

NORTH CAROLINA STATE UNIVERSITY
DEPARTMENT OF NUCLEAR ENGINEERING
PULSTAR REACTOR ANNUAL REPORT

DOCKET NUMBER 50-297

For the Period: 01 January 2018 - 31 December 2018

The following annual report for 2018 is submitted in accordance with Section 6.7.4 of the North Carolina State University PULSTAR Reactor Technical Specifications:

6.7.4.a Brief Summary:

Reactor operations have been routine during this reporting period.

i Operating experience including a summary of experiments performed.

The reactor facility had a total of 2776 utilization hours. The utilization hours exceeded critical hours (1423 h) since there was typically more than one user of the reactor facility at a given time. The following is a brief summary of the types of experiments performed:

Teaching Laboratories, Short Courses, Research and Services:

- Core thermal power measurements
- Dynamic reactivity measurements
- Axial power and peaking factor measurements (flux mapping)
- Reactor power determination using photodiode arrays
- Neutron fluence and spectral measurements
- In-core detector certification
- Accelerated lifetime testing for nuclear detectors
- Neutron radiography
- Positron production facility
- Neutron Diffraction
- Isotope Production
- Crude oil
- Food samples
- Fish tissues
- Laboratory animal tissue
- Human hair, nails, and urine
- Polymers and plastics
- Sediment/soil/rocks
- Silicon crystals
- Textiles
- Water

ii Changes in Performance Characteristics Related to Reactor Safety:

None

iii Results of Surveillance, Tests, and Inspections:

The reactor surveillance program has revealed no significant or unexpected trends in reactor systems performance during this reporting period. The Reactor Safety and Audit Committee (RSAC) performed its annual audit for the facility and determined that all phases of operation and supporting documents were in compliance.

6.7.4.b Energy Output and Critical Hours:

Total Energy Output in 2018:	56.4 Megawatt-days
Critical hours in 2018:	1423.0 hours
Cumulative Total Energy Output Since Initial Criticality:	1985.8 Megawatt-days

6.7.4.c Number of Emergency and Unscheduled Shutdowns:

Emergency Shutdowns - NONE

Unscheduled Shutdowns – One

8-JAN-2018 SCRAM due to Air in Flow Annubar. On January 8, 2018, at approximately 15:09, a Low Flow SCRAM was received in the control room due to high flow indication. The reactor operator followed procedure and confirmed that a SCRAM occurred and verified that the reactor had shutdown and was in a safe condition. The RO then notified the DSRO as required.

The SCRAM was caused by air being trapped in the flow annubar resulting in a false high flow indication. Actual flow was nominally 500 gpm. The annubar had been recently relocated and residual air was still entrained in the system. Refer to Control Number 837.

The reactor was authorized for restart.

6.7.4.d Corrective and Preventative Maintenance:

Preventative maintenance, tests and calibrations are scheduled, performed and tracked utilizing the PULSTAR Surveillance File System. Each major component of the Reactor Safety System defined in Section 3.3, and all surveillance required by Section 4 of the Technical Specifications are monitored by this file system to ensure that maintenance and calibrations are performed in a timely manner. All historical data relating to those components, in addition to many other sub-systems, are maintained in these files.

837 PS-2-03A – Primary Flow Annubar – Relocation and calibration of flow annubar as per Design Change 830 (approved in 2017). The modification was to relocate the annubar to a more ideal location to prevent entrained air from entering the annubar and causing false low/high flow indication.

838 PS-1-14-6 – R-63 Fan Switch – Replacement of the R-63 Fan paddle-type flow switch. The annunciator for R-63 Fan Low Flow would not clear even though the fan was operating. Upon inspection it was discovered that the paddle was torn. The switch was replaced and returned to service.

839 PS-3-02-6 – Cooling Tower Filter Skid – It was noticed that there was low flow in the filter system. Upon recommendation from the manufacturer, the filters were cleaned and the unit returned to service.

- 840 PS-2-01-1B/2B – Reactor Air Compressor and Dryer – The air compressor was approaching the useful life (20 years) so it was replaced with a new unit. The air dryer was also replaced at the same time.
- 841 PS-1-02-4B – Log N Channel – The NON-OPER lit would not clear during the performance of the startup checklist. Upon investigation the detector housing o-ring seal had leaked allowing water to enter the housing causing the detector to fail. The detector, cables and connectors were replaced. The drawer was calibrated and returned to service.
- 842 PS-1-05-3A – Safety Channel – During the performance of the Startup Checklist the counts per second indication on the meter and on the recorder were found to be not in agreement. The opto-isolator was replaced and the drawer was calibrated and returned to service.
- 843 PS-3-02-5A – Cooling Tower Solenoid Bleed Valve – The cooling tower solenoid bleed valve was stuck open causing a continuous blowdown of the cooling tower basin. The valve was replaced.

6.7.4.e Changes in Facility, Procedures, Tests, and Experiments:

Facility Changes

Design changes to the reactor facility are reviewed to determine whether or not a 10 CFR Part 50.59 evaluation was required. Evaluations were performed for all design changes.

- 831 Conversion of Shim Rod to 24 VDC Operation – The Shim Rod drive motor is being converted from 120 VAC to 24 VDC to eliminate the electronic noise from AC motors. The conversion involves the replacement of the drive motor and analog position encoder. The drive switch, up/down drive limit switches, up/down limit indication switches and console position indication remain unchanged as are all interlocks associated with the Shim Rod. The modification is scheduled to be completed in 2019. Once completed and tested satisfactorily the other three control rods will be similarly converted under a separate design change.

Document Changes

Procedure changes were reviewed to determine whether or not a 10 CFR Part 50.59 evaluation was required. Based on the screening reviews none required a full 10 CFR 50.59 evaluation.

