

# MANUAL FOR OPERATION & MAINTENANCE OF XL SERIES REVERSE OSMOSIS SYSTEMS



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**MEMBRANES INC.®**  
*Industry Leader in RO Expertise and Membrane Applications Since 1983™*  
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## DESIGN BASIS & SYSTEM DESIGN SPECIFICATIONS

Model	Design Conditions					Limits*		Line Sizes (Inches)			Pump model and HP			
	Permeate Flow		Conc. Flow to Drain (GPM)	Design Recycle Flow (GMP)	Design Recovery (%)	Max. Recovery*	Max. Recycle Flow* (GPM)	Inlet	Perm.	Conc.	Design Pump Flow (GPM)	Pump/Motor Model No.	Motor HP	Full Load Amps (FLA) @ indicated voltage
XL-14A-216	2,000	1.39	3.5	5.1	40	50	5.8	0.75	0.5	0.5	10	HPS10E-01MS3	1 HP	8.5 – 10.4
XL-14A-215	2,000	1.39	3.5	5.1	40	50	5.8	0.75	0.5	0.5	10	HPS10G-01MS2	2 HP	8.5 – 10.4
XL-24A-216	4,000	2.78	4.2	3.0	40	50	4.4	0.75	0.5	0.5	10	HPS10E-01MS3	1 HP	8.5 – 10.4
XL-24A-215	4,000	2.78	4.2	3.0	40	50	4.4	0.75	0.5	0.5	10	HPS10G-01MS2	2 HP	8.5 – 10.4
XL-34A-216	5,800	4.00	4.0	2.0	50	60	3.3	0.75	0.5	0.5	10	HPS10E-01MS3	1 HP	8.5 – 10.4
XL-34A-215	5,800	4.00	4.0	2.0	50	60	3.3	0.75	0.5	0.5	10	HPS10G-01MS2	2 HP	8.5 – 10.4
XL-44A-216	7,500	5.20	3.5	1.3	60	75	3.0	0.75	0.5	0.5	10	HPS10E-01MS3	1 HP	8.5 – 10.4
XL-44A-215	7,500	5.20	3.5	1.3	60	75	3.0	0.75	0.5	0.5	10	HPS10G-01MS2	2 HP	8.5 – 10.4
XL-54A-216	9,000	6.25	3.8	0.0	60	75	1.7	0.75	0.5	0.5	10	HPS10E-01MS3	1 HP	8.5 – 10.4
XL-54A-215	9,000	6.25	3.8	0.0	60	75	1.7	0.75	0.5	0.5	10	HPS10G-01MS2	2 HP	8.5 – 10.4
XL-64A-216	10,000	6.90	3.1	0.0	60	75	1.8	0.75	0.5	0.5	10	HPS10E-01MS3	1 HP	8.5 – 10.4
XL-64A-215	10,000	6.90	3.1	0.0	60	75	1.8	0.75	0.5	0.5	10	HPS10G-01MS2	2 HP	8.5 – 10.4

\*Water must be softened or have antiscalant injection. Check with factory to make sure this recovery will not cause any scaling problems with your feedwater.

- Membranes are model no. M-T4040AXLE. Membrane Housings model no. PV4040SSAW-316
- All models have the membrane array designed in series.

### DESIGN BASIS

- Systems rated at: 77°F (25°C) using 500 PPM sodium chloride solution operating at 140 psi (10 kg/cm<sup>2</sup>) pressure. System capacity changes significantly with water temperature. For higher TDS a water analysis must be supplied and could result in modifications to the system.
- Minimum feed pressure to RO System: 40 PSI.
- Chlorine must be removed if present in feed water prior to RO with a carbon filter or with chemical injection.
- Water must be pretreated with a softener or antiscalant injection to avoid scaling the membranes.
- Feed water turbidity: Less than 1 NTU; Feed water silt density index (SDI): 3 maximum. If exceeded, pretreatment with media filter recommended. All pretreatment equipment and SDI test kits are available from Applied Membranes.
- Capacity Basis: 24 hrs/day

### DESIGN NOTES

1. **Pump flow/Feed flow:** The pump has been designed to include recycle flow (if any) coming back to the pump inlet from the concentrate stream based on desired recovery. The sum of permeate flow, concentrate flow and recycle flow (if any) will equal the pump design flow.
2. **Permeate flow:** Indicates design flow rate from RO membranes as product water for use.
3. **Concentrate flow:** Water flowing to the drain. Concentrate flow is critical for proper system operation. For proper concentrate flows, refer to the system design information above.
4. **Recycle flow:** Flow stream that returns from the concentrate line back to the pump intake, rather than to the drain.

**⚠ Note:** Permeate flow should not exceed recommended flow.

**⚠ Note:** System pressure is a variable. It is important to adjust the pressure to get the correct permeate and concentrate flows. The exact value of the pressure is not important.

**⚠ Note:** Permeate flow will increase at higher temperature.

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## GENERAL INFORMATION AND SAFETY

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### **DISCLAIMER:**

The information contained in this document is subject to change without notice.

Applied Membranes, Inc. shall not be liable for technical or editorial omissions made herein; nor for incidental or consequential damages resulting from the furnishing, performance, or use of this material.

### **READ THIS MANUAL:**

Prior to operating or servicing this unit, this manual must be read and understood. If anything 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.

### **⚠ USE PROPER POWER CONNECTIONS:**

Use proper wiring and connection methods to satisfy local electrical codes. **SHOCK HAZARD:** Connect this unit to a properly grounded connection in accordance with the National Electrical Code. **DO NOT**, under any circumstances, remove the ground wire or ground prong from any power plug. Do not use extension cords or an adapter without proper consideration.

### **⚠ SERVICE WARNING:**

To prevent electrical shock, disconnect power to the system prior to servicing.

### **⚠ WARNING:**

Do not make any alteration or modification in the wiring or plumbing of the system. This can result in damage to the system and cause injury to operators or users.

### **⚠ WARNING:**

Flush the system for at least 30 minutes before use to remove all chemicals present.



### **CAUTION:**

Chlorine will damage the membranes. Chlorine must be removed from the feed stream before entering the system.



### **CAUTION:**

Never let the system freeze. Freezing can damage the membrane and plumbing.

## SYSTEM INSTALLATION

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### **LOCATION**

Select a location for the RO system with adequate clearance from walls and other equipment to enable servicing of the pump / motor assemblies, membranes, cartridge prefilter and other serviceable components. Allow at least four (4) feet of clearance at the top end of the membrane housings for future membrane replacement.

The unit must be located near a drain able to accommodate up to 5 GPM. This is in addition to any other equipment sharing the drain.

A grounded power supply of the appropriate voltage matching your system model's voltage with 15 amp fuse protection and a local disconnect switch is required.

**⚠ Caution:** The system must not be located near any corrosive chemicals, or in an area where the temperature may exceed 113°F (45°C).

**⚠ Warning:** The system must be properly grounded to avoid injury from electrical shock.

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## PLUMBING

Refer to the P&ID on page 26 for further information.

**⚠ Note:** All plumbing is to be done in accordance with state and local codes.

**⚠ Caution:** This unit produces high quality water which can cause corrosion or leaching of the plumbing following the system. Use only plumbing components of inert material that are compatible with the application. Copper plumbing cannot be used.

Plumbing materials can significantly contribute to the contamination of the water. Care must be exercised over the choice of thread sealants. Teflon tape is suitable for all threaded connections in this system. Pipe dope can leach objectionable impurities into the water and must be avoided.

### Feed Water Connection:

Connect the raw water supply to the inlet of the solenoid valve (P.O.C), observing the following:

- The line size shall be 3/4" or larger to minimize pressure loss.
- A manual valve may be installed on this line to shut off the water supply if it will ever be needed. Be sure that this valve in no way restricts the water flow when it is fully open.
- Water supply min pressure 40 P.S.I. Max pressure 100 P.S.I. A pressure regulator may be required.

### Concentrate/Reject Connection

Connect a line to the concentrate connection point on the skid (refer to picture). The drain must have a minimum capacity which meets or exceeds the concentrate output of your system. Check the Design Specification (page 3) for your model.

### Permeate/Product Water Connection

Connect the product water line to the product connection point on the system (refer to picture). Run this line to your storage tank or other downstream equipment, observing the following:

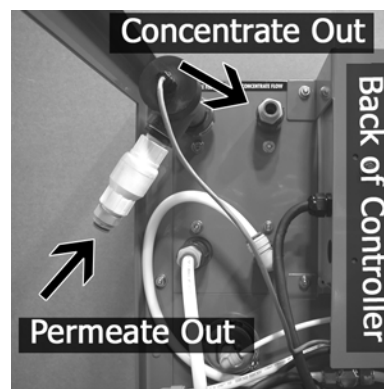
- Run this line in such a manner as to minimize static head pressure in the product line.
- A check valve is recommended to prevent back flow to the RO membranes. This check valve should be installed on the output of the product connection point.
- The product line should have no restrictions to the product flow.
- Connect the product line to a bulkhead fitting at the top of the storage tank.

**⚠ Caution:** RO Membranes will fail immediately if the product water is allowed to flow backward into the elements. Use a check valve and ensure that there are no restrictions on the product flow to prevent backflow.

**⚠ Caution:** The highest point of the tubing should not be higher than four feet above the top of the RO modules, or the elements may be damaged.



View of the side of the system.



View of the back of the control panel.

