UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30323

Report No.: 50-297/88-01

Licensee: North Carolina State University
Raleigh, NC 27607

Docket No.: 50-297 License No.: Pulstar R-120

Facility Name: North Carolina State University

Inspection Conducted: March 1-4, 1988

Inspectors: Frank Jape 4/4/88
for P. T. Burnett Date Signed

C Bassett 3/31/88
C. H. Bassett Date Signed

Approved by: Frank Jape 4/4/88
F. Jape, Section Chief Date Signed
Engineering Branch
Division of Reactor Safety

SUMMARY

Scope: This reactive and routine, announced inspection addressed the discovery of leaks in reactor coolant system piping outside the reactor building and in the isolable portion of the reactor primary system within the building as well as parts of the biennial inspection of Class II research reactors.

Results: No violations or deviations were identified.

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REPORT DETAILS

1. Persons Contacted

Licensee Employees

S. J. Bilyj, Chief of Reactor Maintenance
T. L. Brackin, Reactor Safety Specialist
*T. C. Bray, Reactor Operations Manager
S. M. Grady, Chief Reactor Operator
*K. V. Mani, Reactor Health Physicist
*G. D. Miller, Associate Director Nuclear Reactor Program
*D. W. Morgan, Radiation Protection Officer
*P. J. Turinsky, Head, Department of Nuclear Engineering
*B. W. Wehring, Director, Nuclear Reactor Program

Other licensee employees contacted included Nuclear Engineering Department Faculty, health physics technicians, operators, and office personnel.

*Attended exit interview

2. Exit Interview

The inspection scope and findings were summarized on March 3, 1988, with those persons indicated in paragraph 1 above. The inspector described the areas inspected and discussed in detail the inspection findings. The inspector expressed concern about any consideration of opening the pool isolation valves before the known leak in the cold leg is repaired and the condition of the buried piping is determined by examining a portion of that piping. The licensee acknowledged the concern and agreed to keep the primary system isolated until the integrity of the system was known. No dissenting comments were received from the licensee. Facility management agreed to keep Region II informed by telephone of significant finding resulting from the inspection of primary coolant system and the search for the leaks in the system. Licensee management also agreed to keep Region II informed of the results of the analyses of soil samples and other radiological surveys which will be taken during the ensuing excavation and pipe repair work. The licensee did not identify as proprietary any of the materials provided to or reviewed by the inspector during this inspection.

3. Licensee Action on Previous Enforcement Matters

This subject was not addressed in the inspection.

4. Unresolved Items

No unresolved items were identified.

5. Facility Status (92705)

The facility was shutdown on February 29, 1988 to investigate an increased rate of water makeup to the reactor pool. Over the preceding weekend, total water loss from the primary system had increased to approximately 190 gallons per day. Of this, only 50 to 60 gallons per day could be attributed to evaporation from the pool surface and to reactor coolant pump packing losses; the pump runs continuously, even with the reactor shutdown. This loss did not result in lowering the pool level to the Technical Specification minimum of 17 feet. The loss rate of about 0.16 inches of level per hour was much less than the 7-inch loss in two hours defined as an unusual event in the PULSTAR Emergency Plan. The licensee estimated the reactor service water makeup system could increase pool level at the rate of six inches per hour.

The licensee maintains a log and plot of makeup to the primary system. From those records, the licensee constructed Figure 1, "Primary Water Loss History." From the figure, it can be seen that increases in water losses have been experienced in the past, but that those earlier large losses could be correlated with leakage from the primary pump. (That leakage is directed to the waste processing system, and does not reach the environment). The running plot is not annotated; so the increase in makeup that started in November 1987 did not, early on, look different from earlier experience. The licensee has made measurements of pool surface evaporation in the past and measurement of pump packing leakage is not difficult. Had there been a program in place to resolve makeup into estimates of identified and unidentified leakage, or to make measurements when the gross makeup rate reached some threshold, the current leakage might have been discovered earlier.

