Operating Guidelines

TECHNICAL BULLETIN

Cleaning Spiral-Wound Membranes

These guidelines address when to clean and what cleaners or sanitizers to use for each type of Veolia membrane element. The guidelines are based on technical information, which Veolia believes to be accurate and reliable. They are intended for persons with technical skills to use at their own discretion and risk. Because the conditions of use are outside our control, Veolia does not assume liability for results obtained or damages incurred through the application of the cleaning solutions or procedures suggested.

When selecting a cleaner or sanitizer, several things must be considered, including the foulant to be removed, membrane element compatibility, and membrane type. Cleaning solutions must fall within pH ranges specified for the membrane element. In addition, the cleaner must not contain certain chemical substances incompatible with the membrane element, such as certain surface-active agents and, in some instances, oxidizing agents such as chlorine. Use of cleaning solutions other than those known to be compatible may reduce membrane life and void the Veolia membrane element warranty.

Why Clean

During the operation of a membrane separation system, the incoming water frequently brings suspended solids and organic materials to the membrane surface. The suspended solids might get stuck on the membrane surface, helped by the feed channel spacer that is in contact with the membrane. Dissolved organics might be adsorbed by the membrane, both on the outer surface and on the membrane pore walls. Dissolved species are concentrated in the elements, and it is possible that they reach saturation conditions and precipitate to form a scale on the membrane. Besides, microbes might settle down on the membrane surface and build a biofilm, which becomes thicker the higher the nutrients concentrations are in the feed solution.

The deposits, including the precipitates, adsorbed organics, and the biofilm, are all called foulants, and they all impede the flow of water through the membrane. This can result in unacceptably low permeate flow rate, high operating pressure, and an excessive pressure drop in the system, which may lead to irreversible element damage. The foulants also increase the amount of dissolved material passing through the membrane, resulting in product water of unacceptable quality.

All foulants must be removed through a clean-in-place (CIP) process before irreversible membrane damage occurs. It is, however, much easier to remove foulants at the beginning of the fouling process than when a thick fouling layer has been formed, so a CIP should be performed when there are strong indications that the fouling process has started.

There are exceptions, for example, many wastewater applications, where membrane fouling starts upon start of operation, and in such cases, the suitable cleaning frequency has to be determined case by case.

When to Clean

Membrane elements should be cleaned if either of the following conditions occurs:

1. Normalized permeate flow drops 15% or greater after the initial flow stabilization.

   Note - In many cases, the operator may expect some irreversible loss of permeate flow due to system stabilization during the first 100 hours of initial use.

This loss is usually normal flow loss and does not necessarily indicate a need for cleaning. However, the amount of lost flow should be carefully monitored in case it is the result of an RO pretreatment system malfunction or the existence of conditions not anticipated during system design.

2. Salt passage increases by 30 - 40%.

   Note - Abrupt and significant changes in permeate flow or salt passage can also be attributed to other factors, such as defective O-rings or flow by-pass around element brine seals.

3. An Increase in normalized pressure drop (∆P) of 25% or greater.

   Membrane element ∆P increases when foulants or precipitates plug the feed spacers between the membranes in spiral-wound membrane elements. When the ∆P has increased markedly, a considerable amount of contaminants/sediment already has built up in the membrane element, so cleaning is required.

If element is too badly fouled, it is difficult to restore the membrane element's performance.

The MUNOS spreadsheet, and associated manual, for RO and NF system performance normalization are available in the Veolia document library. Please contact your Veolia representative as needed.

Recommended cleaner recirculation and soaking times

Most cleaning solutions should be circulated for 10-30 minutes, followed by a 10 to 30-minute soaking period and then a final 10-minute recirculation prior to discharging it. Chemical addition may be required during the recirculation to maintain the desired pH. The spent cleaning solution should be thoroughly flushed with RO quality water to drain or holding tank. Please refer to *Table 2* for recommended cleaning solutions.

Note - Enzyme cleaners require longer residence times to allow for complete reaction with the contaminate. Detergents containing enzymes should be allowed to recirculate and soak for at least 1-2 hours before flushing.

When contaminant removal is difficult, longer circulation and possibly additional soaking times may be useful. An additional cleaning cycle with fresh cleaning solution is usually more effective. A foulant may be composed of different types of materials, making different cleaners and/or multiple cleaning cycles necessary to increase cleaning effectiveness.

The circulation flow during cleaning should be in the same direction as during normal system operation. *Do not reverse flush from permeate manifolding through membrane element as damage will occur.*

Cleaning Solutions Temperatures

The circulation of a heated cleaning solution through the membrane elements often proves advantageous because higher temperatures increase chemical reaction rates. Warm solutions often strip scale and/or contaminants faster than ambient temperature solutions. However, cleaning solution temperatures should be kept under the limits specified for each membrane element model. The operator risks damaging the membrane element if cleaning solution temperature goes above its maximum recommended cleaning temperature.

