PermaCare®

BEST PRACTICES

REVERSE OSMOSIS PLANT OPERATION

CONTENTS

STARTUP

Startup

Before starting up an RO system, it should be verified that all pretreatment systems are working according to their specifications. It may be necessary to take water samples for analysis. In the case of polyamide (thin film composite) membranes free chlorine must be 0.0 ppm. The Silt Density Index (SDI) should be according to the RO design guidelines (typically < 5.0). If the water analysis (ions, temperature, pH) has changed significantly, it is recommended to run a new scale projection analysis on PermaCare's RO12™.

On startup, the inlet valve should open prior to the initiation of the high-pressure pump, to completely fill the system with low pressure water (<100 psi [< 7 Bars]). This "soft start" will prevent hydraulic shock at startup. Pre-treatment chemical addition should begin at this time (making sure the chemicals are not over-injected). The high-pressure pump should then be started and the system slowly bought on-line, up to design permeate flow. If starting up after a period of shutdown, flush the permeate to drain for 30 minutes to remove residual preservation chemicals. Produced water permeate can be used when it meets the quality requirement of downstream processes.

SHUTDOWN

Permeate Flush

As salts in the feed water have concentrated up and exceeded their solubility during operation, they should be rinsed out prior to any shutdown (>15 minutes). Rinsing of the membranes with permeate water on shut will also aid the flushing of colloids and bacteria from the membrane surface.

Flow rate during flushing should be based on the recommended cleaning instruction flow rates. This is normally **30 – 40 gpm [6.8 – 9.1 m^3 /hr]** per pressure vessel.

Flushing time should be long enough for the conductivity out to equal the conductivity in. This is typically 15 – 20 minutes.

If the permeate flush is unavailable, feed water can be used by allowing low-pressure water to replace the water within the system by delaying the inlet valve closing. Scale inhibitor should be turned OFF during the permeate flush.

If the water temperature in the membranes exceeds 115^0F, flush water should be continuously passed through the system to prevent membrane degradation.

Preservation

For shut downs longer than as 24 hours, biological growth in the RO system should be controlled. This requires the introduction of a chemical to kill bacteria and prevent growth. Any preservation chemical would then have to be rinsed out from the system when it is re-started.

Various membrane preservation procedures are available. Methods and products recommended are attached.

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PRESERVATION METHODS FOR RO AND NF MEMBRANES AND SYSTEMS DURING SYSTEM OUTAGES.

It is recommended to preserve membrane systems when the unit is out of production for more than 24 hours. Failure to preserve membranes may result in the development of biofilm on the membrane surface, causing operation problems such as increased pressure drops and lower normalized permeate flow to occur.

Methods of preservation

1. Preservation with sodium-bisulfite (1%).

   It is recommended to measure the pH regularly. A fresh solution is needed when the pH < 3.
   A fresh solution is also needed when the liquid becomes turbid or changes colour.
   Regular inspections (weekly) are recommended.
   It has to be verified that the plastic materials (including pressure vessels) used in the membrane plant are resistant to sodiumbisulfite . Otherwise cracks might occur in the plastic materials .

2. Preservation with PermaClean® PC-56.

Preservation period	Concentration PermaClean PC-56
< 2 days	0.018% (180 ppm)
2 - 7 days	0.036% (360 ppm)
1 - 4 weeks	0.054% (540 ppm)
1 - 6 months	0.09 % (900 ppm)
> 6 months	drain and refill

This preservation method can only be applied after the membranes have been in operation for a minimum of 1 month.

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PRESERVATION OF RO CONTINUED

3. Preservation with PermaClean® PC- 55.

Preservation period	Concentration Permaclean PC- 55
< 2 days	0.01% (100 ppm)
2 - 7 days	0.02% (200 ppm)
1 - 4 weeks	0.03% (300 ppm)
1 - 6 months	0.05 % (500 ppm)
> 6 months	drain and refill

This preservation method can only be applied after the membranes have been in operation for a minimum of 1 month

4. Preservation with formaldehyde.

0.5% - 3% (w/w) formaldehyde solutions can be applied dependent on the membrane supplier's recommendations. The preservation solution needs to be renewed latest after 12 months.

