Pure Aqua, Inc.
Water Treatment and Reverse Osmosis Systems
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TW-36K-1580
130 m3/day Reverse Osmosis System
User Manual

IMPORTANT: *Anyone responsible for installation, maintenance, or operation of this equipment must have a thorough understanding of the instructions and safety requirements before attempting to install or service this unit.*

KEEP THIS MANUAL HANDY

May 2010

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SECTION 1
INTRODUCTION

1.1. HOW REVERSE OSMOSIS WORKS

Reverse Osmosis (RO) is the process in which water is forced by pressure through a semi-permeable membrane. Water passes through the membrane while the dissolved and particulate materials are left behind. When pressure is applied to the concentrated solution, water is forced through the membrane from the concentrated side to the dilute side.

1.2. FACTORS AFFECTING THE OPERATION AND THE USEFUL LIFE OF REVERSE OSMOSIS MEMBRANE

There are five main factors that affect RO membrane:

A: Pressure
B: Hydrolysis
C: Bacteria
D: Temperature
E: Surface Coating or Fouling

A. Excessive pressure tends to deform or compact the membrane. The compaction causes the membrane to become less porous, thus decreasing the amount of product water.

B. Hydrolysis is the effect of chemicals in the feed water on the membrane. In general, this happens when the water temperature is high and the pH is below 2.5 and above 7. For optimum life of the membrane, the pH should be between 5 and 6.

C. Bacteria, if allowed to grow on the membrane, will digest the top layer of the membrane and reduce the ability of the membrane to salt.

D. Temperatures above 95 °F are generally avoided because of problems in the membrane support structures and the accelerated compaction and hydrolysis rates. Membrane production rates will go up with higher temperatures and down with lower temperatures.

E. Surface coating or fouling is one of the most common problems with RO. It is the salts (calcium carbonate, etc.) that precipitate on the membrane. These salts plug the pores and channels, reducing the water production rate.

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1.3. SOME COMMON TERMS AND DEFINITIONS RELATED TO REVERSE OSMOSIS:

FEED WATER	:	The raw water introduced into the RO membrane
PRODUCT WATER	:	The pure water produced by the RO membrane
REJECT	:	The reject that will not pass through the RO membrane and is directed to drain.
MEMBRANE	:	Commonly referred to as the RO membrane without the pressure vessel
MODULE	:	Referred to as the complete RO membrane in the pressure vessel.
GPD (**G**allon/ Day)	:	This is the standard at which RO systems are sized. **Example:** 50,000 GPD. RO system will produce 50,000 gallons per day of pure water in a 24 hour period. Systems are generally sized for maximum amount of water used in the heaviest 24 hour period.
PPM (Parts per Million)	:	The method by which the quality of the RO product water is measured.
REJECTION	:	The amount of salts or chemicals rejected by the RO membrane.

1.4. EFFECT OF TEMPERATURE ON REVERSE OSMOSIS

In system design, it is also important to consider incoming water temperature. The units are rated for product flow at 77°F (25°C). The product flow will decrease about 1.8% for every degree below 77°F.

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SECTION 2

REVERSE OSMOSIS WATER TREATMENT

The application of RO to the solution of problems in water treatment requires an understanding of the basic mechanism involved in the process, the limitations of RO and the pretreatment requirements.

2.1) THE MEMBRANE

RO utilizes the unique properties of a semi-permeable membrane to allow fluid to pass while restricting the flow of dissolved ionic material. With pressure applied to impure water on one side of such membrane materials, pure water will pass through, leaving most of the impurities behind. The ion of the dissolved ionic material is a function of both molecular weight and ionic charge. For example, we can expect a nominal 90% ion of sodium concentration of salt approximately one-tenth that of the feed water. The ion of calcium carbonate (hardness) will be near 95%, while most metallic salts will be rejected at a rate of 98% to 99%.

The ion of non-ionic or organic material is primarily by mechanical filtration. Most substances with a molecular weight of over 100 will be completely rejected by an intact RO membrane. Low molecular weight organic matter, such as formaldehyde or phenol can pass freely through an RO membrane, as can most dissolved gasses. Oil, suspended solids and particulate matter are mechanically filtered, as are viruses, bacteria, pyrogen, and larger organic molecules.

To carry the rejected material away from the membrane surface, the feed side of the RO membrane is continually flushed with an excess flow, usually two to five times the product flow. This avoids clogging of the membrane surface and reduces the tendency toward scale formation.

2.2) THE REVERSE OSMOSIS SYSTEM

The RO system is composed of two major parts; the high-pressure pump and the membranes. The initial purified water production rate is measured at this pressure.

The system is carefully designed to make certain that minimum flow rates within the membranes are maintained. This factor is important to the efficient operation of the membrane. The reason for this is as follows: as pure water passes through the membrane under pressure, it leaves behind, at the membrane surface, a very high percentage of the dissolved substances originally present in the supply water. This “boundary layer” becomes more and more concentrated through the system. The membrane tends to a constant percentage of “what it sees.” For example, if the water in contact with the membrane is 500 parts per million (5%). At a different location in the membrane, the water in contact with membrane may be concentrated to 1,000 parts per million; and, at that point, the product water going through the membrane will be about 50 parts per million (5%) and so on. By maintaining sufficient feed flow movement around the membrane, this concentrated boundary layer

is possible. The other benefit of proper flow rates is that suspended matter tends to be carried out of the system more effectively.

For these reasons, the design flow rates should not be changed except in the "safe" direction. The "safe" direction in general is increasing the concentrate flow out of the system (but not to exceed the values specified for the particular membrane used).

It should be noted, as discussed previously, that the less we concentrate the supply water in the RO system, the better is the product water quality. In other words, the lower the water recovery at which we operate, the better the product water quality for outweighs the extra cost of water. An example of this is where RO water is to be deionized subsequently.

It appears that there are longer-term benefits to be gained by operating at lower percent water recovery, particularly in reducing maintenance to the systems, and minimizing precipitation problems that may arise due to operator error.

It is important to realize that the purified water from an RO system is delivered essentially at atmospheric pressure, usually to a vented storage tank. In general, it cannot be operated by opening and closing a valve in the produce water line (unless special pressure relief is provided). The reason for this is that the high pressure in the system drives the water across the membrane, and no flow of water would be possible if the pressure on both sides of the membrane were the same. If, for some reason, the product water line was closed while the system was operating, the pressure would build up. Of course, if the purified waterside of the system were strong enough, the pressure would end up the same as the pump pressure, but at that point no water would flow across the membrane! In real life, the plastic tubing on the product waterside normally would not tolerate such high pressure

The membranes are capable of taking 400 PSI of "forward" pressure, i.e., from the direction of the supply water side to the purified water side. However, they cannot tolerate "back" pressure, i.e., in the direction from the purified waterside to the supply waterside. The maximum back pressure should be no more than 3 or 4 feet head of water. In order to prevent damage to membranes from this source, a check valve is placed (in pressure tank applications) in the purified water line, so that when the system shuts down, back pressure is effectively sealed off. This safety should never be bypassed.

When an RO system is shut down, and the supply water is in a "resting" state over the membranes (i.e., almost no pressure across the membranes) the purified water, which bleeds through, tends to have about the same mineral content as the supply water. As a result, the first water sample obtained after start-up is higher in mineral content, until the system flushes out in a few seconds.

The quality of purified water produced by RO is roughly a constant percentage of the feed water. For example, if the feed water is entering at 3000 ppm the purified water may be about 150 ppm. (95% ion of dissolved minerals). When the feed water is entering at 40,000 ppm, the purified water would be from 350 to 450 ppm. Usually a conductance meter or "dissolved solids" meter is used to measure the mineral content.
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2.3) PURIFIED WATER STORAGE AND DELIVERY SYSTEM

As previously discussed the RO water is almost always delivered to a storage tank. Normally, such a storage tank is sized to provide sufficient water to cope with the number of hours of continuous use, e.g., 8 hours. In an exactly balanced system, the RO system would be running continuously; and it is capable of continuous duty. However, in practice, demand fluctuates, and the storage tank is usually provided with a high level switch which turns off the RO system when the tank is full.

The purified water in the storage tank is distributed to the use points by means of a moderate pressure, high capacity centrifugal pump. This pump can be provided with a demand pressure switch, which turns on the pump when it senses a drop in pressure (due to someone opening a faucet at the user point).
Alternatively it can be operated continuously, with a pressure relief system to recalculate water back to the tank, when there is no demand. Such distribution systems give very satisfactory service, because it avoids the detrimental, repetitive on-off condition for the pump motor. The pumps, however, must never be allowed to run dry, since this will rapidly deteriorate the shaft seal. To prevent this, the storage tank is fitted with a low level switch, which shuts down the distribution pump if the water level in the tank gets dangerously low.

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SECTION 3

PROCESS DESCRIPTION

This plant consists of a TWRO system with reject recycle feature. The plant is designed to deliver 34,600 GPD of permeate water at 65% recovery.

3 REVERSE OSMOSIS UNIT:

3.1 System feed water will pass through two cartridge filter in parallel arrangement where particles down to 5 micron size are removed. This is for the protection of the RO membranes and high-pressure pump.

3.2 The water pressure will then be boosted to approximately 123 psi by effect of the multi-stage centrifugal high-pressure pump (HPP). At the suction of the HPP, a low-pressure switch will be provided to protect the pump from running dry. A high-pressure switch at the discharge of the HPP will protect RO membranes from excessive operating pressure. HPP throttle valve at HPP discharge will regulate feed water flow to membrane elements.

3.3 The pressurized water will then feed the RO membrane pressure vessels. About 54% of the total feed will come out as RO permeate, while the other 46% will flow out to reject water outlet through the concentrate header. This recovery rate will improve by directing a portion of this reject flow to HPP feed. Recycled reject flow will replace part of raw water flow, and result recovery rate of 65%. Then remaining 35% will exit the system through reject control valve.

3.4 The total dissolved solid (TDS) of the RO permeate water will be monitored by a conductivity controller.

3.5 The permeate water from this single pass RO system will be collected in product storage tank (supplied by customer), where the water will be depressurized, and input from tank level switches will shut down the RO unit when the tank is full.

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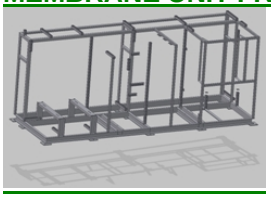
SECTION 4
COMPONENT IDENTIFICATION

The definition for this system is a single pass TWRO filtration system. The product water from RO system will be led to final storage tank for depressurizing and buffering for intermittent use. The following list will identify main components of this system.

4.1 TWRO SYSTEM COMPONENTS

This system will purify feed water with 257 ppm dissolved solids down to about 6 ppm. The concentrated reject water will be directed to waste. The permeate recovery rate will be 65% of feed water flow to the system.

4.1.1 MEMBRANE UNIT FRAME



The membrane unit is fully skid mounted on heavy duty structural steel. Fabricated and welded structure will receive media blasting and powder coating treatment prior the installation of system components.

4.1.2 FEED INLET SHUT OFF VALVE, 2" ELECTRICALLY OPERATED BALL VALVE (MBFV-421)

This valve is located at the entry side of the RO system. This valve will get a command from the main control panel, when to open and when to close.

4.1.3 PRE-POST FILTER PRESSURE GAUGES, 0-100 PSI (PG-472 & PG-473), PURE AQUA, INC.

These gauges will measure the water pressure before and after the cartridge pre-filters. The difference in the pressure readings between the two gauges will give the differential pressure across the cartridge pre-filters. When the differential pressure will exceed 15 PSI, the cartridges should be replaced.

4.1.4 GAUGE ISOLATION BALL VALVES, ¼" (BV-472 & BV-473), RYAN HERCO

These valves will isolate an instrument connection from process line for system service and diagnosis.

4.1.5 CARTRIDGE PRE-FILTER, 1-1/2" (CFH-401 & CHF-402), BIG BLUE

These filters will remove sediment from RO feed water down to 5 micron. Particles over 5 microns in size will harm high pressure pump and membranes. Filter housing will contain one 20" long filter element. Filter elements will be replaced by disconnecting the filter housing from filter base. This filter base will provide support for a complete filter assembly. The filter will be accessible for maintenance due to location near the edge of system skid frame. During operation, this filter will hold pressure equal to high pressure pump feed pressure. Before opening the filter housing, and to avoid damage to personnel and property, the system will be shut off and filter will be vented to atmosphere by opening line drain valve.

NOTE: Under no conditions should the inside core of the pre-filter cartridge become dirty.

4.1.6 LOW PRESSURE SWITCH (PSL-571), NASON

 This switch is located on the high-pressure pump suction. It will protect the high-pressure pump from running dry. When the feed water pressure will drop below 20 PSI, the contacts in this switch will open and shut down the RO unit. When feed water pressure will resume level more than 20 PSI, the RO unit will automatically restart. This switch is adjustable from 5-30 PSI. Recommended setting is 15-20 PSI.

CAUTION! Do not bypass this switch.

4.1.7 HIGH PRESSURE PUMP (P-501), GRUNDFOS CRN10-14

 This pump will provide boost for most of the necessary water flow to feed RO membranes, which will produce the required RO permeate flow. Flow volume and resulting pressure will be adjusted by the pump throttle valve, reject control valve and reject recycling valve.

CAUTION! Do not run pump dry-do not exceed the recommended operating pressure.

4.1.8 HIGH PRESSURE PUMP PRESSURE GAUGE, 0-350 PSI (PG-573), PURE AQUA, INC.

 This gauge will measure the pressure of water discharged from high pressure pump.

4.1.9 HIGH PRESSURE PUMP DISCHARGE THROTTLE VALVE (GV-511)

This valve will be located near high pressure pump discharge connection, and it will regulate water flow from high pressure pump discharge to membrane feed inlet. Valve will be opened by turning counterclockwise for more water flow and closed by turning clockwise for less water flow.

CAUTION! Do not close this valve completely, pump damage will result.

4.1.10 PRE-MEMBRANE PRESSURE GAUGE, 0-350 PSI (PG-671), PURE AQUA, INC.

This gauge will measure the pressure of water discharged from system high pressure pump discharge throttle valve. All this water will be entering to RO membranes.

4.1.11 HIGH PRESSURE SWITCH (PSH-572-1), NASON

This switch is located on the high-pressure pump discharge. It will protect the high-pressure pump and the system from working on a higher pressure. When feed water pressure will reach more than set pressure, the RO unit will automatically shut down. This switch is adjustable from 50-1000 PSI. Recommended setting is 300 PSI.

CAUTION! Do not bypass this switch.

4.1.12 RO MEMBRANE HOUSING, (PV-601), CODELINE 80A30-5

This is FRP housing rated for 300 PSI. Each contains five 8" RO membranes.

4.1.13 RO MEMBRANE, TOTAL 5 PCS, HYDRANAUTICS ESPA1

The RO membrane and how it operates is explained on Section 2 of this manual.

4.1.14 POST MEMBRANE PRESSURE GAUGE, 0-350 PSI (PG-674), PURE AQUA, INC.

This gauge will measure the pressure of reject water discharged from RO system membranes. All this water will be on the way either to drain or back to high pressure pump feed inlet.

4.1.15 HIGH PRESSURE REGULATING VALVE (GV-611)

This valve will control the flow of membrane reject to drain. This valve will be used for obtaining designed rate for system permeate recovery.

CAUTION! This control valve should never be closed completely.

Adjusting this valve is done by turning control knob located on the body of the valve. Turing clockwise will reduce the amount of reject and increase system pressure.

CAUTION! Do not exceed the maximum pressure setting recommended.

Turing counterclockwise will reduce the pressure in the membranes and increase the reject.

4.1.16 AUTO-FLUSH SOLENOID VALVE (SV-422)

This valve will open a by-pass path for otherwise rated flow of membrane reject through high pressure regulating valve to drain. This valve will be used for fluent membrane flush after system shut off.

4.1.17 REJECT FLOW METER (FI-652)

This flow meter will measure the amount of reject flow from RO system. Meter reading will be displayed at touch screen control panel. Reading of this meter is mandatory when determining the instant recovery rate of the system. Expected flow reading is about 20.6 gpm.

4.1.18 PERMEATE SAMPLE BALL VALVE, ¼"(BV-601), RYAN HERCO

This manual valve will provide RO permeate samples right after permeate will flow out of the permeate port of membrane housing.

4.1.19 CONDUCTIVITY MONITOR (CT-643), R & D

This meter will monitor product water quality. The monitor has an adjustable set point at PLC. When the conductivity reading will exceed the set point, the control touch screen will indicate an alarm.

4.1.20 PRODUCT FLOW METER (FI-651)

This flow meter will measure the amount of permeate flow from RO system. Meter reading will be displayed at touch screen control panel. Reading of this meter is mandatory when determining the instant recovery rate of the system. Expected flow reading is about 24 gpm.

4.1.21 RECYCLE REGULATING VALVE (GV-610)

This valve will open path of reject recycle flow to high pressure pump feed. Opening this valve will increase system recovery rate by reduction of wasted reject water.

4.1.22 RECYCLE FLOWMETER (FI-655)

This valve will measure reject recycle flow to high pressure pump feed. Expected flow reading is about 7.6 gpm.

4.1.23 RECYCLE CHECK VALVE, 3/4"(CKV-712), SPEARS

This valve is mounted at down flow from recycle flowmeter. Check valve will prevent feed water backflow to RO system reject drain.

4.1.24 CLEANING RETURN ISOLATING VALVE (BV-813)

This valve will open path for permeate return flow to cleaning tank if membrane cleaning will take place. Membrane cleaning will be possible with an optional cleaning system. This valve will also serve as a line drain during system maintenance.

4.1.25 PRODUCT WATER STORAGE TANK (TK-701), (BY CUSTOMER)

This tank will receive treated product water from TWRO system. This water will be depressurized and vented to atmosphere. This tank will house water level switches for control of RO system.

4.1.26 STORAGE TANK LEVEL SWITCHES (LSH-761 & LSHH-761), COMPAC

These switches will protect the RO system flooding the product water storage tank. When liquid level in the tank will rise too high, the water will lift the switch float, and an electrical signal will be sent to control panel. This will stop the RO system high pressure pump, and the system will be on hold until water level will drop below the lower level switch float, and then restart.

4.2 CONTROL SYSTEM COMPONENTS

This system is an integral part of TWRO system.

4.2.1 CONTROL PANEL (MICROPROCESSOR), R & D S-150

Control panel will come with NEMA 4 enclosure.

Controller, R & D S-150 (Please find attached user's manual): The process sequence, signals, alarms and time delays will be achieved by means of pre-design pre-set program. The settings of the time delays and process sequence can be adjusted.

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SECTION 5
INSTALLATION INSTRUCTIONS

A. INLET WATER SUPPLY

The connection of the feed water is 2" PVC Sch.80 material, flanged (ANSI #150 RF).

B. PRODUCT WATER OUTLET

The permeate outlet connection for the product water is 1.5” PVC Sch. 80 material, flanged (ANSI #150 RF).

C. REJECT OUTLET

The connection of the reject water is 1.5” PVC Sch. 80 material, flanged (ANSI #150 RF).

D. LINE VOLTAGE INLET

380VAC/3 Phase/50Hz

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SECTION 6
PRE-START CHECK LIST & START-UP

1. Raw water supply connected. Water declared contaminant free.
2. Rotation of every pump inspected and corrected.
3. Pre-filter cartridges in place.
4. System flooded, all the air vented from system, pumps primed.
5. Leak check performed, occurred leaks repaired.
6. Make sure to flood all piping before you start any high pressure pump. Never run any high pressure pump without water. Make sure to vent the high pressure pump.
7. Minimum inlet pressure 30 PSI
8. Control switch OFF
9. System is connected into proper electrical supply
10. Open reject valves about 3 turns from fully closed position
11. Reject and product piping connected to drain and storage tank
12. Level controls properly connected (also the ones supplied by customer)
13. All of the skids “or frames” must be grounded, “earthed”

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START-UP

Please refer to the system specification and microprocessor user's manual for more information

1. Do not start system until pre-start checklist is completed.

2. Turn RO system ON by pushing POWER key at system control keypad.

3. Time delay will activate, and unit should start after 5-15 seconds.

5. High Pressure Pump will start. Flowmeter (FI-652) will show 24 GPM reading; if not, adjust pump throttle valve (GV-611) and high pressure regulating valve (GV-611) until readings will stabilize.
This RO system is designed for 65% recovery

- Product water: 24 GPM
- Reject water: 20.6 GPM
- Recycle water: 7.6 GPM

6. System should now be running properly.

7. Product water PPM should take about 20 minutes to reach optimum quality.

8. Continue until some water will enter to product water storage tank.

NOTE: When High Pressure Pumps will start, immediately monitor high pressure gauge to insure that system does not exceed maximum pressure.

