

NEI Steam Generator Task Force

Industry Update

January 8th, 2009

Agenda

- Safety Brief - NEI
- 1:00 pm Introductions - NRC
- 1:05 pm Opening Remarks - NRC and Industry
- 2:30 pm NEI Steam Generator Task Force Update - Industry
- 4:30 pm NRC Issues - NRC
- 4:45 pm Address Public Questions/Comments (10 - 15 minutes) - NRC and Industry
- 5:00pm Adjourn



SGTF Update:

**Divider Plate Cracking
Project Update**



Divider Plate Cracking Project Update

■ Phase I Results

- Westinghouse Model 51 SG limiting case for U.S. plants
- Currently observed cracks in the foreign SGs not capable of causing the divider plate to fail in the worst case domestic SG during accident or normal operating conditions
- Possible for cracks in the divider plate to increase in both length and depth once they have initiated
 - Cause an increase vertical tube sheet displacement



Phase II began 2007

Divider Plate Cracking Project Update

- Phase II Scope
 - Work completed:
 - LOCA Transient Analysis
 - Non-LOCA Transient Analysis
 - Conclusions
 - A fully degraded divider plate does not adversely affect SG performance during LOCA or non-LOCA events
 - EPRI Technical Update 1016552

Divider Plate Cracking Project Update

- Work stopped due to H* Project
 - Multiple Crack Analysis 70% Complete
 - Refined Crack Growth Analysis 60% Complete
 - Review of ASME Code Stresses
 - Define DP Inspection Criteria
 - Assessment of Field Repairs

Divider Plate Cracking Project Update

- Preliminary results from ASME Stress Report review
 - Fatigue limits and usage factors documented in the Model 51 ASME stress report would continue to be met even if cracks reported in the foreign fleet were to develop in the US Model 51 SG divider plate.
- Foreign utilities continue to inspect and continue to operate with no repairs
- Phase II will be completed in 2009 depending on H* progress
 - Final report is planned in 2009
- With current results, no identified need for US plants to inspect



SGTF Update:

**International Operating
Experience Report**



Background

February 2004

- Cruas 1: forced outage due to leak (0.017 GPM) in the upper tube bundle

November 2005

- Cruas 4: forced outage due to leak (0.04 GPM) in the upper tube bundle

February 2006

- Cruas 4: forced outage due to leak (2.8 GPM) in the upper tube bundle

December 2007

- Krsko: loose part damage issue

February 2008

- Fessenheim 2: forced outage due to leak (0.03 GPM) in the upper tube bundle

April 2008

- Saint Alban: Tube plug failure

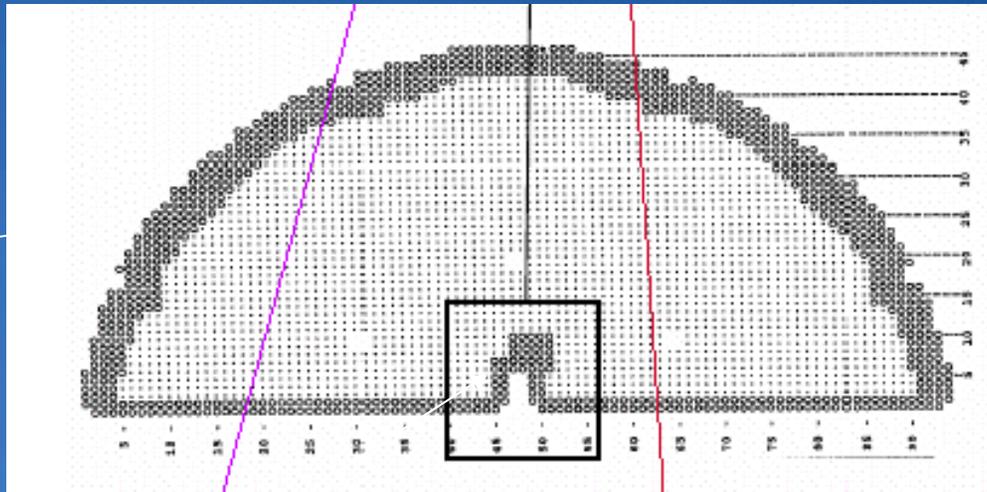
Background (cont)

