WATERMAKER SYSTEM CONTROLLER OPERATION MANUAL

SEA-R.O.

WATERMAKERS

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Drawing Index

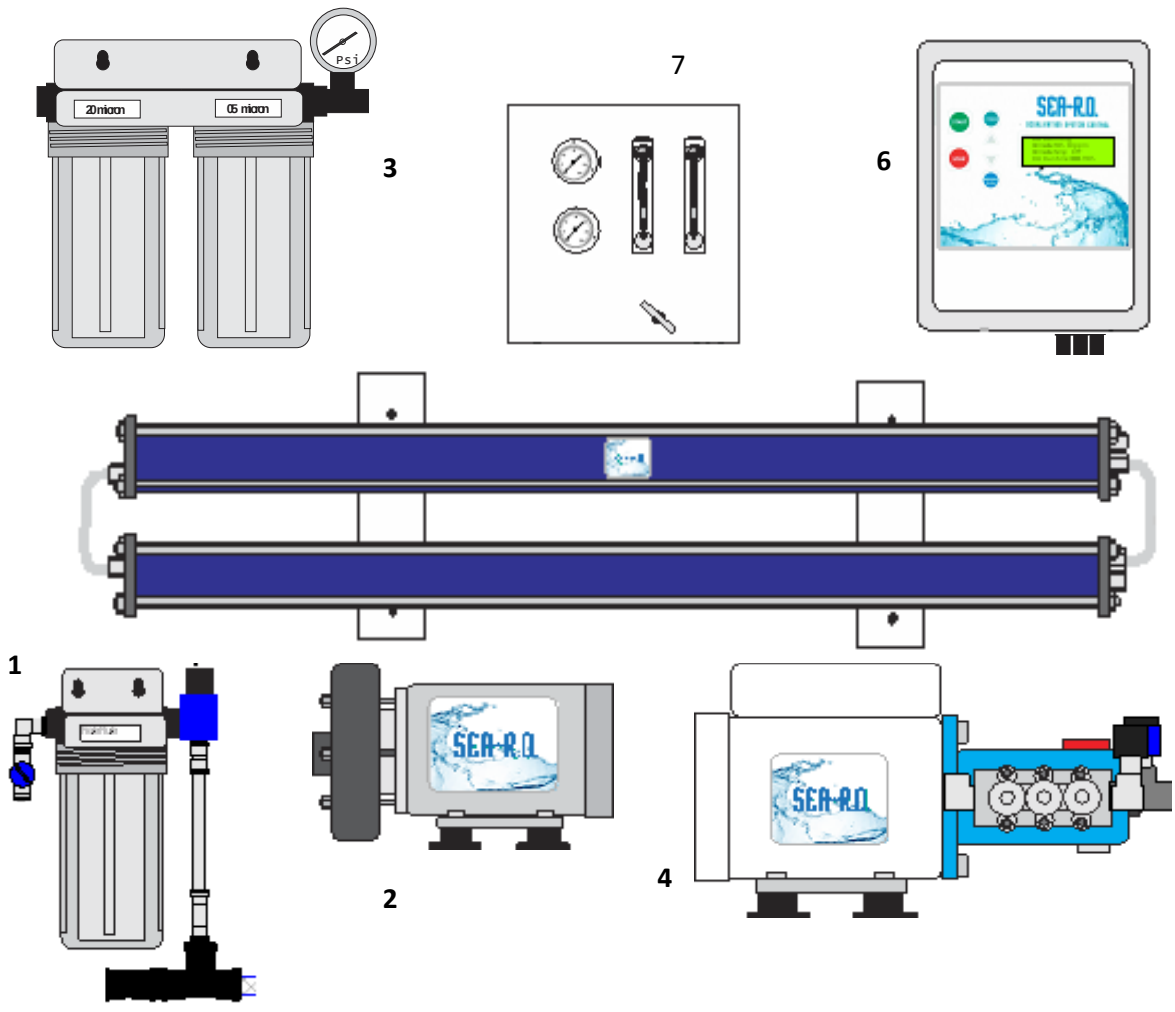
The SEA-R.O., INC. "Sea Horse" series is a complete desalination system, utilizing the highest quality components.

The system is comprised of several modular components which are installed on available bulkhead and shelves and simple plumbing and wiring interconnects the components.

This manual is intended to provide you with the needed instructions to install, operate and properly maintain the system. We are always trying to improve our manual and products, so please contact us with any corrections or suggestions.

The basic components are as follows:

1. Fresh water flush system
2. Boost pump
3. Cartridge Filter assembly
4. High Pressure Pump
5. Pressure Vessel/Membrane Assembly with HP hose
6. System control panel with overload protection
7. Hydro Panel



SPECIFICATIONS

Performance Characteristics

Criteria	Specification
Raw water temperature range, °C (OF)	1-45 (33-110)
Min. raw water inlet pressure, psi	Flooded
Max raw water inlet pressure, psi	60
Design membrane pressure, psi	800
Max. membrane pressure, psi	1000
Max. feed water chlorine residual, ppm	<0.1
Feedwater pH range	6-8
Cleaning solution pH range	1-12 (short term, during cleaning)
Membrane type	Thin film composite, spiral wound
Minimum product water production*	GPM (flow meter reads gpm)
500 GPD, 20.8GPH	0.35
800 GPD, 33.3GPH	0.56
1200 GPD, 50.0 GPH	0.83
1500 GPD, 62.5 GPH	1.04

* Standard conditions of 77°F., 37,000 ppm TDS System production IS dependent on raw water temperature and salinity. Lower raw water temperatures or higher salinity will result in reduced product water output. Conversely, high raw water temperatures or lower salinity will result in increased product water output. Product water discharge should never exceed 120 of the rated capacity of equipment, or membrane damage may occur. See temperature compensation graph at back of this manual.

Power Requirements

Model	Horse Power	Amps 110/230 VAC
500-800 GPD (HP)	1.5	14.7/7.4
1200 GPD (HP)	2.5	24.3/12.2
Boost Pump (LP)	1/2	8.5/4.3

Circuit Breaker requirements (Total System Amp Coverage)

Model	Voltage	Breaker type & rating
500-800 GPD	110 VAC	30 amp single pole
500-800 GPD	230 VAC	20 amp double pole
1200 GPD	230 VAC	30 amp double pole

Plumbing Requirements

Plumbing	Connection	Design press. Psi
Raw water inlet	3/4" male hose barb	Flooded
Reject discharge	3/8” tubing	< 5
Product water discharge	3/8" tubing	< 5

R.O. (Reverse Osmosis) general

The "Sea Horse" system operates using reverse osmosis technology. This is the most efficient and cost effective method of desalinating seawater.

In brief, reverse osmosis functions by pressurizing the seawater against a semi-permeable membrane, which only allows the fresh water molecules to pass through. The salts and other contaminants are restricted from passing through the membrane by their sheer size. These salts, etc. are continuously discharged out the brine discharge back to the ocean, and only pure, fresh water is delivered to your storage tank.

Seawater enters through an inlet through hull and strainer, enters boost pump and is pressurized through 20 and 5 micron prefilters. The clean filtered raw water (now referred to as feedwater) enters the high- pressure (HP) pump and is discharged at an approximate pressure of 800 psi into a fixed arrangement of fiberglass pressure vessels each containing a RO membrane element. The number and size of the actual membranes determine the output capacity of the watermaker.

RO pressure is monitored by the high pressure gauge. The brine discharge from the RO array is directed to the high-pressure regulator valve, which regulates the back pressure through the RO array. The reject water then flows through the brine flow meter before being discharged from the RO unit. This carries away the salts and other contaminants.

