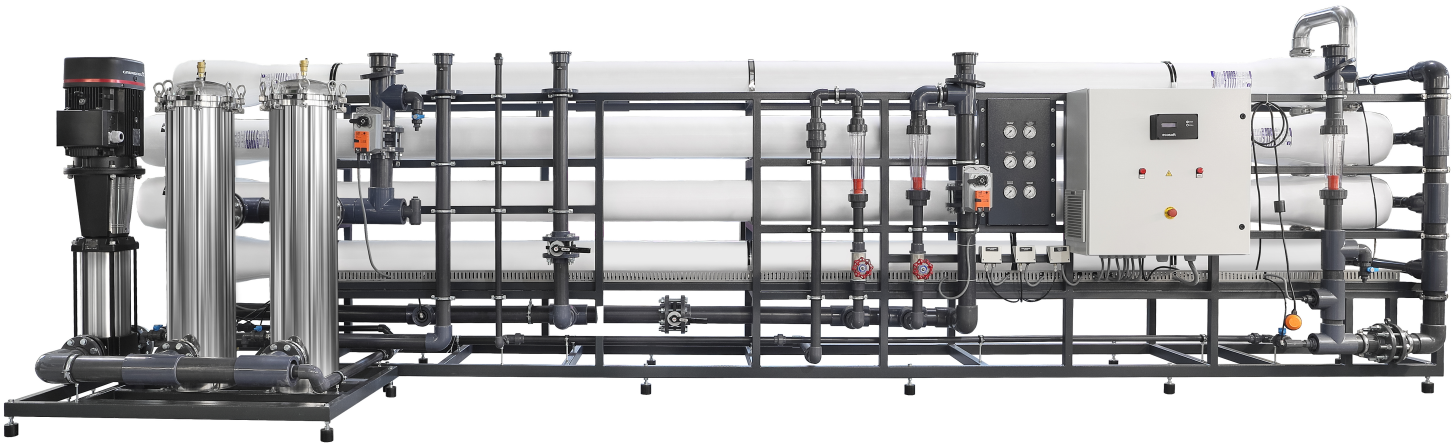
ecosoft

PASSPORT.

Instruction manual for Ecosoft MO36 reverse osmosis system

Model: MO36TP5



Content pages

1. System application.

Ecosoft MO-36 Reverse osmosis system is purposed for water demineralization.

Ecosoft MO-36 Reverse osmosis system is produced in accordance with registered technical specification of Ukraine “ТУ 13680574.002-2000”.

2. Specifications.

2.1. List of equipment.

№	Name	Unit	Q-ty
1	High pressure pump	piece	1
2	Membrane vessel	piece	6
4	Filter housing	piece	2
5	Electrical cabinet with OC5000 controller	piece	1
6	Instrumentation	set	1
7	Metal frame	set	1
8	Electrically operated valves	set	1
9	Manually operated valves	set	1
10	PVC pipes and fittings	set	1
11	Stainless steel pipes	set	1
	Documentation:		
System «ECOSOFT MO-36». Technical data.		piece	1
System «ECOSOFT MO-36». Instruction manual.		piece	1

2.2. Technical data.

Technical specifications:

Voltage	400 V, 50 Hz
Power consumption, kW	18.5
Nominal flow rate at 25 °C, m^3/h	36
Max dimensions (H x W x D), m	2.2 x 6.9 x 2.2
Max weight, kg	1700

Operating specifications*:

Flow rate at 25°C, m^3/h	36
Influent flow rate: - during service, m^3/h - during membrane flush, max m^3/h	 50…75 60
Recommended wastewater flow rate, m^3/h	18…20
Recommended recycle flow rate, m^3/h	0…7
Inlet pressure, bar	2…4
Operating pressure in the membrane array, bar	8…10
Maximum allowed pressure in the membrane array, bar	14
Concentrate pressure after first stage, bar	5…6
Concentrate pressure after second stage, bar	3…4
Max permeate pressure, bar	2

** exact technical and operational specifications are set up during product commissioning and are to be recorded in parameter sheet*

Technical specifications of main equipment:

Sediment filter with replacement cartridge	
- filter vessel material	AISI 304
- filter cartridge material	Polypropylene fiber
- cartridge dimensions	2.5" x 40"
- porosity of the cartridge, μm	5
- quantity of filter cartridges	22
- pressure drop (Δp) in filter under flow-rate 50 m^3/h, max, bar	1
Membrane element (<u>not included to basic set</u>)	
- membrane element type	spiral wound thin-film composite
- maximum turbidity of feed water, mg/L	1
- maximum allowed content of chlorine, mg/L	0.1
- membrane element dimensions, inches	8
Membrane vessel	
- type of membrane vessel	PV80403
- maximum pressure	20 bar
- membrane vessel material	fiber-glass
- temperature of feed water, C°	up to 40
High pressure pump	
- type	multistage centrifugal Grundfos CR
- electric supply, V	400 V, 50 Hz
- power, kW	18.5
- material of working parts	stainless steel, AISI 304

2.3. Feed water requirements

Feed water must meet below requirements:

