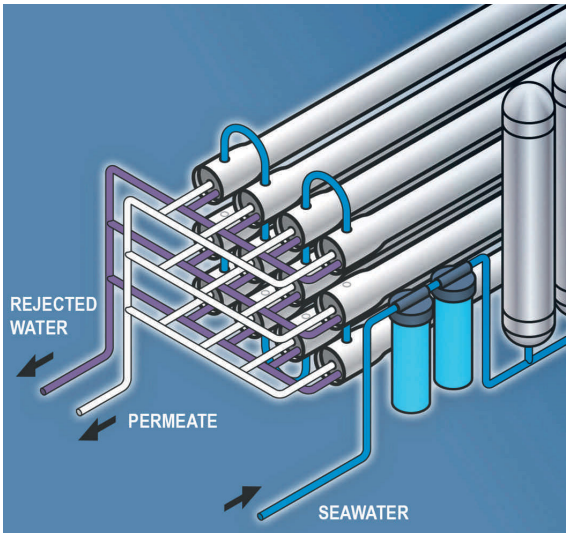
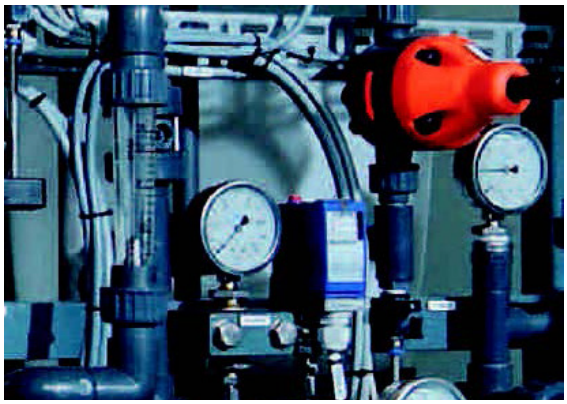
Drew Marine®

RO Membrane Cleaning and Maintenance Guide





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Reverse osmosis (RO) is a filtration process that produces highly purified water using raw water from the sea in marine applications. The purification of seawater using reverse osmosis membranes is one of the most challenging applications of RO technology because of the large quantity of salt, dissolved minerals, suspended solids, organic matter, and biological contaminants. The reverse osmosis process can remove not only salt and dissolved solids, but also the organic material, colloids, and some microorganisms.

