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

June 22, 2021

The Honorable Christopher T. Hanson,
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

SUBJECT: SUMMARY REPORT – 685th MEETING OF THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS, MAY 5-7, 2021

Dear Chairman Hanson:

During its 685th meeting, May 5-7, 2021, which was conducted virtually due to the COVID-19 pandemic, the Advisory Committee on Reactor Safeguards (ACRS) discussed several matters. The ACRS completed the following correspondence:

LETTER REPORT

Letter Report to Christopher T. Hanson, Chairman, U.S. Nuclear Regulatory Commission (NRC), from Matthew W. Sunseri, Chairman, ACRS:

- Preliminary Proposed Rule Language for 10 CFR [Title 10 of the *Code of Federal Regulations*] Part 53, "Licensing and Regulation of Advanced Nuclear Reactors," Interim Report, dated May 30, 2021, Agency-wide Documents Access and Management System (ADAMS) Accession No. ML21140A354

LETTER

Letter to Margaret M. Doane, Executive Director for Operations (EDO), U.S. Nuclear Regulatory Commission (NRC), from Matthew W. Sunseri, Chairman, ACRS:

- NuScale Topical Report – Control Room Staffing Plan, dated May 21, 2021, ADAMS Accession No. ML21139A228 (with attached paper by Member Bley regarding perspectives on the value of an independent shift technical advisor)

MEMORANDA

Memoranda to Margaret M. Doane, EDO, NRC, from Scott W. Moore, Executive Director, ACRS:

- Documentation of Receipt of Applicable Official NRC Notices to the Advisory Committee on Reactor Safeguards for May 2021, dated May 12, 2021, ADAMS Accession No. ML21132A182

- Regulatory Guides, dated May 17, 2021, ADAMS Accession No. ML21132A213

HIGHLIGHTS OF KEY ISSUES

1. Preliminary Proposed Rule Language for 10 CFR Part 53, "Licensing and Regulation of Advanced Nuclear Reactors," Interim Report

The Committee's comments focus on Subparts B and C. The Committee will address additional Subparts, as they mature. A final section raises issues involving other Subparts to alert the staff to areas where the ACRS expects substantial interaction.

Subpart B, "Technology-Inclusive Safety Requirements"

The language of Subpart B has been evolving as the staff discusses the general approach for safety with stakeholders and ACRS members. The discussion is much improved over previous drafts. The staff is still considering alternative presentations, and the Committee looks forward to continuing discussions with stakeholders and the staff. While many members of the Committee are becoming comfortable with the structure and logic of Subpart B, other members and many stakeholders would have approached it much differently. A variety of opinions can be found in the transcripts of the Committee's meetings.

While the staff has clarified their discussion substantially, the Committee finds little value in having two-tiers, both of which are required. Having the second tier tied to the Commission's quantitative health objectives (QHOs) memorializes direct application of the QHOs, which can be difficult. The established subsidiary goals for the QHOs were based on results from a number of light-water reactor (LWR) probabilistic risk assessments (PRAs) that will not be appropriate for specific advanced technologies. The staff should consider alternative measures of integrated risk, such as those investigated in NUREG-1860.

The staff's exposition of safety functions and fundamental principles of safety is based on a top-down analysis of the functions that need to be met to preclude the release of radioactive materials from the facility. A key underpinning of 10 CFR Part 53 is the need for flexibility in meeting safety requirements. The designer, applicant, and regulator desire such flexibility to address the broad range of advanced reactor technologies and power levels under consideration. Such flexibility has been posited to pose unnecessary regulatory uncertainty given the high-level nature of the requirements. However, more prescriptive requirements will limit flexibility and may not be applicable for all advanced reactors.

The staff implemented flexibility by establishing safety criteria that must be satisfied to assure protection of the public and workers. A primary safety function, "limiting the release of radioactive materials," is identified, but the applicant must develop additional safety functions that support the primary safety function, to meet safety criteria. How those additional supporting safety functions are defined, as well as the specific design features (or combinations thereof) and programmatic controls to implement them, will depend on the advanced reactor technology and associated design. The primary and additional safety functions must be maintained during normal and accident conditions throughout the plant lifetime.

