

## **63 Boiler Life and Availability Improvement Program**

### **Program Overview**

#### **Program Description**

This highly collaborative international program develops technology and guidance on safe management of boiler component life to ensure high reliability and reduce operations and maintenance (O&M) costs. Technology development efforts focus on advanced inspection techniques for early and accurate identification of component damage, analytical tools to predict remaining life and risk of in-service failure, and decision-support tools to help balance risk and benefit under a variety of operating scenarios. The program portfolio includes guidelines, reports, software code, and tools applicable to all boilers, with the goal of optimal availability and performance.

#### **Industry Needs and Issues Addressed**

- Boiler tube failures are the leading cause of lost availability (approximately 3%) in fossil-fired steam plants worldwide
- Majority of worldwide fossil plants are more than 30 years old and are experiencing increased demand for operational flexibility, while addressing age-related issues for major components
- High-energy steam and water piping systems are among the most important safety issues at fossil plants and must be managed reliably through the aging process

#### **Impact**

- Reduce cost of lost availability due to boiler tube failures from greater than \$10,000/MW/yr to less than \$1,000/MW/yr when program results applied comprehensively
- Increase safety of high-energy piping systems
- Increase safety through control of flow-accelerated corrosion (FAC) in fossil plants

#### **Key Accomplishments**

- Created and successfully demonstrated a world-recognized program to reduce boiler tube failures by understanding damage mechanisms, their root causes, and corrective options for root causes
- Created the most comprehensive suite of guidelines and analysis tools for boiler component life management
- Leading source of guidance, training, and analysis tools for flow-accelerated corrosion (FAC) management in fossil plants
- World leader in developing and demonstrating nondestructive evaluation (NDE) technologies for boilers and FAC

#### **Current Year Objectives**

- Guidance to address damage from evolving operating modes within current fossil fleet, including fuel switching, cycling, low load, and environmental constraints
- Technology and information to support reliable operation of new and advanced fossil boiler designs

#### **Industry Involvement**

- Estimated 2009 funding: \$4.0M

#### **Program Technical Lead**

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## Summary of Projects

| Project Number | Project Title  | Value  |
|----------------|--|--|
| P63.001        | Research for Boiler Component Inspection and Monitoring        | Project to develop accurate and cost-effective NDE to reduce O&M costs and improve life management options. NDE developments in other industries also will be evaluated for application to fossil plants.  |
| P63.002        | Tools for Boiler Component Life Management                     | A comprehensive approach to creating technical bases for minimizing in-service component damage and for component remaining-life assessment. Both areas are critical for high reliability and maximum equipment life.  |
| P63.003        | High Energy, Steam and Water Piping Safety and Life Management | Project to address safety and reliability of high-energy piping systems in fossil power plants. Information on how damage mechanisms affect piping components and remaining life tools will be provided. Tools will be developed that allow utilities to more accurately predict remaining life of piping systems. |

## Project Descriptions

### P63.001 Research for Boiler Component Inspection and Monitoring (103518)

#### Issue

Maximizing safety and reliability of boiler components and determining optimal timing for repair or replacement requires accurate and timely detection of service-generated damage. Additionally, new technologies for NDE might allow faster examination of boiler components at lower cost, resulting in shorter outages. This project provides the technology, tools, and application support via R&D, applications, workshops, and training required.

#### Description

To achieve longer intervals between inspections and overhauls of boiler components, it is necessary to detect service-related damage at an early stage. EPRI will develop new NDE techniques for detecting damage at an earlier stage than is currently possible. This detection is intended to identify a multi-year period during which the power producer must take action to avoid significant risk-of-failure during service. EPRI also will pursue NDE alternatives that are faster, better, or cheaper than traditional techniques. Guidance will be developed as needed to ensure effective use of NDE tools. EPRI will research the science and application of continuous monitoring technologies that will provide the highest degree of information on damage initiation and progression. In conjunction with remaining-life models developed under P63.002 and P63.003, these approaches will allow optimal decisions for component repair or replacement with minimal risk of failure during the service life.

#### Value

- Improved reliability and lower O&M costs via reduced risk of service failures.
- Extended intervals between examinations via more sensitive and more accurate NDE applied to boiler components.
- Reduced O&M costs via more efficient NDE techniques for damage detection.
- Demonstration of NDE personnel and technology proficiency provides utilities with more accurate examination results.

