USFilter

Operation and Maintenance Manual for

H SERIES

(3180, 3240, 3300 & 3360)

Reverse Osmosis Systems

Serial # _____

U.S. Filter
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10/97 MANOWNROLH REV H

INDICATIONS

This system has not been configured or labeled for medical device applications, and it has not been listed with the U.S. Food and Drug Administration. The use of this system in applications requiring the use of a registered medical device is a violation of federal law.

CONTRAINDICATIONS

There are no absolute contraindications to reverse osmosis water treatment.

CAUTIONS AND WARNINGS

Prior to operating or servicing this device, this manual must be read and understood. If something is not clear, call for assistance before proceeding. Keep this and other associated manuals for future reference and for new operators or qualified service personnel.

All electrical work should be performed by a qualified electrician in accordance with the latest edition of the National Electrical Code, as well as local codes and regulations.

To avoid electrical shock hazard, do not remove covers or panels when power is supplied to the device. Do not operate the device when covers or panels are removed.

WARNING **A faulty pump motor or wiring can be a serious shock hazard if it or surrounding water are accessible to human contact. To avoid this danger, DO NOT remove any grounding wire from the system.**

DISCLAIMER STATEMENT

This operation and maintenance manual is intended to be used with the supplier information provided in the Appendix. These manuals should provide complete and accurate information to meet your operating and/or service requirements based on the information available at the time of publication. However, U.S. Filter Corporation ("U.S. Filter") assumes no responsibility for the technical content of the supplier literature.

This manual should be read fully and understood before installation, operation or maintenance of the system is attempted. The information in this manual may not cover all operating details or variations or provide for all conditions in connection with installation, operation and maintenance. Should questions arise which are not answered specifically in this manual, contact the U.S. Filter, Technical Service Department at the phone number provided on the cover of this manual.

U.S. Filter reserves the right to make engineering refinements that may not be reflected in these manuals. The material in these manuals is for informational purposes and is subject to change without notice and should not be construed as a commitment by U.S. Filter. U.S. Filter assumes no responsibility for any errors that may appear in this document. This manual is believed to be complete and accurate at the time of publication. In no event shall U.S. Filter be liable for incidental or consequential damages in connection with or arising from the use of this manual.

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MANUAL USER'S GUIDE

This manual describes the procedures necessary to install, operate, and maintain your U.S. Filter liquid treatment system. Please read this manual carefully before installing and operating your equipment. The equipment warranty may be voided if installation or operation instructions are not followed correctly.

Warnings, Cautions, and Notes are used to attract attention to essential or critical information. Warnings and Cautions will appear before the text associated with them, and notes can appear either before or after associated text.

WARNING **Warnings indicate condition, practices, or procedures which must be observed to avoid personal injury or fatalities.**

CAUTION **Cautions indicate a situation that may cause damage or destruction of equipment or may pose a long term health hazard.**

NOTE: *Notes are used to add information, state exceptions, and point out areas that may be of greater interest or importance.*

EQUIPMENT SUPPORT

U.S. Filter continually strives to provide safe, efficient, trouble-free equipment using the optimum technology for your application. If problems should develop, U.S. Filter's worldwide network of technical support will be available to provide assistance. For service, sales, parts, or additional manual copies call your area representative or U.S. Filter, Technical Service Department at the number provided on the cover of this manual.

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1.0 INTRODUCTION

Congratulations on your selection of this U.S. Filter water purification system. This system is designed and manufactured to the highest standard of quality and fully tested and inspected by competent personnel. In order to get maximum performance, we ask you to read all of the following instructions *before* installing and operating this system. Any warranty offered will be void unless directions are followed exactly.

This manual is divided into sections for easy reference. Review this manual thoroughly and then return to section 2.0 for the step-by-step installation instructions.

If you need technical assistance in operating or maintaining your U.S. Filter unit please call your local U.S. Filter representative or should you require further assistance call U.S. Filter, Technical Service Department at the phone number on the cover of this manual.

1.1 SYSTEM FUNCTION

The function of a Reverse Osmosis (RO) system is to separate contaminants from a water supply by a RO membrane. The system produces purified water that is low in inorganic salts, organic matter and bacteria. The purified water can be used as a direct feed to a distribution system or stored in a reservoir.

RO systems operate on the principle of passing water through the membrane under high pressure. Most of the water passes through the membrane and is purified. A portion of the water containing the impurities is not passed through the membrane and is rejected to drain. Prefilters are used in many systems to reduce the amount of particulate contamination reaching the membrane thus insuring the membrane does not become clogged.

Please refer to general membrane specifications and System Specifications Sheet in the Appendix for other parameters important to the operation of the system.

1.2 QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance and Quality Control are words that mean many things to many people. All too often they are used as "catch" phrases that sound good but mean little. At U.S. Filter we have defined these phrases into a series of engineering and manufacturing practices and control procedures to insure that you, our customer, receive the finest product available in the world. We will continue to update these practices and procedures in an effort to improve our systems and to insure that they continue to reflect state-of-the-art technology and reliability.

Quality assurance is the cornerstone of our quality program. It begins with the selection and qualification of components and materials. Before vendors are selected, their products must meet or exceed rigid standards set by our Quality Assurance Department. From that point, our incoming material inspection insures only reliable components will be used to manufacture systems. Numerous checks are performed as the system passes through the manufacturing process. The completed system must pass a series of tests before release to insure the system meets technical and performance specifications.

Customer feedback is also an important element of our program. Division heads meet on a routine basis to review customer feedback and initiate actions that result in process and product improvements.

Quality audits do not improve products. They do, however, insure that a system meets or exceeds specifications required for your system.

In the Appendix is a copy of our Quality Control form for your system.

1.3 FUNCTIONS OF THE SYSTEM COMPONENTS

A. Reverse Osmosis Membranes

The prefiltered water enters the RO housing and passes over the surface of an RO membrane. A portion of the input water continues out of the system through a reject needle valve. The remainder of the water permeates the membrane and is directed to an accessory storage reservoir or point of use. Percent conversion (the ratio of RO product water to feedwater) will vary depending on water quality and the application. The reject needle valve and the pump throttle valve are adjusted to provide the proper permeate flux and transmembrane differential pressure. The permeate flux is also a function of temperature.

B. Reverse Osmosis Pump

The RO system contains a centrifugal pump driven by an AC motor. The pump motor is turned on and off by a motor starter relay and will not operate when the pump inlet pressure is less than .69 bar (10 psig). The pump motor starter also contains an overload relay.