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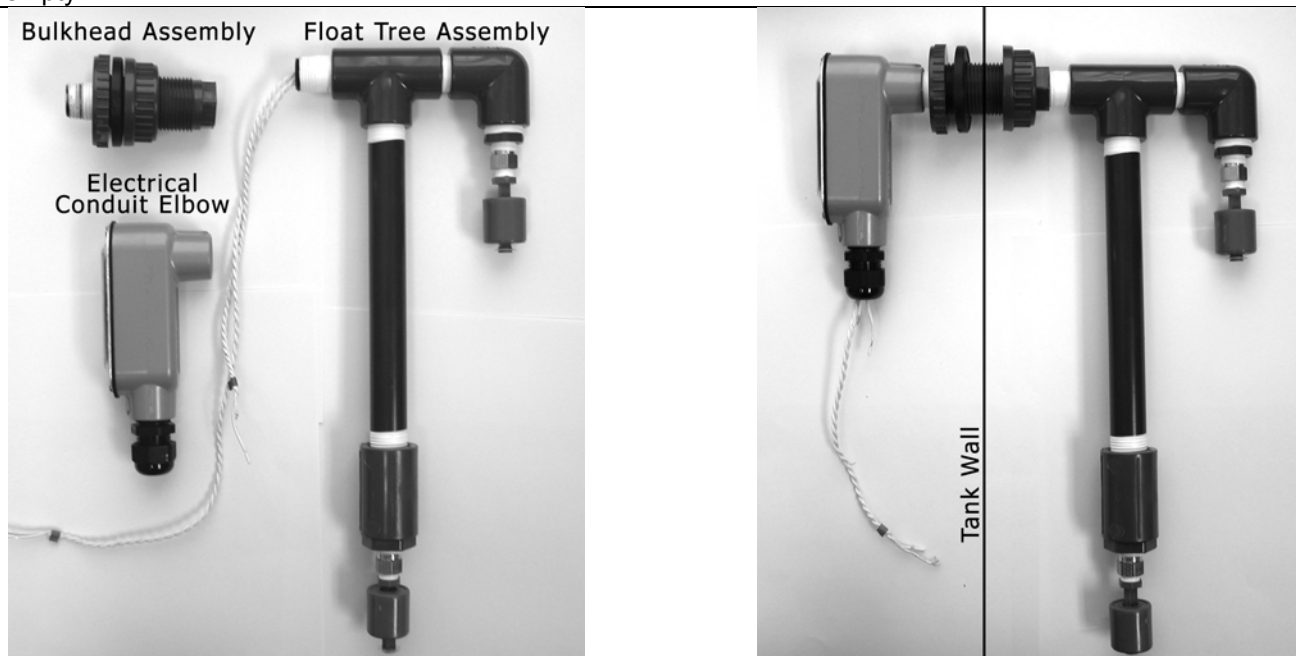
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## PRODUCT WATER STORAGE TANK LEVEL FLOAT INSTALLATION

**Note:** Please read all steps of installation instructions before beginning.

**Note:** If using a repressurization pump, a third float should be used to turn the pump off when the tank is empty.



1. Remove the bulkhead nut from the bulkhead fitting and place the bulkhead through the opening in the tank from the outside, making sure the bulkhead gasket is on the outside of the tank. Loosely connect the bulkhead nut. Do not tighten at this time.
2. Position the float tree assembly on the inside of the tank and pull the float wires through the bulkhead fitting. Connect the float assembly tee to the bulkhead fitting by turning the bulkhead fitting from the outside of the tank. Tighten the bulkhead nut.

**⚠ Caution:** Do not tighten by turning the float assembly inside the tank, float damage can occur. Tighten only by turning the bulkhead fitting from the outside of the tank.

3. Position the electrical conduit elbow on the outside of the tank, pulling with wires into the conduit elbow. Tighten onto the bulkhead fitting.
4. Install SO cord (supplied by customer) through the strain relief fitting and attach it to the bottom of the conduit fitting. Make sure enough wire is run into the conduit fitting.
5. Connect the wires from the SO cord to the float switch wires.

**Note:** It is recommended to test the wiring by placing an OHM meter on the connections testing for possible short or ground. All electrical connections shall be in accordance with the NESC guidelines and as dictated by local authorities holding proper jurisdiction for local/state and or by U.B.C., and U.M.C. guidelines for all mechanical means.

6. Run the SO cord to the RO control panel (detailed instructions in the electrical installation section, page 10).

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## ELECTRICAL CONNECTIONS

**⚠ All electrical connections should be done by a qualified electrician and are to be in accordance with state and local codes.**

**Note:** For Full Load Amps and Fuses Information, please see system design specifications on page 3. Provide circuit breaker protection as outlined in this chart.

### Voltages Codes:

- **216** = 220 Volts, Single Phase, 60 Hz
- **215** = 220 Volts, Single Phase, 50 Hz

**220 VAC 1 phase systems:** The system has a power cord attached to the system. The cord is left without a connector on it. The customer is to supply a connector that matches the receptacle at the installation site. The system can also be hard wired into a disconnect that has an amperage rating to handle the system. The black and white wires are the hot leads and the green goes to a good ground. Follow all NEC and local electrical codes.

## SERIES S100 RO SYSTEM CONTROLLER INSTALLATION AND SETUP

### Introduction

The Applied Membranes Inc. Series 100 controller is a state of the art control system for commercial and industrial reverse osmosis systems. The Series 100 is a microprocessor controlled system that can monitor pressure and level switches. A TDS monitor/controller with adjustable limit is an integral part of the Series 100. The Series 100 displays system status and sensor and switch input status using a status LED and a 3 digit LED display.

### Specifications

- Power: 120/240 VAC -15+10%, 50/60Hz, 6Watts
- Environment: -22°F to 140°F, 0-95% RH, non-condensing
- Enclosure: 7.6" X 4.6" X 2.4" (193mm X 117mm X 61mm)
- Display: 3 digit red LED
- Front Panel: Overlay with LED window, status LED, water quality LED, power and setpoint switches
- Switch Inputs, Dry Contact: Pressure fault, Pretreat lockout, Tank full
- Cell: TDS cell with 3 digit display, range: 0-1000PPM. Wetted parts ABS and 316SS, 3/4" NPT, 300 PSI max.

### Relay Outputs

- RO pump relay 120/240VAC, 1HP
- Inlet valve relay 120/240VAC, 5A
- Flush valve relay 120/240VAC, 5A

*Relays supply same output voltage as board power(120 or 240 VAC)*

### Installation: Power Wiring

Refer to the photograph and drawings on the following pages for location of all terminal strips, connectors and jumpers. All terminals on the board are labeled.

**⚠ Caution:** Before applying power to the unit, verify that the voltage jumpers are configured correctly for the voltage that will power the unit. The voltage jumpers are located below the transformer. For 120VAC operation, there should be a wire jumper installed between J1 and J3 and a second wire jumper installed between J2 and J4. For 240VAC operation, a single wire jumper should be installed between J3 and J4.

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## Installation and Service Manual – L Series Reverse Osmosis System

MATRIX CHART FOR MOTOR HORSE POWER

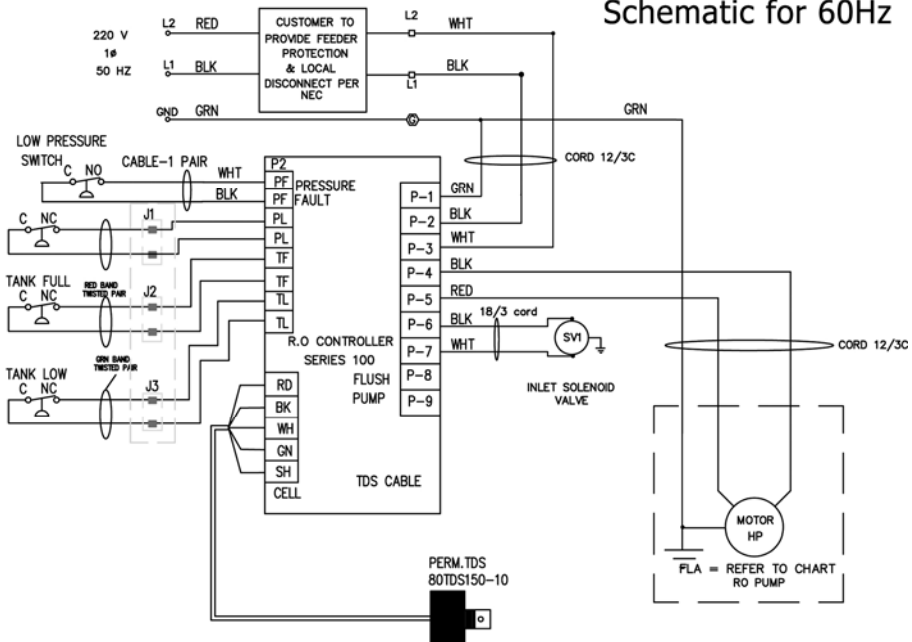
HP	SUPPLY	FLA	FUSE	XL - SYSTEM
1	208-230	10.4A	15A	XL-14A-216 TO XL-64A-216

### Schematic for 60Hz



	J12	ON	A	TANK FULL R.O OFF
	J11	ON	B	TANK FULL INLET OPEN
	J10	ON	B	NORMALLY CLOSE SWITCH
	J9	ON	B	TF RESTART IN 15 MINUTES
	J8	ON	C	PF SHUT DOWN FOR 30 SECOND