**How to Apply Results**

Research results to develop new or improved NDE techniques generally will be licensed to commercial NDE companies that will offer the technology for sale or performed as a service. Larger utilities might use the results directly via in-house NDE organizations. Guideline reports to support correct application of NDE technology can be used by members as training guides and for process or procedure improvements with an eye to improve reliability while lowering O&M costs. Technology will be presented to members via workshops conducted regionally in association with EPRI programs or user or interest group meetings.

**2009 Products**

| Product Title & Description   | Planned Completion Date | Product Type                      |
|---|-------------------------|-----------------------------------|
| <b>Inspection Guideline for Flow Accelerated Corrosion in Piping Systems:</b> A review of NDE technologies as they apply to detection of wall loss from FAC and information on when, where, and how to use each for a successful FAC program. Technologies for examination online, during outages, and without removing insulation will be included.  | 12/31/2009              | Technical Update                  |
| <b>Workshop on Boiler Component Inspection and Monitoring:</b> Workshop materials related to boiler component inspection and monitoring.  | 12/31/2009              | Workshop, Training, or Conference |
| <b>NDE Technology for Quantification of Waterwall Tube Deposits:</b> A technical update documenting the results of field demonstration of NDE technology developed in 2008 for accurate measurement of waterwall tube deposit thickness. The report will include the results of field evaluation and information on how the hardware can be used to measure oxide thickness on boiler waterwall tubing. | 6/30/2009               | Technical Update                  |
| <b>Guided Wave Examination Technology for Superheaters &amp; Reheaters:</b> A technical update documenting the ultrasonic guided wave technology developed in 2008. The report will include field evaluations and information on how the hardware can be used to examine reheater and superheater tubing in boilers.  | 12/30/2009              | Technical Update                  |
| <b>Electromagnetic Examination Technology for Superheaters and Reheaters:</b> A technical update documenting the electromagnetic NDE technology developed in 2008. The report will include field evaluations and information on how the hardware can be used to examine reheater and superheater tubing in boilers.   | 12/30/2009              | Technical Update                  |
| <b>Advanced NDE Systems for Boiler Components:</b> Development of new NDE methods for boiler components. This work may be an application of existing technology, development of new technology, or a combination in which an existing technology is augmented with new hardware in order to apply it to a previously inaccessible location.   | 12/31/2009              | Hardware                          |

### Future Year Products

| Product Title & Description   | Planned Completion Date | Product Type                      |
|---|-------------------------|-----------------------------------|
| <b>Inspection Methods for Boiler Tubing Ceramic Coating:</b> Many companies now offer ceramic coatings for boiler tube protection and ash removal. This project will evaluate examination methods for coating life prediction.  | 2010                    | Technical Update                  |
| <b>Drum Damage Detection and Sizing Guideline:</b> Drum cracking is occurring more frequently. Predicting remaining life and crack propagation requires an accurate assessment of the extent of existing damage. The project will investigate methods to characterize, measure, and document damage.  | 2010                    | Technical Report                  |
| <b>Advanced NDE Systems for Boiler Components:</b> Development of new NDE methods for boiler components. This work may be an application of existing technology, development of new technology, or a combination in which an existing technology is augmented with new hardware in order to apply it to a previously inaccessible location. | 2010                    | Hardware                          |
| <b>Monitoring Technology for Boiler Component Damage:</b> An investigation of on-line monitoring technologies to verify component condition.  | 2010                    | Hardware                          |
| <b>Workshop on Boiler Component Inspection and Monitoring:</b> The workshop materials developed in 2009 will be packaged as a formal workshop that can be conducted regionally; in association with EPRI programs or user or interest group meetings; or otherwise based on interest.   | 2010                    | Workshop, Training, or Conference |

### P63.002 Tools for Boiler Component Life Management (103519)

#### Issue

Boiler tube failures are consistently the leading cause of lost availability for fossil power plants, averaging around 3% worldwide. This project will continue to focus on the technology and tools required to cost-effectively minimize boiler tube failures. The project will address life management issues associated with high-cost and high-impact boiler components such as tubes, headers, and drums. The project includes support for implementing a boiler tube failure reduction program, performing life management of headers and drums, and for peer-to-peer communications on boiler issues through the Boiler Reliability Interest Group (BRIG).

#### Description

Projects will advance the understanding of boiler tube and other pressure component damage mechanisms and their root causes, and establish programs and corrective actions to control risks of in-service failures. This science and information will be captured in practical guides for fossil plant personnel. As needed, tools for more accurate remaining-life analysis will be created to support the life-management objectives.

