

Steam Generator Management (QA)

Program Overview

Program Description

Many factors affect materials degradation in steam generators, including water chemistry, inspection limitations, material performance issues, and the presence of foreign objects. Greater understanding of these factors and their integrated impacts will lead to more effective tools to predict the potential for degradation and more effective inspection and mitigation techniques to identify and address degradation.

The Electric Power Research Institute's (EPRI) Steam Generator Management Program conducts research to ensure the safe, reliable, and economic operation of steam generators in pressurized water reactor plants. Research activities target identification and mitigation of various forms of steam generator degradation, foreign object assessments, optimized operation of replacement steam generators, water chemistry, in-service inspections, and tube integrity.

Research Value

The Steam Generator Management Program drives greater consistency in managing steam generator issues across the nuclear fleet. The program develops guidance for existing issues such as degradation in steam generators with original Alloy 600 MA tubes, as well as emerging issues such as managing degradation in steam generators with the more corrosion-resistant Alloy 600 TT, Alloy 690 TT, and Alloy 800 tubes. Program participants gain access to the following:

- Strategic roadmaps outlining research gaps confronting key issues—such as foreign object management, tube integrity assessment, and steam generator life management—and the collaborative actions needed to address these gaps
- Guideline documents that reduce the potential for steam generator tube ruptures and forced leakage outages, which can cost an estimated \$5 to \$20 million per event
- Better tools for integrity assessments, reducing unnecessary examinations that can cost an estimated \$1 to \$2 million per plant
- Performance information on steam generator examination techniques that can be used to optimize inspections, increasing the probability of detection of existing tube degradation mechanisms
- Chemistry controls that can delay the onset of corrosion and mitigate steam generator fouling
- A database of worldwide steam generator information related to degradation, used to inform decisions on steam generator operation and maintenance

Approach

The Steam Generator Management Program applies an integrated approach for managing steam generator materials degradation in pressurized water reactors. The program develops guidance through improved understanding of how multiple variables impact steam generator operation and maintenance, including thermal hydraulics, water chemistry, tubing materials, inspection techniques, and tube-plugging/repair criteria.

The Steam Generator Management Program closely collaborates with other EPRI programs, including Materials Reliability, Nondestructive Evaluation, and Chemistry, to ensure appropriate technologies and technical guidance are effectively integrated into research activities.

There are both base and supplemental components of the Steam Generator Management Program. The base portion encompasses nondestructive evaluation (NDE) research and development, water chemistry, materials performance/thermal hydraulics, and the Steam Generator Degradation Database.

- Nondestructive Evaluation: This project develops tools such as software algorithms, improved inspection techniques, and database libraries to enhance the accuracy and efficiency of steam generator

inspections. Improved flaw detection and flaw-sizing accuracy capabilities, for example, could better inform decisions regarding operating intervals between inspections.

- **Water Chemistry:** This project develops guidelines, chemistry technologies, and predictive models to minimize steam generator tube corrosion and fouling, and to optimize chemistry for safe, reliable, and long-term steam generator operation. Advanced technology developments are incorporated into application sourcebooks to inform water chemistry control actions, including the use of improved amines, dispersants, molar ratio control, and intergranular stress corrosion cracking inhibition.
- **Materials Performance and Thermal Hydraulics:** Foreign objects and tube wear can threaten safe and reliable steam generator operation. This project conducts experiments and develops computational simulations that more accurately estimate foreign object movements and tube wear rates from steam generator foreign objects. Prediction tools and on-line measurement techniques also are needed to manage issues resulting from buildup on tube support plates. Finally, corrosion studies can help determine the effect of various steam generator environments on tube degradation rates.
- **Steam Generator Degradation Database:** This project maintains a web-based database of steam generator information. This database contributes to the safe and reliable operation of steam generators by providing data to inform decisions regarding inspection scope, tube repair activities, and the effectiveness of steam generator corrective actions, such as chemical cleaning.

To address strategic objectives established for each of its programs, EPRI has developed roadmaps to plan, coordinate, and execute needed research among multiple entities. For the Steam Generator Management Program, roadmaps have been developed to address the technical barriers confronting foreign object management, tube integrity assessment, steam generator life management, and aging management of the steam generator channel head assembly. Additional roadmaps will be developed as conditions warrant.

