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Advanced Reactor Regulatory Framework Development Activities for Fiscal Year 2023

September 2023

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INL ART Program

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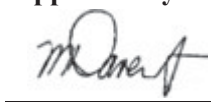
Approved by:



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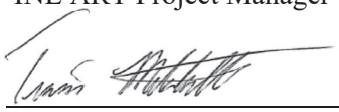

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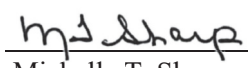

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SUMMARY

This report provides an end-of-year summary that reflects the progress and status of Idaho National Laboratory's (INL) activities concerning the development of advanced reactor (AR) regulatory framework and its implementation in the United States (U.S.). The report also summarizes some general updates on important topics in regulatory development. This work was completed in Fiscal Year 2023 (FY 2023) and was supported by the U.S. Department of Energy (DOE) Regulatory Development subprogram. These activities are managed by INL on behalf of DOE.

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ACRONYMS

AGR	Advanced Gas Reactor
ANR	advanced nuclear reactors
AR	advanced reactor
CFR	Code of Federal Regulations
CNSC	Canadian Nuclear Safety Commission
DOE	Department of Energy
FY	fiscal year
GEIS	Generic Environmental Impact Statement
INL	Idaho National Laboratory
LWR	light-water reactor
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
NRRWG	New Reactor Regulatory Working Group
R&D	research and development
SMR	small modular reactor
TICAP	Technology-Inclusive Content of Application Project
TIRICE	Technology-Inclusive Risk-Informed Change Evaluation
TRISO	tristructural isotopic
U.S.	United States

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Advanced Reactor Regulatory Framework Development Activities for Fiscal Year 2023

1. PURPOSE

This report provides an end-of-year summary that reflects the progress and status of Idaho National Laboratory's (INL) Regulatory Development group activities concerning advanced reactor (AR) (i.e., non-light-water reactor [LWR]) regulatory framework development and implementation. This report was developed to address and satisfy the United States (U.S.) Department of Energy (DOE) milestone M3RD-23IN0702013 under INL work package RD-23IN070201.

2. OBJECTIVE

Regulatory framework development activities are intended to establish a clearly defined regulations structure for the non-LWR community and help implement regulatory and licensing strategies for newly emerging commercial nuclear power technologies. Additionally, this activity was initiated to engage in the progress of regulatory actions conducted by industry and government agencies, and to interact with stakeholders on matters important to licensing in support of commercial deployments.

This activity coordinates DOE regulatory efforts with industry and Nuclear Regulatory Commission (NRC) staff and stakeholders, ensuring that DOE research and development (R&D) activities are appropriately aligned, and that they adequately address aspects of licensing technical requirements development for AR technologies, thereby reducing uncertainty in an evolving regulatory environment.

3. SUMMARY OF COMPLETED ACTIVITIES

The non-LWR regulatory framework development activity encompassed work performed by DOE and INL researchers to plan and develop new R&D activities, participate in industry and government interactions associated with AR development and near-term deployment, and coordinate interactions with DOE and NRC. The following subsections of this report summarize the work performed by INL's Regulatory Development Group in fiscal year (FY) 2023.

3.1 Meetings and Interactions

Throughout FY 2023, INL Regulatory Development Group staff regularly participated in a variety of meetings that supported AR development and deployment. Members of the group researched, attended, and participated in the AR public stakeholder meetings that NRC held approximately every 6 weeks (typically as virtual webinars). Additionally, some INL staff attended and participated in the AR regulatory task force meetings, which were usually held virtually by the Nuclear Energy Institute (NEI) one day prior to the NRC AR stakeholder meetings.

The engagement in and impact of these meetings proved essential to INL staff for maintaining currency in the nuclear industry and remaining knowledgeable about its state—especially regarding ARs—to continue assisting the industry in moving forward on regulatory activities. INL's Regulatory Development department frequently communicated directly with NEI, NRC, DOE, individual applicants, and other national laboratories to engage and actively participate in development and near-term deployment activities related to regulatory development. Additionally, INL staff reviewed and commented on documents developed by NEI, NRC, and DOE as members of the Regulatory Development Coordination and Integration group.