Formaldehyde handling requires more precautions due to its suspected carcogenic. Please stick to the relevant safety regulations.

5. Preservation with gluteraldehyde and other aldehydes.

It is strongly recommended not to use gluteraldehyde or other aldehydes as it can reduce the permeate flow of the membranes dramatically.

6. Preservation with PermaClean® PC-11 and is not recommended due to the very short half-life of this chemistry.

NOTE: Prior to shutdown, RO/NF membranes need to be cleaned (dependent on the operation parameters). The system then **MUST** be flushed with RO permeate before the preservation solution can be pumped into the RO (at low pressure).

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RO DATA COLLECTION AND MONITORING

Data collection is critical for monitoring the performance of the membrane system. Without it, there will bee no idea if the system is fouling, suffering from scale formation, or if the membranes are deteriorating.

When operating data is recorded, it should be compared to previously established alert and alarm levels. These levels should be associated with well-defined response procedures corresponding to the potential problem.

The alert and alarm levels are set for a 15% change from normalized start up data.

Silt Density Index (SDI)

The SDI is an on-site measurement of the suspended solids concentration in the feed water. It should be used to monitor the performance of the pre-treatment equipment.

SDI measurements should be made pre and post multimedia filters and post cartridge filters. An SDI < 5.0 for the RO feedwater should be maintained at all times. Pre-treatment should be controlled efficiently using the designed flow rates and differential pressure limits for back-washing of the multi-media filters and replacing of the cartridge filters to give an SDI before the membranes of < 3.0.

Details on the SDI procedure are on the PermaCare CD and in the Ondeo Nalco Lotus Notes Global Water Document Library.

RO System Pressure Drop

The difference between the inlet to the initial membrane elements and the concentrate stream pressure coming off the tail end elements is what pushes the water across the membrane surface of all the elements. This is called the pressure drop or the hydraulic differential pressure (ΔP).

As long as the flows are constant, the ΔP will not change unless something physically blocks the passage of flow between the membrane envelopes of the elements (fouling). Therefore it is important to monitor the ΔP across each stage of the system. An increase in ΔP can then be isolated as lead end, tail end or both to indicate possible cause.

Salt Rejection

Since the RO systems are used to remove (or concentrate) dissolved salts, measuring salt rejection is a direct way to monitor the performance. Salt rejection is the percentage of the feed water TDS that has been removed in the permeate water. The simple way to monitor the salt rejection is to measure permeate water conductivity.

The permeate water conductivity should be measured for each pressure vessel on a daily basis. This will then help determine if a high salt passage problem is universal (indicating membrane damage), isolated to a certain stage (possible fouling) or isolated to an individual pressure vessel (indicating O-ring problems). Probing of individual pressure vessels can be carried to isolate a salt rejection problem to an individual membrane element.

Normalized Permeate Flow

The permeate (product water) flow of the RO system is related to water temperature and the net driving pressure. Permeate flow should therefore be standardized for the effects of these variables to allow better monitoring of how well water is permeating through the membranes.

The formula used to calculate Normalized Permeate flow is :

$$Q_{norm} = Qi * (NDP_{start} / NDP_i) * (TC_{start}/TC_i)$$

Q_{norm} = Normalized permeate flow

Qi = Permeate flow at point i

NDP_{start} = Net Driving Pressure at startup or reference condition

NDP_i = Net Driving Pressure at point i.

TC_{start} = Temperature Correction Factor at startup or reference condition

TC_i = Temperature Correction Factor at point i.

