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Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Reference Docket 50-005 License R-2
The PSU Breazeale Nuclear Reactor (PSBR)

Subject: Special Report regarding the April 16, 2013 deviation from Technical Specification Limiting Conditions for Operations 3.1.1.c reported on April 17, 2013 to the NRC Operations Center (NRC EN #48938)

Attached please find the special written report - as required by PSBR Technical Specification 6.6.2.a - for the April 16, 2013 event (NRC EN #48938) that resulted in a deviation from Technical Specification Limiting Conditions for Operations 3.1.1.c. The event was reported on April 17, 2013 to the NRC Operations Center by phone (NRC EN #48938) with a follow-up email description on the same date.

Please direct any questions regarding the event to Mark A. Trump - Associate Director for Operations at the facility.

Dr. Kenan Ünlü
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cc
Correspondence file
cc electronic
H. C. Foley
A. A. Atchley
Reactor Safeguard Committee
T. A. Lichatz NRC
X. Yin NRC

Attachments
PSBR Special Report as Follow-up to NRC EN #48938
EN #48938 dtd. 4/17/13

IE22
A020
NRR

PSBR Special Report as Follow-up to NRC EN #48938

OVERVIEW

On April 16, 2013 at 1702, the Breazeale Reactor (PSBR) was operating in the open pool position (R1) at 1 MegaWatt (MW) steady state. A sample capsule containing flux wires with a negative $0.80 reactivity was being irradiated in the central thimble irradiation fixture. At the end of the 2 hour irradiation, the duty senior operator (SRO) pulled the sample up to the "parked" position (approximately 5 feet above the core and 12 feet underwater). The removal of the negative reactivity sample resulted in an increase in reactor power and both the Digital Control Computer (DCC-X) and the Reactor Safety System demanded a high power scram.

All systems operated as designed. The duration of the event was less than one second and post event review showed power reached a peak of 1.3 MW. For Non-Pulse Mode Operation TS 3.1.1.c. states *"The maximum power level shall be no greater than 1.1 MW (thermal)."*

Following a review, the event was deemed reportable as defined in TS 1.1.34.b *"Operation in violation of a limiting condition for operations."*

Per TS 6.6.2 a phone report was made to the NRC Operations Center on April 17, 2013 (NRC EN #48938). Phone calls were also made to the NRC project manager and assigned inspector. A follow-up email was also sent.

Description of the Central Thimble Irradiation Fixture, Sample Capsule, and Planned Irradiation

The central thimble irradiation fixture is a water filled aluminum tube 1.33 inch (ID) located in the center of the reactor core. The fixture is described in Section 10.2.5 of the Safety Analysis Report (SAR). Samples irradiated in the fixture can be removed from the core and usually remain under water for ALARA considerations.

The experiment in progress on April 16, 2013 was a 2 hour irradiation at 1 MW of an aluminum sample capsule designed with internal boron-carbide neutron shielding to minimize undesired thermal neutron interactions with the sample. A flux wire was installed inside the capsule to verify performance of the shielding prior to use in a radio-isotope production research experiment.

An aluminum stand located in the central thimble fixture locates the capsule height in the core and eliminates any possibility of the sample capsule dropping down and out of the core during the irradiation. The sample capsule had been designed and analyzed to limit its reactivity to less than $1. MNCP simulation and measurements had confirmed the design results with the sample capsule reactivity at negative $0.80. A 10CFR50.59 screening of the sample capsule had been completed as well as an evaluation of the experiment as required by TS 3.7 *Limitations of Experiments.* Although the experiment was intended to be a secured experiment per TS 3.7, reactor pulsing was procedurally restricted to meet the movable experiment limits of TS 3.7.

Detailed Event Description

The large majority of timed irradiations are loaded at shutdown or standby conditions. The reactor is started and then secured at the appropriate time for sample removal. Exceptions to this include pneumatic transfer system irradiations and specific precision irradiations in the dry tube irradiation fixtures.

Following a pre-job brief with the Associate Director for Operations (ADO), the duty SRO lowered the sample capsule into the central thimble of the secured reactor. A reactivity check was performed during startup to verify the capsule's position and power escalated to 1 MW in automatic control balance rod configuration in accordance with standard operating procedures.

Core operating parameters were reviewed and determined to be as expected for the addition of the sample capsule. An RO and SRO watch turnover was conducted shortly after the reactor reached 1 MW. The turnover discussion on the irradiation was involved since this was a non-routine irradiation.

Prior to irradiation end, the RO and SRO reviewed the sample procedure and briefly discussed shutting down or pulling the sample at power. The SRO decided to pull the sample as he had done for several past precision irradiations. The knowledge that this sample had an effect on reactivity did not alter his mindset.

When indicated by the sample timer (1701) the SRO pulled the sample from the core to the "parked" position (~5 feet above the core). The removal of negative reactivity from the core caused an immediate increase in reactor power exceeding the scram set points for both the Digital Control Computer (DCC-X) and the Reactor Safety System. All systems functioned as designed.

Both the RO and the SRO were immediately aware that the action to remove the negative reactivity sample at power had caused the power increase and the resultant scram. The following immediate actions were taken:

- The reactor was secured.
- Management notifications were completed.
- The reactor was tagged out to restrict further operations pending review of the event.

Peak indicated power recorded by the monitoring computer was 1.328 MW. Recorded fuel temperature increased approximately 1 °C (to ~500°C) and remained well below limits. No increase in radiation levels were expected or observed; no radioactive release was expected or occurred; and no emergency event criteria were approached.