Note: We highly recommend the use of our equipment (or any watermaker) only in open ocean or the clean waters of most remote anchorages. For US coastal waters, we try not to run the watermaker until we are beyond the sea buoy or beyond the color break. A good rule of thumb is if you would not go swimming in an area, it is not appropriate to operate your watermaker. The fact of the matter is that you can still make good quality product water in areas with some contaminants, but the consequence may be shortened membrane life.

Product Water System

The product water then passes through the product flow meter and on to the product discharge line and into your storage tank(s). It is desirable to sample the quality of the product water being produced. This valve is included with the Sea Horse system. The valve is installed on the product water piping attached to the pressure vessel as standard. If desirable, this valve can be easily removed and can be installed anywhere convenient between the product flowmeter and the storage tank. See drawing for installation tip. A simple handheld test meter is available from Sea-R.O. to provide a digital readout of the water quality in parts per million TDS. This is useful for monitoring and logging your membrane performance. The membrane life is normally 3-4 years.

CONTROLS AND INSTRUMENTATION

At this time, it is advisable to review all drawings to familiarize yourself with the instrumentation and controls.

Description	Function
Fresh water flush system	Dechlorinates fresh water and allows purging of seawater from watermaker for short term shutdown
Pre Filters and LP gauge	Filters out turbidity to a nominal 5 micron particle size. LP gauge monitors filter cartridge condition
Brine Flow Meter	Indicates the rate of reject waste water being discharged from the RO unit
Product Water Flow Meter	Indicates the rate of product water produced ~ the RO unit
High Pressure (HP) Pump	Provides high pressure to membrane array
Boost Pump	Provides boost pressure to cartridge filters and high pressure pump
RO Pressure Gauge	Indicates RO array pressure
HP Regulator Valve	Maintains backpressure through RO array

PREPARATION FOR USE, INSTALLATION AND INITIAL ADJUSTMENT INSTRUCTIONS

UNPACKING AND HANDLING

Care should be taken when unpacking and handling the watermaker system. It is shipped partially pre-assembled; the pressure vessel array should not be bumped, dropped or moved in a way that may cause shifting of the vessels on the bracketing. Be sure to mark all hose and plumbing connections if disconnection is necessary.

Caution: Do not allow the RO unit to be exposed to freezing temperatures without adequate treatment for sub-freezing temperatures. See section in reference to cleaning and preservation for specific instructions on protection procedure for freezing climates.

Installation suggestions

The watermakers components should be installed in a dry, sheltered location. Some type of drain should be provided beneath the components to allow water to drain when performing maintenance or repair. We make every effort to provide a system that is protected from the normal environmental conditions of a marine installation, but it is still beneficial to make every effort to locate the components (especially the pumps and motors) in as dry of a location as possible.

First of all, some "Do nots" to guide you in your installation choices.

2. Do not share the inlet through hull with other equipment that has a high suction demand. We always prefer a dedicated through hull for our system, but some through hulls which may have minimal or infrequent usage are acceptable, with caution. We have successfully installed systems sharing head intakes, deckwash pump inlets, etc. If this is done, insure the other device is not used when the watermaker is operating and that the through hull is adequately sized and has a proper strainer in place. "Open" systems such as air conditioners and refrigeration should not be shared without a shut off valve being installed after the tee on the other devices branch. This prevents the possibility of the watermaker drawing air through the other devices discharge line, much like a snorkel. Obviously, the other device cannot be used with the valve closed. Since the watermaker has a positive displacement pump which in effect is a check valve when shut down, no additional valve is required or recommended in this branch.
3. Do not mount boost pump above waterline. The pump is a centrifugal design and is not self-priming. This requires a flooded suction to function.
4. Do not share the electrical supply with any other equipment. For proper circuit protection, watermaker must have a dedicated breaker.

4. Do not use light duty or thin walled hose, especially on suction or inlet side of boost pump. Reinforced PVC is suitable but is available in various wall thickness. If you can squeeze the hose flat between your thumb and forefinger, it will likely collapse, especially in the hot environment of most engine or machinery spaces.
5. Do not install any components where they are difficult to access for routine service. We realize that this is easier said than done on many boats, but please take the time to read through the service section of this manual to familiarize yourself with the service needed to give you a better idea of access needed.
6. Do Not install pressure vessel and membrane assembly directly next to exhaust manifolds, turbos, or other sources of extreme heat. The ambient temperature of most machinery spaces is suitable, but the intense radiant heat of the above mentioned locations can cause damage to the membrane.
7. Do not plumb the product water into the bottom of storage tanks. Due to the possibility of the tank containing chlorine on occasion when you have municipal water in storage, the membrane can be damaged if any tank water is drawn back into system. A membrane always "sucks back" when shut down, so we recommend filling at the top of the storage tank, which allows an air gap to prevent any water being drawn back into membrane.
8. Do not clean the filters or any system component with any chemicals other than our recommended membrane cleaners. Any oxidizers, such as chlorine will cause irreparable damage to the membrane.
9. Do not install shut off valves in the product water or brine drain lines. If system is operated with no path for the water to exit system, high pressures will result in low pressure piping and component rupture is likely.
10. Do not use any lubricant on fittings or O-rings except for pure silicone grease.
11. Do not mount any components that have the potential to ever leak over any equipment such as generators, inverters, etc. If there is no choice, please take precaution to provide necessary shield or cover on other equipment.

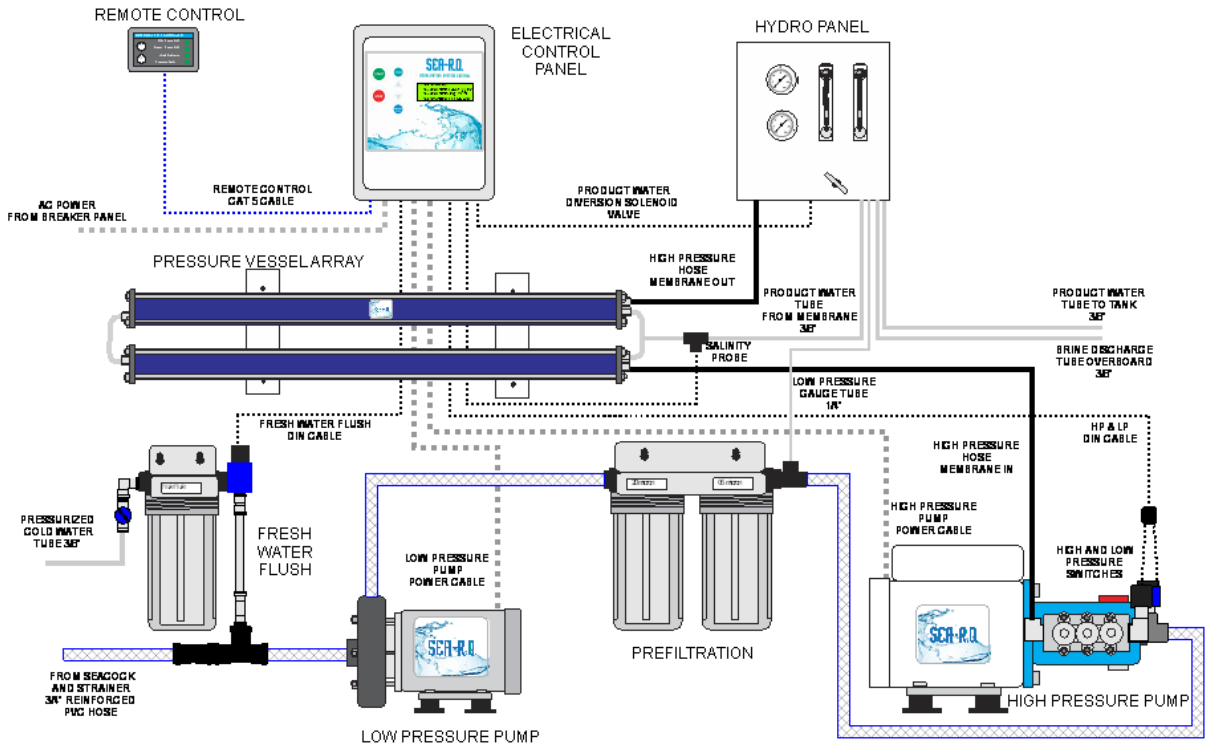
A few general recommendations prior to starting installation.

