

PULSTAR REACTOR ANNUAL REPORT TO
UNITED STATES NUCLEAR REGULATORY COMMISSION

for

01 July 1996 - 30 June 1997

NCSU NUCLEAR REACTOR PROGRAM

27 August 1997

Reference: PULSTAR Technical Specifications
Section 6.7.4

Docket No. 50-297

Department of Nuclear Engineering
North Carolina State University
Raleigh, North Carolina 27695

9709020158 970827
PDR ADOCK 05000297
R PDR

DEPARTMENT OF NUCLEAR ENGINEERING

PULSTAR REACTOR ANNUAL REPORT

DOCKET NUMBER 50-297

For the Period: 01 July 1996 - 30 June 1997

The following report is submitted in accordance with Section 6.7.4 of the PULSTAR Technical Specifications:

6.7.4.a Brief Summary

Reactor operations have been routine during this reporting period. With the exception of an auto-ranging circuit malfunction in the new Safety Power Monitor which was reported to the NRC in January 1997, there have not been any unexpected maintenance or operational problems during this reporting period.

(i) (1) Reactor Operating Experience:

The NCSU PULSTAR Reactor has been utilized for the following:

• Teaching and Short Courses	78.9 hours
• Faculty and Graduate Student Research	58.9
• Isotope Production	18.4
• Neutron Activation Analysis	975.3
• Beam Tube Facilities	13.2
• Nuclear Training (Utilities)	45.9
• PULSTAR Reactor Training	8.0
• Reactor Cal/Measurements & Surveillance	35.2
• Reactor Health Physics Surveillance	7.2
• Reactor Sharing	0.0

TOTAL 1,241.0 hours

Last reporting period: 1,320.8 hours

(2) A Summary of Experiments Performed in the Reactor:

- Reactor thermal power measurements for teaching laboratories.
- Neutron temperature measurements for teaching laboratories.
- Neutron diffusion length in graphite for teaching laboratories.
- Neutron fluence and spectral measurements for teaching laboratories.
- Primary coolant natural convection flow studies using ^{16}N gamma radiation for teaching laboratories.
- Neutron Activation Analysis of tissue, sediments/soil, rain/river water, vegetation, wood pulp, fibers, polymers, ceramics, silicates, dust, coal, fly ash, tar, oil residue, and graphite.
- Prompt gamma analysis of lithium aluminate.
- Radiation damage testing for superconducting materials and detector components.

(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 with one exception. During each startup checklist, tests of the PULSTAR Scram Logic Unit were successfully completed by verifying that each SCRAM input caused magnet power to be disconnected from the control rod magnets. What remained untested was which of the redundant circuits in the unit actually caused the SCRAM. This facility finding was reported to the NRC on 11 December 1996. See 6.7.e.2.b for details of the new procedure. The annual facility and records inspection was determined to be satisfactory by the Reactor Safety and Audit Committee.

6.7.4.b Total Energy Output:

23.3 Megawatt·days

Reactor was Critical:

706.5 hours

Cumulative Total Energy Output Since Initial Criticality:

832.4 Megawatt·days

6.7.4.c Number of Emergency and Unscheduled Shutdowns:

1. Unscheduled Shutdowns - 2 total
 - a. Safety Channel auto-ranging failure
 - b. Spurious Over-the-Pool Radiation Monitor evacuation

Explanation of 1a. above:

The Power Monitor in the Safety Channel unexpectedly downranged from the normal 1MW range during a startup. The operator shut down the reactor by manual SCRAM. The original Safety Picoammeter was re-installed and reactor operations were resumed. See 6.7.4.e.1.a for details of the change. The Power Monitor was returned to the manufacturer for repairs and modifications.

Explanation of 1b. above:

A spurious, non-radiation induced spike caused the Over-the-Pool (O-T-P) Radiation Monitor to initiate Reactor Building evacuation while the reactor was operating at power. The operator shut down the reactor by manual SCRAM. The specific cause of the spike could not be determined, but there was no evidence that it was from radiological sources after comparison with data from other instruments in the Reactor Building. The O-T-P detector was exchanged with a spare unit, calibrated, and placed in service. To date no spiking has been observed.

6.7.4.d Corrective and Preventative Maintenance:

The uncompensated ionization chamber (detector) electrical cables were replaced in the Safety Channel. The original cables had been in service for more than twenty years and started producing spurious spikes of a few percent in magnitude.

Preventative maintenance, tests and calibrations are performed under a system called 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 timely maintenance and calibrations. All historical data relating to those components in addition to many other minor components are maintained in these files.

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

1. Design Changes

- a. DC 97-1 authorized the reinstallation of the original Safety Picoammeter in the console while the Safety Power Monitor is being repaired by the manufacturer. This design change included a 10 CFR 50.59 evaluation and Revision 19 to the PULSTAR Operations Manual which addressed the procedural differences caused by the reinstallation of the original nuclear instruments.
- b. DC 97-2 modified the Startup Channel so that an inhibit could be locked in by a toggle switch after shutdown to prevent spurious alarms. As required by the installation of the new switch, this design change included a 10 CFR 50.59 evaluation and Revision 20 to the PULSTAR Operations Manual.

