UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30303

Report Nos.: 50-280/84-16 and 50-281/84-16

Licensee: Virginia Electric and Power Company
Richmond, VA 23261

Docket Nos.: 50-280 and 50-281

License Nos.: DPR-32 and DPR-37

Facility Name: Surry 1 and 2

Inspection Dates: May 14 - 18, 1984

Inspection at Surry site near Williamsburg, Virginia

Inspector: *J. J. Blake* for W. J. Ross — *6/4/84* Date Signed

Approved by: *J. J. Blake* J. J. Blake, Section Chief, Division of Reactor Safety — *6/4/84* Date Signed

SUMMARY

Areas Inspected

This routine, unannounced inspection involved 41 inspector-hours on site in the area of plant chemistry.

Results:

Of the single area inspected, no violations or deviations were identified.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

*J. L. Wilson, Station Manager
*R. F. Saunders, Assistant Station Manager
*D. L. Benson, Assistant Station Manager
*M. R. Kansler, Superintendent Technical Services
*E. T. Swindell, Supervisor, Chemistry
*L. G. Miller, Assistant Supervisor, Chemistry
W. Hagan, Supervisor Water Management
R. Johnson, Operations Coordinator
J. Patrick, Superintendent Mechanical Maintenance
*W. D. Grady, Supervisor, Quality Control
*R. F. Driscoll, Manager, Quality Control

Other licensee employees contacted included 8 chemistry technicians.

Other Organizations

J. Headden, Westinghouse

NRC Resident Inspectors

*D. J. Burke
*M. J. Davis

*Attended exit interview

2. Exit Interview

The inspection scope and findings were summarized on May 18, 1984, with those persons indicated in paragraph 1 above. The licensee acknowledged the inspection results with no disserting comments.

Inspector Followup Item 84-16-01, "Evaluation of Secondary Water Chemistry Program". (Section 5.b)

Inspector Followup Item 84-16-02, "Leakage of Primary Water Into the Component Cooling Water System. (Section 5.c)

3. Licensee Action on Previous Enforcement Matters

Not inspected.

4. Unresolved Items

Unresolved items were not identified during this inspection.

5. Plant Water Chemistry (92706)

This inspection consisted of the following interrelated efforts:

- Assessment of the capability of the major components of the secondary water system to protect the primary pressure boundary by ensuring the absence of corrosive environments in the steam generator,

- Assessment of the adequacy of the licensee's water chemistry program to monitor the quality of water in primary and secondary water systems, and

- Assessment of the licensee's ability to control the quality of water in the plant through implementation of the Surry water chemistry program.

a. Assessment of the Design of Components In The Secondary Water System

At the time of this inspection both Surry units were operating at full power; Unit 1 has approximately 3 to 4 months remaining in the second fuel cycle since it underwent a major refitting and Unit 2 is in its third fuel cycle since a similar refitting. These refittings were required, in great part, as the result of deterioration of the steam generator tubes in both units and consisted of replacement and/or upgrading of the main condensers, water treatment system, condensate cleanup system, and steam generator. Inasmuch as the degradation of the steam generators was attributed to chemical-induced corrosion of the steam generator tubes, the licensee has also initiated a program to upgrade its capabilities to monitor and control the quality of the water in both the primary and secondary coolant systems.

The inspector compared the "as-built" secondary water system with the description that is in the updated (1982) Final Safety Analysis Report (FSAR), especially Section 10.3.4 "Circulating Water System" and Section 10.3.5 "Condensate and Feedwater" and interviewed cognizant plant personnel to determine what efforts had been made to maximize the effectiveness of the following components of the secondary water system.

(1) Main Condenser

The two Surry units transfer waste heat energy through a condenser to a once-through cooling system that uses water from the James River. Historically, this main condenser has been the principal path of air and water inleakage and subsequent contamination of the condensate and feedwater, and thereby, the source of impurities that cause corrosive environments in the steam generator and in the low-pressure turbines. Ingress of river water is considered especially conducive to corrosion because the James River is tidal and, at the Surry cooling water intake, remains brackish most of the time.

