UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555-0001

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NRC INFORMATION NOTICE 2023-03: RECENT HUMAN PERFORMANCE ISSUES AT NONPOWER PRODUCTION AND UTILIZATION FACILITIES

ADDRESSEES

All holders of and applicants for an operating license or construction permit for a non-power production or utilization facility (NPUF) issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," including those that have permanently ceased operations and certified that fuel has been permanently removed from the reactor vessel.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of recent events at NPUFs that were attributed, at least in part, to inadequate procedures, human performance, or safety culture issues. The NRC expects recipients to review the information for applicability to their facilities and to consider actions, as appropriate, to avoid similar problems. Suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

The following recent events are identified by the NRC staff as human performance or safety culture issues that have occurred at NPUFs. These events are selected and summarized from NRC inspection reports and licensee event notices.

<u>Reactor Power Level Greater than Nuclear Instrumentation Indications</u>

Between August 29, 2019, and February 14, 2020, the Purdue University Research Reactor (PUR-1) personnel performed calibrations of nuclear instruments following replacement of the nuclear instrumentation (NI) system and detectors. The process involves bringing the reactor critical and performing detector calibrations at different power levels to irradiate gold foil. The gold foil in turn is placed in a high-purity germanium (HPGe) detector to obtain a reactor neutron flux rate for that location of irradiation. Using a calibration factor, relating the flux at the location of the gold foil irradiation to the whole core fission rate, the power level of the run can be determined. This calculated power level is then used to determine a calibration factor for each NI channel requiring calibration. The PUR-1 procedures required eight gold foil irradiations; however, the licensee did not complete the irradiations because of unexpectedly high radiation levels at the top of the reactor pool. The PUR-1 personnel declared the NI system operable and operated the reactor several times for student and operator training and experiments.

On October 31, 2019, while attempting to perform gold foil irradiation at 5 kilowatts (kW), the reactor scrammed before reaching 5 kW because of a high-radiation scram signal from the pool top radiation monitor. The PUR-1 personnel declared that the scram signal was erroneously generated and continued to operate the reactor regularly for student and operator training. On February 14, 2020, the reactor automatically scrammed again because of high radiation levels at the pool top area radiation monitor. On October 19, 2020, a gold foil was irradiated to validate the neutron flux levels for an experiment. The gold foil measurements of the neutron flux rate indicated reactor power was higher than anticipated. PUR-1 personnel determined the HPGe detector efficiency factor, which is used to determine gold foil radioactivity for the NI calibrations had been incorrectly calculated. The error resulted in reactor power levels being approximately 3 times that of the power level indicated on the NI channels. It was determined that PUR-1 operated at steady-state levels above the maximum licensed power level on several occasions.

The PUR-1 personnel took the following corrective actions related to this event:

- revised the NI calibration procedure to require independent measurement of the gold foil activity and reactor power data by a second individual.
- revised standard operating procedures to require that members of the Reactor Safety Committee are required to review and approve startup plan deviations.
- revised procedures to reduce the staff's reliance on "skill of the craft" when performing reactor activities and operations.
- implemented additional procedures for radiation area mapping and protocols, including posting signage at the entrance to the PUR-1 facility bearing the radiation symbol and the words, "CAUTION, RADIATION AREA."
- amended the technical specifications, prior to resuming reactor operations, to clarify allowances for reactor operation to calibrate repaired, replaced, or modified NI channels.

Safety Limit Violation

On February 3, 2021, following a refueling outage, the National Institute of Standards and Technology Center for Neutron Research (NCNR) experienced an emergency alert event that resulted in exceeding the licensed technical specification safety limit for reactor fuel temperature. The event was initially discovered when the reactor automatically shut down in response to indications of high radiation from the confinement exhaust stack. Once the reactor was placed in a safe condition, all NCNR personnel evacuated the control room and reactor confinement. For the event, offsite radiation dose measurements were near background levels. Radiation dose to the workers from the event was well below regulatory limits. Subsequently, the licensee determined that operators had improperly verified the placement of fuel elements when performing latch verification rotation checks. A fuel element became unlatched during reactor startup resulting in damage to a fuel element, which caused the exhaust stack radiation alarm. The licensee's root cause analysis determined that the incident was due to several factors, including understaffing and lack of resources, an environment not conducive to staff raising concerns, and management not resolving staff concerns, and other factors related to procedures. The NRC staff determined that the procedures were not followed, were poorly understood, lacked details and precautions, lacked context and significance, and did not reference applicable technical specifications. Other contributing factors were determined to be inadequate leadership, ineffective corrective action programs, safety culture weakness, and failure to implement safety committee recommendations.

The NCNR personnel took the following corrective actions related to this event:

- implemented a program to incentivize staff to identify, raise, and address safety concerns.
- established the Safety Evaluation Committee subcommittee to track and oversee corrective actions.
- modified conduct of operations to strengthen the oversight role of supervisors and to improve training requirements for management and operators.
- modified procedures for latch checks.
- enhanced training for operators performing fuel handling, including core loading, shuffle, rotational latch checks, and visual latch checks.
- revised the reactor startup procedure to provide detailed guidance on evaluation of abnormal conditions.

