

Operation manual

bIo-mimetic and phyto-techNologies DesIghned for low-cost purificAtion and recycling of water -India-H2O

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3.b Manual mode of operation

Pre-start condition

1. Check minimum % level of inlet raw water tank (T01) – level displayed on to the digital outputs of low or high levels of the tank.
2. No safety interlocks in alarm stage
3. System should be operated in manual mode – means manually opening- closing of control valves and On-Off control valves
4. All emergency push buttons should not be in activated conditions

Steps to operate plant in manual mode

Phase 1: operation of RO and collect the concentrated brine

Phase 2: operation of RO and FO and collect the diluted draw solution for recycle

Phase 3: connect the recycle stream to the RO system

1. Turn ON power
2. Prepare BRO and FO
 - a. Prepare BRO to pressurization stage
 - i. CV-001 open
 - ii. CV-002 close
 - iii. CV-003 close
 - iv. V1 to E06-T01
 - b. Prepare FO
3. Choose the order of starting the modules
 - a. Check LT003
 - i. If LT003 > operation value,
 1. start FO (go to “FO operation (phase 2)”)
 2. start BRO (go to “BRO operation (phase 1 and 2)”)
 - ii. If LT003 < operation value,
 1. start BRO (go to “BRO operation (phase 1 and 2)”)
 2. when LT003 > operation value, start FO (go to “FO operation (phase 2)”)
 - b. Check LT004
 - i. If LT004 > operation value,
 1. Start FO (go to “FO operation (phase 3)”)
 2. Start BRO (go to “BRO operation (phase 3)”)
 - ii. If LT004 < operation value,
 1. Go to option 3a, check LT003, and follow the procedure
4. BRO operation (phase 1 and 2)
 - a. Start-up operation

- i. Open Valve V2 and start P01 and P02 (Pump)
 - ii. The feed water is pumped to the BRO with the help of P01 and P02. Set the FIC-003 using P01 variable frequency drive as per the setpoint in FT003 (setpoint 0.85 m³/hr)
 - iii. Bleed the air bubble from the system
 - iv. Stop P01 and P02
 - v. Check the piston position (it should be located on the left-hand side for starting pressurization stage)
 - vi. Turn on BRO pretreatment (select flow setpoints and start P03, P04, P07)
 - vii. Go to pressurization stage
 - b. Pressurization stage
 - i. CV-002 close
 - ii. CV-001 open
 - iii. CV-003 close
 - iv. Run P01, FIC003 (setpoint 0.85 m³/hr), and P02, FIC004 (setpoint 1.56 m³/hr)
 - v. If conductivity CT001 < 250mg/l , change position of valve V1 to tank T07.
 - vi. If pressure PT005 > 20 bar or pressure difference between PT004 and PT005 > 0.5 bar, change to purge-and-refill stage
 - c. Purge-and-refill stage
 - i. CV-002 open
 - ii. CV-001 close
 - iii. CV-003 open (the high concentrated output of RO directed to the tank T03 using CV-003)
 - iv. Run P01, FIC003 (setpoint 0.85 m³/hr), and P02, FIC004 (setpoint 3.33 m³/hr)
 - v. If piston reaches the end of the PX (ZAL=1), change to pressurization stage
- 5. BRO operation (phase 3)
 - a. Pressurization stage
 - i. CV-002 close
 - ii. CV-001 open
 - iii. CV-003 close
 - iv. Set the FIC003 using P01 variable frequency drive as per the setpoint in FT003, and run P01 and FIC003 (setpoint 1.005 m³/hr)
 - v. Run P02 and FIC004 (setpoint 1.857 m³/hr)