C. Pressure Switch

If the pressure on the pump suction falls below .69 bar (10 psig) a pressure switch automatically shuts off the pump motor to prevent damage to pump. The low pressure switch will not be activated with momentary pressure drops of less than 3 seconds during normal system operation.

If the pump discharge pressure exceeds 20.7 bar (300 psi) a pressure switch automatically shuts off the pump motor to prevent damage to the pump.

If the system experiences a pressure switch shutdown the condition should be corrected. The system is manually restored to operation by pressing the reset button on the control panel.

D. Reject Recirculation (optional)

If the system is provided with the reject recirculation option, it permits part of the reject water to be returned to the inlet of the high pressure pump. This increases percent conversion of the system.

E. Auto Flush (optional)

A throttle valve restricts the flow of water through the reject line to maintain proper reject flow. In the "TANK FEED" and "STANDBY" modes, an optional solid state timer automatically opens the reject solenoid valve for one minute every hour, bypassing the throttle valve. The flush time is also programmable to 2 or 4 minutes if the water quality is poor and has a tendency to plug the membranes necessitating longer flush times. During this time, a high velocity flush of water sweeps through the matrix of the RO membrane to prevent the accumulation of scale (carbonate deposits) or other contaminants that tend to collect on the surface of RO membranes. A new flush cycle begins each time the system is turned on. The flush cycle is inhibited during the "DIRECT FEED"

mode. To prevent membrane degradation, the system will continue to flush during the "TANK FEED" mode and during "STANDBY" conditions.

F. Controller (optional)

The controller has the following capabilities:

1. Low pressure shutdown - when the inlet water pressure falls below 1.38 bar (20 psi). There is a 3 second delay to prevent shutdown during momentary pressure losses.

2. High pressure shutdown - to prevent damage to the pump or elements.

3. High temperature shutdown - to protect the RO membrane from exposure to damaging temperatures.

4. Low percent rejection alarm - to warn the operator if the product water quality has gone out of specification.

5. Pump startup delay - there is a ten second delay after turning on the unit before the pump starts.

6. Automatic flush - the system automatically flushes when the power is turned on, when the system is placed in "STANDBY", and every hour during continuous operation ("TANK FEED" mode).

7. Tank full shutdown - will put the system in "STANDBY" when a float switch in the RO water storage tank detects it is full (optional).

8. Interlock - can link the system with a water softener or other pre-treatment equipment to provide coordinated startup/shutdown/ regeneration cycles.

9. The inlet solenoid valve is opened automatically when the system is turned on and closed when the system is put in "STANDBY" or turned off (the valve delays 5 seconds after the pump stops before closing).

G. Accessories

The RO system can be used to feed a distribution loop, another piece of equipment directly, or an accessory reservoir. If an accessory reservoir is used, a level switch is necessary with the "TANK FEED" feature. This accessory is connected to the control box by wiring the electrical leads to the level switch connection after removing the shorting wire. Optional terminals (pretreatment interlock) have been placed in the control box for shutdown by external signals. Normal operation will resume automatically when the pretreatment regeneration is completed.

See the System Installation section of this manual for instructions on electrical connection of the accessories.

2.0 SYSTEM INSTALLATION

2.1 PRECAUTIONS BEFORE INSTALLATION

The following are input water source requirements:

A. Inlet pressure is .69 to 6.9 bar (10 to 100 psig) at design feed flow.

B. Temperature is between 2°C (35°F) and 45°C (113°F). Recommended operating temperature is 25°C (77°F).

C. Free chlorine concentration must be non-detectable on a continuous basis.

If the free chlorine level is detectable, a carbon filter or bisulfite system should be used as pretreatment to remove chlorine from the feed water entering the RO unit. Chlorine will cause irreversible damage to the membranes.

D. Langelier saturation index of the reject must be negative at the system's operating parameters to avoid fouling the membranes.

CAUTION **pH must be between 4 and 11. Chlorine must be non-detectable.**

NOTE: *If input water does not meet the above requirements or there is some doubt, contact your local U.S. Filter representative or U.S. Filter, Technical Service Department at the number provided on the cover of this manual for recommendations.*

2.2 UNPACKING

The U.S. Filter RO system is shipped completely assembled. Pressure switches, gauges, control box, pump, valves and regulators are all pre-mounted on the main frame and factory set to correct values. Carefully remove from the packing crate to avoid damage to gauges, RO membranes, etc. Do not drop or handle with excessive roughness to prevent damage to the electronic components and to prevent damage to the piping joints.

2.3 SYSTEM LOCATION

A drain, capable of handling the flow of reject water during system flushing, should be located as close to the system as possible. The reject line should be secured so that during the high velocity flush the line is not dislodged from the drain.

2.4 POWER REQUIREMENTS

The power requirements for the system are given on the system I.D. plate just below the controller panel. The system should be connected with a multiconductor, grounded cable to a disconnect switch box. The switch box should be located within approximately 10 feet of the system for the convenience of technicians servicing the unit.

The system is provided with a motor starter to permit coordinated over-current protection as defined by the National Electical Code.

Ground the power cable to the ground connection in the motor starter housing box.

Branch circuit conductors supplying the motor shall have an ampacity of not less than 125% of the motor full load current rating as defined by the National Electric Code.

2.5 WATER REQUIREMENTS

The inlet water supply must be adequate to provide the minimum flow requirement shown in the System Specifications in the Appendix. The inlet line should be sized to deliver this flow with a minimum pressure of .69 bar (10 psig) at the RO unit. A shut off valve within 10 feet of the unit and a cleaning connection should be provided. A sample valve to check feed water quality is also recommended.

2.6 PERMEATE LINE

The permeate line should have sufficient internal diameter to minimize line pressure drop. It is recommended that a small sample valve be placed in the product line to facilitate sampling of the permeate water quality. A flow meter is supplied with the unit to continuously measure the permeate flow rate.

2.7 RESERVOIR (OPTIONAL)

Since the RO system is designed to produce a constant supply of purified water, the RO membranes must be maintained in an operational state. To retain full effectiveness, a reservoir is usually required. The reservoir size is a function of spatial location in relation to system output. Reservoir size selection should be in accordance with this factor. Your local U.S. Filter representative can supply reservoirs of any desired capacity as an accessory to the basic RO system.

2.8 ACCESSORY SENSORS (PRETREATMENT INTERLOCK AND TANK LEVEL)

Provisions have been made for shutdown by accessory sensors, provided such sensors are equivalent to a single pole single throw switch. The shutdown is such that normal operation will resume automatically when the failure is removed.