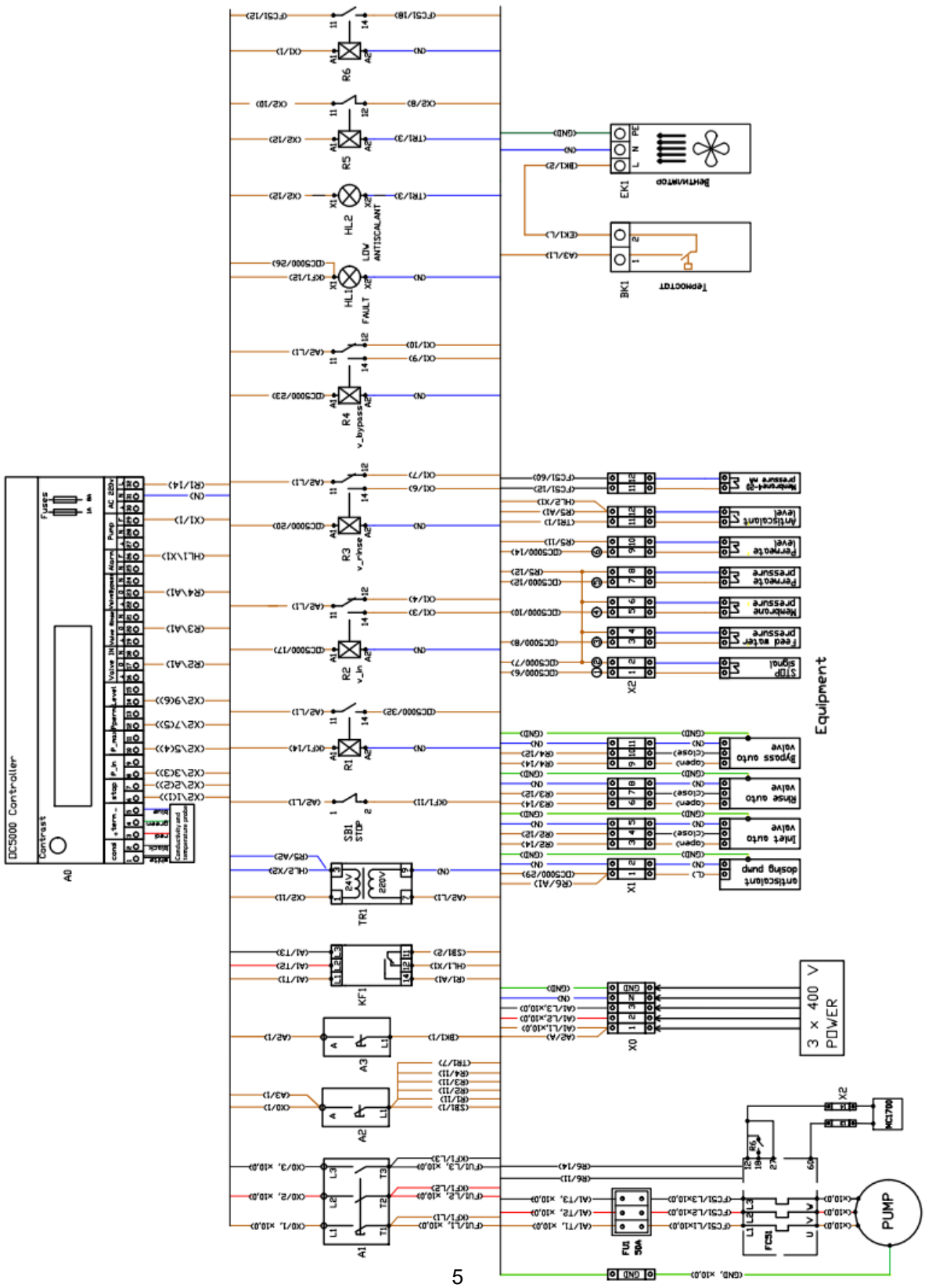
Parameter	Unit	Maximum value
Total dissolved solids	mg/L	3000
Total hardness	mg/L $CaCO_3$	150
Total alkalinity	mg/L $CaCO_3$	50
Chemical oxygen demand	mg O_2/L	4
Active chlorine	mg/L	0,1
Iron, manganese	mg/L	0,1
Hydrogen sulfide	mg/L	none

2.4. Installation requirements

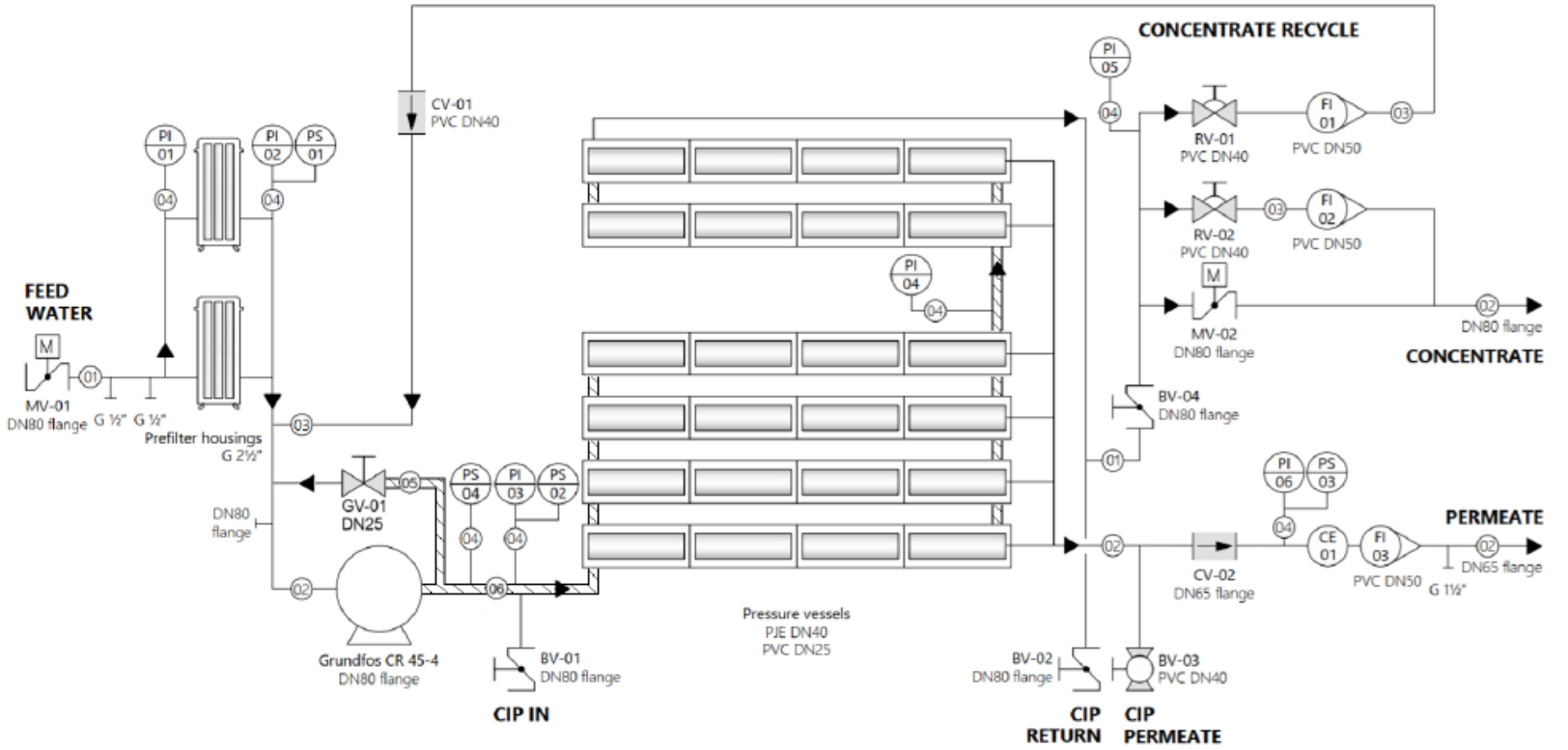
The product is to be installed and operated in rooms meeting all building, electrical and plumbing codes. Air in working area should not contain vapors of aggressive chemicals and meet the following requirements:

