September 21, 2001

Mr. Charles H. Cruse
Vice President - Nuclear Energy
Calvert Cliffs Nuclear Power Plant, Inc.
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway
Lusby, MD 20657-4702

SUBJECT: CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT NOS. 1 AND 2 - CONTAINMENT TENDON LONG-TERM CORRECTIVE ACTION PLAN (TAC NOS. MA7782 AND MA7783)

Dear Mr. Cruse:

During the 1997 tendon surveillance of the Calvert Cliffs Nuclear Power Plant, Unit I containment, corrosion was discovered on some vertical tendons. Calvert Cliffs Nuclear Power Plant, Inc. (CCNNPI) subsequently expanded the inspection scope to include inspection of all the vertical tendons on both the Unit 1 and Unit 2 containments. To address the deficiencies identified, short-term corrective actions were taken during the 1997 inspection and following years. CCNPPI also performed additional inspections to help develop its long-term prestressing tendon corrective action plan which was submitted to the staff for review on May 14, 1998. Revisions to the containment tendon long-term corrective action plan were submitted to the NRC by letters dated December 7, 1999, July 24, 2000, and April 4, 2001. The staff's evaluation of the information concerning the containment tendon long-term corrective action plan is provided in the enclosed Safety Evaluation.

Based on its evaluation, the NRC staff concludes that CCNPPI's containment tendon long-term corrective action plan, if properly implemented, will reasonably ensue that both Unit 1 and Unit 2 containments meet their design requirements until the end-of-life.

Sincerely,

/RA/

Donna Skay, Project Manager, Section 1
Project Directorate 1
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-317 and 50-318

Enclosure: Safety Evaluation

cc w/encl: See next page

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** See previous concurrence

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION FOR

CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT NOS. 1 AND 2

CONTAINMENT TENDON LONG-TERM CORRECTIVE ACTION PLAN

1.0 INTRODUCTION

During the 1997 tendon surveillance of the Calvert Cliffs Nuclear Power Plant, Unit 1 containment, Calvert Cliffs Nuclear Power Plant, Inc. (CCNPPI or the licensee) discovered corrosion on some vertical tendons. CCNPPI expanded the inspection scope to include inspections of all the vertical tendons on both the Unit 1 and Unit 2 containments. The inspections included performing a lift-off test as well as a visual examination under the top end stressing washer to determine the extent of the corrosion. The root cause analysis by the licensee concluded that the tendon wire failures and corrosion problems resulted from combinations of water and moist air intrusion into the end caps and inadequate initial grease coverage of wires in the area just under the stressing washer, thus creating a void. To address the deficiencies identified in the root cause analysis, short-term corrective actions were taken by the licensee during the 1997 inspection and following years (Refs.1 and 2). These actions included spraying hot grease under the stressing washer, re-orienting the shims to leave a gap between the shims to allow a vent path to help eliminate the void, re-greasing non-corroded tendons, and replacing the existing end cap with a new redesigned grease cap at the upper bearing plate to prevent water intrusion. The licensee also performed additional inspections to help develop its long-term prestressing tendon corrective action plan which was submitted to the staff for review on May 14, 1998 (Ref. 3).

By letter dated August 20, 1998 (Ref. 4), the licensee responded to the staff's request for additional information (RAI) regarding the containment tendon long-term corrective action plan. The licensee submitted its revisions to the containment tendon long-term corrective action plan to the NRC by letter dated December 1999 (Ref. 5). By letter dated July 24, 2000 (Ref. 6), the licensee provided its response to the staff's May 25, 2000, RAI concerning the revised containment tendon long-term corrective action plan. Subsequently, a meeting was held on November 16, 2000, between the staff and the licensee to further discuss Calvert Cliffs' containment tendon long-term corrective action plan (Ref. 7). By letter dated April 4, 2001, the licensee submitted additional information concerning its long-term corrective action plan (Ref. 8). The staff's evaluation of the updated information concerning the containment tendon long-term corrective action plan is provided below.