The licensee experienced many leaks in the original copper-nickel condenser tubes that contributed to the poor quality of feedwater and subsequent deterioration of the steam generator. As part of the refitting program, these tubes were replaced by tubes fabricated from titanium to decrease the potential for corrosion and inleakage. The condenser tube sheets are made from an alloy of copper and are susceptible to chemical attack from the circulating cooling water; however, these components have been coated with expoxy to minimize corrosion and inleakage of water. Likewise, the condenser waterboxes have been lined with a rubber-base material to protect the carbon steel shell from corrosion.

The original plant was designed with Amertap systems to clean the condenser tubes. The licensee has had problems with these systems and, although the Amertap system for Unit 2 has been refurbished and is operable, neither it nor the inoperable system for Unit 1 are used. The inspector was informed that the water side of the condenser is cleaned periodically, the tubes are hydrolazed during each refueling (~ 18-24 months), and some of the tubes are eddy-current tested also each refueling outage to ensure their integrity. To date, no tube failure has been caused by corrosion, although twelve tubes in Unit 1 (waterbox 'A') were plugged as the result of mechanical damage. The circulating cooling water is not chlorinated.

The inspector was also informed that air inleakage through rubber expansion joints had been detected (by a contractor) using a helium detection system. Because of the high probability of similar leaks in the future, the licensee is considering acquisition of a helium leak detector to monitor air leaks at such points as the condensate (hotwell) pumps, turbine gland seals, and condenser tubes.

At present, the licensee monitors the integrity of the condenser and hotwells by means of inline continuous analyzers for cation conductivity and sodium (with display in the Control Room) and by taking periodic grab samples for specific conductivity, silica and dissolved oxygen. Instrumentation that will allow the continuous measurement of sodium in each water box is to be installed in the near future. The inspector considered that the use of titanium tubes and the licensee's monitoring program to be acceptable protection against in leakage of water and air.

(2) Condensate Makeup Water

A second potential source of contamination of the condensate is the water used for makeup. At Surry, the source of this makeup water has been wells that were drilled in the coastal sediments in the vicinity of the station. As part of the recent refitting program, the station's water treatment plant was significantly enlarged so as to supply high quality water for use in the new condensate cleanup system. Inasmuch as the licensee is limited by a Virginia Certificate of Groundwater Right to a daily well-flow of 586,788 gallons, a sand filter was added to the water treatment plant so that water from the James River could be processed into makeup water to replace or supplement the well water.

The water treatment process consists of purification of the source water by means of flash evaporators followed by passage of the distillate through a bed of mixed cation and anion resins. The product is stored in a 300,000 gallons Primary Water Storage Tank from which it is pumped to the Condensate Storage Tank (for makeup purposes), to the Emergency Condensate Storage Tanks (for suction for the Auxiliary Feedwater Pumps, or to primary (reactor) coolant makeup. The water treatment plant is operated under the direction of the Water Management Supervisor in the Operations Department.

The inspector was informed that, because of problems with the sand filter, well water was still being used as the principal source of the high quality makeup water for the station. The quality of the makeup water is monitored daily for pH and specific conductivity after each step in the treatment process, and the efficiency of the flash evaporators and demineralizers are also monitored daily by measuring the concentration of sodium and dissolved oxygen in the effluents. Other potential contaminants (i.e., silica, chloride, fluoride) are also determined on a weekly frequency. The licensee does not monitor the product for copper although the flash evaporator tubes are fabricated from copper-nickel alloy and, thus, may be a source of soluble or insoluble copper in the condensate.

Because of the efficiency of the flash evaporator, the concentration of dissolved oxygen in the product is less than 100 ppb. However, the inspector was informed that, through contact with air in the storage tanks, the concentration of dissolved oxygen in the water in the Condensate Storage Tank is usually 1 to 2 ppm and even higher in the other tanks. Although the condensate makeup water is deaerated as it is added to the hotwell, the water used for primary coolant makeup and auxiliary feedwater are not deaerated before being used. Consequently, large amounts of hydrazine are required to bring the dissolved oxygen concentrations within specifications (100 ppb) when large volumes of makeup water are added to the reactor coolant system. Similarly, oxygenated water is added to the steam generator whenever the auxiliary feedwater pumps take suction from one of the Emergency Condensate Storage Tanks.

