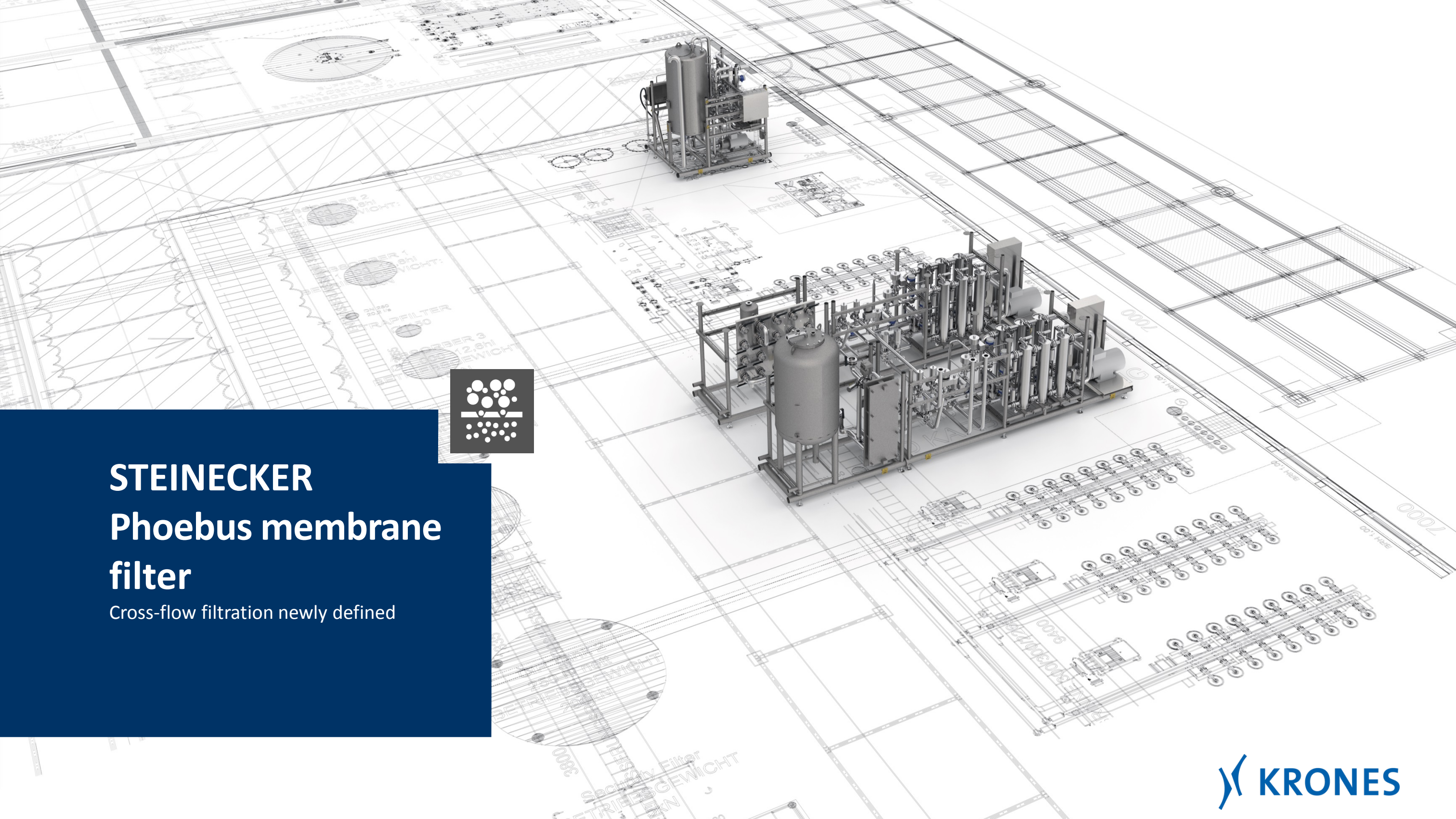
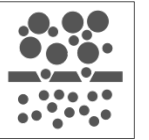




The background of the image is a detailed technical drawing of a membrane filtration system, showing various components like tanks, pipes, and valves. Overlaid on this is a 3D rendering of the same system, highlighting the physical layout of the equipment. The drawing includes labels in German such as 'SPEICHER 1', 'SPEICHER 2', 'SPEICHER 3', 'TRAPFILTER', and 'BETRIEBSGEWICHT'. A small icon of a membrane filter is also visible in the center-left area.

