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

Report No.: 50-261/84-49

Licensee: Carolina Power and Light Company
411 Fayetteville Street
Raleigh, NC 27602

Docket No.: 50-261 License No.: DPR-23

Facility Name: H. B. Robinson

Inspection Conducted: December 12-14, 1984

Inspector: [signature] for W. Ross — 1/8/85 Date Signed

Approved by: [signature] J. J. Blake, Section Chief, Engineering Branch, Division of Reactor Safety — 1/8/85 Date Signed

SUMMARY

Scope: This routine, unannounced inspection entailed 41 inspector-hours onsite in the areas of plant chemistry, Service Water Piping System degradation, inservice testing of pumps and valves, and Inspector Followup Items.

Results: No violations or deviations were identified.

REPORT DETAILS

1. Licensee Employees Contacted

G. P. Beatty, Manager, H. B. Robinson Nuclear Project
*R. E. Morgan, General Manager
*J. M. Curley, Manager, Technical Support
*F. Lowery, Manager, Operations
*R. M. Smith, Manager, Environmental and Radiation Control (E&RC)
W. Christensen, Chemistry Foreman, E&RC
S. Clark, Senior Engineer, Plant Engineering
*W. Farmer, Performance Engineer
W. Flanagan, Engineering Supervisor, Plant Engineering
R. Hitch, Senior Specialist, E&RC
M. Layton, Project Specialist, E&RC
E. Lee, Shift Foreman, Operations
J. Murray, Radwaste Supervisor, Operations
*D. Stadler, Director, Regulatory Compliance
*J. Sturdavant, Technician, Regulatory Compliance
F. Watkins, Chemistry Foreman, E&RC
P. Weir, Engineer, Plant Engineering
*C. Wright, Senior Specialist, Regulatory Compliance

Other licensee employees contacted included two technicians and two operators.

NRC Resident Inspectors

*H. Krug

*Attended exit interview

2. Exit Interview

The inspection scope and findings were summarized on December 14, 1984, with those persons indicated in paragraph 1 above. The licensee acknowledged the inspection results with no dissenting comments.

3. Licensee Action on Previous Enforcement Matters

This subject was not addressed in the inspection.

4. Unresolved Items

Unresolved items were not identified during this inspection.

5. Plant Water Chemistry

During a previous assessment (November 1983) of the licensee's program to protect the integrity of the primary pressure boundary, the inspector was informed that the tubes in all three steam generators had deteriorated to the extent, that the steam generators were going to be replaced in 1984 (see Inspection Report 50-261/83-34). During this planned outage other major modifications of the secondary water system were to be made to minimize corrosion in the new steam generators. Also, the licensee was planning to convert the Robinson water chemistry program from the use of phosphate to all-volatile-treatment (AVT) chemicals for control of chemical variables that might lead to corrosion and failures of components in the steam and Power Conversion System.

Also, at the time of the earlier inspection, the licensee had begun revising procedures used for monitoring and controlling the chemistry of the secondary water system so that the procedures would reflect the proposed design changes.

During the current inspection the licensee was preparing the plant for startup with the new steam generators and other design changes. The inspector reassessed the plant design and the capability of the plant design to protect the integrity of the primary pressure boundary by preventing the formation of corrosive environments within the steam generator. The inspector also reviewed the revised water chemistry program for completeness and adequacy in an effort to close out a followup item from the previous inspection, IFI 50-261/83-34-01, "Completion and Implementation of the Robinson Unit 2 Secondary Water Chemistry Guidelines."

a. Review of the Design of the Secondary Water System

Since many major plant modifications were completed in 1984, the Robinson FSAR, as updated by Amendment 1 (July 1983) no longer provides an accurate description of the Steam and Power Conversion System (Chapter 10). All of the recent modifications that were considered as future actions during the previous inspection (50-261/83-34) have been verified as completed and operable during the current inspection.

(1) Main Condenser

One of the initial steps taken to reduce the corrosion of steam generator tubes was the replacement of the original condenser tubes (made of admiralty brass and Type 354 stainless steel) with tubes fabricated from Type 439 stainless steel. This modification was completed in 1982 and, as a result, plant operation until the 1984 outage was free of air and water inleakage. During the 1984 outage, the condenser vacuum pumps were rebuilt to improve the capability to degassify water in the condenser hotwells and thereby maintain the dissolved oxygen in the condensate within specified limits of 5 ppb.

