensure the simulator was acceptable for RSPV testing.

## 6.1 Detailed Simulator Description

{{

}}2(a),(c)

## 6.2 Simulator Revised Staffing Plan Validation Certification

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

The NuScale simulator remains certified to perform validation testing.

## 6.3 Simulator Deficiencies

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

## 6.4 Simulator Issues during Validation

No simulator issues occurred during validation testing.

# 7.0 Pilot Testing

Pilot testing is a study performed before actual testing to verify the adequacy of the test design, performance measures, and data-collection methods. In addition to checking the methods and process of testing, the pilot tests were used to verify the procedures; alarms and the interface supported the scope of validation testing. At no time was a test participant crew member involved in pilot test activities.

Each scenario was performed using a three-person crew of NuScale staff that were previously licensed operators and were members of the HFE design team. The staff performed in the roles of CRS/SM, and ROs. The scenarios were performed in real time with the staff performing all tasks that would be expected during actual validation test performance. The scenario validation times (i.e., how long each scenario was expected to take) were derived from this phase of pilot testing.

No changes to the scenario guides, procedures, interface, or testing methods were made as a result of pilot testing activities.

## 8.0 Test Plan Implementation

Validation testing was performed from May 20-22, 2019. Within each day of testing, a scenario was performed once in the morning and once in the afternoon.

The Control Room Staffing Plan Validation Methodology, RP-1215-20253, was used to perform this validation {{

}}2(a),(c)

The following staff and qualifications were assumed to be available as part of the on-shift operating crew:

Three licensed operators in the MCR consisted of one CRS maintaining an active SRO license and performing the emergency plan declaration duties of the SM, and two ROs maintaining active RO or SRO licenses.

The personnel used for validation testing did not have active operating licenses, but were trained to perform the duties and tasks expected of licensed operators in an actual plant.

The validation crews trained as three-person teams, filling roles as described in the NuScale Concept of Operations, RP-0215-10815 (Reference 12.1.8). The crew compliment was lowered to three with the combination of the SM and CRS position and the elimination of the shift technical advisor (STA). Justification for removing the STA position is provided in Appendix C.

Each scenario was evaluated by a {{ }}2(a),(c) observation team. There were no instances in which test results were inconclusive between both trials. All test acceptance criteria were met. Slight human performance variances existed between trials (such as place-keeping or communication differences), but did not result in an inconsistent outcome of task performance.

Data was collected manually through the use of TLX data sheets, situational awareness questionnaires, observation forms, and crew critique forms.

## 8.1 Validation Team

{{

}}2(a),(c)

The observation team consisted of HFE and operations personnel and is described in more detail in Section 5.0.

### 8.1.1 Test Administrators' Biographies

{{

}}2(a),(c)

{{

}}2(a),(c)

## 8.2 Data Collection Methods

{{

}}2(a),(c)

## 9.0 Data Analysis

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

## 10.0 Performance Measures

{{

}}2(a),(c)

## 10.1 Acceptance Criteria Overview

Acceptance criteria were developed for each scenario, based on the following criteria:

- {{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

### 10.1.1 Credited Operator Actions

There are a limited number of operator actions that are credited by PRA analysis within the NuScale design. All of the actions credited are used to mitigate beyond-design-basis events. There are no operator actions credited to mitigate design-basis events.

The PRA analysis investigates fault combinations of sequences that can lead to core damage. {{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

### 10.1.2 {{ }}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

### 10.1.3 Primary Tasks

A primary task is one in which the operator must perform the task to directly complete a test goal. {{

}}2(a),(c)

{{

}}2(a),(c)

### 10.1.4 Declaration of Emergency Action Levels

There are no operator actions credited in the FSAR Chapter 15 design-basis events and very few actions credited in beyond-design-basis events. During accident conditions, operators typically will be tasked with verifying passive cooling systems function properly and reporting plant status as required. While not having a direct impact on plant safety, notification tasks were included as acceptance criteria because of their association with the health and safety of the public.

