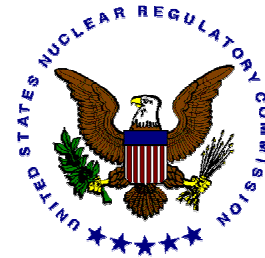


REGULATORY PERSPECTIVE ON STEAM GENERATOR TUBE OPERATING EXPERIENCE



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PRESENTATION OUTLINE

- U.S. Nuclear Regulatory Commission Steam Generator Oversight
- Steam Generator Replacement Status
- Thermally treated (TT) Alloy 600 Steam Generator Tube Experience
- Steam Generator Generic Communications
- New Steam Generator Technical Specifications – Status
- Conclusions

STEAM GENERATOR (SG) OVERSIGHT

- The U.S. Nuclear Regulatory Commission has the responsibility to:
 - Monitor and assess SG tube operating experience
 - Review industry proposals to revise technical specification requirements regarding:
 - SG tube inspections
 - SG tube repair requirements
 - Review significant occurrences, trends, and issues relating to SG tube integrity from a regulatory perspective

STEAM GENERATOR REPLACEMENT STATUS (CONT'D)

- **Early-to-mid 1970s**
 - All plants except one had mill-annealed (MA) Alloy 600 tubing
 - Dominant tube degradation mechanism – tube thinning
- **Mid-to-late 1970s**
 - Tube denting became the dominant tube degradation mechanism
- MA Alloy 600 SG tube degradation has resulted in:
 - Tube leaks
 - Tube ruptures
 - Mid-cycle SG tube inspections
 - Plant shutdown
 - SG replacement

STEAM GENERATOR REPLACEMENT STATUS (CONT'D)

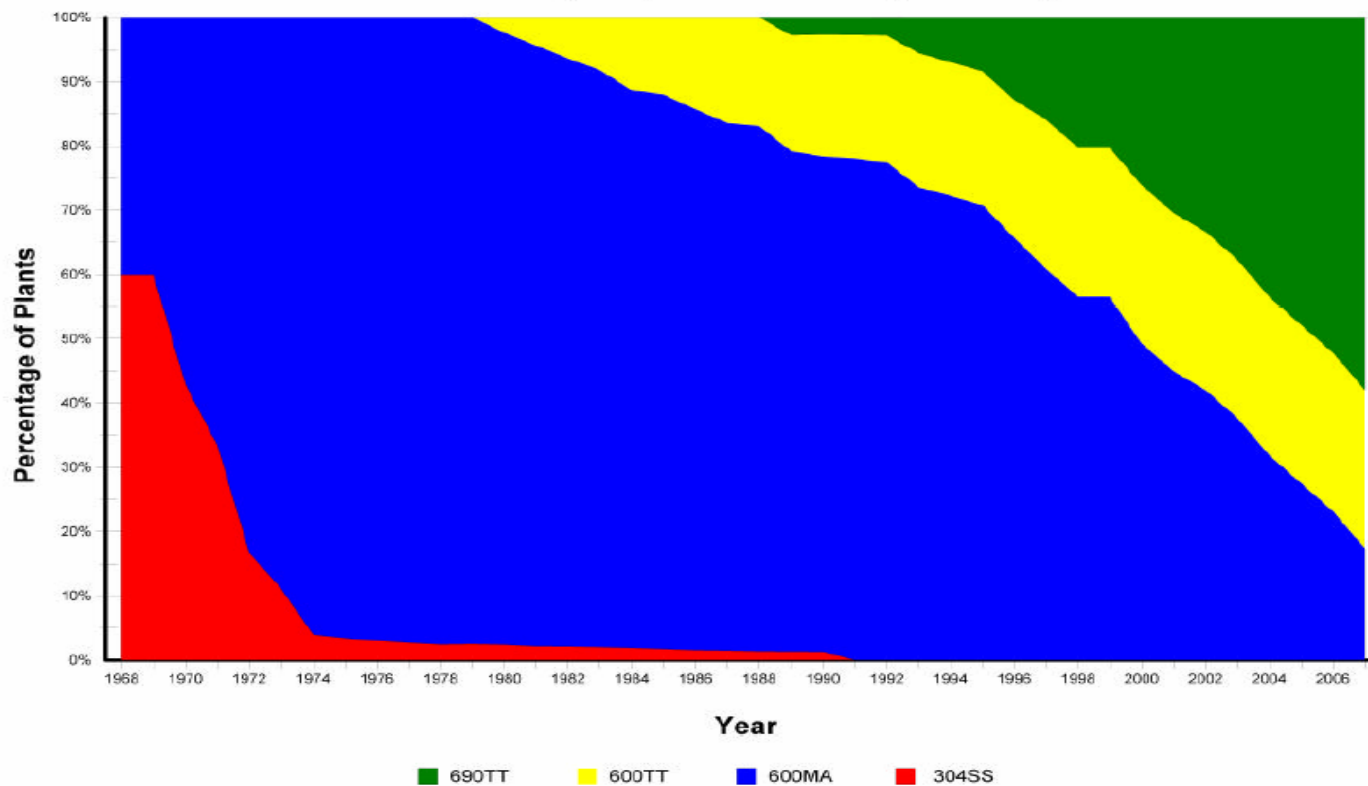
- **1980**
 - First SG replacement – TT Alloy 600
- **Early 1980s**
 - Approximately one plant per year replaced their SGs
- **1989**
 - First replacement SG with TT Alloy 690 SG tubes
- **Current**
 - 39 plants have replaced their SGs
 - 2 to 4 plants with MA Alloy 600 SG tubes are replacing their SGs per year

