aqueoussolutions

OPERATION AND
MAINTENANCE MANUAL

REVERSE OSMOSIS DESALINATION PLANT

ALINTA ENERGY

Port Augusta

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Table of Contents

List of Tables

List of Figures

1. INTRODUCTION

The Aqueous Solutions AS1,200,000 reverse osmosis plant is an automatic membrane desalination plant, capable of producing 50,000 litres per hour of permeate water @ 18℃ from filtered, brackish bore water (approx 550mg/L TDS). The whole R.O system, excluding the SMBS tank and pre-filtration cartridge filters, is completely installed inside a 40ft insulated shipping container. An access door with viewing window and push bar mechanism on one side of the container provides primary access to the container.

The system includes, acid dosing (for pH correction), Sodium Metabisulphite dosing (for chloramines removal) & anti-scalant dosing, along with cartridge filtration pre-treatment, automatic flush cycle, low feed pressure protection, and high pressure protection. The plant includes a post main RO concentrator membrane to enhance the recovery levels. This extra level of recovery is independent of the main system & can be turned on/off as required during normal plant operation.

2. PROCESS DESCRIPTION

2.1 PRE-TREATMENT

Prior to entering the R.O plant, the feed water will be dosed with dilute sulphuric acid for pH adjustment, sodium metabisulphite (SMBS) for chloramines removal, and anti-scalant chemical to prevent scaling of the R.O membranes. The chemical dosing occurs automatically, with chemical dosing rates controlled by the PLC and adjusted for changes to the feed water conditions.

A number of inline sensors are installed throughout the system to monitor process variables such as flow, pressure, temperature, conductivity, pH, ORP etc. These are processed by the PLC and chemical dosing rates adjusted through a proportional control loop to maintain required set-points.

The feed water then passes through two stages of cartridge filtration which will remove small particulate matter which can harm and/or foul the R.O membranes.

The pre-treatment conditions the water to a quality suitable for entry to the R.O plant.

2.2 REVERSE OSMOSIS (R.O) SYSTEM

After pre-treatment, the feed water enters the reverse osmosis system. Dosed and filtered feed water passes through the main system pump where the water is pressurised prior to entering the R.O pressure vessels. A small stream of water is directed from this feed line through the Trasar system. This monitors feed conductivity, temperature, pH and ORP.

These values are transmitted back to the PLC for processing, while the inbuilt controller in the Trasar directly controls the anti-scaling dosing pump.

The pressurised water passes through the main R.O system in 3 stages. Once the water has passed through the first 3 stages, the brine can either be directed through the concentrator system, or passed directly to waste. The concentrator system includes a concentrator pump to boost the pressure before passing through a final stage of R.O membranes. The system has been designed so that the main R.O system can be operated independent of the concentrator system. This allows for cleaning and/or maintenance on the concentrator without requiring the entire system to be shut down.

The desalination plant operates at a nominal recovery of 94%. The system has been designed to process water with a temperature ranging from 15℃ up to a maximum 35℃. Both the main R.O pump and concentrator pump are controlled with variable speed drives to account for changes to the feed water conditions and maintain the system at optimum performance / recovery.

The system employs a permeate flush on shutdown which flushes all brine from the membrane. This prevents salty brine water remaining stagnant on the membranes, potentially causing fouling. A membrane flush on start-up flushes the permeate water from the membranes ready for normal operation.

A Clean In Place system has been installed to allow cleaning In Situ cleaning of the membranes. A dedicated cleaning pump and storage tank is located in the container. The cleaning chemicals can be made up in the cleaning tank and circulated through the system in order to clean the R.O membranes. Cleaning of the membranes only requires the operators to manually adjust valves in order to isolate the vessels for cleaning.

2.3 CONTROL AND MONITORING

The plant is controlled and operated from a Human-Machine Interface (HMI) communicating with the system PLC. All system controls are activated through the HMI screen. The HMI also shows the current status of all instruments and equipment in the container.

2.3.1 HMI and PLC

The entire system is controlled and managed from the touch screen HMI. The HMI screen is located on the main control panel.

2.3.2 Temperature

Feed water temperature is measured using the temperature sensor TT01 on the Trasar line.

2.3.3 pH

The feed water pH is monitored by the Trasar unit. The pH signal is transmitted to the PLC for processing. The PLC then outputs an analogue control signal to the acid dosing pump to maintain the desired pH level.

The pH must remain below 7.5 at all times in order to prevent scaling.

An alarm activates if the pH falls above or below the target level for a period of time.

2.3.4 Conductivity

The conductivity of the water is monitored at a number of locations in the flow path. These provide indication of conductivity levels in the various water streams. Alarm conditions also exist for permeate conductivity outside set-point values.

Table 1: Conductivity transducer locations

Location	Instrument
Feed water	AT03
Permeate – Main R.O	AT04
Permeate - Concentrator	AT05
Permeate - Total	AT06
Brine Waste	AT07

2.3.5 Pressure

System pressure is monitored throughout the process. Alarm and trip conditions exist if the feed water pressure is below the set-point, and alarm only if system pressures exceed the high pressure set-points.

Table 2: Pressure transducer locations

Location	Instrument
Feed – Pre filter	PT01
Feed – Mid filter	PT02
Feed – Post filter	PT04
Concentrator – Pre pump	PT06
Concentrator – Post pump	PT07
Brine waste	PT08

A number of analogue pressure gauges are also installed in the system. These are located on the permeate lines, as well as post cleaning and flush pumps.

2.3.6 ORP

The Oxidation-Reduction Potential (ORP) of the feed water is also measured by the Trasar unit. The ORP level, measured in milli-volts, measures the tendency of a chemical species to acquire electrons and thereby be reduced. This simply means the amount of chlorine (an oxidant) is measured in the feed water.

The level of chlorine in the water is important since chlorine can damage the R.O membranes. SMBS chemical is dosed into the feed stream to neutralise the chlorine. The plant will trip out if the ORP exceeds the set-point value for a period of time.

2.3.7 Permeate Tank Level

The permeate storage tank has a level control sensor which outputs an analogue signal to the PLC. The R.O unit operates automatically based on the level in the permeate tank. When the permeate tank level goes high, the R.O system will automatically enter idle mode. Once the permeate level goes low, the system will automatically start up again.

3. PRE-TREATMENT

The following pre-treatment processes are installed in order to pre-condition the raw feed water for entry to the R.O plant.

3.1 SODIUM METABISULPHITE (SMBS)

Prior to entry to the R.O system, SMBS will be dosed into the feed water to carry out neutralisation of any chlorine and other oxidants in the water stream. This is done to protect the R.O membranes, which are very sensitive to oxidants, especially free chlorine, and can be irreparably damaged by prolonged contact with them.

SMBS solution is stored in the SMBS tank supplied. This tank holds up to 1,200 litres of SMBS solution. The SMBS solution must be made up to 10% (w/v). The SMBS tank has a level indication cylinder on the side to show liquid level. An electric mixer is mounted on the tank which is activated with a manual hand switch.

3.1.1 Make Up Procedure

1. Note SMBS Material Safety Data Sheet (MSDS) and wear appropriate PPE.
2. Fill SMBS tank with 1000 litres of fresh water.
3. Add 100kg of SMBS powder (4 x 25kg bags) to the solution.
4. Activate mixer and allow solution to mix until all powder dissolved and solution is clear.

3.1.2 Top Up Procedure

When level in the SMBS tank drops to below 25% full, the tank must be topped up. SMBS levels must be continuously maintained.

1. Add 500 litres of water, or alternatively add water until tank is full and record volume added.
2. Add 50kg of SMBS powder, or alternatively determine amount of powder required using formula below.

Amount of powder required (kg) = 0.1 x Volume water added to tank (litres)
Eg. 650 litres water added to tank
650 x 0.1 = 65kg powder

Note: SMBS solution is expected to be consumed at a rate of 5.5 litres per hour. Therefore, it is expected the tank will be depleted by 132 litres per 24 hour period.

3.1.3 Dosing Pump Priming Procedure

SMBS dosing pump is a Grundfos DME 12-6 dosing pump.

To prime the pump, follow these steps.

1. Unscrew and remove the remote start/stop control cable from the front of the pump.
2. Loosen the vent valve by giving it a 1/8 to 1/4 turn.
3. Hold down the “100%” button on the front of the pump. This runs the pump at maximum capacity.
4. Hold down until all air is bled out of the system. Release the button and return the vent valve to original position.
5. Replace remote start/stop cable.

For detailed instructions, please consult the manufacturer supplied manual.

3.2 ACID DOSING

Following SMBS dosing, the feed water is dosed with dilute sulphuric acid at 20% concentration. The dilute sulphuric acid is made up utilising existing Alinta dilution equipment. The acid dosing will correct the pH level in the water, and ensure the pH remains below 7.5 at all times.

The pH level of the feed water will be directly measured with an inline pH sensor, located in the Trasar unit inside the container. A feedback control loop (PID) will automatically adjust the dosing rate of the acid pump to maintain the required pH level. Acid dosing rate will be automatically adjusted to account for any fluctuations to pH level of the feed water.

Acid is supplied onsite by Alinta.

3.2.1 Dosing Pump Priming Procedure

Acid dosing pump is a Grundfos DDI 2.5-10 dosing pump.

1. On front of the pump, push the “menu” button until manual mode is activated. Push the “up” arrow button to increase the flow rate to the maximum value of 2.98l/hr.
2. Open the priming valve at the back of the pump so this drains back into tank.
3. Unscrew and remove the remote start/stop cable from the front of the pump (plug 4).
4. Push the “start” button and allow the pump to run until all air is bled out of the system.
5. Push the “stop” button and close off the priming valve.
6. Return the pump to analogue 4-20mA operating mode by pushing the “menu” button.

Note: Pump must be in Analogue 4-20mA, not 0-20mA

7. Replace remote start/stop cable.
8. Push “start” button on pump, amber light should be illuminated (not red light).

3.3 ANTI-SCALANT DOSING

The feed water will be automatically dosed with anti-scalant chemical prior to entering the reverse osmosis plant. Anti-scalant chemical is required to prevent certain dissolved salts (primarily calcium and magnesium) from precipitating out and “scaling” the R.O membranes. Due to the high recovery of this system, preventing scaling is particularly important.

Anti-scalant chemical is dosed into the feed water neat. The anti-scalant chemical tank must be regularly checked for chemical, and extra chemical added when/if required.

The dosing pump delivers the anti-scalant chemical into the feed stream at a rate of approximately 120ml/hr.

Note: Anti-scalant is expected to be consumed at a rate of 120ml/hr. Therefore, it is expected the tank will be depleted by 2.88 litres per 24 hour period.

