ADVANCED REACTOR SIGNIFICANT ACCOMPLISHMENTS FOR CALENDAR YEAR 2023

Enclosure

Introduction

This enclosure summarizes significant accomplishments by the U.S. Nuclear Regulatory Commission (NRC) staff (the staff) to make the safe use of advanced nuclear technology possible. This enclosure covers noteworthy activities completed during calendar year (CY) 2023 in the following areas:

- Regulatory Framework Advancement
- Licensing
- Analytical Tool Capabilities
- External Coordination and Communication
- International Collaboration
- Oversight

Regulatory Framework Advancement

- On January 3, 2023, the staff delivered SECY-23-0001, "Options for Licensing and Regulating Fusion Energy Systems" (ML22273A178), providing options for Commission consideration.
    - In 2023, the staff held five public meetings on its efforts to implement the Commission's April 13, 2023, direction ((Agencywide Documents Access and Management System Accession No. ML23103A449) to prepare a limited-scope rulemaking to establish a regulatory framework for fusion systems that augments the NRC's byproduct material framework in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material."[1]
- On January 31, 2023, the staff published NUREG-2245, "Technical Review of the 2017 Edition of ASME Code, Section III, Division 5" High Temperature Reactors" (ML23030B636) and Regulatory Guide (RG) 1.87, Revision 2, "Acceptability of ASME Code, Section III, Division 5, 'High Temperature Reactors'" (ML22101A263), which endorsed, with conditions the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Section III, "Rules for the Construction of Nuclear Facility Components," Division 5, "High Temperature Reactors."
- On February 28, 2023, the staff published draft interim staff guidance (ISG) DANU-ISG-2023-01, "Material Compatibility for non-Light Water Reactors" (ML22203A175), for public comment. The draft guidance identified areas of staff review that could be necessary for a submittal seeking to use materials allowed under ASME Code, Section III, Division 5.
- On March 1, 2023, the staff delivered the draft proposed Title 10 of the *Code of Federal Regulations* (10 CFR) Part 53 rulemaking package as SECY-23-0021, "Proposed Rule: Risk-Informed, Technology-Inclusive Regulatory Framework for Advanced Reactors (RIN 3150-AK31)" (ML21162A093), to the Commission for consideration.

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[1] https://www.nrc.gov/materials/fusion-energy-systems.html#rule

- On March 29, 2023, the staff delivered a rulemaking plan, SECY-23-0029, “Rulemaking Plan for the Implementation of Changes to Reflect Advanced Reactor Export Licensing Considerations” (ML23037A818), to the Commission for consideration.
- On April 20, 2023, the staff released draft Advanced Reactor Content of Application (ARCAP) DRO-ISG-2023-04, “Facility Training Programs” (ML23017A130), to support discussions at the April 26, 2023, advanced reactor stakeholder meeting.
- On May 23, 2023, the staff issued “Draft Regulatory Guide DG-1404 (RG 1.253 Rev 0), Guidance for a Technology-Inclusive Content-of-Application Methodology to Inform the Licensing Basis and Content-of-Applications for Licenses, Certifications & Non-LWRs” (ML22076A003), for potential endorsement of the industry--led Nuclear Energy Institute (NEI) guidance document NEI 21-07, “Technology Inclusive Guidance for Non-Light-Water Reactors” (ML21250A378), dated August 2, 2021, and nine ISG documents from the NRC--led ARCAP project for public comment (ML23044A038).
    - On August 31, 2023, the staff published for public comment DG-1404, Revision 1 (proposed new RG 1.253), “Guidance for a Technology-Inclusive Content-of-Application Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors” (ML23044A038), which revised the guidance for a Technology-Inclusive Content of Application methodology and included proposed appendix B, providing guidance on the acceptability of a probabilistic risk assessment that supports a non-light-water-reactor (non-LWR) construction permit application based on the Licensing Modernization Project methodology.
- On August 24, 2023, the staff released its draft white paper, “Micro-Reactor Licensing and Deployment Considerations: Fuel Loading and Operational Testing at a Factory” (ML23236A575), with an enclosure titled “Technical, Licensing, and Policy Considerations for Factory-Fabricated Micro-Reactors,” to support a stakeholder engagement meeting which took place at a September 11, 2023.[2]
    - On September 27, 2023, the staff released an updated version of the paper (ML23264A802), to support an October 3, 2023, ACRS meeting. The meeting agenda and transcript are available at the ACRS public website.[3]
    - On January 24, 2024, the staff delivered SECY-24-0008, “Factory-Fabricated Micro Reactor Licensing and Deployment Considerations: Fuel Loading and Operational Testing at a Factory” (ML23207A250), to provide the Commission with options for regulating certain aspects of fuel loading and operational testing of commercial factory-fabricated micro-reactors. This paper also seeks Commission direction on whether a factory-fabricated micro-reactor that includes “features to preclude criticality” would require a facility operating license or a combined license when loaded with fuel.
- On October 18, 2023, the staff published DG-4034 (RG 4.7, Revision 4), “General Site Suitability Criteria for Nuclear Power Stations” (ML23123A090), for public comment. The revision included alternative approaches to the population-density criterion and expanded the regulatory guidance developed for large light-water-reactor technology with appropriate modifications for advanced reactor designs.

