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

MAY 17 1984

Report Nos.: 50-259/84-13, 50-260/84-13, and 50-296/84-13

Licensee: Tennessee Valley Authority
500A Chestnut Street
Chattanooga, TN 37401

Docket Nos.: 50-259, 50-260 and 50-296

License Nos.: DPR-33, DPR-52, and DPR-68

Facility Name: Browns Ferry 1, 2, and 3

Inspection at Browns Ferry site near Decatur, Alabama

Inspector: W J Ross 5/9/84
W. J. Ross Date Signed

Approved by: J J Blake 5/15/84
J. J. Blake, Section Chief Date Signed
Engineering Branch
Division of Reactor Safety

SUMMARY

Inspection on April 16-20, 1984

Areas Inspected

This routine, unannounced inspection involved 48 inspector-hours on site in the areas of plant chemistry and inservice testing of pumps and valves.

Results

Of the two areas inspected, no violations or deviations were identified.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

*G. T. Jones, Plant Manager
*J. E. Swindell, Assistant Plant Manager
*D. C. Mims, Assistant Engineering Supervisor/Chemistry
*J. R. Clark, Chemical Unit Supervisor
*W. G. Tays, Chemistry Lab Supervisor
*J. M. Pleva, Supervisor, Chemical Engineering, Division of Nuclear Power
M. Rollins, Supervisor, Chemical Monitoring, Division of Nuclear Power
*T. L. Chinn, Supervisor, Compliance
*D. L. Smith, Engineer, Compliance
R. McPherson, Supervisor, Engineering and Testing

Other licensee employees contacted included four chemists and one assistant shift supervisor.

NRC Resident Inspectors

G. Paulk
*C. Patterson

*Attended exit interview

2. Exit Interview

The inspection scope and findings were summarized on April 20, 1984, with those persons indicated in paragraph 1 above. The licensee acknowledged the inspection results with no dissenting comments.

Inspector Followup Item 50-259, 260, 296/84-13-1, "Revised Water Chemistry Program", Section 5.b.

Inspector Followup Item 50-259, 260, 296/84-13-2 "Updated Chemical Surveillances and Procedures" Section 5.c.

3. Licensee Action on Previous Enforcement Matters

(Closed) IE Bulletin 83-Bu-05, The licensee responded to this Bulletin by letter dated July 22, 1983. In this letter, the licensee stated that Hayward Tyler pumps are not in use or planned for use in the Browns Ferry Nuclear Plant; therefore, this Bulletin is not applicable to Browns Ferry.

4. Unresolved Items

Unresolved items were not identified during this inspection.

5. Plant Water Chemistry (92706)

The inspector compared the design of the "as built" components of the systems that make up the primary coolant pressure boundary with the description of these components in the licensee's updated (1982) Final Safety Analysis Report (FSAR), especially Section 4.0 "Reactor Water Cleanup System," Section 10.13 "Demineralized Water System," and Section 11.0 "Power Conversion System." The inspector also reviewed the design of secondary cooling water systems (Plant Service Water, RHR Service Water, and Reactor Building Closed Cooling Water). The purpose of this inspection was to assess the combined effectiveness of the components of the primary cooling water system and the licensee's water chemistry program in preventing the deterioration of the primary coolant pressure boundary and in maintaining the reliability of the nuclear steam supply system (NSSS) of the three Browns Ferry units (BF-1, BF-2, and BF-3).

a. Assessment of the Design and Operation Components in the NSSS

The three Browns Ferry units began commercial operation in August 1974, March 1975, and March 1977. At the time of this inspection, BF-1 and BF-2 were operating in their sixth and fifth fuel cycles, respectively, while BF-3 was shut down for major maintenance and modification of the torus. Two significant problems that are attributed in part to water chemistry have been observed during the operational lives of the three units. Intergranular stress corrosion cracking (IGSCC) in recirculating water lines has been identified in Units 1 and 2 and, to a much less degree in Unit 3. The licensee is planning to replace the faulty pipes in Unit 1 and, possibly, in Unit 2. In addition, corrosion of gadolinum-containing fuel rods has been observed in Unit 2. Because of the potential for similar degradation of fuel rods in the other units, the licensee has used an experimental "control-cell" fuel configuration in Unit 3 to reduce the temperature of fuel rods in regions that have been susceptible to corrosion. The licensee is also aware of fuel-rod corrosion that has been attributed to the presence of relatively high (~30 ppb) concentrations of copper in the reactor cooling water, but, as yet, has not attributed fuel degradation to this cause.

The inspector interviewed cognizant plant personnel to obtain background information concerning the operational experience of the major components of the NSSS and relative to plant reliability problems that have been attributed to off-normal chemistry or to chemical-induced corrosion.

