NRC / SGMP Steam Generator Task Force Meeting

January 23, 2018

Agenda

9:00 am ***Introductions & Opening Remarks (NRC and Industry)***

SGMP Steam Generator Task Force Update (Industry)

- Status of In-Plane Fluid Elastic Instability Testing
- Guidelines for Setup and Adjustments of Automated Analysis Systems
- Foreign Material Exclusion / Detection and Trending of Foreign Objects
- Summary of Recently Issued SGMP Technical Reports
- Status of Industry Guidelines
- Interim Guidance
- NEI 03-08 Deviations
- Recent Operating Experience

10:35 NRC items of discussion

10:45 Public comments/questions

Status of In Plane Fluid Elastic Instability Testing

Helen Cothron, EPRI

Two-Phase Freon Tests Planned for 2018

- Preparation work for the test rig is complete
- Commissioning tests are planned to begin in February
- Industry visits are planned to Canadian Nuclear Laboratories early 2018
- The following conferences will be held in 2018 and have sessions on flow induced vibration
  - Week of February 5th in Las Vegas – ASME Code Week
  - Week of July 8th in Toronto – International Symposium of Fluid-Structure Interactions, Flow-Sound Interactions, Flow-Induced Vibration & Noise
  - Week of July 15th in Prague, Czech Republic – PVP Conference

Guidelines for Setup and Adjustments of Automated Analysis Systems

Dan Folsom, TVA

SG Auto Analysis Process

- NRC Requested Topics:
  - Automated analysis process standards
  - Qualification of thresholds
  - Adaptation for site specific use
  - QA process
  - Balance of automated screening between detection and overcalls

SG Auto Analysis Process

1. Automated analysis process standards

- Follow guidance in EPRI SG Examination Guideline Rev. 8 (2016)
  - EPRI recommendations from Rev. 8 Appendix L
    - Generic Qualification through the EPRI Automated Analysis Performance Demonstration Database (AAPDD)
    - Site Specific Performance Demonstration (SSPD)
  - Use of vendor internal procedures for document control
  - Performance Monitoring by a review/resolution process

2. Qualification of thresholds

- Software generically qualified per AAPDD 80% probability of detection and 90% confidence level
- Site data augmented with potential or unexpected degradation
- Augmented data includes a wide range of flaw phase and voltage variations

SG Auto Analysis Process

3. Adaptation for site specific use

- Using plant or like plant specific data/indications
- Augmented data includes an expected range of flaw phase and voltage variations
- Utilize vendor available tools, such as review of noise exceeders, Historic Data Compare, signal injection, multiple detection algorithms, etc.
- Validate configuration parameters with historical data and/or augmented datasets
- Develop SSPD for each system/technique
- Document changes to AAPDD configurations
- Use flaw datasets to verify full coverage of tube

SG Auto Analysis Process

4. QA process

- Vendors procedures ensure the QA process
- Sorts/Configuration(s) are peer checked against AAPDD parameters
- Qualified Data Analyst and Utility review of the final configuration
- Performance Monitoring by a review/resolution process
  - Overcalls
  - Landmarking error
  - Analysis calibration errors
  - Missed or misclassification
  - Incorrect reporting

SG Auto Analysis Process

5. Balance of automated screening between detection and overcalls

- System operation performance is established during the configuration validation process on previous outage inspection data and augmented with additional data when necessary
- When required, the validation process determines the systems ability to detect and report unexpected or unknown signals
- The licensee's system operation performance monitoring process (per Appendix L of Rev 8) is used during auto analysis implementation

Foreign Material Exclusion / Detection and Trending of Foreign Objects

Greg Kammerdeiner

Industry Products Regarding Foreign Material Management

EPRI Nuclear Maintenance Application Center

EPRI Steam Generator Management Program

INPO

Plant training and procedures

INPO's Role

- INPO published Guidelines for Achieving Excellence in Foreign Material Exclusion (FME), INPO 07-008
  - Revised February 2011
  - New revision may be planned at upcoming January meeting
  - This document is intended to help utilities develop and implement excellent foreign material exclusion programs
  - This revision incorporates best industry practices, provides guidance for unrecovered foreign material, new plant construction controls, and supply chain requirements

