

## Pretreatment

### MEMBRANE FOULING CONSIDERATIONS

The feed water, depending on its source, may contain various concentrations of suspended solids and dissolved matter. Suspended solids may consist of inorganic particles, colloids and biological debris such as microorganisms and algae. Dissolved matter may consist of highly soluble salts, such as chlorides, and sparingly soluble salts, such as carbonates, sulfates, and silica. During the RO process, the volume of feed water decreases, and the concentration of suspended particles and dissolved ions increases. Suspended particles may settle on the membrane surface, thus blocking feed channels and increasing friction losses (pressure drop) across the system. Sparingly soluble salts may precipitate from the concentrate stream, create scale on the membrane surface, and result in lower water permeability through the RO membranes (flux decline). This process of formation of a deposited layer on a membrane surface is called membrane fouling and results in performance decline of the RO system. The objective of the feed water pretreatment process is to improve the quality of the feed water to the level which would result in reliable operation of the RO membranes.

The quality of the feed water is defined in terms of concentration of suspended particles and saturation levels of the sparingly soluble salts. The common indicators of suspended particles used in the RO industry are turbidity and Silt Density Index (SDI). The maximum limits are: turbidity of 1 NTU and SDI of 4. Continuous operation of an RO system with feed water which has turbidity or SDI values near the limits of these values may result in significant membrane fouling. For long-term, reliable operation of the RO unit, the average values of turbidity and SDI in the feed water should not exceed 0.5 NTU and 2.5 SDI units, respectively.

The indicators of saturation levels of sparingly soluble salts in the concentrate stream are the Langelier Saturation Index (LSI) and the saturation ratios. The LSI provides an indication of the calcium carbonate saturation. Negative values of LSI indicate that the water is aggressive and that it will have a tendency to dissolve calcium carbonate. Positive values of LSI indicate the possibility of calcium carbonate precipitation. The LSI was originally developed by Langelier for potable water of a low salinity. For high salinity water encountered in RO

applications, the LSI is an approximate indicator only. The saturation ratio is the ratio of the product of the actual concentration of the ions in the concentrate stream to the theoretical solubilities of the salts at a given conditions of temperature and ionic strength. These ratios are applicable mainly to sparingly soluble sulfates of calcium, barium and strontium. Silica could be also a potential scale forming constituent. Other potential scale forming salts, such as calcium fluoride or phosphate which may be present in RO feed, seldom represent a problem.

Depending on the raw water quality, the pretreatment process may consists of all or some of the following treatment steps:

- Removal of large particles using a coarse strainer.
- Water disinfection with chlorine.
- Clarification with or without flocculation.
- Clarification and hardness reduction using lime treatment.
- Media filtration.
- Reduction of alkalinity by pH adjustment.
- Addition of scale inhibitor.
- Reduction of free chlorine using sodium bisulfite or activated carbon filters.
- Water sterilization using UV radiation.
- Final removal of suspended particles using cartridge filters.

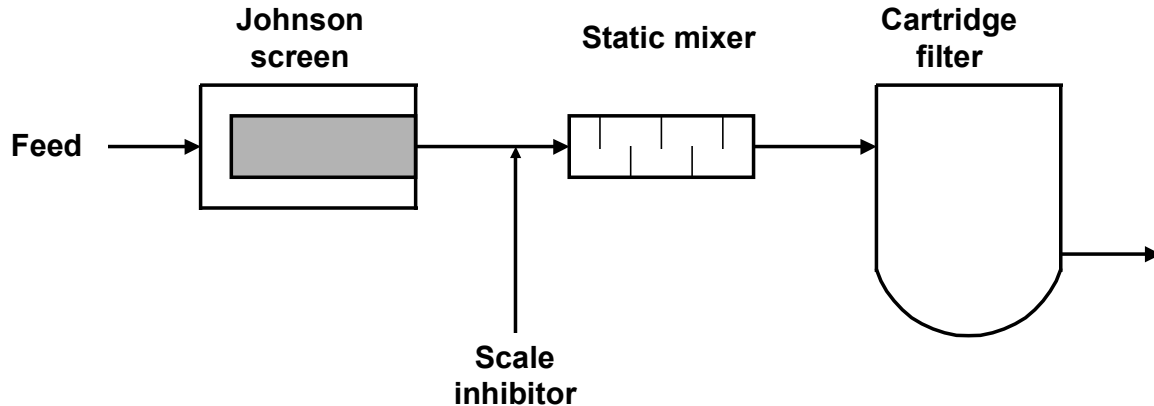
The initial removal of large particles from the feed water is accomplished using mesh strainers or traveling screens. Mesh strainers are used in well water supply systems to stop and remove sand particles which may be pumped from the well. Traveling screens are used mainly for surface water sources, which typically have large concentrations of biological debris.