A. Remove the cover from the back of the control box to expose the terminal connections.

B. See the Reverse Osmosis Controller, Operating Instructions in the Appendix to connect PRETREATMENT INTERLOCK, HIGH TANK LEVEL and MID TANK LEVEL sensors.

NOTE: *If only a high tank level switch is used, a switch should be selected with a built in “dead band” in order to prevent the RO pump from cycling. Using a switch without a “dead band” could cause the motor starter to fail and can contribute to low product water quality.*

C. Both the "Pretreatment Interlock" sensor and the “Tank Level” sensor are normally closed circuits.

D. To connect the accessory, remove the shorting wire and connect a single pole single throw normally closed switch between the respective terminals. It is recommended that shielded cable, properly grounded, be used to avoid radio signal interference with these functions.

2.9 BEFORE POWER TURN ON

The controller circuit board should be installed in the controller housing before connecting electrical power to the unit.

WARNING **Personal injury and permanent damage to the controller can result if the controller is installed with power on the unit.**

Once the inlet water is plumbed to the system and the electrical power is connected, the electrician should verify correct motor rotation. Please refer to the *Pump Information* included in the Appendix.

CAUTION **Verify that all retaining rings are in place on the RO membrane housings before turning on the pump.**

CAUTION **Be sure the product water will not enter the user system during start-up. The RO system must be operated for four hours to flush out the preservative solution before connecting to the user system.**

2.10 INSTALLATION OF REVERSE OSMOSIS MEMBRANE(S)

A. U.S. Filter RO units are normally shipped with the membranes installed and preserved in sodium bisulfite solution. However, should the need arise, the following procedure may be followed to install membranes.

B. See the Appendix for a diagram of the individual components of the membrane assembly. Before sliding the membranes into the fiberglass housing, lightly lubricate the chevron seal and o-rings with glycerin. Be careful not to damage the o-rings when inserting.

C. Load the RO membrane housings from the direction in which the feed will enter, inserting the end without an o-ring first. They should be removed from the opposite end.

WARNING **Never engage or disengage retaining rings without wearing safety glasses.**

D. Place an end cap into the RO housing end opposite from loading end. Hoses should be connected to end cap before insertion into the housing. Secure the end cap with the retaining ring. Snap ring pliers are very helpful for this operation.

E. Install the adapter and end plug on the feed end and secure it with a retaining ring.

CAUTION **Never allow the RO membrane to dry out once it has been wet, or irreversible damage will result.**

3.0 OPERATING INSTRUCTIONS

3.1 CONTROLS AND INDICATORS

The controls and indicators used in the operation of the system are outlined in the Appendix. The operator must be thoroughly familiar with the controls and their respective functions for proper operation and in order to maintain the quality of the permeate and eliminate unnecessary shutdowns.

3.2 INITIAL STARTUP OF REVERSE OSMOSIS SYSTEM

A. The operator should verify that appropriate pretreatment is in place and operating satisfactorily, otherwise the RO membranes will become fouled rapidly.

B. Make all water, electrical and drain connections according to installation instructions.

C. Be sure that the controller is turned off.

D. Turn on the inlet water and the electrical power at the remote disconnect. Direct product water to the sewer until proper operation of the system is verified and product quality is known to be within specifications.

CAUTION **Check to verify all RO housing retaining rings are in place and engaged.**

E. Close the reject recirculation valve.

F. Open the reject valve completely.

G. Open the pump throttle valve one (1) turn.

H. Turn the on/off switch to "ON".

I. Check to verify the pump motor is rotating in the proper direction. Please refer to the *Pump Information* in the Appendix for information concerning motor rotation and any other electrical connections.

CAUTION **Do not run the motor for more than 30 seconds backwards or irreversible pump damage may result.**

J. If your RO system is equipped with the Reject Recirculation Option, set the reject recirculation flow to zero, but DO NOT exceed pressure to membrane limits. Open the reject valve further if necessary to avoid over pressuring the system.

CAUTION **Do not use reject recirculation option for the first 24 hours of operation to avoid recirculating the preservative chemicals.**

K. Check for plumbing leaks and make appropriate repairs as necessary. All systems are leak checked at the factory but vibration during transit can cause new leaks to develop.

3.3 INITIAL FLUSHING OF THE SYSTEM

Since the RO membrane is shipped moist with sodium bisulfite preservative solution, initial flushing of the system is required. Before operating a new system, and also after a replacement of an RO membrane, perform the following steps:

A. Place the outlet of the permeate at a convenient drain.

B. Turn on the input water and the system pump (as outlined in Operating Instructions, Initial Startup of the Reverse Osmosis System section of this manual) and let the system run for 4 hours with the reject valve completely open. Adjust the pump discharge valve so that the membrane feed pressure is approximately 5.2 bar (75 psi). This will flush residual bisulfite solution and any particulate impurities from the membranes, housings and plumbing of the system.

C. Permeate quality will increase slowly for 1 hour. Monitor the inlet quality vs. the permeate quality.

NOTE: *The system should have better than 90% rejection within 2 hours as the membranes equilibrate. If the permeate quality does not improve, refer to the Troubleshooting section of this manual.*

D. After flushing, turn off the system and reconnect the permeate line. The system is now ready to be put into a normal operating mode.

3.4 NORMAL OPERATIONS

It is best to operate the RO system continuously to avoid membrane fouling; however, the automated controls provide periodic flushing of the system. Rather than produce water at a maximum capacity then shutdown the system, it would be better practice to balance the product water rate with demand. This is achieved by increasing or decreasing the membrane feed pressure with the pump discharge throttle valve.

A. Initiate operation by turning on/off switch to "ON".

B. After waiting for completion of the flush cycle, which is initiated each time the unit is put into operation, adjust the reject control valve and/or recirculation flows to give slightly more reject flow than the minimum indicated on the System Specifications sheet in the Appendix. This will assure that inorganic salts will be removed from the reject side of the membranes in concentrations low enough to avoid fouling.

C. If product water is set to slightly exceed demand the unit will automatically shut down when the product water storage tank is full.

D. Check the conductivity of the inlet and product water to verify the unit is operating properly.

E. Enter the operating data on the log sheet (sample in Appendix). Check the unit at least daily and follow the Maintenance Summary section, logging in the operating data as prescribed.

3.5 PROLONGED SHUTDOWN (GREATER THAN 4 DAYS)

When the system is going to be inactive for more than 4 days (not in a "STAND-BY" mode), perform the following steps:

A. Turn off the input water source.

Bisulfite Sanitization (4 days to 1 month shutdown)

Drain water from the system and pump in a 0.5% sodium bisulfite solution to prevent biological growth in the elements.

or

Formaldehyde Sanitization (shutdowns exceeding 1 month)

Drain water from the system and pump in a solution of 3% formaldehyde to prevent biological growth and kill residual bacteria.