- vi. If conductivity CT001 < 250mg/l , change position of valve V1 to tank T07.
- vii. If pressure PT005 > 20 bar or pressure difference between PT004 and PT005 > 0.5 bar, change to purge-and-refill stage
- b. Purge-and-refill stage
 - i. CV-002 open
 - ii. CV-001 close
 - iii. CV-003 open (the high concentrated output of RO directed to the tank T03 using CV-003)
 - iv. Run P01, FIC003 (setpoint 1.005 m³/hr), and Run P02, FIC004 (setpoint 3.93 m³/hr)
 - v. If piston reaches the end of the PX (ZAL=1), change to pressurization stage
- 6. FO operation (phase 2)
 - a. Start-up operation
 - i. FO Flushing
 - 1. V3 connecting T07 and P06
 - 2. V4 connecting T07 and P05
 - 3. When constant feed outlet flows (FT005, FT006) have been reached, stop P05 and P06
 - ii. Open V4 to connect T04 with P05
 - iii. Open V3 to connect T03 with P06
 - iv. Turn on FO pretreatment (select flow setpoints and start P09, P10)
 - v. Once a constant feed outlet flow (FT006) has been reached, turn on P06 and CIC004. Select one control option
 - 1. Flow setpoint (0.173 m³/hr) referring to draw inlet flow rate (link to P06)
 - vi. Turn on FIC001. Select one control option
 - 1. Flow setpoint (0.2625 m³/hr) referring to inlet feed flow rate (link to P05)
 - vii. Adjust the inlet flow rate to ensure that both the feed and draw outlet flow rates (FT006 and FT007) never drop below the minimum outlet flow rates (0.05m³/hr)
 - b. Normal operation
- 7. FO operation (phase 3)
 - a. Start-up operation
 - i. Turn on P06 and CIC004. Select one control option

1. Flow setpoint (0.204 m³/hr) referring to draw inlet flow rate (link to P06)
 - ii. Turn on FIC001. Select one control option
 1. Flow setpoint (0.2625 m³/hr) referring to feed inlet flow rate (link to P05)
 - iii. Turn on P11 and FIC001 to connect T12 with T01
 - iv. Monitor CT008 to reach at 8.65 mS/cm (corresponding to 5.529 g/L)
 - v. Adjust the inlet flow rate to ensure that both the feed and draw outlet flow rates (FT006 and FT007) never drop below the minimum outlet flow rates (0.05 m³/hr)
- b. Normal operation
- i. If LT003 < minimum value,
 1. Turn off P05, P06, and P11
 2. Disconnect T12 with T01
 3. Restart FO operation (phase 3) if LT003 > operation value
 - ii. If LT004 < minimum value,
 1. Turn off P05, P06, and P11
 2. Disconnect T12 with T01
 3. Restart FO operation (phase 3) if LT004 > operation value

8. Check the BRO and FO RO pressures reached desired set-points

Below are pre – condition checks once the plant is turned ON

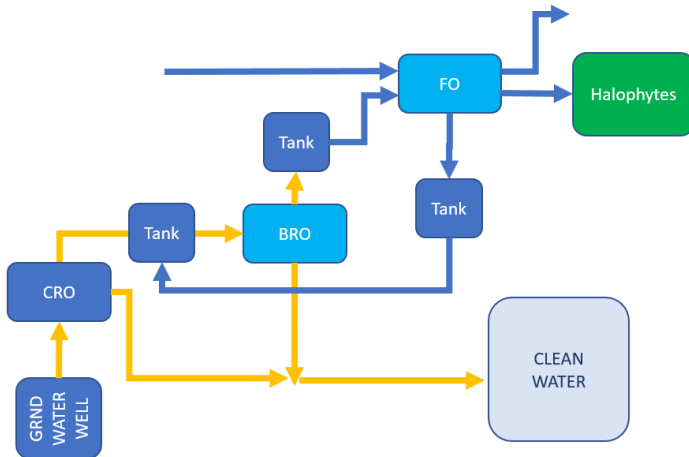
Sr No	Digital output	Threshold (set-point) reached
1	Conductivity CT-xxx	
2	Conductivity CT-xxx	
3		
4		
5	Tank Level Txx	
6	Tank Level Txx	
7		
8		
9	Pressure PT-xx	
10	Pressure PT-xx	
11		
14	Flow rate FT-xx	

