U.S. NUCLEAR REGULATORY COMMISSION
REGION I

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LICENSE NOS:	DPR-53 DPR-69
LICENSEE:	Baltimore Gas and Electric Company
FACILITY NAME:	Calvert Cliffs, Units 1 and 2
INSPECTION AT:	Lusby, Maryland
INSPECTION DATES:	February 22-25, 1994

INSPECTOR: Ricardo C. Fernandes 12 APR 94

Ricardo A. Fernandes, Reactor Engineer
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Areas Inspected: A safety inspection was conducted at Calvert Cliffs Nuclear Power Station to gauge the licensee's planned plant modification to the Unit 1 pressurizer. The inspector reviewed the pressurizer nickel plating activities to determine if the heater sleeve pressure retaining structure will be adversely affected by the nickel plating process. This inspection included a review of the activities surrounding the use of a freeze seal as a method to establish the plant conditions for pressurizer work and to determine if the application of the freeze seal would be performed without elevating the risk on the reactor coolant inventory or the spent fuel pool cooling system.

Results: The inspector determined that the nickel plating of the pressurizer heater sleeves appears to be a sound method of mitigating the process of PWSCC and that the freeze seal evolution can be conducted safely without significantly elevating the risk on the reactor coolant system boundary or the capability of the spent fuel pool cooling system.

DETAILS

1.0 PURPOSE AND SCOPE

The purpose of this safety inspection was to determine whether the licensee's engineering activities, with emphasis on the plant modifications for Unit 1's pressurizer heaters, are being performed in accordance with recommended engineering practices and regulatory requirements.

2.0 BACKGROUND

During the 1989 refueling outage at Calvert Cliffs Unit 2, visual examination detected leakage in 20 pressurizer heater penetrations (see Information Notice No. 90-10). Subsequent examinations determined the mode of failure for the heater penetrations as primary water stress corrosion cracking (PWSCC). The heater sleeves were made of Inconel 600, a material found to be susceptible to PWSCC. During that outage, the licensee performed extensive repair work to resleeve all 120 pressurizer heaters sleeves on the Unit 2 pressurizer with Inconel 690, a material that, to this point, has not been found to be susceptible to PWSCC. In addition, in response to the NRC's Confirmatory Action Letter (CAL) 89-08, the licensee provided a basis for determination that it was safe to continue operation of Unit 1, in light of the know cracks found in the Unit 2 pressurizer. The NRC found the basis for determination satisfactory as stated in CAL 89-08, Supplement 2.

Following the restart of Unit 1, described above, the licensee-monitored industry events related to PWSCC of Inconel 600 components. Based on these events and industry research, the licensee decided that action would be taken during the 1994 Unit 1 outage to reduce the likelihood of PWSCC affecting the Unit 1 pressurizer.

Extensive laboratory testing has shown that intergranular stress corrosion cracking (IGSCC) requires the presence of the following three key elements: an aggressive environment, susceptible material, and sufficient tensile stresses for crack initiation and propagation. PWSCC is IGSCC in the primary water environment of pressurized water reactors (PWRs). The licensee reviewed several options to mitigate or prevent PWSCC and decided to utilize a nickel plating process found to be successful in steam generator tube PWSCC mitigation.

The inspector reviewed the nickel plating process qualification and the planned application of a freeze seal on the pressurizer surge line; the details of which are described below.

3.0 PRESSURIZER HEATER SLEEVE NICKEL PLATING

Following the discovery of PWSCC damage to the unit 2 pressurizer heater sleeves and based on other PWSCC-related Alloy 600 failures at other plants, the licensee elected to nickel plate the PWSCC susceptible portions of the heater sleeves at Unit 1. By plating the susceptible material, Alloy 600, with pure nickel, the reactor coolant does not come in contact with the heat affected zone on the internal bore of the heater sleeve.

The Unit 1 pressurizer has 120 heater sleeve penetrations. During the current outage, the licensee determined by visual inspection that two heater sleeves were leaking. Leakage was detected by the presence of boric acid crystals on the external surface of the pressurizer vessel around the penetrations. The licensee will plug these two penetrations; similar to the method utilized to plug the Unit 2 pressurizer heater sleeve in 1989-1990. The remaining 118, if found to be crack free, by visual inspection, will be nickel plated.