STEINECKER Phoebus membrane filter

Cross-flow filtration newly defined



Cross-flow filtration - newly defined

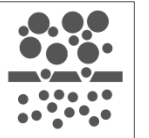
Filtration is one of the key processes in brewery operations. In addition to a bright, shiny filtrate with optimum turbidity, technological requirements also include an improvement in the physical stability of the beer. The filtration achieves high microbiological safety for the filled product.

On top of this, there are also economical requirements: Users want a long filter service life, low operating costs and systems that are easy to operate. These requirements form the basis for Phoebus, the new concept for cross-flow filtration.

At a glance

- Controlled transmembrane pressure depending on the position of the module in the filter unit
- Flow reversal at the membrane modules using a double infeed
- Targeted backflushing of individual membrane modules during filtration and cleaning

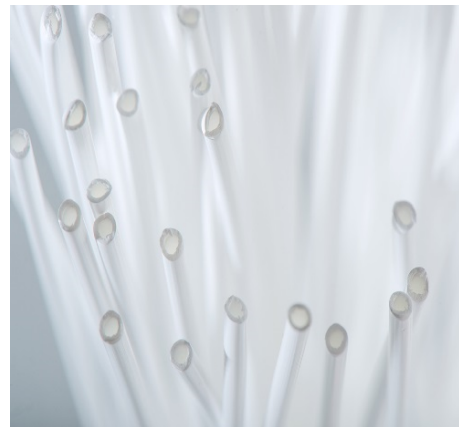




Phoebus – the elements of the cross-flow filtration system

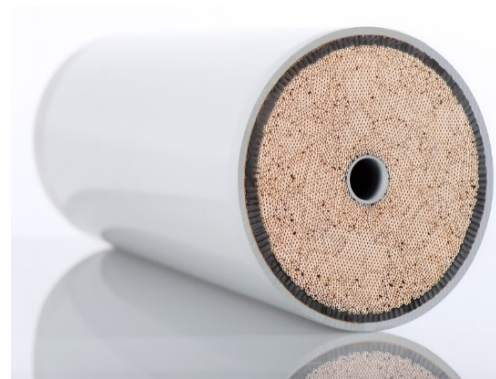
Hollow fibre membranes

- Polyethersulfone was selected as the material for the membrane.
- The average pore diameter is 0.45 µm.
- Sanitisation at 85 °C is possible.



Membrane module

- Several hollow fibre membranes are grouped together to form a membrane module.
- The filtrating surface is 13 m² per module.
- The membrane modules are integrated in stainless steel membrane housings.



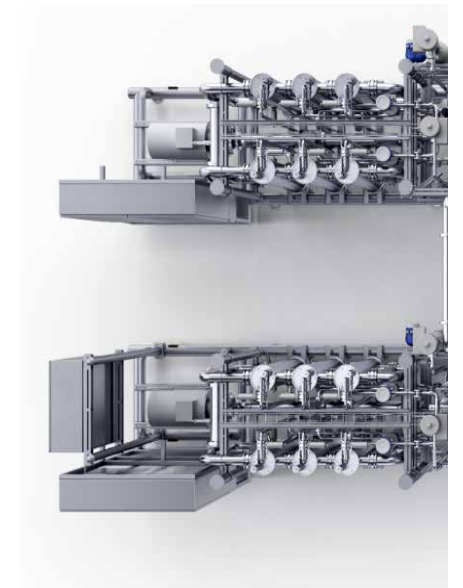
Membrane package

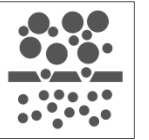
- A membrane package comprises between 3 and 12 membrane modules.
- Two membrane packages are operated per filter unit.



Filter unit

- A membrane filter system is made up of several filter units.
- The filter units can be switched on and off individually.





Phoebus – plant concept of membrane filtration

Pilot system

- Two filter units each with a rated speed of 25 hl/h
- Unfiltrate buffer tank with a volume of 30.0 hl
- Filtrate buffer tank with a volume of 12.7 hl
- Integrated CIP module

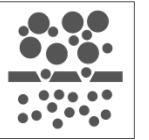


Development project

- The membrane was developed by a project partner.
- The membrane characteristics and filtrate quality were analysed and evaluated by the Technical University of Berlin.
- Design synergies from the KRONES Hydronic UF were also included in the development.

