

Spiral 4x1 – Operating Instructions

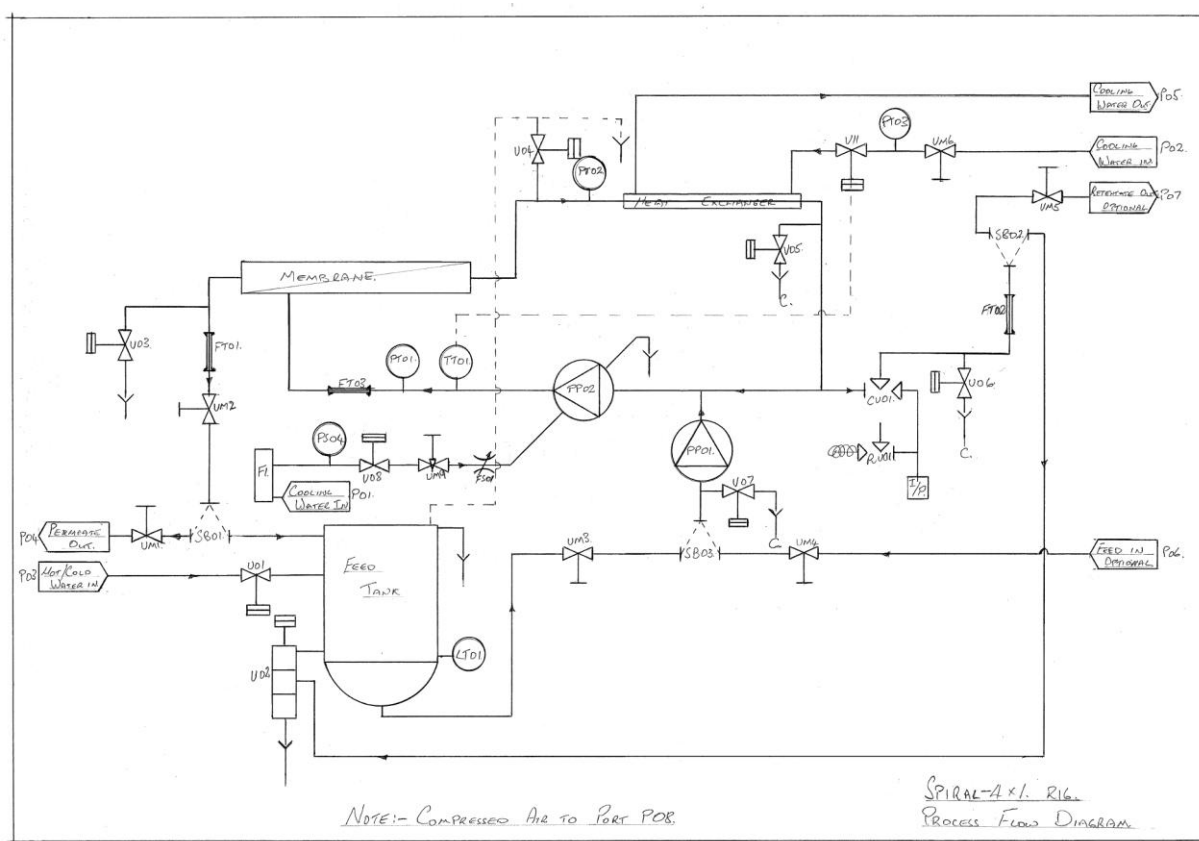
REVERSE OSMOSIS, NANOFILTRATION AND ULTRAFILTRATION RIG

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Introduction

The rig is a Reverse Osmosis (RO), Nanofiltration (NF), or Ultrafiltration (UF) concentrator, depending on the membrane installed. The rig is designed for spiral wound membranes with diameters of up to 4 inches (100mm) and a length of up to 40 inches (1000mm). A process diagram for the rig can be seen below.



For processing, the rig takes material from the feed tank, removes some of the water if an RO membrane is installed or some water and some low molecular weight material if an NF or UF membrane is installed. This permeate is removed from the rig.

The remaining material (retentate) is returned to the feed tank until the desired concentration has been achieved.

The rig can be fitted with either a 2.5", 3.8" or 4" diameter by 38", 39", or 40" long spiral wound membrane. We have various suitable membranes in stock in New Zealand and have a number of adapters to suit various membrane manufacturer's products.