A   B   C   D



MATRIX CHART FOR MOTOR HORSE POWER

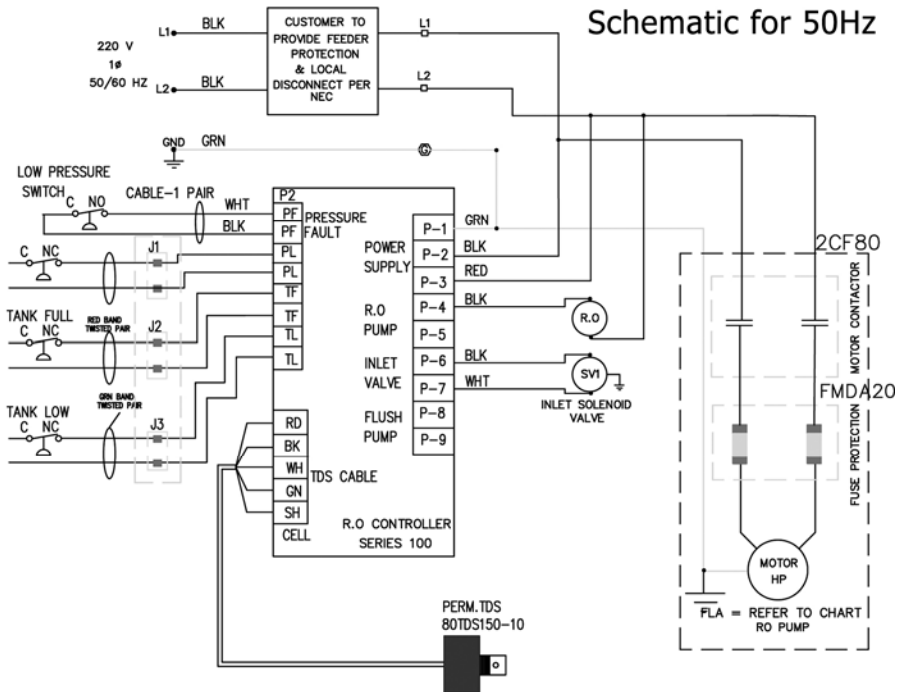
HP	SUPPLY	FLA	FUSE	XL - SYSTEM
1	208-230	12A	20A	XL-14A-215 TO XL-64A-215

### Schematic for 50Hz



	J12	ON	A	TANK FULL R.O OFF
	J11	ON	B	TANK FULL INLET OPEN
	J10	ON	B	NORMALLY CLOSE SWITCH
	J9	ON	B	TF RESTART IN 15 MINUTES
	J8	ON	C	PF SHUT DOWN FOR 30 SECOND

A B C D

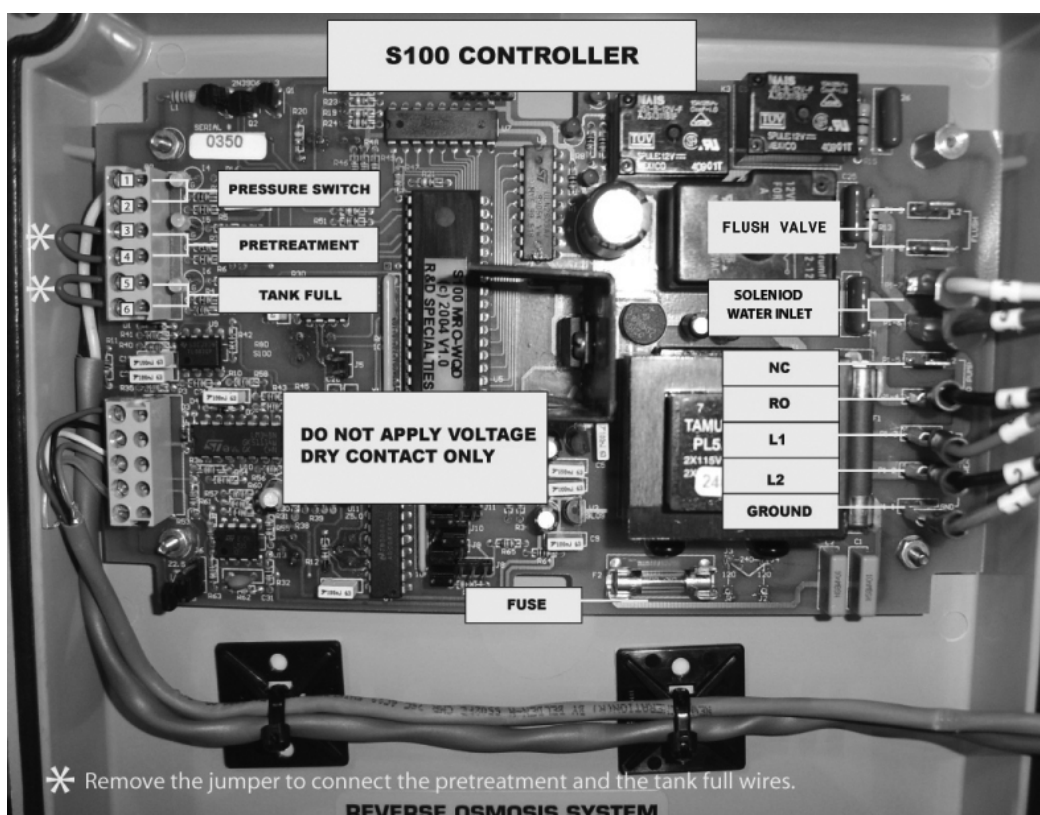


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### **Pump and Valve Relay Outputs**

The Series 100 supplies relay outputs to control the RO pump and solenoid valves. NOTE: The relays output the same voltage as the AC power to the board. If the pump and solenoids operate on different voltages, a contactor will need to be supplied to operate the pump.

### **RO Pump Wiring**

The RO pump connects to P1-4( L1) and P1-5(L2) RO pump terminals. This output can operate 120/240VAC motors up to 1HP directly. For motors larger than 1HP or for 3 phase motors, this output can be used to operate a contactor.

### **Inlet and Flush Valve Wiring**

The inlet and flush valves must operate at the same voltage as supplied to the board. These outputs can supply 5A maximum and are not designed to operate pump motors directly. If these outputs are to be used to operate a boost or flush pump, the output should be used to operate a contactor. The inlet valve connects to P1-6(L1) and P1-7(L2) inlet terminals. The flush valve connects to P1-8(L1) and P1-9(L2) flush terminals.

### **TDS Cell Installation and Wiring**

For accurate TDS readings, the cell should be installed in a tee fitting where a continuous flow of water passes over the cell and no air can be trapped around the cell. The cell is connected with 5 wires to terminal strip P3. Connect each colored wire to the terminal labeled with the same color.

### **Switch Inputs**

Switch inputs are connected to P2. The connections for these inputs are not polarity sensitive and can be connected to either terminal. The switch inputs should be dry contact closures only. CAUTION: Applying voltage to these terminals will damage the controller. The switches can be either normally open or normally closed, but all switches must be the same. If the controller is set for normally open switches, all switches must be open for the unit to run. If the controller is set for normally closed switches, all switches must be closed for the unit to run. NOTE: J10 selects normally open or normally closed operation. When J10 is in the A position, the unit is configured for normally open switches. When J10 is in the B position, the unit is configured for normally closed switches.

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### **Pressure Fault Switch**

On systems where a low feed pressure shut down is required, a feed pressure switch can be connected to the pressure fault input of P2. If a high pump pressure shut down is required, a high pressure switch can be connected to this input. If both low feed pressure and high pump pressure shut down are required, both switches can be connected to this input. Both switches must be either normally open or normally closed to operate properly.

### **Pretreat Switch**

In systems with pretreatment, a pretreat lockout switch can be connected to the pretreat input of P2. This switch should operate when the pretreatment device is out of service. NOTE: The output from the pretreatment device must be a dry contact and must not supply voltage.

### **Tank Full Switch**

For 2 level switch operation, the upper switch is connected to the tank full input and the lower switch is connected to the tank full low input. When both switches are clear, the RO unit will run. The RO unit will continue to run when the water level rises and the lower switch becomes active. When the upper switch becomes active, after the 5 second delay, the RO unit will shut down. FUL will show on the display. When the tank level drops and the upper level switch clears, the status LED will begin to flash and the RO unit will remain off. When the lower level switch clears, the LED will go off, and the RO will restart.

## **SYSTEM OPERATION**

### **SERIES S100 RO SYSTEM CONTROLLER OPERATION**

#### **General Operation**

The unit has 2 modes of operation, a standby mode and an operating mode. In the standby mode, the unit is effectively off. All outputs are turned off and the display shows OFF. In the operating mode, the unit operates automatically. All inputs are monitored and the outputs are controlled accordingly. Pressing the Power key will toggle the unit from standby to operate or from operate to standby. If power is removed from the unit, when power is reapplied, the unit will restart in the mode it was in when power was removed.



1. **LED Display:** Shows status of system and water quality
2. **Status LED:** Shows operating status of the unit.
3. **Water Quality LED:** Green if OK, Red if above the limit.
4. **Power Key:** Places the controller in operating or standby mode.
5. **Setpoint Key:** Places display in mode to display current setpoint.
6. **SP:** Setpoint adjustment screw.
7. **CAL:** Calibration adjustment screw.

#### **Display and Status Indicators**

The display is a 3 digit display. System operating status, the TDS reading and the TDS setpoint are shown on this display. A red/green LED indicates the system status in conjunction with the display. Refer to Table 1 for the description of the operation of the display and LED.

