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

JAN 27 1986

Report No.: 50-400/85-50

Licensee: Carolina Power and Light Company
P. O. Box 1551
Raleigh, NC 27602

Docket No.: 50-400 License No. CPPR-158

Facility Name: Harris 1

Inspection Conducted: December 9 - 13, 1985

Inspector: J. D. Harris for 1-9-86
W. J. Ross Date Signed

Approved by: J. D. Harris for 1-9-86
W. E. Cline, Section Chief Date Signed
Emergency Preparedness and Radiological Protection Branch
Division of Radiation Safety and Safeguards

SUMMARY

Scope: This routine, unannounced inspection entailed 38 inspector-hours onsite in the area of plant chemistry.

Results: No violations or deviations were identified.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

*R. A. Watson, Vice President Harris Nuclear Project
*J. L. Willis, Plant General Manager
J. Harness, Plant Assistant Manager
*J. R. Sipp, Manager, Environmental and Radiological Control (E&RC)
R. Bloch, Project Engineer - Corporate Metallurgy Support
B. Fender, Project Specialist, E&RC
M. McDowell, Principal Specialist - Chemistry, Corporate Radiological and Chemical Support
*C. Nathan, Project Specialist, E&RC
M. Pate, Director, Corporate Craft Technical Training
*D. Piner, Secondary Chemistry Foreman, E&RC
B. Sear, Primary Chemistry Foreman, E&RC
B. Webster, Manager, Corporate Radiological & Chemical Support
*P. Salas, Specialist, Corporate Licensing

NRC Resident Inspectors

*S. P. Burris
G. Maxwell

*Attended exit interview

2. Exit Interview

The inspection scope and findings were summarized on December 13, 1985, with those persons indicated in paragraph 1 above. The inspector described the areas inspected and discussed in detail the inspection findings. No dissenting comments were received from the licensee. The licensee did not identify as proprietary any of the materials provided to or reviewed by the inspector during this inspection.

(Open) Inspector Followup Item 85-50-01 Harris Water Chemistry Program (Paragraphs 5.b and 5.c)

3. Licensee Action on Previous Enforcement Matters

This subject was not addressed in the inspection.

4. Unresolved Items

Unresolved items were not identified during the inspection.

5. Plant Chemistry (79701, 79502)

During this inspection, the inspector began an evaluation of the licensee's ability to protect the integrity of critical components that are in contact with the primary or secondary coolants, i.e., fuel assemblies, steam generator tubes, and low-pressure turbine disks. Degradation of these components, as the results of various forms of corrosion, has been observed in several operating nuclear power plants in NRC Region II. The NRC is especially concerned about steam generator integrity and has recommended actions and review guidelines that are directed toward the resolution of unresolved safety issues related to this subject (e.g., Generic Letter 85-02 and NUREG-0844). As part of this inspection, the licensee's responses and comments related to these documents were reviewed by the inspector.

One of the actions recommended by the staff is as follows:

"Licensees and applicants should have a secondary water chemistry program (SWCP) to minimize steam generator tube degradation. The specific plant program should incorporate the secondary water chemistry guidelines in the Steam Generator Owners Group (SGOG) and Electric Power Research Institute (EPRI) Special Report EPRI-NP-2704, "PWR Secondary Water Chemistry Guidelines," October 1982, and should address measures taken to minimize steam generator corrosion, including materials selection, chemistry limits, and control methods. In addition, the specific plant procedures should include progressively more stringent corrective actions for out-of-specification water chemistry conditions. These corrective actions should include power reductions and shutdowns, as appropriate, when excessively corrosive conditions exist. Specific functional individuals should be identified as having the responsibility/authority to interpret plant water chemistry information and initiate appropriate plant actions to adjust chemistry, as necessary.

The reference guidelines were prepared by the Steam Generator Owners Group Water Chemistry Guidelines Committee and represented a consensus opinion of significant portions of the industry for state-of-the-art secondary water chemistry control."