Failure to Manage Changes in Reactivity

On November 23, 2022, the University of New Mexico reactor (AGN-201M) experienced an unintentional high-power scram while conducting a sample irradiation. The reactor is licensed to a maximum steady-state power level of 5 watts and has an automatic high-power scram at 6 watts. An iodized table salt sample was inserted into the centerline of the reactor core for irradiation for approximately 1 hour with the reactor stabilized at 4 watts. The sample, which provides negative reactivity, was removed adding positive reactivity to the core. During this removal process, the reactor power increased to 6 watts, initiating an automatic high-power scram.

The licensee identified that inadequate communication between sample handlers and reactor operators resulted in a failure to ensure that reactivity differences between samples and control rods were accounted for during operations. Appropriate communication prior to the sample being removed from the core allows the reactor operator to adjust control rods for anticipated reactivity changes.

The University of New Mexico personnel took the following corrective actions related to this event:

- developed and conducted specific training to cultivate awareness about the circumstances of the unscheduled high-power scram.
- implemented specific training on proper communications and coordination between the operator and assistant during evolutions.
- clarified the training and operations manual to emphasize that unscheduled high-power scrams are reportable occurrences and must be promptly reported to the NRC.

Fuel Elements not Inspected

On December 4, 2019, Kansas State University personnel identified four fuel elements that were not visually inspected for corrosion and mechanical damage as required by technical specifications. The four fuel elements outside of the required surveillance frequency were not marked for inspection. The licensee's review of inspection records found different inspection due dates for the same fuel elements. Personnel error in maintaining the fuel element inspection tracking spreadsheet resulted in a mismatch between the fuel element serial numbers and the last inspection date.

Kansas State University personnel took the following corrective actions related to this occurrence:

- suspended reactor operations until the event could be reviewed by the Reactor Safety Committee.
- inspected the four elements identified and performed a complete review of the fuel inspection records.
- reviewed the event with all reactor staff.
- revised the fuel element inspection tracking document to accurately reflect current conditions.

Release Values Not Calculated Correctly

During a routine NRC inspection at the Missouri University of Science and Technology Reactor (MSTR), the NRC inspector discovered that a valid experimental verification of calculated argon-41 release values had not been performed since 2007. Specifically, argon-41 release values were performed incorrectly because of errors in the experimental verification methodology, thus invalidating the verifications. The MSTR technical specifications require the licensee to perform an experimental verification of calculated airborne effluent release values every 5 years and when a change in licensed power occurs. The methodology for the experimental verification of airborne releases from the MSTR facility from 2008 to 2019 did not establish a ventilation configuration that was consistent with assumptions in the airborne radioactivity calculations used to determine the magnitude of airborne radioactive effluents. This error resulted in the licensee underestimating the amount of airborne radioactivity released. The MSTR personnel identified the underlying cause of the errors as inadequate quality assurance, knowledge atrophy, and use of methods and procedures handed down from previous health physics personnel, that had not been questioned or verified. After correcting the data, MSTR personnel reported that the airborne radioactive effluents were within the limits established in 10 CFR Part 20, "Standards for Protection against Radiation."

The MSTR personnel took the following corrective actions related to this event:

- revised the MSTR technical specifications to require argon-41 experimental verification measurements to be taken every 3 years instead of every 5 years to reduce knowledge atrophy and to ensure competency in performing the verification.
- revised the procedures for measurement of argon-41 concentration in the reactor building to improve experimental verification setups.
- implemented a training/qualification program for personnel performing health physics activities and surveys. This program identifies and addresses specific knowledge and training requirements (including refresher training) for each survey type.
- implemented actions for management to address staffing and enrollment in the operator training program to reduce reliance on a single operator to perform all surveillances.

<u>Operation with Unauthorized Fuel Elements</u>

On October 18, 2022, the operations staff at the University of Texas at Austin Nuclear Engineering Teaching Laboratory (NETL) discovered reactor operations were conducted with two unauthorized aluminum-clad standard TRIGA fuel elements loaded in its core. Only stainless-steel clad TRIGA fuel elements are authorized by the technical specifications. On January 4, 2022, following a routine fuel inspection, 10 fuel elements, including the two aluminum fuel elements, were installed in the reactor core to increase excess reactivity. The aluminum-clad elements were chosen for insertion because they were listed in the tracking file as having low burnup. The tracking file also lists the notation “Al SFE,” to specify that the elements were aluminum clad. The operations staff missed this notation when selecting these elements to insert into the reactor core. The NETL procedures did not include instructions or require an independent review to verify the fuel cladding before moving the element into the core. The reactor operated with the aluminum-clad elements in an unanalyzed condition from January 6, 2022, to October 17, 2022. The licensee’s visual inspection determined that there was no damage to the elements. The licensee’s technical analysis of the operating conditions experienced by the unauthorized fuel elements found that the cladding temperature remained below the safe temperature limit. The licensee identified the root cause for the event as the lack of administrative or engineered barriers to segregate or control operator access to disqualified fuel.