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SECTION 7
TROUBLE SHOOTING

SYMPTOM	PROBLEM CAUSE	SOLUTION
RO unit will not start	1- No electrical power to control circuit 2- Storage tank level full 3- On-Off switch 4- Coil in magnetic motor starter burned out 5- Low feed pressure 6- Pump / motor 7- Level control switch	1- Check power 2- Drain some water out of tank 3- Check or replace 4- Check or replace 5- Check feed pressure 6- Check or replace 7- Check or replace
Low feed pressure	1- Feed water valve turned off 2- Feed solenoid valve defective 3- Pre-filter clogged 4- Inlet water restriction 5- Low pressure switch defective 6- Upstream pre-treatment 7- Inlet water pressure	1- Check 2- Check or replace 3- Check or replace 4- Check 5- Check or replace 6- Check 7- Check
No high pressure	1- Reject valve open 2- Reject bypass open 3- High pressure gauge broken 4- Pump impellers worn 5- Low water volume to pump 6- Restriction in tubing to gauge	1- Check (adjust) 2- Check (adjust) 3- Check or replace 4- Check or replace 5- Check 6- Check or replace
No reject	1- Reject valve closed 2- Clogged drain line	1- Check / open 2- Check
No product water or low product water	1- Pump pressure low 2- Reject valve open too much 3- Membrane clogged 4- Water temperature low	1- Check / adjust 2- Check / adjust 3- Check /clean or replace 4- Check
High conductivity product water	1- PPM monitor defective...Probe defective 2- Low pump pressure 3- Membrane clogged or fouled 4-Clogged drain line	1- Check Adjust or replace 2- Check / adjust 3- Check clean or replace 4-Check

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SECTION 8

Pure Aqua, Inc.

MICROPROCESSOR CONTROLLER

USER'S MANUAL

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INTRODUCTION

The R & D Specialties Series 150 controller is a state of the art control system for commercial and industrial reverse osmosis systems. The Series 150 combines features that have not previously been available in one compact unit.

The Series 150 is a microprocessor controlled system that can monitor pressure and level switches. A TDS/Conductivity monitor/controller with programmable Setpoints is an integral part of the Series 150. The Series 150 displays system status and sensor and switch input status on an easy to read backlit display. User programmable Setpoints are provided that allow fast and easy adjustment of system parameters.

SPECIFICATIONS

Power:
120/240 VAC -15+10%, 50/60Hz, 25Watts

Environment:
-22°F to 140°F, 0-95% RH, noncondensing

Enclosure:
8" X 6" X 4" (203mm X 152mm X 102mm) NEMA 4X

Display:
2 line X 20 character, alphanumeric backlit LCD

Front Panel:
Overlay with LCD window, alarm lamp, 7 key membrane switch

Switch Inputs, Dry Contact:
Pressure fault
Pretreat lockout
Tank full high
Tank full low

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)

Cell:

Tds/Conductivity cell with digital display, standard range, 0-250PPM or uS. Other ranges available:0-50, 0-100, 0-500, 0-1000. Wetted parts ABS and 316SS, 3/4" NPT, 300 PSI max.

Optional I/O expander:

Auxiliary/divert relay	120/240VAC, 1HP
Divert/alarm relay	120/240VAC, 5A
Tank low switch input, dry contact	

FRONT PANEL CONTROLS AND INDICATORS

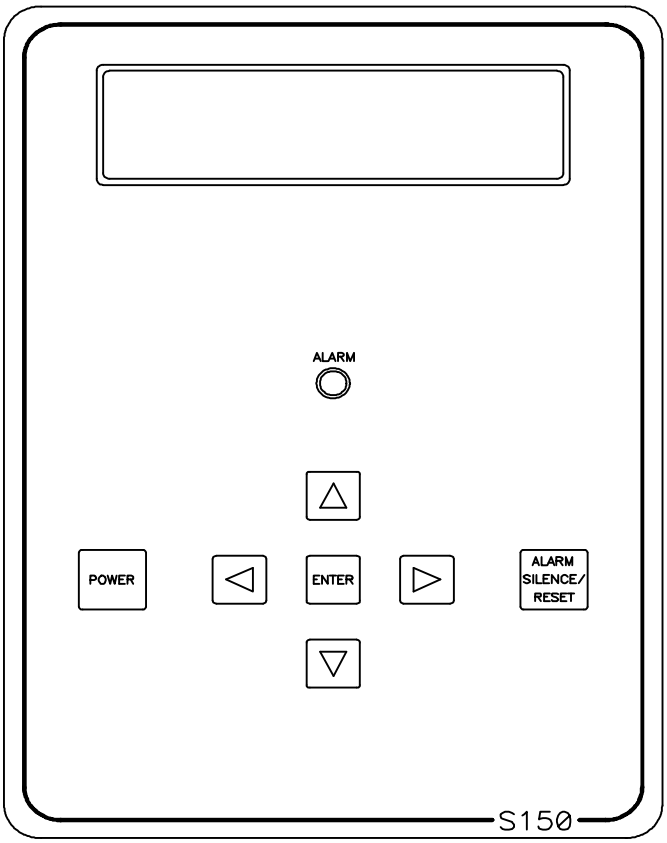

Figure 1

DISPLAY - Shows status of system.

ALARM LAMP - Flashes when fault causes an RO system shut down.
On steady when a Setpoint is exceeded that does not cause an RO system shut down.

POWER KEY - Places controller in operating or standby mode.

LEFT ARROW KEY - Scrolls through Setpoints starting with first Setpoint.

RIGHT ARROW KEY - Scrolls through Setpoints starting with last Setpoint.

UP ARROW KEY - Increases value of Setpoint.

DOWN ARROW KEY - Decreases value of Setpoint

ENTER KEY - Confirms entry of new Setpoint value

ALARM SILENCE/RESET KEY - Push once for alarm silence and twice to reset system after a shut down has occurred.

INSTALLATION

Physical Installation

Mount the Series 150 in a convenient location on the RO equipment using the four mounting ears provided with the unit or the optional panel mounting bracket.

NOTE: All terminals on the board are labeled.

Terminal Strip, Jumper and Adjustment Locations

Refer to figure 2 for the location of all terminal strips and connectors. Figure 2 also shows all jumper and adjustment locations. Figure 3 shows a sample wiring diagram.

Power Wiring

Refer to figure 2-3 for terminal strip and jumper locations. 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 P2 and P3 and a second wire jumper installed between P4 and P5. For 240VAC operation, a single wire jumper should be installed between P3 and P4.

AC power for the unit is connected to terminal strip P1. Connect the ground wire of the AC power to the terminal labeled GND. For AC power with a neutral and hot wire, the hot wire connects to L1 and the neutral wire connects to L2. For AC power with 2 hot wires, either wire can connect to L1 and L2. On AC power with 2 hot wires, the wire jumper between P6 and P7 should be removed and a fuse(GMA 1/4A) installed in F2.

Pump and Valve Relay Outputs

The Series 150 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 the L1 and L2 RO pump terminals of P1. This output can operate 120/240VAC motors up to 1HP directly. For motors larger than 1HP or 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 the L1 and L2 inlet terminals of P1. The flush valve connects to the L1 and L2 flush terminals of P1.

TDS/Conductivity Cell Wiring

For accurate TDS/Conductivity 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. Refer to figure 5 for example installation. The cell is connected with 5 wires to terminal strip P10. Connect each colored wire to the terminal labeled with the same color.

Switch Inputs

Switch inputs are connected to P9. 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. **NOTE:** Applying voltage to these terminals will damage the controller. The switches can be either normally open or normally closed in any combination. The switch connected to an input that is configured as normally open must be open for the unit to run. The switch connected to an input that is configured as normally closed must be closed for the unit to run. The Switch Select Setpoint allows each input to be configured as normally open or normally closed. The Switch Select Setpoint is defaulted to 0 which programs all inputs as normally open. Table 1 lists the values used to program the Setpoint to configure the inputs.

SWITCH	N.O.	N.C.	VALUE
PRESSURE FAULT	0	1	
PRETREAT	0	2	
TANK FULL HIGH	0	4	
TANK FULL LOW	0	8	
TANK LOW	0	16	
		TOTAL	

TABLE 1

Select the type of switch used for each input and put that number in the value column. Add the values and program the total in the Switch Select Setpoint. For example, if the pressure fault and tank low inputs were normally closed and all others normally open, the value programmed in the Switch Select Setpoint would be 17(1 + 16)

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 P9. 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 P9. 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

In systems with a single tank level switch for controlling the RO pump, the level switch connects to the tank full high input of P9. If dual level switches are used for controlling the RO pump, the upper level switch connects to the tank full high input of P9 and the lower level switch connects to the tank full low input of P9.

I/O Expander Board

If the optional I/O expander board is installed, 2 additional relay outputs and 1 additional switch input are provided. Refer to figure 4 for the location of terminal strips, jumpers and wiring for this board. AC power for the relays is connected to the L1 and L2 power terminals of P1. Relay 1 is connected to this power input and will supply the same voltage. This relay is rated for 120/240VAC at 1HP maximum. Relay 2 can be selected to supply voltage, 120/240, 5A maximum, or as a dry contact output. Jumpers J1-J4 are used to select the relay 2 output type. To output voltage, a wire jumper is installed between J1 and J4 and a second wire jumper is installed between J2 and J3. For a contact closure output, a single wire jumper is installed between J3 and J4. The 2 relay outputs can be selected to operate as an auxiliary pump output, a divert output or an alarm output by programming the Expander Mode Setpoint. Table 2 shows the values used to program the relay outputs.

EXPANDER MODE	RELAY 1	RELAY 2
0	AUXILIARY PUMP	DIVERT
1	AUXILIARY PUMP	ALARM
2	DIVERT	ALARM

TABLE 2

Auxiliary Pump

If the Expander Mode Setpoint is programmed to 0 or 1, relay 1 operates as an auxiliary pump output. This output always supplies the voltage applied to the power input and is energized when the tank low input is not active.

Divert Output

If the Expander Mode Setpoint is programmed to 0, relay 2 operates as a divert relay and will supply power whenever the unit is in the divert mode. If the Expander Mode Setpoint is programmed to 2, relay 1 operates as a divert relay and when in the divert mode, will supply voltage or provide a contact closure based on the position of jumpers J1-J4.

Alarm Output

If the Expander Mode Setpoint is programmed to 1 or 2, relay 2 operates as an alarm relay. When an alarm or warning is active, this relay will supply voltage or provide a contact closure based on the position of jumpers J1-J4.

Tank Low Switch

A tank low switch input can be connected to the tank low input of P2 on the expander board. This input will provide a tank low warning on the unit and if the expander is programmed to provide an auxiliary pump output, will provide low tank level protection for this pump.

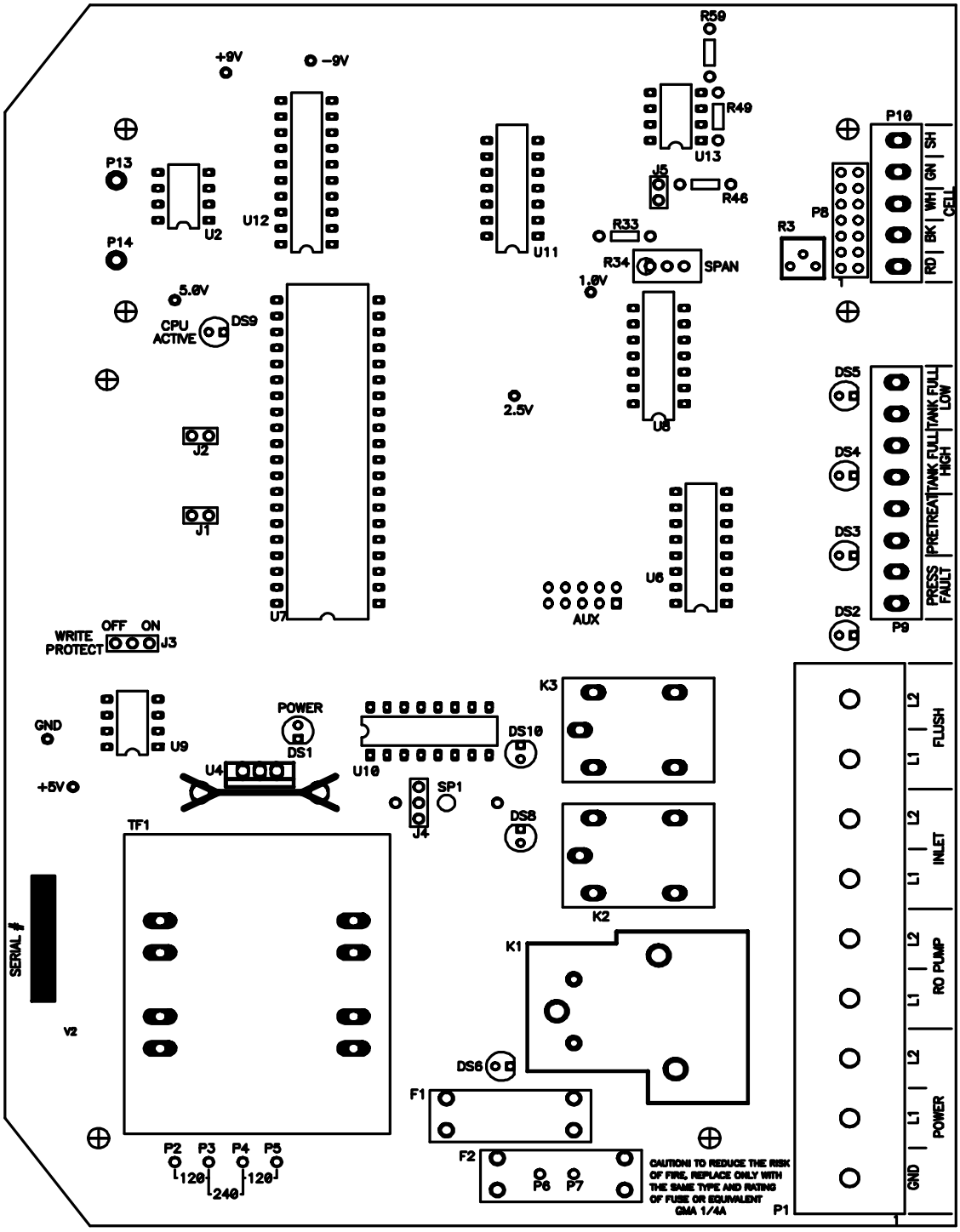
R59
+9V
-9V
R49
U13
P10
P13
U2
U12
U11
J5
R46
SH
GN
WH
BK
RD
CELL
P8
R3
P14
R33
R34
SPAN
1.8V
5.0V
CPU ACTIVE
DS9
U8
2.5V
DS5
DS4
DS3
DS2
TANK FULL LOW
TANK FULL HIGH
PRETREAT
PRESS FAULT
P9
J2
J1
U7
U6
AUX
WRITE PROTECT
OFF
ON
J3
GND
U9
POWER
DS1
U4
U10
DS10
K3
+5V
SP1
J4
DS8
TF1
K2
K1
SERIAL #
V2
DS6
F1
F2
P2
P3
P4
P5
120
240
120
P6
P7
CAUTION! TO REDUCE THE RISK OF FIRE, REPLACE ONLY WITH THE SAME TYPE AND RATING OF FUSE OR EQUIVALENT GMA 1/4A
P1
L2
L1
FLUSH
INLET
RO PUMP
POWER
GND

Figure 2

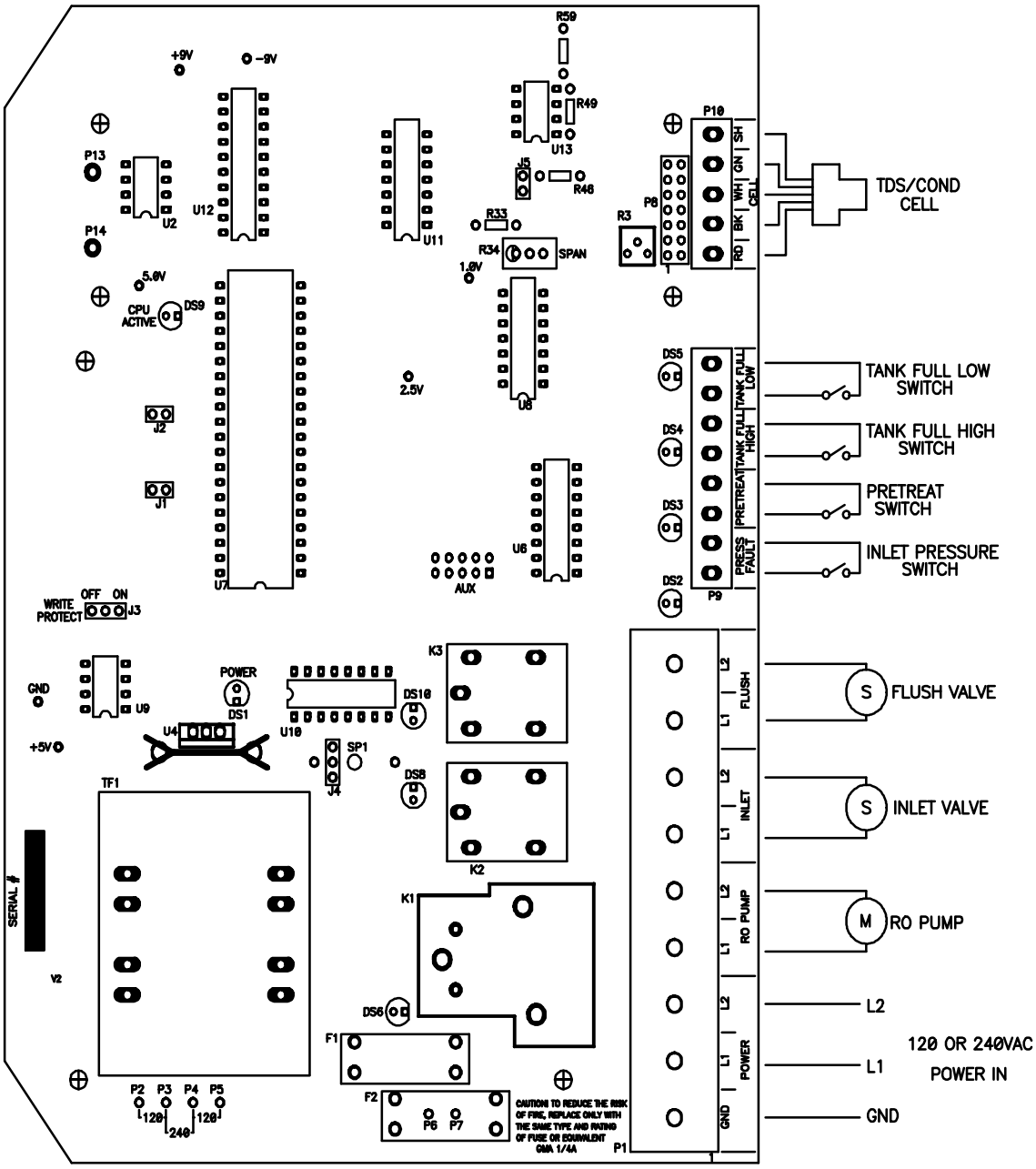
TDS/COND CELL
TANK FULL LOW SWITCH
TANK FULL HIGH SWITCH
PRETREAT SWITCH
INLET PRESSURE SWITCH
FLUSH VALVE
INLET VALVE
RO PUMP
L2
L1
120 OR 240VAC
POWER IN
GND

