Application Note

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Leading Pure Water Analytics

Dissolved Oxygen

Key to Limiting Power Plant Corrosion

To minimize corrosion in boilers, turbines and piping, dissolved oxygen (DO) control is widely used in power plant cycle chemistry treatment. Efficient DO control relies on obtaining fast, accurate measurements from on-line sensors. DO probes based on optical technology are ideal for this purpose.

The need for DO measurement

Oxygen's effect on ferrous and nonferrous metals depends on its concentration, along with many other variables. Controlling DO is key to maintaining adequate metal passivation in order to minimize corrosion and is the goal of cycle chemistry treatment regimes. Dissolved oxygen is one of the core on-line parameters identified by industry experts that is needed to control cycle chemistry in power plants. Therefore, DO is monitored and controlled in both the cycle itself and in the makeup water entering the cycle.

Power plant water treatment

In the quest to minimize corrosion, various strategies have been used for boiler feedwater treatment. These differ based on boiler type and pressure, the alloys used in plant components and the ability to maintain high purity water quality.

A "reducing" feedwater treatment is required if copper alloys are used in feedwater components for maintaining a protective, reduced, cuprous oxide layer on copper surfaces. DO levels are typically maintained at single-digit ppb levels; therefore, reducing treatment requires thorough deaeration plus the addition of a reducing reagent such as

hydrazine. To control this treatment, ORP (oxidation-reduction or redox potential) measurement is also recommended in order to obtain a response to excess reducing agent and to metal surface conditions.

"Oxygenated" treatment may be applied where all-ferrous alloys are used in feedwater components. This treatment generally maintains DO in the 50 to 150 ppb range to produce a durable, red ferric oxide hydrate layer on metal surfaces. No reducing agent is used and deaeration is limited. Small amounts of oxygen may be injected to maintain these levels.

Generator stator cooling

Electric power generators have heavy copper bars in their stationary windings (stators). Efficient operation requires keeping these at a relatively low temperature to minimize their electrical resistance. Some stators are hollow and have high purity water circulating within to cool them. These copper stator bars are vulnerable to oxygen corrosion. And if the stator circulating water is plugged by copper

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corrosion products, a hot spot could occur and the whole unit would have to be shut down.

Copper corrosion has the unusual characteristic of occurring rapidly when DO concentration is between 20 ppb and 2000 ppb. For DO outside of that range, either lower or higher, the corrosion rate drops off dramatically. Therefore, minimizing copper corrosion is achieved by monitoring and controlling DO concentration below 20 ppb or above 2000 ppb.

The interior of large generators also contains a pressurized hydrogen gas atmosphere which has very high heat transfer properties and helps cool the moving windings. Hydrogen is a very small molecule and inevitably leaks, including through stators and into the cooling water. As a result, DO sensors used in this application must not experience interference from dissolved hydrogen.

Dissolved oxygen measurement

To make the above treatment schemes successful requires reliable and accurate DO measurements. For decades DO has been measured using electrochemical sensors with gas-permeable membranes. They use internal electrodes that develop a current signal in proportion to the amount of oxygen that passes through the membrane, which, in turn, is related to DO concentration.

Electrochemical sensors work well but some designs require extensive servicing to replace worn membranes and electrolyte and to keep electrodes responsive. Other designs have eliminated electrode servicing and use membrane cartridges that are easily filled with electrolyte and then installed in the sensor. However, with all electrochemical sensors, membranes and electrolyte must be replaced periodically, lengthy start up time is required for electrode polarization to stabilize measurements, and response time is dependent on membrane condition. Also of concern is that many electrochemical sensors experience significant interference from dissolved hydrogen, making them unsuitable for monitoring stator cooling water.

Optical dissolved oxygen measurement

A more recent technology is optical or chemiluminescent DO sensing. With this type of sensor a light source briefly illuminates a sensing element containing organic chromophores. The chromophores absorb some of the light then re-emit it at a lower frequency which is detected by the sensor. The duration and intensity of the re-emitted light is directly related to the DO concentration in the water. In this way, a reliable DO measurement is obtained without using a membrane, electrolyte or electrodes. Response is six times faster than electrochemical sensors and no polarization time is required. Also, optical sensors are immune to dissolved hydrogen interference. Servicing consists only of replacing the sensing element approximately once a year. Optical DO sensing is becoming widely accepted as the preferred measurement technology in power plant applications.

The METTLER TOLEDO Thornton series of optical dissolved oxygen sensors provides the advantages described here.

For more information: **www.mt.com/opticalDO**

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