Exelon Generation Company, LLC
Braidwood Station
35100 South Route 53, Suite 84
Braceville, IL 60407-9619

www.exeloncorp.com

Exelon Nuclear

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U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Braidwood Station, Unit 1
Facility Operating License No. NPF-72
NRC Docket No. STN 50-456

Subject: Response to Request for Additional Information Regarding the Braidwood Station, Unit 1 Fall 2007 Steam Generator Inspection

References:

1. Letter from T. Coutu (Exelon Generation Company) to U.S. Nuclear Regulatory Commission, "Braidwood Station, Unit 1 Thirteenth Refueling Outage Steam Generator Inservice Inspection Summary Report," dated January 18, 2008.

2. Letter from M. David (Nuclear Regulatory Commission) to C. Pardee (Exelon Generating Company), "Braidwood Station, Unit 1 – Request for Additional Information Related to Steam Generator Tube Inspection Reports for Refueling Outage A1R13 (TAC No. MD7914)," dated June 16, 2008.

Based on the review of the Reference 1 submittal, the NRC determined that additional information was required in order to complete their evaluation of the Braidwood Station, Unit 1 Fall 2007 Steam Generator Inservice Inspection Summary Report.

The attachment to this letter provides the Exelon Generation Company response to these NRC questions (Reference 2).

Should you have any questions concerning this letter, please contact Mr. David Gullott, Regulatory Assurance Manager, at (815) 417-2800.

Respectfully,

Bryan Hanson
Site Vice President
Braidwood Station

Attachment: Braidwood Station Unit 1 Fall 2007 Steam Generator Inspection Summary Report Response to Request for Additional Information

Attachment

Braidwood Station Unit 1
Fall 2007 Refueling Outage Steam Generator Inspection Summary Report
Response to Request for Additional Information

Question 1:

Please clarify the following statement in Section 6.0 of your January 18, 2008, letter: "Since only volumetric wear was identified during A1R13, satisfying the structural limit ensures that the SG tube integrity performance criteria for structural integrity, accident induced leakage and operational leakage will be maintained." Is this statement based on the premise that the structural integrity limits were developed based on uniform wall thinning and, as long as these limits are not violated, there will be no leakage during normal operating and accident conditions (because, if the limits were violated, there would be a tube rupture if the wall thinning were uniform)?

Response to Question 1:

Yes. The structural integrity limits were developed based on uniform wall thinning and, as long as these limits are not violated, there will be no leakage during normal operating and accident conditions. All tube flaws found during the inspection were associated with wear/fretting damage mechanisms. The structural limit for these damage mechanisms was derived using the uniform wall thinning method consistent with the requirements and margins of safety described in draft Regulatory Guide 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes" using ASME Code minimum material properties. The margins of safety used were the most limiting value of 1.4 times accident differential pressure or 3 times normal operating differential pressure. For Braidwood Unit 1, the limiting case is 3 times normal operating differential pressure, which is significantly higher than the most limiting accident condition (i.e., steam line break). The ASME Section III Code minimum wall equation was also used as the basis for the structural limits. For the uniform wall thinning case, the remaining tube wall was determined to meet the applicable stress limits during normal and accident loading conditions. Therefore, with only wear/fretting damage mechanisms, and application of the uniform wall thinning structural limit that meets ASME Code minimum tube wall requirements and draft Regulatory Guide 1.21 margins of safety, a tube will not leak at normal operating or accident conditions.

Some structural limits for wear/fretting, limit the axial extent of the flaw in order to take advantage of the strengthening effect of the remaining tube. In this case, structural limits for flaws that are less than 0.3 inches may result in large leakage events without tube burst. However, these limits were not used during this inspection and therefore, large leakage events without tube burst can be discounted. As discussed above, the structural limits used during the inspection ensure that a flaw would not leak or burst at differential pressures that are less than 3 times normal operating pressure.

For damage mechanisms other than tube wear/fretting (e.g., stress corrosion cracking), meeting the structural limit may not necessarily meet operational or accident leakage limits. However, these damage mechanisms were not found during this inspection.

