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

March 19, 2026

Honorable Ho K. Nieh
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: LESSONS LEARNED FROM ACRS REVIEWS OF NEW REACTOR APPLICATIONS

Dear Chairman Nieh:

During its 732nd and 733rd meetings held on February 5, 2026, and March 5 through 6, 2026, the Advisory Committee on Reactor Safeguards (ACRS) reflected on lessons learned from reviewing new reactor applications. The Committee's discussions occurred against the backdrop of three major themes: (a) ensuring that ACRS continues to meet its statutory responsibilities, (b) advancing the Administration's goal of safe nuclear energy deployment by collaborating with staff to ensure reviews are timely, efficient, and attentive to unique or significant issues, and (c) supporting the NRC's leadership and foremost reputation in nuclear safety.

The Committee's deliberations encompassed the following recent reviews of applications: the NuScale US600 design certification application (DCA) and US460 standard design approval application, the Kairos Hermes and Hermes 2 construction permit applications, and the TerraPower Natrium construction permit (CP) application at Kemmerer, Wyoming; ongoing CP application reviews for X-Energy's Xe-100 in Seadrift, Texas, and General Electric's BWRX-300 at Clinch River, Tennessee; and pre-application topical reports (TRs) from other vendors. Additionally, the Committee considered guidance from the Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy (ADVANCE) Act, Executive Order (EO) 14300 (Ordering the Reform of the Nuclear Regulatory Commission), and other relevant Commission directions.

**Conclusions and Proposed Path Forward**

1. Beginning with the NuScale DCA in 2019, the ACRS has continuously improved its reviews to be more safety focused, streamlined, and resource efficient with less burden on the staff and applicant, while still providing a holistic integrated evaluation consistent with its statutory obligations. We have embraced the EO 14300 direction to focus on the unique, novel, and noteworthy safety-significant aspects of each new reactor application or other licensing reviews and observe this direction is consistent with ongoing Committee process improvements.

2. This streamlined ACRS review takes an integrated safety-case approach focused on fundamental safety functions of the reactor design, which is complementary to the detailed

regulatory compliance aspects of the review performed by the NRC staff. Employing these diverse review strategies is especially beneficial for advanced reactors that introduce many first-of-a-kind features.[1]

3. The Committee conducts its reviews in parallel with the NRC staff, independent of the issuance of the staff's safety evaluation (SE). Reviews begin shortly after application acceptance and involve a limited number of focused engagements with the applicant and staff. This approach has enabled the recent reviews to be completed on or ahead of established schedules. Nevertheless, the Committee continues to pursue further improvements in effectiveness and efficiency, in anticipation of increased application reviews.

4. The Committee has observed substantial variability in the technical detail of applications submitted thus far. Ultimately, the completeness and quality of the license application and its associated supporting documents are key to enabling efficient and streamlined reviews.

5. For unique design features or methodologies associated with advanced reactor designs, it is advantageous that they be submitted in topical reports during the pre-application phase. Earlier reviews of TRs will help expedite the review of the final licensing application.

6. Detailed lessons learned are found in the body of the letter.

**Background**

The 1957 amendment to the Atomic Energy Act established the ACRS as a statutory committee responsible for advising the U.S. Atomic Energy Commission on reactor hazards and safety standards, and for reviewing certain reactor license applications under Section 103 and 104. After the Energy Reorganization Act of 1974, these responsibilities continued under the Nuclear Regulatory Commission.

As the world's longest standing committee focused on nuclear safety, the ACRS has played a key role in reactor licensing, driving the development of new safety requirements and design improvements. Its statutory mandate remains essential today, mirroring that of the Committee's role at the dawn of commercial nuclear power nearly seventy years ago. It also serves to bolster public confidence that new and advanced reactor technologies can be deployed safely and efficiently to meet the Administration's national energy goals.

**Lessons Learned**

The following lessons learned originate from our recently completed reviews. In many cases there were common threads in the applications that led to these lessons learned. In other cases, there were differences across the applications that highlighted the observation. They are presented generically, without referencing specific applicants or the corresponding staff SE.

The items are organized into three major areas: (a) Safety Case Development, (b) Licensing Review Process, and (c) Technology-Specific Impacts on the Safety Review.

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[1] The fundamental safety functions are control of reactivity, control of process heat, and retention of radionuclides.

Safety Case Development

1. It is to the benefit of the applicant (and the staff review) to specifically present the safety case in as transparent and complete a manner as possible. Ample safety margins should be clearly identified to address uncertainties and to compensate both for lack of operating experience and incomplete validation of computational tools. To the extent possible, the safety case should be made clear to the public.

2. When an applicant is taking a major departure from historical precedent in the development of critical aspects of their safety case (e.g., implementation of key safety functions), more detailed focus on the alternative approach being taken and the technical rationale for the departure as early in the process as possible would benefit the overall licensing review.

