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Silica, Hardness, SDI and Colloids Process Removal Technology

By: Horace R. Corbin, P.E. - January 7, 1994
email to: horace@uswca.com
www.uswca.com

Before a raw water supply can be stripped of dissolved salts such as by reverse osmosis, pretreatment work is essential to avoid process and equipment failure. The pretreatment process must be reliable and flexible. It often must perform in a remote environment under varying and unknown conditions. It must not impose operating complexities on the site personnel.

The main pretreatment process needs are:

1. Silica, Metals and Hardness Reduction.
2. Suspended Solids and Colloid Control, Fouling Factors Minimization.
3. Scaling Reduction, Organic Removal and Biological Stabilization.

The Pretreatment Process must be flexible to respond to variations in the water supply characteristics, climatic conditions, temperature and flow. The system design often must proceed based on limited information at hand at the project start. Startup adjustment and operation must be responsive to actual site conditions encountered.

Communication, Training, Maintenance, Service and Technical Support must be accessible for the site. For practical reasons, complex issues must be kept to a minimum. However, when needed, service must be available, effective and responsive.

Thorough Operating and Maintenance Documents must be prepared in the native language of the operating staff. Often, dual language and dual dimensioned documents are required, such as Spanish/English and with Metric/Imperial dimension standards.

TECHNOLOGY FOR SIO2 REMOVAL

Silica exists in all waters in multiple chemical and physical/chemical forms. Generally, quasi-soluble silica is analyzed and reported as $HSiO_2^-$ weak anion. Other forms of silica go undetected. $HSiO_2^-$ is found in most natural waters at levels generally from 5-30 mg/l.
$HSiO_2^-$ becomes troublesome for piping and other equipment at levels of 150 mg/l and above due to formation of hard, glass-like plating that resists removal. These factors are well understood in evaporative cooling tower applications in power generation and in similar other fields.
$HSiO_2^-$ is a serious problem for reverse osmosis operation as concentration occurs at the liquid/membrane interface. Left uncontrolled, the membranes become destroyed in a short time. The problem is avoided by removing the silica prior to the Reverse Osmosis unit.

At a mine location in South America, the silica concentration in the water supply is unusually high (essentially at saturation). A large portion of the silica is removed as the first task (to ~30 mg/l). Although this silica issue is unusually difficult for most designers, it is not an unusual problem in for special plants designed to deal with it, such as for power plant operation in cooling towers.

Horace Corbin has developed the process for enabling cooling towers to reach high cycles of concentration, while stripping excess silica, calcium, magnesium, and alkalinity to maintain safe conditions. This process is also applied to unusual water supply conditions at other locations.

CAUSTIC ZONE STRIPPING

The "Caustic Zone Stripping" process employs specially arranged hardware, computer controls, programming and chemical reaction techniques for removing excess silica from water streams. The hardware includes a solids contact slurry recirculation reactor, dual media "coated adsorption" filters, precision chemical feed units, programmed computer control and complete instrumentation monitoring for assured operations.

The reactor is automatically maintained at the appropriate pH such as by caustic addition with feedback control. Silica is adsorbed from the water as calcium and magnesium are caused to precipitate. Calcium precipitates stoichiometrically as a function of the natural alkalinity in the water supply. Additional calcium can be removed if the alkalinity is insufficient, by adding soda ash. At ambient temperatures, hardness can be reduced to approximately 35 ppm.

Silica is removed in an empirical relationship as a function of Mg(OH)2 formation resulting from caustic reaction with background magnesium. Additional Silica can be removed, by adding magnesium salts, if the background magnesium is insufficient. The magnesium compounds applicable to the process include MgSO4, MgCl2, and MgO. Generally, MgSO4 is the preferred choice due to ease of use. Chemical availability often is a determining factor.

The mechanisms of silica removal in the reactor include magnesium silicate formation, adsorption of silica of the surface of Mg(OH)2 floc, and physical encapsulation of silica within the floc particles. At ambient temperatures, silica can be removed to as low as 15 mg/l. Generally, the design target is established at 30 mg/l.

Lime is used in some applications for economic considerations. This can replace some of the caustic and soda ash requirements. In many cases, caustic and soda ash cannot be completely eliminated. It's a matter of chemistry and must be review on a case by case basis. Lime use complicates operation, adds to equipment & maintenance requirements, and increases the knowledge and attention required by operators. It is often more desirable to keep the system design and equipment as simple and maintenance free as possible; even at the expense of apparent higher chemical costs.

In this way, the actual chemical costs can be lower as the operating efficiency proves to be higher.

Caustic is applied to the reactor at the upper reaction surface creating a stratified high pH zone. This drives Mg precipitation to extreme de-saturation level and increases process efficiency.

Soda ash is applied to the reactor in the lower reaction zone for preferential reaction with calcium to form calcium carbonate precipitate. Soda ash feed and other reactor features are arranged to minimize parasitic magnesium carbonate precipitation, which decreases efficiency. Excess precipitates are blown down from the reactor by gravity; paced by the control system as a function of treated volume.

Considerable design attention is required ensure sludge management and removal as the volumes can become substantial and overload undersized equipment.

Similarly, chemical feeds must be precisely paced by the controlled system. The caustic is a function of pH set-point while the soda ash and Mg salts are paced with flow. Dosing level is preset by the operator as a function of the desired degree of treatment.

In many cases, the reactor effluent displays a characteristic white haze due to the presence of microscopic Mg(OH)2 particle de-saturation. This carries forward to the filtration system by conveyance of a clearwell tank and transfer pumping system.

By design, the Mg(OH)2 particles become enmeshed in the filter media and act as polishing adsorption media. This achieves a high degree of silica extraction and SDI (silt density index) reduction. The filter effluent is sparkling clear, with a very low SDI, and at the target silica content.

The filter system is washed automatically, once per day. The Mg(OH)2 particles are light, non-scaling, and easily removed by the backwashing action provided. Washing is invoked by the control system programming once per day per filter for approximately 15 minutes. During this period, the service flow is temporarily suspended. The control system staggers the washing action of individual filter units throughout the day such that system interface tanks can continuously provide product water for the users.

The technical details described above are transparent to the operating personnel. Essentially, most actions occur automatically without adjustment required or desired. The operator's main duties include system surveillance, preventative maintenance, and repair.

It is desirable to equip the site with basic water chemistry laboratory analytical apparatus and to provide training to operating personnel on its' use. A water analysis kit (such as by Hach), jar test kit, and SDI test equipment are recommended along with

P.O. Box 250 • 50 Elm St. • Westfield, NJ 07091 • 908.232.3473 direct
908.232.4407 gen'l • 908.232.0473 fax • horace@goleader.com

related glassware and reagents. It is highly desirable to have email, Internet and telefax service in the operating control room to facilitate technical service.

The equipment required for plant designs as discussed within this document is of common use throughout the world. Spare parts are readily available. No unusual maintenance requirements are involved. The most important ingredient is proper system design, quality construction, process knowledge, experience and training.

Contact the writer for specific design details and assistance with your project.
horace@uswca.com

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