NRC / EPRI Steam Generator Task Force Meeting
February 12, 2015

Agenda

8:30 am ***Introductions*** ***NRC and Industry***

Opening Remarks ***NRC and Industry***

EPRI SGMP Steam Generator Task Force Update ***(Industry)***

- Open Technical Issues
  - Noise Monitoring
- General Discussion Items
  - San Onofre Lessons Learned
  - Tubesheet Joint Design
  - Steam Generator Requirements in ASME Code
  - Auto Analysis Workshop
  - Thermal Heat Treatment of Tubing
  - Action Levels for Leakage
  - Status of Adopting TSTF-510

Agenda

- General Discussion Items (continued)
  - Consistent Measuring of Flaw Amplitude
  - Basis for Section D3.1 of In Situ Pressure Test Guidelines
  - Anti-vibration Bar Position Verification

10:00 am ***Break***

10:20 *am* ***Standing Discussion Topics*** ***(Industry)***

- Summary of Recently Issued SGMP Technical Reports
- Status of Industry Guidelines
- Interim Guidance
- NEI 03-08 Deviations
- Recent Steam Generator Operating Experience
  - Feedwater Support – Generic Implications

11:20 am **NRC Discussion / Items of Interest** **(NRC)**

- Issues Discussed in Past (Monitoring)
- Tube-to-Tubesheet Weld and Divider Plate Cracking Report

11:45 am ***Address Public Questions/Comments*** ***(NRC)***

12:00 pm ***Adjourn***

Open Technical Issues - SGTF

- Noise Monitoring
  - Recommendations have been provided to the Examination Guidelines Revision 8 Committee and the Integrity Assessment Revision 4 Committee
    - New appendix has been drafted for the Examination Guidelines for noise monitoring
    - Final drafts for industry review scheduled mid 2015

General Discussion Items

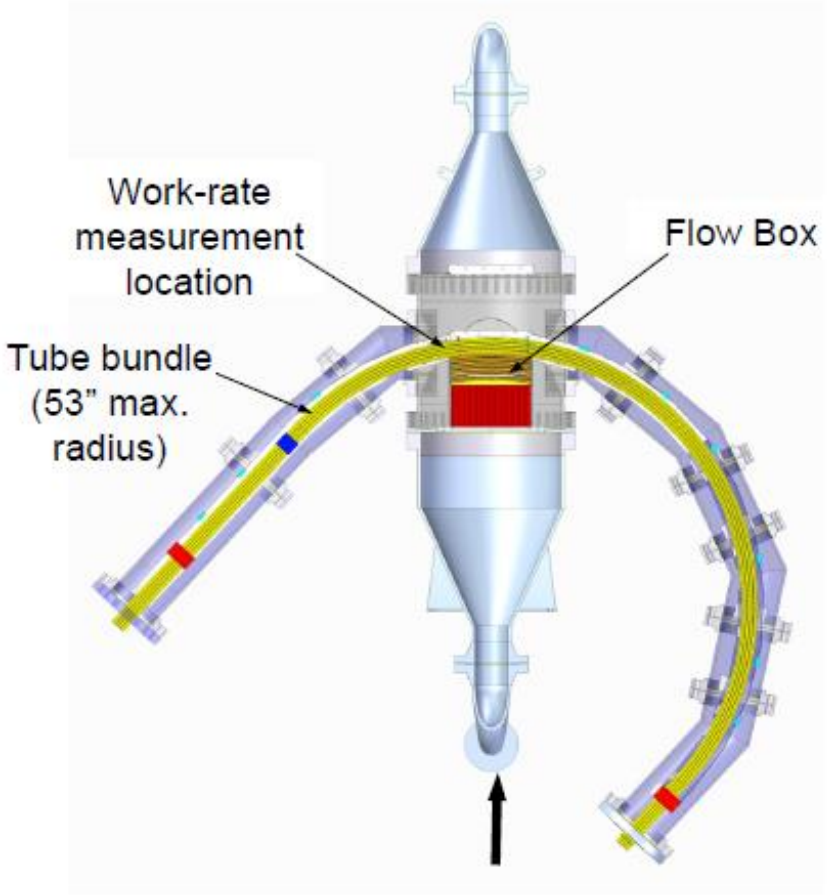
San Onofre Lessons Learned

Investigation into the Onset of In Plane Fluid Elastic Instability

- SGMP funding has been approved for 2015 – 2017 to investigate the onset of in plane fluid elastic instability
- A series of tests have been proposed by Canadian Nuclear Labs
  - Air Flow tests
    - Develop a basic understanding of in plane vibration
  - Two-Phase Freon Tests
    - Use three support configurations and the most relevant two-phase flow conditions, demonstrate in-plane fluid elastic instability

