PoroCep®

THE DISTINCTIVE MBR SOLUTION

Hyflux®

EXPERIENCE SUPERIOR RELIABILITY AND EFFICIENCY.

Designed for use in MBR systems, Hyflux's PoroCep® hollow fibre submerged membrane combines an **innovative, compact design** with **sustained high performance efficiency** that helps save energy and reduce costs throughout a wastewater plant's lifecycle.

Product Features and Benefits

- Enhanced hydrophilic material
- Asymmetric slit pore structure
- Consistently excellent permeate quality
- High packing density
- High pH and chemical tolerance

Operation Features and Benefits

- Low fouling rate
- Long lifespan
- Small footprint
- Low energy requirements
- Efficient system recovery

Key Applications

- Industrial wastewater treatment and reclamation
- Municipal wastewater treatment and reclamation
- Pre-treatment filtration

POROCEP® APPLICATIONS

PoroCep® membranes may be applied for various uses, including:

Industrial Wastewater Treatment and Reclamation

- Wastewater treatment and reclamation for industries like oil and gas, food processing, pulp and paper, steel mills, slaughterhouse and textile

Municipal Wastewater Treatment and Reclamation

- Sewage treatment and reclamation
- Containerised MBR waste treatment plants for military use, rural communities
- Standardised wastewater treatment systems for hospitals and pharmaceutical purposes

Pre-treatment Filtration

- Pre-treatment of high solids-loading feed water for nanofiltration, reverse osmosis, ion exchange, electrodeionisation (EDI)

01 POROCEP®
THE DISTINCTIVE MBR SOLUTION

POROCEP® THE DISTINCTIVE MBR SOLUTION

INTRODUCTION

With its high filtration capacity and superior performance efficiency, PoroCep® can help industries and municipalities save energy and reduce costs throughout a wastewater plant's lifecycle.

Growing populations, rising industrialisation and urbanisation, with attendant problems such as water pollution and depleting water resources, have prompted the search for more sustainable sources of water. As a result, water reuse is becoming an increasingly viable solution for municipalities and industries.

Water reuse enables municipalities to become less dependent on freshwater sources. It can also address the stringent restrictions many industries face on their water usage and on the quality and quantity of water that can be discharged from their facilities.

A pioneer in providing NEWater (municipal wastewater recycling) solutions in Singapore, Hyflux has drawn on its experience in wastewater filtration and membrane research to develop PoroCep®, a submerged hollow fibre membrane designed for use in membrane bioreactor (MBR) systems. PoroCep® is a reliable, high performance solution particularly well suited for industrial wastewater treatment and reclamation.

POROCEP® THE DISTINCTIVE MBR SOLUTION

INTRODUCTION

Manufactured and assembled in Singapore, PoroCep® membranes are made from high-density polyethylene (HDPE), a non-toxic, non-leaching material with excellent tensile strength as well as strong pH and oxidation resistance. Each hollow fibre membrane is produced through environmentally friendly processes such as melt-spinning and stretching which do not use harmful chemicals. The membranes are housed in unit boxes that are in turn mounted on a skid that comes with its own air diffusing module.

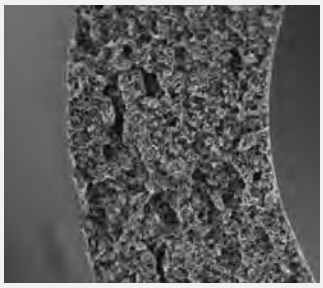
Unlike conventional wastewater treatment systems, MBR systems require less footprint, produce less sludge and allow for higher mixed liquor suspended solids (MLSS) content with less hydraulic retention time. The compact design of the PoroCep® skid allows a higher packing density to be achieved within a MBR. With its high filtration capacity and superior performance efficiency, PoroCep® can help industries and municipalities save energy and reduce costs throughout a wastewater plant's lifecycle.

POROCEP® THE DISTINCTIVE MBR SOLUTION

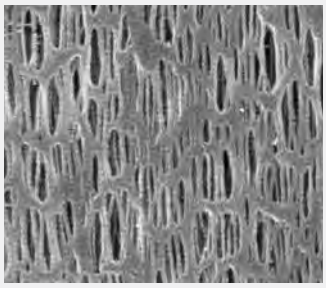
ASYMMETRIC, SLIT PORE STRUCTURE

Improved contaminant rejection and membrane permeability

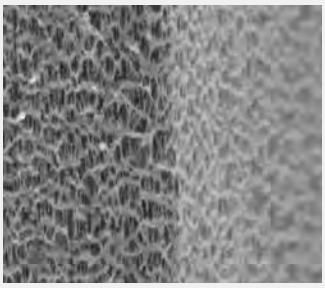
The slit pores of the PoroCep® membrane reject contaminants such as suspended solids and microorganisms more efficiently and are not clogged as easily as the regular circular pores. This slit pore structure is created by an exact stretching method which ensures a narrow pore size distribution. In addition, the asymmetry of the membrane gives it good permeability for high flux rates, and at the same time, high rejection efficiency.



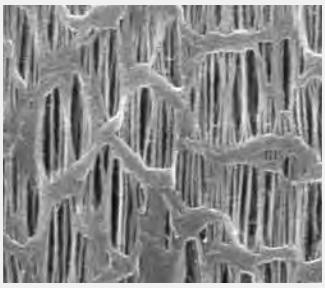
Front cross-section structure



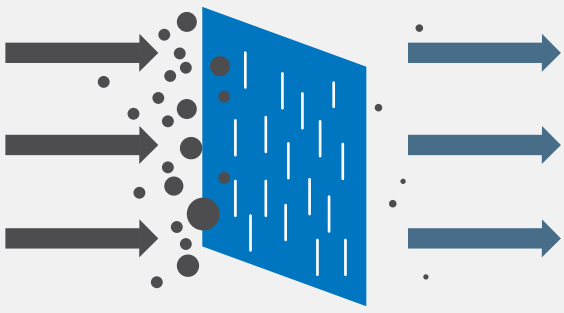
Outer surface morphology



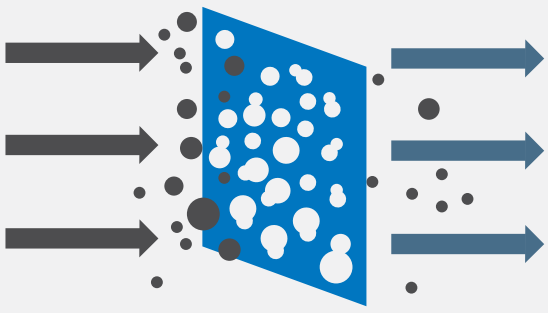
Section along membrane's slit pore structure



