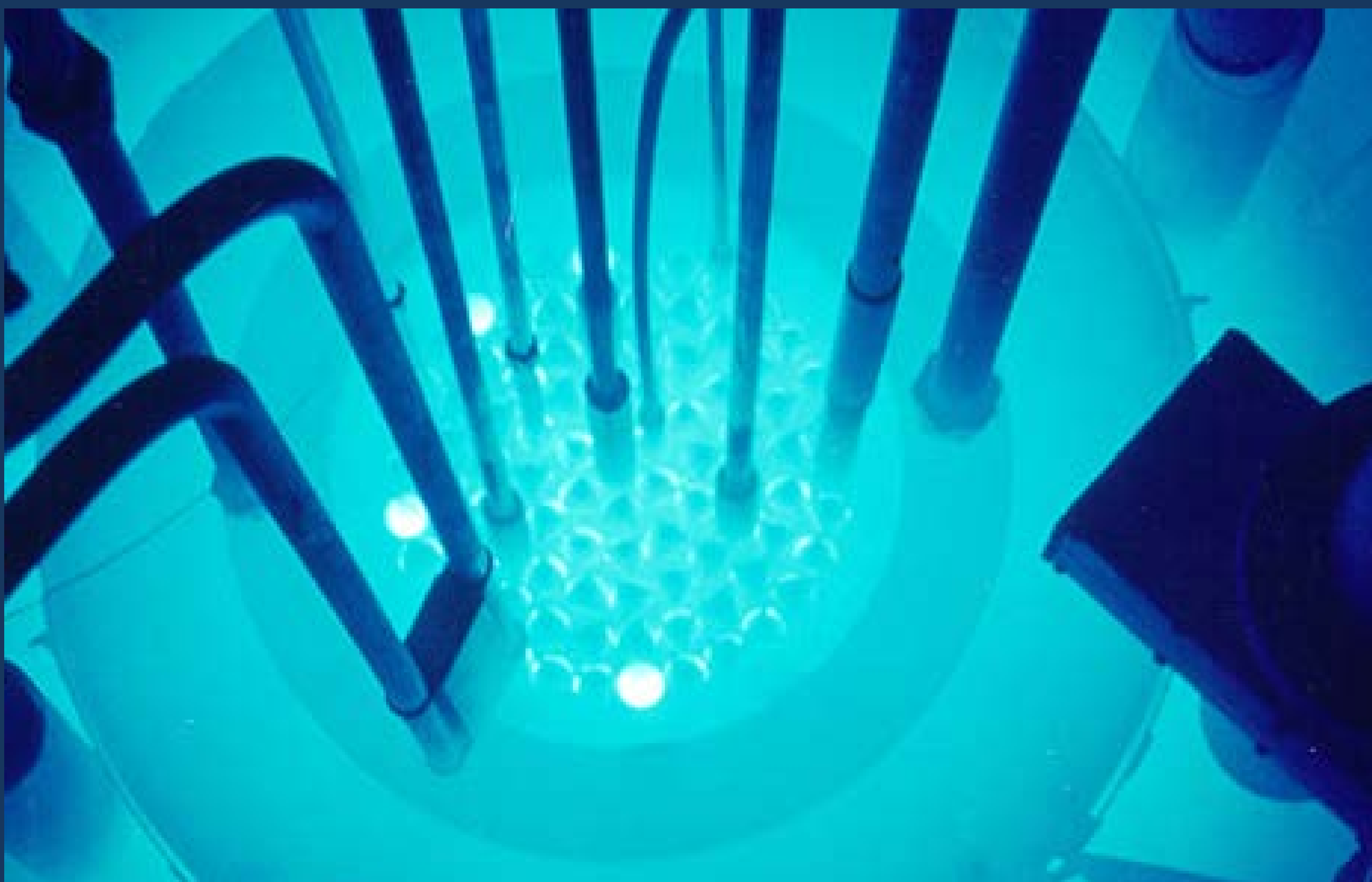
Special Inquiry into the U.S. Nuclear Regulatory Commission's Oversight of Research and Test Reactors

OIG Case No. I2100162
September 29, 2023



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MEMORANDUM

DATE: September 29, 2023

TO: Christopher T. Hanson
Chair

FROM: Robert J. Feitel
Inspector General

Robert J. Feitel Digitally signed by Robert J. Feitel
Date: 2023.09.29 08:02:34 -04'00'

SUBJECT: SPECIAL INQUIRY INTO THE U.S. NUCLEAR REGULATORY COMMISSION'S OVERSIGHT OF RESEARCH AND TEST REACTORS (OIG Case No. I2100162)

The attached report by the Office of the Inspector General (OIG), U.S. Nuclear Regulatory Commission (NRC) is furnished for whatever action you deem appropriate. Please notify the OIG by January 29, 2024, what corrective actions, if any, the NRC will be taking based on the results of this Special Inquiry.

cc: Commissioner Wright
Commissioner Caputo
Commissioner Crowell
D. Dorman, EDO
J. Weil, OPA

Results in Brief

OIG Case No. I2100162
September 29, 2023

Why the OIG conducted this Special Inquiry

The Office of the Inspector General (OIG) initiated this Special Inquiry following a radioactive release to the environment from the National Institute of Standards and Technology (NIST) test reactor located in Gaithersburg, Maryland on February 3, 2021. After the release, the NIST test reactor was shut down for more than two years before receiving authorization to restart from the U.S. Nuclear Regulatory Commission (NRC). This NIST event was one of eight unscheduled incidents or events in fiscal year 2021 that the NRC determined to be significant to public health or safety.

This Special Inquiry's focus broadened from the 2021 NIST event to include consideration of the NRC's oversight of other Research and Test Reactor (RTR) facilities to assess potential systemic issues. However, this report primarily discusses the NRC's oversight of the NIST test reactor prior to the February 2021 event because the event highlights areas in which the agency's oversight could be improved as it relates to other smaller nuclear facilities.

Findings

The agency's RTR program failed to identify and address problems with the NIST test reactor and other RTRs, specifically: (A) the NRC failed to identify problems with fuel movement, including precursors to later events; (B) the NRC's inspection practices often lacked direct observation of activities important to safety; (C) RTRs other than the NIST reactor experienced significant fuel oversight issues; and, (D) the agency's RTR program has not been substantively updated for at least two decades, and does not reflect the agency's risk-informed and safety culture positions.

The OIG's findings highlight future challenges for the agency's oversight programs for RTRs and advanced reactors.

Results in Brief

SUMMARY OF FINDINGS

A. The NRC's approach to inspections at the NIST test reactor prior to the February 2021 event resulted in the failure to identify and address fuel movement problem areas that were potential event precursors. From 2016 through 2020, the NRC inspected NIST audit reports, fuel movement records, and fuel movement procedures that had indications of potential problems. However, the NRC failed to follow up on NIST audit committee reports identifying deficiencies with safety culture and operator training and requalification that contributed to the event. The NRC also failed to identify records that revealed unlatched fuel elements and procedures that lacked adequate steps to ensure fuel elements were latched.

B. The NRC's oversight of RTRs lacked direct observation of activities important to safety. The OIG found that the NRC staff's routine inspections at NIST were scheduled primarily based on the annual frequency requirements stated in staff guidance documents, rather than by considering the timing of fuel movement or other planned activities that would have allowed inspections through direct observation. As a result, the NRC had not directly observed the fuel element latch checks following fuel movement at the NIST test reactor in the five years prior to the event. An unlatched fuel element was the direct cause of the 2021 event.

C. The NRC's oversight practices were not unique to NIST and were implemented in the same manner at two other RTRs that experienced fuel issues. The OIG also found inadequate technical specifications and dated license bases that contributed to these fuel issues. Additionally, in one instance, the NRC failed to take action for at least five years to address damaged fuel as described in NRC inspection reports.

D. The agency's RTR inspection program policy and guidance are outdated because they do not implement risk-informed approaches and safety culture elements. The last major revision to the safety inspection program was in 2004. Additionally, the 2004 safety inspection procedures underestimate the resources needed to complete all requirements that are defined in policy as "mandatory activities."

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I. ALLEGATION/INCIDENT

The OIG initiated this Special Inquiry following a radioactive release to the environment from the NIST test reactor on February 3, 2021.

This report is an investigative product documenting those instances when inadequacies in NRC regulatory oversight may have resulted in a potentially adverse impact on public health and safety.

Potential violations relevant to this Special Inquiry include failure to adhere to policy or procedures stated in Inspection Manual Chapter (IMC) 2545, "Research and Test Reactor Inspection Program," and Inspection Procedure (IP) 69009, "Class I Research and Test Reactor Fuel Movement."[1]

This Special Inquiry discusses the NRC's oversight of the NIST test reactor prior to the 2021 event and its collateral implications for the RTR program. Additionally, this Special Inquiry includes the results of an investigation concerning the adequacy of the NRC's oversight of the Aerotest research reactor from approximately 2000 to 2010. The OIG also reviewed the NRC's oversight of the University of Texas research reactor prior to a 2022 event.

The OIG interviewed more than 30 witnesses for this report, including licensee employees and NRC principals regarded as knowledgeable about the RTR program, as well as senior executives at NRC Headquarters. The OIG also performed site visits at all five Class I and several Class II RTRs, and reviewed agency documents, such as the agency's RTR program policies and guidance, NRC inspection reports, safety evaluation reports, and agency enforcement actions, as well as licensee records.

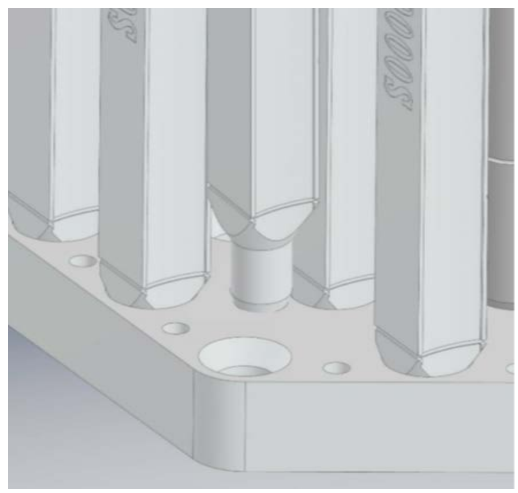
[1] As stated in IMC 2545, Subsection 08.01, Class I RTRs have licensed power levels of 2 megawatts (MW) or greater. Subsection 08.02 of IMC 2545 states that Class II RTRs have licensed power levels of less than 2 MW.

II. BACKGROUND

NIST Event Chronology

On February 3, 2021, the NIST test reactor experienced an automatic shutdown in response to indications of high exhaust stack radiation levels during a start-up after a six-week outage for reactor refueling. Consequently, NIST staff declared an "alert" in accordance with its emergency instructions and notified the NRC as required by its emergency plan. After NIST staff members placed the reactor in a safe condition, they evacuated the reactor confinement building and the control room, but six NIST personnel had been externally contaminated. Following decontamination, the contaminated personnel were cleared to go home later that day. Although exhaust stack samples showed a release to the environment involving the presence of fission product gases, including isotopes of cesium, xenon, and krypton,[2] the radiation release was less than 0.5 millirem, which is a fraction of the regulatory annual public dose limit of 100 millirem established in Title 10 of the *Code of Federal Regulations* (C.F.R.) Section 20.1301.

Figure 1: Misaligned fuel element



Source: NRC

After additional analyses, NIST officials notified the NRC on March 2, 2021, that its test reactor had exceeded the fuel temperature safety limit defined in its technical specifications. Therefore, the licensee was required to remain shut down until the NRC authorized restart of the reactor. NIST officials also determined that its licensed operators failed to ensure a fuel element was fully latched in its designated core position at the end of refueling operations on January 4, 2021. Between January 4, 2021, and February 3, 2021, the unlatched fuel element became misaligned due to NIST operators starting and stopping primary pumps to maintain required temperatures. During reactor start-up on February 3, 2021, at approximately 50 percent power (10 MW), this fuel element did not receive sufficient cooling because it was not in the proper orientation to receive design cooling water flow (see Figure 1). As a result, the fuel element partially melted.

