Technical Manual

MICRODYN NADIR

ADVANCED SEPARATION TECHNOLOGIES

MICRODYN-NADIR

MICRODYN BIO-CEL® XS-1 Pilot Plant

Manual

Headquarters
MICRODYN-NADIR GmbH
Building D512
Kasteler Straße 45
65203 Wiesbaden
Germany
info@microdyn-nadir.de
www.microdyn-nadir.de

USA Office
MICRODYN-NADIR US, Inc.
93 South La Patera Lane
Goleta, CA 93117
USA
info@microdyn-nadir.com
www.microdyn-nadir.com/en
www.microdyn-nadir.com/trisep

China Office
MICRODYN-NADIR (Xiamen) Co. Ltd.
No. 66 Jinting North Road Xinglin
Xiamen, China 361022
infochina@microdyn-nadir.com

Singapore Office
MICRODYN-NADIR Singapore Pte. Ltd.
18 Tuas Avenue 8
Singapore 639233
info@microdyn-nadir.com

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1 About this Document

This operating manual contains information about the MICRODYN BIO-CEL® XS-1 pilot plant. The plant is constructed for mobile applications at changing locations. The following chapters comprise descriptions of the general plant design and the test area as well as important operating information and safety instructions.

The suitability of the BIO-CEL modules installed in this plant for a special application depends on the quality of the medium to be filtered, the applied biology and its quality. The suitability also depends on keeping the directives for the process technology. In general, the BIO-CEL instruction manual must be considered for the operation of BIO-CEL modules.

All information in this manual corresponds to the actual knowledge of MICRODYN-NADIR. It should provide an overview of the most important data that are needed to operate the pilot plant. Please make sure that you always use the up-to-date version of this manual.

MICRODYN-NADIR reserves the right to update data due to new developments. The data given in this manual cannot be taken to claim warranties. MICRODYN-NADIR does not give guarantees for the performance or life time of the product used in the pilot plant.

MICRODYN-NADIR refuses responsibility for any defects occurring directly and indirectly with objects or persons if these defects are attributed to improper handling or to not complying with safety and operating conditions as mentioned in this manual respectively.

The system is property of MICRODYN-NADIR. Improper handling can result in defects of parts of the plant or the membrane module. Please check the system and the modules regularly by appropriate tests and measuring. If the filtrate quality worsens, this may be due to several reasons. Please insure just at the time of start-up that suitable measuring devices for the detection and prevention of possible defects are available.

Warranty claims are refused for any defects due to improper handling of the modules (see BIO-CEL manual) or to disregarding the operating parameters given in this operating manual or the module data sheet.

The leaser takes care of the correct return of the system to MICRODYN-NADIR. At the time of delivery, the pilot plant is cleaned, and it must be returned also clean. If the plant is not cleaned before return, all the costs for cleaning will have to be paid by the leaser.

All the components inside the system must be fastened before the transport to prevent sliding or falling. (Further instructions for the transport see chapter 0.)

Any defects at the pilot plant must be reported to MICRODYN-NADIR immediately. If defects are not reported, and therefore further defects occur, the emerging costs must be paid by the leaser.

In the case of failure or operation disruption please immediately inform your contact partner or MICRODYN-NADIR.

2 Safety & Warning

This operations and maintenance (O&M) manual highlights certain potential hazards related to handling, operation and maintenance of the equipment. The intent of this chapter is to supplement any safety and health standards that are applicable to the facility in which the equipment is being used. The manual does not cover the full spectrum of published safety and health standards that are mandated by law. Consequently, users should not assume that they are responsible only for those standards referenced in this manual or that those standards quoted are current. The user of this manual is responsible for ensuring that their own safety program and operation and maintenance procedures comply with all applicable safety rules, regulations and standards in accordance with prudent industry standards. In the event that the safety recommendations in this manual conflict with local safety and health laws, regulations and/or standards, the user is encouraged to follow the more stringent standard or law.

2.1 Safety Guidelines

It is highly recommended to follow the safety guidelines provided in this manual, to comply with applicable local safety rules, regulations and standards or to operate and maintain the equipment according to prudent industry practices. Failure to follow these safety guidelines, local safety rules, regulations and standards may result in a potentially hazardous situation. The severity of the potentially hazardous situations highlighted in this manual have been indicated using the symbols listed below.

Symbol	Meaning
DANGER	DANGER indicates an imminently hazardous situation. If not avoided, it may result in death, serious injury, or equipment damage.
WARNING	WARNING indicates a potentially hazardous situation. If not avoided, it may result in death, serious injury, or equipment damage.
CAUTION	CAUTION indicates a potentially hazardous situation. If not avoided, may result in injury or equipment damage.

DANGER - PRESSURIZED DEVICE: Improper installation, operation or maintenance of the equipment, including but not limited to the membrane units, electrical system and piping may result in loss of life, severe bodily injury and/or property damage. Please read and understand all equipment guidelines provided before attempting to open, operate or service the equipment. Failure to follow these instructions and observe precautions may result in malfunction and catastrophic failure. Misuse, incorrect assembly or use of damaged or corroded components may result in serious injury.

WARNING: Certain operating situations require the use of chemicals and other hazardous substances. Material safety data sheets (MSDS) should be provided by chemical suppliers and all instructions therein should be adhered to. Safety briefings for the operating personnel should be carried out by plant health and safety personnel. Always use caution and wear the correct personal protective equipment (PPE) when handling chemicals.

WARNING: Comply with all pressure and temperature limits specified in the technical data sheet when operating membrane products.

WARNING: The use of chemicals that are not approved or in concentrations higher than those specified, may cause premature failure of the equipment, including the membrane products.

WARNING: Do not perform any equipment or membrane maintenance unless the system control power is OFF, the pump starters are OFF, lock out/tag out procedures have been followed and internal pressure has been relieved from the equipment. Failure to do so may result in serious injury or death.

WARNING: Do not drink treated water. Treated water is not potable.

CAUTION: The membranes should not be allowed to dry out. The membranes must remain wet at all times including when the equipment is shut down or for maintenance. Dried out membrane may result in irreversible membrane damage.

CAUTION: No anti-foam agents of any kind are to be added into the equipment, without prior review and written approval from MICRODYN-NADIR. If approved, the anti-foam agents should only be used in accordance with the conditions specified by MICRODYN-NADIR.

