FILMTEC Membranes

Opportunities to reduce RO system operating costs by optimizing system design and operating procedures.

Introduction

The current operating costs of many existing RO systems can be reduced by implementing hardware modifications, and/or cleaning program modifications.

This document discusses the importance of:

1. Correct cleaning sequence.
2. pH and temperature for effective cleaning.
3. Avoid interstage cleaning.
4. Interstage pressure indicators.
5. RO permeate flush.
6. Temperature controlled heating device for CIP (Cleaning in Place) skid.
7. Cartridge filters on CIP skids.
8. Avoid the use of the high pressure pump for cleaning.
9. Regulating and measuring concentrate recycle flows.

1. Importance of correct cleaning sequence: alkaline cleaning followed by an acid cleaning.

The recommended cleaning sequence for FILMTEC™ reverse osmosis (RO) membranes is alkaline cleaning followed by acid cleaning. RO permeate or deionized water should be used for the preparation of the cleaning solution and for flushing out the cleaning solution after each cleaning step.

Element fouling typically consists of a combination of foulants and scalants, for example a mixture of organic fouling, colloidal fouling, biofouling, inorganic and metal scaling. Very often, the cleaning sequence “acid cleaning followed by an alkaline cleaning” is applied. This cleaning sequence has many limitations because the acid cleaner reacts with silica, organics (such as humic acid) and biofilm present on the membrane surface, causing a further decline of the membrane element performance.

Sometimes, an alkaline cleaning may restore the decline caused by the acid cleaning but often an extreme cleaning will be necessary. An extreme cleaning is carried out at pH and temperature conditions that are outside the membrane manufacturer’s guidelines, or by using cleaning chemicals that are not compatible with the membrane elements. An extreme cleaning is carried out only as a last resort as it can cause irreversible membrane damage.

The acid cleaning is performed only when the alkaline cleaning has effectively removed the organic fouling, colloidal fouling and biofouling. The acid cleaning is effective in removing calcium carbonate scale from the membrane surface. Typically, calcium carbonate scale is located in the last stage of the system. The acid cleaning is then only applied on the last stage.

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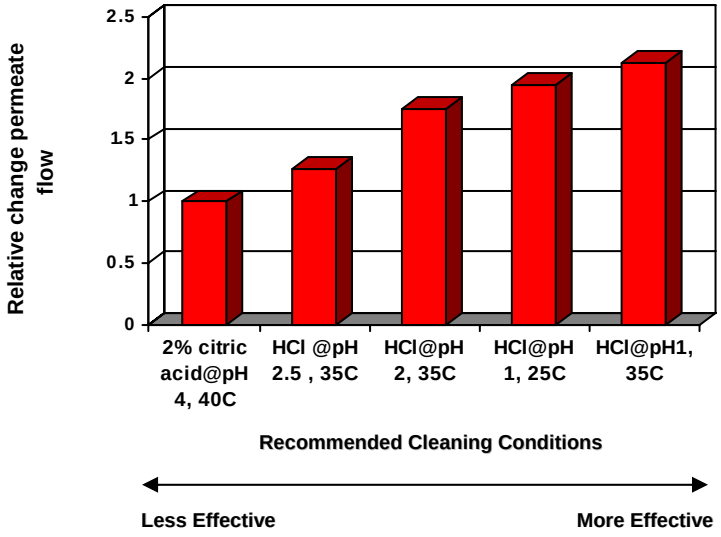
2. Importance of pH and temperature for effective cleaning.

Cleaning programs are often carried out at a pH between 3 and 11 based on recommendations of chemical suppliers, membrane manufacturers and OEMs. The characteristics of the membrane element determines the minimum and maximum allowed values for pH and temperature.