16	Valve conditions, CV-xxx / V1	Open/Close
17	Valve conditions, CV-xxx / V2	Open/Close
18		
19		
20	Pump conditions, SC – xxx	Set value
21	Pump conditions, SC – xxx	Set value

The plant start-up illustrations are given in flow diagrams for phase 1, phase 2 and phase 3

Start-up procedure (phase 1)

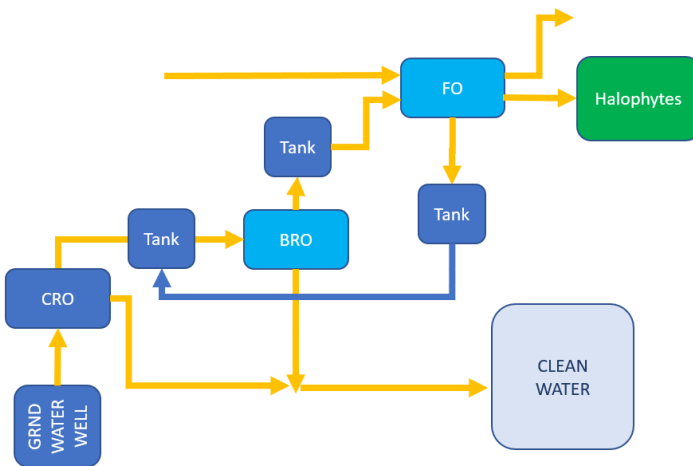
Connect the recycling stream and operate the whole system to reach at steady-state.



Symbol	State
	Active Pass Line
	Inactive Pass Line
	Operating Component
	Auxiliary Components

Start-up procedure (phase 2)

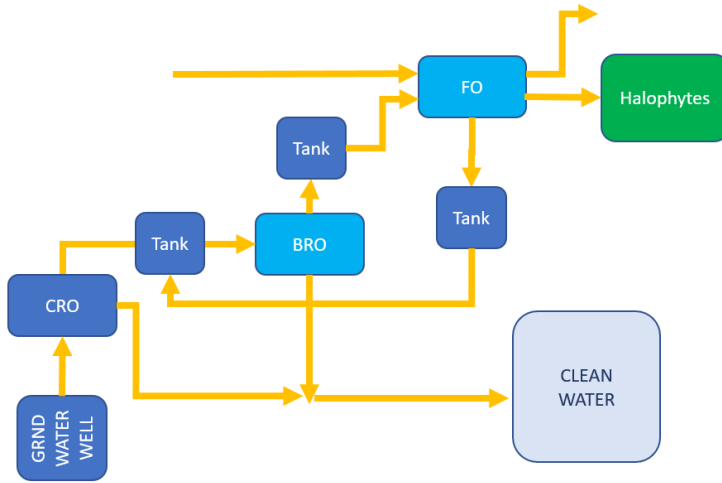
Connect the recycling stream and operate the whole system to reach at steady-state.