REVERSE OSMOSIS

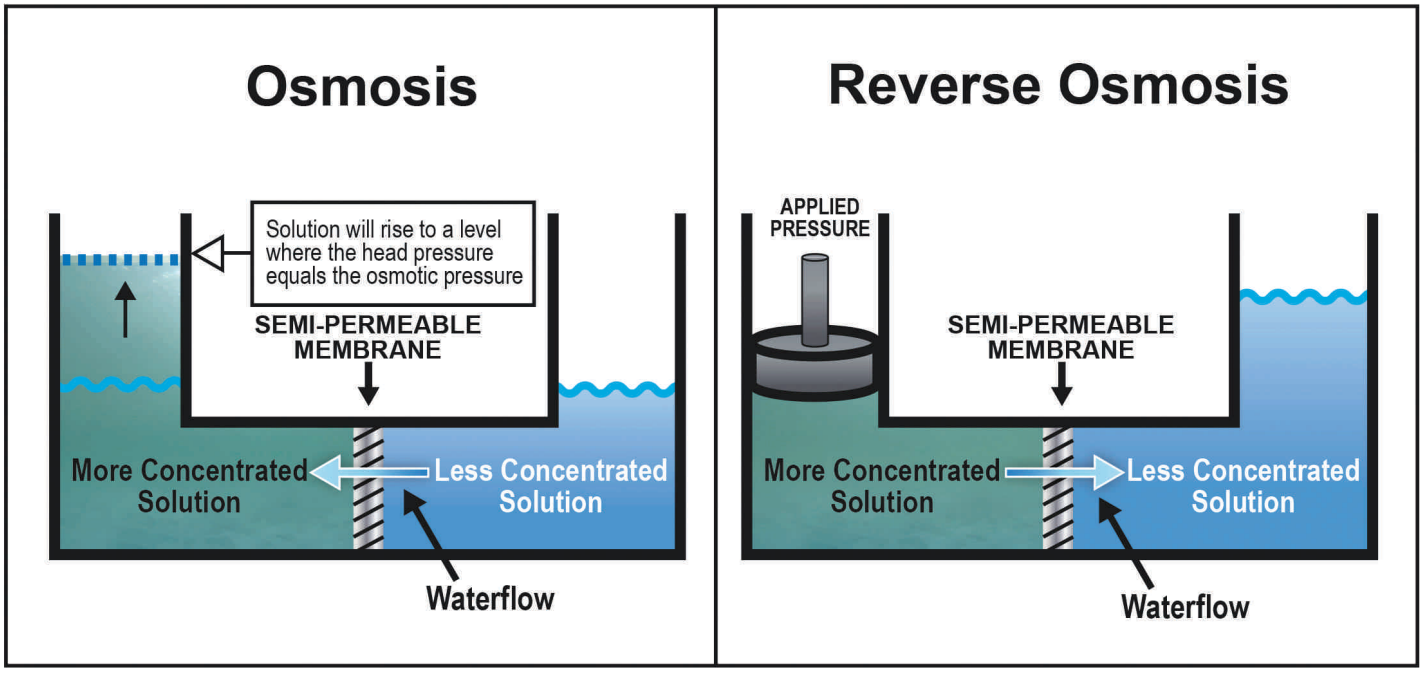
Reverse osmosis is the opposite of osmosis, a naturally occurring process. Osmosis is described as the process in which water flows across a membrane separating a stronger from a weaker solution; the water flows in the direction that will reduce the concentration of the stronger solution. The flow of water between solution compartments can be observed as the liquid in the compartment of stronger solution increases in volume (Fig. 1a). Osmotic pressure is a term used to quantify the driving force required to increase the level of solution in the compartment of the stronger solution.

When RO is used for desalination, high pressure is used as a driving force to oppose and reverse osmotic pressure. The pressure is applied to the high concentration solution forcing pure water through the semipermeable membrane. The pressure difference between the high pressure (concentrated) feed side and the lower pressure (dilute) side is known as the transmembrane pressure, abbreviated as ΔP. The transmembrane pressure must greatly exceed the osmotic pressure in marine systems to enable purified water to flow from the concentrated solution to the dilute side of the membrane. (Fig. 1b).

A simple schematic of a RO system is shown in Figure 2. The solution of seawater is pumped into a pressure vessel and flows across the surface of the semipermeable membrane. A portion of the water permeates the membrane leaving impurities behind. The purified water is referred to as “permeate” or “product water”, and is recovered at atmospheric pressure. The pressurized concentrate, is known as “brine” or “reject water”.

RECOVERY RATE DEFINED

An important concept in RO is the recovery rate. The recovery rate is defined as the percent of feedwater that is recovered as product water. Operation at a 40 percent recovery rate means that from 10 tons of seawater fed, 4 tons of product water will be produced, together with 6 tons of concentrated brine that contains most of the dissolved solids.



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MAINTENANCE OF RO MEMBRANES

An important characteristic for users of RO systems is the membrane's tendency to become fouled by the contaminants it is removing.

Three common types of fouling affect RO membranes:

1) **Scaling** – mineral deposits on the feedwater side of the membrane containing calcium and magnesium. Scale initially forms at the discharge end of a RO element because the brine has become concentrated compared to the start of the process.

2) **Biofouling** – consists of microbial growth often in the form of biofilm that contains a complex mixture of microbes and an adhesive surface that adsorbs and accumulates additional contaminants.

