

November 13, 2017

Dr. Robert Bean, Director  
Purdue University Radiation Laboratory  
School of Nuclear Engineering  
400 Central Drive  
West Lafayette, IN 47904-2017

SUBJECT: PURDUE UNIVERSITY - REQUEST FOR ADDITIONAL INFORMATION FOR  
DIGITAL CONTROL AND INSTRUMENTATION UPGRADE LICENSE  
AMENDMENT REQUEST

Dear Dr. Bean:

The U.S. Nuclear Regulatory Commission is continuing its review of the Purdue University license amendment request dated February 27 and 28, and June 21, 2017 (Agencywide Documents Access and Management System Accession Package Nos. ML17061A257 and ML17220A077), for upgrading the instrumentation and control systems for the Purdue University Reactor.

During our review, questions have arisen for which additional information and clarification is needed. The enclosed request for additional information (RAI) identifies the additional information needed to continue our review. We request that you provide responses to the enclosed RAIs within 30 days from the date of this letter.

In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.30(b), "Oath or affirmation," you must execute your response in a signed original document under oath or affirmation. Your response must be submitted in accordance with 10 CFR 50.4, "Written communications." Information included in your response that is considered sensitive or proprietary, that you seek to have withheld from the public, must be marked in accordance with 10 CFR 2.390, "Public inspections, exemptions, requests for withholding." Any information related to security should be submitted in accordance with 10 CFR 73.21, "Protection of Safeguards Information: Performance Requirements." Following receipt of the additional information, we will continue our evaluation of your license amendment request.

R. Bean

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If you have any questions regarding this review, please contact me at 301-415-3398 or by electronic mail at [Cindy.Montgomery@nrc.gov](mailto:Cindy.Montgomery@nrc.gov).

Sincerely,

*/RA/*

Cindy K. Montgomery, Project Manager  
Research and Test Reactors Licensing Branch  
Division of Licensing Projects  
Office of Nuclear Reactor Regulation

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

Enclosure:  
As stated

cc: See next page

SUBJECT: PURDUE UNIVERSITY - REQUEST FOR ADDITIONAL INFORMATION FOR DIGITAL CONTROL AND INSTRUMENTATION UPGRADE LICENSE  
AMENDMENT REQUEST DATE: NOVEMBER 13, 2017

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**ADAMS Accession No.: ML17300B451** \*concurrence via e-mail **NRR-106**

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Purdue University

Docket No. 50-182

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OFFICE OF NUCLEAR REACTOR REGULATION  
REQUEST FOR ADDITIONAL INFORMATION  
REGARDING LICENSE AMENDMENT REQUEST TO UPGRADE  
THE INSTRUMENTATION AND CONTROL SYSTEMS AT THE  
PURDUE UNIVERSITY REACTOR  
LICENSE NO. R-87; DOCKET NO. 50-182

The U.S. Nuclear Regulatory Commission (NRC) is continuing its review of the Purdue University license amendment application dated February 27 and 28, and June 21, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession Package Nos. ML17061A257 and ML17220A077), for upgrading the instrumentation and control (I&C) systems for the Purdue University Reactor (PUR-1).

The proposed upgrade of the I&C systems will replace the current neutron flux detector equipment, reactor operating console, reactor protection system and the reactor control system for PUR-1 with new digital systems. During the review of the license amendment request (LAR), several open items were identified.

The NRC staff performed an audit at the PUR-1 in West Lafayette, Indiana on August 22-24, 2017, in accordance with the audit plan (ADAMS Accession No. ML17220A243). The purpose of the audit was to determine if the design and development processes used, and the outputs of those processes resulted in upgrades to I&C systems that meet applicable regulatory requirements, and the guidance from the applicable criteria in Section 7.4, "Reactor Protection System," of the draft Interim Staff Guidance for NUREG-1537, Part 2, "Guidelines for Preparing and Reviewing Applications for Licensing of Non-Power Reactors: Acceptance Criteria" (ADAMS Accession No. ML15134A486). In addition, the regulatory audit was conducted to address open-items and identify information that would be required to be docketed in order to support the basis of the licensing decision and allow the NRC staff to perform a more efficient review of the PUR-1 digital upgrades.

During the audit, NRC staff reviewed the design, development, fabrication and testing of the new digital I&C for PUR-1.

NRC staff identified several requests for additional information (RAI), which were discussed during the audit and are necessary to support NRC review. We expect that you will provide responses to the following RAIs within 30 days from the receipt of this letter. Purdue may provide alternative justification that demonstrates the ability of PUR-1 to maintain and perform the safety function(s) associated with these RAIs.

