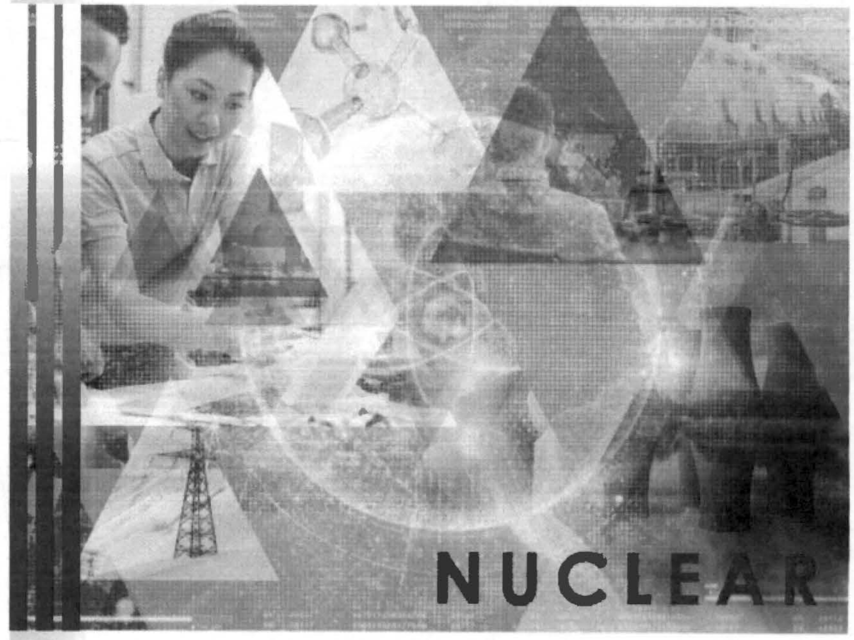
ELECTRIC POWER RESEARCH INSTITUTE

Technical Meeting Between Steam Generator Task Force and NRC Technical Staff

EPRI Public – Redacted Version

November 14, 2019



www.epri.com

Industry Response to NRC Comments on Automated Data Analysis

Jim Benson

Background

- NRC comments were provided to the SG Task Force following the 2011 and 2015 EPRI Steam Generator Automated Data Analysis Workshops
- Industry responses to the NRC comments have been developed
- The responses are primarily based on:
  - The experience gained by the industry in implementing automated data analysis systems
  - The following references:
    1. EPRI PWR Steam Generator Examination Guidelines: Revision 8 (3002007572), 2016
    2. EPRI technical report "Assessment of Processes for Implementation of Automated Data Analysis Systems" (3002007712), 2016
    3. EPRI Information Letter "Eddy Current Techniques and Scope for Foreign Objects and Foreign Object Wear" (SGMP-IL-16-01), 2016
    4. EPRI technical report "Approach for Assigning a Confidence Measure to SG Auto Data Analysis Results" (3002013009), 2018

Overview

- This presentation provides a high level overview of the NRC comments and the industry response to the comments
- A complete list of the NRC comments and detailed industry responses to each comment have been documented in a separate letter report that is planned to be provided to the NRC
- From NRC feedback on the 2011 EPRI SG Auto Data Analysis Workshop (ML110670317), 14 unique comments were identified, which are numbered 1 through 14 in the industry response.
- From NRC feedback on the 2015 EPRI SG Auto Data Analysis Workshop (ML16047A365), 15 unique comments were identified, which are numbered 15 through 29 in the industry response.

NRC Comment #1

Need a minimum false call rate for the SSPD test to ensure that the algorithm will continue to perform at the "required" probability of detection level when subjected to a much more robust sample of tubes in the field exam

Industry Response #1

- Results of the EPRI AAPDD tests on multiple auto data analysis systems do not show a consistent correlation between POD and false calls.
  - Some systems that have fewer false calls, achieve a higher POD than other systems with a higher number of false calls.
- Specifying a minimum false call rate may lead to unintended consequences (i.e., negative effect on the reliability of the reported calls).
- As the number of false calls increase, the likelihood of deleting a reportable indication during the manual review process also increases.
- Having some false calls is not detrimental, particularly if they are handled appropriately without increasing the workload of the data analysis crew resulting in a loss of focus.

NRC Comment #2

Auto analysis software packages developed by two different vendors may not be truly independent if EPRI provides algorithms to both vendors

Industry Response #2

- Many NDE vendors had developed automated data analysis software prior to the EPRI-developed automated data analysis algorithms being made available to NDE vendor organizations.
- Although the EPRI-developed algorithms were made available to all NDE vendors that requested the algorithms, it was left up to the vendors to decide which specific algorithms, if any, that they would incorporate into their commercial data analysis software.
- The expectation was that only the EPRI algorithms that provided an improvement to the vendor's existing software would be incorporated.
- Independence has been demonstrated by field experience with two-party data analysis that has shown differences in the reported results when both parties use different auto data analysis systems.