B. Remove the prefilter cartridges and discard. Clean the prefilter housing, leaving the cleaned components to dry during the shutdown period.

C. Turn off the input water and electrical power until the system is to be placed into operation again.

D. To resume system operation, first drain the solution from the RO housings, install new prefilter cartridges, disconnect the permeate line from the reservoir and run to drain. Then turn on the input water and start the system, run the permeate water to drain for 4 hours to flush the system. The product water should be analyzed with the Fast Formalert or other formaldehyde test kit until detection limits are reached. Reattach the permeate line and start the system as outlined in the Operating Instructions, Normal Operations section of this manual.

4.0 SYSTEM MAINTENANCE

4.1 GENERAL

Routine customer maintenance procedures consists of periodic replacement of the RO membranes and the filter cartridges in the prefilter unit and sanitization of the RO membranes and the storage reservoir. Cleaning/sanitizing is recommended every four to eight weeks. The RO membranes should have a life of about 3 years if used properly. In addition, the system's external surface should be kept clean by occasionally wiping down all surfaces with a dust-free cloth and visually checking for cracked glass on gauges, loose fittings, and broken or missing hardware.

Whenever prefilters or RO membranes are replaced, inspect the serviceability of the o-ring seals prior to assembly. Inspect o-rings for signs of deterioration or cracking, and replace as required. It helps to lubricate o-rings with silicone grease before reassembly.

4.2 SANITIZING THE REVERSE OSMOSIS MEMBRANE(S)

Periodically, the RO Systems may require sanitization in order to maintain the performance of the RO membrane, and to ensure a low bacterial count in the product water. How frequently the system is sanitized depends on the quality of the water needed for your particular application. Monitor bacterial levels in the feed and permeates as needed. When bacterial levels increase above an acceptable level for the application, sanitize the system.

The choice of the sanitizing agent depends on its compatibility with the polyamide thin film composite RO cartridges and system components, and the agent's effectiveness as a sanitant. Three commonly used sanitants are formaldehyde, hydrogen peroxide and peracetic acid.

CAUTION **Chlorine is not compatible with thin film composite cartridges, and must not be used to sanitize them.**

A. Different Sanitizing Agents

CAUTION **When using formaldehyde to sanitize thin film composite cartridges, the cartridges must have been in use for 24 hours prior to sanitization, or a severe loss in flow rate may occur.**

1. Formaldehyde

Formaldehyde is one of the most effective agents used for sanitization. It is compatible with most materials, is highly active as a biocide over a relatively wide pH range, and easily penetrates the RO membrane, thus ensuring that the downstream side of the filter is sanitized. But, formaldehyde is difficult to flush from the system after sanitization, has an objectionable odor, and causes irritation to the eyes and nasal passages. In addition, formaldehyde is a suspected carcinogen. Even so, formaldehyde is commonly used for sanitizing RO cartridges. Formaldehyde, in solution, is purchased as formalin, which is a 37% solution of the formaldehyde gas stabilized with methanol.

2. Hydrogen Peroxide

Advantages of using hydrogen peroxide are that it has no toxic vapors, is biodegradable, is easily disposable, has good biocidal activity, and breaks down into oxygen and water, which does not harm the environment. Because of these qualities, operators can be assured that they are not handling toxic materials.

3. Peracetic Acid

Advantages of using peracetic acid are that it has no toxic vapors, is biodegradable, easily disposable, and has good biocidal activity. Because of these qualities, operators can be assured that they are not handling toxic materials. Peracetic acid decomposes into oxygen, water, and acetic acid, which does not harm the environment. Several peracetic acid solutions are commercially available, including; Minncare and Renalin Dialyzer Reprocessing Concentrate, both products of Minntech Corporation, and P3-Oxonia Active, a product of Henkel Corporation. For ordering information call the number provided on the cover of this manual.

B. Selecting a Sanitant

Table 4-1 lists the type and concentration of sanitizing agent that should be used for polyamide thin film composite cartridges, as well as the minimum contact time for sanitization.

Sanitant	Sanitant Concentration	Sanitant Contact Time
Formaldehyde *	2-3%	30-60 minutes
Hydrogen Peroxide **	up to 2000 ppm (0.2%)	30-60 minutes
Peracetic Acid **	up to 2000 ppm (0.2%)	30-60 minutes

Table 4-1: Sanitization Times and Concentrations for Polyamide Thin Film Composite Cartridges.

* When using formaldehyde to sanitize thin film composite cartridges, the cartridges must have been in use for 24 hours prior to sanitization.

** When using hydrogen peroxide or peracetic acid with thin film composite membranes, the temperature should not exceed 25° C (77° F). Also, the presence of iron or heavy metals can cause membrane degradation. Clean the membranes first if iron is present in the feed water.

C. Testing for Residual Sanitant

After flushing the sanitant from the RO system, the permeate water should be checked for residual levels of sanitizing agent before the system is placed back

on line. Use the following guidelines to determine if the system is clear of residual sanitizing agents.

1. Formaldehyde

The product water should be analyzed with the Fast Formalert or other formaldehyde test kit until detection limits are reached.

2. Hydrogen Peroxide

The product water should be analyzed with a hydrogen peroxide test kit.

3. Peracetic Acid

The product water should be analyzed with the Minncare Residual Test Strip or other peracetic acid test kit. For ordering information call the number provided on the cover of this manual.

D. Methods of Sanitization

Sanitization is most effective when the RO system is operating at normal pressure and flows. This allows the maximum amount of sanitant to penetrate through the membrane, ensuring adequate sanitization of the product side of the system. Three methods of sanitization may be used: Continuous Injection, Recirculation and Static Soak.

1. Continuous Injection Method

In this method of sanitization, an accessory chemical feed system injects concentrated sanitant into the feed line while the RO is operating at normal flows and pressure. Both the product and reject streams are sent directly to drain.

The continuous injection method is most typically used to sanitize with hydrogen peroxide. It is not practical for formaldehyde sanitization because the dilution ratio used for formaldehyde (1:10 to 1:20) would require the use of a very large chemical feed pump. The advantages of the continuous injection method are minimal chemical handling and minimal dead legs in the system piping. One disadvantage is the relatively high chemical consumption.

