January 15, 2004

Mr. John L. Skolds, President
Exelon Nuclear
Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: SUMMARY OF CONFERENCE CALL WITH EXELON NUCLEAR REGARDING THE 2003 STEAM GENERATOR INSPECTIONS AT BRAIDWOOD UNIT 2 (TAC NO. MC1367)

Dear Mr. Skolds:

On November 10, and November 20, 2003, the U.S. Nuclear Regulatory Commission (Commission) participated in conference calls with Exelon Nuclear representatives to discuss their 2003 steam generator tube inspection results for Braidwood Unit 2.

The discussion topics included the steam generator (SG) tube inspection scope and the associated results. The calls focused on two issues identified by the licensee: axial outside diameter stress corrosion cracking indications at the tube-to-tube support plate intersections and loose parts. Subsequent to these calls, representatives from Braidwood Unit 2 provided additional clarifying information regarding their inspections.

At the time of the second call, all inspections of the SG tubing were complete. The Nuclear Regulatory Commission staff did not identify any issues requiring follow up at this time.

Enclosed is a summary of the conference call and the written material provided by the licensee in support of the second call. If you have any further questions, please contact me at (301) 415-8371.

Sincerely,

/RA/

Mahesh Chawla, Project Manager, Section 2
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. STN 50-457

Enclosures: 1. Summary of the conference call
2. Braidwood Unit 2 Refueling 10 Fall 2003 Results Summary

cc w/encls: See next page

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<u>CONFERENCE CALL SUMMARY</u>

<u>2003 STEAM GENERATOR TUBE INSPECTIONS</u>

<u>BRAIDWOOD UNIT 2</u>

On November 10, and November 20, 2003, the Nuclear Regulatory Commission (NRC) staff participated in conference calls with representatives for Braidwood Unit 2 to discuss their 2003 steam generator (SG) tube inspection results. The discussion topics included the SG tube inspection scope and the associated results. The calls focused on two issues identified by the licensee: axial outside diameter stress corrosion cracking indications at the tube-to-tube support plate intersections and loose parts. In support of the second phone call, the licensee provided written material to facilitate the discussion. This material is attached. Subsequent to these calls, representatives from Braidwood Unit 2 provided additional clarifying information regarding their inspections which is incorporated into the following summary.

Braidwood Unit 2 has four Westinghouse model D5 SGs. Each SG contains 4,570 thermally treated Alloy 600 tubes. Each tube has a nominal outside diameter of 0.750-inch and a nominal wall thickness of 0.043-inches. The tubes were hydraulically expanded at both ends for the full length of the tubesheet and are supported by a number of stainless steel tube supports with quatrefoil shaped holes. The U-bend region of the tubes to be installed in rows 1 through 9 was thermally stress relieved after bending.

At the commencement of the 2003 refueling outage (i.e., 2R10), on November 4, 2003, the plant had operated for 12.68 effective full power years (EFPY). When the EFPYs are normalized to the hot-leg temperature used at the Seabrook Nuclear Power Plant, Braidwood 2 had operated for 10.9 EFPY.

At the commencement of the 2R10 outage, 122 tubes were plugged in the four Braidwood Unit 2 SGs and there was no evidence of primary-to-secondary leakage.

During the 2003 outage, the licensee performed the following tube inspections in each of the four steam generators:

Bobbin probe inspection of 100 percent of the tubes from tube-end to tube-end

Rotating probe inspection (+Point™ coil) of the hot-leg expansion transition region of 50 percent of the tubes

Rotating probe inspection (+Point™ coil) of the U-bend region of 50 percent of the row 1 and 2 tubes

Rotating probe inspection (+Point™ coil) of the 50 percent of the hot-leg dents with bobbin voltage amplitudes greater than 5 volts

Visual examination of all hot-leg and cold-leg plugs (all plugs in the Braidwood 2 SGs are of the Westinghouse mechanical plug design except for 7 plugs that were installed prior to commencing commercial operation (these latter plugs are welded plugs)

In addition to the above examinations, a rotating probe was used to inspect 20 percent of the tube expansions at preheater baffles B and D (i.e., cold-leg tube support plate 2C and 3C, respectively) in SGs B and C. In addition, foreign object search and retrieval (FOSAR) was performed in all four SGs. The FOSAR was performed on the top of the tubesheet and in the preheater region of the SGs. This was the first time that FOSAR was performed in the preheater region at Braidwood 2.

Prior to the commencement of the SG tube inspections, the licensee for Braidwood 2 had used a low frequency bobbin coil eddy current screening technique to identify tubes that may have an eddy current offset similar to that observed at Seabrook. At Seabrook, several tubes were identified to have crack-like indications associated with this offset (refer to NRC Information Notice 2002-21, "Axial Outside Diameter Cracking Affecting Thermally Treated Alloy 600 Steam Generator Tubing" dated June 25, 2002, and its supplement dated April 1, 2003 for additional details).

