



**UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001**

May 21, 2021

Ms. Margaret M. Doane
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: NUSCALE TOPICAL REPORT – CONTROL ROOM STAFFING PLAN

Dear Ms. Doane:

During the 685th meeting of the Advisory Committee on Reactor Safeguards (ACRS), May 5-7, 2021, we completed our review of the staff's evaluation of NuScale topical report, TR-0420-69456, Revision 1, "NuScale Control Room Staffing Plan," and the referenced documents. During our 684th meeting, April 8-9, 2021, we had the benefit of discussions with NuScale and the NRC staff. Our NuScale Subcommittee reviewed this matter on March 16, 2021. We also visited the NuScale facilities at Corvallis, Oregon, on July 23-25, 2019, which included a demonstration of the control room simulator for a 12 NuScale Power Module (hereafter "module") power plant.

CONCLUSIONS AND RECOMMENDATIONS

1. The proposed staffing of a NuScale power plant of up to 12 modules by a minimum shift crew of two senior reactor operators (SROs) and a single reactor operator (RO), from a single control room, is adequate for safe operation of the plant.
2. The staff's final safety evaluation report on the NuScale control room staffing plan topical report should be issued.
3. Several items identified in this letter report will not be completed until an applicant takes up this topical report and references it for the purpose of seeking an exemption on staffing requirements. We look forward to reviewing license submittals that reference this topical report.

BACKGROUND

Current requirements for on-site staffing of nuclear power units by SROs and ROs, licensed under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 55, are specified in § 50.54(m). While the regulations do not address a 12 module power plant operated from a single control room, Footnote 3 to the table in § 50.54(m)(2)(i) would suggest a minimum shift crew of two SROs and four ROs for a three-unit power plant operated from a common control room. However, as documented in SECY-11-0098, dated July 22, 2011, the staff recognized over a decade ago that operator staffing for evolving small modular reactor designs and multi-unit plants would require resolving issues on the appropriate number of on-shift licensed operators.

Their recommended path forward, pending rulemaking, was to process exemption requests using the general framework of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR [Light Water Reactor] Edition," Chapter 18, "Human Factors Engineering"; NUREG-0711, "Human Factors Engineering Program Review Model"; and NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in § 50.54(m)." Critical to the staffing plan validation would be the task analysis review wherein:

- Task requirements for accomplishing functions allocated to operators are identified;
- Requirements for display and instrumentation and control are identified;
- Factors such as task timing, workload, and situational awareness are identified; and
- Adequate staffing and qualifications are assessed.

Following the accident at the Three Mile Island nuclear power plant, the NRC required in NUREG-0737, "Clarification of TMI Action Plan Requirements," the establishment at all operating plants of an independent Shift Technical Advisor (STA) position to provide engineering expertise and advice to the shift supervisor in the event of abnormal or accident conditions. The STA may serve more than one unit at a multi-unit site. It was recognized early on that as qualifications of operators were upgraded, and human-system interfaces were improved, the STA position could be eliminated. In its "Final Policy Statement on Engineering Expertise on Shift" (SECY-84-355 and subsequent Generic Letter GL-86-04), the staff offered two options for meeting these requirements: 1) eliminate the separate STA position by combining one of the required SRO positions with the STA position into a dual-role SRO/STA position; or 2) continue the NRC-approved STA program. The Commission encouraged licensees to move to the dual-role SRO/STA position. Of the several ACRS letter reports on this topic, the letter of August 14, 1984, endorsed the Commission's recommendation (although differing views were expressed in added comments).

DISCUSSION

NuScale proposed a main control room minimum shift crew of six licensed operators in its recent design certification application. After reviewing the results of initial staffing plan validation efforts, NuScale conducted an additional study to evaluate a minimum shift crew of three licensed operators (two SROs and one RO). This topical report, TR-0420-69456, Revision 1, and reports referenced therein, provides the technical justification for a NuScale power plant with up to 12 modules to be operated from a single control room with a minimum operating crew of three licensed operators, comprised of two SROs and one RO. NuScale also proposed to combine the functions of the STA with that of the Shift Manager/Control Room Supervisor (an SRO position) and crew, eliminating a separate, independent STA position. Consistent with the requirements of § 50.54(m)(2)(iv), the staffing plan provides for an additional SRO on the plant floor during refueling operations and evolutions. NuScale requests NRC approval of the control room staffing plan as described in this topical report. The topical report would then serve as the basis for future 10 CFR Part 50 or 52 license applicants to request an exemption from the licensed operator staffing requirements specified in § 50.54(m) and § 50.120, and as discussed in NUREG-1791.

