Application Note: Measuring Hydrogen in Water Steam Cycle to Predict and Prevent Potential Corrosion

Every year, corrosion costs the electric utility industry billions of dollars. International guidelines are available for water chemistry control to minimize corrosion. Parameters such as pH, oxygen, iron, hydrogen and others are directly related to corrosion control and used for monitoring corrosion. International technical organizations and power plant chemists are working diligently to find a suitable method to provide real-time corrosion trend monitoring in their process during commissioning and normal operation.

Hydrogen monitoring in this case is becoming important in corrosion monitoring for water steam cycle [1, 2, 3]. Corrosion occurs in the presence of water contact with iron at high temperature. According to the Schikorr reaction (Eq. 1), hydrogen is released as a by-product during the formation of the magnetite and hematite layer in the power plant. Therefore its concentration is a direct measure of the rate of corrosion.

$$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2 \qquad \text{(Eq. 1)}$$

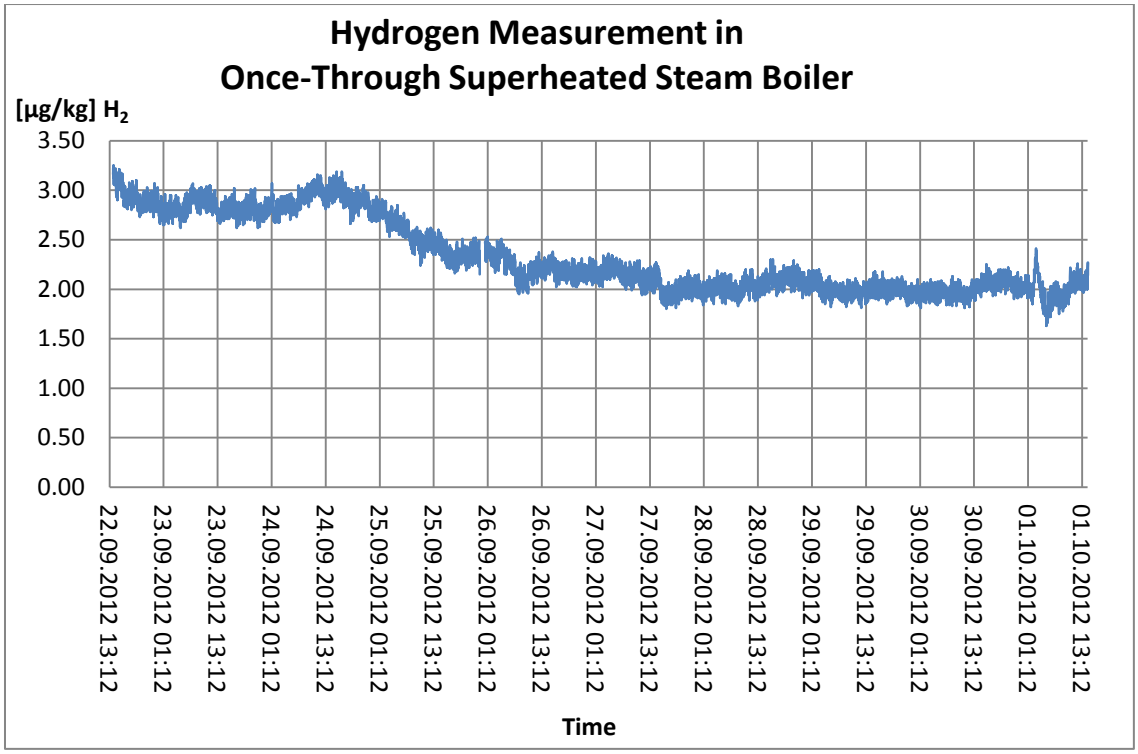
During commissioning of a new power plant, commissioning engineers need the formation of uniform iron oxides as a protective layer on the surface of the metallurgy to limit further corrosion of the steel. However, some iron oxides are disrupted and formed again during operation. The disruption and formation of the iron oxides layer will release hydrogen gas. Even though other possible sources of hydrogen exist, measuring dissolved hydrogen concentration in the process will provide valuable indication of an active corrosion rate in the system.

Various tests and research have been carried out to identify suitable sampling points for a representative sample. Hydrogen concentration is commonly measured in the steam or feedwater[4] to ensure that corrosion rates are kept at an acceptable level.

