July 14, 2004

Mr. L. William Pearce
Vice President
FirstEnergy Nuclear Operating Company
Beaver Valley Power Station
Post Office Box 4
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SUBJECT: REVIEW OF THE BEAVER VALLEY POWER STATION, UNIT NO. 1 (BVPS-1) STEAM GENERATOR TUBE 90-DAY INSPECTION REPORT ASSOCIATED WITH THE SPRING 2003 REFUELING OUTAGE (TAC NO. MC0249)

Dear Mr. Pearce:

By letter dated July 24, 2003, FirstEnergy Nuclear Operating Company (FENOC or the licensee), submitted the Cycle 16, Steam Generator Voltage-Based Repair Criteria 90-Day Report. Included as an appendix to the 90-day report was the FENOC response to a June 4, 2003, request for additional information (RAI) from the Nuclear Regulatory Commission (NRC) staff, concerning mix residual signals. The NRC staff reviewed the 90-day report and issued a November 20, 2003, RAI. FENOC's February 12, 2004, response to the RAI has been received and reviewed by the NRC staff. The enclosure provides the NRC staff's evaluation of the BVPS-1 90-day report and the licensee's treatment of the BVPS-1 support plate mix residual signals. This evaluation completes our review under TAC No. MC0249.

As discussed in the enclosed evaluation, the NRC staff did not identify any technical issues that require follow-up action at this time; however, the NRC staff did have several observations related to the 90-day report. 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. 50-334

Enclosure: Evaluation

cc w/encl: See next page

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ACCESSION NO.: ML041830118 *Evaluation received. No substantive changes made.

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EVALUATION OF THE STEAM GENERATOR TUBE

90-DAY REPORT

ASSOCIATED WITH THE SPRING 2003 REFUELING OUTAGE AT

BEAVER VALLEY POWER STATION, UNIT NO. 1 (BVPS-1)

DOCKET NO. 50-334

In a series of telephone conference calls conducted during the BVPS-1 spring 2003 refueling outage, the Nuclear Regulatory Commission (NRC) staff and licensee discussed the treatment of steam generator (SG) tube eddy-current support plate residual (SPR) signals. As a result of those discussions, the NRC issued a June 4, 2003, request for additional information (RAI) Agencywide Documents Access and Management System (ADAMS) accession number ML031550196. By letter dated July 24, 2003 (accession number ML032100660), the licensee for BVPS-1 submitted the Cycle 16 (spring 2003 outage) SG Voltage-Based Repair Criteria 90-Day Report and included the response to the June 4, 2003, RAI concerning mix residual signals as an appendix. The NRC staff reviewed that submittal, concluded that additional clarification was necessary, and issued an RAI on November 20, 2003 (accession number ML033070299). FENOC responded by letter dated February 12, 2004 (accession number ML040490547).

The scope and results of the licensee's inspections are contained in the documents referenced above. Based on a review of these documents, the NRC staff concludes that the licensee provided the information required by the BVPS-1 Technical Specifications (TSs). The NRC staff did not identify any technical issues that warrant follow-up action at this time; however, the NRC staff has the following observations regarding the information provided by the licensee.

- In the 90-day report, the licensee compared the operational assessment (OA) projections to the as-found condition monitoring (CM) results. In this comparison, the licensee indicated that the differences between the projections and actual results are insignificant when compared to the acceptance or reporting limits. The NRC staff agrees that the results of both the projections and the actual results are well within the acceptance or reporting limits. However, assessing whether the projections are conservative compared to the as-found results, even when the results are well within the acceptance or reporting limits, may permit the timely identification of a non-conservative methodology. Identification of this non-conservative methodology would then permit prompt corrective action to be taken prior to exceeding a safety limit (e.g., the acceptance or reporting limit).