Ambient temperature, °C	10 - 25
Relative humidity, %	less than 75, excluding the condensation conditions.

2.5 Wiring diagram



2.6 Flow charts



PIPE SPECIFICATIONS

01	PVC pipe	110 mm O.D.
02	PVC pipe	80 mm O.D.
03	PVC pipe	50 mm O.D.
04	PE hose	1/4" O.D.
05	Stainless steel pipe	25 mm O.D.
06	Stainless steel pipe	80 mm O.D.

VALVE AND INSTRUMENT SPECIFICATIONS

Ball Valve · Regulating Valve · Motorized Valve · Pressure gauge (panel mount) · Rotameter

Globe Valve · Check Valve · Pressure switch (panel mount) · Conductivity probe (process mount)

The manufacturer reserves the right to make changes in the design of the systems to improve their operating parameters without notice.

3. Description of reverse osmosis technology.

3.1. Glossary.

Reverse osmosis is the level of filtration of the smallest particles among all possible. The RO membrane acts as a barrier for all dissolved salts and inorganic molecules, as well as for organic molecules with a molecular weight more than 100. On the other hand, water molecules are free to penetrate through the membrane to form a purified stream of the final product. The typical rate of rejection for most dissolved salts ranges from 95% to 99% and higher.

Terms that are used in the reverse osmosis processes are given below.

Permeate means product water purified by reverse osmosis.

Permeate yield (or **Recovery**) is a part of purified water given in per cents (relative to the feed flow) on the membrane system outlet as produced water or "permeate". The membrane system is designed based on the expected quality of the feed water, therefore the yield is determined by the initial position of the concentrate flow control valves. It is measured in percent.

Salt rejection is a concentration of the solution in percent, that is the amount of salt removed by the membrane from the feed water.

Salt passage is the opposite to salt rejection; salt passage is the percent of dissolved components (pollutants) in the feed water that pass through the membrane.

Quality of permeate is measured of its salt composition or mineralization, that is the amount of dissolved salts passed through the membrane. Mineralization is measured in mg/L.

Electrical conductivity (of the permeate) is an indirect parameter that is used to measure the mineralization of the permeate. High quality of permeate corresponds to low mineralization and correspondingly low electrical conductivity. It is measured in μS/sm.

Flow rate is the capacity of permeate, concentrate or feed water per unit time. It is usually measured in m^3 per hour (m^3/h).

Concentrate flow rate is a flow rate of waste water leaving the membrane element or the membrane system. This concentrate contains most of the dissolved components originally introduced into the element or into the system with the feed water. It is measured in cubic meters per hour (m^3/h).

Specific permeate capacity is the permeate throughput per unit area of the membrane system, usually measured in liters per square meter per hour ($L/(m^2 \cdot h)$).

3.2. Membrane array.

Demineralization of water by reverse osmosis method is carried out in the following way: water is continuously fed into the membrane system under increased pressure by high-pressure pump. The feed water inside the membrane system is separated into a demineralized (purified) product water, called permeate, and a concentrated solution (concentrate). The flow control valve, called the concentrate valve or pressure control module in the module, controls the proportion of water that enters the concentrate stream and, consequently, the amount of permeate produced from the source water.

The membrane system or module includes one or more membrane vessels in which

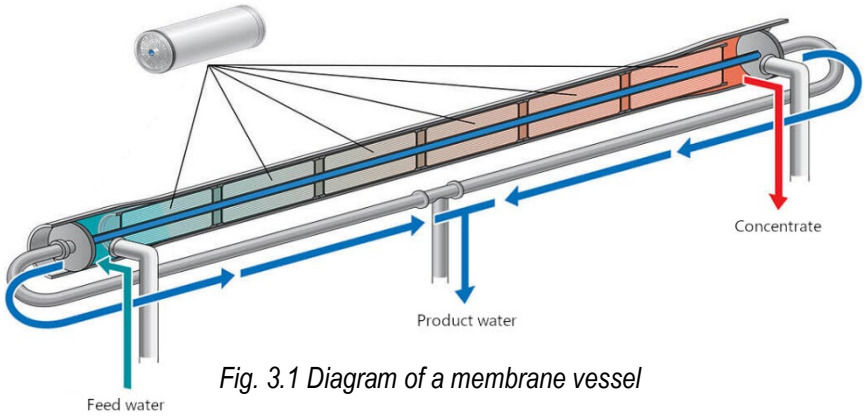


Fig. 3.1 Diagram of a membrane vessel

there are sequentially installed one or more membrane elements, see Fig. 3.1.