The rig is built to food grade standards, controlled by a PLC, and is set up for automatic cleaning in place (CIP). It has pressure, flow, and temperature measurement so that data is recorded for the design of more extensive facilities.

Spiral 4x1 has a minimum processing volume of approximately 29 litres. Thus if you wish to achieve a concentration of say 4:1 then you would need at least 116 litres of initial feed stock.

Process Description

The feed pump (PP01) takes feed from the feed tank and provides the processing pressure.

A second pump (PP02) is a circulating pump providing circulation in the membrane loop. This pump requires a supply of clean cold water.

From this circulation pump, material is passed through the single membrane inside a membrane tube. Within the membrane, some water (if an RO membrane is installed) or some water plus some low molecular weight material (if an NF or UF membrane is installed) passes across the membrane and is discharged from the permeate port. There is a flow meter, (Rotameter FT01) in this permeate discharge line. The permeate port has a RJT coupling allowing permeate to be taken to a storage vessel or dumped to drains.

The circulating pump (PP02) requires a supply of clean, cold water to cool and lubricate the pump seal. The flow is small. It is adjusted using the manual needle valve VM9. There is also a flow switch (FS01) which automatically causes the rig to shut down if insufficient flow to the pump seal is detected.

From the membrane, after the permeate has been extracted, the material (now referred to as retentate), is passed through a jacketed heat exchanger, which is used to keep the processing temperature in control. Cold water circulating in the jacket removes heat from the retentate. The temperature is controlled by adjusting the volume of water flowing in the jacket, using valve V11 and Temperature Transmitter TT01. For most processing cold tap water should be sufficient. If lower processing temperatures are desired, a circulating chilled water plant is available allowing processing temperatures as low as 7°C to be maintained.

From the heat exchanger, the bulk of the retentate is fed back to the circulating pump for recycling but an amount is removed from the circulating loop via valve CV01, passing through a flow meter (FT02) and discharging into the feed tank. The process is controlled by a PLC in the control cabinet. During production this controls

- The speed of pump PP02 to maintain acceptable conditions in the membrane (circulating) loop.
- The temperature of the material in the circulating loop
- The speed of pump PP01 to control overall operating conditions.
- The pressure in the circulating loop by controlling the pressure at which CV01 allows retentate to circulate back to the Feed tank.

The PLC also checks:

- Swing bends SB01, SB02 and SB03 are in the correct position.
- Sufficient cooling water is being supplied to the seal on pump PP02.
- Automatic valves V01, V02, V03, V04, V05, V06, and V07 are in the correct position.

While the processing is proceeding the liquid level in the feed tank is constantly monitored. The PLC can be set to stop the process at the desired feed tank level, indicating the degree of concentration, however this feed tank level cannot be taken below a level where the function of pump PP01 is interrupted.

Any air entering pump PP01 will cause processing issues. The concentration process must be stopped (by pressing the lighted "Production" button) at any sign of a vortex in the feed tank that allows air to be fed into pump PP01.

Once concentration has been achieved and the plant stopped (by pressing the lighted “Production” button) the retentate in the rig can be recovered by collecting the material from valves V05, V06 and V07 (the discharges of these valves are manifolded to one discharge point). This is done by pressing the flashing “Dump” button.

Note that the discharge from valve V04 can be either directed to the feed tank or discharged to ground and waste. During processing and CIP, this discharge should be directed back to the feed tank. During rinsing, it should be directed to ground. This is not checked by the PLC. It is an “operator responsibility”.

Interface Principles



Function Buttons

There are four function-controlling buttons on the control panel door. They are labelled “Production”, “Rinse”, “CIP” (for Cleaning in Place), and “Dump”. These buttons are programmed to flash if the function can be selected.

Pressing a flashing button will initiate the function and cause the button to light continuously; other flashing buttons will stop flashing.

Pressing a continuously lit button will cause the function to stop. That button will then start flashing (possibly along with other buttons) again indicating that the functions that may be selected.

Pressing a button that is neither lit nor flashing will have no effect, but the reason why this function is not available will be displayed on the LCD screen.

LCD Screen

The control panel also has an LCD screen that displays sensor values and the PLC’s state.

Of the buttons surrounding the screen, two are functional: the up and down buttons. Use the up and down buttons to scroll through the values for FT01, FT02, FT03, LT01, LT02, PT01, PT02, DP12 (the differential pressure PT01 - PT02), PP01’s speed, PP02’s speed, TT01, CV01, CV02, and information on the PLC’s state.