1. Do take the time to read the manual through in entirety prior to beginning installation. Also, please contact us if you have any questions. Forethought in your installation will make things go much easier and you will be proud of your installation and simplify the operation overall.
2. Do set the individual components in place, prior to mounting anything. This allows you to plan the best routing for hose and wire runs for a "yacht quality" installation. Make sure all needed access areas for servicing are thought out prior to drilling your first hole. It is helpful to set heavy components on towels or carpet scraps to be able to slide into position without scuffing or scratching surfaces prior to mounting.
3. Do use the best quality hose, wire, fasteners, and fittings available. We use only heavy walled reinforced PVC, multi-stranded, tinned boat cable, 316 stainless steel and nylon fittings. If these materials are not readily available locally for you, we will gladly provide for you. Make sure your electrical service and any wiring is of an adequate gauge for the system. Please consult with Sea-RO if you have any questions on this.
4. Do plan your hose routing to try to eliminate any potential for chafing. The high pressure hose between the high pressure pump and first pressure vessel will have some normal vibration. If this is routed across a rough or sharp edge, the hose can chafe through in time.
5. Do plan on taking your time to install. While our systems are quite simple by design, it still takes us an average of about 16-20 man hours to install a system properly.

Since every installation is unique, the installation instructions are generic in nature. Below we have tried to highlight the individual component installation in the same sequence as the water flows through the system. Once again, it is beneficial to read the manual in its entirety prior to starting to get an overall understanding of the system operation and maintenance for best component locations.

Caution: Inlet and discharge plumbing should be constructed of PVC, 316 stainless steel pipes or from a reinforced non-collapsing hose. Iron or galvanized piping material must not be used as rust will form and pass into the RO membranes causing irreversible damage and voiding their warranty. Additionally, the raw water source should be designed to minimize or eliminate intake of silt, oil, algae, barnacles and other sea life.

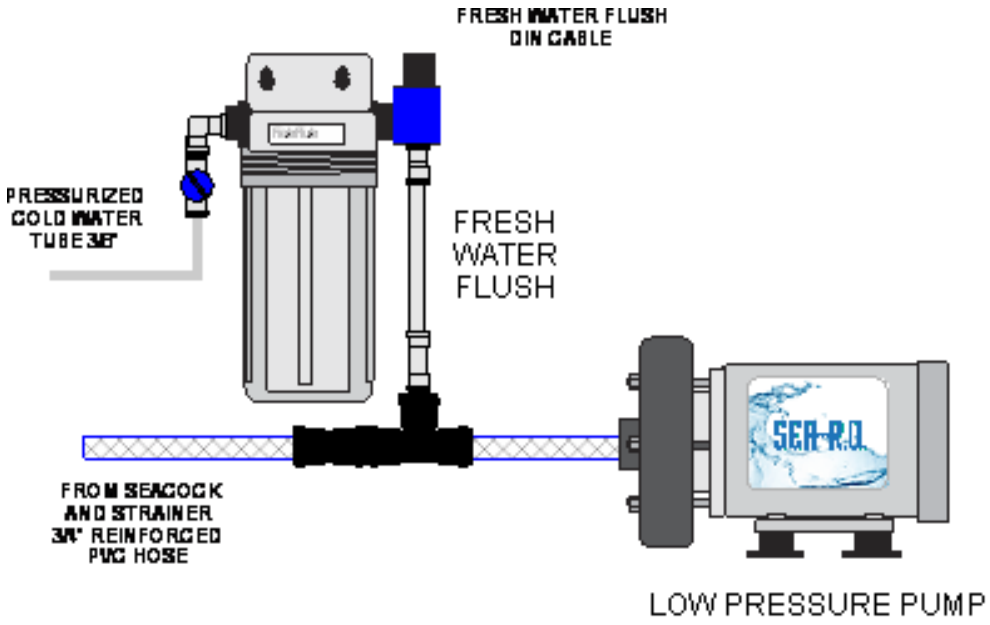
5.



Intake through hull (Installation suggestions)

The intake through hull, seacock, and strainer are not provided as part of our system. Below we outline the recommended placement of these items. Due to the importance and safety of a properly installed below waterline through hull we highly recommend having a local boatyard facility complete the installation of the through hull.

The through hull should be at least " in diameter and located as deep on the vessel as possible. This through hull should not be located in any areas of turbulence or other discharges form marine heads, bilge pumps, scuppers, or sink drains. A sea cock should be attached to the through hull. An easily serviced strainer must also be provided. We have used Groco ARG series strainers for years without any problems and feel confident in recommending them for this service.



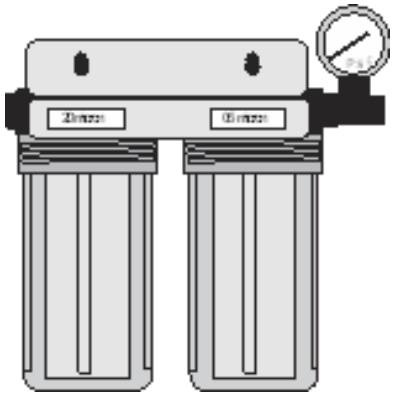
Fresh Water Flush System (Installation suggestions)

The fresh water flush system is installed prior to the boost pump to allow complete flushing of the entire system when system is shut down for short periods. The filter cartridge is only replaced once a year, so access is not as important for servicing filter as the prefilters. However, the valve must be easily accessed for flushing. Since the valve is actually located in the suction hose from the strainer to the boost pump, the valve must remain below waterline to maintain a flooded suction at the boost pump. If it is not possible to mount the filter housing in a location that allows this, the valve can be removed and relocated to a lower location. The inlet water supply for the filter must be pressurized cold water from the vessels pressure system or the dock water connection. This pressure must be regulated to 10-30 psi. An in line regulator can be added on this branch if necessary. It is also beneficial to be able to shut the branch supply line off with an in line valve for filter servicing without depressurizing the entire boat system.

Drawing on left shows normal configuration if entire filter assembly can be located below vessels waterline. Drawing on right shows simple modification. If modified, valve should be secured to a frame or bulkhead for easy operation.

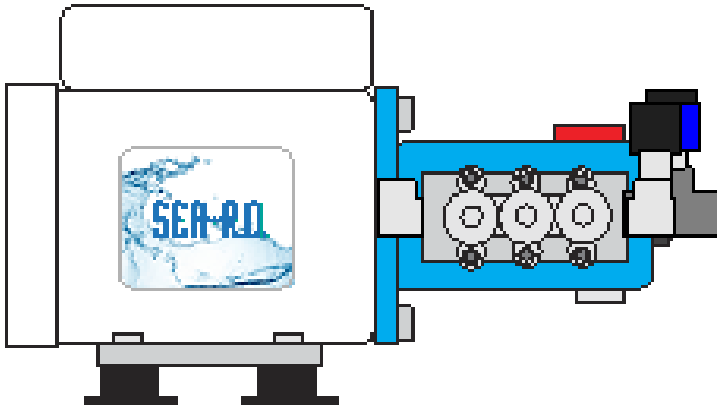
Boost pump (Installation suggestions)

The boost pump is provided to provide a low pressure raw water supply to and through the prefilters and into the high pressure pump. Mount horizontally on provided vibration isolation mounts. It is best to keep the inlet or suction hose as short as possible for best performance. The inlet hose should also have adequate reinforcement to prevent collapse when pump is operating. Consider that hose will soften in the heat of a typical engine or machinery space. We also recommend double clamping all hose to fittings. Air leaks on the suction side of the boost pump are difficult to diagnose and can cause cavitation damage to pumps and fittings over time. Minimize the number of elbows used in plumbing in both inlet and output sides of pump. This pump is protected against low pressure operation and will shut down if boost pressure drops below 2 psi. See pump manual at back of this manual for complete instructions in maintenance and seal replacement.