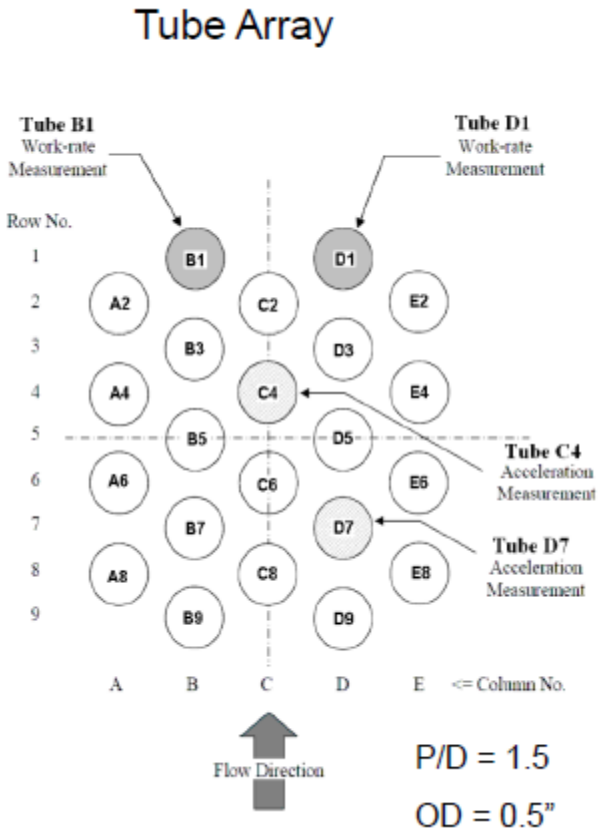
Phase 1 Test Setup - 2015

- Meeting among industry experts to determine tube bundle and/or support configuration(s) and flow conditions
- Complete test section assembly and calibration



Phase 2 Air Flow Tests – 2015-2016

- Observe in plane vibration and fluid elastic instability behavior in air flow to make preparations for testing in two-phase Freon flow
- Examine a variety of support configurations
- Tests will be representative of very high void fractions where the supports could be made wet or dry
- Approximately 24 configurations could be tested
  - Different number of U-bend support locations
  - Different tube-support designs
  - Wet and dry supports
  - Centered and preloaded supports
- A specific test matrix will be developed after the first industry expert meeting



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Phase 3 Two-Phase Freon Tests – 2016-2017

- Convert the test rig for use with Freon
- Develop test plans and procedures
- Test at least three support configurations in a two-phase flow condition most relevant to the industry
- Measure tube damping with flow
- Measure vibration at 0 to 98% void fraction up to and slightly beyond critical flows

Application of Test Results

- Prediction of the final solution is difficult (new Connor's constant, more effective supports, etc.)
- Goal is to understand what leads to the onset of in-plane fluid elastic instability
  - Utilities may be able to use results to avoid operating in these regimes
  - SG designers may be able to understand their margins in operating SGs and avoid it with new designs
- This is a learning effort that will be adjusted or stopped as each phase is completed, depending on the results
- Triton's FIV code can be updated to include information from the results of this research

Tubesheet Joint Design

Tubesheet Joint Design

- The NRC learned that the tube-to-tubesheet joint at one plant with replacement steam generators (alloy 690 tubing) was designed as the pressure boundary instead of the tube-to-tubesheet weld.
- NRC requested the SGMP to determine if other steam generators have this design
- Based on an SGMP survey provided to the NRC in December 2014, there are 5 other domestic units identified designed and fabricated by the same vendor
  - The tube-to-tubesheet welds were designed to meet ASME Section III requirements

ASME Code Section III Requirements for Tube-to-Tubesheet Welds Credited as Pressure Boundary

- In addition, for those plants that consider the tube-to-tubesheet weld as the pressure boundary, a difference exists in the practices of the vendors regarding whether or not the welds are analyzed in accordance with NB-3000
  - If the tube-to-tubesheet weld satisfies the requirements currently specified in NB-4350, all the ASME design requirements for tube-to-tubesheet welds in a Class 1 component have been satisfied
- An inquiry was sent to Section III Code Committee for the January 28th inquiry meeting
  - Chair of the Interpretations committee will circulate the question to the entire BPV III standards committee on a letter ballot
  - Some committee members stated that it was never intended to require full stress analysis of a tube to tubesheet weld and that NB-4350 was intended as a design rule
  - A working group has been given the responsibility to resolve the issue
  - The results of the inquiry may be a Code revision