3.1.1 NRC Activities

INL staff interacted regularly with NRC throughout FY 2023, with the NRC staff continuing to focus on the completion of priority regulatory framework development activities as outlined in its "NRC Non-Light-Water Reactor Near-Term Implementation Action Plans" document [1]. These efforts focused on establishing a clearly defined regulatory pathway for AR deployments and creating NRC-endorsed and -approved guidance for pursuing that pathway, thus significantly reducing the regulatory uncertainty that has historically plagued AR developers. Much of the initial NRC guidance was based on industry proposals and ongoing interactions that were supported by DOE and developed through this area of the regulatory development program. These interactions included participating in stakeholder discussions, reviewing new and revised regulatory documentation, providing comments, and engaging with NRC through industry stakeholder and public meetings to discuss proposals, work products, and future licensing activities. Significant progress was made in many areas and this progress is reflected in the associated Advanced Reactor Program-Summary of Integrated Schedule and Regulatory Activities [2], found on NRC's public website.

INL staff reviewed the impacts of these activities and their influences and likely consequences on future AR licensing. These included:

- NRC/Canadian Nuclear Safety Commission (CNSC) report on tristructural isotopic (TRISO) fuel qualifications (see Section 4.4)
- Emergency preparedness, which is approved by the Commission in August 2023
- Physical security, which is currently in NRC Commission review.

3.1.2 Industry Engagement – NEI New Reactor Regulatory Working Group

3.1.2.1 Background

The established mission of the NEI's New Reactor Regulatory Working Group (NRRWG) is to provide industry coordination and strategic guidance on key generic licensing and regulatory issues for new reactors to achieve a modern and efficient regulatory framework for new reactors that:

- Meets the industry's cost, timing and predictability needs
- Enables new reactors to maximize their societal benefit by helping the nation to meet its energy, environmental, economic, and national security goals.

The scope of NRRWG work is focused on:

- New Reactors. Any new reactor technology, including large light-water reactors, small modular reactors), non-light-water reactors (non-LWRs), and microreactors.
- Licensing and Regulatory Framework. Regulations applicable to licensing new reactors (e.g., 10 Code of Federal Regulations [CFR] Parts 50, 52 and 53), other regulations as applicable to new reactors (10 CFR Parts 51, 73, etc.) and guidance associated with these regulations.
- International Regulatory Efficiency. International regulatory harmonization initiatives, bilateral cooperation with NRC, international codes and standards, and NRC support for regulatory authorities in other countries.

The NRRWG establishes the goals, strategy, priorities, and principles for industry's positions for the NRC regulatory framework for new reactors. The NRRWG provides direction, oversight, and leadership support (as necessary) to NEI and new reactor task forces responsible for developing the details of industry's positions and achieving resolution with the NRC. This includes direction for the NEI Advanced Reactor Regulatory Task force, which INL directly supports through the Regulatory Framework Modernization Program.

NRRWG membership consists of an Industry Chair, NEI, AR developers, and owners/operators that have informed the NRC of their intent to submit a new reactor application. In addition, an INL representative was invited and has been participating in an advisory role since the group's inception, representing the DOE and its national laboratory system.

3.1.2.2 INL Participation and Support of NRRWG FY 2023 Activities

NRRWG January 11, 2023 (virtual) meeting

The two primary agenda topics for this meeting included discussion of how to promote increased international regulatory efficiency and to review planned 2023 industry NEI and NRC actions intended to improve NRC's regulatory efficiency.

Identified NEI 2023 actions:

- Submit Technology-Inclusive Risk-Informed Change Evaluation (TIRICE) guidance for NRC endorsement (It's noted here that TIRICE is a DOE-funded and industry-led effort being managed through INL's Regulatory Framework Modernization Program).
- Submit white paper on Seismic Event Selection for Emergency Planning Zone development.
- Develop and submit paper on Population-Related Siting Considerations.
- Reactor Operator Cold License Training.

Identified 2023 actions to request of NRC:

Industry to request/encourage the Commission to provide direction on draft rule content it currently has for action, including:

- Advanced Nuclear Reactor Generic Environmental Impact Statement draft rule
- Emergency Planning final rule
- Physical Security draft rule
- Part 50/52 rule
- Part 53 rule.

