Rensselaer

DEPARTMENT OF MECHANICAL,
AEROSPACE, AND NUCLEAR ENGINEERING

RCF 19-04
August 22, 2019

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

05000225

To Whom It May Concern:

This letter submits a reportable occurrence report to the NRC in accordance with the Rensselaer Polytechnic Institute Critical Experiments Facility, license CX-22 Technical Specifications.

On August 14, 2019 an omitted step in the Pre-Startup Procedures allowed the RCF to be operated without a required nuclear instrument channel. This is a reportable occurrence and requires a report on the event be provided to the NRC within 14 days of the event.

The required report is attached.

Yours truly,

Wei Ji

Wei Ji, RCF Facility Director

cc:

Hyun Gook Kang, NSRB Chair
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Anthony Mendiola, NRC
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Reportable Occurrence (NRC Event Number 54222)
at the Rensselaer Polytechnic Institute Critical Experiments Facility

Abstract

At approximately 19:00 on August 14, 2019, a reportable event occurred at the RCF. A step in the Pre-Startup Checklist was inadvertently skipped, resulting in a test signal cable remaining plugged into the power/period meter (PP2), effectively rendering it inoperable. The reactor was subsequently operated in this state, violating a limiting condition for operation, per Technical Specifications (TS). The reactor was manually scrammed once a discrepancy between PP2's indicated power level and indicated power levels from the other instrumentation were noticed by the SRO on duty, near 0.14 W (far below the 100 W license limit). The following report provides further detail of the reportable occurrence, along with corrective actions, and is intended to satisfy the reporting requirements detailed in the RCF TS and license.

Background

The Rensselaer Polytechnic Institute (RPI) Critical Experiments Facility (RCF) is a low power, 100-watt license limit, research and training reactor located in Schenectady, NY. The RCF uses four control rods and five nuclear instrumentation channels for reactor control. Figure 1 shows the four control rods spaced around and outside the array of fuel pins. The neutron detectors for the five nuclear instrumentation channels are not in view but are also outside the fuel array.

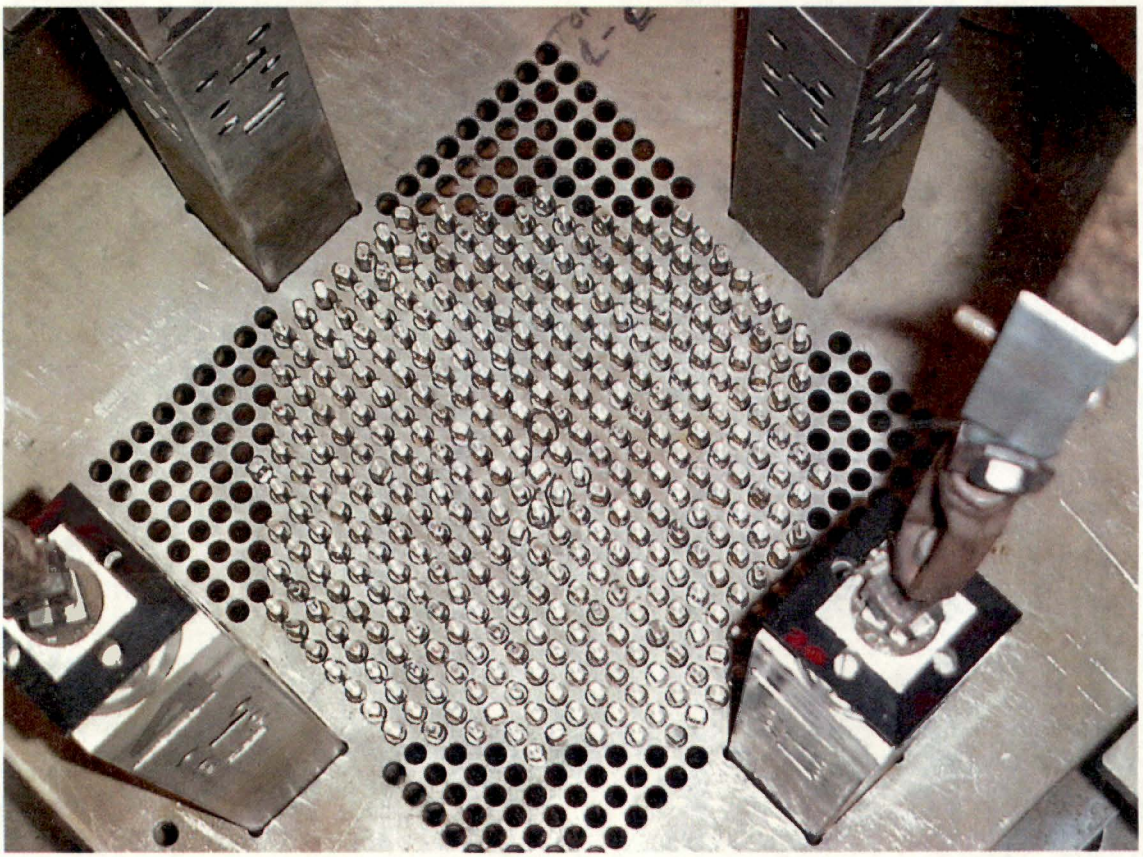

Figure 1: Top View of RCF Fuel Array (333-pins) and Control Rods

The nuclear instrumentation channels include two boron trifluoride Start-up detectors identified as Start-up A (S/U A) and Start-up B (S/U B), and three ion chambers identified as log power 2 (PP2), linear power 1 (LP1) and linear power 2 (LP2). The electronics for the ion chambers are picoammeters and provide an automatic scram function. PP2 also provides a rod outmotion interlock for reactor period less than 15 seconds. The start-up channels have no scram function but one of those provides a rod outmotion block if channel count rate is less than 2 cps. Normally, this is assigned to S/U B, but S/U A can be assigned that function.

