June 21, 2002

Mr. John L. Skolds, President
and Chief Nuclear Officer
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Exelon Generation Company, LLC
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Warrenville, IL 60555

SUBJECT: THREE MILE ISLAND NUCLEAR STATION, UNIT 1 (TMI-1), SUMMARY OF CONFERENCE CALLS WITH AMERGEN REGARDING THE 2001 TMI-1 STEAM GENERATOR TUBE INSPECTION (TAC NO. MB3148)

Dear Mr. Skolds:

On October 22, 23, 26, and 30, and November 2, 2001, the Nuclear Regulatory Commission (NRC) staff held conference calls with Amergen Energy Company, LLC, representatives regarding the once-through steam generator (OTSG) tube inspection activities during the Cycle 14 refueling outage at TMI-1. Enclosure 1 is a summary of the conference calls. Enclosures 2 and 3 are faxed information to support the calls.

The NRC staff has received the AmerGen March 5, 2002, Cycle 14, Inservice Inspection (ISI) Summary Report of the results of the ISI of the OTSG tubes in accordance with TMI-1 Technical Specification 4.19.5.b. The NRC staff will complete its review of the Summary Report under TAC No. MB3148 after which time we will close TAC No. MB3148.

If you have any questions, please contact me at 301-415-1402.

Sincerely,

/RA/

Timothy G. Colburn, Senior Project Manager, Section 1
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-289

Enclosures:
1. Summary of Conference Calls
2. Faxed Information to Support October 22, 2001, Telephone Call (18 pp)
3. Faxed Information to Support October 26, 2001, Telephone Call (14 pp)

cc w/encls: See next page

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SUMMARY OF CONFERENCE CALLS WITH
AMERGEN ENERGY COMPANY, LLC
REGARDING CYCLE 14 STEAM GENERATOR INSPECTION RESULTS
AT THREE MILE ISLAND NUCLEAR STATION, UNIT 1 (TMI-1)

On October 22, 2001, the Nuclear Regulatory Commission (NRC) staff conducted an outage phone call with the licensee to discuss its preliminary results from the once-through steam generator (OTSG) tube inspections at TMI-1. The licensee planned to perform the following inspections and all sample inspections were subject to 100% expansion based on inspection findings:

1. Inspect 100% of the unexpanded tubing below the kinetic expansion using a bobbin coil probe.
2. Inspect 33% of the installed sleeves with bobbin coil probe and low frequency plus point coil probe.
3. Inspect the kinetic expansion by motorized rotating pancake coil (MRPC) probe for approximately 5,100 tubes in OTSG-A and 5,900 tubes in OTSG-B.
4. Inspect one tube border around the installed sleeves (15th tube support plate (TSP) and upper tubesheet (UTS) secondary face) in the lane/wedge region with an MRPC probe.
5. Inspect 33% of the defined lower tubesheet (LTS) kidney region with an MRPC probe.
6. Inspect 33% of Westinghouse upper head I-600 thermally treated plugs, 33% of LTS explosive plugs, and two I-600 upper head Babcock & Wilcox rolled plugs with an MRPC probe.
7. Inspect all of the flaw-like indications reported from bobbin coil inspections with an MRPC probe.
8. Inspect the dent indications, including all those located at the UTS secondary face, 33% of the dents above LTS up to the UTS, and all dents >16 volts in the LTS outside the kidney region with an MRPC probe.
9. Inspect degraded inside diameter intergranular attack (IDIGA) indications below the kinetic expansion.

During these inspections, the licensee identified significant indications of outside diameter (OD) upper span groove intergranular attack (IGA), similar to those observed previously at TMI-1 and in other OTSGs. The licensee indicated that these particular groove IGA indications were not present in their last inspection in 1999, based on their look back at the data from the previous outage. The licensee also identified one short OD circumferential indication just above the UTS secondary face (UTS crevice).