Inner surface morphology



Slit Pores

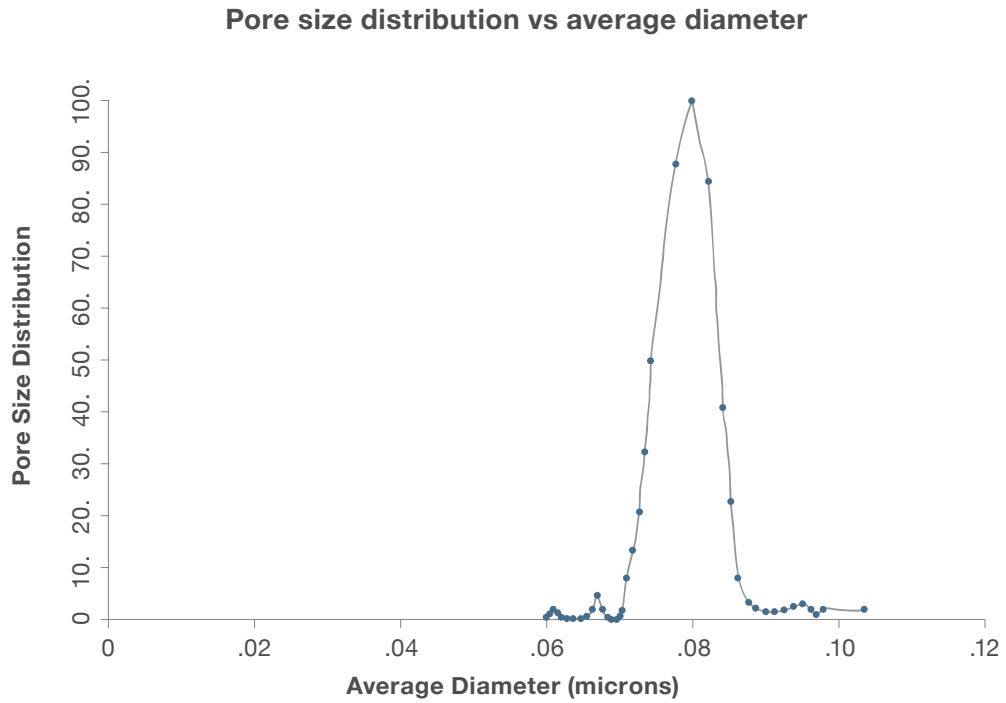


Normal Pores

Rejection provided by slit pores compared to normal pores

POROCEP® THE DISTINCTIVE MBR SOLUTION

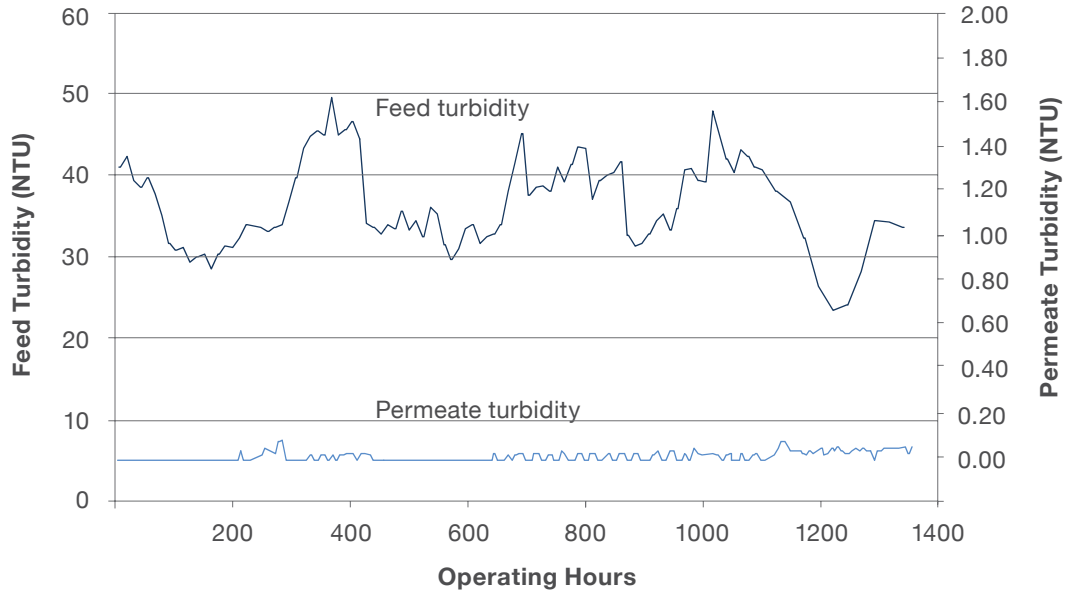
ASYMMETRIC, SLIT PORE STRUCTURE



Narrow pore size distribution of a PoroCep® membrane

Consistent, high quality permeate

PoroCep® delivers consistent, high quality permeate regardless of the fluctuations in feed water quality. This is illustrated in the graph below.



POROCEP® THE DISTINCTIVE MBR SOLUTION

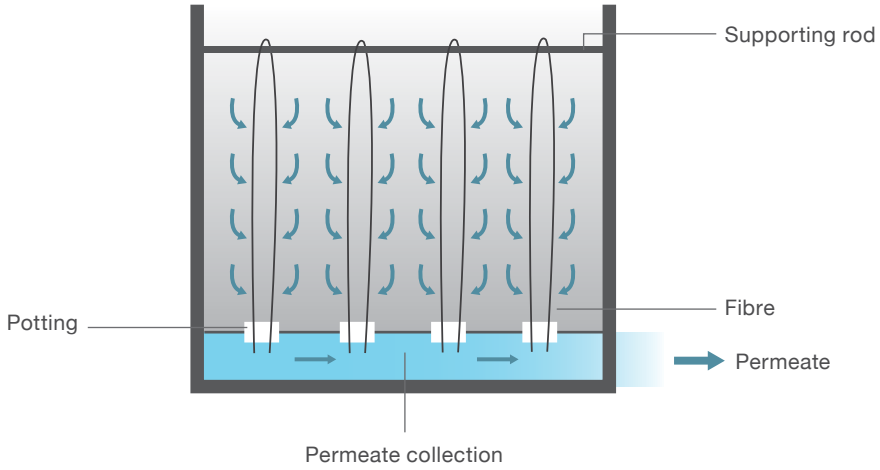
FREE-FLOATING FIBRE DESIGN

PoroCep® is designed to minimise fouling and maximise membrane packing density through a unique free-floating fibre design.

Lower rate of membrane fouling

One of the key concerns with membrane filtration is fouling and the buildup of a cake layer on the surface of the membranes. Fouling causes membrane permeability to decrease. While a higher cleaning frequency can restore membrane performance, it gradually reduces the lifespan of the membranes. PoroCep® is designed to minimise fouling and maximise membrane packing density through a unique free-floating fibre design.

Hollow fibres made of HDPE material are looped over a supporting rod and potted at the ends. They float freely when submerged in water, preventing contaminants and fibrous material from being trapped within the fibres. At the same time, a steady stream of air bubbles scour the membrane surface to keep it free from solids buildup. As a result, PoroCep® can function for extended periods of time without the need for chemical cleaning. This translates to cost savings and minimal system downtime.



Simplified drawing of free-floating PoroCep® membrane elements

POROCEP® THE DISTINCTIVE MBR SOLUTION

LOW ENERGY REQUIREMENTS

The aeration required for air scouring is a key component of energy costs for a MBR system. PoroCep® requires an air flow of approximately 0.1 - 0.2 $Nm^3/hr/m^2$ which is possibly the lowest in the market today. Users can thus enjoy significant savings on operational expenses with this energy-efficient membrane system.

HIGH PACKING DENSITY

With a membrane per footprint area of approximately 835 m^2/m^2 for a double-deck skid, PoroCep® has one of the highest membrane packing densities among submerged membranes for MBR systems today. Its greater filtration capacity and smaller tank footprint means savings on capital and operating expenditure for users.

POROCEP® THE DISTINCTIVE MBR SOLUTION

STACKABLE UNIT BOX ARRANGEMENT

PoroCep® membranes are housed in unit boxes which are then “stacked” together onto a skid. Operation and maintenance are made easier with this modular, stackable design as each individual unit box can be simply mounted and dismounted without hassle when installing, inspecting and cleaning.

OPTIMISED AIR FLOW

Air scouring plays a key role in membrane performance by inhibiting and removing foulants from the membrane surface. PoroCep®’s stackable design, coupled with the even distribution of air from the air diffusing module at the bottom of the skid ensures that the scouring action of the air bubbles is effectively channelled throughout the skid, reaching all parts of the membranes and preventing any “dead zones” from forming.