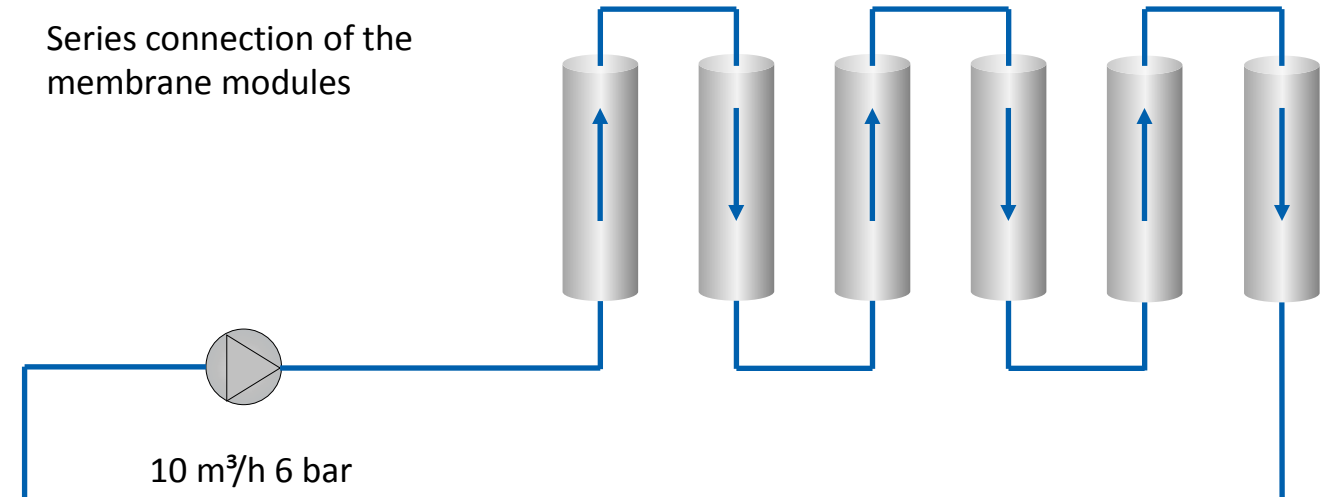
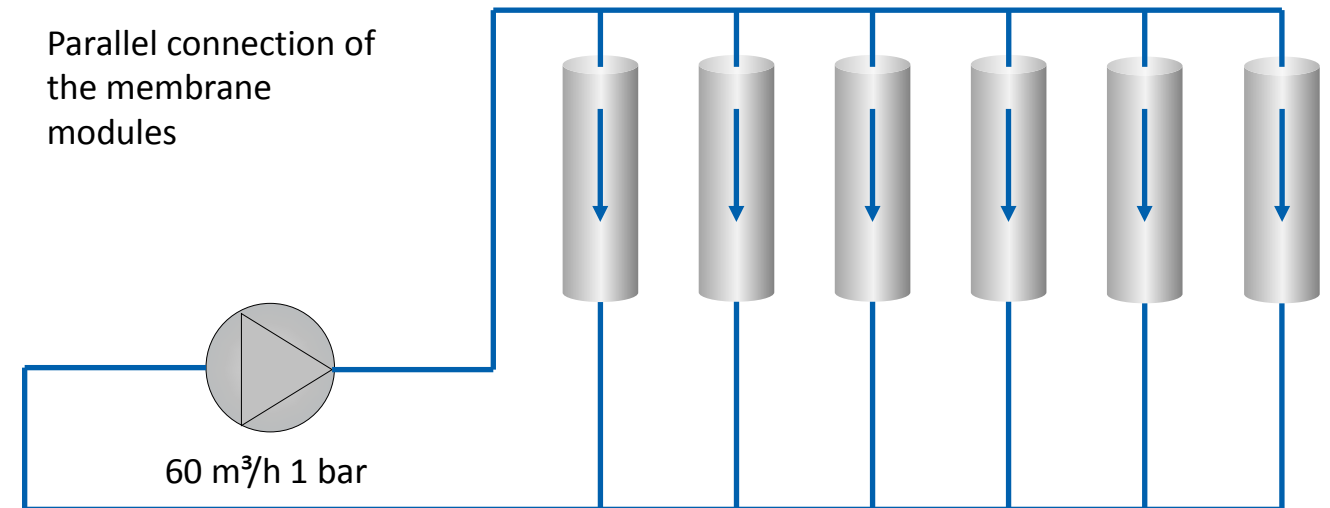


