PULSTAR REACTOR ANNUAI REPORT TO

UNITED STATES NUCLEAR REGULATORY COMMISSION

for the

Period 01 July 1993 - 30 June 1994

NCSU NUCLEAR REACTOR PROGRAM

24 August 1994

Reference: PULSTAR Technical Specifications
Section 6.7.5

Docket No. 50-297

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

DEPARTMENT OF NUCLEAR ENGINEERING

PULSTAR REACTOR ANNUAL REPORT

For the Period: 01 July 1993 - 30 June 1994

The following report is submitted in accordance with Section 6.7.5 of the PULSTAR Technical Specifications:

6.7.5.a Brief Summary

In November of 1993 the PULSTAR Reactor was placed in a shutdown status when primary water inventory calculations showed a slight increase in unaccountable water loss. After extensive testing and data collection, it was determined that the most probable location for the leak was at a gasketed flange in the buried primary piping. Isolation valves were closed and the buried portion of the piping was drained. Reactor operations, limited to 10 percent power and natural convection cooling mode, resumed in January 1994 after approval was granted by the Radiation Protection Committee while repairs are being made.

(1) Reactor Operating Experience:

The NCSU PULSTAR Reactor has been utilized for the following:

a.	Teaching and Short Courses	119.1	hours
b.	Faculty and Graduate Student Research	252.1	
c.	Isotope Production	1.9	
d.	Neutron Activation Analysis	1,278.5	
e.	Beam Tube Facilities	0.0	
f.	Nuclear Training (Utilities)	203.1	
g.	PULSTAR Reactor Training	8.9	
h.	Reactor Cal/Measurements & Surveillance	50.5	
i.	Reactor Health Physics Surveillance	11.9	
j.	Reactor Sharing	10.3	
	TOTAL	1,936.3	hours
	Same reporting period 1992-1993	2,664.7	hours

A cross section of experiments performed in the reactor:

a. Neutron Activation Analysis of filters, tissue, bone, protein solutions, hair, sediments/soil, rain/river water, vegetation, wood pulp, dyes, paper, electronic components, fibers, plastics, resins, polyfoam, coal, fly ash, graphite, steel, titanium, steam turbine residue, etc.
b. Reactor thermal power measurements for teaching laboratories.
c. Neutron diffusion length measurements in graphite.
d. Neutron Radiography of carbon cloth.
e. Prompt gamma analysis of silicon wafers.
f. Neutron fluence and spectral measurements.
g. Transmutation of silicon for semiconductor research.

(2) Changes in Performance Characteristics Related to Reactor Safety:

None

(3) Results of Surveillance, Tests, and Inspections:

The reactor surveillance program has revealed no significant or unexpected trends in reactor systems performance during this report period.

6.7.5.b Total Energy Output:

357.7 Megawatt · hours 14.9 Megawatt · days

Pulse Operations:

None

Reactor was Critical:

740.5 hours

Cumulative Total Energy Output since Initial Criticality:

18,822.6 Megawatt · hours 739.4 Megawatt · days

6.7.5.c Number of Emergency and Unscheduled Shutdowns:

Unscheduled Shutdowns - 3 total

(1) Safety #2 Drive stalled during startup.
(2) Safety #1 Drive stalled during startup.
(3) No Intermediate Range period information during Source Range/Intermediate Range overlap.

Inadvertent SCRAMs - 9 total

(4) Operator error - 1
(5) Spurious signals - 8

Explanation of (1) and (2) above:

The upper and lower sealed bearings of Safety #1 and #2 Control Rod Drive Mechanisms failed. See 6.7.5.d later in this report.

Explanation of (3) above:

The Intermediate Range INFINITY CK switch failed open during a routine startup and subsequent power increase. This failure prevented rate information from being displayed on the period meter. A new switch was installed and the channel was returned to service after calibration.

Explanation of (4) above:

Operator downranged the Linear Channel range switch instead of upranging causing an instantaneous reactor SCRAM.

Explanation of (5) above:

A trip circuit in the Intermediate Range Channel and the Safety Channel will generate a SCRAM upon loss of forced primary flow or if the safety flapper valve opens when power is above 15 percent. Recently the PULSTAR Reactor has been operating up to 10 percent power in natural convection cooling mode and with the safety flapper valve open in accordance with Section 3.9 of the PULSTAR Operations Manual. Electrical noise spikes generated within the console electrical system may instantaneously exceed the trip circuit setpoint and generate a SCRAM. This was verified by testing several combinations of switch actuations and causing a SCRAM signal to happen. The Intermediate Range

Channel was tested or calibrated after each occurrence and found to be operational. Only one Intermediate Range SCRAM occurred since April when an administrative limit of 8.5 percent power for routine operations was established. Since initial criticality most reactor operations were conducted at or near full power. During that time these circuits were always in their enabled state and as long as forced primary flow was present and the safety flapper valve was shut no SCRAM would occur. New Intermediate and Power Ranges instruments have been purchased and are undergoing acceptance testing. It is expected that these new instruments will greatly reduce the number of spurious SCRAMs.

6.7.5.d Major Maintenance Operations:

All of the Control Rod Drive Mechanisms (CRDM) were disassembled and inspected due to two of the units inability to withdraw control rods full travel. Several of the upper and/or lower bearings were starting to fail due to age. Because of the problems experienced with two of the CRDMs, the bearings in all of the drives were replaced. All drives were returned to service after post-maintenance testing.