CAUTION: Silicone-based materials, such as waterproofing sprays, lubricating or cutting fluids, or greases, should not be used in or around the equipment. Using these materials may result in complete and irreversible membrane fouling.

2.2 DOs & DON'Ts

DO – Conduct a site-specific safety review before installation and operation of the equipment.

DO – Install and operate the equipment following the recommendations within this manual.

DO – Familiarize yourself with this entire manual and the equipment, including the controls, before attempting to operate or perform maintenance on the equipment.

DO – Follow equipment manufacturer recommendations for operation and maintenance.

DO – Wear the appropriate personnel protective equipment.

DO – Routinely inspect for wear and tear on equipment and perform maintenance when necessary.

DO – Monitor the equipment's performance and maintain log sheets.

DO – Contact MICRODYN-NADIR with any questions or concerns related to the equipment.

DO – Follow all applicable safety practices and precautions.

DON'T – Install or operate the equipment without knowledge of its operations.

DON'T – Allow unqualified personnel to operate or perform maintenance on the equipment.

DON'T – Allow unsafe conditions: such as water on the floor, worn equipment, exposed wires, etc.

DON'T – Exceed the mentioned thresholds (i.e. for temperature, pressure, chemical limits) of the membrane and/or equipment.

DON'T – Use chemicals without prior review and understanding of their MSDS information and compliance with applicable safety precautions.

DON'T – Use chemicals which have not been approved by MICRODYN-NADIR in writing.

DON'T – Operate the system for purposes other than those described in this manual.

DON'T – Allow the biological processes to perform differently from their intended conditions.

2.3 General Operational Safety

Symbol	Instruction
	Wear a safety helmet.
	Wear safety shoes.
	Read the manual before using the product.

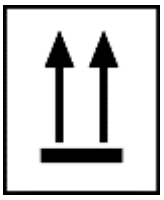
2.4 Interim Storage

The membrane modules have a shelf life of 12 months when stored according to the conditions below. More details regarding decommissioning and storage are given in Chapter 8.

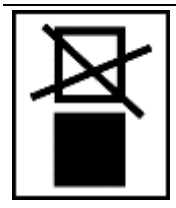
⚠ Caution

INSTALL THE MEMBRANE MODULE INTO THE TANK DIRECTLY PRIOR TO WATER COMMISSIONING.

Symbol	Instruction
	Do not place the product under direct sunlight.
	Do not exceed a humidity of 70 % during storage. Do not place the product in rain. The membrane is preserved and after the preservative is washed out, the membrane module should be kept wet at all times to prevent irreversible damage from drying out.
	Store within the following temperature range only: 5-40°C (41-104°F). Note that this product is not frost-resistant.

Symbol	Instruction
	Always place the product upright unless stated differently in a specific instruction document.
	Handle the product with care. No direct contact with the membrane itself should occur. Ensure that no damage occurs to the membrane during transport, assembly and installation. Do not separate the membrane sheets if they are attached to each other.
	Do not damage the outer packaging at the top of the product with knives or sharp tools. The product must be stored in the delivered packaging till commissioning is performed.

2.5 Transport & Handling

Symbol	Instruction
	Only use the eye bolts at the lifting points for elevating the product.
	Do not step or stand under a suspended load.
	Be cautious of forklift traffic.
	The product is top-heavy.
	Do not stack the product.

2.6 Modifications

MICRODYN-NADIR must be notified of any modifications to the product or any provided parts.

2.7 Commissioning

The commissioning process should be performed by personnel trained by MICRODYN-NADIR or under the supervision of MICRODYN-NADIR.

2.8 Operation

Ensure the proper use of all equipment e.g. pumps, blowers. Contact the manufacturer of these devices for handling instructions.

The membrane is preserved and after the preservative is washed out, the membrane module should be kept wet at all times to prevent irreversible damage from drying out.

2.9 Cleaning & Storage Chemicals

To safely perform chemical cleanings and safely store chemicals, please follow the instructions provided by the chemical manufacturer. The pH range and maximum concentration for chemicals used for cleaning purposes should not exceed the limits of the MICRODYN BIO-CEL® MBR module as listed on the module data sheet. For further information, please contact the chemical manufacturer.

3 Product Description MICRODYN BIO-CEL® XS-1

The MICRODYN BIO-CEL® XS-1 is a very compact membrane module for pilot testing and small-scale applications. It combines the membrane unit and the aeration system into one easy to handle module.

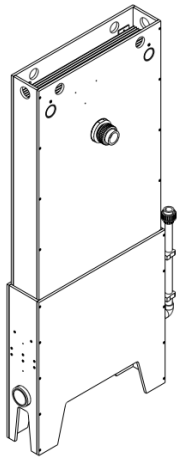


Figure 1. BIO-CEL XS-1 module

3.1 Membrane

The membrane used is the NADIR®-UP150, a membrane specifically developed for MBR applicationsThis membrane has been used for numerous MBR plants worldwide. The membrane is characterized by an excellent chemical and mechanical durability. It is also hydrophilic, which allows high flows with a low fouling potential.

Table 1: NADIR-UP150 properties

Material	polyethersulphone (PES)
Nominal pore size	0.04µm (150 kDa).
Allowable pH range	2-11
Allowable temperature range	40 °C
Preservative	Glycerine 20% / Sodium benzoate 3%

3.2 Laminate

The membrane is fused with a drainage layer (polyester) in a lamination process. A solid connection and at the same time a high water permeability are realized with this process. This compound creates a backwashable membrane laminate (

Figure 2). This self-supporting membrane laminate with only 2 mm thickness has a high packing density and a low specific weight.

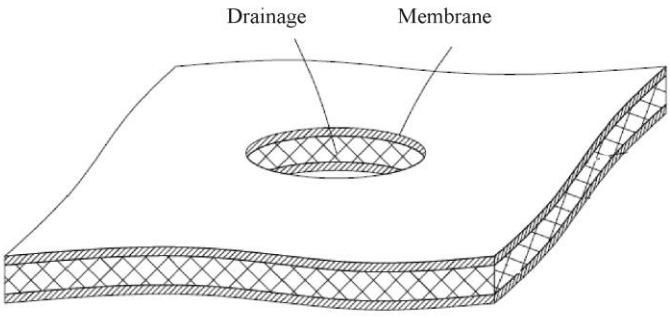


Figure 2. BIO-CEL Laminate

3.3 Module

The single laminate sheets are combined in the module. The module housing provides protection for the membranes and mechanical stability. It also helps to direct the cross flow of air and activated sludge through the laminate sheets.

