



In its dissolved form, oxygen is highly corrosive to most metals, especially the mild steel used for boiler tubes. Photo courtesy of ABB

Four Boiler Contaminants that Jeopardize Power Plant Operation and Maintenance

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Keeping key boiler water and steam contaminants in check can help to ensure a safe and efficient process. Power generation requires vast quantities of water to produce steam. Achieving well-balanced water chemistry can optimize the efficiency of steam raising and its distribution.

The elevated temperatures and pressures inherent in power generation applications greatly increase the speed of chemical reactions taking place in

a boiler. The American Society of Mechanical Engineers (ASME) advises that to control deposition and corrosion in the boiler, plant operators should effectively monitor makeup water, condensate, feedwater and boiler water qualities.

The absence of adequate monitoring and control will almost certainly lead to both increased costs and more frequent component failures. Evidence shows that allowing boiler chemistry to vary from specified limits can result in expensive plant outages, potentially

incurring costs of more than \$1 million per day.

By measuring and monitoring not just the water in the boiler but also the steam distribution loop and other areas around a power plant, operators obtain a better overview of current conditions. When incorporated into a planned preventative maintenance program, this information can help to substantially reduce the risk of unplanned outages.

Even in a well-controlled system, it is not possible to totally eliminate the presence of potential contaminants present in boiler feedwater. For example, in a 500 megawatt boiler, about 1,500 tons of water is boiled off every hour, equating to one million tons per month. Most of the contaminants present in the water remain in the boiler. Close monitoring and control can determine the optimum time for boiler blowdown operations to bleed off a measure of contaminated water. Otherwise precipitated scale deposits can thermally insulate heat exchange surfaces, decreasing the rate of steam generation and leading to inefficient operation.

Extensive on-line chemical monitoring is now a very well established practice in the power industry. Online monitoring enables careful control of the water chemistry to achieve peak efficiency and minimize downtime caused by excessive boiler corrosion or scaling. The following discusses four key parameters that should be subject to online monitoring.

DISSOLVED OXYGEN

Oxygen contamination of steam condensate can lead to inefficient or improper feedwater aeration; air leakage at pump seals, receivers and flanges; leaking heat exchangers; and ingress into systems that are under vacuum. It can also promote localized pitting corrosion, which can cause rapid failure of critical equipment in the steam system.

One way to control dissolved oxygen levels is by dosing boiler feedwater with oxygen scavenging chemicals, such as hydrazine. When these chemicals are used, operators can assess the efficiency of their dosing regime by measuring for dissolved oxygen at the economizer or boiler inlet. Any fluctuations can be addressed by increasing or reducing the dose quantities.

The dramatic variations in oxygen levels during the load cycle of a plant, combined with the different levels required for different boiler chemistry regimes, require an analyzer that offers a fast response across both high and low dissolved oxygen concentrations.

HYDRAZINE

As an oxygen scavenger, hydrazine is widely used to remove trace levels of dissolved oxygen in boiler feedwater, forming nitrogen and water. But at high temperatures and pressures, it will also form ammonia, which increases the feedwater pH level, reducing the risk of acidic corrosion.

Hydrazine also reacts with soft

haematite layers on the boiler tubes to create a hard protective magnetite layer. This layer acts to protect the tubes from further corrosion. Placing a hydrazine monitor at the feedwater inlet will help check the correct dosage. Too much hydrazine is both wasteful and costly. Too little hydrazine will not adequately control dissolved oxygen levels and will prevent adequate formation of magnetite. Typically, the most effective dosage of hydrazine is 3:1 parts hydrazine to the expected level of dissolved oxygen. This should result in a dissolved oxygen concentration level of five parts per billion.

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SODIUM

As the sixth most abundant element on Earth, sodium is the root cause of many different types of corrosion in boilers. It's one of the most important parameters to measure in power plant applications. Traditionally, conductivity measurement has been used to indicate the total dissolved solids. However, it lacks the sensitivity to measure sodium at low levels.

A particular problem with sodium is the cycle it undergoes during hydrolysis. During this process, sodium carbonate is turned into sodium hydroxide, which then attacks iron in the boiler. As iron dissolves, it forms sodium ferroate, which under hydrolysis

regenerates into sodium hydroxide. Prolonged exposure to this cycle will put boiler components such as bends and joints under constant attack, causing them to become embrittled and increasing the risk of leaks and cracks.