Figure 3

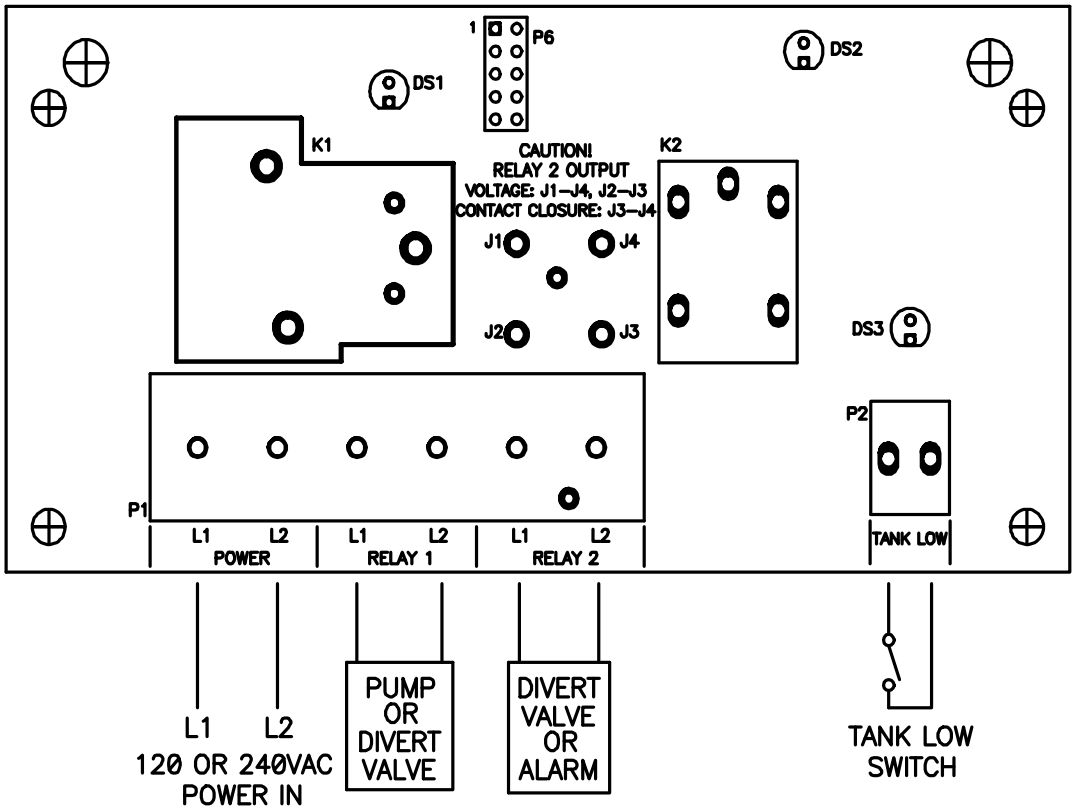

Figure 4

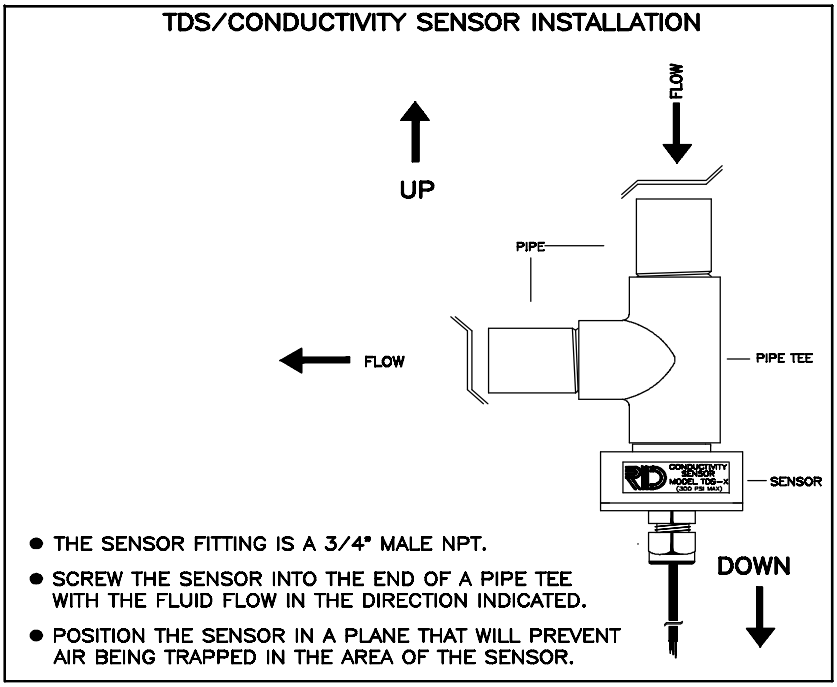

Figure 5

STANDARD SETPOINTS

SETPOINT	DESCRIPTION	RANGE	DEFAULT
TDS/Cond Limit	When this value is met or exceeded, the alarm lamp will light and high TDS/Cond will show on the display. To disable, set to 0.	0-999 uS or PPM	100
TDS/Cond Delay	When the limit Setpoint is exceeded, no alarm will be given until this time has expired.	0-999 seconds	30
RO Start Delay	The amount of time between the inlet valve opening and the RO pump start.	0-99 seconds	5
Press Fault Delay	The time a pressure fault must be active before a pressure fault shut down occurs.	0-99 seconds	5
Auto Reset	When a pressure fault shut down is active, the system will attempt to restart after this delay. If set to 0, system must be manually reset.	0-99 minutes	60
Alarm Silence	If the audible alarm is silenced, after this delay, the alarm will resound. If set to 0, the alarm will remain silenced.	0-99 minutes	0
TF Restart Delay	When a tank full condition clears, the system will restart after this delay.	0-99 sec/min	5
TF Restart	Selects whether the tank full restart delay is in seconds or minutes. 0=seconds, 1=minutes.	0-1	0
TFO Time	The amount of time that a tank full override lasts.	0-9 minutes	5
Tank Lo Restart	When a tank low condition clears, the auxiliary pump will restart after this delay.	0-99 Minutes	15
Flush Type	Selects the type of flush. Set to 0 to disable flush.	0-8	0
Flush Time	The length of time a membrane flush cycle will last when flush is active.	0-99 minutes	5

SETPOINT	DESCRIPTION	RANGE	DEFAULT
Flush Interval	The interval between flush cycles. Only valid with op hour, elapsed time or off flush types.	0-99 hours	24
Flush Mode	Selects if the inlet and RO pump relays operate during flush.	0-3	0
Maximum Hours	If the current operating hours exceed this limit, the operating hours warning will occur. To disable, set to 0.	0-65000 hours	0
Current Hours	Current number of hours of RO system operation.	0-65000	0
Expander Mode	Selects how the relays on the I/O expander board operate.	0-2	0
Temp Offset	Allows adjustment of temperature reading by +-5 degrees.	-5 - +50	
Temp UOM	Selects display of temperature in °F or °C	0-1	0
Switch Select	Selects if switch inputs are normally open or normally closed.	0-32	0
TDS/Cond UOM	Selects display of water quality in uS or PPM NOTE: If this Setpoint is changed, the unit must be recalibrated.	0-1	0
TDS/Cond Range	Selects range of TDS/Conductivity monitor 0-50, 1-100, 2-250, 3-500, 4-1000, 5-2500 6-5000 NOTE: If this Setpoint is changed, the unit must be recalibrated.	0-6	2

TO DISPLAY OR CHANGE SETPOINTS

1. Refer to figure 1 for the location of the keys used to display or change the Setpoints and figure 2 for the location of the write protect jumper, J3. For the unit to be able to accept a change in a Setpoint, the shorting jumper must be in the off position(center and left pins). **NOTE:** Setpoints cannot be changed if the write protect jumper is in the ON position.

2. Use the Left and Right arrow keys to display the Setpoints. Each press of an arrow key will advance the display to the next Setpoint. The Left arrow key starts with the beginning Setpoint and the Right arrow key starts with the last Setpoint.

3. The Up and Down arrow keys are used to increment or decrement the Setpoint value. The value will change by 1 count each time a key is pressed. If the key is pressed and held for ~1 second, the Setpoint value will change at a fast rate. When the key is released, the fast rate will be reset. Pressing both the Up and Down arrow keys together will reset the Setpoint value to 0.

4. Pressing the Alarm Silence/Reset key at any time will cancel the operation and return the display to the main screen.

5. To accept the new Setpoint value, press the Enter key.

6. The unit will beep twice if the change is accepted. If the write protect jumper is on, the unit will show WRITE PROTECTED on the display and one long beep will sound.

7. When finished changing Setpoints, the write protect jumper should be placed in the on position(center and right pins).

SYSTEM 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 STANDBY. 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.

Display

The display is a 2 line x 20 character backlit liquid crystal display. System operating status and sensor readings are shown on this display. Setpoint information is also shown on this display.

Operating Status Messages

The operating status of the unit is shown on the top line of the display. The following list describes the items shown for the operating status.

STANDBY - The unit is in the standby mode.

DELAY 99 - The unit is in the RO start delay. The number is the seconds remaining before the RO pump starts.

OPERATING - The RO unit is operating.

TANK FULL - The unit is shut down due to a tank full condition.

TANK FULL 99 - The unit is shut down due to a tank full condition. If the number is blinking, the tank full high switch has cleared, but the tank full low switch is still active. If the number is on steady, both tank level switches have cleared and the delay is counting down.

PRETREAT - The unit is shut down due to a pretreat lockout condition.

PRESS FAULT - The unit is shut down due to a pressure fault condition.

MEMB FLUSH 99 - Membrane flush is active. The number is the minutes remaining in the flush cycle.

TDS/Conductivity

The TDS/Conductivity is shown on the top line after the unit operating status. When the unit is offline because of a shut down condition, the reading is replaced with ›----: If the reading is over range, the reading is shown as ›^^^^:.

Operating Hours

The current operating hours are shown on the bottom line.

Temperature

The current water temperature is shown on the bottom line after the operating hours. When the unit is offline because of a shut down condition, the reading is replaced with ›---=.

Warning Messages

Warning messages are also shown on the second line. If any warnings are active, the active warnings will alternate with the normal displays for the bottom line. The following lists the warning messages.

HI TDS/COND - The TDS/Conductivity reading has exceeded the programmed limit.

TANK LOW - The tank low input is active.

TANK LOW 99 - The tank low input has cleared, but the tank low restart delay is active. The number is the minutes left in the delay.

OP HOURS EXCEEDED - The current operating hours have exceeded the programmed limit.

Tank Full Operation

The unit can be operated with 1 or 2 level switches. With 1 level switch, the switch is connected to the tank full high input. When this switch has been active for 5 seconds, the unit will shut down on tank full. TANK FULL will show on the display. When the tank full condition clears, the display will show TANK FULL 99. The number is the tank full restart time and the unit will restart when this delay times out.

For 2 level switch operation, the upper switch is connected to the tank full high 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. TANK FULL will show on the display. When the tank level drops and the upper level switch clears, the display will show TANK FULL 99 and the RO unit will remain off. The number is the tank full restart time and the number will blink until the lower level switch clears. When the lower level switch clears, the number will remain steady and the RO will restart when the delay times out.

Tank Full Restart

The tank full restart is the delay before the RO unit starts when a tank full condition clears. This delay can be in minutes or in seconds. The TF Restart Setpoint selects seconds or minutes.

Tank Full Override

A timed tank full override can be initiated when the RO unit is shut down due to a tank full condition. Pressing the Alarm Silence/Reset key for 3 seconds during a tank full condition will enable the tank full override. The RO will start and TF OVERRIDE 9 will show on the display. The number is the minutes remaining in the override timer. When the override times out, the unit will return to the tank full shut down condition.

Pressure Fault

If the pressure fault input becomes active and stays active for the delay programmed in the PF Delay Setpoint, the unit will shut down for a pressure fault. The display will show PRESS FAULT, the alarm lamp will flash and the audible alarm will sound. The pressure fault can be cleared by pressing the Alarm Silence/Reset key twice.

Auto Reset

If a pressure fault shut down occurs and the Auto Reset Setpoint is programmed to 0, the unit will remain shut down until manually reset. If the Auto Reset Setpoint is programmed to a value greater than 0, the unit will automatically clear the pressure fault and attempt to restart after this delay times out.

Alarm Silence

When a shut down occurs that causes the audible alarm to sound, the alarm can be silenced by pressing the Alarm Silence/Reset key once. The alarm will remain silenced if the Alarm Silence Setpoint is programmed to 0. If the Alarm Silence Setpoint is programmed to a value greater than 0, the alarm will resound after this delay times out. Pressing the Alarm Silence/Reset key will silence the alarm and reset this delay.

Pretreat

If the pretreat input becomes active and stays active for 2 seconds, the unit will shut down in a pretreat lockout condition. PRETREAT will show on the display and the unit will remain shut down as long as the pretreat input is active.

Membrane Flush

If the Flush Type Setpoint is programmed to 0, flush is disabled. If membrane flush is desired, several types of flush are available. When the unit enters a flush cycle, the flush relay will activate. The flush cycle will last for the time programmed in the Flush Time Setpoint. Table 3 shows the value that must be programmed in the Flush Type Setpoint for each type of flush.

FLUSH TYPE	DESCRIPTION
0	NO FLUSH
1	TANK FULL
2	OPERATING HOURS
3	OPERATING HOURS AND TANK FULL
4	ELAPSED TIME
5	ELAPSED TIME AND TANK FULL
6	OFF HOURS
7	OFF HOURS AND TANK FULL
8	RO START/STOP

TABLE 3

TANK FULL - The RO unit will flush each time a tank full condition occurs.

OPERATING HOURS - A flush will occur when the RO pump has operated for the number of hours programmed in the Flush Interval Setpoint.

ELAPSED TIME - A flush will occur after the number of hours programmed in the Flush Interval Setpoint has passed.

OFF HOURS - A flush will occur when the RO has been shut down due to a tank full condition for the number of hours programmed in the Flush Interval Setpoint.

RO START/STOP - A flush will occur each time the RO starts or stops.

The tank full flush can be combined with any of the 3 interval flush types. A manual flush can be initiated by pressing the Alarm Silence/Reset key for 3 seconds.

Flush Mode

The Flush Mode Setpoint can be used to control the operation of the inlet valve and RO pump during flush. Each can be independently programmed to operate during flush. Table 4 shows the values to program into the Flush Mode Setpoint to control the operation of the inlet and RO outputs during flush.

FLUSH MODE	RO PUMP	INLET VALVE
0	OFF	CLOSED
1	OFF	OPEN
2	ON	CLOSED
3	ON	OPEN

TABLE 4

High TDS/Conductivity

If the TDS/Conductivity reading exceeds the limit programmed the TDS/ Cond Limit Setpoint for the delay programmed in the TDS/Cond Delay Setpoint, the alarm lamp will light and the HI TDS/COND warning message will show on the display. This warning will clear when the TDS/Conductivity drops below the Setpoint.

Operating Hours Exceeded

If the current hours exceed the limit programmed in the Maximum Hours Setpoint, the alarm lamp will light and the OP HOURS EXCEEDED warning message will be shown. This warning can be cleared by programming the current hours to 0 or by increasing the maximum hours limit.

I/O Expander

The I/O Expander board adds 2 relays and 1 switch input. The operation and programming of the 2 relays is described in the installation section.

Auxiliary Output

Relay 1 can be used to control a repressurization pump when relay 1 of the expander board is configured to operate an aux relay. In this mode, this relay will be energized as long as the tank low input is not active. When energized, the relay supplies power to the repressurization pump.

Tank Low

When the tank low input has been active for 5 seconds, the auxiliary output will turn off. The alarm lamp will light and the TANK LOW warning message will show on the display. When the tank low condition clears, the TANK LOW 99 warning message is displayed. The number is the delay in minutes before the auxiliary relay will energize.

Divert Output

When relay 1 or relay 2 has been programmed to operate as a divert relay, the relay will energize when the TDS/Conductivity exceeds the TDS/Cond Limit Setpoint. This will occur as soon as the reading exceeds the limit, there is no delay. When the reading drops below the limit and stays below the limit continuously for 5 seconds, the divert relay will turn off.

Alarm Output

When relay 2 has been programmed to operate as an alarm relay, the relay will energize whenever a warning or alarm condition occurs. The relay will remain energized as long as the warning/alarm condition is active.

ADJUSTMENTS

TDS/Conductivity Calibration

Refer to figure 2 for adjustment location. To calibrate the TDS/Conductivity, place the cell in a known standard solution. Adjust the span adjustment for the correct reading. If the cell is installed, the unit can be calibrated by taking a sample of the permeate water and testing it with a known, good meter. Adjust the span control until the reading matches the meter.

Display Adjustment

The display contrast can be adjusted for best viewing by adjusting control R3. This control is located toward the upper right corner of the board, just to the left of the cell connector.

TROUBLESHOOTING

CAUTION: Hazardous voltages are present when power is applied to the unit. Care should be taken when troubleshooting any of the input power or output circuits. When disconnecting or connecting any board or accessory, be sure power is turned off at the disconnect.

Before contacting R & D Specialties for technical help, verify the programming of all Setpoints, check the display and check the status of all lights and indicators. The more information available when you contact us, the easier it will be to determine the source of the problem. NOTE: Phone support is only available from 8AM to 5PM Central Standard Time, -6 GMT.

System Inoperative

Is the yellow CPU active LED blinking? If no, is the green power LED, DS1 Lit? If no, is the fuse OK? If no, replace the fuse. If yes, with a voltmeter, verify power is applied to the power terminals L1 and L2. If power is applied to the power terminals and the above checks are OK, the board is probably defective and should be replaced. If no power is applied to the board, check the power wiring to the system.

Display Blank

Is the green power LED, DS1 lit? If no, refer to the system inoperative section. If yes, is the CPU active LED, DS9 blinking? If no, replace the board. If yes, adjust the display contrast adjustment, R3. Is the display still blank? If yes, replace the board.

Inlet Valve Will Not Operate

Is the system in standby? If no, are any shut down conditions active? If no, is the inlet LED, DS8 lit? If no, replace the board. If yes, with a voltmeter, verify if there is power on the inlet terminals. Is there power? If no, replace the board. If yes, check the valve and wiring.

RO Pump Will Not Operate

Is the system in standby? If no, are any shut down conditions active? If no, is the RO LED, DS6 lit?
If no, replace the board. If yes, with a voltmeter, verify if there is power on the RO pump terminals. Is there power? If no, replace the board. If yes, check the pump and wiring.

Unit Not Flushing or Not Flushing Correctly

Verify that flush is enabled and what type of flush is selected. Is flush enabled? If no, enable flush. If yes, press the Alarm Silence /Reset key for 3 seconds. Does the unit show flush on the display? If no, replace the board. If yes, is the flush LED, DS10 lit. If no, replace the board. If yes, with a voltmeter, verify if there is power on the flush terminals. Is there power? If no, replace the board. If yes, check the valve and wiring.

No or Incorrect TDS/Conductivity Reading

Is sensor wired correctly? If no, correct wiring. If yes, is sensor installed as described in the installation section? If no, install correctly. If yes, verify correct TDS/Conductivity range. Range correct? If no, correct range. If yes, calibrate unit. Does unit calibrate OK? If no, disconnect green and white wires of sensor. 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 cell. If yes, short pins of cell together. Does reading show ›^^^=? If no, replace board.

