Cleaning

Over time, membrane systems can become fouled with any of a number of foulants such as colloids, organic matter, metallic scales, and biological constituents. (See Pretreatment). These materials can build up on the membrane surface and in the feed brine channel. If left uncorrected, the accumulation of these foulants can cause a severe loss of performance in the system: pressure requirements increase to maintain flow, pressure drops increase, and salt rejection can suffer. If the system is not cleaned and the system continues to build up foulants, the elements may "telescope," or shear internally, causing the integrity of the membrane surface to be compromised and rendering the membrane irreversibly damaged.

This section will cover several points related to cleaning. The first part will concern itself with data collection and symptoms of membrane fouling. The second part will define the components of a cleaning system and provide guidelines for building and operating a cleaning skid. Finally, directions and guidelines for performing a cleaning will be given; the reader is encouraged to double click on topics related to specific procedures for cleaning specific membrane elements.

DATA Monitoring

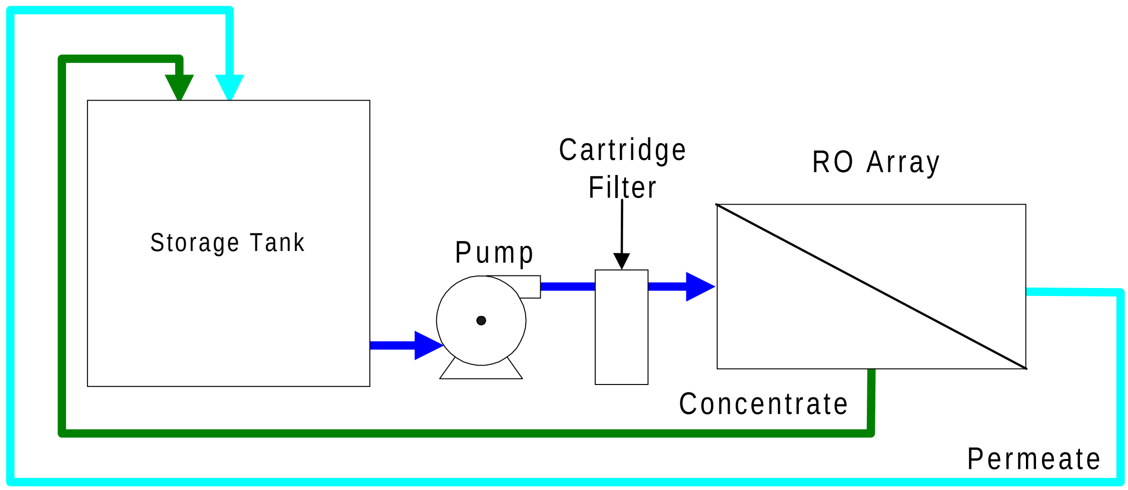
Good monitoring of the performance of a system can alert the user to possible fouling before the situation becomes severe. The practice of entering operational data several times a week into a normalization program can provide the means to track performance over time. Symptoms of fouling would include one or all of the following conditions:

- Normalized water flow has decreased by 10-15% from start-up (reference) conditions.
- Delta P, or pressure drop over a stage or the system, has increased by 10-15%.
- Salt rejection has decreased (ie permeate TDS has increased) significantly over time.

Note that it is important to use normalized data. Normalized data corrects for temperature effects on system performance. For instance, if the temperature drops, it is expected to require more pressure to achieve the same flow. Loss of flow due solely to a reduction in temperature does not mean the system is fouled.

Cleaning System Specifications

The following diagram gives the basic parts of an RO cleaning skid. Cleaning solution is pumped from a storage tank through a cartridge filter to the RO array. Solution is then recycled back to the tank. The volume of solution should be adequate to fill the volume of the vessels, filters and piping. The diagram below shows no instrumentation, however, it may be adviseable to add a low level switch to the tank to prevent the pump from running dry. Additionally, a temperature controller and heater/cooler unit may be added to maintain solution at the optimum temperature range.



Volume requirements:

To figure the volume of solution required for a system consisting of six 8" vessels with six elements per vessel and 40 feet of 4 inch pipe (3.82 " ID), figure the volume of the vessels and add it to the volume of the piping to obtain the total volume. For example:

<u>Volume of the vessels</u>:

The calculation is made where Vv is the volume of one vessel, Pi = 3.14, and R is the radius of the vessel or pipe. US units are given on the left, SI units on the right

Vv = Pi*(R*R)*length
= 3.14 * (4in * 4in) * 20ft / (144 in2/ft2) = 3.14*(.10m*.10m)*6.1m
= 6.98 ft3 = 0.196 m3
= 6.98 ft3 * 7.48 gal/ ft3
= 52 gal/vessel = 196 liters/vessel

Total vessel volume = 6 vessels * 52.2 gal/vessel = 313.2 gal
= 6 vessels * 196 liters/vessel = 1176 liters

<u>Volume of piping</u>:

Vp = Pi* (R*R) * length
= 3.14 * (1.91in*1.91in) *40 ft/(144 in2/ ft2) = 3.14*(.049m*.049m)*12.2m
= 3.18 ft3 = 0.09 m3
= 3.18 ft3 * 7.48 gal / ft3
= 23.8 gal = 90 liters

Total required volume = 313.2 gal + 23.8 gal = 337 gal

= 1176 liters + 90 liters = 1266 liters

The tank for this system should hold a minimum of 340 gallons or 1270 liters of cleaning solution.