ROs membranes are thin-film composite spiral wound membranes (see Fig. 3.2.). For most reverse osmosis applications in water purification the spiral wound design presents multiple advantages in comparison with other formats such as a tubular, flat, frame and hollow fiber. Typically, spiral wound configuration provides a significant reduction in costs associated with the replacement of elements, it is easier to install, maintain and provides greater design freedom than other configurations, making it an industrial standard for reverse osmosis membranes for water purification.

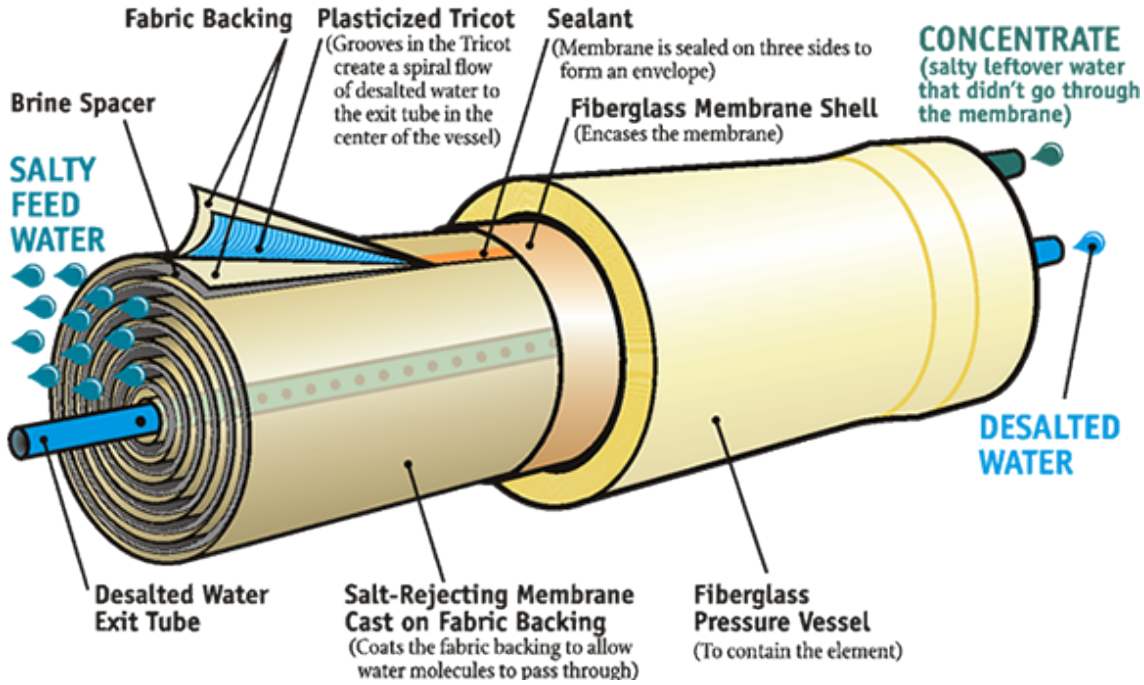


Fig.3.2. Drawing of spiral wound membrane element

The feed water is separated into permeate and concentrate inside the membrane elements (see Fig. 3.2). Permeate is collected in the permeate manifold, the rest of the water, dissolved salts and suspended particles in it, are removed from the element on the other side of the membrane (concentrate).

The described process, when the flow of water is divided into two streams: permeate (demineralized water) and continuously discharging concentrate, is called cross-flow filtration, in contrast to dead-end filtration as in ultrafiltration membranes and conventional filters, when all water passes through a filter. The ratio of feed water, permeate and concentrate on the membrane module depends on the quality of the feed water and the requirements to purified water.

3.3. Reverse osmosis considerations.

The key parameters of the reverse osmosis process are the specific capacity of permeate and its quality.

The quality of the permeate is determined by its mineralization, that is the number of dissolved salts passed through the membranes. Mineralization is measured via electrical conductivity of the permeate. High quality of permeate corresponds to low mineralization and correspondingly low electrical conductivity.

The following factors mainly influence the specific capacity and quality of the permeate of the membrane system:

- Pressure
- Temperature
- Recovery, that is a permeate output (in %) relative to the source water flow
- Mineralization of the source water

Pressure

As the effective water supply pressure increases, the overall quality of the permeate will decrease, while the specific permeate flow rate will increase, as shown in Fig. 3.4.

Temperature

If the temperature rises and the other factors remain unchanged, permeate capacity will increase and the permeate quality will decrease (see Figure 3.5).

Recovery

The yield of permeate is the ratio of the permeate flow to the feed water stream. If recovery increases, the specific permeate capacity will decrease and the flow will stop altogether if the salt concentration reaches a value when the osmotic pressure of the concentrate is equaled with the applied initial water pressure. As the yield increases, the permeate quality will decrease (see Figure 3.6).

Salt concentration in feed water

In Fig. 3.7 is shown the effect of salt concentration in water on specific permeate capacity and permeate quality.