- Cruas - Circumferential cracks were found in tubes R8[C47/C48/C49] at top TSP
 - TSP: broached, 13% Cr steel
 - Located near chimney region (tube-free region at the bundle center)
 - Secondary-side deposits on the upper support plates (TSP#4-8) increased flow rates further near the bundle center
 - Affected tubes had no AVB support by design due to their small radius bends
 - Believed to be caused by high-cycle fatigue due to locally increased flow velocities and consequent flow-induced vibration
 - **Note:** TSP 1 is the flow distribution baffle

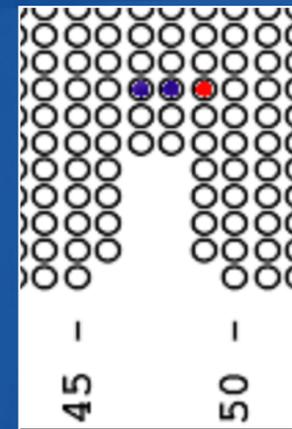


Project Objective

- To perform a thermal-hydraulic and flow induced vibration/fatigue analyses of a steam generator to address the Cruas events
 - With and without chimney
 - With and without flow blockage



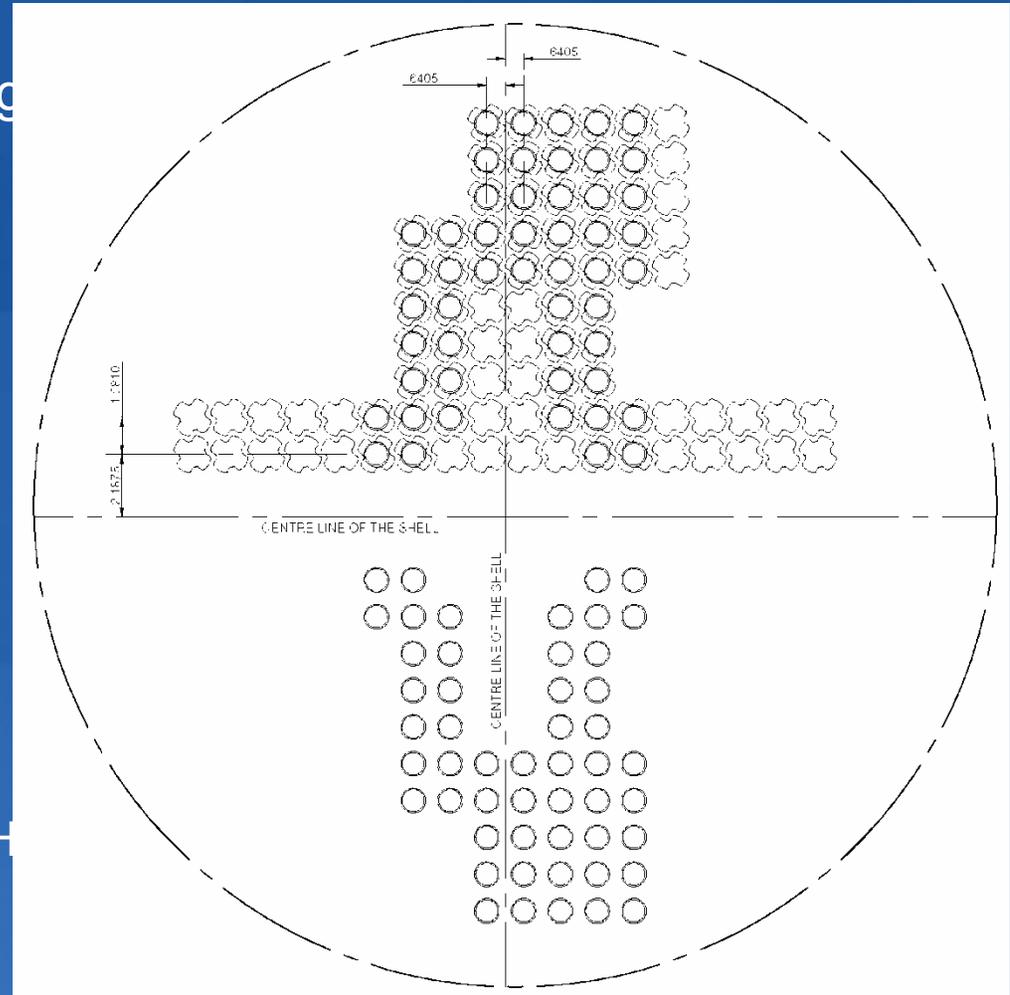
Chimney (12 quadrefoil holes without tubes)