Long-term integrity of the new, Type 439 stainless steel condenser tubes remains a concern, however, because of the aggressiveness of the circulating cooling water that is taken from Lake Robinson. Evidence that this water can cause corrosion of stainless steel pipe has been observed recently in the Service Water System. This subject is addressed further in Section 6 of this report.

(2) Makeup Water System

During the 1984 outage, the licensee replaced the plant's original water treatment plant and modified the tanks used to store makeup water for the primary and secondary water systems. These actions were taken to minimize contamination of condensate/feedwater and the reactor coolant. Water used for makeup is pumped from deep wells on the Robinson site and then purified in a double chamber degasser and two sets of mixed-resin demineralizers. The product is stored in either the Primary Water Storage Tank (PWST) or the Condensate Storage Tank (CST). Both of these tanks have been equipped with "bladders" so that the degassified water remains isolated from air when the water level fluctuates within the tanks. The quality of the water in both tanks is monitored as part of the water chemistry program.

During this inspection, the licensee was attempting to find and repair a source of air inleakage into the CST that was causing the limit for dissolved oxygen (0.1 ppm) to be exceeded.

(3) Condensate Cleanup System

One of the major design changes to the secondary water system has been the construction of a condensate cleanup system to be used, in conjunction with the AVT chemical program and an improved steam generator blowdown system, to provide high quality feedwater/steam generator water that will reduce the possibility of corrosion. The inspector was informed that the condensate cleanup system is operable and is capable of providing cleanup of the condensate at 100% flow with five of the six mixed-resin demineralizer beds in operation.

Criteria for removing a bed from service and regenerating the ion-exchange resins have not, as yet, been developed. The licensee is also still considering the advantages and disadvantages of bypassing the polishers when the desired quality of feedwater has been achieved. The principal advantage of bypassing is to eliminate leakage of resin and/or "throw" of sodium, chloride, or silica into the feedwater. The main disadvantage is that full protection against inleakage of circulating cooling water or contamination from makeup water will no longer be provided. The operation of the condensate cleanup system and its use in minimizing the effect of an abnormal secondary water chemistry transient is discussed later, in Section 5.b of this report.

(4) All Volatile Treatment (AVT) Chemistry Control

The inspector established that design modifications have been made to the secondary water system so that the licensee can implement an AVT chemistry control program. The licensee has the capability to add ammonia and hydrazine to the effluent of the condensate polishers to maintain the pH and dissolved oxygen content of the feedwater within limits that were established to minimize corrosion in the steam generators. In addition, hydrazine can be added at the following locations: downstream of the feedwater isolation valves to provide layup conditions for the steam generator; to the discharge of the auxiliary feedwater pumps to control the oxygen content of water taken from the CST during plant startup and shutdown; and also to the crossover pipe between the low pressure turbines to regain desired pH and oxygen conditions in the turbines and hotwell after partial thermal degradation of hydrazine occurs in the steam generators.

(5) Feedwater and Extraction Steam Systems

The licensee has made additional design modifications to protect the quality of the feedwater. During the 1984 outage, the original copper alloy tubes (902 admiralty, 70-30 Cu-Ni, 90-10 Cu-Ni), as well as some stainless steel tubes in the feedwater heaters and in the moisture separator reheaters were replaced with tubes fabricated from Type 439 stainless steel. Consequently, there are no longer any copper-containing alloys in contact with the secondary cooling water, and the licensee has greater flexibility in the use of AVT chemicals, i.e., pH control.

The inspector established that as part of the new AVT chemistry program, the licensee has developed new procedures for ensuring that dissolved solids and corrosion products released during layup, shutdown, startup, and transient cycles are removed with the condensate cleanup system before these contaminants can be transported to the steam generators. In order to implement these procedures, the secondary water system has been modified to allow water in the condensate/feedwater lines and in the extraction steam/heater drain system to be cycled through the condensate polishers and back to the suction of the condensate pumps until both soluble and insoluble corrosion products have been reduced below the operations specifications for feedwater. Only then is the feedwater allowed to enter the steam generators.

