



**DEPARTMENT OF FINANCE WA**  
**50 M<sup>3</sup>/DAY EUCLA TOWN RO PLANT**

**INSTALLATION, OPERATION AND  
MAINTENANCE (IOM) MANUAL**

Tristar Project No	P1236
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Client Reference No.	BMW 2016/ 07109
Document No	P1236 – IOM– 001
Revision	1
Date	24/06/2019

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## 2 REFERENCE DOCUMENTS

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Ref. No	Document Title	Document Number
1	Piping and Instrument Diagram	P1236-P-101
2	Piping and Instrument Diagram	P1236-P-201
3	Control Philosophy	P1236-CP-001

### 3 INTRODUCTION

The Brackish Water Reverse Osmosis (BWRO) Potable Water Treatment Plant is configured as a 1 x 100% system, designed to produce up to 50 m<sup>3</sup>/day of potable water, as detailed below:

Project	BWRO Potable Water Treatment Plant – Eucla Town
Location	Eucla, WA
Design Potable Water Flow	50 m <sup>3</sup> /day
System Type	Configured as 1 x 100% train, comprising a single pass, one stage Brackish Water Reverse Osmosis module (BWRO) complete with Remineralization System, Potable Water Recirculation, Aeration and Sodium Hypochlorite Sterilization
BWRO Recovery	50%
Pre-filtration	Media Filtration and 1 micron Cartridge Filters
BWRO Membrane Type	Hydranautics; ESPA2 MAX
Number of BWRO Membranes	2 units
Average Flux	26.9 l/mh
Feed Water Quality	Bore Water as per Hydraulic Services Specification
Product Quality	Potable Water as per Australian Drinking Water Guidelines (ADWG)

The BWRO and Potable Water Recirculation System are installed on skid. The following is a summary of the major components included in the BWRO:

- 4 units of 38kL Polytank as Raw Water Tanks (Existing)
- 1 x 100% Pre-treatment systems including:
  - Duty/Standby Low Pressure Pump variable speed pump
  - Duty/Standby Anti Scalant Dosing System
  - Automatic Backwash Media Filtration
  - 1micron nominal Cartridge Filtration
- 1 x 100% BWRO modules including:
  - Duty/Standby High Pressure variable speed pump
  - One stage BWRO System
- 1 x Clean in Place (CIP) including CIP Tank
- Remineralisation System
  - Calcite Filter
  - Duty/Standby Sulphuric Acid Dosing System
- Chlorination System

- Duty/Standby Recirculation Pump
- Duty/Standby Sodium Hypochlorite Dosing Pump
- Aeration System
- 2 units of 38kL Polytank and 3 units of 22kL Polytank as Potable Water Tanks (Existing)
- Duty/Standby Potable Water Distribution Pumps (Existing)

The purpose of this manual is to provide necessary information for:

- Installation
- Operation
- Maintenance



**CAUTION:**

- Read this manual carefully before installation, operation and maintenance this product.
- Installing or operating or maintaining the unit in any way that is not covered in this manual could cause death, serious personal injury or damage to the equipment. This includes any modification to the equipment or use of parts not provided by TSW. If there is a question regarding the intended use of the equipment, please contact TSW representative before proceeding.

**NOTICE:**

- Save this manual for future reference, keep it readily available at the location of the unit.

## 4 HEALTH, SAFETY AND ENVIRONMENTAL INFORMATION

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### 4.1 PLANT STARTS AUTOMATICALLY



- Ensure that the plant is isolated at the main motor control center panel and locked-out prior to any maintenance being undertaken. Under the normal operations the plant starts and stops automatically.

### 4.2 ELECTRICAL HAZARD



- Always make sure the power is isolated before performing any work on any of the field instruments as they may still be live even when the plant has shut down.
- All work to be completed by a qualified electrician and must only be carried out once the power is isolated at the main motor control centre panel. Failure to follow these instructions could result in serious personal injury or death, or property damage.

### 4.3 PRESSURE HAZARD



- The plant has been designed to operate at 14 bar (1400 kPag). The low pressure and high pressure pipe-work has been made from uPVC.
- Care must be taken when disconnecting any pipe-work, gauges etc., to ensure that the system is isolated and that there is no residual pressure on the system as shown on the gauges.



## 4.4 CHEMICAL HAZARDS

There are 5 kinds of chemicals that are used in BWRO Plant:

### 1. Sulphuric Acid



- Sulfuric Acid is dense, colourless, oily, corrosive liquid.
- Sulfuric Acid is very strong acid.
- It is used to adjust the pH (lower the pH of water).
- Refer to Safety Data Sheet to have more detail information of Sulphuric Acid.

### 2. Anti Scalant



- This anti scalant functions as chelating agents and scale inhibitors. This product is effectively bind metal, calcium and magnesium ions thereby reducing scale formation.
- This chemical has moderate toxicity if swallowed and a very low toxicity is applied to the skin.
- This chemical is minimally irritating to the eyes and skin.
- Refer to Safety Data Sheet to have more detail information of Anti Scalant.

### 3. Sodium Hypochlorite



- Sodium Hypochlorite is a chemical compound with the formula NaClO. Sodium Hypochlorite is frequently used as a disinfectant, oxidator or bleaching agent.
- Skin Corrosion and Eye Damage
- Acute Aquatic Toxicity – Category 1.
- Causes severe skin burns and eye damage.
- Refer to Safety Data Sheet to have more detail information of Sodium Hypochlorite.

### 4. Citric Acid



- Citric acid is a weak organic acid ( $C_6H_8O_7$ ). It is a natural preservative/conservative. In the water treatment plant, it is used to decrease the pH or for RO membrane chemical cleaning.
- Skin Corrosion and Eye Damage
- Refer to Safety Data Sheet to have more detail information of Citric Acid.

#### 5. Alkaline Cleaner



- Alkaline Cleaner is a membrane cleaner developed to support the cleaning acid-insoluble sulfates, barium and strontium as well as calcium fluoride. Alkaline cleaner is also effective in removing iron oxides and hydroxides as well as calcium carbonate.
- Causes severe skin burns and eye damage
- Refer to Safety Data Sheet to have more detail information of Alkaline Cleaner.

The Safety Data Sheets (SDS) for all chemicals used in this plant are located in the Appendices of this document. When handling chemicals ensure the appropriate Protective Personal Equipment (PPE) is worn at all times, such as:

- Splash-Proof Goggles
- Rubber Boots
- Protective Gloves (PVC or Rubber Gloves)
- Hearing Protection
- Face-shield
- PVC Apron
- Coveralls

## 5 UNDERSTANDING REVERSE OSMOSIS

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### 5.1 IMPORTANT TERMS

It will be useful to become familiar with the following terms that are used fairly consistently throughout the desalination industry.

#### *RO Permeate or Product*

The desalinated product water is often called the RO permeate, because it has permeated through the RO membranes. Both terms are used interchangeably throughout this manual.

#### *RO Reject or RO Concentrate*

These terms apply to the discharge to waste, which is rejected by the RO membranes and is concentrated as it passes through the unit. Also sometimes called the BRINE because it is relatively salty. Both RO REJECT and RO CONCENTRATE are used interchangeably throughout this manual.

#### *Feed or Source*

The flow entering the membrane from the high pressure pump/energy recovery device is called the feed which is delivered from the source by the low pressure pump. Other feed flows referred to should always be identified, such as for example *cartridge filter feed*.

#### *System Pressure*

The operating pressure of the system in the RO membrane housings is called the system pressure. It is further divided into the PRE-MEMBRANE PRESSURE (at the inlet end of the membrane housing) and the POST-MEMBRANE PRESSURE at the exit end.

#### *Membrane Pressure Differential*

Membrane Pressure Differential is the PRE-MEMBRANE PRESSURE minus the POST-MEMBRANE PRESSURE and is an important indicator of membrane condition.

#### *Recovery Ratio*

The ratio of permeate flow rate to feed flow rate is called the recovery ratio because it denotes the proportion of product water recovered from the feed. It is usually expressed as a percentage and is calculated as follows:

$$\text{Recovery Ratio} = 100 \times \text{Permeate flowrate} / (\text{Reject flowrate} + \text{Permeate flowrate})$$

For example, suppose the permeate rate was 2.7 m<sup>3</sup>/h and the Reject rate was 3.3 m<sup>3</sup>/h. Then the recovery ratio would be  $100 \times 2.7 / (3.3 + 2.7) = 270 / 6.0 = 45\%$

### Rejection Ratio

This is the percentage reduction of salt in the permeate with respect to the average feed supply that the membrane sees and is dependent on both the membrane itself and the RO system design in general. For modern membranes it is usually in the range 98 to 99.5%.

The important point to note is that the average salt concentration in the vessel must be calculated because the feedwater salt concentration increases as the water passes from membrane to membrane. The last membrane sees a higher salt concentration than the first, depending on the recovery ratio.

## 5.2 OSMOSIS

Osmosis is a process found in all biological systems and results in water from a dilute solution passing spontaneously through a semi-permeable membrane into a more concentrated solution on the other side. This is counter-productive to the requirements of desalination where, in fact, we require the reverse to occur, i.e. we need fresh water to pass out of the concentrated solution and to accumulate on the other side of the membrane where we may collect and use it. A reversed process of this type requires the input of energy, and one such mechanism is called, for obvious reasons, Reverse Osmosis, commonly abbreviated to R.O.

## 5.3 REVERSE OSMOSIS

Reverse Osmosis is a process that achieves this separation of dissolved salts and impurities from a water solution by means of pressure exerted on a semi-permeable membrane. The passage of dissolved materials through the membrane is resisted, but the chemical structure of the membrane material itself allows pure water to permeate through relatively easily. The salts and other impurities that build up on the feed side of the membrane are continuously flushed away as a more concentrated solution (the Concentrate), while the purified water (the Permeate) is drawn off for use.

The diagram below shows a vessel having two compartments that are separated by a semi-permeable membrane. On one side of the membrane we have fresh water and on the other side a salt solution.

By normal osmosis, water will pass from the pure water side, through the semi permeable membrane, into the salt solution. The level will fall on the left and increase on the right.

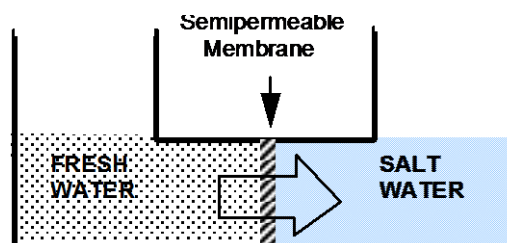


FIG 1. OSMOSIS

## 5.4 OSMOTIC PRESSURE

If we close off the compartment containing the salt solution in Fig. 1, thus restricting any increase in volume and install a pressure gauge as shown below, this gauge will soon read the osmotic pressure of the salt solution. It is this value of pressure that we have to overcome before reverse osmosis can occur.

As an example, if we placed seawater in the right hand compartment, the pressure gauge would quickly rise to about 2,600 kPa (about 360 psi) and so we say that the osmotic pressure of seawater is about 2,600 kPa. If we wished to produce fresh water from the seawater in this apparatus, we could mechanically apply in excess of 2,600 kPa to the right hand chamber to force the fresh water out of the seawater through the membrane as shown in Fig. 3; in fact a typical Reverse Osmosis seawater desalinator uses 5-7,000 kPa (i.e. up to 1000 PSI) to do just this. The excess pressure over the osmotic pressure is utilised to overcome the natural flow resistance of the membrane.

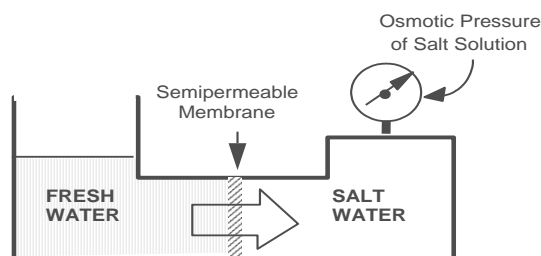


Fig.2 Osmosis against a closed head

For practical purposes, the osmotic pressure of salt water may be regarded as directly proportional to the salt concentration. This means that if the seawater in the above illustration was diluted 50/50 with fresh water, the osmotic pressure would fall to only 1,300 kPa, or half that of undiluted seawater. Conversely, if the concentration of salt doubles, the osmotic pressure doubles. It becomes obvious therefore, that the lower the salt content of the water, the easier it is (i.e. the lower the pressure required) to desalinate it. This is an extremely important point to understand.

It can readily be seen that the process described above would not be a very practical Desalinator because the salt concentration would quickly rise in the right hand chamber of Fig. 3 as a result of the fresh water passing out through the membrane to the left and leaving the salt behind. This would result in a higher osmotic pressure to be overcome by the piston to maintain the flow and the process would quickly be brought to a halt when the osmotic pressure reached the applied pressure.

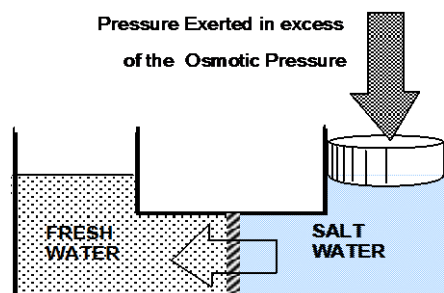
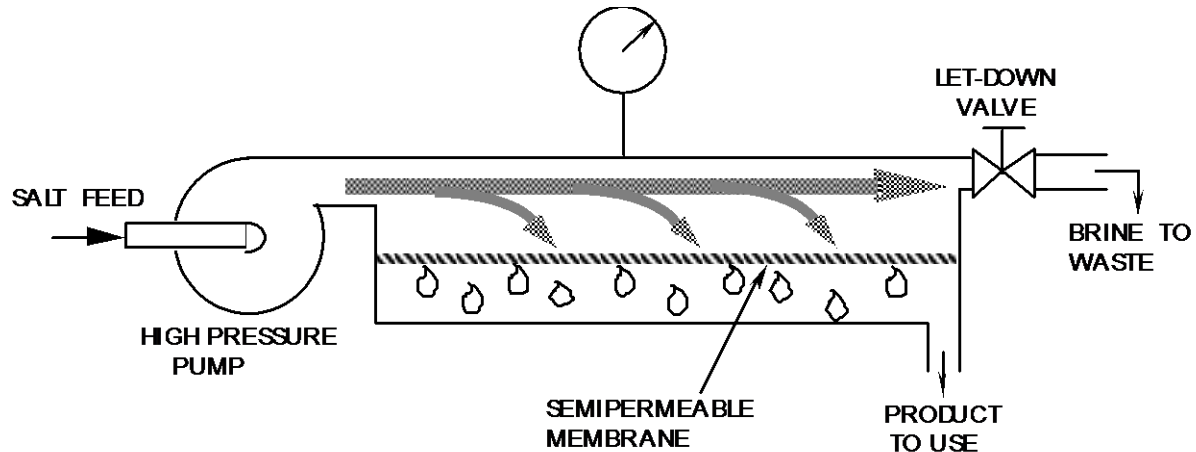


FIG 3. REVERSE OSMOSIS

One could of course stop the process, empty out the concentrated seawater and replace it with a further quantity of untreated seawater before repeating the procedure. This would be a cumbersome process and in practice reverse osmosis is carried out as in Figure 4.

Fig.4 Schematic of Reverse Osmosis Desalination Process



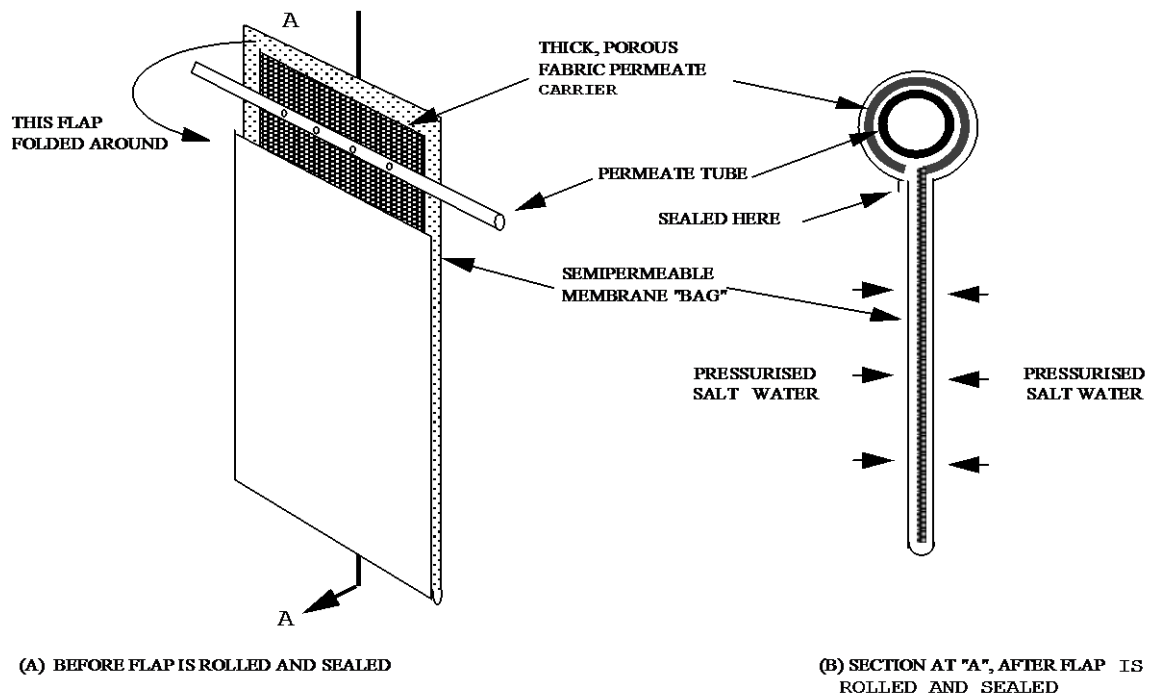
Salt water is forced by the high-pressure pump along the upper chamber and out via the let-down valve which is set to maintain the desired operating pressure of the particular system. In passing along the upper chamber, some of the water passes through the membrane into the lower chamber as the product, leaving the salt behind. The salt concentration of the feed water therefore increases as it passes from left to right before being directed to waste, carrying the concentrated salts and other impurities with it.

The actual proportion of fresh water removed from the salt water feed varies depending on the design of the machine and the type and quality of the salt water being processed. This ratio of the permeate flow rate to the feed flow rate is called the Recovery Ratio and typically varies from about 25% to 75%.

## 5.5 MEMBRANE CONFIGURATION

The first question that may spring to mind is how the thin semi-permeable membrane withstands the high pressures that we have been considering. A number of different techniques have been used to do this but we will consider only the most common configuration presently used, the Spiral Wound configuration.

It is perhaps easiest to visualise the spiral wound configuration by considering the membrane material as a sheet having been made into a bag with a lip like a letter envelope. Consider now a sheet of thick, porous fabric inserted into the bag and the lip sealed around a tube that contains a number of small holes drilled in it as in Fig. 5.



**FIG. 5 METHOD OF MEMBRANE SUPPORT IN THE SPIRAL WOUND CONFIGURATION**

Imagine the entire representation depicted in Fig. 5b now being placed into a pressure resistant box with the ends of the permeate tube protruding from and sealed into the box. If we were to now pump salt water into this box, we can see that the water would exert equal force on each side of the membrane bag so that it would be evenly supported. Permeate would pass through the membrane into the porous permeate carrier and flow up through the carrier to the permeate tube. It would then pass through the perforations in the tube and out of the box through the permeate tube itself.

Because such a configuration would require a lot of space and a large pressure vessel, the representation of Fig. 5b is rolled into a spiral something like a swiss roll. A sheet of coarse mesh is rolled up with it to act as a spacer and prevent the two membrane surfaces from coming into contact and restricting water flow. The result is depicted in Figure 6; the space between the membranes in which the permeate carrier lies constitutes the schematically represented upper chamber in Figure 4.