NRC Comment #3

Auto analysis software systems should be programmed to screen for all types of flaws despite the conclusions of a degradation assessment

NRC Comment #4a

Auto analysis should identify indications (e.g., MBMs, dents, dings, and permeability) that may negatively affect the quality of inspection to ensure proper probes are used. Algorithm capabilities should be demonstrated.

NRC Comment #4b

Auto analysis should identify potential loose part signals (with no associated wear). Algorithm capabilities should be demonstrated for identifying potential loose parts.

NRC Comment #5

Develop a standardized method for assessing the results of a single party analysis system (e.g., missed calls, false calls, and severity of missed/false calls) against the results of the traditional dual analysis process.

  EPRI ELECTRIC POWER RESEARCH INSTITUTE

NRC Comment #6

Requirements are needed for applying single party auto analysis to data from new inspection technology (e.g., new probe designs)

NRC Comment #7

Recommend requiring performing a comparison of the raw eddy current data from the current outage to the raw eddy current data from a prior outage (or baseline exam) as part of the data analysis process; especially when performing single party auto analysis.

NRC Comment #8

Need to include periodic calibration checks to ensure auto analysis algorithms continue to perform as desired throughout the inspection (e.g., Judas tube, process channel checker)

NRC Comment #9

Implement special qualification requirements for single party auto analysis system operators

NRC Comment #10

Need to require verification of missing landmarks and whether a group of tubes consistently has landmark locations at one end of the landmark band potentially indicating a support has shifted

NRC Comment #11

Need to require the data analysis software to correctly identify SG landmarks and to appropriately apply location based data analysis algorithms

NRC Comment #12

Industry guidance should consider if the performance requirements of a single party system should be more restrictive than the current requirements of a dual party system

NRC Comment #13

Auto analysis should report low level signals to detect the onset of new degradation near the detection threshold (e.g., long axial flaws in the freespan)

NRC Comment #14

Internal diagnostic tools should be incorporated into the software that monitors how flaws are being detected and for identifying when a corrective action (for ensuring adequate detection by the auto analysis algorithm) should be taken

NRC Comment #15

Given that most plants no longer have active corrosion mechanisms, data may not be available for an NRC inspector to verify that the auto system is functioning adequately, so 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) to ensure the system is robust and can detect a new/emerging degradation mechanism.

NRC Comment #16

Industry guidance on pre-inspection planning may be useful to ensure standard implementation of an auto-analysis system. This is an area where an NRC inspector may want to focus part of their inspection effort.

NRC Comment #17

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. 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. In addition, standardization of auto-analysis terminology appears to be necessary.

Industry Response #17

- Discussion on the following topics is included in the Reference 2 report: (1) duality of the analysis, (2) expectations and standards for an auto system to include the necessary level of independence, diversity and redundancy, (3) standardization and utilization of terms, (4) methods for measuring the performance of an auto system and of an entire process that includes the human review/resolution/disposition, (5) terminology for false calls.
- The content of the Reference 2 report was considered as the EPRI SG Exam Guidelines Revision 8 was being developed.

NRC Comment #18

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. 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.

NRC Comment #19

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). History comparisons would also seem to be very useful in identifying new or unexpected/unknown degradation. 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.

Industry Response #19

- Datasets for testing historical signal comparison software are expected to be available to SG NDE organizations by early 2020.
- The datasets will be assembled into an EPRI controlled performance database, similar to the EPRI AAPDD.
- The performance of historical signal comparison software is expected to demonstrate the extent to which the historical signal compare process can be a redundant and/or a diverse method in the single pass and/or single platform automated data analysis process.

NRC Comment #20

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 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).

Industry Response #20

- Comment provided above correctly identifies the fact that automated systems process the signals more comprehensively than a human analyst with multiple processes "happening behind the scene" (i.e. signals extracted from filtered data).
- The decision made by the automated system, whether to keep the indication and proceed to the reporting phase or to discard the indication, is made based on the logic applied to a particular raw and/or process channel that may or may not be filtered.
- These raw and process channels are typically available to the review/resolution analyst and can be used when reviewing the indication.
- The probability of deleting a legitimate degradation call that was reported by a process channel that cannot be displayed, and was not indicative of degradation on any of the channels available to the review/resolution analyst, is extremely low based on SG OE.