The pressurizer is ASME SA-508 CL 2 low alloy steel with 3/8" nominal Inconel 600 cladding, the heater sleeve is alloy 600 ASME SB-167. The reactor coolant system (RCS) pressure boundary in the area of the pressurizer heaters consist of two welded joints: a partial penetration J-weld on the heater sleeve to pressurizer internal shell interface and a fillet weld on the opposite sleeve end to heater element interface.

The inspector reviewed the qualification procedures and interviewed licensee personnel to determine if the heater sleeve pressure retaining structure will be adversely affected by the nickel plating process.

The plating process begins by brushing the area to be plated to eliminate most of the oxidation and deposition products accumulated on the internal bore of the heater sleeve. The sleeve is then visually inspected for PWSCC. Nickel plating will not be applied to sleeves with cracks. If no questionable indications are found, the plating tool is inserted into the sleeve and the surface electrochemically prepared to ensure that the plating adheres well. The nickel plating is performed and immediately rinsed with water. The plating is visually inspected and any defective plating is removed and replaced.

Based on review of licensee procedures and proprietary vendor documentation, the inspector noted the following:

* The actual nickel plating application will be performed by B&W Nuclear Technologies (BWNT) personnel using BWNT procedures.

* Chemical monitoring will be performed to verify plating solution and anodes that are used during installation are the same as those used during equipment and personnel qualification. Samples will be tested during the process to further verify proper plating is being performed.

* Pressurizer internal cleanliness will be maintained during the process by utilizing caps, vacuums and neutralizing agents.

* The nickel plating qualification process is consistent with American Society for Testing Materials (ASTM) standards and Materials Engineering guidance.

* Plating procedures; welders; nondestructive examination; and plating equipment were qualified on a mock-up with licensee oversight.

* This modification will not change future maintenance or inspection activities.

* The heater sleeve surface preparation before plating will limit the reduction in heater sleeve wall thickness so that ASME Code-required minimum wall thickness is maintained.

* The licensee stated that the plating process will not bring existing flaws to the surface because the relatively low temperature application of the nickel does not alter the metallurgical structure of the heater sleeve.

* The original axial rupture leak rate calculations are essentially the same, because the sleeve integrity and dimensional clearances are not significantly affected by the new heaters or plating process.

Conclusions

Nickel plating the internal bores of the pressurizer heater sleeves appears to be a sound method of mitigating the process of PWSCC. The inspector had no further questions.

4.0 PRESSURIZER SURGE LINE FREEZE SEAL

Freeze seals are used for repairing and replacing components such as valves, pipe fittings, pipe stops and pipe connections when it is not feasible to isolate the area of repair in another manner. Fluid flow in the piping system is prevented by freezing the fluid in the pipe. The area of frozen fluid performs the same function as a valve. In this application, the licensee installed a freeze seal on a 12-inch nominal diameter, stainless steel pressurizer surge line. This seal was required to facilitate repair of the pressurizer heater sleeves. The pressurizer is not isolable from the RCS.

The NRC has noted instances in which failure of freeze seals can lead to a rapid nonisolable loss of reactor coolant. This concern is of particular importance in PWRs because the emergency core cooling system is not designed to automatically mitigate accidents initiated at low pressures, (NUREG-1449).

The inspector reviewed the activities surrounding the freeze seal to determine the adequacy of procedures, equipment, and personnel training and to determine if the application of the freeze seal would be performed without elevating the risk on the reactor coolant inventory or the spent fuel pool cooling system.

The inspector reviewed procedures, conducted interviews, and performed freeze seal equipment walkdowns, and observed the following:

* A sufficient supply of liquid nitrogen is available and includes a redundant supply in addition to back-up supply features.

* A specialty contractor is being utilized for installation, operation, and maintenance of the freeze seal equipment; including control of nitrogen bottles.

* The licensee has a documented contingency program with implementing procedures to utilize in the event of freeze seal failure or other condition adverse to the freeze seal operations.

* The licensee freeze seal procedures include pre-evolution and post-evolution freeze seal liquid penetrant and dimensional checks.