Question 2:

For each refueling outage and SG tube inspection outage since installation of the SGs, please provide the cumulative effective full power months that the SGs have operated.

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Response to Question 2:

The Braidwood Unit 1 original SGs (Westinghouse Model D-4 design) were replaced during the Unit 1 seventh refueling outage (A1R07), fall 1998. The Braidwood Unit 1 replacement steam generators (Babcock and Wilcox Canada Replacement SGs) have been in service since start-up from the seventh refueling outage. The table below provides the cumulative effective full power months that the SGs were in service at the time of fall 2007 thirteenth refueling outage (A1R13).

Braidwood Unit 1
Replacement Steam Generator
Cumulative Operating Duration

Refueling Outage	Cumulative Effective Full Power Years	Cumulative Effective Full Power Months
A1R07	0	0
A1R08	1.29	15.49
A1R09	2.73	32.76
A1R10	4.22	50.64
A1R11	5.64	67.68
A1R12	7.09	85.05
A1R13	8.49	101.88

Question 3:

Please discuss the scope and results of any secondary side inspections (other than foreign object search and retrieval).

Response to Question 3:

During the Braidwood Unit 1 Refueling Outage A1R13 SG inspection the following secondary side inspections were performed:

- Visual inspection of the top of tubesheet in all four SGs
  - 100% visual of the periphery tube region.
  - Limited in-bundle visual inspection. (Typically 8 columns, 4 hot leg / 4 cold leg)

- Visual inspection of the top lattice grid in the 1B SG.
  - 100% visual through the tube lane.
  - Limited in-bundle visual inspection. (Four columns, 2 hot leg / 2 cold leg)

- Visual inspection of the feedring header in the 1D SG
  - Visual inspection of all accessible interior surfaces.
  - Visual inspection of the internal surface of eight (8) J-Nozzles
  - Visual inspection of external attachment components in the vicinity of the access opening.

- Visual inspection of the steam drum region in the 1D SG
  - Visual inspection was performed on accessible areas of the following components:

    Upper steam drum region
    - Steam venturi nozzles
    - Secondary deck plate seal skirt welds
    - Secondary deck plate
    - Secondary deck access cover
    - Secondary deck fasteners
    - Secondary separators (12)

    Lower steam drum region
    - Ladder and supports
    - Primary deck plate
    - Primary deck support lugs
    - Primary separators (12)
    - Secondary separator drain tube attachments
    - Riser tube to primary deck joint area

Visual inspection of the regions above did not identify any anomalies such as erosion, wear, cracking, misalignment, etc. No secondary side foreign objects, other than those identified in the top of tubesheet region as discussed in the response to question 4 below, were identified.

Question 4:

Several tubes were identified with wear attributed to a loose part. In addition, several loose parts were identified visually. For the indications of wear attributed to loose parts, please discuss how these indications were initially identified (i.e., bobbin and/or rotating probe examination or visual inspection). In addition, discuss whether a turbo mix was used during the evaluation of the bobbin coil data near the top of the tubesheet to assist in the detection of loose parts or wear attributed to loose parts. For the loose parts that were detected visually, please discuss what types of probes were used to inspect the tubes in the vicinity of the part and discuss whether the part or any wear was detected with these probes. If rotating probe examinations of these tubes was not performed, discuss how you confirmed that no wear occurred at these locations (given the potential interference in the bobbin coil data due to the tubesheet and expansion transition). Please discuss whether any visible signs of wear were present on these tubes.

Response to Question 4:

During the Braidwood Unit 1 Refueling Outage A1R13, secondary side visual inspection was performed in the top of tubesheet region of all four SGs. The visual inspection scope included 100% of bundle periphery including hot leg, cold leg, and open tube lane. Additionally, in-bundle visual inspection was performed on a limited basis in order to determine post sludge lance cleanliness conditions and view accessible areas when eddy current identified locations of possible foreign objects.