(1) Main Condensers

The three Browns Ferry units transfer waste heat from the main condensers to circulating cooling water that is taken either directly from the Tennessee River (Wheeler Reservoir) or from a closed cycle cooling system, with six mechanical- draft cooling towers, that uses river water for makeup. The condenser tubes and tube sheets are fabricated from admiralty brass and are cleaned by

means of an Amertap system. Although the licensee has experienced mechanical failures that have caused damage to condenser tubes, there has been little problem with water inleakage. Ingress of air has been observed, however, even though the condensers were designed to maintain the dissolved oxygen content of the condensate to 0.005 cc/l. The inspector was informed that air inleakage into BF-1 and BF-2 was currently ~70 scfm and ~170 scfm. (1 scfm of air completely dissolved in water is equivalent to ~400 ppb of dissolved oxygen.)

Because of the high (~700 mr) radiation level at the surface of the condensers, the extent to which inspections can be made is limited. The licensee has a helium leak testing procedure that has been used very successfully to detect condenser tube leaks. The shell side of the condensers are visually inspected each refueling outage and cleaned of accumulated sludge.

(2) Condensate Makeup System

Makeup water for condensate/feedwater is obtained from the river and treated to remove all soluble and insoluble organic and inorganic constituents. The design and operation of this system is consistent with the descriptions in Sections 10.13 and 11.9 of the FSAR except that potassium permanganate and chlorine are not used as oxidants as stated in the FSAR. The licensee is planning to upgrade portions of the relatively small (60 gpm) water treatment plant; however, the inspector observed that the quality of water specified in the FSAR was being achieved.

(3) Condensate Cleanup System

The inspector verified that the condensate cleanup system described in Section 11.7 of the FSAR is installed in each unit. Each system consists of nine Powdex demineralizer beds (manufactured by Grave Water Conditioning Company) and a resin trap. Although the FSAR indicates that eight beds are sufficient for full-flow cleanup, the licensee actually uses all nine beds in order to improve the efficiency of each bed by reducing the flow rate and to extend the useful life of a bed to ~ 12 days.

The resin coats are replaced whenever one of the following criteria is exceeded; the differential pressure (ΔP) of a bed exceeds 23psid; the ΔP of any three beds exceeds 18 psid; or the specific conductance of the effluent of a bed exceeds 0.1 umho/cm. The individual Powdex cells are replaced each refueling cycle in order to maintain the desired efficiency of the polishing system. Similarly, all valves associated with the demineralizers are replaced each refueling outage to decrease the possibility that the cleanup system will need to be taken out of service; thereby causing a plant shutdown during the fuel cycle.

The licensee has also installed an air-surge backwash system as part of the condensate cleanup system of BF-1 both to reduce the volume of demineralized makeup water that has to be subsequently processed as radwaste and to achieve better cleanup of each Powdex cell.

The licensee also uses the demineralizer beds as filters during the "short" and "long" cleanup cycles that are implemented to purify the condensate/feedwater during plant startup. In an effort to minimize the amount of scale, sludge, and other contaminants that must be removed before the desired quality of feedwater is achieved, the plant is "layed-up" dry by draining the condensate and feedwater while the water and pipes are still hot.

Although the licensee has devoted significant effort to maintaining a high degree of cleanup with the demineralizers and to achieving longer periods of usefulness from the Powdex beds, the useful life of the polisher remains considerably shorter than the vendor's design (2-3 months). The inspector observed that the specific conductivity of the effluent of the demineralizer was ≤1 umho/cm. This level of water quality is considered to be acceptable for preventing IGSCC (if dissolved oxygen is maintained below 20 ppb). The inspector also observed that the concentration of copper in the condensate is reduced from ~3ppb to 0.3 ppb by the condensate polishers. The licensee believes that both soluble and insoluble forms of copper are formed through erosion and corrosion of the admiralty condenser tubes. This element is monitored because of its potential adverse effect on fuel elements through the formation of adhesive and corrosive iron-copper oxides "sludge".

(4) Feedwater Lines

As described in Section 11.0 of the FSAR, the effluent of the demineralizers is pumped through three low-pressure feedwater heaters and two high pressure feedwater heaters to the reactor. The condensate in the feedwater drains is cycled back to the hotwell and, therefore, cannot contaminate the feedwater. The inspector verified that the feedwater heater pipes are fabricated from stainless steel and, thus, do not add to the soluble copper content of the feedwater.

(5) Reactor

As discussed earlier, IGSCC has been observed in the recirculating water lines of BF-1 and BF-2, and, to a much less extent, in BF-3. The inspector was informed that plans have been tentatively made to replace the fuel in the three units (beginning in 1987) with new-fuel designed to reduce the potential for degradation through corrosion.

