February 18, 2016

MEMORANDUM TO: Gloria J. Kulesa, Chief
Steam Generator Tube Integrity and
Chemical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

FROM: Alan T. Huynh, Materials Engineer ***/RA/***
Steam Generator Tube Integrity and
Chemical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF THE FEBRUARY 3, 2016, CATEGORY 2 PUBLIC MEETING WITH THE STEAM GENERATOR TASK FORCE TO DISCUSS STEAM GENERATOR ISSUES

The industry's Steam Generator Task Force (SGTF) met with U.S. Nuclear Regulatory Commission (NRC) staff on February 3, 2016, at the NRC Headquarters in Rockville, MD. The purpose of the meeting was to discuss a variety of steam generator issues. The topics are shown in the industry and NRC slides, which are available in the Agencywide Documents Access and Management System (ADAMS) under Accession No. ML16047A358 and ML16047A345, respectively. The enclosure to this letter provides a list of people who attended the meeting in person and by phone. This meeting was noticed as a public meeting and the agenda is available in ADAMS under Accession No. ML16020A057.

Acronyms used and not defined in the industry slides include:

- 690TT – Thermally Treated Alloy 690
- BWXT – Babcock & Wilcox Technologies, Inc.
- CNL – Canadian Nuclear Laboratories
- EdF – Électricité de France
- MHI – Mitsubishi Heavy Industries
- MRPC – Motorized Rotating Pancake Coil
- NDE – Non-destructive Examination
- ODSCC – Outside Diameter Stress Corrosion Cracking

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During the meeting, industry made a presentation which addressed topics described in the meeting notice. At various points in the meeting, there were additional discussions about agenda topics. Information exchanged during these discussions and not included in the presentation materials is summarized below:

- The tests planned to investigate the onset of in-plane fluid elastic instability (FEI) will evaluate the effect of several variables including varying tube-to-tube support gaps, one or two supports, wet and dry supports, and varying numbers of flexible tubes.

- An expert panel was formed to provide recommendations regarding the FEI testing. The panel suggested some changes to the test setup and asked for additional instrumentation which required an upgrade of the data acquisition system. The expert panel also suggested performing a subset of tests and reviewing the data before continuing more tests. Representatives from the Electric Power Research Institute (EPRI) plan to look at the preliminary data onsite.

- Industry indicated that the main purpose of the tests is to first gain an understanding of the basic phenomenon of in-plane FEI. Industry also indicated that out-of-plane fluid elastic instability will also be observed during the tests.

- If the setup for the FEI tests is determined to not adequately represent operating steam generators (SGs) or the data cannot be scaled, then tests will be proposed that are more representative of actual tube bundles.

- The NRC staff inquired about similar FEI tests being performed internationally. Areva Germany has an elaborate facility for similar tests and agrees with the general setup for the tests planned in Canada. Industry indicated that EdF may be performing similar tests, but the objectives are likely to be different.

- The information letter on loose part wear was issued in December 2015.

- Industry indicated that although the “soft” chemical cleanings tables in the slides show results with fewer deposits removed than “hard” chemical cleanings, the “soft” chemical cleanings were not necessarily for the full bundle.

- *Generic Elements of U-Bend Tube Vibration Induced Fatigue Analysis for Westinghouse Model D5 SG* describes U-bend analyses used to determine the susceptibility of tubes in Model D5 SGs to U-bend failure. A similar report was issued in 2013 for Model F SGs.

- *Dispersants for PWR Secondary Side Fouling Control: 2014 Field Evaluations* was updated with field experience from online and offline dispersant use.

- *Eddy Current System Examination Technique Equivalency Process* incorporated an alternative process to streamline the process for site-specific qualification.

- *Steam Generator Tube-to-Tube Support Plate Burst Test Results* discusses eggcrates and broached tube supports providing little enhancement to strength and how in-situ pressure tests can be used to demonstrate integrity.

- *Steam Generator Degradation Specific Management Flaw Handbook, Revision 2* is used in condition monitoring operational assessments. Modifications to this document include the addition of latest experience and example calculations.

- *Triton SG Thermal-Hydraulics Code: Interim Report on Validation Using Experimental Test Results* documents plans for the validation and verification of Triton code.