The membrane manufacturer provides the temperature correction factors (at a constant net pressure) to allow normalization for temperature effects. An example of temperature correction factors for a TFC membrane is as follows:

Temperature ^{0}C	Temperature ^{0}F	Temperature Correction Factor (TC)
16	60.8	1.312
18	64.4	1.234
20	68.0	1.161
22	71.6	1.093
24	75.2	1.030
25	77.0	1.000
26	78.8	0.971
28	82.4	0.917
30	86.0	0.866
32	89.6	0.819
34	93.2	0.774
36	96.8	0.733

The net driving pressure is the applied pressure minus the permeate back-pressure minus the osmotic pressure. This driving pressure is proportional to the permeate flow rate. We can multiply by a ratio of the startup driving pressure to the current driving pressure to obtain the permeate flow rate if we were at startup pressure conditions.

The calculated permeate flow rate can then be multiplied by the membrane temperature correction factor to give the normalized permeate flow.

To save time and give accurate measurements, either the membrane manufacturers or Ondeo Nalco *RO-Trend* software should be used to normalize all permeate flow readings. Ondeo Nalco *RO-Trend* software can be found on the PermaCare Program CD or in the Lotus Notes Global Water Document Library.

A decline indicates that fouling or scale formation is reducing permeate flow through the membranes. An increase indicates that fouling/scaling has been removed or that membrane deterioration is occurring.

It is recommended that normalized permeate flow is monitored for each stage. This will help identify and isolate problems more accurately.

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MONITORING LOG

Reference base line data is useful for assessing future performance and trouble shooting performance. Use this form to record and store reference base line data.

REFERENCE BASE LINE DATA

STANDARD PLANT DATA DATE OF COMMISSIONING:		
	DESIGN	START-UP
MEMBRANE MODEL		
CONFIGURATION		
OUTPUT		
% RECOVERY		
FEED CONDUCTIVITY		
REJECT CONDUCTIVITY		
PERMEATE CONDUCTIVITY		
FEED PRESSURE		
STAGE 2 FEED PRESSURE		
REJECT PRESSURE		
FEED TEMPERATURE		

FEED WATER REFERENCE ANALYSIS DATE: As mg/l As $CaCO_3$													
pH	Ca	Mg	Na	K	SiO_2	SO_4	Cl	HCO_3	Ba	Sr	Fe	F	Ω

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PERFORMANCE MONITORING LOG

The following **Log Sheet** can used to record system performance parameters. Frequency is site specific and based on the variability of the system and critical value of system performance on the customer's operation. Typical frequency is 1 data set per 8 hours.

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PERFORMANCE LOG							
TIME							
PRODUCT FLOW STAGE 1							
PRODUCT FLOW STAGE 2							
TOTAL PRODUCT FLOW							
FEED FLOW STAGE 1							
FEED FLOW STAGE 2							
REJECT FLOW							
FEED CONDUCTIVITY							
PRODUCT CONDUCTIVITY TOTAL							
PRODUCT CONDUCTIVITY STAGE 1							
PRODUCT CONDUCTIVITY STAGE 2							
FEED PRESSURE STAGE 1							
FEED PRESSURE STAGE 2							
REJECT PRESSURE							
ΔP STAGE 1							
ΔP STAGE 2							
FEED TEMPERATURE							

PRESSURE VESSEL PRODUCT CONDUCTIVITY												
PV	1	2	3	4	5	6	7	8	9	10	11	12
STAGE 1												
STAGE 2												

CHEMICAL ANALYSIS REPORT								
	Time							
FEED WATER	pH							
	Conductivity							
	Chlorine							
	SDI							
PRE-MEMBRANE	pH							
	SBS/Cl_2 REDOX							
	SDI							
REJECT	Conductivity							
	PermaTreat Antiscalant							
PRODUCT WATER	pH							
	Conductivity							