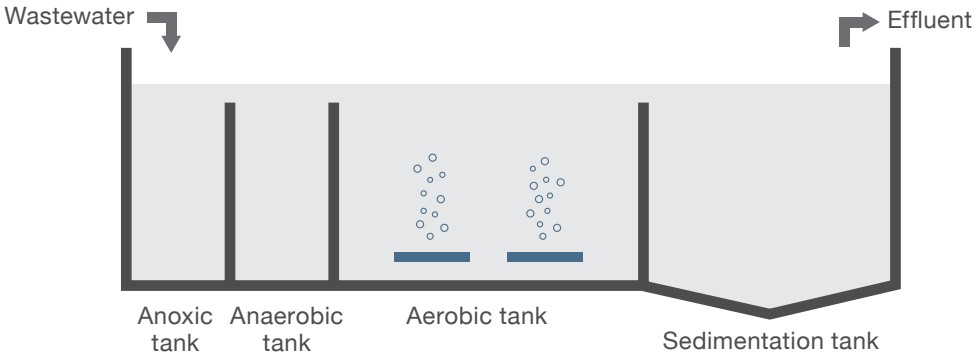
THE CASE FOR MBR OVER CONVENTIONAL TREATMENT

Conventional wastewater treatment generally involves the biological degradation of organic content in the influent followed by secondary gravity sedimentation to settle out the sludge from the aqueous activated sludge solution. Rather than employing sedimentation, a MBR system passes the aqueous activated sludge solution through membrane filtration to separate water from the sludge. By using membranes in place of a secondary sedimentation tank or clarifier, the MBR system offers several benefits over conventional wastewater treatment.

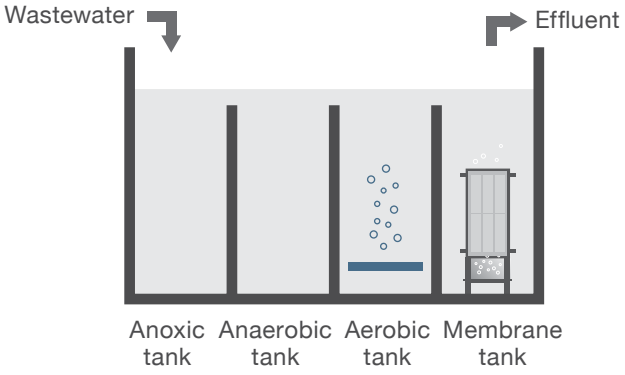
1. Smaller footprint

MBR systems can operate at a considerably higher mixed liquor suspended solids concentration compared to conventional activated sludge systems (CAS). This high concentration results in a lower tank volume and a substantial reduction in the footprint of the plant which is an advantage for highly populated areas where space availability is a chief concern. Conventional treatment systems typically take up 30% or more footprint as compared to MBR systems.

Conventional Treatment (Activated Sludge) Process



Membrane Bioreactor Process



Simplified schematic of conventional treatment and MBR processes

THE CASE FOR MBR OVER CONVENTIONAL TREATMENT

2. Superior effluent quality independent of influent quality

Membrane filtration in MBR systems provide an effective and reliable barrier that removes suspended solids, including harmful microorganisms to produce consistent, higher quality effluent compared to conventional treatment systems. This can be seen from the parameters in the following table where Hyflux's PoroCep® membrane effluent quality is compared with that of typical CAS systems.

Comparison of typical effluent quality between MBR and CAS

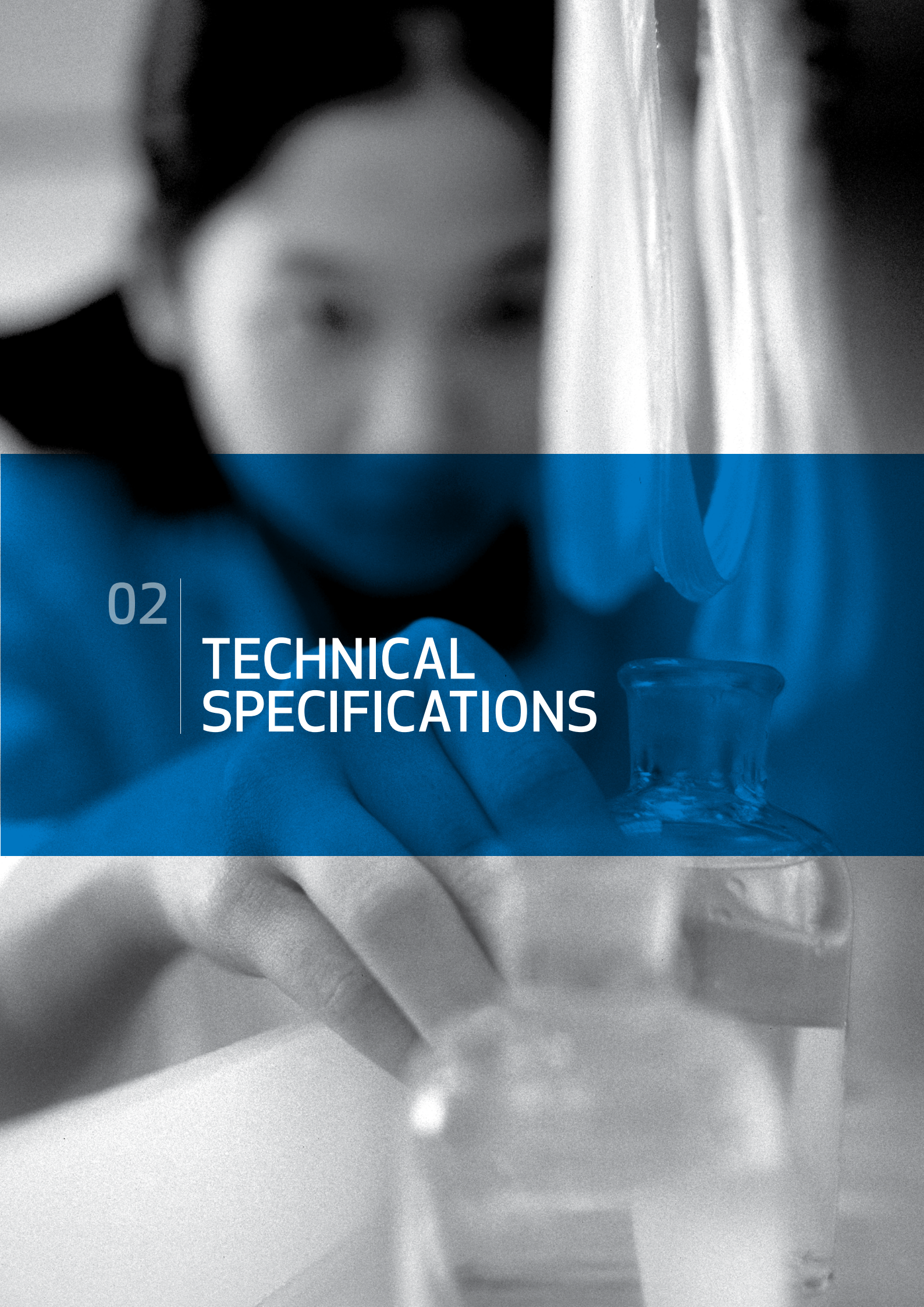
Parameter	Feed/Influent	Effluent		
	Municipal Wastewater (Typical)	MBR System Using PoroCep®		CAS
Turbidity (NTU)	-	Membrane process	< 0.2	5 - 20
SDI	-		< 3	> 5
TSS (mg/L)	100 - 300		< 1	10 - 30
BOD_5 (mg/L)	300	Biological process	< 5	< 30
COD (mg/L)	600		< 30	< 100
NH3-N (mg/L)	30		< 0.5	5 - 10
TN (mg/L)	40		< 15	> 25
TP (mg/L)	10 - 20		< 0.5	5 - 8

Additional Notes:

- BOD and COD removal depends on the efficiency of the biological process.
- The removal of ammonia nitrogen can vary based on the degree of nitrification.
- The removal of TN can vary based on the degree of denitrification.
- Chemical addition (e.g. ferric chloride) may be required for TP removal.

