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MEMORANDUM TO: Philip McKenna, Acting Division Director
Division of Reactor Oversight
Office of Nuclear Reactor Regulation

FROM: David Aird, Branch Chief
Reactor Assessment Branch
Division of Reactor Oversight
Office of Nuclear Reactor Regulation

Signed by Aird, David on 12/09/25

SUBJECT: OVERSIGHT AND INSPECTION STRATEGIES FOR MICROREACTORS DURING OPERATIONAL PHASE

PURPOSE:

The purpose of this paper is to address Section 208 of the Accelerating Deployment of Versatile, Advanced Nuclear for Clear Energy (ADVANCE) Act of 2024 which, in part, tasked the U.S Nuclear Regulatory Commission to develop strategies and guidance for microreactor oversight. This paper will discuss a potential regulatory approach for the oversight of microreactors during the operational phase. This proposed approach will leverage lessons learned from established oversight programs for large light water reactors and non-power utilization facilities, respectively, while incorporating innovative inspection methodologies and a scalable inspection footprint informed by licensee performance and risk insights. The proposed approach is intended to facilitate further stakeholder engagement through meetings and workshops.

CONTACT: Casey Smith, NRR/DRO
301-415-0504

BACKGROUND:

The U.S. Nuclear Regulatory Commission (NRC) Office of Nuclear Reactor Regulation (NRR) is responsible for the policies, programs and procedures for the inspection of utilization facilities such as those licensed under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 "Domestic Licensing of Production and Utilization Facilities;" Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants"; and the proposed 10 CFR Part 53 "Risk-Informed, Technology-Inclusive Regulatory Framework for Commercial Nuclear Plants".[1] Under this authority, the agency oversees operating large light water reactors (LLWRs) under the Reactor Oversight Process (ROP)[2] and non-power production and utilization facilities. Oversight of LLWRs in the construction phase is governed by the construction oversight process, which is currently being revised to reflect the new technologies expected, and the Office of Nuclear Material Safety and Safeguards has responsibility for reactors that have entered the decommissioning phase.[3] Additionally the agency shares the responsibility of regulating the transportation of radioactive materials with the U.S. Department of Transportation (DOT) and requires the materials to be shipped in accordance with the DOT's safety regulations.

In its Advanced Reactor Policy Statement,[4] the Commission stated the expectation that advanced reactors will have enhanced safety margins. These include simpler designs and the use of inherent, passive, or other innovative means to accomplish safety and security functions. Smaller and simpler reactor plant designs may require fewer safety-significant systems, structures, and components (SSCs) to accomplish safety and security functions. These design differences could result in reduced risk profiles for many microreactors. As such, the NRC staff will consider the likelihood of a range of plant risk profiles to inform and scale the scope of oversight needed to provide reasonable assurance of adequate protection of public health and safety.

In the staff requirements memorandum (SRM) for SECY-24-0008, "Microreactor Licensing and Deployment Considerations: Fuel Loading and Operational Test at a Factory", the Commission approved Option 3b, which will allow the agency to use the regulations for non-power reactors to authorize operational testing of commercial microreactors at a factory. This approach highlights that there are instances in which the regulations of research and test reactors are appropriate to apply to microreactors, consistent with Commission direction.

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[1] Title 10 Code of Federal Regulations, Part 1, Section 43, "Office of Nuclear Reactor Regulation."
[2] Management Directive 8.13, "Reactor Oversight Process," January 16, 2018 (Agencywide Documents Access and Management System Accession No. ML17347B670).
[3] IMC 2561, "Decommissioning Power Reactor Inspection Program," January 1, 2021, (*ML20358A131).
[4] U.S. NRC, "Policy Statement on the Regulation of Advanced Reactors," October 7, 2008 (ML082750370).

The ADVANCE Act[5] was enacted on July 9, 2024, and in part, mandates that the agency develop risk-informed, performance-based strategies and guidance for the oversight and inspection of microreactors, as outlined in section 208 of the Act. The staff previously developed and detailed its vision and strategies for overseeing the construction of advanced reactors, including microreactors, in the Advanced Reactor Construction Oversight Process (ARCOP).[6]

DISCUSSION:

Definitions and Scope

Although there is no standard definition for microreactors, these reactors are expected to have significantly lower power capability compared to the current operating fleet of LLWRs. Microreactors are expected to have simpler designs, inherent safety features, and to be fabricated in a factory. This paper focuses on the oversight strategies for microreactors during the operational phase. The operational oversight strategies and guidance for microreactors will be consistent with the methodologies and rationale used to develop the construction oversight program for advanced reactors. While this paper focuses on microreactors, the methodologies and principles should be evaluated for applicability to the development of an oversight program of the broader fleet of advanced reactors.