Enclosure

### Regulatory Basis for the Request

These RAIs have been developed based on the following requirements and guidance applicable to the LAR for the Purdue I&C upgrade:

- The regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) 50.9, “Completeness and accuracy of information,” require that information provided to the Commission by a licensee shall be complete and accurate in all material respects.
- The regulations in 10 CFR 50.34, “Contents of applications; technical information,” require the submission of information related to design bases and the principal design criteria of the I&C systems.
- The regulations in 10 CFR 50.36, “Technical specifications [TSs],” require each applicant to propose TSs. Additionally, 10 CFR 50.36(c) provides requirements for safety limits, limiting safety system settings, limiting conditions for operation (LCOs), surveillance requirements (SRs), design features, and administrative controls. These TSs are derived from the analyses and evaluation included in the safety analysis report (SAR) and submitted pursuant to 10 CFR 50.34.
- The American National Standards Institute/American Nuclear Society (ANSI/ANS)-15.1-2007, “The Development of Technical Specifications for Research Reactors,” provides guidance acceptable to the NRC staff, and, unless acceptable alternatives are justified by the licensee, should be utilized whenever appropriate. ANSI/ANS-15.1-2007 provides guidance that “appropriate surveillance testing on any technical specification required system shall be conducted after replacement, repair, or modification before the system is considered operable and returned to service.”
- The regulations in 10 CFR 50.90, “Application for amendment of license, construction permit, or early site permit,” require that the applicant fully describe the changes desired, and follow to the extent applicable, the form prescribed for original applications.
- The regulations in 10 CFR Part 55, “Operators’ Licenses,” provide requirements for the issuance of operator licenses for utilization facilities.
- The regulations in 10 CFR 55.59, “Requalification,” Section (a)(2)(ii) require an operating test that ensures the operator or senior operator demonstrate an understanding of and the ability to perform the actions necessary to accomplish a comprehensive sample of items specified in 10 CFR 55.45(a) (2) through (13), inclusive, to the extent applicable to the facility. Under 10 CFR 55.45, “Operating tests,” Section (a)(8) requires the operating test to demonstrate that the operators can “Safely operate the facility’s auxiliary and emergency systems, including operation of those controls associated with plant equipment that could affect reactivity or the release of radioactive materials to the environment.” The regulations in 10 CFR 55.59, Section (c)(3)(i)(W), requires licensed operators to demonstrate that they can manipulate controls in response to a “Malfunction of an automatic control system that affects reactivity.”
- The regulations in 10 CFR Part 73, “Physical Protection of Plants and Materials,” require each licensee who possesses, uses or transports special nuclear material of moderate or low strategic significance establish and maintain a physical protection system. Regulatory

Guide 5.59, "Standard Format and Content for a Licensee Physical Security Plan for the Protection of Special Nuclear Material of Moderate or Low Strategic Significance," provides guidance for the development of security plans.

- NUREG 1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Format and Content," issued February 1996 (ADAMS Accession No. ML042430055), describes the acceptable format and content of the safety analysis report to be submitted to the NRC by an applicant or licensee of a non-power reactor for a new license, license renewal, or license amendment.
- NUREG-1537, Part 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Standard Review Plan and Acceptance Criteria," issued February 1996 (ADAMS Accession No. ML042430048) is the companion document for Part 1 and gives criteria to assist NRC staff reviewers in effecting comparable, complete, and consistent reviews of licensing applications for non-power reactors. Chapter 13, "Accident Analysis," indicates that the LAR should also describe how equipment will work when needed in potential accident situations.
- Draft Interim Staff Guidance Augmenting Chapter 7 of NUREG-1537 Parts 1 and 2, dated November 9, 2015 (ADAMS Accession Nos. ML15134A484 and ML15134A486) is a draft chapter of NUREG-1537 and provides revised guidance for preparing and reviewing applications for I&C for non-power production or utilization facilities (NUPFs). This guidance also expands the applicability of Chapter 7 for non-power reactors to all NPUFs, including medical isotope facilities, for licensing under 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

#### Request for Additional Information (by Topic)

For the RAIs, provide the information requested or explain why additional information is not needed.