Safety Precautions

When using any cleaning chemical, follow accepted safety practices. Read the labels on cleaning chemical container and refer to the system operating manual. If in doubt about handling, safety, or disposal procedures, contact the cleaning chemical supplier for detailed information before proceeding to prepare or use the products. Several cleaners contain surfactants. This may cause foaming during the CIP. It is recommended to have anti-foam on site. Consult with Veolia Membrane Chemical specialist for further recommendations.

Cleaning Solution Preparation

All solid cleaning chemicals should be fully dissolved and well mixed before the cleaning solution is introduced into the system. Use RO quality water or filtered, low hardness water (less than one grain per gallon or 17 mg/L as CaCO3 of hardness to prepare cleaning solutions. Reuse of cleaning solutions is not recommended. Some cleaners have limited shelf life, so check the age of cleaners before using them.

Suggested Cleaning Equipment

A cleaning solution mixing tank with a cover and a temperature gauge is suggested. Appropriate valving, sample ports, flow meters, pH monitor, pressure gauges,

recirculation pump, and cartridge filter are also recommended. When selecting cleaning system equipment, the material of construction of the system's components should be chemically and physically compatible with the cleaners and temperatures to be used. A cartridge filter on the cleaning solution return-to-tank or feed line to the crossflow filtration machine will remove particles dislodged from the membrane elements.

Amount of Cleaning Solution Needed

To determine the amount of cleaning solution required, estimate the hold-up volume of the cleaning loop piping and membrane element housings. Then add sufficient water to the CIP tank to prevent it from emptying when filling the system. At the beginning of the cleaning cycle, the process water in the system should be discharged to drain as it is displaced by the cleaning solution. This process will prevent dilution of the cleaning solution.

To estimate the CIP tank recirculation dimension, calculate the hold-up volume of the system and then multiply it by 2. For the hold-up volume in the element housings, use the following estimate, provided the housings are filled with maximum number of elements.

- 20 liters for every 8in element (5 gal/element)
- 4 liters for every 4in element (1 gal/element)

CIP Protocol

In most cases, clean with a low pH cleaner first, except in cases where silica scale, sulfate scale, or oil/grease fouling is suspected. Colloidal fouling can be covered by slow forming scale. It must be removed by a low pH cleaner first to uncover the silt and therefore make it available to be removed by a high pH cleaner.

The following general cleaning procedure can be followed. For the optimum cleaning procedure for your system, contact Veolia representative.

1. Inspect cleaning tank, hoses, and cartridge filters. Clean tank and flush hoses if necessary. Install new cartridge filters. Use a 5-micron or tighter rating filter on the cleaning system.
2. Fill cleaning tank with RO permeate or DI water. Turn on agitator or tank recirculation pump.
3. Slowly add cleaner to cleaning tank and allow mixing thoroughly.
4. Check solution temperature. If solution temperature is lower than recommended level, adjust heating control to provide optimum temperature. If manufacturer's recommendation is not available, contact Veolia representative. If a heater is not available, recirculate cleaning solution by using the membrane system's high-pressure pump. This may help to reach a higher temperature.
5. Check solution pH. Allowable pH ranges are given in Table 4. If pH is too low, adjust pH upward with NaOH or other chemical as recommended by the membrane manufacturer. If pH is too high, adjust with hydrochloric acid.
6. Circulate solution through one stage at a time in the direction of feed flow for 10 - 30 minutes. Recommended maximum recirculation flow rates are given in Table 1. To ensure that this maximum flow is not outside the limits, it is strongly advisable not to exceed 0.7 bar of pressure drop per element and 3 bar per pressure vessel. A too high flow, indeed, induces foam building that can make rinsing fastidious.

Table 1: Recommended maximum cleaning flows

Size	Fiberglass or Tape m^3/hr (gpm)	Cage m^3/hr (gpm)
2.5"	1.2 (5.3)	1.8 (7.9)
4"	3 (13.2)	4.5 (19.8)
8"	12 (52.8)	18 (79.3)

Do not exceed 0.7 bar of pressure drop per element.

7. Pressure should be low enough so that minimal permeate is produced during cleaning, but always less than 60 psig (4.2 bar); 2.5 - 4 bar for the reverse osmosis membranes and 1.5 - 2.5 for the other membrane types (nanofiltration, ultrafiltration and microfiltration). Higher pressure will cause increased permeation and hold foulant to the surface of the membrane. In cases of heavy fouling, the first return flow (up to 15% of the cleaning tank volume) should be diverted to drain to prevent redeposition of removed solids. For optimum results, each stage must be cleaned separately in a multistage system.

8. Soak the membrane during 25 min. This enhances cleaner efficiency.
9. If the first stage cleaning solution becomes turbid or discolored, dump the tank and prepare a fresh cleaning solution before proceeding. If solution pH or temperature moves out of the recommended range, a new solution should be prepared. In any event, a new cleaning solution should be prepared for each stage.
10. Rinse with RO permeate before returning system to service.
11. When returning unit to service, divert product water to drain until any residual cleaning solution has been rinsed from system.

