August 24, 2007

Mr. Timothy G. Mitchell
Vice President, Operations
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Entergy Operations, Inc.
1448 SR 333
Russellville, AR 72802

SUBJECT: ARKANSAS NUCLEAR ONE, UNIT 1 - SUMMARY OF APRIL 30 AND MAY 5, 2007, CONFERENCE CALLS REGARDING 2007 STEAM GENERATOR TUBE INSPECTIONS (TAC NO. MD4817)

Dear Mr. Mitchell:

On April 30 and May 5, 2007, the NRC staff participated in conference calls to discuss the 2007 steam generator tube inspections performed at Arkansas Nuclear One, Unit 1, during their 20th refueling outage (1R20). To facilitate these conference calls, the licensee was provided some discussion points for the call. On April 29, 2007, the licensee provided preliminary information regarding the results of its inspections.

Based on the information provided during the conference call, other than the investigation into the several pair of tubes that were found to have moved closer to each other, the NRC staff did not identify any issues that warranted additional follow-up at this time. Enclosed is a summary of the conference calls.

This completes our review of the preliminary results for the 2007 steam generator tube inspections at Arkansas Nuclear One, Unit 1. If you have any questions regarding this matter, please contact me at (301) 415-1447.

Sincerely,

/RA/

Alan B. Wang, Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-313

Enclosure: Summary of Conference Calls

cc w/encl: See next page

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SUMMARY OF CONFERENCE CALLS ON APRIL 30 AND MAY 5, 2007

STEAM GENERATOR TUBE INSPECTIONS

ARKANSAS NUCLEAR ONE, UNIT 1

DOCKET NO. 50-313

On April 30 and May 5, 2007, the U.S. Nuclear Regulatory Commission (NRC) staff participated in conference calls to discuss the 2007 steam generator tube inspections performed at Arkansas Nuclear One (ANO), Unit 1, during their 20th refueling outage (1R20).

The two steam generators at ANO Unit 1 are Areva replacement once-through steam generators (OTSG). This is the first in-service inspection since the OTSGs were replaced in the fall of 2005. Each OTSG contains approximately 15,596 thermally treated Alloy 690 tubes. Each tube has a nominal diameter of 0.625 inches and a nominal wall thickness of 0.037 inches. Each tube is hydraulicly expanded for the full length of both tubesheets in a sequence designed to produce a tensile pre-load on the tubes. The steam generator tube-support plates are 1.18-inch thick heat-treated 410 stainless steel with broached trefoil-holes. The tube-support plates are held in place with stay rods. For additional information concerning the design of the replacement OTSGs, see Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML060590367 and ML061730358.

Prior to the call on April 30, 2007, the licensee was provided with discussion points to help facilitate the phone conference. In support of the phone call, the licensee provided the attached documents (see Attachments 1, 2, 3, and 4) that provided inspection status as of April 29, 2007. At the time of this call, the eddy current inspections for OTSG "A" were complete. In OTSG "B," a few special-interest inspections were still in progress.

Additional clarifying information or information not included in the material provided by the licensee is summarized below:

- Acronyms used by the licensee in the material they provided include: SG (steam generator), OTSG (once-through steam generator), TSP (tube-support plate), ET (eddy current testing), TTS (top of tubesheet), FIV (flow-induced vibration), TW (through wall).

- The X-probe examinations at the top of the tubesheet included the outermost three tubes around the periphery of the tube bundle.

- The special-interest examinations involved inspecting non-quantifiable indications, wear indications, manufacturing burnish marks, and dents with no indications with a +Point probe.

- Only three dents were reported in each steam generator using a 1-volt threshold. These dents were present in the preservice examination.

- The aspiration port is near the tenth tube-support plate.

- With respect to the wear indications identified at the tube-support plates:

  – The 700 wear indications in OTSG "A" are contained within approximately 651 tubes. Approximately 500 wear indications in OTSG "B" are associated with approximately 431 tubes.

  – Wear indications were reported at all tube-support plate elevations; however, most of the indications are at the 8th, 9th, 10th, and 11th tube-support plates.

  – Most of the wear indications are in the periphery of the tube bundle; however, in OTSG "A" there is a crescent band of indications approximately six to seven tubes into the tube bundle.

  – The wear indications are approximately 0.5 inches in axial extent.

  – The tubing was manufactured by Sumitomo and the tubing does not result in noisy eddy current data (i.e., high signal-to-noise ratio).

  – The number of wear indications at the tube-support plates (~1210) was consistent with expectations (approximately 600 indications per steam generator); however, the depths of some of the wear indications exceeded expectations.

  – Some of the tubes had multiple indications at the same tube-support plate elevation.