3. Less sludge production, longer sludge age

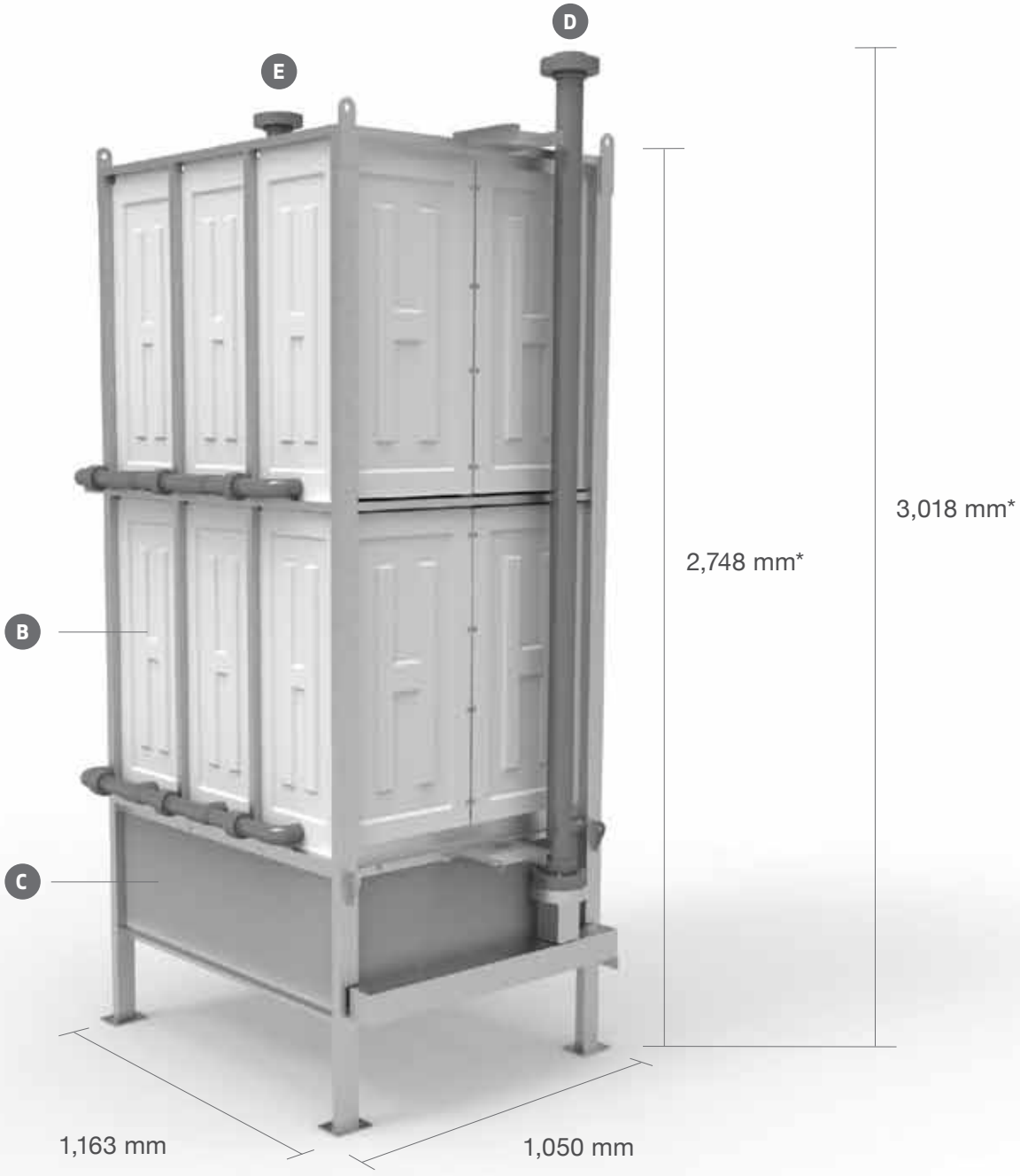
MBR systems typically generate about 25% less sludge than conventional treatment systems and have a longer sludge age. This makes MBRs more environmentally friendly and also translates to cost savings in terms of lower sludge disposal frequency and volume.



02

TECHNICAL SPECIFICATIONS

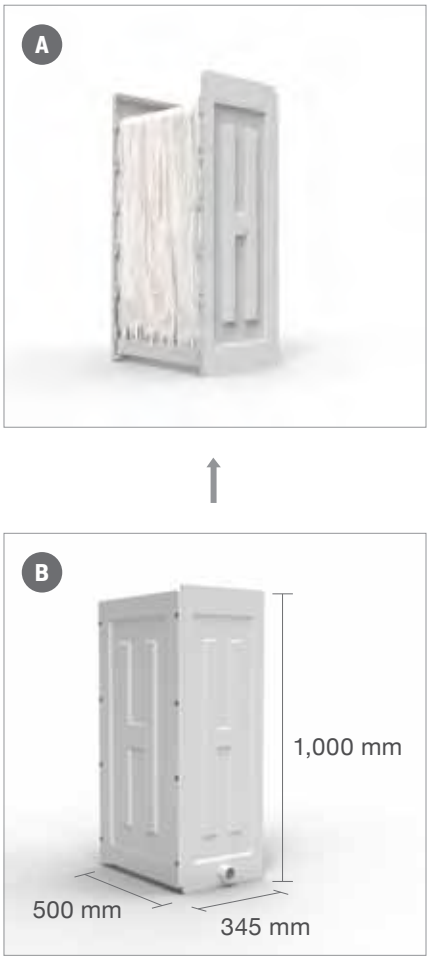
POROCEP® SKIDS



Item	Description
A	Membrane element
B	Unit box
C	Air diffusing module
D	Air inlet port
E	Permeate outlet port