Tube Crack Locations
Cruas 4 (purple)
Cruas 1 (red)

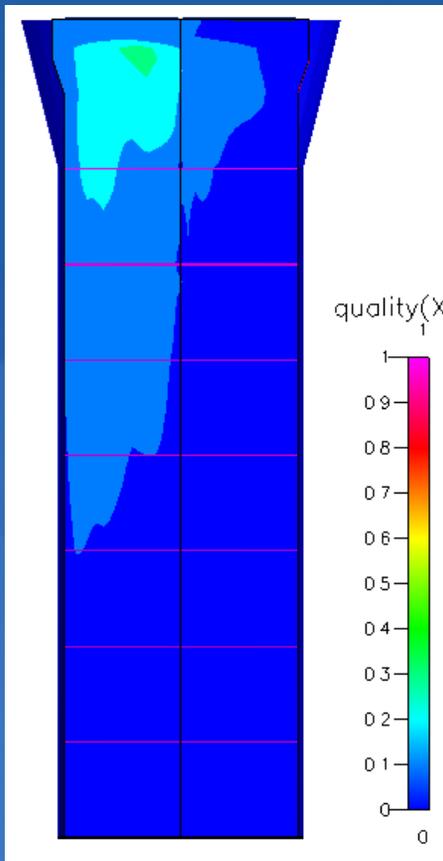
Case Descriptions for Parametric Survey

- Chimney
 - Chimney-12 tubes missing
 - No Chimney-no tubes missing
- Tube Free Lane
 - TSP's are fully blocked
 - Flow holes provide 65% porosity
- Deposit Build Up
 - Clean condition
 - TSP's partially crudded
 - Pattern A: Uniform HL & CL sludge distributions
 - Pattern B: Non-uniform H sludge distributions & uniform CL distributions