INPO 07-008 Describes FME as a Site Culture

- Plant Manager reinforces the culture that is intolerant of poor foreign material practices
- Maintenance Manager is the owner of the foreign material exclusion program
- All Department Managers conduct work site observations to verify adherence to FME standards
- Supply Chain Personnel ensure that vendors are cognizant of the site FME expectations
- FME Coordinator is the single point of contact onsite for the FME program
- Work Group Supervisor ensures FME controls required for the job are understood
- The Worker maintains a thorough understanding of the program requirements and ensures they are applied during work

INPO 07-008 Describes FME as a Site Culture

- FME Monitor assertively ensures that proper FME behaviors are exhibited in high-risk areas
- Training Department designs, develops, and delivers initial and continuing FME training

FME Program Oversight

- Off-Site Vendors are required to adhere to the same level of standards expected at the station and equipment received is inspected to identify any shortfalls
- Periodic self-assessments are performed to determine the health of the FME program
- Corrective action program trends provide valuable information about the ongoing state of the FME program
  - Performance indicators are suggested to help trending
    - FME significant event
    - FME threat
    - Minor or administrative issue
- Management observations are trended to identify subtle problems

FME Program Requirements

- Training – A section of INPO 07-008 describes specific training to support an effective FME program
- Work Preparation – Identifies the systems or components that could be exposed to foreign material and records cleanliness requirements and closeout requirements
- Prior to Work Implementation set up FME zones based on the probability of FM intrusion, difficulty of FM detection and recovery, and consequence of intrusion
- Include operating experience in work instructions

Detailed Guidance in INPO 07-008

- Work Practices
- Work Instructions
- Supply Chain Requirements
- Preventing Debris-Induced Fuel Failure (also mentions steam generators)
- Guidance for Addressing Unrecovered Foreign Material including tracking and trending
- FME Controls for New Plant Construction
- Training

EPRI Nuclear Maintenance Applications Center – Several Documents Addressing Foreign Material Exclusion

- FME Site Coordinator Training Student Handbook, December 2010, 1021238
- FME Changing Site Behavior DVD, June 2010, 1021397
- Maintenance Work Package Planning Guidance, February 2016, 3002007020
- Foreign Material Exclusion Practices in the Field: What Good Looks Like, October 2014, 3002003061
- Foreign Material Exclusion Process and Methods: November 2014, 3002003060

SG Design Improvements to Address Foreign Material Exclusion

- 28 US units have steam generators with internal foreign material exclusion systems that were installed during the SG fabrication.
  - Only six have reported foreign object wear.
- To address the feasibility of retrofits to SGs without FME exclusion systems, EPRI prepared SGMP Report, PWR Steam Generator Foreign Object Exclusion Systems, 1014722, March 2007.
  - Major steam generator vendors offer three different types of foreign object exclusion systems
  - The results show that the payback period for these systems is strongly dependent on the risk of foreign object tube damage and the risk is not the same for all PWRs

Inspection for Foreign Objects

- There are no generically qualified eddy current techniques for detection of foreign objects, although eddy current can detect foreign objects
  - Factors effecting eddy current detection of foreign objects include:
    - Size of the object
    - Distance of the object from the tube
    - Proximity of the object to SG structures
    - Foreign material electrical properties (i.e., conductivity)
- SGMP Information Letter Eddy SGMP-IL-16-01 issued January 2016 describes current techniques and scope for foreign objects and foreign object wear
- SGMP Technical Reports 1020631and 1018561 provide eddy current data analysis guidance and data sets for detection of foreign objects.

