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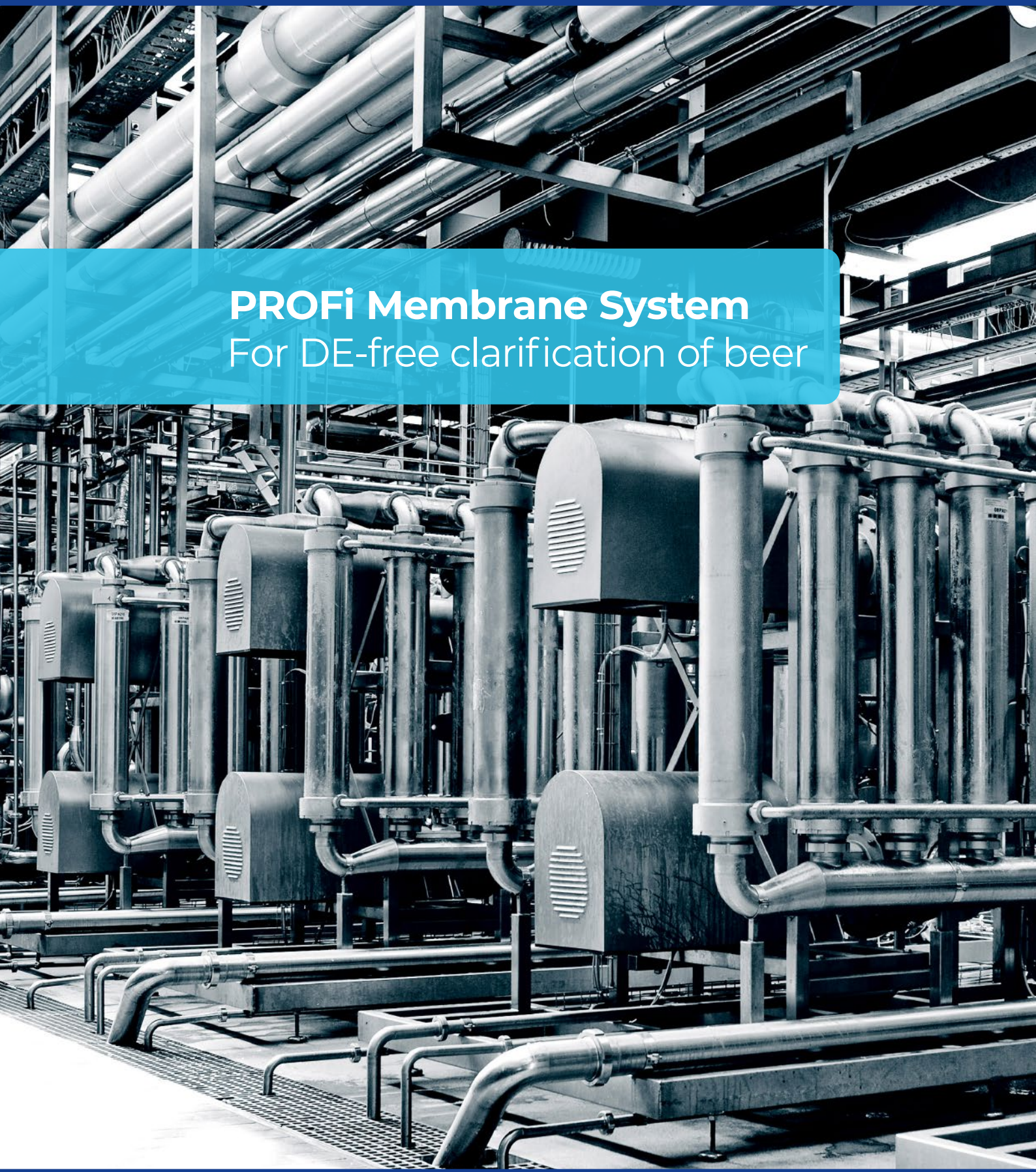


PROFi Membrane System

For DE-free clarification of beer

PROFi Membrane System
For DE-free clarification of beer

Changing requirements in the brewing industry have encouraged brewers to rethink their production technologies. Environmental aspects, consumer protection, water shortages, variations in raw material quality, labor costs and an increasing sort-variety are all factors influencing future decisions for new installations.

The PROFi membrane system is a modern beer clarification solution that minimizes waste, water and utility consumption while increasing brewery production efficiency. Designed for automated, continuous operation, PROFi membrane systems deliver speed and flexibility of brand changes with bright beer quality and high yield. The modular block design maximizes product security, cleaning effectiveness and utility usage.