Applicability of the Reactor Oversight Process

The Reactor Oversight Process (ROP) has been implemented continuously since its inception in 1999.[7] The NRC tested the revised ROP during a six-month pilot program at nine sites across the country, beginning in June 1999. NRR is the responsible program office, but the ROP execution is completed primarily by the regional offices. The NRC staff reported the results of the pilot program to the Commission in SECY-00-0049, "Results of the Revised Reactor Oversight Process Pilot Program" dated February 24, 2000; the Commission approved the staff's recommendation to implement the revised ROP for all plants in SRM for SECY-00-0049.

The ROP in its current form focuses on Gen II, III and III(+) LLWRs and the risk metrics used to measuring performance were designed to the level of risk associated with LLWRs designs. The ROP is not designed to provide oversight of the unique designs and risk profiles of the new types of reactors currently being considered. The inherent safety features and lower risk profiles of these new reactor designs will most likely warrant less direct inspection and modified risk metrics to ensure adequate protection of public health and safety. The Commission previously directed the staff to not alter or create new special metrics for new reactor designs, which would discourage new reactor development using safer designs. Instead, “[n]ew reactors with these enhanced margins and safety features should have greater operational flexibility than current reactors.”[8]

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[5] ADVANCE Act of 2024, Enacted on July 9, 2024
[6] SECY-23-0048, “Vision for The Nuclear Regulatory Commission’s Advanced Reactor Construction Oversight Program,” June 6, 2023, (ML23061A086).
[7] SECY-99-0007A, “Recommendations for Reactor Oversight Process Improvements,” March 22, 1999, (ML12265A454).
[8] Staff Requirements Memorandum -SECY-10-0121 – “Modifying the Risk-Informed Regulatory Guidance for New Reactors,” March 2, 2011, (ML110610166).

In modifying the ROP for Generation III+ reactors, the staff used the same Principles of Good Regulation that guided the development of the original ROP: independence, openness, efficiency, clarity, and reliability.[9] The agency designed the ROP to ensure that it meets its intended goals of being objective, risk informed, predictable, and understandable.[10] Those same principles and goals, to include performance-based considerations, will be used to develop oversight for Generation IV reactors, which include microreactors.

Applicability of the Non-power Production and Utilization Facilities Inspection Program

Research and test reactors (RTRs) are licensed under §§10 CFR 50.21(a), 10 CFR 50.21(c) or 50.22, "Class 103 licenses; for commercial and industrial facility," for research and development.[11] All current RTRs are licensed under 50.21(c), which corresponds to a license issued through the Atomic Energy Act of 1954 (AEA), section 104c. Under section 104.c of the AEA, as amended:

> The Commission is directed to impose only such minimum amount of regulation of the licensee as the Commission finds will permit the Commission to fulfill its obligations under this Act to promote the common defense and security and to protect the health and safety of the public and will permit the conduct of widespread and diverse research and development.[12]

As such, the current RTR inspection program is limited in scope. Currently, RTR operating oversight is conducted by one branch within NRR which maintains subject matter expertise. Notably, there are limitations to being licensed as an RTR under 50.21(c), connected to intended purpose of the facility and on use of facility for non-research and development purposes. Because of limitations in the AEA, it is expected that microreactors will be licensed as commercial reactors. Therefore, microreactors may merit a different level of oversight comparatively, depending on risk profile and deployment model than what is used for RTRs; however, the RTR inspection program can and should inform the model for the oversight of low power reactors with fewer safety related systems and lower risk profiles.

Oversight Strategy for Microreactors during Operational Phase

The NRC staff's vision for microreactor operational oversight includes a scalable level of oversight, that will leverage aspects from both the ROP and RTR oversight program harnessing the agency's oversight experience while remaining responsive to the risk posed by the facility. The oversight strategy will align with the NRC's mission of protecting public health, safety and security while integrating advancements in proportion to the lower risk profiles associated with microreactors. The vision and strategies are based on the following guiding principles:

- *Effective* – focuses inspection effort on critical and risk-significant components and activities while leveraging alternative means of oversight

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[9] https://www.nrc.gov/about-nrc/values.html
[10] SECY-18-0091, "Recommendations for Modifying the Reactor Oversight Process For New Large Light Water Reactors With Passive Safety Systems Such as The AP1000 (Generation III+ Reactor Designs)," September 12, 2018, (ML17166A238).
[11] IMC 2545 "Research and Test Reactor Inspection Program"
[12] Atomic Energy Act, As Amended Through P.L. 118–67, Enacted July 9, 2024.

