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

December 20, 2024

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

SUBJECT: SUMMARY REPORT – 720th MEETING OF THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS, NOVEMBER 6-8, 2024

Dear Chair Hanson:

During its 720th meeting, November 6 through 8, 2024, which was conducted in person and virtually, the Advisory Committee on Reactor Safeguards (ACRS) discussed several matters. The ACRS completed the following correspondence:

LETTER

Letter to Dr. Mirela Gavrilas, Executive Director for Operations, U.S. Nuclear Regulatory Commission (NRC), from Walter L. Kirchner, Chair, ACRS:

- Draft Safety Evaluation of the TerraPower Topical Report, "Plume Exposure Pathway Emergency Planning Zone Methodology," Revision 3, dated November 26, 2024, Agencywide Documents Access and Management System (ADAMS) Accession No. ML24324A305.

MEMORANDA

Memoranda to Dr. Mirela Gavrilas, Executive Director for Operations, U.S. Nuclear Regulatory Commission (NRC), from Scott W. Moore, Executive Director, ACRS:

- Documentation of Receipt of Applicable Official NRC Notices to the Advisory Committee on Reactor Safeguards for November 2024, dated November 13, 2024, ADAMS Accession No. ML24318C428, and

- Regulatory Guides (RGs), dated November 14, 2024, ADAMS Accession No. ML24318C433.

HIGHLIGHTS OF KEY ISSUES

a. Draft White Paper, “Nth-of-a-Kind Micro-Reactor Licensing and Deployment Considerations”

Member Bier led a discussion of topics associated with the draft white paper that were addressed at the Regulatory Rulemaking, Policies, and Practices Subcommittee meeting on October 17, 2024 (the transcript and slides may be found at ADAMS Accession No. ML24303A213). The Subcommittee recommended that the Committee not write a letter on this subject. After some discussion, the Committee agreed with the Subcommittee recommendation.

b. Triennial Review and Evaluation of NRC Safety Research Program

Member-At-Large Petti led a discussion of the Committee’s efforts associated with generating the subject report and noted that its content was based on numerous interactions with representatives of the NRC’s Office of Nuclear Regulatory Research (RES) regarding the following topics: (1) integration of source term activities in support of advanced reactor initiatives, (2) digital twins, (3) materials harvesting activities, (4) level 3 probabilistic risk assessment, (5) artificial intelligence strategic plan, (6) high burnup fuel source term accident analysis, (7) fuel fabrication, relocation, and dispersal for high burnup fuel, (8) advanced manufacturing, (9) machine learning in non-destructive examination and in-service inspection, (10) non-light water reactor (non-LWR) code development, (11) high energy arc faults, and (12) risk assessment and human factors for non-LWRs.

The Committee deliberated on the letter presented and discussed by Member-At-Large Petti and approved its issuance. In addition, the Committee authorized Member-At-Large Petti and the ACRS staff to make appropriate edits to the numerous appendices to ensure accuracy. The letter will be processed and issued in the first quarter of calendar year 2025.

The Committee discussed that, overall, the research portfolio is well balanced considering the major regulatory challenges facing the agency over the next 3 to 5 years: subsequent license renewal, higher-burnup higher-enrichment fuels for the current fleet, and advanced non-LWR reactor licensing applications. The depth and breadth of the on-going safety research program continues to meet the Agency’s current needs for anticipated regulatory decisions.

The research program enables staff to maintain core competencies and prepare for reviews of anticipated submittals. This was demonstrated by presentations from the research staff. The RES uses a systematic approach to prioritize research emphasizing “enterprise risk” in project selection, evaluation, and termination. The use of the future focused research program, the establishment and implementation of integrated action plans, and the recent RES leadership of agency-wide initiatives are enabling the Agency to become agile and more proactive in preparing for emerging technologies associated with future licensing submittals. The result is a research program that is having greater impact on agency priorities. These activities are all signs of a healthy research organization and support the Agency’s broader efforts to transform itself into a more efficient risk-informed regulator.

c. Draft Safety Evaluation of the TerraPower Topical Report (TR), "Plume Exposure Pathway Emergency Planning Zone Methodology," Revision 3

The Committee heard from representatives of TerraPower and the NRC staff, and it issued a November 26, 2024, letter, with the following conclusions and recommendations:

1. The proposed methodology is expected to result in an emergency planning zone (EPZ) size that is consistent with the principles historically used as part of the emergency preparedness framework.