Visual inspection of the bundle periphery region in the 1A, 1B, and 1D SGs was performed by R. Brooks Associates Inc. using the Shell Wrapper Annulus Transport System (S.W.A.T.S.) remote video inspection system. Visual inspection of the tube bundle periphery in the 1C SG, and tubelane region of all four SGs was performed using either 8 millimeter or 6 millimeter video probe technology. In-bundle visual inspection was performed using 2 millimeter x 4 millimeter video probe technology.

A total of five indications of secondary side foreign object wear were identified during A1R13. The EPRI Appendix H qualified Plus Point (+Point™) technique 21988.1 Revision 4 was utilized in this inspection for depth sizing of all foreign object wear.

Of the five indications, four were associated with relatively small amounts of tube wear (i.e., 15% TW, 15% TW, 14% TW and 22%TW). These tubes were identified during the previous SG inspection (A1R12) and were allowed to remain in service since they were below the TS plugging criteria of greater than or equal to 40% TW, coupled with secondary side visual inspection confirming that the objects that caused the tube wear were no longer present. Re-inspection of these indications during A1R13 confirmed that the associated wear had not changed since first identified during A1R12. Therefore, these indications were allowed to remain in service.

One tube had secondary side foreign object wear that was newly identified during A1R13. The object that caused the wear was initially detected during visual inspection of tube bundle from the periphery using the S.W.A.T.S. inspection system. The object could not be successfully retrieved. The six tubes in the vicinity of the object were inspected with +Point™. One tube was identified with wear. In the 1A SG, Tube Row 112 Column 59 had an 11% TW wear at the top of the cold leg tubesheet + 0.26 inches. The wear was associated with a piece of metallic gasket material approximately 1.7 inches long. The tube with the 11% TW indication, along with five tubes surrounding the gasket material, were preventatively stabilized and plugged based on engineering disposition. Visual inspection of the tubes in the vicinity of the object did not identify any wear.

In the 1C SG, seven tubes were preventatively plugged and stabilized in the hot leg top of tubesheet region due to a piece of metallic gasket material approximately 2.5 inches in length that could not be removed from the SG. The object was initially detected during visual inspection of tube bundle from the periphery using the video 8 millimeter video probe inspection system. The seven tubes in the vicinity of the object were inspected with +Point™. No degradation was identified during the +Point™ inspection. Since this object was in a high flow area and could not be successfully retrieved, the tubes surrounding the object were preventively stabilized and plugged based on engineering disposition even though they showed no signs of degradation based on eddy current or visual inspection.

In the 1B SG, eight tubes were preventatively plugged and stabilized in the hot leg top of tubesheet region due to visual inspection identifying a piece of weld slag approximately 2.0 inches in length. The object was initially detected during visual inspection of tube bundle from the periphery using the S.W.A.T.S. inspection system. The object could not

be successfully retrieved. The eight tubes in the vicinity of the object were inspected with +Point™. No degradation was identified during the +Point™ inspection. Since this object was in a high flow area and could not be successfully retrieved, the tubes surrounding the object were preventively stabilized and plugged based on engineering disposition even though they showed no signs of degradation based on eddy current or visual inspection.

Objects Identified by Visual Inspection

During the Braidwood Unit 1 Refueling Outage A1R13, there were a number of secondary side foreign objects that were newly identified by visual inspection that did not require tube plugging as previously discussed above. Table 4-1, attached, lists each of these foreign objects including additional actions taken, and final disposition for each object. The objects were either removed from the secondary side of the SG, or if retrieval was not successful, the objects were determined to be acceptable via engineering disposition. Details for those objects that required preventative plugging, since they were in high flow regions that had the potential to cause additional significant tube wear over the next cycle of operation, were provided above.

Ability to Identify Secondary Side Foreign Objects/ Wear

In response to industry issues concerning the ability to identify SG secondary side foreign objects / wear, as discussed in NRC Information Notice 2004-17, "Loose Part Detection and Computerized Eddy Current Data Analysis in Steam Generators", Exelon has taken the following actions:

- As identified in Operating Experience Report (OE18385) dated May 11, 2004, and summarized in NRC Information Notice 2004-17, a utility utilizing computerized data screening did not identify wear at the top of tubesheet region due to improper setup of the sort parameters. The improper setup dealt with an analysis "gap" in which the eddy current data for a section of the tube was not being analyzed. In response to OE18385, SG Program Procedures were revised in order to preclude similar events. The automated eddy current data sorts are reviewed to ensure there are no "gaps" over the required inspection lengths.