(3) Condensate Polisher Demineralizer

Before the refitting program in 1979-1980, the licensee had only steam generator blowdown to control water quality in the secondary water system. Each Surry unit now has a seven-bed demineralizer system (manufactured by Infilco-Degremont) that is designed for a flow of 2200-2500 gpm through each bed. Six beds can handle 100% flow, thereby allowing one bed to be in a regeneration or standby mode. The licensee has elected to regenerate 5 beds per week; consequently, each bed is in use for 12 days. This schedule has ensured that the capacity of each bed has not been overloaded and, thus, has prevented sodium breakthrough. Each bed is instrumented to alarm if the specific conductivity of its effluent increases of 0.12 umho.

The performance of the Surry condensate polishers system is being evaluated as part of the Steam Generator Owners Group (SGOG) effort to address corrosion problems. Although the efficiency of the resin beds has been adequate, elevated levels of cation conductivity in the steam blowdown have been observed as the result of throw of regenerant chemicals (i.e., sodium and sulfate). The licensee changed out of the resins (hydrogen and hydroxyl forms) in Unit 2 two years ago and improved their performance. The inspector was informed that one bed of the Unit 1 system will be replaced, during the upcoming refueling outage, with a new resin (Monosphere) and possibly with an inert resin layer to determine if better separation of the cation and anion resin beds can be achieved and, thus, reduce throw of the regenerant chemicals (sulfuric acid and sodium hydroxide).

The inspector considers the design and operation of the condensate polishers to be acceptable and also believes that the licensee's effort to maintain the quality of feedwater recommended by the Steam Generator Owners Group/Electric Power Research Institute (SGOG/EPRI) guidelines (e.g., cation conductivity <0.2 umho/cm) will minimize corrosion of the steam generator tubes.

(4) Feedwater Lines

At Surry, the effluent of the Condensate polishers is pumped to the steam generator through the following intermediate components:

- air ejector condenser
- gland steam condenser
- flash evaporated condenser
- heater drain coolers
- 10 low-pressure feedwater heaters
- feedwater pumps
- 2 high-pressure feedwater heaters

During layup or extended outages, these components become potential sources of iron and copper oxide scale that could be transported to the steam generators when the plant is restarted. The inspector established that the licensee flushes these lines, as far as the suction of the feedwater pumps, back to the hotwell during startup until the feedwater is of sufficiently high quality to be added to the steam generators. Likewise, the licensee ensures the high quality of the water from the heater drain tank that is cycled forward to the suction of the feedwater pump during plant operation. This water consists of condensate from the No. 1 - 4 feedwater heaters and from the moisture separator reheaters and accounts for ~ 6000 gpm at full power (i.e., ~ 30% of total feedwater). During startup, these lines and the drain tank are flushed to the hotwell until the plant reaches ~ 60% power.

The licensee cannot flush the feedwater lines from the feedwater pumps to the steam generators (~ 250 feet). Consequently, this portion of the secondary system must be protected during shutdown by maintaining proper wet layup conditions to prevent the formation of large amounts of unstable iron oxide (hematite) on the carbon steel surfaces that would be transported to the steam generator as sludge.

During plant operation, there is the potential for contamination of the feedwater by copper that is eroded or dissolved from the tubing in the feedwater heaters, in the moisture separator reheater, and in the flash evaporator. Inasmuch as all of these components are downstream from the condensate polishers, there is the possibility that copper would be transported to the steam generators.

Although it is uncertain what effect soluble or particulate forms of copper would have in the absence of iron oxide sludge deposits, previous experience has shown that the presence of copper is conducive to the formation of local corrosive environments on inconel steam generator tubes and stainless steel (SA-240 Type 405) tube support plates. During plant operation, the licensee monitors the feedwater for dissolved oxygen on a continuous basis and for the following parameters on a daily basis; pH, hydrazine, cation and specific conductivities, and sodium. Ammonia, copper, and iron are determined on a weekly frequency.

The inspector considers the licensee's cleanup system adequate for ensuring high quality feedwater as long as the pipes between the feedwater pumps and the steam generator are not exposed to air. If, during an outage, the protective film of black iron oxide (magnitite) that now covers the interior surfaces of these pipes is converted to rust (less adhesive, hematite) there is the potential for transporting this red iron oxide to the steam generators when the plant is restarted.