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COMMON SYSTEM FAILURES

FAILURE	EFFECT	RECOMMENDED MONITORING PRACTICE
Antiscalant	Scale formation on membranes, usually in the back-end stages – high salt passage, ΔP in final stage	Check dosing equipment and monitor changes in water quality.
Ineffective sanitization procedures	Bio-fouled pipe-work, cartridge filters and membranes – high ΔP	Sanitize sand filters and GAC filters. Microbiological analysis, chlorine dosing, contamination in chemical dosing tanks.
High iron content	Iron loading on cartridge filters. Iron fouling of membranes – high ΔP, low permeate flow	Pipe-work corrosion, ferric breakthrough from media beds, failure of media filters.
High organic content	Humic substances and organic fouling on membrane – low permeate flow, high feed P	Feed water composition, review flocculation procedures, feed watercolor, TOC.
Colloidal breakthrough	Colloidal particles foul micron filters and membranes – high ΔP, low permeate flow	Silt Density Index (SDI), condition of cartridge filters, eliminate media fines.
Granular activated carbon filters	Carbon fines foul micro filters and membranes.	Check washing procedure to remove fines from GAC filters.
Overdosing of coagulant	Cationic coagulant fouls membrane – low permeate flow, high feed P	Check dosing levels and detect excess traces.
Overdosing of chlorine	Membrane damage – high salt passage and increased flux	Dosing equipment, Redox meters, bisulfite dosing levels and positioning of dosing point, chlorine test kit.
Permeate tube "O" ring failure	High salt passage	Check individual pressure vessel conductivity, probe suspect PV's to check individual membrane product conductivity.
Ineffective biocide	High bacterial/fungal counts in water samples. Biofouling of membranes – high ΔP	Biocide adsorption on GAC, check contact times and dose rate, select broad-spectrum biocide, Select biocide for organic content.
Sand/Multi-media filter breakthrough	Colloidal and bacterial fouling of micron filters and membranes.	Check wash procedures to remove fines.
Acid dosing	Scale formation – $CaCO_3$ only.	pH monitor/controller.
Seasonal algae blooms (sea water)	High microbiological loading, biofilm, severe cartridge filter fouling.	Microbiological counts in water samples, evidence of biofilms, check algae counts.
Poor performance on start up after shutdown.	Fouling/scaling of membranes.	Check membrane flush procedures on shut down and preservation procedures on extended shutdown.

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MEMBRANE CLEANING

Membrane cleaning is an important part of any reverse osmosis maintenance program. Effective cleaning usually requires some knowledge of the type of foulant and the cleaning options available.

Membrane fouling
Foulants on the membrane surface can cause flux loss (permeate flow), an increase in differential pressure (∆P), higher product water conductivity, a need for increased feed pressure to maintain output or a combination of these effects.

Effect of common foulants on system performance

Foulant	Normalized Permeate Flow (NPF)	Salt Passage	Pressure Drop ∆P
Scaling	⇓⇓	⇔	⇑
Colloidal Fouling	⇓⇓	⇑	⇑⇑
Biofouling	⇓	⇔	⇑⇑
Organic Fouling	⇓⇓	⇔	⇔

When to clean?
It is essential to clean membranes at an early stage of fouling. It is often difficult to clean excessively fouled membranes and irreversible damage may occur during the cleaning process. **Cleaning is recommended when on or more of the following parameters change by 10 – 15% after data normalization**:

- An increase in product water conductivity or salt passage
- An increase in ∆P across the plant
- An increase in feed pressure
- A decrease in normalized permeate flow (NPF) output or flux

If any of the above performance parameters deteriorates by more than 30%, it may be impossible to recover plant performance by routine cleaning practices.

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RECOMMENDATIONS FOR EFFECTIVE MEMBRANE CLEANING

1. Clean membranes on a regular basis or when differential pressure (DP), normalized permeate flow, salt passage or feed pressure changes by 10 – 15% from the design limits. Regular and careful membrane cleaning is necessary and should not shorten the membrane life.

2. i) **Organic Foulants:** clean with an alkaline surfactant such as PermaClean® PC-67 or PermaClean® PC-99 to break down and remove organic matter and biofilms. Acid flushing may follow this program, if necessary .*

   ii) **Scale Deposits:** - Calcium carbonate, iron oxide and iron hydroxide; clean with a PermaClean® low pH cleaner.
   - Calcium sulfate, strontium sulfate, barium sulfate, calcium fluoride; clean with PermaClean® PC- 33 at alkaline conditions.