On February 9, 2021, in response to this event, the NRC dispatched a Special Inspection Team (SIT) in accordance with NRC Management Directive 8.3, "NRC Incident Investigation Program." The SIT was charged with conducting an onsite review of the sequence of events leading up to the radioactive release and the licensee's response to the event, assessing the consequences of the event and the adequacy of the facility's procedures, reviewing the maintenance or outage actions preceding the event, and

[2] These isotopes are normal byproducts of fission in a nuclear reactor, normally contained inside fuel elements.

determining the root cause of the event and the completed or planned corrective actions to prevent recurrence.

On March 5, 2021, the NRC expanded the SIT's resources, technical expertise, and scope of chartered activities because the licensee had self-reported its violation of Safety Limit 2.1 (Greater than 450 degrees Celsius in a single fuel element).[3] On October 1, 2021, NIST officials provided the NRC with a root cause analysis of the event that identified fundamental or systemic causes that permitted the development of direct and contributing causal factors.

On March 16, 2022, the SIT reported its results related to the NIST event, identifying seven apparent violations.[4] The SIT also identified 14 inspection follow-up items that required additional assessment during future inspections.[5] These items related to equipment, procedures, processes, programs, system conditions, training, corrective actions, safety culture, and leadership.

On August 1, 2022, the NRC issued a legally binding Confirmatory Order, which NIST officials agreed would be issued as settlement of the apparent violations.[6] The NIST license was modified by this order, which included the following required activities by the licensee: a nuclear safety culture assessment, a nuclear program assessment(s), development of a problem identification and resolution program, increased attention to employee concerns, and establishment of a safety culture monitoring panel. Based on the Confirmatory Order, the NRC did not issue a Notice of Violation for the apparent violations discussed in its inspection report dated March 16, 2022, nor did the agency levy an associated civil penalty.

On March 9, 2023, NRC staff authorized the restart of the NIST test reactor.[7] NIST required NRC authorization to restart its reactor since the reactor exceeded its fuel temperature technical specification safety limit during the February 3, 2021 event.

[3] Revision to National Institute of Standards and Technology Test Reactor Special Inspection Team Charter (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21062A301).
[4] National Institute of Standards and Technology – U.S. Nuclear Regulatory Commission Special Inspection Report No. 05000184/2022201 (ADAMS Accession No. ML22056A361).
[5] IMC 0615, "Research and Test Reactor Inspection Reports," Subsection 03.09, defines an inspection follow-up item as a matter that requires further inspection because of a potential problem, because specific licensee or NRC action is pending, or because additional information is needed that was not available at the time of the inspection.
[6] National Institute of Standards and Technology, Center for Neutron Research – Confirmatory Order (ADAMS Accession No. ML22206A213).
[7] National Institute of Standards and Technology – Authorization to Restart following Exceedance of the Safety Limit (ADAMS Accession No. ML23040A337).

Role of the NIST Test Reactor

The NIST test reactor has been operating in Gaithersburg, Maryland, a suburb of Washington, DC, since 1967. NIST is an agency under the Department of Commerce. The reactor typically operates at 20 MW 24-hours-a-day, 7-days-a-week, with a routine shutdown every 5½ weeks.

The test reactor's neutrons can pass easily through many heavy materials, such as steel or iron, but interact strongly with light materials, particularly hydrogen. These characteristics make neutrons capable of seeing what X-rays cannot. Researchers use the neutrons to obtain a wide variety of information that can lead to improved pharmaceuticals, more efficient fuel cells for electric vehicles, and high-density data-storage systems. Approximately 3,000 researchers from over 260 organizations use the NIST test reactor annually (see Figure 2).

Figure 2: Cold neutron guide hall at NIST

Source: NRC

NIST Refueling

NIST staff refuel the test reactor approximately eight times per year to maintain full power operation. The reactor contains 30 fuel elements, and two shifts of licensed operators work approximately 12 hours to refuel it. This process involves replacing and reshuffling fuel elements in the core. During refueling, licensed operators use "pick-up" tools positioned above each fuel element.[8] Due to the reactor's design at the time of the event discussed in this report, the operators were not able to directly observe whether the fuel elements were securely latched in the reactor core. Instead, the operators had to rely on their experience using these tools and written procedures to ensure they properly latched the fuel elements in the reactor core.[9]

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[8] At times, operator trainees or other licensee staff may assist licensed operators with fuel movement activities. Title 10 C.F.R. Section 55.13(b) does not require a license for an individual who, under the direction and in the presence of a licensed senior operator, manipulates the controls of a facility to load or unload the fuel into, out of, or within the reactor vessel.

[9] Based on the corrective actions implemented following the February 2021 event, NIST operators must now perform visual checks using a camera, moved by the fuel transfer system, inside the reactor vessel to ensure fuel elements are securely latched.

NRC Regulatory Framework

One of the main components of the NRC's regulatory process is the oversight of licensees' facility operations through inspections. The purpose of the agency's RTR inspection program is not to provide a systematic certification for every aspect of RTR safe operations. Rather, the NRC inspects RTRs to ensure licensees meet the requirements in NRC regulations and NRC-issued licenses. Through these inspections the NRC seeks to provide reasonable assurance the public and the environment are protected from undue nuclear risk from RTR operations.

The general basis for regulation of RTRs is in the Atomic Energy Act of 1954, as amended, Section 104, "Medical Therapy and Research and Development." Section 104(c) states:

> 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.

The Office of Nuclear Reactor Regulation (NRR) is the NRC office responsible for oversight of RTRs, including the RTR inspection program. The general policy for the inspection program is described in IMC 2545, "Research and Test Reactor Inspection Program." The program establishes an inspection methodology for operating, safeguards, and decommissioning activities and conditions. The program is designed to allow sufficient flexibility to optimize the use of inspection resources and provide inspection commensurate with the safety significance of the RTR.

Inspection Manual Chapter 2545, Section 07, "General Program Guidance," addresses the scheduling, conduct, and implementation of NRC inspections at RTRs. Section 07 includes the following subsections:

- 07.01, Program Timeliness;
- 07.02, Performance Based Approach;
- 07.03, Program Feedback;
- 07.04, Use of Inspection Procedures;
- 07.05, Inspection Plans;
- 07.06, Management Entrance and Exit Meetings;
- 07.07, Inspection Reports; and,
- 07.08, Responding to Events and Event Reports.

Inspection Manual Chapter 2545, Subsection 08.01, provides additional guidance for Class I RTRs, which are those having licensed power levels of 2 MW or greater. For these RTRs, the NRC staff completes the operations portion of the inspection program annually using the following 11 IPs:

- IP 69003, Class I Research and Test Reactor Operator Licenses, Requalification, and Medical Activities;
- IP 69004, Class I Research and Test Reactor Effluent and Environmental Monitoring;
- IP 69005, Class I Research and Test Reactor Experiments;
- IP 69006, Class I Research and Test Reactors Organization and Operations and Maintenance Activities;
- IP 69007, Class I Research and Test Reactor Review and Audit and Design Change Functions;
- IP 69008, Class I Research and Test Reactor Procedures;
- IP 69009, Class I Research and Test Reactor Fuel Movement;
- IP 69010, Class I Research and Test Reactor Surveillance;
- IP 69011, Class I Research and Test Reactor Emergency Preparedness;
- IP 69012, Class I Research and Test Reactors Radiation Protection; and,
- IP 86740, Transportation.

Finally, Inspection Manual Chapter 0615, “Research and Test Reactor Inspection Reports,” Subsection 04.04.d, states that the NRC addresses enforcement-related findings in accordance with the NRC Enforcement Policy and the NRC Enforcement Manual.

III. DETAILS

Findings: NRC's inadequate RTR oversight led to a failure to identify and address problems with the NIST test reactor and other RTRs

The NRC's inadequate RTR oversight led to a failure on the part of the agency to identify and address problems with the NIST test reactor and other RTRs.[10] Specifically: (A) the NRC failed to identify problems with fuel movement, including precursors to the NIST event; (B) the NRC's inspection practices often lacked direct observation of activities important to safety; (C) other RTRs experienced significant fuel oversight issues; and, (D) the RTR program has not been substantively updated for two decades or more and does not reflect the agency's risk-informed and safety culture positions.

A. NRC Failed to Identify and Address NIST Event Precursors

The OIG determined the NRC failed to identify precursors and take regulatory action to address known safety concerns prior to the NIST event. The concern areas discussed in this Special Inquiry were related to the licensee's audits, fuel movement records, and fuel movement procedures.

<u>NRC review of licensee's audit reports</u>

NIST Technical Specification 6.2.5, "Safety Assessment Committee (SAC)," states that the committee "shall review or audit the [NIST Center for Neutron Research (NCNR)] reactor operations and the performance of the [Safety Evaluation Committee (SEC)]."[11] The OIG determined, however, that the NRC failed to monitor and address NIST's implementation of its audit committee's recommendations. These recommendations were later determined to identify deficiencies similar in nature to many of the root causes of the February 3, 2021 event identified by NIST.

Inspection Procedure 69007, "Class I Research and Test Reactor Review and Audit and Design Change Functions," is one of the IPs that the NRC must perform annually. One of the eight requirements in Section 69007-02 is to "[d]etermine if the licensee implemented or resolved the recommendations of [its] review and audit committee as required by the technical specification and licensee administrative controls."

[10] As used in this Special Inquiry, "address" refers to the agency taking steps in accordance with inspection and enforcement policies and practices. This excludes required licensee actions.
[11] The NIST Center for Neutron Research is the organizational unit with responsibility for the NIST test reactor.

Inspection Procedure 69007, Subsection 03.01, includes the following guidance to NRC inspectors regarding review and audit committee recommendations and audit requirements:

> The inspector should pay particular attention to the committee's actions and recommendations on audits and facility events, and the related follow-up actions by the committee and line management. The recommendations of the licensee's audit and review committee should have been resolved and the resolutions communicated to responsible personnel, such as operators and experimenters.
>
> If a safety or non-compliance issue raises the need for NRC required audits, the inspector should inform appropriate management, and the NRR project manager.

Between 2016 and 2020, the NRC reported reviewing the 2015 through 2019 SAC reports during annual inspections.

- In the 2016, 2017, and 2019 inspection reports, the NRC stated, "SAC audit provided good insight into the licensee's program and the committee made various worthwhile recommendations for program improvement. The licensee responded to the findings and took actions/corrective actions as needed."
- In the 2018 inspection report, the NRC stated, "The audit teams also made various observations which the licensee had addressed or was in the process of addressing. The audits appeared to be beneficial to the licensee in addressing issues that could be improved."
- In the 2020 inspection report, the NRC stated, "The inspector reviewed the last audit which showed that the audit team provided an independent review of the [NIST test] reactor operations and the performance of the SEC, as required."

However, the OIG reviewed SAC reports from 2015 through 2019 and noted the following SAC-identified concerns that the NRC did not capture in its inspection reports.

- The SAC identified at least four safety culture and/or complacency issues. For example, in 2019, the SAC noted that there was a complacency issue at NCNR and recommended a periodic Safety Conscious Work Environment (SCWE) survey be performed across the NCNR to assess the underlying safety culture and general attitude toward safety. The report stated, "NIST and the NCNR are fortunate and have not had a recent major safety incident..."
- The SAC also identified at least six issues with operator training and/or requalification. For example, the SAC noted: "The current shift rotation has the crews inadvertently phase-locked to perform the same evolution every cycle. This could affect knowledge management for some of the operations activities. The SAC recommends shifting the maintenance or shift schedules so that staff rotate through all the maintenance activities over time."