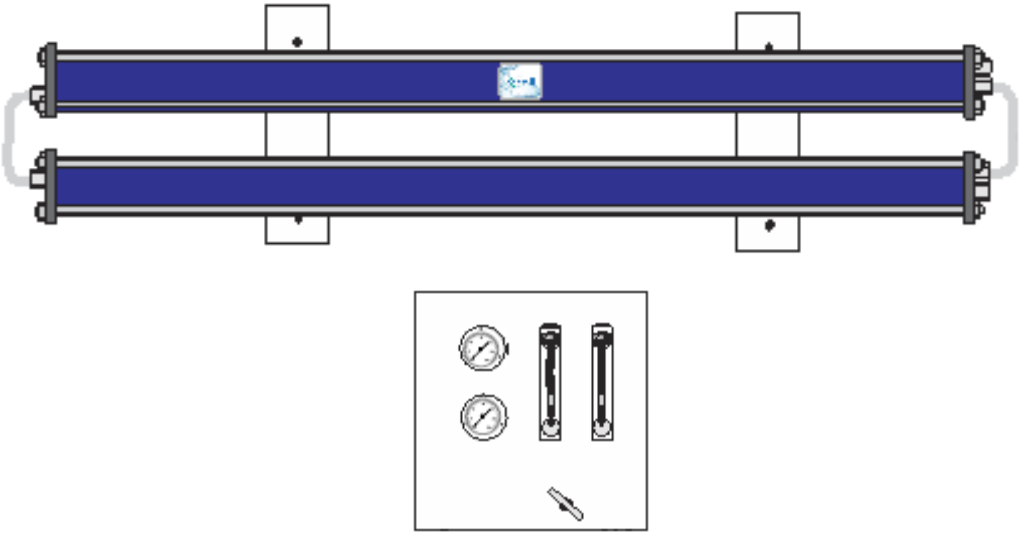
Prefilters and Low pressure gauge (Installation suggestions)

The prefilters are the single most serviced component of the watermaker. The duration between the required changes in entirely dependent upon the water quality you are operating the system in. The more suspended solids and algae., plankton, etc. the more often the filters must be changed. We always try to install the prefilters in an easily accessed location which drains to the bilge in case of spilling when servicing. The filters tanks should be removable and replaced with hand tightening only. Sometimes it is necessary to use a wrench, which we provide with the system. Be certain that the installation location chosen allows the needed room for use of the wrench. The gauge should also be visible. If necessary, the gauge can be relocated with " fittings and hose or tubing. It is preferred not to have the filters at a high point that can catch air. This is especially true on fast shallow draft vessels such as catamarans and sportfish boats.



High pressure Pump and Motor (Installation suggestions)

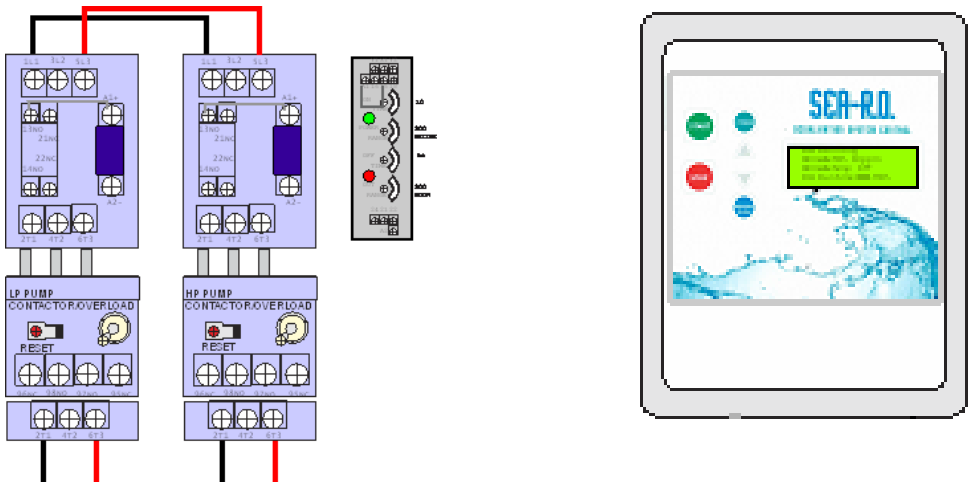
Special consideration should be given in the location and installation of the high pressure pump and motor. This is the heaviest component to our system and is the only component that produces any noise of note. We provide Vibration isolation mounts which greatly reduce any transmitted noise and elevate the motor from direct mounting to a surface that helps prevent motor from rusting. The high pressure pump requires an oil change at 50 hours for break in, then every 500 hours. The seals and valves are normally replaced at approximately 1500-2000 hours. There is also an "eye" in the pump that allows the operator to visually check the oil level (only when pump is shut down). Because of these service needs, we recommend mounting in a location where the above service functions are easily accomplished. These pumps are normally mounted in a machinery space to further dampen any noise generated. The pump and motor must be securely mounted due to the weight, and through bolting on a platform or shelf is recommended. Hose routing for the high pressure hose to the pressure vessel is very important to prevent any possible chafe points. If necessary, the hose can be covered with refrigeration insulation foam (neoprene) where the hose may contact any surfaces. Do not wire tie directly to the high pressure hose or route through any bulkheads without adequate protection. We have provided an elbow in the high pressure pump which can be repositioned or removed if best for your installation. Please note, if fittings need to be realigned, you must remove and clean the thread tape off, re-tape and reinstall to correct alignment. If you attempt to re-align simply by loosening the fitting even slightly, leaks will result.



“Sea Horse” 800-1200 GPD Membrane and Pressure Vessel Array and Hydro Panel

The pressure vessel and membrane are shipped with a mild preservative solution (commonly known as pickling). This allows the membrane to be stored for up to 1 year without performance loss. Do not drain this fluid until you are ready to commission the system. Once this fluid is flushed from the system, the unit is ready for use or should be re-pickled. See specific chemical use and safety data sheets in the chemical cleaning section of this manual

The pressure vessel assembly incorporates the hydraulic controls and instrumentation, so it must be accessible for operation. The high pressure hose connects directly from the high pressure pump, so consideration must be given to the best routing of this hose. The pressure vessel is provided with a high pressure elbow fitting which can be removed if installation does not require it. The pressure vessel fitting is unique because it can swivel for alignment to any position without removing or re-taping of fittings. The membrane will generally last 3-4 years before replacement is required. Generally, the entire pressure vessel assembly is removed from the boat for membrane replacement, so no excess space is required on each end for membrane removal. When installing hose onto flowmeter fittings, do not put excessive force on flowmeter fittings. Warm hose end in hot water and use a small amount of silicone grease on fitting if necessary. This will allow hose to attach with minimal force. The product water sample valve can be relocated if more convenient by adding some 3/8" diameter tubing between valve and tee. Brine discharge hose and product water hose should not have any shut-off valves in line that could prevent normal flow. If these lines are blocked. excessive pressure will result and cause component failure. The product water till line should enter into the storage tank at the highest point, usually tee'd into either the till or vent lines. When using the vent line, it is important that the water have a direct path into the tank with no droops or low points which can act as a trap. If this is not done, the water you are trying to fill your tank with is actually flowing overboard out your vent line!