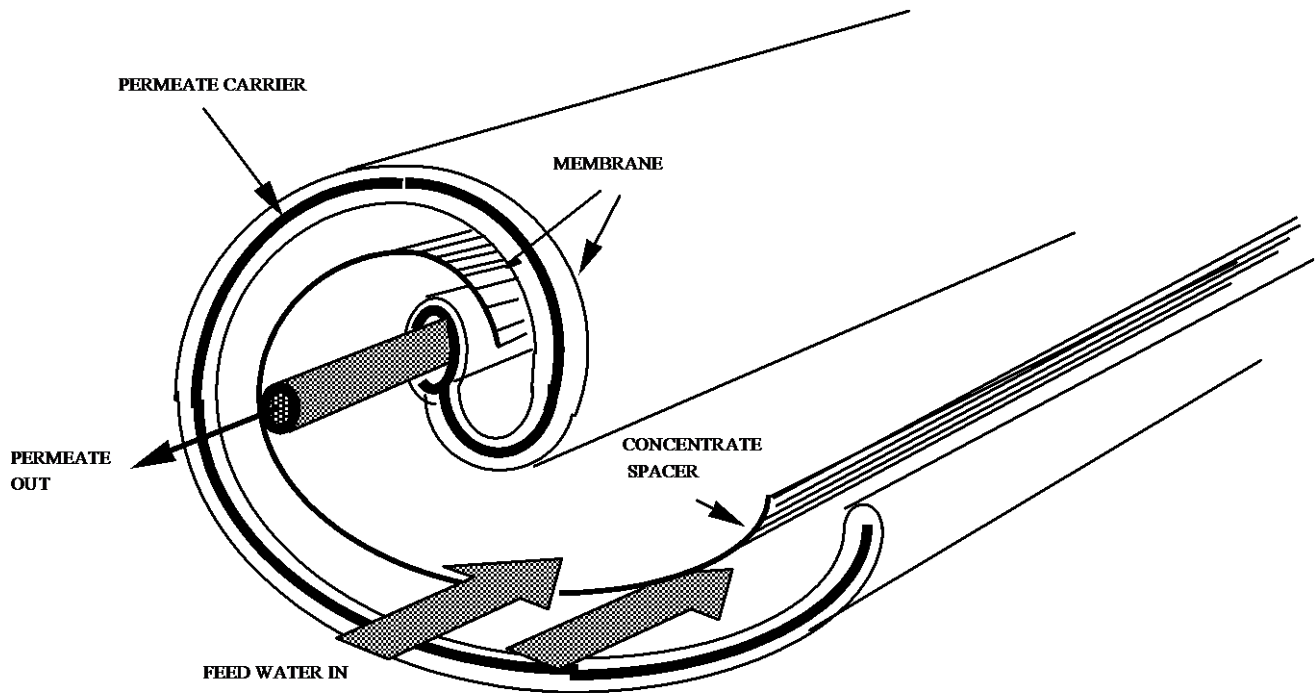
The concentrate spacers also act to promote turbulence in the feed flow which in turn tends to discourage the deposition of fouling materials on the membrane surface.

Turbulent flow over the membrane is also important for another reason. As we have seen, removal of the fresh water from the feed results in a concentration of the salts in the remaining solution. This concentration is most pronounced at the membrane surface, as this is the area where the desalination process takes place and the membrane is called upon to desalinate water of higher salinity than is necessary. Turbulence helps to disperse this concentrated layer into the more dilute bulk of the feed flow.

Using this general configuration, large surface areas of membrane can be formed relatively cheaply into the membrane elements. Several of these elements can be fitted into a housing made of fiberglass



pipe, which is corrosion resistant, strong and relatively cheap. The most common size for these elements is 4 or 8 inches diameter and 40 inches long.



*FIG. 6. SPIRAL WOUND MEMBRANE CONFIGURATION*

## 6 TECHNICAL INFORMATION

### 6.1 TECHNICAL DATA AND SUPPLY SUMMARY

The following list of significant components is arranged in approximately the same logical order of water flow as depicted in the P&ID included in Section 6 of this manual.

<b>Feed Water Tanks</b>	4 units of 38kL Poly Tank
<b>Inlet Connection</b>	DN 50
<b>Inlet Isolation Valve</b>	DN 50 PVC Ball Valve Driven by an Electric Actuator
<b>CIP/Flush Isolation Valve</b>	DN 50 PVC Ball Valve Driven by an Electric Actuator
<b>Low Pressure Pumps</b>	316 Stainless Steel Horizontal Multistage Centrifugal Pump, Close Coupled to a 1.2 kW, IP55 Rated Three Phase Motor, VSD
<b>Media Filter</b>	FRP Vessel Charged with Glass Filtration Media with Automated Backwash Control Valve
- Diameter	533 mm
- Backwash Flow Rate required	8,400 litres per hour
<b>1 Micron Cartridge Filtration</b>	UPVC Housing Containing Five 30" long 1 Micron Nominally Rated Filter Cartridges
<b>Antiscalant Dosing Pumps</b>	Electronic Peristaltic Metering Pump Rated to Deliver up to 240 mL per hour
<b>Antiscalant Tank</b>	Bunded 100 litre Drum
<b>RO High Pressure Pumps</b>	316 Stainless Steel Vertical Multistage Centrifugal Pump, Close Coupled to a 5.5 kW, IP55 Rated Three Phase Motor
<b>RO Membrane Housings</b>	One, Fiberglass Reinforced Plastic, 600 PSI Maximum Working Pressure Rated, 8" Diameter x 80" Long, Reverse Osmosis Membrane Housings in a 1:1 Array
<b>RO Membranes</b>	Three Thin Film Composite Polyamide, Brackish Water Reverse Osmosis Membranes, Each 8" Diameter x 40" Long
<b>RO Permeate Flow Meter</b>	Vortex Flow Meter, DN20
<b>Calcite Filter</b>	FRP Vessel Charged with Glass Filtration Media (Up Flow)
<b>Sulphuric Acid Dosing Pumps</b>	Electronic Metering Pump Rated to Deliver up to 6.0 litres per hour

<b>Sulphuric Acid Tank</b>	Bunded 100 litre Drum
<b>RO Permeate Connection</b>	DN40
<b>Concentrate Recirculation Throttling Valve</b>	DN15 Stainless Steel Needle Valve
<b>Concentrate Recirculation Flow meter</b>	Vortex Flow Meter, DN20
<b>Reject Let-down Throttling Valve</b>	DN15 Stainless Steel Needle Valve &
<b>Automated Bypass Valve</b>	DN40 uPVC Ball Valve Driven by an Electric Actuator
<b>Reject Flow Meter</b>	Paddle Wheel, DN40
<b>Cleaning-In-Place Outlet Valve</b>	DN 40 uPVC Valve
<b>Reject/Backwash Connection</b>	DN40
<b>Membrane Chemical Cleaning Tank</b>	550 litre Polyethylene Tank Fitted a Low Level Switch With and Drain Valve
<b>Potable Water Tanks</b>	2 units of 38kL Poly Tank and 3 units of 22kL Poly Tank
<b>Potable Water Recirculation Pumps</b>	316 Stainless Steel Horizontal Multistage Centrifugal Pump, Close Coupled to a 0.5 kW, IP55 Rated Three Phase Motor
<b>Sodium Hypochlorite Dosing Pumps</b>	Electronic Metering Pump Rated to Deliver up to 7.5 litres per hour
<b>Sodium Hypochlorite Tank</b>	Bunded 20 litre Drum

## 6.2 FEED WATER SUPPLY

Feed water to the new Eucla Town RO WTP is supplied under pressure from the bore water supply (by others) into existing four 38kL tanks via a tank mounted aerator.

The Feed Water Storage Tank is fitted with a new level indicator transmitter (by Tristar Water) that monitors the level inside the Feed Water Storage Tanks. The control philosophy of the Feed Water Storage Tanks level indicator transmitter is as follows:-

- Feed water level is above high-high level = activate high-high Feed Water Tank Alarm.
- Feed water level is above working level = ready for RO Plant to run.

Feed water level is below low level = stop RO plant.

## **6.3 PRE-FILTRATION SYSTEM**

### **6.3.1 Low Pressure Pumps**

At the suction of duty/standby Low Pressure (LP) Pumps, the inlet strainer with 1.5mm aperture is installed to remove solid impurities that are larger than 1.5mm. The duty Low Pressure Pump draws feed water from Feed Water Storage Tanks and discharges it at the required flow rate and pressure controlled by a variable speed drive through the Multimedia Filtration and one micron Cartridge Filter to the suction of the RO High Pressure Pumps.

It is also used for Multimedia Filtration backwash, RO flushing and to recirculate chemical cleaning solutions during membrane cleaning-in-place (CIP) procedures.

As per tender requirement that is stated in the document Reference: SP004800H (Specification), some instrumentations such as Temperature Gauge, pH Analyser and Conductivity Analyser are installed at the suction line of LP Pumps. These pH and Conductivity Analyser send the information of feed water condition to the control panel that will help for remote monitoring and trouble-shooting purposes.

### **6.3.2 Pre-Filtration**

Pre-filtration of the feed water prior to the RO Plant is intended to remove suspended solids which may otherwise lodge in the RO membranes where they would be difficult to remove as there is no effective way of reversing the flow and backwashing RO membranes.

The feed water is pumped through a media filter which removes suspended solids (10 micron or greater) from the water. Pressure indicator transmitters upstream and downstream of the media filter is used to measure the differential pressure across the filter for monitoring. The differential pressure of media filter is monitoring online and if the differential pressure across the media filter is more than high set point, the media filter will be backwashed automatically.

The media filter is backwashed via a control valve. The backwashing and rinsing can be carried out based on filtration time or high differential pressure across the media filter. The media filter is backwashed and rinsed once at a time for 15 – 30 minutes. The default filtration timer actually in use is 24 hours.

The multimedia filtrate water then passes through a single duty 1 micron cartridge filter housing. A single duty 1 micron cartridge filter housing is installed which contains five 1 micron cartridges each of which is 30 inches long. Cartridge filtration of the feed water with 1 micron nominally rated cartridges is intended to filter out suspended solids nominally larger than 1 micron in size which would otherwise lodge in and block the pores of the RO membranes.

Pressure indicator transmitters upstream and downstream of the cartridge filter housing is used to measure the differential pressure across housing. Upon indication of a high differential pressure, a warning and then an alarm will be generated and the Operator will be required to change the filter cartridges in the housing.

### **6.3.3 Anti Scalant Dosing**

Based on the design bore water analysis, at the design recovery rate and feed water temperature envisaged there is the potential for calcium carbonate scale to form on the high pressure side of the RO membranes progressively blocking them and increasing the operating pressure of the RO Arrays.

The potential for scale formation in the RO membranes is eliminated by a combination of:-

- Limiting the recovery rate to 50%.
- The injection of a specific liquid chemical antiscalant into the feed water.

The antiscalant serves to raise the solubility of the compounds responsible for scale formation so that they do not come out of solution and crystallise in the RO membranes. These scale forming compounds together with any residual antiscalant are then flushed from the system in the brine concentrate reject and disposed of to the Reject Drain/Evaporation Pond (by others).

A one unit of 100L anti scalant storage tank is located within a containment bund to contain leaks and spills. Any fault with the anti scalant system such as a low tank level will generate an alarm and shutdown the RO plant. Operating the plant without anti scalant could lead to deposition of scale upon the surface of the membranes which may not be able to be removed during a CIP process.

## **6.4 BWRO PLANT**

### **6.4.1 High Pressure Pump**

The duty/standby High Pressure (HP) Pumps serve to generate the pressure required to overcome the osmotic pressure of the feed water together with the friction losses in the RO membranes, so as to produce low salinity RO permeate by squeezing molecules of water through the RO membranes.

Feed pressure at the suction of the HP Pump is monitored by a pressure indicator transmitter which serves to ensure that the HP Pump does not run if there is insufficient feed pressure. This protects the HP Pump from running dry and also protects against the ingress of air into the RO Pressure Vessels where it can compress with detrimental effects to the operation of the plant.

### **6.4.2 BWRO Pressure Vessels and Membranes**

The RO Membranes are housed in Pressure Vessel. Downstream of the Pressure Vessel is a back pressure control device which is called the Let-down Valve because it lets down or dissipates the residual pressure in the system.

Under sufficient pressure the RO Membranes serve to split the feed water into two streams. The first of these streams is relatively pure desalinated water which passes through or permeates the Membranes and this is called RO permeate which is delivered to the Potable Water Storage Tanks. A flow indicator transmitter monitors the permeate flow rate.

The second stream contains most of the salts from the feed water which concentrate up and are unable to pass through the RO Membranes. This stream variously referred to as brine, concentrate, or reject contains the residual pressure generated by the HP Pump which is then relieved through the Let-down Valve before this stream is disposed to the Reject Drain/Evaporation Pond (by others). A flow indicator transmitter monitors the reject flow rate.

Some portion of RO Concentrate water is recirculated into the RO Membrane feed to increase the RO system recovery. This flow is controlled manually using a diaphragm throttling valve and flow indicator transmitter.

Pressure transmitters installed in the feed to the Pressure Vessels and in the reject stream from the Pressure Vessels indicate the pressure drop across the Membranes. Upon indication of a high differential pressure the RO Array will shut down to protect the RO Membranes from damage. This

differential serves as an indication as to when periodic membrane cleaning-in-place (CIP) procedures are required.

The RO Array is fitted with one fibre glass RO Pressure Vessels each containing two 8" diameter by 40" long latest generation energy efficient brackish water reverse osmosis membranes. The Pressure Vessel in RO Array is arranged in a single stage arrangement.

Correct operation of the RO Array is monitored by the RO permeate Conductivity Meter. If the conductivity of the RO permeate is out-of-spec for a pre-set time, the RO Plant will shut down to allow the Operator to take corrective action.

## **6.5 CIP/FLUSH SYSTEM**

When the RO Plant is shut down they will be flushed using RO permeate delivered by the LP Pump from the CIP/Flush Tank. This further assists in limiting the risk of scale formation on the surface of the RO Membranes.

The LP Pump and the CIP/Flush Tank are also used to undertake periodic membrane cleaning in place (CIP) procedures.

## **6.6 pH AND HARDNESS CORRECTION SYSTEM**

The simulated calcium carbonate precipitation potential (CCPP) of the RO permeate produced is quite low at -13.2 suggesting that it is corrosive/aggressive. The ideal CCPP of potable water is between 0 and -5 when it is considered to be passive, meaning that the water is neither corrosive nor has the tendency to form scale in the reticulation.

To correct the CCPP of the RO permeate produced so as to make it passive, the RO permeate will be treated to produce potable water controlled at:-

- A pH of 7.4.
- An alkalinity approximating 13.6 mg/L  $\text{CaCO}_3$
- A calcium content approximating 35 mg/L  $\text{CaCO}_3$ .

This is achieved by a combination of:-

- Dosing Acid into the RO permeate water, upstream Calcite Filter.
- Calcite Filter.

### **6.6.1 pH Correction System**

To have the correct required level of Calcium in the Potable Water, the acid is dosed in the upstream of Calcite Filter to reduce the pH and promote sufficient calcite dissolution into the water. The dosage rate of the Acid Dosing Pump is fixed and set during commissioning.

The Acid Dosing Storage tank is fitted with a low level switch that will send an alarm signal to shut down the RO plant if the level in the Acid Tank is low to prevent the plant from producing a potable water which is out of specification.

### **6.6.2 Hardness Correction System**

One effective way to increase the pH and Calcium Hardness level in the water is to pass the outlet of acid dosed RO Permeate through a calcite filter which provides remineralisation and neutralises the pH. The Up-flow configuration of the calcite filter prevents compaction of the calcite bed without the need for backwashing and to ensure maximum contact time between water and calcite media.

Calcite is a naturally occurring calcium carbonate media. One of the advantages of Calcite is its self-limiting property. When properly applied, it corrects pH only enough to reach a non-corrosive equilibrium. It does not overcorrect under normal conditions. Upon contact with calcite, acidic waters slowly dissolve the calcium carbonate to raise the pH which reduces potential leaching of copper, lead and other metals found in typical plumbing systems. Depending on pH, water chemistry and service flow, the Calcite bed will have to be periodically replenished as the Calcite is depleted. As the Calcite's calcium carbonate neutralizes the water, it will increase Calcium hardness to the correct required Calcium level.

## **6.7 CHLORINATION SYSTEM**

### **6.7.1 Potable Water Storage**

The potable water produced will be stored in the existing Potable Water Storage Tanks prior to distribution to point of use.

The existing Potable Water Storage Tanks are fitted with three new level switches that supplied by Tristar Water to monitor the level inside the Potable Water Storage Tanks. The control philosophy of the Potable Water Storage Tank level switches is as follows:-

- Potable water level high
  - HP Pump stop.
  - Acid dosing stops.
  - Antiscalant dosing stops.
  - RO Plant flushed.
  - Low Pressure Pump stops.
- When potable water level falls to low (below working level)
  - Low Pressure Pump starts.
  - Antiscalant dosing starts.
  - RO Plant start.
  - Acid dosing starts.
- If potable water level falls to low-low
  - Recirculation Pump stops.
  - Sodium hypochlorite dosing is disabled.
  - Alarm condition indicated.

### **6.7.2 Recirculation Pump**

Potable water will be continuously recirculated from the Potable Water Storage Tank by a Recirculation Pump, through the Aeration system to increase Dissolved Oxygen (DO) level in the Potable Water and

sodium hypochlorite added as necessary before the recirculated water is returned to the Potable Water Storage Tank.

As per tender requirement that is stated in the document Reference: SP004800H (Specification), some instrumentations such as Temperature Gauge, pH and Turbidity Analyser are installed at the discharge line of Recirculation Pumps. These pH and Turbidity Analyser send the information of potable water condition to the control panel that will help for remote monitoring and trouble-shooting purposes.

### **6.7.3 Sodium Hypochlorite Dosing**

The potable water stored in the Potable Water Storage Tanks should at all times be disinfected and sterile so that it is safe for use.

Australian drinking water guidelines call for potable water to have a free chlorine residual of up to 0.6 mg/L though this is an aesthetic requirement. This is a nominal odour threshold but some people can smell the chlorine if the residual is as low as 0.2 mg/L. The drinking water guidelines also state that for health reasons the free chlorine residual should not exceed 5 mg/L.

The free chlorine residual serves as an insurance against subsequent contamination of sterile water so that if there is subsequent contamination there is chlorine left over in the potable water to disinfect the water before it can be consumed.

The sodium hypochlorite dosing system therefore serves to maintain a pre-determined free chlorine residual disinfectant content in the potable water stored in the Potable Water Storage Tanks. The potable water stored in the Potable Water Storage Tanks is continuously recirculated and the free chlorine in it is continuously measured by an online free chlorine residual analyser and chlorine in the form of sodium hypochlorite is added as necessary to maintain the desired free chlorine residual.

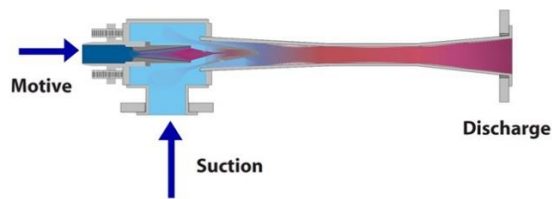
A microprocessor-based controller in the free chlorine residual analyser compares the free chlorine residual measurement against a set point and drives the output of the Sodium Hypochlorite Dosing Pump as necessary to maintain the pre-determined free chlorine residual in the potable water stored in the Potable Water Storage Tanks.

The Sodium Hypochlorite Dosing Storage tank is fitted with a low level switch that will send an alarm signal if the level in the Sodium Hypochlorite is low to prevent the plant from producing potable water without the requisite free chlorine residual.