NRC technical staff will be requested to develop and finalize:

- Issue Regulatory Guide endorsing Technology-Inclusive Content of Application Project (TICAP) (Note that TICAP is a DOE-funded and industry-led effort being managed through INL's Regulatory Framework Modernization Program).
- SECY document summarizing key microreactor policy issues to be addressed to support deployment.
- Issue updated guidance regarding the applicability of Regulatory Guide 4.7 on the topic of population density considerations related to reactor siting.

NRRWG March 3, 2023, (virtual) Meeting

This was a shorter virtual meeting. It included a review/discussion of industry/NEI progress in addressing the industry actions identified in the January meeting. In addition, the INL representative gave a presentation on DOE regulatory programs, and included a request for follow-on discussion in the next meeting of industry regulatory needs and priorities that could be addressed through those programs, pending available DOE funding.

NRRWG May 18, 2023, (in-person) Meeting

The agenda for that meeting included:

- Updates on Congressional legislative actions currently underway or in development to modernize and improve efficiency of the NRC's regulatory processes.
- Review of implementation actions included within Regulatory Pillar portion of the NEI/EPRI North American Advanced Reactor Roadmap [3] Implementation.
- Discussion of regulatory challenges that might be addressed by the DOE.

Regarding this third agenda item, the INL representative led a discussion on the topic of key industry regulatory priorities that may be addressed by the DOE-funded Regulatory Framework Modernization Program going forward into FY 2024. Topics identified by the group for consideration in that work scope included the following:

- Establishing regulatory strategies and approaches for addressing the Waste Confidence Rule [4] for AR "non-traditional" fuel and waste forms.
- Assessing the potential to utilize cloud computing when performing reactor safety analyses, including addressing regulatory requirements and expectations regarding configuration and export controls.
- Establishing regulatory strategies and approaches for implementing autonomous reactor facility operations.
- Establishing methods for satisfying Material Control and Accountability requirements for liquid fuel forms.
- Proposing an approach for the regulatory qualification of liquid fuel forms- this effort would likely need to be closely aligned with the guidance in NRC's NUREG-2246.
- Developing proposals for significance determinations associated with AR technologies within the NRC's Reactor Oversight Process.

In addition to participation in the above meetings, members were asked to provide industry stakeholder review and input into various NEI-developed documents and strategies. Those topics included papers focused on international regulatory initiatives:

- "International Regulatory Efficiency Framework"
- "Recommendations for Implementation of the Framework in Canada and the U.S."

3.1.3 Interfacing with Industry-led Technical Working Groups

The national technical directors (NTDs) and other key regulatory development sub-program staff work to maintain a regular and open dialogue with established industry-led technical working groups for high-temperature gas-cooled reactors, fast reactors, and molten-salt reactors (MSRs). These interactions are critical for ensuring that high-priority, high-impact regulatory framework issues are clearly understood, efficiently integrated, and appropriately prioritized within the associated areas of the regulatory development initiatives in direct support of the timely commercial deployment of these technology types. INL staff's attendance of these technical working groups meetings helped inform the Integrated Planning List for the Regulatory Framework Modernization area in FY 2024.

3.1.3.1 Fast Reactor Technical Working Group

The INL Regulatory Development Group supported the Fast Reactor Technical Working Group through industry interactions and program reviews. During program reviews and interactions, novel conceptual research instrumentation including developmental technologies for real-time, in situ, monitoring of corrosion and defect propagation were discussed. These technologies (Electromagnetic Transducer [EMAT]/Ultrasonic Testing) represent potential options for a licensee, to monitor performance of a material used in a new Fast Reactor technology. The regulatory considerations were discussed and how regulatory endorsement could be obtained through research to prove it as a vetted technology and report out to the NRC.

3.1.3.2 Molten-Salt Reactor Technical Working Group

Several Molten-Salt Reactor Technical Working Group meetings, workshops, and program reviews were attended by INL regulatory development staff in FY 2023. Molten-salt reactor researchers and vendors are still developing the thermophysical properties database, online fuel salt monitoring, and identifying regulatory uncertainties for resolution.