2. The TR proposal to assess potential cliff-edge effects for EPZ sizing only when accident event sequence frequency exceeds a threshold (1x10-8/plant-year) is not aligned with more recent regulatory guidance provided for the risk-informed, performance-based, technology inclusive licensing methodology for non-LWRs. The EPZ regulatory guidance recommends retention of event sequences below a frequency cutoff (for Natrium this value is 1x10-7/plant-year) when assessing for cliff-edge effects. However, there is no specific guidance on how to further screen the large number of sequences that must be considered in practice. Given this lack of specificity, the threshold used in the TR should have been justified.

3. The SER should not be issued until the rationale for the use of the frequency threshold when assessing the potential for cliff-edge effects is addressed, as discussed above.

4. The committee continues to observe that additional clarifying guidance is warranted regarding selection criteria for the spectrum of events to consider for determination of the source term that is to be applied for EPZ sizing.

d. Discussions during the Planning and Procedures Session

1. The Committee discussed the Full Committee and Subcommittee schedules through April 2025 as well as the planned agenda items for Full Committee meetings.

2. The ACRS Executive Director led a discussion of significant notices issued by the Agency since the last Full Committee meeting in October 2024. The Executive Director documented this activity in a memorandum dated November 13, 2024, ADAMS Accession No. ML24318C428.

3. The Executive Director also led a discussion of two draft RGs regarding possible review by the Committee. The Executive Director documented this activity in a memorandum dated November 14, 2024, ADAMS Accession No. ML24318C433.

4. Member Dimitrijevic led a discussion on the NuScale Mitigation of Beyond-Design-Basis Events TR and the associated draft safety evaluation.

   The NuScale Design-Centered Review Subcommittee met with the staff and NuScale on October 1, 2024. The Subcommittee reviewed the staff's evaluation of NuScale Topical Report, "NuScale Power Plant Design Capability to Mitigate Beyond-Design-Basis Events Defined by 10 CFR 50.155."

In the TR the applicant made a case that the NuScale design capabilities and features enable mitigating beyond-design-basis-events (covering an extended loss of electrical power, loss of normal access to the normal heat sink, and loss of large areas due to explosions or fire) using only permanently installed plant equipment that is safety-related. As described in the TR, these design features, including passive safety systems and a large reactor pool serving as the ultimate heat sink for the facility, can maintain core cooling, containment, and spent fuel pool cooling for a specified extended duration without the need for alternating current power, external equipment, or additional guidelines and strategies.

However, the TR does not contain or reference any analyses supporting the above determination. In response to staff's audit questions, the TR was revised to define four conditions of its use in section 1.3: (1) maintain plant specific design features described in report, (2) provide a thermal analysis to validate proposed coping period, (3) establish a maintenance rule program in accordance with 10 CFR 50.65, and (4) establish an emergency plan in application.

In summary, the TR is to be generically applicable to NuScale reactor designs with the capabilities and features discussed in the TR, while the supporting analyses to demonstrate these capabilities are to be provided by an applicant or a licensee who adopts the TR. As stated in Condition of Use no. 2, an adopter of the TR must provide a plant specific thermal analysis (including configuration of the plant, number of modules, spent fuel pool (SFP) capacity, for all modes of operation) demonstrating its capability to maintain core cooling, containment, and SFP cooling for at least 30 days with installed plant equipment identified in the TR.

To cover the above conditions of use, the staff imposed seven limitations and conditions (L&C) for using the TR:

- L&C 5.1 requests an adopter of the topical report to satisfy Conditions of Use in TR Section 1.3, by providing analysis and potential guidelines and strategies dependent on the analysis,
- L&Cs 5.2, 5.3, 5.4 and 5.5 addresses the requirement for long term mitigating capabilities associated with the NuScale design discussed in the TR,
- L&C 5.2 specifically addresses inventory makeup to the ultimate heat sink,
- L&C 5.3 specifically addresses the assigned control room monitoring function,
- L&C 5.4 specifically addresses the capability of site support personnel to ascertain plant conditions to determine necessary coping requirements once onsite power systems are depleted,
- L&C 5.5 specifically addresses long-term support related to SFP level monitoring instrumentation,
- L&C 5.6 addresses the Fire Protection Program, including plant-specific design features and procedures, that would provide assurance of adequate LOLA coping capability, and

- L&C 5.7 requests an adopter of the topical report to confirm that the training program includes the required activities related to replacement of SFP level monitoring power supply and addresses the training of the operators to make the necessary connections to establish replacement power sources.