Enclosure

2.0 EVALUATION

2.1 Degraded Vertical Tendon Replacement Criteria

The licensee stated that the goal of its long-term corrective action plan is to ensure that the containments meet design requirements until the end-of-life. As one part of the long-term corrective action plan, all the vertical tendons will be re-greased with new corrosion inhibiting grease. The non-corroded tendons were re-greased in 2000 and the tendons with corrosion that are not being replaced will be re-greased in 2001. The remaining vertical tendon population is scheduled to be replaced in 2002 and will have the new grease put in place at that time. In addition, all the vertical tendons will have a redesigned grease cap installed on the upper bearing plates to prevent water intrusion. A substantial part of the long-term corrective action plan involves the replacement of a portion of the corroded tendon population. To determine which vertical tendons will be replaced, the licensee proposed the following set of selection criteria:

I. To replace all tendons that currently have two or more broken wires. The licensee stated that most of the additional broken wires discovered in a 1999 inspection were in tendons with two or more previous broken wires. Therefore, these tendons appear to be the most likely to have future broken wires. The licensee also indicated that one isolated wire break in a tendon did not warrant replacement of the tendon by itself. However, if a tendon with a single broken wire was found to meet any of the following replacement criteria, it was selected for replacement.

2. To replace corroded tendons demonstrating lower lift-off forces. This applies to all tendons that were classified as having extreme or heavy corrosion and had a lift-off force of less than 649 kips. The small additional strain imparted by lift-off testing has the potential to cause additional wire breaks, as occurred in 1997. Corroded tendons with lower than predicted lift-off forces will be replaced to eliminate the possibility of premature wire breakage during lift-off testing in future code mandated inspections. Furthermore, replacing severely corroded tendons with low lift-off forces would prevent potential prestress losses associated with wire breakage from re-stressing of these tendons.

3 To replace corroded tendons to ensure uniform distribution of prestress. This third criteria was specifically designed for Unit 1 containment since it has two tendons that were not installed and therefore has two areas with lower running force distribution. The licensee will replace all the tendons that have extreme or heavy corrosion near the two empty tendon sheaths.

4. To replace corroded tendons to ensure uniform distribution after accounting for prestress losses from statistical model predictions. This criteria ensures the loss of prestress that would result from the conservative prediction of wire breakage, would not violate design criteria at end of plant life. The licensee applied the statistical model predictions to all of the remaining original tendons that were not replaced based on one of the first three criteria. This last criteria identified the areas around the constrainments that, if the predicted wire breaks occurred, had the potential of driving the running force distribution below the minimum of 606 kips. Once those areas were identified, appropriate corroded tendons were selected for replacement until all of the running averages exceeded the 606 kip minimum at end of plant life.

Based on these selection criteria, the licensee determined that the total number of tendons that will be replaced is 46 on Unit 1 and 46 on Unit 2. According to the licensee, these numbers will provide sufficient margin to ensure that design requirements of the constrainments are met or exceeded through the plants' licensed lifetime of 2034 for Unit 1 and 2036 for Unit 2.

The licensee stated that there is a possibility that a condition exists which could prevent the replacement of select tendons. The licensee indicated that its main goal is to replace 46 tendons on each unit, but if conditions exist where replacement of a tendon is not possible, the situation will be evaluated to determine if additional re-stressing is required to compensate for this condition. The replacement is scheduled to be completed by December 31, 2002. If however, conditions exist, such as poor weather, that do not allow safe and event free maintenance on top of the constrainments, the licensee will complete the replacement work as close to the original planned date as possible.

The staff evaluated the technical basis and the scope of these criteria for tendon replacement. The staff finds that these criteria are field-inspection-data based and are supported by sound technical justifications as well as practical site installation considerations. Therefore, they are adequate and acceptable. Provided that the validity of the statistical model used for the prediction of tendon wire breakage is adequately monitored over the plants' operating life, the staff believes that implementation of these criteria should provide reasonable assurance that pertinent design requirements of the containment vertical tendons will be met or exceeded through the plants' extended period of operation.