3. Working top down from safety functions and associated principal design criteria to systems that implement those functions, combined with the bottom up evaluation of those unique, novel or noteworthy aspects of a specific technology (e.g., new fuel, new coolant, new materials) allows a very focused holistic integrated safety review that complements rather than duplicates the staff's chapter by chapter review approach. This review strategy diversity is especially important as advanced reactors introduce first-of-a-kind features, greater reliance on inherent and passive safety attributes, limited operational experience, reduced experimental databases and validation, and novel licensing methodologies. Our integrated approach results in significant resource savings and is also consistent with the directions provided in the ADVANCE Act, EO 14300, and by the Commission to reinforce the Committee's ongoing efforts to streamline its reviews.

4. Some applicants are changing or even deleting principal design criteria with insufficient technical justification. This approach dilutes the intent of the criteria that have been established through a rigorous process as outlined in Regulatory Guide (RG) 1.232. For new designs with little or no relevant technical data or operating experience, such inadequately documented technical bases potentially diminish lines of defense, weaken defense-in-depth, and thereby increases the potential for a reactor accident and adverse consequence to the public.

Licensing Review Process

1. As allowed by the two-step licensing process, CP applications may lack sufficient technical analyses and design detail to support a robust safety case and demonstrate defense-in-depth. As a result, much of the technical burden shifts to the operating license (OL) application. While this is not new or unanticipated, we reaffirm that OL application reviews are expected to use more resources and potentially take more time than CP application reviews.

2. Effective pre-application engagement and technically complete TRs early in the process lay important foundations for building the safety case in CP and OL applications of advanced reactors. However, TRs that focus primarily on concepts or plans without technical details offer limited value, resulting in numerous limitations and conditions imposed by the staff and inefficient use of review time. These types of TRs may appear to demonstrate progress towards a successful licensing application but actually do not and may tie up valuable resources both with the staff and the Committee. TRs should strategically focus on the

foundational aspects of the safety case and provide sufficient detail to clarify overall safety implications.

3. Applications using the Technology-Inclusive Content of Application Project/Advanced Reactor Content of Application Project (TICAP/ARCAP) structure should directly incorporate all necessary evidence to support reasonable assurance findings at both the CP and OL stages. Not including critical details, such as hazards and accident analyses that exist in subsidiary documents, requires audit time by the staff and is inefficient. Furthermore, by only presenting high level information without the supporting details, it is difficult to discern safety margins in key components that underpin the safety case. Timely access to relevant audit results, especially on unique, novel and noteworthy items, will expedite ACRS's parallel review.

4. We have identified the following aspects from recent licensing reviews as noteworthy:

    a. The risk-informed approach used in the licensing modernization project (LMP) helps focus on key structures, systems and components that impact the safety case. The risk-optimized safety profile of current gas and sodium reactor designs compared to historic designs demonstrate an important value of the LMP by focusing on risk significance.

    b. When designs represent small evolutionary changes over previously reviewed designs, the use of a "delta" review process is very useful and time efficient. Furthermore, having a red-line strikeout showing changes between the previous and current preliminary safety analysis reports (PSARs) allows reviewers to quickly identify changes and assess their impact on the overall safety case.

    c. The use of a line of defense methodology is an excellent structured and systematic process that has the potential:

        i. to implement a balanced approach to addressing the adequacy of safety function integration in the design,

        ii. to establish the effectiveness of defense-in-depth implementation, particularly for reactor designs that credit reduced accident likelihood as the only justification for simplified approaches to containment and siting,

        iii. to be suitable for the evaluation of residual risk and cliff edge effects, and

        iv. to confirm the completeness of the probabilistic risk assessment (PRA).

<u>Technology-Specific Impacts on the Safety Review</u>

1. Each design has distinct safety attributes or technology features that require experimental confirmation, sometimes only achievable during initial plant start up. While computational methods have advanced, reliable data remains essential for verifying key safety aspects. The staff's documentation at the CP application stage of all of the research and development (R&D) items necessary to support the OL application is a noteworthy essential practice.

2. The safety case for a specific nuclear technology is shaped by its unique attributes. For liquid metals and molten salts, heat transfer is relatively straightforward unless phase changes occur. Instead, fast reactors require greater attention to reactivity feedback and fire risks. In salt systems, oxidation-reduction (REDOX)/corrosion control and freezing of molten salts are more important. Potentially life limiting material behavior for structures, systems and components in gas reactors may be more of a safety issue than the capabilities of the passive heat removal. As a result, direct application of historic regulatory guides, analytical protocols, and safety norms from light water reactors (LWRs) without adaptation may not be effective or efficient for advanced reactor licensing. For example:

   a. A holistic safety review for an advanced reactor should focus not only on the performance of the fuel but also on the safety design limits of other structural and pressure boundary systems because these plant elements may be more limiting in many designs.

   b. While RG 1.203 provides a useful framework for establishing and validating an applicant's analytical evaluation model, many of the details such as the scaling methodology are focused on the complex behavior of water (flashing, critical heat flux, two phase flow) in large LWRs. The emphasis for advanced reactors should be on the *intent* of RG 1.203, and the specific requirements need to be balanced against safety margins so that attention remains focused on the most critical safety issues for each technology.

