PENNSTATE

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RADIATION SCIENCE & ENGINEERING CENTER

Annual Operating Report, FY 14-15
PSBR Technical Specifications 6.6.1
License R-2, Docket No. 50-5

November 23, 2015

Attention: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555-0001

Dear Sir or Madame:

Enclosed please find the Annual Operating Report for the Penn State Breazeale Reactor (PSBR) located at the Radiation Science and Engineering Center. This report covers the period from July 1, 2014 through June 30, 2015, as required by our Facility Operating License R-2 Appendix A Section 6.6.1.

If you have any questions, please contact Mark Trump, Associate Director for Operations (814-865-6351).

Sincerely yours,

Kenan Ünlü

Kenan Ünlü, Ph.D.
Director, Radiation Science
and Engineering Center

Enclosures:
Annual Operating Report, FY 14-15

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PENN STATE BREAZEALE REACTOR

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Reactor Utilization

The Penn State Breazeale Reactor (PSBR) is a TRIGA Mark III facility capable of 1 MW steady state operation, and 2000 MW peak power pulsing operation. Utilization of the reactor and its associated facilities falls into three major categories:

EDUCATION:
Several radiation laboratories at the facility provide support for graduate and undergraduate courses at the University as well as many high school classes that visit the reactor each year. These classes cover topics such as Neutron Activation Analysis and identification of unknown samples, half-life determination, and nuclear security. In total, the PSBR receives about 2500 visitors each year ranging from researchers to middle school students.

RESEARCH:
Much of the RSEC's usage supports research by reactor staff, professors, and graduate students from colleges throughout the University, and includes, for example, Radio-Chemistry applications, Neutron Imaging, and detector development.

SERVICE:
The RSEC's unique facilities and employee skill-set support the National economy by serving industry and fulfilling domestic and global needs. For example, the RSEC has been involved in the production of radio-isotopes which enable the petro-chemical industry to run at full capacity; the facility's neutron beam laboratory provides material testing used in the quality control program for the Primary Life Support Systems used by NASA; and fast-neutron irradiation fixtures support the Nation's defense infrastructure and industry semiconductor production.

The PSBR facility operates on an 8 AM - 5 PM shift, five days a week, with early morning, evening, and weekend shifts as-necessary to accommodate laboratory courses, public education, University Research, or Industrial service projects.

Summary of Reactor Operating Experience - Technical Specification 6.6.1.a.

Between July 1, 2014 and June 30, 2015, the PSBR was utilized as follows:

Mode of Operation	Time [hours]	Time / Shift [hours / shift]
Critical	925	3.18
Sub-Critical	214	0.74
Shutdown	1296	4.45
Unavailable for Use	0	0
Total Usage	2435	8.37

The reactor was pulsed a total of 21 times with the following reactivities:

Reactivity	Number of Pulses
< $2.00	4
$2.00 to $2.50	16
> $2.50	1
Total	21

The square wave mode of operation was used 4 times to operate the reactor at power levels between 100 and 500 KW.

Total energy produced during this report period was 580.8 MWh with a consumption of 29.9 grams of U-235.

Unscheduled Shutdowns - Technical Specification 6.6.1.b.

During the reporting period, there were **two** unscheduled shutdowns resulting from reactor SCRAM.

- On 3/17/15, the digital control system requested SCRAM during a startup at the FNI Tube when both facility exhaust fans momentarily lost power. Investigation revealed the fans had lost power during a transfer from normal power to diesel generator power. The transfer occurred while testing the diesel following maintenance. The power transfer is a "break before make" function. All systems performed as designed. Minor changes to training and procedures were implemented to prevent recurrence. ***See AP-4 (2015-02) and AP-13 (2015-5)***

- On 6/23/15, while operating at 800 kW at the D_2O tank, the digital control system requested SCRAM when it sensed both facility exhaust fans had shutdown. Investigation revealed a contract painter had bumped the operating FES Hand/Auto switch to "off" position while moving equipment. All systems performed as designed. ***See AP-4 (2015-04)***

Major Corrective or Preventative Maintenance with Safety Significance - Technical Specification 6.6.1.c.