### **6.7.4 Aeration System**

The water jet pump – injector is installed at the discharge line of Recirculation Pump to increase Dissolved Oxygen (DO) level in the potable water. The driving liquid (water discharge from Recirculation Pump), which comes in main flow direction out of the nozzle installed in the water jet pump – injector, is accelerated by the diameter reduction of the nozzle. This acceleration causes low pressure at the suction spigot end sucking air from atmospheric. The suction volume is a function of the driving liquid pressure and the nozzle bore.





The potable water from Aeration Outlet will produce DO is larger than 85% saturation or DO level is higher than 5 mg/L.

## 6.8 WASTE WATER

All Multimedia Filtration backwash waste outlet, RO reject, wash water from flushing the RO plant as well as CIP waste will be discharged to Reject Drain/Evaporation Pond (by others).

## **7 INSTALLATION PROCEDURE**

---

### **7.1 POSITIONING OF EQUIPMENT**

The BWRO and Chlorination Plant is installed on a skid. The plant should be placed on a firm, level surface.

The location chosen for the BWRO Plant needs to be convenient for:

- Feed water supply.
- Fresh water storage facilities.
- Reject water disposal facilities.
- Three phase power supply.

The area is to have suitable waste drainage as the spillage of water during servicing and maintenance is unavoidable.

### **7.2 PLUMBING TO AND FROM THE PLANT**

The plumbing connections need to be made to interface from the facilities to the respective connections on the BWRO Plant. Pipework size, fittings and any other equipment plumbed to the container needs to be of negligible restriction to the required flows and pressures. Pipework should be of minimum listed size and rated for pressures of up to 1500kPa. The brine concentrate Reject produced by the BWRO Plant should be plumbed to the existing disposal.

Refer to the general arrangement in Appendix 2.

### **7.3 POWER SUPPLY**

The BWRO plant has been wired and tested prior to dispatch. The following connections need to be made on Site and the necessary terminations are detailed in the electrical schematics included in Appendix 2 for:

- Three phase power supply. This should be run into the incoming power control panel on the skid.
- The level indicator transmitter needs to be installed in the feed water storage tank and terminated in the control panel on the skid.
- The high, working and low level float switch needs to be installed in the potable water storage tank and terminated in the control panel on the skid.

## 8 OPERATING PROCEDURES

### 8.1 PRE-COMMISSIONING CHECKLIST

Step	Description
1	Ensure the skid is clean, barricading is in place and it is safe to commence commissioning.
2	Ensure that the power supply is wired into the control cabinet on the skid.
3	Verify feed water conductivity.
4	Load the media filter into Media Filter Vessel (MF-101). Loading Schedule from Bottom to Top Layer: <ul style="list-style-type: none"> <li>- 1/5 x 1/12 Gravel, 25 kg (2mm to 5mm) = 2 bags</li> <li>- 8/16 Sand #6 Sand 25kg (1mm to 2mm) = 1 bag</li> <li>- AFM Glass Media, Grade 1, 0.4 - 1.0 mm, 21kg = 7 bags</li> <li>- Australian Filter Coal 1.3 - 1.4mm (1.15cuft), 22kg = 2 bags</li> </ul>
5	Load the Calcite media into Calcite Filter Vessel (CAL-101). Loading Schedule from Bottom to Top Layer: <ul style="list-style-type: none"> <li>- 1/4 x 1/8 #5 Gravel 25kg (3mm to 6mm) = 2 bags</li> <li>- 8/16 Sand #6Sand 25kg (1mm to 2mm) = 1 bag</li> <li>- Calcite 22.68kg Bag (0.55cuft) = 11 bags</li> </ul>
6	Check that pipe work is secure and that additional supports are not required.
7	Ensure all guards are in place including pump guards.
8	Check all nuts and bolts are tight around pumps and that all unions and pipe-works connections are tight.
9	Ensure Victaulic fittings are tight.
10	Ensure that the level switches for Potable Water Tank is installed.
11	Ensure that the Level Transmitter for Feed Water Tank is installed.
12	Ensure that the existing feed water supply is plumbed to the inlet/suction of Low Pressure Pump.
13	Ensure that the RO reject and backwash out is plumbed into the existing RO Reject and Backwash Pipe.
14	Ensure the potable water outlet is plumbed into the existing Potable Water Pipe.
15	Ensure the existing recirculation inlet is plumbed to the inlet/suction of Recirculation Pump.
16	Ensure the recirculation outlet is plumbed into the existing recirculation pipe outlet.
17	Calibrate Feed Water pH Analyser.
18	Calibrate Potable Water pH and Chlorine Analyser.
19	Calibrate Potable Water Turbidity Analyser.
20	Open the underneath isolation manual valves: V-101, V-102, V-103, V-105, V-107, V-108, V-109, V-110, V-111, V-112, V-113, V-114, V-117, V-118, V-122, V-123, V-123, V-125, V-127, V-128, V-129, V-130, V-135, V-136, V-137, V-138, V-141, V-201, V-202, V-204, V-206, V-207, V-208, V-209, V-210, A quarter open of V-211, V-213, V-216. The rest of the valves are closed.

## 8.2 COMMISSIONING CHECKLIST

Step	Description
1	Verify that the emergency stop button is functioning and registers as an alarm.
2	Verify Low Pressure Pump 1 (PU-101A) start and stop manually and motor rotation is correct.
3	Verify Low Pressure Pump 2 (PU-101B) start and stop manually and motor rotation is correct.
4	Verify Anti Scalant Dosing Pump 1 (PU-102A) start and stop manually. Ensure Anti Scalant Dosing Pump 1 (PU-102A) delivers the correct flowrate. Use cylinder to confirm flowrate. Confirm dosing point is correct.
5	Verify Anti Scalant Dosing Pump 2 (PU-102B) start and stop manually. Ensure Anti Scalant Dosing Pump 2 (PU-102B) delivers the correct flowrate. Use cylinder to confirm flowrate. Confirm dosing point is correct.
6	Verify High Pressure Pump 1 (PU-103A) start and stop manually and motor rotation is correct.
7	Verify High Pressure Pump 2 (PU-103B) start and stop manually and motor rotation is correct.
8	Verify Sulphuric Acid Dosing Pump 1 (PU-104A) start and stop manually. Ensure Sulphuric Acid Dosing Pump 1 (PU-104A) delivers the correct flowrate. Use cylinder to confirm flowrate. Confirm dosing point is correct.
9	Verify Sulphuric Acid Dosing Pump 2 (PU-104B) start and stop manually. Ensure Sulphuric Acid Dosing Pump 2 (PU-104B) delivers the correct flowrate. Use cylinder to confirm flowrate. Confirm dosing point is correct.
10	Verify Recirculation Pump 1 (PU-201A) start and stop manually and motor rotation is correct.
11	Verify Recirculation Pump 2 (PU-201B) start and stop manually and motor rotation is correct.
12	Verify Sodium Hypochlorite Dosing Pump 1 (PU-202A) start and stop manually. Confirm dosing point is correct.
13	Verify Sodium Hypochlorite Dosing Pump 2 (PU-202B) start and stop manually. Confirm dosing point is correct.
14	Verify Inlet Feed Water Automatic Valve (AV-101) open/close function works manually.
15	Verify CIP/Flush Inlet Automatic Valve (AV-102) open/close function works manually.
16	Verify Let Down Bypass Automatic Valve (AV-103) open/close function works manually.
17	Verify Inlet pH Analyser (pH-101) is installed and registered on HMI.
18	Verify Inlet Feed Conductivity Analyser (KI-101) is installed and registered on HMI.
19	Verify RO Permeate Conductivity Analyser (KI-102) is installed and registered on HMI.
20	Verify Potable Water Conductivity Analyser (KI-201) is installed and registered on HMI.
21	Verify Potable Water Turbidity Analyser (TUR-201) is installed and registered on HMI.
22	Verify Potable Water pH and Chlorine Analyser (pH-201/CL-201) is installed and registered on HMI.
23	Verify Feed Tank Level Transmitter (LT-101) is installed and registered on HMI.
24	Verify Low Level Float Switch (LS-101) inside Anti Scalant Tank is installed and registered on HMI.
25	Verify Low Level Float Switch (LS-102) inside Sulphuric Acid Tank is installed and registered on HMI.
26	Verify Low Level Float Switch (LS-103) inside CIP Tank is installed and registered on HMI.
27	Verify Low Level Float Switch (LS-201 & LS-202) inside Sodium Hypochlorite Tank is installed and registered on HMI.
28	Verify High Level Float Switch (LS-203) inside Potable Water Tank is installed and registered on HMI.
29	Verify Working Level Float Switch (LS-204) inside Potable Water Tank is installed and registered on HMI.
30	Verify Low-Low Level Float Switch (LS-205) inside Potable Water Tank is installed and registered on HMI.
31	Verify Media Filter Inlet Pressure Indicator Transmitter (PIT-101) is installed and registered on HMI.

Step	Description
32	Verify Media Filter Outlet Pressure Indicator Transmitter (PIT-102) is installed and registered on HMI.
33	Verify 1 Micron Cartridge Filter Outlet Pressure Indicator Transmitter (PIT-103) is installed and registered on HMI.
34	Verify RO Inlet Pressure Indicator Transmitter (PIT-104) is installed and registered on HMI.
35	Verify RO Concentrate Pressure Indicator Transmitter (PIT-105) is installed and registered on HMI.
36	Verify Recirculation Pump Discharge Pressure Indicator Transmitter (PIT-201) is installed and registered on HMI.
37	Verify RO Permeate Flow Indicator Transmitter (FIT-101) is installed and registered on HMI.
38	Verify RO Reject Flow Indicator Transmitter (FIT-102) is installed and registered on HMI.
39	Verify RO Concentrate Recirculation Flow Indicator Transmitter (FIT-103) is installed and registered on HMI.
40	Backwash Media Filter Vessel (MF-101) until backwash water out is clear.
41	Flush out all preserved media from RO system for 10 minutes until there is no any preserved media inside RO system.
42	Start-up RO Plant in Manual mode and run for 15 minutes.
43	Ensure all leaks in RO System are rectified.
44	Set all flow rates / pressures as per RO simulation and record in table below.
45	Once the RO plant is manually tested and verified, run the system in Automatic mode. Ensure RO plant starts/stops automatically as per control philosophy.
46	Verify Remineralisation (Calcite and Sulphuric Acid dosing System) operation.
47	Verify Media Filtration Backwash trigger activation by timer and High Differential Pressure.
48	Put RO system in offline. Ensure plant offline as per control philosophy.
49	Run CIP mode and ensure operability.
50	Start-up Potable Water Recirculation system in Manual mode and run for 15 minutes.
51	Ensure all leaks in Recirculation System are rectified.
52	Once the Recirculation system is manually tested and verified, run the system in Automatic mode. Ensure Recirculation System starts/stops automatically as per control philosophy.
53	Verify Aeration system (Ejector) operation.
54	Put Recirculation system in offline. Ensure plant offline as per control philosophy.
55	Run the RO and Recirculation System in Auto Mode.
56	After Recirculation System is running in Auto mode for 24 hours, calibrate the pH/Cl probe.
57	Test Remote Monitoring Connection System

## 8.3 HUMAN MACHINE INTERFACE (HMI) SCREEN NAVIGATION

### 8.3.1 Main Screen

In this main screen, BWRO and Recirculation/Chlorination System can be started /stopped. Also from this screen, OPTIONS button can be accessed to have more program function (Refer to Section 8.3.2). The forward arrow button will bring to Low Pressure Section P&ID Screen (Refer to Section 8.3.1.1).

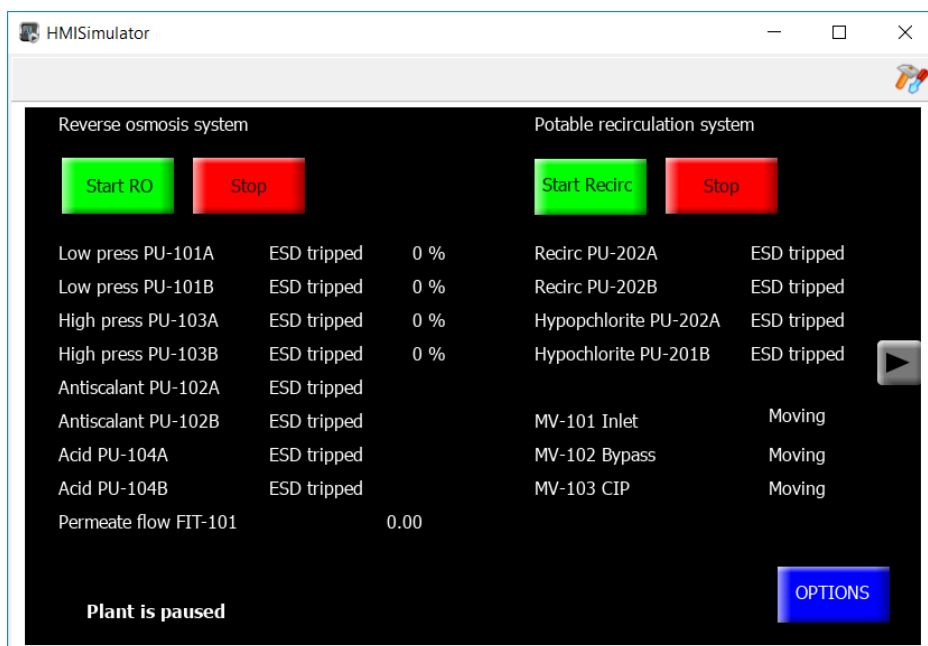


Figure 8-1 Main Screen

#### 8.3.1.1 Low Pressure Section P&ID Screen

In this screen shows the process flow for low pressure section and all analog instrumentation reading can be read.

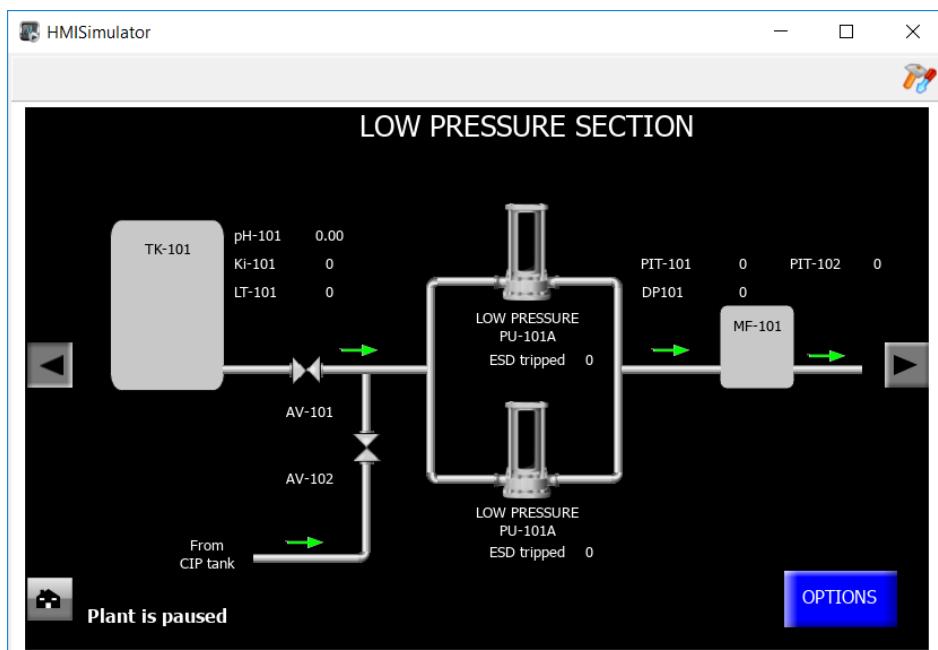


Figure 8-2 Low Pressure Section P&ID Screen

### 8.3.1.2 High Pressure Section P&ID Screen

In this screen shows the process flow for high pressure section and all analog instrumentation reading can be read.

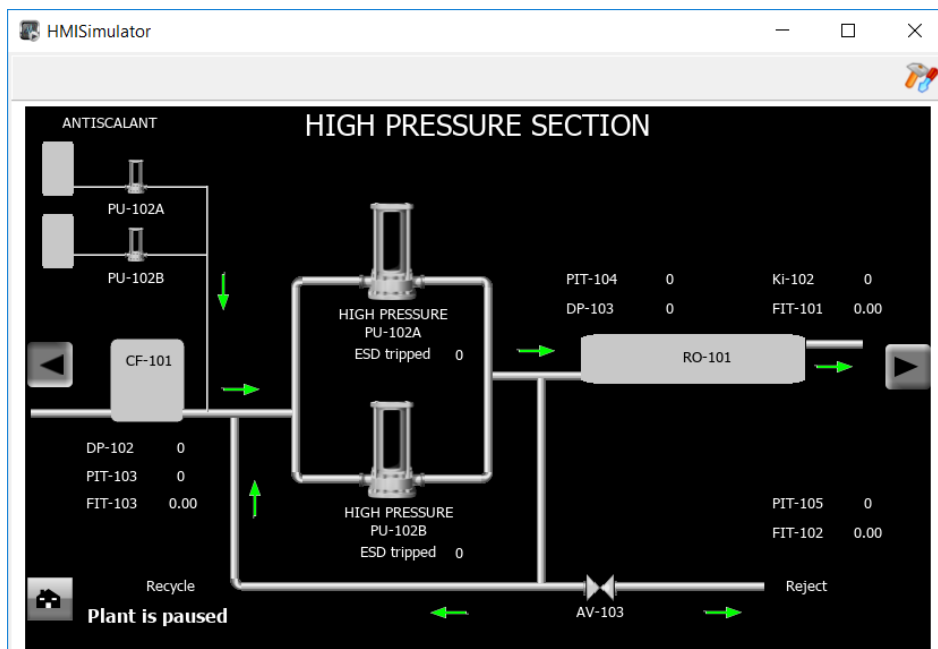


Figure 8-3 High Pressure Section P&ID Screen

### 8.3.1.3 Potable Water Section

In this screen shows the process flow for potable water section and all analog instrumentation reading can be read.