Further, the special inspection report that the NRC issued following the February 2021 event at NIST listed the following deficiencies identified in SAC reports.

- SAC audit completed October 24, 2019, identified a complacency issue at the NCNR.
- SAC report dated March 2, 2017, identified many of the above issues and identified shift staffing issues, as well as the aging reactor management program lead needing more authority to ensure cooperation from all other NIST staff. While that report did not list specific recommendations to improve training, it did suggest that a more structured training program would benefit the facility.

As described above, the SAC reports indicated issues with safety culture, shift staffing/rotation, training, and requalification. These reports also identified event precursors that the NRC failed to capture in its inspection reports.

An NRC principal stated that the SAC reports did indicate that there were safety culture issues. With respect to the event, this NRC principal asserted "it wasn't a coincidence that a number of those [SAC recommendations and findings] were identified as root causes … of the event … so clearly there were opportunities to fix those issues prior."

Review of licensee's fuel handling records

The OIG determined that the NRC failed to identify and address partially latched fuel element issues at NIST on several occasions.

Inspection Procedure 69009, Subsection 02.05, "Fuel Movement Problem Resolution," is one of the six requirements performed to "[d]etermine whether significant fuel movement or inspection problems are identified and resolved in accordance with the licensee's procedural controls."

Inspection Procedure 69009, Subsection 03.05, provides the following guidance: "the licensee is required to resolve identified problems … to meet technical specification requirements."

Between 2016 and 2020, the NRC reported reviewing defueling/refueling logs for Core 626 through Core 652. The log sheets are used to record compliance with technical specifications. For these record reviews, the associated NRC inspection reports documented no findings with regard to fuel movements.

However, the OIG reviewed these logs and identified several fuel movement problems that the licensee recorded on the log sheets. Specifically, the licensee commented that a "universal tool" was used instead of the standard tool on more than 10 occurrences and that partially latched elements were found on 4 occurrences (see Figure 3 and Appendix A).

Figure 3: Example of recorded fuel movement problems

1138	1726	A4	F1	1736	[redacted]	UNIVERSAL TOOL REMOVED PARTIALLY LATCHED.

Source: OIG generated from licensee records

The OIG learned the "universal tool" was used when a fuel element was in a partially latched condition.

As discussed in the Background section of this Special Inquiry report, the NIST event followed refueling and resulted from an unlatched fuel element that partially melted. The OIG learned that, after the event, the licensee reviewed the latch position of all 30 fuel elements and identified three additional fuel elements that were partially latched. Additionally, licensee records showed the NIST test reactor had nine previous unlatched fuel elements from 1981 through 2009. As discussed above, licensee records also showed at least four partially latched fuel elements from 2016 through 2020.

Further, the NIST root cause investigation report states:

> Video surveillance of this and all other checks shows that the latch checks were performed improperly: (1) the tool was rotated in the wrong direction, and (2) the rotation orientation check used an improper reference. In addition, the subsequent check of height of J-7 (a check to see if the tool collar was flush with the index plate) was found to be slightly high. This was attributed to the longer new tools. The effect of this improper check is uncertain but could possibly have worsened the condition of a partially latched element, rotating it towards a more fully unlatched position.[12]

When the OIG showed NRC principals the defueling/refueling logs with the many comments regarding issues with fuel movement, one NRC principal said they may have "missed" those comments, and another principal said that they did not follow-up with the licensee regarding those comments. One NRC principal also confirmed that the IP 69009 resource estimate is four hours and only allows for a "cursory" review of defueling/refueling logs. Both NRC principals agreed these were areas of fuel movement concern. One of the NRC principals then added, "you don't have the time to look at them as you should, in depth, and you don't have time to look at all of them, really."

Review of licensee's fuel movement procedures

The OIG determined that the NRC failed to identify and address fuel movement procedure concerns at the NIST test reactor.

[12] NIST root cause investigation of the February 2021 Fuel Failure (ADAMS Accession No. ML21274A019).

Inspection Procedure 69009, Subsection 02.01, "Fuel Handling Procedures," is one of six requirements performed to "[d]etermine whether the licensee's fuel handling procedures are adequate to perform intended functions."

Inspection Procedure 69009, Subsection 03.01, provides the following guidance: "[t]he licensee's fuel movement activities are governed by the licensee's procedures. The use of approved procedures is required in accordance with [technical specification] and security plan requirements."[13]

NIST Technical Specification 6.4.(2), "Fuel Loading, Unloading, and Fuel Movement Within the Reactor Vessel," requires the use of written procedures for moving fuel. NIST Operation Instruction 6.1, "Fueling and Defueling Procedure," is an example of a required licensee procedure.

In 2018, 2019, and 2020, the NRC stated in its inspection reports that it had verified the "licensee procedures and operator instructions provided approved methods to move and handle fuel consistent with the provisions of the [technical specifications] and the licensee safety analysis." The OIG identified that the NRC inspections from 2018 through 2020 included review of NIST Operation Instruction 6.1; for these annual inspections, the NRC reported no findings.

However, the OIG found the NIST root cause investigation report (referenced above) identified the inadequacies in NIST Operation Instruction 6.1 as one of the factors primarily contributing to the event. The report stated that "refueling latch-checking procedures did not capture the necessary steps to ensure that fuel elements were properly latched." Additionally, the report stated that "procedural compliance was not enforced" by licensee staff.

An NRC principal stated that record reviews of procedures primarily consist of identifying whether technical specifications require use of the procedure, verifying the licensee has a properly approved procedure, and reviewing recent changes and associated documentation. When asked about direct observation of procedure performance, this NRC principal explained they would obtain a copy of the licensee's procedure, attend the licensee's pre-job brief,[14] follow along in the field while the operators perform the steps, observe how licensees disposition issues, and ask questions on observed anomalies. The NRC principal asserted that either approach satisfies the IP requirements.

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[13] Title 10 C.F.R. Section 50.36(c)(5), "Administrative Controls," requires, in relevant part, procedures to ensure safe operation of the facility. NIST TS 6.4, "Procedures," implements this regulatory requirement with written procedures for seven categories of activities.

[14] NUREG/CR-6751, "The Human Performance Evaluation Process: A Resource for Reviewing the Identification and Resolution of Human Performance Problems," describes a pre-job brief as a meeting of workers and supervisors conducted before performing a job to communicate expectations, ensure personnel are qualified to perform the task, ensure procedures and instructions are complete and understood by personnel performing the task, verify prerequisite conditions are met before the work begins, and obtain authorization to start the task.

This NRC principal stated, however, that they would not be able to identify errors in the NIST procedures without observing performance of the procedure, adding that NIST Operation Instruction 6.1 "seemed reasonable as it was written, but that's without actually looking at the tools and looking at the index plate."[15]

The principal recalled:

> One of the biggest issues with the procedure is it told you to line a mark-up and the mark didn't exist…and the only way you're really going to be able to figure that out is if you went and chatted with folks and see what they do…and somebody tells you that it's not there or you observe the evolution.

B. NRC's Inspection Practices Often Lacked Direct Observation of Activities Important to Safety

The OIG determined the NRC was deficient when implementing existing requirements in the inspection policy and procedures for Class I RTRs. Specifically, the NRC performed limited direct observations of fuel movements and other licensee activities important to safety. Although the NRC met the inspection frequency requirement for Class I RTRs listed in agency policy, the OIG found the NRC did not typically coordinate inspections to coincide with licensee activities important to safety.

Limited direct observation of activities identified in inspection procedures

The OIG found that from 2016 through 2020, the NRC completed most inspection activities at NIST by reviewing records instead of directly observing activities important to safety.

In 2004, the NRC revised IMC 2545 in its entirety to incorporate performance-based concepts, including an emphasis on direct observation. Specifically, Subsection 07.02, "Performance Based Approach," states:

> Using a performance-based approach, inspectors focus their attention on activities important to safety. Performance-based inspection emphasizes observing activities and the results of licensee programs over reviewing procedures or records. For example, an inspector may identify an issue through observing a facility activity in progress, monitoring equipment performance, or the in-facility results of an activity (e.g., an engineering calculation), and then let the observation lead to evaluation of other associated areas. Discussions with facility personnel and reviewing documents should be used to enhance or verify performance-based observations. This approach is designed to emphasize observation of activities. Although most aspects of the inspection program are performed

[15] NIST Operating Instruction 6.1 states that the index plate is positioned above the reactor to guide the positioning of tools during the refueling process.

onsite using the performance based approach, certain activities can be conducted in the inspector's office, i.e., portions of procedure review and administrative program inspection.

NRC principals stated that it is preferable to directly observe RTR operations. They added that inspectors should "try to observe maintenance, surveillance, or some activity instead of just paperwork" and stated that direct observation should be the "norm."

NIST inspection reports showed that from 2016 through 2020 the NRC completed on average 14 direct observations for the annual inspections at NIST. Inspection procedure guidance recommends approximately 37 direct observations for annual inspections (see Table 1).

Table 1: Number of direct observations at NIST by inspection year

Sample Inspection Year	Documented Direct Observations
2016	17
2017	9
2018	15
2019	20
2020	9
Average	14

Source: OIG generated from NRC inspection reports

Additionally, an NRC principal explained that, during week-long inspections in 2022, two other Class I RTRs received between 15 and 25 percent of the direct observations listed in the IP guidance.[16] When the OIG asked another NRC principal if they knew whether NRR management preferred direct observation or record reviews, they replied that they were not aware of management's preference.

An NRC senior executive stated that, unlike a power reactor, there may be some "flexibilities" with respect to the RTRs that allow inspectors to rely on a paperwork review of completed activities, but it would be more ideal for them to "try and strategically, smartly schedule their annual reviews so they...coincide with those activities using a risk-informed approach." The senior NRC executive added, "I'd expect there to be more direct observation. It just makes sense."

Limited direct observation of fuel movement at the NIST test reactor and other Class I RTRs

Inspection Manual Chapter 2545, Section 06, "Policy," states that the IPs applicable to RTR inspections "were designed to gather facts to support inspection findings and conclusions," and provide guidance to inspectors. One of them, IP 69009, "Class I

[16] Class I RTRs receive two one-week inspections annually to complete all IP requirements.

Research and Test Reactor Fuel Movement," guides inspectors in determining "whether fuel was inspected, handled, and maintained as required, since the last inspection." Table 2 lists IP 69009's six requirements.

Table 2: IP 69009-02 inspection requirements

Section 02.01	**Fuel Handling Procedures**. Determine whether the licensee's fuel handling procedures are adequate to perform intended functions.
Section 02.02	**Fuel Handling and Inspection.** Determine whether fuel is moved and inspected consistent with the requirements of the TS and the licensee's procedures.
Section 02.03	**Radiological Controls.** Determine whether fuel handling activities are conducted in accordance with 10 C.F.R. Part 20 and the licensee's procedures and programs for radiation protection.
Section 02.04	**Security Plan**. Determine whether the licensee satisfied security plan requirements for fuel movement activities.
Section 02.05	**Fuel Movement Problem Resolution**. Determine whether significant fuel movement or inspection problems are identified and resolved in accordance with the licensee's procedural controls.
Section 02.06	**Tests and Checks**. Determine whether the licensee was within TS limits and met procedural requirements before resuming normal operation after fuel movement.

Source: NRC

The "General Guidance" section of IP 69009 states, "Be aware of the facility's plans and schedules for refueling or other major fuel movement. It is not necessary to directly observe the entire fuel movement activity. However, observation of a portion of the fuel movement activities is desirable." Section 69009-03.02 additionally states, "*If direct observation of a fuel movement activity is not possible at the time of inspection*, verification of the final fuel location, the review of respective records, and discussions with personnel involved in the most recent fuel movement activity will provide an acceptable sample for inspection." (emphasis added.)