Operator Instructions

Initial Setup

The rig should be checked for obvious damage and completeness. The rig will arrive with some storage liquid in the pipework to preserve the membrane. Except for short periods, it is important that this situation is maintained. Should the membrane dry out it is are likely to be damaged beyond redemption.

1. The rig should then be connected to the utilities supply
 - Cold water to port P01 for pump PP02 seal water supply.
 - Cold water to port P02 for heat exchanger cooling water supply. The cold water supply may be replaced by connecting a re-circulating cooling water system if low temperature processing is intended.
 - Hot (not more than 45°C, as the membrane is damaged at 50°C) or cold water to Port P03 for CIP/sanitising. This water should be demineralised and chlorine-free as per the “KMS Water Quality Guidelines for Cleaning and Diafiltration” (see attached document).
 - Make a connection to port P04 to collect or discharge the permeate produced.
 - P05 is the discharge for the cooling water; it may be left to drain to ground.
 - P06 is not in use.
 - P07 is not in use.
 - Clean, dry compressed air, at least 5 barg pressure, to Port P08.
 - Electric power – 5 pin, 3 phase, 400v, 50 Hz, to electrical socket on the control box.
 - With these connections made and turned on, the control panel should come to life and showing “Spiral 4x1 Membrane Process”. It will then display the valves of the flow meters FT01 and FT02 and some of the function buttons should begin to flash. Note: should the buttons not flash but remain unlit, and if the PLC screen has powered on, press any function button to learn why the function is not available.
2. Check that swing bend SB01 is directing liquid off-rig (in anticipation of next flushing the rig).
3. Check that the manual valves are in their correct positions. Note that the state of these manual valves cannot be checked by the PLC and must be checked by the operator; **incorrect positioning could damage the rig.**

Manual Valve	Description	Correct Position
VM1	Permeate out	Open
VM2	Permeate to SB01	Open
VM3	Feed-tank out	Open
VM4	Off-rig retentate in	Not in use
VM5	Off-rig retentate out	Not in use
VM6	Cooling water isolation	Open

4. Check that the discharge from valve V04 is directed to ground. Note that the position of the discharge from valve V04 is not checked by the PLC. It is the responsibility of the operator.
5. With these checks complete the “CIP” and “Dump” buttons should be flashing. Press “Dump” to clear the rig of storage liquid.
6. When the “Dump” button light goes from solidly lit to flashing and the “CIP” button resumes flashing, the dump sequence is complete.
7. Clean the rig including the optional sanitisation step (see below).

Flushing the Rig

1. Connect water to port P03. Hot water should be connected if washing is to follow, while cold water should be connected if sanitising. Finally, for a water flux test, water at 25°C allows for the most accurate results.
2. Set the discharge from valve V04 to ground.
3. Set the swing bend SB01 so the permeate discharges off-rig. Ensure the blanking plate is used to cover the hole in the feed tank!
4. Ensure all manual valves are in their correct position i.e.
 - VM1 open
 - VM2 open
 - VM3 open
 - VM4 not in use
 - VM5 not in use
 - VM6 open
5. The "Rinse" and "Dump" buttons should now be flashing. (The "Production" button will not be flashing as the feed tank is empty.) Press the "Rinse" button. The rig will flush itself and then drain to ground.

Cleaning the Rig

Cleaning is typically achieved by a flush, followed by an alkali wash, possibly followed by an acid wash, possibly followed by sanitisation, and then at least one final flush to remove the chemicals. The cleaning process will however depend on your product and process. For specific advice on cleaning, please contact us.

1. Flush the rig with hot water (see above).
2. Set the swing bend SB01 to direct permeate to the feed tank. Remember to store the blanking plate on the inlet to valve VM1.
3. Set the discharge from valve V04 to return to the feed tank.
4. Check that the manual valves are in their correct positions i.e.
 - VM1 is open
 - VM2 is open
 - VM3 is open
 - VM4 is not in use
 - VM5 is not in use
 - VM6 is open

Note that these valves and the position of the discharge from valve V04 are not checked by the PLC. They are "operator responsibility".