3.1.3.3 High-Temperature Reactor Technical Working Group

The High-Temperature Reactor Technical Working Group met several times in FY 2023, culminating in a report sent to DOE-NE outlining the major research, development, and deployment needs for high-temperature reactors. These needs included:

- Timely completion of TRISO fuel qualification efforts.
- Continued support and funding for the Advanced Gas Reactor (AGR) program.
- Irradiation and post-irradiation examination of additional fuel forms and conditions (with major focus on AGR-5/6/7 post-irradiation examination).
- Development of topical reports to maximize the value of the AGR program.
- Development of additional fundamental data on pyrocarbon (PyC) irradiation performance, including dimensional change and irradiation-induced creep.
- Collaboration in discussion of supply chain challenges, including issues such as the availability of High-Assay, Low-Enriched Uranium (HALEU), which the group named the single greatest supply chain challenge.
- Support of the Advanced Graphite Creep (AGC) program.

Broader, industry-level initiatives were also heavily discussed, including:

- AR regulatory framework (with risk-informed, performance-based safety case).
- HALEU safeguards and security.
- International codes and standards harmonization.
- Reliability and Integrity Management program implementation processes and guidance.

3.1.4 Work Scope Planning for Fiscal Year 2024

Under the regulatory development framework task, the INL regulatory development team evaluated and prepared the work scope for FY 2024 and beyond that include a DOE Integrated Priority List. The group participated in extensive interactive DOE laboratory dialogues and interacted with industry stakeholders and researchers across the DOE laboratory complex to develop R&D and regulatory development work scopes and determine resource requirements. This included review and incorporation of items from the NEI Industry Priorities List [5]. Additionally, the group worked to identify and prioritize industry and government needs, using them as the basis for developing a work scope for FY 2024. By coordinating with industry stakeholders, DOE, and NRC, INL staff successfully identified areas of near-term R&D needs for current and near-future AR licensing support activities that generally aligned with industry goals and priorities.

3.2 Alternative Physical Security Regulations

The NRC staff submitted the Alternative Physical Security Requirements for Advanced Reactors (NRC-2017-0227 [6]) to the Commission on August 2, 2022. While awaiting the Commission vote and SRM, INL staff have been monitoring vendor and industry activities. INL staff participated in an NRC public meeting on July 6, 2023, regarding the NRC development of modeling and simulation guidance. INL staff observed reactor vendors engage with NRC staff on licensing and technical guidance needs. INL staff reported these needs to INL and DOE security researchers. INL submitted a FY 2024 work package proposal to the Advanced Reactor Safeguards National Technical Director, Ben Cipiti, to address these industry needs.

3.3 Emergency Preparedness

While no official task in this area was designated during FY 2023, NRC has been soliciting comments on its proposed emergency planning rulemaking, known as 10 CFR Part 50.160 [7]. Current emergency planning regulations and guidance fail to consider the significant advances in reactor designs and safety research afforded by new technologies such as non-LWRs and small modular reactors. Thus, in 2015, the Commission approved the NRC staff's recommendation that a new performance-based emergency planning program be developed. The proposed rule was sent before the Commission for approval by December 31, 2021. The rule has since been voted on and approved by the Commission and the final rule's publication is now expected to occur on January 3, 2024. INL staff will continue to track its progress and review any changes stemming from the Commission voting.

3.4 NRC/CNSC TRISO Fuel Joint Report

NRC and CNSC worked together to develop a series of reports addressing TRISO fuel that attempted to establish a common regulatory position on TRISO fuel qualification. This common regulatory position would be based on existing data and knowledge and would identify gaps in analytical or testing that need to be addressed prior to the use of TRISO fuel in AR licensing.

NRC presented the initial draft of this report during the Advanced Reactor Stakeholder Meeting on October 12, 2022. The NRC presented the following conclusions:

- Defining an acceptable range of Silicon Carbide (SiC) layer end-state attributes that ensure good (AGR like) fission product retention is desirable but not practical based on currently available information.
- Recommended additional research/study to identify acceptable ranges for generic licensing.

- Report provides AGR-1, Variant 3 property values, but does not state these are neither sufficient to determine or are necessary to ensure acceptable performance.
- The range of acceptable SiC coating parameters is dependent on the applicant licensing needs (i.e., assumed TRISO releases and release pathways), which is usually related to the proposed plant siting.

The working group also announced that it was seeking stakeholder input which would better define information on relevant SiC parameters and acceptable ranges. INL staff had significant questions/comments for the working group and supported NRC in addition to the public meeting to discuss and clarify the technical inputs to the report that were based on DOE AGR Program outcomes. INL and the NRC working group developed language that supported previous testing and the previous approval of TRISO testing in the NRC's 2020 Safety Evaluation Report for TRISO [8]. This language was published in the final copy of the NRC/CNSC report [9] issued in 2023.

