EPRI | ELECTRIC POWER RESEARCH INSTITUTE

SUCCESS STORY

ENTERGY USES EPRI-RECOMMENDED APPROACH TO ELIMINATE IRON TRANSPORT IN HEAT RECOVERY STEAM GENERATORS

Entergy operating companies used an approach, as recommended by EPRI research, to virtually eliminate iron corrosion and transport in the feedwater of a heat-recovery steam generator (HRSG). The approach, which injected oxygen downstream of the unit's low-pressure (LP) drum, arrested corrosion product transport and reduced the risk of single-phase flow-accelerated corrosion (FAC) in the downstream feedwater tubing.

The success of this cycle chemistry strategy led the utility to install oxygen injection systems in two more plants and plan for installation at five more. Mitigating the risk of FAC can reduce costly equipment damage. Lower corrosion product transport that minimizes the risk for underdeposit corrosion in the high-pressure (HP) evaporator and reduces the need to perform a chemical cleaning is a significant achievement for the utility.

FLOW-ACCELERATED CORROSION

FAC causes localized wall thinning (metal loss) in carbon steel piping, tubing and vessels exposed to flowing water (single-phase) or wet steam (two-phase). If undetected, the degraded component can suddenly rupture, releasing high-temperature steam and water into neighboring plant areas that often include locations where personnel may be present. Over the years, FAC has caused hundreds of piping and equipment failures in all types of fossil, industrial steam and nuclear power plants, as well as tube failures in HRSGs.

FAC is recognized as among the most important HRSG tube failure mechanisms. It generally has been located in the LP evaporator circuits. Incidents have occurred in LP, intermediate pressure (IP), and high-pressure (HP) economizer and preheater tubing, in the riser/feeder systems, and in IP drums.

EPRI GUIDELINES

To help operators of combined-cycle plants utilize the latest scientific research and field results for reduction of corrosion and deposition in their plants, EPRI has published an ongoing set of cycle chemistry guidelines. In 2013, EPRI published the third major revision of its *Comprehensive Cycle Chemistry Guidelines for Combined Cycle/Heat Recovery Steam Generators (HRSGs)* (3002001381).

This report, the cornerstone of the EPRI HRSG Cycle Chemistry Program, combines information from the previous guidelines and numerous other documents and reports into a single, comprehensive document, which covers all applicable feedwater and evaporator/drum-water treatments for combined-cycle/HRSG plants. Operating at higher pH and correlating the pH and specific conductivity helps to reduce iron corrosion in two-phase FAC locations.

Ninemile Unit 6 Combined Cycle

> *"This effort is a good example of how our company achieves success through our partnership with EPRI and its participating member utilities in the area of boiler chemistry management. These 'real-world' results will contribute to the long-term equipment health of our HRSG fleet and provide benefits to our key stakeholders, including our employees and our customers."*
>
> – **BOBBY BREEDLOVE**
> *Director Plant Support*
> Entergy

RELATED EPRI PRODUCTS

Title	Product ID
Guidelines for Control of Flow-Accelerated Corrosion in Fossil and Combined Cycle Plants.	3002011569
Heat Recovery Steam Generator Oxygen Injection: Case Study for Corrosion Reduction	3002006355
Comprehensive Cycle Chemistry Guidelines for Combined Cycle/Heat Recovery Steam Generators (HRSGs).	3002001381

Additionally, in recent years, the EPRI fossil plant cycle chemistry program has conducted research and field demonstrations specifically to better understand the mechanism of FAC and the most effective practices for its mitigation. In 2017, this work was summarized in *Guidelines for Control of Flow-Accelerated Corrosion in Fossil and Combined Cycle Plants* (3002011569).

One aspect of this work focused on optimizing the feedwater treatments to minimize single-phase FAC. Particular emphasis has been given to reducing iron-based feedwater corrosion products, which are a key FAC on-line indicator.

A technique for reducing iron transport, recommended in the EPRI *Cycle Chemistry Guidelines for Combined Cycle/HRSGs*, is oxygen injection into the feedwater piping immediately downstream of the feed-forward low-pressure (FFLP) drum. This innovative technique was first used by American Electric Power and documented in a case study report (3002006355) and in the recent EPRI *Guidelines for Control of FAC*.

APPLICATION AT ENTERGY PLANTS

In 2016, Entergy Louisiana, LLC began a series of initiatives at its 560-MW Ninemile Unit 6 HRSG in Westwego, Louisiana to reduce FAC. The initiatives included data collection, chemistry improvements, and operational changes.

The plant used iron transport as a tool to indirectly measure FAC potential. An on-site chemistry technician collected iron transport data on a weekly basis from an in-line Corrosion Product Sampler. Iron test results from an off-site lab were also trended in the Sample IQ database. A unit blowdown regime was implemented and incorporated, particularly at low loads, to remove hideout and drum contamination and to lower the iron concentrations.

At the center of the effort was installation of an oxygen injection system downstream of the LP drum. Results of this installation showed a significant reduction in the iron transport. Prior to the treatment, iron readings were recorded at 35-38 parts per billion (ppb) in the IP and LP drums. After implementation of the oxygen injection system and drum blowdown control, the iron readings were less than 1 ppb. At this level, FAC is basically eliminated in feedwater downstream of the LP drum.

The oxygen injection is also considered responsible for improvements in the plant's attemperators nozzles. After deployment of the oxygen treatment, only two nozzles needed replacement, down from eight prior to the treatment. Thus the oxygen injection provided a side benefit of reduced maintenance.

"The Plant Support Chemistry Group is committed to maintaining EPRI Chemistry guidelines and incorporating new technologies to protect plant assets by being proactive, plant involved and active team members within our Power Generation Fleet," said Elizabeth Johnson, Plant Support Water Chemistry Manager. "The reduction of flow-accelerated corrosion measured at less than 1 ppb iron transport, directly correlates to reduced long-term equipment damage, minimization of safety risk, and reduction in maintenance costs.

"The success of this cycle chemistry strategy was made possible by the leadership of Doug Lamalie, our Ninemile 6 Chemistry Specialist, and the teamwork between the NM6 plant personnel and the Plant Support Chemistry group," Johnson added. "We listened and incorporated the technology and data from EPRI and other utilities. Our plant personnel then listened and applied the Plant Support Chemistry personnel's advice. This is a win-win for everyone."

Following the success of the oxygen injection program at Ninemile Unit 6, Entergy operating companies installed oxygen injection systems at the Hinds Energy Facility and one unit of the Attala Generating Plant. Plans are also under way for oxygen injection projects at the other Attala unit, and at the Perryville Power Station, the Ouachita Power Facility, the Hot Spring Energy Facility, and the Union Power Station.

"This effort is a good example of how our company achieves success through our partnership with EPRI and its participating member utilities in the area of boiler chemistry management," said Bobby Breedlove, Director Plant Support. "These 'real-world' results will contribute to the long-term equipment health of our HRSG fleet and provide benefits to our key stakeholders, including our employees and our customers."

FOR MORE INFORMATION

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

Steve Shulder		*Program Manager*
Program		Boiler and Turbine Steam and Cycle Chemistry
Phone		704.595.2953
Email		sshulder@epri.com

3002012576 May 2018

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