The notification acceptance criteria were based on timing requirements that are currently being used by the nuclear industry. This is a conservative assumption for a NPP. For instance, emergency plan entry conditions must be detected and declared by the crew within 15 minutes under current guidelines. This is done to support notification of offsite agencies for plants with an emergency planning zone that is outside of the owner-controlled property. It is probable that a NPP will either have less restrictive times or no times at all based on a smaller planning zone.

Emergency action level declarations were required to be completed within 15 minutes from the time the event malfunction was initiated. The CRS was assigned the dual role of SM and had the responsibility to declare EALs.

{{ }}2(a),(c)

{{ }}2(a),(c)

{{ }}2(a),(c)

{{ }}2(a),(c)

## 10.2 Diagnostic Measures Overview

Diagnostic measures were used to aid in identifying issues related to HSI design, procedures, and staffing roles. Each measure had a defined method of data collection and a means to evaluate against a threshold. The purpose of thresholds was to identify issues at a low level for further analysis. The following diagnostic measures were used.

- {{

}}2(a),(c)

### 10.2.1 Workload

The NASA TLX was used to provide a measure of workload that can be quantitatively evaluated. This measurement tool is used in other industries and studies and has a track record of effectively measuring workload for individuals performing tasks.

- {{

}}2(a),(c)

- {{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

### 10.2.2 Situational Awareness

Participant crew members completed situational awareness questions using a paper form during a specific point during and at the conclusion of each scenario.

Situational awareness questions were developed to assess an operator's ability to maintain awareness during the various tested sampling conditions. The questions were designed to check the crew's awareness of the following items:

- Current plant status (typically major evolutions and activities)
- How important parameters are either changing or expected to change
- Current important plant conditions such as EAL
- Crew priorities and goals (major actions expected to be performed)
- Current or expected operator roles (which operator is responsible for which tasks)

{{

}}2(a),(c)

### 10.2.3 Participant Crew Critique

At the conclusion of each validation scenario, the participant crew members assembled in a quiet conference room to discuss the performance of the crew and to capture additional comments. The crew members were instructed to focus on how the plant design, his design, procedures, automation, and training impacted the performed tasks as a three-person crew.

A post-scenario critique check sheet was completed with the following categories intended to provide structure to the critique session:

- {{

}}2(a),(c)

{{

}}2(a),(c)

- {{

}}2(a),(c)

- {{

}}2(a),(c)

### 10.2.4 Observation Team Critique

During each validation test, each member of the observation team documented their observations on an observation form.

{{

}}2(a),(c)

{{

}}2(a),(c)

- {{

}}2(a),(c)

## 10.3 Human Engineering Discrepancies Overview

Comments obtained through acceptance criteria and performance measures were analyzed to identify specific problem statements. These problem statements resulted in the set of identified HEDs. Each HED was assigned a priority, defined as:

Priority 1: potential to impact plant safety or a cross-cutting issue that may directly or indirectly impact plant safety

Priority 2: potential to impact plant operating performance or operability as described in technical specifications

Priority 3: does not meet the definition of Priority 1 or Priority 2

{{

}}2(a),(c)

Each HED lists a title, description, proposed resolution, and is traceable to the original comments accrued during ISV that led to the HED. Human engineering discrepancies have been entered into the human factors engineering issues tracking system (HFEITS) database to track work assignments and resolution.

## 10.4 Human Engineering Discrepancy Description

{{ }}2(a),(c)

{{

}}2(a),(c)

{{ }}2(a),(c)

## 11.0 Record Retention

This test report and the NuScale internal documents that support it are NuScale-approved documents and are retained as required per NuScale document control procedures. These files are provided to DCRM for lifetime record retention.

The SBT data obtained before validation testing is listed in individual approved documents, as listed in Section 3.4, and is retained in the records management system.

Simulator version release notes, documenting changes from ISV to the version of the simulator used for this validation testing, are listed in individual, approved documents as listed in Section 6.2, and are retained in the records management system.

Simulator recordings and raw data are captured on specific hard drives and maintained by the NuScale simulator group.

