RO Pretreatment

Proper pretreatment using both mechanical and chemical treatments is critical for an RO system to prevent fouling, scaling and costly premature RO membrane failure and frequent cleaning requirements. Below is a summary of common problems an RO system experiences due to lack of proper pretreatment.

FOULING:

Fouling occurs when contaminants accumulate on the membrane surface effectively plugging the membrane. There are many contaminants in municipal feed water that are naked to the human eye and harmless for human consumption, but large enough to quickly foul (or plug) an RO system. Fouling typically occurs in the front end of an RO system and results in a higher pressure drop across the RO system and a lower permeate flow. This translates into higher operating costs and eventually the need to clean or replace the RO membranes. Fouling will take place eventually to some extent given the extremely fine pore size of an RO membrane no matter how effective your pretreatment and cleaning schedule is. However, by having proper pretreatment in place, you will minimize the need to address fouling related problems on a regular basis.

Fouling can be caused by the following:

1. Particulate or colloidal mater (dirt, silt, clay, etc.)
2. Organics (humic/fulvic acids, etc)
3. Microorganisms (bacteria, etc). Bacteria present one of the most common fouling problems since RO membranes in use today cannot tolerate a disinfectant such as chlorine and thefore microorganisms are often able to thrive and multiply on the membrane surface. They may product biofilms that cover the membrane surface and result in heavy fouling.
4. Breakthrough of filter media upstream of the RO unit. GAC carbon beds and softener beds may develop an under drain leak and if there is not adequate post filtration in place the media can foul the RO system.

By performing analytical tests, you can determine if the feed water to your RO has a high potential for fouling. To prevent fouling of an RO system, mechanical filtration methods are used. The most popular methods to prevent fouling are the use of multi-media filters (MMF) or microfiltration (MF). In some cases cartridge filtration will suffice.

SCALING:

As certain dissolved (inorganic) compounds become more concentrated (remember discussion on concentration factor) then scaling can occur if these compounds exceed their solubility limits and precipitate on the membrane surface as scale. The results of scaling are a higher pressure drop across the system, higher salt passage (less salt rejection), low permeate flow and lower permeate water quality. An example of a common scale that tends to form on an RO membrane is calcium carbonate ($CaCO_3$).

CHEMICAL ATTACK:

Modern thin film composite membranes are not tolerant to chlorine or chloramines. Oxidizers such as chlorine will 'burn' holes in the membrane pores and can cause irreparable damage. The result of chemical attack on an RO membrane is a higher permeate flow and a higher salt passage (poorer quality permeate water). This is why microorganism growth on RO membranes tends to foul RO membranes so easily since there is no biocide to prevent its growth.

MECHANICAL DAMAGE:

Part of the pretreatment scheme should be pre and post RO system plumbing and controls. If 'hard starts' occur mechanical damage to the membranes can occur. Likewise, if there is too much backpressure on the RO system then mechanical damage to the RO membranes can also occur. These can be addressed by using variable frequency drive motors to start high pressure pumps for RO systems and by installing check valve(s) and/or pressure relief valves to prevent excessive back pressure on the RO unit that can cause permanent membrane damage.

Pretreatment Solutions

Below are some pretreatment solutions for RO systems that can help minimize fouling, scaling and chemical attack.

MULTI MEDIA FILTRATION (MMF):

A Multi-Media Filter is used to help prevent fouling of an RO system. A Multi-Media Filter typically contains three layers of media consisting of anthracite coal, sand and garnet, with a supporting layer of gravel at the bottom. These are the Medias of choice because of the differences in size and density. The larger (but lighter) anthracite coal will be on top and the heavier (but smaller) garnet will remain on the bottom. The filter media arrangement allows the largest dirt particles to be removed near the top of the media bed with the smaller dirt particles being retained deeper and deeper in the media. This allows the entire bed to act as a filter allowing much longer filter run times between backwash and more efficient particulate removal.

A well-operated Multi-Media Filter can remove particulates down to 15-20 microns. A Multi-Media Filter that uses a coagulant addition (which induces tiny particles to join together to form particles large enough to be filtered) can remove particulates down to 5-10 microns. To put this in perspective, the width of a human hair is around 50 microns.

A multimedia filter is suggested when the Silt Density Index (SDI) value is greater than 3 or when the turbidity is greater than 0.2 NTU. There is no exact rule, but the above guidelines should be followed to prevent premature fouling of RO membranes.

It is important to have a 5 micron cartridge filter placed directly after the MMF unit in the event that the under drains of the MMF fail. This will prevent the MMF media from damaging downstream pumps and fouling the RO system.

MICROFILTRATION (MF):

Microfiltration (MF) is effective in removing colloidal and bacteria matter and has a pore size of only 0.1-10µm. Microfiltration is helpful in reducing the fouling potential for an RO unit. Membrane configuration can vary between manufacturers, but the "hollow fiber" type is the most commonly used. Typically, the water is pumped from the outside of the fibers, and the clean water is collected from the inside of the fibers. Microfiltration membranes used in potable water applications usually operate in "dead-end" flow. In dead-end flow, all of the water fed to the membrane is filtered through the membrane. A filter cake that must be periodically backwashed from the membrane surface forms. Recovery rates are normally greater than 90 percent on feed water sources which have fairly high quality and low turbidity feeds.

ANTISCALANTS AND SCALE INHIBITORS:

Antiscalant and scale inhibitors, as their name suggests, are chemicals that can be added to feed water before an RO unit to help reduce the scaling potential of the feed water. Antiscalant and scale inhibitors increase the solubility limits of troublesome inorganic compounds. By increasing the solubility limits, you are able to concentrate the salts further than otherwise would be possible and therefore achieve a higher recovery rate and run at a higher concentration factor. Antiscalant and scale inhibitors work by interfering with scale formation and crystal growth. The choice of antiscalant or scale inhibitor to use and the correct dosage depends on the feed water chemistry and RO system design.

SOFTENING BY ION EXCHANGE:

A water softener can be used to help prevent scaling in an RO system by exchanging scale forming ions with non-scale forming ions. As with a MMF unit, it is important to have a 5 micron cartridge filter placed directly after the water softener in the event that the under drains of the softener fail.

SODIUM BISULFITE (SBS) INJECTION

By adding sodium bisulfite (SBS or SMBS), which is a reducer, to the water stream before an RO at the proper dose you can remove residual chlorine.

GRANULAR ACTIVATED CARBON (GAC)

GAC is used for both removing organic constituents and residual disinfectants (such as chlorine and chloramines) from water. GAC media is made from coal, nutshells or wood. Activated carbon removes residual chlorine and chloramines by a chemical reaction that involves a transfer of electrons from the surface of the GAC to the residual chlorine or chloramines. The chlorine or chloramines ends up as a chloride ion that is no longer an oxidizer.

The disadvantage of using a GAC before the RO unit is that the GAC will remove chlorine quickly at the very top of the GAC bed. This will leave the remainder of the GAC bed without any biocide to kill microorganisms. A GAC bed will absorb organics throughout the bed, which is potential food for bacteria, so eventually a GAC bed can become a breeding ground for bacteria growth which can pass easily to the RO membranes. Likewise, a GAC bed can produce very small carbon fines under some circumstances that have the potential to foul an RO.