The membrane modules of the MICRODYN BIO-CEL® XS-1 series are made of polyethylene (frame), PVC (membrane cassettes and aeration system) and a few parts of stainless steel (clamping elements). They are resistant to corrosion when used in activated sludge. The aeration system is integrated in this module and is located at the base of the module. The air is required in order to generate a small amount of cross flow in the module and on the membrane surface in order to be able to discharge the sludge out of the module. The pressure differences and the turbulences created by the air dissolve adhering particles from the membrane surface. The fine-bubble aerators are made of polyurethane (PUR) with small slit openings to achieve the highest possible oxygen yield and to prevent sludge penetration even when the modules are in stand-by.

Table 2: BIO-CEL XS-1 module properties

Housing material	Polyvinyl chlorides (PVC), Polyethylen (PE)
Dry weight	45kg (99lb)
Length	280mm (0.9ft)
Width	747mm (2.5ft)
Height	1515mm (5.5ft)
Diffuser Material	Polyurethane (PUR), Polypropylene (PP)
Nominal membrane area	10m² (108ft²)

4 MICRODYN BIO-CEL® XS-1 Pilot Plant

The pilot plant solely contains the membrane filtration part for separating cleaned waste water from activated sludge – the main pre-treatment steps (mechanical pre-treatment) is not part of the pilot plant. You may use the integrated 1 mm inlet screen as a final step of the pre-treatment or directly guide the pre-treated waste water to the filtration tank. Instructions for the construction of the pre-treatment can be found in the MICRODYN BIO-CEL® Design Guidelines.

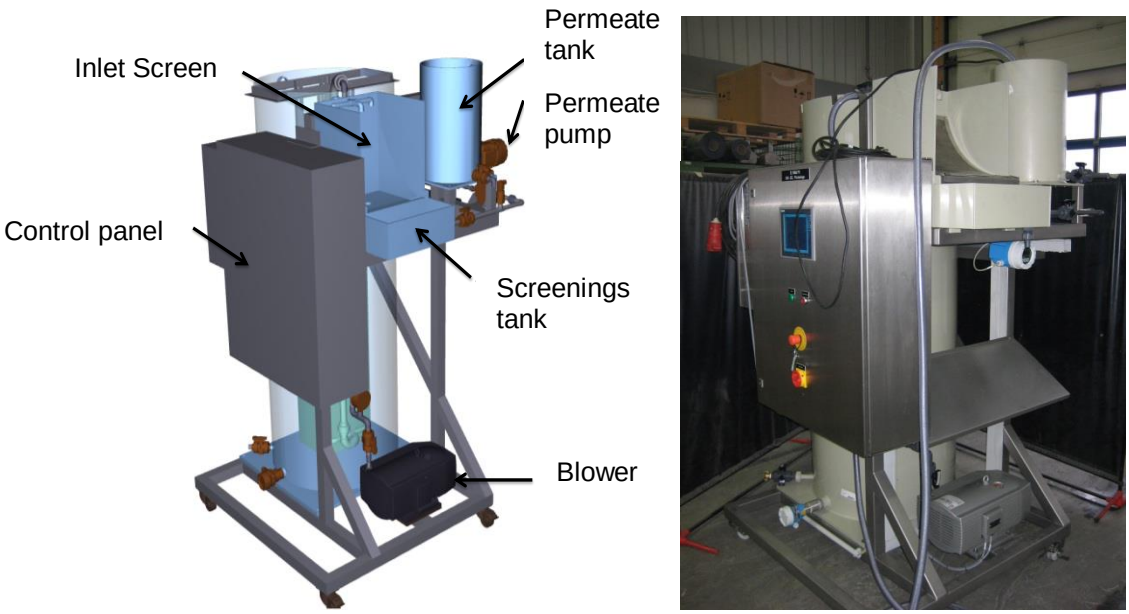


Figure 3. drawing (left) and photo (right) of the pilot plant

4.1 Equipment

The equipment installed in the pilot plant is listed below. The specifications are equal to the specifications in the P&ID (Figure 5. P&ID of the pilot plant).

Table 3: Overview of equipment

Specification	Abbreviation	Description	Remark
Membrane module		1 x BIO-CEL XS-1	10m² membrane surface
Tanks	B1	Inlet tank screen	1mm bar screen
	B2	Screenings tank	Not on P&ID
	B3	Filtration tank	900 L
	B4	Permeate tank	35 L
Pumps	P1	Feed pump	(not included in delivery)
	P2	Permeate pump	80 – 250 L/h
Blower	G1	Blower for cross flow aeration	
Sensors	PICR	Pressure sensor permeate	
	FICR	Flow meter permeate	
	LS	Level permeate tank	
	LSIC	Filling level membrane tank	

Specification	Abbreviation	Description	Remark
	TIR	Temperature aeration tank	
	TI	Temperature air	
	PI	Pressure indicator air	
	FI	Flow indicator air	
Valves	V6	Excess sludge outlet / drain	
	V7	Permeate pipe	
	V8	Permeate sampling	
	V9	Permeate pipe	
	V10	Air pipe	
	V11	Air pipe	

4.2 Functional Description

The MICRODYN BIO-CEL® XS-1 pilot plant serves to separate the aerated sludge from cleaned waste water by means of membrane filtration. The aeration tank of the pilot plant is fed with the mechanically pre-treated waste water via flexible pipes. Before the effluent reaches the filtration tank it is flowing through a 1mm bar screen to remove any coarse materials (optional). The filtration tank is a round tank with an inner diamerter of 75cm and houses the membrane module. It is possible to operate the filtration tank with an intermittent denitrification, in this case a separate anoxic tank for the denitrification is not required.