Phoebus – assemblies in detail



Series connection of the membrane modules

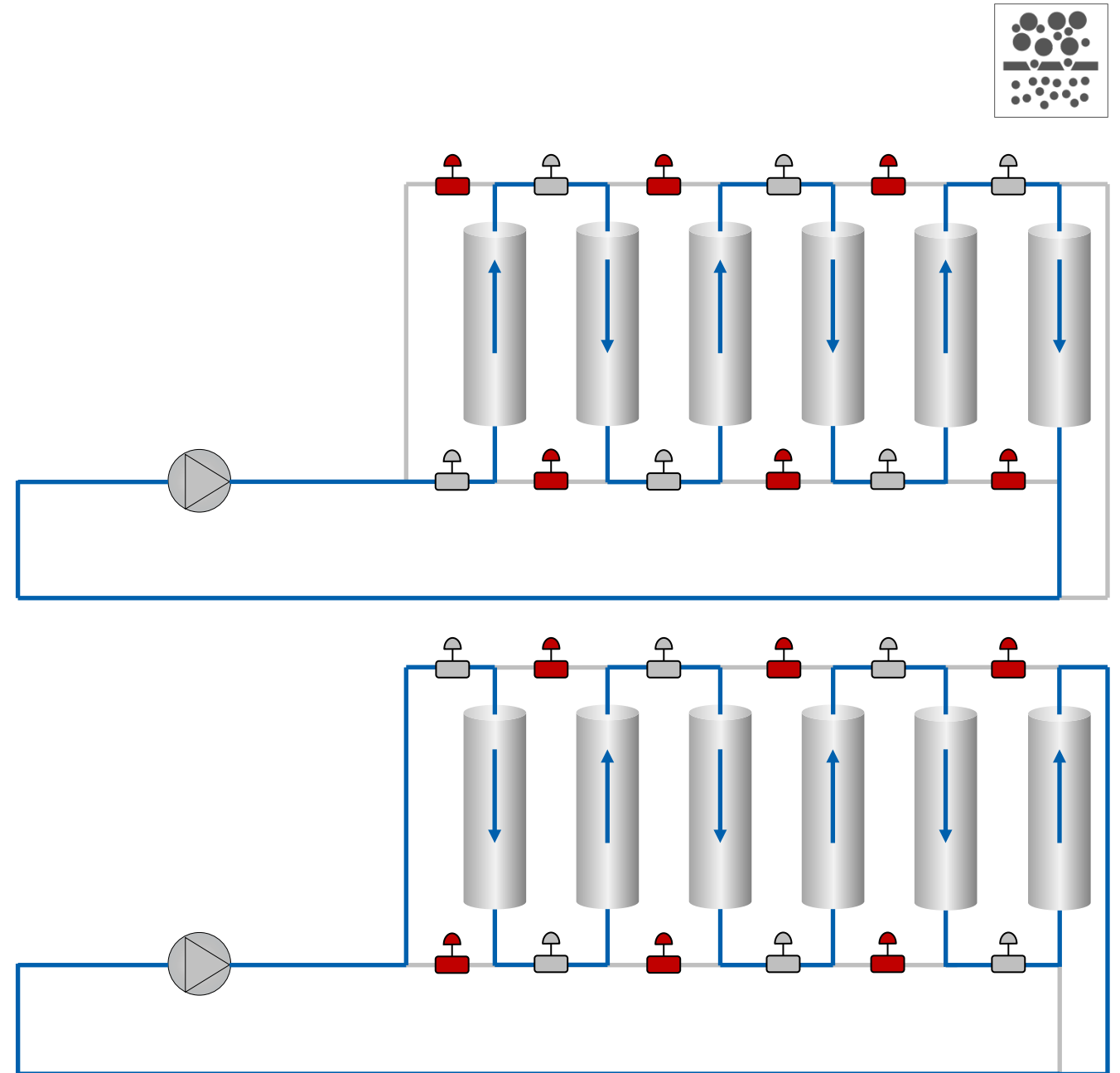
- The unfiltrate flows through each of the membrane modules one after another.
- This keeps the cross-flow volume flow rate consistent, regardless of the number of modules installed in the membrane package.
- The pump's connected load is lower in the series connection shown below compared to the parallel connection shown above.