2.2 Validation of Tendon Wire Breakage Statistical Model via Future Enhanced Inspections

The licensee plans to implement a two-tiered approach for future inspection of the vertical tendons. First, code inspections, done every 5 years, will be performed as required by the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, Subsection IWL. The licensee will conduct testing on the replacement tendons as required by the current ASME Code, the 1992 Edition through the 1992 Addenda. Second, enhanced inspections will be performed to examine the tendons for potential wire breaks. The goal of enhanced inspections is to validate if the actual conditions of the containment tendons are within the conditions predicted by the statistical prediction model. By ensuring that the model bounds existing field conditions, the licensee is ensuring that the design requirements, as affected by corrosion of the vertical tendons, continue to be met.

The licensee indicated that to accomplish the enhanced inspections, the anchorhead and buttonhead region should be examined to determine if any wire breaks have occurred in the area under the vertical tendon top stressing washers. The licensee stated that by the end of 2005, they will complete an enhanced inspection of the vertical tendons on Units 1 and 2. Based on existing information, a minimum of 16 randomly selected remaining original tendons on Unit 1 and 23 randomly selected remaining original tendons on Unit 2 will be inspected. The licensee indicated that these minimum numbers are derived statistically and represent the amount of inspection data necessary to provide a 95 percent confidence that the actual fraction of broken tendon wires (from both hydrogen-induced cracking (HIC) and general corrosion) is less than or equal to the statistical model-predicted fraction. The 30-year tendon surveillance is required to be completed by the end of 2007. Concurrent with that surveillance, the licensee will complete an enhanced inspection of the vertical tendons. Based on existing information, a minimum of 10 randomly selected remaining original tendons on Unit 1 and 13 randomly selected remaining original tendons on Unit 2 would be inspected. These minimum numbers are intended to ensure that a 95 percent confidence exists that the actual fraction of broken tendons wires (from both HIC and general corrosion) is less than or equal to the statistical model-predicted fraction.

In 2007, following results of the code and enhanced inspections, the licensee will assess the need to continue with enhanced inspections. This assessment will determine if enhanced inspections need to continue every 2 to 3 years and determine if the code inspections would be adequate in determining whether the statistical model provides a bounding prediction of future wire breaks for the vertical tendons. Factors that will determine how often the enhanced inspections should be completed and the number of tendons that should be inspected are: (a) Whether the statistical model continues to bound field conditions in 2005 and 2007, and (b) whether the statistical minimum sample size for 95 percent confidence become the same or less than the sample size required by the next required code inspections. If both factors are yes, then, as a minimum, the code required inspection program will envelop the enhanced inspections. If the model continues to bound field conditions but requires more of a sample than that provided by the code mandated population, then the enhanced inspection frequency will be changed to a 5-year span and the required number of inspections completed concurrently with the code inspections.

The staff evaluated the above discussed enhanced tendon inspection program including the tendon sampling size and the inspection schedule and concludes that implementation of the program should suffice to validate if the actual conditions of the containment tendons are within the conditions predicted by the statistical prediction model. Therefore, the program is acceptable.

2.3 Use of Radiography in lieu of Visual Tendon Buttonhead Inspection

CCNPPI has done some preliminary work to evaluate if radiography provides accurate results when looking for potential broken wires. This new methodology appears to allow a faster and less invasive inspection than currently accomplished by removing the end cap, removing a portion of the grease, and then examining the buttonhead area for wire breaks. In order to validate that radiography provides as accurate a depiction of tendon wire status as the current visual exam does, radiography will be conducted by the licensee. In both 2001 and 2002, during the re-greasing and replacement of tendons, radiography will be conducted on a portion of the tendons. These same tendons will then be visually inspected during their respective re-greasing or replacement. A detailed comparison of the radiography and visual results will then be made, to verify that data from radiography is as complete and accurate as data from visual examinations. The licensee has successfully performed some initial testing using radiography and found it to be as accurate as the visual examinations. If radiography continues to provide accurate results, it could be relied on to conduct future enhanced inspections.

The staff has reviewed the above information pertaining to CCNPPI's use of radiography as a potential replacement for visual inspection of buttonhead area for wire breakage and determined that the licensee should submit more comprehensive test-based information for staff evaluation prior to using radiography in lieu of visual tendon buttonhead inspection.