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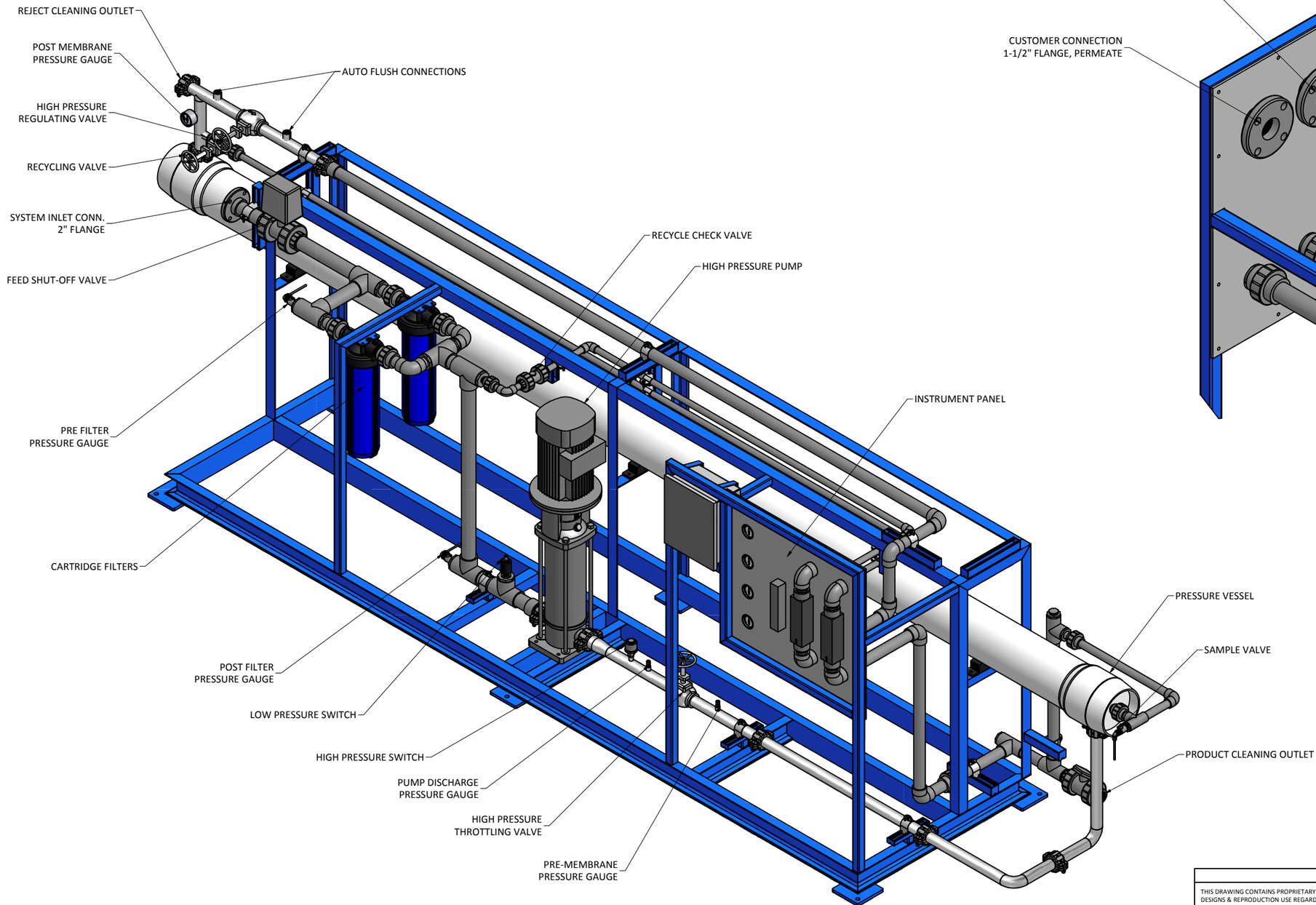
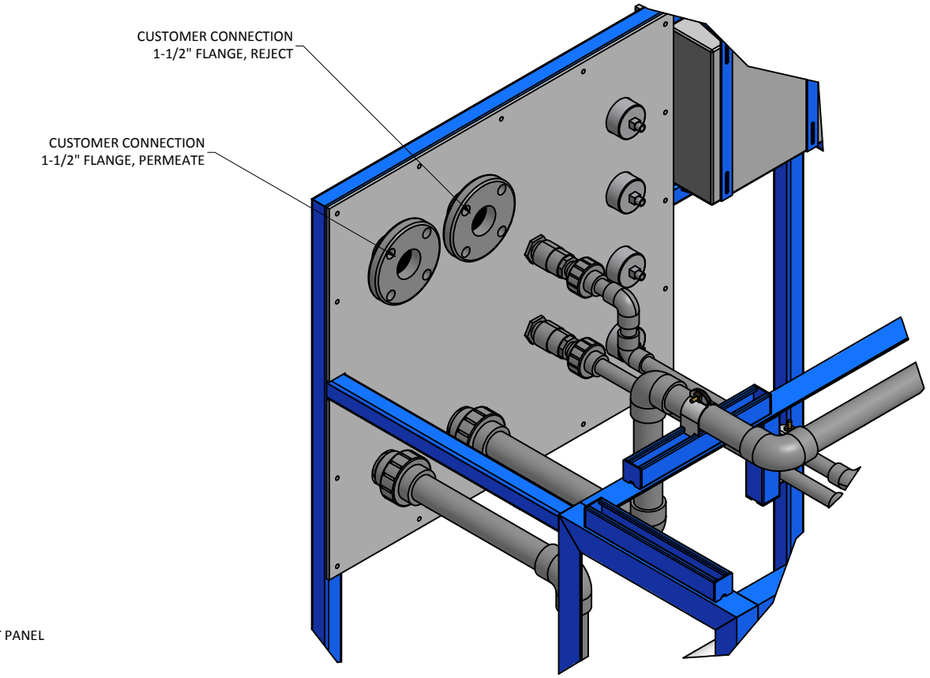
sales@pureaqua.com, www.pure-aqua.com

SECTION 9

DRAWINGS





BACK PANEL VIEW

FABRICATION DRAWING

Pure Aqua, Inc.
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Santa Ana, CA 92704 USA
Phone: (714) 432-9996
Fax: (714) 432-9898
www.pure-aqua.com

TITLE:	BRACKISH WATER REVERSE OSMOSIS
PROJECT:	TW-36K-1580
CUSTOMER:	VIGI SARL

DRAWN:	REVIEWED:	VERIFIED:	VALIDATED:	DWG NO.:	REVISION
A. KHATIB				VIGI-GA	
DATE: 12/24/2009	DATE:	DATE:	DATE:	JOB NO.:	SHEET: 1 OF 2

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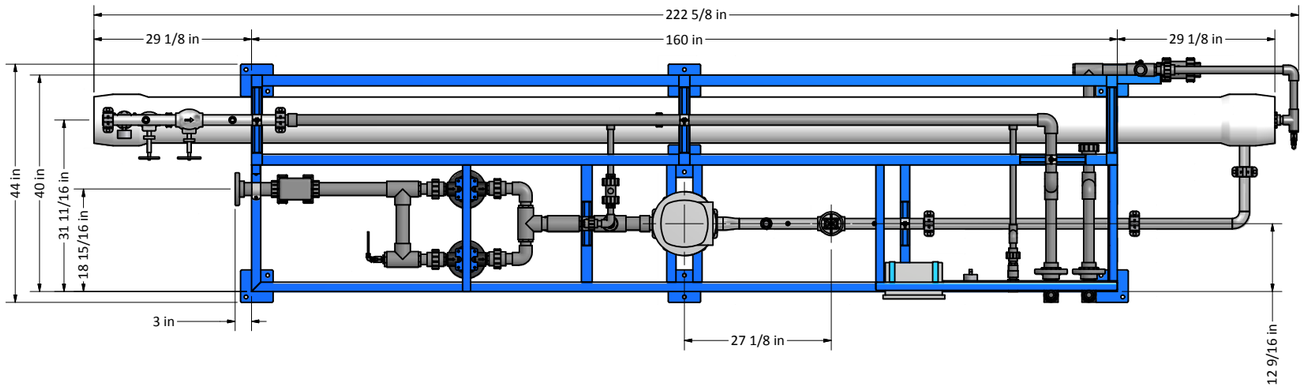
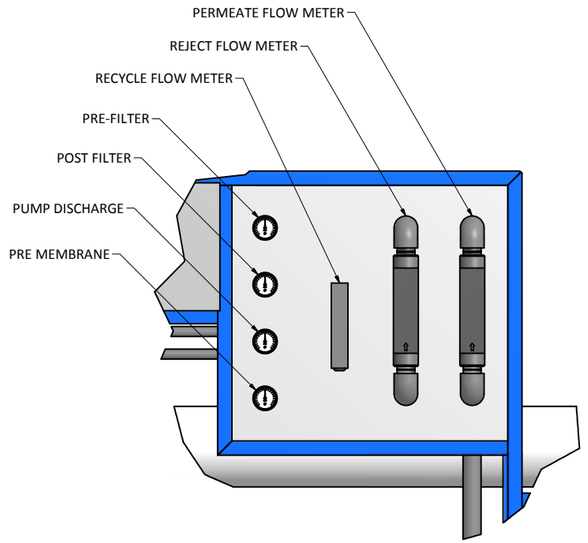
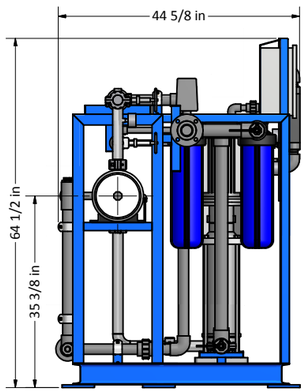
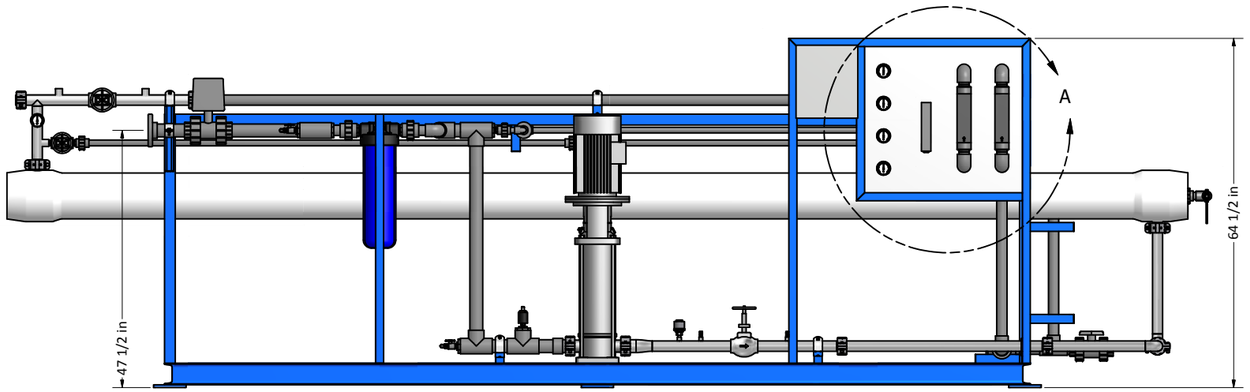
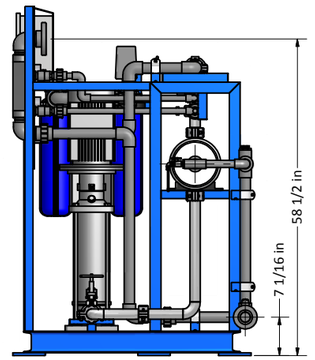




DETAIL A







FABRICATION DRAWING

Pure Aqua, Inc.
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TITLE: BRACKISH WATER REVERSE OSMOSIS

PROJECT: TW-36K-1580

CUSTOMER: VIGI SARL

DRAWN: A. KHATIB	REVIEWED:	VERIFIED:	VALIDATED:	DWG NO.: VIGI-GA	REVISION
DATE: 12/24/2009	DATE:	DATE:	DATE:	JOB NO.:	SHEET: 2 OF 2

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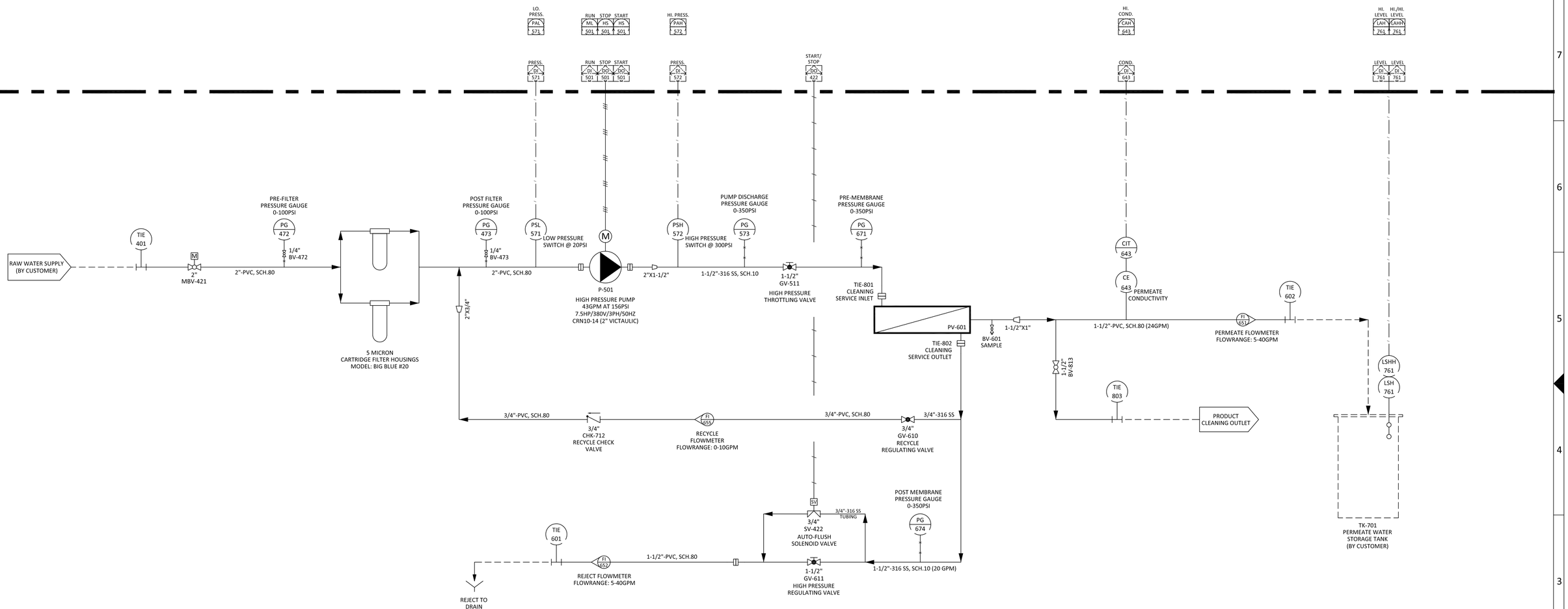
REVERSE OSMOSIS SYSTEM

1 PRESSURE VESSEL (300 PSI)
3 ELEMENTS LONG (55% RECOVERY)



SERVICE CONNECTIONS:

TIE	DESCRIPTION	CONNECTION TYPE	MATERIAL
401	SYSTEM FEED INLET	2"-FLANGE, ANSI 150#	PVC, SCH.80
402	CARTRIDGE FILTER DIRTY DRAIN	1/2" FNPT	PVC, SCH.80
403	CARTRIDGE FILTER CLEAN DRAIN	1/2" FNPT	PVC, SCH.80
601	RO REJECT OUTLET TO DRAIN	1-1/2"-FLANGE, ANSI 150#	PVC, SCH.80
602	R.O. PERMEATE OUTLET	1-1/2"-FLANGE, ANSI 150#	PVC, SCH.80
801	CLEANING SERVICE INLET	1-1/2"-VICTAULIC	S.S.
802	REJECT CLEANING OUTLET	1-1/2"-VICTAULIC	S.S.
803	PRODUCT CLEANING OUTLET	1-1/2"-SOCKET/FNPT	PVC, SCH.80

LETTER	DATE	DESCRIPTION	DRAWN
A			
0			

REVISION BLOCK

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SANTA ANA, CA 92704 USA
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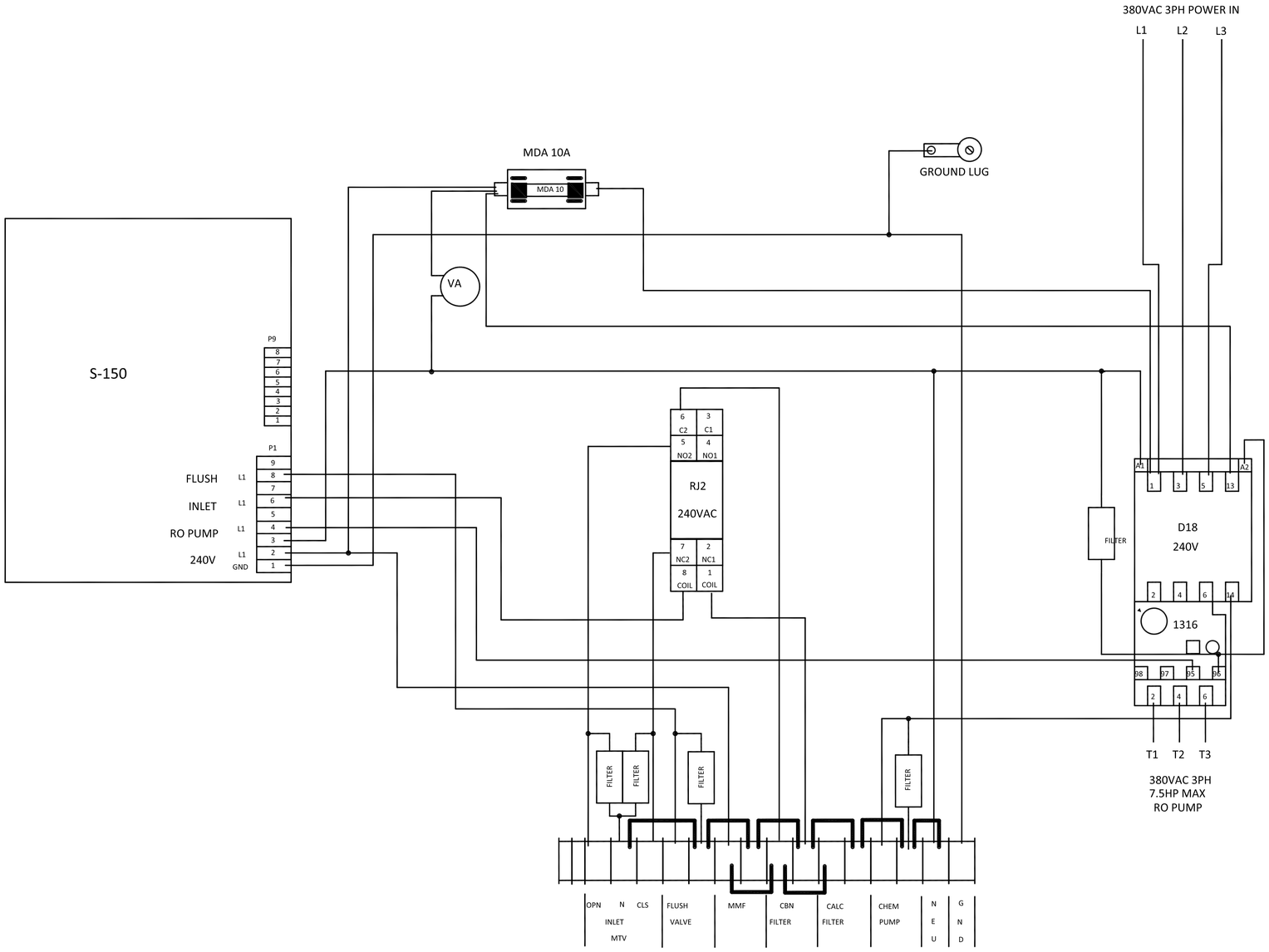
www.pure-aqua.com

TITLE: PROCESS & INSTRUMENTATION DIAGRAM (P&ID)

PROJECT: TW-36K-1580
BRACKISH WATER REVERSE OSMOSIS SYSTEM

CUSTOMER: VIGI SARL

DRAWN:	REVIEWED:	VERIFIED:	VALIDATED:	DWG NO.:	SCALE:	REVISION
A. KHATIB				VIGI-PID-01	NONE	0
DATE: 1/4/10	DATE:	DATE:	DATE:	JOB NO.:	SHEET: 1 OF 1	



NOTE: OUTPUTS 220VAC
10A. MAXIMUM TOTAL LOAD

LETTER	DATE	DESCRIPTION	DRAWN
A			
0			

REVISION BLOCK

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SANTA ANA, CA 92704 USA
Tel: (714) 432-9996
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TITLE: ELECTRICAL DIAGRAM

PROJECT: TW-36K-1580
BRACKISH WATER REVERSE OSMOSIS SYSTEM

CUSTOMER: VIGI SARL

DRAWN	REVIEWED	VERIFIED	VALIDATED	DWG NO.	SCALE	REVISION
K. BROWN	P. SIPPU			VIGI-EE-01	NONE	0
DATE: 1/4/10	DATE: 5/18/10	DATE:	DATE:	JOB NO.:	SHEET: 1 OF 1	

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SECTION 10

BROCHURES & CATALOGS & RECOMMENDED SPARE PARTS LIST

Pure Aqua, Inc.

