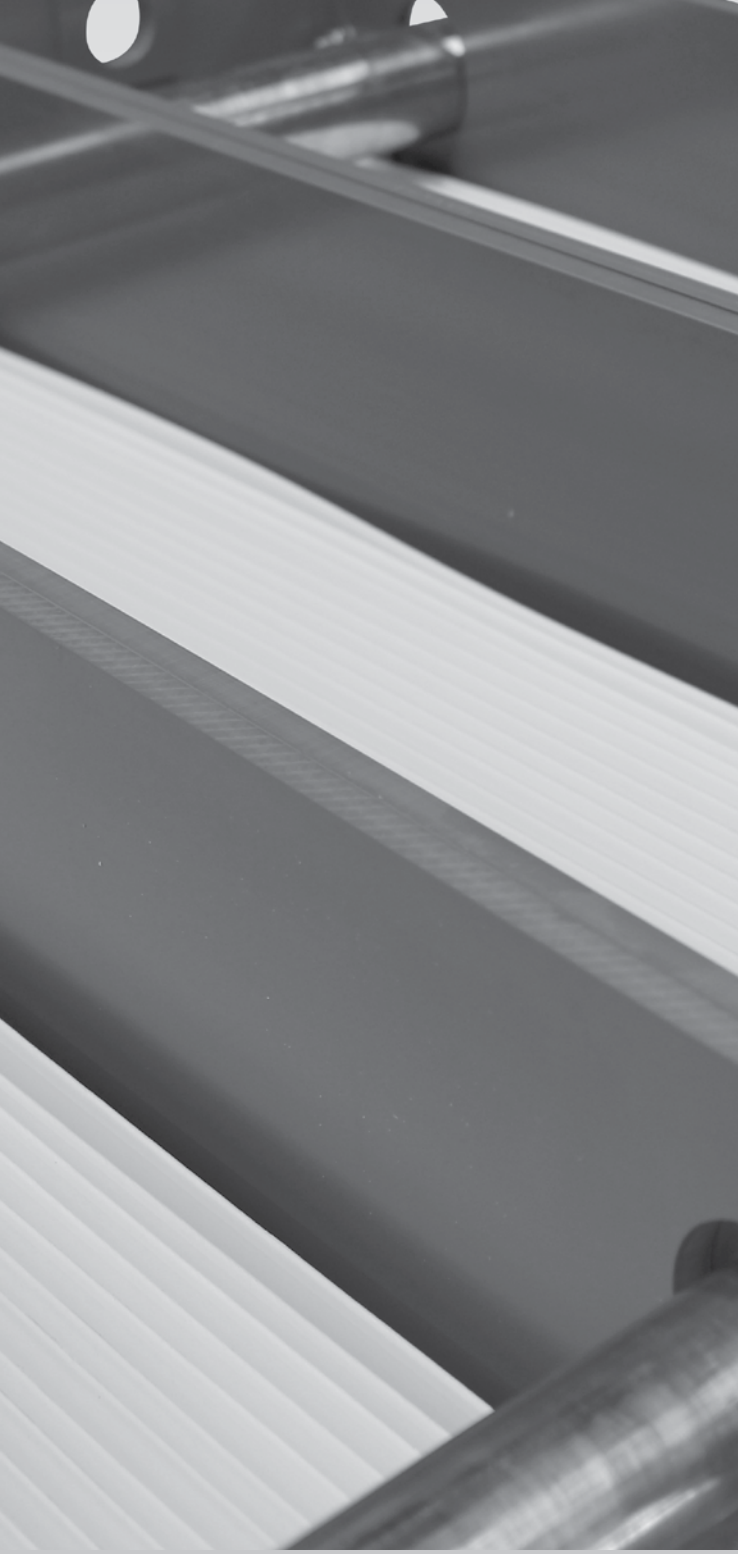
BIO-CEL®-MCP

Mechanical Cleaning Process

SELFHEALING MEMBRANE LAMINATE

MICRODYN NADIR

ADVANCED SEPARATION TECHNOLOGIES



BIO-CEL®

Submerged MBR Modules

The MBR process is the most advanced wastewater treatment process currently available and offers many advantages over conventional water treatment systems. The submerged BIO-CEL® membrane modules replace space-intensive secondary clarifiers which results in minimal footprint and safely separate the purified wastewater from the biomass.