The basic steps for continuous injection sanitization are as follows:

a. Reject and product lines from the RO are diverted to drain.

b. The system is placed in the normal operating mode.

c. An accessory chemical feed system is turned on to inject concentrated sanitant into the feed water. The sanitant is diluted by the feed water to the recommended concentration.

d. The system is left running in the normal operating mode for 30 to 60 minutes.

e. The chemical feed pump and the RO system are shut down, and the sanitant solution is allowed to sit in the system (optional).

f. The RO is run in the normal operating mode with the product diverted to drain until all residual sanitization chemical is flushed from the system.

2. Recirculation Method

This method requires an accessory tank and booster pump. A sanitant solution is prepared in the tank and fed to the RO system via the booster pump. The product and reject streams are diverted to the tank and the sanitant is recirculated through the system for a period of time.

The advantages of the recirculation method of sanitization are minimal usage of chemical, and ease in obtaining the proper sanitant concentration. In addition, the accessory tank and booster pump may also be used for system cleaning.

The following steps provide a general guideline for the recirculation method of sanitization.

a. A batch of sanitant, typically 40 to 100 gallons (160 to 400 liters), is prepared in the tank by diluting sanitization chemical with water.

b. The product and reject lines are diverted to the tank.

c. The feed to the RO is connected to the outlet of a booster pump, which pumps sanitant out of the tank.

d. The booster pump is turned on and the RO is run in the normal operating mode for 30 to 60 minutes.

CAUTION **Monitor the solution temperature during recirculation. Do not allow the temperature to exceed 25° C.**

e. The booster pump and the RO system are shut down and the sanitant is allowed to sit in the system (optional).

f. The RO is switched back to the normal feed source and run in the normal operating mode with the product diverted to drain until all residual sanitization chemical is flushed from the system.

g. The tank and booster pump are drained and flushed with clean water.

3. Static Soak Method

This sanitization method may be used in combination with either recirculation or continuous injection sanitization for heavily bio-fouled systems. In this method, sanitant is introduced into the system and then the system is shut down. The membranes are allowed to soak in the sanitant solution for a period of time ranging from as little as 30 minutes up to several days (check with U.S. Filter, Technical Service Department at the number provided on the cover of this manual for recommended maximum soak time).

Occasionally a system must be sanitized without a chemical feed system or an accessory tank and booster pump. In this case it is possible to perform a static soak sanitization by placing concentrated sanitant in the RO system prefilter housing, or by manually injecting it into the feed line. The RO pump is then turned on briefly to flush the sanitant into the system. The system is then shut down so that the cartridges may soak in the sanitant solution. The drawback of this method of introducing sanitant is the sanitization chemical is not evenly distributed throughout the RO

system. Localized areas of high sanitant concentration could degrade the RO membranes. Also, the length of time that the RO pump is turned on will be different with each model of RO system and the means used to introduce the sanitant.

CAUTION **Do not use the static soak method of sanitization with any chemical other than formaldehyde.**

E. Cleaning the System

When the RO systems are properly operated, they do not require frequent cleaning. In time, however, the RO membrane cartridges can become fouled to a point where system performance is adversely affected, resulting in diminished product output or salt rejection. When the product flow rate drops by 10% and/or the salt content in the product water rises noticeable, this may indicate fouling of the cartridge membrane. However, other factors such as temperature decreases, or malfunctioning pretreatment systems, pressure controls and pumps may also cause these conditions. It is important to rule out these factors before cleaning the system.

Clean the cartridges if the system performance (based on flow rate or salt rejection) decreases because of membrane fouling. An increase in the feed to reject differential pressure also indicates that cleaning is needed. Membrane foulants include colloidal materials such as aluminum and silica compounds, precipitated metal hydroxides of iron and manganese, biological films, and calcium or magnesium carbonate scale.

The type of cleaning solutions (See Table 4-2), and the sequence in which they are used, depends on the type of foulant present (organic compounds, metal hydroxides, Ca/Mg carbonates, etc.). The need for frequent cleaning (twice a week or more), may indicate that pretreatment is inadequate. This section includes general guidelines for developing a cleaning procedure for your particular application.

F. Effects of Foulants on RO System Performance

1. Colloidal fouling

Causes product flow rate to decrease, and salt passage to increase, usually in that order. RO systems that operate on high SDI feed water are prone to colloidal fouling.

2. Metal hydroxide (iron, manganese)

Causes a significant and rapid decrease in the product flow rate, and an increase in salt passage.

3. Biological fouling

Causes a biofilm to form on the membrane surface. This biofilm inhibits the membrane's ability to reject salt, and therefore salt passage increases. The product flow rate may also decrease, but not necessarily at a rapid rate.

4. Scaling

Causes a decrease in the product flow rate and an increase in salt passage.

G. Factors to Consider when Cleaning RO Cartridge

1. Use RO product water for cleaning and rinse solutions.

Use RO product water to prepare cleaning solutions, and as flush water between each cleaning step. If RO product water is not available, use softened filtered tap water. Completely flush the system between applications of different cleaning solutions.

2. Increase flow rates and decrease pressure.

During cleaning, reject flow rates should be as high as possible without exceeding the maximum design flow of the system. The reject regulating valves should be fully opened to minimize transmembrane pressure. Transmembrane flow keeps foulants within, or on the membrane surface during cleaning. Optimally, a high flow, low pressure accessory cleaning pump should be used.

3. The temperature must not exceed 35° C.

The temperature of the cleaning solution must not exceed 35° C. It may be necessary to install a heat exchanger to prevent the temperature from exceeding 35° C. The optimum temperature of the cleaning solution is 25° C to 30° C. Cold water reduces the effectiveness of the cleaning solution.

H. Choosing the Correct Cleaning Method

1. Recirculation Method (try this first)

This is the cleaning method of choice. Recirculate each cleaning solution through the RO system for 45 to 90 minutes. Recirculation cleaning requires an accessory recirculation tank and pump. The system is fed from the tank, and the reject and product lines are diverted to the tank. The RO system should be placed in the manual flush mode during recirculation with the inlet pneumatic valve and accessory motorized 3-way valve open, and the RO pump off.

CAUTION **If the system temperature approaches the maximum recommended operation temperature during recirculation, shut down the system and allow it to cool off before continuing the recirculation.**

If the cleaning solution becomes highly discolored during recirculation, discard it and repeat the application. If any cleaning solution becomes highly discolored during the first application, the soak and flush method may be more applicable.

2. Soak and Flush Method

Pump the cleaning solution into the RO system, soak the cartridges for 15 to 60 minutes, then flush the unit to drain. Flush the system until the cleaning solution exiting the system is clear, or nearly clear. Repeat soak and flush cycles until discolored solution is no longer being flushed from the system. Use this method when the recirculation method is not effective.