NRC Comment #21

It was stated that the probability of not recognizing real degradation increases when reviewing a large number of false calls. However, adjusting the auto-analysis parameters to reduce the number of overcalls may not be a conservative approach, particularly when dealing with noisy data.

NRC Comment #22

It was stated that performance evaluation studies on auto-analysis systems indicated that single party systems did not always* perform better than two party auto-analysis. It is not clear how these comparisons were performed.

***Correction by EPRI: Added "always"**

Industry Response #22

- The study was limited to data from one SG with Alloy 600MA tubing
- The two-party field analysis results were compared to post-outage single-party auto analysis results.
- Ground truth ("expert opinion") was determined by reanalysis of data where differences existed (i.e., flaw vs. non-flaw) between the two-party field analysis results and the single-party analysis results.
- For some types of degradation the performance of single-party auto analysis appeared to be superior and for other types of degradation the performance of two-party analysis appeared to be superior.
- Significant improvements with auto data analysis systems have been made since this study was performed in 2014.

NRC Comment #23

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 associated processing techniques for evaluating their independence should be able to* be conducted by an independent party without the need to share any information that may be considered proprietary.

*** Modified by EPRI based on assumed intent of the comment**

NRC Comment #24

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.

NRC Comment #25

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... it would be useful if the guidelines establish a clear definition of a single party auto-analysis system.

NRC Comment #26

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. 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.

NRC Comment #27

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. Interpretation of signals by a human analyst ... is not based only on a fixed set of rules and thus manual analysis is more likely to report an unknown or atypical signal.

Industry Response #27

- Both manual and automated analysis will report unknown and/or unexpected signals assuming that (1) manual analyst has adequate training, experience, knowledge and a questioning attitude, (2) automated system is configured appropriately applying a set of detection, classification and reporting techniques for unexpected degradation and reporting of any signal that exhibits behavior (magnitude, phase angle, location, shape, etc.) that seems abnormal is reported as unknown degradation.
- Other analysis processes, that can assist in identifying unknown/unexpected signals, include:
  - Automated noise monitoring tools which report noise signals that exceed threshold values
  - Historical data comparison techniques

NRC Comment #28

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.

Industry Response #28

- EPRI has conducted studies to assess the capabilities of eddy current probes for detecting foreign objects.
- Reference 3 provides a summary of the results of those studies.
- It is left up to the licensee to determine both the eddy current and visual inspection methods that they will implement in order to identify the presence of foreign objects.
- In order to assess loose part detection algorithms, loose part data has been added to the EPRI Automated Analysis Performance Demonstration Database (AAPDD).
- The addition of loose part data to the AAPDD, although not graded on a Pass/Fail basis, is intended to elevate loose part detection awareness and provide training, testing and feedback for multiple loose part materials, shapes, and sizes.

NRC Comment #29

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.

Industry Response #29

- Random sampling by an IQDA of tubes with no detectable degradation (NDD and NDF) is currently recommended by the examination guidelines.
- It is left to the licensee to identify the extent to which the random sampling is performed.

Planned EPRI Report on Auto Data Analysis

- An additional EPRI technical report is planned to be published in December 2019 which will provide additional information on automated data analysis
  - *Reference: Steam Generator Management Program: Considerations for Implementing Single Pass Automated Data Analysis for SG Eddy Current Inspections (3002015984)*
  - The report will provide technical information that can be reviewed by the SG Examination Guidelines Committee when they consider requirements for the multiple algorithm single integrated automated analysis process for alloys that have experienced service-induced cracking within steam generator tubing.

Summary

- Since the 2011 and 2015 EPRI SG Auto Data Analysis Workshops, EPRI has published documents which address the primary topics contained in comments that the NRC has provided to the SG Task Force.
- The industry's development and implementation of auto data analysis tools has improved the quality of the SG tube inspections.
- EPRI continues to work on improving the implementation of automated data analysis of SG eddy current data.
  - Technical Reports
  - SG Examination Guidance
  - AAPDD Updates
- The industry welcomes additional NRC feedback on automated data analysis.