Thus, a continuously high effluent quality is ensured, which also meets the hygienic requirements set forth by the European Bathing Water Directive and California Title 22. Moreover, the biomass concentration can be increased considerably, resulting in much smaller reactor volumes.

Even in case of damage caused to the membrane the high effluent quality can be assured. The spacer material used for the construction of the BIO-CEL® laminate allows for a sealing of the damage through the help of the biomass in the system.

Even after the occurence of a severe detraction of the membrane laminate, solids and bacteria can still be rejected by the membrane laminate. Laboratory tests have proven that the membrane laminate “heals” itself in less than two minutes even under worst case conditions.

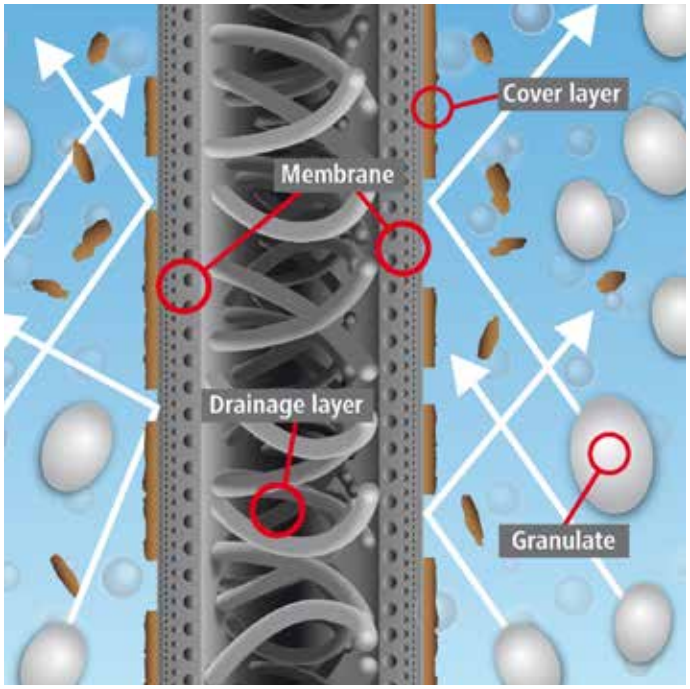
In the MBR process, the submerged BIO-CEL® ultrafiltration membranes are protected against membrane fouling in a multi-stage process. Besides the process-integrated aeration (crossflow along the membranes) and periodic backflushing/ relaxation phases, chemical cleaning may also be used to reduce the fouling layer. The chemicals effectively clean the membrane surface, thereby restoring its original permeability and enabling stable and reliable process operation.

On the one hand, membrane bioreactors represent progressive technology for the biological treatment of wastewater but on the other hand, the energy demand is in many cases higher compared to conventional treatment options.

This augmented energy demand is mainly caused by the additional aeration which induces the crossflow aeration of the membrane. Approximately 50-70 % of the required energy is used for aeration.

Energy optimization through BIO-CEL®-MCP

(Mechanical Cleaning Process)



As a further process-integrated feature, the BIO-CEL® membrane module can also be cleaned mechanically, through the use of the patented BIO-CEL®-MCP [2] (Mechanical Cleaning Process), which helps to reduce operating costs as well as to minimize the energy demand. This innovative process reduces the formation of a fouling layer. The membrane cleaning process is being supported by the crossflow aeration and the use of the cleaning efficiency of inert, organic material (MCP granulate).

The MCP granulate is added directly into the activated sludge. The airflow induced by the module-integrated membrane aeration system draws the MCP granulate up between the membrane sheets. As the MCP granulate rises, the membrane area is continually cleaned through the direct contact of the granulate with the sludge on the membrane surface. The fouling layer formed during the filtration process is removed reliably without compromising the functionality of the membrane.