Routine preventative maintenance required by Technical Specifications (TS) was completed within the TS required time frames. The following safety related maintenance actions affecting reactor control or safety equipment were also completed.

- On 12/22/14, the test circuit board assembly in the Power Range drawer of the Reactor Safety System was replaced with a spare following failure of the Fuel-1 Reference Test button during the daily test. The Power Range drawer was then retested and functioned as designed.
- Various dates 2015, Emergency Exhaust System components were replaced to correct excessive current draw observed during the extremely cold winter weather. Corrective maintenance included replacement of the supply breaker, fan and motor bearings, and the use of low temperature grease in the assembly.
- On 5/6/15, a rebuilt Transient Rod Shock Absorber was installed to correct binding in the absorber. The design function - to absorb rod inertial and minimize shock on Transient Rod ejection - was preserved.

Major Changes Reportable Under 10 CFR 50.59 - Technical Specification 6.6.1.d.

One change made at the facility in this year required a review and is reportable under 10 CFR 50.59:

- In November of 2014, a modification package to install a hard stop in place of the Transient Rod Shock Absorber was completed after a 50.59 review confirmed the acceptability of the modification. The temporary modification was installed to allow for rebuild of the shock absorber following identification of binding during operations. The screening determined this temporary modification had the potential to adversely affect the operation of the SSC. The subsequent review determined that ejection of the transient rod with the modification in place might result in damage to the component. However, even if the damage resulted in a loss of function, no new event would be created and failure of the component to function was addressed in the design of the SSC. The possibility of rod ejection with the modification in place was eliminated by disabling the function in the digital control system and by administrative restriction. The Reactor Safeguards Committee has reviewed the 50.59 document. *(See **AP-12 2014-09 Removal of Transient Rod Shock Absorber**)*

Facility Changes of Interest

Although the following modifications are not reportable under 50.59, they are notable and are provided for information:

- In June of 2014, installation of core load 55a swapped the position of two similarly burned 12 wt.% elements in the core layout. The swap was completed after element 221 was observed to have close tolerances during inspection. The swap ensures element 221 can be removed for followup inspection without difficulty. The change had no discernable impact on the core performance. *(See **AP-12 2014-4 Core 55a)***
- In July of 2014, the PSBR transitioned from core load 55a to core load 56. The change encompassed four different groups of fuel movements and included loading 2 additional (for a total of 4) instrumented fuel elements into the core for future experiments. The loading pattern was generally symmetric and similar to past patterns. Analysis showed the core to be in compliance with Technical Specifications without encroachment to any limit. Pursuant to Technical Specification 2.2 the Safety System instrumented fuel element I-17 (a new 12 wt. % element) was loaded such that it is in the position of Maximum Elemental Power Density. Therefore, the LSSS set point is not required to be proportionally lowered. The table below compares key parameters for Core 55a and Core 56 at their most limiting positions. *(See **AP-12 2014-06 Core 56)***

Parameter	Initial Core 55a	Initial Core 56
Total TRIGA Fuel Elements	102	105
12 wt%	37	38
8.5 wt%	65	67
Excess Reactivity (at D_2O Tank)	$6.16	$6.66
Power Defect at 1MW (at R1)	$3.42	$3.18
Transient Rod Worth (at R1)	$3.03	$2.88

Procedures

Procedures are normally reviewed biennially, and on an as-needed basis. Numerous minor changes and updates were made to maintain procedures during the year and do not require a report under 10 CFR 50.59.

New Tests and Experiments

In September of 2014, a new experimental structure was reviewed and approved for installation on the west core face of the reactor. The evaluation indicated the experimental structure would not significantly alter core power distribution or introduce an unanalyzed condition and did not require a report per 10 CFR 50.59. The structure was placed in the core in March of 2015. *(See **AP-12 2014-08 Westinghouse long-term irradiation**)*

Radioactive Effluents Released - Technical Specification 6.6.1.e.