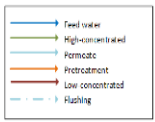
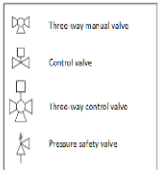
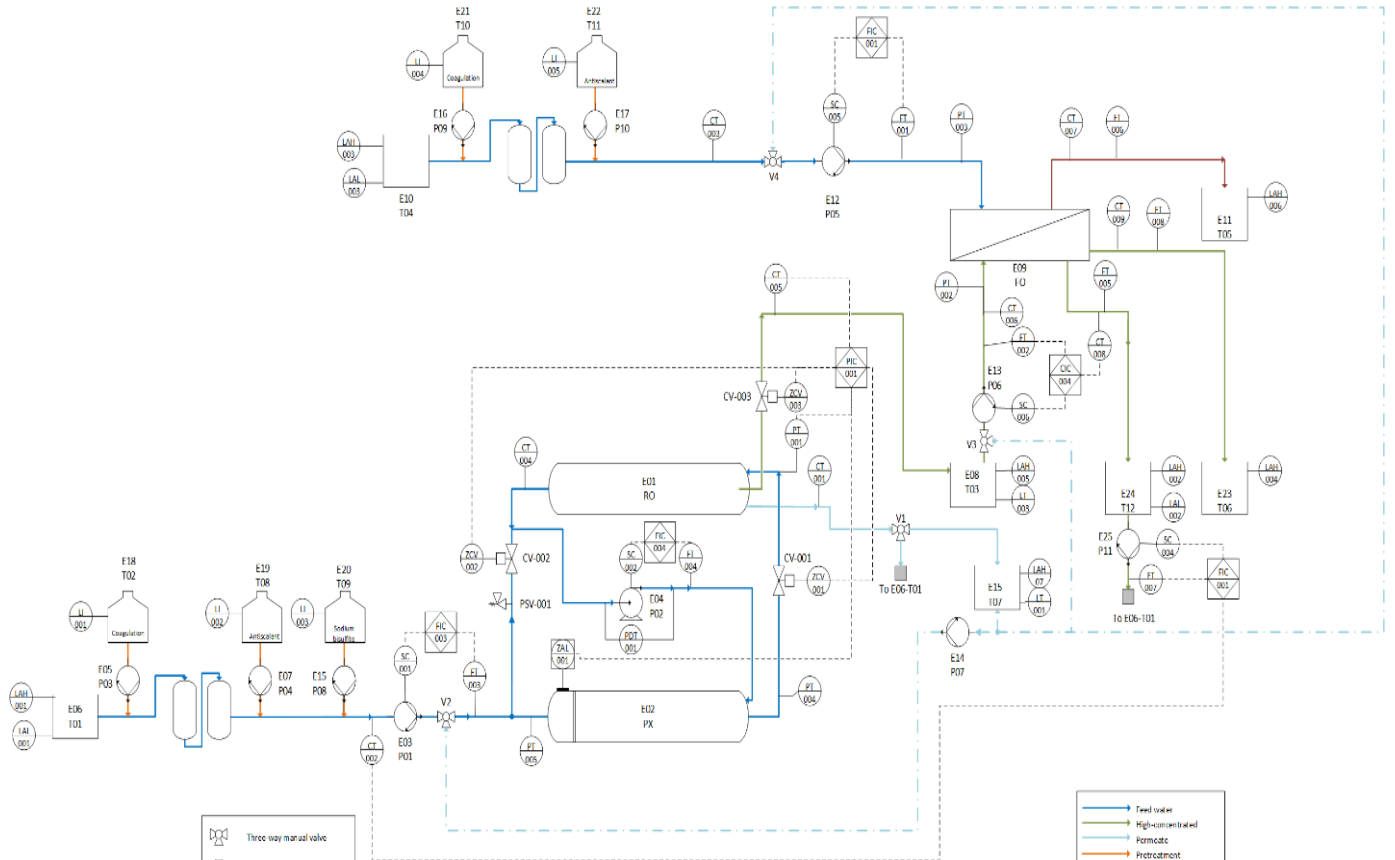
Symbol	State
	Active Pass Line
	Inactive Pass Line
	Operating Component
	Auxiliary Components

Start-up procedure (phase 3)

Connect the recycling stream and operate the whole system to reach at steady-state.