In the downstream area outside the membrane modules, the current draws the granulate back to the base of the module where it enters again into the upstream flow. The MCP granulate has been designed for permanent usage. It is retained in the filtration tank by suitable separation systems.

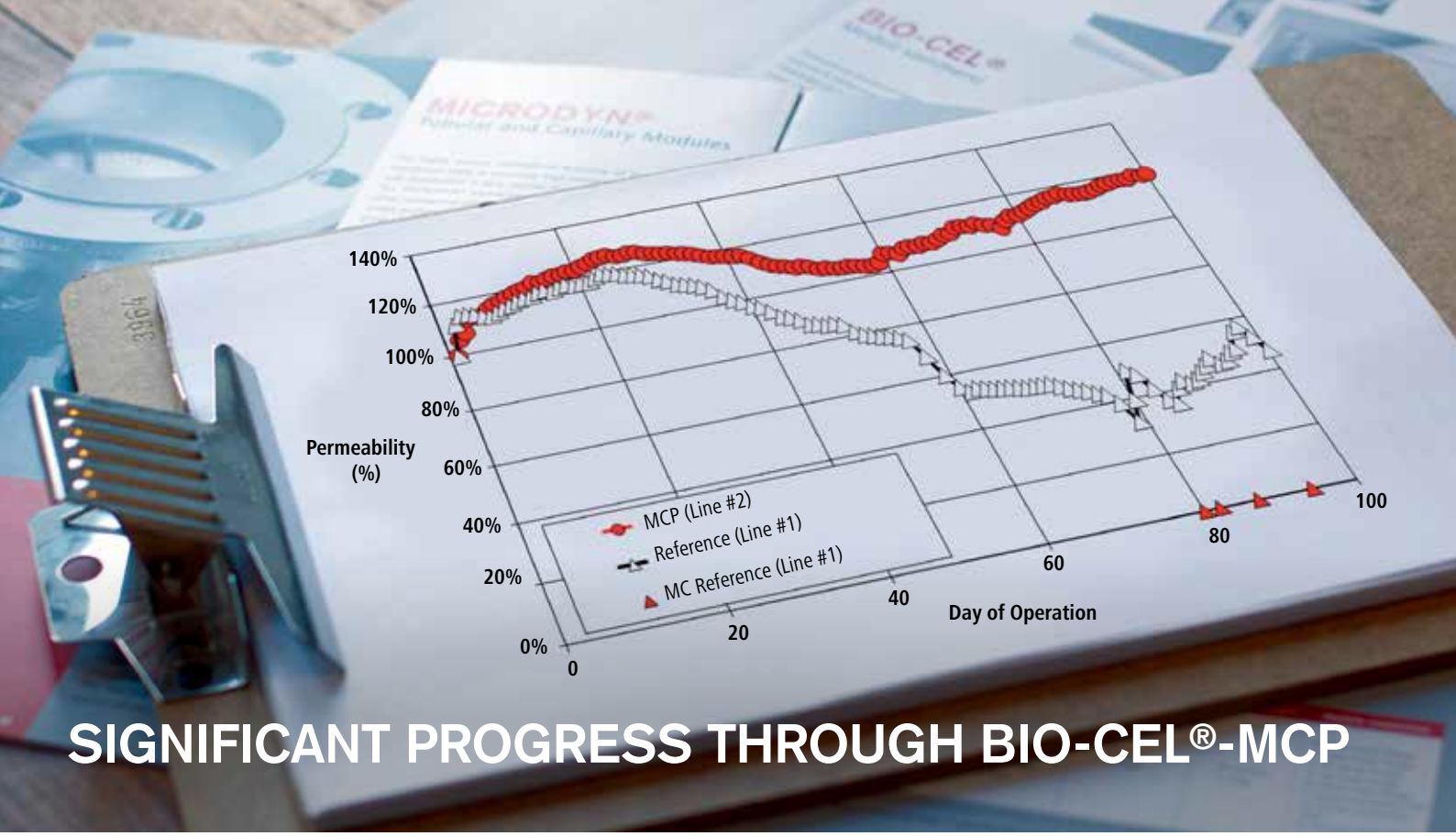
This mechanical cleaning can only be used in conjunction with BIO-CEL® modules, because other module types do not incorporate the required constructional and hydraulic characteristics to perform a mechanical cleaning.