The Committee supports the additional flexibility offered by this approach. It promotes technology inclusiveness and minimizes exemptions that might be required if a detailed list of safety functions were enumerated within the rule. During the Committee's discussions, staff

clarified that assurance of the primary safety function requires sufficient integrity of radionuclide retention barriers for functional containment performance criteria to be met. The staff should revise the proposed rule text to include this clarification and expand the list of candidate additional safety functions to include independently "control reactivity."

The preliminary language of 10 CFR Part 53 emphasizes implementation of defense-in-depth. Defense-in-depth, when used in combination with risk-based tools, is a powerful means to systematically assess the design and identify weaknesses that need to be bolstered by either reducing the frequency of specific off-normal events (through improvements in system reliability, redundancy and diversity) or minimizing the consequences with additional structures, systems, and components (SSCs). This systematic examination should result in a balanced approach for safety implementation in the design, providing additional protection where necessary. It also provides a mechanism for establishing when sufficient defense-in-depth is achieved. In particular, this approach is critical for advanced reactor designs that have never been built, preventing ad-hoc adoption of safety criteria that may be of little substantive value.

The Committee has had a continuing dialog with the staff on the question of design criteria—should the general design criteria (GDC) of 10 CFR Part 50, Appendix A, be included in the rule; should the advanced reactor design criteria (ARDC) of Regulatory Guide (RG) 1.232 be included? Because the rule is to apply to a wide range of technologies, certain of the GDCs and ARDCs may not apply to all and some additional ones could be needed. The Committee is reaching a consensus that, as a minimum, the rule should include a set of over-arching general criteria that would apply to any reactor concept, something like the generic ARDCs 1-5. While some of these are already scattered throughout the Subparts, they should be presented as a set in one place in Subpart B. The process described by the staff in the Committee's April meeting that should lead the applicant to something close to the GDCs/ARDCs must be reduced to text and included in the rule. There also is general agreement that safety analyses must demonstrate that for normal operation and anticipated operational occurrences (AOOs) all safety related barriers to release are maintained. Also, the rule should state that safety analyses must demonstrate that DBAs achieve and maintain a safe, stable, and subcritical condition.

Subpart C, "Design and Analysis Requirements"

The Committee agrees with the requirement for risk-informed analysis. However, the use of PRA should be approached in a graded fashion, scaled to the potential consequences of accident scenarios. This will require developing guidance on how to select an appropriate depth of analysis. A risk assessment is represented by the complete set of triplets $<S_i, L_i, C_i>$, i.e., the scenario S_i (what can go wrong?), the likelihood L_i, and the consequences C_i. Experience has shown that one can scale the analysis effort by bounding the likelihood and consequences with simplified analyses but failing to perform a complete search for initiating events and scenarios will always underestimate the risk, possibly to a catastrophic degree. The Committee has discussed in previous letters the importance of providing guidance for a structured, systematic search starting with no preconceptions that could limit the creative process. Although the staff has added language offering alternative risk-informed processes to Subpart C, they should continue the effort to clarify a graded PRA and other approaches.

The selection rules for licensing basis events and DBAs in § 53.450(e) and (f) need to be stated or there should be a reference to appropriate guidance such as RG 1.233 and NEI 18-04. Otherwise, there is no defined meaning to these terms. Alternatively, the explanation of the relationship between the rule and its guidance and a description of how the process is to work

should clarify the requirements of the rule. Likewise, the meaning of 'deterministic' and 'conservatively' in § 53.450(f) "Analysis of design basis accidents" must be clarified. If a PRA is performed, the identification of DBAs by a process similar to that described in NUREG-1860 and NEI 18-04 provides a way to select safety-related SSCs and demonstrate that each DBA, using only safety-related SSCs, meets established safety criteria. In this process, the results of the PRA are recalculated modeling all non-safety-related SSCs as failed and using estimated failure rates including uncertainty for the safety-related SSCs (rather than assuming the most limiting single failures as described in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition" (SRP), Chapter 15). Without a PRA, lack of the application of the single failure criterion to the analyses described in Chapter 15 of the SRP could substantially erode safety. It is possible that this problem can be addressed if effective system reliability requirements are specified. Because the language in the rule is currently vague in this area, the Committee would like the staff to brief it on new and existing tabletop exercises to demonstrate and clarify the process.

