Pretreatment
Controlling High Levels of Silica

The following are general recommendations for controlling high levels of silica in systems using reverse osmosis (RO) and nanofiltration (NF) elements. For additional information on cleaning membrane systems, please see MANN+HUMMEL Water & Fluid Solutions' Cleaning Guides or contact MANN+HUMMEL Water & Fluid Solutions Technical Service.

INTRODUCTION

Silica can be present in feed waters as particulate silica, colloidal silica (also called unreactive or amorphous silica) or dissolved silica (also known as molybdate-reactive silica).

Particulate silica (i.e. clays, soils and sand) are typically introduced into a surface water source via runoff and are usually 1 micron or larger and can be measured using the SDI (Silt Density Index) test. Particulate silica may foul an RO/NF system by physically blocking the element flow channels. This blockage essentially results in an increase in pressure drop across the elements. Removing silica can be difficult, but a standard alkaline cleaning solution may be able to remove enough of the build-up if the scale formation is not too severe.

Unreactive silica is colloidal or polymerized silica, acting more like a solid than a dissolved ion and tends to be present in acidic water conditions. It is well-rejected by an RO/NF membrane, but may cause the front end of the system to foul or the back end of the system to scale. Since it is well rejected, silica becomes heavily concentrated in the reject stream and may foul the membrane. Colloidal silica, with sizes as small as 0.008 micron can be measured empirically by the SDI test, but only the portion that is 0.45 micron or larger. Polymerized silica, which uses silicon dioxide as its building block, exists in nature (i.e. quartzes and agates) and can also result from exceeding the reactive silica saturation level.

Reactive silica is dissolved silica that is slightly ionized and has not been polymerized into a long chain. Reactive silica, though it has anionic characteristics, is not counted as an anion in terms of balancing a water analysis, but is counted as a part of total TDS (Total Dissolved Solids). The solubility of dissolved silica will depend on pH and temperature. Once the solubility limit is exceeded, silica scale is slow to crystallize.

Silica is challenging for RO and NF systems because of its stability once it falls out of solution. There are many factors involved in controlling fouling in a membrane system with high concentrations of silica in the feed and concentrate water. Specific temperature and pH ranges are as important as the use of silica inhibitor or antiscalant in order to keep silica in solution. If silica is present in the feed water at a concentration greater than 20 mg/L, the potential for silica precipitation should be evaluated.

Reactive silica solubility increases with increasing temperature, increases at a pH less than 7.0 or more than 7.8, and decreases in the presence of iron which acts as a catalyst in the polymerization of silica.

PRETREATMENT

If the maximum allowable recovery is lower than desired, lime plus soda ash softening employing either magnesium oxide or sodium aluminate can be used in the pretreatment system to decrease the SiO_2 concentration in the feed stream and thus permit higher conversion with respect to scaling by silica. It is important that the softening process be performed properly in order to prevent formation of insoluble metal silicates in the RO/NF system.

A high quality silica control scale inhibitor may be used in the feed stream prior to the membrane system. For extremely high silica applications, the dosage rate should be predetermined by the chemical manufacturer.

Many installations worldwide operate at lower recoveries to lower the potential for silica scale. In many applications, the tendency for silica scale formation has the effect of lowering the system recovery that may adversely affect the system economics. TriPol™ 9510 is a scale and silica inhibitor and dispersant that protects and enhances the operation of RO and NF systems by controlling mineral scale formation due to silica, carbonate, sulfate and fluoride compounds. TriPol™ 9510, when used properly, may significantly increase the allowable system recovery. Please refer to the specification sheet for TriPol™ 9510 for more information or contact MANN+HUMMEL Water & Fluid Solutions Technical Service.

OPERATIONAL CONSIDERATIONS

Temperature

The feed water temperature for a membrane system with greater than 200 mg/L of silica in the concentrate stream should always be above 21°C (70°F). Silica is less likely to stay in solution below this temperature.

The maximum allowable recovery with respect to silica scaling can be increased significantly by increasing the water temperature using a heat exchanger. The maximum temperature permitted for continuous use is 45°C (113°F) for standard water application elements.

pH

Since the solubility of silica increases below a pH of about 7.0 and above a pH of about 7.8, pH adjustment with either acid or base can permit a higher recovery with respect to silica scaling. For high pH, however, $CaCO_3$ scaling must be prevented. Lowering the RO permeate recovery may also lower the concentration of hardness and silica.

Permeate Flush

The membrane elements should be flushed for a minimum of 3 minutes with permeate water each time that the membrane system shuts down. This will flush out the highly concentrated water in the tail-end of the system which will prohibit precipitation during this stagnant flow period.

CLEANING PROCEDURE

A customized cleaning procedure is recommended on a scheduled maintenance basis. This will ensure complete removal of any precipitated silica. Silica, although it can be extremely difficult to clean when precipitated, can be successfully cleaned under the proper conditions.

Please refer to MANN+HUMMEL Water & Fluid Solutions' **Membrane Cleaning Guide – Water Application Elements** (TSG-C-001) for cleaning recommendations using alkaline cleaners TriClean™ 214TF or TriClean™ 212TF (for thin-film composite RO and NF membranes) to battle silica.

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FORM NO.: TSG-C-008
REVISION DATE: 07/01/2021

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