Long-term testing shows that a chemical free operation is possible. The efficiency and reliability of the MCP technique could be proven by the continuous operation of a pilot plant for two years. Other large scale applications have been operating successfully for a number of years.

MAJOR ADVANTAGES OF THE BIO-CEL®-MCP:

- **BIO-CEL®-MCP mechanically removes the cake layer from the membrane which significantly enhances the flux.**
- **Cost efficient process through a minimization of the installed membrane area and significantly lower energy demand as a result of reduced air sourcing requirements due to an enhancement of the specific flux**
- **Continuous membrane integrity – stable and reliable effluent quality**
- **No or low demand for chemical cleaning – thus, a continuous filtration process is possible**

2) The Mechanical Cleaning Process (MCP) for BIO CEL® membrane bio reactors was developed by MICRODYN-NADIR (S. Krause), Darmstadt Technical University (Peter Cornel) and Osnabrueck University of Applied Sciences (Frank P. Helmus and Sandra Rosenberger).



SIGNIFICANT PROGRESS THROUGH BIO-CEL®-MCP

One of the main advancements through the use of BIO-CEL®-MCP is the reduction of operating costs of the MBR plants.

50-70% of the whole energy demand of MBR systems is needed for the crossflow aeration, which is incurred independently of the specific flux. The BIO-CEL®-MCP system enables much higher specific flows than conventional operations, which results in a minimization of the energy demand. Moreover, investment costs are decreasing due to the reduction of the membrane area which can be achieved through the enhancement of flux. This drastically lowers investment costs (smaller membrane area needed) and reduces energy consumption (crossflow) for the entire system.

The membrane laminate's self-supporting structure allows for chemical as well as mechanical cleaning of the membrane surface, thereby ensuring permanently high membrane system availability. Test results show that no chemical membrane cleaning has been necessary for a two year period through the application of BIO-CEL®-MCP.

The chart below outlines the advantages of the application of a BIO-CEL®-MCP, using the example of a model wastewater treatment plant designed for 10,000 PE (2,000 m³/d). The yearly costs can be reduced by almost 30 % through the use of MCP.

Comparative values of BIO-CEL® vs. BIO-CEL®-MCP for a model wastewater treatment plant for 10,000 PE:

	BIO-CEL®	BIO-CEL®-MCP
Average flux [1]	13.9 l/m²h	16.5 l/m²h
Peak Flux [1]	27.8 l/m²h	33.0 l/m²h
Membrane area needed	6,000 m²	5,000 m²
Lifetime	8a	8a
Annual charges "Membrane Invest"	33,750 €/a	28,125 €/a
Energy demand	365,000 kWh/a	280,769 kWh/a
Annual charges "energy" [2]	36,500 €/a	28,077 €/a
Annual charges "chemical cleaning" [3]	15,075 €/a	0 €/a
Annual charges "MCP"	0 €/a	5,863 €/a
Annual charges "total" (incl. invest)	**85,325 €/a**	**62,065 €/a**

(1) the assumed flux is based on the minimum achievable performance improvement through the application of MCP
(2) valid for energy costs of 0.10 Euro per KWh / (3) assumption: no chemical cleaning

BIO-CEL®-MCP in large scale applications

Location	Size of plant	Type of wastewater	Date of startup
Canada	2 x BC 100 (200m²) I 72 m³/d	Industrial (food industry)	2009
Greece	3 x BC 100 (300m²) I 120 m³/d	Municipal (shopping center)	2011
Mexico	10 x BC 400 in 2 trains I 1,000 m³/d	Industrial (fish processing)	2012
Czech Republic	2 x BC 400 I 180 m³/d	Municipal	2012
Germany	12 x BC 400 in 3 trains I 641m³/d	Municipal	Mid 2014
Italy	26 x BC400 in 2 trains I 4200 m³/d	Municipal	2014

Since 2009, a MBR plant using BIO-CEL®-MCP has been in operation for the treatment of wastewater in the food industry. After more than one year of continuous operation, the plant still shows excellent filtration performance without conducting a chemical cleaning.