#### Value

- Improve boiler availability through fewer boiler tube failures.
- Lower O&M costs through longer operating lives for major boiler components.
- Reduce risk of in-service failures in tubes, headers, and drums.

### How to Apply Results

Guidance on boiler tubing, headers, and drums can be used by members to establish a boiler tube failure reduction program and perform life-management analyses. Peer-to-peer communications on boiler issues, optimally through attendance at the Boiler Reliability Interest Group (BRIG), give members the opportunity to take advantage of industry lessons learned. Analytical tools may be licensed to commercial vendors to take the technology to market, allowing members to apply the tools directly or via a service. Targeted workshops with EPRI staff bring worldwide expertise to a member's shop to increase the likelihood of implementing these research results.

### 2009 Products

| Product Title & Description  | Planned Completion Date | Product Type                      |
|--|-------------------------|-----------------------------------|
| <b>Member-Specific Boiler Tube Failure Reduction Support:</b> Support will be provided as necessary to assist utilities in reducing boiler tube failures. This support may involve tube failure analysis for new damage mechanisms.  | 12/31/2009              | Technical Resource                |
| <b>Boiler Reliability Interest Group (BRIG) Meetings and Information Exchange:</b> Meetings will be conducted semi-annually to exchange information on damage mechanism, life assessment, and NDE for various boiler components. The meetings are recognized as the leading information exchange forum for the fossil industry related to boiler and piping issues. The meetings include utility, vendor, and EPRI presentations on topics of interest to the utility community. Topics for future BRIG meetings are selected by attendees based on recent utility experiences. Discussions are facilitated by a BRIG Chairman selected from among the members of Program 63, and these discussions frequently lead to projects. | 12/31/2009              | Technical Resource                |
| <b>Workshop on Advanced Techniques for Remaining Life Assessment of Boiler Components:</b> This workshop will provide information on setting up and administering a life assessment program for boiler components. It will incorporate the latest information on damage mechanisms and NDE techniques to enable decisions on how long components may be operated safely. Life assessment techniques for various components will be reviewed.   | 12/31/2009              | Workshop, Training, or Conference |
| <b>Operational Issues with Advanced Ferritic Boiler Tubing:</b> Premature failures are common in superheat and reheater tubes manufactured from advanced ferritic materials including Grades 91 and 92. It remains unclear if this damage is occurs during manufacture, startup, operation, or shutdown. This project will demonstrate monitoring techniques and recommendations for operational procedures for units with advanced materials. It will include case histories of recent failures and provide information about how to avoid repeat failures.   | 12/31/2009              | Technical Update                  |
| <b>Update of Boiler Tube Failure Books:</b> These books were last updated in 2006. New failure mechanisms have been recognized since then. This project will provide a minor update to the books and include additional information on carburization, strain-induced precipitation hardening, cold creep, advanced ferritic tube material degradation, and other damage mechanisms. It also will incorporate advanced oxidation information currently being developed in Program 87.   | 12/31/2009              | Technical Update                  |

### Future Year Products

| Product Title & Description  | Planned Completion Date | Product Type                      |
|--|-------------------------|-----------------------------------|
| <b>Boiler Condition Assessment Guideline—Update:</b> EPRI has developed a guideline for boiler components that is the industry standard for determining the amount of time that a component may be operated. This update will provide new information on inspection technologies and remaining-life calculations for specific boiler components. | 2010                    | Technical Report                  |
| <b>International Conference on Advances in Condition and Remaining Life Assessment for Fossil Power Plants:</b> EPRI conducts the International Conference on Advances in Condition and Remaining Life Assessment of Boiler Components every three years. This conference will present the latest information on managing boiler assets.         | 2010                    | Workshop, Training, or Conference |
| <b>Cold Air Balancing for Fly Ash Erosion Control:</b> This will be the final report of a two-year project examining computational fluid dynamics to simplify installation of flow control devices used to minimize fly ash erosion.   | 2010                    | Technical Report                  |
| <b>Member-Specific Boiler Tube Failure Reduction Support:</b> BRIG meetings are conducted semi-annually to provide an open forum for industry issues.  | 2010                    | Technical Resource                |
| <b>Boiler Reliability Interest Group Meetings and Information Exchange:</b> Begin Typing Here  | 2010                    | Technical Resource                |

### P63.003 High Energy, Steam and Water Piping Safety and Life Management (060364)

#### Issue

High-energy steam and water piping failures are one of the most important safety and availability issues in fossil power plants. EPRI research has identified key damage mechanisms such as creep, fatigue, and corrosion that can lead to piping failure. Flow-accelerated corrosion (FAC) is a major safety issue in fossil plants. Research continues to refine the understanding of these damage mechanisms and how they are affected by component aging and variation in operating modes for the plant. Safe and reliable operation of piping systems requires active damage prevention, period inspection, remaining-life assessment, and repair or replacement programs. These activities are a proactive life-management approach. This project will provide information about damage mechanisms, their root causes, and appropriate responses to ensure safe operation of these piping systems, and will include workshops and training to ensure proper application of life management processes.