- 828 PS-6-16-2 W/M/A – *Processing, Sampling, Analysis, and Assessment of Liquid Effluent, Revision 3* – The purpose of the change was to include leak testing of the liquid waste line, waste tank integrity check, and to change sample preparation for tritium analysis. System diagrams were also updated.

Test and Experiments

Experiment changes were reviewed to determine whether or not a 10 CFR Part 50.59 evaluation was required.

- 832 Production of Mo-99 – The purpose of this experimental review is to allow for the continued testing of the production of Mo-99. Experience after the first two short irradiation tests (Refer to Control Number 821 from 2017) have resulted in predictable and manageable activities and dose rates. This document sets the requirements and limitations for the production, handling and shipping of Mo-99.

Other Changes

- 820 License Renewal – A partial response to RAI dated October 18, 2018 was submitted on December 13, 2018.
- 734 License Amendment for Fueled Experiments – A license amendment for fueled experiments was submitted on December 4, 2018. This request is based on revised analysis and replaces all previous submittals.

Other Items

None.

6.7.4.f Radioactive Effluent:

Liquid Waste (summarized by quarters)

i. Radioactivity Released During the Reporting Period:

Releases to the sanitary sewer are given below:

Period	(1)	(2)	(3)	(4) ¹	(5)
2018	Number of Batches	Total μ Ci	Total Volume Liters	Diluent Liters	Tritium μ Ci
01 JAN – 31 MAR	2	954	6,750	23,600	951
01 APR – 30 JUN	3	716	9,990	10,300	712
01 JUL – 30 SEP	4	281	13,200	13,300	274
01 OCT – 31 DEC	2	130	6,340	6,400	129
2018	2,066 μ Ci of tritium was released during this year.				
2018	2,077 μ Ci of total activity was released during this year.				
¹ Based on gross beta activity only. Tritium did not require further dilution.					

ii. Identification of Fission and Activation Products:

The gross beta-gamma activity of the batches in (i) above were less than 2×10^{-5} μ Ci/ml. Isotopic analyses of these batches indicated low levels of typical corrosion and activation products. No fission products were detected.

iii. Disposition of Liquid Effluent not Releasable to Sanitary Sewer System:

All liquid effluent met the requirements of 10 CFR Part 20 for release to the sanitary sewer.

Gaseous Waste (summarized monthly)

i. Radioactivity Discharged During the Reporting Period (in Curies) for:

(1) Gases:

Year	Month	Total Time Hours	Curies
2018	JANUARY	744	0.694
	FEBRUARY	672	0.407
	MARCH	744	0.315
	APRIL	720	0.224
	MAY	744	0.532
	JUNE	720	0.130
	JULY	744	0.096
	AUGUST	744	0.665
	SEPTEMBER	720	0.305
	OCTOBER	744	0.756
	NOVEMBER	720	0.359
	DECEMBER	744	0
	TOTAL	8760	4.483

(2) Particulates with a half-life of greater than eight days:

Particulate filters from the Stack Particulate Monitoring Channel were analyzed upon removal. There was no particulate activity with a half-life greater than 8 days detected.

ii. Gases and Particulates Discharged During the Reporting Period:

(1) Gases:

Total activity of Argon-41 released was 4.483 Curies in 2018.

The yearly average concentration of Argon-41 released from the PULSTAR reactor facility exhaust stack in 2018 was 2.2×10^{-8} $\mu\text{Ci/ml}$. Dose calculations for the year were performed using methods given in the Final Safety Analysis Report and gave results less than the 10 CFR Part 20 constraint level of 10 mrem. These results are consistent with environmental monitoring data given in Attachment A.

(2) Particulates:

Refer to gaseous waste i.(2) above. No activation or fission products were detected.

Solid Waste from Reactor

i. Total Volume of Solid Waste Packaged

Total volume of solid waste was 26 ft³.

ii. Total Activity Involved

Total activity for solid waste was 0.918 mCi.

iii. Dates of shipments and disposal

Transfer of solid radioactive waste to the university broad scope radioactive materials license was made in February 2018, March 2018, and April 2018. The University Environmental Health and Safety Center arranges disposal of hazardous wastes.

6.7.4.g Personnel Radiation Exposure Report:

Thirty individuals were monitored for external radiation dose during the reporting period. Internal dose monitoring was not required for any individual. Collective deep dose-equivalent for 1 Jan 2018 to 31 Dec 2018 was 1.329 person-rem. Individual deep dose-equivalent ranged from 0.001 rem to 0.483 rem with a median of 0.036 rem and average of 0.043 rem.

6.7.4.h Summary of Radiation and Contamination Surveys Within the Facility:

Radiation and contamination surveys performed within the facility indicated that:

- Radiation in the majority of areas was 5 mrem/h or less.
- Radiation in the remaining areas was higher due to reactor operations.
- Contamination in most areas was not detectable. When contamination was detected, the area or item was confined or decontaminated.

6.7.4.i Description of Environmental Surveys Outside of the Facility:

Refer to Attachment A for results of environmental sampling and analysis.

Radiation surveys performed in unrestricted areas near the reactor facility indicated that:

- Radiation was at background levels for most areas (background is approximately 10 μ rem/h).
- Contamination was not detectable.
- Net radiation readings ranged from 0 to 30 μ rem/h while the reactor was operating at power. However, radiation was at background levels in all routinely occupied spaces.
- Water samples from Rocky Branch Creek and an on-site ground water monitoring well were analyzed in 2018 for tritium, gross beta activity, gross alpha activity, and gamma radiation. All sample results were consistent with background radioactivity. Environmental monitoring of Rocky Branch Creek and groundwater is routinely performed in accordance with facility procedures.