To justify its staffing plans, NuScale conducted two staffing plan validation exercises. The first was for the design certification application proposed six-person shift crew (shift manager, control room supervisor, a shift technical advisor, and three reactor operators). Using two

trained operator crews on its control room simulator, scenarios were developed to measure operator performance, workload, and situational awareness for a spectrum of challenging, high-workload operating conditions, including design basis events, beyond design basis events, multi-module transient and upset events, and large-scale loss of control room display functions. Trained, qualified observers were used to record performance using established human performance indicators such as the National Aeronautics and Space Administration's task-load measures. Acceptance criteria included performance within specified task completion times, and qualitative measures such as those tracked with situational awareness questionnaires. This testing was repeated, using different scenarios within the same spectrum of events, for the revised staffing plan validation, using a three-person shift crew consisting of an SRO as shift manager/control room supervisor, an SRO, and an RO. The operating crews were able to successfully operate the plant with up to 12 modules, meeting all task performance and evaluation acceptance criteria. No high priority human engineering design discrepancies, retesting, or corrective actions were identified.

The staff's safety evaluation report, and supporting audits, of the revised staffing plan validation focused primarily on simulator testing of high-workload scenarios that presented the greatest challenges to the successful task performance of the proposed three-operator crew. First, the NuScale simulator testbed (in Corvallis, Oregon) was determined to be adequately representative, with a high degree of fidelity, of the expected, as-designed plant control room. Second, revised test scenarios similar to those used for the six-operator crew staffing plan validation were evaluated, determined to be sufficiently representative, and audited to ensure that pilot testing results were not available to actual revised staffing plan validation test participants. Last, successful performance of task assignments in the three revised staffing plan validation test scenarios by two different operating crews was determined to be a satisfactory demonstration. The staff concluded that a 12 module NuScale power plant can be operated safely and reliably by a minimum of three licensed operators from a single control room under high-workload conditions.

In evaluating the elimination of the STA position, the staff cited substantial control room human-system interface improvements, passive design features that reduce reliance on operator actions, and upgraded qualifications and training of operators as justification for combining the STA position with that of the shift manager/control room supervisor.

We considered several factors in support of the proposed crew staffing, including:

- Passive safety characteristics and enhanced safety margins of the NuScale design;
- Simplicity of tripping a module and placing it in a passive cooling mode;
- No operator intervention within 72 hours required in response to the spectrum of defined design basis events;
- Improved human-system interfaces in terms of control room design, functionality, and displays ("at a glance" display of critical safety functions, tiered alarms, multi-module trending, direct links to response procedures and emergency operating procedures, and several others); and
- Pilot operator training programs and high-fidelity simulator validation exercises that demonstrate adequate performance, including multi-module events, assuring safe operation of the plant and shutdown of each module to a safe, stable condition.

We agree that the combination of the above points provides sufficient justification for NuScale's crew staffing approach and their elimination of the STA position. This represents a major

departure from the regulatory approach used for decades with the current light water reactor fleet. As such, it could represent a strong precedent.

There are several issues that we expect to review, when the topical report is used to support any specific construction permit, operating license, or combined license application. These include technical specifications on operations and staffing requirements; conduct of operations with operating and refueling procedures; training and validation programs for licensed operators, including assurance that the models and algorithms used by the simulator during testing and training accurately describe operation of control room indicators for the as-built plant; impact of a future power uprate; and verification and validation of control room design functionality, particularly independence of each module's reactor protection system and engineered safety features, and the associated safety display and indication system. Further, we note that as stated in the staff's safety evaluation report, a license applicant will have to demonstrate that the as-built control room design retains the human-system interface features of the topical report: critical safety functions and defense-in-depth monitoring and display, which provide direct links to response procedures; tiered alarm scenario scheme, which provides computer-based alarm response procedures that assist the operator in efficiently locating the correct instruction(s); and 12 module trend monitoring.