#### Description

Projects will improve the understanding of damage mechanisms and their root causes and establish programs and corrective actions to control risks of in-service failures. Tools for more accurate and cost-effective NDE and analysis of damage rates will be created. This project will begin to develop life assessment tools to address aging in advanced ferritic piping systems.

**Value**

- Reduce risk of high-consequence failures of high-energy steam and water piping systems by applying tools and guidance developed by this project.
- Eliminate FAC as a safety issue in fossil plants.
- Reduce O&M cost associated with piping life management by improving inspection accuracy and efficiency.
- Reduce O&M costs by lessening very conservative assumptions of piping life and providing more accurate assessment of timing for pipe replacement.

**How to Apply Results**

This program will help members establish a proactive life-management approach to high-energy piping systems and FAC control. This project will provide information about damage mechanisms, their root causes, and appropriate responses to ensure safe operation of these piping systems, and will include workshops and training to ensure proper application of life management processes. Advanced NDE and analysis tools developed in the project may also be licensed to third parties for application at fossil plants.

**2009 Products**

| Product Title & Description  | Planned Completion Date | Product Type                      |
|--|-------------------------|-----------------------------------|
| <b>Webcast Training for BLESS and RLSM:</b> Webcast training will provide hands-on instruction for new users of the BLESS and RLSM software programs.  | 12/31/2009              | Workshop, Training, or Conference |
| <b>Update of EPRI's Long Seam Welded Piping Guideline:</b> Failures of long seam piping are one of the most catastrophic events in the utility industry. The EPRI guideline includes background on historic failures, inspection guidance, and other information needed by utilities for an effective longitudinal seam welded piping program. This update will include information about recent longitudinal seam failures, a review of the new allowables in the ASME Boiler and Pressure Vessel Codes, including B31.1, and their impact on existing and new piping systems.                                    | 12/31/2009              | Technical Report                  |
| <b>Guideline on management of Piping Systems using Creep Strength Enhanced Ferritic Alloys:</b> Premature failures are common in piping systems using advanced ferritic alloys including Grade 91. EPRI's Program 87 has evaluated many of these failures and determined a number of the causes, including fabrication and operational issues. A large project was kicked off in 2007 to determine degradation methods, NDE techniques, and life management procedures with these alloys. A guideline started in 2009 will compile this information for managing piping components manufactured from these alloys. | 12/31/2010              | Technical Update                  |
| <b>Guideline on State-of-the-Industry use of Acoustic Emission</b>   | 12/31/2009              | Technical Update                  |

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**Future Year Products**

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| <b>Product Title &amp; Description</b>   | <b>Planned Completion Date</b> | <b>Product Type</b>               |
|--|--------------------------------|-----------------------------------|
| <b>Evaluation of Coatings for FAC Protection:</b> FAC continues to be an active damage mechanism in feedwater piping systems, deaerators, and economizers. Possible coating solutions for this failure mechanism will be evaluated, including nano-coatings and spray-on coatings.                                   | 2010                           | Technical Update                  |
| <b>Update to High Energy Piping: Theory and Practice:</b> This report will provide an updated guideline on high-energy piping damage mechanisms and remaining life tools.  | 2011                           | Technical Report                  |
| <b>Workshop on High-Energy Steam Piping:</b> A regional workshop will be provided on high-energy piping life management.   | 2010                           | Workshop, Training, or Conference |
| <b>Guideline on Piping Stress Analysis and Hanger Testing:</b> This guideline will include detailed assumptions made in a piping stress analysis and will show benefits for life assessment of piping systems. The guideline also will provide information about hanger testing and the importance of piping stress. | 2010                           | Technical Update                  |
| <b>Cold Reheat Piping and Attemperator Inspection Guideline:</b> The guideline will describe options for inspection of cold reheat lines, desuperheater sprays, and liners.  | 2010                           | Technical Update                  |

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