ROBERT E. DENTON
Vice President
Nuclear Energy

Baltimore Gas and Electric Company
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway
Lusby, Maryland 20657
410 586-2200 Ext. 4455 Local
410 260-4455 Baltimore

BGE

July 29, 1994

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit No. 1; Docket No. 50-317
Pressurizer Heater Sleeves and Instrument Nozzles Inspection Plan Modification / Heater Sleeves Nickel Plating

REFERENCES:

(a) Letter from Mr. G. C. Creel (BGE) to Document Control Desk (NRC), dated October 2, 1989, Clarification of Unit 1 Pressurizer Sleeve Inspection Plans

(b) Letter from Mr. J. J. Hutchinson (Chairman C-E Owners Group) to Mr. J. T. Wiggins (NRC), dated February 26, 1992, C-E Owners Group Report CE NPSD-690-P, "Evaluation of Pressurizer Penetrations and Evaluation of Corrosion After Unidentified Leakage Develops"

The purpose of this letter is to inform you of a modification to the inspection plan for the Calvert Cliffs Unit 1 pressurizer heater sleeves and instrument nozzles as previously reported to you in Reference (a). In addition, this letter provides you with information regarding the recently completed Unit 1 pressurizer heater sleeves nickel plating project.

The modification to the inspection plan is based on the recommendation of the Combustion Engineering Owners Group (CEOG) study submitted to the NRC by Reference (b). The CEOG study permits a longer inspection interval than the one in the original Baltimore Gas and Electric Company (BGE) inspection plan. Attachment (1) contains both the original and the modified plans. Baltimore Gas and Electric Company implemented the original inspection plan following the 1989 discovery of the Unit 2 pressurizer penetration leakage. The leakage was determined to have been caused by primary water stress corrosion cracking (PWSCC) of Inconel 600 material.

In addition to the inspection plan, BGE had also assembled a task force to look into Inconel 600 susceptibility to PWSCC and develop a long-term preventive measure. After studying several options, the task force recommended nickel plating as the most effective preventive measure for the heater sleeves. The task force's recommendation was implemented during the 1994 refueling outage by nickel plating all Unit 1 pressurizer heater sleeves. A description of the nickel plating process and some background information on Calvert Cliffs pressurizers are provided in Attachment (2).

The nickel plating preventive measure, along with the favorable CEOG findings concerning the consequences of axially oriented PWSCC, has made it unnecessary for BGE to continue the inspection plan as outlined in Reference (a). In addition to the Technical Specifications requirement for In-Service Inspection, the original plan required an ASME VT-2 visual exam during each reactor shutdown where hot standby (Mode 3) condition is reached and cold shutdown (Mode 5) duration of seven or more days is not anticipated. It also required an ASME VT-1 visual exam to be performed during each reactor shutdown where a Mode 5 duration of 7 days or more is anticipated with a maximum of 18 months between inspection intervals. The "18 month" requirement was arbitrarily selected because it coincided with Calvert Cliffs' 18-month fuel cycle which was in effect at the time. Baltimore Gas and Electric Company has since converted to a 24-month fuel cycle.

As in the original plan, the modified plan continues to require an ASME VT-2 visual exam during each reactor shutdown where hot standby (Mode 3) condition is reached. However, the modified plan requires the VT-1 visual exam to be performed only during each refueling outage. The 24-month refueling outage inspection schedule is supported by the CEOG study which recommends a detailed inspection at least once every 36-months. The basis for the 36-month selection is an analysis performed in the CEOG study that determined the corrosion profile, the amount of undetected corrosion potentially present, and the amount of pressurizer shell material that could be lost as a result of corrosion before the ASME Code reinforcement requirements will be violated. The CEOG study also recommends a more frequent VT-2 type visual exam similar to the one in our inspection plan.

Baltimore Gas and Electric Company believes that nickel plating will prevent PWSCC in the Unit 1 pressurizer heater sleeves. Furthermore, the modified inspection plan will ensure that the integrity of the pressurizer will not be threatened as a result of corrosion due to low level leakage.

Should you have any questions regarding this matter, we will be pleased to discuss them with you.

Very truly yours,

RED/GT/dlm

Attachments:

(1) Calvert Cliffs Nuclear Power Plant Unit No. 1 - Pressurizer Heater Sleeve and Instrument Nozzle Inspection Plan

(2) Calvert Cliffs Nuclear Power Plant Unit No.1 - Pressurizer Heater Sleeve Nickel Plating

cc: D. A. Brune, Esquire
J. E. Silberg, Esquire
M. K. Boyle, NRC
D. G. McDonald, Jr., NRC
T. T. Martin, NRC
P. R. Wilson, NRC
R. I. McLean, DNR
J. H. Walter, PSC

ATTACHMENT (1)

Calvert Cliffs Nuclear Power Plant Unit No. 1

Pressurizer Heater Sleeve and Instrument Nozzle Inspection Plan

Page 1: Original Pressurizer Heater Sleeve and Instrument Nozzle Inspection Plan

Page 2: Modified Pressurizer Heater Sleeve and Instrument Nozzle Inspection Plan

Baltimore Gas and Electric Company
Docket No. 50-317
July 29, 1994

Page 1
Original Pressurizer Heater Sleeve and
Instrument Nozzle Inspection Plan

In addition to the examinations required by Technical Specification 3/4.0.5, the following inspections will be performed to detect evidence of leakage at Unit 1 pressurizer vessel heater sleeves (120) and pressurizer vessel instrument nozzles (7).