- The slides show several potential causes for the volumetric indication in the 690TT tube. With regards to sizing, the two relevant potential causes are loose part wear and pitting, both of which are sized using the same technique.

- The industry was not aware how other degradation mechanisms (e.g., intergranular attack) were dismissed as potential mechanisms for the volumetric indication in the 690TT tube.

- In the case of the volumetric indication in the thermally treated Alloy 690 (690TT) tube, industry conveyed various reasons for ensured tube integrity. For example, industry indicated that the signal of the indication is very small (0.09 V) and thus "extraordinary" measures were not warranted given the size of the signal. The in-situ pressure test guidelines do not require in-situ pressure testing if the voltage amplitude of the signal is less than 0.4 V regardless of the damage mechanism. The industry also stated that there is no guidance on how to perform a root cause analysis if a mechanism is not known. The NRC staff stated that licensees typically need to know the mechanisms of indications to adequately assess tube integrity.

- The industry indicated that Korea Hydro & Nuclear Power presented information to them regarding previously observed primary-to-secondary leakage. Industry will consider the lessons learned from this event when they update the primary-to-secondary leakage guidelines.

- The NRC staff indicated it would provide feedback regarding the automated data analysis workshop that EPRI hosted on August 19-20, 2015. The feedback is included as an enclosure to this meeting summary.

Project No.: 689

Enclosure:
Attendance List

- *Steam Generator Tube-to-Tube Support Plate Burst Test Results* discusses eggcrates and broached tube supports providing little enhancement to strength and how in-situ pressure tests can be used to demonstrate integrity.

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ADAMS ACCESSION Nos.: Package: ML16047A346
Meeting Summary: ML16047A365
Meeting Notice: ML16020A057
Industry Slides: ML16047A358
NRC Slides: ML16047A345

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Attendance List
February 3, 2016, NRC Public Meeting with the
Steam Generator Task Force to Discuss Steam Generator Issues

Note: The list of phone participants may not be all-inclusive

SGTF/Industry Participants
Viki Armentrout, Dominion
Jesse Baron, Westinghouse
James Benson, EPRI
Jana Bergman, Curtiss-Wright
Cotasha Blackburn, Southern Nuclear
Steven Brown, Entergy
Kent Colgan, Areva
Helen Cothron, EPRI
Robin Dyle, EPRI
Steve Fluit, BWXT Canada
Daniel Folsom, TVA
Carl Lee Friant, Exelon
Greg Kammerdeiner, FirstEnergy
Edward Korkowski, NextEra
Rick Maurer, Westinghouse
Dan Mayes, Duke Energy
Scott Redner, Xcel Energy
Phil Rush, MPR Associates

NRC
Marissa Bailey
Alan Huynh
Andrew Johnson
Ken Karwoski
Gloria Kulesa
Greg Makar
Seung Min
Matt Rossi
Abhijit Sengupta

Phone Participants
Alexander Butcavage, NRC
Brent Capell, EPRI
Warren Leaverton, Palo Verde
Tom Watson, Westinghouse

ENCLOSURE 1

Feedback from NRC Staff Regarding
August 19-20, 2015 Automated Data Analysis Workshop

We appreciate the Electric Power Research Institute's (EPRI's) efforts in organizing and conducting the workshop on the auto-analysis of steam generator tube eddy current data. It was very useful for the U.S .Nuclear Regulatory Commission (NRC) staff. As evidenced by the number of questions addressed to the panel during the workshop, it is clear that there is a lot of interest with steam generator tube auto-analysis systems. The discussion with the panel and the various points of view from the participants, including utility personnel and the vendors was very informative.

As a result of the workshop, the NRC participants developed the following feedback for industry consideration:

The details of how the auto-analysis system analyzes the data will most likely not be readily available to an NRC inspector. As a result, the focus for an inspector may be evaluating the data that shows the system is functioning adequately. Re-evaluating past inspection data with the auto-analysis system and understanding and resolving any differences between past calls and the current review of past data seems critical. However, given that most plants no longer have active corrosion mechanisms, this re-evaluation may need to include eddy current signals from other steam generators to ensure the system is robust and can detect a new/emerging degradation mechanism. It may be useful to have guidelines for what should be required for using an auto-analysis system on site (in addition to the site specific performance demonstration). For example, 100% of the prior cycle data should be analyzed to demonstrate performance of an auto-analysis system.

