

September 14, 2015

Document Control Desk  
US Nuclear Regulatory Commission  
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11555 Rockville Pike  
Rockville, MD 20852

Attn: Ms. Cindy Montgomery, Research and Test Reactors, Mailstop O12 D20

SUBJECT: Restart Plan for the Purdue University Reactor (Sep 3 2015). Docket 50-182

Dear Ms. Montgomery,

Enclosed please find the "Restart Plan for the Purdue University Reactor," dated Sep 3, 2015. Should you have any questions or require further information, please don't hesitate to call me at 765-496-3573, or email me at [bean@purdue.edu](mailto:bean@purdue.edu).

I hereby certify under penalty of perjury with my signature below that the information contained in this submission is true and correct to the best of my knowledge.



Robert S. Bean  
Director of Radiation Laboratories  
Purdue University

Attachments:

Restart Plan for the Purdue University Reactor, Rev. 1.01, September 3, 2015.

Cc: Leah Jamieson, Dean, Purdue University College of Engineering  
Jim Schweitzer, Purdue University Radiation Safety Officer, CORO Chair  
Ahmed Hassanein, Head, Purdue School of Nuclear Engineering

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# Restart Plan for the Purdue University Reactor

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Prepared by

Robert Bean, Facility Director

September 3, 2015

Approved by CORO Sep 8, 2015

Docket 50-182

## **History**

The Purdue University Reactor (PUR-1) first went critical in 1962. The reactor safety systems are vacuum tube and analog circuits, and are mostly original except for replacement parts. Whenever possible, replacements were with like-for-like, and often factory equivalent, components and systems. The start-up channel, Channel 1 (CH1), is a fission chamber connected to a linear amplifier and single channel discriminator. This system is highly susceptible to electronic noise, and noise issues have been noted by operators dating back to the first PUR-1 operations (They were first noted in the reactor log book on October 18, 1962.). In 2010 the noise issues began to often cause instrumentation scrams, due to interpretation of a noise spike as a sudden, short period. Many reactor operational runs were scrubbed, and the reactor was last brought critical on April 3, 2013. As of May 22, 2013 the reactor instrumentation was declared inoperable until it could be repaired and subsequent runs were precluded due to the noise issues with CH1.

The instrumentation induced outage occurred at the same time as the retirement of one key staff member, and the departure of the other (in August 2013). A new facility director was hired in August 2013, but the PUR-1 reactor was left without any licensed operators for a period of 12 months. During this time, the surveillance requirements of the Technical Specifications that could be performed without a licensed operator were maintained. Activities that required a licensed operator or senior operator were curtailed. A Senior Reactor Operator (SRO) license was granted to the facility director in August 2014, which allows him to also be the acting reactor supervisor. An electronics technician was hired in October 2014, and a reactor supervisor was hired to start in September 2015.

## **Restart Plan**

The restart plan consists of reviewing and repairing the reactor instrumentation and reactor safety systems, performing all surveillances required by the Purdue University Technical Specifications (TS) that can be performed without critical operation, and then carefully taking the reactor critical to low power to complete the remaining TS surveillances. Finally, the reactor will be taken to its full power of 1 kW.

## **Review and Repair**

Purdue contracted for engineering support from RGA Labs, Inc. in November 2014. RGA Labs provided two nuclear engineers with extensive operations and instrumentation experience. Working with them, the PUR-1 staff went through the instrumentation systems and repaired many age related issues. Notably, power cords with cracked insulation, detector cables that had failed insulation, a meter that had control current leaking through it, a failed trip relay, and a failing power supply for a strip chart recorder were identified and replaced. These issues were fully expected with aged equipment and may have been contributing to the CH1 noise issues. Regardless, they were repaired or replaced as a good engineering practice. Also, many of the cables within the console and racks were rerouted to increase the distance between sensitive signal cables and potential sources of noise. Working with the original manufacturer's manuals, existing facility procedures, and notes and data sheets that had been archived by the previous electronic technician, the electronic calibration was performed and all instruments were

declared operable on March 20, 2015 and the PUR-1 instrumentation is in compliance with Table I of the Technical Specifications for the TS, *Safety Channels Required for Operation*.