SG Requirements in ASME Section XI

Steam Generator Requirements in ASME Code

- NRC Observations from recent meetings
  - Section XI has rules that go beyond what is covered by the plant Technical Specifications
  - If ASME deletes all the SG requirements from the ASME Code, the NRC will assess whether 10 CFR 50.55a should be modified to incorporate similar requirements
  - NRC preference is to use consensus codes and standards; however, if there are no consensus codes and standards, the NRC may develop its own requirements
- NRC encouraged the SG industry to evaluate the situation, engage the ASME Code, and discuss in a future meeting

Steam Generator Requirements in ASME Code

- ASME Code action to delete steam generator requirements from Section XI did not pass
  - 4 negative votes out of 43
- Working on putting the preservice requirements in Section III
- Changes to personnel qualification Section XI, IWA-2300 passed Working Group Personnel Qualification, Surface, Visual, Eddy Current and Subgroup NDE at the January Code meeting
- All other requirements should be deleted
- The next opportunity to make change is the 2017 Code

Auto Analysis Workshop

Steam Generator Auto Data Analysis Workshop

- At the August 2014 NRC meeting with the SGTF, the NRC requested that the industry hold a workshop on SG automated data analysis
- The purpose of the meeting would be to :
  - Discuss industry's response to previous NRC feedback on auto data analysis
  - Discuss Industry guidance
  - Provide info on current auto data analysis systems
  - Discuss auto analysis operating experience
  - Provide an opportunity to ask questions of industry auto data analysis experts
- The previous EPRI Auto Analysis Workshop was in Feb 2011
  - The 54 registrants included: NRC (12), Utilities (14), NDE Vendors (20), Researchers (2) and EPRI (6)

Steam Generator Auto Data Analysis Workshop

- 2015 Auto Data Analysis Workshop Location:
  - EPRI Charlotte
- Schedule:
  - Follows Aug 19 (AM) NRC meeting with SGTF
  - Workshop Day 1 - Aug 19: 1:00 PM – 5:30 PM
  - Workshop Day 2 - Aug 20: 8:00 AM – 4:30 PM
  - Planned Participants
    - Utilities
    - SG NDE Vendors
    - NRC
    - Research organizations

Steam Generator Auto Data Analysis Workshop

- Proposed 2015 Auto Data Analysis Workshop Format
  - Session 1 - Industry Perspective
  - Session 2 - Technology
  - Session 3 - Operating Experience
  - Session 4 - Panel Discussion
  - Session 5 - Technology Demonstrations

Thermal Heat Treatment of Tubing

Thermal Heat Treatment of Tubing Material

- NRC Question
  - Guidelines have a temperature range specified with uncertainty bands (716 degrees C, -0, +22)
  - Does this range consider measurement uncertainty?
  - Should guidelines be revised to be clearer?
- Measurement uncertainty is not explicitly addressed within the specification requirements or their technical basis in SGMP Technical Report 3002003124
  - Section 3.3.6.2 describes the technical basis for the thermal treatment temperature

Thermal Heat Treatment of Tubing Material

- Thermal treatment requirements were developed for Alloy 600 to:
  - Enhance carbide decoration of grain boundaries for SCC resistance
  - Allow Cr to diffuse back to grain boundaries (reduces possible “sensitization” associated with Cr-depletion at grain boundaries)
  - Reduce residual stress from straightening and surface grinding.
- None of these objectives are strongly influenced by temperature variations in the range of 716°C to 738°C.
- Thermocouple instrument error is insignificant relative to temperatures for carbide precipitation and stress relief.
- In the 1999 revision of the specification, the thermal treatment time was increased to add additional conservatism

Thermal Heat Treatment of Tubing Material

- Most significant source of uncertainty is the temperature variation within the furnace:
  - Tubing is produced in accordance with ASME III NB-2000, which requires calibrated and temperature-surveyed furnaces
  - Hottest and coldest temperatures in the furnace are recorded to ensure compliance.
- Specification ensures that thermal treatment objectives are met through metallurgical analysis and stress measurements.
- Specification guidance is sufficient and does not require revision

Action Levels for Leakage

Primary-to-Secondary Leakage Limits

- NRC Question
  - Action Levels are based on 150 gallon per day limit
  - Is there any guidance to utilities if leakage limit in Technical Specification is less than 150 gallons per day?
- Guidelines require station procedures to contain limits and actions as required by Technical Specifications
  - Guidelines note that, in most facilities, the alarm set points are determined by the plant Technical Specifications (actions to adjust set point ensure that the new set point is within Tech Spec limits)