After turning off the primary pump, the reactor pool was isolated by closing hot and cold leg valves located in a pit near the biological shield. Prior to closing the valves, pressure gauges were installed in the hot and cold legs. Following isolation, the pressure in the cold leg decayed rapidly, indicative of a leak. The pressure in the hot leg fell off slowly at a rate typical of that observed in the triennial system pressure test.

Following isolation, the hot and cold legs were drained to assure there would be no further leakage to the environment and to monitor the status of the valves. Subsequently, leakage past the hot leg valve was estimated to be less than one-half gallon per day and leakage past the cold leg valve was estimated to be 4.2 gallons per day. All leakage was diverted to the waste tanks.

Nevertheless, the pool continued to show a loss of about two inches (100 gallons) per day, or an excess over valve leakage and evaporation of about 70 gallons per day. Although not known to be present when the concern over leakage was first raised, by mid week, small quantities of clean water were being found in the valve trench for the beam tube service valves. None of the valves or pipes in the trench, which skirts the perimeter of the biological shield, showed signs of leakage. One may speculate that the pool liner was leaking; the concrete of the biological shield had become saturated by the leakage; and excess, well-filtered water was now finding its way to the trench.

By the end of the week, the licensee was pursuing the following actions:

a. Setup a pool purification system with anti-siphon features for an over-the-pool-wall system. (RSAG)

   Unisolating the pool to use the normal purification system was discussed. The low activity level of the pool water, see Paragraph 6, and the small size of the outside pipe leak, about five gallons per day, seemed to favor such a course.

   The inspector expressed concern over unisolating the primary system before the integrity of the outside pipe had been established and the known leak repaired in a manner consistent with ASME Section 8. The licensee acknowledged the concern and agreed that the primary system should remain isolated until the integrity of the system was determined. At that time a decision would be made as to the efficacy of maintaining the entire system isolated or if further developments might warrant another course of action.

b. A low pool water level alarm was to be installed with the alarm at campus security. Until installed there was to be periodic around-the-clock surveillance of pool level. (RSAG)

c. A detailed, step-by-step, fuel unloading procedure was to be written in anticipation of future need. (RSAG)

d. There was to be a detailed visual inspection of the biological shield surfaces for signs of leakage.

e. A special shutdown activities log was to be established.

Items labelled (RSAG) were specifically requested by the Reactor Safety Advisory Group during its meeting on March 3, 1988.

No violations or deviations were identified.

6. Health Physics Followup of Significant Events (93701)

Along with signs of leakage around the biological shield, other indications of possible leakage were noted on February 29, 1988. In a valve pit cubicle located adjacent to the Mechanical Equipment Room (MER) and outside the building at a point below ground level, moisture was noted on the west wall. Because both hot and cold leg piping passes through the cubicle, smears were taken on the walls and floor of the cubicle and a sample of the debris from the floor was collected to determine if contamination was present. The smears revealed activity up to 986 disintegrations per minute one hundred square centimeters (dpm/100 cm^2) on the west wall but no activity was indicated in other locations. A radiation survey in the area of the valve pit cubicle, along the outside areas where the piping was buried and in office spaces adjacent to the area revealed no radiation levels above background of from 10-12 micro rem per hour (uR/hr).

In addition to the smear and radiation surveys, seven soil samples were taken at a depth of approximately three feet and at ten feet intervals along the pipe run adjacent to the building. All samples showed naturally occurring radioactive isotopes were present but no radioisotopes which would have come from the primary coolant were detected, specifically Manganese (Mn-56), Sodium (Na-24), Zinc (Zn-65) or Silver (Ag-110m).

The inspector requested and received a split sample from each of the seven soil samples taken by the licensee for subsequent analysis by the regional staff. Smear and radiation surveys were also conducted on March 2, 1988 to confirm the licensee's results. A sample of primary coolant was also collected for analysis at the Region as was a sample of the soil, leaves and other debris located in the bottom of the valve pit cubicle.

