PENNSTATE

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RADIATION SCIENCE & ENGINEERING CENTER

Annual Operating Report, FY 11-12
PSBR Technical Specifications 6.6.1
License R-2, Docket No. 50-5

December 5, 2012

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

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, 2011 through June 30, 2012, as required by Facility Operating License R-2 Appendix A Section 6.6.1.

Also enclosed you will find a copy of the *Audited Financial Statements for The Pennsylvania State University Fiscal Year Ended June 30, 2012*. This along with Penn State's *Financial Assurance for Cost of Decommissioning Activities* has been forwarded to Mr. Christopher Ryder (USNRC Licensing Project Manager) by Mr. Joseph Doncsecz (Assoc. Vice President for Finance and Corporate Controller) on November 16, 2012 as requested.

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

Sincerely yours,

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

Enclosures: Annual Operating Report, FY 10-11
Audited Financial Statements for The Pennsylvania State University Fiscal Year Ended June 30, 2011

cc: H. C. Foley w/o Financial Statement
D. N. Wormley w/o Financial Statement
A. A. Atchley w/o Financial Statement
J. S. Brenizer w/o Financial Statement
E. J. Boeldt w/o Financial Statement
G. Schoenebeck - NRC
X. Yin – NRC



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# PENN STATE BREAZEALE REACTOR

Annual Operating Report, FY 11-12

PSBR Technical Specifications 6.6.1

License R-2, Docket No. 50-5

## 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** use is primarily in the form of laboratory classes conducted for graduate and undergraduate students and numerous high school science groups. These classes vary from neutron activation analysis of an unknown sample to the calibration of a reactor control rod. In addition, an average of 2500 visitors tour the PSBR facility each year.

**RESEARCH** accounts for a significant portion of reactor usage which involves Radionuclear Applications, Neutron Imaging, Neutron Beam Techniques, Detector development and testing and multiple research programs by faculty and graduate students throughout the University.

SERVICE use provides vital techniques for industries in support of the national economy. Some examples include: radio-isotopes produced at the facility enable the critical petro-chemical industry to run at full capacity; the facility neutron beam laboratory serves an critical need in quality control of materials used to store the nation's spent nuclear fuel; 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 to accommodate laboratory courses, public education and research or service projects as needed.

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

Between July 1, 2011 and June 30, 2012, the PSBR was utilized while:

| Mode of Operation | Time [hours] | Time / Shift [hours / shift] |
|---|---|---|
| Critical | 977 | 3.12 |
| Sub-Critical | 239 | 0.76 |
| Shutdown | 700 | 2.24 |
| Unavailable for Use | 54 | 0.17 |
| **Total Usage** | 1971 | 6.29 |

The reactor was pulsed a total of 101 times with the following reactivities:

| Reactivity | Number of Pulses |
|---|---|
| < $2.00 | 16 |
| $2.00 to $2.50 | 83 |
| > $2.50 | 2 |
| **Total** | 101 |

The square wave mode of operation was used 35 times to operate the reactor at power levels between 100 and 500 KW.

Total energy produced during this report period was 585 MWh with a consumption (and absorption) of 30.12 grams of U-235.

## Unscheduled Shutdowns - Technical Specification 6.6.1.b.

During the reporting period, there were two unscheduled reactor shutdowns including one SCRAM.

On 10/26/2011, the South Bay Rad monitor spiked high while the reactor was operating at 800 kW and coupled to the $D_2O$ tank. This momentary reading activated the Building Evacuation System and, by design, initiated an automatic reactor SCRAM. The reactor was secured and evacuated per procedure. Upon reentry, It was determined that this event was caused by a failure of the radiation monitor. The monitor was replaced with a spare and operation resumed.

On 2/24/2012, while operating at power, the RO observed that an unused display indicator on the Reactor Safety System Wide Range drawer had one bar at the top of the display blinking erratically. The RO called the SRO to determine if this indication was normal. The SRO expressed doubt about its normality and the reactor was shut down to investigate further. Following a review by the system expert the reactor was restarted.

## 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.

In August 2011, the Power Range Channel Test Keyboard assembly was replaced after the ***Fuel Calibration*** pushbutton failed to operate during the reactor daily checkout (SOP-2). The cause was a failed switch/contact internal to the keypad. The keypads were replaced in both the Power Range and the Wide Range safety system drawers as corrective/preventative maintenance.

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

There was one change to the facility that was determined to require an amendment to the facility Technical Specifications and no other changes were reportable under 10 CFR 50.59. That change along with several others is listed below.

## Facility Changes of Interest

The following changes were completed during the 2011 to 2012 fiscal year:

- In August of 2011, a change was made to the reactor make-up water system to eliminate the University water surge tank and associated piping (shown in SAR Figure 5.1) and replace it with a normally-disconnected hose connection between the University water system and the reactor pool recirculation system. This change simplified the process of providing backup reactor pool make up water by decreasing the operator actions required to deploy it. Additionally, this modification enabled University water to be added to the reactor pool through the recirculation system without an electrical source at the reactor facility thereby increasing the reliability of this backup method of make-up.
- In February of 2012, a license amendment request was submitted to the Nuclear Regulatory Commission to support the operation of new reactor bay heating and ventilation equipment. The Reactor Bay Heating Ventilation and Exhaust system (RBHVES) replaces much of the antiquated equipment and assumes the functions of the Facility Exhaust System (FES), recirculation air conditioning unit and steam heating units. The existing FES roof fans remain in place but their use has been reduced to a backup for the new system to ensure continuity of reactor operations and provide additional air flow when demanded for cooling efficiency. A new energy efficient commercial HVAC unit was installed to provide exhaust, recirculation and temperature control for the reactor bay and low bay environments. The modification adds a

separate heating and cooling unit for the control room. For more information on this system, consult the February 2012 license amendment request or AP-12: 2012-01, on file at the PSBR.