**The Path Forward**

The ACRS has continually improved its review approach to be more efficient, which is consistent with the directions provided in the ADVANCE Act and EO 14300. The ACRS will prioritize future reviews based on the unique, novel and noteworthy safety aspects of advanced reactor designs, including both light-water and non-light water technologies. Key features include advanced fuels (such as tri-structural isotropic (TRISO) coated-particle fuel and metallic fuel), dissolved fuels in molten salt reactors, innovative neutron moderators, new structural materials, and novel coolants. These reactors also use new systems for containment, heat removal, and reactivity control—many of which operate passively. Understanding the performance of these technologies under normal and accident conditions is essential to validate the safety case.

The Committee now conducts an early, independent scoping review to identify the unique, novel and noteworthy aspects of each application to focus its review. The Committee monitors staff reviews, including audits and requests for information, to inform our application review. Instead of reviewing every chapter, the Committee provides an integrated assessment of design elements impacting facility safety. This approach was used for the Kemmerer CP application and is being used in ongoing reviews of Long Mott and Clinch River CP applications. While the Committee has demonstrated its ability to complete reviews ahead of established schedules, we continue to identify ways to further enhance effectiveness and efficiency in anticipation of increased application reviews.

Ultimately it is the completeness and quality of a license application and associated supporting documents that facilitate efficient and streamlined reviews. Applicants should be strongly encouraged in pre-application to thoroughly address unique methodologies and approaches in topical reports well ahead of actual license application submittals.

Beyond license applications, it will be essential to demonstrate the capability to safely operate and maintain these new facilities. This includes establishing a strong safety culture, developing appropriate technical qualifications, gaining operating experience, providing effective oversight, managing worker radiation doses, displaying commitment to worker health and safety, providing specialized training (such as for sodium or molten salt environments), and creating robust maintenance practices.

**Final Thoughts**

Congress created a statutory requirement for the ACRS to ensure an extra layer of oversight in regulation of the then new and evolving technology. At the time, the complexities of nuclear technology were not fully understood. Thus, the ACRS was given a broad mandate to offer expert advice based on knowledge and experience. This approach helps identify potential safety concerns that might not be covered by regulations alone. Nearly seventy years later, advanced reactor technologies are again presenting similar challenges. The ACRS continues to serve in its essential role, offering in-depth, experience-based reviews to ensure safety remains the highest priority.

To serve the Commission and the public effectively, the Committee is committed to making its reports clear and well-structured. By building expert consensus and clearly outlining key safety issues, the ACRS provides timely, evidence-based recommendations. Each recommendation is supported by thorough, technically sound explanations that highlight the safety, rigor, and completeness of licensing actions or rulemaking.

We are not requesting a response to this letter.

In accordance with Article VI, Section 8 of the ACRS Bylaws, the Additional Comments from Member Martin in Enclosure 2 represent the personal views of only the signatory member. The comments were not endorsed or adopted by the Committee and must not be interpreted as an official Committee position or recommendation.

Sincerely

Signed by Halnon, Gregory
on 03/19/26

Gregory H. Halnon
Chairman

Enclosure
1. List of Acronyms
2. Additional Comments by ACRS Member Robert P. Martin

**REFERENCES**


1. U.S Nuclear Regulatory Commission, Regulatory Guide (RG) 1.232, “Guidance for Developing Principal Design Criteria for Non-Light Water Reactors,” April 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17325A611).

2. U.S. Nuclear Regulatory Commission, RG 1.233, “Guidance for a Technology Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors,” June 2020 (ADAMS Accession No. ML20091L698).

3. U.S. Nuclear Regulatory Commission, RG 1.203, “Transient and Accident Analysis Methods,” December 2005, (ADAMS Accession No. ML053500170).

4. Advisory Committee on Reactor Safeguards, “Report on the Safety Aspects of the Construction Permit Application for a TerraPower Natrium Reactor at the Kemmerer Power Station,” November 16, 2025 (ADAMS Accession No. ML25311A150).

5. Advisory Committee on Reactor Safeguards, “Report on the Safety Aspects of the NuScale US460 Small Modular Reactor Standard Design Approval Applications,” May 21, 2025 (ADAMS Accession No. ML25136A329).

6. Advisory Committee on Reactor Safeguards, “Safety Evaluation of the Kairos Non-Power Reactor Hermes 2 Construction Permit Application,” July 17, 2024 (ADAMS Accession No. ML24197A152).