Pall developed the PROFi system, the ideal crossflow technology for beer, in 1993 in a German craft brewery. Today this system is still in operation and Pall continues to improve PROFi technology to ensure safe and reliable performance:

- Insert design for easy module changes and maintenance
- Oxidative cleaning for longer service life
- Cluster technology for compact, modular design
- Continuous or batch operation for flexible processing
- Gross failure test to identify membrane defects

The PROFi philosophy combines a pre-clarification step – typically a centrifuge – with a dead-end crossflow system, characterized by:

- small system volumes (800l/block)
- low circulation volumes inside the blocks (453 m^3/h)
- low Reynolds numbers in process (1,500) combined with little shear stress (75 Pa) on product
- low crossflow velocity inside the modules (1–1.3 m/sec)

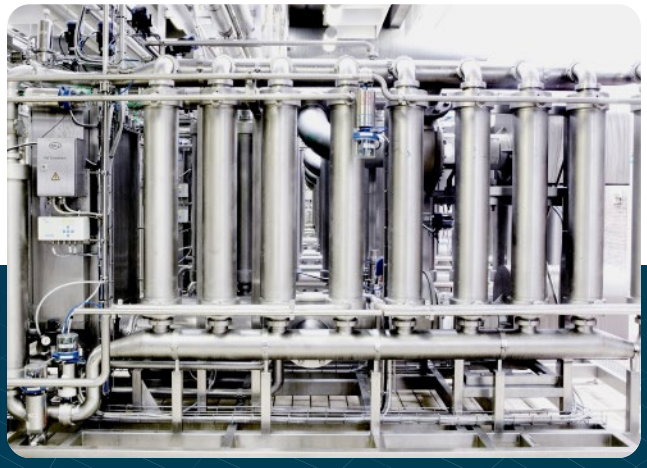
These characteristics offer a gentle treatment of the beer preserving the brand by providing a brilliant clarity and high microbial safety.

The low block volumes result in:

- low beer losses during brand changes
- minimized water and cleaner consumption
- fast brand changes
- low crossflow circulation volumes
- less energy consumption

The PROFi system offers a smart solution to meet the demands of the brewing industry offering complete DE-free clarification with direct value to the brewery.

Typical centrifuge for pre clarification upstream filtration for 400 hl/h performance



Typical filter block with 20 membrane inserts split in 4 clusters

Benefits*[1]

Cost Reduction

- **No use of filter aids like DE**
  - No purchasing, quality assurance, storage, preparation, health and safety risk management or disposables
- **Reduced beer losses**
  - Solids discharge with high % of dry matter
  - Single pass process without any beer retentates after batch end or brand changes
  - Special membrane block design reduces dead volume
  - Empties modules by forward flow using CO_2
- **Reduced energy consumption**
  - "Zero retentate" crossflow filtration with minimal energy input
  - Low crossflow velocity
  - No internal cooling required
- **Reduced water and chemical consumption for cleaning**
  - Low hold-up volume in membrane blocks
  - Intelligent cleaning fluid management in terms of media re-use
- **Environmentally friendly cleaning**
  - No use of chlorine
  - Only simple technical grade chemicals
- **High production safety**
  - Cluster technology allows Module Functioning Test (MFT) and enables ongoing production availability
- **Reduced labor costs due to full automation**
- **Reduced CAPEX**
  - No need for internal cooling or retentate tank due to single pass crossflow filtration
  - Eliminates need for additional particle or fine filtration
  - Continuous operation resulting in smaller system and footprint (standard PROFi system)
  - Flexible operation resulting in less bright beer tank (BBT) capacity
  - No pre and post runs even when changing from dark beers to light beers
- **Reduced OPEX**
  - Continuous filtration (standard PROFi system)
  - Stable filtration cycles nearly independent of incoming beer, yeast and particle load
  - 24/7 operation (standard PROFi system)
  - Flexible for different brand changes independent of the beer stabilization method
  - Low energy, water and chemical demand
  - Low waste stream
- **Higher system availability**
  - Fully automated, 24/7 operation
  - Clearly defined filtration and cleaning cycle times
  - Forward flow module emptying
  - No additional handling of pre and post runs

Pay Per Use Option

- Predictable expense for budgeting
- Reduced inventory
- Service alignment with customer demand
- Performance monitoring and optimization

Excellent Beer Quality

- Low crossflow velocity with reduced shear forces
- High clarification efficiency of centrifuge and membrane system
- Negligible oxygen pick-up from process

Microbiological Safety Due to MFT*[2]

- Modules can be tested in-situ before production and removed from service if any defect detected Sustainability
- No filter aids to dispose
- Reduced water consumption and waste stream
- Reduced chemical consumption
- Low energy consumption
- Low CO_2 footprint

Consumer Protection

- Product traceability
- High process safety
  - *In-situ* module functioning test
  - Fully automated system

Flexibility

- Low investment costs for increased capacity due to modular design
- Fast product / brand change due to forward flow module emptying

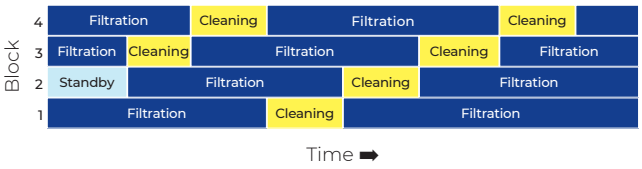
*[1]Benchmarked against traditional DE pre-coat filtration
*[2]MFT: Membrane failure test

Continuous System Process

Stabilized beer from fermentation/maturation is pre-clarified with a high efficiency centrifuge, which ensures gentle treatment of colloids and minimal oxygen pick-up. Bulk yeast is separated from the beer and discharged with a high percentage of dry solids. This membrane pre-clarification delivers longer filtration cycles and enhanced system economics.