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2 https://www.nrc.gov/pmns/mtg?do=details&Code=20230975

3 https://www.nrc.gov/reading-rm/doc-collections/acrs/agenda/2023/index.html

- On October 23, 2023, the staff released the draft white paper "Development of New Reactor Application Standard Content to Support Timely, Efficient, and Effective Reviews of Subsequent Applications" (ML23296A032), to support discussion at a public meeting. This white paper provides initial concepts for high-level guidance for the development of standard content for future applications for reactor licenses using the design-centered review approach.
- On November 16, 2023, the staff published the final rule on "Emergency Preparedness for Small Modular Reactor and Other New Technologies" (ML23226A019). The final rule and associated guidance amended the regulations in 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," to include a risk-informed approach to emergency preparedness for small modular reactors and other new technologies.
    - On November 13, 2023, the staff issued RG 1.242, Revision 0, "Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities" (ML23226A036), which is guidance that supports the new emergency preparedness for small modular reactors (SMRs) and other new technologies rule.
- On November 29, 2023, the staff released the draft white paper "Guidelines for Risk Assessment and Severe Accident Information in a Light-Water Reactor Construction Permit Application" (ML23326A185), for discussion at a public meeting. This white paper provides preliminary concepts to inform development of guidance on the content of general and technical information for a preliminary safety analysis report (PSAR) to support the staff's review of probabilistic risk assessment (PRA) and non-PRA evaluations used in support of a construction permit application.

Other Rulemakings

On August 2, 2022, the staff delivered SECY-22-0072, "Proposed Rule: Alternative Physical Security Requirements for Advanced Reactors" (ML21334A003), to the Commission for consideration. If approved, the rule would establish voluntary alternatives to certain physical security requirements and opportunities to credit security by design under the existing regulatory framework in 10 CFR Part 50 and 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," commensurate with the potential consequences to public health and safety and the common defense and security. The staff anticipates issuing the proposed rule for public comment in 2024, pending Commission approval. More information on this rulemaking and the associated policy issue can be found on the NRC's advanced reactors rulemaking and guidance website.[4]

On June 6, 2022, the staff delivered SECY-22-0052, "Proposed Rule: Alignment of Licensing Processes and Lessons Learned from New Reactor Licensing" (ML21159A055), to the Commission for consideration. If approved, the rule would ensure the consistency of technical requirements between reactor licensing processes in Parts 50 and 52 and would incorporate lessons learned from new reactor licensing into the regulations. The staff anticipates issuing the proposed rule for public comment in 2024, pending Commission approval. More information on this rulemaking can be found on the NRC's rulemaking public website.[5]

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4 https://www.nrc.gov/reactors/new-reactors/advanced/modernizing/rulemaking-and-guidance/physical-security.html

5 https://www.nrc.gov/reading-rm/doc-collections/rulemaking-ruleforum/active/ruledetails.html?id=27