Phoebus – assemblies in detail

Double infeed and flow reversal

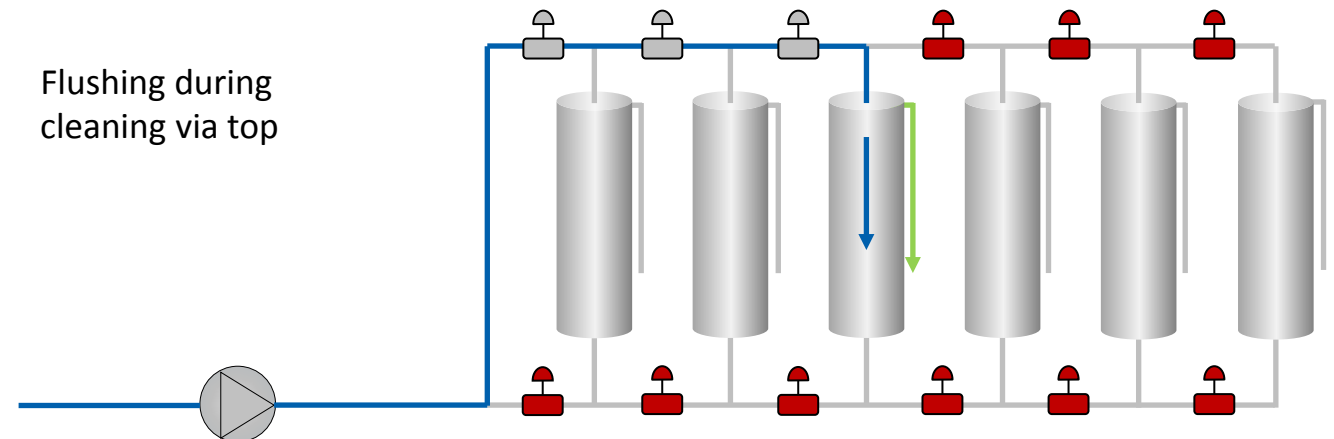
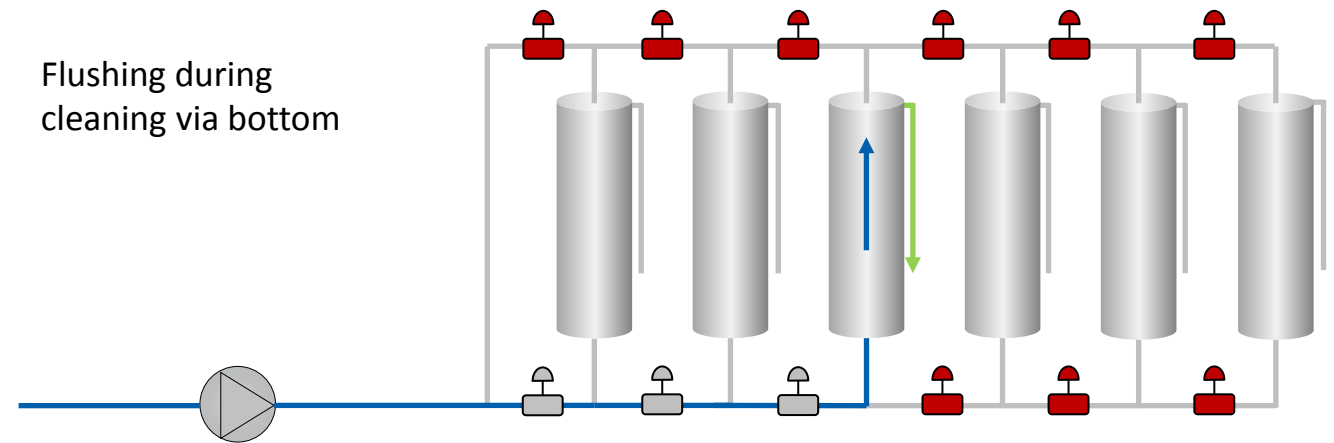
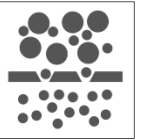
- The membrane modules can be charged from above and below.
- Shut-off valves between the modules allow the flow direction to be reversed during filtration.

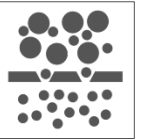


Phoebus – assemblies in detail

Targeted backflushing

- During module backflushing, individual modules or small groups can be flushed separately.
- Backflushing is performed from the filtrate to the unfiltrate side during production.
- The modules can also be flushed from the unfiltrate to the filtrate side during cleaning.
- Flushing is possible via the top or bottom infeed at the unfiltrate side.
- The backflushing of individual modules provides a considerably better rinsing result than if the complete filter unit is backflushed at once.