Based upon its review, subject to the limitations and conditions discussed above, the NRC staff concludes that TR-141299-P, Revision 1, provides a reasonable approach for an applicant or licensee to demonstrate the NuScale plant design capability to mitigate beyond-design-basis-events as defined by 10 CFR 50.155.

The recommendation of the Subcommittee is that the staff's safety evaluation report is sufficiently complete to recommend that it be issued, and that this summary be placed in the summary report.

The Committee agreed with the recommendations.

5. Members Ballinger and Martin led a discussion on WCAP-18850-P, "Adaptation of the FULL SPECTRUM LOCA (FSLOCA) Evaluation Methodology to Perform Analysis of Cladding Rupture for High Burnup Fuel."

   As a part of the efforts by Westinghouse (WEC) to provide a technical basis for their justification of increased enrichment, they have proposed a "no-burst" criteria in an updated loss-of-coolant accident (LOCA) analysis. WEC has requested review and approval of TRWCAP-18850-P, Revision 0, "Adaptation of the FULL SPECTRUM LOCA (FSLOCA) Evaluation Methodology to Perform Analysis of Cladding Rupture for High Burnup Fuel," as a part of this effort. This report presents an evolution of WEC's evaluation model (approved in 2016) to demonstrate compliance with 10 CFR 50.46 and anticipated rulemaking, accommodating increased enrichment and burnup, including fuel fragmentation, relocation, and dispersal (FFRD). This TR follows the recent Committee meetings on related topics. These include review of WCAP-18446, "Incremental Extension of Burnup Limit for Westinghouse (WEC) and Combustion Engineering (CE) Fuel Designs," (ADAMS Accession No. ML24132A009). The Committee also had an information briefing with EPRI on the industry-proposed Alternative Licensing Strategy, which is a potential solution to the FFRD issues.

   One approach to resolution of the FFRD issue is to demonstrate, by analysis, that cladding rupture does not occur during a LOCA.

   The WCAP-18850 documents evaluation model changes to FSLOCA to accommodate analysis of high burnup conditions (beyond the limitation on WCAP-18446) and to demonstrate sufficient margin to cladding rupture to avoid rupture. Hence, while fuel fragmentation and relocation may occur, fuel dispersal is precluded. Specifically, the WCAP details fuel rod model updates related to fission gas release, cladding deformation, pre-burst fuel relocation, and cladding rupture and other updates such as the decay heat and kinetics models and uncertainty analysis methods.

   The WCAP provides the entire basis for the "no-rupture" criteria that WEC is proposing as a solution to the FFRD issue. It is thus important that the committee fully understands the technical basis and justification for this claim. Members Ballinger and Martin propose that the Subcommittee review this document and be provided a detailed presentation. A

letter recommendation would be based on the outcome of this briefing.

The Committee agreed with the Subcommittee recommendation on arranging a future Subcommittee meeting on this subject.

6. Member Ballinger led a discussion of the ACRS activities associated with the increased enrichment draft rulemaking package to include:

   a. November 19, 2024, Subcommittee meeting on RG 1.183, revision 2, topics: pathway specific source term using MELCOR (Electric Power Research Institute Modular Accident Analysis Program runs), and updated to 2023 source term presentation,

   b. December 17 and 18, 2024, Subcommittee meeting on draft rule language and package,

   c. December 19, 2024, Subcommittee meeting on entire RG 1.183, revision 2,

   d. January 2025 Subcommittee meeting on transition break size, FFRD guidance documents, and

   e. Letter report on draft rule language during February 2025 Full Committee meeting.

7. Member Martin led a discussion on the University of Illinois at Urbana-Champaign (UIUC) IMRDD-MMR-24-01-P, Release 1, Fuel Qualification Methodology Topical Report.