It is common practice to disinfect surface feed water in order to control biological activity. Biological activity in a well water is usually very low, and in majority of cases, well water does not require chlorination. In some cases, chlorination is used to oxidize iron and manganese in the well water before filtration. Well water containing hydrogen sulfide should not be chlorinated or exposed to air. In presence of an oxidant, the sulfide ion can oxidize to elemental sulfur which eventually may plug membrane elements.

Settling of surface water in a detention tank results in some reduction of suspended particles. Addition of flocculants, such as iron or aluminum salts, results in formation of corresponding hydroxides; these hydroxides neutralize surface charges of colloidal particles, aggregate, and adsorb to floating particles before settling at the lower part of the clarifier. To increase the size and strength of the flock, a long chain organic polymer can be added to the water to bind flock particles together. Use of lime results in increase of pH, formation of calcium

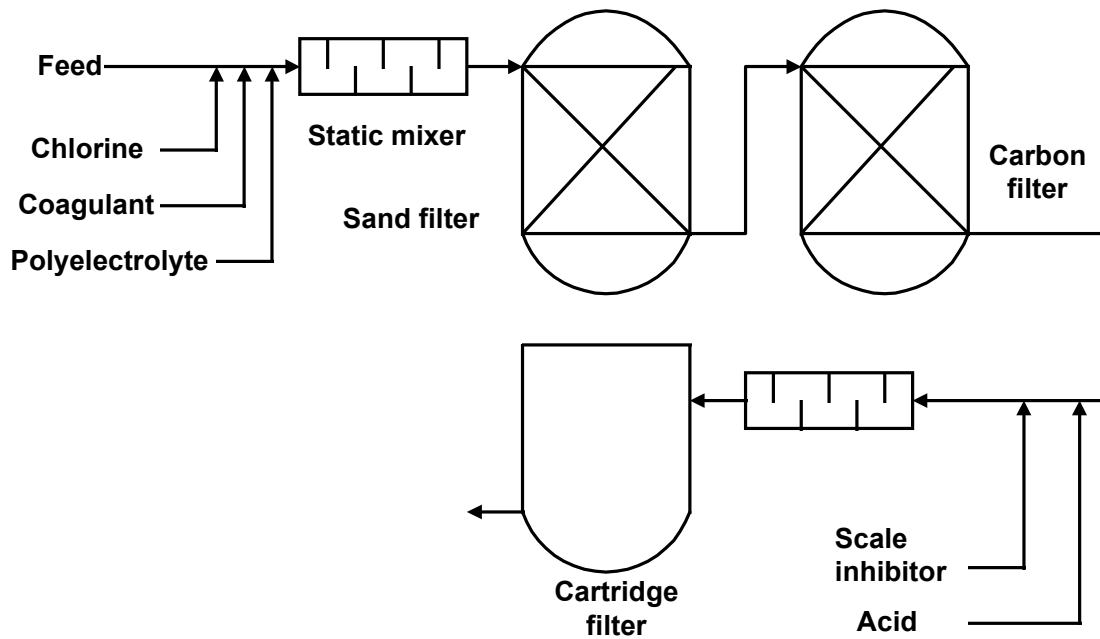
carbonate and magnesium hydroxide particles. Lime clarification results in reduction of hardness and alkalinity, and the clarification of treated water.

Well water usually contains low concentrations of suspended particles, due to the filtration effect of the aquifer. The pretreatment of well water is usually limited to screening of sand, addition of scale inhibitor to the feed water, and cartridge filtration.



**Pretreatment system for well water source**

Surface water may contain various concentrations of suspended particles, which are either of inorganic or biological origin. Surface water usually requires disinfection to control biological activity and removal of suspended particles by media filtration. The efficiency of filtration process can be increased by adding filtration aids, such as flocculants and organic polymers. Some surface water may contain high concentrations of dissolved organics. Those can be removed by passing feed water through an activated carbon filter. Depending on composition of the water, acidification and addition scale inhibitor may be required. The flow diagram of pretreatment system for surface water is shown below.



**Pretreatment system for surface water source**

Cartridge filters, almost universally used in all RO systems prior to the high pressure pump, serve as the final barrier to water born particles. The nominal rating commonly used in RO applications is in the range of 5 - 15 microns. Some systems use cartridges with micron ratings as low as 1 micron. There seems to be little benefit from lower micron rated filters as such filters require a high replacement rate with relatively small improvement in the final feed water quality.

Recently, new pretreatment equipment has been introduced to the RO market. It consists of backwashable capillary microfiltration and ultrafiltration membrane modules. This new equipment can operate reliably at a very high recovery rates and low feed pressure. The new capillary systems can provide better feed water quality than a number of conventional filtration steps operating in series. The cost of this new equipment is still very high compared to the cost of an RO unit.

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