Inspection for Foreign Objects

- Steam Generator Integrity Assessment Guidelines (3002007571), June 2016, provides guidance for inspecting for foreign objects
- SGMP maintains a Foreign Object Handbook (3002007858), July 2016, that provides operating experience and best practices

Guidance in the Integrity Assessment Guidelines

- Visual inspections are an important part of maintaining pressure boundary integrity
  - Limitations of eddy current are discussed along with references to research performed by EPRI
- For recirculating steam generators, visual inspections should be performed each time sludge lancing is performed or when parts are identified in the feedwater system and there is reason to expect the occurrence of parts in the steam generators
- Guidance is provided for determining the appropriate interval between inspections
- Guidance is provided for determining the inspection scope for foreign objects
- Coordination between eddy current inspections and visual inspections is recommended

Summary

- EPRI, INPO, and utilities work together to eliminate foreign object events
  - Not all foreign objects originate from poor worker practices
- Guidance is available to develop a comprehensive FME program
- Foreign object trapping devices in some replacement steam generators have been effective
- SGMP provides some guidance for excluding foreign material but primary focus is on inspection, assessment, and retrieval

Summary of Recently Issued SGMP Technical Reports

Helen Cothron, EPRI

Evaluation of Detector Response Time for Primary-to-Secondary Leakage – 3002010394 – December 2017

- The *Primary-to-Secondary Leak Guidelines* provide guidance for a defense-in-depth leak monitoring program that reduces the risk of steam generator tube rupture by prescribing a series of action levels triggered by measured leakage values
- In practice, a delay exists between the time a leak reaches a specified value and when the plant becomes aware of that condition.
- This delay time was not explicitly accounted for in the guidelines
- The project described in this report was undertaken to quantitatively evaluate this delay time for common primary-to-secondary leakage continuous radiation monitor configurations
- The findings of this project will be reviewed by the committee that is revising the guideline document

Effect of Organic Acids on Steam Turbine Materials: Pitting Susceptibility Testing – 3002010693 – December 2017

- This project used an electrochemical corrosion test technique to determine the susceptibility to pitting corrosion of several materials commonly used in steam turbine construction
- Tests were performed in four different environments and at three different temperatures
- The main conclusion of this study was that there is no evidence that acetate and formate increase the susceptibility of turbine materials of construction to pitting corrosion
- This work supports the use of secondary side additives such as film forming amines

Steam Generator Foreign Object Wear Estimation Model – 3002010358 – December 2017

- The research conducted in this project investigates whether a software tool can be developed to accurately estimate the time for a known foreign object to cause steam generator tube wear of a specific depth
- An extensive database of common steam generator foreign objects has been developed, along with the associated drag and lift forces that would be imparted on the foreign objects
- If this software tool is developed, it would be an additional resource for the steam generator engineer to use when planning retrieval of foreign objects identified in the tube bundle

Steam Generator Eddy Current Simulation Model – 3002011673 – October 2017

- A computational finite element model for simulating eddy current signal responses from steam generator tube inspections
  - The software can generate simulated eddy current signatures representing degradation of various dimensions (i.e., length, width, depth).
- A user-friendly interface allows the user to input desired test parameters (e.g., flaw dimensions, tube dimensions, tube material, probe type, test frequencies, etc.) and then run the model to produce the corresponding eddy current signals
- The eddy current signals, representing common SG probe types (i.e., bobbin, rotating and array coils), can be generated in a format that is compatible with NDE vendor data analysis software
- The simulated signals that are generated can be used to assist in: signal interpretation, determination of probe performance, development of new probe designs and for training and testing of data analysts and data analysis systems

PWR Secondary Water Chemistry Guidelines – 3002010645 – September 2017

- State-of-the-art water chemistry programs reduce equipment corrosion and enhance steam generator reliability.
- A committee of industry experts prepared these revised *PWR Secondary Water Chemistry Guidelines* to incorporate the latest field and laboratory data on secondary system corrosion and performance issues
- This document contains Mandatory, Needed, and Best Practice elements per Nuclear Energy Institute (NEI) 97-06 and NEI 03-08

Model Assisted Probability of Detection Using R Software Version 2.1 – 3002010334 – September 2017

- Developed to calculate a site-specific SG eddy current probability of detection using generically qualified datasets.
  - AHat data input contains the voltage and depths of flawed samples from the datasets
  - Eddy current noise voltage values are input that represent the plant's tubing condition
  - The publically available R statistical package is then used to create probability of detection information
- Minor changes were incorporated in this revision:
  - The ability to choose the optimal fit for the dataset being evaluated instead of the current default log linear fit
  - The ability to specify analyst reporting threshold for wear mechanisms instead of the default value for cracking mechanisms
  - The ability to choose where output files are stored