3. Flush Residual Cleaning Agents Using Reduced Pressure

Flush the cleaning chemical from the system, starting with a 10 to 15 minute manual flush cycle. Then place the system in the operate mode, and for the first ten minutes, reduce the feed pressure to approximately half of the normal operating pressure by opening the reject throttle valve. This prevents residual foulants from being impacted into the membrane. After ten minutes, return the system to normal operating pressure, and continue flushing until the product water is clear of all residual cleaning agents.

I. Testing for Residual Cleaning Agents After Flushing

Use the following guidelines to determine if the system is clear of residual cleaning agents.

1. Acids and Bases

The pH of the product water would be equal to, or nearly equal to, the pH of the feed water.

2. Sodium Bisulfite

The conductivity of the product should be equal to, or less than, the conductivity of the product before cleaning.

3. EDTA/Na-EDTA

The conductivity of the product should be equal to, or less than, the conductivity of the product water before cleaning. If the guidelines for residual EDTA in the product water are more stringent, use the Hach Model ED-3 EDTA test kit. For ordering information call the number provided on the cover of this manual.

Table 4-2: Cleaning Solutions for Polyamide Thin Film Composite Membranes.

	Metal Oxides (Fe, Mn)	Inorganic Salts ($CaCO_3$)	Silica	Biofilms	Organics

HCl, pH 2-2.5	x	x		x	x
Citric acid, 1% pH 4 (adjust with NaOH)	x	x			
Oxalic acid, 1%	x				
Citric Acid 2% Ammonium Bifluoride, 2% pH 2, 30° C. maximum			x		
NaOH, pH 12				x	x
Sodium Bisulfite*, 1%, pH6	x				
NaEDTA 0.1% pH6	x	x			
NaEDTA 0.1% NaOH 0.1% pH 12, 30° C. max.			x	x	x
NaOH, 0.1% Sodium Dodecylsulfate, 0.1% pH 12, 30° C. max.				x	x
Sodium Triphosphate, 1.0% Trisodiumphosphate, 1.0% Na-EDTA, 1.0%				x	x
Phosphoric Acid, 0.5%	x	x			
Sulfamic Acid, 0.2%	x	x			
Sodium Hydrosulfite, 2.4%	x				

* Prepare sodium bisulfite using a buffered solution of 0.1% $Na2CO_3$ or 0.15% $NaHCO_3$

J. Preparing the Cleaning Solutions

Use the following procedures to make 10 liters (L) of solution. For larger volumes, increase chemical amounts accordingly. The total volume of cleaning solution depends on the system size. A minimum of 100 liters is recommended.

WARNING **Use caution when preparing these solutions. Wear safety glasses, gloves, and a protective apron. Consult the appropriate Material Safety Data Sheets (MSDS) before working with any chemicals.**

1. 1% Oxalic Acid, pH 2-4

Add 100g anhydrous oxalic to 8.8L RO water in your cleaning tank. To adjust the pH to 3.0, add 1.2L of 1.0N NaOH.

2. 2% Citric Acid, pH 3-5

Add 200g of anhydrous citric acid to 9L RO water.

3. 1% Sodium Bisulfite, pH 5-6

Add 15g of sodium bicarbonate ($NaHCO_3$) or 10g of sodium carbonate ($Na2CO_3$) to 10L of RO water. Add 100g anhydrous sodium bisulfite ($NaHSO_3$). The pH of the solution is approximately 5. Adding sodium bicarbonate or sodium carbonate before the sodium bisulfite, adjusts the pH and minimizes sulfur dioxide gas liberation.

4. 0.1% EDTA/Na-EDTA, pH6

(EDTA is ethylene, diamine, tetra acetic acid.) Add 10g of Na-EDTA to 10L RO water. Add 10g EDTA. pH is approximately 6.

5. Hydrochloric Acid, pH2

Add 0.5L of 1.0N HCl to 9.5L RO water. This amount of HCl will vary, depending on the buffering capacity of the makeup water. Check the addition of acid with a pH meter.

6. Sodium Hydroxide, pH12

The amount of NaOH needed will vary, depending on the makeup water quality. If solid NaOH pellets are available, add 4.0-40g to 10L of RO water. Check the addition of caustic with a pH meter. If 50% NaOH is used, start with 5ml per 10 liters, and add until a pH of 12 is reached.

K. Shutdown Procedures

1. Short-Term Shutdown (Less than 48 hours)

The RO systems may be shut down for up to 48 hours with no adverse effects to the system or cartridges. No special re-startup procedures are required.

2. Long-Term Shutdown (Greater then 48 hours)

If the RO system is shut down for longer than 48 hours, fill the system and cartridges with a sanitizing solution to prevent the growth of bacteria and to help maintain proper flow rate. The following table lists the recommended concentrations of storage solutions of the RO cartridges.

Storage Solution	Concentration
Aqueous solution of glycerin (by weight) or propylene glycol mixed with sodium bisulfite (by weight).	20% glycerin or propylene glycol, 1% sodium bisulfite
Formalin (see caution below)	1% Formaldehyde
Sodium Bisulfite	1% Sodium Bisulfite

Table 4-3: Storage Solutions for Polyamide Thin Film Composite Cartridges.

CAUTION **New thin film composite cartridge MUST be operated for a minimum of 24 hours before contact with formalin, or a permanent reduction in flow rate may occur.**

4.3 SANITIZING A STORAGE RESERVOIR

A storage reservoir can easily become contaminated with bacteria, and if this is critical to the end use of the water, it should be regularly monitored using a sampling device.

If a storage reservoir is contaminated with bacteria, first clean all inner surfaces with a sponge and drain off all contained water. Add enough sodium hypochlorite solution (ordinary liquid bleach) to make a dilution of 1 to 1,000 (hypochlorite solution to reservoir capacity). Allow the RO system to refill the reservoir, then drain the reservoir again completely. Thereafter, processed water collected in the reservoir will be uncontaminated and of laboratory grade quality.

4.4 MAINTENANCE SUMMARY LOG

(See the Reverse Osmosis System Maintenance Log in the Appendix.)

A. Input Water

1. Check pressure daily; record weekly. Adjust as necessary to maintain .69 to 6.9 bar (10 to 100 psig).

2. Monitor feed and permeate conductivity and record weekly.

3. If there is a possibility of the presence of chlorine in the feed water, measure free chlorine weekly. (It must be non-detectable or the membranes may be damaged).

4. If there is a possibility of significant pH variations (i.e. the feed is pH controlled) monitor and record pH weekly by independent pH meter or litmus paper.