3.3.1 Dosing Pump Priming Procedure

Anti-scalant dosing pump is a Grundfos DDI 2.5-10 dosing pump. Normal operating mode is analogue, 4-20mA.

If R.O plant off

9. Open electrical cabinet.
10. Force relay K25 “on” by lifting orange tag.
11. On front of the pump, push the “menu” button until manual mode is activated. Push the “up” arrow button to increase the flow rate to the maximum value of 2.98l/hr.
12. Open the priming valve at the back of the pump so this drains back into tank.
13. Push the “start” button and allow the pump to run until all air is bled out of the system.
14. Push the “stop” button and close off the priming valve.
15. Return the pump to analogue 4-20mA operating mode by pushing the “menu” button.

    Note: Pump must be in Analogue 4-20mA, not 0-20mA
16. Return relay K25 to normal position.

17. Push “start” button on pump, amber light should be illuminated (not red light).

If R.O plant on

1. Follow steps 3 onwards.

3.3.2 Trasar Monitoring

The precise concentration of anti-scalant in the feed water is directly monitored by the Nalco “Trasar” Flourometer. The anti-scalant chemical contains fluorescent dye which is directly measured by the Trasar system. A PID feedback control loop within the Trasar system directly controls the dosing rate of the anti-scalant pump to ensure adequate concentrations of anti-scalant in the feed water at all times.

Note: Flow through the Trasar system must be 0.5 gpm (approx 1.9 lpm) for it to function properly.

3.4 CARTRIDGE FILTERS

After chemical dosing, the feed water passes through a series of nine round filter housings containing cartridge filtration. Stage 1 consists of 4x 9 round housings containing 40” 1 micron depth cartridge filters in parallel. Stage 2 consists of 3x 9 round housings containing 40” 1 micron absolute cartridge filters in parallel. These filters are installed to protect the high pressure pump and lead end/surfaces of the R.O membranes from particles and debris present in the feed water.

The cartridge filters should be replaced when the pressure difference between the inlet and outlet of the filters exceeds 100kPa (15psi).

Note: Low pressure shutdown set at approx 100kPa. The low pressure cut-out trips the plant.

4. REVERSE OSMOSIS PLANT OPERATION

The Aqueous Solutions R.O plant has a number of modes of operation. The plant is configured so that the main R.O system can be operated independent to the concentrator system. While the main R.O is operational, it is possible to carry out maintenance and/or cleaning on the concentrator system.

All modes of operation are initiated using the HMI. Please refer section 6 for details on HMI.

4.1 PRE-SYSTEM CHECK

1. Remove “start enable” from Alinta SCADA system.

SMBS:

2. Check SMBS solution is made up with sufficient volume in tank.
3. Ensure pump is primed and powered.
4. Check SMBS solution is less than 1 month old. If more than 1 month old, dump and make new batch before starting.

Acid:

5. Check acid dilution tanks full
6. Ensure pump is primed and powered.

Anti-scalant:

7. Check anti-scalant solution is made up with sufficient volume in tank.
8. Ensure pump is primed and powered.

Filters:

9. Ensure all cartridge filters vented and contain no air (requires water pressure).

Valves:

10. All valves to permeate tank open.
11. All valves to reject/disposal open.

4.2 AUTO MODE 1 – MAIN R.O + CONCENTRATOR OPERATIONAL

4.2.1 Start-Up

1. See flow sheet PFD-01-Mode1 for flow path.
2. Set valves as per list. See PID-01-Mode1 for complete valve positioning guide.
3. Initiate system start from HMI screen

4.2.2 Valve positions

Table 3: Valve positions - Auto Mode 1

Valve Description	Valve Numbers	Status
Inlet feed	V01, V02, V03, V04, V05, V08, V10	OPEN
Stage 1 inlet	V13, V14, V15, V16, V17, V18	OPEN
Stage 2 inlet	V19, V20, V21	OPEN
Permeate valves	V24*, V25*, V49*, V31	OPEN
Permeate to tank	V27 (Critical)	OPEN
Concentrator	V32, V34	OPEN
Brine	V38, V41*	OPEN
Cleaning	V12, V36, V37, V69, V70, V72, V26	CLOSED
Brine	V39, V48	CLOSED

* Denotes control valve. These are manually adjusted to control back pressure and flow rate.

Note: Limit switch valves (V32, V38, V39, and V48) incorrectly positioned will prevent the system from starting up. This will deliver a fault warning on the HMI. Re-configure the valves as required and continue start-up procedures.

4.2.3 Operational Description

Once the system start has been initiated, the following will occur:

1. Alinta feed pump starts from signal out from PLC.
2. MOV1 will open, allowing feed water to enter the container.
3. Feed water will be dosed with SMBS, acid and anti-scalant chemicals automatically Acid dosing starts after main system pump starts.
4. Feed water will pass through cartridge filtration external to the container.
5. Feed water will re-enter the container and be delivered to the main system pump. A side stream will be directed to the Trasar unit.
6. Trasar unit will measure raw water conductivity, temperature, ORP, pH and anti-scalant concentration. All values displayed on the HMI screen.
7. Main system pump will supply water at high pressure to the R.O vessels. Flow from main system pump controlled by variable speed drive, VSD-01.

8. Water will pass through stage 1, 2 and 3 R.O pressure vessels, through the concentrator pump, then through stage 4 R.O pressure vessel. Flow through concentrator pump controlled by variable speed drive, VSD-02.
9. The waste stream from the concentrator will pass through the reject manifold where the flow rate and pressure are monitored and displayed on the HMI. Control valve V41* is used to adjust this flow rate.

4.3 AUTO MODE 2 – MAIN R.O OPERATION ONLY

In this mode, only the main R.O is operational. The concentrator is switched off and isolated from the main R.O system. In this mode, cleaning and/or maintenance on the concentrator can be carried out while the main R.O is running.

4.3.1 Start-Up

4. See flow sheet PFD-01-Mode2 for flow path.
5. Set valves as per list. See PID-01-Mode2 for complete valve positioning guide.
6. Initiate system start Auto Mode 2 from HMI screen

4.3.2 Valve positions

Table 4: Valve positions - Auto Mode 2

Valve Description	Valve Numbers	Status
Inlet feed	V01, V02, V03, V04, V05, V08, V10	OPEN
Stage 1 inlet	V13, V14, V15, V16, V17, V18	OPEN
Stage 2 inlet	V19, V20, V21	OPEN
Permeate valves	V24*, V25*, V49*	OPEN
Permeate to tank	V27 (CRITICAL)	OPEN
Brine	V41*, V39, V48, V40*	OPEN
Concentrator	V32, V34, V38	CLOSED
Cleaning	V12, V36, V37, V69, V70, V72, V26	CLOSED
Permeate Valve	V31	CLOSED

* Denotes control valve. These are manually adjusted to control back pressure and flow rate. Once set, these should not require adjusting.

Note: Limit switch valves (V32, V38, V39, and V48) incorrectly positioned will prevent the system from starting up. This will deliver a fault warning on the HMI. Re-configure the valves as required and continue start-up procedures.

4.3.3 Operational Description

Once the system start has been initiated, the following will occur:

1. Alinta feed pump starts from signal out from PLC.
2. MOV1 will open, allowing feed water to enter the container.
3. Feed water will be dosed with SMBS, acid and anti-scalant chemicals automatically. Acid dosing starts after mains system pump starts.
4. Feed water will pass through cartridge filtration external to the container.
5. Feed water will re-enter the container and be delivered to the main system pump. A side stream will be directed to the Trasar unit.
6. Trasar unit will measure raw water conductivity, temperature, ORP, pH and anti-scalant concentration. All values displayed on the HMI screen.
7. Main system pump will supply water at high pressure to the R.O vessels. Flow from main system pump controlled by variable speed drive, VSD-01.
8. Water will pass through stage 1, 2 and 3 R.O pressure vessels. Concentrator system is isolated, and waste stream flows directly to the reject manifold.
9. The waste stream will pass through the reject manifold where the flow rate and pressure are monitored and displayed on the HMI. Control valve V41* and V42* are used to adjust this flow rate.

4.4 START-UP FLUSH

On start up, MOV4 opens after MOV1 which allows filtered, dosed water to flow unrestricted to waste. This flushes out the permeate water from the membranes which was flushed through the system on previous shutdown. The flush time is adjustable on the HMI.

Once flush is complete, MOV4 will close and the main system pump, and concentrator pump if in Auto Mode 1, will start-up and bring the whole system up to pressure.

The permeate water is flushed through the membranes by the flush pump. When MOV4 opens, MOV3 opens and FS01 senses water flow which starts the flush pump

All operational parameters can be monitored on the HMI screen.

4.4.1 Kelco Flow Switch

The F50 Kelco flow switch, FS01, controls the operation of the flush pump. The flow switch has 4 rotary switches located under the clear cover on the top deck of the F50. These should not require adjusting once plant has been fully commissioned.

There are a number of LED lights on the controller which indicate the status of the controller.

Table 5: LED indication lights on F50 pump controller

LED Colour	LED Status	Controller Status
Green	Steady	Paddle of flow switch held on by flow. Pump operational.
Red	Steady	Pump stopped in normal operation.
Red	Flashing	Pump has run dry. Pulses slowly in a coded fashion to indicate the number of times the F50 has tried to restart the system. One pulse – first run dry Up to four pulses – up to fourth run dry. If the system is unable to restart after 4 attempts, the controller enters full lock out mode.
Blue	Steady	Run-on time is running
Blue	Flashing	Start-up timer is running.

For detailed information on operation and setup of the F50, refer product manual.

4.5 SHUTDOWN

Upon selecting system shutdown from the HMI, the following sequence will occur.

1. Main system pump and concentrator (if running) pump will stop. Acid dosing stopped when main system pump is stopped.
2. MOV1 will remain open.
3. MOV4 opens for a time (adjustable at HMI), dosing continues.
4. MOV1 closes and all remaining dosing pumps are stopped.
5. MOV3 opens and flush pump will be engaged. Permeate water is flushed through the system for a time (adjustable at HMI). This removes all brine water from the membranes so that no fouling occurs during while the system is not operating.

6. MOV3 and MOV4 close. This completes the system shutdown.

Note: Full shutdown sequence must be completed before the machine will respond to system controller panel inputs to restart the unit.

4.6 SYSTEM IDLE

If the permeate tank level goes above the high set-point (adjustable on the HMI) for 5 minutes, the machine goes into full shutdown mode, including system flush, and then enters idle mode. When in idle mode, “tank high” is displayed on the HMI and the “system idle” light is illuminated.

When the permeate tank goes below the low level set-point (adjustable on the HMI) the machine automatically restarts.