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Table 1

Condition	Display	Status LED
RO Off	OFF	
RO Start Delay	- - -	
RO Operating		Steady Green
Tank Full	FUL	
Tank Full Restart	FUL	Slow Flash Green

Condition	Display	Status LED
Pretreat Lockout	PL	
Flush	FLS	
Pressure Fault	PF	Flashing Red
PF Auto Reset	PF	
PF Auto Retry	PF	Steady Red

### **RO Start Delay**

When the controller is placed in the operating mode or restarts from a shut down condition, the inlet valve will open and a 5 second time delay will start. During the delay, “- - -” will show on the water quality display. After this delay, the RO pump will start. The water quality display will now show the current water quality. The status lamp will show steady green.

### **Pressure Fault**

If the pressure fault input is active for 2 seconds, a pressure fault condition will occur. This will cause the controller to shut down. PF will show on the water quality display and the status lamp will flash red. To clear the pressure fault, press the power key twice.

### **PF Auto Reset/PF Retry**

With J8 in the A position, the power must be cycled using the Power key to clear a pressure fault shut down. A PF auto reset function is enabled by placing J8 in the B position. When a pressure fault occurs with the PF auto reset enabled, the controller will automatically reset after a 60 minute delay and the controller will start. If the pressure fault has cleared, the controller will continue to run. If the pressure fault condition is still active, the controller will again shut down for the pressure fault condition and the auto reset cycle will repeat. During the auto reset delay, the water quality display will show PF and the status lamp will be off.

A PF retry function is enabled by placing J8 in the C position. When a pressure fault occurs with the PF retry enabled, the controller will shut down for 30 seconds and then attempt to restart. If the pressure fault is still active, the controller will shut down for 5 minutes and then attempt to restart. If the pressure fault is still active, the controller will shut down for 30 minutes and attempt to restart. If the pressure fault is still active, the controller will lockout for the pressure fault. During the retry delays, the water quality display will show PF and the status lamp will be a steady red. If during one of the retries, the controller is able to start and run continuously for 10 seconds, the retry function is reset. If a pressure fault occurs, the PF retry cycle will repeat from the beginning.

When J8 is in the D position, both the PF auto reset AND the PF retry functions are enabled. If a pressure fault condition occurs, the PF retry function will operate as described above. If the retry function locks out, the PF auto reset function will operate as described above. The PF retry and PF auto reset functions will continue in a 30 second, 5 minute, 30 minute and 60 minute cycle until the pressure fault condition clears.

### **Tank Full**

For 2 level switch operation, the upper switch is connected to the tank full input and the lower switch is connected to the tank full low input. When both switches are clear, the RO unit will run. The RO unit will continue to run when the water level rises and the lower switch becomes active. When the upper switch becomes active, after the 5 second delay, the RO unit will shut down. FUL will show on the display. When the tank level drops and the upper level switch clears, the status LED will begin to flash and the RO unit will remain off. When the lower level switch clears, the LED will go off, and the RO will restart.

### **Pretreat Lockout**

If the pretreat lockout input is active for 2 seconds, the controller will shut down for a pretreat lockout condition. The water quality display will show PL. When the pretreat lockout condition clears, the unit will restart.

### **Membrane Flush**

A feed water flush takes place every time the system shuts down in a Tank Full condition. With the pump off, the inlet valve opens for 5 minutes.

### **Water Quality Display**

The water quality display shows the current water quality when the controller is operating normally and status messages when the controller is shut down. The water quality display is 0 - 999PPM. If the water quality is above 999, the display will show “^ ^ ^”. If the water quality is below the setpoint, the water quality lamp will be green. If the water quality is above the setpoint, the water quality lamp will be red.

### **Water Quality Setpoint**

The water quality setpoint can be adjusted from 0-999. If set to 999, the water quality lamp will always remain green. To set the water quality setpoint, press the Setpoint key. The display will alternate between the setpoint and SP. Use a small screwdriver to adjust the SP adjustment to the desired setpoint value. Press the Setpoint key to return the display to the water quality display.

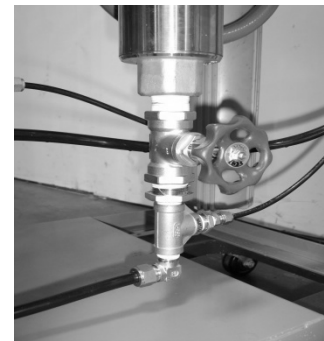
### **Calibration**

To adjust the calibration of the water quality, measure the water with a meter calibrated to a known standard. Using a small screwdriver, adjust the CAL adjustment to get the correct reading on the display.

## **INITIAL SYSTEM START-UP**

*Refer to the P&ID on page 26 for valve and gauge locations.*

1. Direct the product water tubing to drain.
2. Open the feed water supply valve.
3. Open the system pressure (pump throttle) control valve (CV-1) fully counterclockwise. Open the concentrate control valve (CV-2) fully counterclockwise. Close the recycle valve (CV-3).
4. Press the power button to turn the system on. Note inlet water pressure must be at least 40 psi.



Throttle Valve (CV-1)



**Caution:** If the pump chatters loudly, it is starving for water (cavitating). Turn the unit OFF immediately to prevent pump damage. Correct the low pressure condition before proceeding.

5. If incoming pressure is too high, an inlet pressure regulator (not included) may be installed. This should be set at 40 psi.
6. Some fittings may have loosened during shipment. Check for leaks at all tube fittings and threaded joints.
7. Allow the unit to run for at least 30 minutes to flush the preservative solution from the system.

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8. Once the preservative solution has been flushed from the system, shut down the system by pressing the 'power' button and redirect the permeate flow to desired product storage tank or down-stream equipment.
9. Restart the System.
10. Adjust the Throttle Valve (CV-1) to get the specified permeate.
11. Adjust the Control Valve (CV-2) and Recycle Valve (CV-3) until the specified permeate flow and recycle flow are obtained. It may be necessary to readjust the Throttle Valve (CV-1).



Concentrate Control Valve (CV-2) & Recycle Valve (CV-3)

**⚠ Caution:** Do not exceed the rated permeate flow or the rated recycle flow – otherwise membranes may be irreversibly fouled.

**⚠ Caution:** Do not operate the system with the control valve closed.

**Note:** By setting the feed pressure as low as possible to meet the application requirement, the service life of the pump and RO elements will be optimized. The system should be run continuously when possible, rather than go through frequent start/stop cycles.

12. Run unit and check again for leaks, repair prior to placing unit in service.
13. Test the operation of the pressure switch by slowly closing the inlet water supply valve. The unit should shut off after a short 5 second time delay.

**⚠ Caution:** If the unit does not shut off, turn the unit OFF immediately to prevent pump damage. Disconnect the electrical power source, then check the wiring and replace or adjust the switch if necessary. (Pressure switch adjustment instructions in maintenance on page 20.)

14. Once all the desired flows are set, allow the system to run for approximately 30 minutes. Then record the performance information using the system operation data log on page 15. The values recorded at startup will be important for determining system performance at a later date.

## OPERATING DO'S & DON'TS

### DO:

1. Change the cartridge filters regularly
2. Monitor the system and keep a log daily
3. Run the system, as much as possible, on a continuous basis.
4. Adjust the system recovery to the recommended value

### DON'T

1. Permit chlorine in the feed water.
2. Shut down the system for extended periods.
3. Close the throttle valve completely.
4. Operate the system with insufficient feed flow.

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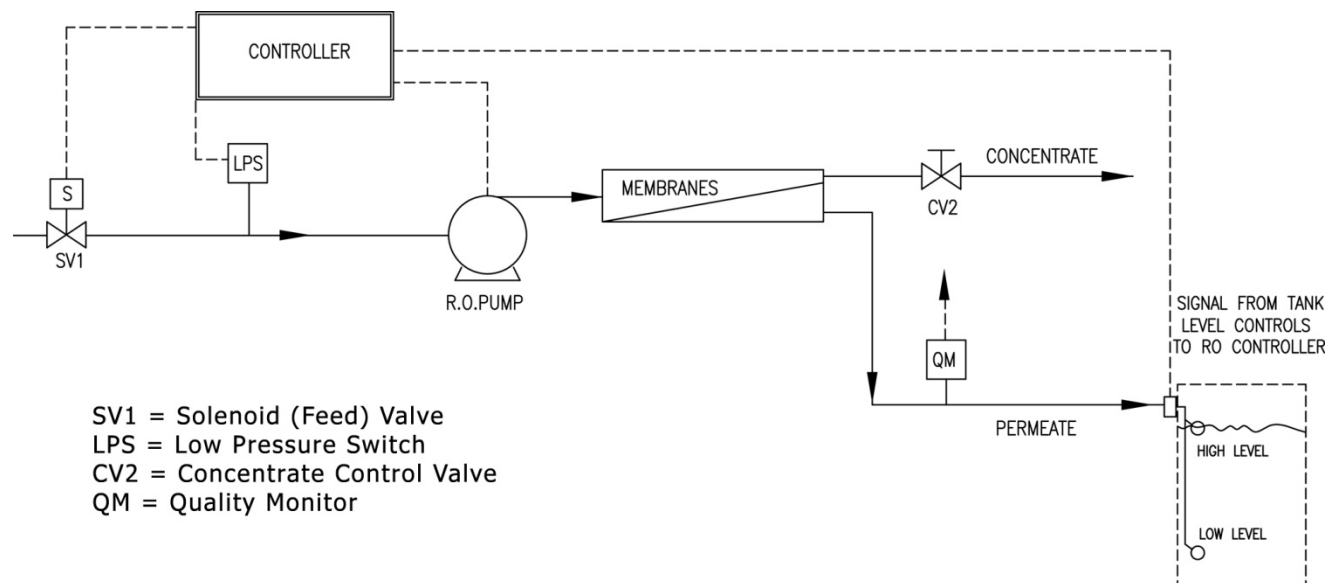
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## SYSTEM AUTOMATION

The system will automatically turn on when the water level in the permeate tank reaches the mid level float, and turn off when the water meets the high level float.