References

1. EPRI PWR Steam Generator Examination Guidelines: Revision 8 (3002007572), 2016
2. EPRI technical report "Assessment of Processes for Implementation of Automated Data Analysis Systems" (3002007712), 2016
3. EPRI Information Letter "Eddy Current Techniques and Scope for Foreign Objects and Foreign Object Wear" (SGMP-IL-16-01), 2016
4. EPRI technical report "Approach for Assigning a Confidence Measure to SG Auto Data Analysis Results" (3002013009), 2018

NRC comments on the Integrity Assessment Guidelines

Lee Friant

Integrity Assessment Guidelines – Section 4.2.3, page 4-4

- *Do the ETSS's provide both the nominal regression and 95% lower confidence POD curves? The integrity guidelines appear to provide no guidance on how to consider POD uncertainty in the simplified and fully probabilistic OA models in Section 8. Suggest guidance be included.*

- **Response:**
  - Not all ETSSs provide 95th lower confidence POD curves
  - This is not a requirement
  - All evaluations are at 50% confidence

Integrity Assessment Guidelines – Section 4.3, page 4-7

- Appendix I, Supplement 1.3, in the EPRI examination guidelines cites a study of performance demonstrations that shows that analyst variability does not significantly change NDE system sizing uncertainty relative to Appendix H sizing uncertainty alone. Therefore, system sizing uncertainties can be established in accordance with Appendix H. However, *Section 4.3 of the integrity guidelines seems to suggest that the above "study of performance demonstrations" may have been limited to ODSCC performance demonstration sizing using voltage amplitude. If so, it is not clear that human factor effects on depth sizing error can necessarily be assumed to be small.* The guidelines should clarify this issue

Response

- With the performance demonstrations conducted to develop the first system PODs (Appendix I ETSSs), it was noted that if the analyst followed the procedure, there was little change in the sizing results
- The axial ODSCC grading units consist of plant data from Combustion Engineering, Westinghouse, and Babcock & Wilcox units and lab samples. Flaw locations include sludge-pile, freespan, and tube support structures

Integrity Assessment Guidelines – Section 5, page 5-2

Response

Integrity Assessment Guidelines – Section 6.6.1, page 6-13

- *The guideline states that the conservative upper bound growth rate distribution includes a "maximum temperature effect." Is this 611 degrees Fahrenheit, or something higher?*

Integrity Assessment Guidelines – Section 6.6.1, page 6-13

Integrity Assessment Guidelines – Section 6.6.1, page 6-13

Response

Integrity Assessment Guidelines – Section 6.6.3, pages 6-14 to 6-16

- Section 6.6.3 lacks some necessary details. *What are the objectives that the expanded inspection sample is intended to achieve?* Should the expanded inspection sample *bound regions of the tube bundle observed to be experiencing active degradation during the initial sample inspection*? *Are the initial and expanded inspection samples together intended to detect flaws that may be present and that may satisfy the applicable tube repair criteria*?
- **Response**:
  - We will add an objective section similar to the response above in the next revision

Integrity Assessment Guidelines – Section 8.1, page 8-1

Integrity Assessment Guidelines – Section 8.2.3, page 8-6

- Provides largely qualitative guidance on situations where the use of simplified single tube methods may lead to non-conservative results relative to full bundle analysis.
- *Section 8.2.4 only deals with simple cases where there is one NDE size variable (depth) instead of the more general case of two NDE variables (depth and length).*
- Sections 8.2.3 and 8.2.4 should be enhanced as necessary to *ensure that the user will employ the simplified methods only in situations where they are appropriate.*
- Guideline Section 8.2.3 is part of Section 8.0, "Operational Assessment." *Section 7, "Condition Monitoring," makes no mention of applicability limits pertaining to the simplified models.* A cross reference to Section 8.2.3 should be included in Section 7

Response

- Section 8.2.4 inherently assumes a limiting length since it would not be possible to establish a CM limit without considering flaw length
- CM is always a flaw by flaw assessment
  - Identifying the worst case flaw directly from the evaluation of the detected flaw data
  - Addressing OA evaluation methods in Section 7 is not appropriate. Section 7 discusses the various strategies for combining uncertainties for CM purposes.
  - Section 3.2 identifies the limits for both CM and OA.
- The choice of a CM limit evaluation method is a matter of practicality and convenience

Integrity Assessment Guidelines – Section 8.2.4, page 8-7,8

Response

Integrity Assessment Guidelines – Section 8.4, page 8-14

Response

Integrity Assessment Guidelines – Section 8.5, page 8-24

Response

Integrity Assessment Guidelines – Section 9.7 and 9.8

Response

NRC Comments on In Situ Pressure Test Guidelines

Steve Brown

In Situ Pressure Test Guidelines, Section 4.3, third bullet

- States that all flaws shall be screened for both leakage and flaw testing.
- *Is this requirement meant to apply to only Section 4 screening, or is it also meant to apply to the "proof and leak test limit curve" approaches (discussed in Section 4.1 and in Appendix A) which are basically the simplified, worst tube approaches discussed in the Integrity Assessment Guidelines?*

Response

- The requirement is that all degradation sites must be evaluated against the structural and leakage integrity performance criteria.
- When NDE sizing uncertainties are fully quantified, an evaluation following Appendix A can be used or the Integrity Assessment Guidelines can be used without using the In Situ Pressure Guidelines
- If the calculation proves that the severity of degradation does not meet the CM limit, the In Situ Pressure Test Guidelines is used to determine if in situ testing is required.