   The UIUC requested NRC review and approval of TR IMRDD-MMR-24-01-P, Release 1, “Fuel Qualification Methodology,” for referencing in licensing a research reactor. The ACRS review does not apply per 10 CFR 50.58. This TR describes the fuel qualification methodology for the Ultra Safe Nuclear Corporation (USNC) Micro Modular Reactor (MMR) to be deployed at UIUC. The fuel for the MMR consists of micro-encapsulated tristructural isotropic fuel particles embedded in a ceramic matrix to form a Fully Ceramic Micro-encapsulated annular fuel pellet. The Committee had tentatively scheduled an information briefing on the staff’s evaluation of the TR for March 19, 2025. The staff met with Members Martin and Petti, ACRS staff and management to discuss a possible agenda and whether an information briefing was necessary. The staff affirmed that future USNC MMRs would be commercial facilities and are expected to be licensed and operate at a higher power level (compared to 10 Megawatts thermal for the UIUC reactor). Therefore, the staff expects any license application(s) for other USNC MMRs would be subject to future ACRS review. Members Martin and Petti mentioned the Committee’s December 20, 2022, letter on the Kairos fuel qualification methodology and the importance of the referenced Electric Power Research Institute, TR EPRI-AR-1(NP)-A, 3002019978, “Uranium Oxycarbide Tristructural Isotropic (TRISO) Coated Particle Fuel Performance,” to the UIUC design.

   Members Martin and Petti agree that a review by the Committee is not warranted. The ACRS review should be considered for the first commercial application as discussed by the staff.

   The Committee agreed with the recommendation.

8. Technical Assistant Rob Krsek led a discussion of recent improvements in providing meeting information (agendas and slides) to the NRC's public meeting notification system and other improvements.

9. Vice Chair Halnon led a discussion about the need to capture important follow-up items from Subcommittee and Full Committee meetings. The ACRS staff engineers will, in consultation with the lead ACRS member, keep track of important items and highlight those actions in status reports.

10. Executive Director Moore led a discussion of the ACRS officer elections planned for the December 2024 Full Committee meeting.

    At the last regularly scheduled Full Committee meeting of the year, i.e., December Full Committee meeting (December 4 through 6, 2024), ACRS will hold its annual election for officers. See ACRS Bylaws Chapter 8, Section 8.3, which states, in part:

    The Chair shall be elected by a numerical majority of the current membership using a secret ballot, with all members as candidates. Members may withdraw their names from consideration by written notice to the Executive Director, no later than two weeks before the scheduled election.

11. Executive Director Moore led discussion of one reconciliation on the subject of Revision 9 of Standard Review Plan Branch Technical Position 7-19, "Guidance for Evaluation of Defense in Depth and Diversity to Address Common-Cause Failure Due to Latent Defects in Digital Safety Systems."

    The Committee discussed how to proceed on this issue and decided to have Member Roberts conduct an informal meeting with the staff to ensure that they understand the concerns raised. It was also agreed that Member Roberts would provide an update at the December 2024 Full Committee meeting.

12. There was a closed portion of the meeting to discuss proprietary and administrative topics.

13. The following topics are on the agenda of the 721st ACRS Full Committee meeting which will be held on December 4 through 6, 2024:

    - Material Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines (MRP-227, Revision 2)

Sincerely,

Walter L Kirchner Signed by Kirchner, Walter on 12/20/24

Walter L. Kirchner
Chair

Enclosure:
List of Acronyms

December 20, 2024

SUBJECT: SUMMARY REPORT – 720th MEETING OF THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS, NOVEMBER 6-8, 2024

Accession No: ML24346A120 **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	RKrsek	WKirchner
DATE	12/12/2024	12/12/2024	12/19/2024	12/20/2024

OFFICIAL RECORD COPY

List of Acronyms

ACRS	Advisory Committee on Reactor Safeguards
ADAMS	Agencywide Documents Access and Management System
CE	Combustion Engineering
EPZ	Emergency Planning Zone
FFRD	Fuel fragmentation, relocation, and dispersal
FSLOCA	Full Spectrum LOCA
L&C	limitations and conditions
LOCA	loss-of-coolant-accident
non-LWRs	non-light water reactors
NRC	Nuclear Regulatory Commission
MMR	Micro Modular Reactor
PMNS	public meeting notification system
RES	Office of Nuclear Regulatory Research
RGs	Regulatory Guides
SFP	Spent Fuel Pool
TR	Topical Report
TRISO	tristructural isotropic
UIUC	University of Illinois at Urbana-Champaign
USNC	Ultra Safe Nuclear Corporation
WEC	Westinghouse Electric Corporation