The technique for detecting the eddy current offset was a quantitative technique for the tubes in rows 1 through 9 and a semi-qualitative technique for the tubes in rows 10 and above (there are 49 rows of tubes in the SG). For the low row tubes (i.e., rows 1 through 9, inclusive), the thermal stress relief of the U-bend region of the tube should result in consistently low stresses throughout the tube (i.e., there should be no eddy current offset). Any significant eddy current offset would be indicative of higher stresses in the straight span section of the tube. In the higher row tubes (i.e., greater than row 9), an eddy current offset is expected since the U-bend region of the tube is not stress relieved after bending. As a result, the licensee developed a methodology for the higher row tubes which involved calculating the average eddy current offset associated with the higher row tubes. They also determined the standard deviation associated with this average. To identify tubes with an offset that may be a precursor for cracking, the licensee "flagged" tubes that had an offset whose magnitude was less than the mean minus two standard deviations. That is, for the higher row tubes, the absence of an offset may indicate higher stresses in the straight span portion of the tube.

As a result of applying this low frequency bobbin coil screening technique to their previous bobbin coil examination results (i.e., prior to 2003) from each SG, the licensee identified 77 tubes with possibly high residual stresses in the straight span portion of the tube (these higher stresses may result in a higher likelihood for cracking). Three of these 77 tubes were in low row tubes (i.e., rows 1 through 9, inclusive) and 74 were in higher row tubes. Prior to the outage, the licensee planned on plugging all 3 tubes in the low row tubes with the offset and any of the tubes in the higher row tubes with the offset that had a distorted bobbin coil indication regardless of whether a flaw was confirmed to be present at the location of the distortion with a rotating probe.

No crack-like indications were found at any location except for at the tube support plates during the SG tube inspections at Braidwood 2. At the tube support plates, four axially-oriented indications indicative of outside diameter stress corrosion cracking were observed.

These four indications were observed in three tubes (i.e., one tube had two indications) and each of the tubes had an offset in the eddy current data (i.e., the indications were in 3 of the 77 tubes identified with an offset prior to the outage). The expansion transition of the three tubes with crack-like indications was inspected with a rotating probe and no degradation was detected during these inspections. In addition, the expansion transition of 31 of the remaining 74 tubes with the eddy current offset were inspected with a rotating probe, and no degradation was detected during these inspections.

In SG C, two axial indications were observed in the tube located at Row 21 Column 50 (R21C50) and one axial indication was observed in the tube located at R38C20. In the tube at R21C50, one indication was located at hot-leg tube support 3H and had a bobbin voltage of 0.34 volts while the other indication was located at hot-leg tube support 5H and had a bobbin voltage of 0.17 volts. In the tube at R38C20, the axial indication was located at hot-leg tube support 7H and had a bobbin voltage of 0.13 volts. None of the these three indications were present during the prior inspection of these tubes in 2000 (based on a hindsight review). In SG A, one axial indication was observed in the tube located at R25C42. This indication was located at hot-leg tube support 3H and had a bobbin voltage of 0.08 volts. With hindsight, a bobbin signal could be identified at this location in the 2002 tube inspection data. Each of these four bobbin indications was confirmed to be present with a rotating probe (+Point™ coil) and all of them were associated with a tube support plate land and were confined to within the tube support plate thickness. The offset in these three high row tubes was the least of any of tubes in the respective rows, indicating that the residual stresses in the straight spans of these tubes may be higher than the rest of the tubes making these tubes more susceptible to cracking. These inspection findings were communicated to the industry on November 10, 2003.

The licensee assessed the safety significance of these indications and concluded that all tubes had adequate integrity. This conclusion was based in part on their assessment of the sizes of these indications and a comparison between their axial crack indications to those found at Seabrook (see material provided by licensee).

None of these indications were in-situ pressure tested since they did not meet the criteria established by the industry for in-situ pressure testing. An in-situ pressure test to verify leakage integrity would have been required if the voltage of an indication exceeded 1.1 volts as determined from the +Point™ coil, and an in-situ pressure test to verify structural integrity would have been required if the voltage of an indication exceeded 0.5 volts as determined from the +Point™ coil. All three of these tubes were plugged. In addition, the three low row tubes with the eddy current offset were plugged.

In addition to the crack-like indications, mechanical wear was observed at the anti-vibration bars (AVBs) and at the tube support plates in the preheater region. In addition, wear attributed to loose parts in the SG secondary side was also observed. The maximum depth reported for the AVB wear indications was 49-percent through-wall, which is less than the licensee calculated structural limit of 71-percent through-wall for this type of degradation. The structural limit is the largest size the flaw can be and still retain adequate structural integrity. The maximum depth for the wear in the preheater region was 18-percent through-wall, which is less than the licensee calculated structural limit of 60.7-percent through-wall. The maximum depth for the wear associated with loose parts was 38-percent through-wall, which is less than the licensee calculated structural limit of 58-percent through-wall. Different structural limits are possible because of the different shapes of the wear scars.