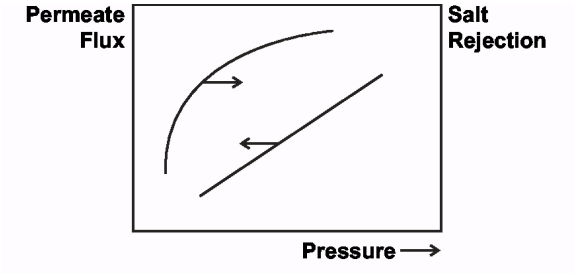


Figure 3.4 Permeate flux and salt rejection dependence from pressure

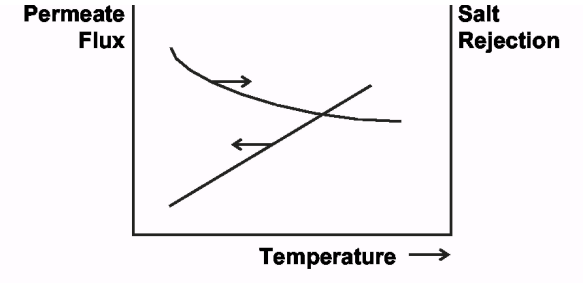


Figure 3.5 Permeate flux capacity and quality dependence from temperature

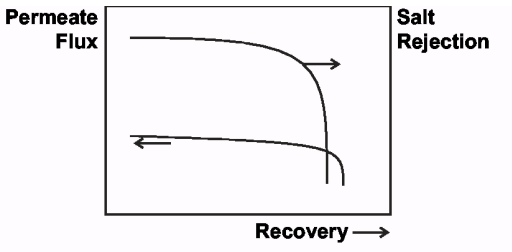


Figure 3.6 Permeate flux capacity and quality dependence from recovery

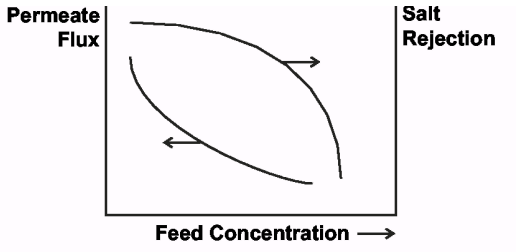


Figure 3.7 Permeate flux capacity and quality dependence from feed concentration

Permeate Flux	– specific permeate capacity
Salt Rejection	– salt removal or quality of permeate
Recovery, %	– permeate yield in % to feed water
Feed Concentration	– salt concentration in feed water

Table 3.1 summarizes the factors affecting the performance of the reverse osmosis unit.

Table 3.1 Factors affecting the performance of the reverse osmosis unit and quality of permeate

Parameter	Permeate flow	Salt passing
Effective pressure	↑	↓
Temperature	↑	↑
Recovery, %	↓	↑
Feed capacity	↓	↑

Increase ↑ Decrease ↓

3.4. Membrane performance and lifespan considerations.

Effective operation of the membrane system with properly selected hydrodynamic mode of operation depends on the operating conditions of the unit and the preliminary treatment and preparation of the feed water.

To increase the efficiency and extend the life of reverse osmosis systems, water must be pretreated. Proper pre-treatment increases the efficiency and service life of the membrane and minimizes clogging, scaling, destruction of the membrane.

Clogging results from deposition of insoluble impurities on the surface of the membrane and/or brine spacer, which leads to malfunctions. Deposition means any build-up on the membrane and the brine spacer, including scale.

Colloidal deposition involves clogging with solid or colloidal particles, such as iron dust or flakes, biological deposition (biofouling) that is the build-up of biofilms, and organic deposition that is the adsorption of specific organic compounds, such as humic substances and oil, on the surface of the membrane.

Scale is the result of sedimentation of sparingly soluble salts in the system, including calcium carbonate, barium sulfate, calcium sulfate, strontium sulfate and calcium fluoride. The pre-treatment depends on the quality of the feed water and can include filtration, softening, de-ironing, regent dosing processes: either continuous dosing, or periodic at intervals.

The quality of the purified water should exclude the deposition on the membranes of suspended solids, sparsely soluble inorganic compounds, organic substances. There should be taken measures to prevent growth in the installation of microflora, which leads to the destruction of membrane elements.

For the preliminary treatment of water, it may be necessary to use special reagents, antiscalant, etc., as recommended by the manufacturer.

If using improperly setup system and/or untreated feed water, it is necessary to chemically clean the membrane elements more often to restore their specific capacity and the quality of the permeate. The cost of chemical cleaning, downtime and loss of capacity can be significant. Membranes can also wear out prematurely in poor operating conditions.

Additionally, it is important to follow operating guidelines. Avoid prolonged downtime (in excess of 12-24 hours), which leads to microbial outgrowth on the membranes. Monitor operating parameters and repair any technical failures. Correct any deviations from the properly setup operating parameters as provided in the parameter sheet. Carry out chemical cleaning and replacement of membranes in a timely fashion.

ROs membranes can withstand very short-term exposure to free chlorine. Exposure of free chlorine in concentrations above 0.1 mg/L will lead to the destruction of membranes. Chlorine (hypochlorite) should not be used for sanitization of membrane systems.

4. System design.

P&ID and specification of the Ecosoft MO-36 reverse osmosis system are given in the Appendices.

The feed water is supplied to the inlet of the installation through the MV-01.

The pressure gauge PI01 shows the pressure of the feed water. The initial water is fed to 5-micron cartridge filters provides a fine cleaning of water from mechanical impurities. The pressure gauge PI02 shows the water pressure after the filter.

At the inlet of the sedimental filter is mounted an antiscalant dosing port, to which, if necessary, can be connected a dosing pump of the antiscalant.

With sufficient inlet pressure (controlled by pressure switch), the plant controller issues a signal to turn on the Grundfos high-pressure pump. If installed, the antiscalant pump is switched on simultaneously with the high-pressure pump.

Water from the high-pressure pump is fed to the membrane vessels, where reverse osmosis membranes are placed.

The pressure gauge shows the operating pressure in the membrane array. The protection of the unit from exceeding the pressure in front of the membranes is realized from the high-pressure switch (HPH).

In the membrane module, the water flow is separated into permeate (purified water) and concentrate, a stream with increased salt content. The permeate from the membrane modules is directed to the outlet of the reverse osmosis unit, its flow is measured by a rotameter and depends on the pressure in the membrane array – with increasing pressure, the permeate flux increases.

Concentrate from the first stage of the membrane array is fed to the membrane array of the second stage.

The pressure of the concentrate of the first stage is measured by a pressure gauge.

A part of the reverse osmosis concentrate after the second stage is discharged into the sewage system, the discharge of the concentrate is measured by a rotameter.

The pressure of the concentrate of the second stage is measured by pressure gauge.

The pressure adjustment in the membrane array, the permeate flow and the discharge of the concentrate is regulated by the valve.

Part of the concentrate, the so-called recycle, is sent back to the suction end of the high-pressure pump. The recycle provides the required flow through the membrane vessels, together with the feed water. Recycle rate is regulated by valve.