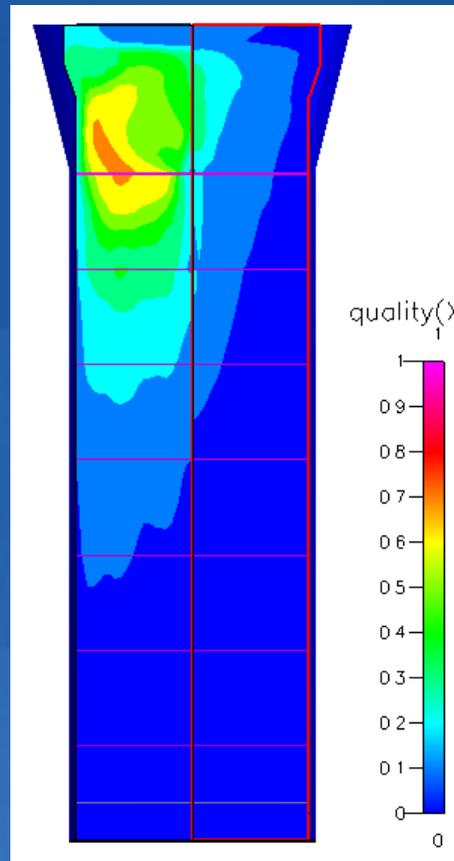


Steam Quality on Plane of Symmetry 12 Tubes Missing Near Centerline, Blocked TFL

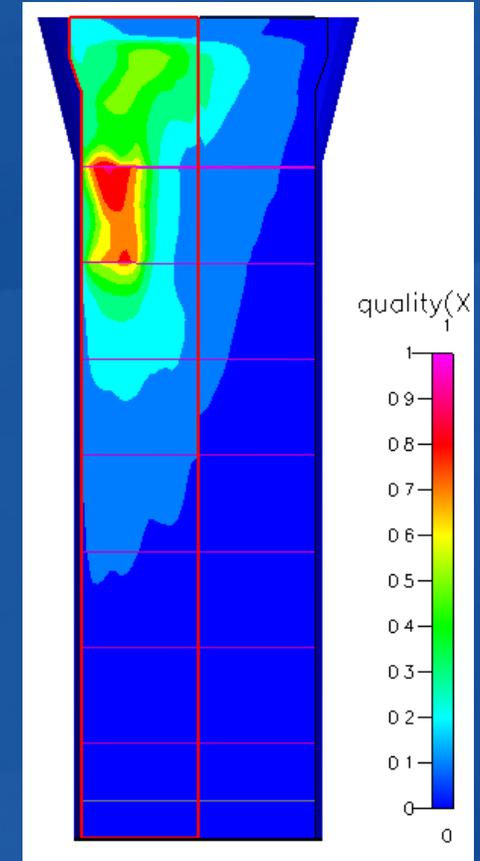
Hot Side Cold Side



(a) Case 1–Clean



(b) Case 2–Crud Pattern A



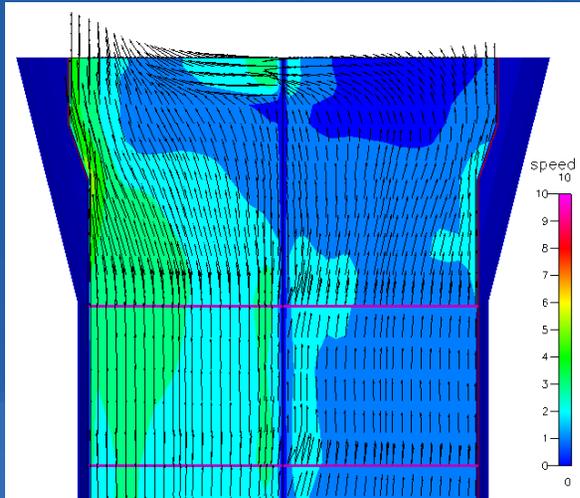
(c) Case 3–Crud Pattern B

- Maximum steam quality increases dramatically with TSP blockage
- Quality distributions look similar for other cases

