NRC / EPRI Steam Generator Task Force Meeting
August 19, 2015

Agenda

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

Opening Remarks ***NRC and Industry***

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

- Status of In-Plane Fluid Elastic Instability Tests
- Industry Involvement in New ASME Code Task Group
- Tube-to-Tubesheet Joint Design Issue
- Action Levels for Leakage
- Tube Support Plate Burst Tests
- Summary of Recently Issued SGMP Technical Reports
- Status of Industry Guidelines
- Interim Guidance
- NEI 03-08 Deviations
- Recent Operating Experience

Agenda

9:30 am ***Break***

9:45 *am* **NRC Discussion / Items of Interest** **(NRC)**

- Divider Plate and Tubesheet Weld Cracking
- Inspections for Wear at the Top of the Tubesheet

11:00 am ***Address Public Questions/Comments*** ***(NRC)***

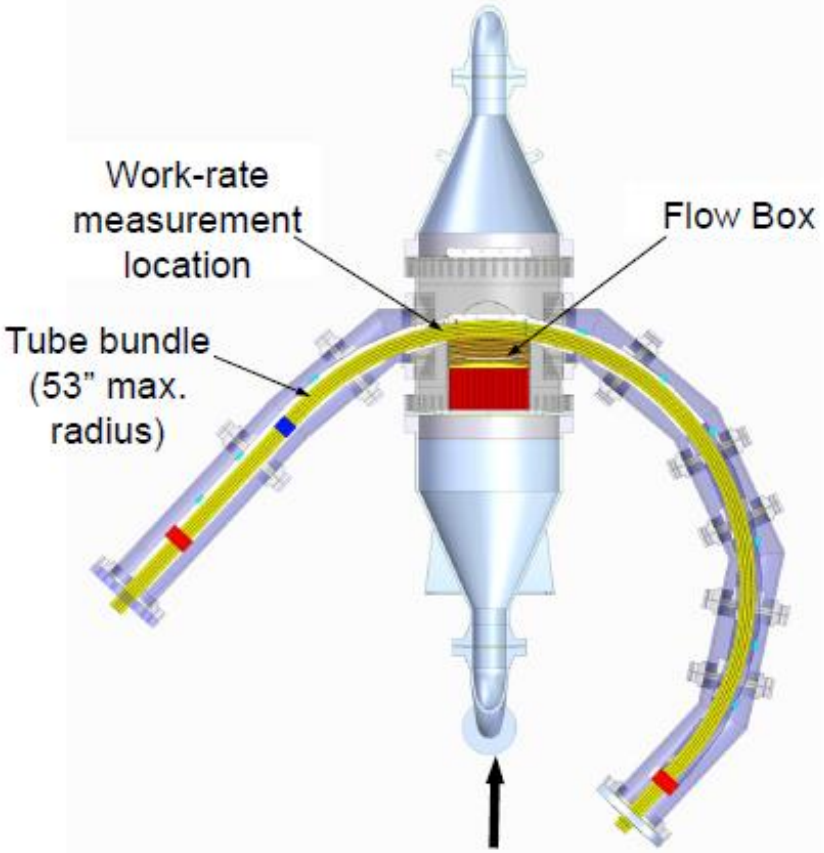
Status of In-Plane Fluid Elastic Instability Tests

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 – In Progress

- Assembly of the test rig for the air flow tests is complete and commissioning tests were successful
  - Verified the proper functioning of:
    - Air blower and flow rate measurement system
    - Tube vibration instrumentation and data acquisition system
  - Generated flow-induced vibration data that compared well with existing test data



Phase 1 – Develop Test Matrix for Air Flow Tests

- Meeting among industry experts July 14-15 developed the test matrix
  - Westinghouse
  - AREVA
  - BWXT
  - Intertek
  - MHI
  - EdF
  - Utility Reps from Duke and First Energy
  - EPRI staff

Actions from July Meeting

- Begin the air tests with a subset of the planned tests
  - Sensitivity study for the following parameters
    - Gap size
    - Preload
    - Wet vs dry supports
    - Three flexible tubes vs 22 flexible tubes
    - Current bundle configuration