On the permeate line of the 1st stage and in whole, is installed the pressure switch to protect the membranes from exceeding the pressure, for example, when the output valve is closed.

Permeate from the outlet of the unit enters the storage tank, which must be fitted with the level switch.

Normally, when the high-level indicator is activated, the unit is automatically put into Standby mode, before which starts the program for hydraulic flush of the membrane module.

In the hydraulic flush mode, for about 60 seconds, the gate valve is opened during flushing, while the entire flow of water from the membrane module is sent to the reset.

The permeate line is equipped with a conductivity sensor, whose reading is displayed on the screen of the OC5000 controller.

The reverse osmosis system works almost continuously, with occasional hydraulic flush that is performed automatically. Either before the system goes into Standby mode, when the permeate tank is full, or, at continuous operation, at a specified frequency (by default every 4 hours).

In the process of operation, membranes become clogged, so periodic chemical cleaning is required. It is performed offline every 1-3 months, depending on the quality of the feed water.

Chemical cleaning of membranes is carried out using a chemical cleaning (CIP) unit.

5. Automation and control.

The system is complete with an automation cabinet controlling its operation. Monitoring of the operating parameters is carried out by the instrumentation shown in the table, # 5.1.

Table 5.1.

Parameter	Controlled parameter, action
Panel mounted pressure gauge	Feed water pressure
Panel mounted pressure gauge	Pressure after prefilter
Pressure switch	Inlet pressure (shut down system when low feed water pressure)
Panel mounted pressure gauge	Pressure in the membrane array
Panel mounted high-pressure gauge (HPG)	Pressure in the membrane array (shut down system when operating pressure is too high)
Panel mounted pressure gauge	Pressure of the concentrate after first stage of the membrane array
Panel mounted pressure gauge	Pressure of the concentrate after second stage of the membrane array
Rotameter	Concentrate drain flow rate
Rotameter	Permeate flow rate
Pressure switch	Permeate pressure (shut down system when permeate pressure is too high)
Panel mounted pressure gauge	Permeate pressure
Electric conductivity probe	Electric conductivity of the permeate is displayed on the controller display
Panel mounted pressure gauge	1st stage permeate pressure
Pressure switch	1st stage permeate pressure (shut down system when permeate pressure is too high)
Level probe in the permeate tank	When level is high, the unit goes to the Standby mode after running hydraulic membrane flush. When level is low, the unit goes to Production mode.

The control of the system is carried out by the digital controller OC 5000, the inputs of which are signaled by the following devices:

- pressure gauge, PI02
- pressure gauge, PI03
- pressure gauge, PI06
- external stop signal
- level sensor in the storage tank

The controller manages the operation of the system and provides control signals to the actuators of the installation:

- high-pressure pump Grundfos CR
- valves with electric drives, MV-01, MV-02.

6. Operating modes.

Ecosoft MO-36 system has the following modes:

- Service mode
- Membrane flush mode
- Standby mode
- Fault mode
- Low pressure mode

6.1. Service mode

In Service mode, the system produces demineralized water supplied to the output.

Activation of the Service mode occurs when the system is switched on by pressing the "► " button of the OC 5000 controller and there are no inhibitory signals:

- high-level signal (full tank) from the storage tank level sensor;
- low pressure signal at the input of the installation (pressure switch # 203).

When Service mode is activated, the electric driven gate valve opens at position and starts work the high-pressure pump. If Service mode is manually stopped using the "STOP" button or due to some fault signal, then it is manually activated by the "START" button.

6.2. Flush mode

The frequency of the "Flush" mode is set when the controller is programmed. If you select "Flush before Standby", the Flush will be activated before the unit goes into "Standby" mode.

The duration of the flushing is set by the digital controller.

In the Flush mode, all the water going through the membrane array is discharged to the drain.

When Flush starts, motorized flush valve opens for programmed time. After Flush, valves are closed, the pump is switched off and the unit is put into the "Standby" mode.

6.3. Standby mode

The system in Service will stop and go to Standby mode when the level switch signals high level of permeate in the permeate tank. Purified water is not produced in this mode. When high permeate level signal disappears, the system goes back to Service mode automatically.

6.4. Fault/Stop mode

The operation of the plant can be terminated and transferred from the "Service" mode to the "Fault" mode in the cases of signal arrival:

1) low pressure (pressure switch);

2) high pressure in the membrane array (HPR, may occur when valves are closed on the concentrate line, shutting off the permeate line, or membranes clogged with deposits);

3) high pressure on the permeate line from the pressure switch.

4) the alarm signal of the pump;

These conditions will bring about Fault mode on the controller.

To return to the "Service" mode, operator involvement is required. The system, in this case, is activated by the operator with the "START" button after the fault signal has been eliminated.

6.5. Low pressure mode

Low pressure mode occurs before Fault mode when low pressure signal is first detected.

If there is a signal “low pressure” from the pressure switch, the controller will restart several times. If there is a low pressure signal each time it restarts, then it will go to the Fault mode.

7. Installation and disassembling of the system.

7.1 The installation is performed by specially trained staff holding the necessary qualifications.

7.2 The system must be installed indoors according to the requirements for the placement of equipment, see section 2.4. The unit is not designed for operation outdoors where it can be exposed to atmospheric phenomena: low temperatures and direct sunlight.

7.3 The system must be installed on flat horizontal surface removed from sources of heat, in a location with easy access for operating and maintenance.

7.4 The system consists of two subunits: pump skid and membrane array skid. Pump skid is installed in front of the membrane skid in an appropriate place during setup. The two skids are fastened to one another and piping system is then connected with the use of unions and joint flanges.

7.5 The system must be connected to:

- feed water main;
- pipe to the permeate tank;
- concentrate drain pipe;
- Clean-in-place (chemical cleaning) pipe for venting cleaning chemicals from the permeate manifold;
- Clean-in-place (chemical cleaning) pipe for running cleaning chemicals into the system and out of the concentrate manifold;

7.6 Feed water must conform with quality requirements in p.2.3.

7.7 The level switch must be installed inside the tank of treated water.

7.8 All supply pipelines should meet the local codes and have sufficient diameter to provide the required flow capacity of feed water, permeate, and concentrate.