#### 1.0 Reactor Room Heating, Ventilation, Air Conditioning

In Section 3.1.1 of the PUR-1 Reactor Protection and Control System (RPCS) functional requirements specification (FRS) (ADAMS Accession No. ML17172A638) for Environmental Qualification, the equipment design specification is stated to be:

- Temperature 5 degrees Celsius (°C) to 35°C (41 degrees Fahrenheit (°F) - 95°F)
- Humidity 20% to 80% (non-condensing)

There are no known (documented) accident conditions that would cause temperature or humidity to go outside of these ranges. However, the potential exists for normal changes in the seasons to affect temperature (i.e., no Heating, Ventilation, Air Conditioning (HVAC) in extreme summer or winter climate). There is no direct readout for reactor room environmental conditions.

Provide the following information:

RAI #1: Describe how Purdue determined the operating temperature and humidity range listed in the RPCS functional requirements specification.

RAI #2: Describe how the HVAC unit will maintain the environmental conditions identified.

RAI #3: Describe the means to measure temperature within the cabinets.

## 2.0 Electromagnetic Interference/Radio Frequency Interference

The electrical requirements (FRS 3.1.1) state that there are no equipment Electromagnetic Interference/Radio Frequency Interference requirements except verifying operability (however, no such test has been documented or performed). During the regulatory audit, the NRC staff observed that much of the cabinet wiring is single strand copper or Cat-5 twisted pairs. At the same time, there are major alternating current sources (240 Volts Alternating Current (VAC) for UPSs and 120 VAC from UPSs to other loads), as well as convenience outlets at top of the cabinet.

RAI #4: Explain how electromagnetic compatibility is assured and verified.

## 3.0 Uninterruptible Power Supplies

The new RPCS uses two rack-mounted SmartPro® 3000CRXML Uninterruptible Power Supplies (UPSs) to provide power to the system. One UPS provides power to the magnetic current supplies. Section 13.1.7 of the SAR "Loss of Normal Electric Power," states loss of normal electric power at PUR-1 will shut down the reactor. With the addition of the UPS, this is no longer the case because the UPS will continue to provide magnet power.

RAI #5: Update the SAR to describe the role of the UPS during a loss of normal electric power.

Purdue personnel stated, during the site audit, that the UPS can provide ride-through for loss of facility power. The UPSs are specified and sized to provide up to 30 minutes of backup power to the RPCS. Further, Purdue staff identified that a casualty procedure would be established for controlled shutdown following the loss of building power.

RAI #6a: Explain how the operator would know if the building alternating current (AC) power is lost and describe the operator actions, associated procedures (including method of controlled shut down (e.g., ganged drive-in or scram)) and the approach the operator would use to ensure safe shutdown.

RAI #6b: Propose a TS that states that normal operations of the reactor shall not be allowed on emergency power or state why this is not needed.

Section 7.3.f.i.(b) of the SAR states that each UPS "unit supports loading up to 3600 watts when hard wired." During the Purdue site audit, the NRC staff noted that the test bed (as shown in PUR-1 SAR, Figure 7-4) for the RPCS had removable power connectors for the supplied power to the UPS.

RAI #7: If the final install will also have removable power connectors for the UPS power inputs, describe the loading supported by each UPS and explain if the load rating is

sufficient for the intended loads, including any anticipated use of the cabinet mounted Tripp Lite, 120 VAC, and convenience outlets.

#### 4.0 User Access

Section 7.9.a.iv of the SAR states that the RPCS operator workstation has multiple login groups for both user authentication and for establishing access control and privileges. In addition, the RPCS operator workstation has a "super-user" login with full privileges to control or modify any aspect of operation, maintenance, and program administration and configuration management. During the audit, NRC staff reviewed the "System Generation," factory acceptance test (FAT) in which the level of privilege was stated, in Table 8-1, as level 5, 10, 15, 20, and 31; however, no description is provided to differentiate the permission associated with these levels.

RAI #8: Provide a detailed description of the permission levels associated with each of the group levels, the criteria for assignment of individuals to the various levels, and how the permission levels (i.e., group assignments) will be administratively assigned and controlled.

Proposed TS definition 1.32, "Reactor Secured," contains a new condition for the PUR-1 reactor to be secured that states "the control console is placed in a permissions status where the controls are not operable." During the regulatory audit, the NRC staff observed that this added condition is related to the password control for the RPCS operator workstation.

RAI #9: Describe in detail how the permission status is used to render the controls inoperable and explain the basis for adding this new reactor secured condition.

#### 5.0 Operator Training

Purdue currently does not have any documentation identifying how operator training is being revised to reflect the changes in the system. Scientech provided a revised Operator Manual for the new digital I&C systems but there is no information that indicates that it will be used to train operators.

RAI #10: Provide a description of the operator training applicable for the proposed I&C upgrade implemented with this LAR that will be used to qualify the operators on the new console and equipment before the system is approved for use.

