Antiscalants and Dispersants

There are a large number of chemical suppliers who supply a variety of proprietary antiscalants and dispersants to improve the operation of RO and NF systems.

Antiscalants are a family of chemicals designed to inhibit the formation and precipitation of crystallized mineral salts that form scale. Most antiscalants are proprietary organic man-made polymers (e.g. polyacrylic acids, carboxylic acids, polymaleic acids, organo-phosphates, polyphosphates, phosphonates, anionic polymers, etc.). The molecular weight of these polymers can range from 2,000 to 10,000 Dalton.

Antiscalant technology for RO systems was initially derived from chemistries used in cooling water and boiler water applications. It should be duly noted that the large number of different antiscalant chemistries that have evolved have produced a wide variety of results and efficacy depending on the application and organic polymer used.

Caution should be used in the use of antiscalants made of polyacrylic acid. They are susceptible to the formation of a foulant that settles on the membrane surface if there are high levels of iron. This foulant will increase feed pressure requirements, but typically can be cleaned using a low pH cleaning.

Caution should also be used in the use of antiscalants that are anionic in nature (e.g. polyacrylic acids) when a cationic-based coagulant or filtering aid is used in the pretreatment. A very viscous, sticky foulant can be produced that will increase feed pressure requirements, and it can be very difficult to clean off.

An antiscalant that was popular in the early days of RO was sodium hexametaphosphate (SHMP), but its use has been greatly reduced with the advent of proprietary antiscalants. SHMP has a number of limitations. Batches of diluted SHMP must be made every 2 to 3 days due to hydrolysis by exposure to air, which would dilute its efficacy and create a potential calcium phosphate scaling risk. SHMP has a reduced protection to calcium carbonate scaling with a maximum LSI rating in the concentrate of +1.0.

Antiscalants retard the growth of crystalline salt structures in the RO feed and concentrate streams, thereby allowing a concentration of sparingly soluble salts in excess of the normal

solubility limits. Antiscalants can be used to replace, or can be used in conjunction with, acid feed to control calcium carbonate scaling.

A number of factors can affect the rate of mineral scale formation. Lower temperatures reduce the solubility of mineral scales (the exception here is calcium carbonate scale formation is enhanced when temperature increases). The solubility of sparingly soluble salts increase with higher TDS levels (this is due to the increased interference by all the ions in the seeding process of scale formation).

The most common mineral scalants of concern:

- Calcium carbonate [CaCO3]
- Calcium sulfate [CaSO4]
- Strontium sulfate [SrSO4]
- Barium sulfate [BaSO4]

Less common mineral scalants are:

- Calcium phosphate [CaPO4]
- Calcium fluoride [CaF2]

Dispersants are a family of organic man-made polymers designed to inhibit the agglomeration and deposition of foulants onto the membrane surface. Dispersants are sometimes referred to as anti-foulants. Foulants tend to be a softer, non-crystalline deposit. Dispersant chemicals frequently have antiscalant properties. The efficacy of differing dispersants can vary for different foulants, so one needs to know what foulant they are treating for.

Foulants treated by dispersants:

- Mineral Scales
- Metal Oxides and Hydroxides [iron, manganese, aluminum]
- Polymerized Silica
- Colloidal material [defined as very small particles that stays in an infinite suspension and can be composed of clay, iron, aluminum, silica, sulfur and/or organic matter]
- Biological matter

Predicting the maximum solubility of super-saturated silica can be difficult. In particular, iron present in the feed water can readily produce iron silicates and dramatically reduce the allowable concentration of silica in the RO concentrate stream. Other major factors are pH and temperature.

Predicting the maximum levels of metals (e.g. iron, manganese, aluminum) can also be difficult. The soluble forms of the metal ions allow for higher levels of saturation. The insoluble forms tend to act more like particles and colloids.

Optimal dosing and allowable maximum saturation levels of scalants and foulants for antiscalants/dispersants are best determined by the chemical supplier who utilizes a proprietary software package. Hydranautics utilizes conservative estimates in its IMSDesign software for alarm purposes in estimating the allowable level of super-saturation of sparingly soluble salts.

Maintaining proper dosing levels of an antiscalant/dispersant is important. Under-dosing can cause scaling or fouling. Over-dosing can cause a deposition of the antiscalant/dispersant onto the membrane, creating a fouling problem.

It is important that the antiscalant/dispersant be thoroughly flushed from the RO elements at shutdown, as it can settle onto the membrane and cause a fouling problem. The injection of antiscalant/dispersant should cease during low pressure flushes when the RO feed water is the source of flush water.

The design of the antiscalant/dispersant injection system into the RO feed stream needs to make sure that it is properly mixed before it enters the RO elements. The use of a static mixer is the most effective mixing method, but adds cost to a system. Most systems have the injection point just before the RO feed cartridge filter and rely on the cartridge filter residence time and RO feed pump agitation to affect the mixing.

It is recommended that if there is an acid pH adjustment of the RO feed water, the acid should be injected upstream and thoroughly mixed before it reaches the antiscalant/dispersant injection point. Concentrated pockets of low pH acid may destroy the efficacy of antiscalant/dispersant.

The chemical metering pump used for the injection of antiscalant/dispersant should be adjusted to maximize the frequency of injection. A suggested minimum stroking frequency is once every 5 seconds. Typical dosing rates of antiscalants/dispersants are 2 to 5 ppm. To achieve a reasonable stroking frequency of the metering pump, a dilution of the antiscalant/dispersant may be required.

Antiscalants/dispersants are supplied as either a concentrated liquid or in a powder form. Dilution water should be hardness-free and preferably be of RO permeate quality. Diluted antiscalant/dispersants can become biologically fouled in the day tank depending on room temperatures and how much it has been diluted. A suggested residence time for a diluted solution is 7-10 days. Normally, undiluted antiscalant/dispersant solutions do not suffer from biological fouling.

The table below reflects the upper operating limits of saturation reported by chemical suppliers and the typically conservative alarm points used in the Hydranautics RO design program. These values are based on the concentrate stream, with normal saturation limit of 100% without use of an antiscalant/dispersant. Hydranautics will always recommend that you contact the chemical supplier to confirm the efficacy of a product.

Scalant or Foulant	**Maximum Reported**	**Hydranautics Alarm**
LSI (calcium carbonate)	+ 2.9	+ 1.8
Calcium Sulfate	400%	230%
Strontium Sulfate	1,200%	800%
Barium Sulfate	8,000%	6,000%
Calcium Fluoride	12,000%	Not alarmed
Silica	300 ppm or more	100%
Iron	5 ppm	not alarmed
Aluminum	4 ppm	not alarmed

Another major issue in selecting an antiscalant/dispersant is the assurance that it is compatible with the RO membrane being used. There are incompatible chemicals that can irreversibly foul or damage a RO membrane. Hydranautics relies on the supplier of the chemical to have performed all RO membrane compatibility and process efficacy tests.

Some recommended questions to ask chemical suppliers of antiscalants and dispersants are:

- Is it compatible with the RO membrane type in question.
- Is there an installation list of end-users with over 1000 hours of successful operation?
- Does it react adversely with any other constituents in the RO feed water (e.g. iron, heavy metals, cationic polyelectrolytes, etc.)?
- What are the recommended dosing rates and maximum dosing rates?
- What are the projected limits of solubility for individual scaling and fouling components?
- Are there any special discharge concerns?
- Is it suitable for potable water applications (if required)?
- Does the supplier offer other RO chemical feeds like antiscalant-compatible coagulants, biocides and cleaning chemicals?
- Does the supplier offer off-site technical support services like membrane autopsies or cleaning of elements?