An approximate 0.7 gallons per hour leak was suspected to have developed at a flange on the buried N-16 Delay Tank in the primary piping. As of this report a contractor has been selected to excavate the tank, build an underground vault enclosing the tank and the primary piping, make any repairs and return the primary system to service. Work is expected to take five months.

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

1. Design Changes

   (a) DC 93-1 installed a new temperature measuring recorder with digital display in the PULSTAR control console.

   (b) DC 94-1 authorized the installation of new Linear Power, Safety Power, and Intermediate Range instruments. Installation and testing should be completed by the end of this calendar year.

2. Procedure Changes

   (a) PC 32-93 was Revision 11 to the PULSTAR Operations Manual. These documented changes were required by the necessity to operate

in natural convection cooling mode due to pending repairs in the primary piping.

(b) PC 1-94 was Revision 12 to the PULSTAR Operations Manual. This revision documented changes required by the implementation 10 CFR 20 which went into effect in January 1994.

(c) A total of twenty-one procedures have been revised (most minor editorial changes) and twelve new procedures (ten Health Physics and two purification system special procedures) have been submitted or have already been reviewed and approved by the Radiation Protection Committee.

6.7.5.f Radioactive Effluent:

Liquid Waste (summarized by quarters)

1. Radioactivity released during the reporting period:

Period	(a) No. of Batches	(b) Total μCi	(c) Tot. Vol. Liters	(d) Diluent Liters	(e) Tritium μCi
01 Jul - 30 Sep 93	2	33	539	2.4×10^3	23
01 Oct - 31 Dec 93	5	198	1488	6.3×10^4	173
01 Jan - 31 Mar 94	4	125	1121	8.2×10^4	117
01 Apr - 30 Jun 94	2	25	537	2.6×10^4	22

NOTE: Increases in the total volume discharged from 01 Oct 93 to 30 Mar 94 was due to water loss testing and draining of the N-16 Tank and buried piping. The entire Primary System was isolated within the Reactor Building following the discovery of the leak.

(f) 381 μCi total activity released during this reporting period.

(g) 335 μCi of tritium were released during this reporting period.

2. Identification of Fission and Activation Products:

The gross alpha-beta-gamma activity of the batches in (a) above were less than 2×10^{-5} μCi/ml. An isotopic analysis of these batches indicated low levels of typical corrosion and activation products.

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3. Disposition of liquid effluent not releasable to Sanitary Sewer System:

All batches of 1(a) above when diluted by campus water (2.80×10^6 liters; the minimum daily campus intake) resulted in activity considerably less than 1×10^{-7} μCi/ml (10 CFR 20 limit). Therefore, all batches were released to the sanitary sewer system.

Gaseous Waste (summarized monthly)

1. Radioactivity discharged during the reporting period (in Curies) for:

(a) Gases:

Year	Period	Total Time In Hours	Curies
1993	01 Jul - 30 Jul	720	0.192
	31 Jul - 31 Aug	744	0.127
	01 Sep - 28 Sep	696	0.046
	29 Sep - 27 Oct	690	0.040
	28 Oct - 26 Nov	713	0.082
	27 Nov - 31 Dec	852	0.000
1994	01 Jan - 31 Jan	744	0.015
	01 Feb - 28 Feb	672	0.082
	01 Mar - 31 Mar	744	0.074
	01 Apr - 30 Apr	720	0.071
	01 May - 31 May	744	0.039
	01 Jun - 30 Jun	720	0.023
	Totals	8,759	0.791

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

Filters from the particulate monitoring channel were analyzed upon removal and again the following week. There was no particulate activity ((b) above) indicated on any filter during this reporting period.

2. Gases and particulates discharged during this reporting period:

(a) Gases:

The yearly average concentration of Argon-41 released from the PULSTAR reactor facility exhaust stack during this period was 5.27×10^{-9} μCi/cc. This is below the regulatory limit of 1×10^{-8} μCi/cc. (10 CFR 20 Appendix B)

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

Solid Waste from Reactor

1. Total volume of solid waste - 2.9 m^3 (102 $ft.^3$)

2. Total activity of solid waste - 0.1 mCi

3. Dates of shipments and disposal:

03 Jun 93	Chem-Nuclear Systems Inc. (CNSI)
06 Oct 93	Chem-Nuclear Systems Inc. (CNSI)
24 Nov 93	Chem-Nuclear Systems Inc. (CNSI)
14 Mar 94	Chem-Nuclear Systems Inc. (CNSI)

6.7.5.g Personnel Radiation Exposure Report[1]

Twenty-three members of the faculty and staff were monitored for external radiation exposure during the reporting period. Fourteen of the twenty-three received measurable exposure which ranged from 0.010 to 0.120 Rem. Total person-Rem for the faculty and staff was 0.810.

Approximately 18 film badges were issued to graduate students and temporary staff, 216 for short courses, and 225 film badges were issued for visitors. No significant radiation exposures were reported. The majority of these exposures were in the "no measurable exposure" range.

[1]Compiled and prepared by the Radiation Protection Office.

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

Neither the radiation nor the contamination surveys indicated any trend or shift of data from past experience or surveys.

6.7.5.i Description of Environmental Surveys Outside of the Facility

See Attachment A