Materials/components:

Materials for the skid should be the following:

Tank:	Fiberglass reinforced plasitc (FRP) or polypropylene.
Piping:	PVC schedule 80 or Nylon reinforced flex hose.
Victaulics:	Stainless Steel
Valves:	Stainless Steel
Pump	Stainless Steel or Non-metallic composite polyesters.

Pump should be a centrifugal type able to attain the flows and pressures listed in table 1of the next section. Cartridge filters should be 5 micron rating string wound modules. Valves should be installed appropriately to control flow. Tank should have a removable cover. All components should be able to withstand extremes in pH, temperatures up to 113 F (45 C), and electrical sources/switches should be protected and well grounded.

Cleaning Procedures

Generally, low pH solutions are used to clean metallic scales while alkaline solutions are used to clean biological and organic fouling. Relatively high flow (governed by the size of the element) with low pressure is recommended. (Do not, however, exceed maximum flow limits for the elements). Table 1 provides guidelines for pressures and flows per vessel for a range of element diameters.

Table 1: Pressures and Flows for Elements

Element diameter inches (cm)	Feed Pressure psi (bar)	Feed Flow/vessel GPM (lpm)
2.5 (6.4)	20-60 (1.4-4.1)	3-5 (11-20)
4 (10.1)	20-60 (1.4-4.1)	8-10 (30-40)
6 (15.2)	20-60 (1.4-4.1)	16-20 (60-75)
8 (20.2)	20-60 (1.4-4.1)	30-40 (115-150)

To clean a system, follow these six basic steps:

1. Prepare the cleaning solution per the instructions found in the appropriate TSB.
2. Displace the solution in the vessels either by flushing with permeate water or by pumping cleaning solution at a low pressure and low flow. To prevent dilution of the

cleaning solution, the process water can be dumped to drain until the cleaning solution has filled the vessels.

3. Recycle the solution through the elements and back to the tank.
4. Soak the elements for 1 hour. (For heavy fouling, overnight soaking may be required).
5. Recycle at the flow rates listed in Table 1 for an hour. The turbulence created in this high flow regime will help to displace the foulants from the membrane. Do not exceed 10 psi pressure drop per element; if the pressure drop is too great, reduce the flow.
6. Flush the system with clean permeate water or pre-filtered raw water.

TSB100: RO Membrane Foulants and Their Removal from Cellulose Acetate Blend (CAB) RO Membrane

TSB102: RO Membrane Foulants and Their Removal from Polyvinyl Derivative (PVD) RO Membrane Elements

TSB107: RO Membrane Foulants and Their Removal from Composite Polyamide (ESPA, ESNA, CPA, LFC, and SWC) RO Membrane Elements

TSB 112: Cleaning Procedure for Ultrafiltration Membranes used for E-Coat Paint Applications

TSB113: Cleaning Procedure for Ultrafiltration Membranes used for Oily Water Separations

In general, the steps and solutions listed in the above TSB's are similiar. However, it is worthwhile emphasizing the following points:

- Use of chlorine or other strong oxidants on polyamide membranes can cause irreversible damage to the membrane.
- Warm water, ie 90 F - 100 F (32 C - 37 C), gives significantly better cleaning than lower temperature solutions.
- If the pH of an acid solution increases during recirculation, add more acid to return the pH back to the target value. What is occurring is that acid is being consumed as it dissolves inorganic scale.
- Do not use sulfuric acid for low pH solutions as this creates a risk of creating sulfate scale.
- Permeate water is preferred for mixing solutions.
- Use of filtered tap water for high pH solutions can result in carbonate fouling if the water is hard.
- Flush the membranes with permeate water following cleaning to remove the cleaning solutions.
- Under severe fouling conditions, it may be necessary to soak overnight.

If elements are to be out of service for more than 24 hours, please refer to the following TSB's for storage instructions:

TSB101: General Storage Procedures for Cellulose Acetate Blend (CAB) RO Membrane Elements

TSB108: General Storage Procedures for Composite Polyamide (ESPA, ESNA, CPA, LFC, and SWC) and Polyvinyl Derivative (PVD) RO Membrane Elements