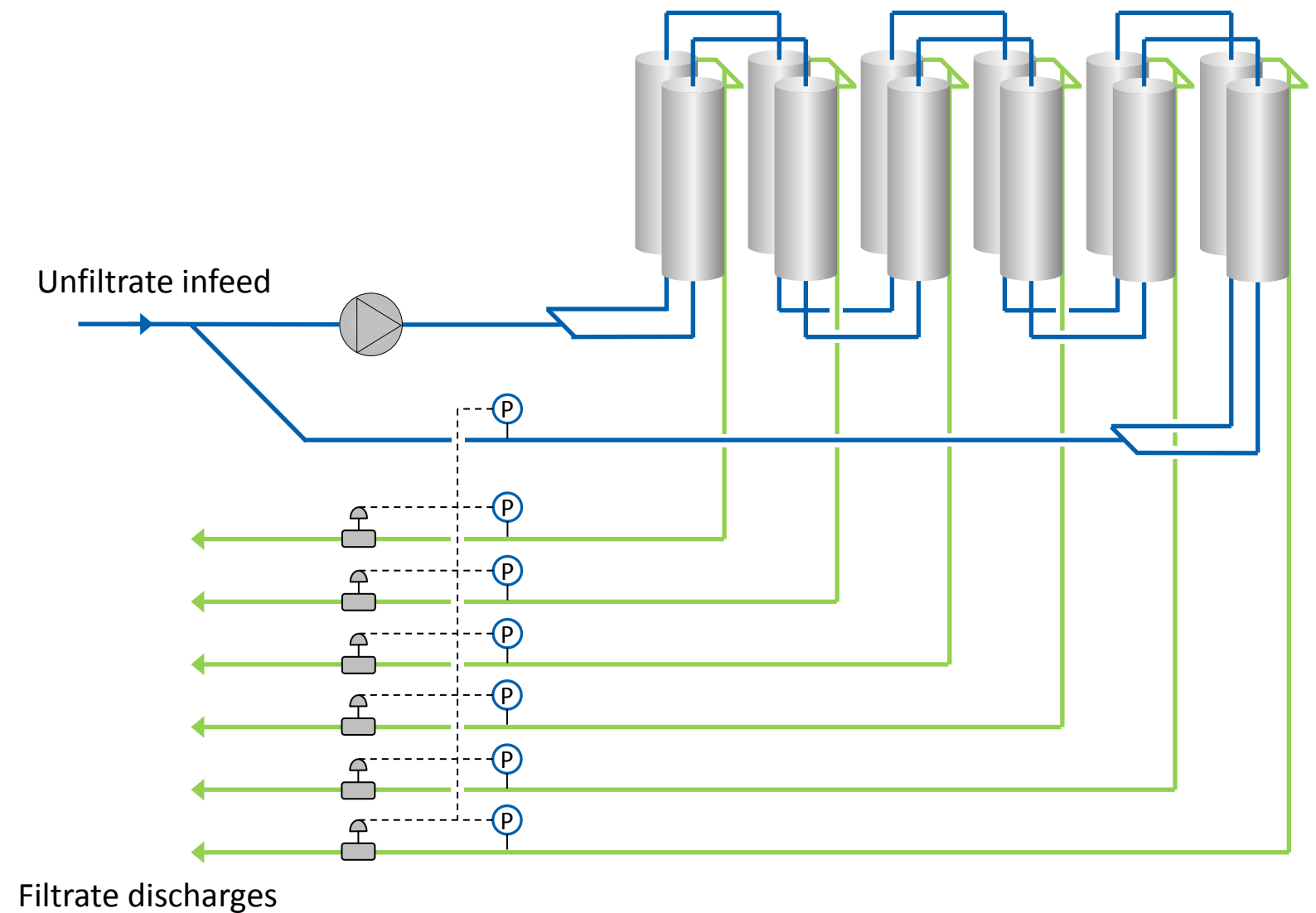


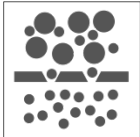


Phoebus – assemblies in detail

Controlled transmembrane pressure

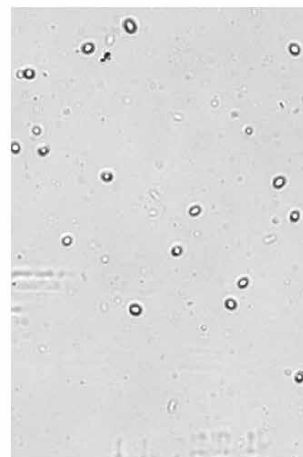
- The membrane modules of both membrane packages are controlled together in the flow depending on their position.
- The transmembrane pressure for each position is set as the basis for the controlled variable.
- If several filter units are operated simultaneously, this allows for the overall control of the positions.