"Sea Horse" System Control Panel

System Control Panel (Installation suggestions)

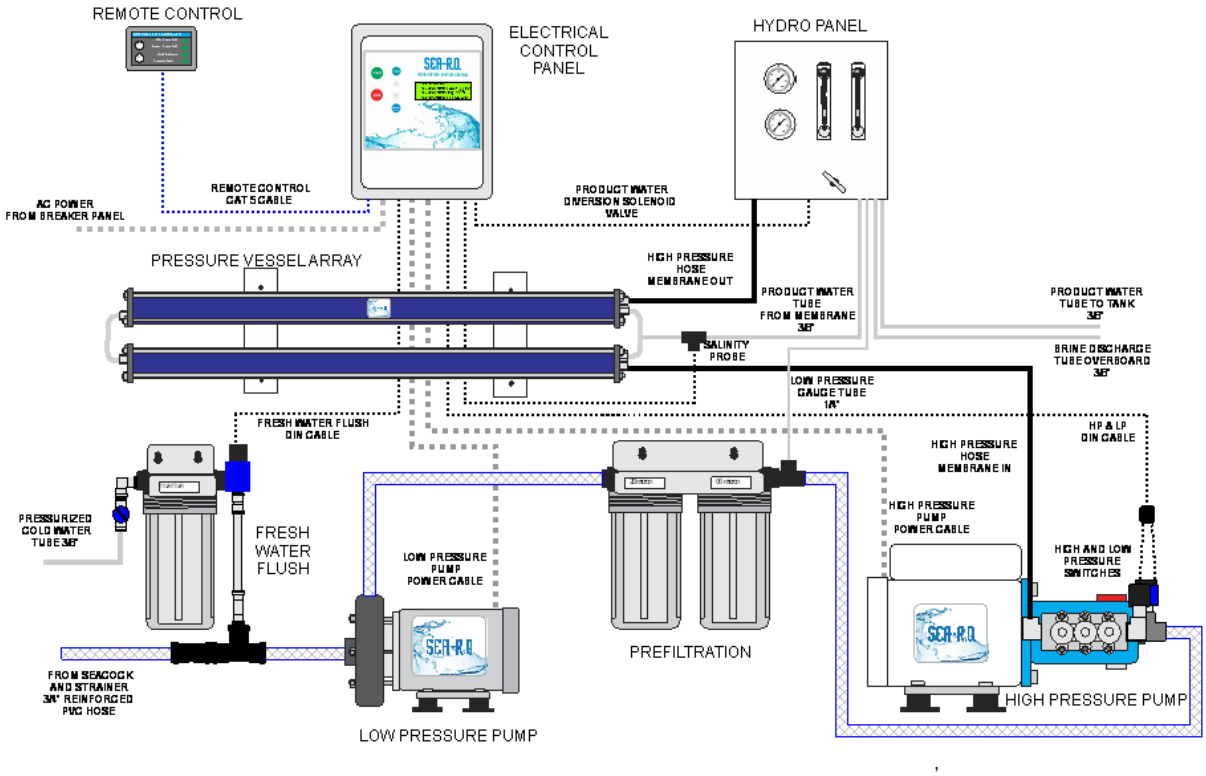
The System Control Panel (SCP) is provided pre-wired to both the boost pump and the high pressure pump. We recommend if at all possible, the wiring is left intact. The SCP is used to operate the electrical functions of the machine and it is most beneficial to locate this panel in close proximity and visibility of the Pressure Vessel Assembly that contains the hydraulic controls. Mount SCP on bulkhead using holes in molded on flanges. Do not drill through enclosure. Panel removes straight off, so minimal clearance is needed above or to the sides. Wire route downward. The main power lead needs to be connected to the ships main breaker panel of the correct voltage and amperage rating as detailed below. If you are unfamiliar with the correct technique to connect into your vessels electrical panel, stop now and hire a professional. This is a simple task for any electrician and should not take more than an hour for them to accomplish. Due to the potential risk involved in this part of the installation, do not proceed unless you are totally familiar with your vessels electrical system and correct safety procedures.

Power Requirements

Model	Horse Power	Amps 110/230 VAC
500-800 GPD (HP)	1.5	14.7/7.4
1200 GPD (HP)	2.5	24.3/12.2
Boost Pump (LP)	1/2	8.5/4.3

Circuit Breaker requirements (Total System Amp Coverage)

Model	Voltage	Breaker type & rating
500-800 GPD	110 VAC	30 amp single pole
500-800 GPD	230 VAC	20 amp double pole
1200-2000 GPD	230 VAC	30 amp double pole



OPERATION

INITIAL START-UP PROCEDURE & OPERATION PROCEDURE

Note: We highly recommend the use of our equipment (or any watermaker) only in open ocean or the clean waters of most remote anchorages. For US coastal waters, we try not to run the watermaker until we are beyond the sea buoy or beyond the color break. A good rule of thumb is if you would not go swimming in an area, it is not appropriate to operate your watermaker. The fact of the matter is that you can still make good quality product water in areas with some contaminants, but the consequence may be shortened membrane life.

Note: If system must be tested dockside, a test tank and salt solution to simulate ocean conditions can be used. Follow cleaning instructions, but instead of using cleaning chemicals, mix 1.5 lbs of salt into 5 gallons of water. Salt must be non-iodized (Kosher is suitable) and mixed fully into solution before starting system. Monitor the water temperature and do not run the system for more than about ten minutes. Overheated water will give high salinity results and may damage membrane.

These instructions apply when the RO unit is being started for the first time or if the unit is being started after a prolonged shut-down period. The normal start up instructions follow on the next page.

Caution: take all reasonable precautions when starting up any mechanical equipment for the first time or after long periods of shut down. Inspect the unit, check the oil, check all electrical connections, check to see that rotating and moving parts are free moving.

Note: If for any reason equipment does not operate as described below during start up, refer to troubleshooting section immediately to identify and correct any problem.

1) Check and clean strainer. Open inlet valve or seacock if present.
2) Check the HP pump oil level (see pump manual for procedure).
3) Check all lines and fittings for security, tighten clamps as needed.
4) Loosen the RO unit's high pressure regulating valve.
5) Turn on Main breaker to System Control Panel
6) Turn on boost pump by pressing and holding start button for 5 seconds.
7) Verify raw water supplied to RO unit for proper flow and pressure. Low pressure gauge should read approximately 15-18 psi and the flow through the brine flowmeter will show approximately 1 gpm until HP pump is started

Caution: Failure to open HP regulating valve during the initial startup can result in hydraulic shock to the system.

8) Turn on high pressure pump. Brine flow will increase to 2.4gpm (200-800 gpd systems) or 4.0 gpm (1200 gpd system).
9) Inspect all plumbing connections in the unit for leakage. Temperature changes during shipment or long term storage may cause plumbing connections to seep when started on-site. If any leaks are present STOP UNIT and repair them before proceeding.
10) When flow through reject discharge flow meter appears to be free of air bubbles, slowly tighten HP regulating valve until the high pressure gauge reads 800 psi.
11) Initial product water made upon initial startup should be discarded for approximately 30 minutes by opening sample valve and sending water to the bilge. This eliminates any trace amounts of the pickling solution.

Note: Pressure requirements will be lower in fresh water (200 psi) and brackish water (400 psi) applications. Product water output should not exceed 120% of rated capacity of individual unit. Reduce pressure at the high pressure regulating valve as necessary.