Based on discussions with licensee principals and review of licensee records, a direct observation of fuel movement at the NIST test reactor would involve sampling a portion of licensee activities over at least a 12-hour period in areas that include defueling, refueling, and latch verification. During this 12-hour period, the inspector would be in the facility observing the licensee's activities in progress and verifying they were consistent with license requirements and procedures.

From 2016 through 2020, the NRC concluded in all five NIST inspection reports, "the licensee maintained and followed procedures which effectively implemented [technical specification] requirements for fuel handling." However, review of these inspection reports and interviews with the inspectors revealed that the NRC did not directly observe fuel element latch verifications in the five years prior to the event. While one of the five inspection reports stated that "the inspector had the opportunity to observe a portion of the fuel handling operation process following the removal of four used/spent fuel elements," the other four reports reflected a review of logbooks, records, and related procedures.

An NRC principal explained that "...NIST [has a] "very complicated procedure" and "direct observation is much more preferable than just reviewing paperwork." The principal added that they have advocated for more than two inspections per year "because there's so much stuff in a large facility like that to look at...you need to watch the operators as they're working." The principal stated that inspectors did not have enough time to look at everything in depth, saying "it's very hard to see, it's hard to judge where they move the fuel around."

An NRC senior executive stated, "I would expect there would have been more physical observation, especially if...the evolutions or the operations are taking place...once every 38 days...that would suggest to me that there is at least some opportunity to observe."

Additionally, the OIG found that the NIST reactor was not the only Class I RTR for which the NRC conducted limited direct observations of fuel movement. As shown in Table 3, from 2018 through 2022, the NRC directly observed approximately 5 percent of fuel movements at the other Class I RTRs.

Table 3: Direct observations of fuel movement at Class I RTRs

	2018	**2019**	**2020**	**2021**	**2022**
University of Missouri – Columbia	**Yes**	No	No	No	No
Massachusetts Institute of Technology	No	No	No	No	No
Rhode Island Atomic Energy Commission	No	No	No	No	No
University of California, Davis[17]	No	No	No	No	No

Source: OIG generated from NRC Inspection Reports

Three NRC principals with RTR inspection responsibilities stated that they had yet to directly observe a Class I RTR fuel movement.

Inspection planning based on program frequency requirements

Inspection Manual Chapter 2545, Section 07, "General Program Guidance," describes the scheduling, conduct, and implementation of NRC inspections at RTRs. The section has various subsections that are relevant to inspection scheduling.

Subsection 07.01, "Program Timeliness," provides that "the time allowed to complete the [inspection] program has a nominal period with a 25 percent maximum allowed

[17] During the referenced timeframe, the University of California, Davis was a Class I RTR based on licensed power level. The University of California, Davis is now considered a Class II RTR due to a reduction in licensed power level following license renewal.

period in the definitions of annual, biennial and triennial." This guidance is reflected in IMC 2545, Section 04, "Inspection Frequencies," which defines the intervals for inspections. Annual RTR inspections should be performed at least once per year, with the interval not to exceed 15 months (Subsection 04.01); biennial RTR inspections should be performed at least once every two years, with the interval not to exceed two years and six months (Subsection 04.02).

As discussed previously, IMC 2545, Subsection 07.02, "Performance Based Approach," provides that, "[u]sing a performance-based approach, inspectors focus their attention on activities important to safety. Performance-based inspection emphasizes observing activities and the results of licensee programs over reviewing procedures or records."

Inspection Manual Chapter 2545, Subsection 07.05, "Inspection Plans," provides that "the inspector shall annually develop facility-specific inspection plans consistent with this Manual Chapter." Further, "[t]he results of past inspections, event evaluations, and inspector and management reviews shall be used to schedule and determine the focus of planned inspections at each facility."

Inspection procedures also provide guidance to inspectors for planning purposes. For example, IP 69009, Section 03, "Inspection Guidance," states:

> Be aware of the facility's plans and schedules for refueling or other major fuel movement. It is not necessary to directly observe the entire fuel movement activity. However, observation of a portion of the fuel movement activities is desirable. Under no circumstances is the licensee to adjust schedules for these activities to fit the inspection schedule. At some facilities, the licensee may move fuel only once a year, which emphasizes the need to know the licensee's plans and schedules.

For both the NIST reactor and RTRs generally, the NRC used inspection program timeliness as the primary criterion for developing inspection schedules. The NRC's actions were contrary to the program guidance cited above, which encourages NRC staff to coordinate with licensees to determine times for observation of activities important to safety, such as fuel movement.

The NRC had opportunities to directly observe fuel movement at NIST and other Class I RTRs. From 2016 through 2020, the NRC had between three and seven opportunities per year to schedule inspections to directly observe fuel movement activities at NIST. The NRC also had numerous opportunities per year to observe such activities at other Class I RTRs. For instance, the University of Missouri-Columbia research reactor conducts fuel movement activities approximately weekly.

An NRC principal stated, "There is no specific requirement to observe...a percentage of fuel movement or outage activities." This NRC principal could remember only one time in three years that they tried to schedule around an outage activity at a facility, but they "didn't get to actually go" because the licensee was concerned about COVID. Another NRC principal explained that some Class I RTRs move fuel more than other facilities do, "so it should be easier to get there when they're moving fuel. It's just that sometimes you have scheduling problems, that this licensee can't support the inspection at this time, so you juggle that. Then you end up juggling others. I mean, there's a lot of excuses, but there's no good excuses."

C. NRC's Inadequate Oversight Extends to Other RTRs

The OIG identified instances of inadequate NRC oversight involving two Class II RTRs that experienced fuel-related issues.

Example 1: Aerotest

The OIG initiated an investigation of the Aerotest research reactor, located in San Ramon, California, after receiving allegations that the NRC failed to provide adequate regulatory oversight and inspections at this facility while it was operating. Additionally, the alleger asserted that "the NRC inspection reports were misleading as indicated by the areas of requalification, 50.59, and fuel."

The OIG found that, between 2000 and 2010, NRC biennial inspections of Aerotest were inadequate. Specifically, the NRC did not perform direct observation of fuel movement and failed to adequately conduct oversight activities related to damaged fuel, the facility's licensing basis, its ALARA program, and its technical specifications.[18]

Direct observation of fuel movement

The OIG determined the NRC did not directly observe fuel movement at Aerotest. During the 10-year period the OIG reviewed, the NRC had opportunities to directly observe fuel movements because Aerotest staff inspected 20 percent of the fuel elements annually to remain cognizant of the physical status of the fuel. An NRC principal stated, "...[I] never was able to be there during an inspection of the fuel but look[ed] at the records."

Inadequate oversight of damaged fuel

The OIG determined the NRC did not take timely action on damaged fuel. Specifically, the NRC acknowledged the presence of precursors to fuel damage during inspections conducted in 2005, 2007, and 2009. Ultimately, in December 2013, the NRC reported 22 fuel elements as having varying degrees of damage.

In 2005, the NRC had opened an Inspector Follow-Up Item (IFI) because recent fuel inspections showed that several fuel elements had been deformed such that they were

[18] Title 10 C.F.R. Section 20.1003 defines ALARA [as low as is reasonably achievable] as "making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest."

stuck in the reactor core, making them difficult to remove.[19] The IFI stated, "To ensure that the deformation of these fuel elements is not a precursor to a more significant issue, the NRC will continue to monitor the licensee's fuel inspections and any possible indications of a fuel element cladding failure."

In 2007, during a scheduled biennial inspection, the NRC reviewed the data sheets for the Fuel and Graphite Transfer forms for 2005, 2006, and 2007. In the associated inspection report, the NRC stated:

> As a result of the fuel problem, the licensee decided to remove all fuel possible from the core and conduct an inspection of all the fuel elements. In January 2006, those elements that could be removed were placed in storage. The licensee then used a moveable camera and monitor set-up to conduct an inspection of those elements that were "stuck" in place. After that was completed, an inspection of all the remaining elements was also completed and the elements were returned to their original positions in the core. No new or unusual problems were identified.

During this inspection, the NRC also closed out the IFI. In addition to referencing the licensee's 2006 inspection, the inspection report stated:

> To further help with this problem, the licensee had developed a plan to purchase enough new fuel elements over time to replace the ones that cannot be removed from the core. Once enough fuel is on hand, the reactor core will be defueled. Then the top grid plate will be raised slightly and the remaining 'stuck' elements will be worked out of their positions and out of the core. Then the new fuel elements will be placed in their positions. This issue is considered closed.

The cover letter of the 2007 NRC Inspection Report stated, "Based on the results of this inspection, no findings of significance were identified." The 2007 Inspection Report further stated that the inspector had reviewed the 2007 Data Sheet for Fuel and Graphite Transfer during that inspection.

Contrary to NRC reporting, the OIG reviewed the Aerotest Data Sheets for Fuel and Graphite Transfer for the 2007 inspection and found 20 fuel elements and 5 graphite elements were indicated as stuck in the reactor core. The OIG also found that one sheet listed "crack" in the Comments section for element 631E, and that this element had been removed from the core and placed into a storage rack.

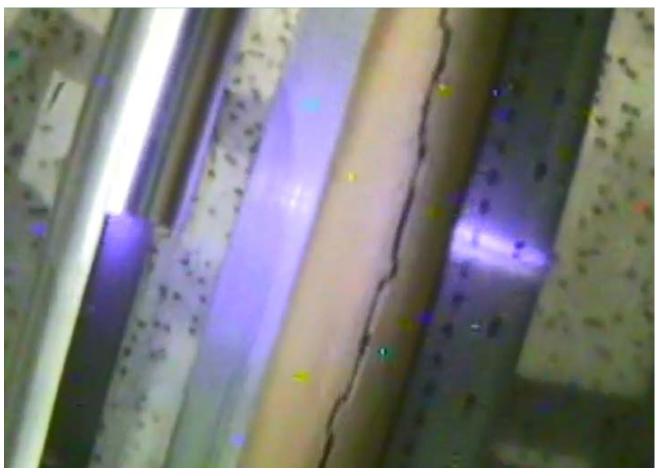
The OIG's review of inspection reports for Aerotest revealed there had been reports of stuck fuel rods as far back as 1980; likewise, Data Sheets for Fuel and Graphite Transfer from 1994 to 2012 revealed that of the 22 cracked elements initially identified, 7 had been stuck in the reactor core since the 1990s. Three of the initial four fuel elements

[19] IMC 0615, "Research and Test Reactor Inspection Reports," Subsection 03.09, defines an inspection follow-up item as a matter that requires further inspection because of a potential problem, because specific licensee or NRC action is pending, or because additional information is needed that was not available at the time of the inspection.

identified by Aerotest staff as cracked had been reported on the Data Sheets for Fuel and Graphite Transfer as stuck since 1994.[20] Of the 17 fuel elements that were inside the reactor core at the time of discovery, 14 had been previously indicated as stuck on the Data Sheets for Fuel and Graphite Transfer.

On December 18, 2013, approximately 3 years after Aerotest voluntarily ceased operation of the reactor, the NRC issued Aerotest a Notice of Violation against Technical Specification 10.2. The violation stated that "from an indeterminate period of time beginning at a point after the last full inspection in 2006 up until October 15, 2010, when the facility ceased reactor operation, the licensee operated the reactor with significant defects in the fuel elements." The first 4 cracked elements were discovered in late 2011, and in a subsequent inspection, 22 fuel elements were identified as having varying degrees of discoloration, blistering, swelling, and/or cracking in the aluminum cladding (see Figure 4). These characteristics represented a significant defect in the fuel elements and the loss of the integrity of a fission product barrier.