There are two float switches on this system:

- High level float switch: Signals when tank is full and shuts down the unit.
- Low level float switch: Signals when the tank is half empty and turns the unit on.
- (Optional third switch) Tank empty switch: Signals when the tank is empty to shut off the repressurization pump (not included with the system).



### Example of typical start-up sequence:

1. Water level in tank drops to low level.
2. Solenoid opens to allow feed water into the system.
3. Incoming feed must meet/exceed low pressure setpoint for the pump to turn on. (This will indicate sufficient inlet water supply to operate the pump without cavitation.)
4. Pump will start after delay (typically 5-10 seconds).
5. Permeate and concentrate flows are determined by manual control of concentrate valve.
6. System will continue to run until the water level in the tank reaches high level.
7. Once the water reaches high level, pump will stop and a flush cycle will begin. The solenoid will close once the flush is complete.

## SYSTEM SHUT-DOWN

1. Press the Power Button. Allow sufficient time for the system to go through the flush cycle before proceeding.
2. Turn off the main power disconnect. This removes all power from both the power and control enclosures.
3. If the RO System is to be shut down for more than a week, a membrane preservative should be used. Refer to the instructions for preserving the system.
4. When the system is restarted after extended shutdown, both permeate and concentrate should be diverted to the drain for at least 30 minutes.

## SYSTEM MONITORING AND RECORD KEEPING

The system should be monitored and all pertinent data recorded on a daily basis. Data is needed to determine the operating efficiency and for performing system maintenance. The latter includes cleaning of the membranes, adjusting the operating conditions, replacement of the membranes, and antiscalant use. Use the system data logging form the following page.

\*Membrane warranty claims cannot be processed without adequate operating data and history of the RO System.

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## DATA LOG

	Data for Each Date/Time						
Date/Time							
Temperature (Deg. F)							
Feed							
Pressures (PSI)							
Feed							
System							
Media Filter IN							
Media Filter* OUT							
Cartridge Filter* IN							
Cartridge Filter OUT							
Flow (GPM)							
Permeate** (P)							
Concentrate (C)							
Feed = P + C							
TDS (PPM)							
Feed							
Permeate							
Other							
pH, Feed							
Cl <sub>2</sub> , Feed (ppm)							
Scale Inhibitor (ppm)							

\* If Included.

\*\*Temperature and net pressure of the feed water must be taken into account before comparing or evaluating the performance of the reverse osmosis system.

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## DATA NORMALIZATION – SYSTEM OPERATING TEMPERATURE

The water temperature is one of the key factors in the performance of the reverse osmosis membrane element. A higher temperature will result in more product flow and a lower temperature will result in less product flow. All reverse osmosis membrane elements and systems are rated at 77° Fahrenheit (25° Celsius).

To find the membrane permeate rate at a different temperature, follow these steps:

Find the temperature correction factor (TCF) from the below table. Divide the rated permeate flow at 77° Fahrenheit by the temperature correction factor. The result is the permeate flow at the desired temperature.

Feed Water Temperature C °	Feed Water Temperature F°	TCF for Thin Film
1	33.8	3.64
2	35.6	3.23
3	37.4	3.03
4	39.2	2.78
5	41	2.58
6	42.8	2.38
7	44.6	2.22
8	46.4	2.11
9	48.2	2.00
10	50	1.89
11	51.8	1.78
12	53.6	1.68
13	55.4	1.61
14	57.2	1.54
15	59	1.47
16	60.8	1.39
17	62.6	1.34

Feed Water Temperature C °	Feed Water Temperature F°	TCF for Thin Film
18	64.4	1.29
19	66.2	1.24
20	68	1.19
21	69.8	1.15
22	71.6	1.11
23	73.4	1.08
24	75.2	1.04
25	77	1.00
26	78.8	0.97
27	80.6	0.94
28	82.4	0.91
29	84.2	0.88
30	86	0.85
31	87.8	0.83
32	89.6	0.80
33	91.4	0.77
34	93.2	0.75

Feed Water Temperature C °	Feed Water Temperature F°	TCF for Thin Film
35	95	0.73
36	96.8	0.71
37	98.4	0.69
38	100.4	0.67
39	102.2	0.65
40	104	0.63
41	105.8	0.61
42	107.6	0.60
43	109.4	0.58
44	111.2	0.56
45	113	0.54
46	114.8	0.53
47	116.6	0.51
48	118.4	0.49
49	120.2	0.47
50	122	0.46

## TROUBLESHOOTING

### GENERAL TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	SOLUTION
Inlet pressure low	Low supply pressure	Correct incoming supply pressure
	Cartridge filters plugged	Change filters
	Solenoid valve malfunction	Replace solenoid valve and/or coil
Permeate flow low	Low water temperature	Adjust water temperature
	Low system pressure	Adjust control valve
	Membranes fouled	Clean membranes
Pump noisy	Low inlet flow	See "Inlet pressure low"
Permeate quality poor	Low inlet flow	Adjust control valve
	Low system pressure	See above
	Recovery too high	Reduce recovery
	Membranes fouled	Clean membranes
	Membranes damaged	Replace membranes
Feed pressure present, even after tank full	Solenoid malfunction	Replace solenoid
	Coil malfunction	Replace coil
	Controller malfunction	Inspect or replace



## SYSTEM CONTROLLER TROUBLESHOOTING – SERIES S100

**⚠ Caution:** Hazardous voltages are present when power is applied to the controller. Pressing the Power key DOES NOT remove these voltages. The power must be disconnected from the power source. When connecting or disconnecting any wiring to the unit, be sure the power is turned off at the disconnect or breaker.

**Note:** If fuse F1 is blown, none of the outputs will operate. If fuse F2 is blown, the controller will be inoperative.

<b>PROBLEM</b>	<b>TROUBLESHOOTING STEPS</b>
<b>System Inoperative</b>	Is the water quality display lit? If no, check fuse F2 located below the transformer. If the fuse is OK, use a voltmeter to verify that power is applied to power terminals L1 and L2 . If power is applied to the power terminals and the above checks are OK, the board may be defective and should be replaced. If no power is applied to the board, check the power wiring to the controller.
<b>Inlet Valve Will Not Operate</b>	Is the controller off? If no, are any shut down conditions active? If no, is the inlet LED, I2 lit? If no, replace the board. If yes, check fuse F1. If bad, replace the fuse. If it is OK, check the inlet terminals for power. Is there power? If no, replace the board. If yes, check the valve and valve wiring.
<b>RO Pump Will Not Operate</b>	Is the controller off? If no, are any shut down conditions active? If no, is the RO LED, I1 lit? If no, replace the board. If yes, check fuse F1. If bad, replace the fuse. If it is OK, check the RO pump terminals for power. Is there power? If no, replace the board. If yes, check the pump motor and motor wiring.
<b>No Flush or Not Flushing Correctly</b>	Verify that the flush jumpers, J11 and J12 are set correctly.
<b>No or Incorrect TDS Reading</b>	Is the sensor wired correctly? If no, correct wiring. Is the sensor installed as described in the installation section? If no, install correctly. Is unit calibrated correctly? If no, recalibrate. Disconnect green and white wires of sensor from P3. Does reading show 0? If no, replace board. If yes, reconnect wires and remove sensor from piping and dry. Does reading show 0? If no, replace sensor. If yes, short pins of sensor. Does reading show ^ ^? If no, replace board.

## SYSTEM MAINTENANCE

### Maintain proper operating conditions.

(See section: “Design Basis” on page 3)

## SEDIMENT PRE-FILTER CARTRIDGE

### When to Change Sediment Prefilter Cartridge

Sediment cartridge Filters should be changed regularly to maintain proper pump pressure and flow. If the pressure drop across the cartridge filter (as indicated by the differential between the filter inlet and filter outlet pressure gauges) increases by 10 psi, the cartridge filters should be changed.

### Changing Cartridge Filters

1. Turn unit off.
2. Close inlet supply valve.
3. Un-assemble the filter housing (twist the sump counter-clockwise).
4. Remove and inspect the cartridge. Replace as needed.
5. Before replacing housing, insure that O ring seal is lubed and placed in groove of housing. Inspect seal and replace as needed.
6. Assemble housing (turn the sump clockwise into the cap until tight).



## MEMBRANE CLEANING

### When to Clean Membranes

In normal operation, the membrane in reverse osmosis elements can become fouled by mineral scale, biological matter, and grime. These deposits build up during operation until they cause loss in water output or loss of salt rejection, or both.

**Elements should be cleaned whenever the water output rate drops by 10 percent from its initial flow rate** (the flow rate established during the first 24 to 48 hours of operation), or when salt content in the product water rises noticeably.

**⚠ Note:** Check water temperature and apply temperature correction (page 16) to determine if flow loss is due to low feedwater temperature. A malfunction in the pretreatment, pressure control or pump can cause a drop in feedwater delivery pressure, feedwater flow, or product water output, or an increase in salt passage. If such adjustments are needed, the element may not require cleaning.