The licensee has had approval for a number of years for an alternate repair criteria leaving small inside diameter (ID) IGA flaws in service that have been present since a sodium thiosulfate incursion in the early 1980s. Indications of IDIGA below the kinetic expansion were evaluated for growth using a sign test and a paired t-test. Preliminary results reflected no growth in the IDIGA indications. TSP wear indications that were dispositioned as wear with an MRPC probe during the previous outage, and were unchanged using the bobbin coil technique, were not MRPC-examined during the Cycle 14 outage.

In addition, the licensee identified four tubes which exhibited signs of tube wear near the secondary face of the UTS. There were no signs of tube wear on these tubes during the

previous OTSG tube inspections performed approximately 2 years earlier. The maximum depth of tube wear observed in the four active tubes was estimated by eddy current examination to range from 37% to 92% through-wall. The overall length of the wear scars on the four tubes ranged from approximately 2.8 inches to 8.3 inches. The licensee discussed these four tubes with the NRC staff in the first phone call, on October 22, 2001, and in subsequent follow-up phone calls held on October 23, 26, and 30, and November 2, 2001. During the October 22, 2001, phone call, the licensee also discussed a severed tube that they had discovered. The presence of the four tubes with wear scars, and the orientation of these four tubes around a plugged tube, caused the licensee to suspect that a plugged tube had severed. This suspicion was confirmed by removing the plug and inspecting the tube.

During the phone calls held on October 23 and 26, the licensee discussed their plans for evaluating the root cause of the severed tube, determining extent of condition, and determining corrective actions. In addition, based on the risk analysis of this situation (as evaluated in accordance with NRC Management Directive 8.3, “NRC Incident Investigation Program”), a special inspection was initiated to provide an independent review of the conditions and circumstances surrounding this degraded OTSG condition. The results of this inspection are contained in NRC Inspection Report No. IR 05000289/2001-012, dated January 9, 2002. This may be found in the Agencywide Documents Access Management System (ADAMS) at ML020090673.

Additionally, a meeting was held on November 9, 2001, at NRC headquarters to discuss the licensee’s root cause assessment, review of extent of condition, and planned corrective actions. The meeting summary was issued on November 21, 2001, and is located in ADAMS at ML013240523. Follow-up of the licensee’s activities to assess the root cause of the severed tube is being reviewed by the NRC staff under TAC No. MB3305. The following information was provided during the phone calls and meeting with the licensee.

As a result of the pattern and location of wear, the licensee suspected a plugged tube may have caused the wear on the active tubes. The plug in the UTS was removed from this tube, located in Row 66 Tube 130 (R66-T130), and a video inspection of the tube was performed. The video inspection indicated the tube was severed near the secondary face of the UTS. This tube was plugged in 1986 with an alloy-600 mechanical plug as a result of IGA near the fifth tube support plate (i.e., there was no observable degradation at the location of the severance at the time the tube was originally plugged). The original plug in this tube was replaced in 1997 with an alloy-690 mechanical plug as part of a program to replace many of the alloy-600 plugs in the UTS.

To investigate the severity of the wear indications, the licensee performed in-situ pressure testing of a few of these tubes and removed the degraded portion of two of these tubes for testing and destructive examination. In addition, other tubes were chosen for in-situ testing based on degradation identified as IDIGA, ODIGA, groove IGA, and axial and circumferential stress corrosion cracking. Based on information provided for a November 2, 2001, phone call, the licensee tested 9 tubes in “A” SG and 10 tubes in “B” SG.

One of the two tubes removed for destructive examination included the most degraded tube, the one with the 92% through-wall degradation. As a result of the pressure tests performed on the tubes with wear indications, two tubes challenged the design-basis structural performance

criteria for SG tubes. The burst pressure for one of these tubes was near the differential pressure that would be observed during a postulated main steam line break. Another tube's burst pressure exhibited a margin against burst which was near the margin of 3 against the normal operating pressure differential discussed in the Nuclear Energy Institute's (NEI's) guidelines, NEI 97-06, "Steam Generator Program Guidelines."