4.7 EMERGENCY STOP

An emergency stop has been provided in order to shut down the plant in the event of an emergency.

The emergency stop button is located on the main control panel in the container.

When the emergency stop is engaged, all power to all operations is immediately killed.

When emergency stop is disengaged, unit will commence shutdown procedure and remain in alarm condition “emergency stop” until reset on the HMI

4.8 ADJUSTING PLANT PERFORMANCE

The performance of the plant will vary with changing feed conditions. A number of factors can influence the performance of the plant, such as feed water temperature, feed TDS, system pressure, etc. These changes can be accounted for by normalising the system performance, which involves comparing the actual plant performance and conditions with a reference set of conditions. For further explanation on normalisation, please refer to section 6.6, “Normalisation”.

4.8.1 Adjusting Permeate Flow Rate

The permeate flow rate from the Main R.O can be adjusted by throttling the flow using the manual valves V24, V25 and V49. Throttling these valves will alter the back pressure on stage 1, 2 and 3 permeate lines respectively, thus changing the permeate flow rate. This is done to balance the flux through the membranes. Pressure gauges are installed on each of these lines to provide an indication of the line pressure.

Permeate flow through the concentrator cannot be throttled.

Table 6: Approximate permeate back-pressure levels

Gauge Location	Gauge ID	Approximate Pressure
Stage 1 permeate	PI01	400kPa
Stage 2 permeate	PI02	200kPa
Stage 3 permeate	PI03	-

4.8.2 Adjusting Brine Flow Rate

The brine flow can be throttled in a similar fashion as the permeate flow. The needle valve V41 is used to throttle the brine flow when in Auto Mode 1 (main R.O and concentrator operational). When in Auto Mode 1, a lower brine flow rate is achieved due to the higher recovery.

When the plant is operating in Auto Mode 2 (concentrator off); the brine flow rate is greater and a larger amount of waste must pass through the brine manifold. When operating in Auto Mode 2, V39 is opened to allow flow through both needle valve V41 (as above), and also globe valve V40.

Table 7: Adjusting brine flow rate

Operating Mode	Brine Throttling
Auto Mode 1	V41
Auto Mode 2	V41 and V40

4.8.3 Adjusting Main R.O Pump

The operational performance of the main system pump is controlled by varying the power supply frequency using the variable speed drive, VSD-01.

Adjusting VSD-01 will mainly be required when the feed water temperature varies significantly from the design temperature of 18℃. In this case, it will be required to adjust the frequency of the pump using VSD-01 to maintain the desired performance.

Please refer compensation charts provided in Appendix 1.

4.8.4 Adjusting Concentrator Pump

The operational performance of the concentrator pump is controlled by varying the power supply frequency using the variable speed drive, VSD-02.

Similar to the system pump, the concentrator pump will be required to be adjusted in order to maintain the design concentrator pressure when feed conditions vary significantly from the design.

Please refer compensation charts provided in Appendix 2.

5. CLEANING SYSTEM

5.1 CLEANING SYSTEM

A fully integrated Clean In Place (CIP) system has been installed in the container to allow in-situ cleaning of the membranes. The cleaning system consists of a cleaning tank with heating elements and controls, dedicated cleaning pump, cartridge filtration and required valves and piping to deliver the cleaning fluid through the membranes as required.

Note: When full, the cleaning tank holds a maximum of 640 litres of water.

5.2 CLEANING FLUIDS

Three cleaning chemicals have been provided for cleaning. Table 8 lists the chemicals provided along with the target foulant.

Table 8: List of cleaning chemicals supplied

Cleaning Product	Type	Target Foulant
PermaClean PC-33	Sequestrant	Insoluble Sulfates
PermaClean PC-77	Acid Cleaner and Sequestrant	Iron oxide and $CaCO_3$ scale
PermaClean PC-99	Alkaline detergent	Organics and colloids

5.2.1 PermaClean PC-33

PermaClean PC-33 is a good general purpose membrane cleaner designed to support the cleaning of acid insoluble sulphates of calcium, barium and strontium, as well as calcium fluoride.

- Suitable for use with polyamide thin film composite and acetate membranes.
- Supports the removal of acid insoluble scale
- Liquid product for ease of application.
- High level of active substance
- Broad spectrum of application

PermaClean PC-33 is effective in removing iron oxides and hydroxides as well as calcium carbonate.

Used at 2.0 – 2.5% concentration by volume.

Please refer MSDS and product bulletin.

5.2.2 PermaClean PC-77

PermaClean PC-77 is a membrane cleaner specifically developed to remove iron fouling from R.O membranes. It can also be used to remove light calcium carbonate deposition. The efficacy of PermaClean PC-77 is enhanced by the addition of PermaClean PC-33 to the cleaning solution; some minor pH correction may be necessary.

- Suitable for use with polyamide thin film composite and cellulose acetate membranes.
- Liquid product for ease of use
- High level of active substance
- Buffered to ensure consistent pH control

Used at 4.0% by weight solution (1kg PC-77 per 25kg of water)

Please refer MSDS and product bulletin.

5.2.3 PermaClean PC-99

PermaClean PC-99 is a liquid blend of dispersant and inorganic builders with an amphoteric surfactant. It has been specially developed as an alkaline cleaning formulation for removing organic debris and bio-fouling from R.O membranes. PermaClean PC-99 does not contain any amino carboxylic acid sequestrants.

- Suitable for use with polyamide thin film composite and cellulose acetate membranes.
- Concentrated liquid product for ease of use.
- Effective cleaner, for removing organic deposits from membranes.
- Has a wide range of applications and compatibility with many other cleaners.
- Has efficacy in reducing bio-fouling.

Used at 1.0 – 2.0% concentration by volume.

Please refer MSDS and product bulletin.

5.3 CLEANING SEQUENCE

Membrane cleaning should be carried out in the following sequence.

1. Alkaline clean – Using PermaClean PC-99
2. Acid clean – Using mixture of both PermaClean PC-33 and PermaClean PC-77.

5.4 CLEANING MODE 1 – MAIN R.O

See flow sheet PFD-01-CLEAN1 for flow path.

When cleaning the main R.O, the entire system is shutdown and not producing permeate.

Cleaning of the main R.O must happen in two phases:

- Mode 1A – cleaning of stage 1 vessels; two vessels at a time in parallel
- Mode 1B – cleaning of stage 2 and 3 vessels; one stage vessel at a time in series with stage 3 vessel.

5.4.1 Mode 1A – Cleaning Stage 1 vessels

- The vessels in stage 1 are cleaned 2 at a time in parallel.
- See flow sheet PFD-01-CLEAN1A for flow path.

1. Isolate the desired vessels for cleaning, as per the valve position guide.
2. Initiate clean operation as per section 5.3.3.

Table 9: Valve positions - Clean Mode 1A

Valve Description	Valve Numbers	Status
Inlet feed	V01, V02, V03, V04, V05, V08, V10	OPEN
Stage 1 inlet	V13, V14, V15, V16, V17, V18 Open two at a time per clean	OPEN
Stage 2 inlet	V19, V20, V21	CLOSED
Permeate valves	V24*, V25*, V49*	OPEN
Permeate to tank	V27 (CRITICAL)	CLOSED
Brine	V41*, V39, V48, V40*	OPEN
Brine	V38	CLOSED
Concentrator	V32, V34	CLOSED
Cleaning	V12, V70, V43, V44 V36, V37, V69	OPEN CLOSED
Permeate Valve	V31	CLOSED
Three Way Valve	V65	POSITION 1

* Denotes control valve. These are manually adjusted to control back pressure and flow rate. Once set, these should not require adjusting.

Note: When draining cleaning tank through valve 46 **DO NOT** drain tank completely as this will result in airlock and potential damage to cleaning pump.

5.4.2 Mode 1B – Cleaning Stage 2 and 3 vessels

- The vessels in stages 2 are cleaned one at a time, in series with the stage 3 vessel.
- See flow sheet PFD-01-CLEAN1B for flow path.

1. Isolate the desired vessels for cleaning, as per the valve position guide.
2. Initiate clean operation as per section 5.3.3.

Table 10: Valve positions - Clean Mode 1B

Valve Description	Valve Numbers	Status
Inlet feed	V01, V02, V03, V04, V05, V08, V10	OPEN
Stage 1 inlet	V13, V14, V15, V16, V17, V18	CLOSED
Stage 2 inlet	V19, V20, V21 Open one at a time per clean	OPEN
Permeate valves	V24*, V25*, V49*	OPEN
Permeate to tank	V27 (CRITICAL)	CLOSED
Brine	V41*, V40*	OPEN
Brine	V38, V48, V39	CLOSED
Concentrator	V32, V34, V37	CLOSED
Cleaning	V12, V70 V36, V69, V42, V43, V44	CLOSED OPEN
Permeate Valve	V31	CLOSED
Three Way Valve	V65	POSITION 1

* Denotes control valve. These are manually adjusted to control back pressure and flow rate. Once set, these should not require adjusting.

Note: When draining cleaning tank through valve 46 **DO NOT** drain tank completely as this will result in airlock and potential damage to cleaning pump.

5.4.3 Clean Mode 1 - Procedure

1. Set valves as per list.

2. Select “clean mode” from the HMI screen
3. Select “fill tank” from the HMI. Tank will fill with permeate until high level reached.
4. “Stop fill” button interrupts and stops filling at any time.
5. Select “heater on” from HMI. Heater cannot turn on and will not remain on unless LS03 is high. Cleaning tank regulates temperature to set-point using PLC control. Heater only runs to maintain set-point temperature.

   Note: Heater will stop anytime LS03 goes low, and will automatically restart once LS03 goes high and heater is turned on.

6. **Alkaline Clean:** Add 12.8 litres of PermaClean PC-99.

   Acid Clean: Add 12.8 litres of PermaClean PC-33 and 25.6kg of PermaClean PC-77.

7. Select time values for “run”, “soak” and “run”.
8. Select “start clean” from HMI. Will run automatically according to run times entered. Will display “clean complete” on HMI when cleaning cycle finished.
9. “Pause” button on/off will pause and resume the cleaning pump mid cycle.
10. “Stop” button will completely stop the cleaning cycle.
11. “Run clean pump” will run the cleaning pump to allow the system to be drained. Cleaning pump will stop when LS03 goes low.
12. Repeat as required.
13. Return all valves to service position once cleaning procedure completed.

Note: When draining cleaning tank through valve 46 **DO NOT** drain tank completely as this will result in airlock and potential damage to cleaning pump.

5.5 CLEANING MODE 2 – CONCENTRATOR

- See flow sheet PFD-01-CLEAN2 for flow path.
- When cleaning the concentrator, the main R.O system can still be operated.
- Set valves as per list. See PID-01-CLEAN2 for complete valve guide.