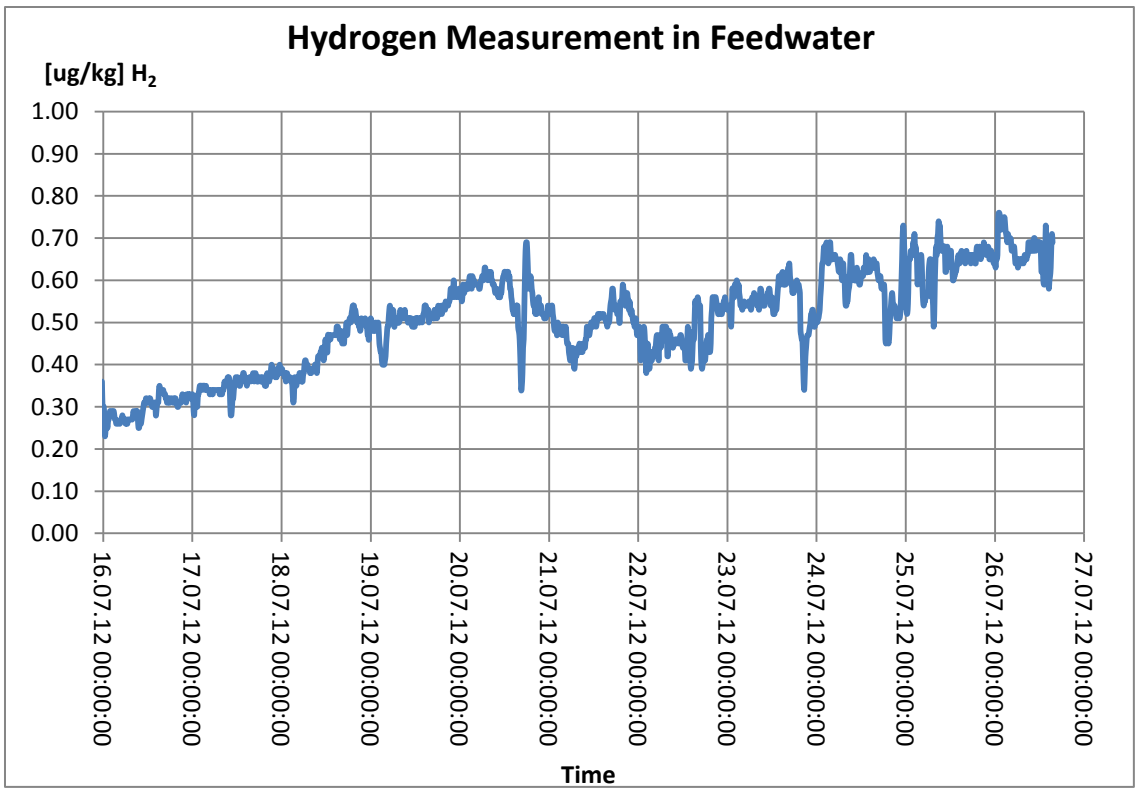
Guidelines for hydrogen levels are not well defined and may vary from plant to plant. Available research indicates hydrogen levels occur at a few ppb (part per billion) during normal operation and as much as several hundred ppb during commissioning. However, hydrogen values greater than 10ppb-50ppb under normal working condition may be an indication of permanent damage to the boiler.

Graph 1 shows typical hydrogen measurement in a once-through superheated steam boiler. The power plant is using oxygen treatment with ammonium as an alkalizing agent in the water steam cycle. Dissolved hydrogen measurement tracking in superheated steam provides an indication of the corrosion trend in the boiler. This information is very useful to plant chemists for corrosion monitoring and control. The plant chemist could take the necessary action to mitigate corrosion. Information in the graph indicates that the corrosion rate is under control.

Graph 2 shows hydrogen measurement in feedwater (economizer inlet). The graph indicates increase of dissolved hydrogen in feedwater at various times. This indirectly represents increasing of corrosion rate in the feedwater system. The dissolved hydrogen increase appears *before* corrosion is excessive. Corrective action was taken to reduce and control corrosion in feedwater.



Graph 1: *Online Hydrogen measurement in Superheated Steam for Once-Through Boiler in 1100MW Lignite-Fire Unit Power Plant.*



Graph 2: *Online Hydrogen measurement in Feedwater (or Economizer inlet) in 660MW Coal-Fired Unit Power Plant.*

References:

1. VGB Powertech; Feed Water, Boiler Water and Steam Quality for Power Plant/ Industrial Plant; VGB-S-010-T-00; 2011-12.EN (formally VGB-R 450Le).
2. EPRI Technical Report 1012209; Fossil Plant Cycle Chemistry Instrumentation and Control-State-of-Knowledge Assessment; March 2007
3. Baldessari A.; An Introduction to Corrosion Monitoring; June 05; Protan S.A.
4. EPRI Technical Report 112024; Reference Manual for Online Monitoring of Water Chemistry and Corrosion; Final Report; April 1999.