If carried over in the steam, sodium can also build up on critical components as the steam condenses, including the steam turbine, where it can attack the turbine blades. The importance of safeguarding against sodium means that operators should measure levels at key points in the steam generation and distribution loops. Sample points should include the water treatment plant, the condenser extractor pump, the polishing plant outlet, and the saturated and superheated steam distribution loops.

At the water treatment plant, monitoring for sodium helps to identify any breakthrough from the cation exchange and mixed bed outlets caused by exhaustion of the ion exchange beds. As sodium is a monovalent ion, it is much more likely to break through first, providing an early indicator of bed exhaustion. As such, monitoring for sodium also acts as a useful measure of bed efficiency as well as a precursor measurement for potential sodium contamination further down the line. On-line measurement of sodium after the extraction pump provides a useful indicator of condenser leaks. Operated under high vacuum, the condenser is prone to leaks that cause cooling water to become mixed with the condensate.

A key concern here is the ingress of chloride and sulfate, which occurs mainly in the form of sodium chloride and sodium sulfate. Since sodium monitors have 10 to 100 times the sensitivity of on-line chloride measurement techniques, measuring sodium levels provides a good way of detecting for the presence of chloride and sulfate.

Working in a similar way to water treatment plant, polishing plants can use sodium monitors to detect ion exchange bed exhaustion as well as for monitoring water quality. In some power stations, the polishing plant is incorporated into the main water treatment plant.

In high pressure boilers, any chemical contaminants present in the steam can quickly build up in the boiler drum and can be carried over in the steam to the turbine. Monitoring for sodium in the saturated and superheated steam distribution loops helps to protect against corrosion and the formation of sodium salts on the superheater or turbines caused by steam carryover.

By measuring the purity of the steam and comparing it to the measurements taken from the saturated steam before the superheater and condensate stages, operators can assess whether quality is being affected by issues such as deposition of sodium salts or condenser leaks. The same measurement can also be performed for once-through boilers. But since these have no separate superheaters, the sample is taken from the superheated steam before the turbine.

SILICA

Silica is a major culprit behind the build-up of hard and dense scale inside the boilers and turbines of power generation plants. It has a very low thermal conductivity and forms a dense porcelain-like scaling that cannot be removed even with acid. Even a 0.5mm build-up of silica can reduce thermal transfer by 28 percent, reducing efficiency, leading to hot spots and eventual rupturing, ultimately resulting in plant failure. The only way to control silica buildup is through an effective monitoring regime. Like sodium, silica should be measured at multiple points around the steam system, including the demineralization plant, boiler feedwater, boiler drums, superheater

and condenser outlets.

Measuring silica in the steam from the boiler, either at the superheater or at the entrance to the turbine, gives a good indicator of overall steam purity. Provided that the silica concentration remains below 20 parts per billion, the level of scale deposition should be minimal. Unlike many other potential contaminants, dissolved silica is only very weakly ionized, so it cannot be detected using a simple conductivity measurement. It requires a dedicated monitor.

Other parameters that power plant operators may also wish to monitor include phosphate, ammonia, and chloride, using sensors that respond quickly, tolerate process temperature, and require minimal maintenance.

TIPS FOR ONLINE MONITORING

For the best return on investment, online monitoring systems must themselves be well maintained and where possible use the latest developments in technology to ensure they deliver maximum benefits.

To cut the costs and maintenance effort, modern analyzers for power plants should include:

- carefully designed wet sections
- remote management
- automatic calibration and cleaning
- diagnostic messaging

Any program aiming to maximize the efficiency of online monitoring systems should include using instruments that can respond quickly to changes in boiler chemistry and offer self-diagnostic capabilities where possible.

The location of monitoring equipment is a vital factor in ensuring the best return on investment in a power plant. Ideally, monitoring equipment should be situated in an environment that has less potential for damage, has easy access for maintenance, and allows for enhanced measurement accuracy.

Capability of digital communications, such as Ethernet, enables data to be relayed to a central control room. This helps to open up the accessibility of the measurement data beyond the local operator. **pe**



ABB Navigator 600 silica analyzer installed in Pennsylvania combined cycle power plant. Photo courtesy of ABB