5. Optionally, wash the rig with alkali (see below).
6. Optionally, wash the rig with acid (see below).
7. Optionally, sanitise the rig (see below).
8. Flush the rig with cold water (see above). This flush may need repeating two or three times to remove all traces of the CIP or sanitising solution. This can be checked by observing the pH of the discharges from valves V05, V06, and V07 to waste. Once the discharges have a similar pH to the water supply, the rig has been sufficiently flushed.
9. Optionally, carry out a water flux test (see below).

Washing with Alkali

1. The “CIP” and “Dump” buttons should be flashing. Press the “CIP” button.
2. The rig will now fill with water and pump PP01 will start. After a time, valve V04 will close indicating that the plant is full of water and is about to be pressurised before pump PP02 starts circulating liquid. Once valve V04 has closed and water is circulating, the operator should add concentrated alkali cleaning chemical (Ecolab Ultrasil 91) to the feed tank to obtain and maintain a pH of 10.5 to 11.0, as measured in the feed tank.
3. The rig will continue circulating this CIP solution for 20 minutes before dumping it to waste then it will carry out a rinse and dump before stopping with “CIP” and “Dump” buttons flashing.

Washing with Acid

1. The “CIP” and “Dump” buttons should be flashing. Press the “CIP” button.
2. The rig will now fill with water and pump PP01 will start. After a time, valve V04 will close indicating that the plant is full of water and is about to be pressurised before pump PP02 starts circulating liquid. Once valve V04 has closed and water is circulating, the operator should add concentrated acid cleaning chemical (Ecolab Ultrasil 75) to the feed tank to obtain and maintain a pH of 2 to 3, as measured in the feed tank.
3. The rig will continue circulating this CIP solution for 20 minutes before dumping it to waste then it will carry out a rinse and dump before stopping with “CIP” and “Dump” buttons flashing.

Sanitising the Rig

This process should only be carried out immediately after washing the rig (see above).

1. Flush the rig with cold water (see above). Cold water is important as the sanitiser degrades when heated.
2. Set the swing bend SB01 to direct permeate to the feed tank.
3. Set the discharge from valve V04 to return to the feed tank.
4. Check that the manual valves are in their correct positions i.e.
 - VM1 is open
 - VM2 is open
 - VM3 is open
 - VM4 is not in use
 - VM5 is not in use
 - VM6 is open

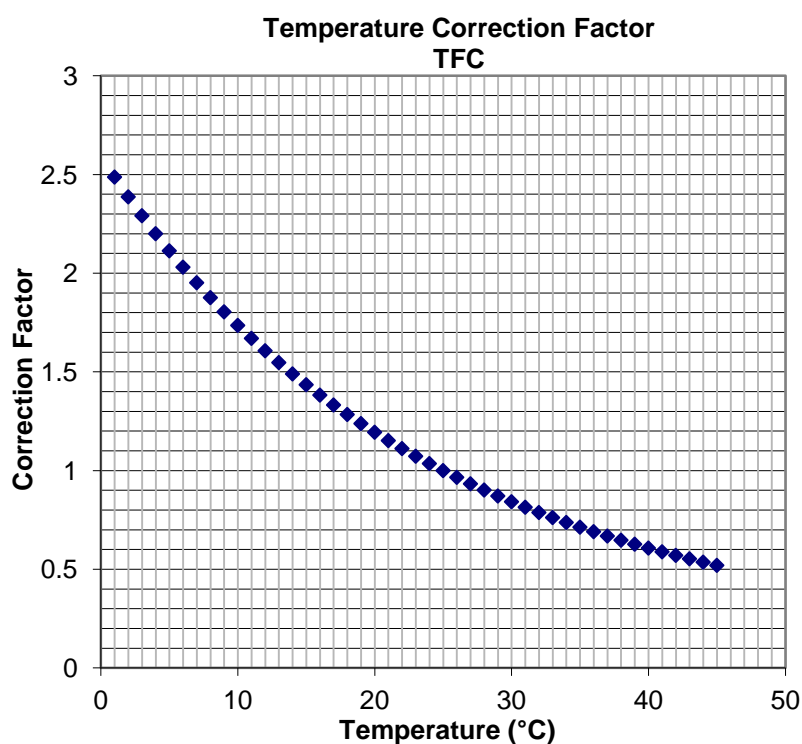
Note that these valves and the position of the discharge from valve V04 are not checked by the PLC. They are “operator responsibility”.