### Common Foulants and Their Associated Symptoms

Foulant	Symptoms	Solution/Cartridge Part #
<b>Biological Growth</b>	Element may have strong odor, possible mold growth on scroll end. Element will likely exhibit low permeate flow, but salt rejection will usually be as good if not better than original test.	Alkaline Cleaner: AM-22 Cartridge: C-C2520-A22
<b>Carbonate Scale</b>	Usually on tap water or brackish water elements only. The element may be noticeably heavier than normal. Element will exhibit low permeate flow and poor salt rejection.	Acid Cleaner: AM-11 Cartridge: C-C2520-A11
<b>Iron Fouling</b>	Rust coloring seen on end of scroll. Possibly some large rust flakes from iron plumbing. Element will exhibit low permeate flow and poor salt rejection. Rust colored reject water may be seen on start of baseline test	Acid Cleaner: AM-11 Cartridge: C-C2520-A11

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## **Cleaning Sequence**

Whether the system needs acid or alkaline cleaning will depend on the type of foulant suspected. We recommend acid cleaning be performed first, even when alkaline cleaning is desired. If system performance recovers with acid cleaning, then alkaline cleaning is not necessary.

1. ACID CLEANING (AM-11, C-C2520-A11)
2. FLUSH
3. ALKALINE CLEANING (AM-22, C-C2520-A22)
4. FLUSH

## **Cleaning Procedure Using Membrane Cleaning Cartridges**

1. Shut down the RO system.
2. Disconnect the permeate line and divert permeate to drain during cleaning.
3. Remove the pre-filter cartridge from the filter housing.
4. Replace the sediment pre-filter cartridge with the cleaning cartridge and assemble into the filter housing.
5. Turn system ON. After 30-40 seconds\*, shut down the system.
6. Let the membrane(s) soak in the cleaning solution overnight.
7. Remove the empty cleaning cartridge and replace it with the original filter.
8. Restart the system. Direct the permeate to drain for 5 minutes.
9. Go back to normal operations.

*\*Instead of time, you may use one of the following criteria:*

- a. Run the system until the pH of the concentrate is almost the same as the cleaning solution.
  - AM-11 pH = 3                      • AM-22 pH = 10-12
- b. Permeate rate for the system drops to a very low value.



**Caution:** Handle all chemicals with care. Wear protective clothing and eye protection.



**Note:** The system must be flushed thoroughly between acid and alkaline cleanings.

## **MEMBRANE REPLACEMENT**

1. Remove clamps from vessel using 9/16" socket or wrench. Use two screw drivers on each side to push end caps out of vessel slowly.
2. Push the membrane out through the vessel from the feed end towards the concentrate end.
3. If there is not enough room to remove the membrane from the vessel through the concentrate end it can be removed from the feed end.
4. Install the new membrane from the feed end. Ensure that the brine seal is oriented towards the feed end. Check that the end adapters and all o rings are in good condition and in position.
5. Replace end plug(s) using glycerin lubricant as required on O rings (AMI Model No. H-C111DC).
6. It is highly recommended to have a spare set of O-rings and brine seal while replacing the membranes.
7. As the membranes may have preservative or be contaminated, please wash your hands thoroughly after replacing membranes.



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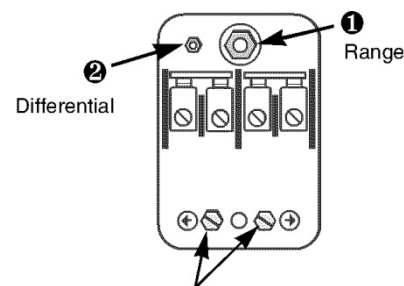
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## LOW PRESSURE SWITCH ADJUSTMENT

Adjust in the proper sequence:

1. **Range:** Turn nut down (clockwise) for higher cut-in pressure, or up (counterclockwise) for lower cut-in.
2. **Differential:** Turn nut down (clockwise) for higher-cut-out pressure, or up (counterclockwise) for lower cut-out.



Grounding provisions: #10-32 screws.  
Torque screws to 15–20 lb-in (1.7–2.3 N•m).

## PUMP MAINTENANCE

**⚠ WARNING: Hazardous Voltage.** Can shock, burn or cause death. Disconnect power to the pump before servicing.

Tools required:

- 7/16" open end wrench (2 required)
- Flat blade screwdriver with insulated handle
- Work bench with vise recommended
- Pliers or similar tool
- Pipe wrench

### Impeller Stack Changeout (see diagram on following page)

Remove pump from service and mount vertically in vise (if available) motor side down. Hold at center of motor. It may be desirable to wrap motor with a shop rag to protect outside surface. Proceed as follows:

1. Attach pipe wrench to flats on discharge connection and turn clockwise to remove (left hand threads).
2. Remove screws holding motor canopy and remove canopy. Pull straight off as shown. Leave switch wires attached (if present).

**⚠ WARNING: Capacitor voltage may be hazardous.** To discharge capacitor, hold insulated handle screwdriver **by the handle** and short capacitor terminals together. Do not touch metal screwdriver blade or capacitor terminals.

3. Unscrew the overload and move it aside. Do not disconnect wires. Slide 7/16" open end wrench in behind spring loaded centrifugal switch as shown. Place on motor shaft flats to hold shaft stationary.
4. With one 7/16" wrench in place on motor shaft, place second wrench on shaft hex at pump end and unscrew impeller stack by turning counter-clockwise.
5. Once loose from motor shaft, hold shaft by snap ring using a pliers or similar tool, and pull stack from shell. You may have to apply a back and forth motion to break stack loose from shell.

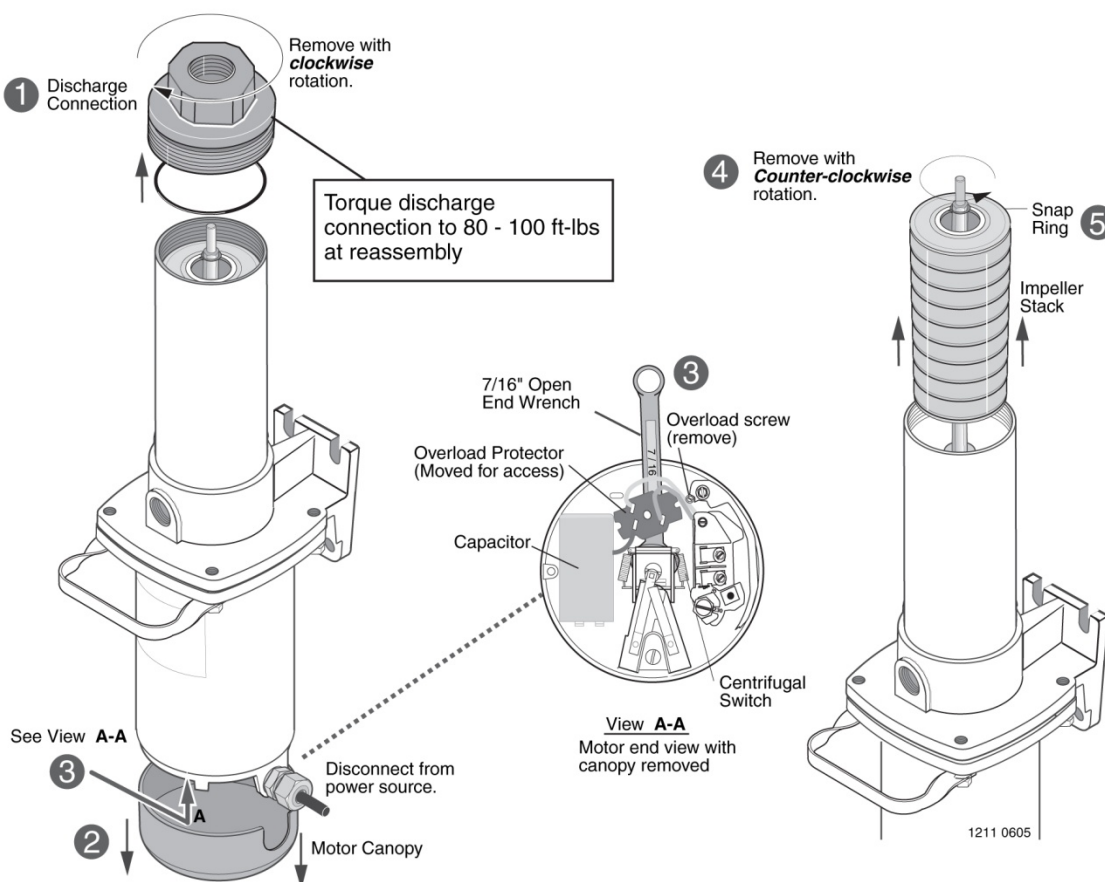
To assemble with replacement impeller stack, keep pump in the vertical position, motor down, and reverse instructions 1 through 5.

**Assembly hints:**

- Apply a soapy water solution to suction and discharge O-Rings to ease seating of shell.
- Make sure mechanical shaft seal spring is in proper position on motor shaft.
- On three-phase models, apply Loctite No. 271 to motor shaft threads before reinstalling stack.

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### **Mechanical Seal Changeout (refer to figures above and on following page)**

This procedure is best completed with the pump held in a vertical position, motor down.