Application of an auto-analysis system appears to require a lot of pre-inspection preparation by the plant owner and the eddy current contractor. This is an area where an NRC inspector may want to focus part of their inspection effort. Industry guidance on pre-inspection planning may be useful to ensure standard implementation of an auto-analysis system.

Historically, eddy current data has been evaluated by two independent teams. It is not clear that this type of approach is needed for a single pass auto-analysis system. Rather, an alternate adequacy verification process may be more appropriate. A major challenge appears to be the development of expectations and standards for an auto-analysis system to include the necessary level of independence, diversity, and redundancy. Throughout the workshop, it was not clear that these terms were used consistently. We encourage the industry to develop a set of guidelines to ensure reliable implementation of auto-analysis systems for the review of eddy current data. This may need to include the methods for measuring the performance of an auto-analysis system. It may also need to address whether the performance of just the analyst (human or auto-analysis system) is measured or whether the performance of the entire process including the resolution/disposition process is measured. In addition, standardization of auto-analysis terminology appears to be necessary (e.g., overcalls versus extra-calls).

It was stated that redundancy provided by the two-party independent analysis (manual and automated) is a defense-in-depth approach. The question was posed as to what elements (e.g., calibration, location, detection, classification, etc.) of a single-party auto-analysis system should be using independent algorithms. From an algorithmic standpoint, independence of two auto-analysis systems, either from different vendors or from the same vendor offered under a common platform (single pass/party auto-analysis), could be better determined through comparison of both the overall structure of the software (i.e., sequence and types of data manipulation stages) and the processing method applied by an individual algorithm. Independent development of two auto-analysis systems does not necessarily mean they produce independent results, as the two could use a series of common routines for processing of the data. For example, if two separate systems use a standard peak detection and threshold based algorithm, their signal detection method may not be considered as truly independent. Algorithms that are based on different signal processing techniques (e.g., spatial domain vs. frequency domain signal processing techniques) would be considered independent regardless of whether they produce similar results or not when applied to the same data set. Determination of independence of auto-analysis systems for steam generator tube inspection applications would be a challenging task as the guidelines for such assessments have not been developed.

We appreciate the industry's response to our comments from the 2011 auto-analysis workshop. We understand that some of the issues that were raised in those comments may be addressed in future revisions to the industry's steam generator examination guidelines.

History comparisons are already an integral part of the manual eddy current data analysis process. It would seem there is a benefit to include automatic history comparison in an auto-analysis system. It would permit identifying changing tube conditions (flaw and non-flaws). The NRC staff recognizes there are challenges associated with history comparisons especially for older plants, but operating experience indicates that history evaluations are very useful in identifying degradation mechanisms (e.g., Vogtle U-bend crack). History comparisons would also seem to be very useful in identifying new or unexpected/unknown degradation.

It was stated that good detection techniques outperform analysis techniques based on comparing current data to historical data. Historical comparison of data appear to be a viable technique that can help detect small changes in signals that may not be readily discernible through conventional analysis of data. As such, it should be viewed as a complementary method to, rather than replacement for, the existing detection techniques.

Human rejection of valid signals from auto-analysis systems due to humans having to review an abundance of signals appears to still be a challenge. It was stated that the majority of signals identified by an auto-analysis system are dismissed by resolution analysts, some of which have resulted in missing indications in the past. It should be noted that it is not always possible to make a direct comparison of a signal detected by an auto-analysis system with that detected through manual analysis. This is because of preconditioning of data performed by auto-analysis algorithms prior to detection, which may not be applied during manual analysis. Therefore, the possibility exists for a human analyst to dismiss a valid signal detected by an auto-analysis system, particularly in the presence of background interference/noise. Regardless of whether there is an abundance of signals identified by the auto-analysis system, it may be useful to provide the manual analyst with the signal (with all filters/data processing applied) for review when dispositioning auto analysis calls rather than just the general location of the flaw (unprocessed data). Some of these auto analysis systems may process the signals more comprehensively than a human analyst.

It was stated that the probability of not recognizing real degradation increases when reviewing a large number of false calls. This is based on field experience showing an increase in human performance error as a result of reviewing a large number of false calls. Although this may be true, adjusting the auto-analysis parameters to reduce the number of overcalls (false or extra calls) may not be a conservative approach particularly when dealing with noisy data.