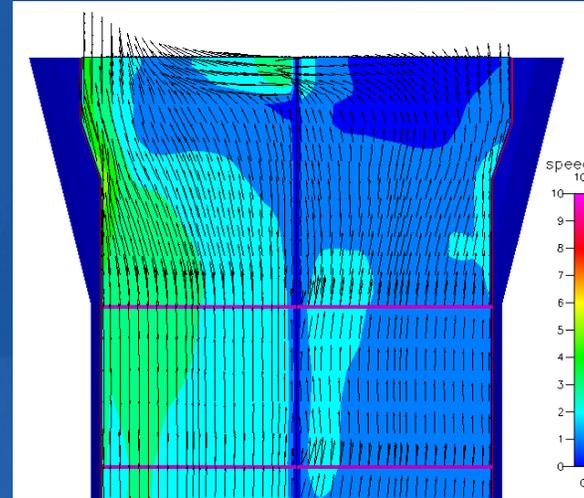
TFL Blocked

Chimney

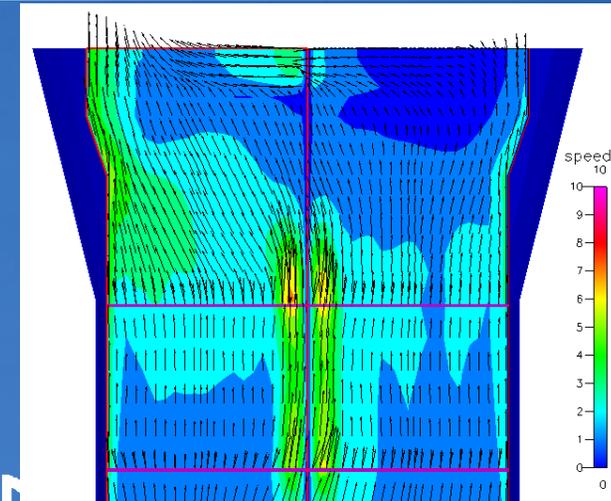
No Chimney



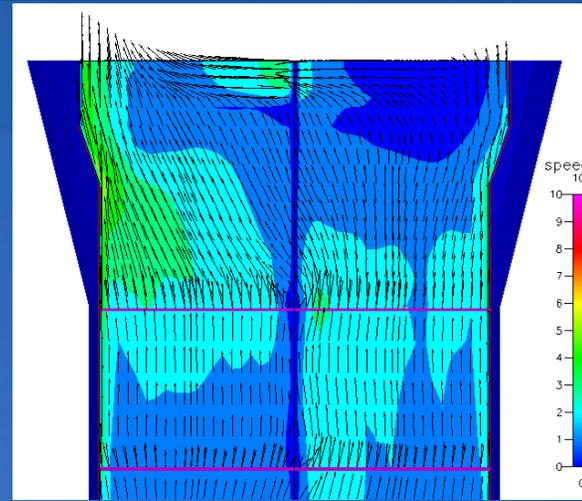
Case 1-Clean



Case 4-Clean



Case 2-Crud Pattern A



Case 5-Crud Pattern A

- As deposits build up on the TSPs
- Chimney
Velocity increases significantly near generator centerline and impinges on small-radius tubes in U-bend
- No Chimney
Velocity does not increase preferentially near generator centerline

Summary

- Chimney
 - Chimney region causes a jet of fluid to impinge on a small region in the U-bend
 - Velocities in this region are higher in the bundle with the chimney than in a full bundle
- TSP Build Up
 - Velocity can increase further due to TSP blockage for both the chimney and no chimney cases
 - Steam quality increases due to TSP blockage
- EPRI report published December 2008 (1018344)
- Detailed presentation given at TAG meeting by EdF
- SGMP IIG considering future actions

SGTF Update: Fessenheim Event

Fessenheim 2

February 2008

- Fessenheim 2: forced outage due to leak (0.03 GPM) in the upper tube bundle
- Circumferential crack was found in tube R12C62 at top TSP, attributed to vibration induced instability
 - TSP: drilled, carbon steel
 - Secondary side deposits, but tube was not dented
 - Affected tube was not supported by AVB (AVBs inserted after tubing)
 - FIV analysis conducted in the early 1990s (following North Anna 1 and Mihama events) showed tube had enough margin

Fessenheim 2

- EdF Corrective Actions
 - For 900 MW plants, EdF has preventively plugged all Row 11 and 12 tubes that are not supported by AVB.
 - Regardless of SG model, TSP type, instability ratio
 - For 1300 MW plants, EdF is performing reanalysis to demonstrate margins.

Impact to Domestic SGs

- NRC Bulletin 88-02 required Westinghouse designed plants with carbon steel TSPs to perform analyses to determine if tubes were susceptible to rapidly propagating fatigue cracking such as occurred at North Anna 1 in 1987.
- Presence of following conditions could lead to tube failure:
 - Denting, fluid elastic stability ratio approaching that of North Anna failed Row 9 tube, and absence of AVB support.
- Analyses typically conservatively assumed that limiting susceptible tubes were dented.

Impact to Domestic SGs

- Many plants were required to plug and stabilize susceptible tubes.
- Corrective actions were effective at preventing high cycle fatigue cracks.
- Plants were typically required to evaluate significant changes to plant conditions (e.g., steam pressure) to verify continued compliance with 88-02 analyses.
- Only 4 plants with carbon steel TSPs are still in operation and have NRC Bulletin 88-02 analyses in effect.
- Detailed presentation given at TAG meeting by EdF
- Will be discussed further by IIG

Krsko Loose Part Experience

- In outage 2007, secondary inspection revealed two loose parts.
 - Parts identified as “vaness” belonging to the Auxiliary Feed Water distributor.
 - Visual inspection of distributors in both steam generators revealed two missing vanes on steam generator SG #2 distributor in addition to the vane’s cracks on the outer shroud of AF distributors in both steam generators.
 - Distributors were replaced
 - Visual inspection and Eddy Current test performed in the area of the found vanes in steam generator SG #2, identified 16 affected U-tubes (indications of partial wall degradation). They were preventively plugged with removable plugs.

