PennState
College of Engineering

RADIATION SCIENCE &
ENGINEERING CENTER

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BREAZEALE
Nuclear Reactor

December 21, 2021

Attention Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555-0001

To Whom It May Concern:

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, 2020 to June 30, 2021, as required by our Facility Operating License R-2, Appendix A, Section 6.6.1.

Please contact me with any questions you have regarding this report.

Sincerely,

Jeffrey A. Geuther, Ph.D.

Acting Director
Associate Director for Operations

Radiation Science and Engineering Center
109 Breazeale Nuclear Reactor
University Park, PA 16802

Enclosures:

Annual Operating Report, FY 20-21

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Penn State Breazeale Reactor
Annual Operating Report, FY 2020 – 2021

License R-2, Docket 50-005

Reactor Utilization

The Radiation Science and Engineering Center (RSEC) houses the Penn State Breazeale Reactor (PSBR), a TRIGA Mark III reactor capable of 1 MW steady state operation and pulses of up to approximately 2000 MW peak power. Utilization of the reactor and its associated facilities falls into three major categories:

Education

The RSEC's several radiation laboratories allow for an interactive learning environment and supply the equipment necessary for several Nuclear Engineering courses. The RSEC hosts approximately 3000 visitors each year for public outreach and educational support. These visits vary from visiting faculty and graduate level classes to scouting and middle school field trips. The number of in-person visits was greatly reduced in 2020 and 2021 due to COVID restrictions. However, many of the outreach activities previously supported through in-person visits were successfully converted to online activities. Our facility also strives to educate members of the public about the many benefits of nuclear power as well as the diverse applications of radiation across several fields of study. Some of the major topics covered in public outreach sessions are radiation basics, nuclear security, and reactor physics.

Research

The research performed at the RSEC is associated with several different colleges as the University. RSEC staff, professors, and graduate students all play a key role in maintaining a constant flow of research projects through the facility. The RSEC maintains flexibility with radiation laboratories and equipment to support research such as thermo-acoustic testing, reactor instrumentation testing, neutron and gamma ray detection, radiation signatures from used fuel elements, neutron activation analysis, and neutron imaging applications. With the new core moderator assembly and new beam ports installed in 2018 the RSEC has five new neutron beam ports with total seven neutron beam lines. One of the neutron beam ports will have a mesitylene based cold neutron source. Three super mirror neutron guides are being installed on cold neutron beam line. The RSEC is working to expand the neutron beam hall, including the installation of a small angle neutron spectrometer (SANS) donated by Helmholtz Zentrum-Berlin, Germany. In order to fit the SANS facility and other new neutron beam techniques ,an expanded neutron beam hall building is being constructed. The new expanded neutron beam hall will add approximately 5,000 sq ft of the existing neutron beam laboratory. The SANS is scheduled for delivery in 2022, shortly after the completion of the neutron beam hall.

Service

The resources available at the RSEC, paired with the diverse capabilities of the PSBR, allow us to serve the industry, government institutions, and other universities and satisfy the unique needs of several domestic and international entities. The RSEC is frequently involved in neutron radiography for composition uniformity testing as well as providing fast neutron irradiation fluxes to support the nation's defense infrastructure. Also, the RSEC remains at the forefront of neutron transmission testing for spent fuel storage and equipment to be used at nuclear utilities.

The PSBR facility operates on an 8 AM – 5 PM shift, five days per week, with early morning, evening, and weekend shifts as necessary to accommodate laboratory courses, public education, university research, or industrial service projects. This schedule was reduced in 2020 and 2021 due to COVID-based restrictions on campus access; however, all procedures required by the Technical Specifications were completed on schedule, and research identified as critical infrastructure support was supported throughout the pandemic.

Technical Specification 6.6.1.a – Summary of Reactor Operating Experience

Between July 1, 2020 and June 30, 2021, the PSBR was utilized as follows.

Mode of Operation	Time [hours]	Hours per Shift
Critical	557.9	2.5
Sub-Critical	150.5	0.7
Shutdown	447.6	2.0
TOTAL	1158.0	5.2

The reactor was pulsed a total of 55 times with the following reactivities:

Reactivity	Number of Pulses
<$2.00	12
$2.00 to $2.50	42
> $2.50	1
TOTAL	55

The square wave mode was used a total of 21 times to operate the reactor with power levels between approximately 100 and 500 kilowatts.
Total energy produced during this reporting period was 238.7 MWh, corresponding to the consumption of approximately 12.3 g of ^{235}U.

Technical Specification 6.6.1.b – Unscheduled Shutdowns

There were zero unscheduled shutdowns due to unintentional scrams during the reporting period. The operations team, as well as all RSEC staff, work to maintain a safe and efficient operating environment. They work to maintain a high level of facility knowledge by reviewing previous events and holding routine training sessions that allow them to operate successfully and without incident.