- In Section 6.6 of the 90-day report, the licensee compared the actual and projected end of cycle -15 (EOC-15) voltage distributions. In this section, the licensee indicates that the reason for underestimating indications below 0.6 volts is due to the assumption that all new indications appear at the beginning of the cycle. Full-cycle growth is applied to all new indications in the Monte Carlo simulations whereas in reality new indications are initiated throughout the cycle and experience only a fraction of the full-cycle growth. Therefore, the licensee concluded, the Monte Carlo projection is conservative. The NRC staff agrees that the results of both the projections and the actual results are well within the acceptance or reporting limits. In addition, the NRC staff agrees that indications will initiate throughout the cycle (i.e., all new indications may not be present at the beginning of the cycle). However, Tables 3-3 through 3-5 of the 90-day report indicate that voltage growth was calculated for 3977 indications, which represent all of the indications detected. Since Generic Letter (GL) 95-05, "Voltage-Based Repair Criteria for the Repair of Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," dated August 3, 1995, indicates (refer to Section 2.b.2(2) of Attachment 1 to the 90-day report) that voltage growth rates should only be evaluated for those intersections at which bobbin indications can be identified at two successive inspections, except if an indication changes from non-detectable to a relatively high voltage such as two volts, this suggests that for all the indications detected in 2003, the licensee was able to go back to the prior outage, find the indication, and determine a voltage growth. Therefore, it does not appear that any of the indications that were detected in 2003 initiated in the middle of the cycle; and therefore, the Monte Carlo projection would not be conservative on the basis indicated.

- In response to RAI Question 2, the licensee indicated that the Cycle 15 operational assessment was carried out using both Cycle 13 and Cycle 14 growth distributions since the average voltage growth was less for Cycle 14 than Cycle 13, however, the Cycle 14 distribution included one relatively large value in the tail which may yield a higher burst probability than the Cycle 13 growth distribution. The larger steamline break (SLB) leak rate and tube burst probability values from the two sets of analysis were reported. GL 95-05 indicates (refer to Section 2.b.2(2) of Attachment 1 to the 90-day report) that the most limiting of the two previous growth rate distributions should be used to estimate the voltage growth rate distribution for the next inspection cycle. Although the licensee reported the probability of burst and leakage using both the Cycle 13 and 14 growth rate distributions, it was not clear to the NRC staff which analysis the licensee considered as the analysis of record and the basis for that selection. To be consistent with GL 95-05, the analysis of record should be the one resulting in the most limiting (highest) estimates of the probability of burst and leakage. This may not, in all instances, coincide with the distribution containing the highest average growth rate.

- The licensee's response to RAI Question 3 about probe wear indicates that potential issues with missing indications due to worn probes would be more readily apparent in those plants where no probe wear criteria is applied (e.g., those not implementing GL 95-05). The NRC staff agrees with the logic provided by the licensee that plants that operate eddy-current probes until failure have a higher susceptibility of missing indications due to a worn probe. However, since the NRC staff is not aware of any systematic study of the effects of worn probes on flaw detection for those plants not using a probe wear criteria, the NRC staff could not make any conclusions based on this general statement. A robust study could confirm the licensee's hypothesis.

- While discussing the conservatism in the methodology used to project the leakage at the EOC-15 (RAI Question 5), the licensee stated that only two distorted support indication (DSI) signals at 1R15 had sufficient +Point™ amplitudes to suggest leakage potential at EOC conditions. In addition, they stated that the actual predicted leakage of 5.0 gallons per minute (gpm) is inconsistent with only two potential indications that could contribute to leakage. The NRC staff understands that two indications were identified that had larger +Point™ voltages than other indications; however, the NRC staff could not conclude (based on the information provided) that all other tubes had no potential to contribute to leakage at the EOC-15. The reasons the NRC staff could not conclude this are (1) +Point™ examinations were not performed at all locations, (2) there are uncertainties in correlations of voltage to depth, (3) there are uncertainties in depth measurements from eddy current examination, and (4) all potential leakers may not have been identified (since there is a probability of detection). Nonetheless, the NRC staff agrees with the licensee that the limiting projected leak rates and tube burst probabilities are well below the allowable values.

- In the response to RAI Question 6 concerning the 90-day report, the licensee refers to the elevated voltage growth of deplugged tubes as occurring between the time of plugging and the time of deplugging. The NRC staff's question, however, was intended to address the elevated growth rate exhibited by tubes during the first cycle of operation after being returned to service. This question was based on discussion from page 3-3 of the licensee's 90-day report that indicated the growth rate for a deplugged tube returned to service becomes normal after showing increased growth during one cycle of operation. The Electric Power Research Institute Steam Generator Degradation Specific Management Database, Addendum 5, also provides a similar observation that for several plants with 7/8 inch diameter steam generator tubing, deplugged tubes returned to service have experienced a significantly larger in-service growth rate than tubes active during the prior cycle. The NRC staff recognizes the licensee did not return any tubes to service during the previous (1R15) outage.