Water Treatment and Reverse Osmosis Systems

Spare Parts and Consumable for Two (2) Years' Operation of One System

1.0 High Pressure Pump CRN10-14

- Shaft Seal Kit 96511844
- Stack Kit 96491731
- Wear Parts Kit 96511922
- Gasket Kit 96509609

2.0 Cartridge Filters

- Filter Cartridge
  Five-micron cartridge element PA-205B
  Two years supply 48 elements

4.0 Instruments

- Pressure Gauge, 0-100psi Pure Aqua PG-100-PA
- Pressure Gauge, 0-350psi Pure Aqua PG-350-PA
- Conductivity Sensor R & D 80TDS150R1-10
- Low Pressure Switch Nason CJ-U1C2-15G/HM
- High Pressure Switch Nason CD-U1C5-300J/HR

5.0 Miscellaneous

- ¼" Sample Valve, Ryan Herco 5053.608
- Tank level switch, Compac 10-782-PP
- One – can of PVC solvent cement
- One – can of PVC cement primer
- One (1) lot pipe flange gasket for each size

8.0 BW Membrane Housing 80A30-5

- Victaulic Coupling Gasket, 1.5"
- Head Seal 45321
- Adapter Seal 52245
- Permeate Port Seal 45342
- Adapter 50161
- Membrane Hydranautics ESPA1

CR, CRI, CRN, CRT

Installation and operating instructions

US

LIMITED WARRANTY

Products manufactured by GRUNDFOS PUMPS CORPORATION (Grundfos) are warranted to the original user only to be free of defects in material and workmanship for a period of 24 months from date of installation, but not more than 30 months from date of manufacture. Grundfos' liability under this warranty shall be limited to repairing or replacing at Grundfos' option, without charge, F.O.B. Grundfos' factory or authorized service station, any product of Grundfos' manufacture. Grundfos will not be liable for any costs of removal, installation, transportation, or any other charges which may arise in connection with a warranty claim. Products which are sold but not manufactured by Grundfos are subject to the warranty provided by the manufacturer of said products and not by Grundfos' warranty. Grundfos will not be liable for damage or wear to products caused by abnormal operating conditions, accident, abuse, misuse, unauthorized alteration or repair, or if the product was not installed in accordance with Grundfos' printed installation and operating instructions.

To obtain service under this warranty, the defective product must be returned to the distributor or dealer of Grundfos' products from which it was purchased together with proof of purchase and installation date, failure date, and supporting installation data. Unless otherwise provided, the distributor or dealer will contact Grundfos or an authorized service station for instructions. Any defective product to be returned to Grundfos or a service station must be sent freight prepaid; documentation supporting the warranty claim and/or a Return Material Authorization must be included if so instructed.

GRUNDFOS WILL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, LOSSES, OR EXPENSES ARISING FROM INSTALLATION, USE, OR ANY OTHER CAUSES. THERE ARE NO EXPRESS OR IMPLIED WARRANTIES, INCLUDING MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, WHICH EXTEND BEYOND THOSE WARRANTIES DESCRIBED OR REFERRED TO ABOVE.

Some jurisdictions do not allow the exclusion or limitation of incidental or consequential damages and some jurisdictions do not allow limit actions on how long implied warranties may last. Therefore, the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights and you may also have other rights which vary from jurisdiction to jurisdiction.

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Warning

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

Warning

Shock Hazard: A faulty motor or wiring can cause electrical shock that could be fatal, whether touched directly or conducted through standing water. For this reason, proper grounding of the pump to the power supply's grounding terminal is required for safe installation and operation.

In all installations, the above-ground metal plumbing should be connected to the power supply ground as described in Article 250-80 of the National Electrical Code.

1. General

The CR range is based on the inline multistage centrifugal pump first pioneered by Grundfos. CR is available in four basic materials and over one million configurations. CR is suitable for pumping water and water-like liquids in industry, petrochemical, water treatment, commercial buildings, and many other applications. Some of CR's outstanding characteristics are:

- superior efficiency
- reliability
- ease of maintenance
- compact size and small footprint
- quiet operation.

2. Shipment inspection

Examine the components carefully to make sure no damage has occurred to the pump during shipment. Care should be taken to ensure the pump is NOT dropped or mishandled.

2.1 Ensure you have the right pump

Read the pump nameplate to make sure that it is the one you ordered.

- **CR**
  Centrifugal pump with standard cast iron and 304 stainless steel construction
- **CRI**
  Centrifugal pump; all parts in contact with water are 304 stainless steel construction
- **CRN**
  Centrifugal pump; all parts in contact with water are 316 stainless steel construction
- **CRT**
  Centrifugal pump; all parts in contact with water are titanium construction
- **CRE**
  Centrifugal pump with a Grundfos MLE VFD motor attached.

2.2 Checking the condition of the pump

The shipping carton in which your pump arrived is specially designed around your pump during production to prevent damage during shipment. As a precaution, the pump should remain in the carton until you are ready to install it. Examine the pump for any damage that may have occurred during shipping. Examine any other parts of the shipment as well for any visible damage.

Note: If the pump is shipped as a complete unit (motor attached to pump end), the position of the coupling (that connects the pump shaft to the motor shaft) is set at factory specifications. No adjustment is required. If the unit is delivered as a pump end only, follow the adjustment procedures in the section on replacing the motor.

Pump without Motor (CR(I)(N) 1s, 1, 3, 5, 10, 15, and 20 Only): If you purchased a pump without a motor, the shaft seal has been set by the factory. Do not loosen the three set screws on the shaft seal when attaching the motor.

Pump without Motor (CR(N) 32, 45, 64, 90, 120, and 150 Only): If you purchased a pump without a motor, you must install the seal. The seal is protected in its own sub boxing within the pump packaging crate. To protect the shaft and bearings during shipment, a shaft holder protective device is used. This device must be removed prior to installation of the seal. Read the seal installation instructions which are included in the pump package.

2.3 Verifying electrical requirements

Verification of the electrical supply should be made to be certain the voltage, phase and frequency match that of the pump motor. The proper operating voltage and other electrical information can be found on the motor nameplate. These motors are designed to run on –10 % / + 10 % of the nameplate-rated voltage. For dual-voltage motors, the motor should be internally connected to operate on the voltage closest to the 10% rating, i.e., a 208 voltage motor wired per the 208 volt connection diagram. The wiring connection diagram can be found on either a plate attached to the motor or on a diagram inside the terminal box cover. If voltage variations are larger than –10 % / + 10 %, do not operate the pump.

US

US

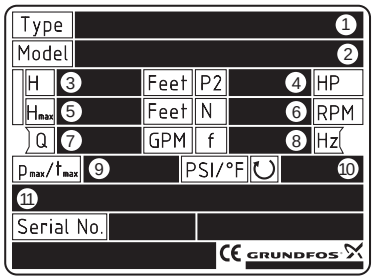
3. Understanding nameplate data

Type key
CR, CRI, CRN 1s, 1, 3, 5, 10, 15, and 20

Example

Type range: CR, CRI, **CR 3 -10 A FG A E HQQE**

- Rated flow rate in [m^3/h] (x 5 gpm) — **3**
- Number of impellers — **-10**
- Code for pump version — **A**
- Code for pipe connection — **FG**
- Code for materials — **A**
- Code for rubber parts — **E**
- Code for shaft seal — **HQQE**



TM04 3895 0309

1. Type designation
2. Model, material number, production number
3. Head in feet at nominal flow
4. Nominal motor hp
5. Head at zero flow
6. Rated rpm
7. Nominal flow
8. Rated frequency
9. Maximum pressure and maximum fluid temperature
10. Direction of rotation
11. Production country

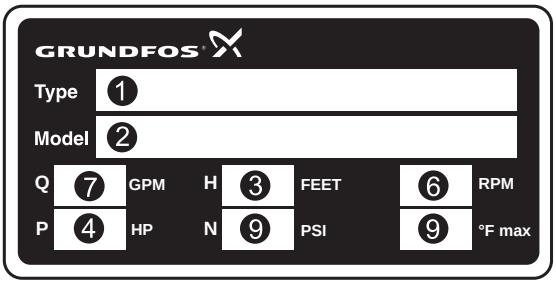
Fig. 1 Nameplate

CRT 2, 4, 8, and 16

Example

Type range: **CRT 16 -30 /2 U G A AUUE**

- CRT
- Rated flow rate in [m^3/h] (x 5 gpm) — **16**
- Number of stages x 10 — **-30**
- Code for impellers (used only if the pump has fewer impellers than stages) — **/2**
- Code for pump version — **U**
- Code for pipe connection — **G**
- Code for materials — **A**
- Code for shaft seal and rubber parts — **AUUE**



TM04 3894 0309

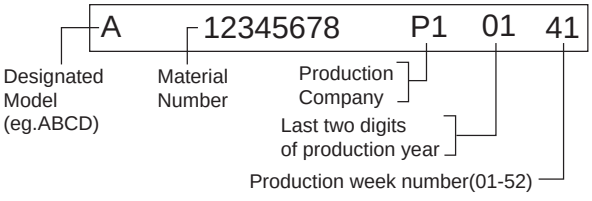
Fig. 2 Nameplate

CR, CRN 32, 45, 64, 90, 120, and 150

Example

Type CR, CRN: **C 32 -2 -1 U G A E KUBE**

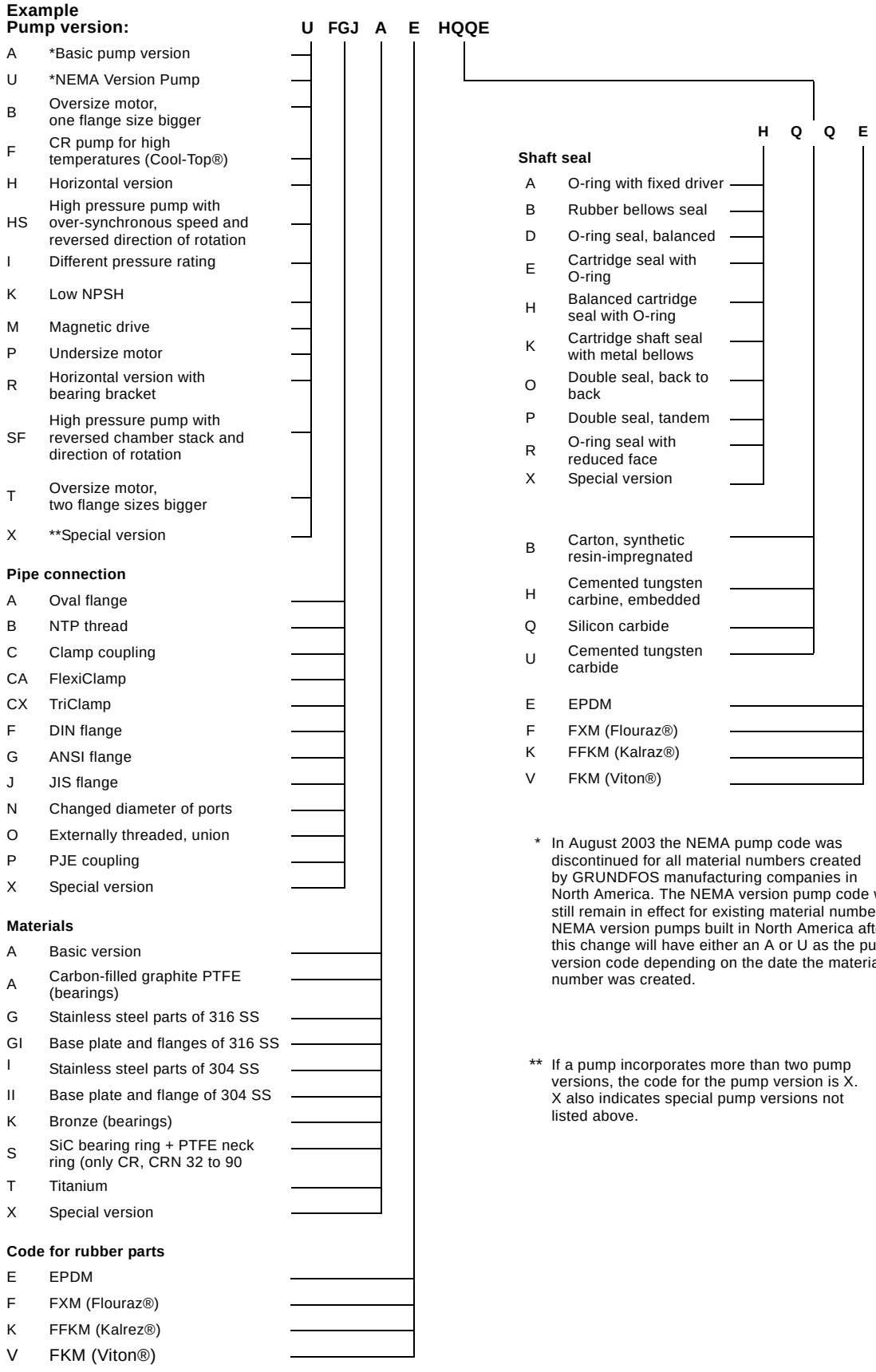
- Rated flow rate in [m^3/h] (x 5 gpm) — **32**
- Number of impellers — **-2**
- Number of reduced diameter impellers — **-1**
- Code for pump version — **U**
- Code for pipe connection — **G**
- Code for materials — **A**
- Code for rubber pump parts — **E**
- Code for shaft seal — **KUBE**



TM04 3904 0409

Fig. 3 Model key

3.1 Understanding codes



* In August 2003 the NEMA pump code was discontinued for all material numbers created by GRUNDFOS manufacturing companies in North America. The NEMA version pump code will still remain in effect for existing material numbers. NEMA version pumps built in North America after this change will have either an A or U as the pump version code depending on the date the material number was created.

** If a pump incorporates more than two pump versions, the code for the pump version is X. X also indicates special pump versions not listed above.

US

US

4. Confirming proper application

Compare the pump's nameplate data or its performance curve with the application in which you plan to install it. Will it perform the way you want it to perform? Also, make sure the application falls within the following limits.

Type	Designed to pump
CR	Hot and chilled water, boiler feed, condensate return, glycols and solar thermal fluids.
CRI/CRN	Deionized, demineralized and distilled water. Brackish water and other liquids unsuitable for contact with iron or copper alloys. (Consult manufacturer for specific liquid compatibilities.)
CRN-SF	High pressure washdown, reverse osmosis, or other high pressure applications.
CRT	Salt water, chloride based fluids and fluids approved for titanium.

5. Checking operating conditions

5.1 Fluid temperatures

Pump	Fluid Temperatures
CR(I)(N) 1s, 3, 5, 10, 15, and 20	–4 to +248 °F (–20 to +120 °C)
*CR(N) 32, 45, 64, and 90	–22 to +248 °F (–30 to +120 °C)
*CR(N) 120 and 150 (up to 60 hp)	–22 to +248 °F (–30 to +120 °C)
CR(N) 120 and 150 (75 and 100 hp)	+32 to +248 °F (0 to +120 °C)
CRT 2, 4, 8, 16	–4 to +248 °F (–20 to +120 °C)
CRN-SF	–4 to +221 °F (–15 to +105 °C)
with Cool-Top™	up to +356 °F (+180 °C)

All motors are designed for continuous duty in +104 °F (+40 °C) ambient air conditions. For higher ambient temperature conditions consult Grundfos.

* xUBE Shaft Seals are recommended for temperatures above +200 °F. Pumps with hybrid shaft KUHE seals can only operate up to +200 °F (+90 °C). Pumps with xUUE shaft seals can be operated down to –40 °F (–40 °C) (where "x" is the seal type).

5.2 Minimum inlet pressures

All CR, CRI, CRN	NPSHR + 2 feet
CRN-SF	29 psi (2 bar)

5.3 Maximum inlet pressures

Pump Type/ Connection	50 Hz Stages	60 Hz Stages	Max. psi/bar
CR, CRI, CRN 1s	2 to 36	2 to 36	145 / 10
		27	217 / 15
CR, CRI, CRN 1	2 to 36	2 to 36	145 / 10
		27	217 / 15
CR, CRI, CRN 3	2 to 29	2 to 15	145 / 10
	31 to 36	17 to 25	217 / 15
CR, CRI, CRN 5	3 to 16	2 to 9	145 / 10
	18 to 36	10 to 24	217 / 15
CR, CRI, CRN 10	1 to 6	1 to 5	116 / 8
	7 to 22	6 to 18	145 / 10
CR, CRI, CRN 15	1 to 3	1 to 2	116 / 8
	4 to 17	3 to 12	145 / 10
CR, CRI, CRN 20	1 to 3	1	116 / 8
	4 to 17	2 to 10	145 / 10
CR, CRN 32	1-1 to 4	1-1 to 2	58 / 4
	5-2 to 10	3-2 to 6	145 / 10
	11 to 14	7-2 to 11-2	217 / 15
CR, CRN 45	1-1 to 2	1-1 to 1	58 / 4
	3-2 to 5	2-2 to 3	145 / 10
	6-2 to 13-2	4-2 to 8-1	217 / 15
CR, CRN 64	1-1 to 2-2	1-1	58 / 4
	2-1 to 4-2	1 to 2-1	145 / 10
	4-1 to 8-1	2 to 5-2	217 / 15
CR, CRN 90	1-1 to 1		58 / 4
	2-2 to 3-2	1-1 to 1	145 / 10
	3 to 6	2-2 to 4-1	217 / 15
CR, CRN 120	1 to 2-1	1-1 to 1	145 / 10
	2 to 5-1	2-2 to 3	217 / 15
	6-1 to 7	4-1 to 5-2	290 / 20
CR, CRN 150	1-1 to 1	1-1	145 / 10
	2-1 to 4-1	1 to 2	217 / 15
	5-2 to 6	3-2 to 4-2	290 / 20
CRT 2	2 to 11	2 to 6	145 / 10
	13 to 26	7 to 18	217 / 15
CRT 4	1 to 12	1 to 7	145 / 10
	14 to 22	8 to 16	217 / 15
CRT 8	1 to 20	1 to 16	145 / 10
CRT 16	2 to 16	2 to 10	145 / 10
CRN-SF	all	all	72 / 5*
			362 / 25**

* while pump is off or during start-up

** during operation

5.4 Maximum operating pressures

at +250 °F (194 °F for CRN-SF)

Pump type/ connection	50 Hz stages	60 Hz stages	Max. psi/bar
CR, CRI, CRN 1s			
Oval flange	1 to 23	1 to 17	232 / 16
FGJ, PJE	1 to 36	1 to 27	362 / 25
CR, CRI, CRN 1			
Oval flange	1 to 23	1 to 17	232 / 16
FGJ, PJE	1 to 36	1 to 27	362 / 25
CR, CRI, CRN 3			
Oval flange	1 to 23	1 to 17	232 / 16
FGJ, PJE	1 to 36	1 to 27	362 / 25
CR, CRI, CRN 5			
Oval flange	1 to 22	1 to 16	232 / 16
FGJ, PJE	1 to 36	1 to 24	362 / 25
CR, CRI 10			
Oval flange CR		1 to 6	145 / 10
Oval flange, CRI	1 to 16	1 to 10	232 / 16
FGJ, GJ, PJE	1 to 16	1 to 10	232 / 16
FGJ, GJ, PJE	17 to 22	12 to 17	362 / 25
CRN 10			
All	1 to 22	1 to 17	362 / 25
CR, CRI 15			
Oval flange	1 to 7	1 to 5	145 / 10
FGJ, GJ, PJE	1 to 10	1 to 8	232 / 16
FGJ, GJ, PJE	12 to 17	9 to 12	362 / 25
CRN 15			
All	1 to 17	1 to 12	362 / 25
CR, CRI 20			
Oval flange	1 to 7	1 to 5	145 / 10
FGJ, GJ, PJE	1 to 10	1 to 7	232 / 16
FGJ, GJ, PJE	12 to 17	8 to 10	362 / 25
CRN 20			
All	1 to 17	1 to 10	362 / 25
CR, CRN 32			
	1-1 to 7	1-1 to 5	232 / 16
	8-2 to 14	6-2 to 11-2	435 / 30
CR, CRN 45			
	1-1 to 5	1-1 to 4-2	232 / 16
	6-2 to 13-2	4-2 to 8-1	435 / 30
CR, CRN 64			
	1-1 to 5	1-1 to 3	232 / 16
	6-2 to 8-1	4-2 to 5-2	435 / 30
CR, CRN 90			
	1-1 to 4	1-1 to 3	232 / 16
	5-2 to 6	4-2 to 4-1	435 / 30
CR, CRN 120			
		1-1 to 3	232 / 16
	1-1 to 5-2	4-2 to 5-2	435 / 30
CR, CRN 150			
		1-1 to 3	232 / 16
	1-1 to 4-2	4-1 to 4-2	435 / 30
CRT 2	2 to 26	2 to 18	305 / 21
CRT 4	1 to 22	1 to 16	305 / 21
CRT 8	1 to 12	1 to 8	232 / 16
	14 to 20	10 to 16	362 / 25
CRT 16	1 to 8	1 to 8	232 / 16
	10 to 16	10 to 12	362 / 25

Consult Grundfos for other working conditions.

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6. Installing the pump

Warning

Do not energize pump until properly installed.

6.1 Pump location

The pump should be located in a dry, well-ventilated area which is not subject to freezing or extreme variation in temperature.