Status of Adopting TSTF-510

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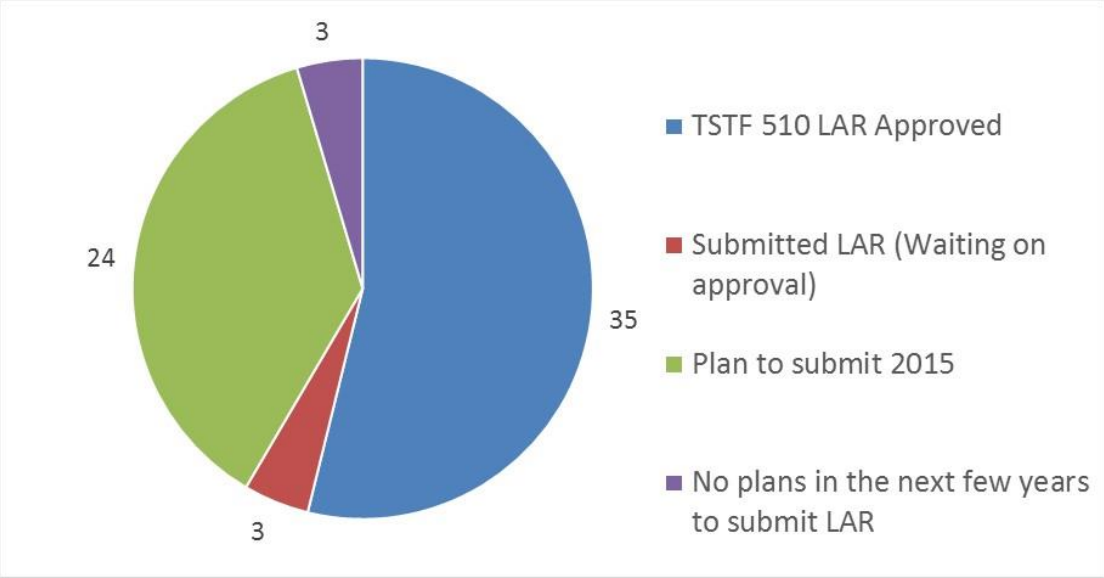
- Majority of the US Utilities will have TSTF-510 submittals to the staff by the end of 2015
- Three units (3 plants) economic evaluation does not support submittals at this time