Krsko Loose Part Experience

- Experience not considered to be directly applicable to US Fleet
- SGMP 2009 project to focus on steam generator secondary side degradation

SGTF Update:

Saint Alban
EdF Plug Failure Experience



Plug Failure Experience

- **Recently, 5 mechanical plugs with anomalies**
 - 1 lost during the High Pressure Test (205 b) - detected by He test
 - SAL2 L29C29 hot leg: found on the other side of the tube
 - 1 with Boron deposit
 - 1 displaced
 - 2 with atypical plugging parameters, easily pulled out
 - (different SGs: SAL2 & PEN2, different batch, different tools)

EdF Plug Failure Experience

- Destructive examinations performed on failed and new plug
 - Chemical composition
 - Microstructure
 - Mechanical characteristics
 - Dimensions (tube, envelope, expander): within the tolerance
- Significant wear on different parts of failed plug

Failure Analysis Conclusions

- EdF Conclusions on failed and new plugs
- Lubricant problem
- Visual tests performed on more than 5000 plugs
- no other visible problems identified

SGTF Review

- Detailed presentation given at TAG
- EdF experience appears to be manufacturing specific
 - Plug expander wear identified possibly due to manufacturing lubrication problem
- Manufacturing and installation performed to rigorous Codes and Standards
- Field QA verifications performed
- No actions required

SGTF Update

Incorporating Recent OE into Degradation Assessments

Incorporating Recent OE into DAs

- The following section was added the Integrity Assessment Guidelines
 - The draft guidelines are out for industry comment

The potential exists for the industry to issue new applicable operating experience after the unit's DA has been approved for the upcoming/present outage. If practical, the DA should be revised to reflect the operating experience and the outage plans adjusted as required. In the event that circumstances do not lend to a timely consideration of the operating experience in the DA, such as a lengthy approval process, the operating experience should be captured and evaluated in the plant's corrective action program. The evaluation should consider the safety significance for the unit and identify any appropriate actions, such as additional inspections or inspection techniques needed, for the upcoming/present outage and any impact on operation until the next scheduled inspection.
- Industry decided not to issue interim guidance

SGTF Update: Noise Monitoring



Noise Monitoring

- EPRI Report 1016554, Measuring and Monitoring Noise in Steam Generator Tubing Eddy Current Data for Tube Integrity Applications
 - Includes specification for automated software
- Westinghouse has developed a prototype and has performed one field trial
 - Needs further development
 - Still labor intensive
 - Additional field trials are needed as the software progresses

SGTF Update: Time Dependent Leak Rates

Time Dependent Leak Rates

- EPRI report 1015123 lists five types of crack growth identified in ANL leak rate tests
 - Mechanical tearing of ligaments as internal pressure is increased
 - Low cycle fatigue failure of small ligaments from stop/start pressurization cycles
 - Fracture of small ligaments via time dependent plastic deformation at very high stress/strain levels
 - Fatigue cracking of ligaments via pump operation and bypass flow effects in the test system
 - Fatigue cracking from fluid jet/structure interactions at high flow rates

Time Dependent Leak Rates

- Metallographic and fractographic work performed in 2008 confirm these observations.
 - Jet/structure interactions can lead to substantial fatigue crack growth in full thickness material when flow rates are in the vicinity of 2 gpm
 - Not all fatigue crack growth in the tests is due to jet/structure interactions
 - Pump action alone, in the absence of flow, has been shown to cause fatigue failure of small ligaments
 - EPRI Report 1016560

Time Dependent Leak Rates

- Leak tests are recommended at constant pressure without use of pumps on steam generator tubing specimens containing 100% TW fatigue cracks
 - Project received funding for 2009
 - Leak rate range of interest 0.05 to 1.5 gpm
 - Time scale of interest 1 to 24 hours
- ANLs blowdown facility is recommended but not available
- ANL is purchasing a dampener for the RT facility
 - Proceed with tests if we are satisfied with the performance of the dampener to eliminate the pump pressure pulsations
- SGMP evaluating whether an in situ pressure test adjustment can be developed in lieu of longer hold times

SGTF Update:
**Industry Project for Demonstrating
Examination Technique
Equivalency**



Development of Standardized Process for Determining Examination Technique Equivalency

Objective: Develop a consistent and cost effective method to evaluate system performance, evaluate technique performance and to demonstrate substitute component equivalency

Approach: Develop a process that will test for an equivalent magnetic field within the tubing as a basis for establishing equivalency between two similar yet differing acquisition setups.