**If there is uncertainty of the type of fouling, always start with an alkaline cleaning product.*

3. Flow rates during cleaning, must be sufficient to remove foulants from the membrane element but not exceed manufacturer's limits. Flow rate should not exceed the feed pressure and pressure drop (ΔP) limitations determined by the membrane element manufacturer. Typical flow rates for membrane cleaning are provided in the table below.

Element diameter (inches)	Feed flow rate per Pressure vessel, m^3/hr	Feed flow rate per pressure vessel, gpm
2.5	0.7 - 1.2	3-5
4	1.8 - 2.3	8-10
6	3.6 - 4.5	16-20
8	6.8 - 9.1	30-40
8 (400 and 440 ft^2 membrane surface area)	8.0 – 10.2	35-45

4. The maximum recommended pressure drop during membrane cleaning of 8" membranes should not exceed 1.4 bar [20 psi] per element or 4.1 bar [60 psi] for a multi-element pressure vessel.
5. A cleaning solution volume of 55 liters [14.5 gallons] is recommended per 8" x 40" membrane element; this excludes pipe work volumes. A minimum of 40 liters [10.5 gallons] of cleaning solution is advised for each membrane element.
6. Where practicable, warm the cleaning solution to the highest temperature allowed by the membrane manufacturer. Typical cleaning solution temperatures should be 25 – 35 °C [77 – 95 °F]. Increasing the temperature of the alkaline cleaning solution will improve results.
7. Soak the membranes in cleaning solution for a minimum of 15 minutes before recirculation. This procedure should be repeated regularly throughout the cleaning.
8. Flush pipework, membranes and cleaning tank thoroughly with chlorine-free water between each cleaning cycle and when returning the plant to normal operation.
9. When cleaning multi-staged plant, clean each stage individually.
10. Don't panic when the plant returns to service and operating conditions are not improved or are even worse than at the start of the cleaning. Many of the cleaners used *temporarily* affect the membrane or polysulphone support structure, and routine operation for 4-24 hours may be necessary to stabilize operating conditions.

Membrane Manufacturer's recommendations should always be followed with respect to pH, temperature, pressure and flowrate.

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Membrane Cleaning Log Sheet

It is recommended to keep good records on the procedure used to clean membranes. This log sheet can be used to monitor and optimize the membrane cleaning process based on results.

CLEANING DATA COLLECTION SHEET

RO System : **Chemical** ______________ **DATE:** ______________

Stage:

Tank Gallons: **Volume or LBS.** ______________ **OPERATOR:** ______________

Minutes	0	15	30	45	1 hour	15	30	45	2 hours	15	30	45
pH												
Flow												
Inlet Pressure												
Temperature												

Comments

Minutes	3 hours	15	30	45	4 hours	15	30	45	5 hours	15	30	45
pH												
Flow												
Inlet Pressure												
Temperature												

Comments

Minutes	6 hours	15	30	45	7 hours	15	30	45	8 hours	15	30	45
pH												
Flow												
Inlet Pressure												
Temperature												

Comments

CHEMICAL TREATMENT PROGRAM APPLICATION

Coagulant

Coagulant can be used to improve filtration and aid the removal of fine colloids, reducing SDI values of RO feedwater. The coagulant should always be dosed prior to the multi-media/sand filters and as far back in the system as possible for good mixing and coagulation.

Cationic coagulant can foul RO membranes. It is therefore important that the dosage is accurately controlled. Over-dosing, particularly of organic coagulants, can cause the coagulant to break-through the filters and end up in the RO plant. Organic coagulant reaction with anionic polymer antiscalants can also occur, resulting in membrane fouling. It is therefore important to ensure a coagulant compatible antiscalant (e.g. PC-191) is used when using cationic coagulants in the pre-treatment.

Chlorine

Chlorine (Na/Ca hypochlorite, bleach or gas) can be dosed to control biological fouling of the pre-treatment system. If biological contamination is an issue, chlorine can be dosed prior to the pre-treatment system to give a free chlorine residual of 0.2 – 1.00 ppm depending on severity of contamination.