Schedule

- Perform air tests: Fall 2015 – March 2016
- Review air-tests and plan Freon tests: April 2016
- Prepare for Freon tests: May – November 2016
- Freon tests: December 2016 – March 2017
- Final reporting: April – August 2017

Industry Involvement in ASME Section III Appendix N Task Group

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- Two conference call meetings have taken place
  - April 24 and July 22
  - NRC and utilities participated in both calls
- Reviewed the Rolling Action Item Log
  - Status of Section N-1330 In-Plane Fluid Elastic Instability
    - The group is interested in the EPRI test
    - Low hanging fruit could be written into Appendix N
      - Victor Jansen can distribute the Canadian guidelines / framework.
      - Task Group on flow induced vibration will review these guidelines and be prepared to discuss in Fall 2015 meeting
    - The NRC supports adding some basic requirements
- Industry will continue to participate

Tube-to-Tubesheet Joint Design

Tube-to-Tubesheet Joint Design

- Operating experience in 2014 informed the industry that some of the steam generators in the US did not have a documented stress and fatigue analysis of the tubesheet welds
- An inquiry was sent to the ASME Code Section III Standards Committee to determine if Section III, Division 1, Article NB-3000 requires an analysis of the tubesheet weld when fabricated using weld procedures and personnel qualified in accordance with NB-4350 and examined in accordance with NB-5274
  - The response received on May 15, 2015 indicated that the requirements of Section III, Division 1, Article NB-3000 apply to the tubesheet welds when the tubesheet weld is the pressure boundary
  - They also stated that NB-3000 does not provide specific rules for the design of the tube-to-tubesheet welds
  - A new ASME Code action has been opened to consider Code changes

Industry Actions

- SGMP funded an emergent project with AREVA and B&W to perform an operability assessment for the affected steam generators
  - No immediate operability concerns have been identified
  - SGMP and INPO conducted a search of INPO's operating experience database and found no case where a tubesheet weld failure has been reported due to design issues
- Affected utilities entered the issue into their Corrective Action Programs
  - AREVA fleet received generic stress/fatigue analysis on July 28, 2015
  - B&W plant-specific stress analyses are in progress
    - Will be complete by end of 2015
- SGMP issued an Information Letter to all members providing details of the issue and actions that have been taken

Action Levels for Leakage

Primary-to-Secondary Leakage Limits

- NRC Question from August 2014
  - 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?
- Industry's discussion during the February 2015 Task Force meeting
  - 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)
- Following February 2015 Task Force Meeting, the industry received three additional comments from the NRC

NRC Comment #1

- There is a “shall requirement” that states that station procedures shall contain limits and actions as required by Technical Specifications. We believe this should be mandatory.

Industry Response #1

- The initial feedback from the Guideline Review committee is that the relationship between the Guidelines and Tech Specs warrants explanation in the Guidelines.
  - Guidelines requirements are established to mitigate a SG tube rupture.
  - Tech Spec requirements are established to ensure meeting off-site dose limits for other accident scenarios.
- The Guidelines are not intended to duplicate Tech Spec requirements, although some reference to Tech Specs seems appropriate to assist utilities in establishing procedures so that both sets of requirements are met.
- Mandatory and shall requirements will be reviewed during the Guideline revision process which will begin in late 2016

NRC Comment #2

- It is our understanding from the February 12th meeting that this “shall” statement (in item 1 above) was the reason that the industry thought the guidelines were sufficient in the case where a plant has a primary-to-secondary leakage limit less than 150 gpd.
- It would seem that more guidance on how to establish action levels for units with technical specification leakage limits less than 150 gpd would be useful (since there does not appear to be any guidance on how to adjust the action levels or what to consider when adjusting the action levels).