Table 11: Valve position guide - Clean Mode 2

Valve Description	Valve Numbers	Status
Inlet feed	V01, V02, V03, V04, V05, V08, V10	OPEN
Stage 1 inlet	V13, V14, V15, V16, V17, V18 (Main R.O can operate)	OPEN

Stage 2 inlet	V19, V20, V21	OPEN
Permeate valves	V24*, V25*, V49*	OPEN
Permeate to tank	V27 (CRITICAL)	OPEN
Brine	V41*, V39, V48, V40*	OPEN
Brine	V38	CLOSED
Concentrator	V32, V34	CLOSED
Cleaning	V12, V70, V69	CLOSED
	V36, V37, V72,V26, V43, V45	OPEN
Permeate Valve	V31	CLOSED
Three Way Valve	V65	POSITION 1

* Denotes control valve. These are manually adjusted to control back pressure and flow rate. Once set, these should not require adjusting.

Note: When draining cleaning tank through valve 46 **DO NOT** drain tank completely as this will result in airlock and potential damage to cleaning pump.

5.5.1 Clean Mode 2 - Procedure

1. Set valves as per list. See PID-01-CLEAN2 for complete valve positioning guide.
2. Select “clean mode” from the HMI screen
3. Select “fill tank” from the HMI. Tank will fill with permeate until high level reached.

   Note: When cleaning the concentrator system, less cleaning fluid is required. In this mode, it is only required to fill the tank to half full. When operating in this mode, only 1 heating element operates.
4. “Stop fill” button interrupts and stops filling at any time. Stop tank fill when tank is approximately half full (about 750 litres)
5. Select “heater on” from HMI. Heater cannot turn on and will not remain on unless LS03 is high. Cleaning tank regulates temperature to set-point using PLC control. Heater only runs to maintain set-point temperature.

   Note: Heater will stop anytime LS03 goes low, and will automatically restart once LS03 goes high and heater is turned on.

6. **Alkaline Clean**: Add 7 litres of PermaClean PC-99.

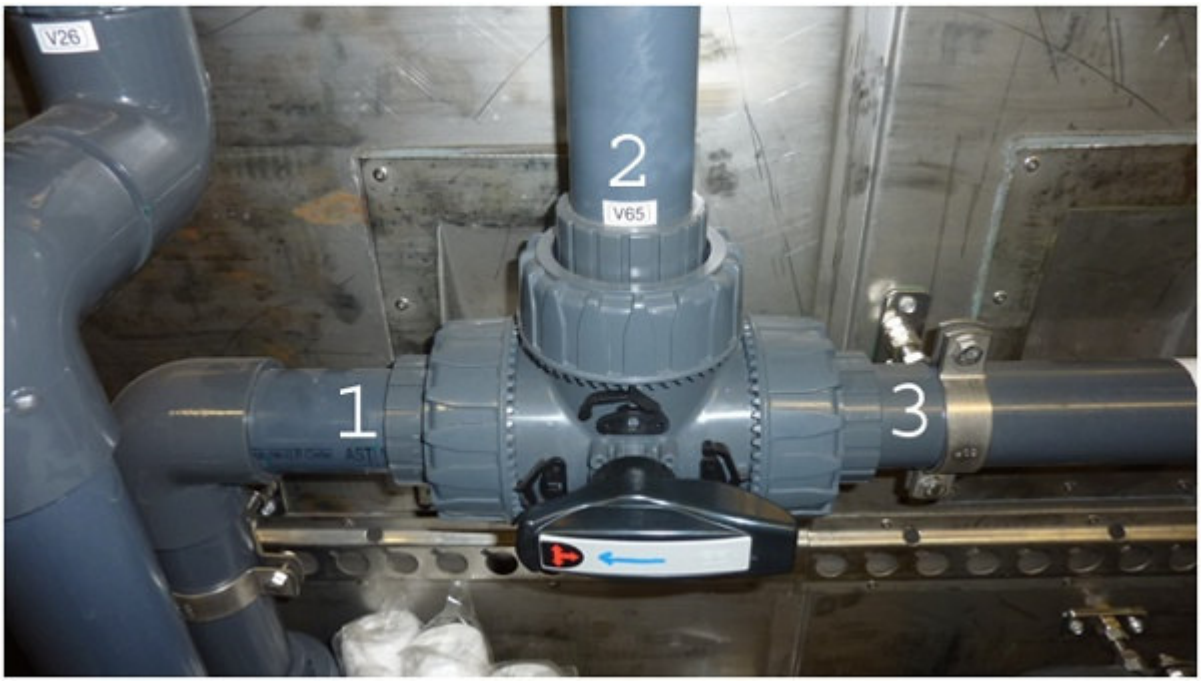
   Acid Clean: Add 7 litres of PermaClean PC-33 and 14kg of PermaClean PC-77.

* Assuming the tank is filled with approximately 350 litres of water. If unsure, make up cleaning chemicals to the appropriate concentrations as per section 5.2.

7. Select time values for “run”, “soak” and “run”.
8. Select “start clean” from HMI. Will run automatically according to run times entered. Will display “clean complete” on HMI when cleaning cycle finished.
9. “Pause” button on/off will pause and resume the cleaning pump mid cycle.
10. “Stop” button will completely stop the cleaning cycle.
11. “Run clean pump” will run the cleaning pump to allow the system to be drained. Cleaning pump will stop when LS03 goes low.
12. Repeat as required
13. Return all valves to service position once cleaning procedure completed.\

Note: When draining cleaning tank through valve 46 **DO NOT** drain tank completely as this will result in airlock and potential damage to cleaning pump.

5.5.2 Three Way Valve V65



Position 3 – Normal service position.

Position 1 – Circulation of cleaning solution.

Position 2 – Directs cleaning solution to drain. Caution: Monitor cleaning tank level whilst in this position.

5.6 FINE-TUNING CLEAN SYSTEM

5.6.1 Cleaning flow rate

The cleaning system flow rate can be modified by manually adjusting the globe valve, V44. This will throttle the cleaning rate to achieve the desired flow.

Each vessel requires a cleaning flow rate of approximately 8m^3/hr. The recommended cleaning flow rate for each mode is shown below.

Table 12: Recommended cleaning flow rates

Cleaning Mode	Recommended flow rate
Clean Mode 1A	16m^3/hr
Clean Mode 1B	8m^3/hr
Clean Mode 2	8m^3/hr

6. HUMAN MACHINE INTERFACE (HMI)

The R.O plant is controlled entirely through the HMI. The HMI displays current system information, including all process variables, conductivity levels, temperature, flow rate, pressure. The HMI shows the status of limit switch valves, and displays any alarm or fault warnings.

The HMI is also used to control the R.O system. Start-up, shutdown, and all operating modes, including cleaning, are activated through the HMI. The HMI consists of a touch screen interface, along with a number of hard press buttons down the left hand side.

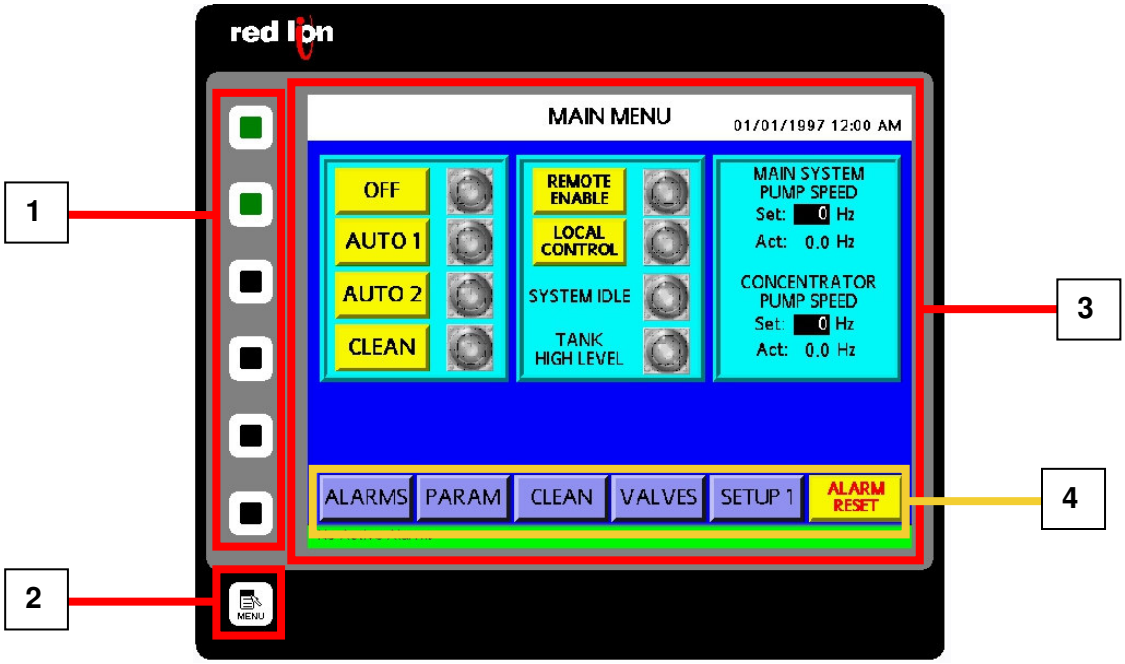


Figure 1: HMI panel layout.

Table 13: HMI layout identification

Number	Description
1	Hard press navigation buttons
2	Hard press menu Button
3	Active Screen (touch activated)
4	Touch screen navigation buttons

6.1 HMI SCREENS

The HMI has 6 screens. These are listed and described in Table 14 below.

Table 14: HMI screens

No.	Screen Name	Description
1	Main Menu	Allows selection of the mode of operation. Enables remote / local control. Displays main system and concentrator pump speeds.
2	Alarms	Displays list of current / active alarms. Alarm reset from this screen.
3	Parameters	Displays current operating parameters, including flow rates, pressure, temperature, pH, ORP, conductivity, permeate tank level, pump speed and hours run for system pumps.
4	Setup	Allows entering of all set-points for plant operation, including PID loop settings and time outs.
5	Clean	Shows current status for the cleaning system, including tank level and tank temperature. Allows start / stop / pause / heater control for cleaning system Allows entering of cleaning cycle times and tank temperature set-point
6	Valves	Displays current status of all motorised valves. Displays status of position feedback valves, including indication of whether these valves are incorrectly positioned.

6.1.1 Navigating Between Screens

Navigating between the various screens is simple. Each of the screens can be accessed by pressing on the corresponding touch screen navigation button along the bottom of the current screen. This will direct the system to the desired screen.