12) Close sample valve and observe product water flow meter, this flow meter indicates, in gallons per minute (GPM), the product water flow rate. First reading should be recorded but is usually inaccurate. Record indication

again after 48 hours of operation, this will be your baseline reading. This indication will provide a standard for determining RO membrane cleaning requirements. Normally, a drop of 10-15 in the product water production from this baseline rate indicates the need for RO membrane cleaning. However, an increase in feedwater salinity, a decrease in feedwater temperature or a decrease in RO feed pressure will cause a drop in production. Loss of production due to these factors DOES NOT indicate the need for membrane cleaning.

13) Log all data onto log sheet.

NORMAL START -UP PROCEDURE & OPERATION PROCEDURE

Note: We highly recommend the use of our equipment (or any watermaker) only in open ocean or the clean waters of most remote anchorages. For US coastal waters, we try not to run the watermaker until we are beyond the sea buoy or beyond the color break. A good rule of thumb is if you would not go swimming in an area, it is not appropriate to operate your watermaker. The fact of the matter is that you can still make good quality product water in areas with some contaminants, but the consequence may be shortened membrane life.

1) Check and clean strainer. Open inlet valve or seacock if present.
2) Check the HP pump oil level (see pump manual for procedure).
3) Check all lines and fittings for security, tighten clamps as needed.
4) Loosen the RO unit's high pressure regulating valve.
5) Turn on main breaker to System Control Panel
6) Turn on boost pump by pressing and holding start button for 5 seconds.
7) Verify raw water supplied to RO unit for proper flow and pressure.
8) Turn on high pressure pump
9) Inspect all plumbing connections in the unit for leakage.
10) When flow through reject discharge flow meter appears to be free of air bubbles, slowly tighten HP regulating valve until the high pressure gauge reads 800 psi.
11) Initial product water made upon normal start up should be discarded for approximately 2 minutes. This eliminates any trace amounts of the salts which are present as membrane begins to produce water.
12) Close sample valve and observe product water flow meter, this flow meter indicates, in gallons per minute (GPM), the product water flow rate.
13) Log all data onto log sheet

Note: Pressure requirements will be lower in fresh water (200 psi) and brackish water (400 psi) applications. Product water output should not exceed 120 of rated capacity of individual unit. Reduce pressure at the high pressure regulating valve as necessary.

SHUT DOWN PROCEDURES

Short Term Shutdown Procedure

It is recommended that the system be flushed with fresh water anytime it will be unused for over 48 hours

1) Turn off the unit, open (loosen) the high pressure regulating valve
2) Open fresh water flush system valve and flush unit for 5 minutes with fresh water. This will greatly enhance the life of the membranes and the stainless steel components.

Note: This shutdown procedure applies if the RO unit is to be shut down for periods less than 7 days. If the anticipated shutdown is 7 days or greater, refer to the Extended Shutdown Procedure given below or simply flush the system every 7 days repeatedly. It is important that for extended repeated fresh water flushing, that the prefilter cartridges be cleaned or changed prior to starting process. This is to eliminate any organic material that is trapped in fouled filters that will increase organic fouling of the system.

Extended Shutdown Procedure

If the RO unit is to be shut down for periods exceeding 7 days, stagnant water in the system will breed bacteria and other biological growths. These organisms will not attack the membranes or other components but may increase in numbers sufficient to block the product water channels in the membranes, resulting in a product water output loss of up to 40.

Caution: Failure to follow the extended shutdown procedure can result in irreversible damage to the RO membranes and will void their warranty.

Bacterial contamination can be avoided by following one of the following procedures:

1) Flush the RO unit with UNCHLORINATED fresh water for 5 minutes weekly. Prefilters must be clean.
2) Flush the RO unit by operating the system for 5 minutes every 3 days. (This assumes that the water conditions where the boat is moored is appropriate, not harbor or canal water.)
3) Flush the RO unit with a preservative solution every 90 days.

If a preservation solution is to be used, follow the preservation instructions given in the RO Membrane Maintenance section listed below.

MAINTENANCE INSTRUCTIONS

GENERAL

The following lists the frequency of basic maintenance required by the watermaker to keep the system in good operating condition.

1) Clean strainer as required
2) Clean / replace filter cartridges: as required
3) Clean RO membranes: as required
4) Check HP Pump oil level: 50 hours
5) Change HP pump oil after first 50 hours, every 50 hours thereafter
6) Lubricate motor: annually

FILTER CARTRIDGE CLEANING OR REPLACEMENT

The filter(s) should be replaced when it appears fouled or the low pressure gauge reads less than 2 psi. The system is designed to shut down at 2 psi to protect the pumps. Anytime the system shuts down, always check the strainer and filter conditions prior to attempting restart. Even though our filters are an industry standard size, we highly recommend only using our filters in your system. We use only 100 poly filtration media which is superior in performance and longevity over any cellulose or paper based cartridges. Using incorrect filter cartridges will cause irreparable membrane damage and voids the membrane warranty.

Replace the filter(s) using the following procedure:

1) Shutdown RO unit, close raw water supply (external) to the RO unit
2) Loosen and remove the filter housing by rotating the housing in a counter-clockwise direction.
3) Remove the cartridge and replace with correct replacement filter. The old filter may be cleaned and re-used several times by using a hose stream to remove matter from filter pleats. If filter appears oil-fouled or is damaged in any way discard and install new filter.
4) Replace filter housing, ensure that housing O-ring is clean and in good condition. If lubrication is necessary, pure silicone grease is the only acceptable lubricating medium.
5) After the housing (with new or cleaned filter) is has been replaced, we recommend a momentary fresh water flush (5-10 seconds) to purge any air from the system. Operate the RO unit and check for leaks.

HIGH PRESSURE PUMP

The CAT high pressure pumps used in the "Sea Horse" series are a ceramic plunger design. Ceramic plungers have a unique ability to operate with only water as a lubricant. This provides the longest possible seal life. These pumps have 3 individual identical chambers containing the plunger, low and high pressure seals and inlet and discharge valves. The valves and seals are normally replaced at approximately 1500-2000 hours of use. Seal wear is first indicated by small drips of water below the pump manifolds. When this is evident, pump should be serviced as detailed in manufacturers manual. Rebuilding these pumps is actually quite easy and we encourage anyone with normal mechanical skills to try this yourself. Consult manufacturers manual for the tools required. For complete rebuild instructions, refer to pump manufacturer's literature contained in this manual. The pump features an oil filled crankcase which requires oil changes at 50 hours for a break-in period, then every 500 hours. The oil is drained from a plug under the crankcase. We have found that a foil baking pan, available at grocery stores to be very handy to fashion a "custom" drain pan. Since the space is quite narrow, you can bend and mold the tray into the shape required to fit under the pump

SYSTEM CONTROL PANEL

The System Control Panel (SCPI) is designed for the purpose of simple system operation and to protect the system components, both electrical and hydraulic. The SCP is a very reliable design and we recommend only that the below tests be conducted annually to insure the operational condition of the safety components. The SCP is connected to two pressure sensor switches, which are attached to the high pressure pump.

The low pressure switch monitors to inlet pressure at the high pressure pump and if it is insufficient «2psi), the system will shut down if running, or will not start. This switch is a normally open switch and does not complete the circuit until 2 psi is available to close the contacts. To test the function of this switch, when system is on line and operating, slowly close the inlet sea cock while observing the pressure at the low pressure gauge. The system should shut down when gauge reads approximately 2 psi. There is a momentary delay from what the gauge and the switch are reading, so exactly 2 psi may not be observed, but as long as the system shuts down, the switch is operational.