  This review is performed prior to the start of data collection and signed off by the Exelon Eddy Current Level III, Independent Qualified Data Analyst and Westinghouse Lead Level III.

- As identified in NRC Information Notice 2004-17, a utility was unable to detect secondary side foreign object wear using bobbin eddy current techniques since the wear indication was masked by the residual signal from the top of tubesheet expansion transition. Subsequent review of the bobbin eddy current data determined that the signal could have been detected if a three-frequency mix had been used at the top of tubesheet transition. The three-frequency mix helps to minimize the residual interfering signal from the top of tubesheet transition. Prior to issuance of the NRC Information Notice, the Braidwood Unit 1 Refueling Outage A1R11 steam generator inspection included use of a three-frequency mix at the top of tubesheet

transition in order to identify indications of secondary side foreign object wear. The Exelon Steam Generator Program procedures require use of the three-frequency mix at the top of tubesheet transition. Therefore, the three-frequency mix was used during the Braidwood Unit 1 Refueling Outage A1R13.

- Realizing the potential for SG secondary side foreign objects to cause significant tube wear, the Braidwood Unit 1 Refueling Outage A1R13 inspection included detailed video inspection of the accessible regions of the top of tubesheet region. The highest flow areas at the top of tubesheet region in the Braidwood Unit 1 SGs are at the periphery regions of the tube bundle. Once inside the tube bundle the secondary side flow velocities significantly reduce, thus having less potential to cause significant tube wear between inspections.

- During the Braidwood Unit 1 Refueling Outage A1R13 SG inspection, video inspection was performed from the bundle periphery looking towards the tube bundle in order to determine if foreign objects were present that were not able to be detected via eddy current inspection. If foreign objects were visually identified in high flow regions, the surrounding tubes received additional +Point™ inspection. The +Point™ inspection was performed in order to determine if wear was present that might not have been detectable using the bobbin eddy current techniques, and if other potential foreign objects were present that might not have been able to be seen via the video inspection.

Question 5:

Please discuss whether the number of tubes in close proximity is comparable to prior outages and whether the distance between the tubes is similar to what had been observed in the past.

Response to Question 5:

Tube-to-Tube Proximity – The condition of tube-to-tube being in close proximity was monitored as part of the 100% full-length bobbin coil inspection of all SGs during A1R13. The inspection results, including historical data related to tube-to-tube proximity, is provided in the Table 5-1 below. No tube degradation was identified associated with tube-to-tube proximity.

Table 5-1
Tube-to-Tube Proximity Summary

	Tubes Identified In-Proximity During Pre-Service Inspection	Tubes Identified In-Proximity A1R08 (Spring 2000)	Tubes Identified In-Proximity A1R10 (Spring 2003) Note 1	Tubes Identified In-Proximity A1R11 (Fall 2004) Note 2	Tubes Identified In-Proximity A1R12 (Spring 2006)	Tubes Identified In-Proximity A1R13 (Fall 2007)
Total	508	85	132	39	188	196

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Note 1: During A1R10 the 1A SG received 100% full-length eddy current inspection and the 1B, 1C and 1D SGs received 54% full-length inspection.
Note 2: Only the 1B SG received 100% full-length inspection through the area of interest during A1R11.

With regard to the 8 tube-to-tube proximity calls that were identified in the A1R13 outage, but not in the A1R12 outage:

- Six of the tubes had been identified in outages prior to A1R12 but did not meet the lower level of the recording criteria during A1R12. Therefore the signals were not reported during A1R12.
- Two of the tubes met the lower level of the recording criteria during A1R13 but had not met it in prior outages. Review of prior outage data indicates that the signals were present slightly below the recording level, but were not required to be reported in prior outages.
- All of the 188 tube-to-tube proximity calls identified in the A1R12 inspection were identified during the A1R13 inspection.

