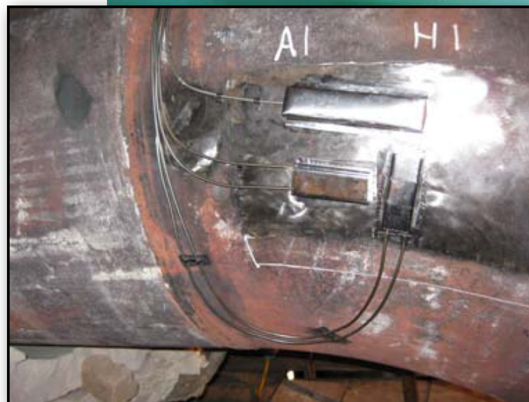
EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Success Story

TECO Uses EPRI Guidelines on CSEF Steel to Prevent Failures and Avoid Costly Repairs



Installation of high-temperature strain gauges on P91 at TECO's Bayside Plant

Tampa Electric Company (TECO) is using EPRI guideline documents on life management of creep strength enhanced ferritic (CSEF) steels to assist in the procurement, fabrication, erection, and field evaluation of these materials in the utility's combined-cycle plants. The guidelines have helped TECO to identify issues of concern with CSEF steels and to follow proper welding and heat treatment procedures. These practices, in turn, are enabling the company to ensure the expected material performance of the CSEF steel, preventing component failures and avoiding costly unplanned outages.

In addition, TECO served as a host site for the first U.S. implementation of elevated-temperature, strain-monitoring equipment on a piping section of degraded Grade 91 steel.

"Through this project, Tampa Electric saw significant cost savings. EPRI guidelines outlined installation, assessment and monitoring of the components, and we avoided making a costly replacement."

~ Zyad Jabal, *Consulting Engineer, Tampa Electric Company*

Deficiencies and Irregularities of CSEF Steels

Grade 91 steel, one of several CSEF steels, was initially developed in the 1970s for use in nuclear reactors. The alloy has a number of enhanced mechanical properties, including high creep-rupture strength and fracture toughness. This higher strength makes Grade 91 attractive for fossil plant applications because of the potential for higher operating temperatures—up to 1100°F (593°C)—and lower wall thicknesses. Grade 91 is suitable for use as a retrofit material in conventional subcritical power plants and as a building material for advanced supercritical plants.

In recent years, damage has been found early in the life of CSEF steels, including Grade 91, used in the boiler tubes, piping, and headers of fossil-fuel-fired and combined-cycle power plants. This discovery has raised concerns among users due to the potential for tube failures and the implications for the safety of plant personnel and the reliability of equipment. Additionally, utilities currently have few tools at their disposal to assess CSEF components in-service and to accurately predict the life of these steels.

Life Management of CSEF Steel

EPRI has conducted a broad-based collaborative project, entitled "Life Management of CSEF Steel," to address the critical issues. The project, which brings together experts from around the world, provides information and tools to assist companies with material procurement, shop fabrication, field erection, evaluation of the in-service behavior of the base metal and weldments, life prediction, and maintenance optimization.

For example, a guideline document developed for the project provides information to assist utilities with the "front-end" issues — specifying and ordering the optimum CSEF steel for a specific plant, and monitoring how the steel is processed and which quality controls are employed during processing. Other guidelines developed in the EPRI project are identifying best practices for inspection strategies and inspection methods, such as hardness testing and metallographic replication. A third area of deliverables includes tools for life prediction and management of CSEF steel. In this regard, as a first step in understanding the basic factors in the behavior of CSEF steel at elevated temperature, the EPRI project is developing an "Atlas of Microstructures," which will compile a large number of Grade 91 samples, representing both acceptable and unacceptable conditions of tempering of base and weld metals.

Through TECO's participation in this project, the company identified fabrication and installation issues with Grade 91 in its combined-cycle power plants. With this information, plant operators repaired and planned future installations with greater control to ensure expected material performance.

Monitoring Strain Accumulation

In a separate demonstration project, being conducted in parallel with the larger CSEF project, EPRI and TECO tested the use of high-temperature, capacitive strain gauges on Grade 91 steel components at the utility's Bayside Power Station, an 1800-MW combined-cycle power plant near Tampa, Florida.

In-service, high-temperature strain gauges directly monitor strain accumulation at critical sites on a component during plant operation. By monitoring the rate of strain accumulation in material in an area of high stress on a component, the gauges allow plant personnel to more accurately assess the material's time-to-rupture. This assessment would enable plants both to ensure timely replacement of deficient material, where the operating conditions are particularly rigorous, and to avoid unnecessary replacement of deficient material, where the operating conditions are not severe.

In the TECO project, the cheeks (sides) of two elbows made of Grade 91 steel in the hot reheat piping system were identified as having relatively low hardness values. The two elbows were instrumented with high-temperature capacitive strain gauges and thermocouples, and the sensors were monitored for a period of three months. The project found that creep strain rates could be successfully measured, resulting in proof-of-concept. Through the use of the elevated temperature strain gauges and assessment of the data produced, TECO avoided making a costly piping system repair.

"Through this project, Tampa Electric saw significant cost savings," said Zyad Jabal, consulting engineer for Tampa Electric. "EPRI guidelines outlined installation, assessment and monitoring of the components, and we avoided making a costly replacement."

Related EPRI Work

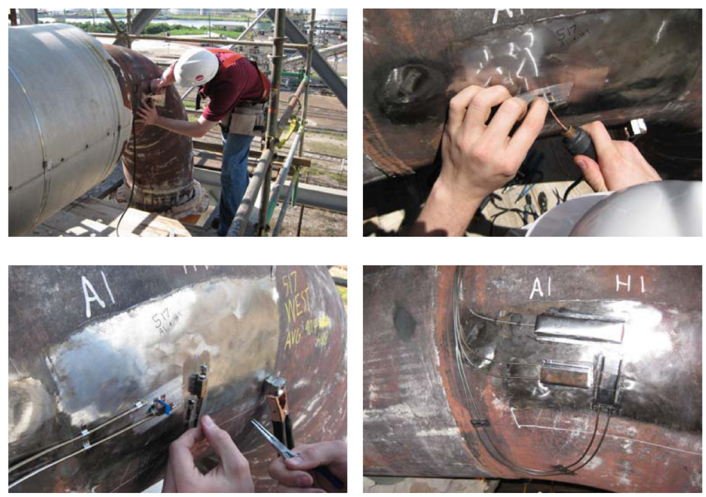
Instrumentation and Data Analysis for Creep Monitoring of P91 Material at TECO Bayside. EPRI. Palo Alto, CA: June 2011: 1023200.

Guidelines and Specifications for Best Practice Guideline for Manufacturing and Construction of Grade 91 Steel Components. EPRI. Palo Alto, CA: November 2011. 1023199

Service Experience with Grade 91 Components. EPRI. Palo Alto, CA: August 2009. 1018151.

Evaluation of Factors Affecting the Accuracy of Field Post-Weld Heat Treatment. EPRI, Palo Alto, CA: October 2012. 1024722

Kent Coleman, "EPRI Targets CSEF Steel Life," Energy-Tech Magazine, February 2010, pages 6 to 11.



Installation of strain gauges and thermocouples at TECO Bayside

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com)

CONTACTS

John Shingledecker, *Senior Project Manager, Materials and Chemistry*
704.595.2619, jshingledecker@epri.com

Kent Coleman, *Program Manager, MCR Major Component Reliability*
704.595.2585, kcoleman@epri.com

3002001714 June 2013

Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com