Reference

Section 2.5 of NUREG-0844

The inspector reviewed the licensee's program (1) to determine if the design of the Shearon Harris Plant (Harris or the plant) will ensure long-term protection of the boundaries of the primary and secondary water systems and (2) to establish if the licensee is developing an adequate water chemistry program, and the capability to implement this program, so that an acceptable level of chemistry control will be provided during the pre-operational and operational phases of the plant. Such control will be needed during the hot functional tests that are scheduled to begin around January 1, 1986. Also, fuel loading is anticipated in March 1986, with additional pre-operational tests to follow soon after.

a. Assessment of Plant Design/Secondary System

Selected components of the secondary systems that are known to be critical to corrosion control were inspected and reviewed with the licensee to ascertain if the design of the "as built" plant is the same as the description in the Final Safety Analysis Report (FSAR), especially in Section 10.0, Steam and Power Conversion System and in Section 9.2, Service Water System. The design of the plant, as constructed, was then evaluated relative to current understanding of both the cause and effect of corrosion of the secondary water side of pressurized water reactors (PWRs).

(1) Main Condenser and Condenser Cooling Water System

Industry experience has shown that several forms of corrosion in the secondary water cycle are initiated by soluble and insoluble chemical species, and that the predominant pathway of these species into the secondary water is through leaking condenser tubes or at the junction between these tubes and the condenser tube sheet. The inspector verified that the condensers at the plant are fabricated as described in Section 10.4.1 of the FSAR. Most of the condenser tubes are made of 90-10 copper-nickel alloy, although the tubes in the uppermost tube layers are made of 70-30 copper-nickel alloy for increased protection against erosion from impingement of steam and chemical attack by ammonia in the steam. Recent industry experience has shown that copper-alloy condenser tubes are more susceptible to corrosion and leaking than tubes fabricated from stainless steel or titanium. Also, erosion of copper from the shell side of the condenser tubes and subsequent transport of soluble or insoluble copper species to the steam generator has been found to facilitate the initiation of stress corrosion cracking and denting of steam generator tubes and tube support plates.

The inspector found that the licensee was knowledgeable of problems that have been attributed to failure of steam generator tubes and of the role of copper in corrosion mechanisms and was taking the following measures to minimize the incompatibility of the condenser material and the condenser cooling water.

Condenser cooling water for the Harris plant is provided by a closed-cycle, natural-draft cooling tower system that uses water from Lake Harris, a reservoir developed by the licensee for this purpose, for makeup. Currently, water taken from the sump of the cooling tower for both condenser cooling and for use in the Service Water System is treated with chlorine and proprietary chemicals for the following purposes: to inhibit biologically induced corrosion in the condenser tubes and in various lines and heat exchangers in the Service Water cooling system; to inhibit corrosion of carbon steel pipes; to prevent precipitation on surfaces and in crevice regions; and to prevent chemical attack of

the copper-alloy condenser tubes. Compatibility tests are being performed to establish the long-term effect of these chemicals on the types of metals that will be in contact with this chemically treated cooling water. The number of cycles that the tower sump water will be allowed to concentrate before being blown down to Lake Harris will be based on the results of these compatibility tests.

The inspector noted that all of these actions are expected to help reduce the probability of degradation of the cooling water boundaries. However, since industry experience has shown that tube leaks may also occur as the result of mechanical damage, there still exists the possibility that the secondary coolant might become contaminated by the condenser cooling water and by such water treatment chemicals as chlorine and zinc phosphate. The effect of these chemicals on the AVT control chemicals (hydrazine and ammonia) and on the structural materials in the steam generator has not been factored into the licensee's compatability tests.

