Monitoring Dissolved Oxygen in High-Pressure Boiler Systems

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Application Note

Many power plants use fossil fuels or nuclear power as sources of heat to boil purified water for the production of steam. The pressurized steam drives turbines to produce electricity. The quality of boiler feedwater must be carefully controlled throughout operations to optimize system performance. Proper water quality maintenance maximizes operating efficiency and the lifespan of boiler equipment.

Maintaining Water Quality in High-Pressure Boilers

Dissolved oxygen, or DO, is one of the most important water quality parameters to control in a boiler system. It is the primary corrosive agent of steam-generating systems. Even low concentrations of DO can be highly destructive, causing localized corrosion and pitting of metal system components. Pitting is a concentration of corrosion in a small area of the total metal surface, effectively drilling a hole in the metal. Over time, DO can cause an oxygen tubercle, or scab, to form over the point of original attack. Once the scab forms, the corrosion will continue, even if the system is then properly maintained. The high temperatures and pressures in steam-generating systems accelerate the rate of corrosion. Improper water quality management results in not only inefficiency, but also costly repairs and downtime. Operators of high-pressure boilers try to eliminate DO entirely from feedwater.

Mechanical deaeration is commonly the first and most economical technique employed by plant operators to remove DO. Deaeration equipment heats the feedwater and vents the released gases, including oxygen. Properly maintained deaerators can typically reduce DO levels to as low as 10 ppb (parts per billion).

Plant operators supplement mechanical deaeration with chemical treatment, using oxygen scavengers such as hydrazine, DEHA and carbohydrazide to consume remaining DO. Theoretically, maintaining a high residual of an oxygen scavenger would consume all dissolved oxygen. In reality, competing chemical reactions between oxygen and boiler surfaces are more likely to occur, resulting in significant corrosion within the system.

Consequently, maintaining high scavenger levels may not provide adequate protection. Routine monitoring of DO levels is crucial to confirm sufficient removal of DO within the system.

Common Methods for Monitoring DO

Various kinds of dissolved oxygen monitoring equipment are commercially available. Probes and analyzers with galvanic, polarographic, and optical sensors are often mounted permanently inline. Portable colorimetric test kits that are sensitive enough to measure low levels of dissolved oxygen are also routinely used in boiler applications. Plant engineers consider equipment performance, reliability, measurement frequency, and maintenance costs to determine the most suitable methods for monitoring DO in their systems.

Online analyzers offer continuous DO measurement, but require routine calibration of the

sensors. Calibration is typically based on measurements of water-saturated air, which can be accomplished by placing the probe in the air space above the water level in a closed container of water. Calibration frequency depends on vendor guidance, the type of sensor, and the water quality conditions to which the probe is exposed. With the use of either a sensor or an analyzer, it is recommended that plant operators periodically compare online data to results obtained with an alternate test method, ensuring that equivalent results are obtained. This helps to identify calibration drift, sensor corrosion, or other factors that could compromise the validity of online results.

CHEMetrics, Inc. is the only manufacturer of a portable test kit for detecting trace levels of dissolved oxygen in boiler applications. CHEMetrics® Test Kits feature the convenience of "snap and read" self-filling ampoules, offering plant operators a rapid, reliable, maintenance-free means of determining ppb levels of DO within one minute. Over the course of nearly 50 years, CHEMetrics has earned a reputation for providing quality DO test kits to this marketplace.

Test kits provide all the components necessary for analysis and do not require calibration by the operator. CHEMetrics ampoules are subjected to a rigorous quality control process where product performance is verified with certified oxygen gas standards, ensuring accurate results. In addition, CHEMetrics is the sole source supplier of the test kits specified in ASTM D5543-15, Standard Test Method for Low-Level Dissolved Oxygen in Water.

CHEMetrics® Test Kits are commonly used as a primary means to measure DO in boiler systems. They are also used as a secondary means to verify online equipment readings or as a backup method when online equipment is out of service.

Sampling and Analysis

Each online analyzer continuously monitors a single location, typically near the discharge side of the boiler feedwater pump. A single CHEMetrics portable test kit, on the other hand, can be moved from one sampling point to another to allow for testing at the deaerator or any potential leakage points throughout the system.

For both online and test kit methods of analysis, it is imperative that the sample water not be exposed to the air. Atmospheric oxygen would contaminate the sample, causing erroneously high results. Therefore, collection of a grab sample is unacceptable for DO analysis.

CHEMetrics test kits are equipped with a special "sampling tube" that is vertically mounted and connected to the sampling port of the boiler system.

A continuous flow of sample through the tube prevents contamination from atmospheric oxygen. When the operator submerges the vacuum-sealed ampoule in the flowing sample and snaps the tip, sample is drawn into the ampoule. The highly sensitive colorimetric Rhodazine D™ reagent reacts instantaneously to produce a pink color.

The color intensity is visually matched to a color comparator to determine the DO concentration. CHEMetrics also offers a Comparator Light Source (CLS) for use in low-light conditions. A video illustrating the use of CHEMetrics DO test kits is available on all ppb DO product pages at www.chemetrics.com.

Conclusion

Dissolved Oxygen must be monitored and controlled to avoid catastrophic failure of steam-generating boiler systems. CHEMetrics' portable, easy-to-use Dissolved Oxygen Test Kits[1] provide plant operators with many advantages when used as a primary monitoring method or alongside online equipment for DO testing. With sensitivity down to 2 ppb, CHEMetrics® ampoules employ an ASTM method for measuring trace levels of DO in boiler applications.

For more information on dissolved oxygen and other test kits applicable to industrial water treatment, please visit www.chemetrics.com.

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[1]CHEMetrics® Visual Test Kits: K-7511, K-7518, K-7540 and K-7599