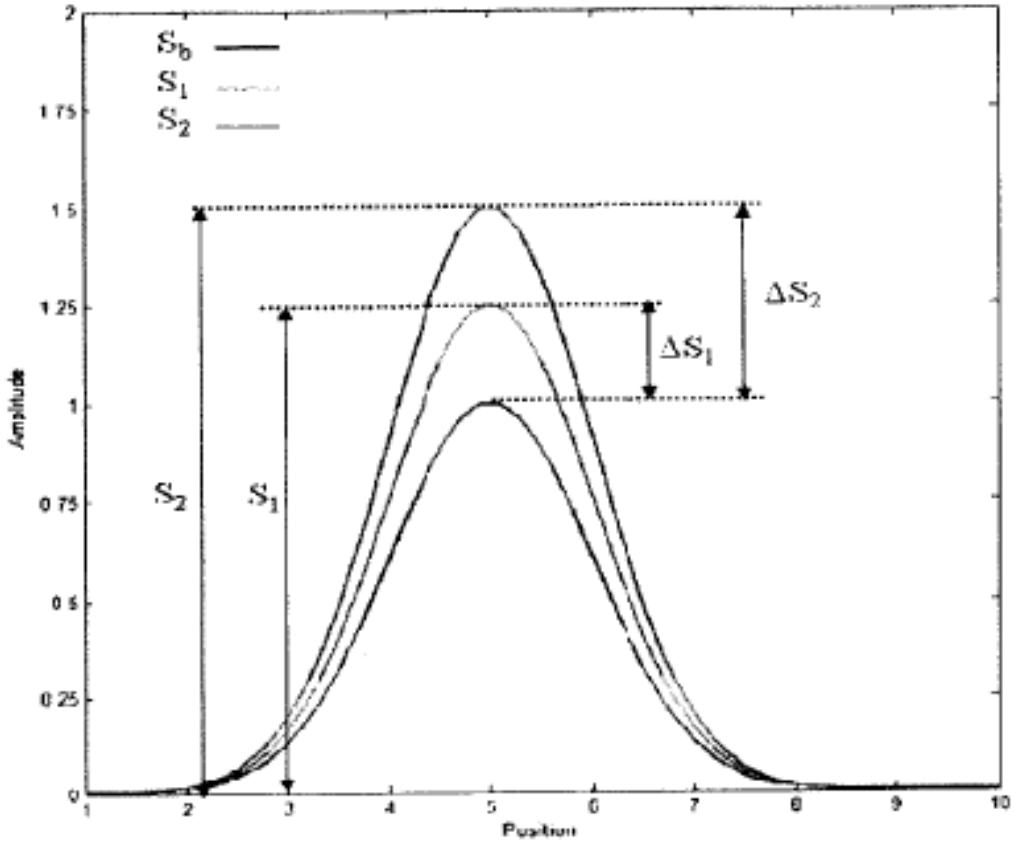


Consistent Measuring of Flaw Amplitude

Feb 2013 SGTF Meeting with NRC

- The NRC staff inquired about the industry guidance on evaluating signal amplitude, and phase during eddy current testing when substantial noise is present.
- The NRC also asked if there was industry guidance to ensure a method for consistently quantifying flaw signal amplitude changes and phase changes in the presence of tube noise.

