



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 2, 2021

EA-21-126

Dr. Seungjin Kim, Reactor Director
Purdue University
School of Nuclear Engineering
516 Northwestern Avenue
West Lafayette, IN 47906

SUBJECT: PURDUE UNIVERSITY – U.S. NUCLEAR REGULATORY COMMISSION
FOLLOW-UP SAFETY INSPECTION REPORT NO. 05000182/2021204

Dear Dr. Kim:

From July 30 – October 12, 2021, the U.S. Nuclear Regulatory Commission (NRC) staff conducted a follow-up inspection of Purdue University Research Reactor operations related to an event notification (EN 55359) communicated to the NRC on July 19, 2021, and later supplemented on July 29, 2021, describing the causes of, and corrective actions for, operating the Purdue University Research Reactor at power levels in excess of the licensed maximum power level. The NRC inspector discussed the preliminary inspection findings with you and your staff on August 11, 2021, and at the conclusion of the inspection on October 12, 2021. The enclosed report presents the results of this follow-up inspection.

Based on the results of this inspection, one violation of your license was identified by the NRC inspector. The violation is related to the Purdue University Research Reactor exceeding the maximum licensed power level (License Condition 2.C.1). Purdue identified the violation and notified the NRC in EN 55359. The violation is discussed in the enclosed report.

The NRC considered whether enforcement discretion is appropriate for the violation described above. The NRC Enforcement Policy (Policy), Section 3.3, "Violations Identified Because of Previous Enforcement Action," states, in part, that the NRC may refrain from issuing a Notice of Violation (NOV) for a violation identified after the NRC has taken enforcement action if the violation is identified by the licensee as part of the corrective action for the previous enforcement action and the violation has the same or similar root cause as the violation for which enforcement action was previously taken. Additionally, Section 3.3 notes that the new violation must not substantially change the safety significance, or the character of the regulatory concern arising out of the initial violation and must be corrected, including immediate corrective action and long-term comprehensive corrective action to prevent recurrence, within a reasonable time following identification.

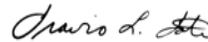
The violation discussed in this letter was identified by the licensee as part of the corrective actions taken for a Severity Level III problem (EA-20-144) issued on February 16, 2021, after the reactor was inadvertently operated at power levels greater than 12 kilowatts (thermal) due to nuclear instrument (NI) calibration calculation errors that caused the NIs to indicate incorrect reactor power levels (Agencywide Documents Access and Management System (ADAMS)

Accession No. ML21035A348). The first issue was an overpower of greater magnitude that masked the second issue, and the cause of the second issue is viewed as historical because an erroneous factor involved in calibrating the NIs was determined several decades ago. The current issue does not substantially change the safety significance of the original violation because the magnitude of the over-power is less than the first example and within Purdue University's safety analysis assumptions. Purdue has also completed corrective actions for the second violation. Therefore, I am authorized, after consultation with the Director, Office of Enforcement, to exercise enforcement discretion in accordance with Section 3.3 of the Policy and refrain from issuing an NOV for this violation.

In accordance with Title 10 of the *Code of Federal Regulations* Part 2, "Agency Rules of Practice and Procedures," Section 2.390, "Public inspections, exemptions, requests for withholding," a copy of this letter, its enclosure(s), and your response, if you choose to provide one, will be made available electronically for public inspection in the NRC Public Document Room or from ADAMS, accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html>. To the extent possible, your response should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the public without redaction.

If you have any questions concerning this matter, please contact Phil O'Bryan at 301-415-0266, or by electronic mail at Phil.OBryan@nrc.gov.

Sincerely,



Signed by Tate, Travis
on 12/02/21

Travis L. Tate, Chief
Non-Power Production and Utilization Facility
Oversight Branch
Division of Advanced Reactors and Non-Power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Docket No. 50-182
License No. R-87

Enclosure:
As stated

cc w/enclosure: See next page

Purdue University

Docket No. 50-182

cc:

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Test, Research and Training
Reactor Newsletter
Attention: Amber Johnson
Dept of Materials Science and Engineering
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4418 Stadium Drive
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SUBJECT: PURDUE UNIVERSITY REACTOR – U.S. NUCLEAR REGULATORY
 COMMISSION INSPECTION REPORT NO. 05000182/2021204
 DATE: DECEMBER 1, 2021

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ADAMS Accession No.: ML21294A279**NRC-002**

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DATE	10/21/2021	10/26/2021	10/26/2021	12/01/2021

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U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION