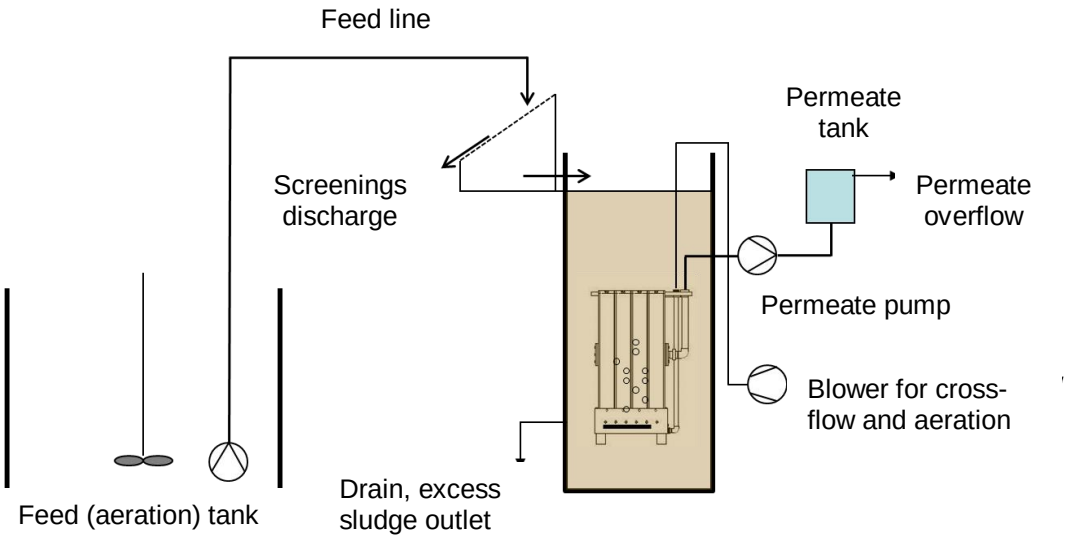


Figure 4. Pilot plant and auxiliary equipment

The raw waste water is transported into the plant by means of an external pump. Feed supply and sludge discharge are not part of this plant. They must be provided by the leaser.

The membrane filtration process consists of the steps:

- filtration
- backwashing
- relaxation
- (de-aeration)

- cleaning

During filtration permeate is sucked through the membranes. After regular and well-defined periods of time a so-called periodical backwashing is made to keep the membrane surface free of deposits. In doing so, the permeate pump delivers permeate against the filtration direction.

There is always a relaxation period between the two modes of filtration and backwashing. This period is called relaxation phase. Usually, in longer, regular time delays the permeate pipe is de-aerated. Due to the arrangement of the permeate tank, de-aeration is not necessary in this special case. Cleaning procedures are carried out after definite periods of times to maintain the membrane permeability. The exact description and the operation principle of the MICRODYN BIO-CEL® XS-1 modules are to be taken from the BIO-CEL operation and maintenance manual.

The plant is controlled via the integrated touch panel at the switch cabinet. A detailed description is given in chapter 7.

4.3 Connections and Interfaces

4.3.1 Waste water/ sludge supply

The pilot plant may be operated with aerated sludge from a biological cleaning facility (e.g. a waste water treatment plant) or with raw waste water (after mechanical pre-treatment).

The leaser/operator will use his own pump or feed supply (e.g. by means of controlling the valve via level differences). The feed pipe from the feed source to the connector at the pilot plant is supplied by the leaser/operator.

4.3.2 Clean water supply

The MBR pilot plant must be provided with clean water. The leaser/operator has to make sure that clean water is supplied to the plant, because it is needed for intensive cleaning as well as for the start-up and shut-down procedures.

4.3.3 Permeate discharge

The cleaned waste water (permeate) is discharged from the plant in free fall.

The drain pipe from its connection to the pilot plant to the suitable terminal reservoir is provided by the leaser/operator. The proper and professional discharge and disposal has to be warranted by the operating company.

4.3.4 Filtration tank overflow

The pilot plant is equipped with an emergency overflow of the filtration tank. This overflow must be connected to the drain or to the waste water feed tank.

4.3.5 Surplus sludge

Surplus sludge is discharged by a manual valve (V6) near the bottom of the filtration tank. The drain pipe from this connection to a suitable terminal reservoir is provided by the leaser/operator.

The proper and professional discharge and disposal has to be warranted by the operating company.

4.3.6 Power supply/emergency shutdown

Electric power is supplied via a main high-voltage lead (16A), and an appropriate electrical connection must be provided by the leaser/operator.

5 Installation

The installation and adjustment of technical components of the MICRODYN BIO-CEL® XS-1 pilot plant must imperatively be done by expert staff. The pilot plant must be operated by personnel trained by MICRODYN-NADIR. The operation of the pilot plant must be monitored by expert staff.

The pilot plant must be installed horizontally on a plane surface.

Figure 3 shows a possible setup for system integration of the BIO-CEL XS-1 pilot plant. The following works needed to be performed before commissioning date:

1. All tanks which are intended to be used for piloting must be cleaned.
2. Connect all auxiliary tanks and pipes according to chapter 4.3.1 - 4.3.5.
3. The membrane module is stored with a preservative solution. Avoid wetting the membranes until the pilot plant is ready for commissioning. Once wet, the membranes have to remain submerged in water at all times.
4. Prepare a recent water analysis of the feed water (including at least COD/BOD/NH4-N, TP and TSS)