Industry Response #2

- Guideline Action Levels and actions are designed to provide utility personnel with a defense-in-depth approach to ensuring that operating with low-level primary-to-secondary leak rate has a low probability of escalating to a tube rupture.
- Technical Specification limits may be lower than 150 gpd due to other factors such as off-site dose or increased margin for accident induced leakage (which do not necessarily influence the probability of tube rupture from a leaking defect).
  - As a consequence of the fact that Tech Specs are addressing these other factors, there's no direct way that the Guideline Action Levels are connected to the Tech Spec limit.
  - Setting of administrative limits for considerations other than tube rupture are outside the scope of the Guidelines.
- Utilities adhere to the Technical Specifications and the Primary-to-Secondary Leak Guidelines by implementing the more restrictive limits in plant procedures. This ensures that the bases are being met for both tube rupture and for the cause of the Tech Spec limit being less than 150 gpd.
- This comment will be considered by the Guideline Committee in 2016

NRC Comment #3

- Lastly, we note that the guidelines require either selecting a rate of change limit methodology or a constant leakage limit methodology. It would appear that a unit would always want to factor in the rate of change of leakage into any decision making process including the timing for the shutdown (if leakage is increasing at a very high rate, moving into *shutdown within time requirement* may not prevent the technical specification limit from being exceeded or prevent a tube rupture).

Proprietary information has been reworded.

Industry Response #3

- The constant leak rate methodology already factors in the rate of change methodology in a conservative manner. For example, for leakage at the Action Level 2 constant leak rate limit:
  - Leakage increasing at a high rate of change (*i.e.,* above the rate of change methodology Action Level 3 rate of change) will result in Action Level 3 entry in less than an hour. The Action Level 3 response for the constant leak rate methodology is consistent with the rate of change methodology.
  - For leakage increasing at a lower rate, the required actions for the constant leak rate methodology are consistent with the rate of change methodology.
- These limits and actions are more conservative than the standard Tech Specs (be in Mode 3 within 6 hours of reaching 150 gpd), and help to ensure that the probability of tube rupture is low.

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

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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 supports.

- Basis for this note was testing performed in the 1990's on axial flaws within eggcrate supports, not documented in the guidelines
- NRC questioned the industry about the validity of this statement
  - **Does the eggcrate and broached supports elevate the burst pressure of a flawed tube during an in situ pressure testing?**
- Tests have recently been completed to provide technical basis for this note
- Guidelines are being updated 2015