5. The “CIP” and “Dump” buttons should be flashing. Press the “CIP” button.
6. The rig will now fill with water and pump PP01 will start. After a time, valve V04 will close indicating that the plant is full of water and is about to be pressurised before pump PP02 starts circulating liquid. Once valve V04 has closed and water is circulating, the operator should add concentrated alkali cleaning chemical (Ecolab Ultrasil 91) to the feed tank to obtain and maintain a pH of 10.5 to 11.0.
7. Add 150ml of concentrated sanitising solution (Kochkleen 410) to the feed tank (making a 0.25% solution of Kochkleen 410). Maintain a pH of 10.5 to 11.0 during circulation by adding the alkali cleaning chemical if necessary.
8. The rig will continue circulating this sanitising solution for 20 minutes before dumping it to waste then it will carry out a rinse and dump before stopping with “CIP” and “Dump” buttons flashing.

Water Flux Testing

1. Carry out a flush (see above). Approximately two minutes into the flush cycle, record the permeate flow at FT01 and the circulating flow at FT03, the pressures at PT01 and PT02, and the temperature at TT01. Use the record sheet provided with the membrane.
2. Correct the permeate flow rate by multiplying it by the temperature correction factor (which can be found by referring to the graph in the figure below).
3. Compare the observed permeate and circulating flow rates and the observed pressures with previous values. There should be no significant variation.

Problem	Solution
Significant decrease in permeate flow rate may indicate the membrane has become blocked across the membrane.	Consider cleaning the membrane.
Significant decrease in circulation flow may indicate the membrane is blocked longitudinally.	Consider cleaning the membrane.
Significant increase in either permeate flow rate or circulating flow rate may indicate damage to the membrane or its seals.	Consider checking the membrane seals. If that does not help, consider replacing the membrane.
Significant change to the pressures PT01 or PT02 or the pressure along the membrane (PT01 - PT02) may indicate a control system issue.	Phone us for assistance.



Normal Operating Procedure

Before any processing is undertaken, it is important to carry out the Initial Setup as described above and ensure that all traces of cleaning and sanitising chemicals have been eliminated by repeated water flush. It is also important to have established a water flux rate so that checks can be made after future cleaning to ensure that the cleaning process has restored the membrane element to its original performance conditions.

The PLC will control the normal operating procedure, according to a predetermined program that involves:

- a) Checking that sufficient liquid is in the feed tank.
 - b) Pressurising the rig
 - c) Circulating liquid around the membrane loop.
 - d) Slowly adjusting the pump speeds and pressure settings to achieve processing conditions that have been pre-programmed into the PLC. These conditions protect the membrane from damage due to excessive flow or pressure and establish reasonable running conditions that can be used as reference for future development.
 - e) Setting up conditions such that when the requested concentration ratio is approached, the rig automatically stops processing.
1. Check that the swing bend SB01 is in a position to discharge permeate off the rig through valve VM1 and port P04. Ensure the blanking plate is used to cover the hole in the feed tank!
 2. Check that the discharge from valve V04 is directed into the feed tank.
 3. Check that the manual valves are in their correct positions i.e.
 - VM1 is open
 - VM2 is open
 - VM3 is open
 - VM4 is not in use
 - VM5 is not in use
 - VM6 is open
 4. Disconnect the water supply to the feed tank at port P03.
 5. Fill the feed tank with liquid to be processed.
 6. At this point the buttons "Production" and "Drain" will be flashing.
 7. Press the "Production" button which should cause the "Production" button to be lighted continuously and the "Dump" button to stop flashing.
 8. The rig will automatically fill the plant, which may cause some liquid to discharge from valve V04 into the feed tank. The rig will then pressurise itself, start circulating, and permeate will discharge from port P04.
 9. When the requested concentration ratio is reached, or the liquid level in the feed tank is at minimum, the rig will automatically cease processing.
 10. If, after checking the concentration of the liquid in the feed tank, a slightly longer production run is desired, then the rig can be caused to run for an additional 1 minute by pressing the "Production" button. This can be repeated as many times as is desirable until the liquid level in the feed tank reaches minimum level. Note: Care must be taken not to continue concentration to a point where the liquid being processed is too viscous. This can cause irreparable blockage of the membrane.
 11. The concentrated liquid can be collected from the manifold joining the discharges of valves V05, V06 and V07, by pressing the "dump" button.
 12. When dumping is complete the rig will automatically close valves V05, V06 and V07 and effectively be ready to carry out another concentration with "Dump" buttons flashing.