- *Risk-informed* – uses facility risk insights to inform the inspection strategy specific to the technology
- *Performance*-based – adaptive oversight response based on licensee and vendor performance
- *Innovative* – leverages new inspection tools and approaches
- *Scalable* – uses a graded approach to inspection efforts commensurate with a facility's public health and safety risk

Performance Monitoring

The staff anticipates the foundation for effective, performance-based oversight for microreactors will emphasize performance monitoring. This could be accomplished by implementation of an allegation program; operational experience; the inspection program, including a voluntary performance indicator (PI) program; and potentially having real-time monitoring of structures, systems and components by qualified NRC inspectors.

Licensee engagement through the PI program would enhance operational oversight and provide diverse, periodic means of monitoring the quality of licensee operational performance, accompanied by inspection for verification. The operational performance data should be performance-based and risk-informed and address critical safety functions or areas of significant concern for safety and security during operation. Insights from the PI program should also be used to inform the inspection strategy, focusing inspection scope on areas of concern that may impact safety or security. Additionally, the PI data, coupled with consistent operational performance, could be used to support scaling inspection scope and periodicity. The inspection program would also include PI verification, in which the NRC staff would review information provided by the licensee on a periodic basis to assess data fidelity.

Like the ROP, licensee participation in the PI program is expected to be voluntary. However, should licensees elect not to participate in the PI program, the NRC would need to rely on additional inspections which could be more frequent and larger in scope, to assess licensee performance and verify compliance with safety and security regulations. The staff plans to engage with the microreactor industry and other stakeholders throughout the development of PIs for microreactors, aiming to establish a comprehensive PI program that accurately reflects overall licensee performance and is focused on information that has a direct correlation to aspects important to safety and security. Additionally, the staff would consider opportunities to engage and collaborate with international regulatory peers to standardize the dataset for microreactor PIs.

Inspection Program Strategy for Microreactors

The microreactor oversight program will employ effective, risk-informed and performance-based inspection. The amount of inspection will vary depending on several factors, including, but not limited to, the level of risk posed by the facility; periods of increased risk-significant activity including various testing, significant maintenance, or installation or refuel of a microreactor unit. The inspection strategy for microreactors will be scalable, corresponding to performance and technology while focusing on higher risk or infrequently performed evolutions over the course of the life cycle. During normal, steady state operation of microreactors, the inspection frequency is expected to align similarly with that of the RTRs.

This approach reflects an effective risk-informed and performance-based oversight strategy, commensurate with the anticipated impact of these facilities on public health and safety. Additionally, as the NRC and the industry gain experience in the deployment of a given technology, the staff expects to adjust the inspection footprint to reflect the experience gained. This means the program will be scalable such that the amount of inspection performed would be adjusted appropriately while ensuring the staff meets program objectives for a given site. The amount of scalability that can be achieved depends largely on the degree of standardization of the deployed technology. Significant changes to the technology itself or the incorporation of significant site-specific features could limit the degree to which experience can be incorporated in scoping.

It is expected that the microreactor oversight inspection program will consist of direct, periodic inspection while also leveraging diverse and remote means of inspection afforded by the new microreactor designs. For example, some designs or deployment models may incorporate a centralized location for the operation and monitoring of multiple microreactors simultaneously. Performing inspections at a centralized location that provides remote monitoring capabilities for multiple operating units while also inspecting a sampling of deployment sites could provide an innovative and effective means of executing the inspection program. The agency should continue to identify novel means of performing inspections by leveraging the monitoring and operating systems inherent to the designs of microreactors and consider new and emerging technologies for inspection applications.

During development of the inspection program and the focus areas for inspection, the NRC staff should ensure that the inspection methodology incorporates risk insights garnered from operational experience, the licensing basis, and other available risk related information. These risk insights would enable staff to prioritize oversight activities in areas of greater importance to safety and security. Additionally, these risk insights can provide a technical basis to scale the oversight response. They can provide additional rationale for flexible oversight and inspection implementation such that if the risk posed by the facility and potential consequences of a radiological release have a minimal impact on public health and safety, in tandem with satisfactory operational performance, then the inspection effort may be reduced through the assessment program.