  – The 95th percentile growth rate (at 95 percent confidence) was used for the tube integrity operational assessment. Although the 28 percent through-wall indication was acceptable for two cycles of operation, the licensee elected to plug the tube.

  – The tube-support plate lands are flat (i.e., not hour glassed). The amount of pre-load in the tubes differs from that at other replacement OTSGs.

  – Rotating probe examinations were performed on all wear indications that measured greater than or equal to 15 percent through-wall based on bobbin coil examination. All of the "large" wear indications are tapered; however, a few of the smaller wear scars (12 to 13 percent through-wall) are not tapered.

  – The growth rates listed in the licensee-provided information are based on 1.3 effective full power years (EFPY). The next operating cycle is planned for 1.4 EFPY.

  – No indications were reported less than 5 percent through-wall.

- A loose part was found on the primary side of one of the OTSGs. The loose part was located approximately 5 inches into one of the tubes. A visual examination was performed to identify the source of the restriction in the tube. The part (a machine winding) was removed from the steam generator. An examination of the affected region with an X-probe did not identify any tube degradation.

- There are two tubes plugged in OTSG "A" with Inconel 690 welded plugs. The plugs in both tubes were visually examined.

- There were approximately five to six pairs of tubes identified that were in close proximity at the time of the April 30, 2007, call. These tubes do not appear to be touching and there was no wear at these "close proximity" locations.

An additional call was held with the licensee on May 5, 2007, to discuss their investigation into the tubes that were in close proximity. Information provided during these calls is summarized below.

- In OTSG "A," there were 690 wear indications. The maximum reported depth in OTSG "A" was 23 percent through-wall.

- In OTSG "B," there were 512 wear indications. The maximum reported depth in OTSG "B" was 28 percent through-wall. The tube with the 28 percent through-wall flaw was plugged.

- Seven locations were identified in OTSG "A" in the lower or first span that had tubes in close proximity. For all seven locations, a total of 18 tubes in OTSG "A" were determined to be in close proximity. These locations are all associated with stay rods (rods that support and maintain the spacing of the tube-support plates—these rods are also referred to as "tie rods"). It appears that the stay rods bowed and pushed some of the adjacent tubes closer together. There were no similar indications in OTSG "B." There was no wear associated with the 18 tubes in close proximity. The tubes are in close proximity midway between the first span (i.e., approximately 23 inches above the lower tubesheet). The axial length of proximity could not be estimated, but there is a drift on the low-frequency eddy current data. The tubes appeared to have deflected towards the center of the tube bundle (i.e., away from the periphery).

- In OTSG "A," the eighth tube-support plate has a large number of wear indications in a unique pattern. Of approximately 700 wear indications in OTSG "A," approximately 400 are at the eighth tube-support plate. The pattern of wear indications at the eighth tube-support plate is not similar to other OTSGs. The wear at the eighth tube-support plate is primarily between the outermost row of tie rods and the second row of tie rods (from the periphery). There is a similar pattern of wear indications at the seventh and ninth tube-support plates, but to a much lesser extent than that at the eighth tube-support plate. The wear indications at the eighth tube-support plate are located in the region above the seven locations where the tubes are in close proximity.

- All seven locations where the tubes are in close proximity are on one side of the steam generator and are located in a crescent shape. The affected locations are approximately 180 degrees from the inspection port for the first span (making visual inspection of this region difficult).

- There was no tube wear identified during the eddy current examination for the seven locations where the tubes are in close proximity. It is unknown whether there is any tube-to-tube contact.

- There are 52 tie rods in the first span of the steam generator. The inspection data for all 52 tie rods was reviewed to ensure all affected locations were identified. The diameter of the tie rods in the first span (5/8 inch) is less than the diameter of most of the other tie rods (which are 7/8-inch diameter). This was done to facilitate sludge lancing at the top of the lower tubesheet. The tie rods in the first span are longer than the tie rods between the other tube-support plates.

- The tie rods in the first span are attached to the lower tubesheet. The tie rods are not connected to the upper tubesheet. The tie rods are made from Type 410 stainless steel.

- There was no evidence of tubes being in close proximity during the preservice inspection.

- The gap between the tubes is approximately 0.25 inches.

- A bounding evaluation was in the process of being performed and it will consider the following: (1) analysis of tie rod bowing relative to stresses and strains for load cases; (2) tube-support plate stress analysis; (3) remaining tie rod analysis (assuming the seven tie rods are failed); and (4) tube-to-tube wear.

- The maximum amount of tie-rod bowing was estimated as 0.5 to 0.75 inches. This was assumed since one of the tubes in close proximity is three tubes away from a tie rod.