*Measurements given are for a double deck skid

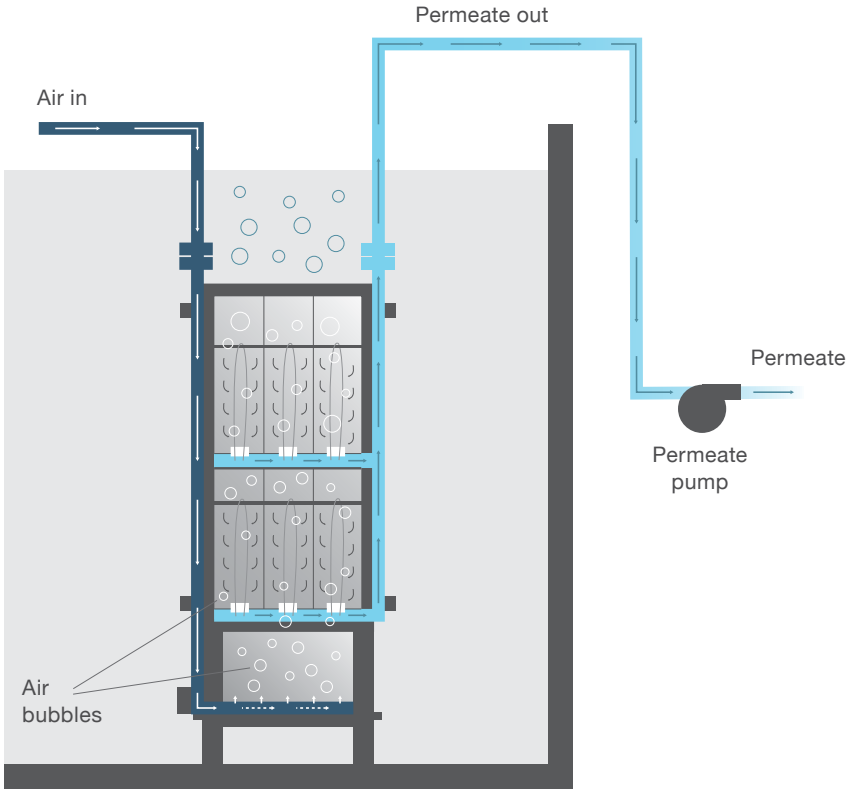
POROCEP® SKIDS



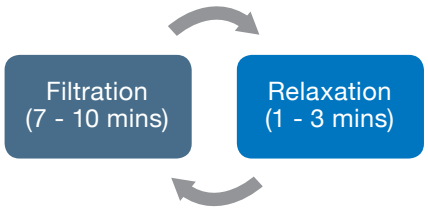
POROCEP® SPECIFICATIONS

PoroCep® Membrane Specifications		
Material	HDPE	
Type	Hollow fibre	
Pore structure	Asymmetric slit pore	
Nominal pore size (micron)	0.1	
Outer diameter (mm/inch)	0.4 / 0.016	
Inner diameter (mm/inch)	0.3 / 0.012	
Wall thickness (mm/inch)	0.05 / 0.002	
Tensile strength (MPa)	80	
Chlorine resistance (ppm-hrs)	1,000,000	
PoroCep® Unit Box Specifications		
Overall dimensions: length x width x height (mm/inch)	345 x 500 x 1,000 / 13.6 x 19.7 x 39.4	
Box material	PVC	
Membrane elements per box	10	
Membrane area per box (m^2)	85	
Permeate outlet diameter (inch)	1.5	
Specific membrane area per box (m^2/m^3)	493	
Dry weight (kg/lbs)	19 / 42	
PoroCep® Skid Specifications		
Skid model	POR 101-510 (Single deck)	POR 102-1020 (Double deck)
Dimensions: length x width x height (mm/inch)	1,163 x 1,050 x 1,744 / 45.8 x 41.3 x 68.7	1,163 x 1,050 x 2,748 / 45.8 x 41.3 x 108.2
Unit boxes per skid	6	12
Membrane area per skid (m^2)	510	1,020
Specific membrane area per skid (m^2/m^3)	239	304
Dry weight (kg/lbs)	260 / 572	450 / 990
Connection - air inlet (inch)	2 (Union; butt-weld)	3 (Flange)
Connection - permeate outlet (inch)	2 (Union; socket)	3 (Flange)
Material - permeate outlet	PVC	PVC
Material - air inlet	SS304	PVC
Skid frame material	SS304	

FILTRATION PROCESS



PoroCep® membranes housed in a skid are immersed inside the membrane tank of an MBR system, in direct contact with the mixed liquor. The membranes are operated in a continuous cycle in which filtration and relaxation alternate. During filtration, a vacuum is applied through the use of a permeate pump to draw permeate through the hollow fibre membranes. The effluent produced is of a consistent, high quality that meets stringent requirements. Filtration typically lasts nine minutes and is followed by relaxation of one minute. During relaxation, filtration stops and the membranes are allowed to “rest”.

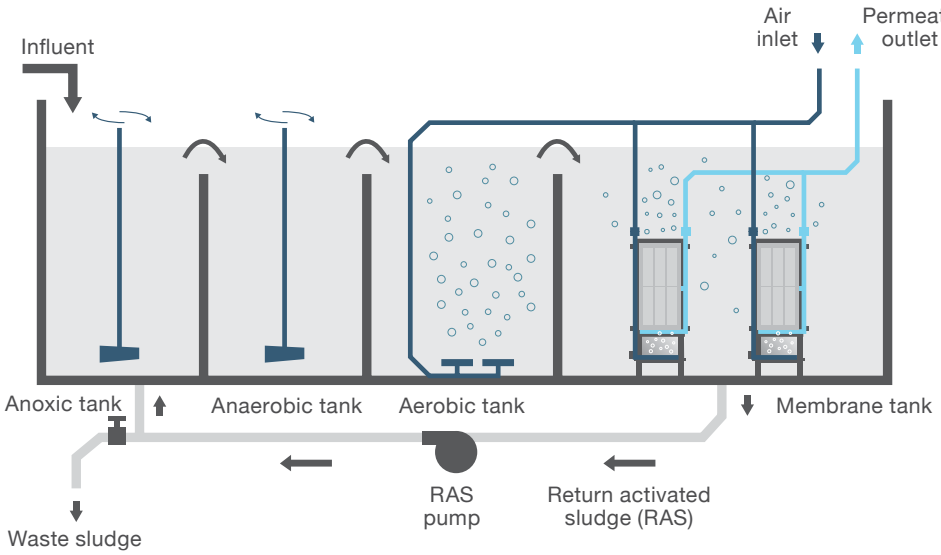


Typical operation cycle for PoroCep® membranes

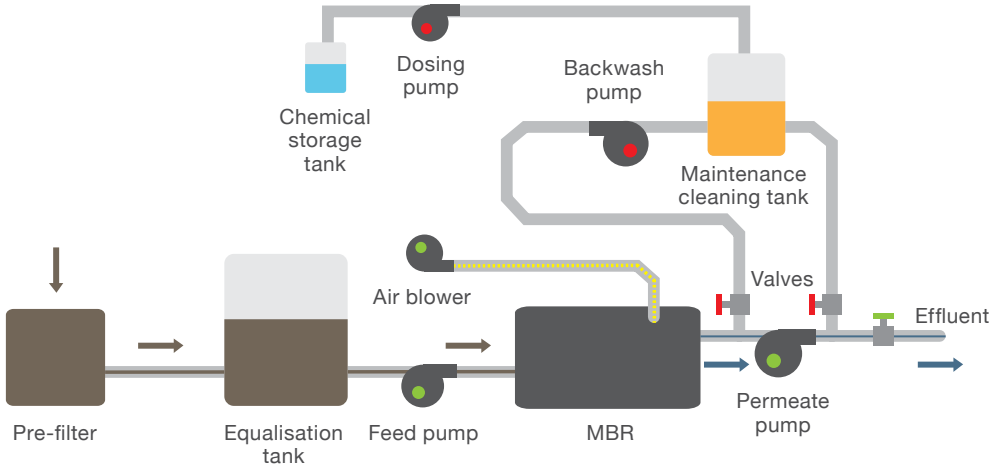
The air diffusing module at the bottom of the skid introduces a constant airflow to the membranes, producing a turbulence that scours the external surface of the hollow fibres to prevent foulants from building up.

BASIC CONFIGURATION

The PoroCep® MBR process combines biological treatment with membrane filtration technology that uses PoroCep® hollow fibre membranes to filter out suspended solids including harmful microorganisms such as viruses, bacteria and cysts.



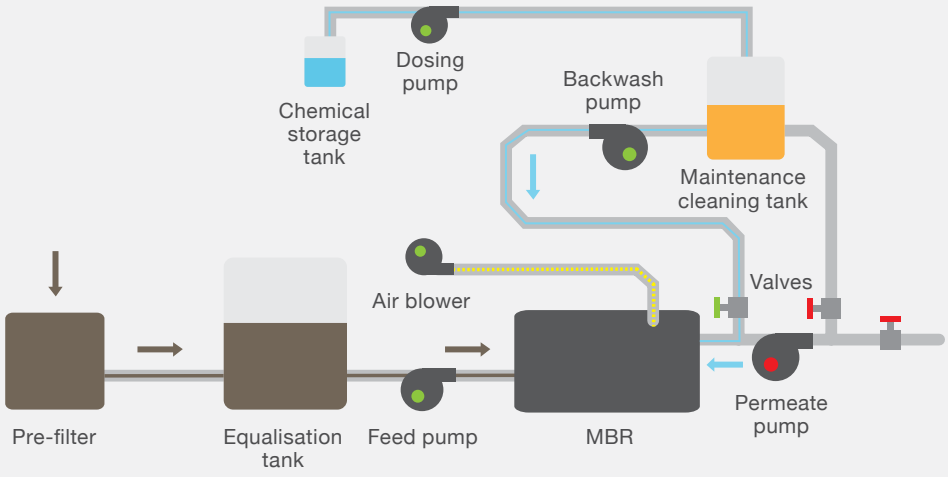
The schematic below shows an example of a typical MBR system including the pre-filtration, equalisation and clean-in-place (CIP) system during operation.