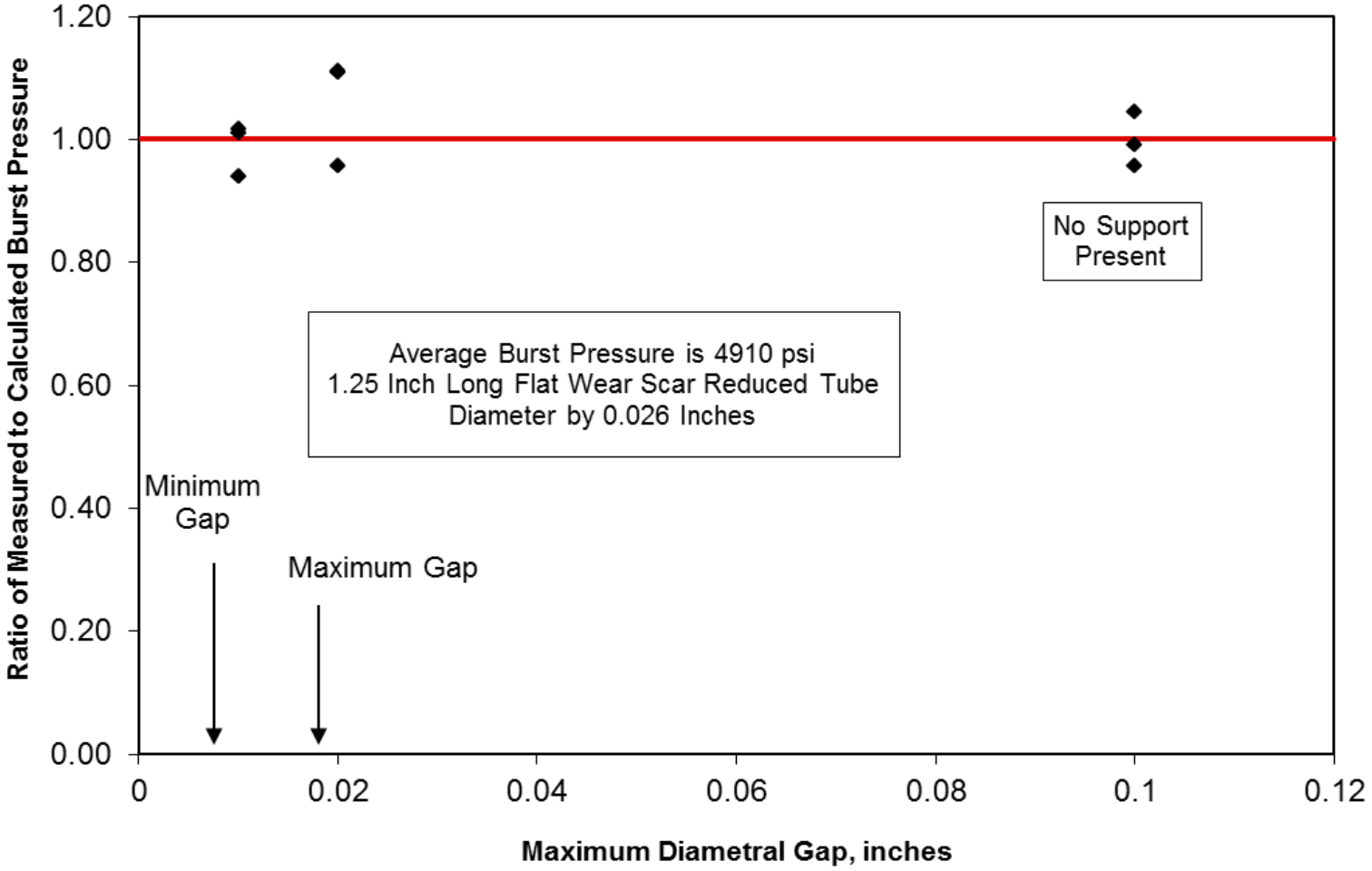
Overview of Tests Performed

- Tests were performed to evaluate the effect, if any, of the presence of a support structure on the burst pressure of a wear flaw in a steam generator tube
  - Interested in support wear flaws that challenge the 3dP structural integrity performance criterion and would require in situ testing
- Tubes and supports selected are representative of operating steam generators with Alloy 600MA, 600TT, and 690TT tubing material (not drilled holes)
  - Tubes used for tests
    - Nominal 0.625” OD x 0.037” wall thickness, Alloy 690 material
    - Nominal 0.688” OD x 0.0425” wall thickness, Alloy 690 material
  - Supports used for tests
    - Trefoil broached support plates, 1.25” thickness, stainless steel material
    - Egg-crate supports, 2.0” and 1.0”, 3.17” thickness bars, stainless steel material