Chlorine will destroy polyamide thin film composite membranes. It is essential that ALL chlorine be removed from the feed water prior to entering the membranes (CA membranes can tolerate up to 1ppm free chlorine). Even trace amounts of free chlorine can cause oxidation damage, especially in the presence of metals such as iron. Chlorine can be removed by bisulfite/metabisulfite addition or by the use of carbon filters.

Sodium Metabisulfite/Bisulfite/Sulfite

Sodium Bisulfite, Sodium Meta-bisulfite or Sodium Sulfite can all be used to de-chlorinate the feed water. De-chlorination is essential with polyamide type membranes.

Sodium Metabisulfite (SMBS = $Na_2S_2O_5$) is a 100% active solid and dissolves in water to form sodium bisulfite. It is 100% active. The fumes from mixing with water can be irritating.

$$Na_2S_2O_5 + H_2O \ggg 2NaHSO_3$$ (2 moles of Sodium Bi-sulfite)

De-chlorination reaction with bleach (HOCl):

$$HOCl + NaHSO_3 \ggg NaCl + H_2SO_4$$

Sodium Bisulfite (SBS = $NaHSO_3$) is liquid and usually sold as a 40% active. Ondeo Nalco offers product N-7408.

De-chlorination reaction with bleach (HOCl):

$$HOCl + NaHSO_3 \ggg NaCl + H_2SO_4$$

Sodium Sulfite (SS = Na_2SO_3) is a liquid, usually with a maximum active of 20%.

De-chlorination reaction with bleach (HOCl):

$$HOCl + Na_2SO_3 \ggg HCl + Na_2SO_4$$

A 40% sodium bisulfite solution (either as supplied or made up with metabisulfite) will be the most stable solution to use. The dose rate of 40% bisulfite (7408) needed for chlorine removal is 3.66 ppm for each 1.0 ppm of free chlorine.

The SBS solution should be dosed as close to the RO system as possible (to keep as much of the pre-treatment as possible in contact with chlorine – e.g. cartridge filters). However, if the free chlorine level is high, the SBS should be dosed prior to the antiscalant injection point (or antiscalant dosage adjusted to compensate for chlorine attack). Some antiscalants are attacked by free chlorine. The antiscalant and SBS dosing point should be far enough apart to prevent neat product mixing (SBS and antiscalant can often be mixed when diluted correctly, but pH differences of the neat products can cause problems).

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Microbial Biocide

Non-oxidizing, non-ionic biocide can be used either on line or as part of a cleaning program to control biofouling in RO membranes. When used as an on-line treatment, the biocide should be dosed prior to the RO system to control bio-growth in the membranes. Application frequency will depend on biological loading and biofilm growth rate. The program should be used to control differential pressures in the RO plant to reduce cleaning frequency. Application rates and frequency of application (biocide program costs vs. effectiveness) vs. reduction in cleaning frequency, down time, membrane life (operating costs without biocide program) should be balanced to determine the most cost effective biocide dosing frequency.

Dosing biocide further back in the pre-treatment will help control bio-growth but will greatly increase demand and application costs. The main goal of an effective biocide program is to control biofouling in the membranes to an acceptable and cost effective level compared to cleaning program costs (and associated costs).

The two products widely used are 2,2-dibromo-3-nitrilopropionamide (DBNPA) – PermaClean PC-11 and isothiazolone – PermaClean PC-55 and PC-56. These products are fully compatible with polyamide (PA) and cellulose acetate (CA) membranes.

PermaClean PC-11 (DBNPA)
DBNPA is fast acting and readily decomposes to harmless by-products on discharge. On-line, it is dosed just prior to the RO system to control biofouling in the membranes. Dose rate is typically 100 ppm for 1 hour. Frequency of application depends on degree of biological contamination in the feed water and rate of biofilm growth in the membranes. Typically frequency of application can vary from every other day to once a month. The half-life of DBNPA is reduced with the increase of pH. In high pH feed waters (>8.5) the dose rate and contact time should be doubled.

DBNPA biocide should not be dosed with stainless steel injection quills as corrosion of the injection assembly will occur.