The licensee has no plans to extend the use of "controlled fuel cells" to BF-1 or BF-2.

(6) Moisture Separator Reheaters

The inspector verified that these components do not contain copper tubes, and, therefore, do not contribute to the copper concentration of the condensate. Also, the inspector was informed that the condensate from these reheaters is cycled to the hotwell and, thus, is not a potential contaminant of the feedwater.

(7) Turbines

The inspector was informed that stress corrosion cracks had been observed in the low-pressure turbine disks (wheels) in BF-2 and replacement rotors are on order. The vendor (General Electric) does not consider the initiation and propagation of this type of crack to be chemically induced and is providing the licensee with guidance on further operation of the flawed rotors.

Summary -

Both BF-1 and BF-2 developed IGSCC in the recirculating lines during the initial 7 to 9 years of operation. This type of degradation has been attributed by EPRI to both metallurgical causes and to a corrosive electropotential formed in water that has high specific conductivity (>0.3 umhos/cm) and high dissolved oxygen concentrations (>25 ppb 02). Because of the high radiation environment associated with the main condenser of a BWR, the licensee has not been able to eliminate all sources of air and water inleakage and to achieve a conductivity of < 1 umho/cm for the condensate. However, through the use of the condensate polishers the conductivity of the condensate (and makeup water) is being reduced to ~0.1 umho/cm at the point of effluence and 0.5 umho/cm in the reactor coolant. The dissolved oxygen concentration of the reactor coolant is ~80 to 100 ppb (less than normally found in BWRs as the result of radiolysis of water). Consequently, the conditions for IGSCC remain until the magnitude of both of these parameters can be reduced. The licensee also recognizes the potential for fuel rod degradation as long as the low (0.3 ppb) content of copper in the feedwater is being concentrated by a factor of 100 in the reactor coolant and has the potential for forming a corrosive environment on the surfaces of fuel rods. However, the inspector was informed that no plans to eliminate the source of this potential problem (i.e., the admiralty condenser tubes) were being considered at this time.

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

Control and surveillance of key chemical parameters in the reactor coolant (i.e., conductivity, chloride, and pH) are required by Browns

Ferry Technical Specifications 3.6 and 4.6. In addition, Technical Specification 3.4 requires that boron be monitored for reactivity control. Two sections of the FSAR (§10.13 "Demineralized Water System" and §11.9 "Condensate Storage and Transfer") set limits on the following chemical variables in the Condensate Makeup System: silica, chloride, conductivity, pH and solids. Finally, limits on the chemical variables that may affect the quality of the feedwater are specified in §11.7 "Condensate Filter Demineralizer System," i.e., pH, silica, chloride, iron, copper and total/dissolved solids.

The inspector verified that the licensee is implementing the requirements of the Technical Specifications by monitoring the required parameters on a daily frequency. Likewise, the inspector established that the objectives of the FSAR were being met to the extent that the designated key parameters are being monitored. Through a review of administrative and technical procedures, especially Technical Instruction TI-38, the inspector also established that the following elements of a water chemistry program are being addressed:

- Training and Qualification of Analysts (TI-38 §1400)
- Developing Procedures (TI-38 §1000 and 1100)
- Quality assurance (TI-38 §1500)
- Data Control (TI-38 §700)
- Control of impurities in bulk chemicals (TI-38 §900)

In addition, §800 of TI-38 sets limits on certain key parameters that should be monitored during various modes of plant operation.

The inspector was unable to establish in the time available that the many documents identified as directives and guidance provide the elements of an effective water chemistry program. This judgement was made more difficult because the licensee is carrying out a comprehensive Water Quality Improvement Program that will revise essentially all the documents that were reviewed by the inspector. This upgrade effort is in response to an ongoing revision of the "TVA Chemical Management and Performance Program." The licensee discussed several phases of the upgrade program with the inspector and identified a large number of elements that are now considered to be inadequate when compared to the guidelines for a BWR Water Chemistry Program that are being developed by the BWR Owners Group and the Electric Power Research Institute. Consequently, the inspector is deferring evaluation of the licensee's water chemistry program until the ongoing revisions have been completed and are being implemented. Pending completion of this review, this subject will be designated as Inspector Followup Item 50-259, 260, 296/84-13-01 "Revised Water Chemistry Program."

c. Implementation of the Browns Ferry Water Chemistry Program

The deficiencies in the licensee's Water Chemistry Program became apparent as the inspector assessed the degree to which the integrity of the primary water pressure boundary is being protected by the licensees chemical control and surveillance activities. This part of the inspection is summarized as follows:

(1) The water chemistry program is implemented by personnel under the direction of the Assistant Engineering Section Supervisor and the Chemistry Unit Supervisor. Control and surveillance activities are performed under the supervision of a Laboratory Foreman and Shift Foremen who are designated on a weekly basis. During the past year additional chemists and chemical engineers have been added to the staff of the Chemistry Unit Supervisor to provide support in systems and radiochemistry. The remainder of the staff of 26 personnel are technicians, all of whom meet the qualifications of ANSI 18.1 and most have scientific academic degrees. During this inspection, the inspector observed that one senior level chemist from the TVA Division of Nuclear Power was assigned on a full-time basis to assist in the upgrade program. Likewise, a specialist in radiochemistry had been contracted on a full-time basis to assist in improving the performance of the radiochemistry personnel and equipment. In addition, two other chemists from the TVA Central Office and another radiochemistry contractor were on site part time to support the upgrade program.

(2) Training has been provided primarily through on-the-job training program for new technicians, currently all senior technicians are trained in both radiochemical and non-radiochemical functions.

(3) The licensee implements the requirements of Technical Specifications as scheduled and directed by the Plant Services Department, which also tracks these activities for regulatory purposes. Non-Technical Specification requirements are scheduled by the Laboratory Foreman by means of a large number of Data Sheets. The inspector had difficulty in placing the directives for performing such actions as testing, reviewing results, taking appropriate action on the basis of these results, and trending selected parameters in the proper sequence. The licensee's personnel, however, appeared to understand the guidance and directions needed to perform the analyses that are scheduled on a 24-hour frequency. With considerable assistance, the inspector verified that all requirements related to the reactor coolant and reactor water cleanup system had been performed as scheduled for BF-1 during the first four months of 1984. All results were within the limits prescribed in TI-38 §800. The licensee showed the inspector revisions of Data Sheets that will significantly clarify and abbreviate the guidance for implementing these requirements as well as to facilitating judgements to be made as

to the acceptability of the results and action to be taken when specified limits are not met.

(4) The most critical parameters (i.e., conductivity of the demineralizer influent and effluent and of the Reactor Cleanup System (RWCS) influent and effluent) are monitored continually in the Control Room. All other parameters are determined from grab-samples taken daily from Reactor Coolant and RWCS sample taps (i.e., silica, pH, iron, chloride, boron, dissolved oxygen, and conductivity) and on a less frequent basis (e.g., three times a week or weekly) from taps on the hotwell, condensate storage tank and feedwater line. The licensee informed the inspector that the sampling system will be improved as part of the upgrade program. In-line monitors may also be placed at the existing sample taps; however, there are no plans to extend these sampling lines to the laboratory area.

(5) The inspector verified that technicians had been instructed to advise the Shift Foreman of all results that are out-of-specification. The Shift Foreman then alerts the Control Room operators of this condition. Currently, the Control Room operators follow the directions in Operating Instructions No. 69 "Reactor Water Cleanup" whenever a parameter covered by Technical Specifications is out of limits or when other abnormal conditions arise. These instructions will be clarified and improved as part of the upgrade program.

(6) The inspector verified that all analytical results are documented either on a Data Sheet or in the Laboratory Log Book. These results are reviewed each shift by the Shift Foreman and daily by both the Laboratory Foreman and Chemistry Unit Supervisor. Several parameters are being trended; however, the inspector found this activity had been neglected during several time periods. The licensee informed the inspector that a computer was being acquired so that this trending effort can be upgraded and extended.

(7) The inspector read several procedures in §1100 of TI-38 and found them to be acceptable as to clarity, format, and content. The licensee is reviewing all procedures to assure that they are accurate and acceptable for use. The inspector will evaluate the acceptability of the new procedures in a later inspection and designates this pending action as Inspector Followup Item 50-259, 260, 296/84-13-02 "Updated Chemical Surveillances and Procedures."

Summary -

The inspector verified that the licensee is correctly monitoring the four parameters required by Technical Specifications and has a surveillance program for key parameters that provides indication of the quality of the makeup water, condensate, and feedwater. The inspector identified several areas where improvement is

needed; however, it was evident that the licensee recognizes these deficiencies areas and is actively endeavoring to bring about the necessary improvements. The inspector did not identify any violations or deviations, but proposes to review the licensee's water chemistry program and the implementation of this program in greater detail in a future inspection.

6. Inservice Testing of Pumps and Valves - (92706)

The inspector discussed the resolution of items that have arisen during the staff's review of the Brown Ferry "Pump and Valve Program." The licensee informed the inspector that a response to the staff's recent request for additional information was being drafted. The inspector elaborated on the NRC position that the IST program should include all systems and components "important to safety." The inspector advised the licensee that a documented clarification of this position will be requested from the Office of Nuclear Reactor Regulation Project Manager for Browns Ferry.