Licensing

Non-Light-Water Reactors

Kairos Hermes 1

- On June 13, 2023, the staff issued "Safety Evaluation Related to the Kairos Power LLC Construction Permit Application for the Hermes Test Reactor" (ML23158A265).
- On August 17, 2023, the staff issued "Environmental Impact Statement for the Construction Permit for the Kairos Hermes Test Reactor" (ML23214A269).
- On September 13, 2023, the staff delivered SECY 23-0080, "Environmental Review Approach for the Kairos Power, LLC, Hermes 2 Construction Permit Application" (ML23214A165) to the Commission for consideration. This paper describes the staff's intent to prepare an environmental assessment to determine whether a finding of no significant impact is justified or whether an environmental impact statement is necessary, fulfilling the NRC's National Environmental Policy Act obligations as part of the Hermes 2 environmental review.
- On October 19, 2023, an uncontested hearing was held regarding the Hermes 1 test reactor construction permit application (ML23342A148).
- On December 12, 2023, the Commission issued Commission Memorandum and Order CLI-23-05 (ML23346A068), which authorized issuance of the Hermes 1 test reactor construction permit and the associated record of decision.
- On December 14, 2023, the staff issued Kairos Power LLC Hermes Test Reactor Construction Permit No. CPTR-6 (ML23338A258) and the associated record of decision (ML23338A257).

Abilene Christian University Research Reactor

- On March 9, 2023, the staff issued "Abilene Christian University—Environmental Audit Plan for the Molten Salt Research Reactor Construction Permit Application Technical Topics" (ML23061A126), in which the staff identified initial information needs that would promote a better understanding of the detailed analysis and bases underlying the construction permit application.
- On June 22, 2023, the staff issued its "Interim Report on Regulatory Audits of the Abilene Christian University Preliminary Safety Analysis Report" (ML23157A064), in which the staff anticipated that the scope of planned changes to the PSAR for the molten salt research reactor will be significant and that many of the revisions discussed with Abilene Christian University will affect multiple areas or chapters of the PSAR.
- On September 14, 2023, the staff issued "Abeline Christian University—Update to the Construction Permit Application Technical Review Schedule" (ML23249A095), which informed the applicant of the staff's need to reassess the application review schedule.
- On December 21, 2023, the staff issued "Abilene Christian University – Transmittal of Requests for Additional Information" (ML23348A196), which requested information pertaining to the application of ASME Boiler and Pressure Vessel Code, Section VIII, and surveillance procedures for materials degradation mechanisms. Additionally, the staff communicated its intent to issue a revised schedule and level of effort estimate for the remainder of the review once responses are provided.

Kairos Hermes 2

- On September 11, 2023, the staff issued "Acceptance for Docketing of the Hermes 2 Test Reactor Facility Construction Permit Application submitted by Kairos Power LLC" (ML23233A167), which documented the staff's acceptance of the Hermes 2 construction permit application for review.
- On October 11, 2023, the staff issued "Kairos Power LLC—Hermes 2 Construction Permit Application Review Schedule and Resource Estimate" (ML23269A176), outlining the schedule and resource estimates for the Hermes 2 construction permit application review.

X Energy, LLC

- On March 9, 2023, the staff issued "X Energy, LLC—Final Safety Evaluation for 'Xe-100 Topical Report: TRISO-X Pebble Fuel Qualification Methodology' (Revision 3)" cover letter (ML22327A198), and redacted safety evaluation (ML22327A201).
- On March 29, 2023, the staff issued "X Energy, LLC—Safety Evaluation of Xe-100 Topical Report: Transient and Safety Analysis Methodologies Framework, Revision No. 1" (ML23037A943).
- On May 17, 2023, the staff issued "X Energy, LLC—Final Safety Evaluation of Topical Report Xe-100 Licensing Topical Report: Control Room Staffing Analysis Methodology, Revision 2 and Associated Implementation Plans" (ML23107A044).