At the time of this inspection, the main condenser was filled with demineralized, deaerated water from the condensate storage tank. The pH of this water had been adjusted with ammonia to protect the carbon steel surfaces of the secondary cycle against oxidation. The licensee was preparing to evacuate the hotwell and turbine to determine if the vacuum required during plant operation could be achieved and maintained with <10 CFM (cubic feet per minute) of air inleakage. (Although excessive air inleakage is encountered at many plants in Region II, some licensee's are able to control this leak rate to <5 CFM.) The licensee recognizes that inleakage of air under the surface of the water in the hotwell increases the concentration of dissolved oxygen in the condensate and enhances the possibility of oxidation of carbon steel pipe by the hot water in the condensate/feedwater systems. Also, the presence of air in low-pressure turbines has been correlated, by Westinghouse, with stress corrosion cracking in the disk and bore regions of the turbine rotor.

The condenser tube bundle is parallel to the axis of the turbines; thereby resulting in relatively long tubes and a single hotwell. Two condensate pumps take suction from this common hotwell. This design makes the location of a leaking condenser tube more difficult than when the hotwell is segmented. The inspector was informed that a helium leak detector is available for this purpose; however, a leaker will not be able to be isolated without shutting down both condensate pumps.

It appears to the inspector that the design of the main condenser will not preclude the possibility of ingress of chemically treated condenser cooling water; also the design is not conducive to rapid isolation of a leak. Consequently, increased reliance must be

placed on the effectiveness of the condensate cleanup system and the development of an efficient monitoring system to keep the steam generators from being contaminated.

(2) Water Treatment Plant/Condensate Makeup System

Experience in the nuclear industry has shown that the water used for condensate makeup is also a potential pathway for corrosive contaminants to enter the secondary water system. Consequently, the licensee has attempted to design all systems and components associated with the production and storage of makeup water for the primary and secondary systems so that this water will be free of air as well as ionic, and organic impurities. The inspector verified that the water treatment plant was built in the manner described in Section 9.2.3 of the FSAR. In order to facilitate the deaeration of the water to be used for makeup, a heater has been installed in the purification train upstream from the vacuum degasifier.

The product of the water treatment plant is stored in the Demineralized Water Storage Tank (DWST) where it is protected from contact with air by means of a rubberized bladder that floats on the surface of the water and acts as a liner for the tank wall. Nitrogen is also bubbled upward through the tank to displace any air that might be trapped in the water or under the bladder. When needed, water is pumped from the DWST to the Condensate Storage Tank (CST) or to the Reactor Water Makeup Storage Tank (RWMST). Both of these tanks are also equipped with bladders and with nitrogen bubbler systems. The water in these three tanks is essentially free of oxygen (10 ppb) and has a conductivity of <0.1 umho/cm, i.e., essentially demineralized water.

This makeup water system should prevent contamination of the primary and secondary systems and will provide a source of high purity water during startup and shutdown of the plant when the steam generators will be fed by the auxiliary feedwater pumps since these pumps take suction from the CST.

(3) Condensate Cleanup System

As described in Section 10.4.6 of the FSAR, the condensate will be polished during passage through a system of five deep-bed demineralizers (mixed cation-anion ion exchange resins); consequently, the feedwater will approximate pure water. These resin beds will also be used to filter any solid material that may be removed from the carbon steel pipes of secondary system during plant startup. In addition, the condensate cleanup system will allow the licensee to cycle steam generator blowdown water back to the hotwell rather than wasting this water (and thermal energy) because it contains elevated concentrations of soluble impurities. In the case of a primary to secondary leak the resin beds might

become a radiation hazard; therefore, they are encased in concrete bunkers for shielding purposes.

The licensee plans to monitor the depletion of individual resin beds by measuring the cation conductivity of each bed's effluent as well as that of the total effluent. The licensee estimates that one bed would have to be regenerated every 1 1/3 days if the allowable loading is based on 60% of a single bed's capacity. However, if the limit is based on 60% of the capacity of the entire system the frequency of regeneration of the most loaded bed can be extended to 3 days. This technique will further reduce the possibility for contamination of the feedwater with regenerant chemicals. To prevent contamination of the effluent with "tramp resin" (cation resin that has not been regenerated to the hydrogen form), the regenerated resin will be subjected to the Aminex (TM) process whereby all sodium that remains on the cation resin will be converted to the ammonium form. The licensee's procedure for controlling the loading and regeneration of the resin beds should reduce the probability of sodium leakage into the feedwater and provide an extra level of protection against hydroxide induced corrosion of steam generator tubes.