The supplemental portion of the Steam Generator Management Program provides mechanisms for responding to emerging issues and for developing effective monitoring and assessment programs.

- **Supplemental Research and Emerging Issues:** This project enables EPRI to conduct research to address emerging technical, operational, and regulatory issues not anticipated in annual research planning. This project also facilitates research in specific areas that may not be of interest to the broader base of program participants. Such research could include additional capabilities for software products, database maintenance for alternate tube repair criteria, and review of newly developed chemical additives.
- **Structural Integrity Assessment and Nondestructive Evaluation Field Support:** This project develops products to ensure steam generator tube integrity through thorough inspections, condition monitoring, and operational assessments. Cornerstone products include the *Steam Generator Examination Guidelines* and its qualification program, the *Steam Generator Integrity Assessment Guidelines*, the *Steam Generator Primary-to-Secondary Leakage Guidelines*, and the *Steam Generator In-Situ Pressure Test Guidelines*.

Accomplishments

EPRI's Steam Generator Management Program supports nuclear power industry efforts to minimize the potential for steam generator tube ruptures, forced leakage outages, and other steam generator integrity issues. Accomplishments include both technology development and technical support, spanning more cost-effective nondestructive evaluation techniques for steam generators to technical input into regulatory issues.

- Updated guideline and supporting technical documents implementing the requirements of nuclear industry initiative NEI 97-06, which imposes requirements for a nuclear plant's steam generator program.
- Developed new applications for dispersant use beyond online addition to reduce steam generator fouling: dispersant addition during steam generator wet layup as well as during the long-path recirculation cleanup of the condensate and feedwater systems just prior to plant startup.
- Developed software algorithms for automatic eddy current data analysis, demonstrated high levels of performance for detection of steam generator tube degradation, and transferred the technology to NDE organizations for field application.
- Developed eddy current data analysis guidance for detection and depth sizing performance indices relating to steam generator wear.

- Published a computer-based training course for steam generator engineers.
- Assessed potential mechanisms for lead transport to steam generator tube crack tips; hindering lead transport to the crack tips can help prevent lead-induced stress corrosion cracking.
- Developed guidance for steam generator upper internals inspection scope and frequency.
- Analyzed the impact of advanced amine use on iron transport, flow accelerated corrosion, and steam generator fouling in pressurized water reactor secondary systems.
- Developed guidance and tools for eddy current noise measurement and monitoring, which will enable steam generator engineers to better understand the probability of tube leak detection in the presence of eddy current noise.

Current Year Activities

Steam Generator Management Program research and development for 2013 will focus on continued development of dispersant applications; advanced inspection and inspection analysis methods; root causes of steam generator degradation; and guideline revisions related to water chemistry. Specific efforts include the following:

- Update the *Steam Generator Integrity Assessment Guidelines*, which provides guidance and procedures for performing steam generator tube integrity assessments and demonstrating compliance with performance criteria.
- Evaluate the significant plant experience with dispersant application (online, long-path recirculation cleanup, and wet layup) to more fully develop and optimize current guidance.
- Update the *Steam Generator PWR Primary Water Chemistry Guidelines*, which define needed requirements and provide guidance in optimizing primary water chemistry programs.
- Update the *PWR Steam Generator Examination Guidelines*, which provide requirements for examination plans and processes that are necessary to meet performance criteria set forth in industry initiatives.
- Continue development of advanced software algorithms for automated eddy current data analysis for detection of steam generator degradation and foreign objects.
- Update *Generic Predictions*, which includes predicting the future extent of tube degradation in steam generators with Alloy 800NG, Alloy 600TT, and Alloy 690TT tubes.
- Assess the effect of deposit removal frequency on management of sludge in steam generators.
- Evaluate plant experience and perform research to understand the root cause of denting of tubes at the top of the tubesheet.
- Continue to develop the next generation steam generator thermal-hydraulics code (Triton) and initiate a supporting experimental program.
- Continue research to understand the safety significance of divider plate crack propagation during extended periods of performance.
- Conduct a steam generator engineering training course.

Selected reports and products may be prepared in whole or in part in accordance with the EPRI Quality Program Manual that fulfills the requirements of 10CFR50 Appendix B and 10CFR21. The QA status of reports and products will be marked and identified.

Estimated 2013 Program Funding

\$7.1 million

Program Manager

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