TerraPower, LLC

- On November 17, 2023, the staff issued "TerraPower, LLC—U.S. Nuclear Regulatory Commission Staff Feedback Regarding White Paper: 'Natrium Human Factors Engineering Concept of Operations,' Revision 0," letter and enclosure (ML23321A086, and ML23321A087, respectively), which provided feedback on the ways users interact with the human system interfaces and with one another to monitor, control, and maintain the Natrium plant.
- On August 14, 2023, the staff issued "TerraPower, LLC—U.S. Nuclear Regulatory Commission Staff Feedback and Observations Regarding Nat-3049, 'Nascent Thermal Hydraulic Model White Paper'" (ML23229A541), which provided feedback on the Natrium Simplified Coolant Energy Transport (Nascent) model. This model will be used to predict steady-state coolant temperatures within Natrium fuel assembly subchannels.
- On September 28, 2023, the staff issued "TerraPower, LLC—Final Safety Evaluation for Topical Report NATD-LIC-RPRT-0001, 'Regulatory Management of Natrium Nuclear Island and Energy Island Design Interfaces,' Revision" (ML23257A260). This topical report evaluates the applicability of several regulations relevant to the interface between the Natrium design's nuclear and energy islands.
- On November 15, 2023, the staff issued "TerraPower, LLC—U.S. Nuclear Regulatory Commission Staff Feedback Regarding White Paper: 'Preliminary Consensus Codes and Standards,' Revision 0" (ML23319A338), which provided feedback on the use of codes and standards that TerraPower intends to use for the Natrium reactor design.

<u>Small Modular Reactor Licensing</u>

NuScale Power, LLC

- On January 19, 2023, the NuScale small modular reactor design certification final rule was published in the *Federal Register* (88 FR 3287).

- On April 25, 2023, the staff issued its safety evaluation report on Topical Report TR-107522, Revision 1, “Applicability Range Extension of NSP4 Critical Heat Flux Correlation, Supplement 1 to TR-0116-21012-P-A, Revision 1” (ML23115A008).
- On July 31, 2023, the staff completed the acceptance review and issued a docketing and resource estimate letter (ML23198A163), to finalize acceptance for docketing of NuScale’s standard design approval application for the NuScale US460 SMR design. The staff’s goal is to conduct an efficient, high-quality safety review to support issuance of a final safety evaluation report by July 31, 2025.
- On December 28, 2023, the staff issued its final safety evaluation report on Topical Report MN-122626, Revision 1, “NuScale Power, LLC Quality Assurance Program Description” (ML23361A122).

Carbon Free Power Project

- On April 7, 2023, the staff issued its safety evaluation report on Topical Report TR-121173NP, Revision 3, “Carbon Free Power Project (CFPP) Quality Assurance Program Description” (ML23094A061).
- On April 24, 2023, the staff issued a letter providing feedback on the CFPP’s proposed decommissioning cost estimate methodology (ML23114A047).
- On September 5, 2023, the staff completed the acceptance review and issued a docketing and resource estimate letter (ML23236A263) for the CFPP limited work authorization application.
- On December 1, 2023, the staff published a notice in the *Federal Register* (88 FR 83977), granting the request of CFPP and NuScale, dated November 10, 2023, to withdraw a limited work authorization application and an associated exemption request, which had sought to conduct certain early construction activities at the CFPP site at the Idaho National Laboratory, near Idaho Falls, Idaho (ML23318A512).
- On November 10, 2023, CFPP and NuScale submitted a letter and informed the NRC staff that the CFPP project has been terminated and requested to withdraw the limited work authorization application, exemption request, and the topical reports associated with the CFPP combined license application (COLA). Accordingly, effective November 13, 2023, the NRC staff suspended its review of the CFPP submittals in support of its COLA.

Tennessee Valley Authority

- On September 15, 2023, the staff issued observations resulting from an audit of an annotated outline of a construction permit application for the Clinch River Nuclear Site (ML23236A476).
- On November 21, 2023, the staff issued an exemption from certain requirements of NRC regulations pertaining to the submission of a construction permit application (ML23320A261). Specifically, the NRC will permit a portion of the PSAR, required to be included in the first part of a two-part application, to be deferred to the second part of the application.
- On December 12, 2023, the staff issued its safety evaluation report on Topical Report NNP-TR-001-NP, Revision 2, “Quality Assurance Program Description for TVA New Nuclear” (ML23254A052).

SMR, LLC, a subsidiary of Holtec International

- Throughout 2023, the staff held 30 public meetings with SMR, LLC (Holtec) and provided feedback on 12 white papers related to design features, regulatory compliance, and licensing approaches. The staff also responded to 20 clarification questions on guidance and the SMR design through routine correspondence.[6]

Fuel Cycle Licensing

TRISO-X, LLC

- On April 28, 2023, the NRC approved an exemption that supports TRISO-X's new fuel facility application review and allows for storage and transportation of fabricated fuel in shipping containers as Category III material (ML23187A629).

