UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 24, 2014

Mr. Michael J. Pacilio
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: THREE MILE ISLAND NUCLEAR STATION, UNIT 1 - SUMMARY OF CONFERENCE CALLS REGARDING THE FALL 2013 STEAM GENERATOR TUBE INSERVICE INSPECTION (TAC NO. MF2799)

Dear Mr. Pacilio:

On November 8 and 18, 2013, the Nuclear Regulatory Commission (NRC) staff participated in conference calls with representatives from Exelon Generating Co., LLC, regarding the ongoing steam generator tube inspection activities at Three Mile Island Nuclear Station, Unit 1. A conference call summary is enclosed.

This completes the NRC staff efforts associated with TAC No. MF2799. If you have any questions, please contact me at (301) 415-3204.

Sincerely,

John D. Hughey

John D. Hughey, Project Manager
Plant Licensing Branch I-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-289

Enclosure:
Steam Generator Tube Inspection
Conference Call Summary

cc w/encl: Distribution via Listserv

SUMMARY OF CONFERENCE CALLS

THREE MILE ISLAND NUCLEAR STATION, UNIT 1

REGARDING THE FALL 2013 STEAM GENERATOR TUBE INSPECTION RESULTS

DOCKET NO. 50-289

TAC NO. MF2799

On November 8 and 18, 2013, the Nuclear Regulatory Commission (NRC) staff participated in conference calls with representatives of Exelon Generating Co., LLC, (Exelon or the licensee) regarding the steam generator (SG) tube inspection activities at Three Mile Island Nuclear Station (TMI), Unit 1 during Refueling Outage 20 (RFO20). (NOTE: TMI counts refueling outages as occurring prior to the same numbered operating cycle, so Refueling Outage 20 precedes Operating Cycle 20.)

TMI Unit 1 has two once-through SGs manufactured by AREVA. Each SG has 15,597 tubes made out of thermally-treated Alloy 690. The tubes have a nominal outer diameter of 0.625 inches and a nominal wall thickness of 0.037 inches. The SGs contain 15 stainless steel tube support plates (TSPs) that have broached tri-foil holes. The broached trefoil holes in each TSP have flat landings with chamfered edges (not hour glass-shaped). The tube-to-tubesheet joints were hydraulically expanded over the full depths of the upper and lower tubesheets. The normal operating differential pressure is 1276 pounds per square inch.

Conference Call on November 8, 2013

The licensee stated that no primary-to-secondary leakage had been detected during the previous operating cycle (Cycle 19), no secondary side pressure tests had been conducted during the outage, and no exceptions or deviations to industry guidelines had been taken during the outage.

At the time of the call, the scope of inspections planned by the licensee included a full-length inspection of 100 percent of the SG tubes using a bobbin coil probe, a visual inspection of 100 percent of the installed SG tube plugs, and a remote visual exam of the upper and lower SG channel head bowl. In addition, the X-probe was used to inspect: (1) the peripheral tubes (2-tubes deep) from the lower tubesheet to the first TSP to identify possible loose part signals, (2) all tube-to-tube (T-T) wear signals, and (3) other wear signals (both new and historical) that were greater than or equal to 10 percent through-wall (TW).

At the time of the call, tube inspections in SG A and SG B were approximately 91 percent complete. In SG A, approximately 85 T-T wear indications had been identified, of which four were new indications. The largest new indication was approximately 12 percent TW. The average growth rate of all T-T wear indications was approximately 1.3 percent TW per cycle, while the growth rate of just the historical T-T wear indications was approximately -0.31 percent TW per cycle. In SG B, approximately 200 T-T wear indications had been identified, of which three were new indications. The largest new indication was approximately 13 percent TW. The average growth rate of all T-T wear indications was approximately 0.36 percent TW per cycle,

while the growth rate of just the historical T-T wear indications was approximately 0.38 percent TW per cycle.

In SG A, 1,663 new TSP wear indications were identified at the location where the tube passes through the TSP (commonly referred to as TSP wear), of which the largest was approximately 30 percent TW in a tube near the periphery and the x-axis. The average growth rate of the new TSP wear indications in SG A was 5.6 percent TW per cycle, while the historical TSP wear indications in SG A had a growth rate of 0.49 percent TW per cycle. In SG B, 2,220 new TSP wear indications were identified, of which the largest was approximately 63 percent TW and located in the tube in row 49 tube 119 (R49T119). The average growth rate of the new TSP wear indications in SG B was 7.8 percent TW per cycle, while the historical TSP wear indications in SG B had a growth rate of 3.5 percent TW per cycle.

The licensee stated that all tubes taken out of service would have full-length stabilizers installed and would then be plugged with mechanical roll plugs. The licensee planned to plug all tubes with indications greater than or equal to 40 percent TW and may plug tubes less than this value (preliminary value of 30 percent) based on their operational assessment (OA). The number of tubes plugged would depend on the final eddy current inspection and OA results.