### Technical Specifications Compliance

All activities that could be performed without a licensed operator present (surveillances of the reactor coolant water, surveillance of the negative room pressure, etc.) were maintained throughout the outage. After the facility director was granted his SRO license, work began in earnest to identify and repair the instrumentation issues that were the cause of the outage. When the instruments were again in working order, the required electronics calibration was performed and the reactor was declared operable on March 20, 2015. Subsequently, the physical inspection of the control rods was completed on May 6, 2015 and the physical inspection of the fuel was completed on May 11, 2015. There was no visual degradation of either the fuel or control rods noted at the time of the inspection. Measurement of wipes showed that there was no contamination indicative of failed fuel plates.

### Status of Technical Specifications Requirements

The following surveillance requirements from the TS must be performed. The current status is shown below.

Requirement	Description	Status
4.1.a	The shim-safety rod reactivity worths shall be measured and the shutdown margin calculated annually with no interval to exceed 15 months, and whenever a core configuration is loaded for which shim-safety rod worths have not been measured.	<b>Outstanding</b>  Last performed on October 31, 2011
4.1.b	The shim-safety rods shall be visually inspected annually with no interval to exceed 15 months. If the rod is found to be deteriorated, it shall be replaced with a rod of equivalent or greater worth.	Complete  May 6, 2015
4.1.c	The reactivity worth of experiments placed in the PUR-1 shall be measured during the first startup subsequent to the experiment's insertion and shall be compared with the prior calculated value, and shall be verified if core configuration changes cause increases in experiment reactivity worth which may cause the experiment worth to exceed the values specified in Specification 3.1	No experiments installed at this time
4.2.a	A channel test of each of the reactor safety system channels listed in Table III shall be performed prior to each reactor startup following a shutdown in excess of 8 hours or if they have been repaired or de-energized.	Instruments are operable and will be checked again before operation.
4.2.b	A channel check of each of the reactor safety system measuring channels in use or on scale shall be performed approximately every four hours when the reactor is in operation.	A channel check will be performed after start-up.

Requirement	Description	Status
4.2.c.1	A channel calibration of the reactor safety channels shall be performed at the following average intervals: An electronic calibration will be performed annually, with no interval to exceed 15 months.	Complete March 20, 2015
4.2.c.2	A channel calibration of the reactor safety channels shall be performed at the following average intervals: A power calibration by foil activation will be performed annually, with no interval to exceed 15 months.	<b>Outstanding</b> Last performed on January 6, 2012
4.2.d	The operation of the radiation monitoring equipment shall be verified daily during periods when the reactor is in operation. Calibration of these monitors shall be performed semiannually, with no interval to exceed 7 1/2 months.	Complete July 22, 2015
4.2.e	Shim-safety rod drop times will be measured annually, with no interval to exceed 15 months. These drop times shall also be measured prior to operation following maintenance which could affect the drop time or cause movement of the shim-safety rod control assembly.	Complete May 14, 2015
4.3.a	The pH of the primary coolant shall be recorded weekly.	Maintaining Periodicity
4.3.b	The conductivity of the primary coolant shall be recorded weekly.	Maintaining Periodicity
4.3.c	The reactor pool water will be at or above the height of the skimmer trough whenever the reactor is operated.	Maintained weekly and before operation.
4.3.d	Monthly samples of the primary coolant shall be taken to be analyzed for gross alpha and beta activity.	Maintaining Periodicity
4.4.a	The negative pressure of the reactor room will be recorded weekly.	Maintaining Periodicity
4.4.b	Operation of the inlet and outlet dampers shall be checked semiannually, with no interval to exceed 7 1/2 months	Complete July 23, 2015
4.4.c	Operation of the air conditioner shall be checked semiannually, with no interval to exceed 7 1/2 months	Complete July 23, 2015
4.4.d	Representative fuel assemblies shall be inspected annually, with no interval to exceed 15 months	Complete May 11, 2015
4.5.a	Calculations shall be made on samples of known composition to assure that the limits of specification 3.5.f and 3.5.g, are not exceeded.	No samples are in the reactor at this time.
4.5.b	The mass of samples of unknown composition shall not exceed 10 grams.	No samples are in the reactor at this time.