(5) Steam Generators

Each Surry unit has three recirculating steam generators that were refitted with new tubes and tube support plates, new feedwater and blowdown distribution lines, and new moisture separation equipment after approximately seven years of operation. In addition, the licensee has installed a blowdown cleanup system so that the blowdown can be recycled to the hotwell rather than wasted as before. The new steam generator tube bundle assembly contains thermal treated Inconel (ASME - SB-163) U-tubes that are expanded the full depth of the tubesheet and welded to the tubesheet cladding to minimize sites conducive to crevice corrosion. The tubes are supported by seven tube support plates and a flow distribution baffle made of Type 405 stainless steel and which have quatrefoil shaped holes. These materials and designs were selected to reduce the potential for corrosion of the tubes caused by buildup of iron oxide sludge on the tubesheet and tube support plates. The piping for blowdown is located so as to achieve maximum removal of particulates that fall through the quatrefoil holes onto the tubesheet. The inspector was informed that visual examination of the tube bundles had been made during each outage and no indication of degration had been observed. Also the steam generators have been sludge lanced during the refueling outages; however, essentially no solids have been found. The licensee has observed small amounts (~700 ppb) of 'hideout' silica in the steam generator water.

Each steam generator was designed to operate with blowdown rates up to 7.4% of the feedwater flow; however, the capacity of the blowdown cooling system limits this rate to ~1% (30-60 pgm). The quality of the blowdown water is used to establish the overall effectiveness of the secondary water system to protect the primary coolant pressure boundary. Cation conductivity is measured continually and the following parameters are determined daily: pH, specific conductivity, sodium, chloride, hydrozine, dissolved oxygen and silica. Copper and iron are monitored on a weekly frequency. The inspector considers the scope of this monitoring program to be acceptable.

(6) Main Steam System and Turbines

This licensee was one of the first to identify the presence of cracks in the keyway regions of Westinghouse low-pressure turbine disks in 1979). Although the vendor attributes the initiation of such cracks to metallurgical causes (i.e., corrosion caused by the condensation of steam on surfaces with high stress risers), the possibility exists that these cracks may be caused by chemical-induced stress corrosion. Consequently, the licensee monitors the quality of the steam to determine the extent of carry-over and to establish the identity of impurities that may attack the low-pressure turbine disks. Sodium and cation conductivity are continually measured; chloride is measured daily when the cation conductivity exceeds 0.3 umhos/cm; pH and specific conductivity are measured five days per week; and silica, oxygen, ammonia, iron, and copper are determined once per week.

The licensee has replaced the original rotors in Unit 1 with rotors of a new design, with less stress in the critical regions of the disks. The original rotors have been rebuilt with the new disks and will be installed in Unit 2 during the next refueling outage.

The licensee has also observed corrosion/erosion of the 90-10 copper-nickel tubes in the moisture separator reheaters in Unit 1 and plans to refit these heaters with stainless steel tubes during upcoming refueling outage. This refitting will also remove one source of copper contamination of the feedwater.

(7) Summary

The secondary water systems in both Surry units have been refitted on the basis of experience developed in the nuclear industry during the past ten years - especially new knowledge related to the control of water quality and chemical-induced corrosion. The inspector considers that each of the refitting actions should increase the capability to prevent the ingress of contaminants and/or to maintain the concentration of corrosive impurities (i.e., oxygen, chloride, hydroxide) to less than recommended by the SGOG/EPRI guidelines. Three sources of impurities still remain; i.e., ppm concentrations of dissolved oxygen in the water used for condensate makeup and primary coolant makeup and for emergency cooling water; sulfate and sodium 'throw' in the effluent of the condensate polishers; and the presence of copper in components that are in contact with the feedwater.

b. Scope and Adequacy of the Licensee's Water Chemistry Program

The Surry Technical Specifications (TS 3.1-15, 3.1-15a, 3.1-20, 3.1-21, 3.2-4, 3.3-1, 3.4.2-2, 3.17-1, 3.17-2, 4.2-2, 4.1-10, and 5.4-2) identify the chemical parameters that must be monitored and controlled in the primary coolant system. Similar requirements for the secondary water system are not addressed in the Technical Specifications; however, the licensee has described the goals and basis for a secondary water chemistry program in Section 10.3.1.4 of the updated FSAR. In addition to maintaining an environment in the secondary coolant system that "is innocuous to the steam generator" the program should accomplish the following objectives:

(1) Maintain a high integrity of all systems components.