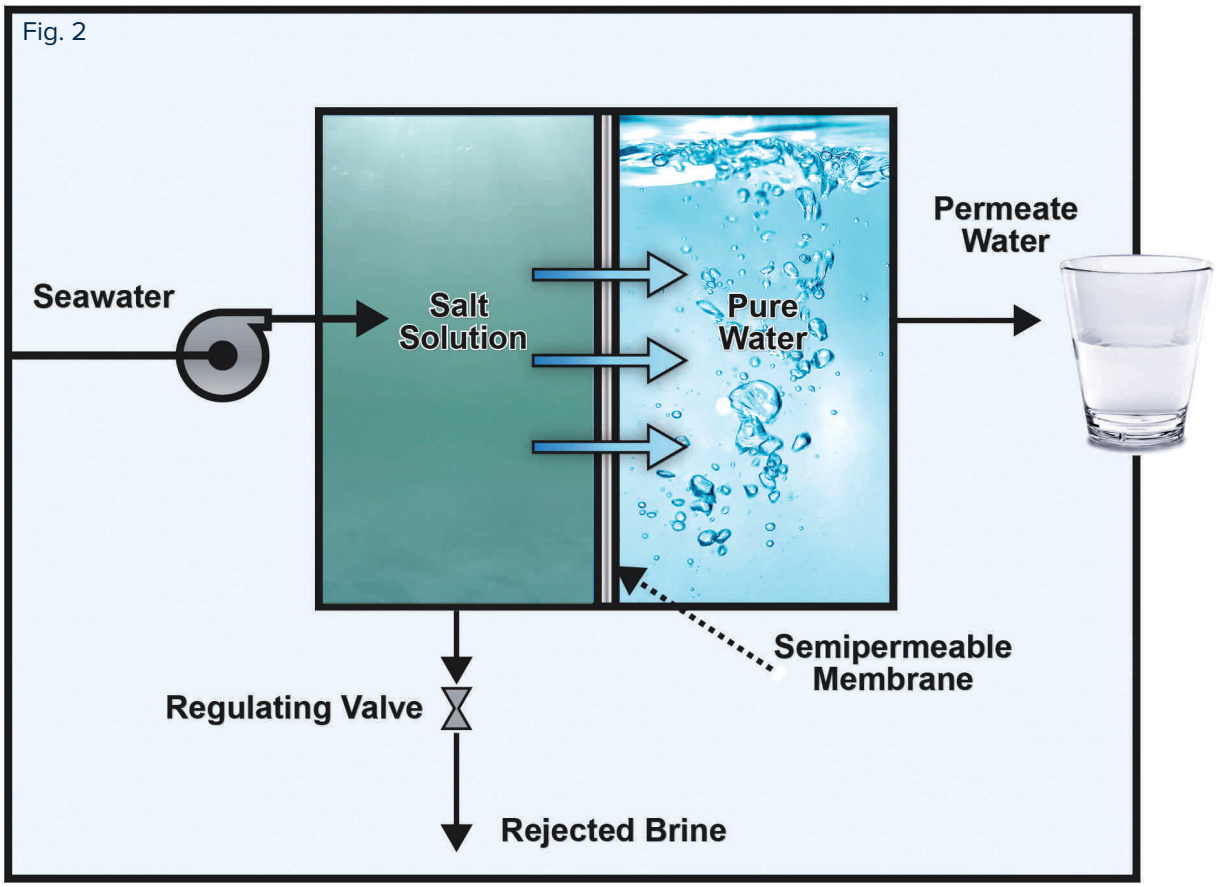
3) **Particles** – suspended solids in the feedwater, such as small sand particles, clays, or organic matter that were not removed in the prefiltration processes, and cannot pass through the membrane.

The accumulation of these foulants can cause a severe loss of performance in the system resulting in reduced permeate production.

Marine RO systems should be fitted with pre-filtration beds to remove suspended solids. These beds, located before the high-pressure pumps, are routinely backflushed to maintain flow. For RO systems operated at sea, biofouling is not the limiting fouling mechanism and is addressed during membrane cleaning. If a system is not protected with online antifoulants specifically designed to reduce scaling, then foulants will accumulate rapidly. Under these conditions frequent offline cleanings are required to maintain production and prevent contaminants from irreversibly damaging the integrity of the membrane.