Between January and June 2011, MCP pilot tests were accomplished successfully in two fish processing companies in Mexico. Thereby, the positive effects of applying granulate could be successfully proven.

Despite the extreme effluent concentrations (COD > 5000 mg/l), no chemical cleanings have been necessary throughout the entire duration of the pilot tests. In mid 2012, an MBR using the BIO-CEL®-MCP with a daily effluent flow of 1,000 m³/d has been put into operation. No chemical cleanings have been conducted up to today.

ADVANTAGES

- » improved operating stability
- » simple, mechanical membrane cleaning
- » cost savings
- » performance significantly better than "conventional" MBR systems
- » higher peak flow over longer periods of time
- » maximum system availability
- » optimized energy consumption
- » minimized chemical demand

MICRODYN-NADIR GmbH
Kasteler Straße 45
65203 Wiesbaden / Germany
Phone: + 49 611 962 6001
info@microdyn-nadir.de

MICRODYN TECHNOLOGIES INC
2700 Sumner Blvd. Ste. 136
Raleigh, NC. 27616, USA
Phone: + 1 919 341 5936
info@microdyn-nadir.com

MICRODYN-NADIR
(Xiamen) Co. Ltd
No. 66 Jinting North Road Xinglin
Xiamen, China 361022
Phone: + 86 592 677 5500
infochina@microdyn-nadir.cn

MICRODYN-NADIR Singapore Pte. Ltd.
2 Tuas Avenue 10
639126 Singapore
Phone: +65 6457 7533
info@microdyn-nadir.com

MANN+HUMMEL Fluid Brasil
Rua Antonio Ovídio Rodrigues, 845
Parque Industrial Jundiaí III (FAZGRAN)
13213-180 Jundiaí - SP
Phone: +55 11 3378 7500
comercialmwbr@mann-hummel.com

MICRODYN NADIR

ADVANCED SEPARATION TECHNOLOGIES

0079007/15

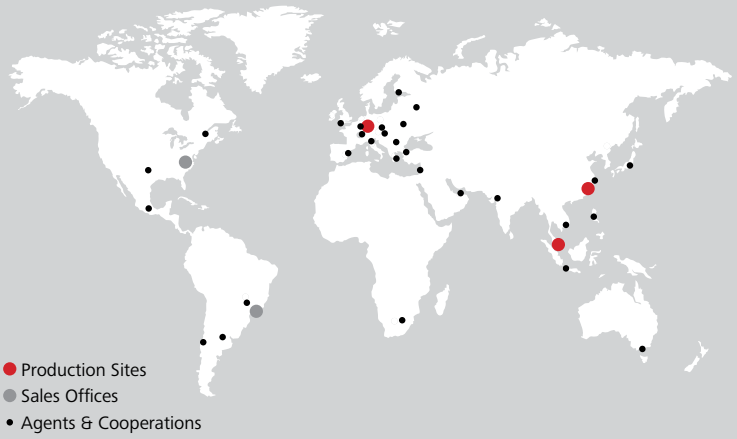
SEPARATION – OUR PASSION

For almost 50 years, MICRODYN-NADIR has developed innovative membranes and membrane modules for micro-, ultra- and nano-filtration as well as solutions to support our customers' needs in operation, performance, efficient membrane processes and regulatory compliance.

We will deliver products, information and services, which fully meet or exceed customer expectations. Our team focuses on continual improvement to achieve the highest possible level of customer satisfaction and to be recognized by our customers as the technology and quality leader.

We are not satisfied until our products have been successfully integrated into your customers' plants and processes. That is our passion.

Our quality system is designed to support these goals.



WE SUPPORT YOU – WORLDWIDE!

- Global availability
- Intensive technical consulting
- Ideal choice of membranes and modules
- Support with engineering and plant design
- Laboratory and pilot tests
- After Sales Service

WWW.MICRODYN-NADIR.COM