(4) Feedwater Heater Chain

The inspector also verified that the plant has been constructed so that the high quality effluent from the condensate polishers will be pumped to the steam generators as described in Section 10.4.7 of the FSAR. The flow path includes a series of four low-pressure heaters and two high-pressure heaters. All of the feedwater heater tubes that will be in contact with the feedwater on the tube side and steam on the shell side, were fabricated from 316 stainless steel.

Condensate from the shell side of the high-pressure heaters is required as feedwater in order for the plant to achieve full power. Therefore, this water will be pumped forward to the suction of the feedwater pumps, rather than back to the hotwell, when the power level reaches 50%.

Both the low-pressure regions of the secondary water cycle (condensate and feedwater pipe) and the high pressure portions (steam and condensate drains) are vulnerable to oxidation when the plant is in a shutdown mode, especially during refueling outages. The licensee has made provision, through chemistry (CRC-150) and operating (GP-2, GP-4, GP-5) procedures, to prevent solid iron oxides from being transported to the steam generator when the plant is restarted. These procedures require that the water be cycled to the hotwell and back through the condensate cleanup system until it meets specifications set for the feedwater during plant operation. Inline monitors for conductivity (as well as

grab samples for the determination of solids) will be used to monitor the effectiveness of this phased, cyclic cleanup process.

(5) Steam Generators/Blowdown System

The Harris plant has three Model D-4 steam generators. Provisions are made through means of a spool piece to cycle the chemically treated water in the steam generator during long outages to provide greater protection against loss of chemistry control during plant layup. This capability will supplement the cyclic cleanup of the other portions of the secondary water system and minimize the formation of iron oxide sludge in the steam generators. Sludge deposits provide localized environments that are conducive to the concentration of corrosive irons.

The normal means for removing soluble and solid contaminants from the steam generator water is through continual blowdown of a relatively small fraction of the volume of water inventory in each steam generator. The Harris blowdown system has been designed to remove up to 300 gpm; however, the licensee expects to limit blowdown to 10% of this capability. Except when the quality of blowdown is not conducive to cleanup, such as during the initial phase of plant startup, the licensee plans to conserve this water and cycle it back to the hotwell. In order to reduce the amount of solids transported to the hotwell, the blowdown recovery train includes an electromagnetic filter that is designed to remove iron and iron oxide particulates. This is the first filter of this type to be installed in a plant in Region II. The removal of any solids before the blowdown is recycled to the hotwell will extend the useful life of the deep-bed demineralizers because, otherwise, these solids would coat the resins and reduce their effectiveness.

By conserving the blowdown water the licensee will also be reducing the need for condensate makeup water, thereby reducing the potential for ingress of contaminants by this pathway..

(6) Moisture Separator Reheaters (MSR)

The inspector established that the tubes in the MSR are fabricated from Type 439 stainless steel and, therefore, will not add to the burden of copper in the feedwater.

(7) Primary Coolant System

The inspector did not address the compatibility of structural materials or the design of the primary water system and closed cycle cooling systems during this inspection.

(8) Summary

The inspector did not identify any significant discrepancies between the FSAR description and the as-built secondary water system. The licensee is aware of the need to minimize or eliminate all potential corrodants and has designed the components of the secondary system accordingly. The main remaining concern centers around the use of copper-nickel condenser tubes. Copper-nickel alloy tubes have not only been more subject to degradation than have stainless steel or titanium tubes but the very existence of copper in structural components of the secondary system places constraints on the use of all-volatile-chemistry control because of the incompatibility of copper and ammonia. However, the potentially adverse effect of copper in the condensate should be reduced to a minimal level as long as the condensate polishers remain effective.

b. Water Chemistry Program

Section 10.3.5.4 of the FSAR describes the secondary water chemistry control and monitoring program that was to be implemented at Harris in response to draft Technical Specifications. This description and the initial implementation procedures were based on guidance provided by Westinghouse.