1. During each reactor shutdown where **HOT STANDBY (MODE 3)** condition is reached and a **COLD SHUTDOWN (MODE 5)** duration of 7 or more days is not anticipated, a visual exam [VT-2]**(as described in ASME XI IWA-2212)** shall be performed to detect evidence of leakage. The exam shall be performed from a location that will directly view the visible portion of the pressurizer heater sleeve, the insulation and insulation seams around the penetration point. This exam need not be performed if an examination was performed within 30 days prior to the shutdown.

2. During each reactor shutdown where a **COLD SHUTDOWN (MODE 5)** duration of 7 days or more is anticipated, a visual exam [VT-1] **(as described in ASME XI IWA-2211)** shall be performed to detect evidence of leakage by viewing each penetration region for boron deposits. This exam need not be performed if an exam of this type was conducted within the previous six-month period. This exam shall be performed at least once per 18 months.

Page 2
Modified Pressurizer Heater Sleeve and Instrument Nozzle Inspection Plan

In addition to the examinations required by Technical Specification 3/4.0.5, the following inspections will be performed to detect evidence of leakage at Unit 1 pressurizer vessel heater sleeves (120) and pressurizer vessel instrument nozzles (7).

1. During each reactor shutdown where **HOT STANDBY (MODE 3)** condition is reached, **a visual exam [VT-2](as described in ASME XI IWA-2212)** shall be performed to detect evidence of leakage. The exam shall be performed from a location that will directly view the visible portion of the pressurizer heater sleeve, the insulation and insulation seams around the penetration point. This exam need not be performed if an examination was performed within 30 days prior to the shutdown.

2. During each **refueling outage (MODE 6)**, a visual exam, **VT-1 (as described in ASME XI IWA-2211)** shall be performed to detect evidence of leakage by viewing each penetration region for boron deposits.

ATTACHMENT (2)

Calvert Cliffs Nuclear Power Plant Unit No. 1

Pressurizer Heater Sleeve Nickel Plating

Baltimore Gas and Electric Company
Docket No. 50-317
July 29, 1994

CALVERT CLIFFS NUCLEAR POWER PLANT UNIT 1
PRESSURIZER HEATER SLEEVE NICKEL PLATING

BACKGROUND

In 1989, an in-service inspection of Calvert Cliffs Unit 2 pressurizer discovered evidence of reactor coolant leakage from approximately 28 of the 120 pressurizer heater penetrations and one upper level instrument nozzle. The cause of the leakage was determined to be primary water stress corrosion cracking (PWSCC) of Inconel 600 alloy used for the heater sleeves and the instrument nozzles. Inconel 600 is susceptible to stress corrosion cracking at high tensile stresses (applied plus residual stresses) in high purity water, such as is found in the primary water environment of nuclear power plants. All cracks were axial and determined to have minimal safety significance. Upon the discovery of the Unit 2 pressurizer leakage, Unit 1 was shut down to allow inspection of its pressurizer. Visual examination of all heaters and instrumentation penetrations in the Unit 1 pressurizer revealed no signs of leakage. In addition, 12 heaters were removed, and non-destructive examinations (visual, eddy current, liquid penetrant) were performed on the heater sleeves. No indications were found.

A review of fabrication records of both pressurizers showed they are essentially the same. The only differences identified were in the amount of sleeve reaming performed and the extensive rework done on one of Unit 2's four upper instrument nozzles. Unit 2 heater sleeves were reamed prior to welding in the pressurizer lower head in order to increase the clearance between the sleeve and the installed heater. Additional reaming was performed after welding on some sleeves to provide the required clearance. In Unit 1, reaming was only performed after welding as required to maintain specified sleeve/heater clearances. Metallurgical evaluations of the reamed surface on Unit 2 sleeves indicated increases in surface hardness in the reamed area which could have contributed to the susceptibility of Inconel 600 to cracking. Consequently, the following repair and replacement work was performed on Unit 2 pressurizer: (1) 119 heater sleeves were replaced with new dual sleeves of Inconel 690 alloy, which is less susceptible to PWSCC than Inconel 600; (2) one heater sleeve was plugged with Inconel 690 material; and (3) all four upper-level instrument nozzles were replaced using Inconel 690 material.