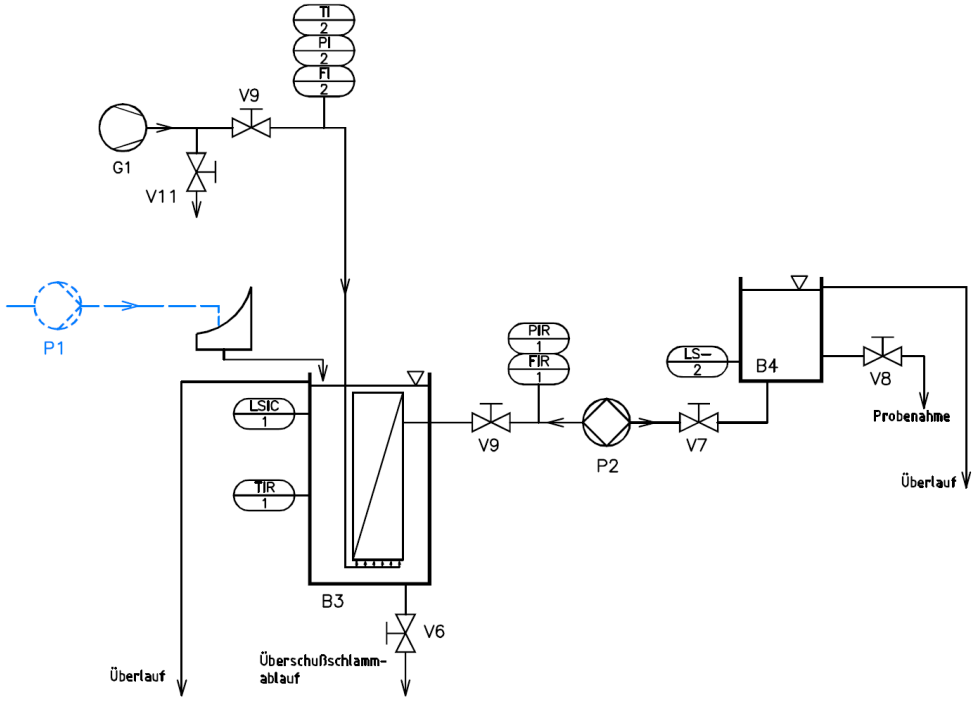


Figure 5. P&ID of the pilot plant

6 Commissioning

Before the start-up the instructions of the MICRODYN BIO CEL® Operation and Maintenance manual are to be adhered imperatively. For start-up a supervisor of MICRODYN-NADIR is recommended onsite.

6.1 Start-up

1. Connect electricity
2. Fasten all screw connections of pipes
3. Check, whether the hand valves are easy to move, and control the valve positions

6.2 Start-up with clean water

In starting-up with clean water all components are tested with respect to functionality. Leakages must be eliminated, and program parameters may be corrected.

1. Fill clean water into the filtration tank up to the overflow (in ideal case let the water overflow continuously).
2. Fill clean water into the permeate tank, permeate piping will be filled as well.
3. Open manual valves V7, V9, V10, V11
4. Switch on panel
5. All electronically controlled actuators/sensors have to be checked in manual operation (see instruction manual for the plant control)

    a) Check the pump performance (never run pump with closed V7 and/or V9)
    b) Check the blower performance (adjust V10 and V11 in a way to achieve **5-6 Nm^3/h** air flow)

⚠ **CAUTION**	Air flow to diffuser must not exceed 6 Nm^3/h. Too high air flow can cause irrevocable damage of diffuser.

Notice: In the beginning increased foaming will be noticed, due to the stabilizing agent on the membranes. Thus, during the start-up procedure, the filtration tank should once be emptied completely and refilled with water to wash out the stabilizer.

6.3 Start-up with aerated sludge

Before the plant can be operated in the automatic mode, all fault messages and the communication with external components (e.g. with a feed pump) must be checked.

Feed flow and effluent flow must be checked.

The permeate pipe must be de-aerated often during the first filtration cycles, until all air has passed from the system.

At the beginning of the pilot phase the plant is operated with aerated sludge without sludge discharge to achieve the designated TSS concentration of about 10-12 g/l as possible fast. The age of the seed sludge should be at least 5 days.

7 Operation

The MICRODYN BIO-CEL® XS-1 module is operated as dead end filtration, but with air crossflow, which is induced by a blower. The permeate pump is controlled by the given flow. The cycle of filtration is:

- Filtration (510 s standard operation)
- Relax 1 (50 s standard operation)
- Back washing (30 s standard operation)
- Relax 2 (10 s standard operation)

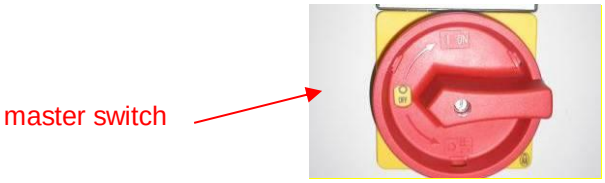
The above listed intervals are freely adjustable within a certain range, so that a flexible adaptation to the operational conditions on site is possible. Plesae note, that usually a regular de-aeration is necessary for propper function of the filtration stage. Due to the position of the permeate tank, the permeate system de-aerates trough the tank automatically, so that no separate de-aeration step is necessary.

For backwashing the conveying direction of the permeate pump is changed. Filtrate from the permeate tank is pressed into the membrane pockets, reversing the flow and removing the filter cake and all particles that have entered the membrane pores. In addition to the back washing, the air crossflow remains on to clear the removed particles off the membrane surface. For this, the permeate tank must always be filled. The allowable pressure during backwashing is limited to avoid membrane damage.

An accumulation of air bubbles in the permeate line due to outgassing can occcur, especially during high transmembrane pressures. To avoid this effect, the permeate tank is situated at the highes point of the permeate line so the air can easily escape.

The pilot plant runs fully automated after the initial start up.

The power supply of the plant can be interrupted by means of a master switch at the switch cabinet in the control cabinet.



In emergency cases the plant can be shut down as follows:

Shutdown of the feed pump (P1) and shutdown of the permeate pump (P2) at the control computer. To switch off the power supply turn the master switch in position “0”.

7.1 Operational Sequence and PLC Settings

The operation sequence starts with filling the filtration tank with waste water. The filling sequence is triggered by the level sensor in the filtration tank. Filling ends when the max level in the filtration tank is reached and starts again when the min level is reached.

The next step is the denitrification phase (if required). During this phase, the aeration is mainly switched off to maintain anoxic conditions in the filtration tank. The blower is only running for short amounts of time to ensure the sludge is properly mixed. The duration of the denitrification phase is controlled by a timer and can be adjusted to match the local requirements, if not required set T_{DN} to 0.

After the denitrification follows the filtration. To start this phase, there is a pre-aeration cycle to get the sludge mixed. The pre-aeration also serves as an initial cleaning of the membrane surface. The duration of the pre-aeration is adjustable.
Next comes the filtration, which consist of 4 steps (filtration, relaxation 1, back washing and relaxation 2), as mentionend previously. During filtration the level inside the filtration tank will go down. Filtration will continue until the level hits the min level. Once this happens the operation sequence starts anew with the filling sequence.

The operation sequence as well as the recommended settings are descibed in Table 4: Overview of operation settings.