Issues and Questions for the Future

As the Committee progresses through the language in all Subparts of the rule, there are a number of issues members have already identified that the Committee will want to discuss with the staff. These include:

- Will there be a regulatory guide on mechanistic source term? Existing guidance may not be directly applicable to some reactor concepts.

- How will the forms of licenses [construction permit (CP), combined operating license (COL), Early Site Permit (ESP), operating license (OL)…] be included in the rule and what will be the requirements during each phase of the licensing process? How much design information will be required at each phase of the licensing process?

- How will the equivalent of the general design criteria be addressed?

- Defense-in-depth and quality assurance are important concepts and should be kept in one place, up front, rather than being distributed through other Subparts or buried in guidance. Will this be the case?

- How will external and internal hazards be applied in the rule—on a per-module, per-facility, or per-site basis? What if there are existing facilities on site? What if there are multiple licensees?

- How will microreactor transportation to and from the site be addressed, including the impact on siting considerations if a licensed facility for defueling spent microreactors is not available?

This rulemaking, given the almost real-time interactions with stakeholders and the ACRS and the multitude of expectations, presents the staff with a very difficult challenge. The Committee finds the staff's ability to graciously accept comments from all sources and to seek resolution of competing requests commendable. The draft preliminary language is progressing at a fast pace. However, the associated design-specific guidance that should be issued jointly with the rule will be difficult to keep on-track. Describing the needed guidance and setting priorities on the order in which documents should be developed will help clarify the relationships between

rule and guidance. Bringing a discussion of the relationship between the rule and guidance into the rule itself would increase confidence in the suitability of the rule language and how the process would work in practice.

The Committee has made a few specific recommendations, but generally agrees with the direction the rule is taking. The Committee looks forward to continued interactions with the staff, as they refine the language of the rule.

Committee Action

The Committee issued a letter on May 30, 2021, with the following conclusions and recommendations:

- The overall structure of Subparts A through I provides a logical framework for the rule. It is complete with respect to topics that must be covered and addresses the lifetime of a power reactor. It will be helpful to all applicants and to the NRC staff.

- A coherent and detailed explanation of the integrated intent of the rule and its associated design-specific guidance should be developed as soon as possible and enshrined in the rule itself.

- Subpart B, “Technology-Inclusive Safety Requirements,” is coming together, but the Committee would like to offer a few specific comments and see some further improvements:

    - To this point in the development, the Committee finds no value in the two-tiered approach to safety requirements. Alternative integral risk criteria to the QHOs should be investigated.

    - Desired flexibility to address the broad range of technologies and power levels is provided by establishing high-level safety criteria that must be assured in top-down fashion as the applicant identifies needed lower-level safety functions. This allows novel technologies to make their safety case specific to their designs, while still precluding release of radioactive materials from the facility.

    - The rule should include a set of over-arching general principles in one place (Subpart B) that would apply to any reactor concept.

    - The rule should state that safety analyses must demonstrate that for normal operation and AOOs all safety related barriers to release are maintained.

    - The rule should state that safety analyses must demonstrate that Design Basis Accidents (DBAs) achieve and maintain a safe, stable, and subcritical condition.

- Subpart C, “Design and Analysis Requirements,” is generally in good shape.

    - The requirement for risk-informed analysis is appropriate if the use of PRA is approached in a graded fashion commensurate with the potential consequences and the simplicity of the design.

  - The requirements for selection and analysis of DBAs must be clarified.

  - The rule eliminates single failure criteria but needs to define the process that replaces it.