Caution: If switch does not shut system down, do not let system continue to run. Switch is faulty and should be replaced immediately.

The high pressure switch monitors the outlet pressure of the high pressure pump and will immediately shut the system down if the pressure reaches over

1000 psi. This switch is a normally closed switch that opens the contacts at excess pressure and interrupts the circuit. To test this switch, operate the system as normal and then very slowly tighten the high pressure regulator valve while observing high pressure gauge. Continue to increase pressure until system shuts down or 1000 psi is observed.

Caution: Do not exceed 1000 psi. If system does not shut down during this test, switch is faulty and must be replaced immediately.

The SCP contains a separate contactor and overload for both the boost pump and the high pressure pump. These provide thermal protection of the motors in the event of low supply voltage. This is a fairly common occurrence on boats and without this protection, the motors can be damaged.

See trouble shooting guide and electrical section to determine the correct way to troubleshoot these components and for details regarding contactors and complete wiring diagram.

RO MEMBRANE MAINTENANCE

This section is designed to guide the operator in the periodic care and cleaning of the membranes used in this watermaker system. The membrane elements in this system require occasional servicing and adherence to a preventative maintenance program to assure longest possible life and lasting performance.

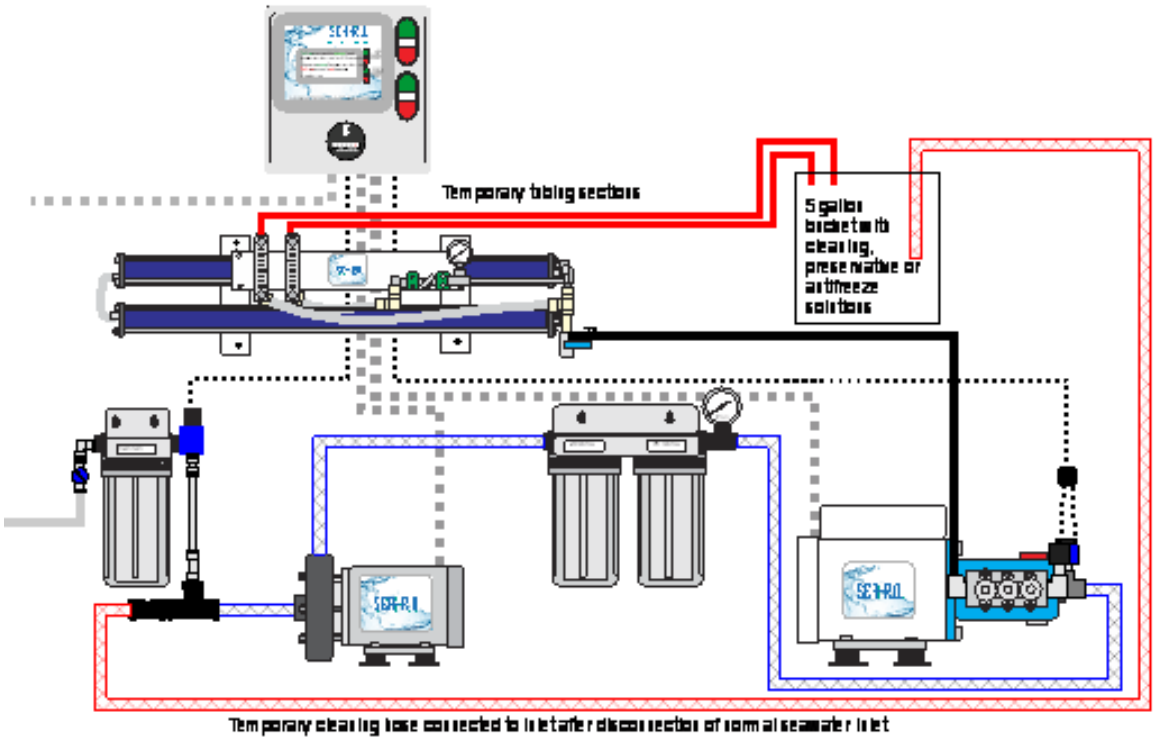
Normal membrane life is usually 3-4 years. Over time the membrane may begin to allow small amounts of salt to pass through which will increase the TDS (total dissolved solids) of the product water.

Product water quality is measured with a simple meter that reads out in TOS. When membranes are new, in a seawater system, you should expect approximately 300 parts per million (PPM) of total dissolved solids. As the membrane ages, the PPM may climb to 500, which is the USEPA limit for drinking water. At this time, the membranes should be replaced.

Water quality standards do vary around the world, with the USEPA standards being the most strict. World Health Organization (WHO) has established the PPM level at 1000 PPM.

From our experience, you will not taste the salt content in drinking water as salt until the level reaches approximately 1300 PPM. For this reason, a handheld salinity tester is recommended. With this meter, you can accurately test and log the membranes performance and accurately determine when the membrane needs replacement.

Note: We highly recommend the use of our equipment (or any watermaker) only in open ocean or the clean waters of most remote anchorages. For US coastal waters, we try not to run the watermaker until we are beyond the sea buoy or beyond the color break. A good rule of thumb is if you would not go swimming in an area, it is not appropriate to operate your watermaker. The fact of the matter is that you can still make good quality product water in areas with some contaminants, but the consequence may be shortened membrane life.



Chemical Cleaning and Preservation - General for all Models

For cleaning and/or preservation treatment, the procedure is basically the same: a chemical solution is re-circulated through the system. Our system is designed to be as simple as possible to operate and maintain. For this reason, we do not build in a cleaning "loop" or manifold system that is used in some systems. From our experience, when you start adding a number of three way valves, manifolds, etc., even the most skilled operators can get mixed up during a cleaning process. These systems also create unnecessary complexity of the system for day to day operation. These closed loop systems also do not retain a volume of water which is sufficient to properly clean a system. Re-circulated cleaning solution becomes excessively heated and can actually cause membrane damage.

We also have found with the proper and regular use of the fresh water flushing system, you may never even need to clean the membrane. With that in mind, for

the limited need to clean the system, disconnecting a few hoses when (if ever) it is time to clean a system, is not a big deal.

Depending upon the installation and the components layout, it may be beneficial to have some extra lengths of the appropriate size hoses for this procedure, with some in-line hose mender fittings to allow you to extend the hoses to a convenient location for your cleaning bucket.

The alkaline detergent (#1) is for the removal of oil, grease, biological matter and grime from the membranes. The acid cleaner (#2) is for the removal of mineral scale deposits on the membrane surface. The preservative (#3) is a food grade preservative that will allow system shut down for up to 90 days. All below references to UNCHLORINATED water indicate that you should not use any water directly from a municipal water supply or stored water in your boats tank without dechlorinating the water with your fresh water flush system.

When to Clean

In normal operation the membranes will become fouled by biological matter and mineral scale, these deposits build up during operation until they cause a loss of product water output, salt rejection or both. The membranes should be cleaned whenever product water output drops by 10-15 from the initial flow rate established after the first 48 hours of operation. The membranes should also be cleaned when the TDS level of the product water exceeds 500 ppm. The results of a cleaning process vary greatly, sometimes improving product flow rate and quality of water, but more commonly improving just the quantity without notable improvement of the quality. It is important to remember that the first 24 hours of operation after a cleaning may give erroneous readings. Allow the system to operate for at least 24 hours prior to recording flow or quality readings. Individual membrane testing of the product water should be performed on a monthly basis.

Note: Product water output of the system is dependent upon feedwater temperature, RO feed pressure and feedwater salinity. Product water output reductions due to these factors are normal and may not indicate the need for membrane cleaning.