Significant discussions between the NRC staff and the licensee have been held regarding the licensee's treatment of SG tube support plate mix residual signals. In several instances, the licensee's response to the initial RAI concerning mix residual signals was incomplete (e.g., the July 24, 2003, RAI response to questions 2 and 4). Although we are always open to a response that (1) provides greater insight into an issue, or (2) responds to an issue that the licensee perceives as the basis for the NRC staff's question, in order for the NRC staff to complete its review, explicit answers to the NRC staff's RAI questions are needed.

In order to provide some background information and greater clarity to the discussion in this evaluation concerning mix residual signal treatment, the NRC staff evaluation is preceded by a brief discussion of mix residuals from GL 95-05, a summary of BVPS-1 treatment of SPR signals during the 2003 outage (as the NRC staff understands it), and a summary of the BVPS-1 position concerning mix residual signals (as the NRC staff understands it).

GL 95-05 states that the voltage-based repair criteria for SG tube support plate intersections do not apply at locations where there are mixed residual signals of sufficient magnitude to cause a 1.0 volt Outside Diameter Stress Corrosion Cracking (ODSCC) indication (as measured with a bobbin probe) to be missed or misread. Therefore, large mix residual signals are defined in GL 95-05 as those that could cause a 1.0 volt ODSCC indication (as measured with a bobbin probe) to be missed or misread. The GL also states that all tube support plate intersections with large mix residual signals should be inspected with a rotating eddy-current probe. Any indications found at such intersections with a rotating probe should cause the tube to be repaired.

The NRC staff has reviewed the licensee's RAI responses concerning mix residual signals. Figure 1 (Attachment 2 to the 90-day report) provides the NRC staff's understanding of the SG eddy current SPR signal data treatment during the BVPS-1 spring 2003 outage. Computerized data screening (CDS) indiscriminately flags all bobbin coil signals with amplitudes greater than 1.5 volts. These signals include not only SPR signals but also indications representative of degradation (i.e., DSIs) and other indications. For those indications flagged by CDS and also identified by the primary/secondary manual data analysis process as having a flaw-like signal, these signals are recorded and tracked as DSIs even if the residual signal is greater than 1.5 volts. During the 2003 SG inspection, a total of 1228 SPRs were identified with the CDS. These 1228 SPRs do not include those signals for which the primary/secondary manual data analysis process resulted in the identification of a DSI at that location (i.e., these CDS identified signals are "automatically" converted to a DSI). Of these 1228 SPRs, 115 were converted to DSIs by the resolution analyst (i.e., they were not identified by the primary/secondary manual data analysis process). Another 57 SPRs were declared to not be valid SPRs. The remaining 1056 SPRs identified by computerized data screening were inspected with the +Point™ probe. The +Point™ probe inspection resulted in the identification of 273 DSIs. No DSIs were detected by +Point™ at the other 783 SPR locations. Therefore, from the original 1228 SPRs, 388 contained DSIs (115 converted to DSI based on re-analysis of the bobbin data and 273 DSIs identified with +Point™). ODSCC was not detected in the other 840 SPRs (57 from manual analysis of the bobbin data and another 783 with no +Point™ indications).

The primary/secondary manual data analysis process of the spring 2003 outage bobbin coil data identified 3591 DSIs (some of which had residual components in excess of 1.5 volts). When these 3591 DSIs are combined with the 388 DSIs identified during the review of the SPRs, a total of almost 4000 DSIs were identified in the BVPS-1 SGs in 2003.

As discussed in GL 95-05, the two main issues associated with mix residual signals are: (1) the mix residual effects on the detectability of flaw-like indications (i.e., DSIs) and (2) the mix residual effects on the amplitude sizing of detected flaw-like indications. Each of these areas are discussed separately below.

Detection

Each licensee implementing the alternate repair criteria discussed in GL 95-05 determines when a mix residual signal can result in a 1 volt indication being missed. Based on interactions with the licensee, the NRC staff questioned the adequacy of the licensee's criterion given that several DSIs with voltages in excess of 1 volt were identified in SPRs (i.e., mix residuals in excess of 1.5 volts). In fact, DSIs with voltages in excess of 1 volt were detected in SPRs near the licensee's 1.5 volt threshold for reporting SPRs.

To address the NRC staff's questions, the licensee provided several arguments for why the mix residual signals are not an inspection challenge to the bobbin coil at BVPS-1. These arguments included the following:

The largest SPR voltage in which a DSI was identified was only 2.82 volts while the largest mix residual voltage in a 166 indication sample of the 3591 DSIs called during the primary/secondary manual data analysis process was 3.42 volts. In other words, the magnitude of the mix residual signals for SPRs determined to contain flaws was less than the magnitude of the residual signals for those intersections called DSI during the primary/secondary manual data analysis process.