STEAM GENERATOR REPLACEMENT STATUS (CONT'D)

- 69 operating pressurized water reactors in the U.S.
- 22: MA Alloy 600 plants
- 17: TT Alloy 600 plants
- 30: TT Alloy 690 plants
- The number of plants with MA Alloy 600 SG tubes will continue to decrease while the number of plants with TT Alloy 690 SG tubes will increase

STEAM GENERATOR REPLACEMENT STATUS (CONT'D)

**Steam Generator Tube Materials
1968-2004 (Projected through 2007)**



THERMALLY-TREATED ALLOY 600 SG TUBE EXPERIENCE

- All SGs with TT Alloy 600 tubes were designed and fabricated by Westinghouse
- Dominant degradation mode in TT Alloy 600 tubes is wear (53-percent of plugged tubes plugged due to wear)
- **2002 - Seabrook**
 - First confirmed instance of SCC affecting TT Alloy 600 tubing
 - Seabrook SGs did not have the longest run time when compared to similarly designed and operated plants
 - Axially oriented linear indications were detected on the outer diameter tube surface at a number of tube-to-tube support plate intersections - associated with a distinctive offset signal

THERMALLY-TREATED ALLOY 600 SG TUBE EXPERIENCE (CONT'D)

- Degraded tubes exhibited elevated residual stresses that made them more susceptible to corrosion
- Elevated residual stress levels were attributed to a manufacturing anomaly
- Precise processing steps responsible for adverse stress state could not be conclusively determined from a review of the records
- All tubes with cracks were plugged
- **2003 – Seabrook**
 - 6 tubes with the same distinctive eddy current (EC) offset signal were identified
 - 3 of the tubes contained 9 outside diameter SCC indications at the tube support plate (TSP) elevations
 - All 6 tubes were plugged
 - Attributed to non-optimal tube processing

THERMALLY-TREATED ALLOY 600 SG TUBE EXPERIENCE (CONT'D)

- Plants with TT Alloy 600 tubing began to review their EC data for similar offset signals
- Several plants found tubes with similar offset signals
- **2003 – Braidwood 2**
 - Braidwood 2 SGs did not have the longest run time
 - 4 hot-leg TSP intersections in 3 tubes with the offset signal were identified as containing outside diameter SCC - all 3 tubes plugged
 - Occurred in region of the tube that passes through TSP
 - Attributed to non-optimal tube processing
 - To-date, only other plant with cracks in tubes exhibiting the offset signals

THERMALLY-TREATED ALLOY 600 SG TUBE EXPERIENCE (CONT'D)

- **2004 – Catawba**

- 3 circumferential indications were found in an overexpanded region within the tubesheet region of one tube
- Indications located approximately 7-inches below the top of the hot-leg tubesheet
- 9 tubes were found to have circumferentially oriented indications in the tack roll region (near the tube-end)
- Several hundred tubes were found to have indications in the tube-to-tubesheet weld

THERMALLY-TREATED ALLOY 600 SG TUBE EXPERIENCE (CONT'D)

- **2005 – Vogtle 1**
 - 3 circumferential indications were found on the inside diameter of 2 tubes
 - Indications were associated with bulges or overexpansions within the tubesheet region

THERMALLY-TREATED ALLOY 600 SG TUBE EXPERIENCE (CONT'D)

- In general, the operating experience for TT Alloy 600 SG tubes is favorable
- Operating experience for TT Alloy 690 SG tubes has been favorable - no reported incidence of cracking