* Freeze seal procedures include communications between the control room and maintenance personnel, including communication test each shift. Additionally the freeze seal sleeve chamber and thermocouple reading is monitored continuously.

* The freeze seal sleeve chamber is located in an open area with provisions for back-up ventilation. The chamber is located so that damage to other equipment from liquid nitrogen leakage is not likely. The chamber is located so that piping system damage from forces developed as a result of ice formation is not a concern.

* Temporary pressurizer heater sleeve plugs will be installed as a precaution in all but five or six heater sleeves in the event the freeze seal fails. The licensee stated that the work area will be continuously manned and the installation of the remaining temporary plugs is not expected to take more than fifteen minutes.

* If the freeze seal fails, the water level will rise in the pressurizer, draining water from the refueling pool and the spent fuel pool. The drop in water level in the refueling and spent fuel pools will be insignificant (a few inches) due to the relative size of the pressurizer compared to the pools.

* The freeze seal contractor stated that, based on experience, the melt time for the freeze seal was about 12 hours, but gave the licensee a conservative estimate of six hours.

* The licensee and contractor installed a similar freeze seal on the unit 2 pressurizer surge line during an outage in 1989.

<u>Conclusions</u>

Based on the above, the inspector concluded that the freeze seal evolution can be conducted safely without significantly elevating the risk on the reactor coolant system boundary or the capability of the spent fuel pool cooling system.

At the time of the exit meeting, the inspector expressed three observations:

The six-hour freeze seal melt time referenced in your engineering evaluation and contingency plan was based on vendor experience. Albeit it appears to be a conservative number and significantly greater than the estimated amount of time to install the heater plugs; the fact that the six hour freeze is experience-based and not a technical basis should be conveyed in station documentation.

The contingency plan does not explore the impact of complete pressurizer boundary failure: final RCS water level of 10 feet above the spent fuel. Numerous failures would have to occur for the final RCS inventory to get to this level; however, the effect of the low spent fuel pool water level should be further explained in the contingency plan.

The licensee's project management staff involvement with operations personnel in the preevolution briefings was a positive observation and provided additional strength to the freeze seal operations planning.

5.0 POST-INSPECTION ACTIVITIES

Subsequent to the inspection activities, the licensee was unable to obtain a freeze seal on the Unit 1 pressurizer. Initial observations by the vendor and licensee indicated a seal was formed. However, monitoring of the freeze seal chamber during draining of the pressurizer revealed RCS flow across the seal. The licensee discontinued draining of the pressurizer and secured the freeze seal operations.

The failure of the freeze seal method in providing an adequate RCS boundary is currently under investigation by the licensee. Preliminary information indicates the piping and water created a heat sink to large for the freeze seal chamber. The licensee has collected data on nitrogen consumption rates and other information to allow modeling the freeze seal process.

Conclusions

The safety analysis for the freeze seal uses industry experience and not empirical data to convey the integrity of the freeze seal. This may be a weakness in the safety analysis or freeze seal process where a large heat sink or large component piping is involved.

6.0 MANAGEMENT MEETINGS

Licensee management was informed of the scope and purpose of the inspection at an entrance meeting for the inspection. The findings of the inspection were discussed with licensee management at an exit meeting on February 25, 1994. See Attachment 1 for attendance.

Attachment: Persons Contacted

6.0 MANAGEMENT MEETINGS

Licensee management was informed of the scope and purpose of the inspection at an entrance meeting for the inspection. The findings of the inspection were discussed with licensee management at an exit meeting on February 25, 1994. See Attachment 1 for attendance.

Attachment: Persons Contacted

ATTACHMENT

Persons Contacted

Baltimore Gas and Electric Company

* C. Sly	Compliance Engineer
* R. Fretz	System Engineer
* C. J. Ludlow	Principal Engineer
* B. C. Rudell	General Supervisor
* J. Richards	Project Engineer
* J. Calle	Design Engineer
W. Maki	Compliance Engineer
M. Siewertsen	System Engineer
M. Kostelnik	Project Engineer
J. Stimely	Freeze Seal, Inc.

U. S. Nuclear Regulatory Commission

* P. R. Wilson	Senior Resident Inspector
* H. K. Lathrop	Resident Inspector

* Denotes those present at the exit meeting.