For effective prevention and removal of foulants in membrane systems, Drew Marine offers high performance antiscalants and cleaning products formulated in accordance with membrane manufacturer specifications.

Fig. 2



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TYPICAL CLEANING INDICATORS

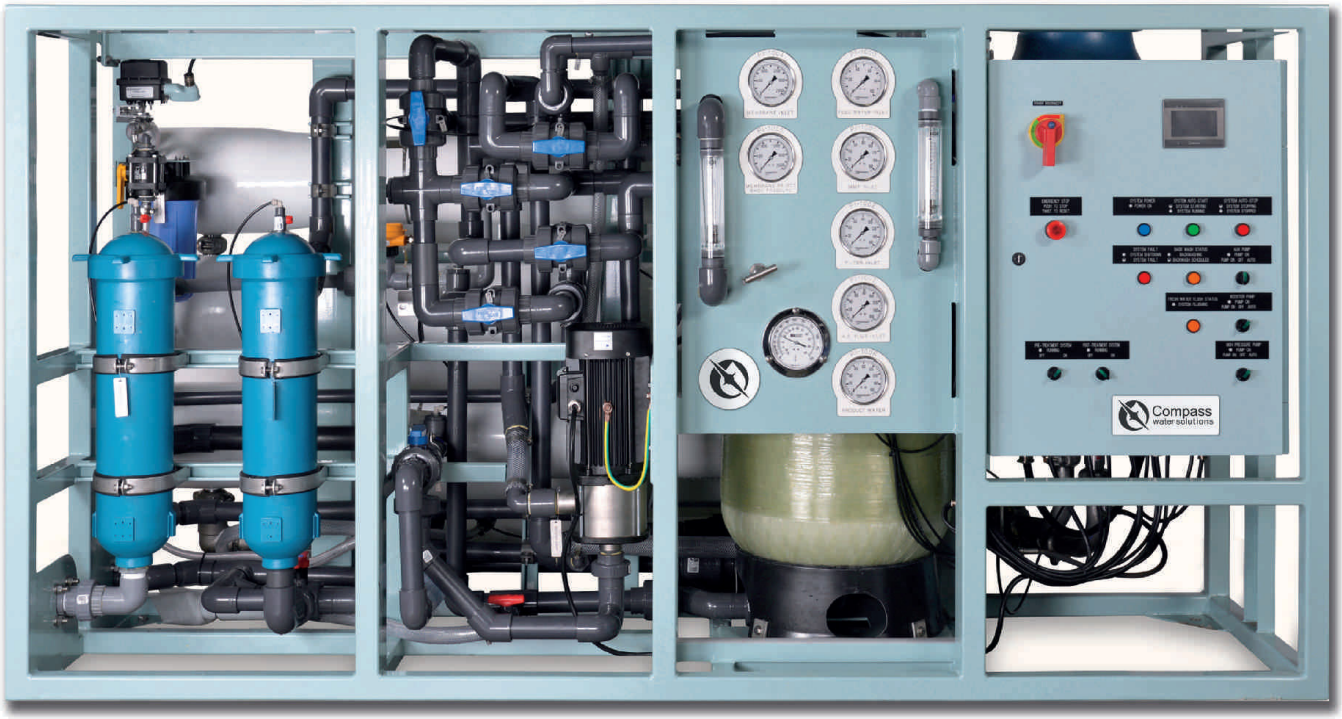
It is important to implement an effective, routine monitoring program of RO system performance. A proactive, predictable approach to system maintenance can identify possible fouling before the situation becomes severe. The practice of recording operational data on a daily basis can provide the means to track performance over time.

The following symptoms of fouling are typical indicators used to predict cleaning requirements:

- A 10-15% or greater decrease in permeate flow.
- A 10-15% or greater increase in the pressure drop across the membrane, i.e. transmembrane pressure (ΔP).
- A 10-15% increase in salinity or dissolved solids measured in permeate.