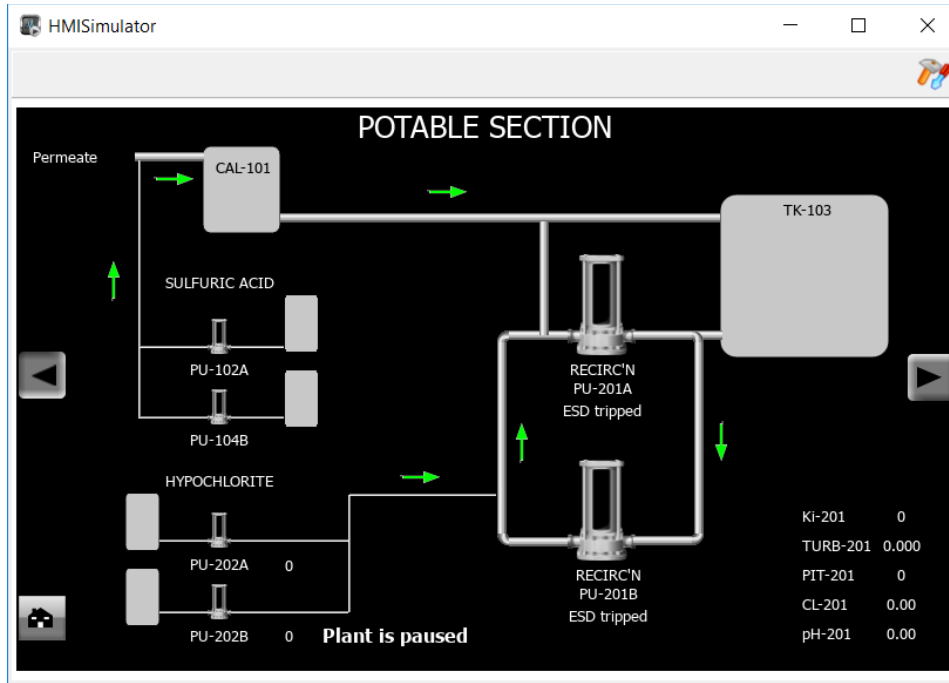


Figure 8-4 Potable Water Section P&ID Screen

### 8.3.2 Options Screen

Various sub-screens can be accessed from the OPTIONS screen including:

- LP Pumps
- HP Pumps
- Antiscalant
- Hypochlorite
- Acid
- Recirculation
- Valves
- Start Conditions
- Backwash
- Alarm Setpoints
- Clock
- Calibration
- CIP
- Charts
- Login



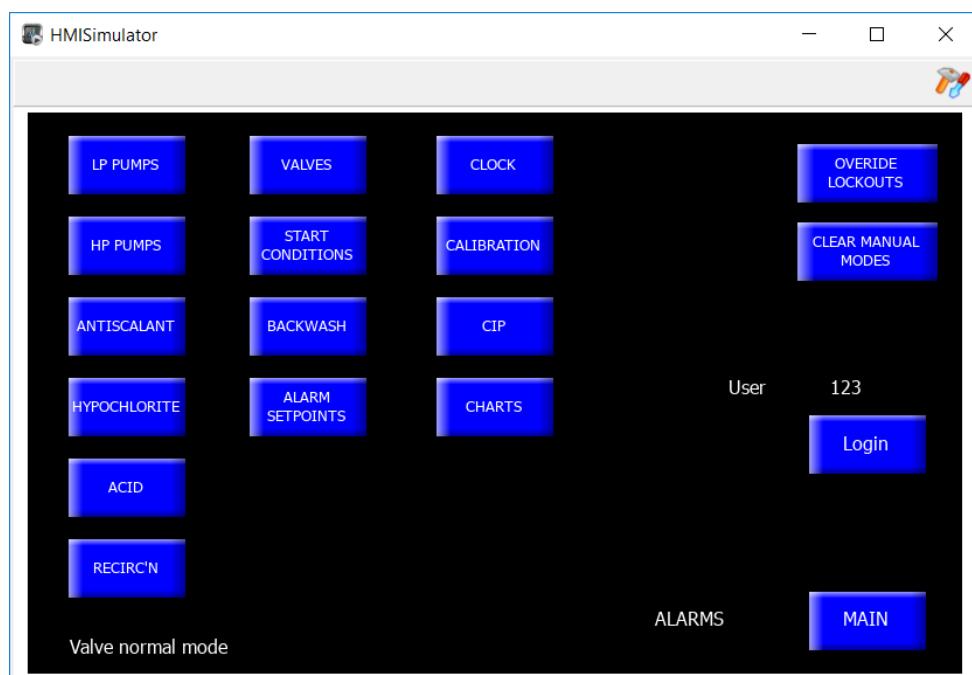


Figure 8-5 Options Screen

### 8.3.2.1 LP Pumps Screen

In this screen, Low Pressure Pumps (PU-101A/PU-101B) can be set as Auto mode and/or started/stopped manually. Also, from this screen, it can be navigated to PID page ((refer to Section 8.3.2.1.1). The hours run for low pressure pumps are recorded in this screen.

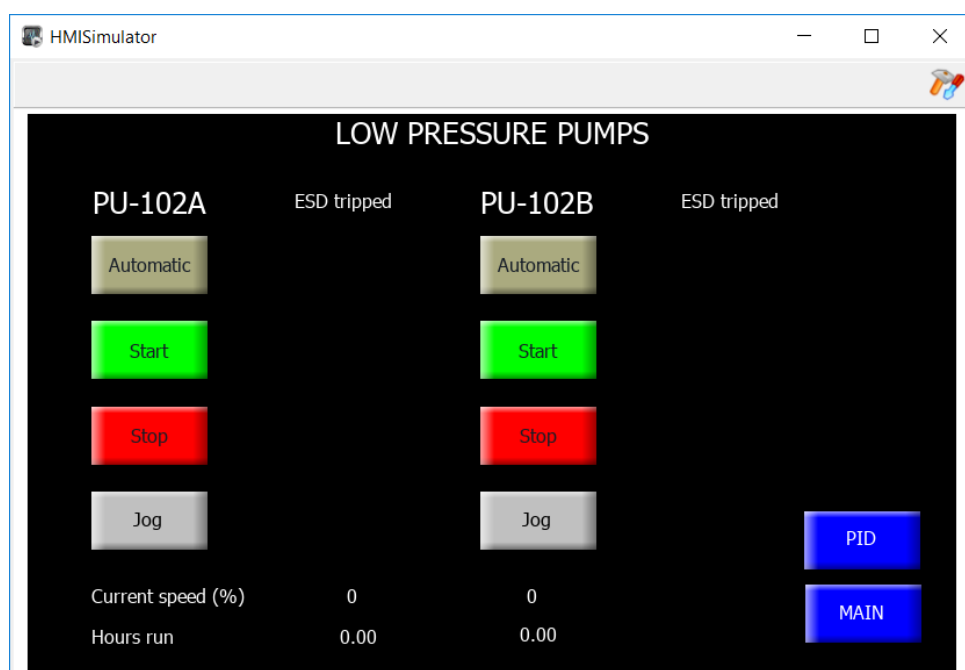


Figure 8-6 LP Pumps Screen

### 8.3.2.1.1 PID Screen

In this screen, PID (Proportional Integral Derivatives) values must be set up.

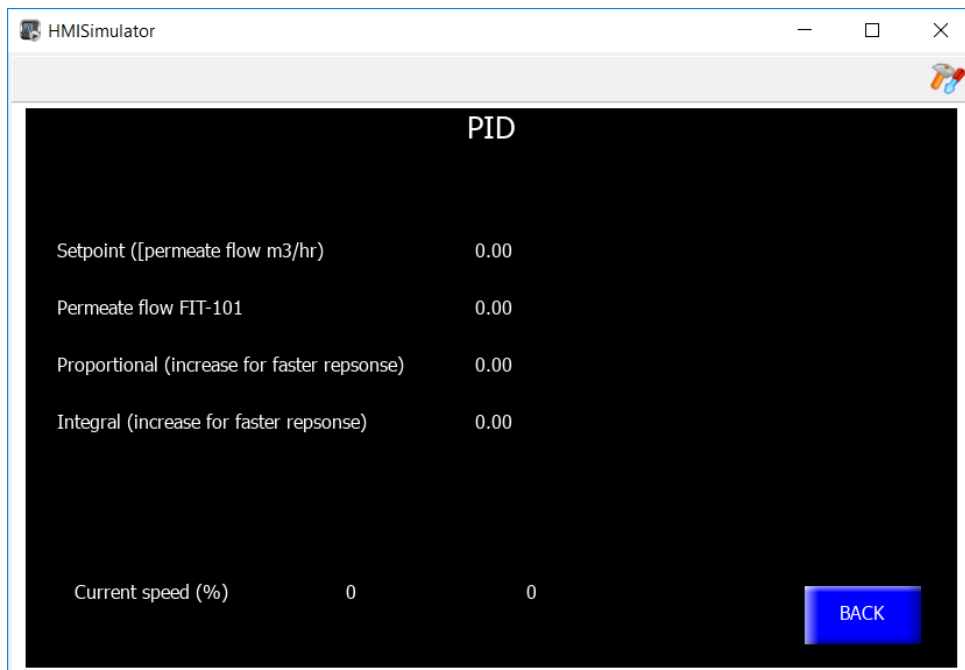


Figure 8-7 PID Screen

Set up the values as per underneath table:

Setpoint (Permeate Flow m <sup>3</sup> /h)	2.2
Proportional (increase for faster response)	10
Integral (increase for faster response)	10

### 8.3.2.2 HP Pumps Screen

In this screen, High Pressure Pumps (PU-103A/PU-103B) can be set as Auto mode and/or started/stopped manually. Also, from this screen, it can be navigated to PID page (refer to Section 8.3.2.1.1). The hours run for high pressure pumps are recorded in this screen.

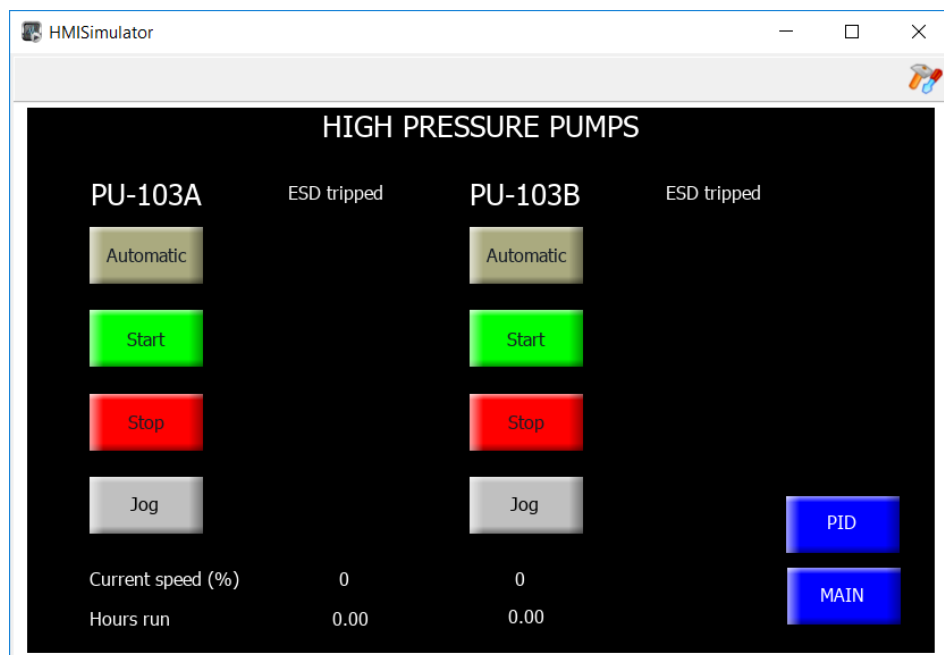


Figure 8-8 HP Pumps Screen

### 8.3.2.3 Antiscalant Pumps Screen

In this screen, Antiscalant Dosing Pumps (PU-102A/PU-102B) can be set as Auto mode and/or started/stopped manually. The hours run for antiscalant dosing pumps are recorded in this screen.

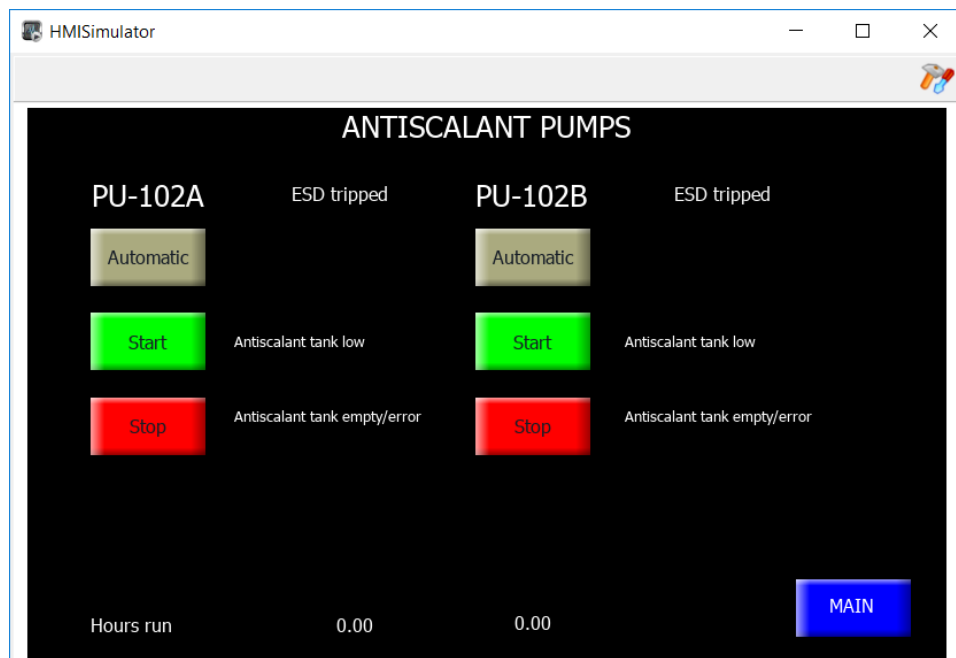


Figure 8-9 Antiscalant Pumps Screen

### 8.3.2.4 Hypochlorite Pumps Screen

In this screen, Hypochlorite Dosing Pumps (PU-202A/PU-202B) can be set as Auto mode and/or started/stopped manually. The hours run for hypochlorite dosing pumps are recorded in this screen. From SETTINGS button, it will navigate to Hypochlorite Dosing Pumps Settings (Refer to Section 8.3.24.1)

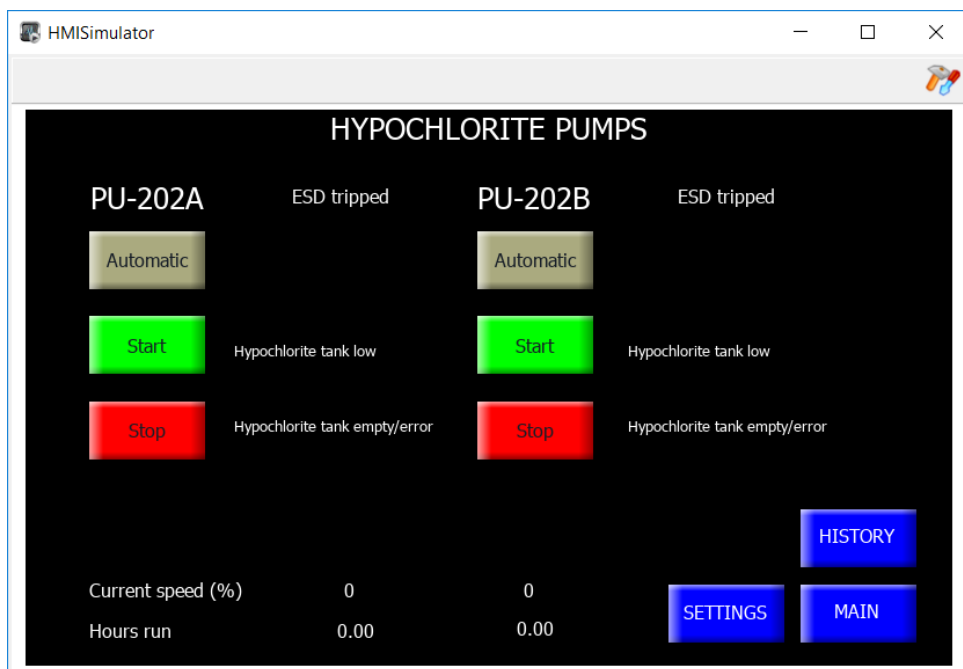


Figure 8-10 Hypochlorite Pumps Screen

### 8.3.2.4.1 Hypochlorite Dosing Pumps Setting Screen

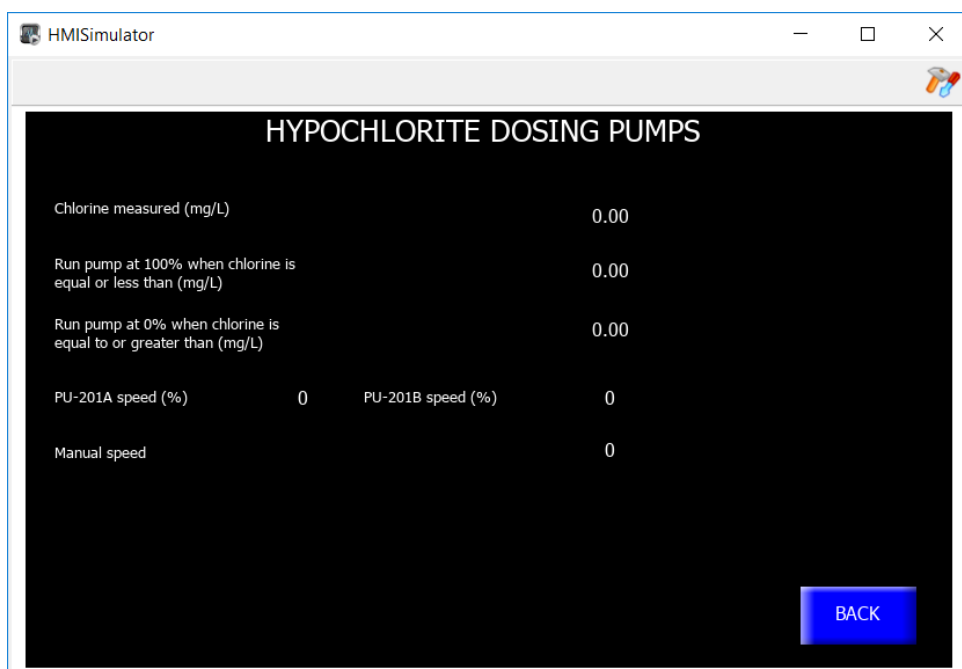


Figure 8-11 Hypochlorite Dosing Pumps Setting Screen

Set up the values as per underneath table:

Run Pump at 100% when chlorine is equal or less than (mg/L)	0.3
Run Pump at 0% when chlorine is equal or greater than (mg/L)	0.6
Manual Speed (%)	19%

### 8.3.2.5 Sulphuric Acid Pumps Screen

In this screen, Sulphuric Acid Dosing Pumps (PU-104A/PU-104B) can be set as Auto mode and/or started/stopped manually. The hours run for sulphuric acid dosing pumps are recorded in this screen.

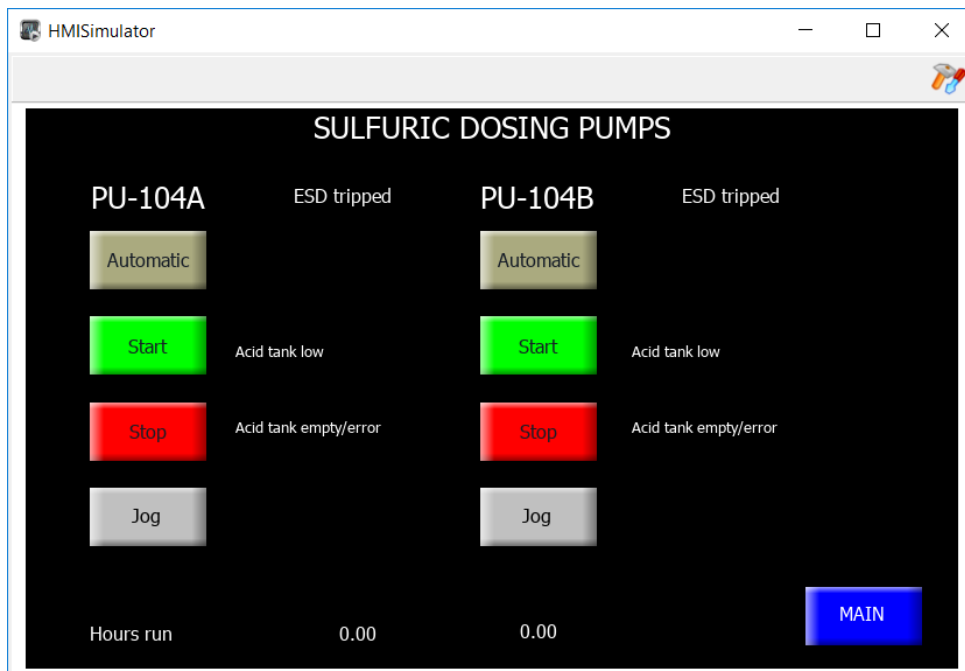


Figure 8-12 Sulphuric Acid Pumps Screen

### 8.3.2.6 Recirculation Pumps Screen

In this screen, Recirculation Pumps (PU-201A/PU-201B) can be set as Auto mode and/or started/stopped manually. The hours run for recirculation pumps are recorded in this screen.