The hard press navigation buttons also redirect the user to the required screen. The hard press buttons, from top to bottom, correspond to the screen numbers as per Table 14.

The hard press menu button will automatically redirect to the Main Menu screen when pressed.

6.1.2 Entering Set-Points and Values

To enter set-point data into the HMI, the user simply touches the box for data to be changed. This will activate a pop-up menu with numerical pad for entering values. Enter the desired value and press the enter button. If the value entered is out of the allowable range, the system will not allow the value to be entered.

Note: Once plant is setup and commissioned, changing of set-point values should not be required. See section 6.5 for list of set-points.

6.1.3 Security and Password Protection

The setup page is password protected to prevent unauthorised access to the important system set-points. The default username and password for the system is shown below.

Table 15: Default security settings

Item	Value
Username	alinta
Password	1234

6.1.4 Main Menu Screen

The mode of operation can be selected by pressing the corresponding buttons on the screen. The current process will be highlighted in green when active.

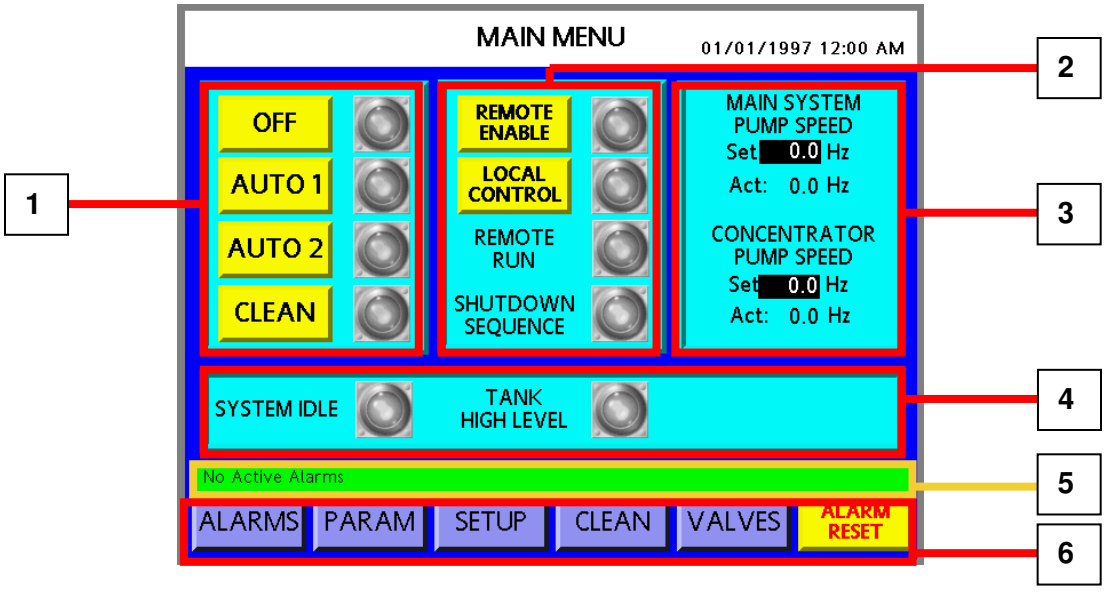


Figure 2: Main menu screen

Table 16: Main Screen layout identification

Number	Description
1	System operation mode select
2	Remote enable/disable, local control select and system status
3	Main R.O and concentrator pump speed select
4	Status indication (system idle and permeate tank)
5	Alarm status bar
6	Soft press navigation buttons

6.1.5 Alarm Screen

The alarm screen displays current / active alarms, which are displayed as a list on the HMI screen. The alarm message will show a description of the fault, and what instrument is the cause for the particular alarm. If the alarm also has a trip plant condition, the plant will have gone into shutdown mode and have to be reset. Please refer section 0 for full description of alarms and trip conditions, and alarm reset procedure.

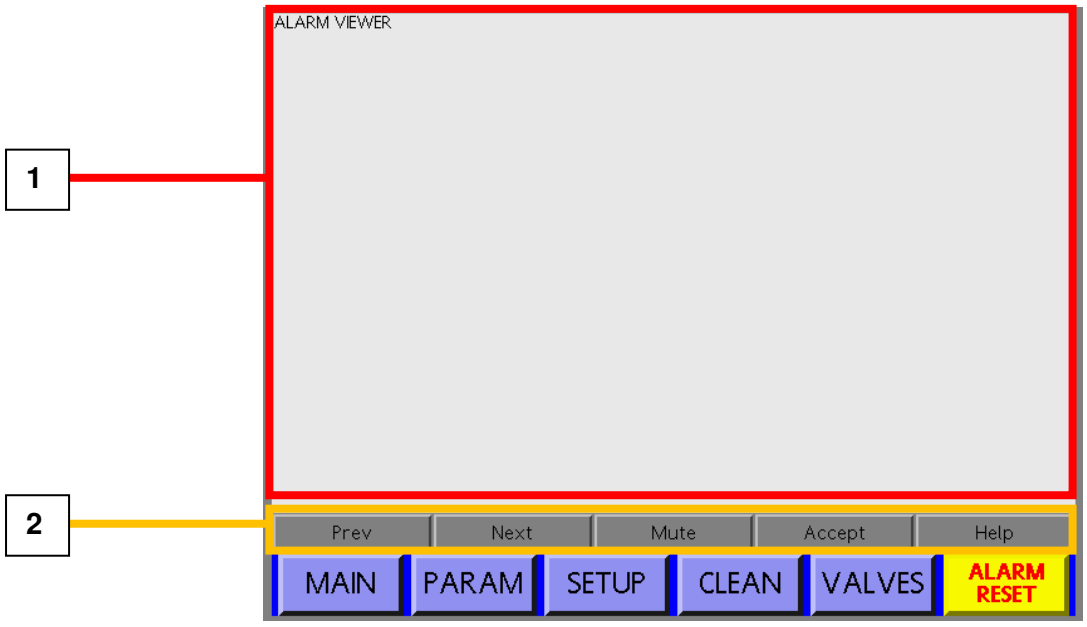


Figure 3: Alarm screen

Table 17: Alarm screen items

Number	Description
1	Alarm viewer window. Shows current alarms and faults
2	Alarm navigation keys. Prev/Next – Moves between different alarms Mute – Mutes current alarm Accept – Accepts the current alarm

6.1.6 Parameter Screen

The parameter screen shows the current process values for all instruments. This includes flow rates, pressures, temperature, salinity, conductivity, permeate tank level, system pump speeds and system pump hours run. The units for each variable are displayed on the HMI.

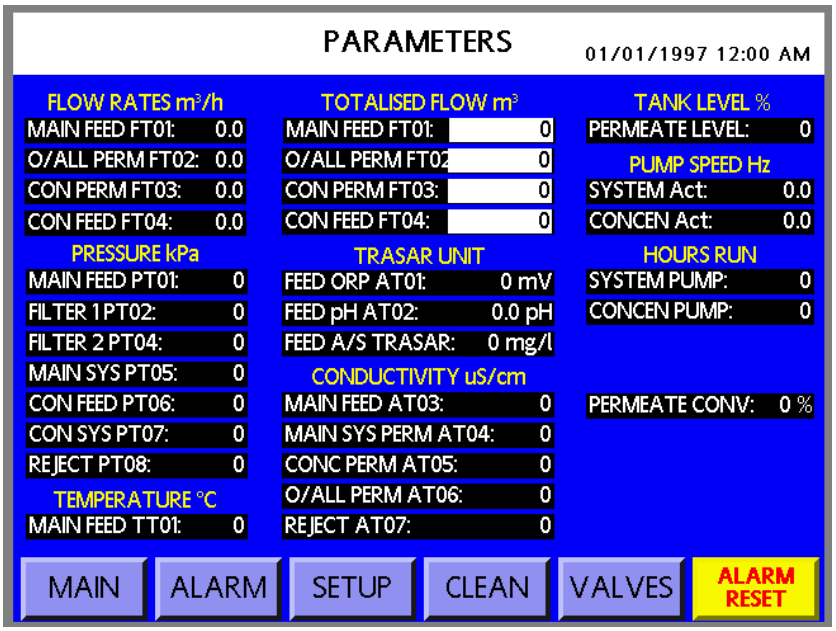


Figure 4: Parameter Screen

6.1.7 Setup Screen

The setup screen (excluding the cleaning screen) is the only screen which allows the user to enter data. This screen allows the user to view and edit all set-point parameters for the system. To change / edit a parameter on the setup screen, simply touch the screen on the value you wish to edit, and this will activate up the pop-up menu.

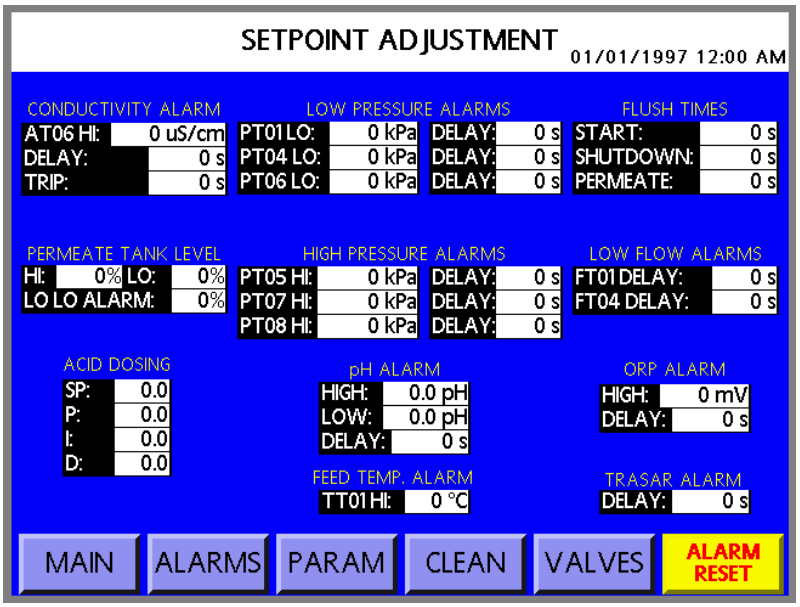


Figure 5: Setup screen

6.1.8 Clean Screen

The clean screen shows the current status of the cleaning system. This screen only requires access when carrying out a system clean.