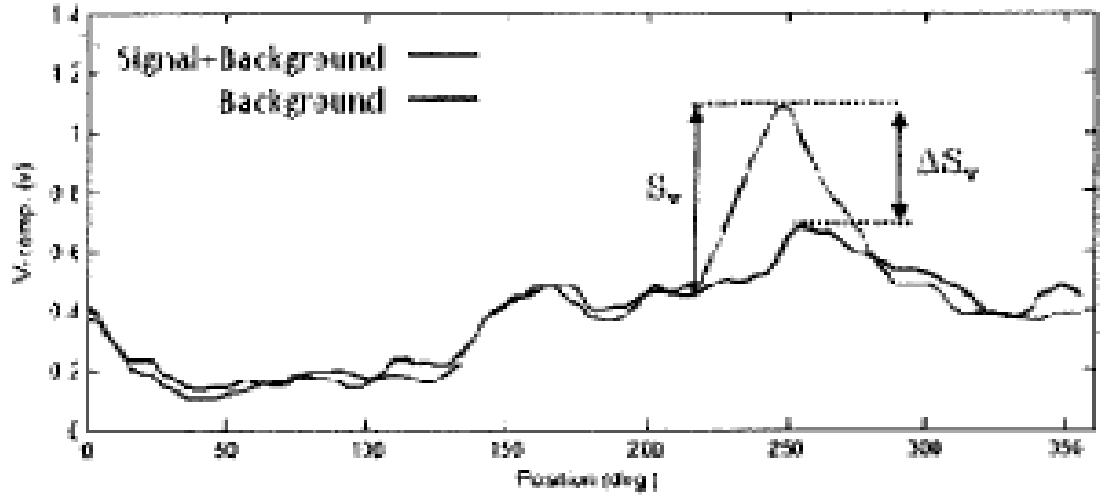
Example of Amplitude Comparison

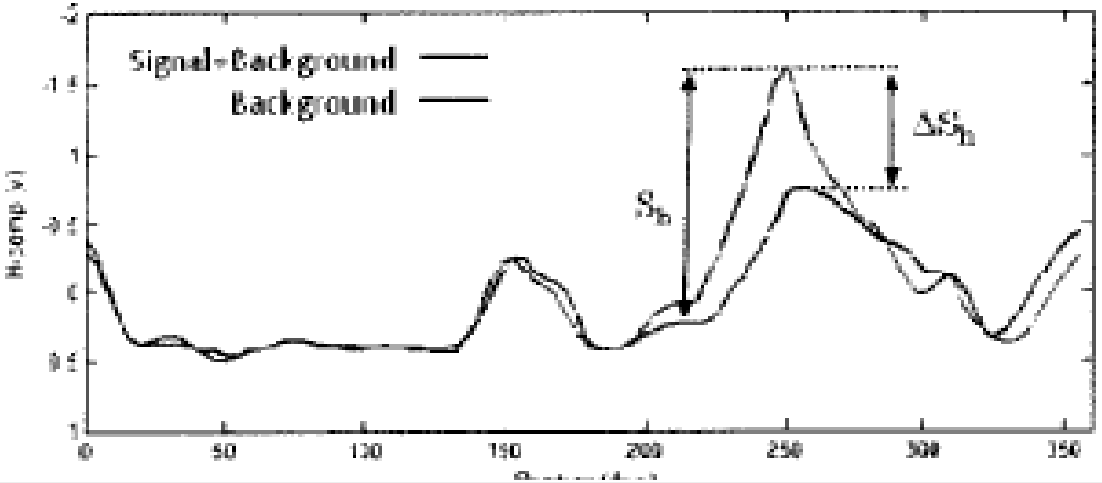


$$\frac{S_2}{S_1} = \frac{S_b + \Delta S_2}{S_b + \Delta S_1} = 1.2$$

$$\frac{\Delta S_2}{\Delta S_1} = 2$$

Example of Amplitude Comparison





EPRI SG Examination Guidelines

- Present Guidance – Revision 7
  - When historical reviews are performed to determine if supplemental testing is warranted, the licensee shall define what constitutes change in terms of voltage and/or phase angle from the Lissajous signal in the current inspection as compared to the same Lissajous signal in the first ISI or the first ISI recorded on optical disk.
  - When cracking mechanisms are present, the process of historical review is reviewing the actual raw or processed eddy current data; review of database report entries is not acceptable. When cracking mechanisms are not present, a review of the database report entries is acceptable.
- Revision 8 committee is considering additional guidance

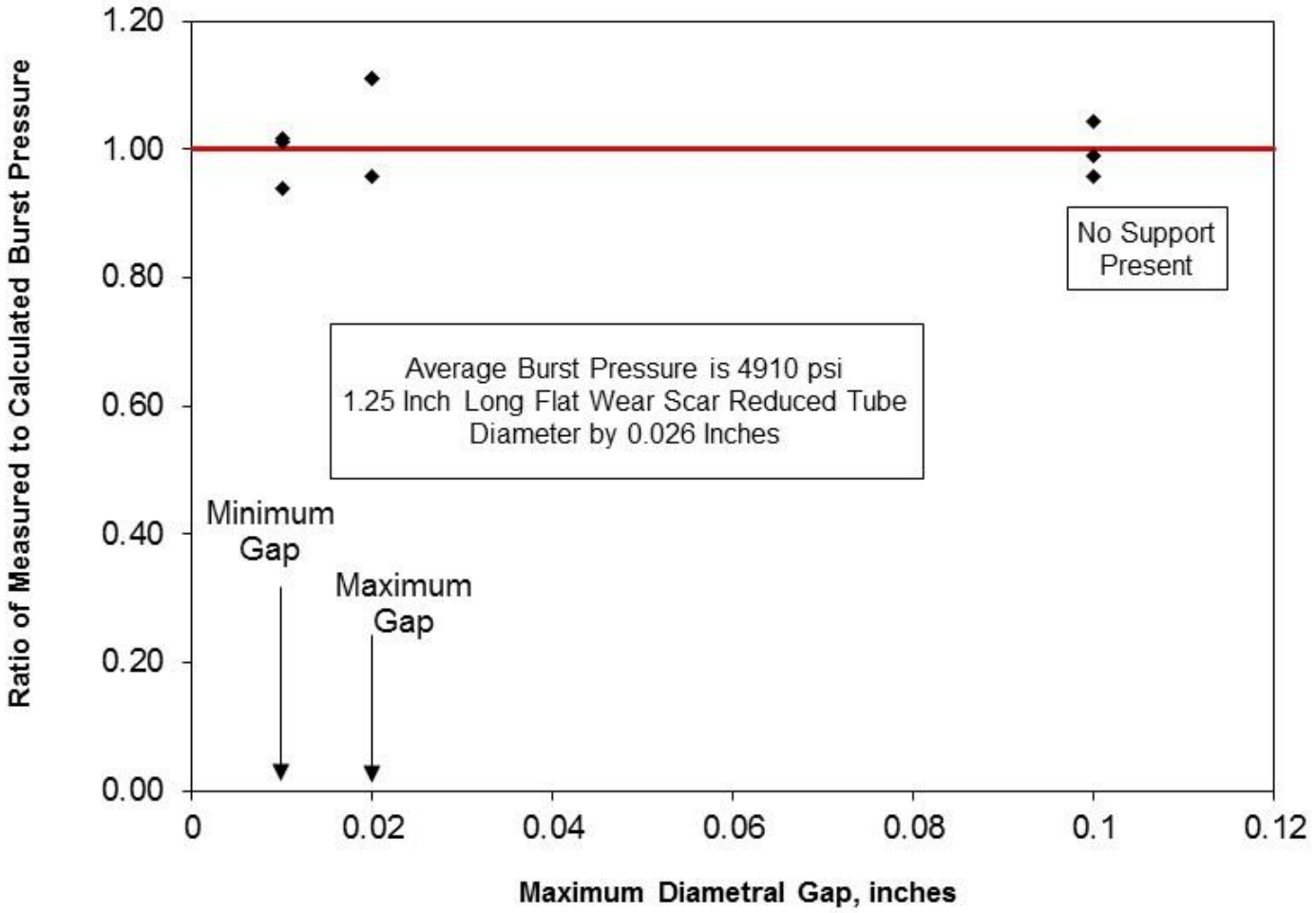
Basis for Section D3.1 of In Situ Pressure Test Guidelines