The TS includes an instrumentation Limiting Condition for Operation[1] (LCO). One start-up channel with low count rate interlock, both linear power channels and the log power channel are the minimum operable nuclear instrumentation channels for reactor operation. The TS also specifies what interlocks must be operable whenever rods are not on the bottom.[2].

The Pre-Startup Procedures prepare the reactor for operation. During checks of PP2, LP1 and LP2 a current source is provided to the picoammeters to simulate a current from the associated ion chamber. The test current is raised to verify the channel scram function occurs at the correct setpoint. The verification of the scram is observation that the current to the control rod drive magnetic clutches drops to zero. No actual rod motion occurs because the rods are bottomed when these tests are performed.

A later step in the procedure verifies scram functionality by raising control rods until the rod bottom indication extinguishes, about 1 inch of rod withdrawal, setting the dump valve bypass to NORMAL and inserting a scram, either from one of the ion chamber channels or alternate manual trips. There are eight different scram sources and one is checked, in rotation, at every performance of the procedure. This check verifies that the rods actually insert (rod bottom light is activated) and the dump valve opens to remove the moderator from the reactor tank. When the scram source is PP2, LP1 or LP2, the channel picoammeter receives a simulated detector current from the test source cable.

Reactor Start-up August 14, 2019

For this performance of the Pre-Startup Procedures the scram functionality test used PP2 period as the trip source. Therefore, the test source cable was attached to PP2 picoammeter in place of the signal cable from the PP2 detector. The Pre-Startup Checklist was completed, and a startup was authorized.

The Duty Senior Reactor Operator (SRO) raised control rods and noted increasing neutron level, first on the Start-up channels, then on the linear power channels. PP2 is the least sensitive channel, but it became apparent that there was no corresponding increase in signal from PP2. The reactor was manually scrammed. A visual inspection quickly revealed that the test source cable had not been removed from PP2 picoammeter after the scram functionality test as required by the procedure and the PP2 detector was not being monitored.

Immediately after the scram the Duty SRO observed that there was no rod bottom light for Rod 3. This problem will be discussed later in this report.

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[1] Technical Specifications 3.2, Table 1
[2] Technical Specifications 3.2, Table 2

PP2 is the only channel that shows reactor power in watts and is the only channel with a rate scram. Power at the time of the scram was calculated from LP1 current and determined to be 0.14 watts. Based on the known characteristics of the core, reactor period was about 70 seconds. The high rate trip is set at 5 seconds and the rod outmotion interlock is set at 15 seconds. No limiting safety system setting was exceeded.[3].

Operating the reactor with PP2 disabled violates the LCO in the TS. This meets the condition of a reportable occurrence.[4]

Stuck Rod on August 14, 2019

As noted above, the manual scram performed by the Duty SRO caused Rod 3 to fail to fully insert. Inspection showed that the rod was about 2 inches from fully bottomed. No reason could be determined from above the reactor. The reactor tank was drained, and an operator entered the empty reactor tank to examine the control rod. It was quickly determined that a foreign object within the lowest section of the control rod had protruded into the lip of the hydraulic buffer on the core lower support plate. This buffer absorbs the mechanical shock of the control rod reaching it fully inserted position.

By manipulating the control rod linkage to the drive system, pressure on the foreign object was reduced and it was extracted from the control rod. The object was a ¼-20 x 1.5 inches cap screw. Reversing the manipulations of the control rod linkage gradually lowered the control rod to the fully inserted position and the rod bottom light was illuminated.

Corrective Actions for LCO Violation

The immediate corrective action was a manual scram and verification that the reactor was shut down as indicated on LP1 and LP2. The test source cable was disconnected from PP2 and the ion chamber signal cable reconnected. PP2 then also showed the expected decrease in power level.

In accordance with the TS, the Facility Director and the Chair, NSRB were informed that same evening. The NRC Headquarters Operations Officer (HOO) was informed by phone the following day. Event number 54222 was assigned.

A revision to the Pre-Startup Procedures was prepared to require a tag be placed on the shim switch informing the operator that detector inputs may be coming from the test current generator. The tag is attached the first time an ion chamber signal cable is disconnected from the associated picoammeter in order to attach the test source cable[5]. The tag is not removed until the Pre-Startup Procedures tests are completed[6].

At a meeting of the NSRB on August 16, 2019, the proposed revision was presented to the NSRB and it was approved. The NSRB further requested that the test source cable be made more visible. This was accomplished by winding yellow vinyl tape around several inches of the

[3] Technical Specifications 2.2, Limiting Safety System Settings
[4] Technical Specifications 1.3, Definitions
[5] Pre-Startup Procedures, Log Power Tests, step K.4.
[6] Pre-Startup Procedures, Prepare for Reactor Startup, step R.3

cable. At the same meeting, the NSRB approved a return to operations pending distribution of the revised procedure and applying tape to the test source cable. The procedure change and the reason for it was briefed to all licensed operators on August 21, 2019.

Corrective Actions for Stuck Rod 3

Visual inspections on August 14, 2019 of the Rod 3 drive mechanism and that of the two adjacent control rods did not identify any missing fasteners. There are several cap screws among the mechanism hardware, but none were missing and those in place are blackened steel, quite unlike the one that jammed Rod 3. No maintenance work that added similar fasteners or removed any fasteners of that size and shape has been conducted on the reactor in several years. The origin of the object remains unknown.

A rod drop timing test will be performed at the next opportunity in accordance with Surveillance Procedures[7].

[7] Surveillance Procedures, Rod Drop Timing, procedure B