- There were two thermal cycles during the first operating cycle (i.e., one associated with the startup/shutdown associated with the refueling outages and one forced outage startup/shutdown during the middle of the cycle).

- The tube supports are designed to float within the steam generator. The licensee suspects that eighth tube-support plate may be locked to the shroud (i.e, wrapper).

- There are eight wedges around the circumference of the tube-support plate. These wedges are attached to the shroud. The tube support is designed to slide up and down the wedge (i.e., the edge of the tube support permits sliding of the support by the wedge). There is no gap between the wedge and the tube-support plate during cold conditions. Since the thermal expansion coefficient for the tube-support plate is less than the thermal expansion

coefficient for the shroud, there is a slight gap between the tube-support plate and the wedge under normal operating conditions.

- Two possible scenarios were identified as having resulted in the bowing of the tie rods: (1) the tube-support plate is restrained during heat-up, and (2) the tube-support plate is restrained during cool-down. The licensee believes that it was more likely that the tube-support plate was restrained during heat-up; however, it is more conservative to assume the plate was restrained during cool-down.

- If it is assumed that during heat-up the eighth support plate was not free to move, the tie rods are expected to yield (since the steam generator shell elongates more than the tie rods as a result of thermal expansion). During the subsequent cool-down, the tie rods would then bow. This scenario is consistent with the abnormal number and pattern of wear at the eighth tube-support plate and explains why there is no tube wear at the locations which are in close proximity. The licensee also considered that the eighth tube-support plate was free to move during heat-up and that during cool-down the plate became restrained (and as the plant cooled down, a compressive load was put on the tie rods and they bowed). Although this latter scenario is not consistent with the abnormal wear at the eighth tube-support plate, it is conservative to assume this scenario in some of the analyses.

- The licensee analyzed the tie rods to ensure the stresses were acceptable (i.e., to ensure the tie rods would not become loose parts and to ensure that the remaining 45 tie rods would provide adequate support). These analyses were performed for one heat-up and cool-down cycle (at the time of the call). Additional analyses were underway for additional heat-up and cool-down cycles. The maximum deflection of the tie rod was assumed to be 1.0 inch (based on the observed maximum of 0.75 inches and adding some margin). In addition, it was assumed that the tie rods were permanently deformed (which is a conservative assumption since there is dead load on the tie rods). In order to achieve a 1.0-inch deflection of the tie rod, approximately 168 mils (milli-inch) of axial deflection is needed (based on plastic analysis). In the analyses, it was assumed an additional 168 mils of axial deflection would occur. The results of the analyses indicated that the stresses/strains in the tie rods were still acceptable (i.e., the tie rods would not sever; however, the results of the analyses were not compared to the limits in the American Society of Mechanical Engineers Code (e.g., 3 membrane stress intensity limit)).

- The licensee also analyzed the axial load-carrying capability of the tie rods given that they have laterally displaced 0.25 inches (the licensee expects that 0.25 inches is the maximum lateral deflection that could occur without being detected during the eddy current examination). This analyses demonstrated that the tie rods would still have adequate structural integrity.

  The licensee analyzed whether a restrained tube-support plate had any adverse affect on the structural integrity of the tube-support plate and whether the

redistribution of loads among the 45 "non-bowed" tie rods had adequate load-carrying capability. This analysis was in final review during the phone call; however, the results were acceptable.

The licensee also assessed the potential for tube-to-tube wear assuming the tubes are in contact (and at the steam generator design-power level which is higher than they are currently allowed to operate (e.g., 3000 to 3100 megawatts thermal rather than 2568 megawatts thermal). The resulting wear on the tubes was determined to be acceptable. This was due in part, to the low flow in the first span of the tubes. The licensee also analyzed the tube wear occurring at the eighth tube-support plate elevation and concluded that a full cycle of operation is acceptable.

Following the conference calls, the licensee provided a letter dated May 11, 2007 (ADAMS Accession No. ML071420160), which summarizes the actions taken by the licensee in response to identifying several tubes in close proximity. The NRC issued a response to this letter on May 11, 2007 (ADAMS Accession No. ML071310446).

Other than the investigation into the tubes in close proximity, the NRC staff did not identify any issues (at the time of the conference call) that warranted additional follow-up action.

ATTACHMENT 1

PRELIMINARY RESULTS

ADAMS Accession No. ML072250257

ATTACHMENT 2

OUTLINE OF OTSG

ADAMS Accession No. ML072250272

ATTACHMENT 3

TSP WEAR MAP

ADAMS Accession No. ML072250281

ATTACHMENT 4

EOTSG STRUCTURAL DESIGN

ADAMS Accession No. ML072250291