Table 4: Overview of operation settings

Operation step	Description	Settings	Recommended
Filling of the aeration tank (FILL)	Feed pump starts at L_{min} and stopps at L_{max} Blower off	L_{MIN} = 150 – 160 cm L_{MAX} = 165 – 175 cm	L_{MIN} = 155 cm L_{MAX} = 170 cm
Denitrification (DN)	Denitrification with intermittent aeration for sludge mixing	T_{DN} = 0 - 99 min	T_{DN} = 30 min
	Intervall between the aeration times Blower off	$T_{DN,DELAY}$ = 0-99 min	$T_{DN,DELAY}$ = 10 min
	Aeration for sludge mixing Blower on	$T_{DN,MIX}$ = 0-99 sec	$T_{DN,MIX}$ = 10 sec
Filtration (FN)	Pre-aeration to make sure the sludge is well aerated and mixed Blower on	T_{PRE} = 0-99 min	T_{PRE} = 10 min
	Filtration, Permeate pump is running Blower on	T_{FILT} = 0-999 sec Q_{FILT} = 80-250 L/h	T_{FILT} = 510 sec Q_{FILT} = 130 L/h
	Relax 1 Back wash (Permeate pump running in reverse) Relax 2 Blower on	T_{R1} = 0-999 sec T_{BW} = 0-999 sec Q_{BW} = 80 – 500 L/h T_{R2} = 0-999 sec	T_{R1} = 50 sec T_{BW} = 30 sec Q_{BW} = 130 L/h T_{R2} = 10 sec

There are start and stop ramps for the permeate pump to avoid sudden pressure shocks in the system. These rams are pre-set and cannot be changed. The ramping time is set to T_{RAMP} = 5 sec. The up ramp is always part of the pump interval, the down ramp is part of the following interval.
Example: The permeate pump is set to run for 510 sec., followed by 50 sec. relaxation. The actual runtime will be 5 sec. ramping up, 505 sec. running at target flow, 5 sec. ramping down followed by 45 sec. relaxation.

Figure 6 to 11 show the control panel graphics to navigate trough the PLC settings.