PermaClean PC-55 or PermaClean PC-56 (Isothiazolone)
Isothiazolone has a longer contact time than DBNPA. Dose rate is typically 50 – 100ppm for 4 hours contact. Isothiazolone is more effective than DBNPA in waters with high organic loading. Isothiazolone can also be used at low dose rates on a continuous basis (10 – 20ppm).

If discharge is an issue, SBS can be dosed to the concentrate line to de-activate the biocide (1:1).

Scale Inhibitor

Antiscalant dilution and dosing guidelines follow.

The antiscalant can be dosed before or after the system cartridge filters. If iron is present in the feed water, the antiscalant can be dosed post to prevent “pick-up” of iron (or in the case of polymer antiscalants de-activation by iron – in this case use a phosphonate based product with good iron sequestering properties – e.g. PC-191). Dose point should be after the sodium bi-sulfite (N-7408) injection to ensure chlorine is removed (especially with high levels of free chlorine). Dose point should be sufficiently down-stream of the SBS injection point to avoid “neat” product mixing.

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GENERAL GUIDELINES FOR THE DILUTION OF SCALE INHIBITORS

It is preferred to dose antiscalants neat. However, in some cases dilution might be necessary due to the capacity of the antiscalant dosage pump.
The below mentioned guidelines should be followed.

1. Use RO permeate for the dilution of the antiscalant.

2. Prepare a fresh antiscalant solution every 3-5 days.

3. Inspect the antiscalant tank before adding the new solution. If needed, the antiscalant tank is cleaned prior to filling.

4. Dilution rate up to a factor 10 are typically applied. Dilution factors higher than 10 will require more attention with respect to the condition of the antiscalant tank (cleaning) and preparation of a new solution (every 1-3 days).

5. In case of the antiscalants PermaTreat PC- 191 , PermaTreat PC-391 and PermaTreat PC-510:
   NaOH can be added to the dilution to increase the pH to 10-11. This is especially recommended for warm environments.

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TROUBLE SHOOTING TECHNIQUES

Profiling an RO Array

When problems arise with an RO system, the ability to isolate the problem to a particular location within the system provides valuable information as to the nature of the problem. This will determine the remedial action such as cleaning, O-ring replacement or membrane element replacing.

Attached data collection tables show the minimum data required to monitor and accurately trouble shoot the RO systems.

Probing

Once profiling has isolated a salt rejection problem to a particular pressure vessel, or set of vessels, probing can be used to further isolate the problem.

Probing involves inserting flexible tubing through one of the vessel permeate connections as a means of diverting the permeate from a specific area within the elements. This water is then tested for conductivity with a portable meter.

Probing must be performed while the RO is operating. The tubing is worked through various fittings to the other end of the vessel. It is then gradually pulled back as diverted water samples are tested. The end of the vessel should be sampled and then every 8 inches [20-cm] through the whole of the vessel. Sufficient time (30 seconds) should be allowed between samples to be sure that water from the new sampling location has completely displaced the water within the tubing.

Replacing O-rings

Movement of the spiral wound membrane elements within their pressure vessel can commonly cause abrasion and breaking of the O-rings that seal the inter-connector to the element permeate tube.

A sudden increase in permeate conductivity, not accompanied with a noticeable increase in permeate flow rate could indicate a broken or missing O-ring. Profiling and then probing to determine if only individual pressure vessels/membrane elements are causing the increased conductivity will indicate if O-ring damage is the problem.

To replace the O-ring, the RO should be shut down and allowed to drain by opening the sample valves. The end-cap is then removed. Usually O-ring damage is visible. The O-ring is replaced by hand, wetting with lubricant (glycerin – use sparingly) if necessary.

Shimming

It is normal to have some movement of the membrane elements within their pressure vessel housings. This occurs because the pressure drop across the elements can cause them to compress. Fouling or high flow rates can result in significant movement, mostly when the system starts up. When it shuts down, the elements will then relax.