Liquid

There were no planned or unplanned liquid effluent releases under the reactor license for the reporting period.

Liquid radioactive waste, from the radioisotope laboratories at the PSBR, is under the University byproduct materials license and is transferred to the Radiation Protection Office for disposal with the waste from other campus laboratories. Liquid waste disposal techniques include storage for decay, release to the sanitary sewer per 10 CFR 20, and solidification for shipment to licensed disposal sites.

Gaseous

All gaseous releases were less than 10% of the allowed concentrations and do not require specific report.

Argon-41 (^{41}Ar)

Gaseous effluent ^{41}Ar is generated from dissolved air in the reactor pool water, air in dry irradiation tubes, air in neutron beam ports, and air leakage to and from the carbon-dioxide purged pneumatic sample transfer system.

The amount of ^{41}Ar released from the reactor pool is dependent upon the operating power level and the length of time at power. The release per MWH is highest for extended high power runs and lowest for intermittent low power runs. The concentration of ^{41}Ar in the reactor bay and the bay exhaust was measured by the Radiation Protection staff during the summer of 1986. Measurements were made for conditions of low and high power runs simulating typical operating cycles.

For a conservative calculation of the ^{41}Ar release, all power operations were assumed to take place at the location of greatest ^{41}Ar generation and release (Fast Neutron Irradiator (FNI) tube). The calculation method includes direct release from the pool as well as release from the FNI fixture and estimates a production of ~2360 mCi for 580.8 MWh of operation during 2014-2015 fiscal year. A portion of this ^{41}Ar will decay in place however if all the ^{41}Ar were released it represents less than 4% of the release limit.

Parameter	*Value*	*Units*
Argon-41 Produced	2,360	micro curies
Average concentration, unrestricted area	<4x10-10	µCi/ml
Permissible concentration, unrestricted area	1x10-8	µCi/ml
Percentage of permissible concentration	<4.00	%
Calculated effective dose, unrestricted area	<3.00	mRem/yr

Tritium (^3H)

Tritium is released by evaporation of reactor pool water as a gaseous release. The total makeup to the reactor pool in 2014-2015 was approximately 13,300 gallons or 1.52 gallons per hour. The evaporative loss rate is dependent on relative humidity, temperature of air and water, air movement, etc.

For an average pool tritium concentration of 35,400 pCi/l (average for July 1, 2014 to June 30, 2015), the Tritium activity released from the ventilation system would be ~1,780 µCi. A dilution factor of 2 x 10^8 ml /sec was used to calculate the unrestricted area concentration. This is from 200 m^2 (cross-section of the building) times 1 m/sec (wind velocity). These are the values used for the safety analysis in the reactor license.

Parameter	*Value*	*Units*
Tritium released	1,780	micro curies
Average concentration, unrestricted area	<3x10-13	µCi/ml
Permissible concentration, unrestricted area	1x10-7	µCi/ml
Percentage of permissible concentration	<0.0003	%
Calculated effective dose, unrestricted area	<2x10-4	mRem

Environmental Surveys - Technical Specification 6.6.1.f.

The only environmental surveys performed were the routine environmental dosimeters measurements at the facility fence line and two off-site control points (one residential area several miles away). The net measurements (in millirems) tabulated below represent the July 1, 2014 to June 30, 2015 reporting period.

Location	*3rd Qtr '14*	*4th Qtr '14*	*1st Qtr '15*	*2nd Qtr '15*	*Total*
Fence North	3	5	2	5	15
Fence South	4	6	4	5	19
Fence East	1	4	1	6	12
Fence West	2	6	4	6	18
Pleasant Gap	0	0	0	3	3
Child Care UP	0	0	0	2	2

The exposures measured at all points on the facility fence-line were well within historical norms. Licensed operations remain well within the limits for the current fiscal year.