Care must be taken to ensure the pump is mounted at least 6 inches (150 mm) clear of any obstruction or hot surfaces.

The motor requires an adequate air supply to prevent overheating and adequate vertical space to remove the motor for repair.

For open systems requiring suction lift the pump should be located as close to the water source as possible to reduce piping losses.

6.2 Foundation

Concrete or similar foundation material should be used to provide a secure, stable mounting base for the pump.

See table of bolt hole center line dimensions for the various pump types.

Secure the pump to the foundation using all four bolts and shim pump base to assure the pump is vertical and all four pads on the base are properly supported (uneven surfaces can result in pump base breakage when mounting bolts are tightened).

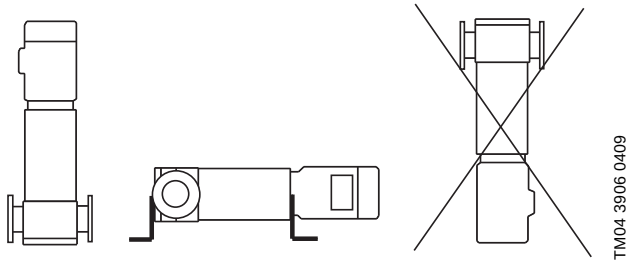


Fig. 4 Pump position

The pump can be installed vertically or horizontally; see fig. 4.

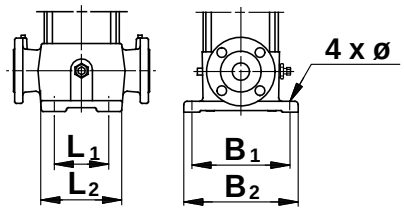
Ensure that an adequate supply of cool air reaches the motor cooling fan. The motor must never fall below the horizontal plane.

Arrows on the pump base show the direction of flow of liquid through the pump.

To minimize possible noise from the pump, it is advisable to fit expansion joints on either side of the pump and anti-vibration mountings between the foundation and the pump.

Note: Care should be taken to ensure that the vent plug is located in the uppermost position.

Isolating valves should be fitted either side of the pump to avoid draining the system if the pump needs to be cleaned, repaired or replaced.



Pump type	L1		L2		B1		B2		ø	
	in	mm	in	mm	in	mm	in	mm	in	mm
CR 1s, 1, 3, 5	3 15/16	100	5 11/16	145	7 1/16	180	8 11/16	220	1/2	13
CRI, CRN 1s 1, 3, 5	3 15/16	100	5 7/8	150	7 1/16	180	8 11/16	220	1/2	13
CR 10, 15, 20	5 1/8	130	6 15/16	176	8 7/16	215	10 1/16	256	9/16	13.5
CRN 10, 15, 20	5 1/8	130	7 7/8	200	8 7/16	215	9 3/4	248	1/2	13
CR 32	6 11/16	170	8 3/4	223	9 7/16	240	11 3/4	298	9/16	14
CRN 32	6 11/16	170	8 7/8	226	9 7/16	240	11 3/4	298	9/16	14
CR 45,64	7 1/2	190	9 3/4	248	10 1/2	266	13 1/16	331	9/16	14
CRN 45,64	7 1/2	190	9 7/8	251	10 1/2	266	13 1/16	331	9/16	14
CR(N) 90	7 13/16	199	10 1/4	261	11	280	13 11/16	348	9/16	14
CR(N) 120, 150	10 13/16	275	13 9/16	344	14 15/16	380	18 9/16	472	11/16	18

6.3 Pump mounting

Warning

CR, CRI, CRN pumps are shipped with covered suction and discharge. The covers must be removed before the final pipe flange to pump connections are made.

6.3.1 Recommended installation torques

Model	Recommended foundation torque (ft - lbs)	Recommended flange torque (ft - lbs)
CR, CRI, CRN 1s/1/3/5, and CRT 2/4	30	37 - 44
CR, CRI, CRN 10/15/20, and CRT 8/16	37	44 - 52
CR, CRN 32/45/64/90/ 120/150	52	52 - 59

6.4 Suction pipe

The suction pipe should be adequately sized and run as straight and short as possible to keep friction losses to a minimum (minimum of four pipe diameters straight run prior to the suction flange). Avoid using unnecessary fittings, valves or accessory items. Butterfly or gate valves should only be used in the suction line when it is necessary to isolate a pump because of a flooded suction condition. This would occur if the water source is above the pump; see fig. 5 and fig. 6. Flush piping prior to pump installation to remove loose debris.

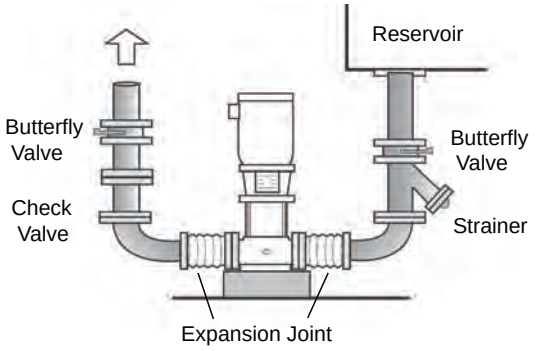


Fig. 5 Flooded suction

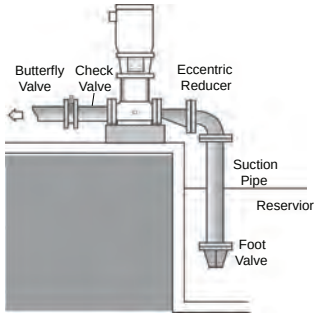


Fig. 6 Suction lift*

*The suction pipe should have a fitting on it for priming. CRN-SF pumps cannot be used for suction lift.

6.5 Minimum suction pipe sizes

The following recommended suction pipe sizes are the smallest sizes which should be used with any specific CR pump type.

The suction pipe size should be verified with each installation to ensure good pipe practices are being observed and excess friction losses are not encountered.

High temperatures may require larger diameter pipes to reduce friction and improve NPHSA.

Model	Min. suction pipe size	
CR(I)(N) 1s, 1, 3; CRT 2	1"	Nominal diameter sch 40 pipe
CR(I)(N) 5; CRT 4	1-1/4"	Nominal diameter sch 40 pipe
CR(I)(N) 10, 15, 20; CRT 8, 16	2"	Nominal diameter sch 40 pipe
CR(N) 32	2-1/2"	Nominal diameter sch 40 pipe
CR(N) 45	3"	Nominal diameter sch 40 pipe
CR(N) 64, 90	4"	Nominal diameter sch 40 pipe
CR(N) 120, 150	5"	Nominal diameter sch 40 pipe

6.6 Discharge piping

It is suggested that a check valve and isolation valve be installed in the discharge pipe.

Pipe, valves and fittings should be at least the same diameter as the discharge pipe or sized in accordance with good piping practices to reduce excessive fluid velocities and pipe friction losses.

Note: Pipe, valves and fittings must have a pressure rating equal to or greater than the maximum system pressure.

Before the pump is installed it is recommended that the discharge piping be pressure checked to at least the maximum pressure the pump is capable of generating or as required by codes or local regulations.

Whenever possible, avoid high pressure loss fittings, such as elbows or branch tees directly on either side of the pump. The piping should be adequately supported to reduce thermal and mechanical stresses on the pump.

Good installation practice recommends the system be thoroughly cleaned and flushed of all foreign materials and sediment prior to pump installation. Furthermore, the pump should never be installed at the lowest point of the system due to the natural accumulation of dirt and sediment. If there is excessive sediment or suspended particles present, it is advised a strainer or filter be used. Grundfos recommends that pressure gauges be installed on inlet and discharge flanges or in pipes to check pump and system performance.

Warning

To avoid problems with waterhammer, fast closing valves must not be used in CRN-SF applications.

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6.7 Bypass orifice

A bypass should be installed in the discharge pipe if there is any possibility the pump may operate against a closed valve in the discharge line. Flow through the pump is required to ensure adequate cooling and lubrication of the pump is maintained. See *6.9 Minimum continuous duty flow rates* for minimum flow rates.

Elbows should be a minimum of 12” from the orifice discharge to prevent erosion.

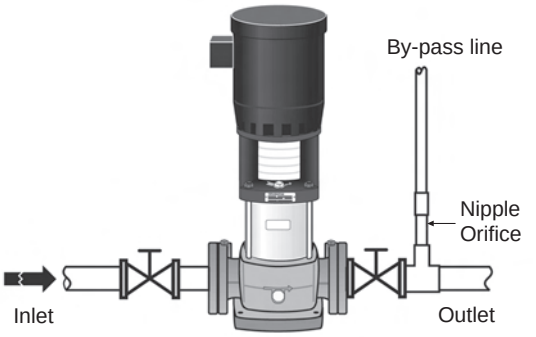


Fig. 7 Recommended bypass arrangement

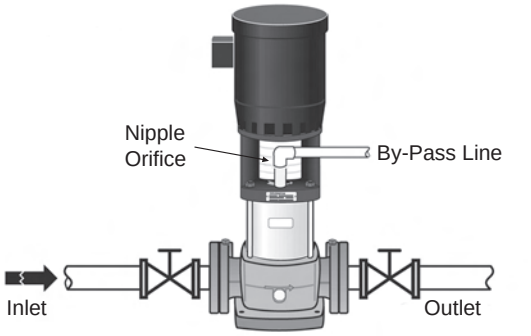


Fig. 8 Optional bypass arrangement

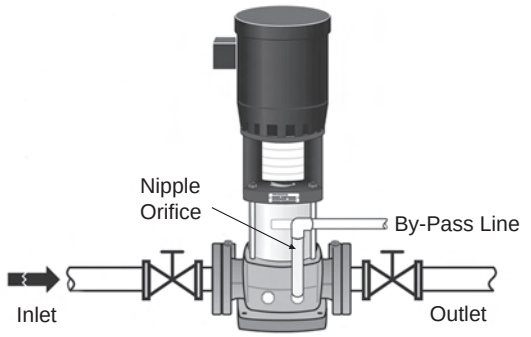
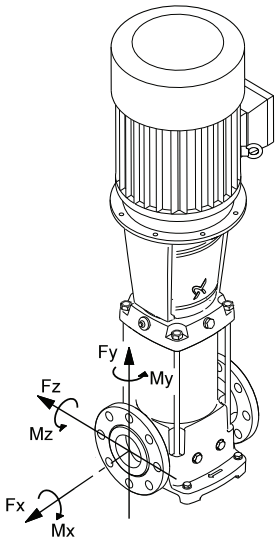


Fig. 9 Optional bypass arrangement for CR(N) 32, 45, 64, and CR 90, 120, and 150 only

6.8 Nozzle loads

If not all loads reach the maximum permissible value stated in the forces and moments tables included here with fig. 10, one of these values may exceed the normal limit. Contact Grundfos for further information.



Y-direction: Direction of chamber stack
Z-direction: 90 ° from inlet/outlet
X-direction: Inlet/outlet

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Fig. 10 Nozzle forces and moments

Flange	CR, CRI, CRN	Forces		
		Y-direction [lb]	Z-direction [lb]	X-direction [lb]
1-1/4"	1s to 5	171	263	175
2"	10, 15 and 20	303	371	337
2-1/2"	32	382	466	422
3"	45	461	562	506
4"	64 and 90	607	753	674
5" & 6"	120 and 150	607	753	674

Flange	CR, CRI, CRN	Moments		
		Y-direction [ft-lb]	Z-direction [ft-lb]	X-direction [ft-lb]
1-1/4"	1s to 5	605	715	900
2"	10, 15 and 20	738	848	1,033
2-1/2"	32	793	904	1,106
3"	45	848	959	1,180
4"	64 and 90	922	1,069	1,291
5" & 6"	120 and 150	922	1,069	1,291

6.9 Minimum continuous duty flow rates

Pump Type	min °F to 176 °F (min °C to 80 °C)	at 210°F (at 99°C)	at 248°F (at 120°C)	at 356°F (at 180°C)
CR, CRI, CRN 1s	0.5	0.7	1.2	1.2*
CR, CRI, CRN 1	0.9	1.3	2.3	2.3*
CR, CRI, CRN 3	1.6	2.4	4.0	4.0*
CR, CRI, CRN 5	3.0	4.5	7.5	7.5*
CR, CRI, CRN 10	5.5	8.3	14	14*
CR, CRI, CRN 15	9.5	14	24	24*
CR, CRI, CRN 20	11	17	28	28*
CR, CRN 32	14	21	35	35*
CR, CRN 45	22	33	55	55*
CR, CRN 64	34	51	85	85*
CR, CRN 90	44	66	110	110*
CR, CRN 120	60	90	N/A	N/A
CR, CRN 150	75	115	N/A	N/A
CRT 2	1.3	2.0	3.3	N/A
CRT 4	3.0	4.5	7.5	N/A
CRT 8	4.0	6.0	10	N/A
CRT 16	8.0	0.7	20	N/A

* Grundfos Cool-Top® is only available in the following pump types.

Pump Type	CR 1s	CR 1	CR 3	CR 5	CR 10	CR 15	CR 20	CR 32	CR 45	CR 64	CR 90
Standard (CR)								•	•	•	•
I Version (CRI)	•	•	•	•	•	•	•				
N Version (CRN)	•	•	•	•	•	•	•	•	•	•	•

6.10 Check valves

A check valve may be required on the discharge side of the pump to prevent the pump's inlet pressure from being exceeded.

For example, if a pump with no check valve is stopped because there is no demand on the system (all valves are closed), the high system pressure on the discharge side of the pump will "find" its way back to the inlet of the pump.

If the system pressure is greater than the pump's maximum inlet pressure rating, the limits of the pump will be exceeded and a check valve needs to be fitted on the discharge side of the pump to prevent this condition. **This is especially critical for CRN-SF applications because of the very high discharge pressures involved. As a result, most CRN-SF installations require a check valve on the discharge piping.**

6.11 Temperature rise

It may sometimes be necessary to stop the flow through a pump during operation.

At shut-off, the power to the pump is transferred to the pumped liquid as head, causing a temperature rise in the liquid.

The result is risk of excess heating of and consequent damage to the pump. The risk depends on the temperature of the pumped liquid and for how long the pump is operating without flow; see the following temperature rise chart.

Pump type	Time for temperature rise of 18 °F (10 °C)	
	Seconds	Minutes
CR 1s, 1, 3	210	3.5
CR 5	240	4.0
CR 10	210	3.5
CR 15	150	2.5
CR 20	120	2.0
CR 32, 45, 64, 90, 120, 150	60	1.0

6.12 Conditions/Reservations

The listed times are subject to the following conditions/ reservations:

- No exchange of heat with the surrounding.
- The pumped liquid is water with a specific heat of 1.0 $^{Btu}/_{lb.}$ °F (4.18 $^{kJ}/_{kg}$ °C).
- Pump parts (chambers, impellers and shaft) have the same thermal capacity as water.
- The water in the base and the pump head is not included.

These reservations should give sufficient safety margin against excessive temperature rise.

The maximum temperature must not exceed the pump maximum rating.

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6.13 Electrical

Warning

The safe operation of this pump requires that it be grounded in accordance with the national electrical code and local governing codes or regulations. Connect the ground wire to the grounding screw in the terminal box and then to the ACCEPTABLE grounding point. All electrical work should be performed by a qualified electrician in accordance with the latest edition of the National Electrical Code, local codes and regulations.

6.14 Motor

Grundfos CR pumps are supplied with heavy-duty 2-pole (3600 rpm nominal), ODP or TEFC, NEMA C frame motors selected to our rigid specifications.

Motors with other enclosure types and for other voltages and frequencies are available on a special-order basis.

CRN-SF pumps are supplied with an IEC (metric) type motor with a reverse thrust bearing.

If you are replacing the pumping unit, but are using a motor previously used on another CR pump, be sure to read *10. Replacing the motor* for proper adjustment of the coupling height.

6.15 Position of Terminal Box

The motor terminal box can be turned to any of four positions in steps of 90°.

To rotate the terminal box, remove the four bolts securing the motor to the pump but do not remove the shaft coupling. Turn the motor to the desired location; replace and securely tighten the four bolts; see fig. 11.

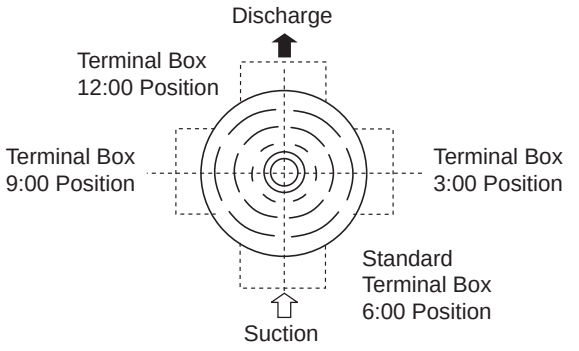

Fig. 11 Motor terminal box positions (top view)

6.16 Field Wiring

Wire sizes should be based on the current carrying properties of a conductor as required by the latest edition of the National Electrical Code or local regulations. Direct on line (D.O.L.) starting is approved due to the extremely fast run-up time of the motor and the low moment of inertia of the pump and motor. If D.O.L. starting is not acceptable and reduced starting current is required, an auto transformer, resistant starter or soft start should be used. It is suggested that a fused disconnect be used for each pump where service and standby pumps are installed.

6.17 Motor protection

6.17.1 Single-Phase Motors

With the exception of 10 HP motors which require external protection, single-phase CR pumps are equipped with multi-voltage, squirrel-cage induction motors with built-in thermal protection.

6.17.2 Three-Phase Motors

CR pumps with three-phase motors must be used with the proper size and type of motor-starter to ensure the motor is protected against damage from low voltage, phase failure, current imbalance and overloads.

A properly sized starter with manual reset and ambient-compensated extra quick trip in all three legs should be used. The overload should be sized and adjusted to the full-load current rating of the motor. Under no circumstances should the overloads be set to a higher value than the full load current shown on the motor nameplate. This will void the warranty.

Overloads for auto transformers and resistant starters should be sized in accordance with the recommendations of the manufacturer.

Three phase MLE motors (CRE-Pumps) require only fuses as a circuit breaker. They do not require a motor starter. Check for phase imbalance (worksheet is provided; see p. 23).
Note: Standard allowable phase imbalance difference is 5%.

6.17.3 CRN-SF

The CRN-SF is typically operated in series with a feed pump. Because the maximum allowable inlet pressure of the CRN-SF increases from 73 psi (when pump is off and during start-up) to 365 psi (during operation), a control device must be used to start the CRN-SF pump one second before the feed pump starts. Similarly, the CRN-SF must stop one second after the feed pump stops. See CRN-SF startup timeline below.

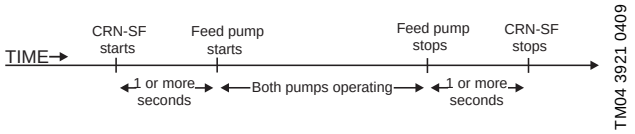

Fig. 12 CRN-SF startup

7. Starting the pump the first time

7.1 Priming

To prime the pump in a closed system or an open system where the water source is above the pump, close the pump isolation valve(s) and open the priming plug on the pump head; see fig. 13 and fig. 14.

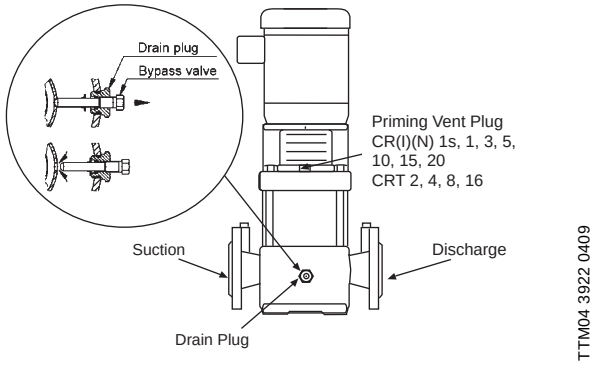

Fig. 13 Plug and valve locations

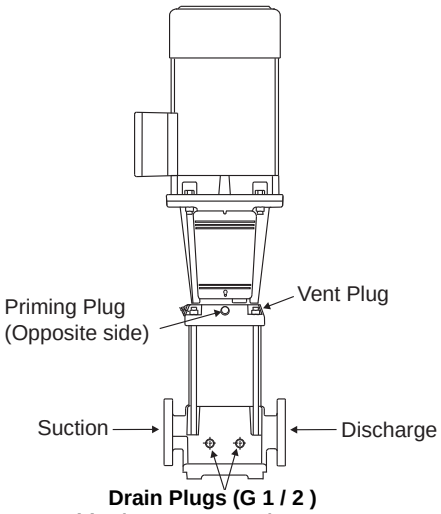

Fig. 14 Plug/valve locations CR(N) 32, 45, 64, 90, 120, 150

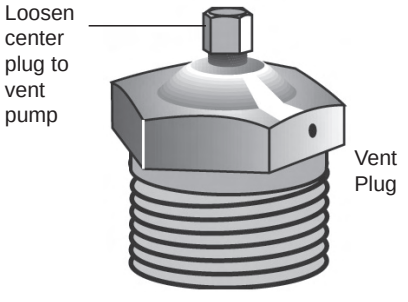

Fig. 15 Vent plug

Gradually open the isolation valve in the suction line until a steady stream of airless water runs out the priming port. Close the plug and securely tighten. Completely open the isolation valves.