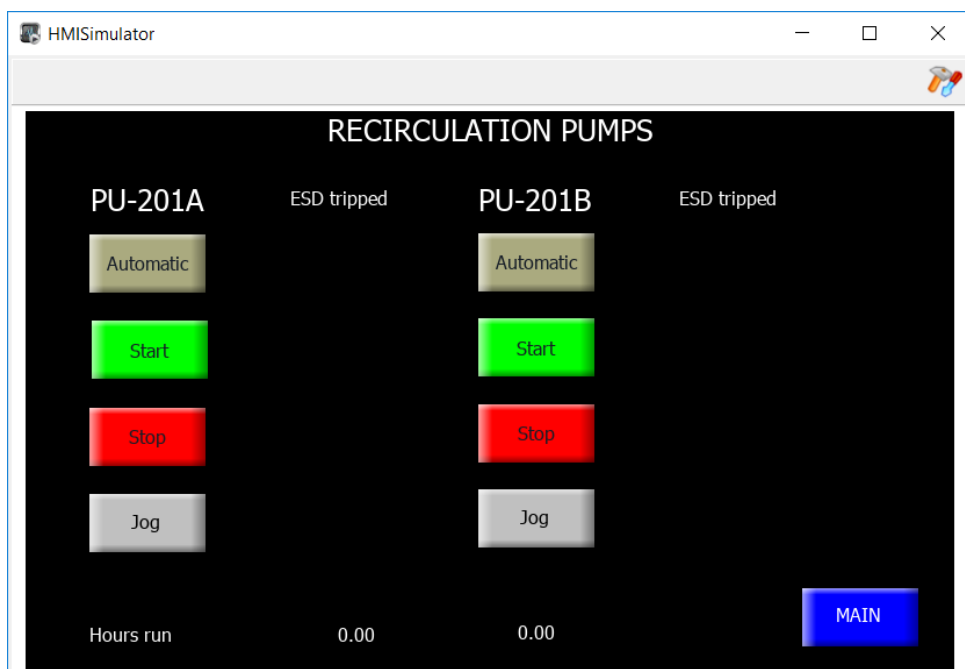


Figure 8-13 Recirculation Pumps Screen

### 8.3.2.7 Valves Screen

In this screen, all automatic valves (AV-101; AV-102; AV-103) can be set as Auto mode and/or opened/closed manually. The default valve timeout is 30 s.

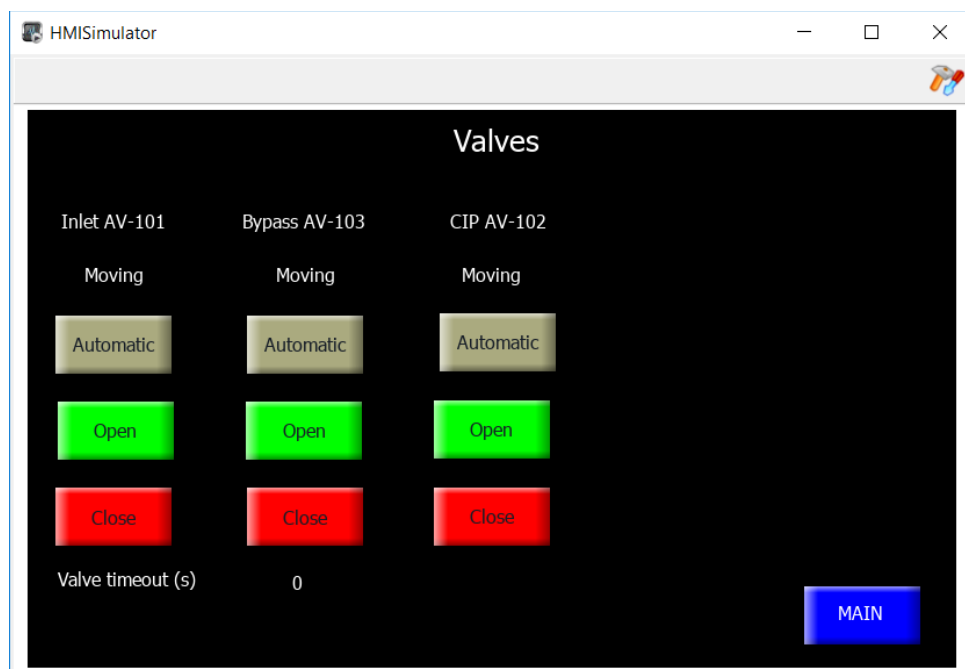


Figure 8-14 Valves Screen

### 8.3.2.8 Set Points Start Condition Screen

In this screen, some parameter value to start the BWRO system.

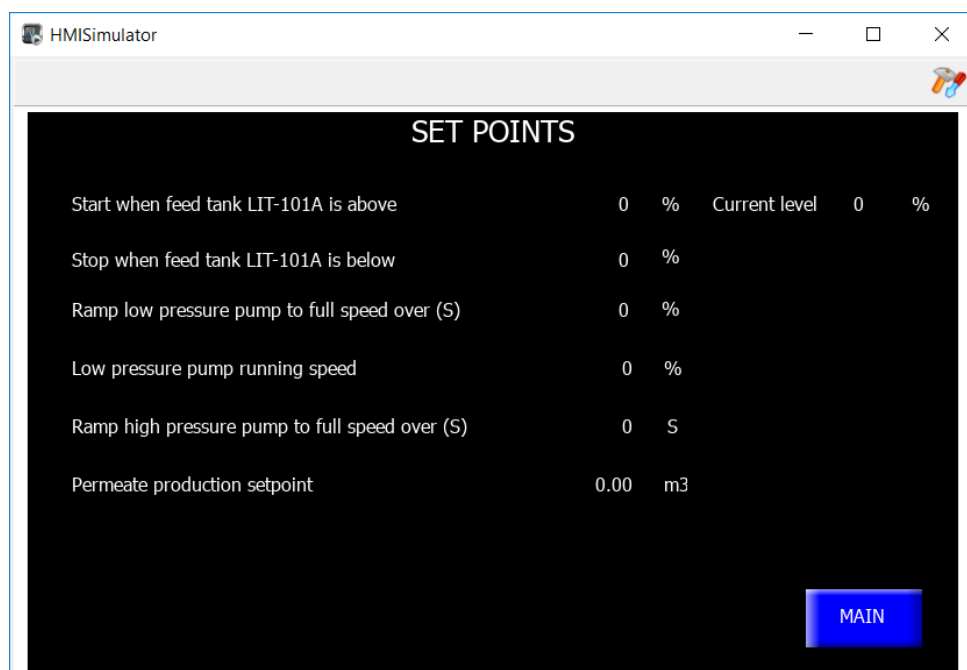


Figure 8-15 Set Points Start Condition Screen

Set up the values as per underneath table:

Start when feed tank LIT-101 is above	30 %
Stop when feed tank LIT-101 is below	20%
Ramp Low Pressure Pump to full speed over	20 s
Low Pressure Pump Running Speed	100 %
Ramp High Pressure Pump to full speed over	20 s
Permeate Production Setpoint	2.2 m <sup>3</sup> /h

### 8.3.2.9 Backwash Screen

In this screen, some parameter input values for Backwash sequence running condition, backwash monitoring current values and backwash request button to start manual initiation Backwash sequence.



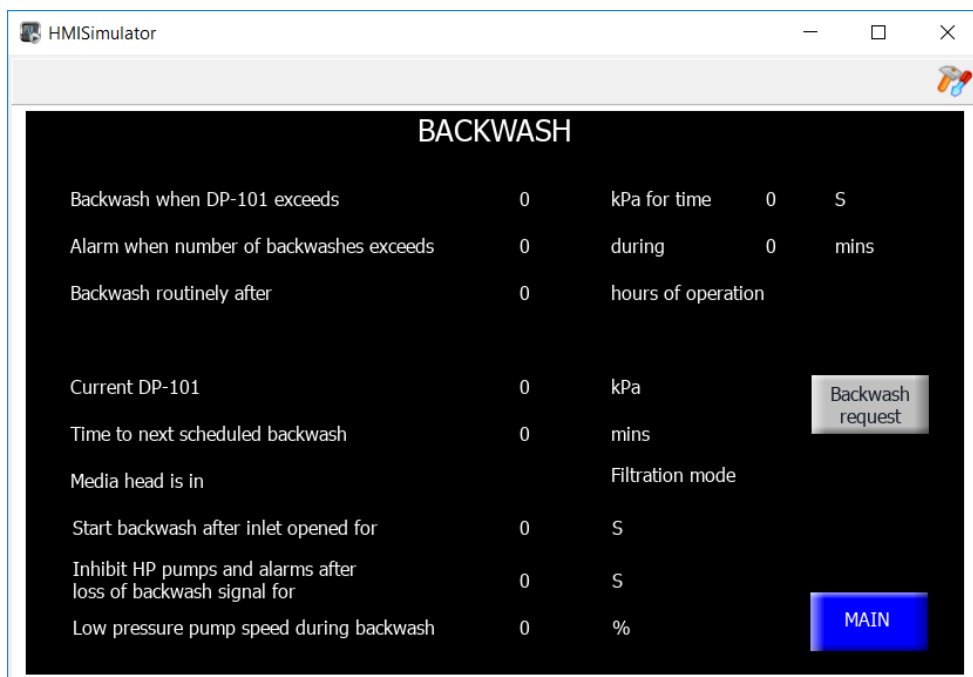


Figure 8-16 Backwash Screen

Set up values as per underneath table:

Backwash when DP-101 exceeds	100kPa
for time	300 s
Alarm when number of backwashes exceeds	3 times
during	60 minutes
Backwash Routinely after	24 hours of operation
Start backwash after inlet opened for	120 s
Inhibit HP Pumps and alarms after loss of backwash signal for	60 s
Low Pressure Pump Speed during backwash	100%

### 8.3.2.10 Alarms Setpoint Screen

In this screen, the alarm setpoint can be set up as per design values.

#### 8.3.2.10.1 Filtration Alarms

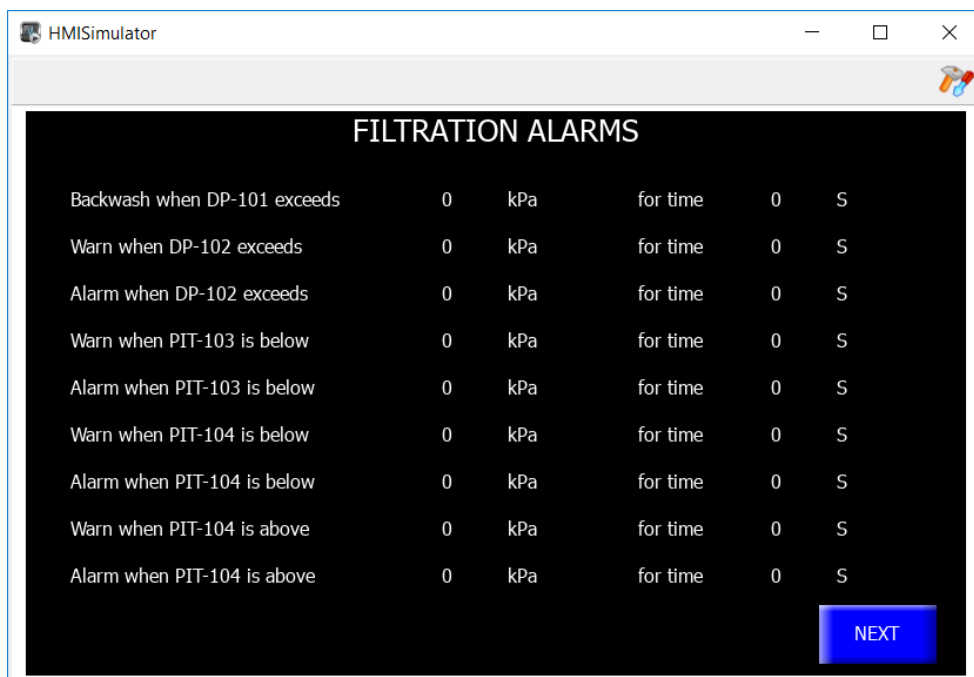


Figure 8-17 Filtration Alarms

Set the values as per underneath table:

Backwash when DP-101 exceeds	100kPa	for time	300s
Warn when DP-102 exceeds	50kpa	for time	300s
Alarm when DP-102 exceeds	80kPa	for time	300s
Warn when PIT-103 is below	75kPa	for time	300s
Alarm when PIT-103 is below	50kPa	For time	300s
Warn when PIT-104 is below	700kPa	for time	300s
Alarm when PIT-104 is below	500kPa	For time	300s
Warn when PIT-104 is above	1600kPa	for time	300s
Alarm when PIT-104 is above	1700kPa	For time	300s

### 8.3.2.10.2 Alarms 2 Screen

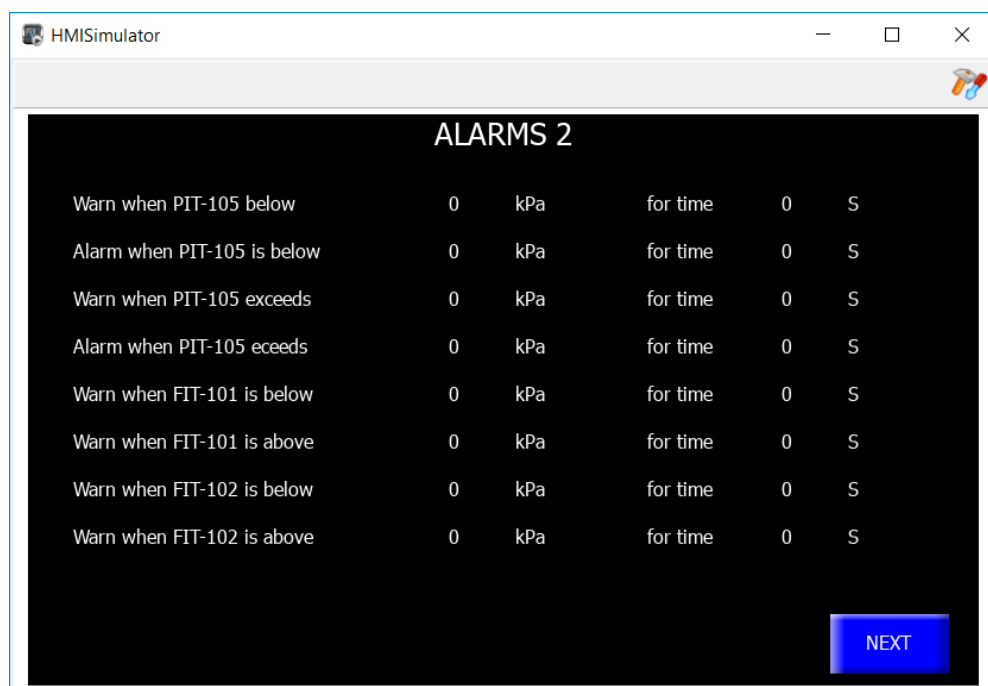


Figure 8-18 Alarms 2 Screen

Set the values as per underneath table:

Warn when PIT-105 is below	600kPa	for time	30s
Alarm when PIT-105 is below	500kPa	For time	30s
Warn when PIT-105 is above	1500kPa	for time	30s
Alarm when PIT-105 is above	1600kPa	For time	30s
Warn when FIT-101 is below	1.75m <sup>3</sup> /h	For time	7200s
Warn when FIT-101 is above	2.75m <sup>3</sup> /h	for time	7200s
Warn when FIT-102 is below	1.75m <sup>3</sup> /h	For time	7200s
Warn when FIT-102 is above	2.75m <sup>3</sup> /h	for time	7200s

### 8.3.2.10.3 Alarms 3 Screen

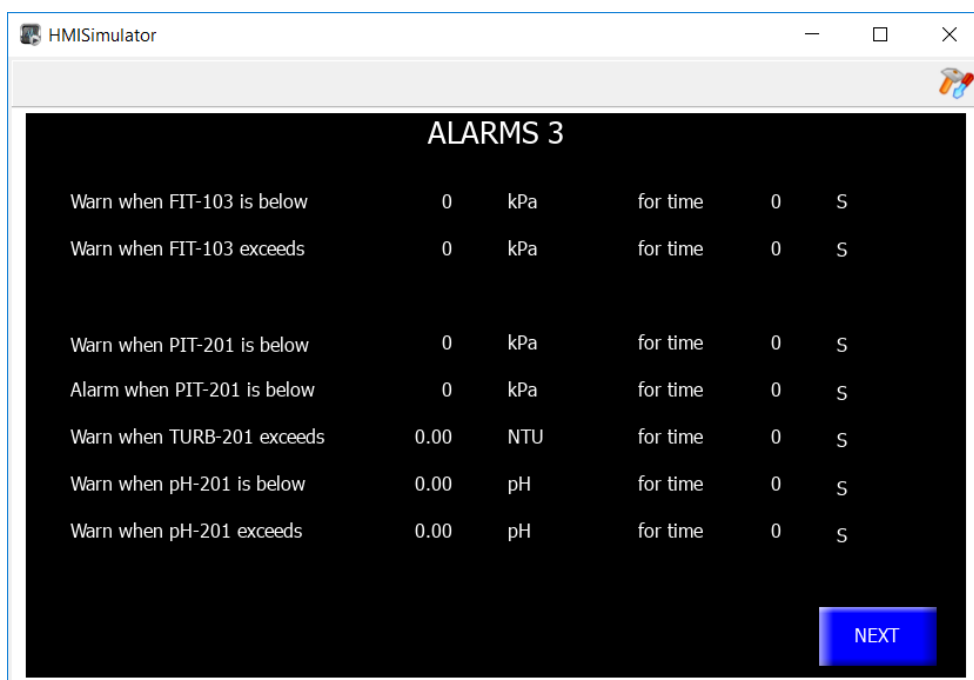


Figure 8-19 Alarms 3 Screen

Set the values as per underneath table:

Warn when FIT-103 is below	2.00m <sup>3</sup> /h	For time	7200s
Warn when FIT-103 is above	3.00m <sup>3</sup> /h	for time	7200s
Warn when PIT-201 is below	50kPa	for time	30s
Alarm when PIT-201 is below	20kPa	For time	30s
Warn when TURB-201 exceeds	10.00 NTU	For time	300s
Warn when pH-201 is below	6.5	for time	300s
Warn when pH-201 exceeds	8.5	For time	300s

### 8.3.2.10.4 Alarms 4 Screen

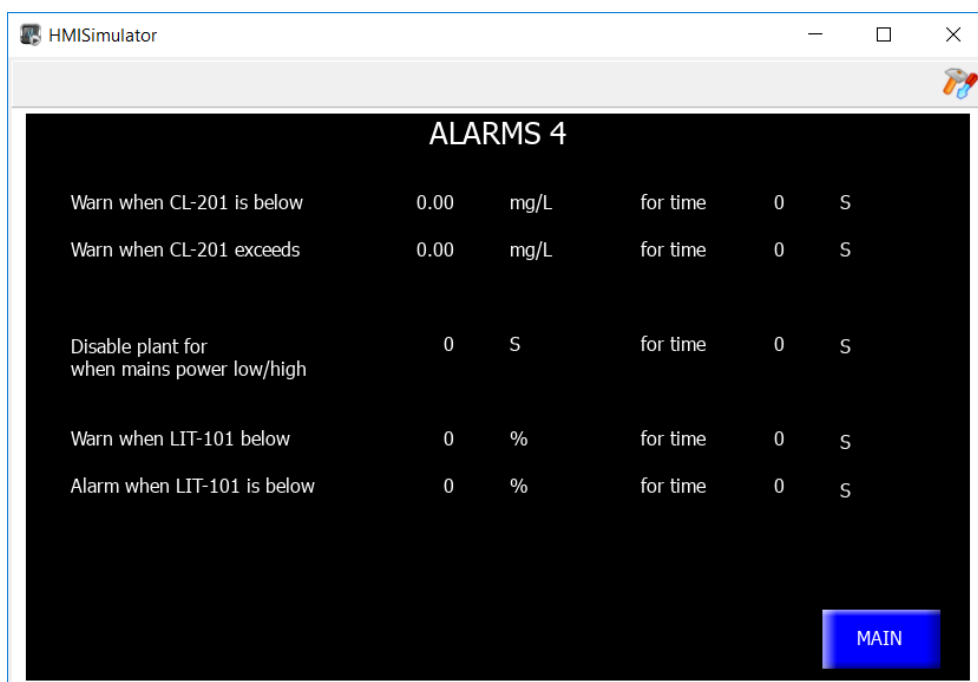


Figure 8-20 Alarms 4 Screen

Set the values as per underneath table:

Warn when CL-201 is below	0.2mg/L	For time	300s
Warn when CL-201 exceeds	0.8 mg/L	for time	300s
Warn when LIT-101 below	30%	for time	5s
Alarm when LIT-101 is below	25%	For time	2s

### 8.3.2.11 Clock Screen

In this screen, date and time can be set up as per time zone.