(2) Avoid or minimize turbine deposits due to carryover and volatility from the steam generator.

(3) Minimize sludge at its point of concentration, the steam generator.

(4) Minimize scale deposits on the steam-generator heat transfer surfaces.

(5) Minimize feedwater oxygen content prior to entry into the steam generator.

(6) Minimize corrosion of the condensate/feedwater system materials.

(7) Minimizing the potential for the formation of free caustic or acid.

(8) Maintaining "zero" dissolved oxygen level."

The licensee committed to accomplish these objectives through "exercising chemistry control over the systems, including sampling and analysis (in-line and laboratory), chemical injection at selected points, continuous system blowdown from the steam generator, and effective protection of the steam generator and feedwater from internals during periods of inactivity."

The inspector verified that responsibilities have been designated and guidance has been provided for the following administrative activities that are required to implement the water chemistry program.

- Establishing key parameters to be monitored when the plant is in wet layup, hot shutdown/standby, and power operation,
- Developing, reviewing, approving, and updating chemical procedures,
- Scheduling tests and analyses,
- Training analysts,
- Performing chemical measurements,
- Providing calibrations and quality control,
- Documenting and reviewing test results, and
- Taking required action on the basis of test results.

The inspector established that procedures (Periodic Tests) have been developed to fulfill the requirements of the Surry Technical Specifications. The details of actions to be taken to achieve the objectives of the secondary water chemistry program are described in other procedures (i.e., Chemistry Administrative Procedures, Periodic Tests, Operating Procedures and Plant Administrative Procedures).

The licensee is currently revising the goals, limits, and requirements of these procedures so that the Surry water chemistry program will conform more closely with the guidelines developed by the SGOG and EPRI for plants with recirculating steam generators. Through interviews of licensee personnel, the inspector was informed that the management of the plant and in corporate positions are cognizant of the need to meet the objectives listed in the FSAR and in the SGOG/EPRI guidelines and are supportive of the water chemistry program. The inspector also verified that the plant's table of organization provides for the chain of responsibility and authority needed to implement the day-to-day chemistry control program.

On the basis of this review, the inspector concluded that the licensee has developed the framework for an effective water chemistry program. Pending completion of the revision of chemistry procedures, the inspector withholds final assessment and designates this activity for future review as Inspector Followup Item 84-16-01 "Evaluation of Secondary Water Chemistry Program".

c. Implementation of the Surry Water Chemistry Program.

The inspector assessed the degree to which the licensee is fulfilling the requirements of the Surry Technical Specifications and is implementing the water chemistry program that is currently being used to meet the FSAR objectives. This assessment was based on discussions with licensee personnel, review of procedures, observation of the performance of chemistry tests, and an audit of recent test results. This part of the inspection is summarized as follows:

(1) Activities related to plant chemistry are performed by personnel in both in the Chemistry Section, under the Chemistry Supervisor (who reports to the Superintendent of Technical Services), and in the Water Management Section of the Operations Department, under the Water Management Supervisor (who reports to the Superintendent to Operations). Although it appeared to the inspector that there is some overlap of responsibilities, the Water Management Section has primary responsibility for operating the water treatment plant, the condensate polishers, the demineralizers in the primary system and in the steam generator blowdown recovery system, the radwaste system, and the Control Room associated with these components and systems. Surveillances required by Technical Specifications and by the water chemistry program, for both the primary and secondary water systems, are performed by the Chemistry Section. The Chemistry Section currently has a staff of

18 personnel, all but one of whom has an academic degree in a science-related field. The Water Management Section is manned by personnel who are in the licensee's training program for Control Room Operators and who are assigned to the Water Management Supervisor on a limited and temporary basis.

(2) Technical training is provided to new technicians principally through on-the-job training after they have received a brief indoctrination course. Chemistry technicians can advance through seven steps of proficiency, each of which involves at least six months of on-the-job experience and successfully passing a written qualification test. The Surry Training Department provides subsequent formal training (8 hours per three months) in areas proposed by the Chemistry Supervisor.