7. Advisory Committee on Reactor Safeguards, “Kairos Non-Power Reactor Hermes Construction Permit Application,” May 16, 2023 (ADAMS Accession No. ML23130A183).

8. Advisory Committee on Reactor Safeguards, “Report on the Safety Aspects of the SHINE Medical Technologies, LLC, Operating License Application Review,” December 15, 2022 (ADAMS Accession No. ML22342A144).

9. Advisory Committee on Reactor Safeguards, “Observations and Lessons-Learned from ACRS Licensing Reviews Relevant to Future Advanced Reactor Applications,” October 2, 2020 (ADAMS Accession No. ML20267A655).

10. Advisory Committee on Reactor Safeguards, “Report on the Safety Aspects of the NuScale Small Modular Reactor,” July 29 2020 (ADAMS Accession No. ML20211M386).

11. Advisory Committee on Reactor Safeguards, “ACRS Activities to Support NRC Transformation,” October 17, 2019 (ADAMS Accession No. ML19290F956).

## LIST OF ACRONYMS

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| ACRS | Advisory Committee on Reactor Safeguards |
| ADAMS | Agencywide Documents Access and Management System |
| ADVANCE | Accelerating Deployment of Versatile, Advance Nuclear for Clean Energy |
| CP | Construction Permit |
| DC | Design Certification |
| EO | Executive Order |
| LMP | Licensing Modernization Project |
| LWR | Light-Water Reactor |
| OL | Operating License |
| PRA | Probabilistic Risk Assessment |
| PSARs | Preliminary Safety Analysis Reports |
| R&D | Research and Development |
| REDOX | Oxidation-Reduction |
| RG | Regulatory Guide |
| SE | Safety Evaluation |
| TRISO | Tri-Structural Isotropic |
| TRs | Topical Reports |
| TICAP/ARCAP | Technology-Inclusive Content of Application Project/Advanced Reactor Content of Application Project |

**Additional Comments by ACRS Member Robert P. Martin on Hazards Analysis, Probabilistic Risk Assessment Scope, and Residual Risk**

Consistent with the observations presented in the Committee's letter, I support the conclusions conveyed, including the value of the Licensing Modernization Project (LMP) risk-optimized safety profile and the promise of a lines-of-defense methodology as a structured tool for evaluating cliff-edge effects and confirming Probabilistic Risk Assessment (PRA) completeness. I offer the following additional observation regarding applicant implementation in the residual-risk (beyond design-basis) domain to further clarify how hazards analysis and PRA scope definition can affect the completeness of cumulative risk insights in this domain.

Across the applications reviewed to date, applicants have generally performed PRA and consequence evaluations for beyond-design-basis events (BDBEs). However, variability has been observed in how hazards and low-frequency sequences are treated when transitioning from hazards identification and analysis to PRA quantification and ultimately to the calculation and reporting of cumulative (comprehensive) risk metrics. For example, some applications expand or modify the set of sequences included in integrated plant performance evaluations relative to the LMP framework, while others adhere more strictly to the License Basis Events structure. This variability may in part reflect limited methodological guidance for hazards analysis in advanced reactor applications, particularly regarding how hazards analyses define PRA scope and document the technical basis for screening decisions.

Events that can be justifiably screened should be screened principally during the hazards and initiating-event evaluation that establishes PRA scope, with an explicit technical basis. Carrying such events into the PRA and subsequently removing them through a fixed frequency cutoff during residual-risk accounting can obscure the connection between hazards and risk quantification. While LMP requires deterministic evaluation of such sequences for defense-in-depth adequacy and potential cliff-edge effects, those evaluations do not fully substitute for the cumulative insights provided by PRA. The Commission's SRM-SECY-23-0021 emphasizes the importance of considering all hazards in this domain and requiring justification for screening. This direction is significant because the residual-risk domain represents the risk that remains beyond the design-basis boundary, including events that may be poorly characterized due to epistemic uncertainties, are low-frequency but have high dose consequences, or associated with unknown or underappreciated hazards.

Frequency thresholds serve a useful role in distinguishing event domains (e.g., anticipated operational occurrences, design-basis events , and BDBEs). However, applying a lower frequency cutoff in the BDBE domain could inadvertently eliminate sequences or families of sequences with similar consequences that collectively represent a credible contributor to cumulative risk. Removing PRA cutsets in this domain solely on the basis of frequency can non-conservatively bias or diminish the insights that PRA is intended to provide and may reduce transparency in how such events are treated.

Note: In accordance with Article VI, Section 8 of the ACRS Bylaws, the Additional Comments from Member Martin in this Enclosure represent the personal views of only the signatory member. The comments were not endorsed or adopted by the Committee and must not be interpreted as an official Committee position or recommendation.