The troubleshooting chart below summarizes probable causes associated with observed changes in indicators of system fouling.

MEASUREMENT	CAUSES IF MEASUREMENT IS HIGHER	CAUSES IF MEASUREMENT IS LOWER
Pressure Drop (ΔP) across the membrane	• Scaling • Inorganic precipitate • Biofouling	• Lower feedwater flow rate
Permeate Quality	• Lower feedwater salinity or solids • Fouling will initially lower, then increase salinity/solids	• Higher feedwater salinity or solids • Membrane break • Seal leak • Fouling • Scaling
Permeate Quantity	• High feedwater temperature • Membrane break or seal leak	• Low feedwater temperature • Faulty HP pump or accumulator • Fouled membrane



Courtesy of Compass Water Solutions

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APPLICATION GUIDE

Drew Marine offers a complete line of treatments to maximize RO product water quality and quantity, the time between system cleanings, and to preserve membrane cleanliness while offline. The product line consists of a high-performance online antiscalant, two offline cleaning products that remove chemically different foulants, and an offline preservative.

Online Antiscalant

AMEROYAL® RO (PCN 0025628) – is a highperformance antiscalant that inhibits calcium and magnesium carbonate and sulfate scales, soluble and insoluble iron deposits, silica, and dispersible particulate fouling. AMEROYAL RO exhibits excellent performance in combatting the most common causes of membrane fouling. It also extends the time between cleanings, maintains permeate flow rates, and maximizes membrane life and permeate quality. When properly applied, AMEROYAL RO helps reduce capital expenditures and operational costs.

AMEROYAL RO should be dosed continuously in proportion to the feedwater flow, upstream of highpressure pumps, but downstream of primary filters using sand or course media.

The recommended dosage is 4.3 milliliters of AMEROYAL RO (undiluted) per metric ton of feedwater (5.0 ppm of product). AMEROYAL RO is certified to NSF/ANSI Standard 60, Drinking Water Treatment Chemicals.

Offline Cleaning

Drew Marine recommends offline cleaning when there is a 10-15% drop in permeate production, a 10-15% increase in transmembrane pressure, or a 10-15% increase in permeate salinity. Offline cleaning should be completed in two separate steps. The first step uses DREWCLEAN® RO, a multipurpose alkaline cleaner, and the second step uses DREWCLEAN® 2010, an acidic cleaner that removes inorganic scales and metals. It is important to perform the cleaning in this order because cleaning membranes with an acidic cleaner, without prior alkaline contaminant removal, can irreversibly bind certain contaminants to the membrane.

DREWCLEAN RO (PCN 7332331) is an alkaline cleaner based on a proprietary blend of chelants and surfactants in the form of a granulated solid. It is used for the removal of organic deposits, microbiological fouling, and mixed colloids.

DREWCLEAN RO should be used as the first step in a cleaning program and followed by DREWCLEAN 2010 for removal of residual calcium and magnesium carbonate scales. DREWCLEAN RO is used at a dosage of 3 kg (3 liters of granules) per 100 liters of cleaning solution.

DREWCLEAN 2010 (PCN 6625331) is a liquid formulation based on citric acid and specialty additives that remove moderate to heavy accumulations of inorganic scales and metals. DREWCLEAN 2010 should be used as a second step of a two-part cleaning program. Do not use DREWCLEAN 2010 prior to removing organic and mixed colloid foulants with DREWCLEAN RO. DREWCLEAN 2010 should be dosed at 3.6% of cleaning solution volume, e.g. 3.6 liters per 100 liters of cleaning solution.

RO Membrane Preservation

DREW® 6134 (PCN 5985405) is a food grade sodium bisulfite solution used to preserve RO membrane systems when they are shut down for any period over 24 hours. Offline cleaning, as instructed above, should be performed if the membranes are known or assumed to be fouled prior to shut down and preservation.