It was stated that performance evaluation studies on auto-analysis systems indicated that single party systems did not perform better than two party auto-analysis. It is not clear how these comparisons were performed. For example, were they based on comparative evaluations using a common generic database (auto-analysis performance demonstration database) or based on independent evaluations at different sites using disparate historical or site specific performance demonstration databases?

It was stated that knowledge of algorithms developed and owned by a particular vendor is intellectual property and may not be shared. Comparison of general structure of different auto-analysis systems and the associated processing techniques for evaluating their independence does not necessarily require access to details of their embedded algorithms. In general, a flowchart listing the processing stages and a generic description of the signal processing or data analysis technique being used should be sufficient for high-level assessments. Furthermore, such evaluations may be conducted by an independent party without the need to share any information that may be considered proprietary.

There does not appear to be any significant difference between single party auto-analysis and what is currently allowed/practiced (i.e., a single vendor performing both primary and secondary auto-analysis). So, there does not appear to be any reason not to accept one auto-analysis system with redundant detection techniques as being equivalent to dual analysis. It would be helpful for the guidelines to define what constitutes a single party/pass auto-analysis system. For example, are the following scenarios equivalent: a) a single non-destructive examination service provider setting up and applying two auto-analysis systems developed by independent vendors but with similar setup parameters, b) a single non-destructive examination service provider setting up and applying two auto-analysis systems developed by the same vendor, c) independent software vendors setting up their auto-analysis systems for the same application, and d) the same non-destructive examination service provider setting up a single pass auto-analysis system composed of a different suite of algorithms under a single platform.

It is worth noting that redundancy may be obtained if two auto-analysis systems with common features are setup independently by different parties. This, however, would not eliminate common mode failures if the two systems use similar techniques or certain common algorithms. The extent of human intervention in setting up and comparing the results (reported calls) of the primary, secondary, or single pass auto-analysis system is further expected to influence the final results. Therefore, it would be useful if the guidelines establish a clear definition of a single party auto-analysis system. This could also help toward development of more inclusive guidance for implementation of auto-analysis systems in view of the differences among the auto-analysis systems.

It was stated that most critical failures, for manual and auto-analysis, are associated with the setup and locating of landmarks as certain support structures have low amplitude signals. Sharing of improper setups by the primary and secondary analyst (manual and auto-analysis) has resulted in missing indications in the past. While "Setup" was discussed only in reference to calibration of bobbin probe data, in general setup involves a number of processes and if any of the components of those process are improperly set, the probability of missing indications could increase. Also, new auto-analysis tools can simultaneously process data obtained with different probe types (bobbin, rotating probe, and array) that require different setup procedures. This further increases the importance of consistency in generating and applying the setup parameters. It would be useful to have guidance and recommendations in the steam generator examination guidelines to help reduce the number of potential common mode failures.

It was stated that the widely accepted assumption that manual analysis performs better than auto-analysis systems when unknown/unexpected signals are encountered is not valid. It would be helpful to know the basis for this assertion. In general, rule-based auto-analysis algorithms report only those signals that conform to a set of pre-defined characteristics. Broad detection and classification rules can improve the probability of detecting and reporting atypical signals at the cost of increasing the number of overcalls. Interpretation of signals by a human analyst on the other hand is not based only on a fixed set of rules and thus manual analysis is more likely to report an unknown or atypical signal. Inclusion of manual analysis as part of the process is thus expected to improve the chance of detecting unexpected signals of potential consequence to tube integrity.

It was stated that the guidance on criteria for detecting possible loose parts is rather subjective. It may be useful to review the guidance for detecting and classifying possible loose part signals.

It was stated that the independent qualified data analyst performs random sampling of tubes with no detectable degradation, which has resulted in detecting missed indications (e.g., low level wear at supports at Fort Calhoun). It was not clear whether the indications were missed by an auto-analysis system, by a human analyst, or both. If they were not detected by an auto-analysis system, presumably adjustments to the auto-analysis parameters would have resulted in their detection. If not already required by the examination guidelines, a random sampling of tubes with no detectable degradation by an independent qualified data analyst appears to be a good practice.