The NuScale proposal is consistent with the NRC Final Policy Statement on Engineering Expertise on Shift and associated guidance. Because of the elimination of the independent STA, especially for this first-of-a-kind design, we recommend that the minimum operating crew be supplemented with independent engineering expertise for initial startup and power ascension to full power until experience is gained with multi-module operations.

We also caution that operators may become over-confident in the operation of the plant by the computer-driven operator interface. Planned training programs should include drills with more confusing partial failures of this interface, as well as with its complete failure.

SUMMARY

Elements of the NuScale design and the simplicity with which modules can be placed in a safe, stable passive-cooling state, along with the successful staffing plan validation studies, give us confidence that a NuScale power plant of up to 12 modules can be safely operated with the proposed minimum operating crew. The staff's final safety evaluation report on the NuScale control room staffing plan topical report should be issued. Nevertheless, we suggest additional independent oversight would be prudent as operating experience accumulates. We look forward to reviewing license submittals that reference this topical report.

Sincerely,



Signed by Sunseri, Matthew
on 05/21/21

Matthew W. Sunseri
Chairman

A perspective on the value of an independent STA is provided in the attached paper by Member Dennis C. Bley (ADAMS Accession Number ML21139A232).

REFERENCES

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3. NuScale Power, LLC, Topical Report TR-0420-69456, "NuScale Control Room Staffing Plan," Revision 1, December 17, 2021 (ML20352A473).
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5. NuScale Power, LLC, "Revised Staffing Plan Validation Test Report," RP-0419-65209, Revision 2, December 17, 2020 (ML20352A471).
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7. U. S. Nuclear Regulatory Commission, NUREG-0737, "Clarification of TMI Action Plan Requirements," November 30, 1980 (ML051400209).
8. U. S. Nuclear Regulatory Commission, NUREG-1791, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," July 31, 2005 (ML052080125).
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15. Øivind Braarud, "An Efficient Screening Technique for Acceptable Mental Workload Based on the NASA Task Load Index - Development and Application to Control Room Validation," *International Journal of Industrial Ergonomics* 76 (2020) 102904, January 26, 2020.
16. U. S. Nuclear Regulatory Commission, SECY-11-0098, "Operator Staffing for Small or Multi-Module Nuclear Power Plant Facilities," July 22, 2011 (ML111870574).
17. Advisory Committee on Reactor Safeguards, "Report on the Safety Aspects of the NuScale Small Modular Reactor," July 29, 2020 (ML20211M386).
18. Advisory Committee on Reactor Safeguards, "ACRS Comments on the Final Policy Statement on Engineering Expertise on Shift Regarding the Dual-Role (SO/STA) Position," August 14, 1984 (ML20094P592).
19. Advisory Committee on Reactor Safeguards, "ACRS Report on a Proposed Rule Requiring On-Shift Engineering Expertise," August 9, 1983 (ML051690229).
20. Advisory Committee on Reactor Safeguards, "ACRS Comments on Rulemaking Concerning Staffing at Nuclear Power Plants and Draft Policy Statement on Shift Crew Qualifications," December 14, 1982 (ML051690208).
21. Advisory Committee on Reactor Safeguards, "NUREG-0600, 'Investigation into the March 28, 1979 Three Mile Island Accident by the Office of Inspection and Enforcement'," November 14, 1979 (ML19211A158).
22. U. S. Nuclear Regulatory Commission, Regulatory Guide 1.149, "Nuclear Power Plant Simulation Facilities for use in Operator Training, License Examinations, and Applicant Experience Requirements," Revision 4, April 30, 2011 (ML110420119).
23. U. S. Nuclear Regulatory Commission, 66 FR 52667, "Operator License Eligibility and Use of Simulation Facilities in Operator Licensing," Final Rule, Federal Register, Volume 66, Number 201, p. 52667, October 17, 2001.

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