To produce a preservative fluid, add 3% DREW 6134 to the highest quality source of water available - permeate or distilled water are the best choices. Produce a sufficient volume of preservative solution to fill the system. Add the solution to the system in a way that allows each pressure vessel to be filled to its highest point. Circulate the system as much as possible, and vent displaced and residual air from the highest point in the system, then close the system to outside air. Change the preservation solution once per month.

Additional Information

For more detailed information, consult the Drew Marine product data sheets, or your local Drew Marine representative.

- AMEROYAL® RO (PCN 0025628)
- DREWCLEAN® RO (PCN 7332331)
- DREWCLEAN® 2010 (PCN 6625331)
- DREW 6134 (PCN 5985405)

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GENERAL CLEANING TIPS

RO systems utilize a variety of semipermeable membranes, each having identifiable specifications. Always refer to the membrane manufacturer's recommendations prior to implementing any cleaning program.

The schematic drawing in Figure 3 represents the basic requirements of a RO cleaning system. The cleaning solution is pumped through a cartridge filter to the RO array and then recycled back to the solution tank. Sufficient cleaning solution must be available to accommodate vessels, filters, and piping. In addition to the basic requirements noted, automated level switches and temperature control sensors can be added to optimize performance.

Distilled water or RO permeate water are the preferred diluents for mixing requirements of cleaning solutions. Within the constraints of the piping for system cleaning, do not attempt to clean the entire RO system with one cleaning. Cleaning too many elements at one time can result in redeposition of the foulants from the first stage into the second stage. Ideally, each vessel should be cleaned independently at the highest velocity and pressure stated by the membrane manufacturer. Removal of high-pressure fittings and end caps should be avoided if possible.

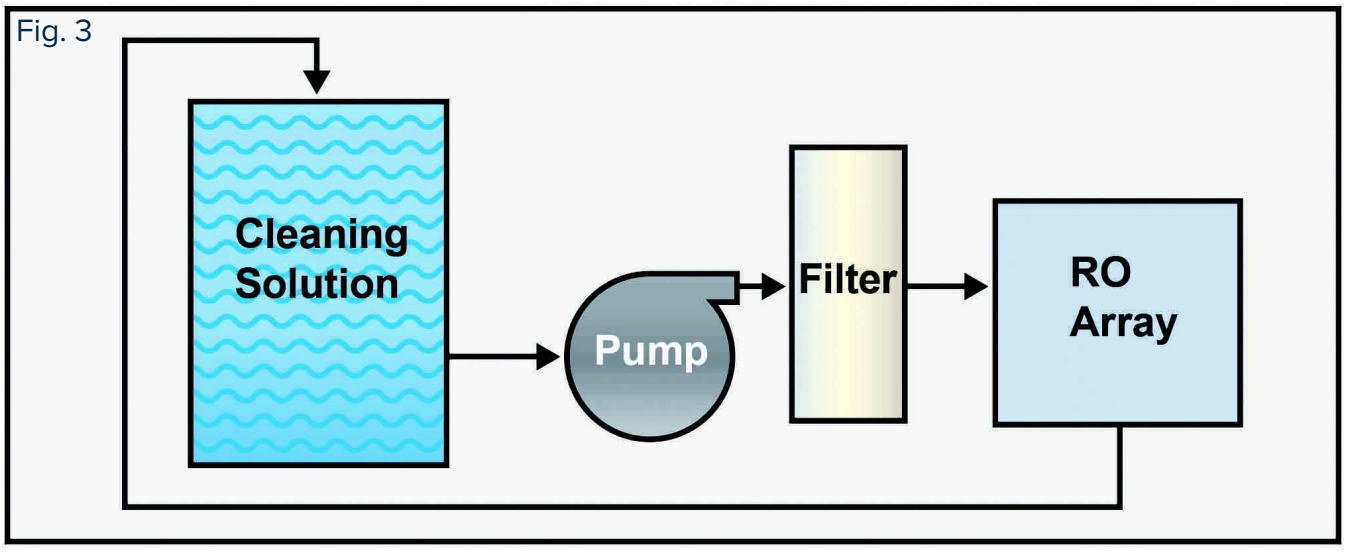
It is recommended that a warm cleaning solution be applied to expedite the cleaning rate. The recommended temperature of the cleaning solution typically falls between 30 – 35 °C with some membrane manufacturers allowing up to 45 °C depending on the pH.