First, complete "Disassembly" instructions 1 through 5 under "Impeller Stack Changeout." (see previous page)

6. Remove 4 capscrews holding pump body to motor. Pump handle will come off with top capscrews.
7. Unscrew pump shell from pump body, turning clockwise (left hand threads).
8. Remove mechanical shaft seal spring and rotating half from motor shaft. Use care not to scratch motor shaft when removing rotating half.
9. Remove pump body from motor and place on flat surface, face down. Again, use care not to scratch motor shaft.
10. Use a screwdriver to push ceramic seat out from seal cavity as shown.
11. Installation of ceramic seat:
  - a. Turn pump body over so seal cavity is up; clean cavity thoroughly.
  - b. Clean polished surface of ceramic seat with a clean cloth.
  - c. Lubricate outside rubber surface of seat with soapy water. Place cardboard washer over polished face of seat and press into seal cavity using a 3/4" socket or a piece of 3/4" standard pipe.
  - d. Be sure polished surface of seat is free of dirt and has not been damaged by insertion. Remove excess soapy water. Dispose of cardboard washer.
12. Installation of rotating half and spring:
  - a. Reinstall pump body on motor using extreme caution not to hit ceramic portion of seal on motor shaft. Reattach pump body to motor using capscrews. Be sure to reinstall pump handle at this time.
  - b. Inspect shaft to make sure that it is clean.
  - c. Clean face of rotating half of seal with a clean cloth.
  - d. Lubricate inside diameter of rotating half with soapy water and slide onto motor shaft (sealing face first).
  - e. Place spring over motor shaft so it rests on rotating half.

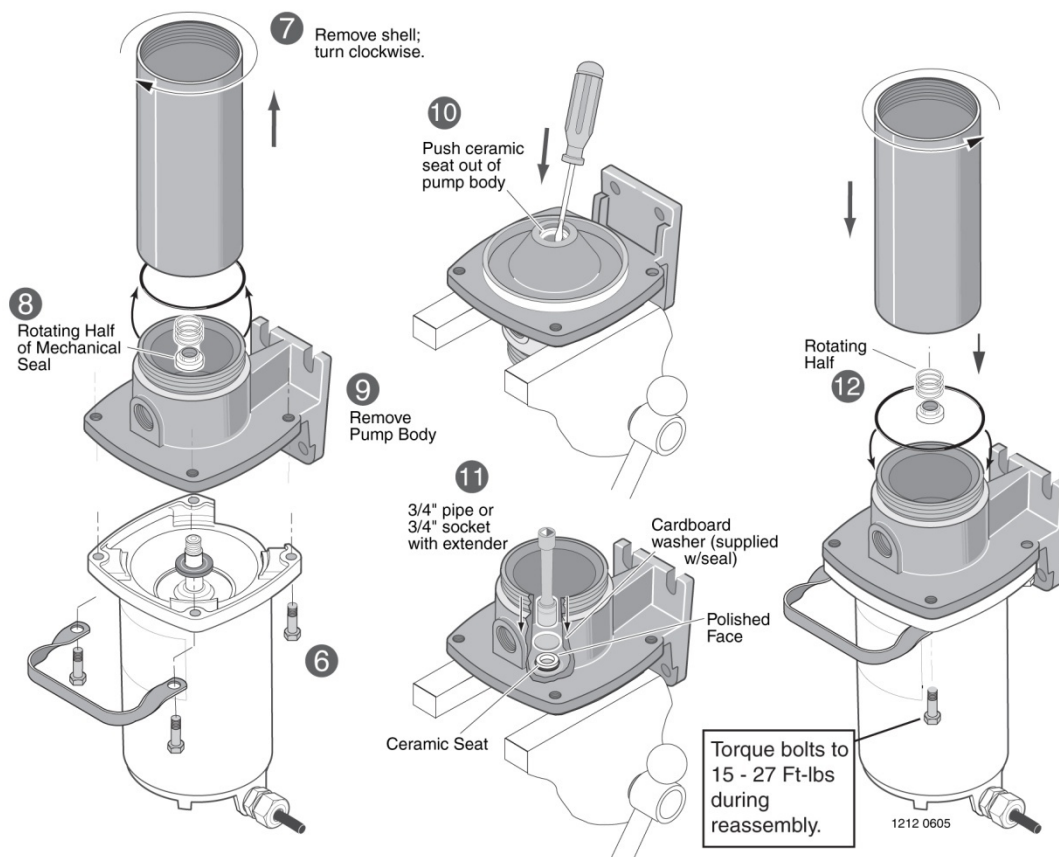
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13. To complete reassembly from this point, reverse instructions 1 through 5 under “Impeller Stack Changeout.”

**NOTE:** Lubricate suction and discharge O-Rings with soapy water for easier installation of shell.



## SHUT-DOWN AND STORAGE



**Caution:** Handle all chemicals with care. Wear protective clothing and eye protection.

### MEMBRANE STORAGE (OUTSIDE OF RO SYSTEM)

To prevent bacterial growth and help maintain flux, it is recommended that elements be immersed in a solution 20.0 percent, by weight, AM-225 and 1.0 percent by weight AM-88.

**Prepare the Solution:** Make a water solution by adding about 1 ounce of AM-88 per gallon of water (use RO permeate if possible). Also add about 1.5 lbs of AM-225 per gallon of water.

**Storing Elements:** Mix the solution well. Soak the elements in this solution for 1 hour. Drain and seal in plastic bags.

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## **RO SYSTEM STORAGE AND BIOCIDAL PROTECTION**

To prevent biological growth during storage, shipping, or system shutdowns, it is recommended that RO systems and membranes be immersed in a solution of AM-88. This can be performed using a membrane preservative cartridge, part # C-C2520-A88.

### **System Preserving Procedure**

1. Shut down to RO system.
2. Disconnect the permeate line and direct permeate to drain during cleaning/preserving.
3. Remove the 5M filter cartridge from the pre-filter housing.
4. Replace the filter cartridge with the preservative cartridge and assemble into the filter housing.
5. Turn system ON. After 30-40 seconds, shut down the system.
6. Drain the system of the permeate solution as much as possible by opening a valve/fitting at a low point in the system. Close off the inlet and outlet to the membrane/system.

### **Flushing out Preservative/Re-start Procedure:**

1. Open valves etc. and put the system back in the position it was before preserving.
2. Remove the empty preservative cartridge and replace it with a new cartridge filter.
3. Re-start the system. Direct permeate to drain for at least 30 minutes.
4. Return to normal operation.

## **DISINFECTION AND STERILIZATION OF RO ELEMENTS**

**An excellent disinfectant** for spiral elements is 0.1 percent **AM-88**. This solution inhibits bacterial growth while maintaining the high flux and salt rejection of elements. It is made by dissolving one ounce of AM-88 in 8 gallons of water. Elements should be flushed with this solution before storage or at the beginning of long down periods.

**Sterilization can be achieved with formaldehyde.** However, this reagent should not be used unless the element is first operated for 24 hours. Otherwise, severe flux losses may occur in the membrane. After this initial period, the membrane will tolerate any customary formaldehyde concentration used in sterilization.

**Other disinfectants and sterilants** can be used. Hydrogen peroxide at 100 to 1000 ppm (0.01 to 0.1 percent) is effective at room temperature. Hydrogen peroxide will damage the membrane at higher temperatures, however. Chloramine, Chloramines T and N chloroisocyanurates can be used in spiral elements. They are not very effective as sterilants, however. Also, if they are used in combination with an already heavily fouled (biological) test loop or system, flux losses are occasionally experienced from dead bacterial matter in the feed stream depositing on membrane surfaces. Chlorine dioxide, free of hypochlorite or chlorine, may be used as a disinfectant. Both Chloramines and chlorine dioxide readily pass through membranes, appearing in the permeate.

**Chlorine** (hypochlorite) is not recommended for disinfecting membrane elements. Permanent damage will occur.

**Iodine**, quaternary compounds, and phenolic disinfectants cannot be used with spiral elements. All three cause severe flux losses.

## COMPONENT IDENTIFICATION- STANDARD FEATURES

Component Identification by P&ID <i>from P&amp;ID on page 26</i>			System Model Numbers <i>(all voltages unless specified)</i>					
#	Part No.	Description	XL-14A	XL-24A	XL-34A	XL-44A	XL-54A	XL-64A
1	8210P095	Solenoid valve, 3/4" normally closed	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
2	H-H234WBE (housing) H-F2005CF (filter)	Sediment filter housing and cartridge filter, 5 Micron	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
3	I-PS915CUL	Pressure switch, low (Mounted on control assembly)	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
4	<b>60 Hz</b> - HPS10E-01MS3	Multistage SS Pump/Motor 220v/1ph/60Hz	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
4	<b>50 Hz</b> – HPS10G-01MS2	Multistage SS Pump/Motor 230v/1ph/50Hz	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
5	YVG075SS (CV-1)	3/4" Throttle Valve (CV-1)	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
6	I-PG400N	System Pressure Gauge, 0-400 psi	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
7	M-T4040AXLE	Membrane 4"x40" Extra Low Energy	Qty 1	Qty 2	Qty 3	Qty 4	Qty 5	Qty 6
7	PV4040SSAW-316	Pressure Vessel, 316 SS	Qty 1	Qty 2	Qty 3	Qty 4	Qty 5	Qty 6
8	D3812G8B (CV-2)	Concentrate Control Valve (CV-2) – 1/2" Needle Valve	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
9	I-FM05P4	Concentrate Flow Meter, 5 GPM	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
10	I-FM05P4	Permeate Flow Meter, 5 GPM	Qty 1	Qty 1	-	-	-	-
10	I-FM10P4	Permeate Flow Meter, 10 GPM	-	-	Qty 1	Qty 1	Qty 1	Qty 1
11	B-626 (CV-3)	Recycle Valve (CV-3) – 3/8" Needle Valve	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
12	80TDS150-10	Permeate TDS Sensor	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
13	C-XLA01TXXXXXX	Control Enclosure 1 HP S100 w/ I-PS915CUL Low Pressure Switch	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
14	46835K32	1/2" Permeate Check Valve	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1	Qty 1
20*	Water Softener (ordered separately)		-	-	-	-	-	-
21*	Carbon Filter (ordered separately)		-	-	-	-	-	-
22*	Media Filter (ordered separately)		-	-	-	-	-	-
23	YFL2PPAS	Float Tree, 2 Float	-	-	-	-	-	-
24*	YFL3PPAS (optional)	Float Tree, 3 Float	-	-	-	-	-	-

\* Optional Component – Not included with system.