The percentage of SPRs subsequently determined to contain DSIs was small (388 of 1228). SPRs determined to be DSIs (388) were few in number compared to the total DSI population of 3977.

The percentage of DSIs called from the SPR population based on +Point™ examination (273 of 1228) is uncharacteristically low when compared to the +Point™ confirmation rate of those signals initially called DSI during the primary/secondary manual data analysis process. The +Point™ confirmation rate for DSIs greater than 1 volt identified during the primary/secondary manual data analysis process is approximately 91%.

The qualification data set for the bobbin coil (documented in Examination Technique Specification Sheet (ETSS) 96007.1), includes residual signals.

Many DSIs were called during the primary/secondary manual data analysis process that had mixed residuals in excess of the 1.5 volt CDS screening threshold indicating that DSIs can be called in the presence of mix residuals.

The amplitude distribution of DSIs in the SPR set is similar to the amplitude distribution of a sample of the DSIs.

For mix residual signals less than 1.5 volts, the probability of detection (POD) for a 1.0 volt or greater ODSCC signal should be high. For mix residual signals greater than 1.5 volts, a probability of detection of 0.6 accounts for any flaws that may not have been detected by bobbin coil or rotating probe due to SPR signal effects.

The mix residual signals at BVPS-1 are not as large as those observed at other plants.

A negligible SPR is considered to be one with no signal response in the 200 kHz bobbin channel. Of the 273 DSIs identified during the +Point™ examination of SPRs, only 6 did not have a signal response in the 200 kHz bobbin coil channel. The maximum +Point™ voltage response for these indications was 0.44 volts. Since this +Point™ amplitude equates to an approximately 65% through-wall flaw and a 65% through-wall flaw measures approximately 1.0 volt by bobbin coil, any SPR without a 200 kHz bobbin signal is considered negligible.

The NRC staff has the following observations regarding these arguments and other information the licensee provided regarding flaw detection.

Detection is a function of not only the mix residual amplitude but also the flaw (signal characteristics, location) and other factors such as denting, noise, and analyst performance. As a result, DSI detection during the primary/secondary manual data analysis process at locations where the mix residual amplitude was high does not necessarily indicate that the mix residual is not affecting detection.

The NRC staff agrees that detecting 388 DSIs in a sample of 1228 SPRs is small when compared to the total DSI population; however, if one were to assume the SPRs have no (or negligible) influence on flaw detection, the implications of finding 388 indications in 1228 "randomly chosen intersections" may indicate that the detectability of DSIs, in general, is a challenge at BVPS-1. That is, it raises questions of whether approximately 30% (i.e., 388/1228) of the tube support plate locations with no detectable degradation could have DSIs that were not detected during the primary/secondary manual data analysis process. If this were the case, the effects on probability of burst and postulated accident induced leakage could be significant.

The comparison of the percentage of DSIs called from the SPR population based on +Point™ examination (273 of 1228) to the +Point™ confirmation rate of those signals initially called DSI during the primary/secondary manual data analysis process does not appear to provide any insights on the detectability of DSIs at SPR locations with the bobbin coil.

The bobbin coil ETSS may contain flaws at tube supports with mix residual signals. However, it is not clear whether the data supporting the technique qualification were robust enough to determine that the probability of detection was unaffected by the mix residual. Once again, the NRC staff recognizes that certain flaws may be detected at locations where the mix residual is high; however, it is not clear whether given the variety of factors affecting detection (including the size of the flaw and the size of the residual) that reliable detection can be ensured.

Given that the amplitude distribution of the DSIs in the SPR set is similar to the amplitude distribution of a sample of the DSIs may lead to a conclusion that the SPRs do not affect detection; however, if this is the case, it raises questions regarding the detectability of DSIs in general, as discussed above.

Given that there are many factors affecting detection, it is important to try to ascertain whether the reason for missing an indication is a result of the mix residual or some other factor. If one wanted to ascertain whether the DSIs detected in the 1228 sample were just randomly missed DSIs, one would try to ascertain whether the probability of detection (as a function of voltage) at BVPS-1 were consistent with probability of detection curves developed by the industry. Such an analysis would need to consider not only the number of missed indications (i.e., the 388 DSIs identified in the SPR screening process) but also the sample size (1228) and the susceptible population (e.g., SPRs in excess of "x" volts or all non-degraded locations). If the POD as a function of voltage was less at BVPS-1 than at other plants, one may conclude that there is a detection issue. Additional analysis of the data could lend insights into why these indications are missed (e.g., not using the 200 kHz data channel, magnitude of the SPRs, etc.).