Docket No.: 50-182

License No.: R-87

Report No.: 05000182/2021204

Licensee: Purdue University

Facility: Purdue University Research Reactor

Location: West Lafayette, IN

Dates: July 30 – October 12, 2021

Inspector: Phil O'Bryan

Approved by: Travis L. Tate, Chief
Non-Power Production and Utilization
Facility Oversight Branch
Division of Advanced Reactors and Non-Power
Production and Utilization Facilities
Office of Nuclear Reactor Regulation

Enclosure

EXECUTIVE SUMMARY

Purdue University
Research Reactor Facility
Inspection Report No. 05000182/2021204

The focus of this announced, follow-up inspection was the review of circumstances associated with the Purdue University event notification (EN) to the U.S. Nuclear Regulatory Commission (NRC) of exceeding the Purdue University Research Reactor's maximum licensed power (EN 55359). The inspection was performed using inspection procedure (IP) 69001, "Class II Research and Test Reactors," and reviewed selected aspects of the Purdue University Research Reactor facility safety program related to the EN.

The Purdue University Research Reactor operating License Condition 2.C.1, states that Purdue University "is authorized to operate the facility at steady state power levels not in excess of 12 kilowatts (thermal)." Contrary to this, between February 26, 2021, and February 28, 2021, Purdue operated the reactor at steady state power levels greater than 12 kilowatts (thermal). This violation was identified by Purdue as part of the corrective actions taken for a Severity Level III problem (EA-20-144) issued on February 16, 2021 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21035A348). The current issue does not substantially change the safety significance of the original violation because the magnitude of the over-power is less than the first example and within Purdue University's safety analysis assumptions. Purdue has also completed corrective actions. Therefore, in accordance with Section 3.3 of the NRC Enforcement Policy, the NRC will refrain from issuing a notice of violation (NOV) for the second violation.

REPORT DETAILS

1. Background

The NRC inspection report No. 05000182/2020-201 (ADAMS Accession No. ML20332A083), describes the circumstances associated with the Purdue University Research Reactor operating above its maximum licensed power of 12 kilowatts between October 31, 2019, and September 15, 2020, which resulted in Purdue University receiving a Severity Level III NOV (ADAMS Accession No. ML21035A348). The Purdue staff determined that an error in the gold foil calibration of the nuclear instruments (NIs) resulted in indicated reactor power being non-conservative by a factor of approximately 3 during this time frame. The cause of this NI miscalibration was corrected and the reactor was returned to service in February 2021.

Purdue recalibrated the NIs in early February 2021. During the first extended, steady-state high-power operation of the reactor after the recalibration of the NIs (8.45 kilowatts indicated reactor power) on February 28, 2021, Purdue staff monitored the reactor pool water temperature and compared the pool water temperature increase to calculated values. This was, in part, to determine if the previous NI miscalibration was fully corrected. Purdue staff noted that pool water temperature rose at an unexpectedly high rate, indicating that the reactor was operating at a power level above the reactor power level indicated by the NIs. Purdue staff then shut down and secured the reactor. The reactor remained secured while Purdue staff investigated the cause of the pool temperature anomaly.

2. Summary of Facility Status

Purdue staff shut down the reactor on February 28, 2021, and maintained the reactor shutdown pending investigation of the NI calibration error. In July 2021, after completion of the submersed heater experiments, Purdue conclusively determined that the reactor was operated above the licensed maximum power level and notified the NRC of the event (EN 55359) on July 19, 2021. Purdue then used the data collected from their analyses to revise the NI calibration procedure. Purdue restarted the reactor and calibrated the NIs again between September 15, 2021, and September 20, 2021. After NI calibration, Purdue returned to normal reactor operations for training, operator exams, and experiments.

3. Inspection Scope

The inspector utilized IP 69001 to review the February 2021 reactor overpower event, including inspection areas related to operations logs and records, procedures, experiments, and design changes. To verify compliance with the technical specifications (TS), license, and other regulatory requirements, the inspector reviewed selected aspects of the licensee's safety program, including:

- TSs for the Purdue University Research Reactor
- reactor logbooks
- incident report for event #55359
- calculations, data, and analyses associated with the Purdue reactor operations between February 23, 2021, and February 28, 2021
- "PUR-1 Restart Plan"
- Standard Operating Procedure-4, "Power Calibration by Gold Foil"
- Purdue University Research Reactor Safety Analysis Report.