Framatome, Inc.

- On November 27, 2023, the staff approved the Framatome facility's minimum margins of subcriticality up to 20 weight percent uranium-235 (U-235) for its Richland, Washington fuel fabrication facility (ML23313A077), which will support future licensing actions to fabricate advanced reactor fuels.

ORANO NCS GmbH

- On March 27, 2023, the staff issued a revision to the Certificate of Compliance for the Model DN30-X transportation package (ML23083B977). This first of a kind package allows for shipment of uranium hexafluoride enriched up to 20 weight percent U-235.

NAC International

- On December 14, 2023, the staff issued a revision to the OPTIMUS-L transportation package (ML23345A093) to authorize shipment of unirradiated TRI-structural ISOtropic (TRISO) fuel particle compacts enriched up to 20 weight percent U-235.

Analytical Tool Capabilities

- On February 28, 2023, the staff issued technical letter report (TLR) TLR-RES/DE/REB-2023-02, "State-of-Technology and Technical Challenges in Advanced Sensors, Instrumentation, and Communication to Support Digital Twin for Nuclear Energy Application" (ML23058A085). The TLR addressed challenges in integrating advanced sensor, instrumentation, and communication technologies with digital twin technologies.
- On March 3, 2023, the staff completed the "MELCOR Accident Consequence Code System (MACCS) Consequence Analysis Demonstration Calculations for an Example Heat Pipe Reactor Source Term" (ML23045A044), which concluded that the MACCS accident consequence analysis code is flexible in analyzing the offsite consequences of an example postulated heat pipe reactor accident release.
- On May 17, 2023, the staff issued TLR-RES/DE/REB-2023-04, "Evaluating Static Isothermal Molten Salt Compatibility with Structural Alloys" (ML23129A786). The report enhances understanding of molten salt compatibility with structural materials and offers guidance for molten salt reactor licensees.
- On September 7, 2023, the staff issued its "Assessment of the Current State of Knowledge on Storage and Transportation of Molten Salt Reactor Waste—Final Report"

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[6] https://www.nrc.gov/reactors/new-reactors/smr/licensing-activities/pre-application-activities/holtec/documents.html#questions

(ML23188A168), which analyzed molten salt reactor designs and salt waste streams, highlighting challenges in waste storage, transportation, and processing.

- On September 30, 2023, the staff issued TLR-RES/DE/REB-2023-08, "Digital Twins for Nuclear Safeguards and Security: Assessment of Challenges, Opportunities, and Current State-of-Practice" (ML23271A055), which explored the application of digital twins in nuclear safeguards and security.
- On October 19, 2023, the staff issued TLR-RES/DE/REB-2023-07, "Reliability Integrity Management Scoping Study" (ML23285A233), which examined the systems-based code concept and reliability and integrity management for non-LWRs.
- On October 20, 2023, the staff completed its "Comparison of Tritium Dose Calculations from MACCS, UFOTRI, and ETMOD" (ML23292A364), which documented the capabilities of the MACCS accident consequence analysis code for assessing tritium release consequences. The report concluded that the MACCS accident consequence analysis code is flexible enough to model inhalation doses arising from tritium releases to the atmosphere but is not currently suited to modeling doses from the ingestion of tritium.
- Throughout 2023, the staff hosted four public workshops on the following research topics: SCALE/MELCOR non-LWR fuel cycle demonstration project for a high temperature gas-cooled reactor (ML23012A085), SCALE/MELCOR non-LWR fuel cycle demonstration project for a sodium-cooled fast reactor (ML23202A091), condition monitoring and structural health management for nuclear power plants (more information can be found on the NRC's public website[7]), and the integration of safety, security, and safeguards (3S) (more information can be found on the NRC's public website[8]).
- Throughout 2023, the staff completed several research activities to support reactor systems and design-basis analyses, which advance the capability of the NRC's BlueCRAB suite of codes to model the operation and upset conditions for many non-LWR designs (ML23354A274).
- Throughout 2023, the staff identified areas of enhancement to the U.S. Department of Energy's (DOE's) Nuclear Energy Advanced Modeling and Simulation codes, which included the need for coupling between the two thermal fluids codes, Nuclear Energy Advanced Modeling and Simulation (NEAMS) Pronghorn and SAM (ML23354A276).

