Water Technologies & Solutions
application note

early ethylene glycol leak detection in power plant steam condensate is essential

background

Fossil fuel and nuclear power plants use heat exchangers to condense process steam back into liquid form. A heat exchanger works by transferring heat from one medium (steam) to another medium (air, water, or ethylene glycol). Many newer, closed cooling water system, power plants use ethylene glycol use ethylene glycol ($C_2H_6O_2$) as a heat transfer fluid because of its high-heat transfer efficiency.

Although ethylene glycol is a superior heat transfer fluid, it can cause severe issues if it leaks out of the condenser and into the condensate stream. At elevated temperatures and pressures, ethylene glycol in water degrades into organic acids which can acidify the condensate and lead to accelerated corrosion within the system. An increase in organic acids can also severely damage ion exchange resin beds and demineralization tanks.

Early detection of pinhole heat exchanger leaks is paramount to maintaining the integrity of the power plant and process equipment. Although many plants use neutralizing amines at trace levels to control steam loop pH, these amines are typically dosed to control the carbonic acid produced from carbon dioxide dissolution. A large influx of organic acids from an ethylene glycol leak would likely overwhelm this pH control and cause significant acidification of the condensate.

problem

Power plants commonly measure pH and cation conductivity to monitor steam loop water purity. However, those parameters are not always sufficient to detect ethylene glycol leaks early enough to prevent significant downstream issues.

Figure 1. Sievers M-Series TOC Analyzers measure ethylene glycol directly and can detect leaks earlier than pH and cation conductivity measurements.

Since pH and cation conductivity excursions can result only after the breakdown of ethylene glycol, these measurements are typically too late in detecting a leak.

Ethylene glycol breaks down in water in a hot, high-pressure steam loop. If a leak were to occur in the heat exchanger, evidence for this leak would likely not be detected via pH and conductivity until after the ethylene glycol degraded. At this point, process equipment (e.g., demineralization tanks, resin beds, condensate polishers, boilers, turbines, etc.) would have been exposed to the acidic condensate or steam.

Ethylene glycol is an organic molecule that is 38.7% carbon and can, therefore, be detected using on-line, continuous total organic carbon (TOC) analysis. The Sievers* M-Series On-Line TOC Analyzers are able to detect ethylene glycol leaks early, before the ethylene glycol breaks down in the condensate stream as shown in **Figure 1**.

solution

In lab studies, the Sievers M-Series TOC Analyzer demonstrated ethylene glycol recoveries of 97.3%–99.1% for carbon concentrations between 0.5 and 25 ppm C (1.3–64.7 ppm ethylene glycol). Recoveries on the Sievers M-Series TOC Analyzer are summarized in **Table 1**.

Table 1. Summary of ethylene glycol recoveries

TOC Concentration	Ethylene Glycol Concentration	%TOC Recovery
0.5 ppm	1.3 ppm	97.6 %
1 ppm	2.6 ppm	99.1 %
5 ppm	12.9 ppm	99.4 %
10 ppm	25.9 ppm	98.0 %
25 ppm	64.7 ppm	97.3%

The Analyzer exhibited a highly linear response to measuring ethylene glycol as demonstrated in **Figure 2.** Based on the quantitative recovery (≥ 97.3%) and the high degree of linearity (R^2 = 1.0000), a Sievers M-Series TOC Analyzer is well suited to detect a broad range of ethylene glycol concentrations in a condensate stream.

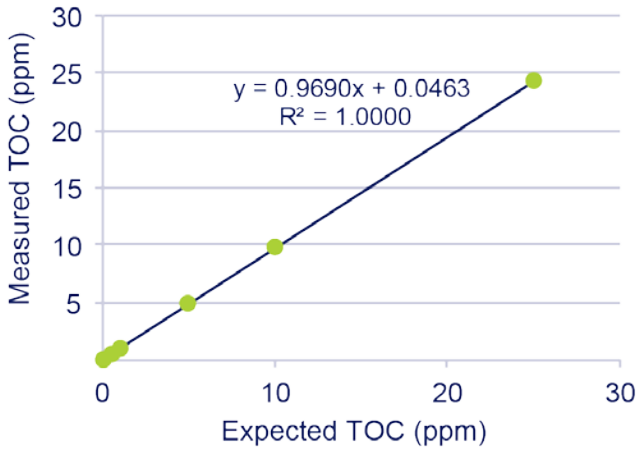

Figure 2. Linear regression results of measured versus expected TOC concentrations for ethylene glycol solutions from 0.5 ppm to 25 ppm TOC.

Several notable organizations (EPRI, VGB, and Eskom) have suggested limits of 100 to 300 ppb as appropriate background TOC levels for makeup water to the steam cycle. This level of TOC background in the water/steam cycle is well above the 0.03 ppb level of detection for the Sievers M-Series TOC Analyzers and is low enough that any TOC excursions from an ethylene glycol leak would be easily detected above the background TOC concentrations.

The cost of failure due to an ethylene glycol leak is potentially hundreds of thousands of dollars or more from equipment repair or replacement and lost energy production due to downtime. Since ethylene glycol is toxic and hazardous, the additional cost of mitigating contaminated condensate water could also be substantial. With a Sievers M-Series On-Line TOC Analyzer, the condensate stream is analyzed every two minutes, giving plant operators high resolution data that can be used to quickly identify and mitigate leaks from heat exchangers using glycol solutions

references

1. Berry, D. and Browning, A. Guidelines for Selecting and Maintaining Glycol Based Heat Transfer Fluids. 2011. Chem-Aqua, Inc.

2. EPRI Lead in Boiler Chemistry R&D. Personal Communication. January 28, 2015.

3. Ethylene vs. Propylene Glycol. www.dow.com. Accessed January 22, 2015. http://www.dow.com/heattrans/support/selection/ethylene-vs-propylene.htm.

4. Heijboer, R., van Deelen-Bremer, M.H., Butter, L.M., Zeijseink, A.G.L. The Behavior of Organics in a Makeup Water Plant. PowerPlant Chemistry. 8(2006): 197-202

5. Faroon, O., Tylenda, C., Harper, C.C., Yu, Dianyi, Cadore, A., Bosch, S., Wohlers, D., Plewak, D., Carlson-Lynch, H. Toxicological Profile for Ethylene Glycol. 2010. US Agency for Toxic Substances and Disease Registry (ASTDR).

6. Maughan, E.V., Staudt, U. TOC: The Contaminant Seldom Looked for in Feedwater Makeup and Other Sources of Organic Contamination in the Power Plant. PowerPlant Chemistry. 8(2006): 224-233.

7. Rossiter, W.J. Jr., Godette, M., Brown, P.W., Galuk, K.G. An Investigation of the Degradation of Aqueous Ethylene Glycol and Propylene Glycol Solutions using Ion Chromatography. Solar Energy Materials. 11 (1985): 455-467.

8. Vidojkovic, S., Onjia, A., Matovic, B., Grahovac, N., Maksimovic, V., Nastasovic, A. Extensive Feedwater Quality Control and Monitoring Concept for Preventing Chemistry-related failures of Boiler Tubes in a Subcritical Thermal Power Plant. Applied Thermal Engineering. 59(2013): 683-694.