All surveillance requirements have been performed and the required frequency has subsequently been maintained except for TS requirements 4.1.a and 4.2.c.2, which require critical reactor operation for completion.

### **Completion of Surveillance Requirements**

The issue with restart after an extended outage is that the TS state that the reactor shall not operate unless a gold foil calibration (to determine actual power vs. indicated power) has been performed within the last 12 (not to exceed 15) months [TS 4.2.c.2]. Additionally, the TS state that the reactor shall not operate unless a calculation of the shutdown margin and a measurement for the reactivity worth of the three control rods has also been performed within the last 12 (not to exceed 15) months [TS 4.1.a]. With an outage of longer than 15 months, these two requirements would disallow a reactor restart.

The reactivity worth of the control rods was last performed on October 31, 2011 and the gold foil calibration was last performed on January 6, 2012. The fuel loading is the same as when those measurements were performed. The physical inspection of the reactor showed that there are no physical changes in the fuel or control rods. Historically, the reactivity worth of the control rods has varied very little due to the minuscule burn-up of the PUR-1 core, and the shutdown margin has always been significantly larger than the TS required amount of  $0.01 \Delta k/k$ . It is valid to assume, therefore, that the control rod worth and the shutdown margin, when measured, will be well within the TS required limits for operation.

We propose, therefore the following steps to restart the PUR-1 reactor and complete the remaining TS required surveillances and measurements:

1. Maintain all currently performed TS surveillances that do not require critical reactor operation
  - a. Weekly and monthly surveillances
  - b. Semi-annual radiation alarm and continuous air monitor calibrations
  - c. Annual electronics calibration, fuel inspection, and control rod inspections
2. Verify operability of the instrumentation subsequent to the electronics calibration
3. Perform a Prestart Checklist
4. Measure the reactivity worth of SS-1 and SS-2 by subcritical multiplication to measure the 0 cm to 40 cm (shim range) portion of their reactivity worth curves.
5. Compare measured SS-1 and SS-2 reactivity worth to most recent measurement records.
6. Take reactor critical and go to indicated reactor power of 0.01 Watts
7. Irradiate a gold foil for actual power level measurement.
8. Repeat Steps 6 and 7 for indicated power levels of 0.1, 1, 10, and 100 Watts
9. Shutdown and secure reactor
10. Measure gold foil activity and perform calculation of actual vs indicated power.

We will stop at this point and assess the results. If necessary, the position of the detectors can be adjusted, or the electronics calibrations can be repeated. If any adjustments are required, the gold foil

calibration will be repeated, starting again at 0.01 Watts. If the results are acceptable (e.g. within  $\pm 20\%$  and trending conservatively), we will continue with the restart:

11. Perform a Prestart Checklist and Startup reactor.
12. Measure the control rod worth by positive period method for SS-1, SS-2, and RR.
13. Raise reactor to indicated power of 200 Watts.
14. Irradiate a gold foil for actual power level measurement.
15. Repeat steps 13 and 14 for indicated power of 500 Watts and full power (nominally 1000 W)
16. Shutdown and secure reactor.

These steps will allow a careful approach to full power (1 kW), while also allowing the performance of the remaining TS required surveillances. Upon completion of these steps, PUR-1 will be in full compliance with all TS requirements for licensed operation.

### **Summary**

The PUR-1 reactor has been down for a maintenance outage since 2013. The instruments have been repaired and the reactor safety systems are now operable. The physical inspection of the fuel and control rods showed no degradation or issues. All Purdue University Technical Specifications required surveillances have been performed and are being maintained at their required periodicity except for those that require critical operation of the reactor. We proposed to bring the reactor critical at low power (0.01 Watts), perform control rod reactivity worth measurements and gold foil calibration (0.01 Watts to 100 Watts). Upon acceptance of those results we propose to then finish the control rod reactivity worth measurements and complete the gold foil calibration up to full power (1000 Watts). When these steps are completed, the PUR-1 reactor will be in full compliance with all Technical Specification requirements.