2.4 Predicted Tendon Prestress at 2034/2036 versus Required Minimum Tendon Prestress

The licensee stated that the design basis calculation for the Unit 1 and 2 containment requires tendon prestress in the vertical direction of 123,620 kips to satisfy all concrete and reinforcing steel stress allowables during all design loading conditions. This minimum vertical gross prestress value equates to a minimum required running force distribution of 606 kips at each of the available 204 vertical tendon locations. The licensee determined that the predicted prestress of 634 and 640 kips for Units 1 and 2 tendons, at years 2034 and 2036, respectively, are greater than the above minimum design basis tendon prestress of 606 kips per tendon location. These values were extrapolated using the original design equations but do not account for wire breaks or corrective actions such as tendon replacement or re-stressing. These values can therefore be considered as the "original design" tendon prestress one would expect at the end of the operating licenses in 2034 and 2036, if tendon corrosion and wire breakage had never occurred. The more realistic predicted tendon prestress values, provided by the licensee, following the planned corrective actions of re-stressing and replacing tendons while accounting for prestress losses associated with relaxation and a conservative amount of predicted wire breaks, are 631 and 625 kips for Units 1 and 2 tendons at years 2034 and 2036, respectively. Comparing these more realistic predicted tendon forces with the 634 and 640 kips noted above, there is minimal difference between the original design margins and the predicted margins affected by potential future wire breaks and accounting for planned corrective measures. In any case, the licensee's analysis has shown that the realistically predicted tendon prestress forces of 631 and 625 kips for Units 1 and 2, respectively, which account for tendon replacement, re-stressing and conservatively estimated wire breaks, are considerably greater than the 606 kips minimum required tendon prestress force at years 2034 and 2036.

Based on the above comparison of the minimum required versus the realistically predicted tendon forces, the use of the conservative degraded tendon replacement criteria, and the implementation of an enhanced tendon inspection program, the staff finds that the licensee's containment tendon long-term corrective action plan is acceptable, provided that the statistical model used to conservatively predict tendon wire breakage is reasonably validated through future enhanced inspections.

3.0 CONCLUSION

The staff has completed its evaluation of CCNPPI's containment tendon long-term corrective action plan. The key items evaluated were: (a) degraded vertical tendon replacement criteria, (b) validation of tendon wire breakage statistical model via future enhanced inspections, (c) use of radiography in lieu of visual tendon buttonhead inspection and (d) predicted tendon prestress at years 2034 and 2036 versus required minimum tendon prestress. Based on its evaluation as discussed above, the staff concludes that the containment tendon long-term corrective action plan, if properly implemented, will reasonably ensure that both Unit 1 and Unit 2 containments meet their design requirements until the end-of-life.

4.0 REFERENCES

1. Letter from Mr. C. H. Cruse (BGE) to NRC Document Control Desk, dated August 28, 1997, Containment Tendon Surveillance - 30-Day Report.

2. Letter from Mr. C. H. Cruse (BGE) to NRC Document Control Desk, dated October 28, 1997, Containment Tendon Engineering Evaluation Report.

3. Letter from Mr. C. H. Cruse (BGE) to NRC Document Control Desk, dated May 14,1998, Containment Tendon Long-Term Corrective Action Plan.

4. Letter from Mr. C. H. Cruse (BGE) to NRC Document Control Desk, dated August 20, 1998, Response to Verbal Request Regarding Containment Tendon Long-Term Corrective Action Plan.

5. Letter from Mr. C. H. Cruse (BGE) to NRC Document Control Desk, dated December 7, 1999, Revision to the Containment Tendon Long-Term Corrective Action Plan.

6. Letter from Mr. C. H. Cruse (BGE) to NRC Document Control Desk, dated July 24, 2000, Response to Request for Additional Information Concerning the Containment Tendon Long-Term Corrective Action Plan (TAC Nos. MA7782 and MA7783).

7. Meeting with NRC and Calvert Cliffs Nuclear Power Plant, November 16, 2000, Regarding Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2 - Containment Tendon Long-Term Corrective Action Plan.

8. Letter from Mr. C. H. Cruse (CCNPPI) to NRC Document Control Desk, dated April 4, 2001, Regarding Calvert Cliffs Nuclear Power Plant, Additional Information Concerning the Containment Tendon Long-Term Corrective Action Plan (TAC Nos. MA7782 and MA7783).

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Date: September 21, 2001