This movement will cause rubbing against the inter-connector O-rings, particularly in the lead end elements. With time, this can cause them to abrade and possibly break. In case of severe pressure drops, O-rings can be completely dislodged and blow out of their slots.

The potential for this movement should be minimized by making certain that the elements fit tightly within their pressure vessel. Any slop should be taken up with shims.

Shims are slices of plastic piping that have an inside diameter that just fits over the outside of an end connector, usually the end connector between the lead end element and the vessel end cap. Enough should be installed so that replacing the end cap in its vessel should be met with some resistance.

Replacing Membrane Elements

Occasionally, it is necessary to replace RO elements. This will be determined if necessary following trouble shooting and other remedial actions.

As with replacing O-rings, the system should be shut down and drained. Prior to installation, the new element serial numbers should be recorded indicating their intended location in the system. This is useful in comparing the membrane manufacturer's test data with the system performance.

It may be necessary to remove both of the vessel end-caps. The elements can then be removed in their normal direction of flow. This will prevent their brine seals from jamming against the pressure vessel. The replacement elements can be inserted in the feed end of the vessel and used to push the other elements through.

The U-cup brine seals and the inter-connector O-rings can be sparingly lubricated with glycerin to aid fitting. Each inter-connector should have O-rings installed. U cup brine seals should be installed only with the open groove of the seal facing the upstream end of each element (note flow arrow on side of element which points toward the downstream end). Never put brine seals on both ends of an element.

After element replacement, any gaps should be limited with shims. The end caps can them be installed and the system started up. It should be filled with low-pressure water prior to starting the high-pressure pump. New elements should be rinsed to drain to remove any residual preservative chemicals. System operating data should be collected after the RO performance stabilizes (within 24 hours).

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FILTER CLEANING PROCEDURE

FILTER TYPE: Sand, Gravel, Anthracite, Mixed Media

NOTE: This procedure should not be used on activated carbon filters. Rinse out of the product may not be complete on activated carbon.

CONTAMINANTS REMOVED: Carryover Products from Clarifier Systems Containing Polymers and Other Organic Substances, Dirt, Silt, Crud, and Biological Growth

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PROCEDURE:

1. Backwash the filter at the regular flow rate for 10 minutes. Drain to about 6 inches above the bed level.

2. Add 20,000 ppm of Ondeo Nalco RESIN RINSE 7290 to the filter bed.

   Use ***water*** lance to mix product with water in filter vessel.

3. Add 2,500 ppm active bleach.

   Use a ***water*** lance to mix bleach with water (containing RESIN RINSE 7290) in filter vessel.

4. **Allow to soak for 24 hours. Shorter soaks will remove a portion of the foulants, but may not completely clean the bed.**

5. After soaking, backwash the filter bed at the normal rate to remove loosened particulate. Be certain the backwash water is wasted and not recycled. Backwash until foam is no longer observed. Use the "shaker test".

6. Rinse the filter at the regular flow rate and be certain the water shows no signs of foaming Use the "shaker test" again. Return the filter to service.

SPECIAL NOTES:

1. Recirculation of the cleaning solution, for the contact time specified, will also increase the efficiency of the cleanup.

2. If the media is badly fouled, a repeat cleaning may be necessary.

3. The use of a water lance will minimize the potential for creating foam.

4. The "shaker test" procedure is:

A. Obtain two small, clean glass bottles with lids.

B. Rinse thoroughly and fill one bottle half way with a sample of clean filtered water obtained before the initiation of the chemical cleaning procedure or from another operating filter. Absolutely no RESIN RINSE or residual detergent of any kind can be in this sample.

C. Rinse thoroughly and fill one bottle half way with a sample of filter backwash water from the filter being cleaned..

D. Shake both bottles vigorously for 15 seconds. Observe the surface of the water sample. RESIN RINSE has been completely rinsed out of the bed if the dissipation of the air bubbles is identical between the baseline filtered water and the RESIN RINSE treated sample.

E. If you notice any foam on the surface of the treated sample, continue to backwash and repeat steps B and C until the both samples exhibit identical surface tension characteristics.

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