- In May 2012, the PSBR transitioned from core load 53 to core load 54. Six used 8.5wt% TRIGA fuel elements in the B-Ring were replaced with six unused 8.5wt% elements. Another thirty-four 8.5wt% elements located throughout the core were replaced with lower burnup 8.5wt% elements. The graphite reflector elements around the core were removed. The table below compares key parameters for Core 53 and Core 54.

| Parameter | Initial Core 53 | Initial Core 54 |
|---|---|---|
| Total TRIGA Fuel Elements | 102 | 100 |
| 12 w/o | 37 | 37 |
| 8.5 w/o | 65 | 63 |
| Graphite Reflectors | 10 | 0 |
| Excess Reactivity (at D2O) | $6.85 | $6.70 |
| Power Defect at 1MW | $3.60 | $3.72 |
| Transient Rod Worth (at R1) | $3.01 | $3.01 |

- In June 2012, the existing Facility Exhaust System was modified after it was determined that its operational design resulted in non-compliance with Technical Specification (TS) 3.5 *Engineered Safety Features – Facility Exhaust System and Emergency Exhaust System* during TS required testing of the Evacuation Alarm. TS 3.5 requires that at least one facility exhaust fan be operating if the reactor is not secured. When an evacuation is initiated, the fans are secured as described in the basis of TS 3.5. In order to terminate the evacuation alarm test and return the fans to service, the reactor key must be used to reset the console. Whenever the key is inserted the reactor is not "secured" as per TS 1.1.29 *Reactor Secured*. In order to allow continued operation of the reactor while awaiting a TS amendment, a three position (Hand|Off|Auto) selector switch was added to override the fan control system and allow testing without violation of TS 3.5.

## Procedures

- In August of 2011, Standard Operating Procedure 1 (SOP-1) "Reactor Operating Procedure", was changed to incorporate multiple improvements to address human performance error traps and standardize operational methods. The changes enhance the safety of the facility and will not alter the function or methods for reactor operation, therefore report by 50.59 is not required.

- In June 2012, Standard Operating Procedure 2 (SOP-2) "Daily Checkout Procedure", and Standard Operating Procedure (SOP-4A) "Radiation, Evacuation and Alarms Check", were changed to reflect the changes made to the Facility Exhaust System (FES). The new revisions of SOP-2 and SOP-4A defeat the emergency operation of the FES to allow for channel checks and Channel Tests of the Evacuation System and Emergency Exhaust. A request for an expedited

amendment to Technical Specification was submitted to the Nuclear Regulatory Commission and was issued October 12, 2012 to allow these changes to be reversed. A report on the changes was not required under 10 CFR 50.59.

Additionally, 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 2011, Pulse Mode operation at the FNI tube experimental fixture was evaluated and implemented at the PSBR facility. Previously, the pulse mode operation was performed only at the open pool (R1) location and had not been evaluated at other locations. The evaluation indicated the pulse operation at the experimental fixture did not require a report per 10 CFR 50.59.

## 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 report 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 20% of the allowed concentrations.

### Argon-41 ($^{41}$Ar)

Gaseous effluent $^{41}$Aris 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 very 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 method

includes direct release from the pool as well as release from the FNI fixture and calculates a production of 2377 mCi for 585 MWh of operation in 2011-2012. Some of this $^{41}Ar$ will decay in place, but if all the $^{41}Ar$ were released it represents less than 4% of the release limit.

### Tritium ($^{3}H$)

Tritium is released by evaporation of reactor pool water as a gaseous release. The total makeup to the reactor pool in 2011-2012 was approximately 13,140 gallons or 1.5 gallons per hour. The evaporative loss rate is dependent on relative humidity, temperature of air and water, air movement, etc.

For a pool tritium concentration of 21,387 pCi/l (average for July 1, 2011 to June 30, 2012) the Tritium activity released from the ventilation system would be ~1,064 µCi. A dilution factor of $2 \times 10^{8}$ 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 | 1100 | micro curies |
| Average concentration, unrestricted area | <2x10-13 | µCi/ml |
| Permissible concentration, unrestricted area | 1x10-7 | µCi/ml |
| Percentage of permissible concentration | <0.0002 | % |
| Calculated effective dose, unrestricted area | <1x10-4 | 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 at control points in one residential area several miles away. The net measurements (in millirems) tabulated below represent the July 1, 2011 to June 30, 2012 reporting period.

| *Location* | *3rd Qtr '11* | *4th Qtr '11* | *1st Qtr '12* | *2nd Qtr '12* | *Total* |
|---|---|---|---|---|---|
| **Fence North** | 2 | 6 | 4 | 5 | 17 |
| **Fence South** | 3 | 7 | 2 | 4 | 16 |
| **Fence East** | 2 | 6 | 2 | 5 | 15 |
| **Fence West** | 6 | 5 | 5 | 3 | 19 |
| **Pleasant Gap** | 7 | 11 | lost | 0 | 17 |

There is no meaningful increase in exposure at the facility fence-line due to licensed operations for the current fiscal year.