Basis for Section D3.1 of In Situ Pressure Test Guidelines

Note in Section D3.1 of In Situ Pressure Test Guidelines: Degradation at lattice type eggcrate supports is not exempt from in situ proof testing, as it has been shown that these supports provide little strengthening to regions with axial degradation. The same is true of broached TSP supports.

- Basis for this note was testing performed in the 1990's on axial flaws within eggcrate supports, not documented in the guidelines
- Tests have recently been performed to provide basis for trefoil and quatrefoil supports and will continue to address eggcrates

Results of Recent Testing



Conclusions

- For wear flaws that challenge 3dP structural integrity performance criterion, trefoil supports do not elevate the burst pressure
- Similar results are expected for quatrefoil and eggcrate supports

Anti-Vibration Bar Position Verification

Anti-Vibration Bar Mispositioning

- White paper developed incorporating information from 2012 meeting among SG vendors regarding AVB position verification
  - Available to utilities on EPRI website
- Recommendations have been provided to the Integrity Assessment Guidelines Committee
- Westinghouse published NSAL 12-7, “Insufficient Insertion of Anti Vibration Bars in Alloy 600TT Steam Generators with Quatrefoil Tube Support Plates”
  - Concluded that it is judged that the worst case consequence of this issue does not result in a Substantial Safety Hazard
- SGMP Project began project in 2012 to provide generic input for plant-specific U-bend tube fatigue analysis
- Follow up survey in 2012 indicates the utilities are familiar with the issue and are taking actions as appropriate

Anti-Vibration Bar Mispositioning

- The issue is considered applicable only to those steam generator manufactured before 1985
  - AVB design has reduced or eliminated gaps as much as possible by controlling AVB and tube tolerances.
  - Manufacturing process control has been improved to document the as-built condition vs. the as-designed condition.
  - AVB depth of insertion and alignment are recorded in manufacturing records.
  - Significant depths of insertion variations are not expected; hence, the potential for flow peaking factors is minimal.

SGMP U-Bend Fatigue Project

- SGMP began a project in 2012 to perform the generic work that would provide necessary inputs into plant-specific analyses
  - ATHOS analysis provides input to flow induced vibration analysis for open and occluded TSP conditions
  - Mean stress and unit bending moment calculations for Fixed, Pinned and Open Gap tube constraints
  - Review of flow peaking factor data from the NRC Bulletin 88-02 analyses to determine a correction factors for application to affected models of SG (F, D5, 44F, 51F)
  - FIV analysis for rows of interest (F: 5-12) for Fixed, Pinned and Open Gap tube constraints and case-specific damping

SGMP U-Bend Fatigue Project

- Model F work completed in 2013 (Report No. 3002001991)
- Model D5 technical work was completed in 2014
  - Technical report will be published in 2015
- Model 44F and 51F work will begin in 2015
  - Technical report will be published in 2016
- Plants with susceptible SGs are investigating the insertion depths of AVBs
  - They need to generic work to be completed prior to the site specific analysis

Standing Discussion Topics

Recently Issued SGMP Technical Reports

- *Steam Generator Management Program: Investigation of Crack Initiation and Propagation in the Steam Generator Channel Head Assembly*
  - SGMP Technical Report 3002002850 (October 2014)
- *Steam Generator Management Program: Lead Stress Corrosion Cracking of Nuclear Grade Alloy 800*
  - SGMP Technical Report 3002002853 (Nov 2014)

SGMP Industry Document Status and Revision Schedule

Guideline Title	Current Rev #	Report #	Last Pub Date	Imple-mentation Date(s)	Interim Guidance	Review Date	Comments
SG Integrity Assessment Guidelines	3	1019038	Nov 2009	9/1/10	SGMP-IG-10-01 SGMP-IG-12-01	TBD	Rev 4 in progress
EPRI SG In Situ Pressure Test Guidelines	4	1025132	Oct 2012	10/10/13	None	TBD	Rev 5 will begin in 2015
PWR SG Examination Guidelines	7	1013706	Oct 2007	9/1/08	SGMP-IG-08-04 SGMP-IG-12-01 SGMP-IG-14-02	TBD	Rev 8 in progress
PWR SG Primary-to-Secondary Leakage Guidelines	4	1022832	Sept. 2011	4/11/2012 7/11/2012	None	2015	