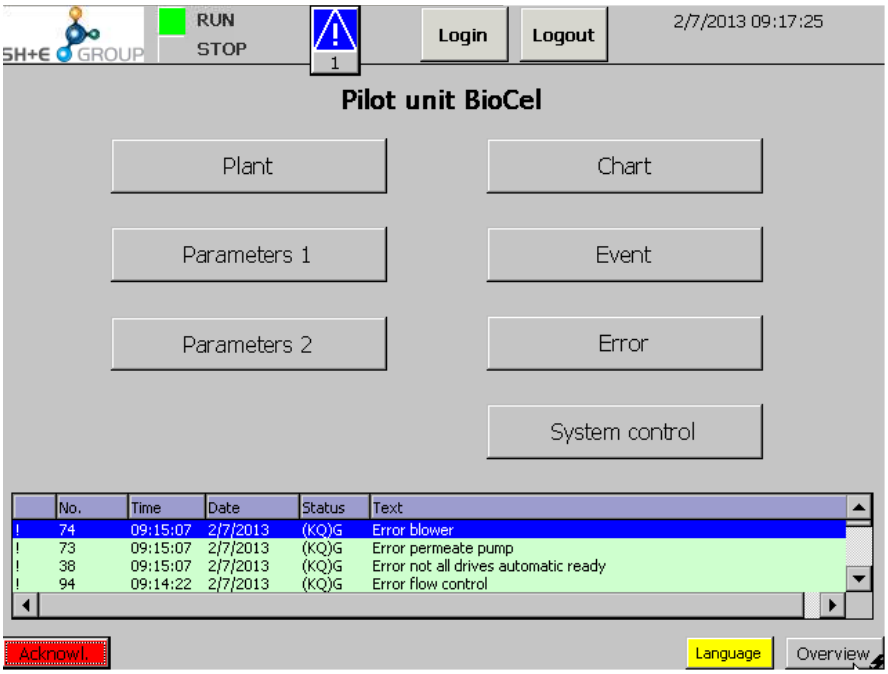


Figure 6: Control Panel – Overview

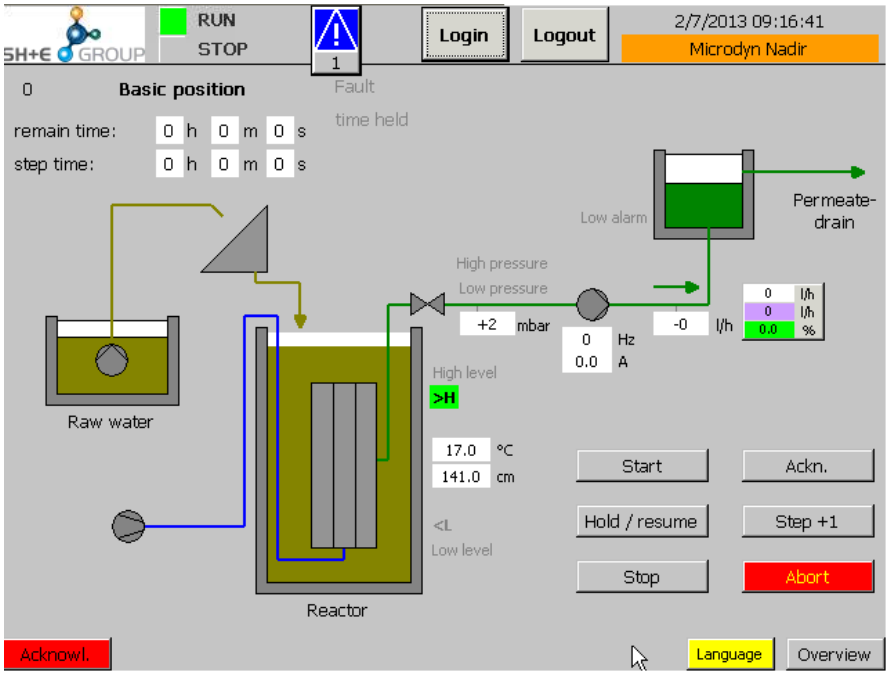


Figure 7: Control Panel - Plant

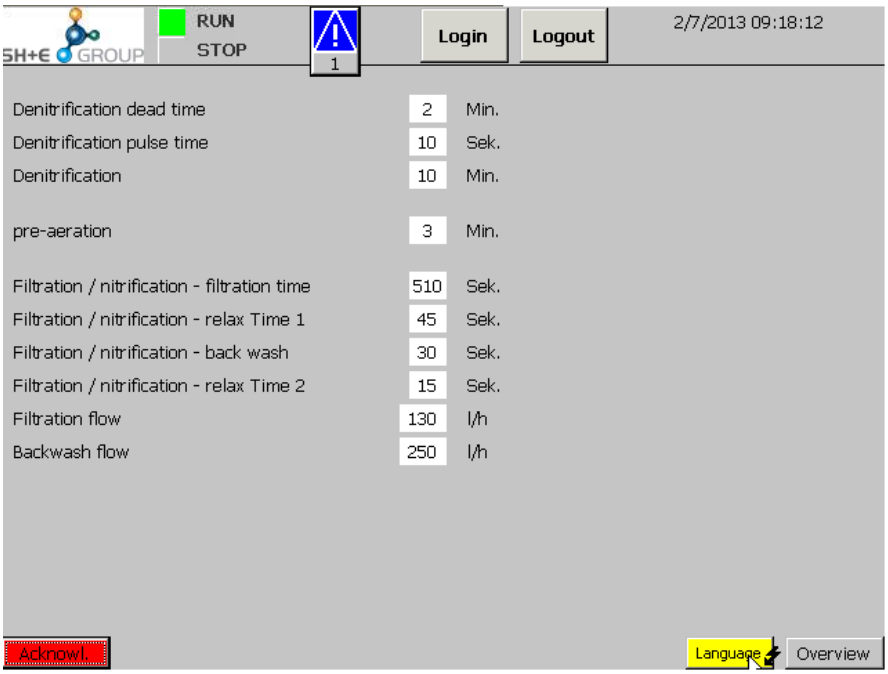


Figure 8: Control Panel – System Control

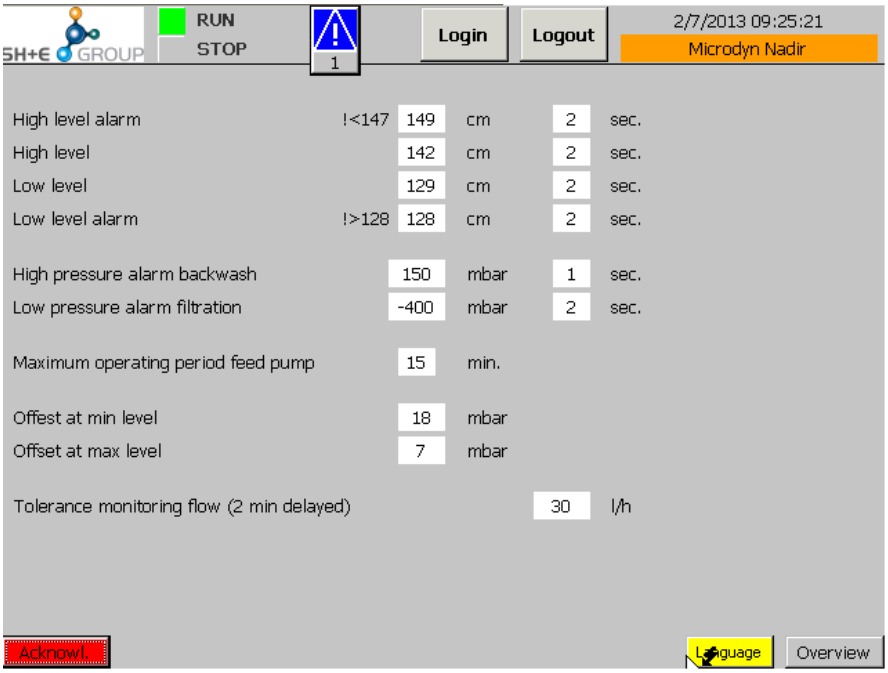


Figure 9: Control Panel – Parameters 1

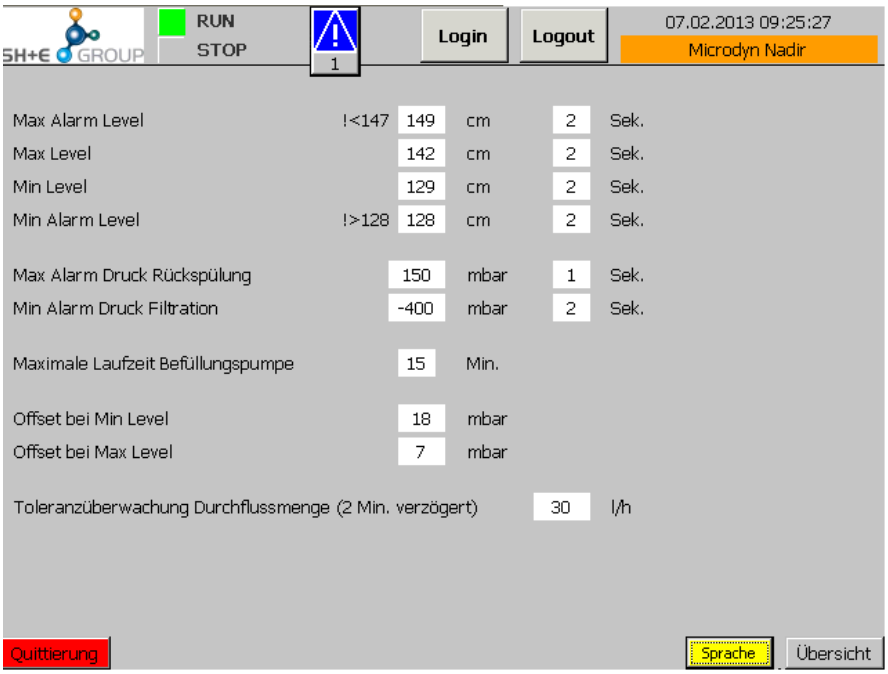


Figure 10: Control Panel – Parameters 2

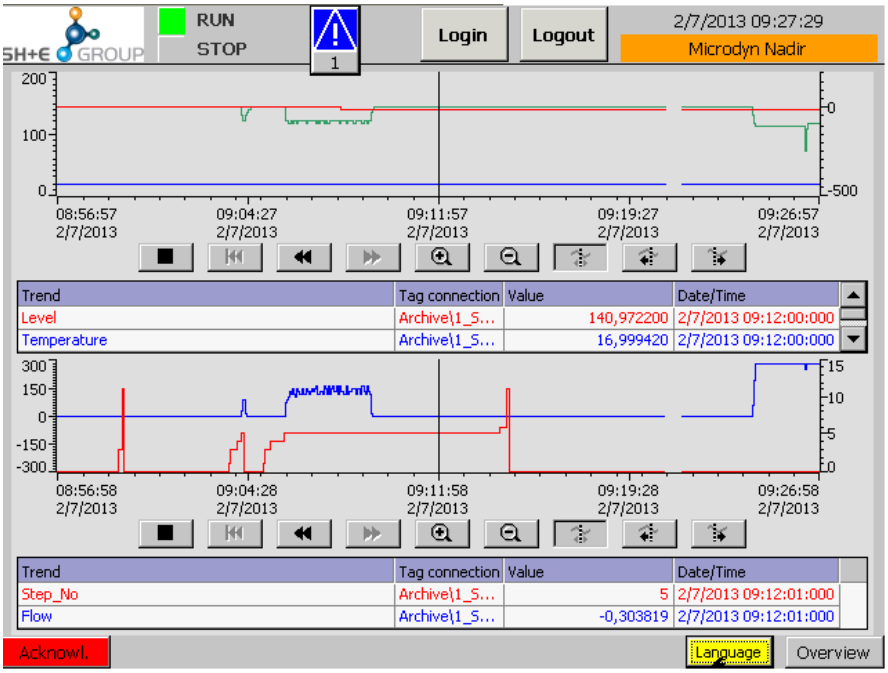


Figure 11: Control Panel – Chart

7.2 Cleaning

Depending on the type of fouling and required cleaning, a sodium hypochlorite solution, citric acid solution or combinations of the two may be required. Sodium hypochlorite is used to remove organic and biological fouling from the membrane while citric acid is used to remove mineral scaling such as iron, metal salts or calcium salt and other scaling compounds.

Important Information

SODIUM HYPOCHLORITE

AVOID EXPOSURE TO HEAT AND DIRECT SUNLIGHT!

- STORE IN COOL (T <15°C or 59°F) AND DARK CONDITIONS
- PLEASE NOTE THAT THE ACTIVE CHLORINE CONCENTRATION WILL DEGRADE OVER TIME AND RENDER CLEANING SOLUTIONS LESS EFFECTIVE OVER TIME.

To safely perform chemical cleanings and safely store chemicals, please follow the instructions provided by the chemical manufacturer. The pH range and maximum concentration for chemicals used for cleaning purposes should not exceed the limits of the MICRODYN BIO-CEL® MBR module as listed on the module data sheet. For further information, please contact the chemical manufacturer.

In full-scale applications, regular cleaning (maintenance cleaning) is done by dosing chemicals directly into the backwash flow of the permeate pipe. The MICRODYN BIO-CEL® XS-1 pilot plant has no automatic cleaning integrated, cleaning needs to be done manually.

The frequency of cleaning depends on several factors such as:

- Temperature corrected permeability
- Type and chemistry of wastewater
- Scaling and fouling potential
- Membrane conditions (extent of fouling)
- Efficiency of production cycles (backwash and relaxation)
- Operating temperature
- Pretreatment efficiency
- Completeness of biological degradation
- Permeate flow rates
- Aeration intensity

For all municipal and most industrial applications with systems using MICRODYN BIO-CEL® MBR modules, the maintenance cleaning frequencies are 1-2/week with Sodium Hypochlorite and 1/2week with citric acid.

Please check and note the normalized permeability before and after the chemical cleaning. A template for a chemical cleaning log book is provided in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** of the MICRODYN BIO-CEL MBR Operation and Maintenance Manual and is used to collect essential data for continuous improvement of the cleaning strategy.

This maintenance cleaning can be done for a biomass/process. The maintenance cleaning procedure is summarized below:

Table 5: Maintenance Cleaning procedure*

Steps	Procedure
1	Stop feed pump, stop filtration. Continue to aerate membranes for 5 minutes.
2	Backwash clean water manually.