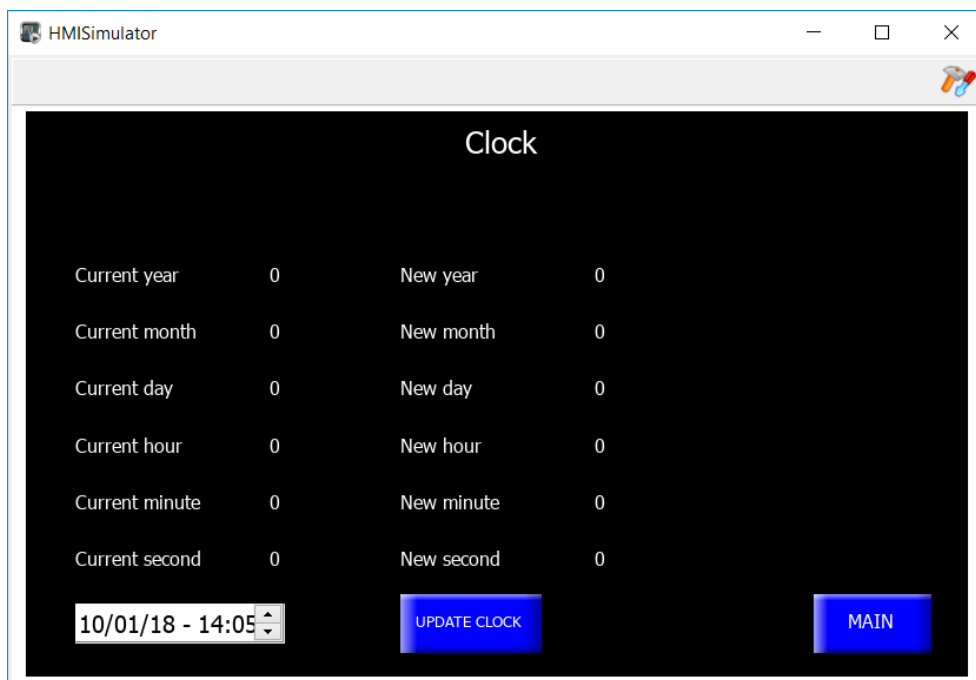


Figure 8-21 Clock Screen

### 8.3.2.12 Calibration Screen

In this screen, all analogue input can be set up as per design.

#### 8.3.2.12.1 Calibration Page 1 Screen

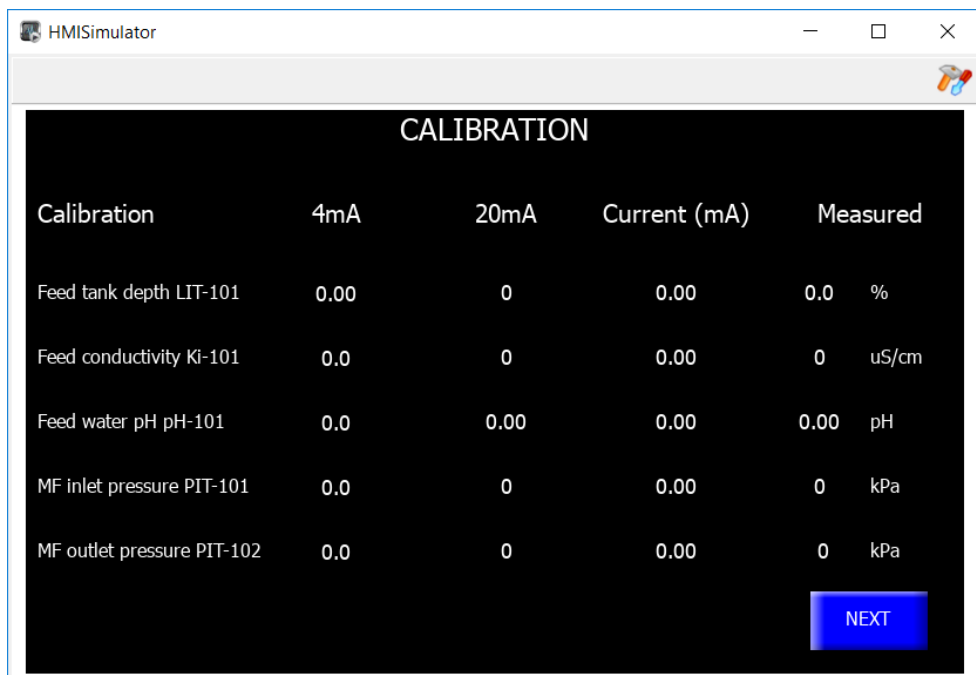


Figure 8-22 Calibration Page 1 Screen

Set the values as per underneath table:

Calibration	4mA	20mA
Feed tank depth LIT-101	0%	207%
Feed Conductivity KI-101	0 uS/cm	50,000 uS/cm
Feed Water pH-101	0.00	14.00
MF Inlet Pressure PIT-101	0kPa	1000kPa
MF Outlet Pressure PIT-102	0kPa	1000kPa

### 8.3.2.12.2 Calibration Page 2 Screen

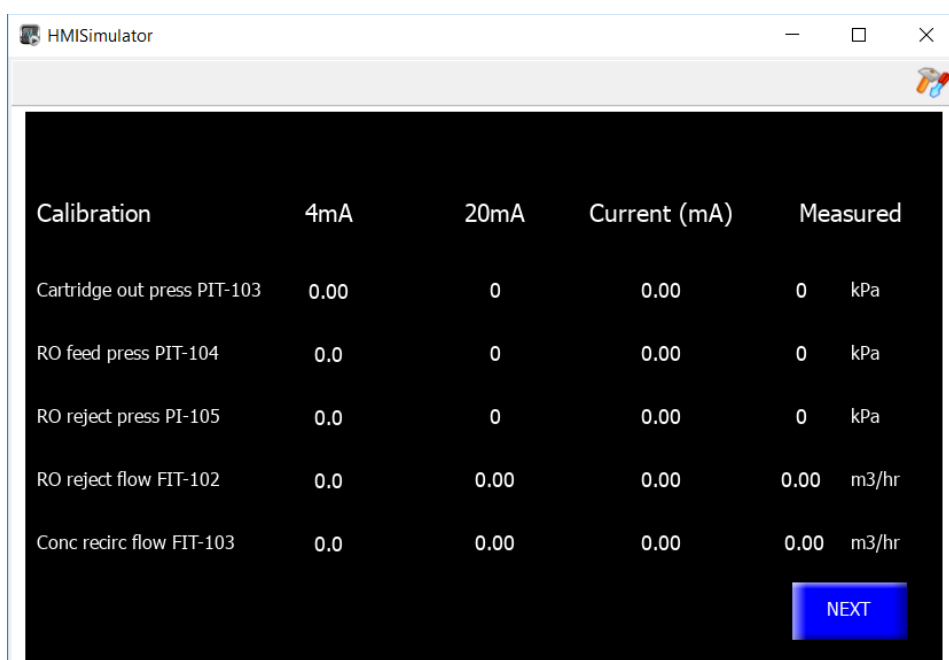


Figure 8-23 Calibration Page 2 Screen

Set the values as per underneath table:

Calibration	4mA	20mA
Cartridge Out Pressure PIT-103	0kPa	1000kPa
RO Feed Pressure PIT-104	0kPa	2500kPa
RO Reject Pressure PIT-105	0kPa	2500kPa
RO Reject Flow FIT-102	0.0m <sup>3</sup> /h	20.0m <sup>3</sup> /h
Conc Recirc FIT-103	0.0m <sup>3</sup> /h	6.0m <sup>3</sup> /h

### 8.3.2.12.3 Calibration Page 3 Screen

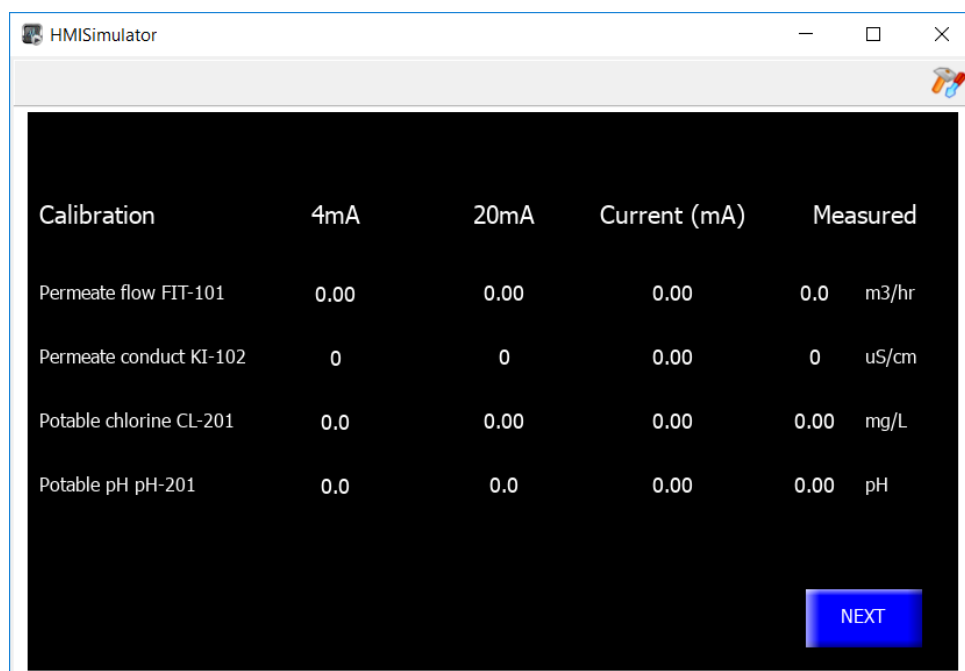


Figure 8-24 Calibration Page 3 Screen

Set the values as per underneath table:

Calibration	4mA	20mA
Permeate Flow FIT-101	0.0m <sup>3</sup> /h	6.0m <sup>3</sup> /h
Permeate Conductivity KI-102	0uS/cm	2000uS/cm
Potable Chlorine CL-201	0.00mg/L	5.00mg/L
Potable pH pH-201	1.00	12.00



### 8.3.2.12.4 Calibration Page 4 Screen



Figure 8-25 Calibration Page 4 Screen

Set the values as per underneath table:

Calibration	4mA	20mA
Recirc Press PIT-201	0kPa	1000kPa
Potable Turbidity TURB-201	0.00 NTU	100.00 NTU
Potable Conductivity KI-201	0uS/cm	2000uS/cm

### 8.3.2.13 CIP Screen

In this screen, parameter input values for CIP sequence running condition and START/STOP button to start/stop manual initiation CIP sequence.



Figure 8-26 CIP Screen

Set up values as per underneath table:

Low Pressure Pump Speed during CIP	100%
------------------------------------	------

#### 8.3.2.14 Chart Screen

In this screen, all analogue instrumentation will be recorded as the graphs.



Figure 8-27 Feed pH and Conductivity Chart Screen

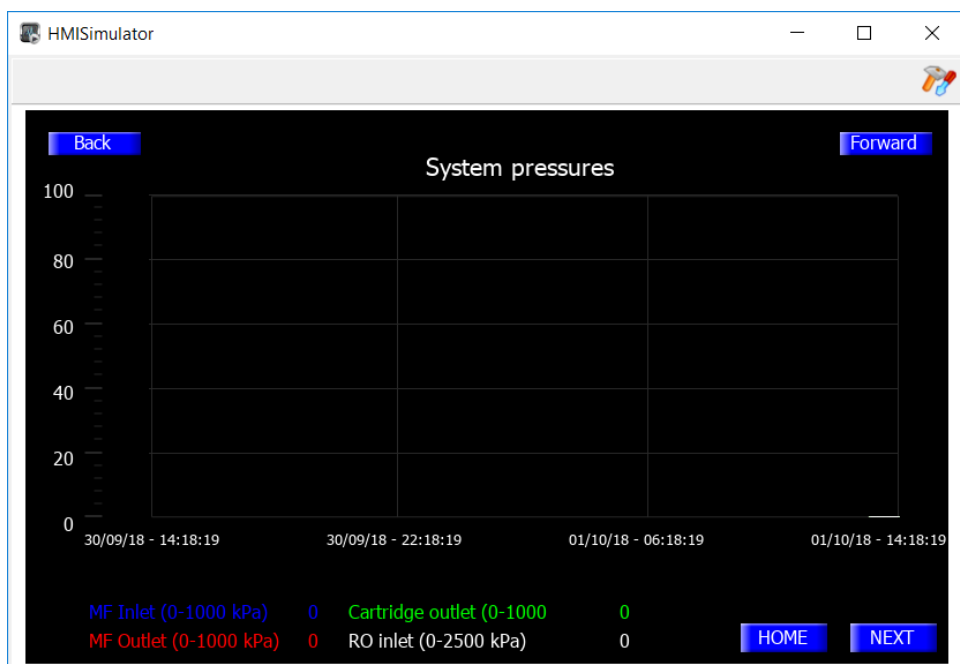


Figure 8-28 System Pressure Chart Screen



Figure 8-29 Differential Pressure (DP-101 & DP-102) Chart Screen



Figure 8-30 System Flows Chart Screen



Figure 8-31 Potable Chlorine/pH

## 8.4 STARTING AND STOPPING THE BWRO AND CHLORINATION PLANT

The Operator interfaces with the BWRO and Chlorination plant PLC through the MAN/OFF/AUTO Pump selector switches and the Human-Machine-Interface (HMI) touch screen mounted in the door of the electrical control cabinet. The status of the BWRO plant is at all times indicated on the HMI touch screen.

### 8.4.1 Automatic Mode Start-up Check List

Step	Description
1	Open the underneath isolation manual valves: V-101, V-102, V-103, V-105, V-107, V-108, V-109, V-110, V-111, V-112, V-113, V-114, V-117, V-118, V-122, V-123, V-123, V-125, V-127, V-128, V-129, V-130, V-135, V-136, V-137, V-138, V-141, V-201, V-202, V-204, V-206, V-207, V-208, V-209, V-210, A quarter open of V-211, V-213, V-216. The rest of the valves are closed.
2	Ensure all Pumps Power Switch including dosing pumps are turning ON.
3	Ensure "MAIN SWITCH" in the control panel is turning ON.
4	Ensure "EMERGENCY STOP" button in the control panel is released.
5	Press "EMERGENCY STOP RESET" in the control panel.
6	From the control panel front door, switch "LOW PRESSURE PUMP (PU-101A)" Into AUTO.
8	From the control panel front door, switch "LOW PRESSURE PUMP (PU-101B)" Into AUTO.
9	From the control panel front door, switch "ANTISCALANT PUMP (PU-102A)" Into AUTO.
10	From the control panel front door, switch "ANTISCALANT PUMP (PU-102B)" Into AUTO.
11	From the control panel front door, switch "HIGH PRESSURE PUMP (PU-103A)" Into AUTO.
12	From the control panel front door, switch "HIGH PRESSURE PUMP (PU-103B)" Into AUTO.
13	From the control panel front door, switch "SULFURIC ACID PUMP (PU-104A)" Into AUTO.
14	From the control panel front door, switch "SULFURIC ACID PUMP (PU-104B)" Into AUTO.
15	From the control panel front door, switch "RECIRCULATION PUMP (PU-201A)" into AUTO.
16	From the control panel front door, switch "RECIRCULATION PUMP (PU-201B)" into AUTO.
17	From the control panel front door, switch "HYPOCHLORITE PUMP (PU-202A)" into AUTO.
18	From the control panel front door, switch "HYPOCHLORITE PUMP (PU-202B)" into AUTO.
19	From "MAIN" screen on HMI, Press "OPTIONS" button.
20	From "OPTIONS" screen on HMI, Press "CLEAR MANUAL MODES" button.
21	From "OPTIONS" screen on HMI, Press "MAIN" button to back to "MAIN" Screen.
22	From "MAIN" screen on HMI, Press "START RO" button and "START RECIRC" button to start BWRO and Chlorination Plant automatically.
23	From "MAIN" screen on HMI, Press "RIGHT ARROW" button to navigate the screen into "LOW PRESSURE SECTION" P&ID Screen.
24	From "LOW PRESSURE SECTION" P&ID screen on HMI, Press "RIGHT ARROW" button to navigate the screen into "HIGH PRESSURE SECTION" P&ID Screen.
25	From "HIGH PRESSURE SECTION" P&ID screen, monitor reject flow rate (FIT-102). Ensure FIT-102 indicates flow rate: 2.2m <sup>3</sup> /h. Adjust the throttling valve (V-130) if the flow rate is higher or lower than this flow rate.
26	From "HIGH PRESSURE SECTION" P&ID screen, monitor concentrate recirculation flow rate (FIT-103). Ensure FIT-103 indicates flow rate: 2.5m <sup>3</sup> /h. Adjust the throttling valve (V-118) if the flow rate is higher or lower than this flow rate.
27	From "HIGH PRESSURE SECTION" P&ID screen, monitor permeate flow rate (FIT-101). Ensure FIT-101 indicates flow rate: 2.2m <sup>3</sup> /h.

<u>Step</u>	<u>Description</u>
28	From "HIGH PRESSURE SECTION" P&ID screen on HMI, Press "RIGHT ARROW" button to navigate the screen into "POTABLE SECTION" P&ID Screen.
29	From "POTABLE SECTION" P&ID screen on HMI, monitor Recirculation Pump Discharge Pressure (PIT-201). Ensure PIT-201 indicates pressure: 200 - 300kPa. Adjust the throttling valve (V-211) if the pressure is higher or lower than this pressure.
30	Adjust Ejector inlet valve to get the flow rate (FI-201) is around 1200 LPH.
31	Ensure Antiscalant dosing pump stroke is 35% and injected into the BWRO system.
32	Ensure Sulphuric Acid dosing pump stroke is 0.7% and injected into Calcite inlet.

#### 8.4.2 Stop Checklist

If the operator need to do any maintenance task that need to stop the BWRO and/or Chlorination plant, follow this underneath check list procedure:

<u>Step</u>	<u>Description</u>
1	From "MAIN" screen on HMI, Press "STOP" button at Reverse Osmosis System and/or "STOP" button at Potable Recirculation System to stop BWRO and/or Chlorination Plant.
2	Turn OFF "MAIN SWITCH" in the control panel.



### **8.4.3 Media Filter Backwash**

Media filter backwash is initiated either by a High Differential Pressure (DP-101) or by a timer programmed into the Media Filter PLC or manual initiation by operator. Either when the differential pressure between the inlet to and the outlet from the Media Filter reaches a figure 100 kPa or when the timer times out (24 hours operation) or operator press "BACKWASH REQUEST" button, the Media Filter goes into backwash mode. When the backwash mode is completed, the BWRO will start to produce potable water automatically.

#### 8.4.4 Cartridge Filter Replacement

It will be necessary to replace the filter elements if the pressure drop across the filters rises by 60kpa (High Warning DP-102 is activated) or every 8 weeks or after CIP sequence, whichever is sooner. The entire plant must be shut down to perform this operation (Refer to Section 8.4.2). The procedure below should be followed when performing this task.