    If a second cleaning is necessary, always rinse your system up to get neutral pH in both permeate and concentrate. Redo the same procedure

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Table 2: Recommended cleaning solutions - Example product selection

Foulant	A, D, G, H, R & S-Series	PW-Series	C-Series
Mineral scale and metal precipitates	• Kleen* MCT113 at 2-4 % • Kleen MCT882 at 2-10% • MemChem* MCT201 at 2-4%	• Kleen MCT113 at 2-4 % • Kleen MCT882 at 2-10% • MemChem MCT201 at 2-4%	• Kleen MCT113 at 2-4 % • Kleen MCT882 at 2-10% • MemChem MCT201 at 2% • Kleen MCT403 at 2-4% Adjust to pH 3 with NH_4OH if needed
Organics, silt, bacterial slime	• Kleen MCT 515 at 2-4 % [1] • Kleen MCT 404 surfactant at 0.1-0.2%, • Kleen MCT411 or MCT400 at 1-3% • Kleen MCT524 as high pH at 0.2-0.5% Products are buffered but if needed pH adjustment either sodium hydroxide or hydrochloric acid can be used	• Kleen MCT 515 at 2-4 %[1] • Kleen MCT 404 surfactant at 0.1-0.2% • Kleen MCT411 or MCT400 at 1-3% • Kleen MCT524 as high pH at 0.2-0.5% Products are buffered but if needed pH adjustment either sodium hydroxide or hydrochloric acid can be used	• Kleen ENV907 at 1-3% • Kleen MCT404 at 0.1-0.2% Adjust to pH 8.0 with HCl if needed Frequent cleaning will cause premature hydrolyzing of the membrane.

[1] Use Kleen MCT515E in Europe

Table 3: Recommended sanitizing solutions - Example product selection

A, D, G, H, R & S-Series	PW-Series	C-Series
• BetzDearborn* DCL30 or BetzDearborn DCL32 at 0.1% • BioMate* MBC781 at 200-400 ppm • BioMate MBC2881 at 100-200 ppm • BioMate MBC2881E at 100–200 ppm [2] • Chlorine dioxide at 30 ppm only pure not having chlorine by-products • Peracetic acid: ask Veolia representative	• BetzDearborn DCL30 or BetzDearborn DCL32 at 0.1% • BioMate MBC781 at 200-400 ppm • BioMate MBC2881 at 100-200 ppm • BioMate MBC2881E at 100-200 ppm [2] • Hydrogen peroxide at 5-10% • Chlorine at 5-10 ppm	• BetzDearborn DCL30 or BetzDearborn DCL32 at 0.1% • BioMate MBC781 at 200-400 ppm • BioMate MBC2881 at 100-200 ppm • BioMate MBC2881E at 100-200 ppm [2] • Chlorine at 30 ppm for 30 minutes

[2] NSF/ANSI Standard 60 Approved. This product is designed to be used off-line and flushed out prior to using the system for drinking water.

Table 4: pH range during a 30-min cleaning - Refer to the element product fact sheet for further data. Contact Veolia for elements that are not listed.

Element type	Max Temp > 50°C (122°F)	50°C > Temp > 35°C	35°C > Temp > 20°C	Max Temp < 20°C
AC, AD, AE	Contact Veolia for assistance	1.0-12.0	1.0 – 12.0	1.0 – 12.0
AG, AG FR, AG LE, AG LF, AK, AK LE, AP, AL, Industrial RO5, RO6, & RO7, PW, BEV RO	Contact Veolia for assistance	1.0 – 10.5	1.0 – 12.0	1.0 - 13.0
S-Series, Industrial RO3	Contact Veolia for assistance	1.0 - 10.5	1.0 – 11.0	1.0 – 11.5
D-Series, DuraSlick* NF, Industrial NF1 H-Series, R-Series	Contact Veolia for assistance	3.0 – 10.0	2.0 – 11.0	2.0 – 11.0
C-Series, BEV-NF-CA	Contact Veolia for assistance	Not allowed	4.0 – 6.0	3.0 - 8.0
G-Series	Contact Veolia for assistance	2.0 – 11.0	1.0 – 12.0	1.0 – 13.0

Table 5: Chlorine tolerances - Refer to the element product fact sheet for further data. Contact Veolia for elements that are not listed.

Element type	Chlorine tolerance
A-Series, Industrial RO5, RO6 & RO7, BEV RO	< 1000 ppm x hours, dechlorination recommended
H-Series, R-Series	< 1000 ppm x hours, dechlorination recommended
C-Series, BEV-NF-CA	1 ppm maximum continuous 30 ppm for 30 min. during sanitization
D-Series, DuraSlick NF, Industrial NF1	500 ppm x hours, dechlorination recommended
G-Series	20-50 ppm x days
PW-Series	5,000+ ppm x days
S-Series, Industrial RO3	500 ppm x hours, dechlorination recommended