The licensee's approach to secondary system cleanup allows the condensate/feedwater train to be cleaned and the quality of water brought to within specified limits while the remainder of the plant is readied for startup; i.e., while the lay-up water in the steam generator is blown down and replaced with demineralized water from the CST, and the reactor taken to hot standby. The licensee estimates that ~18 percent of the transportable corrosion products are removed by the condensate polishers during this phase of cleanup.

When the quality of the feedwater is within specifications, the feedwater pumps are started and the auxiliary feedwater pumps are secured so that the steam generators are fed with feedwater while the plant goes to power. While the plant is at low power, 10 - 30 percent, the licensee estimates that the remaining (82 percent) transportable corrosion products are formed in the steam path, heater shells, and upper shell of the condenser. Therefore, operating procedures place a hold on power ascension at 30 percent power while the heater drains are cycled through the condensate polishers until operational specifications of purity are achieved. When this quality of water is attained, the drain water may be pumped forward to the feedwater pumps and power ascension continued.

(6) Steam Generators

The primary reason for the 1984 outage was to allow the licensee to replace the degraded Model 44 steam generators with three new Model 44f steam generators that were designed to reduce the formation of corrosive environments and degradation of inconel-600 steam generator tubes, (i.e., to prevent deterioration of the primary coolant boundary and to maintain the operability of the steam generators.)

The new steam generators are considered by the licensee to have the following improvements:

- The steam generator tubes were thermally treated after fabrication, and should be more resistant to the initiation of stress corrosion cracking or pitting.
- The tubes are fully rolled into the tube sheets and do not extend beyond the tube sheets; therefore, sites for crevice corrosion have been removed.
- The tube support plates are fabricated from stainless steel rather than from carbon steel and should be more resistant to the type of denting action that caused tube damage in the original steam generators.
- The tube support plates have broached quatrefoil holes, rather than drilled, round holes and should improve coolant flow while reducing plugging if the steam generators develop sludge deposits.

- Blowdown capability has been increased from ~26 gpm to ~150 gpm.

- "J tubes" have been added to the feedring to improve flow and to reduced the possibility of water hammer.

- The new steam generators are equipped with a recycling line that permits selected AVT conditions to be established and maintained during layup.

(7) Summary of Modifications of the Secondary Cycle

It is the inspector's opinion that all of the modifications that were made in the secondary cycle will enhance the integrity of the primary pressure boundary by reducing the potential for the formation of corrosive environments. The licensee's modification program was intended to minimize the most logical sources of corrosive impurities: inleakage through the condenser; carryover from water used for condensate makeup; and transport of corrosion products to the steam generator from other components in the secondary cycle. The potential for a fourth pathway for impurities to enter the steam generators will depend on the licensee's capability to operate and regenerate the condensate polishers in a manner that minimizes leakage of resins and regenerant chemicals.

b. Corrosion in the Primary Water System

The inspector was informed that during the 1984 outage, several of the tubes in the Component Cooling Water heat exchanger had been plugged because of leaks. The leaks appear to have been caused by corrosion of the admiralty tubes from the Service Water side. The licensee is currently investigating the cause of this corrosion and is also evaluating whether the failed tubes should be replaced or a new heat exchanger installed.

c. Evaluation of the Licensee's Revised Chemistry Program

In conjunction with the major modifications of the secondary cycle and conversion to an AVT chemistry control program, the licensee has also built new facilities for carrying out the necessary diagnostic and control activities and has made significant changes in the Chemistry Procedures that define the scope of the Robinson Unit 2 water chemistry program. In light of these changes, the inspector reassessed the adequacy of the licensee's efforts to fulfill a requirement of License DPR-23 to implement a secondary water chemistry program and to implement the requirements of the Robinson Unit 2 Technical Specifications, specifically TSs 3.1.4, 3.1.5, 3.1.6, and Table 4.1-2.