Symbol	State
	Active Pass Line
	Inactive Pass Line
	Operating Component
	Auxiliary Components



BRQ RO design for PUPU Centre of Excellence
 Indle H2O Project
 Revision: 1.4
 Date: 10/08/2020

	Feed in		Feed out		Draw in		Draw out	
	Flow	Fluid	Flow	Fluid	Flow	Fluid	Flow	Fluid
Wetting before start-up	100 L/h < 0.5 bar	RO permeate / Tap water	~80L/h < 0.5 bar	To drain?	100 L/h < 0.5 bar	RO permeate / Tap water	~110 L/h < 0.5 bar	To drain?
Start up	100 L/h – 200 L/h < 0.5 bar	Phyto-treated Wastewater after pre-treatment	~100L/h – 200 L/h < 0.5 bar	Recycle or to feed out collection?	100 L/h < 0.5 bar	RO permeate / Tap water	~110 L/h < 0.5 bar	To drain?
Operation	250 L/h – 350 L/h < 1.0 bar	Phyto-treated Wastewater after pre-treatment	50 L/h – 100 L/h < 0.5 bar	To glycophytic crops	200 L/h – 400 L/h < 0.5 bar	Batch-RO retentate	300 L/h – 600 L/h < 0.5 bar	Recycle BRO + halophytic crops
Acid CIP (if needed)	100 L/h < 0.5 bar	pH2-3	~80L/h < 0.5 bar	Recycle/ Waste tank	100 L/h < 0.5 bar	pH2-3	~110 L/h < 0.5 bar	Recycle/ Waste tank
Alkaline CIP (if needed)	80 L/h < 0.5 bar	pH9-10	~50L/h < 0.5 bar	Recycle/ Waste tank	300-400 L/h < 0.5 bar	RO permeate / Tap water	~300-400 L/h < 0.5 bar	Recycle/ Waste tank

Table 1: Recommended flow and pressure ranges

Parameter	Value
Minimum feed flow rate outlet	30-50 L/h
Maximum feed flow rate inlet	900 – 1000 L/h
Maximum shell flow rate inlet	700-800 L/h
Minimum lumen or shell pressure inlet	0.1 – 0.2 bar
Maximum lumen or shell pressure inlet (module limit)	2.5 bar
Maximum lumen pressure inlet (operating limit)	2 bar
Maximum shell pressure inlet (operating limit)	1 bar
Maximum lumen pressure drop	2 bar
Minimum trans-membrane pressure (average feed pressure – average draw pressure)	> 0 bar (positive value)
Maximum trans-membrane pressure	1.5 to 2.0 bar
Maximum operating flux in array with wastewater	10 LMH (*)
Maximum single pass recovery in any array	< 90%
Minimum header sizing for draw outlet	¾" - 1" ID for > 4 HFFO14
Maximum operating temperature	35°C
Minimum operating temperature	10°C
Maximum cleaning temperature	40°C
Minimum cleaning temperature	20°C
pH range (Maximum)	2 – 11 (feed side), 2 – 7 (shell side)

Table 2: Recommended limits for operations
(*) operating flux is to be investigated during pilot

Control	Purpose
Increase draw inlet flow	Increase recovery, increase feed outlet conductivity / TDS
Decrease draw inlet flow	Reduce recovery, prevent over-recovery / potential clogging of fiber, ensure minimum feed outlet flow
Increase feed inlet flow	Reduce recovery, prevent over-recovery / potential clogging of fiber, ensure minimum feed outlet flow
Decrease feed inlet flow	Increase recovery, increase feed outlet conductivity / TDS
Throttling feed outlet – close	Increase feed inlet pressure, ensure feed outlet pressure > draw inlet pressure
Throttling feed outlet – open	Ensure maximum feed pressure < 2.5 bar
Throttling draw outlet – close	Ensure draw inlet pressure is 0.1 - 0.2 bar
Throttling draw outlet – open	Ensure draw inlet pressure < feed outlet pressure

Table 3: Control action suggested during FO process

Practical note:

- *Always start feed pump first before draw pump*
- *Always stop draw pump first before feed pump*
- *Always ensure module is rinsed with RO permeate or tap water at least before stopping both pumps to shut down*
- *Always leave outlet valves of feed and draw pump opened to prevent over-pressurizing*
- *Always operate higher feed pressure (0.5-1 bar) than draw (0.1-0.5 bar)*
- *Never stop both feed and draw pumps while wastewater is still flowing on feed side*
- *Never let pH on draw side exceed 8 for current HFFO14 model*