In open systems where the water level is below the pump inlet, the suction pipe and pump must be filled and vented of air before starting the pump. Close the discharge isolation valve and remove the priming plug. Pour water through the priming hole until the suction pipe and pump are completely filled with water. If the suction pipe does not slope downward from the pump toward the water level, the air must be purged while being filled. Replace the priming plug and securely tighten. For pumps with Cool-Top®, see *14. Startup for Cool-Top®*.

Follow these steps:

1. Switch power off.
2. Check to make sure the pump has been filled and vented.
3. Remove the coupling guard and rotate the pump shaft by hand to be certain it turns freely.
4. Verify that the electrical connections are in accordance with the wiring diagram on the motor.
5. Switch the power on and observe the direction of rotation. When viewed from the top, the pump should rotate counter-clockwise (clockwise for CRN-SF).
6. To reverse the direction of rotation, first switch OFF the supply power.
7. On three-phase motors, interchange any two power leads at the load side of the starter. On single-phase motors, see connection diagram on nameplate. Change wiring as required.
8. Switch on the power and again check for proper motor rotation. Once rotation has been verified, switch off power again. Do not attempt to reinstall the coupling guards with the motor energized. Replace the coupling guard if the rotation is correct. After guards are in place the power can be reapplied. **Note:** CR, CRI, CRN 1s to 5: For these pumps, it is advisable to open the bypass valve during start-up; see fig. 13. The bypass valve connects the suction and discharge sides of the pump, thus making the filling procedure easier. When the operation is stable, the bypass valve must be closed.

Caution

Motors should not be run unloaded or uncoupled from the pump at any time; damage to the motor bearings will occur.

Do not start the pump before priming or venting the pump; see fig. 15. Never operate the pump dry.

7.2 Operating Parameters

CR multi-stage centrifugal pumps installed in accordance with these instructions and sized for correct performance will operate efficiently and provide years of service. The pumps are water-lubricated and do not require any external lubrication or inspection. The motors may require periodic lubrication as noted in *9. Maintaining the pump's motor*.

Under no circumstances should the pump be operated for any prolonged periods of time without flow through the pump. This can result in motor and pump damage due to overheating. A properly sized relief valve should be installed to allow sufficient water to circulate through the pump to provide adequate cooling and lubrication of the pump bearings and seals.

7.3 Pump Cycling

Pump cycling should be checked to ensure the pump is not starting more than the following.

Grundfos ML motors:

- 200 times per hour on 1/3 to 5 hp models
- 100 times per hour on 7 1/2 to 15 hp models
- 40 times per hour on 20 to 30 hp models.

Baldor motors:

- 20 times per hour on 1/3 to 5 hp models
- 15 times per hour on 7 1/2 to 15 hp models
- 10 times per hour on 20 to 100 hp models.

Rapid cycling is a major cause of premature motor failure due to increased heat build-up in the motor. If necessary, adjust controls to reduce the frequency of starts and stops.

7.4 Boiler-feed installations

If the pump is being used as a boiler-feed pump, make sure the pump is capable of supplying sufficient water throughout its entire evaporation and pressure ranges. Where modulating control valves are used, a bypass around the pump must be installed to ensure pump lubrication (see "Minimum Continuous Duty Flow Rates").

7.5 Freeze Protection

If the pump is installed in an area where freezing could occur, the pump and system should be drained during freezing temperatures to avoid damage. To drain the pump, close the isolation valves, remove the priming plug and drain plug at the base of the pump. Do not replace the plugs until the pump is to be used again. Always replace the drain plug with the original or exact replacement. Do not replace with a standard plug. Internal recirculation will occur, reducing the output pressure and flow.

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8. Preventative pump maintenance

At regular intervals depending on the conditions and time of operation, the following checks should be made:

1. Pump meets required performance and is operating smoothly and quietly.
2. There are no leaks, particularly at the shaft seal.
3. The motor is not overheating.
4. Remove and clean all strainers or filters in the system.
5. Verify the tripping of the motor overload protection.
6. Check the operation of all controls. Check unit control cycling twice and adjust, if necessary.
7. If the pump is not operated for unusually long periods, the unit should be maintained in accordance with these instructions. In addition, if the pump is not drained, the pump shaft should be manually rotated or run for short periods of time at monthly intervals.
8. To extend the pump life in severe duty applications, consider performing one of the following actions:
   – Drain the pump after each use.
   – Flush the pump, through system, with water or other fluid that is compatible with the pump materials and process liquid.
   – Disassemble the pump liquid components and thoroughly rinse or wash them with water or other fluid that is compatible with the pump materials and process liquid.

If the pump fails to operate or there is a loss of performance, refer to *Section 15. Diagnosing specific problems*.

9. Maintaining the pump's motor

Warning

Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt installation, operation, and maintenance of this equipment.

9.1 Motor Inspection

Inspect the motor at regular intervals, approximately every 500 hours of operation or every three months, whichever occurs first. Keep the motor clean and the ventilation openings clear.

The following steps should be performed at each inspection:

1. Check that the motor is clean. Check that the interior and exterior of the motor is free of dirt, oil, grease, water, etc. Oily vapor, paper, pulp, textile lint, etc. can accumulate and block motor ventilation. If the motor is not properly ventilated, overheating can occur and cause early motor failure.
2. Use an Ohmmeter ("Megger") periodically to ensure that the integrity of the winding insulation has been maintained. Record the Ohmmeter readings. Immediately investigate any significant drop in insulation resistance.
3. Check all electrical connectors to be sure that they are tight.

9.2 Motor Lubrication

Electric motors are pre-lubricated at the factory and do not require additional lubrication at start-up. Motors without external grease fittings have sealed bearings that cannot be re-lubricated. Motors with grease fittings should only be lubricated with approved types of grease. Do not over-grease the bearings. Over-greasing will cause increased bearing heat and can result in bearing/motor failure. Do not mix petroleum grease and silicon grease in motor bearings.

Bearing grease will lose its lubricating ability over time, not suddenly. The lubricating ability of a grease (over time) depends primarily on the type of grease, the size of the bearings, the speed at which the bearings operate and the severity of the operating conditions.

Good results can be obtained if the following recommendations are used in your maintenance program. It should also be noted that pumps with more stages, pumps running to the left of the performance curve, and certain pump ranges may have higher thrust loads. Pumps with high thrust loads should be greased according to the next service interval level.

9.3 Recommended lubricant

Severity of service	Ambient temp. (max.)	Environment	Approved types of grease
Standard	+104 °F (+40 °C)	Clean, little corrosion	Grundfos ML motors are greased for life or will have the grease type on the nameplate. Baldor motors are greased with Polyrex EM (Exxon Mobile).
Severe	+122 °F (+50 °C)	Moderate dirt, corrosion	
Extreme	>122 °F (+50°C) or Class H insulation	Severe dirt, abrasive dust, corrosion	

Note: If pump is fitted with a bearing flange that requires grease, see the stickers on either the bearing flange or coupling guards for proper grease type and greasing schedule.

9.4 Motor lubrication schedule (for motors with grease nipples)

New motors that have been stored for a year or more should be regreased according to the following:

NEMA (IEC) Frame Size	Standard Service Interval	Severe Service Interval	Extreme Service Interval	Weight of grease to add [oz (grams)]	Volume of grease to add [in^3 (teaspoons)]
Up through 210 (132)	5500 hrs	2750 hrs	550 hrs	0.30 (8.4)	0.6 (2)
Over 210 through 280 (180)	3600 hrs	1800 hrs	360 hrs	0.61 (17.4)*	1.2 (3.9)
Over 280 up through 360 (225)	2200 hrs	1100 hrs	220 hrs	0.81 (23.1)*	1.5 (5.2)
Over 360 (225)	2200 hrs	1100 hrs	220 hrs	2.12 (60.0)*	4.1 (13.4)

Warning

The grease outlet plug MUST be removed before adding new grease.

9.5 Lubrication Procedure

Caution

To avoid damage to motor bearings, grease must be kept free of dirt. For an extremely dirty environment, contact Grundfos, the motor manufacturer, or an authorized service center for additional information.

Mixing dissimilar grease is not recommended.

1. Clean all grease fittings. If the motor does not have grease fittings, the bearing is sealed and cannot be greased externally.
2. If the motor is equipped with a grease outlet plug, remove it. This will allow the old grease to be displaced by the new grease. If the motor is stopped, add the recommended amount of grease. If the motor is to be greased while running, a slightly greater quantity of grease will have to be added. **Note:** If new grease does not appear at the shaft hole or grease outlet plug, the outlet passage may be blocked. At the next service interval the bearings must be repacked.
3. Add grease SLOWLY taking approximately one minute until new grease appears at the shaft hole in the endplate or grease outlet plug. Never add more than 1-1/2 times the amount of grease shown in the lubrication schedule.
4. For motors equipped with a grease outlet plug, let the motor run for 20 minutes before replacing the plug.

10. Replacing the motor

If the motor is damaged due to bearing failure, burning or electrical failure, the following instructions detail how to remove the motor for replacement.

Caution

It must be emphasized that motors used on CR pumps are specifically selected to our rigid specifications. Replacement motors must be of the same frame size, should be equipped with the same or better bearings and have the same service factor. Failure to follow these recommendations may result in premature motor failure.

10.1 Disassembly

For disassembly, proceed as follows:

1. Turn off and lock out power supply. The power supply wiring can now be safely disconnected from the motor wires. Remove the coupling guards. **Note:** CR 1s, 1, 3, 5, 10, 15, and 20: do not loosen the three shaft seal securing allen screws.
2. Using the proper metric Allen wrench, loosen the four cap screws in the coupling. Completely remove coupling halves. On CR1s-CR20, the shaft pin can be left in the pump shaft. CR(N)32, 45, 64, 90, 120, and 150 do not have a shaft pin.
3. With the correct size wrench, loosen and remove the four bolts which hold the motor to the pump end.
4. Lift the motor straight up until the shaft has cleared the motor stool.

10.2 Assembly

For assembly, proceed as follows:

1. Remove key from motor shaft, if present, and discard.
2. Thoroughly clean the surfaces of the motor and pump end mounting flange. The motor and shaft must be clean of all oil/grease and other contaminants where the coupling attaches. Set the motor on the pump end.
3. Place the terminal box in the desired position by rotating the motor.
4. Insert the mounting bolts, then diagonally and evenly tighten:
   – for 3/8” bolts (1/2 to 2 hp), torque to 17 ft-lb
   – for 1/2” bolts (3 to 40 hp) torque to 30 ft-lb
   – for 5/8” bolts (50 - 100 hp) torque to 59 ft-lb
   – follow instructions for particular pump model in sections *10.2.1 Torque specifications for CR 1s, 1, 3, and 5* through *10.2.4 CR(N) 32, 45, 64, 90, 120, and 150*.

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10.2.1 Torque specifications for CR 1s, 1, 3, and 5

Insert shaft pin into shaft hole. Reinstall the coupling halves onto shaft and shaft pin. Reinstall the coupling screws and leave loose. Check that the gaps on either side of the coupling are even, and that the motor shaft keyway is centered in the coupling half, as shown in fig. 16.

Tighten the screws to the correct torque; see torque specifications table below.

Torque specifications
CR(I)(N) 1s, 1, 3, 5, 10, 15, and 20
CRT 2, 4, 8, and 16

Coupling bolt size	Min. torque
M6	10 ft-lb
M8	23 ft-lb
M10	46 ft-lb

10.2.2 CR 10, 15 and 20

Insert shaft pin into shaft hole. Insert plastic shaft seal spacer beneath shaft seal collar. Reinstall the coupling halves onto shaft and shaft pin. Reinstall the coupling screws and leave loose. Check that the gaps on either side of the coupling are even and that the motor shaft key way is centered in the coupling half, as shown in fig. 16. Tighten the screws to the correct torque. Remove plastic shaft seal spacer and hang it on inside of coupling guard.

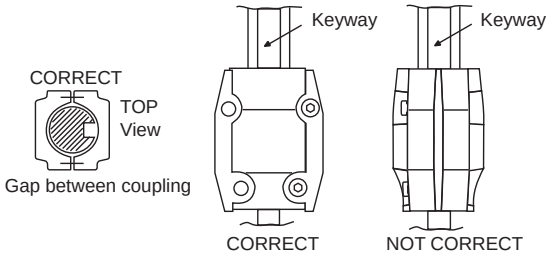

Fig. 16 Coupling adjustment all CR(I)(N)(X)(T)

10.2.3 CRT 2, 4, 8 and 16

Reinstall coupling halves. Make sure the shaft pin is located in the pump shaft. Put the cap screws loosely back into the coupling halves.

Using a large screwdriver, raise the pump shaft by placing the tip of the screwdriver under the coupling and carefully elevating coupling to its highest point; see fig. 17.

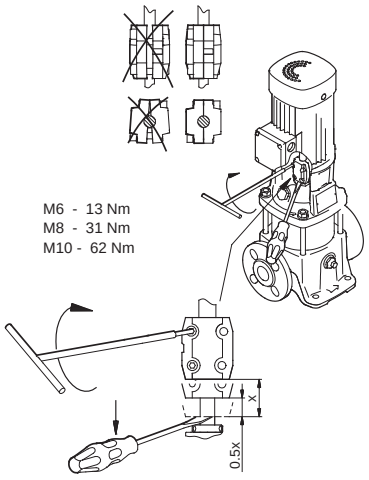

Fig. 17 Coupling adjustment CRT 2, 4, 8, and 16

Note: The shaft can only be raised approximately 0.20 in (5mm). Now lower the shaft halfway back down the distance you just raised it and tighten the coupling screws (finger tight) while keeping the coupling separation equal on both sides. When the screws are tight enough to keep the couplings in place, then torque the screws evenly in a criss-cross pattern.

- Note the clearance below the coupling
- Raise the coupling higher, as far as it will go
- Lower it halfway back down (1/2 the distance you just raised it)
- Tighten screws (see torque specifications below)

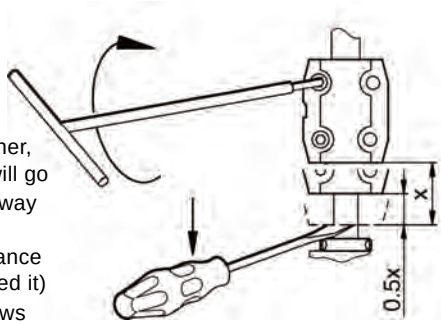

Fig. 18 Coupling adjustment clearance CRT 2, 4, 8, and 16

10.2.4 CR(N) 32, 45, 64, 90, 120, and 150

1. Make sure shaft is all the way down. TIghten the set screws on the mechanical seal.
2. Place the plastic adjustment fork under the cartridge seal collar; see fig. 19.

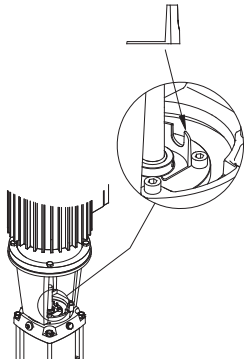

Fig. 19 Coupling adjustment
CR(N) 32, 45, 64, 90, 120, and 150

3. Fit the coupling on the shaft so that the top of the pump shaft is flush with the bottom of the clearance chamber in the coupling; see fig. 20.
   Note: To avoid damaging the coupling halves, ensure that no portion of the keyway on the motor shaft lies within the gap between the two coupling halves.

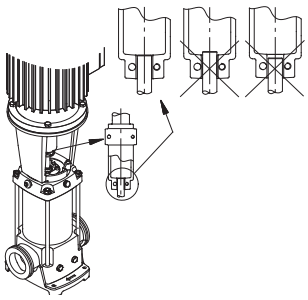

Fig. 20 Coupling adjustment clearance
CR(N) 32, 45, 64, 90, 120, and 150

4. Lubricate the coupling screws with an anti-seize and lubricating compound. Tighten the coupling screws (finger tight) while keeping the coupling separation equal on both sides and the motor shaft keyway centered in the coupling half as shown in fig. 16.
5. When the screws are tight enough to keep the couplings in place, then torque the screws evenly in a crisscross pattern.
6. Torque coupling screws to 62 ft.-lbs (75 and 100 hp motors to 74 ft-lbs). Remove the adjustment fork from under the cartridge seal collar and replace it to the storage location; see fig. 21.

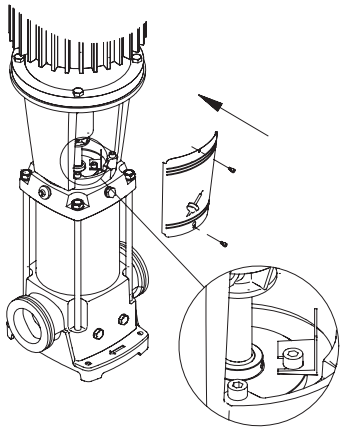

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Fig. 21 Adjustment fork storage
CR(N) 32, 45, 64, 90, 120, and 150

7. Check to see that the gaps between the coupling halves are equal. Loosen and readjust, if necessary.
8. Be certain the pump shaft can be rotated by hand. If the shaft cannot be rotated or it binds, disassemble and check for misalignment.
9. Prime the pump.
10. Follow the wiring diagram on the motor label for the correct motor wiring combination which matches your supply voltage. Once this has been confirmed, reconnect the power supply wiring to the motor.
11. Check the direction of rotation, by bump-starting the motor. Rotation must be left to right (counter-clockwise) when looking directly at the coupling.
12. Shut off the power, then re-install the coupling guards. After the coupling guards have been installed the power can be turned back on.

11. Parts List

For each CR pump model Grundfos offers an extensive **Parts List** and diagram of part used in that pump and is recommended to have on hand for future maintenance. In addition, the listings also provide information about prepackaged **Service Kits** for those pump components most likely to exhibit wear over time, as well as the complete Impeller Stack needed to replace the “guts” of each model. These Parts Lists are available separately from the Grundfos literature warehouse or as a set with extensive service instructions in the Grundfos CR **Service Manuals** (for a small charge).

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Fig. 22 Prepackaged impeller stack kits

TM04 3916 0409

Fig. 23 Prepackaged flange kits

12. Spare Parts

Grundfos offers an extensive list of spare parts. For a current list of these parts, refer to: “All Product Spare Parts/Service Kits” Price List, Form #L-SK-SL-002.

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13. Preliminary electrical tests

Warning

When working with electrical circuits, use caution to avoid electrical shock. It is recommended that rubber gloves and boots be worn, and metal terminal boxes and motors are grounded before any work is done. For your protection, always disconnect the pump from its power source before handling.

13.1 Supply voltage

13.1.1 How to measure the supply voltage

Use a voltmeter, (set to the proper scale) measure the voltage at the pump terminal box or starter.

On single-phase units, measure between power leads L1 and L2 (or L1 and N for 115 volt units).

On three-phase units, measure between:

– Power leads L1 and L2

– Power leads L2 and L3

– Power leads L3 and L1

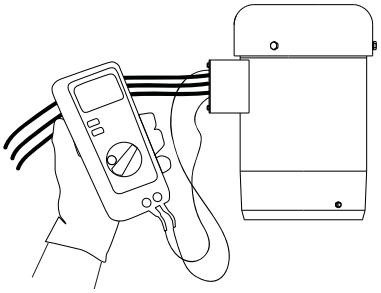

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Fig. 24 Measuring supply voltage

13.1.2 What the supply voltage measurement means

When the motor is under load, the voltage should be within ±10% of the nameplate voltage. Larger voltage variation may cause winding damage.

Large variations in the voltage indicate a poor electrical supply and the pump should not be operated until these variations have been corrected.