Step	Operator Action	Description
1	Shut down plant	From "MAIN" screen on HMI, Press "STOP" button at Reverse Osmosis System to stop BWRO.
2	Isolate the Filter Housings	Close valves V-114, V-122 and V-123
3	Relieve the vessel pressure and drain.	Release the vent valve (V-115) on top of the filter housing and release the drain valve on the bottom (V-116).
4	Remove the vessel.	Open the filter housing.
5	Remove the filter	Remove the old filters and wipe out the inside of the housing.
6	Replace the filter elements	Place the new filters into the housing and close the cartridge filter housing
7	Open Isolation Valves	Open valves V-114, V-122 and V-123. Close vent and drain valves.
8	Restart the BWRO plant	From "MAIN" screen on HMI, Press "STOP" button at Reverse Osmosis System to stop BWRO.
9	Bleed air on start up	On start-up it may be necessary to bleed any trapped air by opening the bleed valve on the Low Pressure pump (PU-101A/PU-101B).

## 8.4.5 Loading Chemical into Chemical Storage

### 8.4.5.1 Antiscalant

Step	Description
1	Carefully read the product label and Safety Data Sheet (SDS) of Antiscalant.
2	Use of safe work practices are recommended to avoid eye or skin contact and inhalation.
3	Observe good personal hygiene, including washing hands before eating.
4	Prohibit eating, drinking and smoking in contaminated area.
5	Wear the appropriate Personal Protective Equipment (PPE) according to the SDS of Antiscalant.
6	Fully open the BWRO Plant shed doors.
7	Open the lid and remove the vent plug from the 200L Antiscalant drum.
8	Place the inlet hose of a dedicated Antiscalant hand pump into the 200L Antiscalant drum.
9	Open the lid of the 100L Antiscalant storage tank.
10	Place the outlet hose of a dedicated Antiscalant hand pump into the 100L Antiscalant storage tank.
11	Pump the Antiscalant from 200 L drum into the 100L Antiscalant storage tank until the level inside Antiscalant storage tank is full.
12	Take out the outlet hose of a dedicated Antiscalant hand pump from the 100L Antiscalant storage tank.
13	Take out the inlet hose of a dedicated Antiscalant hand pump from the 200L Antiscalant drum.
14	Close the lid of the 100L Antiscalant storage tank.
15	Close the lid and the vent plug from the 200L Antiscalant drum.
16	Keep a dedicated Antiscalant hand pump in the safe area.

### 8.4.5.2 Sulphuric Acid

Step	Description
1	Carefully read the product label and Safety Data Sheet (SDS) of Sulphuric Acid.
2	Use of safe work practices are recommended to avoid eye or skin contact and inhalation.
3	Observe good personal hygiene, including washing hands before eating.
4	Prohibit eating, drinking and smoking in contaminated area.
5	Wear the appropriate Personal Protective Equipment (PPE) according to the SDS of Sulphuric Acid.
6	Fully open the BWRO Plant shed doors.
7	Open the lid and remove the vent plug from the 200L Sulphuric Acid drum.
8	Place the inlet hose of a dedicated Sulphuric Acid hand pump into the 200L Sulphuric Acid drum.
9	Open the lid of the 100L Sulphuric Acid storage tank.
10	Place the outlet hose of a dedicated Sulphuric Acid hand pump into the 100L Sulphuric Acid storage tank.
11	Pump the Sulphuric Acid from 200 L drum into the 100L Sulphuric Acid storage tank until the level inside Sulphuric Acid storage tank is full.
12	Take out the outlet hose of a dedicated Sulphuric Acid hand pump from the 100L Sulphuric Acid storage tank.
13	Take out the inlet hose of a dedicated Sulphuric Acid hand pump from the 200L Sulphuric Acid drum.
14	Close the lid of the 100L Sulphuric Acid storage tank.
15	Close the lid and the vent plug from the 200L Sulphuric Acid drum.

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<u>Step</u>	<u>Description</u>
16	Keep a dedicated Sulphuric Acid hand pump in the safe area.

#### 8.4.6 CIP Procedure

A membrane clean is typically conducted every 1 to 3 months and should be done whenever:

- The permeate flow rate drops by more than 15%.
- The permeate conductivity deteriorates by more than 15%.
- The differential pressure across the RO Array (DP-103) increases by more than 15% from the reference conditions noted in the first 24 to 48 hours of operation.

It is important to clean the membranes when they are only lightly fouled – do not wait until they are heavily fouled. Heavy fouling can impair the effectiveness of the cleaning chemical by impeding the penetration of the chemical deep into the foulant and in flushing the foulant out of the membranes. If normalized membrane performance drops by 30 to 50%, it may be impossible to fully restore performance.

Step	Description
1	<p><b>RECORD NORMAL OPERATING CONDITIONS</b></p> <p>Note down the operating parameters of the RO plant. These are required as a starting point to determine how effective the membrane chemical clean has been.</p> <ul style="list-style-type: none"> <li>Feed Water Conductivity (KI-101) : uS/cm</li> <li>Feed Water pH (pH-110): pH</li> <li>Feed Water Temperature (TG-101): °C</li> <li>Media Filter Inlet Pressure (PIT-101): kPa</li> <li>Media Filter Outlet Pressure (PIT-102): kPa</li> <li>1 Micron Cartridge Filter Outlet Pressure (PIT-103): kPa</li> <li>RO Feed Inlet Pressure (PIT-104): kPa</li> <li>RO Concentrate Pressure (PIT-105): kPa</li> <li>RO Permeate Flow Rate (FIT-101): m<sup>3</sup>/h</li> <li>RO Reject Flow Rate (FIT-102): m<sup>3</sup>/h</li> <li>RO Concentrate Recirculation (FIT-103): m<sup>3</sup>/h</li> <li>RO Permeate Conductivity: m<sup>3</sup>/h</li> </ul>
2	<p><b>TURN OFF RO PLANT WITHOUT FLUSHING SEQUENCE</b></p> <ul style="list-style-type: none"> <li>From "MAIN" screen on HMI, press "OPTION" button.</li> <li>From "OPTION" screen on HMI, press "CIP" button.</li> <li>From "CIP" screen on HMI, press "CIP MODE" button and the RO system will stop automatically without Flushing sequence.</li> </ul>
3	<p><b>ALKALINE CLEANER PREPARATION</b></p> <ul style="list-style-type: none"> <li>The operator shall wear PPE as per the relevant SDS.</li> <li>Carefully add 10L of the alkaline cleaner (Permaclean PC-3) slowly to the CIP tank.</li> </ul>
4	<p><b>CHANGE MANUAL ISOLATION VALVE POSITION</b></p> <ul style="list-style-type: none"> <li>Open manual isolation valve V-110 and V-131.</li> <li>Close manual isolation valve V-109, V-112, V-132, V-134 and V-135.</li> </ul>
5	<p><b>START CIP RECIRCULATION</b></p> <ul style="list-style-type: none"> <li>From "CIP" screen on HMI, press "START" button and the CIP Recirculation sequence is running automatically.</li> </ul>
6	<p><b>STOP CIP RECIRCULATION</b></p> <ul style="list-style-type: none"> <li>After CIP Recirculation is running for 1 hour, open manual isolation valve V-132 and close manual isolation valve V-131 to drain all chemicals into Reject line.</li> </ul>

Step	Description
	<ul style="list-style-type: none"> <li>- When CIP/Flush tank is low level, the Low Pressure Pump (PU-101A or PU-10B) will stop otherwise from "CIP" screen on HMI, press "STOP" button to stop PU-101A or PU-101B.</li> </ul>
7	<b>FLUSHING SEQUENCE MANUALLY</b> <ul style="list-style-type: none"> <li>- From "CIP" screen on HMI, press "MAIN" button.</li> <li>- From "MAIN" screen on HMI, press "OPTION" button.</li> <li>- From "OPTION" screen on HMI, press "VALVES" button.</li> <li>- From "VALVES" screen on HMI, press "AUTOMATIC" button underneath Inlet AV-101 to change the Inlet Valve AV-101 mode into "MANUAL" and then press "OPEN" to open the inlet valve.</li> <li>- From the control panel front door, switch "LOW PRESSURE PUMP (PU-101A) or LOW PRESSURE PUMP (PU-101B)" Into "MANUAL" to flush out the RO membrane from any chemicals left over inside the RO membrane.</li> <li>- After Low Pressure Pump is running for 10 minutes, from the control panel front door, switch "LOW PRESSURE PUMP (PU-101A) or LOW PRESSURE PUMP (PU-101B)" Into "OFF" to stop the flushing and then switch into "AUTO".</li> </ul>
8	<b>RUN BWRO SYSTEM IN AUTO MODE TO FILL CIP/FLUSH TANK</b> <ul style="list-style-type: none"> <li>- Open manual isolation valve V-109, V-112, V-134 and V-135.</li> <li>- Close manual isolation valve V-110.</li> <li>- From "MAIN" screen on HMI, Press "START RO" button to start BWRO automatically.</li> </ul>
9	<b>TURN OFF RO PLANT WITHOUT FLUSHING SEQUENCE</b> <ul style="list-style-type: none"> <li>- When CIP/Flush Tank is full, from "MAIN" screen on HMI, press "OPTION" button.</li> <li>- From "OPTION" screen on HMI, press "CIP" button.</li> <li>- From "CIP" screen on HMI, press "CIP MODE" button and the RO system will stop automatically without Flushing sequence.</li> </ul>
10	<b>ACID CLEANER PREPARATION</b> <ul style="list-style-type: none"> <li>- The operator shall wear PPE as per the relevant SDS.</li> <li>- Carefully add 15L of the alkaline cleaner (Citric Acid) slowly to the CIP tank.</li> </ul>
11	<b>CHANGE MANUAL ISOLATION VALVE POSITION</b> <ul style="list-style-type: none"> <li>- Open manual isolation valve V-110 and V-131.</li> <li>- Close manual isolation valve V-109, V-112, V-132, V-134 and V-135.</li> </ul>
12	<b>START CIP RECIRCULATION</b> <p>From "CIP" screen on HMI, press "START" button and the CIP Recirculation sequence is running automatically.</p>
13	<b>STOP CIP RECIRCULATION</b> <ul style="list-style-type: none"> <li>- After CIP Recirculation is running for 1 hour, open manual isolation valve V-132 and close manual isolation valve V-131 to drain all chemicals into Reject line.</li> </ul>

Step	Description
	<ul style="list-style-type: none"> <li>- When CIP/Flush tank is low level, the Low Pressure Pump (PU-101A or PU-10B) will stop otherwise from "CIP" screen on HMI, press "STOP" button to stop PU-101A or PU-101B.</li> </ul>
14	<p><b>FLUSHING SEQUENCE MANUALLY</b></p> <ul style="list-style-type: none"> <li>- From "CIP" screen on HMI, press "MAIN" button.</li> <li>- From "MAIN" screen on HMI, press "OPTION" button.</li> <li>- From "OPTION" screen on HMI, press "VALVES" button.</li> <li>- From "VALVES" screen on HMI, press "AUTOMATIC" button underneath Inlet AV-101 to change the Inlet Valve AV-101 mode into "MANUAL" and then press "OPEN" to open the inlet valve.</li> <li>- From the control panel front door, switch "LOW PRESSURE PUMP (PU-101A) or LOW PRESSURE PUMP (PU-101B)" Into "MANUAL" to flush out the RO membrane from any chemicals left over inside the RO membrane.</li> <li>- After Low Pressure Pump is running for 10 minutes, from the control panel front door, switch "LOW PRESSURE PUMP (PU-101A) or LOW PRESSURE PUMP (PU-101B)" Into "OFF" to stop the flushing and then switch into "AUTO".</li> </ul>
15	<p><b>BWRO SYSTEM IS RETURNING TO AUTO MODE</b></p> <ul style="list-style-type: none"> <li>- Open manual isolation valve V-109, V-112, V-134 and V-135.</li> <li>- Close manual isolation valve V-110.</li> <li>- From "MAIN" screen on HMI, Press "START RO" button to start BWRO automatically.</li> </ul>
16	<p><b>RECORD NORMAL OPERATING CONDITIONS</b></p> <p>Note down the operating parameters of the plant and analyze to ensure the readings have improved post CIP otherwise another CIP sequence may be required.</p> <ul style="list-style-type: none"> <li>• Feed Water Conductivity (KI-101) : uS/cm</li> <li>• Feed Water pH (pH-110): pH</li> <li>• Feed Water Temperature (TG-101): °C</li> <li>• Media Filter Inlet Pressure (PIT-101): kPa</li> <li>• Media Filter Outlet Pressure (PIT-102): kPa</li> <li>• 1 Micron Cartridge Filter Outlet Pressure (PIT-103): kPa</li> <li>• RO Feed Inlet Pressure (PIT-104): kPa</li> <li>• RO Concentrate Pressure (PIT-105): kPa</li> <li>• RO Permeate Flow Rate (FIT-101): m<sup>3</sup>/h</li> <li>• RO Reject Flow Rate (FIT-102): m<sup>3</sup>/h</li> <li>• RO Concentrate Recirculation (FIT-103): m<sup>3</sup>/h</li> <li>• RO Permeate Conductivity: m<sup>3</sup>/h</li> </ul>

#### 8.4.7 Preservation RO Membrane Procedures

If the system is not required to operate for periods greater than 2 to 3 days, dependent upon ambient temperature, then the membrane manufacturers recommend that the membranes are preserved to inhibit expensive biological fouling. Higher ambient temperatures reduce the period of time the system can be left inactive.



Step	Description
1	<b>TURN OFF RO PLANT WITHOUT FLUSHING SEQUENCE</b> <ul style="list-style-type: none"> <li>- From "MAIN" screen on HMI, press "OPTION" button.</li> <li>- From "OPTION" screen on HMI, press "CIP" button.</li> <li>- From "CIP" screen on HMI, press "CIP MODE" button and the RO system will stop automatically without Flushing sequence.</li> </ul>
2	<b>PRESERVATION CHEMICAL PREPARATION</b> <ul style="list-style-type: none"> <li>- The operator shall wear PPE as per the relevant SDS.</li> <li>- Carefully add 3kg of the preservation chemical (Sodium Bisulphite) slowly to the CIP tank and stir to dissolve all the chemical into water.</li> </ul>
3	<b>CHANGE MANUAL ISOLATION VALVE POSITION</b> <ul style="list-style-type: none"> <li>- Open manual isolation valve V-110 and V-131.</li> <li>- Close manual isolation valve V-109, V-112, V-132, V-134 and V-135.</li> </ul>
4	<b>START PRESERVED CHEMICAL RECIRCULATION</b> <ul style="list-style-type: none"> <li>- From "CIP" screen on HMI, press "START" button and the CIP Recirculation sequence is running automatically.</li> </ul>
5	<b>STOP PRESERVED CHEMICAL RECIRCULATION</b> <ul style="list-style-type: none"> <li>- After Preserved Chemical Recirculation is running for 15 minutes, from "CIP" screen on HMI, press "STOP" button to stop PU-101A or PU-101B.</li> </ul>



## 8.4.8 Replacement of RO Membrane Procedures

A replacement of RO Membrane is typically conducted every 3 to 5 years or after intensive chemical cleaning is happened but:



- The permeate flow rate drops by more than 50% (less than 1.1m<sup>3</sup>/h)
- The permeate conductivity is more than 1000uS/cm with the same feed water conductivity as per commissioning period.
- The differential pressure across the RO Array (DP-103) is more than 100kPa.

Step	Description
1	From "MAIN" screen on HMI, Press "STOP" button at Reverse Osmosis System to stop BWRO Plant.
2	Turn OFF "MAIN SWITCH" in the control panel.
3	Close manual isolation valve, V-101, V-132 and V-138
4	Lose "retaining clip" at the Inlet side of RO Pressure vessel and pull out the RO Vessel cap.
	
5	Lose "retaining clip", barrel unions at the reject side of RO Pressure vessel and pull out the RO Vessel cap.
	
6	Push out the RO Membrane from inside RO Pressure Vessel.

<u>Step</u>	<u>Description</u>
7	Apply some glycerin on the RO Vessel cap and Re-install it at the reject side.
8	<ul style="list-style-type: none"> <li>- Record the serial number of RO membranes.</li> <li>- Apply some glycerin on the RO Membranes and push the RO membrane into the RO pressure vessel from inlet side.</li> </ul>
9	After both RO Membranes are installed, close the RO Vessel Cap at the inlet side.
10	Re-install both Retaining Clip at the inlet and reject side and both barrel union at the reject side.
11	Open manual isolation valve, V-101, V-132 and V-138
12	Turn ON "MAIN SWITCH" in the control panel.
13	From "MAIN" screen on HMI, Press "START RO" button at Reverse Osmosis System to start BWRO Plant.

### 8.4.9 Replacement of Filter Media from Media Filtration



A replacement of Filter Media from Media Filtration is typically conducted every 7 to 10 years.

Step	Description
1	From "MAIN" screen on HMI, Press "STOP" button at Reverse Osmosis System to stop BWRO Plant.
2	Turn OFF "MAIN SWITCH" in the control panel.
3	Close manual isolation valve, V-101, V-132 and V-138.
4	<p>Lose all barrel unions from inlet, outlet and backwash drain connection</p>  <p>Barrel Union</p>
5	<p>Lose and pull out the connection of Media Filter Control Valve Head.</p> 
6	Using the sucker truck, suck all the filter media from media filter vessel.

Step	Description
7	<p>After the media filter vessel is empty, load the filter media as per underneath loading schedule.</p> <p>Loading Schedule from Bottom to Top Layer:</p> <ul style="list-style-type: none"> <li>- 5/2 Gravel, 40 kg = 1.6 bags</li> <li>- 8/16 Sand #6 Sand, 25kg = 1 bag</li> <li>- AFM Glass Media, Grade 1, 0.4 - 1.0 mm, 136.5kg =6.5 bags</li> <li>- Australian Filter Coal 1.3 - 1.4mm (1.15cuft), 44kg = 2 bags</li> </ul>
8	Reinstall the connection of Media Filter Control Valve Head.
9.	Reinstall all barrel unions from inlet, outlet and backwash drain connection
10.	Open manual isolation valve, V-101, V-132 and V-138.
11.	Turn ON "MAIN SWITCH" in the control panel.
12.	From "MAIN" screen on HMI, Press "RO START" button at Reverse Osmosis System to start BWRO Plant.

### 8.4.10 Replacement of Calcite Media from Calcite Filter Vessel

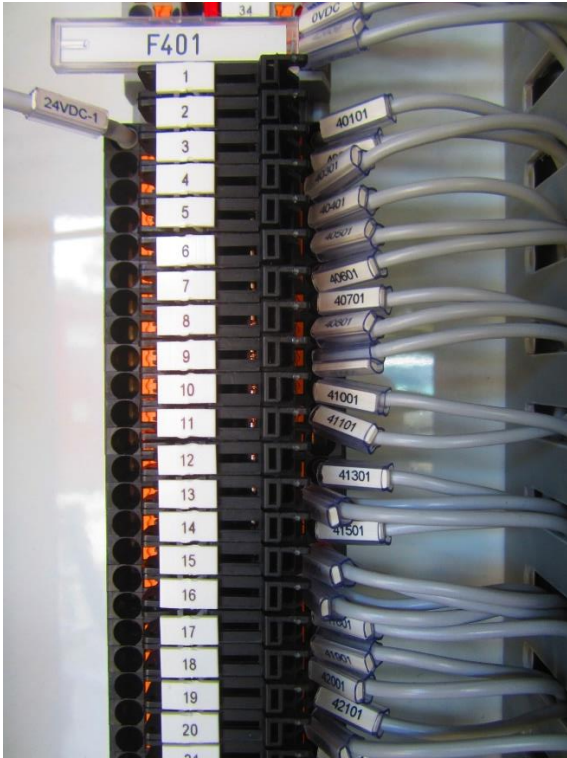
A replacement of Calcite Media from Calcite Filter Vessel is typically conducted every 2 to 3 years.