The practice of identifying flaws from the 200 kHz channel was not clear in the material provided. In the February 12, 2004, letter, it was indicated that (1) DSIs are not called from 200 kHz partly because sizing is based on the mix channel (page 14 of 18); (2) flaw analysis guidelines stress flaw identification from either the mix channel or differential channels (page 9 of 18); and (3) both the 200 kHz and mix channel response are considered by the analyst (page 17 of 18). For the vast majority of intersections called SPR and subsequently reclassified as DSI based on +Point™ probe examinations, the 200 kHz bobbin data clearly showed a signal response. Although the licensee indicated the indications are not being masked by SPRs and that the issue is one of analyst performance and POD; the NRC staff, as mentioned previously, believes a more rigorous study would need to be performed to reach such a conclusion.

Based on NRC review of the information provided, the NRC staff has concluded that tube integrity for DSIs will be maintained for the operating interval between inspections. This conclusion is based, in part, on the licensee's examinations and the significant margin relative to the acceptance criteria/reporting threshold for leakage and the probability of tube burst. The actions taken by the licensee to perform +Point™ probe examinations of all SPRs were appropriate for detecting DSIs that may have been greater than 1.0 volt (as would be measured by bobbin coil). These actions resulted in the detection of an additional 388 indications and reduced the probability of missed indications greater than 1.0 volt remaining in service.

Sizing

Each licensee implementing the alternate repair criteria discussed in GL 95-05 determines when a mix residual signal can result in a 1 volt indication being misread. Given the issues discussed above regarding flaw detection, the NRC staff questioned the licensee concerning when DSIs could be misread (i.e., incorrectly sized). To address the NRC staff's questions, the licensee provided several arguments for why the mix residuals are not resulting in the indications being misread or why this issue should not be a concern. These arguments include the following:

The data used in the voltage correlations are influenced by the mix residual; therefore, the effects that a mix residual has on sizing of indications is already modeled in the scatter of the data.

For equal mix residual levels, the spread and average DSI voltage was similar for those locations called DSI during the primary/secondary manual data analysis process and those locations initially called SPR and determined to be a DSI based on +Point™ inspection. Of the entire DSI population, excluding SPRs subsequently changed to DSI, a sample of 166 were evaluated to determine the magnitude of the residual component.

The flaw component for those SPRs in which a DSI was identified with the +Point™ probe were accurately being measured in the 200 kHz channel.

Graphs of the residual voltage as a function of the flaw voltage for the two sets of indications (DSIs called from the SPR population versus DSIs called during the primary/secondary manual data analysis process) indicates that the voltage associated with the flaws for both sets of indications are comparable.

The ratio of the mix channel flaw measurement divided by the 200 kHz signal measurement is essentially equal for DSIs called from the first SPR sample (e.g., the larger voltage SPRs) versus DSIs called during the primary/secondary manual data analysis process).

The mix residual signal predominantly affect the edges of the tube support plate while the overwhelming majority of DSIs are observed near the center of the support plate.

The NRC staff has the following observations regarding these arguments.

The NRC staff agrees that the effects the mix residual signal could have on the voltage should be accounted for in the database correlations. The size of the mix residual signal for each data point in the correlations is not routinely provided to the NRC staff. In addition, the size of the mix residual signals observed in the field is not routinely provided. As a result, the NRC staff could not ascertain whether the data in the correlations bounds the data in the field.

Since the 200 kHz signal is not affected by the mixing process, assessing the ratio of the voltage of the flaw from the mix channel and the 200 kHz channel for different populations (e.g., DSIs called from SPRs and DSIs called during the primary/secondary manual data analysis process) could provide useful information. This is because there would only be a difference in the two populations if the mix were affecting the voltage; however, for the comparison to be complete, one must divide the data into groups based on the size of the residual since the residual may not be masking the indication (which the original groupings of the data were based on) but it could be affecting the voltage reading.

Based on our review of the information provided by the licensee, the NRC staff concludes the licensee provided the information required by the TSs and that no additional follow-up is required at this time for the reasons discussed above.

Principal Contributor: P. Klein

Date: July 14, 2004