As mentioned above, the licensee performed FOSAR in all four SGs during the 2003 outage. The FOSAR was performed on the top of the tubesheet and in the preheater region of the SGs. This was the first time that FOSAR was performed in the preheater region at Braidwood 2. Numerous objects were found during these inspections primarily in the preheater region. Most of these parts were retrieved and did not result in any tube wear; however, there were a few parts that could not be removed and/or resulted in tube wear. These latter parts are discussed further below.

In SG A, a 1.25-inch long by 0.75-inch diameter object (best described as a bushing) was found located on preheater baffle B (i.e., the second cold-leg tube support). This part was initially identified during the secondary side visual inspection. Once visually identified, the eddy current data for the tubes surrounding the part was reviewed and with hindsight tube wear was identified in one tube and a possible loose part signal was identified in three tubes. This object could not be removed and has been in the SG since 1991. This object resulted in tube wear which measured 38-percent through-wall as determined from a +Point™ coil. This wear indication was present in prior cycles, but was distorted since the part was adjacent to an expanded preheater baffle plate support location. The three tubes surrounding the part (including the tube with the wear indication) were plugged and stabilized. The part was in the periphery of the tube bundle.

In SG B, weld slag measuring 1.125-inch by 1-inch by 0.35-inch was detected on the top of the cold-leg tubesheet. The weld slag was identified during the FOSAR inspection in 2002, but could not be retrieved. No tube wear was associated with this object. Four tubes surrounding this object were plugged and stabilized.

In SG B, two manufacturing fit-up bars (also referred to as backing bars) measuring 1-inch by 1-inch by 3-inches were found on top of preheater baffle B (i.e., the second cold-leg tube support). These bars are used to assist in the assembly of the SG and were installed (i.e., welded) on the bottom of the preheater baffle D (i.e., the third cold-leg tube support). These fit-up bars serve no structural or operational function. After visually identifying the presence of these fit-up bars, the licensee could ascertain from eddy current data that one of these bars has been present on the top of preheater baffle B (i.e., the second cold-leg tube support) since the spring of 1990, while the other has been present since the fall of 1994. These bars resulted in tube wear with one bar resulting in two wear scars (maximum depths of 28-percent and 21-percent through-wall) in one tube and the other bar resulting in one wear scar (maximum depth of 5-percent through-wall). One of these bars was also attributed to a volumetric indication which was detected in a neighboring tube in 1994 (and measured 39-percent through-wall) and was subsequently plugged (but not stabilized) in 1997. With the visual identification of this part, this volumetric indication is now attributed to wear from the fit-up bar.

In evaluating the potential for other fit-up bars to cause tube damage, the licensee determined that there are 22 fit-up bars per SG. Fourteen of these bars are on the bottom of the first hot- and cold-leg tube support, 4 are on the bottom of baffle plate D (i.e., the third cold-leg tube support), and 4 are on a portion of the preheater near the center of the tube bundle and above the first tube support plate (i.e., 1H and 1C). If these latter bars were to fall, they would most likely end up on the first tube support plate. The licensee either directly or indirectly verified that all of the backing bars were present in all four SGs. All of the backing bars were in place (with the exception of the two mentioned above). The licensee attributed the failure of these two backing bars to fabrication loads/weld shrinkage. The licensee indicated that the backing bars were most likely misaligned such that when the permanent wedges and stayrods were installed (which support and position the support plate) it resulted in high loads on the backing bar welds which resulted in their failure. Visual inspection of the two backing bars indicated that the welds had sheared and there was no evidence that the failure was a result of fatigue.

The two backing bars found on top of preheater baffle B could not be removed from the SG. As a result, the licensee plugged and stabilized all of the tubes surrounding them. In addition, they plugged and stabilized the tubes surrounding the tube that was plugged in 1997 for the volumetric indication near one of these backing bars. As a precautionary measure, the licensee plugged and stabilized the tubes in SG B surrounding the two intact backing bars (i.e., those still attached to the bottom of preheater baffle plate D) just in case these backing bars became loose during operation.

In addition to the above loose parts, the licensee also detected five other loose parts that could not be removed. These parts were identified through the secondary side visual inspections (which were performed prior to collection of the eddy current data). Four of these parts were small wires located between a tube and the tube support plate. These four parts affected four tubes. Although these wires could be grabbed, they could not be removed. The fifth part was a small metal object located on top of the tubesheet in the periphery of SG D. This part was 3/8-inch by 1/4-inch by 1/4-inch. This loose part has been present since the sixth refueling outage in 1997 and visually appears to be in the same location and has not changed in size. None of these five parts has caused any tube wear. The licensee performed an analysis to indicate that it was acceptable to leave these parts in service until the next tube inspection.

Two other indications attributed to tube wear associated with loose parts were left in service during the 2003 outage. One of the indications was slightly above the first tube support plate. A visual inspection in the area did not result in the identification of a loose part. This indication was sized and left in service. Similarly, at the location of the other wear indication attributed to a loose part, a visual inspection did not result in the identification of a part so the indication was sized and left in service.