At the time of the call, a localized in-situ pressure test of the tube in R49T119 was planned. The licensee had no plans to pull a tube during the outage, but said they would continue to evaluate all options.

For loose parts detection, the licensee was performing X-probe inspections of peripheral tubes (approximately 902 tubes per SG) near the top of the lower tubesheet. No possible loose part indications were detected and the licensee was not planning to remove any loose parts.

No SG secondary side inspections were planned.

The tube in R49T119 is located between the w- and x-axes of the SG (closer to the x-axis than the w-axis), four tubes in from the periphery of the tube bundle, and is in compression during normal operation. The wear indication was the full length of the TSP (1.19 inches long) and was classified as uniform flat-bottomed wear. The indication had grown from no detectable degradation the previous outage, to approximately 63 percent TW this outage. The wear was attributable to just one land of the TSP. A three-tube cluster of wear existed around tube R49T119. R49T119 had wear indications at multiple TSP elevations (at the 8^{th}, 10^{th}, 11^{th}, 12^{th}, 13^{th}, 14^{th}, and 15^{th} TSPs).

Of the 3500 new TSP wear indications, approximately 30 had axial lengths that approached the thickness of the TSP. Most of these indications are in the periphery, but they are not preferentially oriented towards any one axis.

Approximately 20 tubes in the two SGs exhibited multiple (>5) wear indications at various TSP elevations.

During RFO19 in 2011, a 52 percent TSP wear indication was identified. This indication was shorter than the thickness of the TSP and was tapered (not flat-bottomed) in shape. The tube with the 52 percent TW TSP wear indication was located on the w-axis and is in the periphery of

the tube bundle. The licensee expected to find fewer new indications in RFO20 than RFO19. The number of new indications actually detected was approximately 1.9 times what was found the last outage.

There were two operational transients (reactor trips) in Cycle 19, the second operational cycle of the SGs. There were no reactor trips in Cycle 18, the first operating cycle of the SGs. There was no significant change in the operation of the SG during Cycle 19. The most limiting condition for the SGs is three times the normal operating differential pressure.

A root-cause analysis team was formed prior to the November 8, 2013, conference call. The team was considering all possible causes of the 63 percent TSP wear flaw, including internals locking, TSP locking, preload of tubes, fabrication records, and local thermal hydraulic conditions. A schedule for the root-cause analysis team was not yet established, but the licensee stated a preliminary cause analysis would be completed in time to support the OA and restart. The root cause team would include industry expertise.

No tube-proximity signals were detected during the outage. During cold conditions, the tubes are in tension, while during hot conditions, the tubes are in compression.

The licensee indicated frequency response testing is being discussed with AREVA as a possible testing method to assess the preload in the SG tubes, but the benefits of such testing were not clear. This testing was being considered for assessing T-T wear and the 63 percent TSP wear indication.

The licensee stated that there were no indications of tie-rod bowing, and that they had informed the other owners of SGs of their preliminary findings. The licensee planned to complete eddy current data analysis and in-situ pressure testing on November 9, 2013. Tube stabilization and plugging was scheduled for completion by November 11, 2013.

The licensee agreed to have another call with the NRC staff prior to restart of the plant.

Conference Call on November 18, 2013

On November 18, 2013, NRC staff participated in a follow-up conference call with the licensee for additional discussion regarding the results of the SG tube inspections. At the time of the call, the SG tube inspections were 100 percent complete in both SGs.

Tube-to-tube wear

Tube wear due to T-T contact was consistent with expectations. In SG A, 114 T-T wear indications had been identified, of which 46 were new indications. The largest historical indication was approximately 12 percent TW, while the largest new indication was approximately 16 percent TW. The average growth rate of the historical T-T wear indications was approximately 0 percent TW per cycle. In SG B, approximately 314 T-T wear indications had been identified, of which 116 were new indications. The largest historical indication was approximately 13 percent TW, while the largest new indication was approximately 10 percent TW. The average growth rate of the historical T-T wear indications was approximately 0.2

percent TW per effective full-power year (EFPY). The new indications of T-T wear are in the same general locations as the T-T wear indications detected in the 2011 outage.

Tube support plate wear

In SG A, the average growth rate of historical TSP wear indications was 0.2 percent per EFPY, while in SG B the average growth rate of historical TSP wear indications was 1.8 percent per EFPY.

Most new TSP wear indications were found around the 8th TSP in both SGs, most of these indications were less than 20 percent TW, and these indications formed a donut shaped pattern. The deepest TSP wear indications were found near the periphery of the 13th TSP in SG B. In general, the pattern formed by all the TSP wear indications in both SGs starts as a donut shape near the middle elevation of the SGs, and progresses to the periphery on the sides of the SGs as elevation increases to the top of the SGs (i.e., teacup shaped).