Schematic diagram for filtration

BASIC CONFIGURATION

While air scouring in conjunction with relaxation removes contaminants accumulated on the surface of the membranes, maintenance cleaning (MC) and recovery cleaning (RC) using chemicals may still be required after extended periods of operation to maintain membrane permeability. During such cleaning, cleaning chemicals are added to the permeate which is then back flushed through the membranes.



Schematic diagram for chemical cleaning

OPERATING, FEED AND PERMEATE PARAMETERS

Typical Operating Parameters	
Flow type	Outside-in
Flux rate (LMH)	10 - 20
Filtration duration (min)	7 - 10
Relaxation duration (min)	1 - 3
Operating temperature (°C)	5 - 40
Operating pH range	6 - 8
Cleaning pH range	2 - 13
Operating TMP (bar)	0.1 - 0.5
Recommended air flow rate (Nm^3/skid.hr)	102
Max air flow rate (Nm^3/skid.hr)	125
Maintenance cleaning frequency (day)	5 - 15
Maintenance cleaning duration (hour)	1 - 3
NaOCl dosage for maintenance cleaning (mg/L)	500
Recovery cleaning (by NaOCl) frequency (day)	90 - 180
NaOCl dosage for recovery cleaning by NaOCl (mg/L)	2,000 - 4,000
Recovery cleaning (by citric acid) frequency (day)	180 - 360
Citric acid dosage for recovery cleaning by citric acid (%)	1 - 2
Recovery cleaning duration (hour)	3 - 5

MBR Tank Feed Water Requirements	
MLSS in membrane tank (mg/L)	< 12,000
Temperature (°C)	< 40
Animal or vegetable oil/fat (mg/L)	< 50
Mineral oil and/or grease (mg/L)	< 3

Additional Notes:

- Silicon-based anti-foaming agents should not be used for foam control in an MBR system.
- The feed to the membrane tank should be filtered with a 0.5 - 1 mm screen.

Typical Permeate Quality	
Turbidity (NTU)	< 0.2
TSS (mg/L)	< 1
SDI	< 3

03 POROCEP®
CONTAINERISED MBR SYSTEMS

POROCEP® CONTAINERISED MBR SYSTEMS

INTRODUCTION

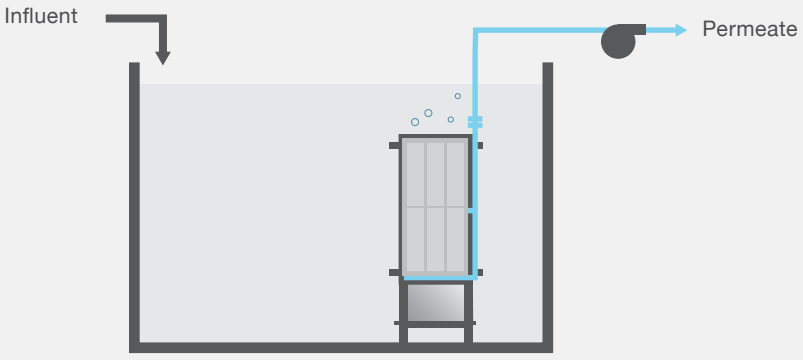
Hyflux's containerised MBR systems simplify the end-user experience by providing comprehensive, pre-designed, ready-to-install systems within standard-sized containers. These systems are ideal for portable applications and situations where temporary wastewater treatment systems are required such as pilot testing, wastewater treatment at temporary work sites, small-scale industrial facilities, disaster areas and rural settlements.

Standard and customised configurations

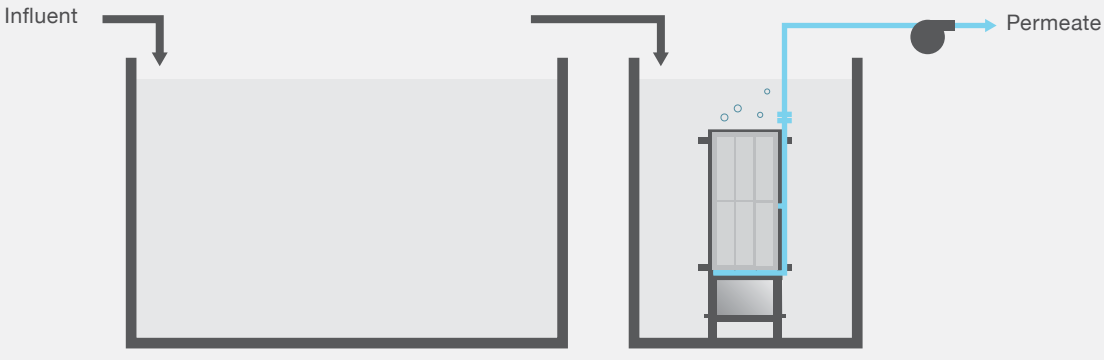
The PoroCep® containerised MBR system can be customised to suit individual feed water requirements and discharge criteria. Some of the process configurations that can be supplied include:

- Anaerobic-Anoxic-Aerobic systems
- Anoxic-Aerobic systems
- Anoxic-Aerobic-Anoxic-Aerobic systems

PoroCep® can be used in either internal submergence or external submergence mode. This means that the user can either choose to have the membrane skid placed inside the bioreactor tanks (internal submergence) or in a separate membrane tank which is isolated from the main bioreactor system (external submergence) depending on the needs of the situation.



Internal submergence



External submergence

POROCEP® CONTAINERISED MBR SYSTEMS

INTRODUCTION

Benefits

- Low capital and operating costs
- Easy to install
- Easy to operate and maintain
- Compact and small footprint
- Consistent, high quality product water
- Efficient, reliable operation with minimum downtime
- Low chemical usage
- Portable and re-usable
- Customisable

PoroCep® containerised MBR systems are available in three configurations:

Model	Treatment Capacity* (litres/day)
MPO-100	100,000
MPO-200	200,000
MPO-400	400,000

*Dependent on feed water quality

POROCEP® CONTAINERISED MBR SYSTEMS

MPO-100

Production capacity (m^3/d)	100
Footprint (m^2)	Approx. 100
Containers	2 x 20-feet
PoroCep® skids	1 x single-deck