- The two recommendations in the Committee's first letter report on 10 CFR Part 53 of October 21, 2020 (ADAMS Accession No. ML20295A647), still apply: for novel designs with uncertainties due to incompleteness in the knowledge base, systematic searches for hazards, initiating events, and accident scenarios should be required; and a licensing pathway including additional testing and monitoring akin to prototype testing should be available.

2. NuScale Topical Report - Control Room Staffing Plan

During the 685th meeting of the ACRS the Committee continued discussion and completed its review of the NuScale topical report TR-0420-69456, Revision 1, "NuScale Control Room Staffing Plan," and the staff's safety evaluation report.

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 senior reactor operators [SROs] and one reactor operator [RO]). This topical report and reports referenced therein provide 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 shift technical advisor (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.

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.

The Committee 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.

The Committee agrees 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 the Committee expects to review, when the 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, the Committee notes 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 that assist the operator in efficiently locating the correct instruction(s); and 12 module trend monitoring.

Because of the elimination of the independent STA, especially for this first-of-a-kind design, the Committee recommends 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.

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

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

Committee Action

The Committee issued a letter on May 21, 2021, with the following conclusions and recommendations:

- The proposed staffing of a NuScale power plant of up to 12 modules by a minimum shift crew of two SROs and a single RO, from a single control room, is adequate for safe operation of the plant.

- The staff's final safety evaluation report on the NuScale control room staffing plan topical report should be issued.

- 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. The Committee looks forward to reviewing license submittals that reference this topical report.

3. Discussions at the Planning and Procedures Session

The Committee discussed the Full Committee and Subcommittee schedules through September 2021 as well as the planned agenda items for Full Committee meetings.

The ACRS Executive Director also led a discussion of significant notices issued by the Agency since the last Full Committee meeting in April 2021 (this activity is documented in the memorandum dated May 12, 2021).

The Committee discussed recommendations on review of several draft and final regulatory guides, as documented in the memorandum mentioned above, dated May 17, 2021.

The Committee discussed proposals for topics and presenters to be included in the draft scheduling note for the Commission meeting scheduled for October 8, 2021. The Committee decided to propose the following topics: Digital Instrumentation and Control activities including the unidirectional communication issue, the activities association with 10 CFR Part 53, and the NuScale control room staffing issue. A final draft scheduling note will be discussed and approved by the Committee at the June Full Committee meeting.

The ACRS staff updated the Members on the status of the ACRS Conference Rooms upgrade.

The ACRS staff, on behalf of Member Ballinger who was unable to attend, provide an update on the SHINE operating licensing application review and the plan for interactions with fuel vendors.

The Committee discussed the ACRS staff recommendation and views by lead Member Bley on the NRC staff responses to the ACRS letters on Advanced Reactor Computer Codes. No further action by the Committee is necessary due to the response by the NRC Staff.

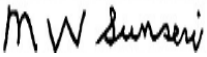
4. Scheduled Topics for the 686th ACRS Meeting

The following topics are on the agenda for the 685th ACRS meeting scheduled for June 2-4, 2021:

- Information session on the Risk-informed Process for Evaluations (RIPE) of Low Safety-significance Issue Resolution (LSSIR)

- ACRS Bylaws Review

Sincerely,


Signed by Sunseri, Matthew on 06/22/21

Matthew W. Sunseri
Chairman

June 22, 2021

SUBJECT: SUMMARY REPORT – 685th MEETINGS OF THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS, MAY 5-7, 2021

Accession No: ML21155A094 **Publicly Available (Y/N):** Y **Sensitive (Y/N):** N
If Sensitive, which category?
Viewing Rights: ☒ NRC Users or ☐ ACRS only or ☐ See restricted distribution

OFFICE	ACRS	SUNSI Review	ACRS	ACRS
NAME	LBurkhart	LBurkhart	SMoore (SWM)	MSunseri
DATE	6/4/21	6/4/21	6/16/21	6/22/21

OFFICIAL RECORD COPY