After analyzing the available data concerning the leak of reactor coolant, the licensee estimated that approximately 4,000 gallons of coolant had been lost since November 1987. However, due to the possibility of a leak in the pool liner, as well as the apparent leak in the primary piping outside the building, no estimate could be made of the quantity that had been lost into the ground outside the building as opposed to the concrete inside the building. A review of the licensee's air sample logs and the results of their analyses of primary coolant samples revealed that, since October 1987, no samples had exceeded the Maximum Permissible Concentration (MPC) limits specified in 10 CFR 20, Appendix B, Table II for release of licensed material to an unrestricted area.

It was noted that the air intake for the building which houses the reactor was located in the valve pit cubicle where some contamination was initially detected. It was also noted that there is a storm drain in the bottom of the cubicle. The licensee indicated that the filters over the air intake duct would be counted for possible contamination and that samples from the storm drain would be analyzed as well.

In discussions as to future actions with regard to excavating and repairing the primary piping located adjacent to the building, the licensee indicated that more soil samples would be taken at varying depths in order to obtain an accurate profile of the radioactivity present. Following the accumulation of those data, a detailed special radiation work permit would be written to cover the radiological controls and requirements for excavating and repairing the piping as well as for handling the contaminated soil. The licensee was also considering the possibility of contracting the excavation work out to a vendor who is knowledgeable of and has had previous experience in dealing with this type of a situation. All these plans would be discussed with and approved by the NCSU Radiation Protection Council prior to implementation.

No violations or deviations were identified.

7. Records Review (40750)

a. Logs and Records

Over 20% of the Operations Log for the period 31 March 1986 to 16 February were reviewed. Particular attention was paid to comparison of Estimated Critical Position (ECP) and Actual Critical Position (ACP) for each startup reviewed. The agreement between ECP and ACP was acceptable in every case. The inspector independently calculate the ECPs in a few cases. The plant data book has xenon curves for only up to eight hours operation. For the rare longer operating periods and for day-to-day operation, the licensee uses superposition. That is, xenon produced during one period of continuous operation is assumed to not be burned out by succeeding operation, but to decay as if there were no later operation. Members of the staff stated that xenon burnout reactivity effects are not observed following hot startups. Considering the short operating periods and low flux of the reactor, this procedure appears to be acceptable. However, if the operating periods were extended to xenon saturation, a more detailed calculation of xenon reactivity might be necessary.

Review of the Operations Logs also focused on recorded power levels, particularly the N^{16} monitor and water quality. Both were uniformly acceptable.

The Scram and Unscheduled Shutdown Log was reviewed for the Period 1 April 1986 to 26 January 1988. In that period, there were twenty-nine scrams and one unscheduled shutdown. Twenty-two of the scrams were from operator errors in changing ranges on the linear nuclear power channel. Considering the extensive use of the reactor for operator training, that number of scrams is not remarkable. Two scrams each came from setpoint drift in the low flow scram, loss of commercial power, and undetermined causes. The licensee concluded the latter were probably from electrical transients. All scrams were reviewed by management before restarts were authorized. The one unscheduled shutdown was caused by someone dropping a survey meter into the pool.

b. Surveillances

Safety Analysis Report Chapter 4.4, Item 6 states, "Hydro-tests on the buried portion of the primary loop will be performed periodically to ensure integrity." Using special Procedure 5.1.3, the first system hydro-test was performed in August 1973. Since then, surveillance Procedure PS-3-01-5:T1, Primary System Hydrostatic Test, has been performed triennially. Review of the test results displayed graphically shows consistent results among the tests, and no evidence of leakage when last performed in 1985.

Control and safety rod worths were measured during August 1987 and the results entered in the Plant Data Book.

c. Experiments

From review of the log books and discussions with the staff, the inspector determined that no new kinds of experiments had been performed since the last inspection.