Figure 4: Aerotest cracked fuel element



Source: OIG generated from video provided by the licensee

When the OIG first received allegations related to Aerotest, an alleger had stated, "The very fact that a fuel element is stuck indicates that the fuel element is damaged" because the fuel rod is blistered, bowing, or swelling. They added that all these fuel damage indicators were documented in Aerotest's fuel inspection records and were "available to the NRC inspector," but "...the NRC inspection reports did not report problems...they indicated compliance."

When the OIG showed the 2007 Data Sheets to an NRC principal, the principal did not recall seeing the fuel element listed with "crack" in the comments. They added that if they had, they would have included that information in the NRC inspection report and called their NRR branch chief and the facility project manager to ask how they wanted to proceed with this issue.

[20] Two of the stuck fuel elements were documented on data sheets in 1994. The remaining stuck fuel element was documented on a data sheet in 2003.

An NRC principal with responsibility for RTR inspections said they had not been trained on damaged fuel and had not seen NUREG/CR-2387 before the OIG provided it to them to review the parameters for fuel evaluation.[21] This NRC principal said they were not aware of fuel damage issues at Aerotest when they were assigned to the facility from 2000 to 2010. The NRC principal stated it was the licensee's responsibility "to keep up with their fuel," and it "was unusual that they would have stuck elements."

The principal said that not acting to report and resolve the stuck fuel was their "mistake," and that they should not have closed the IFI until they verified that Aerotest completed its plan of action. This principal also stated that they relied on "the experience of the project manager and the people above" them when deciding how to handle issues found during RTR inspections.

The NRC principal did not provide a reason why the NRC refrained from issuing a notice of violation until 2013, except to say that the decision would have been a consensus judgment call. Another NRC principal stated, "Typically, if one of these research reactors has a rod that is stuck or they're inspecting them and see a little damage of any sort, they just put it aside in storage and won't re-use it. This facility was very unique in that they did not do that…[and] just operated with the damaged fuel." The NRC principal added, "training and guidance could be greatly improved."

Inadequate oversight of changes to the facility licensing basis

The OIG found that Aerotest staff made several changes to the facility between 2000 and 2010 without required documentation or revisions to the license or technical specifications. These changes included:

- Use of TRIGA (Training, Research, Isotopes, General Atomics) fuel with different weight percentage and cladding type; and,
- Operation with mixed core of fuel elements with different characteristics.

The OIG's review of licensee records and NRC reports did not identify licensing actions, inspection activities, or licensee documentation in support of these changes.[22]

An NRC principal advised that some of these changes "would have triggered some type of [10 C.F.R.] 50.59 review and/or evaluation." They explained that swapping out a component with a duplicate component is a replacement, not a change, and no 10 C.F.R. 50.59 evaluation is required. However, if a component is changed to something different, an evaluation must be completed to ensure the functions remain the same.

[21] NUREG/CR-2387, Credible Accident Analyses for TRIGA-and TRIGA-Fueled Reactors (ADAMS Accession No. ML083660125).

[22] Title 10 C.F.R. 50.59(c)(1) states that a licensee may make changes in the facility as described in the final safety analysis report (as updated), make changes in the procedures as described in the final safety analysis report (as updated), and conduct tests or experiments not described in the final safety analysis report (as updated) without obtaining a license amendment pursuant to Section 50.90 only if a change to the technical specifications incorporated in the license is not required, and the change, test, or experiment does not meet any of the criteria in 10 C.F.R. 50.59(c)(2).

Another NRC principal did not think that a 10 C.F.R. 50.59 evaluation was required if the licensee merely changed the cladding of the fuel from aluminum to stainless steel, but that if the weight percent of the fuel element changed from 8.5 weight percent to something different, or if the type of fuel changed, such an evaluation would need to be completed. If these differences did exist, then a 10 C.F.R. 50.59 evaluation should have been sought. The NRC principal said Aerotest staff did not use the 10 C.F.R. 50.59 process often as the licensee operated with the same equipment and same facilities for many years.

An NRC principal said that he thinks there is now training on 10 C.F.R. 50.59 evaluations in the inspector qualification program, but the guidance available at the time was inadequate. Inspection Procedure 69001 does not provide guidance on this topic; rather, it refers the reader to the NRC Inspection Manual, 10 C.F.R. 50.59, and IP 40745, "Class I Research and Test Reactor Review and Audit, and Design Change Functions." Additionally, Regulatory Guide 2.8, "Guidance for Implementation of 10 C.F.R. 50.59, Changes, Tests, and Experiments at Non-Power Production or Utilization Facilities," an NRC document that provides guidance to licensees on this topic, was not issued until February 2022.

Inadequate oversight of ALARA program

The OIG found the NRC may have failed to identify the exceedance of an occupational dose limit and the Aerotest facility's departure from an ALARA culture.

Personnel exposure levels revealed one Aerotest employee may have been above the NRC's occupational dose limit. A dosimetry report for 2001 indicated that an employee's culminate dose for his whole body (total effective dose equivalent) was 5,010 millirem, 10 millirem more than the annual occupational dose limit in 10 C.F.R. 20.1201(a)(1)(i).

An NRC principal stated that although Aerotest tended to have occupational dose numbers that were higher than other RTR licensees, they were not above regulatory limits. The principal did speak to Aerotest staff about dose numbers and challenged them to limit personnel exposure. The principal acknowledged that the Aerotest facility had issues with maintaining radiation worker doses ALARA. Because the doses did not exceed the regulatory limits, they could only talk with the licensee and encourage them to take action.

The ALARA principle in 10 C.F.R. 20.1101(b) requires licensees to "use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable."[23]

[23] There were no additional, specific ALARA requirements or radiological dose thresholds included in Aerotest's technical specifications.

The OIG also reviewed environmental exposure records and determined that the area radiation readings in the Aerotest Accounting Office ranged from the high 50s to approximately 250 millirem per quarter between October 2010 and June 2017. The high values were due to radioactive waste in the storage room, which was adjacent to the Accounting Office in April 2017. Once the waste was disposed, the readings in the Accounting Office dropped to none detected in the following quarter. The licensee said that the proximity of the waste storage room to administrative space was a violation of ALARA culture, and the waste storage room was relocated.

An NRC principal with inspection oversight responsibilities stated that the licensee did have an ALARA situation but did not exceed regulatory limits. They did not recall, however, the ALARA situation in the Accounting Office. Given that the ALARA situation in the Accounting Office persisted for approximately seven years, it appears that the NRC would have had ample opportunity to identify and address Aerotest's lack of adherence to ALARA principles.

Inadequate oversight of technical specifications

The NRC failed to identify that Aerotest had technical specifications that were inadequate under 10 C.F.R. 50.36.

Aerotest applied for license renewal in 2005, with supplemental letters to the NRC in 2008, 2009 and 2010. Although the facility license was never renewed based on the 2005 application, the Aerotest reactor was allowed to continue operating under the timely renewal provisions of 10 C.F.R. 2.109, "Effect of Timely Renewal Application," until the licensee voluntarily ceased operation of the reactor in 2010.

Although the NRC's regulatory framework allows licensees under timely renewal to continue operating with the technical specifications approved with the granting of the initial operating license, the OIG found this facility's technical specifications missed specific values or actions that would ensure safety. For example, the specifications did not contain a fuel temperature safety limit for aluminum-cladded fuel or stainless-steel cladded fuel. Further, the technical specifications did not contain other provisions required by 10 C.F.R. 50.36(c).

Example 2: University of Texas at Austin

The OIG examined the NRC's oversight of a 2022 fuel-related event at the University of Texas at Austin, Nuclear Engineering Teaching Laboratory (NETL). The OIG found the NRC had determined that the University of Texas violated requirements similar to those involved with the NIST event previously discussed in this Special Inquiry report. Specifically, an SIT reported concerns with the licensee's fuel movement activities, safety culture, and procedures. The NETL event also revealed that the NRC had failed to take action on relevant license amendment requests the University of Texas submitted between 2008 and 2012.

The NETL, which operates a Class II RTR, is open to domestic and international researchers, including clients and services in the fields of education and training, nuclear and radiation related research, nuclear analytical services, radioisotope production, and specialized technical services. The NRC staff also uses the facility for hands-on operations training, akin to the power reactor simulator training provided by the NRC's Technical Training Center located in Chattanooga, Tennessee.

On November 2, 2022, this licensee self-reported to the NRC that it operated with non-compliant fuel, having replaced two of its RTR's compliant stainless steel-cladded fuel elements with aluminum-cladded fuel elements in the core. The NRC dispatched an SIT, in accordance with NRC Management Directive 8.3 and branch reactive inspection guidance, to conduct an onsite review to determine: 1) what facts contributed to the loading of the aluminum-cladded fuel elements in the reactor core and the extent to which operating in an unanalyzed condition had impacted reactor components and reactor safety; and, 2) if any reactor operations with aluminum-cladded fuel elements exceeded operational limits during normal and potential off-normal conditions.

On January 25, 2023, the SIT reported its results related to the NETL event, identifying one apparent violation and one minor violation.[24] In the special inspection report, the NRC listed the licensee-determined root causes that led to its reactor operating with the aluminum-cladded fuel elements. These root causes included procedures that were inadequate in identifying disqualified fuel elements and keeping them out of the core. The licensee also identified, as contributing causes, a lack of attention to detail when selecting the elements to be used in the core, inadequate administrative and engineering controls in place to ensure disqualified fuel elements were easily identifiable, an inadequate safety conscious work environment that led to a procedure revision that was improperly implemented, and a lack of management oversight that led to a single point of failure.

On May 10, 2023, the NRC issued a notice of violation to the licensee for operating with fuel that did not meet technical specification requirements. [25]

Review of NRC oversight activities at the University of Texas

The OIG reviewed root and contributing causes of the NETL event; like the NIST event, these causes included safety-culture deficiencies and inadequate procedures. The OIG also found, however, missed opportunities on the part of the NRC to directly observe and potentially identify conditions relevant to the event.

Inspection Procedure 69001, Subsection 02.12, "Fuel Handling Logs and Records," states that NRC inspectors shall "[d]etermine whether the [licensee's] fuel handling logs or activities satisfy the [technical specifications] requirements and licensee's procedural requirements." The guidance in Subsection 03.12 (also titled "Fuel Handling Logs and Records") further states that actual observation of fuel handling, or the review of about

[24] University of Texas at Austin – U.S. Nuclear Regulatory Commission Special Inspection Report No. 05000602/2022201 (ADAMS Accession No. ML22347A311).
[25] University of Texas at Austin – Notice of Violation (ADAMS Accession No. ML23129A243)

50 percent of the fuel handling logs since the last inspection, is an acceptable sample for this inspection requirement.

While the guidance permits either direct observation of fuel handling or a records review of fuel movement activities, the OIG determined the NRC did not directly observe fuel movement activities or the implementation of related technical-specification-required procedures at the NETL for an extended period. Specifically, the NRC did not directly observe such activities at any time during the five years preceding November 2, 2022, when the licensee self-reported to the NRC that it had operated with non-compliant fuel.

In other words, the NRC was not onsite for fuel movements related to the aluminum-cladded elements and missed an opportunity to identify conditions relevant to the licensee's noncompliance. While the NRC's inspection approach may have been permissible under existing guidance, the NETL event would appear to give the NRC reason to reconsider that guidance to the extent it has not done so already.

Review of facility licensing basis

The OIG found the NRC failed to act on licensee amendment requests to update fuel-related technical specifications for aluminum-cladded fuel.