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	2017	
PWR Secondary Water Chemistry Guidelines	7	1016555	Feb 2009	8/20/09 11/20/09	SGMP-IG-13-01 SGMP-IG-14-01	TBD	Rev 8 process planned to begin in 2015
Steam Generator Management Program Administrative Procedures	3	1022343	Dec 2010	9/1/11 12/31/11	None	N/A	Rev 4 in progress
Steam Generator Degradation Specific Flaw Handbook	1	1019037	Dec 2009	N/A	None	N/A	Rev 2 in progress

Interim Guidance SGMP-IG-14-02 – Examination Guidelines, R7

- Prescriptive guidance not consistent with current performance-based requirements in Technical Specifications were removed from Section 3 of the Examination Guidelines
- Plants' operational assessment dictates operating intervals for each degradation mechanism within the confines of Technical Specification intervals

Example: A plant may be required to inspect 100% of the top of the tubesheet for cracking, but not 100% of the tubing for wear

Interim Guidance SGMP-IG-14-02 – Examination Guidelines, R7

- Sampling shall be performed such that all tubing is examined within the periods established *by Plant Technical Specifications and the Degradation Assessment.*
- Wording removed:

Tube selection within a sample plan shall be governed by the following requirements:

1. The tubes are selected on a random or systematic basis, and evenly distributed across the tube bundle to the extent practical (e.g. As Low As Reasonably Achievable (ALARA) considerations).
2. All inservice tubes that have prior indications of degradation and/or historical possible loose parts (PLP) are examined through the area of interest when the applicable SGs are open for examination.
3. Peripheral tubes, including tubes adjacent to no-tube lane regions, are included or added to a sample plan or considered a separate sample plan when there is reason to expect that loose parts are present or were introduced into the SG secondary side. A secondary-side foreign object search and retrieval (FOSAR) examination may be used to meet this requirement.

Interim Guidance SGMP-IG-14-02 – Examination Guidelines, R7

- Section 3.6 contains a reference to the Steam Generator Integrity Assessment Guidelines for determining steam generator examination scope
- Section 6 of the Integrity Assessment Guidelines requires utilities to develop a Degradation Assessment which includes an inspection scope for all existing and potential degradation mechanisms

NEI 03-08 Deviations

- Three long-term deviations
  - Two Steam Generator Examination Guidelines, R7
    - Single party auto analysis
  - Steam Generator Integrity Assessment Guidelines, R3
    - Use of site-specific sizing indices
- One short term deviations
  - Steam Generator Examination Guidelines, R7
    - PSI prior to hydro

Operating Experience

Recent Operating Experience Reported at December SGMP Technical Advisory Group Meeting

- Spring 2014 outage inspections identified foreign objects laying on the debris screens for both the “A” and “B” steam generators.
- These foreign objects were determined to be part of the support system for the feedrings.
- Additional inspections identified that the feedring supports had been damaged due to a steam void in the feedring system.
- The damaged supports were repaired during the outage.
- The function of the feedring was not impacted.

Recent Operating Experience Reported at December SGMP Technical Advisory Group Meeting

- The cause evaluation included a review of the guidance provided in NUREG-0291 and NUREG-0927
- Potential causes for the steam void:
  - Feedring leakage through inspection port bolted to ends of feedring
  - Back leakage through the feedwater system
- An important mitigating action is to limit the feed rate while the feedring is uncovered; industry accepted limit is 150 gpm
- Follow-up inspections will be implemented to verify effectiveness of actions taken
- This experience was reported at TAG meeting June 2014

NRC Discussions/Items of Interest

Acronyms

Acronyms

- ASME – American Society of Mechanical Engineers
- EPRI – Electric Power Research Institute
- AVB – Anti Vibration Bar
- IG – Interim Guidance
- N/A – Not Applicable
- NEI – Nuclear Energy Institute
- NRC – Nuclear Regulatory Commission
- PSI – Preservice Inspection
- PWR – Pressurized Water Reactor
- SG – Steam Generator

Acronyms

- SGMP – Steam Generator Management Program
- SGTF – Steam Generator Task Force
- TBD – To Be Determined
- TSP – Tube Support Plate
- TT – Thermally Treated
- US – United States

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