5. Measure total calcium monthly.

B. Coarse Prefilter (If Applicable)

1. Measure differential pressure daily; record weekly.

2. Change prefilter when the differential pressure is greater than .69 bar (10 psig) or every 6 months, whichever occurs sooner.

C. Prefilter

1. Measure differential pressure daily; record weekly.

2. Change prefilter when the differential pressure is greater than .69 bar (10 psig) or every month, whichever occurs sooner.

3. Inlet pressure regulator screen should be cleaned once a month.

D. Pump

1. Check pressures daily; record weekly.

2. If the pressures have fallen off, check product and reject flows.

E. Conductivity

1. Observe input and permeate conductivity daily; and record weekly.

2. Record percent salt rejection weekly.

F. Flow Rates

1. Check daily and record permeate and reject flow rate weekly.

2. Calculate the percent recovery using the following formula:

$$100 \times \frac{\text{Permeate Flow Rate}}{\text{Permeate Flow Rate and Reject Flow Rate}} = \%\ \text{Recovery}$$

The percent recovery should not exceed the design value shown on the System Specifications sheet in the Appendix. If minimizing water usage is critical, the percent recovery should be maintained near, but not above the maximum value. Operating with too high a percent recovery will lead to premature fouling of the membrane.

G. Calcium

Measure the input and permeate calcium and calculate the percent rejection using the following formula:

$$100 \times \frac{\text{Calcium Inlet - Calcium Permeate}}{\text{Calcium Inlet}} = \%\ \text{Ca Rejection}$$

H. Bacteria

1. For critical applications, such as dialysis and pharmaceuticals, measure the number of bacteria in the permeate line and the reservoir weekly. Record the results as colony forming units per milliliter (CFU/ml). Sanitize as necessary.

2. For non-critical applications, measure the number of bacteria in the reservoir monthly. Record the results as colony forming units per milliliter (CFU/ml). Sanitize as necessary.

I. If the maintenance log shows steady deterioration in results (product flow, percent rejection, etc.) corrective action should be taken (described in 5.0 Troubleshooting).

5.0 TROUBLESHOOTING

5.1 SYSTEM INOPERATIVE

A. Check to see if power is available to the unit and turned on.

B. Check to see that the motor starter relay is engaging, and if the control lights come on but the pump does not start. With an ohm meter, check to see if the motor starter coil is burned out.

C. With a voltmeter check that power is being supplied to the motor. If proper voltage is going to the motor but it does not run, replace the motor.

D. Check for proper function of the controller circuit board. Replace if necessary.

5.2 LOW SYSTEM PRESSURE

A. Verify the pump is running and the system is not in the flush mode.

B. If pressure is low at system startup, stop system immediately and verify pump rotation is clockwise.

CAUTION **Do not run pump backwards for more than 30 seconds or irreversible damage will result.**

C. Check to verify that the reject, reject recirculation, and product flows are normal. If not, adjust to design flow rates using the System Specifications sheet in the Appendix.

D. If the flows cannot be adjusted to the desired flow rates, slowly close the pump discharge throttle valve to observe the maximum discharge pressure. Do this only briefly and do not completely close the valve. The pressure should be greater than 17.2 bar (250 psig).

E. If pump pressure is okay, check prefilters for plugging/high differential pressure.

F. If the pump pressure is too low, repair or replace the pump. Check the pump/motor coupling to be sure it is not slipping on the pump or the motor shaft.

5.3 LOW PERCENT RECOVERY

A. Check reject flows and pressures to be sure they are normal.

B. If feed to membrane pressure equals system maximum and the permeate flow is low, the RO membranes are beginning to fail. They should be cleaned or replaced.

5.4 HIGH PERCENT RECOVERY

A. Check pressures and flows.

B. Set the membrane feed pressure to 13.8 bar (200 psig).

C. If the permeate flow is high after adjusting the pressures and flows, the RO membranes o-rings may be leaking. Check percent rejection and/or calcium rejection.

5.5 LOW SALT REJECTION

A. Check flows per the System Specifications sheet in the Appendix, and adjust if necessary.

B. Another possibility is high CO_2 content in the inlet water. CO_2 readily permeates the membrane. High CO_2 content water will also have a pH of less than 6.0.

C. Low temperatures can affect percent rejection.

D. RO membrane o-rings may not be seated correctly, so remove membrane and verify o-rings are seated correctly.

E. If the above possibilities are eliminated, RO membrane is beginning to fail. It should be cleaned or replaced.

5.6 LOW CALCIUM REJECTION

A. Check flows per the System Specifications sheet in the Appendix and adjust if necessary.

B. Low temperature can also affect the calcium rejection.

C. RO membrane o-rings may not be seated correctly, so remove membrane and verify o-rings are in good condition and seated correctly.

D. If the above possibilities are eliminated, the RO membrane is beginning to fail. It should be cleaned or replaced.

5.7 SYSTEM KEEPS SHUTTING OFF

A. Observe the control box lights to see if they indicate the cause for system shutdown.

B. If the pump keeps shutting off and starting by itself, this means the thermal overload in the motor starter is being activated. This could be due to a damaged pump or severe over pressure.

C. If an optional sensor is being used (Tank Level, Pretreatment Interlock), check to verify the sensor is not shutting off the system.

D. If the controller itself is malfunctioning, replace the controller.

5.8 SYSTEM SHUT OFF, LOW PRESSURE

A. Check the differential pressure across sediment prefilters. It should be less than 1.38 bar (20 psig).

B. Check the pump suction pressure. It should be greater than .69 bar (10 psig).

C. Verify the low pressure switch is operating properly.

5.9 LOW PERMEATE FLOW RATE

A. Adjust the pump throttle valve to increase membrane feed pressure. Do not exceed 22.4 bar (325 psig).

B. Permeate piping should be of sufficient I.D. to prevent back pressure on the system.

C. For low temperature effects, check permeate flow rate versus temperature curve in the Appendix.

D. If adjusting pump throttling valve does not improve permeate flow rate, the RO membranes are fouled and should be cleaned with an appropriate medium. Depending on the type of fouling suspected, various regeneration/cleaning solutions may be used. Consult your local U.S. Filter representative or should you require further assistance call U.S. Filter, Technical Service Department at the number provided on the cover of this manual.

CAUTION **Certain solutions, especially those containing chlorine or bromine, can permanently damage the membranes.**

5.10 MOTOR OVERLOAD SHUTDOWN

A. Motor overload shutdown is caused by excessive amp draws. An overload relay is provided with the motor magnetic starter to shut the system down if it runs above the service factor amp rating of the motor.