d. Maintenance

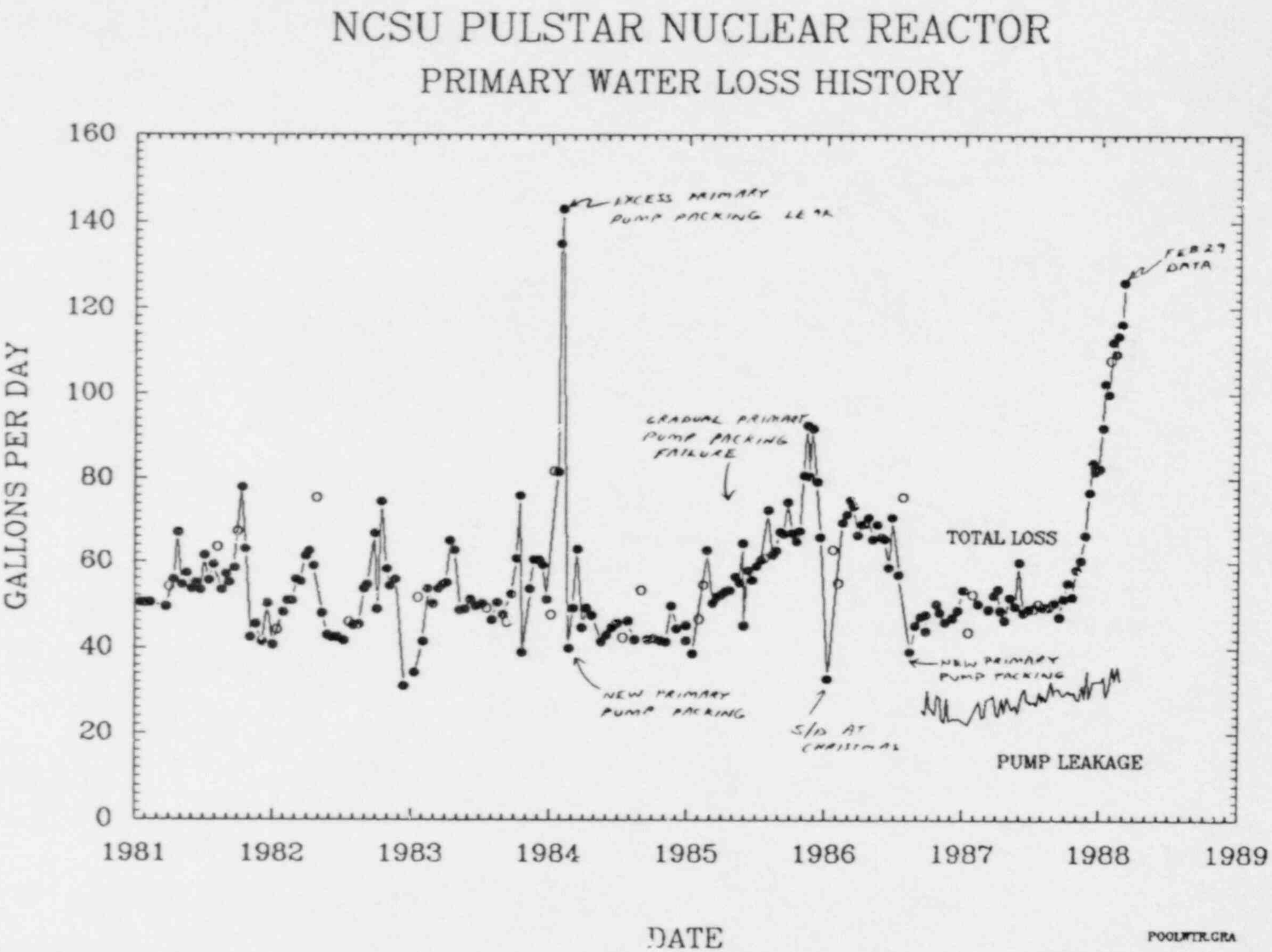
Eight maintenance reports have been written on the auxiliary generator since December 1982. The most common cause of failure was a dead battery. The staff stated that the most recent battery replacement was with a maintainable battery and that a preventive maintenance program had been instituted for it.

Since February 1984, the primary pump has been repaired for leakage on three occasions. In one instance, one packing ring was added. In the others, all packing rings were replaced and a new gasket was installed. The minimum reported post-repair leakage was 63 ml/min or about 1 gal/hr.

There are three open items in the maintenance log including the recently added excessive pool water loss. Only the latter is significant to reactor operation.

ATTACHMENT:
Figure 1

FIGURE 1



REFERENCE - PRIMARY WATER LOG