7.9 Ensure that the system is connected to electrical mains with the right parameters (as per technical requirements). All electrical connections must be made by qualified staff. All safety regulations, electrical and building codes must be complied with.

7.10 The installation is disassembled in the following way:

- Shut off the water supply
- Disconnect electrical supply
- Relieve the pressure inside the piping
- Disconnect feed water, permeate, and concentrate pipeline
- Disconnect pipe unions and flanges joining the two subunits
- Detach the skids apart

8. First run, parameter setup and shutdown.

8.1. The installation is performed by specially trained staff with the necessary qualification.

8.2. Before starting operation, you should carefully inspect the system and make sure that all components and connections are working properly and ready for start-up. During first run, ensure that the membranes are in the membrane vessels.

8.3. Ensure that there are sufficient quantities of RO chemicals (antiscalant, etc.) in chemical tanks.

8.4. Make sure that dosing units are set correctly, according to the parameter sheet.

8.5. Connect the unit to the electrical supply according to specification requirements.

8.6. During first run, it is necessary to set up working parameters, namely the pressure in the membrane array, concentrate recycle and concentrate drain flows.

8.7. Before starting, make sure that the concentrate valve RV-02 and any valves on permeate outlet are open.

8.8. Flow control valves must be open;

8.9. Recycle flow control valve must be closed.

8.10. CIP ports must be closed!

8.11. Fill the pump with water. Do not dry run the pump!

8.12. During the first run, the pressure in the membrane array, concentrate recycle and concentrate drain flows need to be set up according to parameter sheet.

8.13. The unit is started into Service mode with START button on the controller panel and stopped into STANDBY using STOP button.

8.14. If the installation goes to the Standby mode, most likely reason is that level switch is high.

8.15. Using flow control valve, adjust concentrate drain flow (as shown on rotameter PI05) and permeate flow as shown on rotameter. Set up each flow to parameter sheet values.

8.16. Record pressure reading on pressure gauge in the RO parameter sheet.

8.17. If necessary, limit the concentrate drain flow by gradually opening the recycle flow control valve RV-02.

8.18. Adjust the 1st stage permeate pressure according to the specifications or parameter sheet.

8.19. **Caution!** Permeate pressure should never exceed the pressure inside the membrane array.

8.20. Lastly, adjust permeate flow using flow control valve to meet required value on rotameter. Ensure that operating pressure inside the membrane array does not exceed technical specification limitations and parameter sheet data. When feed water temperature is higher than originally recorded, operating pressure may be lower than per parameter sheet. Likewise, lower temperature will require higher pressure to achieve the same permeate flow rate.

8.21. When using new membranes or membranes after chemical cleaning or preservative treatment, it is necessary to flush the membranes from the preservative solution. Discard the permeate into the sewage system for 20-30 minutes, controlling its electrical conductivity.

8.22. After commissioning, a parameter sheet is created with the confirmed operating parameters for this RO system.

9. Operation of the system.

9.1. The system should be operated by specially trained personnel with the necessary qualification.

9.2. When operating the unit, you should strictly adhere to this manual and the general safety regulations during work with electrical equipment.

9.3. The RO system should be operated in temperature-controlled conditions as per technical specification.

9.4. Do not use feed water with more than 0.1 mg/L chlorine.

9.5. When operating the unit, it is necessary to ensure:

- uninterrupted power supply;
- operation of the unit at nominal pressure and flow rates in accordance with the values given in the parameter sheet.

9.6. Inspect the system on a periodic basis to ensure that flow control valves are not re-positioned, operating pressures and flows conform with parameter sheet records.

9.7. Replace sediment prefilters when pressure differential increases beyond 1.0 bar.

9.8. Do not operate the system at critical values of process parameters.

9.9. To keep track of system operation, keep a log book. Record operating parameters 1-2 times per shift: readings on pressure gauges, rotameters, conductivity meter, water temperature, and any faults that occur during operation.

9.10. Open and close the control valves smoothly and gradually when adjusting the parameters of the system. Suddenly opening or closing the valves can damage the equipment.

9.11. It is advisable to check tightness of piping connections at least once a month, to verify their integrity.

9.12. In order to restore the membrane capacity when the membranes become clogged, it is necessary to carry out chemical cleaning of the membranes. Use the following criteria:

- decreased flow capacity 10-15% relative to parameter sheet record;
- increased permeate conductivity 10-15% relative to parameter sheet record;
- increased pressure drop across membrane array 10-15% relative to parameter sheet record.

9.13. The parameters of chemical cleaning (pH values of solutions, circulation time, soaking time, temperature etc) should also be recorded in the log book.

9.14. Replace clogged membranes when chemical cleaning fails to restore membrane capacity.

9.15. **Caution!** In order to keep the membranes in good working condition, it is necessary to operate the system or carry out membrane flush for at least 1 hour a day. In case of long downtime (more than two days), it is necessary to carry out preservative treatment of the membranes to avoid microbial fouling of the membranes. 1% sodium metabisulfite solution is used as the preservative.

9.16. **Caution!** In case of long downtime, repeat preservative treatment with a fresh solution of sodium metabisulfite every month or so. Check pH of preservative solution inside the membrane array. When pH becomes lower than 3, flush the membranes and fill with fresh preservative solution.

10. Maintenance of the system.

Maintenance of the system is carried out by specially trained staff with the necessary qualification.

10.1. Replacing the filter cartridges.

Before replacing the cartridges, disconnect the unit from the electric supply, shut off the water supply to the filters and relieve any pressure inside the pipes.

Unscrew the clamp of the filter housing and remove the lid of the filter. Take care not to spill any water on the electrical equipment.

Remove the filter housing, then remove the used filters, install new filters and put the housing back. Put the lid back on the filter housing and fasten with the clamp.