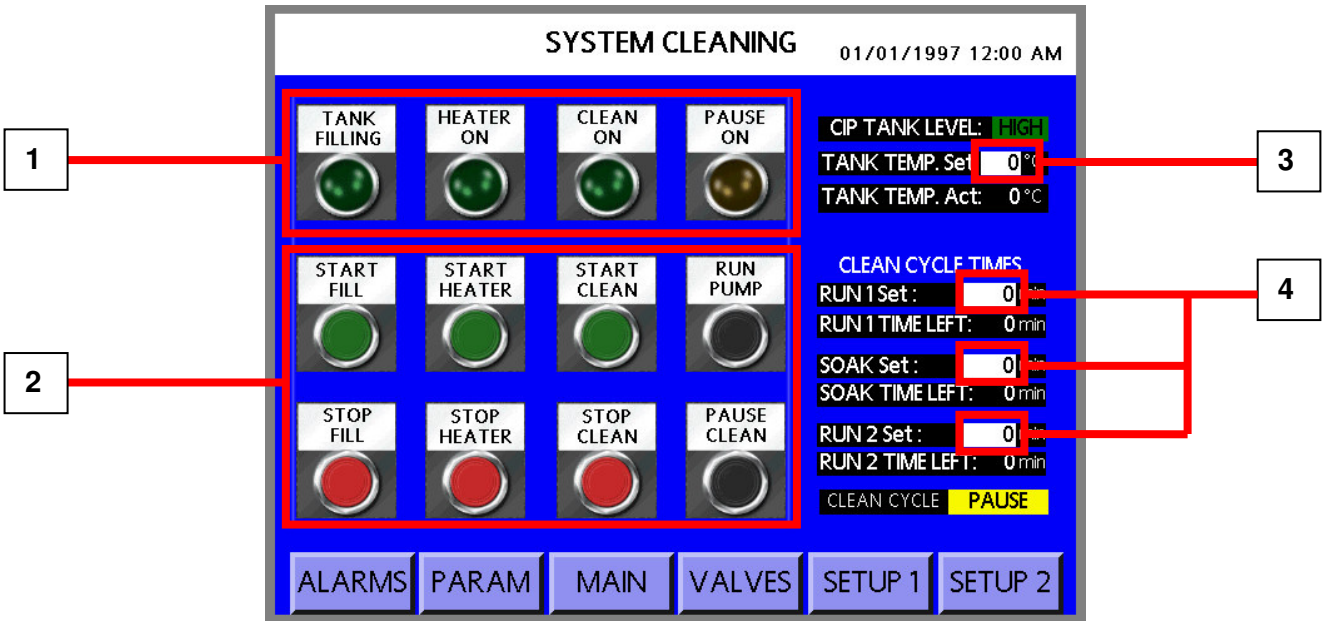


Figure 6: Clean screen

Table 18: Cleaning screen items

Number	Description
1	Cleaning status indication lights
2	Cleaning system operating buttons
3	Cleaning tank temperature set-point adjust
4	Cleaning cycle timer settings adjust

6.1.9 Valve Screen

The final screen shows the current status of all motorised valves and configuration of all position feedback valves. This screen also shows whether the position feedback valves are in the correct configuration for Auto Mode 1 and Auto Mode 2 operation. Refer Section 4 for correct valve positions for each of these modes.

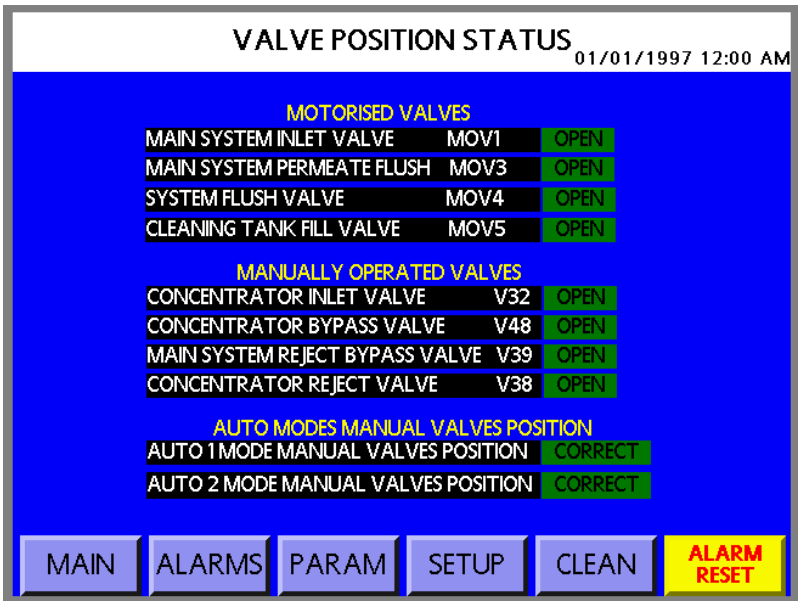


Figure 7: Valve position screen

6.2 ALARMS AND FAULTS

A number of trips and alarms have been incorporated into the PLC logic to provide warning, and automatic shutdown of the system, for certain conditions. Table 19 provides a list of the alarms and trips.

Table 19: List of system alarms

Alarm No.	Description	Source Instrument	Actions on Plant	Notes
1	No water flow to Trasar instrument	FS02	Trip plant	Plant will trip out if no flow sensed after 3 mins from PU01 start.
2	High ORP	AT01	Trip plant	Plant to trip out if ORP above set-point for period above set time.
3A **3B**	pH high pH low	AT02	Alarm only	Plant alarm if pH goes above or below set-point for longer than set time.
4	Trasar anti-scalant alarm	Trasar 01	Alarm only	Plant alarm if anti-scalant levels above or below set-point for longer than set time. Timer starts when PU01 starts.
5	Permeate tank low level	Alinta	Alarm only	Plant alarm if permeate tank below low level.
6	Anti-scalant pump no flow alarm	PU06 error signal	Trip plant	Trip plant if no flow sensed after period of time.
7	Acid pump no flow alarm	PU05 error signal	Alarm only	Acid not required all the time. Plant alarm if PID loop calls for acid but no acid sensed being pumped.
8	Low main feed pressure	PT04	Trip plant	Trip after time out of low pressure signal
9	High main system pressure	PT05	Alarm only	Plant alarm after time out of pressure over set-point during main operation.
10	Low pressure to concentrator	PT06	Trip plant	Auto mode 1 operation only. Trip plant after time out of low pressure below set-point.

11	High pressure to concentrator	PT07	Alarm only	Auto mode 1 operation only. Plant alarm after time out of high pressure above set-point
12	Permeate conductivity high	AT06	Alarm then trip	Alarm not to apply until system running for at least 10 minutes. Alarm if reading above set-point. Trip plant if still above set-point after 15 minutes.
13A	Valve 32 position fault for Auto Mode1	ZI01	Permissive for plant to run	Trip instantly.
13B	Valve 32 position fault for Auto Mode 2			
14A	Valve 48 position fault for Auto Mode1	ZI02	Permissive for plant to run	Trip instantly.
14B	Valve 48 position fault for Auto Mode 2			
15A	Valve 39 position fault for Auto Mode1	ZI03	Permissive for plant to run	Trip instantly.
15B	Valve 39 position fault for Auto Mode 2			
16A	Valve 38 position fault for Auto Mode1	ZI04	Permissive for plant to run	Trip instantly.
16B	Valve 38 position fault for Auto Mode 2			
17	Low flow in main system feed	FT01	Alarm and trip	Trip plant after time delay from MOV1 opening during start up flush if no flow detected.
18	Low flow in concentrator system feed	FT04	Alarm and trip	Trip plant after time delay from MOV1 opening during start up flush if no flow detected.
19	Emergency stop	HS02	Trip plant	Trip instantly.
20	High feed temp	TT01	Alarm only	Plant alarm if feed temperature

	alarm			over set-point
21	VSD fault	VSD01	Trip instantly	Trip plant when fault detected
22	VSD fault	VSD02	Trip instantly	Trip plant when fault detected
23	Flush pump overload	PU03	Trip instantly	Trip plant when overload detected
24	Clean pump overload	PU04	Trip instantly	Trip plant when overload detected
25	Low anti-scalant level	LS04		
26	Low raw feed pressure	PT01		
27	High brine stream pressure	PT08	Alarm only	Plant alarm if brine pressure exceeds set-point after set time
28	High cleaning tank temperature	TC01	Alarm	Plant alarm and stop cleaning pump, PU04
29	Power failure alarm			
30	High conversion alarm		Alarm and trip	Trip plant if conversion exceeds 95% recovery.

6.2.1 Plant Alarms

If the system activates an alarm only, the alarm status bar at the bottom of the main screen will turn from green to red, and will show a description of the alarm.

The alarm can be reset from the alarm page.

6.2.2 Plant Trips

If the plant trips out on any of the conditions shown in Table 19, the system will automatically enter shut down mode.

Note: The alarm / trip condition cannot be reset until the system has been switched to off mode.

6.2.3 Alarm Reset Procedure

Plant Tripped:

1. If plant tripped, switch unit to “Off mode”
2. System must be totally shut down.

3. Navigate to the “Alarm” page
4. Push the “Alarm reset” button. Alarm changes colour from red to grey.
5. Push the “Next” button, the active alarm will highlight.
6. Push the “Accept” button.
7. For multiple alarms, repeat steps 5 and 6 above.

Plant in Alarm mode only

1. Follow steps 3 to 7 above.

6.3 PLC

The system utilises an Allen Bradley PLC for system monitoring and control. The PLC processes all sensor inputs and controls the operation of all motors, pumps, elements, actuated valves etc.

The PLC also processes and activates all alarm conditions.

An hour run meter records all hours run by both the main system pump and concentrator pump. These values are displayed on the HMI parameter screen.

6.4 REMOTE ACCESS AND CONTROL

The PLC system has been installed to allow remote access and control of the plant. An Ethernet port provides a connection interface between the plant PLC and Port Augusta DCS/SCADA system.

6.4.1 Remote Access

The PLC system can be remotely accessed to view the current operating conditions of the plant. This essentially provides all information available from the HMI screen (system status, operating variables etc) remotely.

This also allows logging of plant performance and process variables on the Port Augusta system.

6.4.2 Remote Start/Stop

The system can also be remotely started and stopped. This allows operators remotely monitoring the plant to shut down the system should this be required.

6.5 OPERATING SET-POINTS

The following table lists all of the system set-points as entered during commissioning. These should not require changing once system is setup.