As stated above, a thorough examination of the Unit 1 pressurizer found no indications. However, since the possibility of heater sleeve/instrument nozzle cracking could not be completely ruled out, a safety evaluation of Unit 1 with respect to the potential for future leakage in the heater sleeves or instrument nozzles. The safety evaluation (Reference a) concluded that the presence of cracks in the Unit 1 heater sleeves and instrument nozzles would not be a safety concern as far as the structural integrity of the pressurizer is concerned. It was also concluded that coolant leakage from a typical flaw would be at a low rate which would not normally be detectable by the containment leakage monitoring system. A very low leak rate was observed in Unit 2 where boric acid crystal buildup was limited and there was no evidence of steam cutting or boric acid corrosion in the pressurizer head bore holes surrounding the sleeves. However, the safety evaluation concluded that long-term operation with undetected leaks was undesirable due to the potential for eventual boric acid corrosion of the pressurizer head. Therefore, the In-service Inspection Program for the Unit 1 pressurizer was augmented as described on Page 1 of Attachment (1). A task force was also formed to look into Inconel 600 susceptibility to PWSCC and develop a preventive measure.

PRESSURIZER HEATER SLEEVE NICKEL PLATING

The PWSCC task force (see discussion above) recommended nickel plating as the most effective preventive measure against PWSCC for the Unit 1 heater sleeves. Inconel 600's susceptibility to PWSCC depends on the environment to which it is exposed; specifically, three factors must be present in order for PWSCC to occur: (1) susceptible material; (2) tensile stress (applied plus residual stresses); and (3) primary water environment. When one of these factors is eliminated, such as contact with primary water, PWSCC of the Inconel 600 material will cease to occur. By plating the inner surface of the heater sleeves, the sleeves (in

the plated area) will no longer be exposed to primary water, thus eliminating future PWSCC. During the 1994 refueling outage, the top 4-inches of Unit 1 pressurizer heater sleeves were electroplated with an 8-mil layer of high purity nickel.

The nickel plating process used at Calvert Cliffs has been effectively implemented by Framatome in Europe on steam generator tubes (Reference b). Baltimore Gas and Electric Company (BGE) contracted with Framatome's subsidiary BW Nuclear Technologies (BWNT) to qualify and perform nickel plating on Unit 1 pressurizer heater sleeves. Several tests and studies were performed by BWNT to qualify the process for BGE application. Abrasion testing was performed to ensure the nickel layer would not be damaged during heater insertion. Saw-cut edges of sectioned specimens were inspected for evidence of lifting or peeling of the plating from the base material. The plating adhesion was also verified by attempting to peel or remove the plating at the base material interface with a sharp instrument. Fatigue tests were performed on nickel that had been plated over a half-inch-long through-wall crack. (Note: Although the nickel plating process was previously qualified and used by Framatome for repairing existing through-wall cracks of steam generator tubes, BGE's plan was to prevent cracks. Baltimore Gas and Electric Company did not plan to plate over through-wall cracks.) All test specimens were visually inspected for appearance, freedom from micropitting, cracking, nodules, excessive edge buildup, voids, and other defects and contamination.

The nickel plating process consisted of several steps. The old heaters were removed by cutting the seal weld which attached them to the heater sleeves. The heater sleeves were then flex honed to remove corrosion products and visually inspected with a boroscope to ensure cleanliness. After completing the cleaning and the inspection process, a small chamber (also referred to as "end effector") was inserted into the sleeve and sealed at both ends. Then, the system was tested for leaks. For final cleaning, a chemical solution (10 vol% sulfuric acid in demineralized water) was introduced by the end effector. Following cleaning, a "strike solution" (sulfamate acid, nickel sulfamate, and demineralized water) was introduced via the end effector. The very thin strike solution acts as a surface preparation to enhance adhesion of the main plating solution. Finally, following subsequent flushing, 8 mils of the main plating solution (nickel sulfamate, boric acid, and demineralized water) was electrodeposited by the end effector. After each sleeve was plated, it was inspected and any raised imperfections were buffed out. A total of 118 heater sleeves out of 120 were electroplated, and new heaters were installed. Through-wall cracks were discovered on the remaining two sleeves and were plugged (Reference c).

REFERENCES

(a) Letter from Mr. G. C. Creel (BGE) to Document Control Desk (NRC), dated September 20, 1989, Submittal of Basis for Determination

(b) Larue, F., et. al., "Nickel Plating S.G. Tubing Repair," Proceedings of the 1991 JAIF International Conference On Water Chemistry in Nuclear Power Plants, Japan Atomic Industrial Forum, Inc., Tokyo, Japan, April 22-25, 1991, pp. 163-167

(c) Letter from Mr. C. H. Cruse (BGE) to Document Control Desk (NRC), dated April 20, 1994, Licensee Event Report 94-003 - Pressurizer Heater Sleeve Cracking