3.5 Generic Environmental Impact Statement

A Generic Environmental Impact Statement (GEIS) approach is currently being established for advanced nuclear reactors (ANR) that feature a small generating output and environmental footprint. This will streamline the environmental review process for future small-scale ANR environmental reviews. More specifically, the ANR GEIS [10] activity will determine which environmental impacts may result in essentially the same (generic) impact for different ANR designs, and which ones may result in different degrees of impact, thus necessitating plant-specific analysis.

The GEIS development process will be tracked to ensure that the action adequately bounds emerging ANR technologies and addresses the concerns of the regulated community. INL staff will continue interacting with NRC and providing comments and questions regarding the proposed rule to support the desired outcome of a clear, technically supported rulemaking with appropriate guidance. Since the INL FY 2022 deliverable report was written, the schedule of the GEIS ruling has significantly changed. INL staff will ensure that the new schedule is identified to the Regulatory Coordination and Integration group and will solicit comments from the group upon issuance. The following outlines the significant updated schedule for GEIS development:

1. April 30, 2020 – Federal Register notice of intent to prepare GEIS and conduct scoping
2. June 30, 2020 – Scoping comment period ends
3. November 2021 – Proposed rule submission to the Commission
4. November 2023 (previously February 2023) – Draft GEIS and rule issued for comment
5. February 2025 (previously January 2024) – Final rule publication.

4. FUTURE ACTIVITIES

4.1 Near-Term Activities for Fiscal Year 2024

INL staff have developed the initial Integrated Priority List for FY 2024 activities under the Regulatory Framework Modernization area. INL is expected to receive funding under this area to continue activities similar to the work described in this report.

INL staff will continue efforts associated with the GEN-IV International Forum and International Atomic Energy Agency to support the timely deployment of advanced reactors internationally. These efforts establish updated safety standards that further integrate the use of risk insights into the development of AR technologies.

AR designers and prospective NRC license applicants must utilize existing regulatory constructs to support the licensing and deployment of new technologies. A more clearly defined and accepted process is needed for the early identification of regulatory requirements that are either inherently not applicable or must be adapted to support the licensing of individual AR technologies, consistent with the NRC's AR policy to provide for timely and effective regulation.

INL regulatory development staff will partner with INL molten-salt reactor researchers to pilot the liquid fuel qualification methodology found in NUREG/CR-7299, "Fuel Qualification for Molten Salt Reactors" [11] to determine if it would meet the NRC staff expectations and identify any gaps or areas for additional clarity.

4.2 Activities Continuing Beyond FY 2024

The INL regulatory development team anticipates a large increase in AR demonstration projects over the next decade. These projects will be primarily conducted to obtain integrated proof-of-concept technical information—as well as safety information—essential to regulatory safety assessments and licensing. This will require a general shift in focus from the largely technology-inclusive efforts described in this report to the AR technology-specific topics currently restraining developers. Establishing this shift in focus will require extensive interactions with technology developers/vendors, license applicants, and NRC staff. DOE and the INL-managed National Reactor Innovation Center will also be essential stakeholders in these interactions.

4.2.1 Nuclear Regulatory Commission Guidance and Rulemaking Activities

In addition to the 10 CFR Part 53 rulemaking, other anticipated NRC guidance and rulemaking activities that will be supported by INL staff will include:

- The Technology-Inclusive Risk-Informed Change Evaluation (TIRICE) Process
- Technology-Inclusive Content of Application Plan (TICAP)
- Risk Assessment Change Control During Plant Operations Phase (TIMaSC)
- GEIS
- Advanced Physical Security.

5. CONCLUSION

During FY 2023, the INL regulatory development department utilized funding provided under the "Regulatory Framework Development" activity to support many critical activities while also achieving specific results that aid in reactor deployments. The funding has been critical to maintaining relationships and interactions with the AR community, including with industry partners, applicants, DOE, and NRC. Those interactions have resulted in the development of key parts of an NRC-endorsed regulatory framework for AR technologies, significantly reducing the regulatory uncertainty associated with their near-term deployment.

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