Status of Industry Guidelines, Interim Guidance, NEI 03-08 Deviations

Helen Cothron, EPRI

SGMP Industry Document Status and Revision Schedule

Guideline Title	Current Rev #	Report #	Last Pub Date	Imple-mentation Date(s)	Interim Guidance	Review Date	Comment
SG Integrity Assessment Guidelines	4	3002007571	June 2016	8/31/17	None	2020	
EPRI SG In Situ Pressure Test Guidelines	5	3002007856	Nov 2016	8/31/17	None	2020	
PWR SG Examination Guidelines	8	3002007572	June 2016	8/31/17	None	2020	
PWR SG Primary-to-Secondary Leakage Guidelines	4	1022832	Sept 2011	4/11/2012 7/11/2012	None	2015	Rev 5 in progress – Target 2019 for publication

SGMP Industry Document Status and Revision Schedule

Guideline Title	Current Rev #	Report #	Last Pub Date	Imple-mentation Date(s)	Interim Guidance	Review Date	Comments
PWR Primary Water Chemistry Guidelines	7	3002000505	April 2014	1/28/2015	None	2019	
PWR Secondary Water Chemistry Guidelines	8	3002010645	Sept 2017	6/27/2018	None	2021	
Steam Generator Management Program Admin Procedures	4	3002005168	March 2015	12/9/2015	None	N/A	Common Admin Procedure Supersedes

Interim Guidance and NEI 03-08 Deviations

- No interim guidance has been issued since the last meeting
- No active NEI 03-08 deviations

Significant Operating Experience

Greg Kammerdeiner/Jeff Fleck

Foreign Material Major OE

- Steam generator with Alloy 600TT tubes experienced a very low level tube leak (less than 9 gallons per day)
- Identified the leaking tube by a secondary side hydro test and eddy current inspection identified the tube wear
- Best effort secondary side visual inspection identified appearance of tube wear (Foreign Object wear)
- Foreign material wasn't present during inspection
- Tube was taken out of service by plugging
- In situ pressure test verified performance criteria were met

Framatome (formerly AREVA) Welded Plug Qualification Issue

- Contingency plan for utility included potential removal and replacement of Alloy 600 shop welded plugs with a taper-welded plug (TWP) design (manually installed)
- Framatome reviewed qualification documentation in support of new plug installation and determined that the current analysis methodology that would be utilized to determine tubesheet bore dilations is more conservative and appropriate than the method previously used (c. 1996)
- Dilations (as a result of transients) impact the fatigue life of the weld, originally defined as 40 yrs

Framatome (formerly AREVA) Welded Plug Qualification Issue

- Re-analysis of previously installed TWPs performed with realistic/actual heat up and cool down cycle counts shows an acceptable fatigue life up through the next few operating cycles
  - Requires entering the plugs in the fatigue monitoring program
  - Additional analysis to be performed to maximize life of the installed plugs remaining in the industry (2 plants)
- Framatome has determined there is no Part 21 issue (no substantial safety hazard)
- Given current information, this is a unique situation and no generic implications
  - SGMP is expecting more detailed explanation of the issue in formal communication from Framatome
  - SGMP communicate with other vendors
  - To date the other vendors have identified no issues with their welded plugs

NRC and Public Comments

Acronyms

Acronyms

AAPDD	Automated Analysis Performance Demonstration Database
ASME	American Society of Mechanical Engineers
EPRI	Electric Power Research Institute
FM	Foreign Material
FME	Foreign Material Exclusion
MHI	Mitsubishi Heavy Industries
INPO	Institute of Nuclear Power Operations
NDE	Nondestructive Examination
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
OE	Operating Experience
PVP	Pressure Vessels & Piping
PWR	Pressurized Water Reactor
SG	Steam Generator
SGDD	Steam Generator Degradation Database
SGMP	Steam Generator Management Program
SSPD	Site Specific Performance Demonstration
TT	Thermally Treated
US	United States

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