#### 6.0 Technical Specifications

Purdue TS 3.2 is used to specify the lowest acceptable level of performance or the minimum number of acceptable components for the reactor safety system. Proposed TS 3.2a requires that the safety-related instrumentation shall be operable in accordance with Table I, "Safety Channels Required for Operation," and Table II, "Safety-Related Channels (Area Radiation Monitors)." The SRs under TS 4.2a require a channel calibration through an annual electronic calibration and an annual power calibration. However, nothing is proposed for daily/pre-start checks to "...assure that the reactor safety system is operable as required by Specification 3.2."

RAI #11: Provide a proposed SR that will establish the operability of the safety channels required for operation and explain how the SR will be performed.

RAI #12: Provide additional description or justification to assess the acceptability of the proposed TS 3.2, editorial changes to Table I for “Channel,” “Setpoint,” and “Function.”

PUR-1 SAR, Section 7.6.i, “Configuration Management,” states, in part, that “as part of the prestart checklist, operators will verify the software version listed at the top of the displays on the console match the current release as listed in the Reactor Characteristics and Operations Manual.” During the regulatory audit, the NRC staff observed that the Purdue standard operating procedures (SOPs) have not been updated to reflect this yet.

RAI #13: Describe the update to Prestart checklist (SOP-1) that will be proposed to incorporate this pre-start check for configuration management.

As discussed during the site audit, the current Prestart checklist (Purdue SOP-1), which is a checklist included in the SOPs that is used prior to starting the reactor, contains several inconsistencies, noted below, with both the current and the proposed TSs.

RAI #14: Propose updates to the SOPs that will eliminate the inconsistent references and resolve these inconsistencies. In particular, explain the references to non-existent tables and the incorrect references to checks of each reactor safety system measurement channel. Describe how Purdue will maintain consistency with TS 3.2b, which is only for radiation monitors (Table II) or explain why an update is not required.

The setpoints provided in Chapter 7, Section 7.4.a, Table 7-6 of the PUR-1 SAR, are not consistent with the values in PUR-1 TS Table I for Channel 1 and 2 Safety Channels.

RAI #15: Explain and justify why these setpoints are different, describe how Purdue will revise them such that they match, or explain why no changes are necessary.

PUR-1 TS 4.2.d describes a channel check of each of the scram capabilities specified in PUR-1 TS Table I prior to each startup.

RAI #16: Identify which SR incorporates the guidance for retest following replacement, repair, or modification provided in the ANSI/ANS-15.1-2007 standard.

## 7.0 RCS Programmable Logic Controller

The RTP-3000 programmable logic controller (PLC) receives a heartbeat from the data acquisition system/operator supervisory control system to verify communications with the PLC. A watchdog timer is described that will monitor communications and reset the system (causing a reactor scram) for a communications error. The PLC provides data acquisition, data storage, reactivity control (e.g., automatic start up) and operator display and operator/system interfaces for operator monitoring, control and emergency response. The PLC can also shut down the reactor if necessary. The PUR-1 TSs do not propose an LCO or SR associated with the PLC.

RAI #17: If the PLC fails, explain how controls and displays of important parameters will be monitored by the operator and how the controls and displays will keep PUR-1 parameters within a limiting value. Also, explain how those controls and displays, that affect the reactivity of the core, are readily accessible and understandable to the reactor operator.

RAI #18: If the PLC fails, explain how displays and controls provided to the operator for manual system-level actuation and control of safety equipment will be functional under conditions that may require manual actions or justify why no additional information is needed.

During the audit, NRC staff noted that Purdue has not defined how to verify operability of the PLC.

RAI #19: Propose a TS and SR associated with the PLC to verify its operability.

## 8.0 Other Technical Specification Changes

The proposed TS for this LAR (ADAMS Accession No. ML17061A257) includes a change to the specification wording for TS 4.6, "Fuel Parameters." However, the safety basis for the change was not provided.

RAI #20: Explain the relationship, purpose, and basis for this change, including a safety evaluation of the acceptability of the proposed change; or remove the TS change; or explain why no information or action is necessary.

## 9.0 Mirion Test Switches

The Mirion neutron channels use keyed test switches to control access for test and maintenance of the channels.

RAI #21: Describe the administrative procedural control for access and authorized use of the keys for the test switches (i.e., PUR-1 SOP or TS).

## 10.0 Configuration Management

PUR-1 SAR, Section 7.6.i – Configuration Management states that "current configuration of the [RPCS] software will be maintained and documented as Appendix II to the Reactor Characteristics and Operations Manual (RCOM), an internal facility document." During the regulatory audit, the NRC staff observed that this Purdue internal facility document did not exist.