Reportability Analysis

From TS 1.1.34 *A reportable occurrence is any of the following which occurs during reactor operation*:
Specifically TS 1.1.34.b. *Operation in violation of a limiting condition for operation.*

For *Non-Pulse Mode Operation* TS 3.1.1.c. states *"The maximum power level shall be no greater than 1.1 MW (thermal)."*

As stated in TS 3.1.1, the basis of the specification is to limit the *steady state operations* to within the bounds established in the SAR to protect the assumption for the source term and decay heat. The steady state limit was not approached. However the literal specification was exceeded and the event was deemed reportable under TS 1.1.34.b.

Safety Analysis

The transient was well within analyzed design envelop of the reactor as defined in the SAR and presented no challenge to the integrity of the fuel or the assumptions of the SAR.

The addition of positive reactivity at various conditions is addressed in the SAR Chapter 13. The limiting event is a step addition of $3.50 (pulse) to the critical reactor which approaches the fuel safety limit (1150°C). A step addition ($2.25) from 1.15 MW is also reviewed in the SAR and is found to be less limiting. The rapid ramp of $0.80 is well below the design analysis and did not result in a prompt critical transient (pulse) as analyzed in the SAR. Fuel temperature increased approximately 1 °C before the scram terminated power generation. No safety limits or limiting safety system settings were approached.

The assumptions used in the SAR are protected by TS limits on core design, operation, and experiment limitation. Regarding reactivity additions, the following TS 3.7 *Limits on Experiments* are applicable to the event and were not approached or exceeded:

3.7.a *The reactivity of a movable experiment and/or movable portions of a secured experiment plus the maximum allowed pulse reactivity SHALL be less than 2.45% Δk/k (~$3.50). However, the reactivity of a movable experiment and/or movable portions of a secured experiment SHALL have a reactivity worth less than 1.4% Δk/k (~$2.00). During measurements made to determine specific worth, this specification is suspended provided the reactor is operated at power levels no greater than 1 kW. When a movable experiment is used, the maximum allowed pulse SHALL be reduced below the allowed pulse reactivity insertion of 2.45% Δk/k (~$3.50) to ensure that the sum is less 2.45% Δk/k (~$3.50).*

3.7.b *A single secured experiment SHALL be limited to a maximum of 2.45% Δk/k (~$3.50). The sum of the reactivity worth of all experiments SHALL be less than 2.45% Δk/k (~$3.50). During measurements made to determine experimental worth, this specification is suspended provided the reactor is operated at power levels no greater than 1 kW.*

Therefore the experiment design and the unplanned event was well within the analysis of the SAR and the TS limits for experiments and presented no safety hazard to the core or challenge to the safety analysis assumptions.

Investigation and Corrective Action

An operations stand-down, investigation, and event review was conducted with licensed personnel and management prior to reactor restart. The investigation included operator statements, operator interviews, stored console computer information, and alarm printouts.

The apparent causes of the event are listed below with specific corrective actions:

1. Inadequate procedural guidance or checks to prevent the operator from removing the sample while reactor is critical.
   - Experiment authorization for sample capsule revoked - **complete**
   - Revise and reissue procedure for sample capsule use to include specific requirements regarding sample removal at power – **complete** (SOP-5 2013-20)
   - Perform a review of all 2013 experimental procedures for similar weaknesses, correct or revoke procedures - **complete**
   - Evaluate the experiment authorization process and other sample handling procedures for inclusion of lessons learned from this event. **Due**: Evaluation by end of May, revision by end of June

2. Human error (mindset / group think). The operators had the knowledge and understanding of the results of pulling an $.80 sample from the critical reactor. However, this knowledge did not overcome the incorrect mindset that removal was permissible.
   - Conduct an Operations stand down and review of the event with all licensed operators with emphasis on human performance, questioning attitude, and reactivity affects. - **complete**
   - Conduct additional operator review training on the 4/16 event, prompt jump, reactivity limits and reactivity addition events from the safety analysis **Due**: by end of May

Submitted: 4/29/2013
Mark A. Trump – Associate Director for Operations

Approved: 4/29/2013
Dr. Kenan Ünlü – Director RSEC

Research Reactor	Event Number: 48938
Facility: PENNSYLVANIA STATE UNIVERSITY RX Type: 1000 KW TRIGA MARK III Comments: Region: 1 City: UNIVERSITY PARK State: PA County: CENTRE License #: R-2 Agreement: N Docket: 05000005 NRC Notified By: MARK TRUMP HQ OPS Officer: VINCE KLCO	Notification Date: 04/17/2013 Notification Time: 15:53 [ET] Event Date: 04/16/2013 Event Time: 17:01 [EDT] Last Update Date: 04/17/2013
Emergency Class: NON EMERGENCY 10 CFR Section: NON-POWER REACTOR EVENT	Person (Organization): WILLIAM COOK (R1DO) XIAOSONG YIN (NRR)

Event Text

TEST REACTOR EXCEEDED LICENSED POWER LIMIT DURING A SCRAM

The following information was excerpted from an email from the licensee:

On April 16, 2013 at 1701 EDT, the research test reactor automatically shutdown from 100% power (1 MW) due to a valid high power condition. The duty Senior Reactor Operator removed a timed irradiation sample from the core that added positive reactivity. Both the digital (non-safety system) and the analog safety system acted on the high power condition and initiated the shutdown. All systems functioned as designed. The short duration power transient reached a peak power of about 1.3 MW. There was no increase in radiation levels, personnel radiation exposure, or release of radiation from the facility. No emergency event entry criteria were met. The plant was placed in a secured condition and an event review investigation was conducted.

The event is (potentially) reportable in that the Maximum Power Level observed during the short duration (< 1 second) transient exceeded the steady state power limit for non-pulse mode operation as described in Technical Specification(TS) 3.1.1 Non-pulse mode operation sub-section b. The maximum power level shall be no greater than 1.1 MW (thermal).

The reactor was returned to routine service at approximately 1300 EDT on April 17, 2013.