In Situ Pressure Test Guidelines, Section 4.5.3.1, Step B

- The guideline is assuming that even though flaw depth measurement is not quantifiable, flaw length measurements are quantifiable. *Limited signal-to-noise can adversely impact flaw depth measurements. Why is it reasonable to assume that low signal-to-noise cannot affect the measured flaw length?*
- **Response:**
  - Noise does not degrade the ability to detect deep flaws
  - NDE length sizing typically oversizes the portion of an axial flaw with significant depth. It is a good representation of the effective structural length of a flaw

In Situ Pressure Test Guidelines, Section 4.5.3.1, Step G

- The last sentence states that *if the failed indication has a higher ARF than the previous failure, then CM is met for structural integrity and no additional testing is necessary. Why is CM met for structural integrity if the tube failed at a pressure less than the SIPC?*
- **Response**
  - This appendix was created for plants with many hundreds of indications, which doesn't happen currently
  - Using this methodology, at least 15 in situ pressure tests will be performed
    - The need for additional tests is driven by an indication leaking

In Situ Pressure Test Guidelines, Section 6.1, third paragraph

Response

In Situ Pressure Test Guidelines, Section 8

- This section assumes some familiarity with the equipment and tooling elements comprising in-situ pressure test systems. *The demarcation between what is equipment versus what is tooling is not clear. Some introductory descriptions of these systems could be helpful.*
- **Response:**
  - The first version of these guidelines was written when vendors were developing this tooling a provided a way for consistent equipment qualification
  - Vendor equipment and tooling is proprietary

In Situ Pressure Test Guidelines, Section 9.4, page 9-6, third full paragraph

Response

In Situ Pressure Test Guidelines, Appendix B, Section B.3.2

Response

In Situ Pressure Test Guidelines, Appendix B, Section B.3.2

In Situ Pressure Test Guidelines, Appendix B, Section B.3.2

- *Justify basing VTHR-L on the 5 largest voltages for non-leaking indications above an indication that had a small leak rate?*
- **Response:**
  - Choosing 5 was considered conservative
  - This section is discussing the methodology for screening when there are several hundreds of indications that can't be sized accurately
  - At least 15 tests will be performed and expansion is required if a tube leaks

In Situ Pressure Test Guidelines, Appendix D, Section D.3.2

- *Clarify if this paragraph applies only to carbon steel drilled hole support plates or to support plates in general*
- **Response:**
  - "Exempt from testing" just means that you can't get a good test of structural or leakage integrity. Condition monitoring still needs to be demonstrated
  - This section only applies to carbon steel drilled hole support plates

In Situ Pressure Test Guidelines, Appendix D, Section D.4

- *This section states that flaws at the sleeve joints are exempt from in-situ leak testing. Are such flaws also exempt from proof test? If so, why?*
- Response:
  - We have a gap in guidance regarding in situ testing of sleeved tubes
  - Current plans are to address this in the next revision
  - We know of no indications that have been identified at the sleeve joint

NRC Comments on Examination Guidelines

Rich Guill

Steam Generator Examination Guidelines

Steam Generator Examination Guidelines

Steam Generator Examination Guidelines

- *What applications are reliant on Appendix H ETSSs. What work is ongoing in this area?*
- **Response:**
  - All other locations and probe technologies that are not mentioned on previous page rely on Appendix H ETSSs.
  - The majority of the Appendix H ETSSs don't have the recommended number of samples necessary for an Appendix I ETSS
  - SGMP is currently working toward adding samples to prioritized ETSSs
  - We have collected data on over one-hundred stress corrosion cracks
  - The samples are currently being destructively examined
  - These samples will be used to upgrade Appendix H to Appendix I ETSSs, by adding additional grading units
  - Work will begin in 2020

Steam Generator Examination Guidelines

- *For Appendix H ETSSs still in use, which ones feature POD distributions calculated by MAPOD?*
- ***Response:***
  - Appendix H ETSSs do not have MAPOD PODs
  - They do include a data set that can be used along with plant-specific noise and MAPOD to create a plant-specific POD

Steam Generator Examination Guidelines

Steam Generator Examination Guidelines

Together...Shaping the Future of Electricity