The inspector reviewed the licensee's revised guidelines (dated July 19, 1984) for the development and implementation of a secondary water chemistry program based on AVT chemistry control. These guidelines are consistent with guidelines developed by the Steam Generator Owners Group (SGOG) and the Electric Power Research Institute (EPRI) and are considered by plant management to be requirements. Specific responsibilities have been established and instructions provided for implementing the licensee's guidelines in a series of Chemical Procedures. The inspector reviewed the following selected procedures:

- CP-001 - Chemistry Monitoring Program, Rev. 4 (9/14/84)
- CP-003 - Systems Sampling Procedure, Rev. 3 (10/25/84)
- CP-005 - Secondary Chemistry Corrective Action Program, Rev. 4 (10/22/84)
- CP-006 - Chemical Feed System Operation, Rev. 0 (10/25/84)
- CP-007 - Secondary Sampling System, Rev. 0 (11/7/84)
- CP-020 - pH Determination, Rev. 1 (8/3/84)
- CP-022 - Conductivity Measurement, Rev. 2 (10/12/84)
- CP-028 - Ion Chromatograph, Rev. 0 (3/9/84)
- CP-041 - Ammonia, Rev. 0 (8/24/23)

The licensee has endorsed the concept in the SGOG/EPRI guidelines of quantifying "abnormal chemistry conditions" and establishing when corrective action must be taken in order to minimize damage to the steam generators. The inspector verified that these instructions are provided to members of the Chemistry Department in Chemistry Procedure CP-005 and in Operating Procedure OMM-019 - Secondary Chemistry Corrective Action, Rev. 0 (11/06/84), to the operators in the Control Room. The inspector noted that similar guidance is not provided to the Radwaste Operators who operate the Condensate Cleanup System and who monitor the quality of the influent and effluent of the condensate polishers. The licensee committed to review the procedure that has been developed for monitoring the Radwaste Control Panel to determine if further revision is needed to cover corrective actions.

On the basis of his review, the inspector concluded that the licensee has developed the framework for an effective water chemistry program that is compatible with the modified design of the Steam and Power Conversion System and with the requirements of paragraph 3.G of the Robinson Unit 2 Operating Licensee. Also, the inspector closes Inspector Followup Item 50-261/83-34-01, "Completion and Implementation of the Robinson Unit 2 Secondary Water Chemistry Guidelines."

d. Implementation of the Licensee's Water Chemistry Program

Inasmuch as the plant was not operating during this inspection, the inspector devoted part of his time to evaluating the operation of both the new Condensate Cleanup System and the new secondary water sampling laboratory.

The Condensate Cleanup System is operated, under the supervision of the Radwaste Supervisor, by ten technicians who have been trained for, and are dedicated to, this responsibility and to the operation of the Water Treatment Plant. The inspector was informed that operation of a new Radwaste System, that is currently under construction, would also become the responsibility of the Radwaste Supervisor; however, no decision has been made related to personnel who will operate the radwaste system.

The inspector reviewed the two principal procedures used by the Radwaste Technicians, i.e., OP-509, Operating and Regenerating the Deep-Bed Demineralizers, and OP-915, Operating the Makeup Water Treatment Plant. The inspector was informed that these systems had been in operation long enough to allow the operators to have had actual experience in regenerating the resin beds several times. The operators were cognizant of the need to prevent leakage of resins or regenerant chemicals from the resin beds. The operators briefed the inspector on their experience, to date, with the use of neutral resin beads to facilitate the regeneration of the anion and cation resins in the mixed resin beds.

By constructing a new Secondary Chemistry Sample Laboratory, the licensee has significantly increased his capability to monitor key chemical parameters on a continual basis and to record these data for subsequent evaluation and trending. Key chemical parameters needed for control purposes (hydrazine, pH), or as diagnostic indicators (conductivity, dissolved oxygen, sodium, and chloride) are alarmed within the laboratory, but not at any other location. The inspector expressed concern that this laboratory would not be occupied during much of a normal 24-hour period, and, therefore, these alarms might go unnoticed. In response, the inspector was informed that both Chemistry and Radwaste Technicians would be "in and out" of the laboratory during all shifts; however, additional attention would be given to making the alarms more effective.