## 12.0 References

12.1.1 U.S. Nuclear Regulatory Commission, “Human Factors Engineering Program Review Model,” NUREG-0711, Rev. 3, November 2012.

12.1.2 U.S. Nuclear Regulatory Commission, “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),” NUREG/CR-6838, February 2004.

12.1.3 U.S. Nuclear Regulatory Commission, “Workload, Situation Awareness, and Teamwork,” NUREG/CR-7190, March 2015.

12.1.4 U.S. Nuclear Regulatory Commission, “A Study of Control Room Staffing Levels for Advanced Reactors,” NUREG/IA-0137, November 2000.

12.1.5 National Aeronautics and Space Administration, “NASA Task Load Index (TLX),” Version 1.0, Human Performance Research Group, Moffett Field, CA, 1986.

12.1.6 Eitrheim, M. H., et al., “Staffing Strategies in highly automated future plants: Results from the 2009 HAMMLAB Experiment,” OECD Halden Reactor Project, HWR-938, Halden, Norway, 2010.

12.1.7 NuScale Standard Plant Design Certification Application, Rev 2.

12.1.8 Concept of Operations, RP-0215-10815-P, Rev. 3.

12.1.9 Conduct of Operations, RP-1215-19691, Rev. 1.

12.1.10 Simulator Scenario Based Testing Procedure, OP-0504-50019, Rev 1.

12.1.11 Integrated Systems Validation Simulator Performance Testing Procedure, OP-0503-53351, Rev 1.

12.1.12 HFE Issue Tracking System Procedure, EP-0303-1336, Rev 4.

12.1.13 Control Room Staffing Plan Validation Results, RP-0516-49116, Rev 1.

12.1.14 Control Room Staffing Plan Validation Methodology, RP-1215-20253, Rev 3.

12.1.15 American National Standards Institute/American Nuclear Society, “Nuclear Power Plant Simulators for Use in Operator Training and Examination,” ANSI/ANS-3.5-2017, Draft revision, LaGrange Park, IL.

12.1.16 Integrated System Validation Test Plan, PL-1102-53167, Rev 2.

12.1.17 Generic Technical Guidelines Operator Action Timing, ER-P060-6558, Rev. 1

12.1.18 HFE Verification and Validation Results Summary Report, RP-1018-61289-P, Rev 1.

## 13.0 Appendices

A. List of all tasks included in validation testing

B. Situational Awareness Questionnaires

C. Shift Technical Advisor Proposed Removal

D. Comparison of Staffing Plan Validation Results

E. Human Engineering Discrepancy Detailed Descriptions

## Appendix A. List of All Tasks Included in Validation Testing

The following table contains the list of tasks tested during this validation. Tasks are designated as primary, dependent, or independent. Primary tasks directly impact a sample criteria goal of the scenario and cannot be ignored by the crew. Dependent tasks are those tasks that must be accomplished to support the primary task. Independent tasks are not associated with the primary task and can be ignored by the crew if workload is high and the CRS decides to defer the work. The same task is sometimes designated differently between different scenarios. For example, identifying a degraded safety function may be primary if it requires an operator action or it could be independent in another scenario where no action is required. The trial times and maximum are listed in minutes.

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

## Appendix B. {{ }}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

## Appendix C. Shift Technical Advisor Elimination

The requirements for the position of the Shift Technical Advisor were created following the nuclear accident of Three Mile Island (TMI) in 1979. Following that event, a commission report was generated with the recommendation that a nuclear control room retain an individual knowledgeable in engineering principals until remediation actions could be conducted. These recommendations were incorporated into NUREG-0737, Clarification of TMI Action Plan Requirements.

NUREG-0737 states the following:

“Each licensee shall provide an on-shift technical advisor to the shift supervisor. The shift technical advisor (STA) may serve more than one unit at a multiunit site if qualified to perform the advisor function for the various units.”

NUREG-0737 provides clarification for the basis of the STA position:

“The letter of October 30, 1979 clarified the short term STA requirements. That letter indicated that the STAs must have completed all training by January 1, 1981. This paper confirms these requirements and requests additional information.