Table 20: List of operating set-points

Description	Instrument	Set-Point Value	Time-Out Value
Permeate tank level	LC01	High – 80%	-
		Low – 40%	-
		Low low – 10%	-
Acid dosing	AT02	pH SP – 7.1	-
		P – 3.0	-
		I – 5.0	-
		D – 0.0	-
pH alarm	AT02	Set point –	-
		High – 7.8	120 sec
		Low – 6.0	120 sec
Conductivity alarm	AT06	40µS/cm	Delay – 120 sec
			Trip – 300 sec
Low pressure alarms	PT01	200kPa	10 sec
	PT04	50kPa	5 sec
	PT06	50kPa	10 sec
High pressure alarms	PT05	1800kPa	20 sec
	PT07	1500kPa	12 sec
	PT08	1500kPa	27 sec
Feed temperature alarm	TT01	39℃	-
Flush times	Start	240 sec	-
	Shutdown	240 sec	-
	Permeate	800 sec	-
Low flow alarms	FT01	20 sec	-
	FT04	20 sec	-
ORP Alarm	AT01	High – 390mV	120 sec
Trasar alarm delay	Trasar	120 sec	-

6.6 NORMALISATION

Reverse Osmosis systems often operate under differing feed conditions. Changes in operating conditions (such as temperature, feed TDS, system pressure, permeate flow, recovery etc.) can impact on the performance of the system.

Normalisation is a technique that allows users to compare the operation of the plant at a specific set of conditions to a reference set of conditions. This allows users to determine whether changes in flow or rejection are caused by fouling, damage to the membrane, or are just due to the different operating conditions. The use of normalisation therefore "factors out" the effects of changing feed conditions (pressure, temperature, TDS etc.) and factors relating to fouling, degradation, systemic issues are more clearly discerned.

6.6.1 FTNORM – Normalisation software

FTNORM is a normalisation spreadsheet provided by DOW. The software allows users to manually input operating parameters such as flow rates, pressures, temperatures, salinity etc. and outputs the normalised data. The software also plots the results against time for normalised permeate flow, normalised salt passage and rejection, and differential pressure.

A copy of this spreadsheet has been provided on the supplied disc.

Using the Spreadsheet:

- At the top of the spreadsheet, enter the "Plant Identification" and "Start-up date" in the designated cells.
- The cells requiring date entry contain red lettering. Blue lettering designates calculated values.
- The operating data is entered beginning in row 11 with the date. Overwrite the existing sample data. The equations performing the standardisation calculations will allow approximately one year (356 days) of data entry. You will need to copy the equations for each column when additional operating data is entered.
- When data entry is completed, save the spreadsheet using a unique name associated with the train.

Graphing Data:

The charts in the template are designed to show the first five data points in cells 11 through 15. As additional data is entered, update the chart using the chart/source data portion of the menu. In this section, you will increase the maximum values for the X-axis and Y-axis to reflect the operating data entered. This will update the chart to include the new data.

The images below show examples of the graphs plotted by FTNORM.

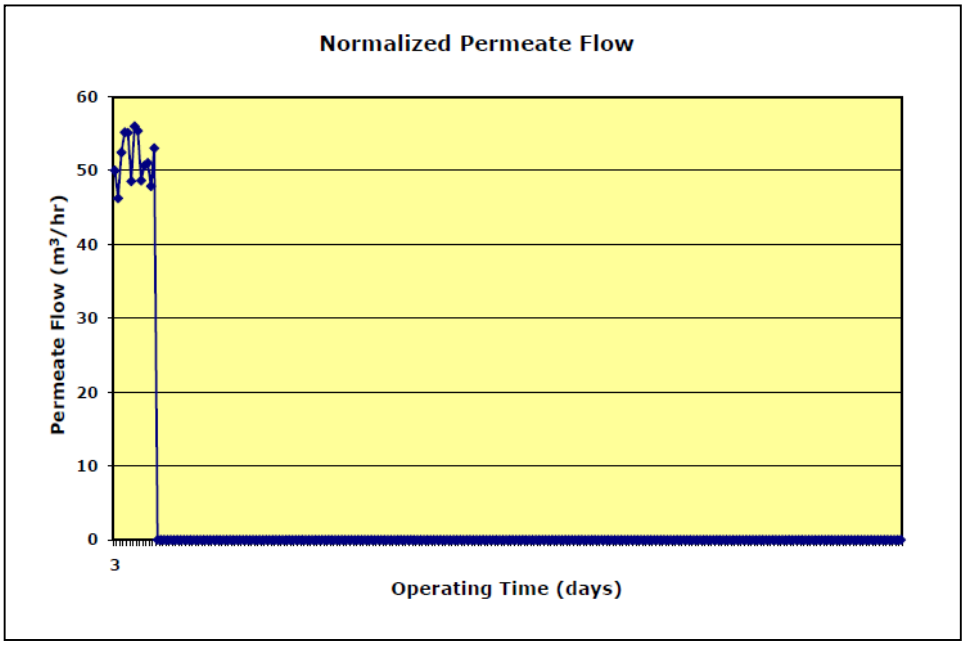


Figure 8: FTNORM output - normalised permeate flow

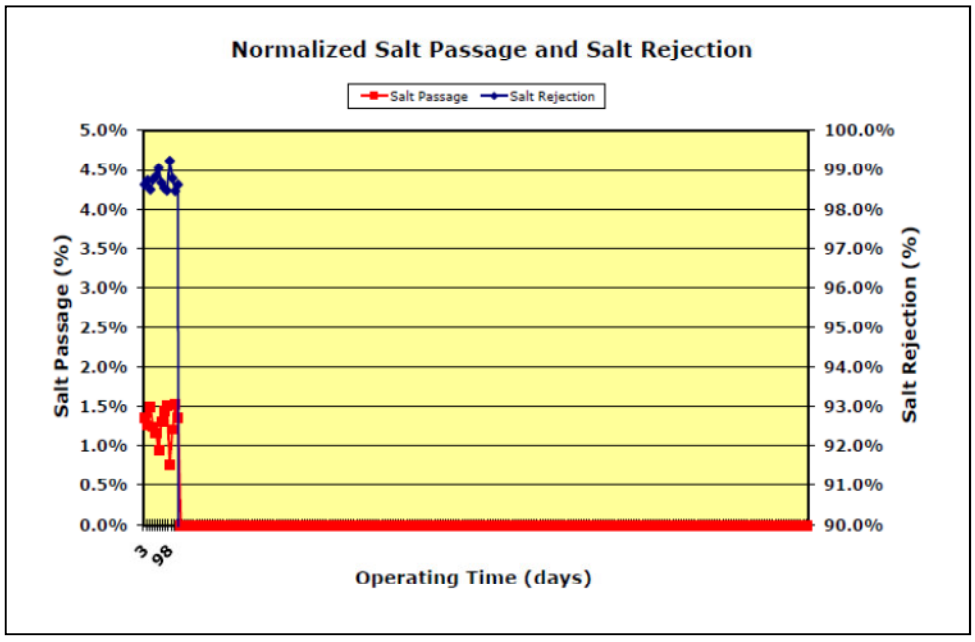


Figure 9: FTNORM output - normalised salt passage and rejection

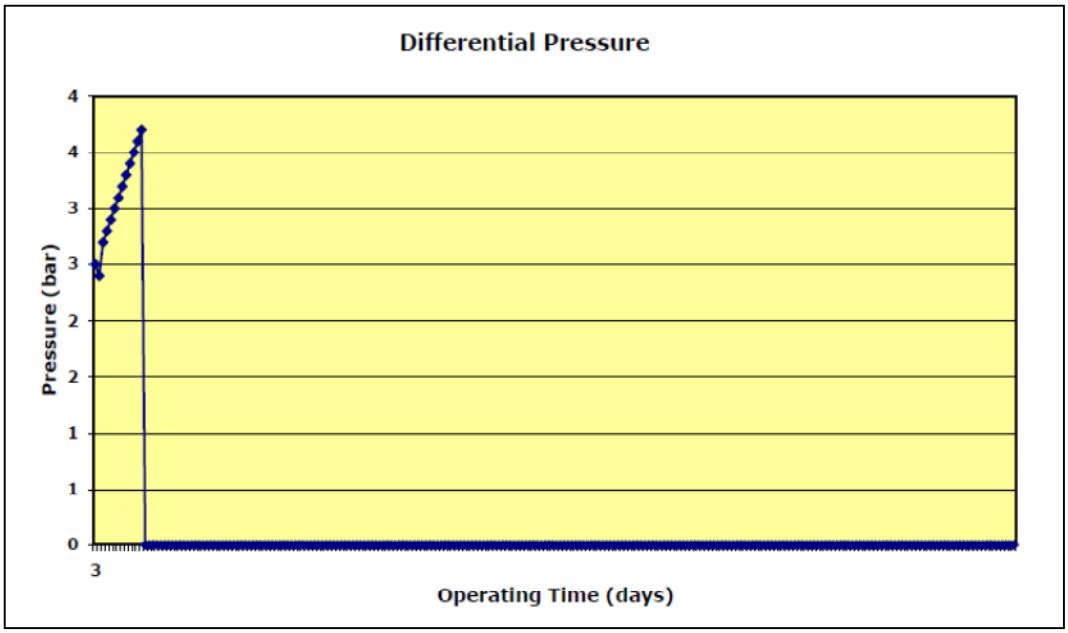


Figure 10: FTNORM output - differential pressure

7. MAINTENANCE AND SERVICE

7.1 ROUTINE MAINTENANCE AND CHECKS

Routine maintenance and checks should be carried out on the system to ensure optimum performance.

7.1.1 Check chemical levels

Each of the chemical tanks should be checked daily to ensure they remain full and do not run out.

- Anti-scalant tank
- SMBS tank

7.1.2 Log sheets

Log sheets should be completed, at least once per week, in order to monitor the performance of the plant. Completed log sheets should be sent to Aqueous Solutions. This allows us to identify potential issues with the operation of the plant and rectify them before they escalate.

A template log sheet has been provided in Appendix 3.

7.2 SERVICE INTERVALS

The following equipment items must be serviced at the intervals listed. Please refer to the individual manuals for each item for specific servicing requirements and procedures.

7.2.1 Grundfos Pumps

A number of Grundfos pumps are installed in the R.O plant. These pumps require routine servicing to ensure long life.

Table 21: Grundfos service intervals

Service Item	Service Interval
Bearing lubrication	4000 operating hours

Bearings should be lubricated with a high-temperature, lithium based grease. See instructions on the fan cover.

Please refer manufacturer supplied manual for complete instructions.

7.2.2 Dosing Pumps

The dosing pumps require servicing at least every 12 months, or after 4,000 operating hours. The following should be carried out when servicing the pumps, or in the event of a fault.

- Clean suction and discharge valves.
- Replace the diaphragm.

Refer product manuals for detailed instructions for each of these items.

7.3 MEMBRANE CLEANING

Membrane cleaning is generally required when normalised plant performance drops by more than 10 percent. Normalised performance monitoring is therefore required in order to determine when membrane cleaning is required.

See section 5 for cleaning procedures.