Table 5: Maintenance Cleaning procedure*

Steps	Procedure
3	Prepare chemical solution with target concentration (250 mg/L sodium hypochlorite or 2,000 mg/L citric acid) and fill permeate tank with solution.
4	Backwash membranes till min level in permeate tank.
5	Soak membranes for total of 240 seconds.
6	Repeat steps 3,4 5 for total of 3 chemical backwash and relax (soaking time) cycles.
7	Backwash membranes in the train for 360 seconds (or longer if needed for larger systems) without adding chemicals to flush out the chemicals from piping.
8	Open the valves that isolate the filtration tank.
9	Turn on mixed liquor recirculation pump and membrane aeration for 5 minutes.
10	Resume normal operation.

Note: Numbers presented in this table are used as a starting point and may need to need to be adjusted for each project.

This cleaning method is very close to the regular maintenance cleaning for full-scale applications. Alternatively or additionally a recovery cleaning can be performed. The recovery cleaning is usually performed 1-2 times per year and with higher shemnical concentrations. The cleaning solution must be prepared in an external tank and pumped to the cleaned filtration tank. The membranes stay in thie solution for several hours. Depending on the fouling degree and the frequency of this cleanings, above concentrations could be applied or even higher up to 2000 mg/L sodium hypochlorite or 5000 mg/L citric acid.

Table 6: Recovery Cleaning procedure*

Steps	Procedure
1	Stop feed pump, stop filtration. Continue to aerate membranes for 5 minutes.
2	Backwash clean water manually.
3	Drain the filtration tank completely and wash out all sludge residulas.
4	Prepare chemical solution (around 800 L) with target concentration (250-2000 mg/L sodium hypochlorite or 2000-5000 mg/L citric acid) in an external tank.
5	Pump chemical solution into filtration tank.
6	Soak membranes for around 6 hours.
7	Drain the filtration tank and flush with water.
8	Fill the thank again with sludge.
9	Open the valves that isolate the filtration tank.
10	Turn on mixed liquor recirculation pump and membrane aeration for 5 minutes.
11	Resume normal operation.

Note: Numbers presented in this table are used as a starting point and may need to need to be adjusted for each project.

8 Shut-Down and Transport

In shutting-down the MICRODYN BIO-CEL® XS-1 pilot plant before transport the following steps should be followed:

1. End the control program and switch off the control cabinet.
2. Disconnect the power line to the pilot plant
3. Drain the filtration tank and dispose of the sludge through proper channels.
4. Rinse and clean all tanks and pipes with permeate water.
5. Stabilize the module with a preservative solution (see MICRODYN BIO CEL® Operation and Maintenance manual).
6. Empty all tanks and pipes totally

   → all valves must be open during transport (hand valves and motor valves)
7. Prepare the pilot plant for transportation and inform MICRODYN-NADIR

NOTE: Don´t ship the pilot plant without conformation of MICRODYN-NADIR .