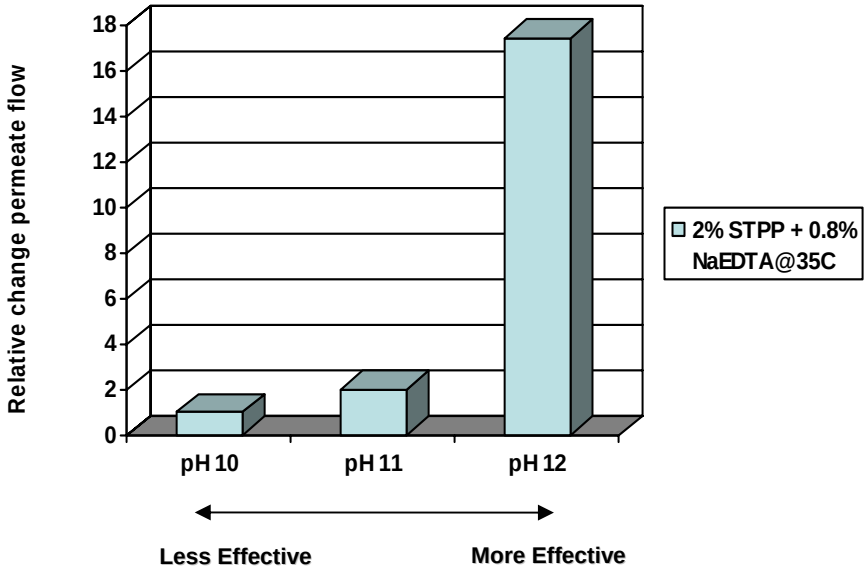
More effective removal of organic fouling and/or biofouling takes place at pH 12 and a minimum temperature of 95ºF (35ºC). FILMTEC reverse osmosis elements (BW30, TW30, LP, BW30LE, LE, XLE, SW30, SW30HR, SW30HR LE and SW30XLE products) may be cleaned at a pH range of 1-13. The following graphs show the importance of pH on foulant removal.

Figure 1. Effect of pH on removal of calcium carbonate



NOTE: Calcium carbonate is more effectively removed at pH 1.

Figure 2. Effect of pH on removal of biofouling



NOTE: Biofouling is more effectively removed at pH 12.

3. Avoid interstage cleaning (cleaning solution enters the first stage and exits the last stage).

FilmTec strongly recommends cleaning each stage in a system separately.

Interstage cleaning may result in foulant (colloidal, microbiological and organic fouling) removed from the first stage by the cleaning solution to be transferred into the other stage(s). When that happens, the performance of the first stage improves, but performance of the subsequent stages decline, resulting in little overall system performance improvement after the cleaning.

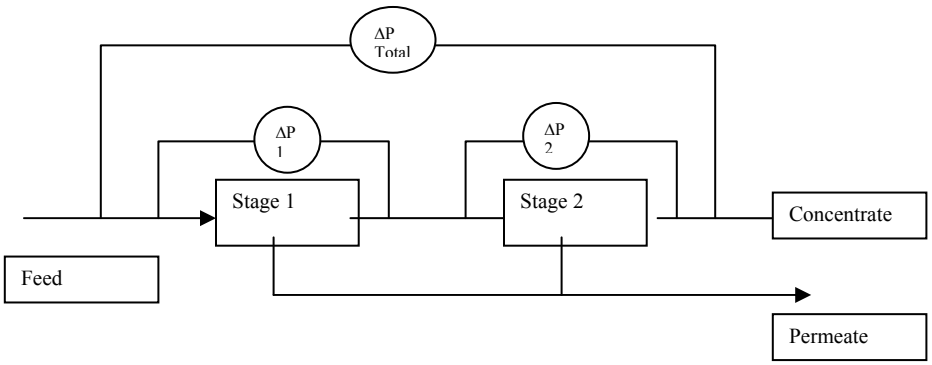
4. Importance of interstage pressure indicators.

Interstage pressure indicators are critical for the assessment of RO plant performance, especially in case of surface waters and city waters since these water sources tend to contribute to high rates of fouling. Interstage pressure indicators enable the pressure drop of each stage to be calculated (feed pressure minus concentrate pressure) so the location (i.e. stage) of the performance problem can be more accurately identified.

Measuring only the total pressure drop of a system can conceal a problem. While the total pressure drop value may be acceptable, it is possible that the pressure drop mainly occurs in one stage. In that case, the membrane elements in that stage may already be damaged.

Example:
A two stage RO system (see diagram below) has a total pressure drop of 40 psi. Pressure drop has increased to 50 psi. This amounts to a 25% total pressure drop increase. However, when reviewing individual stage details: the first stage pressure drop increased from 15 psi to 25 psi while the second stage remained at 25 psi. The first stage pressure drop increased 60%.

Because interstage pressure indicators allow a system operator to pinpoint the areas of high pressure drop, they are strongly recommended.