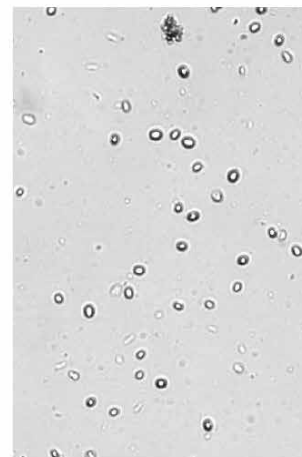


Results for testing the membrane development

- Light beer 11.8 °P
- Nominal membrane pore diameter 0.45 µm
- Amount of yeast cells in the unfiltrate is 5 million/ml at the begin of filtration
- Average turbidity 25° at 0.05 EBC
- Average turbidity 90° at 0.15 EBC
- No yeasts in the filtrate
- Low iron absorption



Unfiltered beer

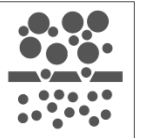


Reverse osmosis concentrate



Filtrate

Analysis	Unfiltered beer	Filtered with kieselguhr	Filtered with MF
Original extract (%)	11.77	11.86	11.77
Alcohol (%)	5.47	5.28	5.53
Degree of final fermentation (%)	87.8	83.9	88.8
Colour [EBC]	6.9	7.3	6.7
pH value	4.20	4.31	4.19
Viscosity (mPa*s)	1.522	1.518	1.416
Total soluble nitrogen (mg/l)	881	947	862
Polyphenols (mg/l)	217	194	193
β-glucan (mg/l)	173	163	102
Iodine value (dE)	0.35	0.33	0.26
NIBEM 30 (s)	247	251	248
Turbidity 25°/90° [EBC] 20°C	20	0.11/0.26	0.05/0.15
Iron (µg/l)	18	61	21

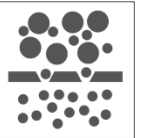


The facts at a glance

The values from the pilot system show that the STEINECKER Phoebus membrane filtration system provides a high beer quality and filtration capacity.

- The pilot test showed consistent beer clarification with a yeast cell amount of 0 in the filtrate, as well as a considerably low iron absorption compared to kieselguhr filtration.
- The membrane characteristics and filtrate quality were analysed in the test performed by the Technical University of Berlin.

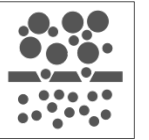




Phoebus filtration systems

- Types of beer filtered so far:
 - Original 5.1 % vol.; 11.7 % original extract
 - Oktoberfest beer 5.1 – 5.7 % vol.; 13.5 % original extract
 - Dark beer 5.5 % vol.; 12 % original extract
 - Maibock beer 7 % vol.; 17 % original extract
- Previously filtered range of yeast cell numbers:
From 0.5 – 12.5 million cells/ml