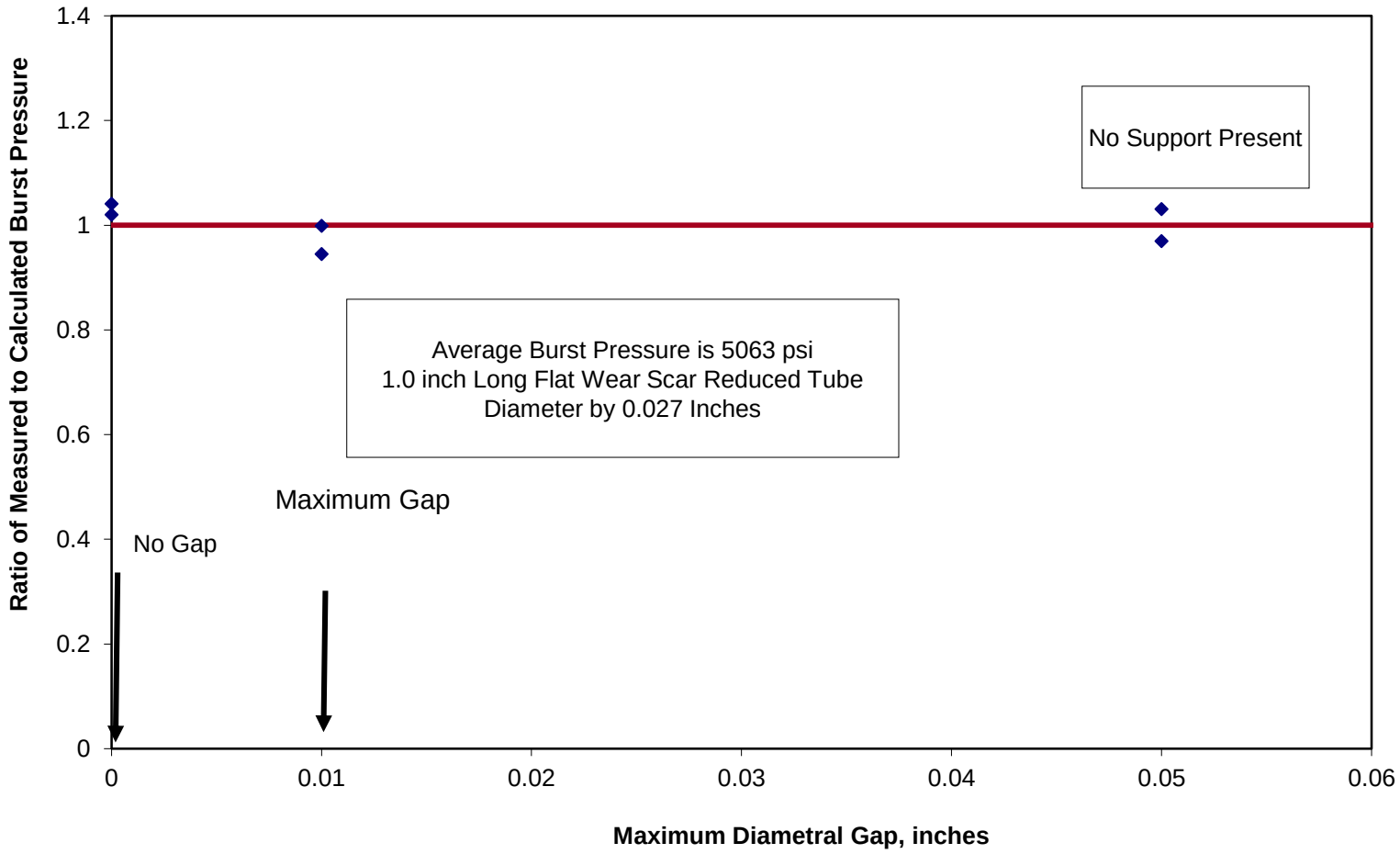
Determination of Material Strength

- Two unflawed samples were burst to empirically determine the material strength of the tubes used in the tests
- Material strength (Sy+Su) = 145 ksi
- Material strength used to calculate a flaw depth that would burst at a target burst pressure of 4700 psi

Measured and Predicted Burst Pressures of 0.625” Samples/Trefoil Supports



Measured and Predicted Burst Pressures of 0.688” Eggcrate Supports



Post Burst 0.688” OD Samples

Conclusion

- Tests verify the original statement in In Situ Pressure Test Guidelines
- Tests were performed on 0.625” and 0.688” tubing with trefoil and eggcrate supports
  - Tested axial wear scars (bounding to axial cracks)
  - The gaps tested bound all tubing sizes
  - Trefoil supports have similar land width and space between the lands as quatrefoil so no tests were required for quatrefoil supports
- In Situ tests in the presence of trefoil, quatrefoil or eggcrate supports for a flawed tube that challenges tube integrity requirements will not provide a false conclusion regarding acceptable tube integrity
- EPRI Steam Generator Task Force considers this issue closed