5. Importance of an RO permeate flush prior to shutdown.

Prior to the shutdown of RO systems, a permeate water flush is recommended to avoid precipitation of salts and organics concentrated on the feed side of the element onto the membrane surface. Unfortunately, many RO systems do not incorporate a permeate flush and apply a feed water flush instead. This accelerates all forms of membrane fouling (biofouling, colloidal fouling, scaling, organic fouling).

NOTE: If anti-scalants are present in the feed water, they are typically effective for only 15-30 minutes after being dosed. If the feedwater is already saturated with certain salts then scaling may start to occur after 15-30 minutes. This is another reason why FilmTec recommends a permeate flush prior to shutdown of the RO unit.

If the shutdown is more than 24 hours, chemical preservation or daily operation for a short period is recommended to avoid microbiological growth during the shutdown period.

6. Importance of a temperature controlled heating device on the CIP (Cleaning in Place) skid.

CIP skids are often not equipped with a temperature controlled heating device. Heating the cleaning solution is very important in case of organic fouling and biofouling. Alkaline cleanings are more effective at temperatures $\geq$ 95°F (35°C). Alkaline cleanings at lower temperatures are less effective resulting in increased cleaning frequency and higher operational costs due to frequent cleaning and membrane replacement.

7. Importance of cartridge filters on the CIP skid.

Cartridge filters on the CIP skid are necessary to remove particulates, including cleaning chemical powders, avoid membrane abrasion and precipitation on the membrane surface area. If the CIP skid is not equipped with cartridge filters, the cartridge filters from the RO system can sometimes be used.

NOTE: If the cartridge filters of the RO system are used to filter the cleaning solution, remember to install new cartridge filters prior to cleaning, otherwise the cleaning solution may dissolve/remove foulant from cartridge filters and deposit it on the membrane surface. System operators have been known to forget to replace the cartridge filters prior to a cleaning, resulting in an inefficient cleaning cycle.

The cleaning solution should always pass through cartridge filters prior to entering the RO/NF system. FilmTec strongly recommends equipping the CIP skid with cartridge filters (absolute pore size < 10 micron).

8. Avoid the use of the high pressure pump for cleaning of RO systems.

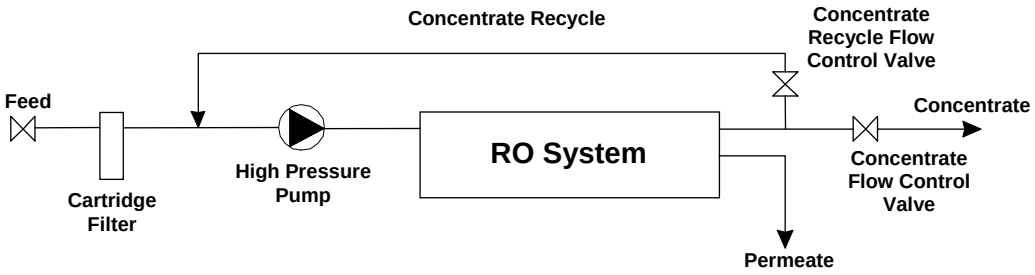
During cleaning, it is necessary to create and maintain a sweeping and turbulent effect across the membrane surface to aid in the removal of foulants on the membrane. Cleaning at low pressure is necessary to limit the production of permeate, so only concentrate is produced which maximizes the sweeping effect.

In cases where the high pressure pump is used during cleaning, the cleaning procedure is less effective. Not only is there less cross-flow if too much permeate is produced (resulting in less turbulence), cleaning at high pressure pushes the foulant deeper into the membrane surface and may also cause mechanical damage (telescoping, membrane intrusion). When that happens, RO system performance after cleaning either remains the same or declines further. It is critical for the CIP skid to have a correctly sized low pressure cleaning pump (CIP pump).

Additionally, the permeate valve must be open during cleaning, to avoid possible permeate back pressure damage. Also, when the RO system is put back into operation, the permeate valve must be open to avoid significant damage to the elements and pressure vessel piping.

9. Regulating and measuring concentrate recycle flows.

Some RO systems are designed with internal concentrate recirculation to increase the recovery of an RO system, while following the system design guidelines of the membrane element manufacturer. Certain applications (like systems operating at a wide temperature range) require adjustment of the RO plant parameters including adjustment of the internal concentrate recycle flow. In these cases, the internal concentrate recycle flow needs to be measured to assess or monitor system performance.



For Further Information

Technical information regarding FILMTEC membrane elements can be found at www.filmtec.com.

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