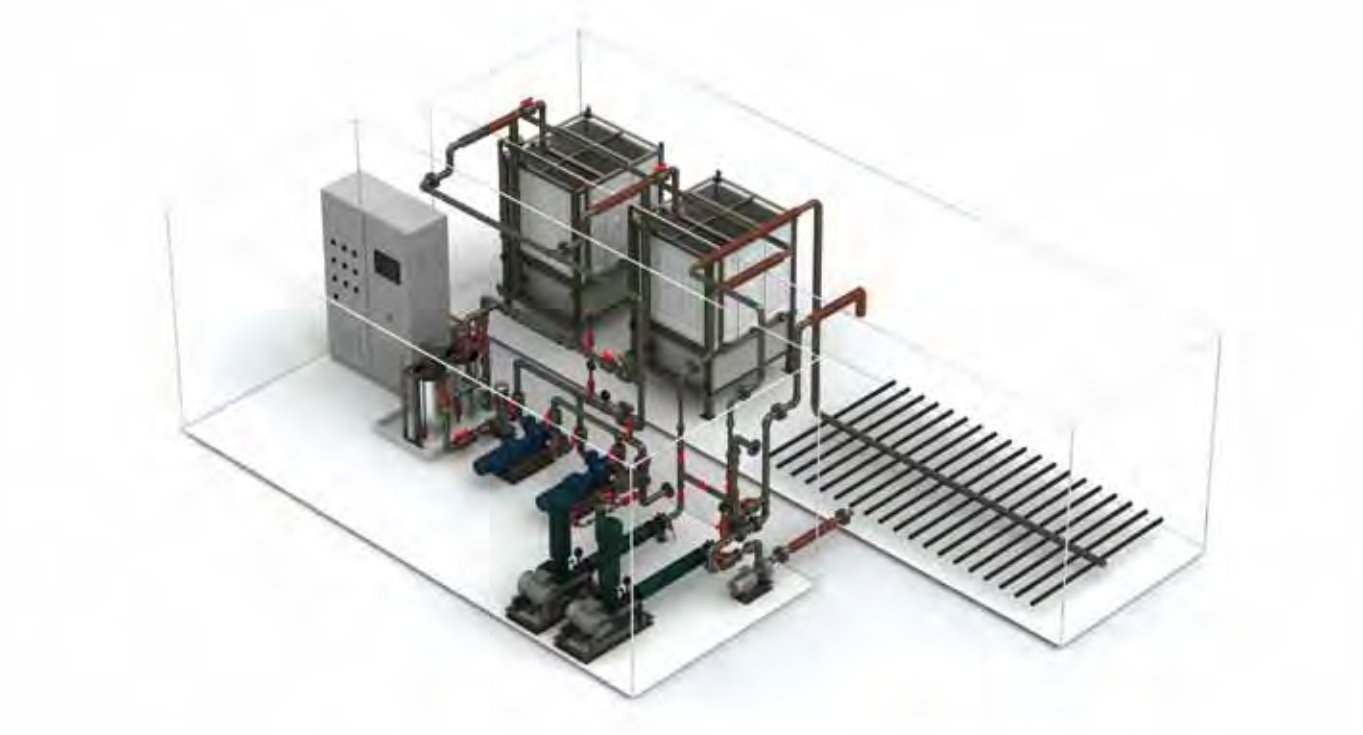
Standard Equipment List

Item	Quantity	Description
Biological/membrane tank	1	FRP, 33 m^3
Sodium hypochlorite tank	1	HDPE, 0.05 m^3, with cover
Citric acid tank	1	HDPE, 0.05 m^3, with cover
Sludge pump (RAS/WAS)	1	Cast iron, 6.25 m^3/h flow, 20 m head
MBR permeate pump	2	Cast iron, 5 m^3/h flow, 20 m head
MC/RC pump	1	SS304 (wet parts), 6 m^3/h flow, 20 m head
Metering pump	2	PVDF, 0.02 m^3/h flow, 20 m head
Bioreactor aeration blower	1	Roots blower, 109 Nm^3/h flow, 5 m head
Tube air diffusers with saddle	8	EPDM, 94 mm tube diameter, 0.9 m long, 16 Sm^3/h flow
Membrane air scour blower	1	Roots blower, 109 Nm^3/h flow, 5 m head

POROCEP® CONTAINERISED MBR SYSTEMS

MPO-200

Production capacity (m^3/d)	200
Footprint (m^2)	Approx. 150
Containers	1 x 20-feet, 1 x 40-feet
PoroCep® skids	2 x single-deck



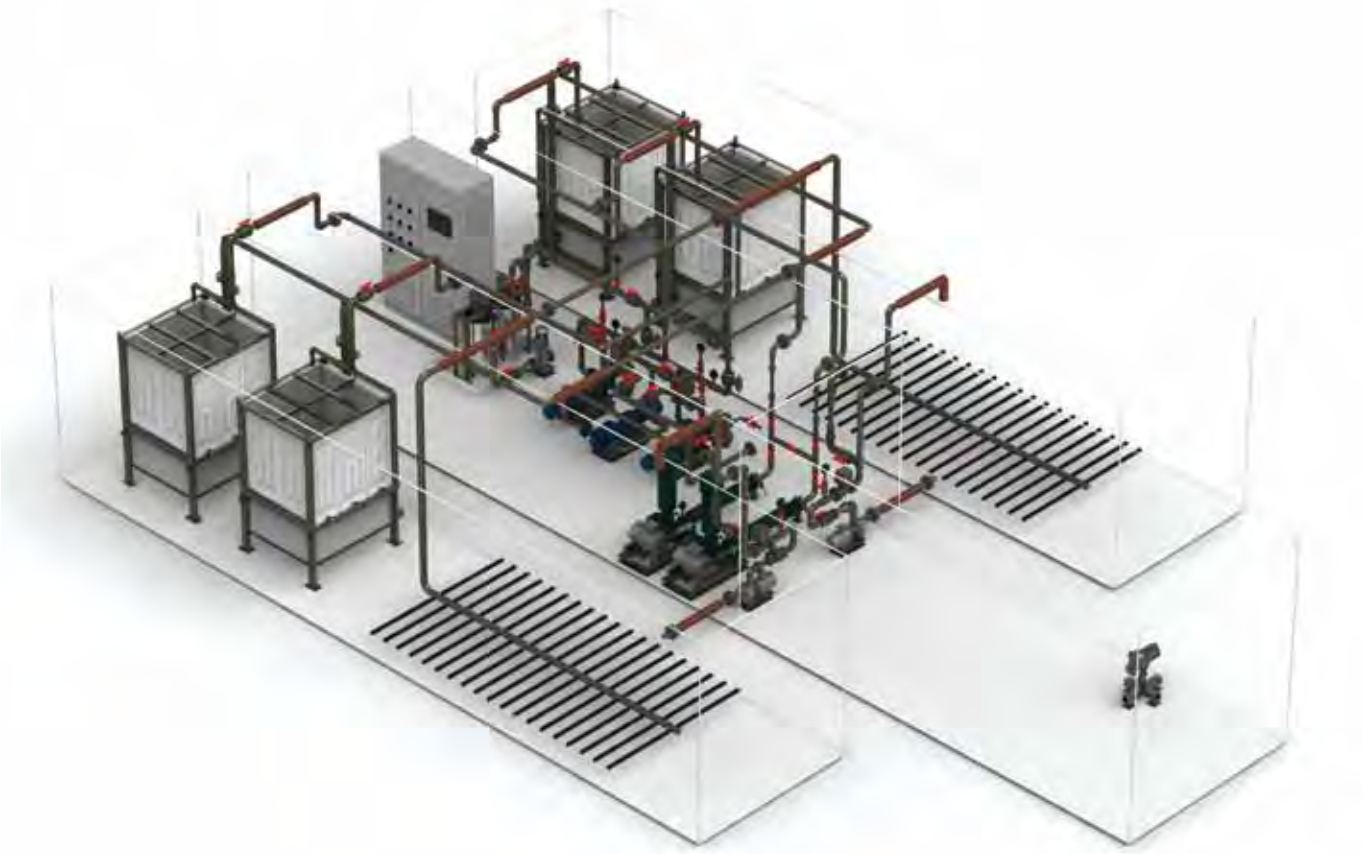
Standard Equipment List

Item	Quantity	Description
Biological/membrane tank	1	FRP, 56 m^3
Sodium hypochlorite tank	1	HDPE, 0.05 m^3, with cover
Citric acid tank	1	HDPE, 0.05 m^3, with cover
Sludge pump (RAS/WAS)	1	Cast iron, 12.5 m^3/h flow, 20 m head
MBR permeate pump	2	Cast iron, 10 m^3/h flow, 20 m head
MC/RC pump	1	SS304 (wet parts), 12 m^3/h flow, 20 m head
Metering pump	2	PVDF, 0.05 m^3/h flow, 50 m head
Bioreactor aeration blower	1	Roots blower, 218 Nm^3/h flow, 5 m head
Tube air diffusers with saddle	14	EPDM, 94 mm tube diameter, 0.9 m long, 16 Sm^3/h flow
Membrane air scour blower	1	Roots blower, 218 Nm^3/h flow, 5 m head

