Predictive Curves on Graphitization of Carbon Steel Enables NRG to Evaluate and Replace Plant Piping System

NRG Energy utilized new information, developed by EPRI, on graphitization of carbon (C) and carbon-molybdenum (C-Mo) steel to evaluate the piping in one of its fossil plants. Results of that assessment led the company to more effectively discover graphitization and to replace affected piping, eliminating a significant safety risk for NRG personnel.



NRG Energy's Kendall Cogeneration Station in Cambridge, Massachusetts

Graphitization of C and C-Mo Steel

Graphitization is a form of material degradation that can lead to component failure. It is primarily associated with C steels in longtime service above 800°F and C-Mo steels above in service 900°F. Severe graphitization significantly reduces the ductility and toughness of the affected areas, and can result in piping failures and extensive damage. The phenomenon was identified in steam piping and other high-temperature power plant components in the 1950s.

EPRI Development of Prediction Curves

In 1993, EPRI published time-temperature predictions for graphitization. However, nearly 20 years later, as the average age of fossil units rose, EPRI member experience indicated that the risk of graphitization was increasing, and that the existing prediction curves might not provide a sufficient level of conservatism to be used as a guideline in assessing the risk of graphitization and to replace affected piping, thereby avoiding a potential catastrophic failure.

As a result, in 2010, EPRI compiled a new, larger database of graphitization experience and updated the prediction curves. The research project collected, reviewed, and analyzed 281 graphitization experience data points from 20 sources. (The prior EPRI research had involved the analysis of about 40 data points.) With this database, researchers developed a set of time-temperature curves to help assess the risk of graphitization failure in C steel weldments. The risk curves identify low, moderate, and significant risks.

The conservative risk predictions provide useful initial guidance for an inspection and examination plan to manage the graphitization risk issue. The predictive tools also give users a quantitative basis to decide on interrogating in-service equipment, which is expected to result not only in preventing graphitization-related failures, but also in performing targeted, more efficient in-service inspections and examinations.

NRG Experience

NRG utilized EPRI's new graphitization risk curves to re-assess materials in its 256-MW Kendall Cogeneration Station in Cambridge, Massachusetts. The company's inspection of the plant's 60-year-old piping system showed regions of moderate-to-severe graphitization. The plant was

"The EPRI report provided the graphitization risk profile that formed the basis to swiftly remove Kendall from service to perform the piping inspection. Replacing the pipe eliminated a significant safety risk for NRG personnel."

~ Eric Barnhouse,
Director of Technical Services, NRG Energy

shut down, and the piping system was replaced. During the replacement of the piping system, a macro crack caused by graphitization was identified.

After the 2010 release of EPRI's graphitization risk curves, a serious graphitization failure occurred in a U.S. power plant in 2011. NRG's proactive approach in implementing a strategy to evaluate graphitization in its system per the EPRI guidelines preempted the potential for a similar failure.

"The EPRI report provided the graphitization risk profile that formed the basis to swiftly remove Kendall from service to perform the piping inspection," said Eric Barnhouse, Director of Technical Services, NRG Energy. "Replacing the pipe eliminated a significant safety risk for NRG personnel.

"A subsequent fleetwide materials review is in process. It is surprising to learn the amounts C and C-Mo materials that have susceptible time at temperature to form graphitization."

Related EPRI Work

Graphitization in Carbon and Carbon-Molybdenum Steels. EPRI. Palo Alto, CA. December 2010. 1019783.

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

CONTACTS

John Shingledecker, *Program Manager, Fossil Materials and Repair*
704.595.2619, jshingledecker@epri.com

1026906 February 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

© 2013 Electric Power Research Institute (EPRI), Inc. All rights reserved. Electric Power Research Institute, EPRI, and TOGETHER . . . SHAPING THE FUTURE OF ELECTRICITY are registered service marks of the Electric Power Research Institute, Inc.