(Service Factor Amp = Full Load Amps X Service Factor)

B. Check flows per the System Specifications sheet in the Appendix, and adjust if necessary. Running pump beyond rated flows can cause excessive amp draw.

C. Pump end may be damaged or binding.

5.11 CONTROLLER MALFUNCTION

The control box may be changed out in its entirety if necessary.

6.0 WARRANTY

6.1 GENERAL LIMITED WARRANTY

United States Filter Corporation ("USF") warrants the products manufactured by it against defects in materials and workmanship when used in accordance with the applicable instructions for a period of one year from the date of shipment of the products. USF MAKES NO OTHER WARRANTY, EXPRESSED OR IMPLIED. THERE IS NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. The warranty provided herein and the data, specifications and descriptions of USF products appearing in USF's published catalogs and product literature may not be altered except by express written agreement signed by an officer of USF. Representations, oral or written, which are inconsistent with this warranty or such publications are not authorized and if given, should not be relied upon.

In the event of a breach of the foregoing warranty, USF's sole obligation shall be to repair or replace, at its option, any product or part thereof that proves defective in materials or workmanship within the warranty period, provided the customer notifies USF promptly of any such defect. The exclusive remedy provided herein shall not be deemed to have failed of its essential purpose so long as USF is willing and able to repair or replace any nonconforming USF product or part. USF shall not be liable for consequential damages resulting from economic loss or property damages sustained by a customer from the use of its products.

6.2 WATER SYSTEM LIMITED WARRANTY

United States Filter Corporation ("USF") warrants the water systems manufactured by it, BUT EXCLUDING MEMBRANES AND CARTRIDGES, against defects in materials and workmanship when used in accordance with the applicable instructions and within the operating conditions specified for the systems for a period of one year from the earlier of: (i) the date of installation; or (ii) 120 days following the date of shipment. USF MAKES NO OTHER WARRANTY, EXPRESSED OR IMPLIED. THERE IS NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. The warranty provided herein and the data, specifications and descriptions of USF systems appearing in USF's published catalogs and product literature may not be altered except by express written agreement signed by an officer of USF. Representations, oral or written, which are inconsistent with this warranty or such publications are not authorized and if given, should not be relied upon.

In the event of a breach of the foregoing warranty, USF's sole obligation shall be to repair or replace, at its option, any product or part thereof that proves defective in materials or workmanship within the warranty period, provided the customer notifies USF promptly of any such defect. The cost of labor for the first ninety (90) days of the above warranty period is included in the warranty; thereafter, labor costs shall be at the customer's expense. The exclusive remedy provided herein shall not be

deemed to have failed of its essential purpose so long as USF is willing and able to repair or replace any nonconforming USF system or component part thereof. USF shall not be liable for consequential damages resulting from economic loss or property damages sustained by any customer from the use of its process systems.

Products or components manufactured by companies other than USF or its affiliates ("Non-USF Products") are covered by the Warranty, if any, extended by the Product manufacturer. USF hereby assigns to the purchaser any such warranty: however, USF EXPRESSLY DISCLAIMS ANY WARRANTY, WHETHER EXPRESSED OR IMPLIED, THAT THE NON-USF PRODUCTS ARE MERCHANTABLE OR FIT FOR A PARTICULAR PURPOSE.

7.0 APPENDIX

GLOSSARY OF TERMS

The terms commonly used in reverse osmosis are defined below:

ANION - Negatively charged ion, such as CO_3^{--}, SO_4^{--}, HCO_3^{--}, Cl^-, NO_3^-, etc.

CATION - Positively charged ion, such as Ca^{++}, Mg^{++}, Fe^{++}, Na^+, K^+, etc.

CONCENTRATE (**REJECT**) - Concentrated portion of the feed remaining outside the membrane which is discarded.

CONDUCTIVITY - A measure of salt concentration due to the ability of dissolved solids (ions) to conduct electricity, usually expressed as micromhos/cm.

CONVERSION - Percent of feedwater converted into permeate.

FEED - The feedwater pumped into a permeator under high pressure.

OSMOSIS - Osmosis is the diffusion of a solvent (such as pure water) from a dilute saline solution into a more concentrated saline solution through a semipermeable membrane separating the two solutions.

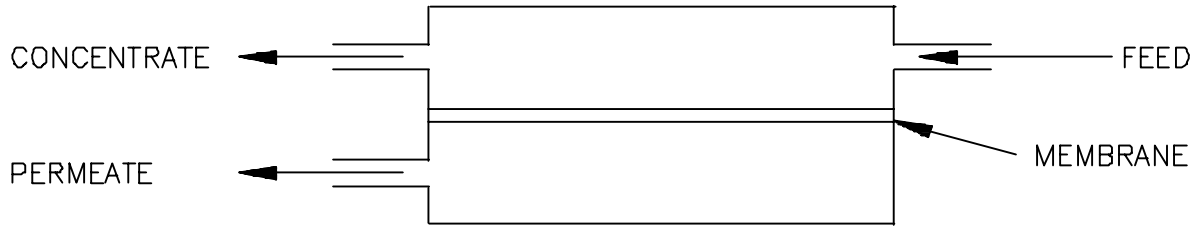
OSMOTIC EQUALIZATION - Osmotic equalization is reached when no further water transport takes place due to equalization of the solute concentration on both sides of the membrane.

OSMOTIC HEAD - Osmotic head (pressure) is the change in head resulting from water transport through the semipermeable membrane separating two saline solutions of different concentrations.

PASSAGE - Ratio of permeate to feed concentration of a particular dissolved material, expressed in percent.

PERMEATE (PRODUCT) - The purified portion of the feed passing through the membrane.

REVERSE OSMOSIS (RO) - The process by which incoming fluid (feed) is forced under high pressure through a reverse osmosis membrane. A portion of the fluid with concentrated ionic materials (concentrate) remains upstream of the membrane and is discarded (unless it is of interest in a particular application). The highly purified portion (permeate) which passed through the membrane would then be collected for use (as in a water purification application).



REVERSE OSMOSIS (RO) MEMBRANE - An RO membrane is a semipermeable membrane generally in sheet or hollow fiber form which rejects not only dissolved materials, but also organics, submicron size colloidal materials and bacteria which may contaminate a high purity water system. The process is not absolute and therefore most reverse osmosis membranes are defined by their rejection characteristics.

SOLUTE - Material (salts) dissolved by solvent (water).

TOTAL DISSOLVED SOLIDS - Total dissolved inorganic salts present in the permeator streams.