In addition to removing the degraded portion of two of the tubes with wear indications for destructive examination, the licensee also removed the lower portion of the fractured surface of the severed tube to assess the root cause. The licensee was unsuccessful in removing the portion of the severed tube that was located within the tubesheet (i.e., the upper portion of the fracture surface), and notified the NRC during the November 2, 2001, phone call that they would abandon efforts to remove it. The preliminary laboratory investigation of the severed tube indicated the tube exhibited signs of high-cycle fatigue, ductile failure, and OD-initiated IGA. In addition, the tube diameter was expanded when compared to the nominal tube diameter indicating the tube had swelled. The video inspections performed in the SG confirmed the severed tube was in physical contact with the drilled hole tube support plate, whereas the tube-to-drilled hole tube support plate crevices for the surrounding tubes were open (i.e., no visual evidence of tube expansion).

The licensee postulates the tube expansion effect (i.e., tube swelling) is caused by relatively cold water leaking into a plugged tube and subsequent expansion of this water during heatup. The in-leakage of water into the tube was most likely a result of leakage around the plugs. As the plant was heated up, the water in the tube expanded at a rate greater than that which it could escape past the tube plugs resulting in a pressure buildup and subsequent swelling of the tube. This overall effect is sometimes referred to as the "diode effect."

For the severed tube, the tube became clamped/restrained at the support structures (i.e., TSP and the tubesheet) as a result of the swelling. From a flow-induced vibration analysis performed by the licensee, which considered the clamping of the tubes, the potential for high-cycle fatigue increased in the UTS region. The stability of the tubes near the LTS was better than that near the UTS because of lower flow velocity profiles. In the upper portion of a OTSG tube bundle, the potential for flow-induced vibration is higher for the peripheral tubes since the flow velocity is greater in that region (when compared to the interior portion of the tube bundle). For this reason, the licensee postulated that the tube swelled resulting in it becoming restrained by the tube support structures, thereby increasing the tube's susceptibility to flow-induced vibration and ultimately, the tube severed. The ODIGA on the tube may have made the tube more susceptible to this phenomena.

To address the concern for other plugged tubes to impact active tubes in future cycles, the licensee embarked on a tube deplugging and inspection program. This program indicated some plugged tubes contained water, some had swelled, and/or some exhibited continued tube degradation even though the tube was plugged (i.e., there was evidence of tube degradation in 2001 that was not present on the tube at the time it was originally plugged).

The only tubes in which water and/or swelling was observed occurred in tubes that were, or had been plugged, at some point, with an alloy-600 mechanical plug. That is, some of the tubes in which water/swelling was observed had alloy-690 mechanical plugs installed, but these

alloy-690 mechanical plugs were installed as replacement plugs for the original alloy-600 mechanical plugs. Based on a sample of tubes with alloy-690 plugs inspected, no tubes which were originally plugged with alloy-690 plugs in both the UTS and LTS had signs of water or swelling. Some of these alloy-690 plugs were installed as early as 1991. The tubes with water and/or swelling were spread throughout the tube bundle (i.e., they were not confined to the periphery of the tube bundle).

To prevent plugged tubes from impacting other tubes in the event of severance, stabilizing cables were installed in tubes. These cables can be inserted to various lengths within the tube. As part of their corrective action, the licensee for TMI-1 stabilized plugged tubes or surrounded plugged tubes with stabilized tubes to “cage” the non-stabilized plugged tube. Stabilizing for non-swelled tubes occurred primarily from the UTS through the fourteenth tube support plate although full-length stabilization was used for the swollen tubes.

Based on the licensee’s evaluation of the inspection data, no reroll or sleeving of any tubes was planned. Follow-up questions based on the information presented at the November 9, 2001, meeting were sent to the licensee to assist the NRC in evaluating the generic implications of the severed tube. The NRC requested a meeting with industry to discuss the generic implications of the TMI-1 severed OTSG tube, and the meeting was held on January 31, 2002. The meeting summary was issued on February 22, 2002, and can be found in ADAMS at ML020580377.

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