Use the following procedure to clean the RO membranes:

1) Freshwater flush the system prior to beginning the cleaning procedure
2) Disconnect hose from inlet of boost pump
3) Disconnect brine discharge hose
4) Disconnect product water hose
5) Place the ends of the three hoses, mentioned above, in a clean, preferably white plastic 5 gallon bucket. Try not to allow the intake hose to drain. If unable to prime, you may need to re-connect the inlet

hose to the fresh water flush system and momentarily flush to re-prime system

6) Open the high pressure regulating valve (counter clockwise)

7) Dissolve appropriate amount of chemical in 5 gallon bucket, using UNCHLORINATED product water. Be sure chemical is completely dissolved before proceeding

8) Start the watermaker and allow the chemical solution to re-circulate for 30 - 40 minutes. Less than 100 psi pressure should be evident on the high pressure gauge.

Note: Make certain the chemical solution is flowing through the system and that suction hose, to inlet of pump, does not contact the bottom of the bucket, causing a vacuum which will stop the solution flow.

9) Stop watermaker, empty the contents of the bucket, re-fill with UNCHLORINATED fresh water

10) Start watermaker again, circulating UNCHLORINATED fresh water through the system for 2 minutes, until bucket is almost empty (discharge hose should be outside the bucket for this flush).

11) Stop watermaker, return discharge hose to bucket and begin cleaning process again (Step #7-#11 above) using chemical #2.

12) Cleaning is now complete, before returning unit to normal operation reconnect hosing to original fittings. Start watermaker and allow to run at 0 (zero) psi for 10 minutes prior to adjusting high pressure regulator valve to 800 psi.

Note: After cleaning, the product water salinity may increase slightly. This is normal and should stabilize to its normal level after 24 hours of operation.

13) To preserve, also called "pickling" the watermaker begin at step #1 and follow through to step #8; with the exception of the duration of circulation which should be 5 minutes.

Note: the preservative chemical is left in the watermaker (not flushed out) and can remain there for up to 90 days. At the end of this time period, either flush with fresh water for 5-10 minutes and re-pickle, or begin fresh water flushing weekly until ready for next use at sea.

Freeze Protection

In order to properly protect a system for long-term winter storage in freezing climates, special procedures must be followed. Failure to protect system can cause component failure throughout system.

Freeze protection is done by following the preservation or "pickling procedure above with the addition of non-toxic water system anti-freeze. One brand is "Camco" and is available at marine chandlers and RV suppliers. 100 propylene glycol.

1) Follow pickling instructions above and when complete, empty most of the contents of the bucket, leaving approximately to 1 gallon of pickling solution left in bucket.
2) Add 2 gallons of the anti-freeze to the solution and mix.
3) Turn system back on and re-circulate for another 5 minutes.
4) Re-connect all hoses.
5) Disconnect product water hose from membrane and blow towards tank. This will clear the product water flowmeter and hose to tank.
6) Depressurize boats water system and remove freshwater flush filter housing and drain water.

This procedure will protect the system from freezing to the rated temperature of the anti-freeze and extend the useful life of the pickling solution. This allows storage of up to 6 months without membrane damage.

Troubleshooting:

This section is divided into three basic sub-sections

Electrical Troubleshooting
Refer to this section if equipment will not start or runs and shuts down.

Hydraulic Troubleshooting
Refer to this section if the equipment operates, but there may be fluctuations in pressures, flows, or noise.

Performance Troubleshooting
Refer to this section if the water quantity or quality is affected.

Electrical Troubleshooting

Symptom:	Pressing boost pump start button has no effect.
Probable cause:	Main breaker at boats panel is off or tripped, or internal overload protection is tripped.
Remedy:	Reset or turn on main breaker, reset overload.

Symptom:	Pressing boost pump start button will cause boost pump to run, but it immediately shuts off when button is released. Low
Probable cause:	pressure switch is preventing system from running due to inadequate pressure.
Remedy:	Check and clean strainer and filters, flush system with fresh water flush system to purge air and re-start.

Symptom:	System shut down in operation. Push button will restart pump
Probable cause:	Low pressure switch shut system down due to a blocked inlet, fouled filters, or air being introduced into system.
Remedy:	Clean and re-prime as above.

Symptom:	System shut down in operation. Push button will not restart pump
Probable cause:	Overload is tripped from low voltage
Remedy:	Verify the supply voltage is correct. Shut down power and reset tripped overload inside of control box.

Symptom:	Overload resets and trips again when trying to restart motor. Motor hums
Probable cause:	Motor capacitors have failed, or connection has come loose
Remedy:	Turn off all power. Inspect capacitors by removing cover on top of motor. If connection is loose, reconnect. Caution: capacitors store energy and can shock you. Do not touch the terminals without discharging the capacitor first or use insulated pliers for this task. Failed capacitors will usually be evident by leaking black substance around the seams or they will be swollen. If failed, record numbers from capacitor and contact Sea-R. O. or electrical supplier for replacement.

Symptom:	Low or High pressure switches have failed.
Probable cause:	Component internal failure
Remedy:	As a temporary means to bypass these switches and allow system to operate until the switch can be replaced, the following procedure can be used. 1. Turn all power off 2. Identify the two wires leading to the failed switch 3. Cut wires and splice the two wires coming from control panel together. This circuit is full voltage of system, so make a good splice and insulate with electrical tape.

Caution: This procedure bypasses the pressure switch and eliminates the usual protection. Monitor system pressures and filter condition closely until switch can be replaced.

Hydraulic Troubleshooting

Symptom:	Pressure is low from boost pump
Probable cause:	Plugged strainer or filters
Remedy:	Clean and change as necessary

Symptom:	Pressure is still low
Probable cause:	Air in boost pump
Remedy:	Briefly flush system with fresh water flush system to purge air and prime system.

Symptom:	Pressure is still low
Probable cause:	Debris inside of boost pump
Remedy:	Remove boost pump chamber and inspect, remove debris

Symptom:	Air in brine flowmeter does not go away, High pressure pump is noisy
Probable cause:	Air leaking into system at boost pump suction line from loose clamps or at strainer cover.
Remedy:	Tighten all clamps, make sure strainer cover gasket is intact.

Symptom:	High pressure fluctuates, brine flowmeter pulsates.
Probable cause:	High pressure pump valves need servicing.
Remedy:	This is a normal required service at 1500-2000 hours of operation. If this occurs early, the valves may just have debris stuck on the sealing surface. Clean, inspect and re-use existing valves if suitable.

Symptom:	High pressure pump does not build pressure, leaks evident below pump manifold.
Probable cause:	Pump seals have worn.
Remedy:	Replace seals following manufacturer’s instructions.

Symptom:	Boost pump shaft seal is leaking.
Probable cause:	Seal is worn.
Remedy:	Replace seal following manufacturer’s instructions.

Performance Troubleshooting

Symptom:	Lower than normal product flow rate
Probable cause:	If operating pressure and salinity and temperature of feedwater has not changed, membrane(s) need cleaning
Remedy:	Follow cleaning instructions.
Symptom:	Product water has increased in IDS
Probable cause:	If operating pressure and salinity and temperature of feedwater has not changed, membrane(s) need cleaning.
Remedy:	Follow cleaning instructions. Membrane life is typically 3-4 years. If cleaning not successful, replace membrane.
Symptom:	Product water has odor, like "rotten eggs".
Probable cause:	Odor is caused by the production of Hydrogen Sulfide (H2S), which is produced by organic decay. This is usually caused by detritus in the strainer basket or fouled prefilter cartridges.
Remedy:	Clean or replace inlet strainer and filters. Fresh water flush system and allow to stand overnight with fresh water. If odor persists, follow pickling instructions, even if system will be used the following day. We have found the pickling chemical to be effective at eliminating odor source.