Comparison of the A1R13 data against historical data continues to show no degradation or significant changes beyond those associated with normal eddy current variability.

This condition will continue to be monitored during future scheduled SG inspections.

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Table 4-1
Secondary Side Foreign Objects
Newly Identified During A1R13
No Tube Plugging Required

SG (Part No.)	Description	Location Based on Visual Inspection	Additional Actions	Disposition	Initial Detection Method
1A (1A007)	Metallic Gasket Material 0.50" X 0.188" X 0.050"	TTS CL Row 107 Col 95	Two (2)adjacent tubes were inspected with +Point™. No evidence of tube wear in area based on visual and eddy current data.	Object removed during FOSAR.	S.W.A.T.S.
1A (1A004)	Metallic Gasket Material 1.0" X 0.180" X 0.050"	TTS HL Row 37 Col 60	Sixteen (16) tubes in region of object were inspected with inspected with +Point™. No evidence of tube wear in area based on visual and eddy current data.	Object removed during FOSAR	2mm x 4 mm Video Probe
1B (1B004)	Metallic Gasket Material 0.80" X 0.188" X 0.050"	TTS HL Row 34 Col 51	Six (6) tubes in region of object were inspected with inspected with +Point™. No evidence of tube wear in area based on visual and eddy current data.	Object could not be successfully removed. Surrounding tubes allowed to remain in service based on engineering evaluation that determined if potential wear were to occur over next cycle of operation it will be substantially below tube integrity limits. Refer to Note 1.	2mm x 4 mm Video Probe

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SG (Part No.)	Description	Location Based on Visual Inspection	Additional Actions	Disposition	Initial Detection Method
1B (1B005)	Metallic Gasket Material 1.610" X 0.188" X 0.050"	TTS HL Row 85 Col 84	Eight (8) tubes in region of object were inspected with inspected with +Point™. No evidence of tube wear in area based on visual and eddy current data.	Object could not be successfully removed. Surrounding tubes allowed to remain in service based on engineering evaluation that determined if potential wear were to occur over next cycle of operation it will be substantially below tube integrity limits. Refer to Note 1.	2mm x 4 mm Video Probe
1B (1B008)	Metallic Gasket Material 1.25" X 0.188" X 0.050"	TTS CL Row 116 Col 66	No evidence of tube wear in area based on visual and eddy current data.	Object removed during FOSAR.	S.W.A.T.S.
1C (1C001)	Metallic Gasket Material 0.92" X 0.188" X 0.050"	TTS HL Row 34 Col 102	Four (4) tubes in region of object were inspected with inspected with +Point™. No evidence of tube wear in area based on visual and eddy current data.	Object could not be successfully removed. Surrounding tubes allowed to remain in service based on engineering evaluation that determined if potential wear were to occur over next cycle of operation it will be substantially below tube integrity limits. Refer to Note 1.	2mm x 4 mm Video Probe
1D (1D001)	Metallic Gasket Material 1.30" X 0.188" X 0.050"	TTS HL Row 40 Col 84	Eight (8) tubes in region of object were inspected with +Point™. No evidence of tube wear in area based on visual and eddy current data.	Object could not be successfully removed. Surrounding tubes allowed to remain in service based on engineering evaluation that determined if potential wear were to occur over next cycle of operation it will be substantially below tube integrity limits. Refer to Note 1.	2mm x 4 mm Video Probe

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SG (Part No.)	Description	Location Based on Visual Inspection	Additional Actions	Disposition	Initial Detection Method
1D (1D002)	Metallic Gasket Material 1.00" X 0.188" X 0.050"	TTS HL Row 42 Col 84	Nine (9) tubes in region of object were inspected with inspected with +Point™. No evidence of tube wear in area based on visual and eddy current data.	Object could not be successfully removed. Surrounding tubes allowed to remain in service based on engineering evaluation that determined if potential wear were to occur over next cycle of operation it will be substantially below tube integrity limits. Refer to Note 1.	2mm x 4 mm Video Probe

Note 1: Engineering evaluation to leave the objects in the SG considered the location, object and thermal hydraulic characteristics.