The inspector observed that the organization of the Chemistry Department remains the same as during the previous inspection (prior to the 1984 outage). Although the Chemistry Section is operating on two 12-hour shifts during plant startup, the inspector was advised that an eight-hour, three-shift rotation would be reinstated soon. The inspector discussed the licensee's plans for using the limited number (13) of Chemistry Technicians while implementing a training program that will frequently reduce the staff by four or more technicians for periods of several weeks. The inspector also raised a concern that the use of the Secondary Chemistry Sample Laboratory will be adversely affected for Chemistry personnel when the barrier of the Radiation Controlled Area is relocated so that it separates the Sample Laboratory from the new laboratories that were also completed during the 1984 outages, for primary, secondary, environmental, and radiochemistry.

Summary - The inspector concluded that the licensee has taken constructive actions to insure implementation of the Robinson water chemistry program by:

- ° Providing dedicated Radwaste Operators to operate the Water Treatment Plant and Condensate Cleanup System.
- ° Equipping the Radwaste Control Panel with monitors for key chemical parameters.
- ° Equipping the Secondary Chemistry Sample Laboratory with continual, inline monitors, as well as with taps for grab samples, from key control points in the secondary cycle.
- ° Providing new, well-designed laboratories and state-of-the-art analytical chemistry instrumentation for monitoring parts-per-billion concentrations of ionic and organic species.

The only potential weakness in the licensee's program appears to be the capability to maintain adequate staffing and instrument-maintenance support to take full advantage of the new Condensate Cleanup System and the upgraded chemistry monitoring facilities.

Within the areas inspected, no violations or deviations were identified.

6. Corrosion of Service Water Lines

The inspector followed up on the subject of "Service Water Piping System Degradation" that was initiated by W. P. Kleinsorge in Inspection Report No. 50-261/84-45 during the week of November 19-23, 1984. Through interviews with cognizant members of the Robinson Unit 2 Plant Engineering Staff, the background and status of this problem was established to be as follows.

During a plant outage in November 1983, all of the coils in the Containment Fan Coolers were replaced, as were some of the three-inch, low-carbon stainless steel headers for these fan coolers.

In November - December of 1984, indications of "water weeping" were found at 54 locations on the six-inch, high-carbon stainless steel pipes that provide flow of Service Water to the Containment Fan Coolers. Thirty-two "weeps" were found inside Containment and 22 inside the Auxiliary Building.

Since the "weeps" appeared in the regions of butt welds in the six-inch Service Water header, the licensee began a program of radiographing these welds. When half of the welds inside containment had been examined, ~85 percent were found to have indications of corrosion. Consequently, the licensee decided to stop the radiographing and to repair all (304) butt welds on Service Water lines inside Containment by welding Type 304L stainless steel sleeves, four-inch minimum length, around the affected weld areas. In addition, the following regions of the Service Water lines were radiographed: all (~304) butt welds in the six-inch header outside Containment, all welds to appendages of the six-inch header inside Containment, all butt welds in the three-inch Service Water headers inside Containment, and all Service Water bypass and return lines of 1.5-inch and 2-inch diameter (even though these small lines have socket, rather than butt joints).

The radiographs revealed some type of indication in nearly every weld region that was examined. Fifteen additional welds on the six-inch Service Water header in the Auxiliary Building had indications that exceeded the sleeving criteria, but no weep was observed. The three-inch headers that were installed in November 1983 did not have indications, while the joints in the old three-inch pipe did. Nine of 29 socket welds on the two-inch pipes also showed indications. Finally, indications were sometimes observed within the weld itself; but, never in the heat affected zone of a fitting that was butt welded to a pipe, nor in regions where hanger lugs had been welded to the pipe.

The licensee has made a preliminary assessment the radiographs of two affected welds that were cut out of six-inch headers. Maximum corrosion occurs where the heat affected zone has received maximum sensitization, i.e., ~¼ inch from the weld fusion zone. Metallographic examination of indications within the weld fusion zone indicate removal of ferrite to form pits in the weld.

In the heat affected zone, the attack appears as voids, within the schedule 10 pipes, which are connected to the inner and outer walls by very small-diameter conduits. The voids are isolated or connected to form gaps several inches long circumferentially and parallel to the weld. In the examination of the weld samples that had been removed from 6-inch Service Water headers, the roots of the welds were observed to be covered with a thick brown to reddish-brown deposit.