“The need for the STA position may be eliminated when the qualifications of the shift supervisors and senior operators have been upgraded and the man-machine interface in the control room has been acceptably upgraded. However, until those long-term improvements are attained, the need for an STA program will continue.”

NUREG-0737 then goes on to provide direction for the training and implementation of the STA position.

Based on an interpretation that the STA position was intended as a relatively short-term, immediate remediation, and that NUREG-0737 provides two conditions in which the STA position may be eliminated, this proposal suggests that accepted industry licensed training programs and the NuScale control room HSI has demonstrated the STA position can be eliminated.

The requirements for a NuScale control room operator training are to be incorporated into NUREG-1021, Operator Licensing Examination Standards for Power Reactors. The COL item 13.2-1 requires that an applicant that references the NuScale plant design provides the initial and requalification programs for licensed operators. Applicable engineering principals are now an integral part of any licensed operator training program and are included in NUREG-1021 requirements. This means that the requirement for senior operators to be sufficiently trained is ensured through regulatory guidance established after the issuance of NUREG-0737.

Three validation activities have occurred of the NuScale control room and HSI. Two validations have occurred focusing on control room staff in high-workload conditions, and one was the ISV focused on HSI and procedures in a large sample of operating conditions. The primary method operators have to assess nuclear safety is through the use of safety functions and the emergency operating procedures. It has been demonstrated in each validation that operators are successful at recognizing and mitigating beyond-design-basis events. There are no operator actions within design-basis that would require a shift technical expertise as there are no actions. Therefore, the HSI has proven able to meet NUREG-0737 criteria as an upgraded, man-machine interface.

NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition, contains the required guidance to be submitted for the construction of a new nuclear power plant, and Section 13.1.2-13.1.3, Operating Organization, provides the following guidance regarding commitments associated with the STA position:

> “The application may be received prior to establishment of the operating organization and detailed staffing has not been finalized, implementation of commitments made by the applicant can be evaluated after issuance of the COL as part of the Construction Inspection Program. The organizational information provided should include the following elements:”

The STA position is then inferred from subparts f and g:

f. The applicant’s commitment to be consistent with one of the options in the Commission Generic Letter (GL) 86-04 “Policy Statement on Engineering Expertise on Shift.”

g. The applicant’s commitment to meet NUREG-0737 and Supplement 1, “Clarification of TMI Action Plan Requirements,” Items I.A.1.1, “Shift Technical Advisor,” and I.A.1.3, ‘Shift Manning.’”

In essence, NUREG-0800 refers back to NUREG-0737 for the applicable requirements of the STA position. Therefore, it is evident that the STA position for the NuScale design is not required and can be eliminated.

# Appendix D. Comparison of Staffing Plan Validation Results

The original staffing plan validation scenarios performed in 2016 were not used for this validation primarily because the previous scenario information was published both internally and submitted to the NRC for review. Therefore, it could not be ensured that participants would be unaware of the contents of that earlier validation test. For this reason, new scenarios were generated using the same method as used to generate the original staffing plan validation scenarios in accordance with the Control Room Staffing Plan Validation Methodology, RP-1215-20253 (Reference 7.1.14).

The original three staffing plan validation scenarios were incorporated into the validation training performed before the start of the current validation testing. {{

}}2(a),(c)

Data were collected during the training using the original validation scenarios to compare with the data collected during this current validation test.

## D.1 Acceptance Criteria

All acceptance criteria for the original staffing plan validation were met. Detailed information and graphs of the data have not been prepared for this draft at this time.

## D.2 Performance Measures

Workload was measured by recording NASA TLX ratings at predetermined points in the scenarios and at the end. {{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

## Appendix E. Human Engineering Discrepancy Detailed Descriptions

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

{{

}}2(a),(c)

**Enclosure 3:**

Affidavit of Carrie Fosaaen, AF-1220-73412

**NuScale Power, LLC**

AFFIDAVIT of Carrie Fosaaen

I, Carrie Fosaaen, state as follows:

(1) I am the Director of Regulatory Affairs of NuScale Power, LLC (NuScale), and as such, I have been specifically delegated the function of reviewing the information described in this Affidavit that NuScale seeks to have withheld from public disclosure, and am authorized to apply for its withholding on behalf of NuScale.

