

Continuous Silica Monitoring in a Power Plant

Increasing Efficiency in Power

New plant designs and technological developments in the power industry are leading to greater efficiency in converting fossil fuels to energy. Leveraging these technologies (once-through boilers, for example) allows plants to operate at higher temperatures and higher pressure, which increases the energy output while decreasing the amount of fuel required. This has allowed many new plants to attain efficiency measurements nearing 50%. This is important, not only to optimize the running of the plant, but due to the reduced amount of fuel required, increasing the efficiency 1% can lead to a reduction in CO₂ emissions of 3%.¹

In the effort to improve efficiency, power plants must guard carefully against any issues that can impede their progress or lead to plant downtime. Continuous monitoring of ultra-low levels of silica in locations throughout the plant helps to manage power plant efficiency and reduce downtime by avoiding costly plant shutdowns and repairs. Continuous on-line silica analyzers provide dependable monitoring and protect against the introduction of harmful levels of silica into the steam cycle.

Background on Silica

Making up a large percentage of the earth's solid crust, silicon (Si) is second only to oxygen in natural abundance. Silicon is found to a certain degree in all natural water supplies, usually as dissolved silica or as small suspended silicate particles (colloidal silica). Silicon dioxide, also known as silica, is a chemical compound that is an oxide of silicon with the chemical formula of SiO₂.

Among the many potential contaminants in the steam cycle, silica plays a crucial role because of its high solubility in steam. Due to this property, silica can deposit on any surface steam touches, creating issues with plant efficiency and safety.

Monitoring Silica is Critical

Silica in the steam cycle can result in deposition of a "glass" layer on surfaces, resulting in a loss of thermal process efficiency. Steam in the system comes in contact with surfaces like the blades of the turbine, and as it cools, dissolved silica in the steam deposits on the surface. Deposition of silica on the turbine blades can result in the turbine becoming imbalanced, reducing efficiency and, in extreme cases, causing extensive damage to the turbine.



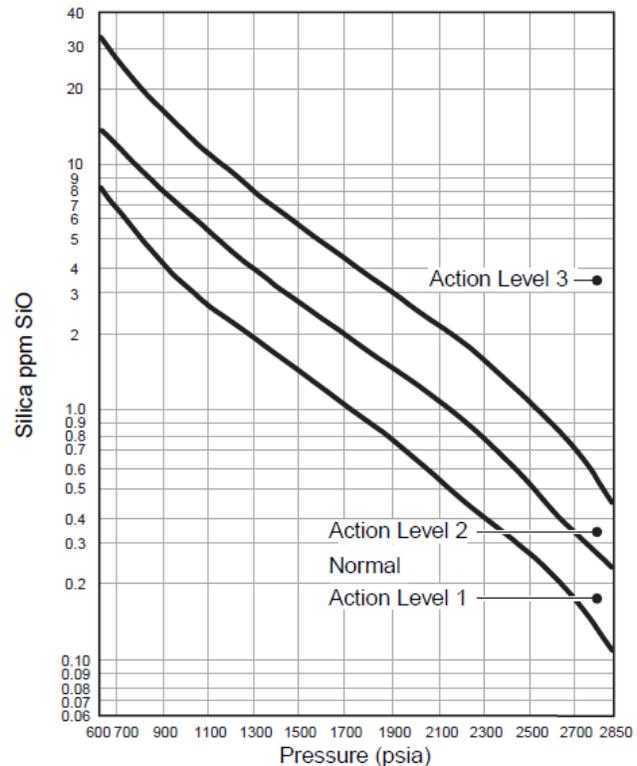
Figure 1: Silica deposition

¹ *Reducing emissions: a central role for efficiency*, World Coal Association (2006)

Years of industry experience, along with research and publications from the Electric Power Research Institute (EPRI) and ASME, have provided extensive information to the power industry regarding allowable concentrations of silica in steam based on the operating pressure of boilers. For example, at an operating pressure of 2,600 psi, the boiler water should not contain more than 100 ppb ($\mu\text{g/l}$) of silica in order to maintain no more than 5 ppb of silica in the steam.

No treatment system can remove 100% of impurities, and the evaporation and replacement of boiler water tends to concentrate dissolved solids, including silica. This is particularly critical for once-through boilers because they convert all water in the boiler into steam and there is no opportunity for boiler blowdown to flush the impurities out of the system. This requires that the silica concentration be held at lower levels in once-through boilers than is necessary in conventional drum boilers. In summary, excessive silica concentrations in the boiler water can have a dramatic impact on the power plant, and it is critical that this parameter be continuously and accurately monitored.

Figure 2: Recommended Silica Concentration chart



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Monitoring Silica for Demineralization

In addition to the measurement of silica in a plant's boiler and boiler feedwater system, the demineralization process is another area where silica is an important parameter. Demineralization is an effective means of removing dissolved solids such as silica through the use of anion or mixed bed ion exchangers. Silica has a very low ionic strength and it is one of the first ions to break through when the bed is reaching exhaustion. Conductivity measurements, long used as a measure of water purity, are unreliable in detecting resin bed exhaustion because the initial breakthrough of silica does not increase conductance in any appreciable amount. Therefore, silica takes on the role of the indicative parameter in the demineralization process and continuous, on-line monitoring is used effectively for determining the efficiency of the resin beds and how close they are to exhaustion.

Monitoring Silica with the Hach 5500sc Silica Analyzer

An industry leader in silica measurement, Hach Company has recently launched a new silica analyzer designed for the Power industry: the Hach 5500sc. This analyzer builds on the trusted technology of Hach's Series 5000 Silica Analyzer, offering new features to reduce maintenance and downtime, thus supporting customers in driving efficiency.

The Hach 5500sc features a unique pressurized reagent delivery system that has no pumps and begins the measurement when silica in the sample reacts with molybdate ions under acidic conditions to form silicomolybdic acid complexes. The addition of citric acid destroys the phosphate complexes. Amino Acid Reagent is then added to reduce the yellow silicomolybdic acid to an intense blue color, which is proportional to the silica concentration. The lower limit of detection on the unit is 0.5 µg/l.

The 5500sc runs unattended for 90 days and includes predictive diagnostic tools to indicate any potential issues before they become problems. The analyzer also features a large, color screen that communicates messages and warnings through a color-coding system. The 5500sc is designed to ensure that customers are confident that their plant is protected against harmful levels of silica and frees up their time to focus on other priorities like driving efficiency gains.

For more information regarding the 5500sc Silica Analyzer, please visit hach.com/silica.



Figure 3: Hach 5500sc Silica analyzer

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