7.4 MEMBRANE PRESERVATION (FOR EXTENDED SHUTDOWN)

If the R.O plant is expected to be shut down for a period longer than 2 weeks, membrane preservation is required. Preservation prevents the formation of biological growth in the membrane housings which can cause major fouling and performance loss.

Membrane preservation is achieved by circulating a solution of 0.5 – 1% SMBS through the membranes, then leaving this in the system during the shutdown period.

7.4.1 Procedure

1. Use same procedure as cleaning procedure, section 5.4.3.
2. Instead of adding cleaning chemicals, add SMBS powder to achieve 1% (w/v) concentration.
3. Circulate SMBS solution through membranes for 5 minutes, then close off valves and leave solution in contact with membranes. Repeat for each stage.

Mass SMBS powder required (kg) = 0.01 x Volume water added to cleaning tank (litres)

Eg. 640 litres water in cleaning tank

0.01 x 640 = 6.4kg SMBS powder

7.5 MEMBRANE REPLACEMENT

The R.O membranes require replacing approximately once every 3 years. Membrane performance may slowly degrade with time.

7.6 CARTRIDGE FILTERS

The cartridge filters require replacing when the pressure difference between the inlet and the outlet of the filters exceeds 100kPa (15psi).

A number of cartridge filters are installed in the system.

Table 22: List of cartridge filters installed in system

Description	Filtration Quality	Filter Length	No. filters per housing	Total number filters
Pre-treatment filters – Stage 1	1 micron depth	40”	9	36
Pre-treatment filters – Stage 2	1 micron absolute	40”	9	27
Cleaning system filter	5 micron	40”	5	5

7.6.1 Change over procedure

1. Ensure system is in shutdown mode and actually shut down.
2. Close off all valves before and after filter

   Stage 1 filter: Close V02, V03, V04, and V05

   Stage 2 filters: Close V03, V04, V05, and V08

   Cleaning filter: Close V12, V36, V43

3. Open vent valve on top of filter
4. Open drain valve at base of filter and allow all water to drain out.

   Stage 1 filters: Open V06

   Stage 2 filters: Open V07

   Cleaning filter: Open V47

5. Unscrew/unlock lid and remove.
6. Unscrew locking pinion and remove bracket.

7. Remove each cartridge filter from the housing.
8. Replace each cartridge with the correct size and type cartridge filter.
9. Replace bracket and screw locking pinion back on. Ensure each cartridge is correctly seated on the mounting spigots and push home.
10. Replace lid and tighten.
11. Close off drain valves and vent valves, and open line valves as required.

7.6.2 System start up

The filters must be adequately vented when brought back into service.

1. Start system as normal.
2. Open vent valves on top of each filter.
3. Observe water flow out of valves (indicating all air expelled from filter) and close off vent valve.

7.7 CALIBRATE INSTRUMENTS

7.7.1 ORP Probe

Calibrate ORP using standard calibration fluid – refer Trasar Manual. Calibrate quarterly.

7.7.2 pH Probe

Calibrate pH probe with pH 4 and pH10 buffer solution – refer Trasar Manual. Calibrate monthly.

7.7.3 Trasar Unit

Calibrate Fluorometer using standard solution pH probe with pH 4 and pH10 buffer solution – refer Trasar Manual. Calibrate quarterly.

8. PRINCIPAL OF REVERSE OSMOSIS

8.1 REVERSE OSMOSIS PROCESS

Reverse Osmosis is a membrane process that acts as a molecular filter to remove between 95% and 99% of dissolved salts and organics, and more than 98% of biological and colloidal matter from water.

Osmosis and reverse osmosis depend on the characteristics of a semi-permeable membrane, which allows water to pass readily but retards the flow of dissolved salts. Osmosis is a natural process in which pure water passes through a membrane from a dilute solution to a more concentrated solution, thus equalising the solute concentration on both sides of the membrane.

In reverse osmosis, the osmotic pressure of the system is overcome by applying an external pressure. By doing so, the flow of water is reversed, and pure water is pushed from the side of the membrane with high concentration to that of the low concentration. The result is a solution of very low concentration (permeate), and a solution of very high concentration (brine).

8.2 FEED WATER SALINITY

The salinity of the feed water (TDS, mg/l) affects the required external pressure required in order to overcome the osmotic pressure. As the salinity of the feed increases, so does the required pressure.

8.3 FEED WATER TEMPERATURE

The reverse osmosis process is significantly affected by changes in feed water temperature. As water temperature increases, the permeability through the membrane also increases. Therefore, a higher feed temperature results in higher permeate flow. Conversely, a lower feed temperature results in a lower permeate flow. If the permeate flow through the membrane remains constant, a higher temperature results in lower required pressure, and conversely a lower feed temperature requires a higher applied pressure.

8.4 RECOVERY

The recovery of a R.O system describes the volume of permeate water as a proportion of the volume of feed water supplied to the system, expressed as a percentage. A higher recovery rate means the majority of the feed water is recovered as permeate, with a lower percentage sent to waste.

9. LIST OF SPARES

The following spares have been supplied with the R.O plant.

Table 23: List of spares supplied

Qty	Description	Manufacturer	Model
1	Bare shaft system pump	Grundfos	CRN 64-8-2
1	Bare shaft concentrator pump	Grundfos	CRN 10-8
1	Anti-scalant dose pump	Grundfos	DDI 2.5-10 AF PVC/V/C – F31331
1	SMBS dose pump	Grundfos	DME 12-6
1	Concentrator end cap assembly		
1	Main R.O end cap assembly		
10	Main membrane interconnectors and O-rings		

10. LIST OF CONSUMABLES

Table 24 shows the system consumables.

Table 24: List of consumables

Item	Description	Amount required
1 micron Nom. Cartridge filter	40” Long 1 Micron NXT 1-40U-DOEN	36 only (Stage 1 filtration)
1 micron Abs. Cartridge filter	40” Long 1 Micron DUO FINE	27 only (Stage 2 Filtration)
5 micron Nom. Cartridge filter	40” Long 5 Micron NXT 5-40U-DOEN	5 only (CIP Cleaning Filtration)
Main R.O membranes	8” Dia. DOW 30-400FR (Foul Resistant)	60 only (main R.O)
Concentrator R.O membranes	8” Dia. DOW 30-400XFR (Extra Foul	6 only (concentrator)
Anti-scalant chemical	Nalco POSM35T (18kg)	
Sequestrant cleaner	PermaClean PC-33 (25kg)	
Acid cleaner	PermaClean PC-77 (25kg)	
Alkaline cleaner	PermaClean PC-99 (25kg)	

11. R.O PLANT SPECIFICATIONS

11.1 DESIGN SPECIFICATIONS

11.1.1 Auto Mode 1 – Main R.O and Concentrator Operational

Table 25: System specifications – Auto Mode 1

Model	AS 1,200,000
Manufacturer	Aqueous Solutions
Plant Design	50,000 lph permeate production
System Pressure	1432 kPa (0.85 fouling factor applied)
System Recovery	94%
Feed flow rate	53.2 m^3/hr
Permeate flow rate	50 m^3/hr
Reject flow rate	3.2 m^3/hr
Feed TDS (max)	1000 mg/l
Permeate Quality	10mg/l
Design temperature	20℃ (Range 15℃ to 35℃)

11.1.2 Auto Mode 2 – Main R.O Operational Only

Table 26: System specifications – Auto Mode 2

Model	AS 1,200,000
Manufacturer	Aqueous Solutions
Plant Design	lph permeate production
System Pressure	1540 kPa (0.85 fouling factor applied)
System Recovery	85%
Feed flow rate	58.8 m^3/hr

Permeate flow rate	50 m^3/hr
Reject flow rate	8.8 m^3/hr
Feed TDS (max)	1000 mg/l
Permeate Quality	6.5mg/l
Design temperature	20℃ (Range 15℃ to 35℃)

11.2 LIST OF EQUIPMENT

Table 27: List of installed equipment

Item	Manufacturer	Model / Specifications
Main System pump	Grundfos	CRN 64-8-1 45kW, 77A, 3ph
Concentrator pump	Grundfos	CRN 10-8 3kW, 6.35A, 3ph
Cleaning pump	Grundfos	CRN 15-3 3kW, 6.35A, 3ph
Flush pump	Grundfos	CRN 20-4 5kW, 11.2A, 3ph
Anti-scalant dose pump	Grundfos	DDI 2.5-10 AF PVC/V/C – F31331
Acid dose pump	Grundfos	DDI 2.5-10 AF PVC/V/C –F31331
SMBS dose pump	Grundfos	DME 12-6
Cartridge filter housings	Aquacorp	40” x 9 Round cluster filter housing
R.O pressure vessels	BEL	8” Dia, 6 element long FRP, 300psi pressure vessel
Motorised valves	Acrodyne	80mm Noah motorised uPVC ball valve 50mm Noah motorised uPVC ball valve 50mm Noah motorised 1000psi SS ball valve
VSD – Main R.O	Vacon	NXS00875A5H0SSVA1A2 45kW, 87A, ceramic coating
VSD - Concentrator	Vacon	NXS00075A5H1SSVA1A2 3kW, 7.6A, ceramic coating
Air conditioning	Fujitsu	ASTA18JCC 5.2kW split cycle
Reject flow control valve		1 ½ ” SS Globe Valve (Main R.O only)

Reject flow control valve	1 ” SS Needle Valve (Main + concentrator)
Cleaning control valve	1 ½” SS Globe Valve

For full component description and operational use/instruction, refer manufacturer supplied manuals.

11.3 LIST OF INSTRUMENTS

Table 28: List of installed instruments

Item	Manufacturer	Model / Specifications
Feed water flow meter	ABB	80mm WaterMaster
Reject flow meter	ABB	50mm MagMaster
Permeate flow meter - concentrator	George Fischer	Signet 8550 Paddle wheel
Permeate flow meter	ABB	80mm Vortex TRIO-WIRL V
Trasar flow meter	George Fischer	In line
CIP flow meter		In line
Pressure transducers	IFM Efector	3 x PA3524 (0 – 10 bar) 4 x PA3523 (0 – 25 bar)
Temperature transducer	IFM Efector	TA3130 (0 - 140℃)
Conductivity monitor	Burkert	2 x Series 8226 (feed / waste) 3 x Series 8225 (permeate)
PLC controller	Allen Bradley	
Trasar Flourometer	Nalco	With pH, ORP add-ons.
Heating elements		2 x 15kW electrical heating elements
Flow switch – flush	Kelco	F50
Trasar PID controller	Yokogawa	UT320

For full component description and operational use/instruction, refer manufacturer supplied manuals.

12. APPENDICES

Table 29: List of Appendices

Appendix No.	Description
1	Calibration plots – Auto Mode 1
2	Calibration plots – Auto Mode 2
3	Log sheet template