On the basis of these preliminary findings and their similarity to other reported case studies, the licensee believes that the pipe degradation is the result of microbiologically induced corrosion (MIC) of highly sensitized regions of high carbon (~0.065%), thin-wall, stainless steel, (i.e., schedule 10 Type 304.) This theory is substantiated by the known presence of bacteria in Lake Robinson water that generates waste products that form corrosion potentials on steel surfaces. Several mechanisms have been proposed to describe the detrimental effect of such bacteria. On the basis of this theory, the licensee has taken precautions to minimize further MIC of the welds used to attach the sleeves around the degraded weld areas. These precautions include the use of Type 304L pipe for sleeves, to reduce the carbon content, and making the welds while the pipes are filled with water, so as to minimize the extent of sensitization in the heat affected zone.

The licensee had earlier initiated a Service Water Problems Study as the result of several operating and maintenance problems, and the inspector was informed that draft findings were issued a few weeks prior to the discovery of degradation of Service Water pipes in the Containment Fan Cooler System.

Recommendations have been drafted to reduce corrosion of the large (30 inch and 12-inch) concrete-lined carbon steel pipes that provide flow of Lake Robinson water from the Service Water Pumps to the Service Water Booster Pumps and as far as the carbon steel isolation valve. Other recommendations relate to corrosion of the six-inch headers of carbon steel that provide flow of Service Water to numerous compressors, motors, pumps, coolers, and heat exchangers in the plant.

7. Inservice Testing (IST) of Pumps and Valves

The inspector also reviewed three issues related to the licensee's program for inservice testing pumps and valves that had been designated for followup by W. P. Kleinsorge in Inspection Report No. 50-261/84-45 as the result of an inspection during November 19-21, 1984.

a. Inspector Followup Item 261/84-45-02, "Bearing Temperature"

This concern related to the basis for the licensee's request for relief from the ASME Code, Section 11 requirement to measure pump bearing temperature. The concern was discussed again with the licensee, and the NRC's position on this requirement was clarified. As the result, the licensee will submit a letter to the NRC (ONRR) to revise the basis of the relief request so as to eliminate reference to a possible change in the Code. Inasmuch as this matter will be resolved by ONRR prior to approval of the licensee's IST program, this IFI is hereby closed.

b. Inspector Followup Item 261/84-45-03, "Pressure Isolation Valves"

This issue arose as the result of a concern that the licensee's proposed IST program does not include any Category A pressure isolation valves. The inspector established that a number of valves that have pressure isolation functions are included in the IST program, but are categorized as "B"; i.e., leak rate testing is not required. The basis for some of these classifications does not appear to be consistent with NRC positions.

Inasmuch as the licensee's proposed IST program is under review by the NRC (NRR), the inspector discussed these apparent discrepancies with the NRR reviewer and was advised that this matter will be resolved through further discussion between the NRR reviewer and the licensee and will be addressed in a Safety Evaluation Report at the conclusion of the staff's review. Consequently, this item is closed.

c. Inspector Followup Item 261/84-45-04, "Maximum Valve Stroke Time"

During Mr. Kleinsorge's inspection, the licensee's bases for setting maximum stroke times for valves were questionable. The principal concern was that some of the stroke times permitted in the IST program were significantly longer than actual stroke times, as measured during operability tests.

In this followup, the inspector was informed that many of the perceived discrepancies exist because allowable stroke times of individual valves were based on the maximum times for a system to operate, as analyzed in the FSAR, rather than on the operation of individual components (valves). The inspector advised the licensee that it is the staff's position that stroke timing must show that individual valves are not degrading as well as verify that the valve's safety-related function will be met, if called upon. Therefore, each component of a safety-related system must be shown to be operable, in addition to establishing that the system will meet is analyzed function. As a "rule of thumb" position, the NRC staff believes that the allowable stroke time for most valves should not be greater than 100 percent of the measured stroke time when the valve is known to be in good condition.

The licensee committed to review the Robinson Unit 2 IST program and re-evaluate the permissible maximum stroke times. This item will be left open for additional followup.