10.2. Chemical cleaning of membrane elements (CIP)

10.2.1. The chemical cleaning process is carried out by trained staff using chemical cleaning unit (CIP unit).

10.2.2. Special cleaning solutions are used for membrane cleaning.

10.2.3. CIP inlet valve and outlet valves are used to connect the CIP unit and perform chemical cleaning.

10.2.4. Position of the valves in different conditions is given in Table 5.2.

10.2.5. In order to run chemical cleaning, first prepare the cleaning solution of the RO cleaners. Shut down the RO system and connect the CIP unit to CIP inlet and outlet ports. Open the CIP in/out valves. Run the cleaning procedure alternating circulation intervals with soak intervals, while keeping track of solution pH, temperature, color and turbidity. After completing the procedure, disconnect the CIP unit and start up the RO system in reverse order.

10.3. Preservative treatment of the membrane elements

10.3.1. Preservative treatment of membranes is carried out with 1% sodium metabisulfite solution using the CIP unit.

10.4. Replacing the membrane element.

Before replacing the membranes, disconnect power supply, water supply, and drain all water from the system. Then, disconnect any pipes joined to membrane vessel end cap. Pull out the retaining ring or remove the retaining half-rims after unfastening the bolts. Remove the end caps of the membrane vessel.

Remove the used membranes in the direction of the water flow (as per the arrow). Push the membranes from feed side and pull out on the opposite side. Insert new membranes, connecting them with each other with permeate interconnectors. Then reinstall the end caps and secure with spiral rings or half-rims.

10.5. Precautions for membrane installation.

10.5.1. Turn off the power supply and drain all water from the system before beginning to take apart the membrane vessels.

10.5.2. Do not subject the membrane vessels to mechanical loads (shock, static load etc)

10.5.3. Take care not to spill any water on the electrical equipment.

11. Storage and shipping.

11.1. The system should be stored indoors in conditions meeting technical specification requirements.

11.2. Carry out preservative treatment of the membranes before prolonged downtime.

11.3. The system must be shipped in enclosed cars firmly secured on the floor.

11.4. Prevent any exposure to low temperatures, mechanical vibrations and shock during shipping.

12 Troubleshooting

Problem	Cause	Solution
1. No permeate is produced by the system	• no electric power	• check that power cable is not damaged and power supply is available
	• the system is in Standby mode	• check if the permeate tank is full
	• the system is in Low pressure mode	• check that feed water is not shut off with a valve • check if the entry valve of the RO system is functional • check that the prefilters are not clogged
	• permeate line is closed with a valve or obstruction inside piping	• open any valves on the permeate line and remove any obstruction inside the pipes
	• pump failure	• test the pump
2. Decreased permeate capacity*	• Increased TDS of the feed water	• Carry out a water test and consult technical support as to the required modification of operating parameters if water analysis has changed
	• Decreased feed water temperature	• If necessary, increase operating pressure within allowed range to compensate for lower temperature
	• Lower pressure in the membrane array	• Check and adjust the pressure in the membrane array
3. High operating pressure inside membrane array*	• Increased TDS of the feed water	• Carry out a water test and consult technical support as to the required modification of operating parameters if water analysis has changed
	• Decreased feed water temperature	• If necessary, decrease operating pressure to compensate for higher temperature
	• Clogged membrane elements	• Perform chemical cleaning of membrane elements
4. Low operating pressure inside membrane array*	• Decreased TDS of the feed water	• Carry out a water test and consult technical support as to the required modification of operating parameters if water analysis has changed
	• Control valve adjustment has gone wrong	• Adjust the flow control valves so as to obtain normal working parameters per parameter sheet
	• Increased feed water temperature	• If necessary, increase operating pressure to compensate for lower temperature
5. Increased pressure drop across membrane array*	• Increased TDS of the feed water	• Carry out a water test and consult technical support as to the required pretreatment of water or RO parameter modification if water analysis has changed
	• Clogged membrane elements	• Perform chemical cleaning of membrane elements
6. Decreased permeate quality*	• Decreased feed water quality	• Carry out a water test and consult technical support as to the required pretreatment of water or RO parameter modification if water analysis has changed
	• Clogged membrane elements	• Perform chemical cleaning of membrane elements
	• Brine seal damage on some of the membrane elements	• Check and replace any damaged seals
	• Membrane damage	• Have an RO specialist inspect and verify if any membranes are damaged

* The easiest way to track changes in operating parameters is to keep an operation log book and compare data with parameter sheet.
More accurate data as to estimated system parameters at given pressure and temperature can be obtained using Dow FTNORM software.

ECOSOFT MO-36 PARAMETER SHEET *(example)*

№	Name of the parameter	Unit	Parameter value		
			Value	Date:	Date:
1	**OPERATING CONDITIONS:**				
1.1	Temperature of feed water	°C			
1.2	Ambient air temperature	°C			
	QUALITY INDICATORS OF FEED WATER:				
1.3	Total dissolved solids	mg/L			
1.4	Total hardness	mg/L $CaCO_3$			
1.5	Total alkalinity	mg/L $CaCO_3$			
1.6	Chemical oxygen demand	mg O_2/L			
1.7	Active chlorine	mg/L			
1.8	Iron, manganese	mg/L			
1.9	Hydrogen sulfide	mg/L			
2	**OPERATING CHARACTERISTICS AND SETTINGS:**		Value	Date:	Date:
2.1	Inlet pressure	bar			
2.2	Pressure after prefilter	bar			
2.3	Operating pressure in the membrane array	bar			
2.4	1st stage concentrate pressure	bar			
2.5	2nd stage concentrate pressure	bar			
2.6	1st stage permeate pressure	bar			
2.7	Permeate pressure	bar			
2.8	Flow rate of concentrate drain	m^3/h			
2.9	Electric conductivity of permeate	µS/sm			
2.10	Permeate flow rate	m^3/h			

Parameter sheet was filled in by:

_____ _____

Organization, position First name, Last name, sign