Fine filtration of beer in the membrane unit is continuous, due to membrane blocks alternating in filtration and regeneration. This design ensures constant filter availability and smaller system sizing, reducing both capital and operating expenses.

Forward flow module emptying with CO_2 enables a fast product change and flexibility without pre or post run blending / loss. Beer protein stabilization may be performed upstream of the centrifuge with silica gel, while polyphenol stabilization is accomplished either upstream of the centrifuge with one way Polyvinylpoly- pyrrolidone (PVPP) or downstream of the membrane unit with regenerative PVPP or other methods. Ideally the PROFi system is combined with a stabilization system which also runs in a continuous mode.



PROFi Membrane System - Continuous Operation

PROFi Membrane Systems

Flow rate (hl/h)	Membrane blocks		Daily production range (hl/day)*
	MBL 20	MBL 28	
150-250	2	2	3,000 - 5,000
250-350	3	2	5,000 - 7,500
350-450	4	3	7,500 - 9,900
450-600	-	3-4	9,900 - 12,000
up to > 900	-	4+	> 12,000

* Values can vary according to beer filterability

Filter Media

At the heart of the PROFi membrane system is the highly engineered membrane module inserts which cover the hollow fiber membranes. The membranes consist of polyethersulfone (PES), which is a reliable, inert material widely applied to beer filtration. The membranes, in combination with the module design, guarantee high mechanical strength resulting in a long service life and optimized costs.

The module design includes:

- High porosity membrane with high solids loading capacity for beer colloids
- Module insert designed for stainless steel housing enabling sanitization up to 74 °C (165 °F) and pressures up to 6 bar (87 psi)
- Fast module exchange
- High mechanical, thermal and chemical resistance
- Reliable yeast reduction
- Reproducible *in-situ* module functioning tests

BeerIoT

To gain maximum advantage from the data generated by a PLC or Scada control system, Pall implemented IoT based digital information and process management to beer systems. With this IOT-based extension of data management in real time, different levels and hierarchies in the brewery have constant access to defined data in a user edited format.

Typical examples for digital data analytics are:

- Specific consumption data e.g., water, cleaning agents, electricity, membranes,
- Performance data e.g., degree of utilization, efficiency, and downtimes
- Quality data e.g., oxygen uptake, color, original extract, haze
- Push notifications e.g., alarms and messages
- Documentation and service data

In addition to actual real time data, trends, historical reviews, brand related influences, and raw material impact, other key influencing factors can be analyzed with the IoT tool. Benchmarking with other installations within a brewery group and against the industry average is also possible and can be switched on and off.

Pall IoT provides direct online availability of all systemspecific documentation and training documents, spare parts lists, service reports, operating instructions, safety instructions and acceptance reports.

Alarm messages can be displayed directly on multiple display devices, reducing response time in the event of a production problem. This function can be switched activated by each individual user, selectively.

In summary, Pall IoT solutions contribute to improve plant KPI`s, process optimization and product assurance.

PROFi Batch System

In order to make DE-free membrane technology accessible for breweries with a lower annual production capacity on an economically attractive basis, the PROFi Batch System was developed. The aim was to use the existing and proven PROFi system technology and design with minor modifications to the installation and process. The PROFi batch system fulfils the technological and economic requirements of breweries with an annual production capacity between 400,000 hl and 1,300,000 hl.

The main difference between the standard PROFi system and the PROFi Batch System is the batch-wise operation mode. Filtration and regeneration take place one after another. All the added benefits customers achieve by using the PROFi technology remain unaffected.

PROFi Membrane System - Batch Operation

The system consists of 1 or 2 module blocks with 20 or 28 modules, depending on the required total flow rate.

Flow rate(hl/h)	MBL	Max. volume / day [hl]*	Max. volume / year [hl]*
120	1 x 20	1,920	480,000
160	1 x 28	2,560	640,000
240	2 x 20	3,840	960,000
320	2 x 28	5,120	1,280,000

Filtration and stabilization - the perfect combination

Pall's PROFi system is an ideal fit to the CBS, the Continuous Stablization System. Both system platforms operate in perfect harmony providing the most economical solution for filtration and stabilization combined with optimal beer quality.

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