Status: Deliverable/Schedule:

March 2008: Technical update report (1015126 issued)

March 2009: Technical update report

March 2010: Final report on the ETSS Equivalency Project will be issued which identifies a method to evaluate system performance, evaluate technique performance and to demonstrate substitute component equivalency.



Development of Standardized Process for Determining Examination Technique Equivalency

Tasks for 2008:

- Field Demonstration of Equivalency Methodology utilizing “common” ETSS (three each from bobbin, RC and Array methods)
- Evaluation of Variances of Tolerances on several essential variables

Development of Standardized Process for Determining Examination Technique Equivalency

Evaluation of Variances of Tolerances on Essential variables

- Tolerances evaluated:
 - Variances in Cable Lengths
 - Variances in Electromagnetic Penetration
 - Variances in Array Probe Crossover Value

Development of Standardized Process for Determining Examination Technique Equivalency

Summary:

- Comparing ETSS data and field data showed the proposed process for equivalency demonstration provided acceptable results for the ETSS's evaluated
- Evaluation of tolerance ranges in essential variables showed little change in ECT signals

Development of Standardized Process for Determining Examination Technique Equivalency

Future Work in 2009:

- Evaluate additional ETSS's
- Evaluate additional tolerances
- Complete equivalency project
- Consider demonstrated alternative technique in future guideline revision

SGTF Update:

**Industry Project for Foreign Object
Detection and Foreign Object Wear
Detection and Sizing**



EPRI Project: Background and Objective

Objectives: Develop guidance for detection of Foreign Objects. Develop ETSS for detection and sizing of Foreign Object wear in the presence of Foreign Objects.

Approach: Investigate foreign object detection capabilities utilizing realistic mock-ups and foreign objects for bobbin, rotating, and array probes. Develop ETSS for detection and sizing of FO wear in the presence of FO's using wear scar standards previously developed.

Status: Data was collected and analyzed utilizing FO 'standards' and FO's considered field typical with each probe type.

Deliverable/Schedule: Technical Update report including FO detection guidance published in March 2009. Final Report including ETSS development in March 2010.



Expected Benefits

- Improved understanding of foreign object detection will benefit the Utility in managing foreign object issues
 - The best technique may be chosen to detect foreign objects with eddy current methods based on plant foreign object history
 - A better understanding of the abilities and limitations of foreign object detection with various probe types
 - Cost reduction by limiting eddy current examinations to those with the applicable detection capabilities

Progress to date

- Lab Data collected and analyzed
- Matrix of results completed
- Currently developing Technical Update Report including guidance for determining the presence of foreign objects based on collected eddy current inspection data
 - Utilizing information gained from mockup and industry data for each probe type

Future Work

- Evaluation of detection capability FO wear in presence of expansion transition
- Collect additional data based on feedback from Technical Update Report
- Collect data from foreign object wear standards with foreign object(s) present – develop ETSS
- Correlate data with Foreign Object library
- Technical Update Report March 2009
- Final Report March 2010

SGTF Update: Operational vs. Accident Leakage



Operational vs. Accident Leakage

- Web cast training held in October and November to address NRC issues with leakage performance criteria
- Slides reviewed by NRR
- Approximately 30 people from 17 utilities attended
- Another training will be held in January to target the utilities that have not participated
- Presentations have been presented at TAG
- This information will be included in the SG Engineering Training material
- Recommend closure of this issue



SGMP Website Access



SGMP Website Access

- SGMP website and SG Degradation Database (SGDD) have been developed to assist SGMP member utilities
- Access is provided only to SGMP members and SG contract organizations sponsored by a member utility
- Direct access to SGMP web sites is not provided to the NRC
 - The NRC can visit the EPRI Charlotte office and review SG NDE performance info (i.e., ETSS)
 - Utility members may provide the NRC with specific information from the SGMP web site

TSTF 510

TSTF 510

- 95% complete
- Full TAG review
- TSTF committee final review
- Submit 2nd quarter 2009

**NRC Issues – NRC
Address Public Questions/Comments
NRC and Industry
Adjourn**