POROCEP® CONTAINERISED MBR SYSTEMS

MPO-400

Production capacity (m^3/d)	400
Footprint (m^2)	Approx. 300
Containers	3 x 40-feet
PoroCep® skids	4 x single-deck

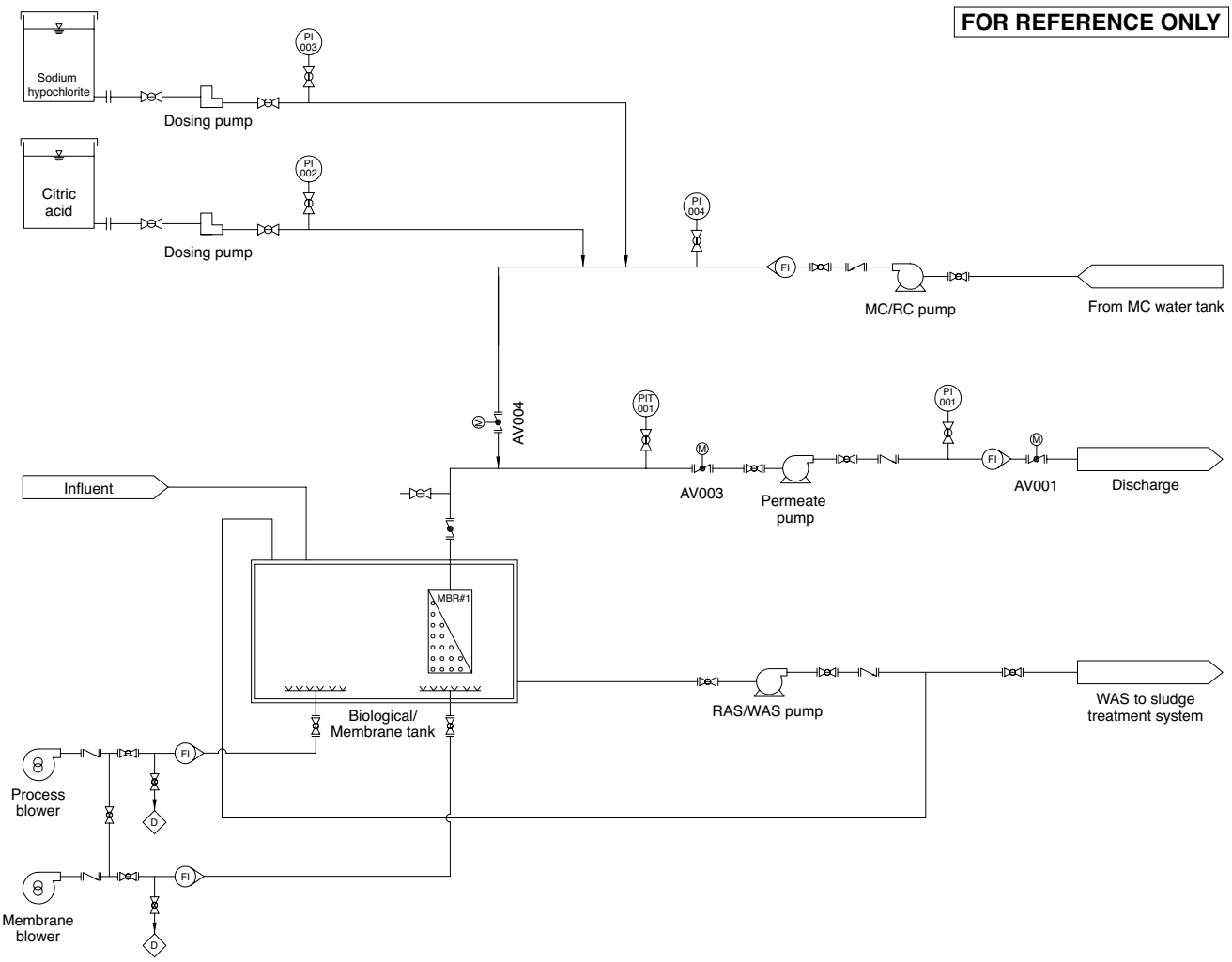


Standard Equipment List

Item	Quantity	Description
Biological/membrane tank	2	FRP, 56 m^3
Sodium hypochlorite tank	1	HDPE, 0.05 m^3, with cover
Citric acid tank	1	HDPE, 0.05 m^3, with cover
Sludge pump (RAS/WAS)	2	Cast iron, 12.5 m^3/h flow, 20 m head
MBR permeate pump	3	Cast iron, 10 m^3/h flow, 20 m head
MC/RC pump	1	SS304 (wet parts), 12 m^3/h flow, 20 m head
Metering pump	3	PVDF, 0.05 m^3/h flow, 50 m head
Bioreactor aeration blower	1	Roots blower, 436 Nm^3/h flow, 5 m head
Tube air diffusers with saddle	36	EPDM, 94 mm tube diameter, 0.9 m long, 16 Sm^3/h flow
Membrane air scour blower	1	Roots blower, 436 Nm^3/h flow, 5 m head

POROCEP® CONTAINERISED MBR SYSTEMS

P&ID



LEGEND

Valve symbols

- Ball valve
- Butterfly valve
- Check valve
- Motorised valve

Primary element symbols

- FI Rotameter

Miscellaneous symbols

- D Drain

Uppercase letter	First position (measured or indication variable)	Second position (modifier)	Succeeding letters (output function/ modifier)
A	Analysis	Alarm	
E		Element	
F	Flow		
H			High
I		Indicator	
L			Low
P	Pressure		
T			Transmitter

ABOUT HYFLUX

At the core of Hyflux's business is its membrane innovation that is focused on the development of membranes, membrane applications, and the design and development of membrane-based plants to deliver solutions for a wide range of applications in water treatment and industrial manufacturing processes.

Founded in 1989, Hyflux has successfully transformed itself into a global fully-integrated water solutions company and one of the top desalination plant suppliers in the world.

Hyflux offers sustainable solutions in the areas of membrane-based desalination, water recycling, wastewater treatment including membrane bioreactor technology, and potable water treatment. Its projects and operations span across South East Asia, China, India, Europe, the Middle East and North Africa, and include landmark projects such as the world's largest seawater reverse osmosis (SWRO) desalination plant in Magtaa, Algeria.

Hyflux is distinctive in its ability to address the challenges at every point of the entire value chain of the water industry – from R&D in membrane technology, component manufacturing, process engineering, engineering, procurement and construction (EPC), to operations and maintenance (O&M), in addition to arranging for project financing of large-scale municipal water projects.

At the core of Hyflux's business is its membrane innovation that is focused on the development of membranes, membrane applications, and the design and development of membrane-based plants to deliver solutions for a wide range of applications in water treatment and industrial manufacturing processes. Today, Hyflux's membrane systems have been installed in more than 1,000 plants in over 400 locations worldwide.

Through its projects across the world, Hyflux has left an indelible imprint on the communities that it serves, driven by its commitment to deliver water that is clean, safe and affordable.

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