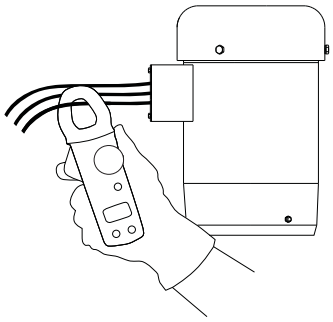
If the voltage constantly remains high or low, the motor should be changed to the correct supply voltage.

13.2 Current measurement

13.2.1 How to measure the current

Use an ammeter (set on the proper scale) to measure the current on each power lead at the terminal box or starter. See the motor nameplate for amp draw information.

Current should be measured when the pump is operating at constant discharge pressure.



TM04 3908 0409

Fig. 25 Measuring current

13.2.2 What the current measurement means

If the amp draw exceeds the listed service factor amps (SFA) or if the current imbalance is greater than 5% between each leg on three-phase units, check the following:

– Burned contacts on motor starter.

– Loose terminals in starter or terminal box or possible wire defect.

– Too high or too low supply voltage.

– Motor windings are shorted or grounded. Check winding and insulation resistances.

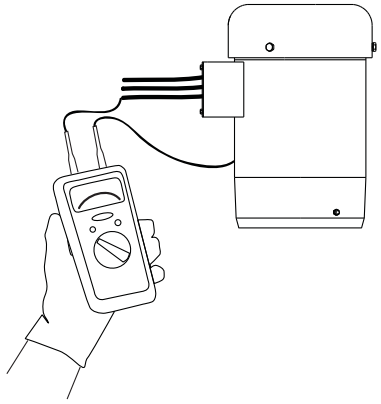
– Pump is damaged causing a motor overload.

13.3 Insulation resistance

13.3.1 How to measure the insulation resistance

Turn off power and disconnect the supply power leads in the pump terminal box. Using an ohm or mega ohm meter, set the scale selector to Rx 100K and zero adjust the meter.

Measure and record the resistance between each of the terminals and ground.



TM04 3907 0409

Fig. 26 Measuring insulation resistance

13.3.2 What the insulation resistance means

Motors of all hp, voltage, phase and cycle duties have the same value of insulation resistance. Resistance values for new motors must exceed 1,000,000 ohms. If they do not, motor should be repaired or replaced.

14. Startup for Cool-Top®

Caution ***Do not start the pump until it has been filled with liquid and vented.***

Warning

Pay attention to the direction of the vent hole and take care to ensure that the escaping liquid does not cause injury to persons or damage to the motor or other components. In hot-liquid installations, special attention should be paid to the risk of injury caused by scalding hot liquid. It is recommended to connect a drain pipe to the 1/2" air vent in order to lead the hot water/steam to a safe place.

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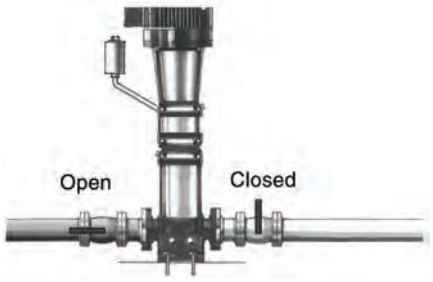
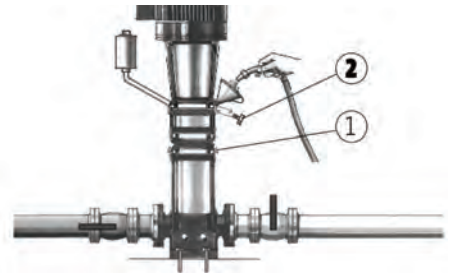
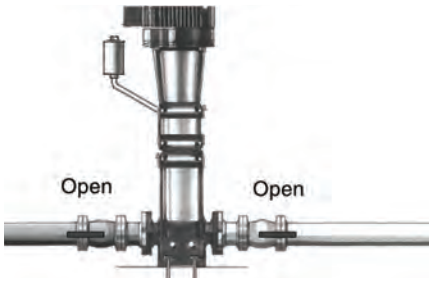
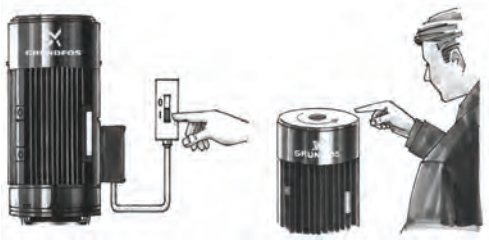
Step		Action
1	 TM02 4151 5001	**Note:** The air-cooled top should only be started up with cold liquid. Close the isolation valve on the discharge side and open the isolation valve on the suction side of the pump.
2	 TM02 4153 1503	Remove the priming plug from the **air-cooled chamber (2)** and slowly fill the chamber with liquid. When the chamber is completely filled with liquid, replace the priming plug and tighten securely.
3	 TM02 5907 4002	Open the isolation valve on the discharge side of the pump. Valve may have to be partially closed when pump is started if no back pressure is present (i.e. boiler not up to pressure).
4	 TM01 41406 3702 TM01 1405 4497	Start the pump and check the direction of rotation. See the correct rotation of the pump on the motor fan cover. If the direction of rotation is wrong, interchange any two of the incoming supply wires. After 3 to 5 minutes, the air vent has been filled with liquid. **Note:** During startup of a cold pump with hot liquid, it is normal that a few drops of liquid are leaking from the sleeve.

15. Diagnosing specific problems

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Problem		Possible cause	Remedy
The pump does not run.	1.	No power at motor.	Check voltage at motor terminal box. If no voltage at motor, check feeder panel for tripped circuits and reset circuit.
	2.	Fuses are blown or circuit breakers are tripped.	Turn off power and remove fuses. Check for continuity with ohmmeter. Replace blown fuses or reset circuit breaker. If new fuses blow or circuit breaker trips, the electrical installation, motor and wires must be checked.
	3.	Motor starter overloads are burned or have tripped out.	Check for voltage on line and load side of starter. Replace burned heaters or reset. Inspect starter for other damage. If heater trips again, check the supply voltage and starter holding coil.
	4.	Starter does not energize.	Energize control circuit and check for voltage at the holding coil. If no voltage, check control circuit fuses. If voltage, check holding coil for shorts. Replace bad coil.
	5.	Defective controls.	Check all safety and pressure switches for operation. Inspect contacts in control devices. Replace worn or defective parts or controls.
	6.	Motor is defective.	Turn off power and disconnect wiring. Measure the lead to lead resistances with ohmmeter (RX-1). Measure lead to ground values with ohmmeter (RX-100K). Record measured values. If an open or grounded winding is found, remove motor and repair or replace.
	7.	Defective capacitor (single-phase motors).	Turn off power and discharge capacitor. Check with ohmmeter (RX-100K). When the meter is connected to the capacitor, the needle should jump towards 0 ohms and slowly drift back to infinity (∞). Replace if defective.
	8.	Pump is bound.	Turn off power and manually rotate pump shaft. If shaft does not rotate easily, check coupling setting and adjust as necessary. If shaft rotation is still tight, remove pump and inspect. Disassemble and repair.
The pump runs but at reduced capacity or does not deliver water.	1.	Wrong rotation.	Check wiring for proper connections. Correct wiring.
	2.	Pump is not primed or is airbound.	Turn pump off, close isolation valve(s), remove priming plug. Check fluid level. Refill the pump, replace plug and start the pump. Long suction lines must be filled before starting the pump.
	3.	Strainers, check or foot valves are clogged.	Remove strainer, screen or valve and inspect. Clean and replace. Reprime pump.
	4.	Suction lift too large.	Install compound pressure gauge at the suction side of the pump. Start pump and compare reading to performance data. Reduce suction lift by lowering pump, increase suction line size or removing high friction loss devices.
	5.	Suction and/or discharge piping leaks.	Pump spins backwards when turned off. Air in suction pipe. Suction pipe, valves and fittings must be airtight. Repair any leaks and retighten all loose fittings.
	6.	Pump worn.	Install pressure gauge, start pump, gradually close the discharge valve and read pressure at shutoff. Convert measured pressure (in psi) to head (in feet): (Measured psi x 2.31 ft/psi = ___ ft). Refer to the specific pump curve for shutoff head for that pump model. If head is close to curve, pump is probably OK. If not, remove pump and inspect.
	7.	Pump impeller or guide vane is clogged.	Disassemble and inspect pump passageways. Remove any foreign materials found.
	8.	Incorrect drain plug is installed.	If the proper drain plug is replaced with a standard plug, water will recirculate internally. Replace with proper plug.
	9.	Improper coupling setting.	Check/reset the coupling; see page 18.

Problem		Possible cause	Remedy
Pump cycles too much	1.	Pressure switch is not properly adjusted or is defective.	Check pressure setting on switch and operation. Check voltage across closed contacts. Readjust switch or replace if defective.
	2.	Level control is not properly adjusted or is defective.	Check setting and operation. Readjust setting (refer to level control manufacturer's data). Replace if defective.
	3.	Insufficient air charging or leaking tank or piping.	Pump air into tank or diaphragm chamber. Check diaphragm for leak. Check tank and piping for leaks with soap and water solution. Check air to water volume. Repair as necessary.
	4.	Tank is too small.	Check tank size and air volume in tank. Tank volume should be approximately 10 gallons for each gpm of pump capacity. The normal air volume is 2/3 of the total tank volume at the pump cut-in pressure. Replace tank with one of correct size.
	5.	Pump is oversized.	Install pressure gauges on or near pump suction and discharge ports. Start and run pump under normal conditions, record gauge readings. Convert psi to feet (Measured psi x 2.31 ft/psi = ____ ft) Refer to the specific pump curve for that model, ensure that total head is sufficient to limit pump delivery within its design flow range. Throttle pump discharge flow if necessary.
Fuses blow or circuit breakers or overload relays trip	1.	Tank is too small.	Check voltage at starter panel and motor. If voltage varies more than –10 % / + 10 %, contact power company. Check wire sizing.
	2.	Motor overloads are set too low.	Cycle pump and measure amperage. Increase heater size or adjust trip setting to a maximum of motor nameplate (full load) current.
	3.	Three-phased current is imbalanced.	Check current draw on each lead to the motor. Must be within –5 % / + 5 %. If not, check motor and wiring. Rotating all leads may eliminate this problem.
	4.	Motor is shorted or grounded.	Turn off power and disconnect wiring. Measure the lead-to-lead resistance with an ohmmeter (RX-1). Measure lead-to-ground values with an ohmmeter (RX-100K) or a megaohm meter. Record values. If an open or grounded winding is found, remove the motor, repair and/or replace.
	5.	Wiring or connections are faulty.	Check proper wiring and loose terminals. Tighten loose terminals. Replace damaged wire.
	6.	Pump is bound.	Turn off power and manually rotate pump shaft. If shaft does not rotate easily, check coupling setting and adjust as necessary. If shaft rotation is still tight, remove pump and inspect. Disassemble and repair.
	7.	Defective capacitor (single-phase motors).	Turn off power and discharge capacitor. Check with ohmmeter (RX-100K). When the meter is connected to the capacitor, the needle should jump towards 0 ohms and slowly drift back to infinity (∞). Replace if defective.
	8.	Motor overloads at higher ambient temperature than motor.	Use a thermometer to check the ambient temperature near the overloads and motor. Record these values. If ambient temperature at motor is lower than at overloads, especially where temperature at overloads is above +104 °F (+40 °C), ambient-compensated heaters should replace standard heaters.

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16. Worksheet for three-phase motors

Below is a worksheet for calculating current unbalance on a three-phase hookup. Use the calculations below as a guide.

Note: Current unbalance should not exceed 5% at service factor load or 10% at rated input load. If the unbalance cannot be corrected by rolling leads, the source of the unbalance must be located and corrected. If, on the three possible hookups, the leg farthest from the average stays on the same power lead, most of the unbalance is coming from the power source. However, if the reading farthest from the averages moves with the same motor lead, the primary source of unbalance is on the “motor side” of the starter. In this instance, consider a damaged cable, leaking splice, poor connection, or faulty motor winding.

Explanation and examples	
Here is an example of current readings at maximum pump loads on each leg of a three-wire hookup. You must make calculations for all three hookups. To begin, add up all three readings for hookup numbers 1, 2, and 3.	**Hookup 1** T1 = 51 amps T2 = 46 amps T3 = 53 amps TOTAL = 150
Divide the total by three to obtain the average.	**Hookup 1** 50 amps 3 | 150 amps
Calculate the greatest current difference from the average.	**Hookup 1** 50 amps — 46 amps 4 amps
Divide this difference by the average to obtain the percentage of the unbalance. In this case, the current unbalance for **Hookup 1** is 8%.	**Hookup 1** .08 or 8% 50 | 4.00 amps

Figure here		
Hookup 1	**Hookup 2**	**Hookup 3**
L_1 to T_1 = ___ amps	L_1 to T_3 = ___ amps	L_1 to T_2 = ___ amps
L_2 to T_2 = ___ amps	L_2 to T_1 = ___ amps	L_2 to T_3 = ___ amps
L_3 to T_3 = ___ amps	L_3 to T_2 = ___ amps	L_3 to T_1 = ___ amps
TOTAL = ___ amps	TOTAL = ___ amps	TOTAL = ___ amps
Hookup 1	**Hookup 2**	**Hookup 3**
___ amps	___ amps	___ amps
3 | ___ amps	3 | ___ amps	3 | ___ amps
Hookup 1	**Hookup 2**	**Hookup 3**
___ amps	___ amps	___ amps
___ amps	___ amps	___ amps
___ amps	___ amps	___ amps
Hookup 1	**Hookup 2**	**Hookup 3**
___ or ___ %	___ or ___ %	___ or ___ %
___ | ___ amps	___ | ___ amps	___ | ___ amps

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SECTION 11
MEMBRANE CLEANING

Membrane filtration systems will require periodical cleaning. Cleaning is recommended when there will be evidence of fouling, just prior to a long term shutdown, or as a matter of scheduled routine maintenance. Fouling characteristics that signal a need for cleaning are a 10-15% decrease in normalized permeate flow, a 10-15% decrease in normalized permeate quality, or a 10-15% increase in normalized pressure drop as measured between the feed and concentrate headers.

RO cleaning frequency due to fouling will vary by site. A rough rule of thumb as to an acceptable cleaning frequency is once every 3 to 12 months. If the need for cleaning will occur more than once a month, further capital expenditures should be justified for improved RO pretreatment or a re-design of the RO operation. If cleaning frequency is every one to three months, improving the operation of existing equipment may become a priority, rather than further capital expenditure.

One RO design feature that is commonly over-looked in reducing RO cleaning frequency is the use of RO permeate water for flushing foulants from the system. Soaking the RO elements during standby with permeate can help dissolve scale and loosen precipitates, reducing the frequency of chemical cleaning.

The need for cleaning will vary site by site depending on the foulant. Complicating the situation frequently is that one more than one foulant can be present. Typical foulants are:

- Calcium carbonate scale
- Sulfate scale of calcium, barium or strontium
- Metal oxides of iron, manganese, aluminum, etc.
- Silica scale
- Colloidal deposits (inorganic or mixed inorganic/organic)
- Organic material of natural origin or man-made origin
- Biological (bioslime, mold, or fungi)

There are a number of factors involved in the selection of a suitable cleaning chemical (or chemicals) and proper cleaning protocol. Before performing a cleaning the first time, it is recommended to contact the manufacturer of the equipment, the RO element manufacturer, or a RO specialty chemical supplier. Once the suspected foulant(s) are identified, one or more cleaning chemicals will be recommended. These chemical(s) can be generic and available from a number of suppliers or can be private-labeled proprietary cleaning solutions. The proprietary solutions can be more expensive but may be easier to use and the

advantage of the intellectual knowledge supplied by these companies cannot be ruled out. An invaluable service offered by some service companies is that they will determine the proper cleaning chemicals and protocol by testing at their facility an element pulled from actual system in question.

It is not unusual to have to use a number of different cleaning chemicals in a specific sequence to achieve the optimum cleaning. There are times that a low pH cleaning is used first to remove foulants like mineral scale, followed by a high pH cleaning to remove organic material. However, there are times that a high pH cleaning is used first to remove foulants like oil followed by a low pH cleaning. Some cleaning solutions have detergents added to aid in the removal of heavy biological and organic debris, while others have a chelating agent like EDTA added to aid in the removal of colloidal material, organic and biological material, and sulfate scale. An important thing to remember is that the improper selection of a cleaning chemical or the sequence of chemical introduction can make the foulant worse.

There are a number of precautions in cleaning chemical selection and usage for a composite polyamide membrane:

- Follow the manufacturer s recommended chemical list, dosage, pH, temperature and contact time guidelines.
- Use the least harsh chemical cleaning to get the job done. This will optimize the useful life of the membrane.
- Be prudent in the adjustment of pH at the low and high pH range to extend the useful life of the membrane. A gentle pH range is 4 to 10, while the harshest is 2 to 12.
- Don t mix acids with caustics. Thoroughly rinse the 1st cleaning solution from the system before introducing the next solution.
- Flush out detergents with high pH permeate
- Verify that proper disposal requirements for the cleaning solution are followed.

If the system has been fouled biologically, an extra step of introducing a sanitizing biocide chemical after a successful cleaning may be worth of consideration. Biocides can be introduced immediately after cleaning, periodically (e.g. once a week), or continuously during service. It will be necessary to confirm in advance that the biocide is compatible with the membrane, does not create any health risks, is effective in controlling biological activity, and is not cost prohibitive.

The successful cleaning of an RO on-site requires a well designed RO cleaning skid. Normally this skid is not hard piped to the RO skid and uses temporary hoses for connections. It is recommended to clean a multi-stage RO one stage at a time to optimize cross flow cleaning velocity. The source water for chemical solution make up and rinsing should be RO permeate, DI water, or at least soft water. The components have to be corrosion proof. Major cleaning system components are:

- RO Cleaning Tank: This tank needs to be sized properly to accommodate the displacement of water in the hose, piping, and pressure vessels. The tank should be designed to allow 100 % drainage, easy access for chemical introduction and mixing, a recirculation line from the RO Cleaning Pump, proper venting, overflow, and a return line located near the bottom to minimize foam formation when using a surfactant.
- RO Cleaning Pump: This pump needs to be sized to develop the proper cross flow velocity to scrub the membrane clean. The cleaning rate for a 8-inch diameter vessel is 30 to 40 gpm and for a 4-inch diameter vessel is 8 to 10 gpm. The maximum recommended pressure is 60 psi to minimize the production of permeate during cleaning and reduce the convective re-deposition of foulant back on to the membrane surface.
- RO Cleaning Cartridge Filter: Normally 5 to 10-micron and is designed to remove foulants that have been displaced from the cleaning process.
- RO Tank Heater or Cooler: The optimal temperature for cleaning is 35 to 45 ^{o} C. One cannot forget that heat is generated and imparted by the RO Cleaning Pump during recirculation.

- RO Tank Mixer: This is recommended to get optimal mixing of chemical, though some designers rely solely on the slow introduction of chemical while maintaining a recirculation through the RO Cleaning Pump back to the tank.
- Instrumentation: Cleaning system instrumentation should be included to monitor flow, temperature, pressure, and tank level.
- Sample Points: Sample valves should be located to allow pH and TDS measurements off the RO Cleaning Pump discharge and the concentrate side recirculation return line.
- Permeate Return Line: A small amount of the cleaning solution can permeate through the membranes and so a permeate side return line is recommended.

RO cleaning procedures may vary dependent on the situation. The time required to clean a stage can take from 4 to 8 hours. The basic steps of cleaning are:

1. Perform a low pressure flush with feed or permeate water to remove service concentrate and foulants.
2. Make up the cleaning solution per the manufacturer s instructions.
3. Introduce the cleaning solution to the first stage for 60 minutes. Throttle the flow up slowly to minimize the plugging of the feed path with dislodged foulant. Send the displaced water and up to 20% of the fouled cleaning solution to drain before returning the cleaning solution back to the RO Cleaning Tank. Readjust the pH to the target when it changes more than 0.5 pH units.
4. An optional soak and recirculation sequence can be used. The soak time can be from 1 hour to overnight depending on the manufacturer s recommendations, care should be taken that the proper temperature and pH be maintained and that this does increase the chemical exposure time of the membrane.
5. A low pressure Cleaning Rinse with permeate water is required to remove all traces of chemical from the Cleaning Skid and the RO Skid.
6. Once all the stages of a train are cleaned, the RO can be placed back into service. It is not unusual for it to take from a few hours to a few days for the RO permeate quality to stabilize, especially after high pH cleanings.