Standing Discussion Topics

Recently Issued SGMP Technical Reports

- *Steam Generator Management Program: Steam Generator Deposit Removal Strategies Sourcebook*
  - SGMP Technical Report 3002005090 (May 2015)
- Steam Generator Management Program: Administrative Procedures, Revision 4
  - SGMP Technical Report 3002005168 (March 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
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	SGMP-IG-15-01	TBD	Rev 5 in progress
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	Will begin 2016

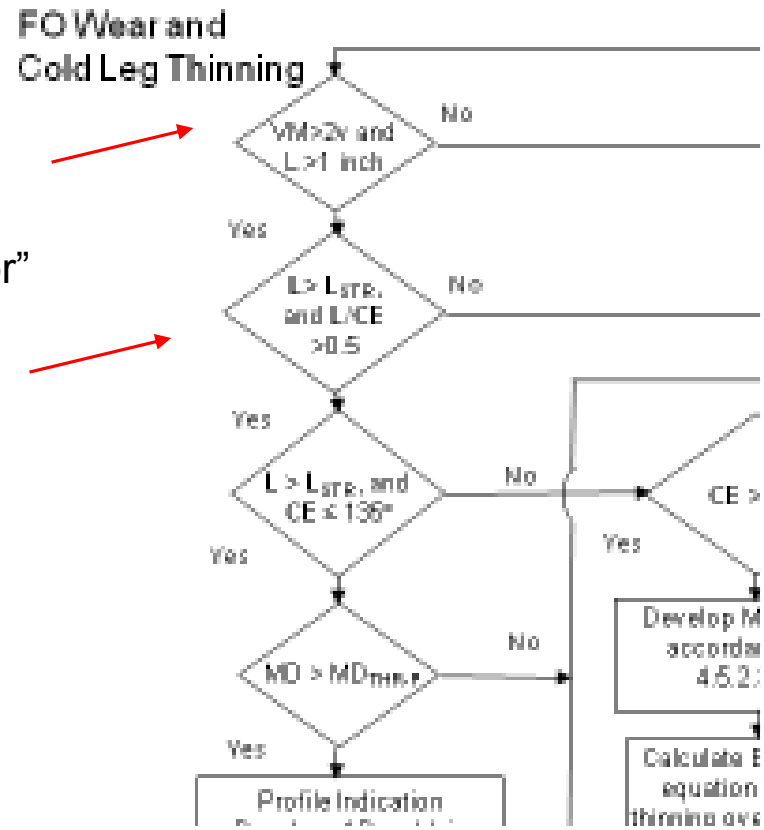
SGMP Industry Document Status and Revision Schedule

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	4	3002005168	March 2015	12/9/15	None	N/A	
Steam Generator Degradation Specific Flaw Handbook	1	1019037	Dec 2009	N/A	None	N/A	Rev 2 in progress

Interim Guidance SGMP-IG-15-01 – In Situ Pressure Test Guidelines, R4

- Error discovered in a flow chart in Section 4
  - First screening level for foreign object wear and cold leg thinning

Should be “or”



Wording in the text of the document is correct

Interim Guidance SGMP-IG-15-01 – In Situ Pressure Test Guidelines, R4

- Entered the error into EPRI's Corrective Action Program
  - Notified all members via interim guidance
  - Reviewed Steam Generator Degradation Database for plants that had plugged tubes for foreign object wear or cold leg thinning
    - None of the plants rely on the flow chart alone for screening flaws for in situ pressure testing
  - Document was corrected and reposted to epri.com

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

Primary-to-Secondary Leak in a Korean Plant 2014

- SGMP has reached out to the utility
  - Utility has supplied limited information to date
  - Root cause in progress
- SGMP has a meeting with KHNP Fall 2015

NRC Discussions/Items of Interest

Acronyms

Acronyms

- ASME – American Society of Mechanical Engineers
- EPRI – Electric Power Research Institute
- IG – Interim Guidance
- N/A – Not Applicable
- NEI – Nuclear Energy Institute
- NRC – Nuclear Regulatory Commission
- psi – pounds per square inch
- 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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