RAI #22: Provide an updated excerpt for Appendix II to the RCOM that describes how configuration management for the RCS software will be maintained and controlled in accordance with the PUR-1 SAR or explain why software configuration management is not needed.

## 11.0 Quality Assurance

PUR-1 SAR, Section 7.8, "Quality Assurance," states "[A] quality assurance (QA) program shall be developed, maintained, and utilized in accordance with the guidance of ANS/ANSI 15.8-1995." During the regulatory audit, the NRC staff observed that this Purdue quality assurance (QA) document was not available.

RAI #23: Describe the QA program used as part of this I&C modification or describe the Purdue administrative procedures and processes to be used as part of this modification to ensure components and modules that impact safety-related items are designed, fabricated,

installed, modified, and of sufficient quality to minimize the potential for challenges to safety systems.

## 12.0 Testing and Inspection Requirements

PUR-1 testing and inspection requirements are provided in Section 4 of the FRS. The FRS specifies the requirements to demonstrate the functionality of the new RPCS and demonstrate conformance to the requirements. FRS Section 4.2 describes a requirement for performing FAT and Section 4.4 describes the site acceptance tests (SAT).

RAI #24: During the regulatory audit, the NRC staff observed that several test procedures for the FAT and SAT were not conducted due to missing hardware, system interfaces, or required connection to the reactor. These procedures were documented as “can’t test.” A master list of tests that were not performed does not exist and no test exception records were generated for the missing tests. Explain how these missing tests are being tracked and how and when these previously untested tests will be completed.

The FAT and Test Plan requires that test exception reports (TER) be created to record failures or issues encountered during tests. The TER should, describe changes necessary to pass FAT, and their resolution requires retest before the completion of FAT. During the regulatory audit, the NRC staff observed that several TERs were documented during the FAT. However, it was not apparent to the NRC staff that documentation exists for the resolution and description of changes made to the system to address TERs, or that, if the changes were made, they were made permanent (e.g., as evidenced by a change in the software build number), or that the changes were retested since the FAT documentation still indicated out-of-specification parameters.

RAI #25: Provide evidence that the TERs generated included a description of the changes made to the system, that the changes are permanent, and that they were retested.

During the regulatory audit, the NRC staff observed a demonstration that revealed that the control functionality for target rod withdrawal (i.e., withdrawal of a rod to a preset height) as related to inhibits for selection and withdrawal of a different rod may have functioned improperly. This error was reported to be corrected by Purdue staff at the exit meeting and a subsequent demonstration to NRC staff was performed satisfactorily. However, it is not apparent to the NRC staff that documentation was created for the description of the changes made to the control functionality for target rod withdrawal.

RAI #26: Provide evidence that a TER or similar document was generated that included a description of the changes made to the system, that the changes are permanent, and that they were formally retested (in accordance with Scientech and Purdue procedures).

## 13.0 Fast Scram

The safety review for PUR-1 provided with the amendment describes operation of Channel 4, Safety Channel. This description talks about “fast scram” that is performed by this channel, and states that the “fast scram capability remains in the new I&C.” However, during the audit, it was clear that this feature is not included in the new I&C system. Instead, all channels have the same capability to scram the reactor.

RAI #27: Explain what was meant by the sentence “fast scram capability remains in the new I&C.”

#### 14.0 Document Request

During the regulatory audit, NRC staff identified several documents that the NRC may consider using as a regulatory basis for use while preparing the safety evaluation.

RAI #28: Docket the following documents or provide an explanation of why it is not necessary:

- PUR1-SRS-SDD-002 – HMI Functions Software
- PUR1-HDD-001 – Hardware Design Document
- PUR1-HDD-001-16 Sh. 2 – Second page of the SCRAM wiring diagram

#### 15.0 Operator Manual

During the regulatory audit, NRC staff reviewed “PUR-1 Operating Principles and Core Characteristics Manual,” Revision 0, which describes the reactor, operation, control and system descriptions. Purdue staff noted that they are considering updating this document to describe how to control and operate the new RPCS system. Also, they are considering using Scientech PUR1-OPS-001, “Operator Manual,” Revision 1, which describes how to use the RPCS, Human-Machine Interface display, and physical controls from the operator console.

RAI #29: Identify if Purdue will update the Operating Principles and Core Characteristics Manual, adopt the Scientech PUR1-OPS-001 Operator Manual, or identify what Purdue is planning to do if they are not updating the manual to operate the reactor.