(2) I am knowledgeable of the criteria and procedures used by NuScale in designating information as a trade secret, privileged, or as confidential commercial or financial information. This request to withhold information from public disclosure is driven by one or more of the following:

(a) The information requested to be withheld reveals distinguishing aspects of a process (or component, structure, tool, method, etc.) whose use by NuScale competitors, without a license from NuScale, would constitute a competitive economic disadvantage to NuScale.

(b) The information requested to be withheld consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), and the application of the data secures a competitive economic advantage, as described more fully in paragraph 3 of this Affidavit.

(c) Use by a competitor of the information requested to be withheld would reduce the competitor's expenditure of resources, or improve its competitive position, in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

(d) The information requested to be withheld reveals cost or price information, production capabilities, budget levels, or commercial strategies of NuScale.

(e) The information requested to be withheld consists of patentable ideas.

(3) Public disclosure of the information sought to be withheld is likely to cause substantial harm to NuScale's competitive position and foreclose or reduce the availability of profit-making opportunities. The accompanying report reveals distinguishing aspects about the process by which NuScale develops its revised staffing plan validation test report.

NuScale has performed significant research and evaluation to develop a basis for this process and has invested significant resources, including the expenditure of a considerable sum of money.

The precise financial value of the information is difficult to quantify, but it is a key element of the design basis for a NuScale plant and, therefore, has substantial value to NuScale.

If the information were disclosed to the public, NuScale's competitors would have access to the information without purchasing the right to use it or having been required to undertake a similar expenditure of resources. Such disclosure would constitute a misappropriation of NuScale's intellectual property, and would deprive NuScale of the opportunity to exercise its competitive advantage to seek an adequate return on its investment.

(4) The information sought to be withheld is in the enclosed report entitled "Revised Staffing Plan Validation Test Report," RP-0419-65209, Revision 2. The enclosure contains the designation "Proprietary" at the top of each page containing proprietary information. The information considered by NuScale to be proprietary is identified within double braces, "{{ }}" in the document.

(5) The basis for proposing that the information be withheld is that NuScale treats the information as a trade secret, privileged, or as confidential commercial or financial information. NuScale relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC §

552(b)(4), as well as exemptions applicable to the NRC under 10 CFR §§ 2.390(a)(4) and 9.17(a)(4).

(6) Pursuant to the provisions set forth in 10 CFR § 2.390(b)(4), the following is provided for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld:

(a) The information sought to be withheld is owned and has been held in confidence by NuScale.

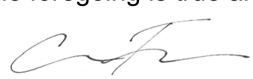
(b) The information is of a sort customarily held in confidence by NuScale and, to the best of my knowledge and belief, consistently has been held in confidence by NuScale. The procedure for approval of external release of such information typically requires review by the staff manager, project manager, chief technology officer or other equivalent authority, or the manager of the cognizant marketing function (or his delegate), for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside NuScale are limited to regulatory bodies, customers and potential customers and their agents, suppliers, licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or contractual agreements to maintain confidentiality.

(c) The information is being transmitted to and received by the NRC in confidence.

(d) No public disclosure of the information has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or contractual agreements that provide for maintenance of the information in confidence.

(e) Public disclosure of the information is likely to cause substantial harm to the competitive position of NuScale, taking into account the value of the information to NuScale, the amount of effort and money expended by NuScale in developing the information, and the difficulty others would have in acquiring or duplicating the information. The information sought to be withheld is part of NuScale's technology that provides NuScale with a competitive advantage over other firms in the industry. NuScale has invested significant human and financial capital in developing this technology and NuScale believes it would be difficult for others to duplicate the technology without access to the information sought to be withheld.

I declare under penalty of perjury that the foregoing is true and correct. Executed on December, 17, 2020.



Carrie Fosaaen