2. Procedure Changes

- a. NP 96-9 was a new procedure to account for primary water inventory. It had previously been a standing order.
- b. NP 96-10 was a new PULSTAR Surveillance procedure to perform quarterly testing of the SCRAM Logic Unit redundant circuits which removes magnet current from the control rods. Testing of the unit to verify that it will cause a SCRAM when required has been and still is done as part of reactor startup checklists. See 6.7.4.a (iii) above.
- c. PC 1-97 updated procedures used by the Environmental Health & Safety Division for PULSTAR related environmental sampling and background radiation measurements.
- d. PC 2-97 was Revision 4 to the PULSTAR Surveillance procedure for the Pool Level Channel calibration.
- e. PC 3-97 was Revision 1 to the PULSTAR Surveillance procedure for the Stack Particulate Measuring Channel calibration.
- f. A total of thirteen procedures were written or revised covering the calibration of reinstalled equipment described in (1) above, reactor operations, surveillance, and Health Physics. These procedures have been reviewed and approved by the Reactor Safety and Audit Committee (RSAC) and the Radiation Protection Committee (RPC).

6.7.4.f Radioactive Effluent:

1. Liquid Waste (summarized by quarters)

i. Radioactivity Released During the Reporting Period:

Period	(1) No. of Batches	(2) Total μCi	(3) Tot. Vol. Liters	(4) ¹ Diluent Liters	(5) Tritium μCi
01 Jul - 30 Sep 96	3	47	8,700	2.0E4	43
01 Oct - 31 Dec 96	1	8	2,400	7.0E3	7
01 Jan - 31 Mar 97	1	24	3,400	1.7E4	23
01 Apr - 30 Jun 97	3	64	8,100	1.4E5	50

(6) 123 μCi of tritium were released during this reporting period.

(7) 143 μCi total activity released during this reporting period.

ii. Identification of Fission and Activation Products:

The gross beta-gamma activity of the batches in (1) above were less than $2 \times 10^5 \mu\text{Ci/ml}$. 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 20 for release to the sanitary sewer.

¹ Based on gross beta activity only. Tritium did not require further dilution.

2. Gaseous Waste (summarized monthly)

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

(1) Gases:

<u>Year</u>	<u>Period</u>	<u>Total Time In Hours</u>	<u>Curies</u>
1996	01 Jul - 31 Jul	744	0.188
	01 Aug - 31 Aug	744	0.304
	01 Sep - 30 Sep	720	0.145
	01 Oct - 31 Oct	744	0.185
	01 Nov - 30 Nov	720	0.074
	01 Dec - 31 Dec	744	0.100
1997	01 Jan - 31 Jan	744	0.156
	01 Feb - 28 Feb	672	0.426
	01 Mar - 31 Mar	744	0.244
	01 Apr - 30 Apr	720	0.170
	01 May - 31 May	744	0.202
	01 Jun - 30 Jun	720	0.177
	Totals	8,760	2.371

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

Filters from the particulate monitoring channel were analyzed upon removal. There was no particulate activity indicated on any filter during this reporting period.

ii. Gases and Particulates Discharged During the Reporting Period:

(1) Gases:

Total activity of argon-41 release was 2.371 curies.

The yearly average concentration of argon-41 released from the PULSTAR reactor facility exhaust stack during this period was $7.1E-9 \mu\text{Ci/cc}$. This is below the regulatory limit of $1 \times 10^{-8} \mu\text{Ci/cc}$ in 10 CFR 20 Appendix B. Dose calculations were performed using "COMPLY" code for the fiscal year. Results were less than the 10 mrem constraint levels given in 10 CFR 20.

- (2) Particulates:
See gaseous waste 1.(b) above.

3. Solid Waste from Reactor²

- Total volume of solid waste - 65.3 ft³ (1.85 m³)
- Total activity of solid waste - 2.18 mCi
- Dates of shipments and disposal:

All waste is in storage at the NCSU Environmental Health and Safety Center disposal facility.

6.7.4.g Personnel Radiation Exposure Report

Twenty-five members of the faculty and staff were monitored for external radiation exposure during the reporting period. Six of the twenty-five received measurable exposure which ranged from 0.01 to 0.04 rem. Total person-rem for the faculty and staff was 0.11.

Approximately 40 film badges were issued to students, short course participants, and visitors. Radiation exposures ranged to 0.03 rem. The majority of these exposures were in the "no measurable exposure" range.

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

Radiation and contamination surveys performed within the facility by the PULSTAR staff indicated that:

- external radiation levels in the majority of areas were <2 mrem/h
- contamination levels in most areas were not detectable
- when contamination was detected, the area or item was confined or decontaminated
- external radiation levels in the remaining areas were as expected due to reactor operations

² Due to the failure of North Carolina to license a low level radioactive waste site, solid waste generated at the PULSTAR Reactor can no longer be shipped for burial and must be stored on campus. A total of 30 ft³ (0.85 m³) of spent resins with an activity of 1.60 mCi from previous years of operation were de-watered and processed for future land burial or incineration. The remaining solid waste is composed of compacted trash, debris, and sources/samples that are no longer useful.

6.7.4.i Description of Environmental Surveys Outside of the Facility

See Attachment A prepared by the Radiation Protection Division of the Department of Environmental Health and Safety.

Perimeter surveys were performed adjacent to the Reactor Building by the PULSTAR staff and indicated that:

- external radiation levels were at background levels for most areas (10 μ rem/h)
- contamination levels were not detectable
- Net external radiation levels ranged up to 20 μ rem/h in some areas when the reactor was operating at power. However, external radiation levels were at background levels in routinely occupied spaces.