Step	Description
1	From "MAIN" screen on HMI, Press "STOP" button at Reverse Osmosis System to stop BWRO Plant.
2	Turn OFF "MAIN SWITCH" in the control panel.
3	Close manual isolation valve, V-135, V-137 and V-138.
4	<p>Lose and pull out the bottom flange connection to remove calcite media. Put the plastic bag underneath calcite filter vessel to collect all the calcite media.</p>  <p>Bottom Flange Connection</p>
5	<p>Lose and pull out the top flange connection to load the calcite media.</p>  <p>Top Flange Connection</p>



Step	Description
7	After the Calcite filter vessel is empty, reinstall the bottom flange of calcite filter vessel. Load the calcite filter media as per underneath loading schedule. Loading Schedule from Bottom to Top Layer: <ul style="list-style-type: none"> <li>- 6/3 Gravel, 40kg = 1.6 bags</li> <li>- 8/16 Sand #6 Sand, 25kg = 1 bag</li> <li>- Calcite, 247.5kg = 11 bags</li> </ul>
8	Reinstall the top flange of calcite filter vessel.
10.	Open manual isolation valve, V-135, V-137 and V-138.
11.	Turn ON "MAIN SWITCH" in the control panel.
12.	From "MAIN" screen on HMI, Press "RO START" button at Reverse Osmosis System to start BWRO Plant.

### 8.4.11 HMI Screen Replacement Procedure

Step	Description
1	<p>Turn off the mains power and open the door.</p> <p>Note: The 415VAC in the cabinet is all covered by clear Perspex but caution must be taken only to work near the areas shown and not to remove any of the covers.</p>
2	<p>The HMI will continue to be powered by the backup battery – open fuse 404 as below i.e. the fuse labelled “4”. The fuse hinges to the left. Note this fuse only carries</p> 
3	<p>Remove black power plug, blue Ethernet cable, green earth wire from HMI. The green earth wire disconnects using a small Philips screw.</p>


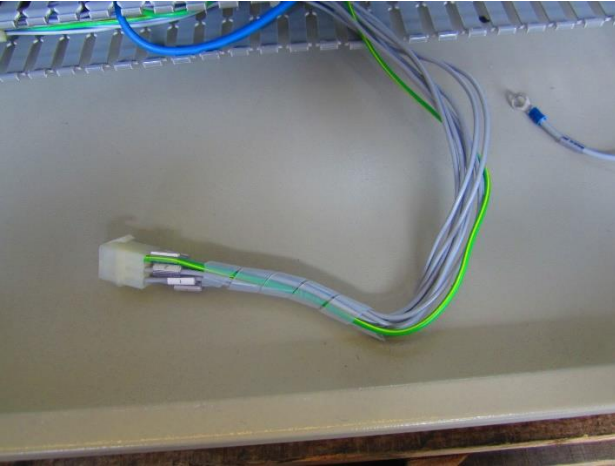
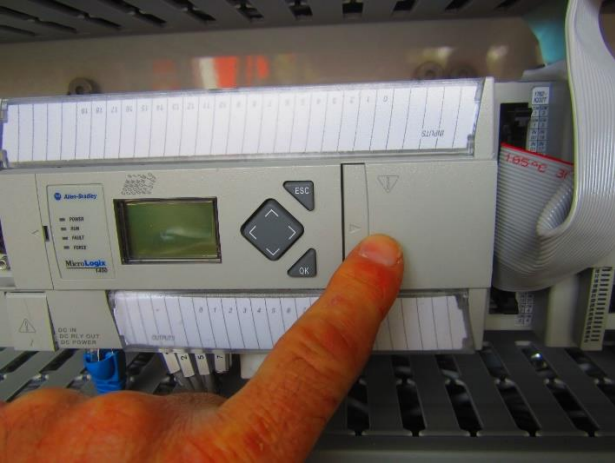
Step	Description
	
4	<p>Using a Philips driver remove four screws securing the HMI to the door panel – unscrew the Philips head anti-clockwise several turns until the angled mounting foot wriggles out of the HMI.</p> <p>Support the HMI with one hand to ensure it does not fall onto the floor.</p> 
5	<p>Installation is reverse – hold the new HMI inside the panel with one hand on the outside. Insert the angled mounting foot into the HMI from the rear side. Tighten the four screws to clamp the angled mounting foot against the rear of the door.</p>
6	<p>Reconnect the wires and close fuse 404 to re-apply power. The unit is pre-programmed and will start functioning immediately.</p>


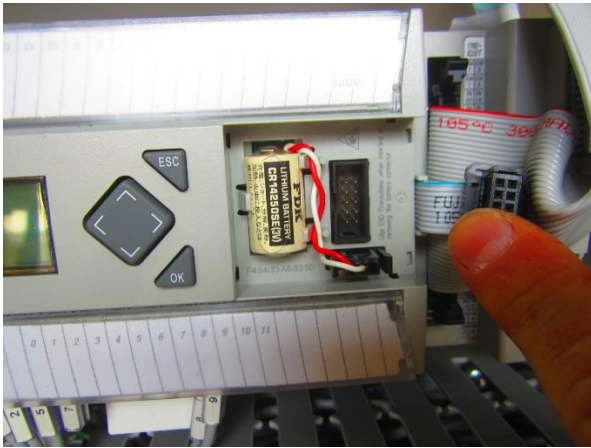



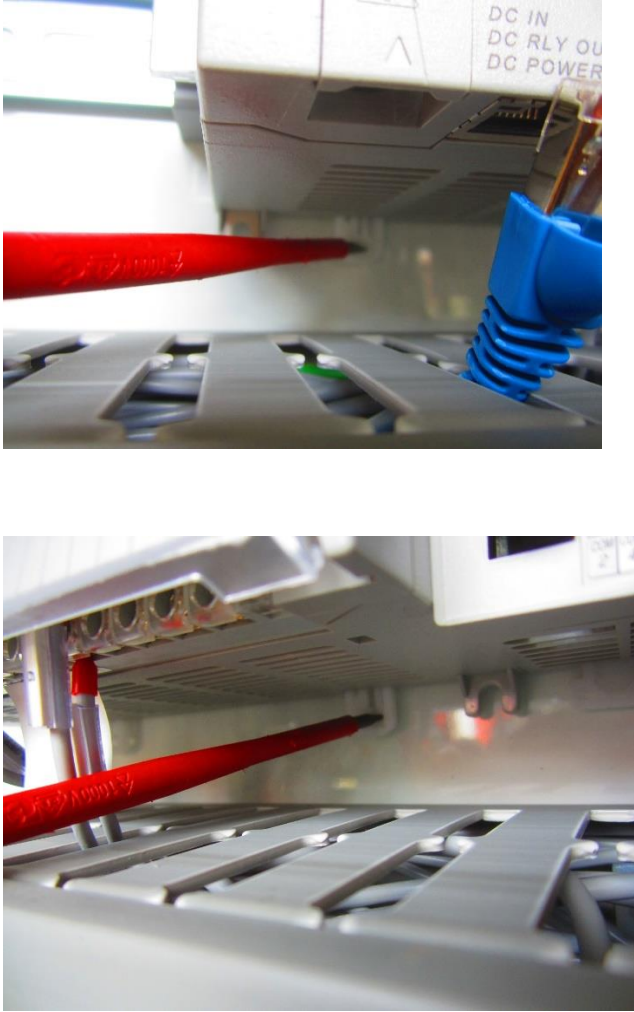
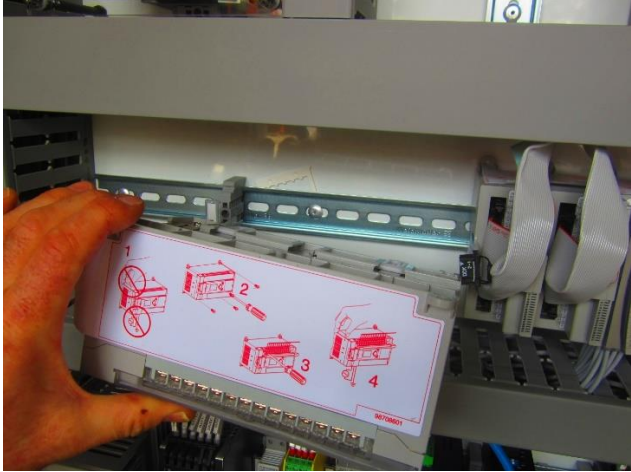
#### 8.4.12 PLC Replacement Procedure

<u>Step</u>	<u>Description</u>
1	Turn off the mains power and open the door. Note: The 415VAC in the cabinet is all covered by clear Perspex but caution must be taken only to work near the areas shown and not to remove any of the covers.
2	The PLC will continue to be powered by the backup battery – open fuses 402 and 403 as below i.e. the fuse labelled “2” and “3”. The fuse hinges to the left. Note this fuse only carries 24VDC and is safe for non-electricians.

Step	Description
	
3	Locate the PLC quick disconnect plug. 
4	Separate the two halves of the plug.

Step	Description
	
5	<p>Remove the loom from the ducting as shown.</p> 
6	<p>Note the small cover on the PLC, this clicks upwards and across to the right to open.</p> 
7	<p>The grey cable loom and black plug connects to the input/output modules. Use the string handle to disconnect this plug.</p>

Step	Description
	
8	Plug is disconnected. 
9	Remove blue Ethernet cable. 
10	Use small flat screw driver to open the two clips under the PLC, one on the left, one on the right.

Step	Description
	
11	<p>PLC being removed.</p> 
12	<p>To install, fit the PLC on the rail and close the retaining clips with a screw driver.</p>

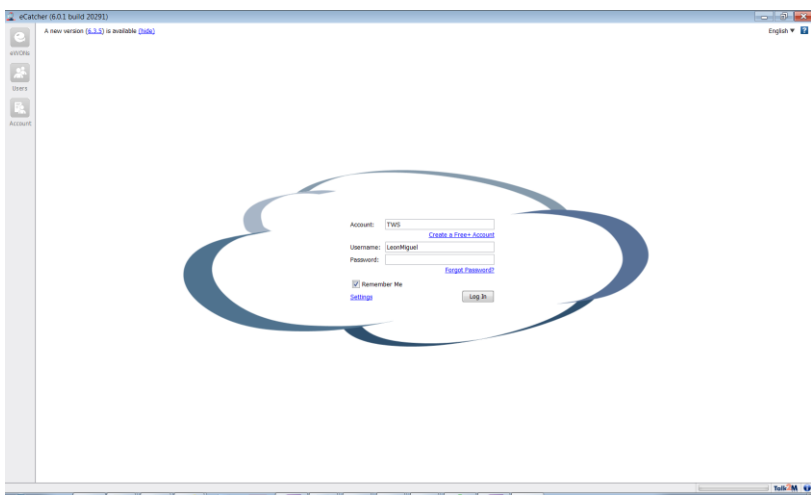
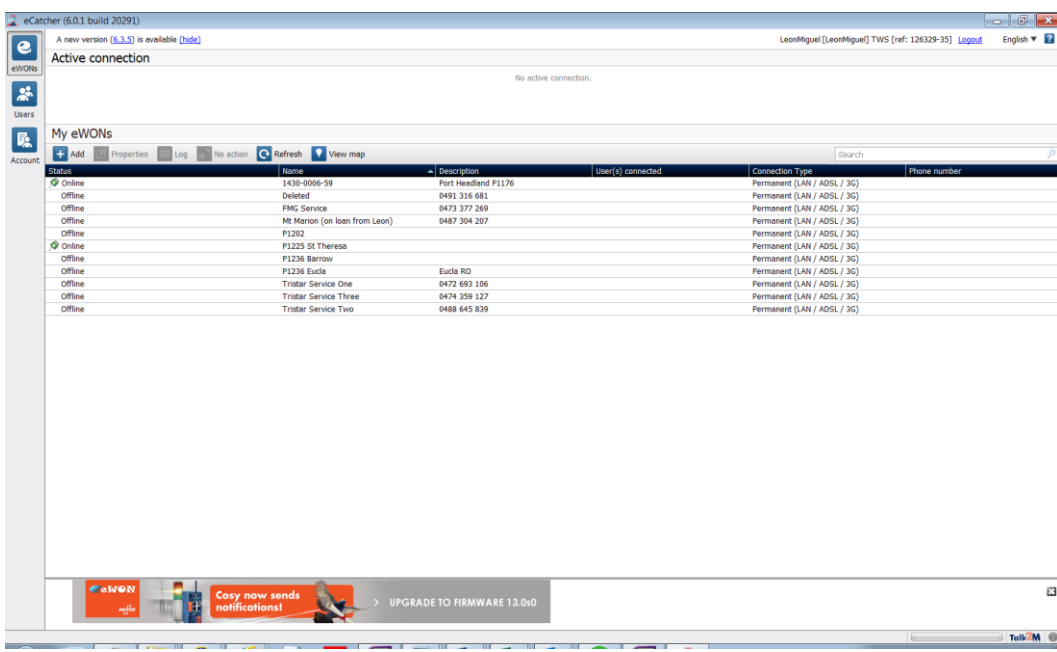
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<u>Step</u>	<u>Description</u>
13	Connect the small grey loom to the righthand side of the PLC and replace the removable cover.
14	Run the loom down through the trunking and re-connect the white plug at the end of the loom.
15	Reconnect the wires and close fuses 402 and 403 to re-apply power. The unit is pre-programmed and will start functioning immediately.



## 8.4.13 Remote Monitoring Connection Procedure

### 8.4.13.1 Via Desktop Computer or Laptop

Step	Description
1	Download "Ecatcher software" from <a href="https://ewon.biz/cloud-services/talk2m/ecatcher">https://ewon.biz/cloud-services/talk2m/ecatcher</a>
2	Install and Run Ecatcher and it will open as below: 
3	Logon as the with the account <b>TWS</b> user <b>DennyDenny</b> or <b>EuclaRO</b> (password has been set up initially as <b>DennyChangeThis1</b> for both accounts)  Note: When log in, may see an error message about certificates expiring in December, ignore this.
4	After logging in you will see 

<u>Step</u>	<u>Description</u>
5	Double click P1236 to connect to the VPN (virtual private network). This creates a highly secure encrypted connection to the PLC via the internet. After 5-25 seconds the VPN will appear in the Active Connection box.
6	Open Firefox or other web browser and go to 192.168.1.102.
7	Log in as <b>tws</b> with password <b>tws</b> .  <b>Now, You have full access to the plant</b>

#### 8.4.13.2 Via Smart Phone (Mobile App)

<u>Step</u>	<u>Description</u>
1	On your phone or tablet download the eWON eCatcher Mobile app from the app store and install.
2	Run the eCatcher app and choose P1236 to connect to the RO plant.
3	Open Firefox or other web browser and go to 192.168.1.102.
4	Log in as <b>tws</b> with password <b>tws</b> .  <b>Now, You have full access to the plant</b>



## 9.1 DAILY MAINTENANCE CHECK LIST

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## WEEKLY MAINTENANCE CHECK LIST

**General Comments:**

### 9.3 MONTHLY MAINTENANCE CHECK LIST

<b>MONTHLY MAINTENANCE CHECK LIST</b>			
CUSTOMER:	DATE:	OPERATOR NAME:	
SITE:	TIME:		
ACTIVITIES			COMMENTS
Low Pressure Pump No Vibration/Heat/Noise	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
Low Pressure Pump mounts and bolts No Vibration or Loose	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
High Pressure Pump No Vibration/Heat/Noise	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
High Pressure Pump mounts and bolts No Vibration or Loose	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
Recirculation Pump No Vibration/Heat/Noise	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
Recirculation Pump mounts and bolts No Vibration or Loose	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
<b>General Comments:</b>			

## QUARTERLY MAINTENANCE CHECK LIST

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## 9.5 SIX MONTHLY MAINTENANCE CHECK LIST

<b>SIX MONTHLY MAINTENANCE CHECK LIST</b>			
CUSTOMER:		DATE:	OPERATOR NAME:
SITE:		TIME:	
<b>ACTIVITIES</b>			<b>COMMENTS</b>
Perform CIP for RO Membrane as preventive maintenance.	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
Visual inspection of the whole pipework network	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
Verify conductivity analyser (Feed Water, RO Permeate and Potable Water) readings against calibrated handheld conductivity meter	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
Verify Feed Water pH analyser reading against calibrated handheld pH meter	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
Verify Potable Water pH analyser reading against calibrated handheld pH meter	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
Verify Potable Water Chlorine analyser reading against calibrated handheld pH meter	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
Verify Potable Water Turbidity analyser reading against calibrated handheld pH meter	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	
Monitor Open/Close function of actuated motorized valves	<input type="checkbox"/> <b>YES</b>	<input type="checkbox"/> <b>NO</b>	

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## 9.6 ANNUALLY MAINTENANCE CHECK LIST

ANNUALLY MAINTENANCE CHECK LIST					
CUSTOMER:		DATE:		OPERATOR NAME:	
SITE:		TIME:			
ACTIVITIES			COMMENTS		
Perform CIP for RO Membrane as preventive maintenance.	<input type="checkbox"/> YES	<input type="checkbox"/> NO			
Visual inspection of the whole pipework network	<input type="checkbox"/> YES	<input type="checkbox"/> NO			
Verify conductivity analyser (Feed Water, RO Permeate and Potable Water) readings against calibrated handheld conductivity meter	<input type="checkbox"/> YES	<input type="checkbox"/> NO			
Verify Feed Water pH analyser reading against calibrated handheld pH meter	<input type="checkbox"/> YES	<input type="checkbox"/> NO			
Verify Potable Water pH analyser reading against calibrated handheld pH meter	<input type="checkbox"/> YES	<input type="checkbox"/> NO			
Verify Potable Water Chlorine analyser reading against calibrated handheld pH meter	<input type="checkbox"/> YES	<input type="checkbox"/> NO			
Verify Potable Water Turbidity analyser reading against calibrated handheld pH meter	<input type="checkbox"/> YES	<input type="checkbox"/> NO			
Monitor Open/Close function of actuated motorized valves	<input type="checkbox"/> YES	<input type="checkbox"/> NO			

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## 10 FAULTS FINDING

Item	Malfunction	Possible Cause	Operator Actions
1	Active Alarm(s) exists	Fault	Rectify the malfunction and then Press unlatch in the Alarm List on HMI
2	The BWRO does not start	1. Plant is not in AUTO 2. Power supply is isolated 3. The Emergency stop button has been pushed	1. Set plant to AUTO on HMI Main Screen 2. Ensure circuit breakers in the Control Panel are turned on. 3. Ensure the equipment is in a safe condition; release the red emergency stop button. Push the reset button, Press Alarm Reset on HMI and return the plant to AUTO.
3	The Chlorination does not start	1. Plant is not in AUTO 2. Power supply is isolated 3. The Emergency stop button has been pushed	1. Set plant to AUTO on HMI Main Screen 2. Ensure circuit breakers in the Control Panel are turned on. 3. Ensure the equipment is in a safe condition; release the red emergency stop button. Push the reset button, Press Alarm Reset on HMI and return the plant to AUTO.

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## APPENDIX 1 – DAILY LOGSHEET

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## APPENDIX 2 - DRAWINGS

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## APPENDIX 3 – EQUIPMENT LIST

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## **APPENDIX 4 – CONSUMABLES & CRITICAL SPARE LIST**

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## APPENDIX 5 – SAFETY DATA SHEET (SDS)

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## APPENDIX 6 – COMMISSIONING RECORDS

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## APPENDIX 7 – COMPLIANCE CERTIFICATE

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## APPENDIX 8 – DEFECTS LIABILITY

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## APPENDIX 9 – WARRANTY INFORMATION

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## APPENDIX 10 – WATERMARK CERTIFICATE

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## **APPENDIX 11 – VENDOR'S INSTRUCTION MANUAL**

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