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

TS-required maintenance and surveillances were completed within required time frames. Non-routine maintenance and repair is documented under facility procedure # AP-13. Safety-related maintenance during the reporting period was as follows. Additional AP-13 records for non-safety significant issues are available for review upon request.

1/7/2021 A battery in the console UPS failed testing during the annual UPS preventative maintenance procedure and was replaced.

1/15/2021 The transient (pneumatic) control rod air supply hose was replaced due to age-related failure.

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

Facility changes are processed via procedure AP-12. The following major change was completed during the reporting period per 10CFR50.59. Various minor changes that did not require 10CFR50.59 reviews are not included below but are available for review upon request. Several change reviews related to changing the control console and control rod drive electronics were open during the reporting period, but were completed during the following fiscal year and are therefore excluded from this operating report.

Change ID	Date Approved	Description
2020-06	5/13/21	The expansion of the neutron beam laboratory, including the addition of new office space in the floor above the laboratory, was approved. This change is tangential to a previously-reported change, AP12 #2020-03, in which the underground waste water and processed water tanks are to be moved into the new beam laboratory. Construction of the beam laboratory is underway and is scheduled for completion around May 2022. The wastewater tanks have been removed and the surrounding soil has been verified to be free of radioactive contamination.

Procedures

Procedures are normally reviewed biennially, and on an as-needed basis. Numerous minor changes and updates are made during the year and do not require a report under 10CFR50.59.

New Tests and Experiments

The tests / experiments performed at the RSEC during FY2020-2021 were typical and did not require 10CFR50.59 evaluation or reporting.

Technical Specification 6.6.1.e – Radiological Effluents Released

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 sanitary sewer per 10CFR20, and solidification for shipment to licensed disposal sites.

Gaseous

All gaseous releases were less than 10% of the allowed concentrations and do not require a 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 CO_2-operated pneumatic sample transfer system (i.e., "rabbit"). The amount of ^{41}Ar released from the reactor pool is dependent on 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 bay exhaust were 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 ^{41}Ar release, all power operations were assumed to take place at the Fast Neutron Irradiator (FNI) Tube, the location of the greatest ^{41}Ar production and release.

The calculation method includes direct release from the pool in addition to release from the FNI fixture and estimates a quantity of 1053 mCi of ^{41}Ar released for the 238.7 MWh of operations which took place during FY2020-21. A portion of the ^{41}Ar will decay in place, however, if all of the ^{41}Ar were released, it represents 0.9% of the annual limit.

Parameter	Value	Units
Argon-41 produced	1490	mCi
Average concentration, unrestricted area	0.9×10^{-10}	µCi / mL
Permissible concentration, unrestricted area	1.0×10^{-8}	µCi / mL
Percentage of permissible concentration	0.9	%
Calculated effective dose, unrestricted area	1.1	mrem / year

Tritium (^{3}H)

Normally tritium is only released from the reactor facility due to the evaporation of reactor pool water. The total makeup to the reactor pool for FY2020-2021 was 12188 gallons, or 1.39 gal / hr. The evaporative loss rate is dependent on air movement, relative humidity, temperature of air and water, etc. Based on the measured average pool tritium concentration of 32052 pCi / L (averaged between July 1, 2020 – June 30, 2021), the total tritium activity released through ventilation would be ~1477 µCi.

A dilution of factor of 2.0×10^{8} mL / sec was used to calculate that unrestricted area concentration. This is from 200 m^2 (cross sectional area of the building) times an assumed wind speed of 1 m / sec. These are the same values used on the reactor Safety Analysis Report.

Parameter	Value	Units
Tritium released	1477	µCi
Average concentration, unrestricted area	2.34×10^{-13}	µCi / mL
Permissible concentration, unrestricted area	1.00×10^{-7}	µCi / mL
Percentage of permissible concentration	0.0002	%
Calculated effected dose equivalent, unrestricted area	$\sim 1.00 \times 10^{-4}$	mrem

Technical Specification 6.6.1.f – Environmental Surveys

The only environmental surveys performed were the routine environmental dosimeter measurements at the facility fence line and an off-site point at a childcare center approximately 100 yards from facility. The following table summarizes the net measurements, in millirem, for the current reporting period.

Quarter	North Fence	South Fence	East Fence	West Fence	Childcare	
2020 Q3	10 [mrem]	14 [mrem]	10 [mrem]	16 [mrem]	4 [mrem]	
2020 Q4	9	11	9	11	1	
2021 Q1	11	11	8	10	1	
2021 Q2	3	2	7	7	1	