In 2004, the NRC issued an amendment to the University of Texas that increased the license limit for reactor fuel and allowed the licensee to acquire, in part, "additional regular fuel elements to compensate for fuel burnup."[26] Following this license amendment, the NETL received two aluminum-cladded fuel elements during a 2004 shipment of fuel from another research reactor. The OIG found the license amendment issued by the NRC did not, however, allow for this aluminum-cladded fuel. Specifically, while the amended facility license increased and modified the limits for possession of special nuclear material and byproduct material, it did not modify the technical specifications to include aluminum-cladded fuel. If this type of fuel was intended to be used, the technical specifications for safety limits, limiting conditions for operation, surveillances, and design features should have been reviewed and updated to include any necessary provisions for aluminum-cladded fuel.

The licensee docket revealed two license amendment requests submitted by University of Texas officials, in 2008 and 2010, to update the technical specifications to account for these aluminum-cladded fuel elements.[27] [28] Both the 2008 and 2010 requests stated that the licensee was seeking a change in specifications that would allow for use of aluminum-cladded fuel (see Figure 5).

[26] University of Texas at Austin – Amendment Re: Special Nuclear Material and Byproduct Material Possession Limits (TAC NO. MC2410) (ADAMS Accession No. ML061320052).
[27] Submission of Changes to License Technical Specifications (ADAMS Accession No. ML080920755).
[28] Request to withdraw previous Technical Specification change request and submission of new change request (ADAMS Accession No. ML101241147).

Figure 5: Excerpt from University of Texas 2008 license amendment request

CHANGE 2

Current Specification:

1.5 Fuel Element, Standard

A fuel element is a single TRIGA element of standard type. Fuel is U-ZrH clad in stainless steel clad. Hydrogen to zirconium ration is nominal 1.6.

Change Specification to:

1.5 Fuel Element, Standard

A fuel element is a single TRIGA element of standard type. Fuel is U-ZrH (<20% enriched uranium) clad in stainless steel or aluminum. Hydrogen to zirconium ration is nominal 1.6.

Justification:

Definition of standard element from General Atomic includes aluminum clad elements. NETL is currently in possession of two aluminum clad standard elements in storage. Second use of the word "clad" in second sentence is redundant. All fuel elements have or will have less than 20% enrichment by reactor license.

Source: OIG generated from NRC docket files

The docket also showed that, from 2008 to 2012, the NRC did not conduct an acceptance review, issue requests for additional information, or render any licensing decisions regarding these amendment requests. In summary, the NRC did not act before the licensee withdrew these requests.[29]

As discussed above, the licensee installed and operated with two aluminum-cladded fuel elements for 9 months before notifying the NRC. If the NRC had acted on the licensee's amendment requests, operation with or possession of these fuel elements may not have resulted in the May 2023 notice of violation.

While an NRC special inspection report concluded that there was "no fuel damage" and there were "no actual nuclear safety consequences" due to operation with the aluminum-cladded fuel elements, the report highlights that the licensee "operated with [limits] that were less conservative than what is necessary to ensure the integrity of a fission product barrier." The report also states that the safety significance of those limits was identified "as necessary to reasonably protect the integrity of the primary barrier against the uncontrolled release of radioactivity." In addition, the report notes

[29] The licensee withdrew the 2008 amendment request in 2010. Request to withdraw previous Technical Specification change request and submission of new change request (ADAMS Accession No. ML101241147). The licensee withdrew the 2010 amendment request in 2012. Request for Change to License Technical Specifications Incorporating 2008, 2010, and 2011 Requests (ADAMS Accession No. ML12082A145).

that aluminum-cladded fuel elements "require a more conservative limit with regard to peak fuel temperature ... to ensure the integrity of the cladding is maintained."

D. RTR Inspection Program Policy and Guidance are Outdated

The agency's RTR inspection program policy and guidance are outdated because the NRC has not implemented risk-informed approaches and safety culture elements. The last major revision to the safety inspection program documents was in 2004, and the 2004 IPs underestimate the resources needed to complete all requirements.

Lack of a risk-informed approach in RTR inspection program

The NRC began assessing risk insights for incorporation into the RTR oversight program as early as 1992. Several examples of the NRC's activities to risk inform the RTR program are described below:

In November 1992, the NRC published NUREG/CR-5756, "Review and Assessment of Non-Power Reactor (NPR) Inspection Schedules."[30] Without site-specific quantitative PRA models available, the report authors developed qualitative risk factors to determine inspection frequencies based on the relative risk of each facility to public and occupational safety.[31]

In 2000, the NRC developed a risk-informed regulation implementation plan that outlined the agency's risk-informed initiatives.[32]

In 2006, the Commission issued a Staff Requirements Memorandum (M060503B) directing the staff to improve the implementation plan so that it is an integrated master plan for activities designed to help the agency achieve the Commission's goal of a holistic, risk-informed, and performance-based regulatory structure.[33]

In 2011, the NRC Risk Management Task Force was chartered to "develop a strategic vision and options for adopting a more comprehensive and holistic risk-informed, performance-based regulatory approach for reactors, materials, waste, fuel cycle, and transportation that would continue to ensure the safe and secure use of nuclear material."[34] The task force issued its findings and recommendations in NUREG-2150, "A Proposed Risk Management Regulatory Framework," which contained several findings and recommendations for RTRs. For example, one finding and one recommendation addressed risk assessment insights for RTRs (see Figure 6).

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[30] RTRs are a subset of non-power reactors.
[31] The qualitative risk factors included: fission products, forced outages/full power hour; number and severity of NRC violations issued, maximum individual whole body exposure (millirem/year), biological shield configuration changes, decay heat rate/kilogram of fuel (Curies/kilogram), whether an active/passive ECCS is required, spent fuel inventory [kilograms U-235], refueling frequency [elements/year], and population density.
[32] SECY-00-0213, Risk-Informed Regulation Implementation Plan (ADAMS Accession No. ML003762669).
[33] SECY-07-0074, Update on the Improvements to the Risk-Informed Regulation Implementation Plan (ADAMS Accession No. ML070890396).
[34] NUREG-2150, A Proposed Risk Management Regulatory Framework (ADAMS Accession No. ML12109A277).

Figure 6: Excerpts regarding RTRs from NUREG-2150

Finding NPR-F-3: The application of modern risk assessment methods at [RTRs] could provide valuable insights into accident scenarios not previously identified by the earlier deterministic safety assessment and could be valuable in focusing the application of licensing and oversight resources on areas of risk importance. Risk assessment insights, in conjunction with a formal risk management decision-making process, could significantly contribute to the development of a more efficient and effective [RTR] regulatory framework. [RTR] PRA models developed by others could be used as a starting point for facility-specific PRA models at NRC-licensed [RTRs]. Even with this background however funding such assessments could be problematic for [RTRs].
Recommendation NPR-R-2: The NRC should evaluate the utility of performing a pilot risk assessment, including consideration of external hazards, using modern risk assessment methods at an [RTR]. This evaluation would assess the value of the risk insights gained from the risk assessment on the basis of possible safety enhancements and possible contributions to a more efficient and effective risk-informed and performance-based regulatory framework for [RTRs].

Source: NRC

The OIG found that the NRC has not implemented these recommendations in the RTR inspection program policy and guidance. The lack of updates to the inspection program is discussed in a later section of this Special Inquiry report. As of September 2023, the NRC's public website stated, "There are no current Risk-Informed and Performance-Based Activities in the Research and Test Reactors Sub-Arena" (see Figure 7).

Figure 7: NRC website "Current Risk Informed Activities"[35]

Research and Test Reactors Sub-Arena

Research and test reactors comprise one of four sub-arenas that the staff of the U.S. Nuclear Regulatory Commission (NRC) identified in considering which areas of the reactor safety arena to target for greater use of risk information.

The staff will be conducting a review of NUREG-2150, "A Proposed Risk Management Framework," that will consider how modifications to the regulatory framework could be incorporated into important agency policy documents. As part of this review, the staff will seek stakeholder input on proposed options and recommendations. The proposed options and recommendations will be included in a paper to the Commission that will identify options and make recommendations. Those options and recommendations may or may not be applicable to research and test reactors. Estimated completion of this review, including the Commission Paper, is August of 2013.

List of Risk-Informed and Performance-Based Activities

There are no current Risk-Informed and Performance-Based Activities in the Research and Test Reactors Sub-Arena

Page Last Reviewed/Updated Monday, June 08, 2020

Source: NRC public website

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[35] https://www.nrc.gov/about-nrc/regulatory/risk-informed/rpp/reactor-safety-rtr.html.

An NRC principal stated that the "risk-informed part is something that we haven't paid much or given much attention as needed" for RTRs, but that it is a "needed addition to our procedures." Several NRC principals stated that they apply engineering judgment to informally "risk-inform" their inspection activities, and that putting together some sort of group to determine the relative risks of specific facility activities would be beneficial. For example, an NRC principal said that the NIST test reactor should be considered a priority from a risk-informed perspective.

An NRC senior executive stated:

> There are activities at nuclear plants and even at research and test reactors that are more significant than others, have more potential for an adverse consequence, have more radiological implication...fuel manipulations would be one of those...I would expect that by using a risk-informed planning approach our inspections would be planned to cover those activities ...[and] I would expect, for example, that an inspector would be probably more interested in going to observe a fuel manipulation [or] fuel loading.

The NRC senior executive added, "the amount of risk associated with these facilities is a lot less than that associated with [power] reactors .... so...there may be...a graded approach [to] what frequency these things get reviewed."

Lack of safety culture element in RTR inspection program

Another process the NRC initiated in the 2011 timeframe but has not implemented into the RTR inspection program is "safety culture." The NRC defines nuclear safety culture as "the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment."

In June 2011, the Commission issued the NRC's Safety Culture Policy Statement "to set forth [its] expectation that individuals and organizations establish and maintain a positive safety culture commensurate with the safety and security significance of their activities and the nature and complexity of their organizations and functions."[36] This policy statement applies to all licensees.[37] In 2015, the NRC updated the Implementation Plan for the Safety Culture Policy Statement.[38] For example, the NRC reported that, "[s]ince 2006, the NRC's oversight of safety culture for power reactors through the [reactor oversight process (ROP)] has included guidance and procedures for inspecting and assessing aspects of licensees' safety culture." However, the NRC did not transition the RTR inspection program to reflect the new culture focus. Specifically, the

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[36] 76 Fed. Reg. 34777 (June 14, 2011).

[37] Though not developed to be used for inspection purposes, the final Policy Statement lists the following nine traits of a positive safety culture: leadership safety value and actions, problem identification and resolution, personal accountability, work processes, continuous learning, environment for raising safety concerns, effective safety communication, respectful work environment, and questioning attitude.

[38] Safety Culture Policy Statement Implementation Plan Update (ADAMS Accession No. ML15180A150).

Future Planned Activities section of the update stated, "Research and Test Reactors: NRR staff will continue to provide safety culture information and communication as opportunities become available."

Lack of safety inspection program updates

The OIG found that the NRC has not updated the safety aspect of IMC 2545, "Research and Test Reactor Inspection Program," since 2004.[39] Additionally, 10 of the 11 IPs routinely performed at Class I RTRs have not been updated since 2004.[40] The lack of updates in these areas appears inconsistent with IMC 2545, Subsection 07.03, "Program Feedback," which states:

> The reactor inspection program is expected to be dynamic and to respond to changes in the RTR community and operational experience. Therefore, management and inspectors are to identify problems in implementing the program, and to recommend changes to the program for consideration by the program office. Any such feedback and recommendations should be submitted to the responsible Branch Chief or Program Director.

Additionally, the OIG found that the RTR inspection program does not have a self-assessment process to determine if the program meets its established goals and intended outcomes. By contrast, for more than 20 years, IMC 0307, "Reactor Oversight Process Self-Assessment Program," has been in place to evaluate if the Reactor Oversight Process meets its established goals and intended outcomes.