4. Observations and Findings

The inspector found that accurately using gold foil irradiation to calibrate NIs requires that the irradiated gold foil radioactivity be measured and converted to a corresponding neutron flux level that the gold foil was exposed to. The resultant neutron flux is correlated to total reactor power using a conversion factor. Prior to receiving a license amendment to raise the maximum operating reactor power to 12 kilowatts, Purdue operated the reactor below 1 kilowatt. Operations at reactor power less than 1 kilowatt does not generate enough heat to meaningfully correlate reactor power to pool temperature changes. Therefore, Purdue historically relied on a calculated correlation factor to determine total core power from the gold foil irradiations performed for NI calibration. However, the inspector found that the gold foil flux to total reactor power conversion factor, which was established for the Purdue University reactor several decades ago, was inaccurate by a factor of approximately 1.76 in the nonconservative direction.

Therefore, the calculated total reactor power was lower than actual total reactor power and the NIs were calibrated so that they read low by a factor of approximately 1.76. The highest power reached on February 26, 2021, was an indicated reactor power level of 9.95 kilowatts. Actual reactor power was 9.95×1.76 , or approximately 17.5 kilowatts.

On February 28, 2021, during the first high-power (approximately 8.45 kilowatts indicated reactor power) extended reactor operation, Purdue staff monitored reactor pool water temperature to ensure that previous NI calibration errors were fully corrected. They noted that reactor pool water temperature increased at a higher rate than expected, and shutdown the reactor pending investigation of the reactor pool water temperature anomaly. This investigation included several diverse methods of analysis including thermodynamic and neutronic calculations, computational fluid dynamics modeling, sample irradiation analysis, and submersed electric heater experiments. The inspector found that the different analysis techniques yielded similar results for the estimated actual reactor power on February 28, 2021, which was approximately 14.8 kilowatts. This represented an error of 1.76 in the nonconservative direction.

Purdue determined that the root cause of the inaccurate correlation factor may include several different errors including errors in the original calculation of the total power correlation factor, inadvertent movement of the gold foil irradiation tube, and changes in neutron flux distribution of the reactor over time.

Since the assumed uncertainty associated with the submersed electric heater experiments was smaller than the uncertainties associated with the other analysis techniques, the results of the submersed electric heater experiments were used to determine a new gold foil flux to total reactor power conversion factor and Purdue revised the NI calibration procedures to include the new factor.

Additional corrective actions included:

- 1) revising the administrative procedure for inserting and removing objects in the vicinity of the reactor core to minimize the possibility of inadvertently moving the gold foil irradiation drop tube;
- 2) revising reactor operating procedures to require cross-checks of indicated reactor power and reactor pool temperature changes; and

- 3) inspecting fuel plates of the other fuel elements in the reactor core to ensure that there were no adverse effects of operating the reactor above the maximum licensed reactor power level.

Additionally, long term corrective actions include evaluating the use of a more secure location for gold foil irradiation during NI calibration.

The inspector found that these corrective actions were sufficient to correct the error in NI calibration which led to the February 2021 overpower event.

5. Conclusion

The inspector found that the Purdue University Research Reactor was operated above its maximum licensed reactor power level of 12 kilowatts from February 26 - 28, 2021. The maximum reactor power reached was 17.5 kilowatts on February 26, 2021. Since 17.5 kilowatts is below the assumed maximum reactor power level (18 kilowatts) in the Purdue University Research Reactor safety analysis, and since results of reactor fuel inspection showed no anomalies, the inspector determined that there were no adverse effects of this overpower event.

Although this overpower event is a violation of the Purdue University Research Reactor Operating License Condition 2.C.1, the NRC determined that application of NRC Enforcement Policy, Section 3.3, was appropriate because this violation was identified by the licensee as part of corrective actions for a previous enforcement action, the violation had a similar root cause as the previous violation, and the current violation does not change the safety significance or the character of the regulatory concern arising from the initial violation. Also, the reactor was shut down upon discovery of the violation and immediate and long-term corrective actions to prevent recurrence were implemented within a reasonable time following identification of the violation and prior to restarting the reactor. Therefore, the NRC exercised enforcement discretion and did not issue a NOV for this issue.

6. Exit Interview

The NRC inspector discussed the inspection results in a preliminary inspection exit meeting with Dr. Kim, Facility Director, and members of his staff on August 11, 2021, and again at the final inspection exit meeting on October 12, 2021.

PARTIAL LIST OF PERSONS CONTACTED

Licensee Personnel

S. Kim	Facility Director
T. Miller	Reactor Supervisor
D. Storz	Reactor Instrumentation Specialist

INSPECTION PROCEDURE USED

IP 69001	Class 2 Research and Test Reactors
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ITEMS OPENED, CLOSED, AND DISCUSSED

OPENED:

None.

CLOSED:

None.