Technology At Work

Alternative, Well-Engineered Weld Repairs in Grade 91

By Garrett Hering

After years of service at high temperatures in coal- and natural-gas-fired power plants, even the strongest steel components succumb to routine wear and tear. For Grade 91 steel tubing, piping, and other components, repairs such as field welding and post-weld heat treatment can be difficult.

Until recently, the National Board Inspection Code (NBIC) did not include guidelines specific to weld repairs of Grade 91 steel. As a consequence, owners and operators of power plant components fabricated from this material have had to follow rules for new plant construction, which require the use of a matching filler metal and post-weld heat treatment. EPRI and others, however, have documented that such approaches are not appropriate for all weld repairs. Post-weld heat treatment is costly, often complex, and can cause signification degradation of the material's performance.

"Weld repairs can be complex, and many component failures have occurred because of improper heat treatment," said John Siefert, EPRI's principal technical leader for research on alternative approaches. "Grade 91 steel is increasing in use, and changes are being made in the repair rules."

Code Revisions

Since 2010, EPRI's Fossil Materials and Repair Program has collaborated with key stakeholders in the power generation industry to develop well-engineered alternatives for Grade 91 steel tubing in steam boilers at coal plants and heat recovery steam generators (HRSGs) at gas plants, as well as in piping and other components.

As outlined in recent EPRI guidelines, these options avoid post-weld heat treatment. For internal boiler and HRSG tubing repairs, for example, the welding method relies on a nickel-based filler material. For repairs of balance-of-plant Grade 91 steel piping and other components, alternatives include nickel- and iron-based fillers and a reduced temperature post-weld heat treatment.

To initiate a code review, EPRI engaged with NBIC members, which include chief boiler inspectors for U.S. states and Canadian provinces. In 2015, NBIC formally approved EPRI's approach for tubing inside boilers and HRSGs, codifying it in Welding Method 6 in Part 3, Repairs and Alterations. Subsequent discussions have resulted in methods to address balance-of-plant repairs outside boilers and HSRGs. The code's 2017 edition may add these in a supplement, pending final determination later this year.

Transfer to Industry

EPRI is prioritizing transfer of the methods to industry. With support from EPRI staff and guidelines, the Tennessee Valley Authority (TVA) in 2014 repaired a Grade 91 steel valve on the main steam line at its Southaven combined-cycle–natural-gas plant near Memphis.

As the world's first such repair without post-weld heat treatment, it validated the approach, documented $5,000 in cost savings, and reduced the outage by three days—avoiding about $1 million in lost electricity sales.

"The outage time savings could vary by a few hours depending on pipe and component sizes," said Dale Sielski, a metallurgical engineer and welding services specialist at TVA.

In 2015, American Electric Power (AEP) achieved similar savings by applying EPRI's approach to a boiler tube at its coal-fired Cardinal Plant Unit 2 in Ohio. The repaired tube continued to operate without problems until it was replaced four months later. EPRI is evaluating the integrity of the repaired tube to assess the component lifetime enabled by such repairs.

"That's important because it can take a year or longer to receive replacement components after they are ordered, as some must be fabricated first," said AEP Principal Welding Engineer Michael Crichton, who helped inform EPRI's best practices guide. Based on EPRI's evaluation, which includes destructive testing, AEP and other power companies will gain further insights into the long-term performance of alternative weld repairs.

"EPRI will continue transferring its weld repair research to industry, while developing targeted guidance on additional common components and connections," said Siefert. These include small-bore connections, where smaller steam pipes connect to main steam pipes or headers, and other welded joints. EPRI also plans to develop weld repair approaches for components made with other steels used in power generation.

TVA's Sielski welcomed the additional research plans while cautioning, "Any procedure you develop is only as good as your welder's willingness to follow the actual steps and not add creativity."

Key EPRI Technical Experts

John Siefert, Jonathan Parker