In SG A, there were 952 TSP wear indications in RFO19, with a maximum depth of 27 percent TW. For RFO20, SG A had 1739 new TSP wear indications, with a maximum depth of 30 percent TW.

In SG B, there were 1342 TSP wear indications identified in RFO19, with a maximum depth of 52 percent TW. For RFO20, SG B had 2384 new TSP wear indications, with a maximum depth of 63 percent TW. The highest occurrence of the indications of TSP wear are at the 8th TSP.

The 63 percent TW TSP indication had flat-bottomed wear and was approximately 1.19 inches long. The tube at R49T119, with the 63 percent TW TSP wear indication, passed an in-situ pressure test at 4800 pounds per square inch. The deepest TSP wear indication left in service in SG A after RFO19, was 27 percent TW, and this indication measured 27 percent TW again in this outage RFO20. Approximately 95 percent of all the TSP wear indications found were less than 20 percent TW.

The licensee reported that the max growth rate for new indications in the first operating cycle was 30.2 percent per EFPY (the first operating cycle was 1.72 EFPY). For the second operating cycle, the licensee reported that the max growth rate for new indications was 33.6 percent per EFPY (the second operating cycle was 1.877 EFPY). The licensee stated that the growth rates seen in the first and second operating cycles were consistent with the growth rates seen in other plants with replacement once-through SGs, where the first cycle maximum growth rate was 33.9 percent TW/EFPY, and the second cycle maximum growth rate was between 26 and 29 percent TW/EFPY.

There were no non-conforming issues related to the tubes with the bounding (i.e., largest) indications. Shroud locking of the TSPs was identified as a possible cause for the TSP wear indications. The licensee is examining plant operations and manufacturing tolerances as part of the root cause assessment they are performing.

The licensee indicated that their preliminary OA supports a 24-month operating cycle.

The OA used a Monte Carlo analysis performed at the 0.95 probability/50 percent confidence level. The analysis assumed 2800 new T-T wear flaws would form in the next cycle of operation and no scaling factor was assumed for growth reduction of the existing flaws. The distribution of new flaws expected at the end of the next cycle was based on the distribution of new indications detected during RFO20. The expected duration of the next cycle, Cycle 20, is 1.919 EFPY. (NOTE: TMI counts refueling outages as occurring prior to the same numbered operating cycle, so Refueling Outage 20 precedes Operating Cycle 20) By contrast, the Monte Carlo analysis used by the licensee at the end of the previous operating cycle (to support restart for the operating cycle just completed), assumed a scaling factor of 0.8 on wear growth rate. The licensee used a structural depth to maximum depth ratio of 0.96 (based on flaw profiling of approximately 60 TSP wear indications) and the maximum flaw length used in the lognormal distribution was 1.20 inches. This flaw size would be expected to occur about 1.3 percent of the time. The licensee had a third party review the OA and the third party agreed with the results.

The licensee also performed a deterministic analysis of TSP wear in SG A and determined the 0.95 probability end-of-cycle depth to be 61 percent TW. A deterministic analysis for the T-T wear in SG's A and B yielded a 0.95 probability end-of-cycle depth of 36 percent for SG A and 30 percent for SG B.

The licensee stated that they believed the maximum growth rates observed in Operating Cycle 19 were consistent with those observed in Operating Cycle 18. The deepest TSP wear indication was assumed to begin growth during the heat-up from RFO19.

The wear pattern seen around the tube in R49T119 in SG B is also seen in five other locations of SG B, but the significance of these patterns is not currently known.

At the time of the call, flaw orientation mapping (i.e., finding the orientation of flaws in the tubes) was being conducted and had been completed on approximately 50 tubes. The orientation of the flaws was being determined by using an array probe with a stationary probe in a neighboring tube. The results of this effort will be incorporated into the final root cause analysis.

The calculated maximum axial compressive load of the SG tubes is approximately 260 pounds per square inch and the buckling limit was calculated to be approximately 341 pounds per square inch. Some tubes are close to the buckling limit, but none of the tubes exceeded the limit. The licensee indicated that their analysis shows that the structural integrity limits and accident induced leakage limits of axially oriented flaws are insensitive to the compressive loading seen in these SGs (since industry testing indicates that the axial loadings on the tube have no influence on the burst pressure from approximately 1000 pounds of compression to approximately 3000 pounds of tension). Additionally, the bending moments seen by the tubes in these SGs are less than the bending stress limit of 42,000 pounds per square inch for flaws at the TSPs (in the shortest span).

The licensee stated that the SGs had adequate integrity. The licensee agreed to provide a copy of the final OA and root cause assessment to the regional inspectors.

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