In general, the more fouled the membrane the longer the cleaning period. In addition, the more fouled the membrane, the greater the potential to damage the membrane. Wide pH swings and high temperatures can shorten the life of membranes.

The following general cleaning tips are provided:

- Begin the cleaning procedure by displacing the process solution in vessels with heated, premixed cleaning solution at a low pressure and low flow rate. The process water should be dumped to a drain until the cleaning solution has filled the vessels to prevent the dilution and/or contamination of the cleaning solution.
- Recirculate the cleaning solution at relatively high cross-flow velocity with low pressure. Pressure should be low enough so that little to no permeate is produced. Do not exceed maximum flow limits for the elements as specified by the membrane manufacturer.
- Recirculate the cleaning solution through the elements, soaking for one hour or longer, depending on the degree of fouling. Some cleaning methods require successive intervals of recycle-soak, recycle-soak, etc. If cleaning solutions become turbid or discolored during the cleaning process, they should be dumped and replaced with fresh solution.
- After the period of soaking and recycling is complete, the cleaning solutions should be drained. The system should be immediately rinsed with the highest quality water available (permeate or distilled water) until all cleaning solution has been removed and the system is thoroughly rinsed clean.
- During the restart of the system, a sufficient volume of permeate should be directed to the drain to remove any fluid that permeated the membrane during the cleaning or preservation process.

Fig. 3



USEFUL TERMS IN REVERSE OSMOSIS

Brackish Water
Typically termed as, water containing significant levels (i.e., greater than 500 ppm) of salt and/or dissolved solids, but less than seawater (35,000 ppm dissolved solids).

Colloids
Solid particulates in the size range of 0.002 – 1.0 microns that do not settle and are dispersed indefinitely in water.

Desalination
Process used to remove salt and other dissolved minerals from water. Some desalination processes also remove other contaminants in water (e.g., dissolved metals, bacteria, and organics).

Freshwater
Water with levels of dissolved salt and other minerals that are low enough (typically less than 500 ppm) to make desalination unnecessary for most uses. Depending on its quality, freshwater may have to be treated in some way prior to use.

Hydrolysis
Chemical deterioration of any given membrane. (Cellulose acetate membranes are especially susceptible).

Ions
Positively or negatively charged atoms or groups of atoms that are often found dissolved in water. Cations are positively charged ions; anions are negatively charged.

Osmotic Pressure
The pressure exerted by the flow of water through a semipermeable membrane separating two solutions with different concentrations of solutes.

Percent Recovery (percent conversion)
The percent of feedwater that is recovered as permeate (or product water).

Percent Rejection
The percent of feedwater that is rejected as concentrated brine.

Potable Water
Water suitable for drinking that generally has less than 500 ppm, of dissolved minerals (including salt).

Permeate (or Product Water)
The freshwater produced from the use of reverse osmosis systems to desalinate seawater or brackish sources.

Seawater
Water that is withdrawn from the ocean (with about 35,000 ppm salt and dissolved solids).

Transmembrane Pressure (ΔP)
The net pressure exerted across a membrane that serves as the driving force against osmotic pressure to produce purified product water (permeate).

Waste Concentrate (reject brine)
Salty wastewater that is produced by desalination operations. Salt concentrations in rejected brine can exceed 50,000 ppm.

OUR VISION

Drew Marine is the most trusted brand and preferred global resource for marine solutions that enhance the longevity and operating efficiency of ocean vessels.

OUR MISSION

To sustain the superiority of the Drew Marine brand by bringing environmentally and technologically superior products and services for the benefit of vessel owners and operators while increasing shareholder value.

Drew Marine®

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