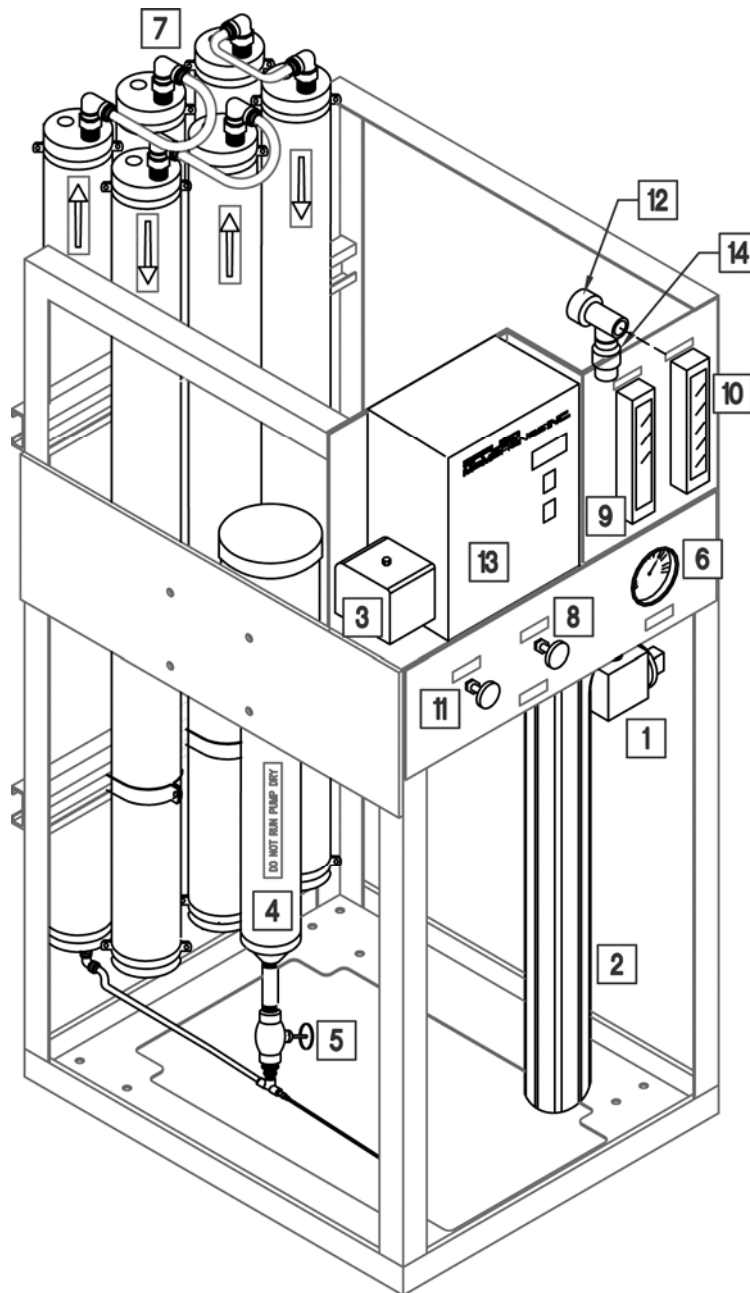
Voltage Codes:

**-216** = 220-240V/1PH/60H

**-215** = 220-240V/1PH/50HZ,



## SYSTEM GENERAL ARRANGEMENT

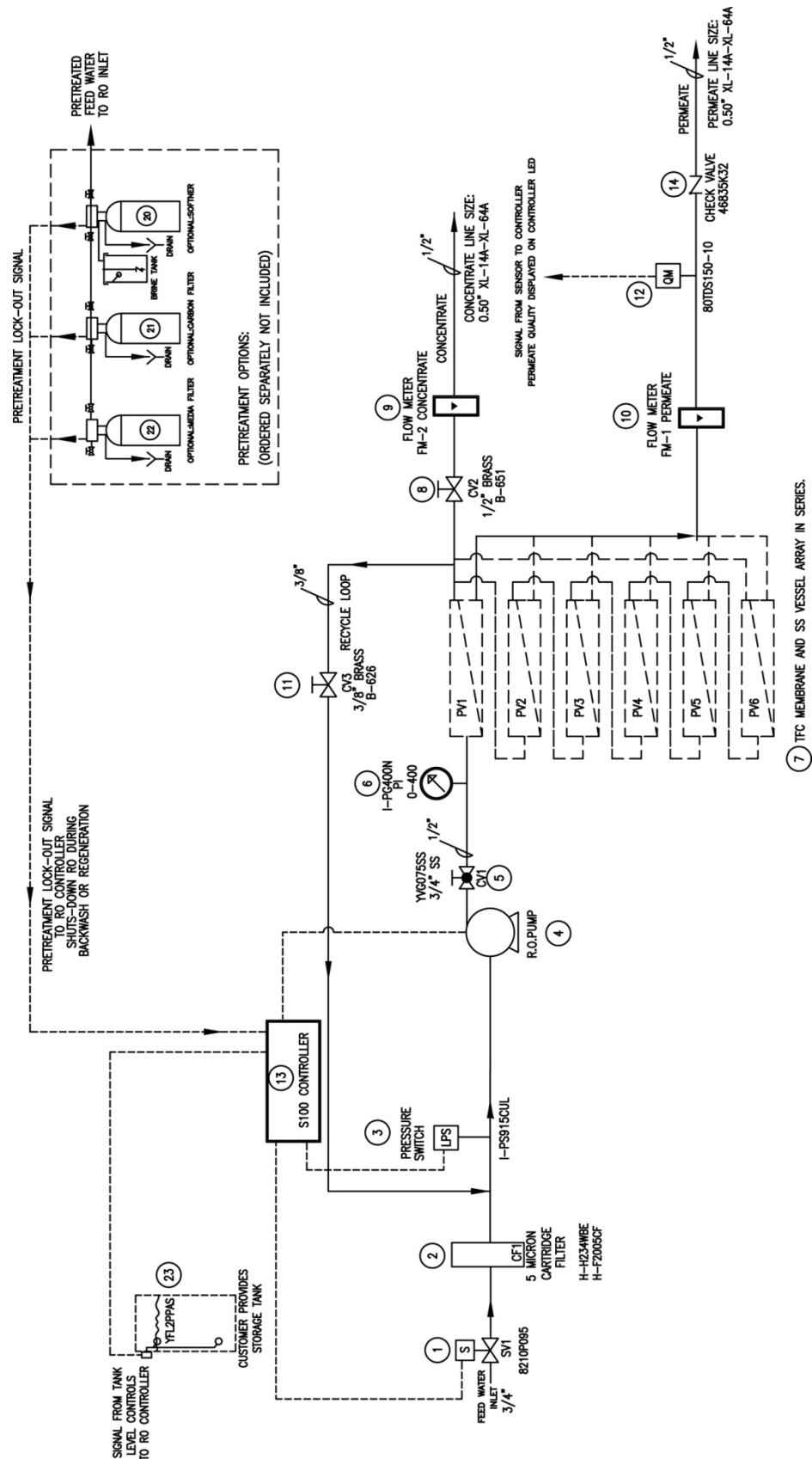


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Model No.	Description
H-F2005CF	5 Micron Sediment Pre-Filter Cartridge
C-C2520-A11	Cleaning Cartridge – Acid for Scale Removal
C-C2520-A22	Cleaning Cartridge – Alkaline for Organics Removal

## Pump Replacement Parts

An exploded view diagram of a mechanical assembly. The components are numbered as follows: 1. A long cylindrical shaft with a central hole. 2. A small pin or screw. 3. A flange or housing component. 4. A small pin or screw. 5. A small pin or screw. 6. A long, threaded rod or bolt. 7. A large, hollow cylindrical component. 8. A small washer or spacer. 9. A small pin or screw. The diagram shows the relative positions and assembly sequence of these parts.

# PRODUCT WARRANTY

- SELLER hereby warrants to CUSTOMER that the goods herein described will be free from any liens or encumbrances, that good title to said goods will be conveyed to CUSTOMER by sale of same.

SELLER warrants materials of its own manufacture against defects in material and workmanship under normal conditions of usage and service for one year from whichever of the following events occurs first:

- First use of the system
- Three (3) months following date of shipment from Vista.

Materials not manufactured by seller receive only such warranty, if any, of the manufacturer thereof and which are hereby assigned to CUSTOMER without recourse to SELLER.

SELLER'S obligation under this warranty is limited to and shall be fully discharged by repairing or replacing any defective part FOB its works. SELLER shall not be liable for repair or alterations made without SELLER's prior written approval; for membrane elements becoming plugged by suspended matter, precipitates, or biological growth; or failure to properly maintain the element. SELLER shall not be liable for damages or delays caused by defective material. Elements returned to SELLER for warranty examination must be shipped freight prepaid.

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