NRC principals recognized the need for inspection program updates, and staff and management have committed to reviewing processes to determine "if it makes sense for us to update our procedures...[and]...just from a purely administrative standpoint they need to be updated." An NRC principal commented that there is not a program for RTRs that is analogous to the Reactor Oversight Process. While the NRC principals recognized the need for updating the inspection guidance periodically, the NRC did not implement substantive updates to reflect operational experience, feedback, and other NRC initiatives.

An NRC senior executive said that the NRC Inspection Manual and procedures should be updated more frequently to make use of the operating experience, technology, and improvements that have been made over the years. "I would expect...the procedures to be at least more up to date [than] 2004...maybe there's just not the priority given to that manual chapter as there is to others."

Inadequate resource estimates to support inspection requirements

Inspection Manual Chapter 0040, "Preparation, Revision, Issuance, and Ongoing Oversight of NRC Inspection Manual Documents," states that Section 04, "Resource

[39] A March 13, 2020, update to IMC 2545 was "to support minor or conforming changes" and did not focus on substantive aspects of the RTR safety inspection program.
[40] The OIG provides a list of these 11 IPs in the Background section of this Special Inquiry report.

Estimate," of each inspection procedure "provides an estimate of the average time needed to complete the inspection (not including preparation and documentation time). This estimate is for broad resource planning and is not intended as a measure for judging the inspector's or the region's performance. Actual inspections may require substantially more or less time, depending on the individual circumstances."

The OIG reviewed the 11 IPs routinely performed at Class I RTRs and determined that inspectors must verify at least 82 requirements (essential tasks that must be completed) through direct observations, interviews, or record reviews. The inspection guidance also recommends specific direct observations to complete inspection requirements, such as direct observation of the completion of a technical specification requirement using procedures. These requirements are intended to ensure the licensee's systems and techniques align with regulations and provide acceptable protection of public health and safety. Additionally, 10 of the IPs for Class I RTRs have resource estimates that total approximately 80 hours on average (see Table 4). In practice, NRC inspectors travel to these facilities twice each year to complete the 11 IPs.

Table 4: Class I RTR inspection procedure requirements and resource hours

Inspection Procedure (Abbreviated Title)	**Number of Requirements**	**Requires Direct Observation**	**Resource Hour Estimate**
IP 69003, Operator Requalification	6	No	3
IP 69004, Environmental Monitoring	7	Yes	10
IP 69005, Experiments	12	Yes	6
IP 69006, Operations and Maintenance	8	Yes	8
IP 69007, Audit and Design Changes	9	No	5
IP 69008, Procedures	4	Yes	5
IP 69009, Fuel Movement	6	Yes	4
IP 69010, Surveillance	4	Yes	8
IP 69011, Emergency Preparedness	9	Yes	12
IP 69012, Radiation Protection	17	Yes	18
Totals	**82**	**8**	**79**

Source: OIG generated from inspection procedures

An NRC principal stated that the four resourced hours to complete the six requirements in IP 69009 were "totally inadequate for a facility like NIST," because NIST's systems are "complicated" and require more time than smaller RTRs. The principal added that "a small research reactor does not have as many changes, have as many operations, and they don't do as much as NIST does." To work around the time constraint and still complete all the IPs for a facility like NIST, this NRC principal said it was necessary to "look at half of them one time and half of them the other." Another NRC principal stated that they develop a smart sample focusing on safety-significant, or the most safety-significant, issues or areas to provide reasonable assurance because "you don't have time to look at everything."

The OIG found that the biennial Class II RTR inspection program similarly directs the inspector to verify 57 requirements through direct observations, interviews, or record reviews (see Table 5). The IP requirements for Class II RTRs have a total resource estimate of 60 hours, although individual sections of IP 69001 are not resource estimated.

Table 5: Class II RTR inspection procedure requirements

Inspection Procedure Subsections	Number of Requirements	Requires Direct Observation
IP 69001-02.01, Organization and Staffing	2	Yes
IP 69001-02.02, Operations Logs and Records	3	No
IP 69001-02.03, Procedures	4	Yes
IP 69001-02.04, Requalification Training	6	Yes
IP 69001-02.05, Surveillance and Limiting Conditions for Operation	2	Yes
IP 69001-02.06, Experiments	8	Yes
IP 69001-02.07, Health Physics	17	Yes
IP 69001-02.08, Design Changes	4	Yes
IP 69001-02.09, Committees, Audits and Reviews	3	Yes
IP 69001-02.10, Emergency Planning	4	Yes
IP 69001-02.11, Maintenance Logs and Records	3	No
IP 69001-02.12, Fuel Handling Logs and Records	1	Yes
Totals	**57**	**10**

Source: OIG Generated from IP 69001

Furthermore, the OIG determined that inspection of all RTRs requires significant resources and planning over a six-year inspection cycle to meet NRC policy and procedure requirements.[41] From 2016 through 2020, the NRR maintained an average of four qualified inspectors for all 30 operating RTRs. NRC principals stated that each RTR inspector is assigned between 6 and 13 facilities to conduct both safety and security inspections.

In response to whether the agency has enough inspectors and resources to meet program and inspection requirements, an NRC senior executive stated, "NRR allocates its resources in accordance with the number of reactors and the number and type of reactors, and the frequency of inspections called for by the procedures, and so they should be hiring accordingly. I have not been made aware of any shortage in that regard, so my understanding is that we do have the resources to [be] conducting inspections."

[41] During a 6-year inspection cycle, the total number of safety and security inspections performed by RTR inspectors varies each year between 33 and 68 inspections.

IV. FUTURE LICENSEES AND NRC'S RTR PROGRAM

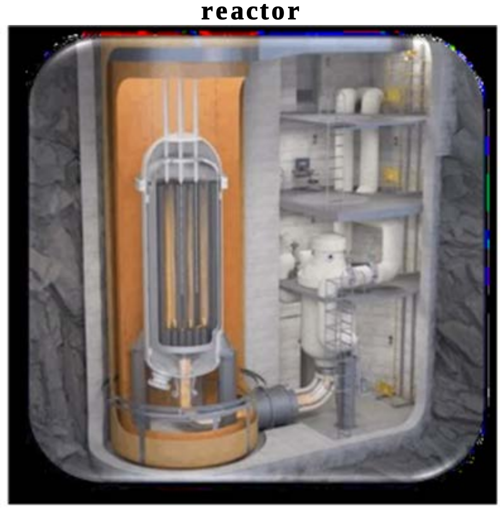
The NRC currently provides oversight to 30 operating RTRs; there are no indications that any of these facilities will cease operations soon. Furthermore, the NRC is anticipating advanced reactor deployments in the near future that could include additional RTRs for prototypes. This could increase the number of licensed RTRs for which the NRC would be responsible for providing adequate oversight.

In May 2023, the NRC submitted its "Semiannual Status Report on the Licensing Activities and Regulatory Duties of the U.S. Nuclear Regulatory Commission" to Congress. The report covers NRC activities from October 1, 2022, through March 31, 2023. Within this report, the NRC refers to potential license applications for reactors that use advanced technologies:

> The staff is reviewing pre-application reports and meeting regularly with vendors on potential future applications, including: X-energy, on its pebble-bed, high-temperature gas-cooled reactor; Kairos on its tri-structural isotropic particle (TRISO) fuel, fluoride-cooled high temperature commercial power reactor; Terrestrial Energy on its molten salt coolant, molten salt fuel reactor; TerraPower on its sodium-cooled fast reactor; Westinghouse Electric Company on its high temperature heat pipe microreactor; General Atomics on its high-temperature gas-cooled reactor; the University of Illinois Urbana-Champaign on its power-generating TRISO fuel research reactor; and Oklo, Inc. on its advanced reactor.

An example of a current application for an advanced reactor is Kairos Power's construction permit application for the Hermes test reactor, which Kairos submitted to the NRC in September 2021. This test reactor is being developed to support development of a fluoride salt-cooled, high-temperature reactor (KP-FHR) technology that will provide steam for electricity. The NRC staff issued their Safety Evaluation for the Hermes test reactor in June 2023, and their Environmental Impact Statement in August 2023. The Commission will render a determination on Kairos's application following completion of a mandatory hearing.

Figure 8: Artistic rendition of proposed University of Illinois reactor



Other recent activities in the advanced-reactor arena include the August 2022 application from Abilene Christian University for a construction permit to be used with its proposed Molten Salt Research Reactor. Approximately one year earlier, in May 2021, the University of Illinois Urbana-Champaign had submitted to the NRC a Letter of Intent to apply for a permit to construct a demonstration high-temperature gas-cooled micro reactor on its campus (see Figure 8).

In addition, a non-power facility currently under construction is the SHINE Medical Isotope Production Facility. SHINE will irradiate and process special nuclear material to produce medical radioisotopes, such as molybdenum-99 (Mo-99), that are primarily used in cancer screening and stress tests to detect heart disease. The RTR branches in NRR have the lead for licensing and oversight of this facility.

Based on statements gathered during this Special Inquiry, the OIG learned that the agency's RTR inspection program may be implemented at some of the facilities described above, if they go forward. Therefore, addressing these problem areas in the RTR program is vital to ensuring successful oversight of new projects, such as medical isotope facilities and prospective RTRs based on advanced reactor technology, since these programs are currently planned to be reviewed under RTR policy and guidance.

V. CONCLUSION

The OIG found that the NRC's inadequate oversight of RTRs led to a failure to identify and address problems with the NIST reactor and other RTRs. In this report, the OIG identified the following three areas:

- **Inadequate Follow-Up.** The NRC failed to follow up on problems identified both by licensees and its own inspectors. At NIST, the NRC failed to follow up on the licensee's audit committee reports that had already identified deficiencies with the licensee's safety culture, shift staffing and rotation, and operator training and requalification. In addition, an OIG review of licensee records showed a history of unlatched fuel elements and a failure by the NRC to ensure that the licensee took adequate steps to ensure fuel elements were latched. At the Aerotest facility, the NRC failed to act for at least five years to address damaged fuel that had been identified in previous NRC inspection reports from 2005, 2007, and 2009. According to NRC guidance in NUREG-1537, "the fuel for a non-power reactor is the most important component bearing on the health and safety of the public and the common security."

- **Insufficient Direct Observation.** The NRC's inspection practices often lacked direct observation of activities important to safety, in part because the NRC did not typically coordinate inspections to coincide with licensee activities. As a result, the NRC did not perform all recommended direct observations at NIST from 2016 through 2020. Additionally, from 2018 through 2022, the NRC directly observed only approximately 5 percent of fuel movements at the other Class I RTRs. Direct observations are, however, an important part of the NRC's regulatory oversight, as illustrated by an NRC principal's statement to the OIG that, although the fuel procedure at NIST seemed reasonable as written, direct observation of licensee activities was necessary to identify errors in the procedure.

- **Outdated Policy and Guidance.** The agency's RTR program has not been substantively updated for at least two decades. Its inspection procedures similarly do not reflect the agency's risk-informed and safety culture policies. Additionally, NRC principals reported that the IP resource estimates for RTR inspection are less than the time needed to meet all requirements.

As noted previously in Section IV, addressing these problem areas in the RTR program is vital to ensuring successful oversight of new projects, such as medical isotope facilities and prospective RTRs based on advanced reactor technology, since these programs are currently planned to be reviewed under RTR policy and guidance.

Additionally, during this Special Inquiry the OIG learned of a number of programmatic issues related to the RTR program from NRC and licensee principals. For example, the NRC's recent reviews of license renewal applications have ranged from 4 to 13 years for the five Class I RTRs, and three of the five RTRs have operated for more than 10 years without an updated licensing basis. Several SECY papers currently before the Commission relate to the RTR program, and potentially to medical isotope facilities and prospective RTRs based on advanced reactor technology. The OIG plans to communicate on these issues separately.