(3) The Chemistry Section operates on two 10 hours shifts (7 a.m. to 5 p.m. and 7 p.m. to 5 a.m.) with the night shift manned by 1 to 3 people. The Water Management Section operates on 3 shifts.

(4) Chemical parameters associated with the Condensate Makeup Water System and the Condensate Polisher Demineralizers are monitored continually by inline instrumentation that displays the results in the Water Management Control Room. Cation conductivity is also monitored continually at sample points for the condensate, feedwater, and steam generator blowdown; sodium is monitored continually in the condensate and main steam, and inline instrumentation for dissolved oxygen is installed for the condensate and feedwater. Although several of these inline analyzers are instrumented to display in the main Control Room, the inspector observed that only the two sodium systems were operable. All other chemical variables are monitored by taking grab samples from taps in a "Hot-Sample Room" (for primary water samples), from a sample station in the Turbine Building, or from local sample taps associated with specific systems. The inspector reviewed selected Periodic Tests (and Operating Procedure OP-12 that supplements the guidance in these Periodic Tests) and concluded that sufficient instructions were given to ensure that sampling would be performed correctly.

(5) The licensee performs analyses on primary water samples in a rather cramped portion of the original chemistry laboratory; however, new facilities are being planned. A secondary water laboratory has been recently constructed in the new Water Treatment Building. The secondary water laboratory is well equipped with new analytical instrumentation that is being placed in service by the recently hired Section Chemist. The inspector verified that all calibration stickers for instruments in the secondary laboratory were up to date.

(6) The inspector audited selected Chemistry Administrative Procedures and Periodic Tests and found them to be acceptable as to format, content, and clarity.

(7) The inspector established that the results of each analysis was being documented on log sheets and then being entered into a computerized data base daily, after being reviewed by the Chemistry Supervisor. The log sheets are subsequently transferred to the Plant's Record Department for storage.

(8) Current limits and specifications are listed in each Periodic Test, as well as the action to be taken if the limit is exceeded. The inspector verified that procedures are being implemented to inform the Control Room Operators by telephone and by written communications when a parameter does not meet the limits in a Technical Specification or in a Periodic Test. The inspector also verified that the Operations Department has a written procedure that must be followed for corrective action in the event of deviation from normal Chemistry Control Specifications.

(9) The inspector also verified that the licensee has written instructions regarding calibration of instruments and chemical reagents and the use of standard samples for quality assurance.

(10) The licensee is currently trending selected parameters manually and is developing the capability to use the computerized data base for this purpose.

(11) The inspector was informed that the licensee operates the Post Accident Sampling System several times a week to train technicians in the use of this system.

<u>Summary</u>

During this part of the inspection, no violations or deviations were identified and all audited results were within the limits set by Technical Specifications or by administrative policy. It was evident to the inspector that the licensee is in the process of upgrading the following features of the secondary water chemistry program:

- inline monitoring of water in the hotwells,
- primary chemistry laboratory and sampling facilities (planning stage),
- instrumentation for measuring parts per billion concentrations of anions and cations,
- computerized trending and analysis of results, and
- size and capability of the chemistry staff.

On the other hand, the inspector considered the inoperability of several inline analyzers and most of the chemistry display instrumentation in the Control Room to be indicative of maintenance problems that are reducing the effectiveness of the licensee's chemistry surveillance program, especially in providing the Control Room with the status of key chemical parameters. The inspector also observed that several valves that have to be exercised when taking samples from process streams are not clearly labelled.

Inasmuch as most of this inspection was devoted to the secondary water system, the inspector did not review in depth the effects of a leak of primary water into the components cooling water system that had occurred recently. The inspector was informed that this leak was apparently in the seal of the "B" Evaporator surge pump. This evaporator was taken out of service and ~20,000 gallons of water were drained so that the carbon steel pipes of the component cooling water system would not be attacked by the boric acid from the primary water. At the time of this inspection the "B" Evaporator was still out of service and the licensee had not completed an analysis of the cause of the problem or the effect on the Component Cooling Water System. The inspector will review this situation at a later date and designates this action as Inspector Followup Item 84-16-02 "Leakage of Primary Water into the Component Cooling Water System".