As the result of later guidance by both Westinghouse and the Steam Generators Owners Group (SGOG), the licensee has been reviewing the elements of his water chemistry program. The inspector was shown drafts of three documents that have been developed in parallel actions by plant and corporate personnel as directives for new administrative and technical procedures. These documents are entitled:

- Carolina Power and Light Corporate Power Plant Chemistry Policy
- Carolina Power and Light Company Power Plant Chemistry Program Description
- PWR Plant Chemistry Guideline Manual for Shearon Harris Nuclear Power Plant

The new corporate policy document commits the utility to "sound chemistry programs" and stresses the importance of the elements of the corporate chemistry program. The corporate chemistry program provides both goals and the means for meeting these goals. This program also incorporates the concept of chemistry limits and action levels for controlling out-of-limit situations. The Harris Chemistry Guideline Manual further expands on the administrative and technical guidance in the corporate chemistry program directives and provides specific guidelines for site specific actions and procedures to control chemistry when the plant is in all modes of shutdown and operation. The Guideline Manual references the SGOG guidelines that were recommended by the NRC staff in Generic Letter 85-02.

Although these three documents have been developed in parallel actions they appeared to be consistent in their present draft form. Much of the philosophy and technical guidance in these documents had already been factored into the existing chemistry and operating procedures; however, the on-going review of all aspects of the role of the Chemistry Unit and the Operations Department in providing long-range protection to the plant will be beneficial. An assessment of the final results will be deferred as Inspector Followup Item 85-50-01, Harris Water Chemistry Program. However, the inspector emphasized the urgency of having a water chemistry program in place and the Chemistry and Operations staffs trained in the final procedures before fuel is loaded.

The inspector reviewed the procedures that have been developed to cover all chemistry activities associated with the upcoming hot functional tests. These procedures appeared to be adequate, and the inspector observed that the licensee was conducting special training classes related to the responsibilities of the Chemistry Unit.

c. Implementation of the Harris Water Chemistry Program

In anticipation of fuel loading in 1986, the licensee has begun to develop the capability to implement the necessary control of chemistry in all process water systems. The chemistry staff consists of approximately 20 Chemistry Technicians and two Chemistry Foremen under a Chemistry Supervisor. This staff and a support group of primary and secondary Chemistry Specialists report to the Manager of Environmental and Radiological Control. At present approximately half of the Chemistry Technicians are contract personnel. A training and qualification program, covering five years, has been developed in the areas of employee qualification, plant specific training, and generic training and will implemented by on-the-job work, the Harris Training Unit, and the Corporate Training Unit. However, most of the current chemistry staff appears to have had considerable experience already, either at the Harris plant or at other nuclear power plants.

All sampling and analytical activities at present are being carried out in the secondary chemistry laboratory. This laboratory is well designed and equipped; however, neither the secondary laboratory nor the unfinished primary chemistry laboratory has a ventilation system as yet, other than air-conditioning units in the walls. The sampling rooms for both the primary and secondary systems are not completed and much of the present inline instrumentation is to be removed and replaced with new instruments before fuel loading. The inspector considered the primary and secondary sampling facilities to have numerous deficiencies in design, appearance, and usefulness. Of special concern is the absence of sample taps for steam generator blowdown in the secondary sample room. Blowdown samples can be taken only in the sink in the primary chemistry laboratory in close proximity to the sample taps for the reactor coolant.

The inspector did not review or evaluate several other important elements of the licensee's water chemistry program, such as analytical procedures, quality control program, or qualification program for chemistry technicians. Also, the role of the Operations Department in controlling normal and abnormal plant chemistry was addressed only briefly through discussions with shift supervisors and by scanning three General Procedures. Further review of these elements will be included as part of Inspector Followup Item 85-50-01.

During this portion of this inspection, no violations or deviations were identified.