The NETL personnel took the following corrective actions related to this occurrence:

- suspended reactor operations.
- removed the aluminum clad fuel elements from the core and visually inspected the affected elements for damage.
- revised the surveillance procedure for fuel element inspection and performed the revised surveillance for the core configuration before startup.
- revised the tracking file to include the date of last fuel inspection and a “qualified” or “disqualified” flag to indicate fuel elements allowed to be used in the core.

<u>Failure to Maintain Minimum Staffing</u>

On March 19, 2018, General Electric-Hitachi (GEH) reported that, while operating at 100 percent power, the licensed operator left the Nuclear Test Reactor (NTR) facility control room without proper relief.

On March 4, 2019, GEH discovered the NTR was not properly secured since the licensed operator exited and locked the control room but failed to remove the console key from the console lock switch and store it in the designated safe. Therefore, the NTR was in violation of minimum staffing when the reactor is not secured as required by the facility technical specifications.

GEH took the following corrective actions related to these occurrences:

- attached the console key to a large, highly visible key chain, and implemented a flagging system to increase the likelihood of operators seeing the flag when the console key is not in proper custody.
- trained the NTR staff on the importance of securing the reactor before exiting the control room.

DISCUSSION

The human performance events discussed above, for the most part, involved failure of licensees to provide adequate procedures, failure of operators to properly follow those procedures, or both. In several instances, it appeared that risk was either underestimated or not considered. Overall, the events can be attributed to weaknesses in safety culture, such as an operator’s loss of focus on safety, (e.g., taking actions when the consequences of those actions are uncertain or acting outside the scope of the relevant procedure(s)).

These examples represent a sample of recent events in which human performance played a key role, and each highlights the notable challenges that human performance weaknesses may present to facility operation. Operating the facility and reactor in accordance with procedures is the primary responsibility of all operating staff. Operating experience shows that errors often occur before, during, and immediately following evolutions that are less familiar to the operations staff because they are performed infrequently. Some events show that individuals became complacent and did not recognize and plan for the possibility of mistakes, latent issues, and inherent risk. The events related to surveillances, such as calibrations and inspections, could have reasonably been prevented by fostering a positive safety culture.

To prevent events related to human performance issues, managers and leaders should reinforce that all individuals should take personal responsibility for safety. Licensees should maintain a positive safety culture at their facilities, including demonstrating a commitment to safety in all decisions and behaviors. This includes reinforcing traits among personnel to identify, fully evaluate, and address issues potentially impacting safety to ensure they are promptly corrected. The facility personnel should avoid complacency and question existing conditions and activities to identify discrepancies that might result in errors or inappropriate actions. Processes and procedures and the work activities they support should be planned, controlled, and implemented so that safety is maintained. Many of the issues identified in this Information Notice were self-identified and corrected by the licensees. The NRC staff continues to encourage all personnel to practice effective safety communication and for licensees to self-identify and correct problems. Refer to https://www.nrc.gov/about-nrc/safety-culture.html for more information on safety culture.

The root causes are not reactor-specific activities, and the operational experience can apply to any NPUF licensee.

CONTACT

This IN requires no specific action or written response. If you have any questions about the information in this notice, please notify the technical contacts listed below.

/RA/

Mohamed K. Shams, Director
Division of Advanced Reactors and
Non-power Production and Utilization
Facilities
Office of Nuclear Reactor Regulation

/RA/

Russel N. Felts, Director
Division of Reactor Oversight
Office of Nuclear Reactor Regulation

Technical Contacts: Duane Hardesty, Senior Project Manager, NRR
(301) 415-3724
E-mail: Duane.Hardesty@nrc.gov

Juan Arellano, Reactor Inspector, NRR
(301) 415-0477
E-mail: Juan.Arellano@nrc.gov

Contributors: Linh Tran, Senior Project Manager, NRR
Cindy Montgomery, Project Manager, NRR
Paulette Torres, Project Manager, NRR
Andrew Waugh, Reactor Inspector, NRR

Note: NRC generic communications may be found on the NRC public website, https://www.nrc.gov, under NRC Library.

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OFFICE	NRR/DANU/UNPL	NRR/DANU/UNPO	QTE	NRR/DANU/UNPO:BC	NRR/DANU/UNPO:BC
NAME	DHardesty	JArellano	JDougherty	TTate	JBorromeo
DATE	4/6/2023	3/8/2023	3/24/2023	4/12/2023	4/12/2023
OFFICE	NRR/DRO/IOEB	NRR/DRO/IOEB:LA	NRR/DRO/IOEB:BC	NRR/DRO/IOEB/D	NRR/DANU/D
NAME	PClark	IBetts	LRegner	RFelts	MShams
DATE	4/28/2023	6/1/2023	6/1/2023	6/5/2023	6/13/2023

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