An OIG audit team is reviewing the inspection program for Class II RTRs. The audit objective is to determine whether the NRC performs safety inspections at Class II RTRs in accordance with agency guidance and inspection program objectives. The OIG anticipates publishing this audit report before the end of 2023.

CONTROL ROOM | CORE DEFUEL/REFUEL 646 | May 16,2019

Element	Time Out	From	To	Time In	SRO Verified	Comments
1112	~~1109~~ 0809	F5	SWC5	NA	[redacted]	
1114	0910	E4	SWC6	NA		
1113	0949	H5	SWD1	NA		
1115	1026	I4	SWD2	NA		
1117	1116	H3	H5	1122		
1119	1124	I6	I4	1127		
1121	1130	K4	H3	1136		
1123	1139	I2	I6	1143		
1125	1147	H7	K4	1153		
1127	1155	K6	I2	1200		
1129	1209	L5	H7	1215		
1131	1218	L3	K6	1224		
1133	1227	K2	L5	1250		
1135	1255	H1	L3	1259		
1137	1302	J7	K2	1308		~~Had to use universal tool to remove~~
1139	1312	M4	H1	1328		used univeral tool to remove from M4 position
1141	1331	J1	J7	1341		
1116	1347	F3	F5	1351		
1118	1435	E6	E4	1439		UNIVERSAL TOOL REMOVED PARTIALLY LATCHED
1120	1441	C4	F3	1445		
1122	1551	E2	E6	1600		
1124	1603	F7	C4	1608		
1126	1611	C6	E2	1616		
1128	1621	B5	F7	1627		
1130	1640	B3	C6	1647		UNIVERSAL TOOL REMOVED PARTIALLY LATCHED
1132	1650	C2	B5	1654		
1134	1658	F1	B3	1702		
1136	1703	D7	C2	1719		
1138	1726	A4	F1	1736		UNIVERSAL TOOL REMOVED PARTIALLY LATCHED.
1140	1740	D1	D7	1747		
1142	N/A	VAULT	A4	1943		
1144	N/A	VAULT	D1	1955		
1143	N/A	VAULT	M4	~~2008~~ 2007		
1146	N/A	VAULT	J1	2020		

Control Room Approved [redacted] 5/13/2019

CONTROL ROOM CORE DEFUEL/REFUEL 647 July 15,2019

Element	Time Out	From	To	Time In	SRO Verified	Comments
1116	0848	F5	SWD-3	NA	[redacted]	
1118	0948	E4	SWD-4	NA	[redacted]	
1117	1024	H5	SWD5	NA	[redacted]	
1119	1100	I4	SWD-6	NA	[redacted]	
1121	1133	H3	H5	1139	[redacted]	
1123	1143	I6	I4	1146	[redacted]	
1125	1148	K4	H3	1152	[redacted]	
1127	1158	I2	I6	1204	[redacted]	
1129	1209	H7	K4	1214	[redacted]	
1131	1221	K6	I2	1229	[redacted]	
1133	1242	L5	H7	1248	[redacted]	
1135	1252	L3	K6	1256	[redacted]	
1137	1300	K2	L5	1306	[redacted]	
1139	1309	H1	L3	1312	[redacted]	
1141	1317	J7	K2	1322	[redacted]	
1143	1326	M4	H1	1332	[redacted]	
1146	1337	J1	J7	1343	[redacted]	
1120	1347	F3	F5	1352	[redacted]	
1122	1355	E6	E4	1358	[redacted]	
1124	1400	C4	F3	1403	[redacted]	
1126	1406	E2	E6	1409	[redacted]	
1128	1413	F7	C4	1421	[redacted]	
1130	1432	C6	E2	1436	[redacted]	
1132	1625	B5	F7	1631	[redacted]	
1134	1633	B3	C6	1637	[redacted]	
1136	1643	C2	B5	1648	[redacted]	UNIVERSAL TOOL NEEDED TO REMOVE.
1138	1651	F1	B3	1657	[redacted]	
1140	1703	D7	C2	1709	[redacted]	
1142	1713	A4	F1	1717	[redacted]	
1144	1720	D1	D7	1726	[redacted]	
1150	N/A	VAULT	A4	1904	[redacted]	
1152	N/A	VAULT	D1	1914	[redacted]	
1149	N/A	VAULT	M4	1925	[redacted]	
1151	N/A	VAULT	J1	1935	[redacted]	

Control Room Approved [redacted] 7/12/2019

Element	Time Out	From	To	Time In	SRO Verified	Comments
1120	0809	F5	SW E-1	NA	[redacted]	
1122	0856	E4	SW E-2	NA	[redacted]	
1121	0934	H5	SW E-3	NA	[redacted]	
1123	1010	I4	SW E-4	NA	[redacted]	
1125	1043	H3	H5	1047	[redacted]	
1127	1053	I6	I4	1055	[redacted]	
1129	1057	K4	H3	1100	[redacted]	
1131	1103	I2	I6	1108	[redacted]	
1133	1118	H7	K4	1126	[redacted]	USED UNIVERSAL to Remove from H7. the Tool would not get below index plate
1135	1129	K6	I2	1132	[redacted]	
1137	1147	L5	H7	1153	[redacted]	
1139	1156	L3	K6	1200	[redacted]	
1141	1202	K2	L5	1206	[redacted]	
1143	1211	H1	L3	1215	[redacted]	
1146	1220	J7	K2	1225	[redacted]	Used universal to Remove from J-7 Same as 1133 for the cause
1149	1228	M4	H1	1233	[redacted]	
1151	1235	J1	J7	1241	[redacted]	
1124	1303	F3	F5	1305	[redacted]	
1126	1308	E6	E4	1311	[redacted]	
1128	1314	C4	F3	1317	[redacted]	
1130	1320	E2	E6	1325	[redacted]	
1132	1329	F7	C4	1335	[redacted]	
1134	1339	C6	E2	1342	[redacted]	
1136	1345	B5	F7	1348	[redacted]	
1138	1351	B3	C6	1355	[redacted]	
1140	1357	C2	B5	1400	[redacted]	
1142	1407 ~~1403~~	F1	B3	1409	[redacted]	F1 RETURNED TO CORRECT FUEL TRANSFER ARM ALIGNMENT.
1144	1414 ~~1412~~	D7	C2	1419	[redacted]	USED UNIVERSAL TOOL TO REMOVE D7 ELEMENT. TOOL WOULD NOT GET BELOW INDEX PLATE
1150	1422	A4	F1	1427	[redacted]	
1152	1429	D1	D7	1434	[redacted]	
1154	N/A	VAULT	A4	1745	[redacted]	
1156	N/A	VAULT	D1	1802	[redacted]	
1153	N/A	VAULT	M4	1832	[redacted]	
1155	N/A	VAULT	J1	1817	[redacted]	

[redacted] 9/5/19

Control Room Approved

CONTROL ROOM CORE DEFUEL/REFUEL 649 November 4,2019

Element	Time Out	From	To	Time In	SRO Verified	Comments
1124	0834	F5	SW-E5	NA	[redacted]	
1126	0912	E4	SW-E6	NA	[redacted]	
1125	0955	H5	SW-F1	NA	[redacted]	
1127	1037	I4	SW-F2	NA	[redacted]	
1129	1135	H3	H5	1137	[redacted]	
1131	1146	I6	I4	1151	[redacted]	
1133	1154	K4	H3	1158	[redacted]	
1135	1203	I2	I6	1209	[redacted]	
1137	1214.	H7	K4	1222	[redacted]	
1139	1225	K6	I2	1230	[redacted]	
1141	1241	L5	H7	1248 m ~~1252~~	[redacted]	USED UNIVERSAL TOOL ON L5
1143	1252	L3	K6	1256	[redacted]	
1146	1301	K2	L5	1306	[redacted]	USED UNIVERSAL TOOL ON L5
1149	1321	H1	L3	1323	[redacted]	
1151	1330	J7	K2	1338	[redacted]	
1153	1343	M4	H1	1348	[redacted]	
1155	1354	J1	J7	1400	[redacted]	
1128	1404	F3	F5	1407	[redacted]	
1130	1409	E6	E4	1410	[redacted]	
1132	1411	C4	F3	1415	[redacted]	
1134	146	E2	E6	1420	[redacted]	
1136	1422	F7	C4	1426	[redacted]	
1138	1428	C6	E2	1434	[redacted]	
1140	1436	B5	F7	1440	[redacted]	
1142	1556	B3	C6	1608	[redacted]	USED UNIVERSAL TOOL ON B3
1144	1618	C2	B5	1625	[redacted]	USED UNIVERSAL TOOL ON C2
1150	1633	F1	B3	1639	[redacted]	USED UNIVERSAL TOOL ON B3
1152	1646	D7	C2	1700	[redacted]	
1154	1712	A4	F1	1724	[redacted]	" " " ON F1 USED UNIVERSAL TOOL ON A4
1156	1728	D1	D7	1736	[redacted]	
1158	N/A	VAULT	A4	1947	[redacted]	
1160	N/A	VAULT	D1	1958	[redacted]	
1157	N/A	VAULT	M4	2019	[redacted]	
1159	N/A	VAULT	J1	2030	[redacted]	

[redacted] /23/19

Control Room Approved

CONTROL ROOM CORE DEFUEL/REFUEL 652 August 31, 2020

Element	Time Out	From	To	Time In	SRO Verified	Comments
1136	0812	F5	WA-1	NA	[redacted]	
1138	0856	E4	WA-2	NA	[redacted]	
1137	0940	H5	WA-3	NA	[redacted]	
1139	1014	I4	WA-4	NA	[redacted]	
1141	1056	H3	H5	1103	[redacted]	
1143	1106	I6	I4	1109	[redacted]	
1146	1116	K4	H3	1120	[redacted]	Used Universal to Remove from K4
1149	1123	I2	I6	1129	[redacted]	
1151	1132	H7	K4	1141	[redacted]	Element went IN with normal tool K4
1153	1145	K6	I2	1150	[redacted]	
1155	1216	L5	H7	1224	[redacted]	
1157	1227	L3	K6	1232	[redacted]	
1159	1235	K2	L5	1240	[redacted]	
1161	1247	H1	L3	1253	[redacted]	
1163	1256	J7	K2	1305	[redacted]	
1165	1308	M4	H1	1312	[redacted]	
1167	1314	J1	J7	1320	[redacted]	
1140	1323	F3	F5	1327	[redacted]	
1142	1330	E6	E4	1332	[redacted]	
1144	1334	C4	F3	1337	[redacted]	
1150	1340	E2	E6	1342	[redacted]	
1152	1345	F7	C4	1349	[redacted]	
1154	1351	C6	E2	1354	[redacted]	
1156	1357	B5	F7	1359	[redacted]	
1158	1402	B3	C6	1405	[redacted]	
1160	1408	C2	B5	1411	[redacted]	
1162	1414	F1	B3	1416	[redacted]	
1164	1420	D7	C2	1425	[redacted]	
1166	1427	A4	F1	1430	[redacted]	
1168	1434	D1	D7	1439	[redacted]	
1170	1604	VAULT	A4	1608	[redacted]	
1172	1611	VAULT	D1	1618	[redacted]	
1169	1623	VAULT	M4	1632	[redacted]	
1171	1635	VAULT	J1	1640	[redacted]	

Control Room Approved [redacted] 8/28/20

TO REPORT FRAUD, WASTE, OR ABUSE

Please Contact:

Email: Online Form

Telephone: 1-800-233-3497

Address: U.S. Nuclear Regulatory Commission
Office of the Inspector General
Hotline Program
Mail Stop O12-A12
11555 Rockville Pike
Rockville, Maryland 20852

If you wish to provide comments on this report, please email the OIG.