STEAM GENERATOR GENERIC COMMUNICATIONS

- NRC uses information notices to inform the industry of recent operating experience
 - NRC anticipates that licensees will review information for applicability and consider taking actions to avoid similar issues
- NRC issues generic letters to obtain information regarding compliance with NRC requirements

STEAM GENERATOR GENERIC COMMUNICATIONS (CONT'D)

- Generic Letter 2004-01, Requirements for SG Tube Inspections
 - Advise industry of the NRC'S interpretation of certain technical specification (TS) requirements
 - NRC Position
 - Plants must use probes capable of detecting degradation that may exist along the entire length of the tube required to be inspected
 - Plants must apply for NRC approval if they do not want to use such probes to inspect certain portions of the tube
 - NRC approval of engagement and leakage models required

STEAM GENERATOR GENERIC COMMUNICATIONS (CONT'D)

- **Information Notice 2004-10, Loose Parts in SGs**
 - Inform industry about loose parts found in SGs
 - Loose parts may result in SG tube degradation and lead to tube leakage
 - Stressed the importance of performing engineering evaluations in cases where the loose part cannot be retrieved to determine whether the part will impair tube integrity if it is left in service
 - Recommended procedures for precluding the introduction of loose parts into the primary- and secondary-system (equipment accountability, post-maintenance inspections)

STEAM GENERATOR GENERIC COMMUNICATIONS (CONT'D)

- **Information Notice 2004-16, Tube leakage due to a Fabrication Flaw in a Replacement SG**
 - Result of a small primary-to-secondary leak at Palo Verde 2 during first cycle of operation with replacement SGs
 - Following root cause analysis, leaking tube had damage similar to what would be observed if a packing screw had contacted the tube during packing of the tubes into a shipping crate
 - Important to monitor fabrication process including packing procedures for the tubes and the receipt inspections performed at the fabrication facility
 - Communicating non-conforming conditions observed during fabrication to the individuals responsible for the preservice examination so that these individuals can further ensure that such conditions do not exist in the SG

STEAM GENERATOR GENERIC COMMUNICATIONS (CONT'D)

- **Information Notice 2004-17, Loose Part Detection and Computerized EC Data Analysis in SGs**
 - Inform the industry about challenges associated with the detection of loose parts and recent experience applying computerized data screening algorithms in evaluation of SG EC data
 - Result of two issues at Shearon Harris
 - A leaking tube with a through-wall flaw caused by a loose part
 - Flaw was not detected by standard bobbin coil analysis techniques - masked by an interfering signal (top of tubesheet region)
 - Improper settings used by the computerized data screening algorithm resulted in skipping the evaluation of a small portion of tubing

NEW STEAM GENERATOR TECHNICAL SPECIFICATIONS - STATUS

- Each U.S. nuclear facility has similar but not identical SG TSs
- Most plants' TSs were developed in the 1970s
- Issue
 - Many plants' TSs do not reflect the current understanding of SG tube degradation and the improvements in SG design

NEW STEAM GENERATOR TECHNICAL SPECIFICATIONS – STATUS (CONT'D)

- New TS Characteristics
 - Consistent with the TSs developed under the Nuclear Energy Institute's 97-06 initiative
 - Risk informed
 - Performance based
 - Reflect current understanding of tube degradation and newer SG improvements
 - Tube integrity program goals are defined in terms of performance criteria
 - Structural integrity, leakage during normal operation, and leakage during postulated accident conditions

NEW STEAM GENERATOR TECHNICAL SPECIFICATIONS – STATUS (CONT'D)

- Adoption Facilitation of the New TS Requirements
 - The industry's Technical Specification Task Force requested the NRC to approve a generic revision to the SG portion of the TSs
 - The U.S. NRC issued a “Notice of Availability” of the Technical Specification Task Force proposal allowing plants to adopt the new SG TSs under a streamlined revision process

NEW STEAM GENERATOR TECHNICAL SPECIFICATIONS – STATUS (CONT'D)

- Currently
 - The NRC has issued a generic letter in the Federal Register for public comment
 - Generic Letter 2004-xx, SG Tube Integrity and Associated Technical Specifications
 - If finalized, this generic letter will request the following from U.S. nuclear facilities that have not adopted the new SG TSs
 - Discuss the adequacy of their SG tube integrity program and their plans to modify their program to ensure it appropriately reflects performance criteria
 - Discuss how bending loads are assessed in their evaluations of tube integrity
 - 6 units have been approved
 - 6 units have requested approval

CONCLUSIONS

- Many plants have replaced their SGs due to tube degradation
- Newer SG designs show favorable operating experience with few instances of cracking reported
- Programs for managing SG tube integrity are improving
- SG tube inspection requirements are being improved