External Coordination and Communication

- On July 5, 2023, the NRC signed "Addendum No. 7 to the Memorandum of Understanding between the United States Department of Energy and Nuclear Regulatory Commission on Nuclear Energy Innovation; Establishing Roles and Responsibilities for National Environmental Policy Act Implementation Requirements for Reactor Demonstration Projects Supported by DOE" (ML23213A147), which seeks to establish functional coordination between the DOE and the NRC regarding National Environmental Policy Act and National Historic Preservation Act section 106 requirements associated with the demonstration and deployment of advanced reactors (to include both light-water reactors and non-LWRs) in the United States receiving DOE

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7 https://www.nrc.gov/public-involve/conference-symposia/structural-health-management.html

8 https://www.nrc.gov/public-involve/conference-symposia/adv-reactors-fuel-fab.html

support for design, license, construction, and operation of advanced reactors at U.S. sites.

- In CY 2023, the staff held over 140 public meetings on advanced reactor topics such as pre-application and licensing documents, staff-developed guidance, and industry-led guidance initiatives.

International Collaboration

- During 2023, the Canadian Nuclear Safety Commission (CNSC) and the NRC issued four joint reports:
    - On June 21, 2023, the staff, in collaboration with the CNSC, issued "U.S. NRC—CNSC Memorandum of Cooperation Interim Joint Report Concerning Classification and Assignment of Engineering Design Rules to Structures, Systems and Components" (ML23172A201), which addressed the similarities and differences in the safety classification process, including scope and outcomes, and two areas involving application of engineering design rules: reliability assurance programs and pressure-retaining components and supports.
    - On June 21, 2023, the staff, in collaboration with the CNSC, issued "Joint Report on GEH BWRX-300 Steel-Plate Composite (SC) Containment Vessel (SCCV) and Reactor Building Structural Design White Paper" (ML23100A032), which addressed a request from GE-Hitachi Nuclear Energy Americas for feedback on its design.
    - On June 30, 2023, the staff, in collaboration with the CNSC, issued "U.S. NRC—CNSC Memorandum of Cooperation FINAL REPORT concerning Tristructural Isotropic (TRISO) Fuel Qualification" (ML23172A242), which summarized data, criteria, and approaches that can help support fuel-related regulatory findings for TRISO-fueled reactor designs.
    - On July 31, 2023, the staff, in collaboration with the CNSC, issued "Joint Report on GEH BWRX-300 Safety Strategy White Paper" (ML23135A151), which addressed a request from GE-Hitachi Nuclear Energy Americas for feedback on its safety strategy white paper.

These and previous reports can be found on the "Joint Reports of the Canadian Nuclear Safety Commission (CNSC) and the NRC" website.[9]

Oversight

- On June 6, 2023, the staff delivered to the Commission for consideration an information paper, SECY-23-0048, "Vision for the Nuclear Regulatory Commission's Advanced Reactor Construction Oversight Program," (ML23061A086), which focused on the development of a framework for an effective and efficient construction oversight program for advanced reactors.
- On July 3, 2023, the staff issued the "TRISO-X At-Risk Construction Letter" (ML23121A151), which communicated regulations relevant to certain construction activities related to their proposed fuel fabrication facility under 10 CFR Part 70, that would be considered "construction at-risk." The letter provided possible risks related to

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[9] https://www.nrc.gov/reactors/new-reactors/advanced/who-were-working-with/international-cooperation/nrc-cnsc-moc/joint-reports.html

construction at-risk and communicated the staff's intent to conduct oversight of these activities.

- In 2023, the staff assessed the need to have a resident inspector stationed at Category II fuel facilities during construction and operation activities. In January 2024, the staff issued memoranda, which documented the staff's assessment and determination that resident inspectors are not needed at the TRISO-X and Centrus' American Centrifuge Plant Category II fuel facilities during construction or operations (ML23355A245, ML23356A124).