It will be necessary to develop inspection manual chapters (IMCs) and inspection procedures (IPs) specific to microreactors. These reactors have unique features such as significant transportation considerations and potentially autonomous or semi-autonomous operations. These inspection documents will provide detailed guidelines and protocols for inspectors to ensure a comprehensive and risk-informed inspection approach. In tandem, the NRC staff should assess the current training and qualification program for inspectors to determine whether new training is necessary to ensure inspectors have the tools and knowledge to effectively execute the inspection program.

Resident Inspectors

The NRR Director has discretion to station resident inspectors at licensee and applicant facilities under 10 CFR Part 50.70 “Inspections.” The NRC does not have specific criteria to determine when resident inspectors should be stationed at a facility. Resident inspectors are stationed at LLWRs and some fuel cycle facilities during the construction and operation phase (under the cROP and ROP). Resident inspectors are not permanently stationed at any RTRs.

It is not anticipated that resident inspectors would be stationed at advanced reactor sites, but the staff should develop objective and predictable criteria that establish clear thresholds for the stationing of resident inspectors at advanced reactor sites and fabrication facilities. Given the various functions that resident inspectors perform, these thresholds should be based on two primary criteria: the anticipated inspection footprint needed at the facility, and the level of emergency response capability that the NRC would need to maintain at the specific nuclear site. Both determinations would be based on the overall risk associated with the facility in question, and they should complement each other, such that as the risk associated with the facility increases, both the amount of inspection and the NRC emergency response capability should increase.

Should the risk or other factors for the individual site change over its lifetime, the NRC staff should reevaluate the new conditions against the established threshold to determine whether resident inspectors should be stationed at the site. However, given the anticipated low risk profiles and source terms; it is unlikely microreactor deployment sites would warrant permanently assigned resident inspector staff. For sites where the thresholds established by the staff do not necessitate stationing a permanent resident inspector, periodic inspections would still be performed at the facility.

Assessment

The assessment program for microreactors will evaluate the outputs from performance monitoring programs to determine whether there are any impacts on safety and security. The assessment program should ensure that the significance of any impact on safety or security is understood and considered during the decision-making process, ensuring a wholistic assessment program. In part, the data from performance monitoring will be integrated and analyzed to determine whether the current oversight response is appropriate based on licensee performance and safety significance or whether the agency's oversight response should be scaled in response to a significant impact on safety or security. In addition, the staff may also choose to outline a set of deterministic criteria to establish thresholds for deeming increased oversight to be necessary. The assessment program and its conclusions should be objective and comprehensive in nature.

The assessment program should periodically reassess the current level of oversight and inspection to determine whether the current oversight level is appropriate. The agency should have a continuous monitoring and assessment approach to ensure awareness of any impact on public health and safety and determine whether regulatory action is necessary, which may include reactive inspections.

Stakeholder Engagement

The NRC staff provided a high-level overview of the agency's direction for microreactor oversight to relevant stakeholders during the microreactor public meeting on June 17, 2025. The staff plans to continue engagement with the public and the industry and solicit feedback on considerations and concerns throughout the development of the oversight program for microreactors. The next opportunity for public engagement is anticipated to occur during the first quarter of 2026.

CONCLUSION:

The NRC staff intends to use the guidance and strategies outlined in this paper to continue to develop the operational oversight framework for microreactors. These strategies build upon established and continuously vetted oversight programs for LLWRs and RTRs, while innovating inspection methodologies and scaling the inspection footprint based on performance and risk insights. The NRC staff will continue to engage with external stakeholders during the continued development of the microreactor operational oversight program, consistent with the Principles of Good Regulation.

RESOURCES:

This paper does not address any new commitments or resource implications.

COORDINATION:

This NRC staff white paper has been prepared and is being released to further stakeholder engagement. This paper has not been subject to NRC management and legal reviews and approvals, and its contents should not be interpreted as official agency positions. A prospective applicant should not use the content of this paper or rely on its contents in preparing an application.

SUBJECT: OVERSIGHT AND INSPECTION STRATEGIES FOR MICROREACTORS DURING OPERATIONAL PHASE DATE: December 9, 2025

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