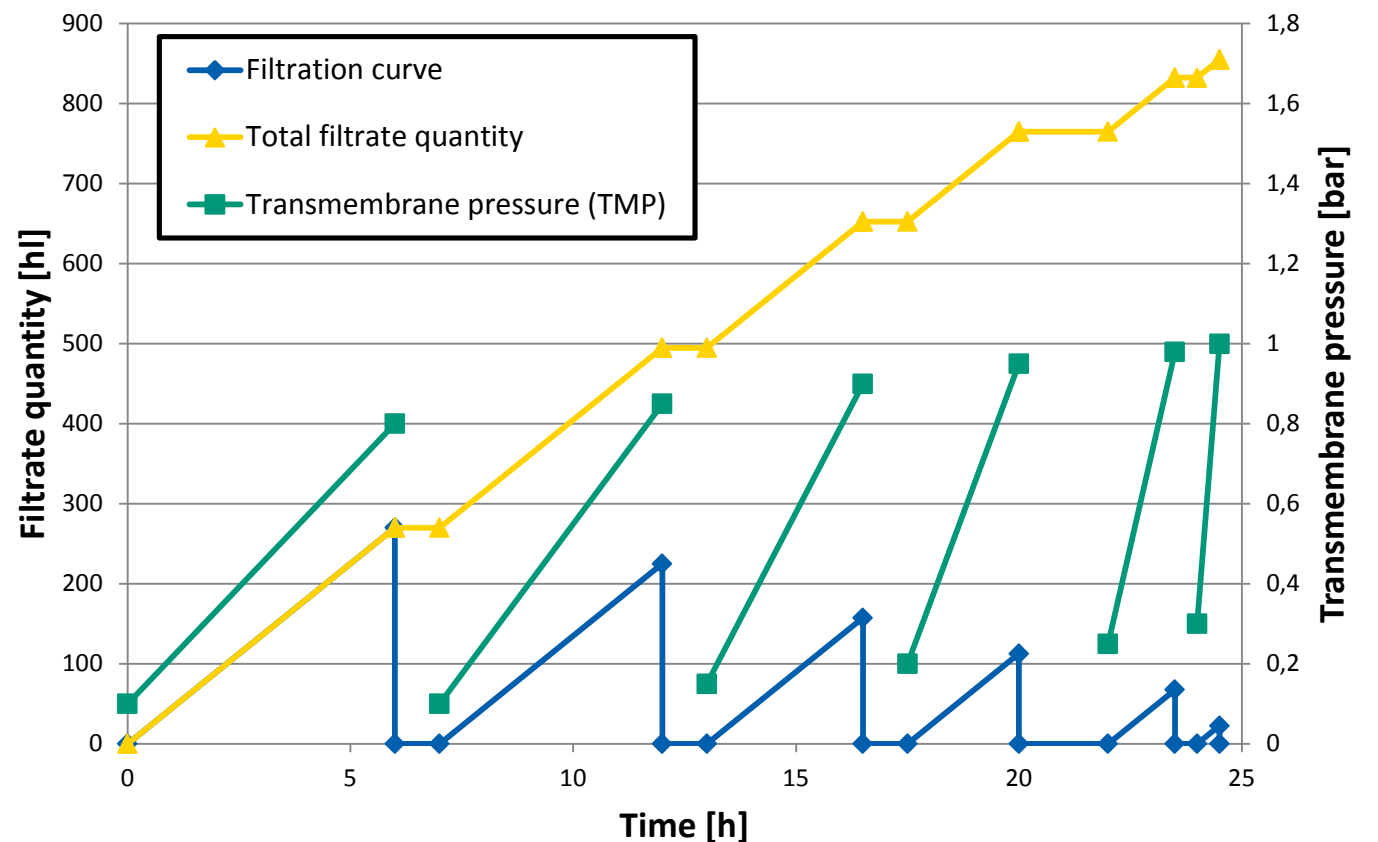
Phoebus filtration systems

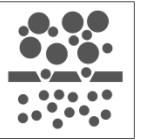
How filtration works

- During filtration the filtrate flow is regulated as a constant.
- The transmembrane pressure increases in a linear fashion as membrane fouling progresses.
- Once a defined maximum pressure has been reached, the membrane is backflushed with the already filtered beer until it is available.
- The next cycle lasts for a correspondingly shorter time and the pressure increases faster as backflushing only partially releases the membrane blockage.

Cleaning

- Small-scale cleaning: backflushing with cold caustic shows very good results
- Large-scale cleaning: backflushing with cold caustic and heating to 50 °C + H₂O₂ dosing + soaking





Benefits to you

Energy-efficient filtration

Thanks to the series connection of the membrane modules, the cross-flow process requires less energy compared to parallel connections.

Controllable filtration modules

It is possible to individually control the transmembrane pressure for different areas in the filter unit. It is also possible to extend the filtration intervals through targeted backflushing sequences with filtrate.

Hygienic plant operation

The ability to provide targeted, intensive flushing during cleaning and to provide 85 °C sanitisation allow a high standard of hygiene to be achieved.

Specific membrane development

Our cooperation with a competent and independent partner during membrane development means that the Phoebus can offer optimum filtration results.

One-stop shop

With complete process technology from the brewhouse right through to filtration, Krones delivers precise and fitting brewery concepts.





Everything from a single source

KIC KRONES cleaning agents make your machine shine

Only if the production environment is immaculate, can your product be brilliant. KIC KRONES provides you with the optimum cleaning agents and disinfectants for each individual production step.

EVOGUARD – excellent valve technology all along the line

The valve series of EVOGUARD comprises a modular system with hygienic and aseptic components which contributes to every point of the production line with increased performance and which has the perfect solution for every process step.

EVOGUARD – pumps for absolute process safety

In addition to the separation and locking of a line, one thing is particularly important - and that is the reliable conveyance of your product. This is why EVOGUARD also offers innovative centrifugal pumps in addition to high-quality valves.





Digitalisation



Process
technology



Bottling and
packaging equipment



Intralogistics



Lifecycle
Service

We do more.

 **KRONES**