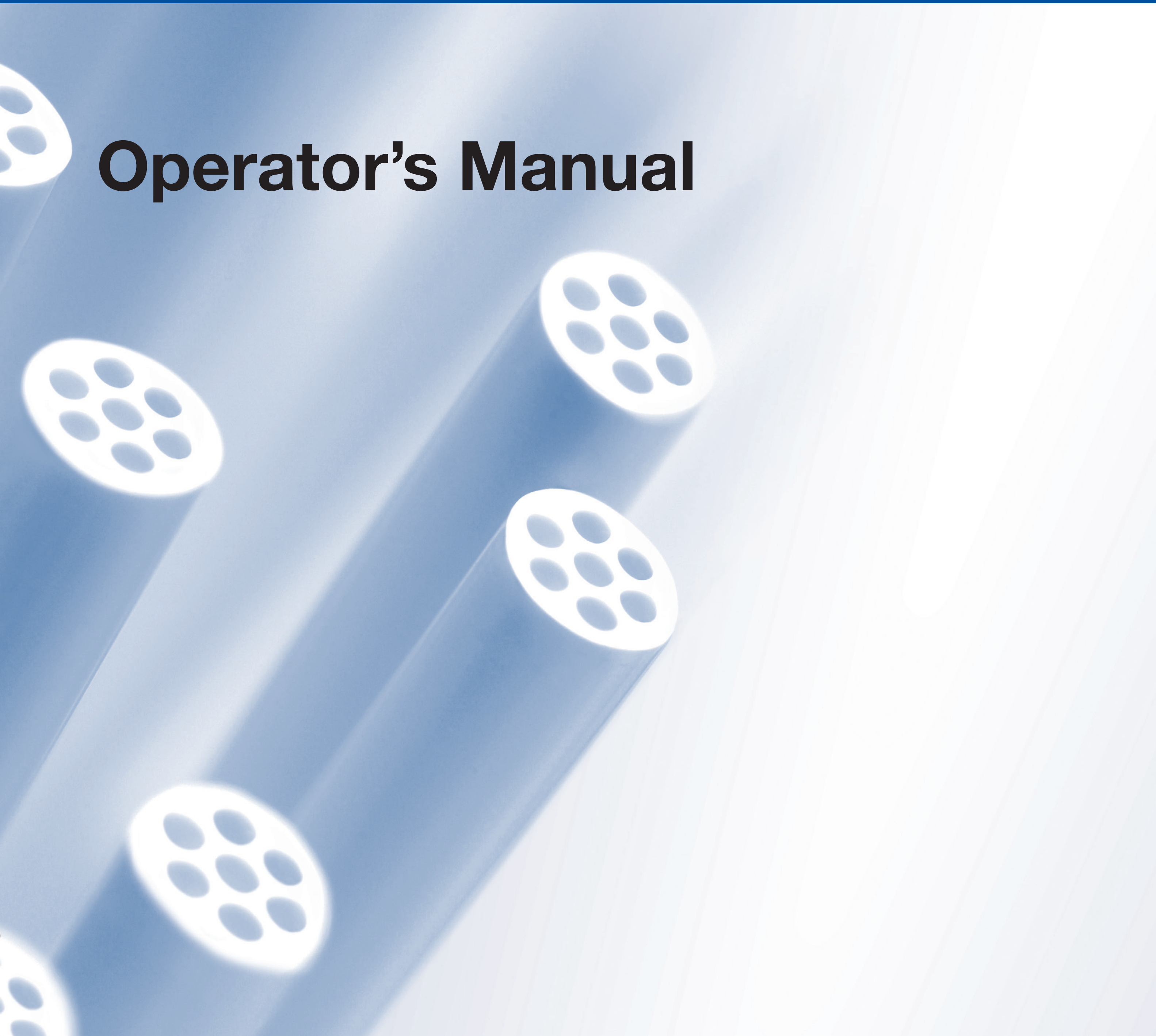
inge heart of pure water

Operator's Manual



BASF
The Chemical Company

BASF
The Chemical Company

Table of Contents

1 Introduction

The company inge GmbH, headquartered in the town of Greifenberg on the Ammersee lake in Bavaria, Germany, is the world's leading provider of ultrafiltration technology, a membrane process used to treat drinking water, process water, waste water and sea water. With a global reach enhanced by a network of partners, inge GmbH has successfully completed numerous reference projects around the globe featuring its cutting-edge technology.

Its range of products include highly-efficient ultrafiltration modules and cost-effective, space-saving rack designs as the core components of water treatment plants, rounded off by the superb technical support it provides to its customers. All the company's products are based on the in-house development of its patented Multibore® membrane technology, providing the top-quality standards for which German-made goods are known.

This is the most recently updated version of our Operator's Manual. We have taken the utmost care to ensure its contents are accurate. These comprehensive operating instructions contain useful information, tips, recommendations and guidelines.

Full and proper compliance with the Operator's Manual is a prerequisite for making a claim under the warranty. Please contact inge GmbH if you wish to deviate from the specifications provided in the Operator's Manual and request written approval in advance. Otherwise you risk invalidating any warranty claims that you may make in the future.

Please note that it is very important to familiarize yourself with the appropriate safety guidelines for storing and handling all the different chemicals used in the water treatment process and accompanying processes. Please also ensure that you follow the guidelines specified in the most up-to-date safety data sheets.

2 The inge® product family

2.1 Multibore® Membrane Technology

The Multibore® membrane developed by inge GmbH (see Figure 2-1) combines seven capillaries of the same diameter into a single fiber. This provides significantly higher mechanical stability than conventional singlebore hollow fiber membranes. Multibore® membranes are typically operated in dead-end mode and are backwashed at regular intervals. Crossflow operation is also feasible in principle, though it is only used in certain circumstances.

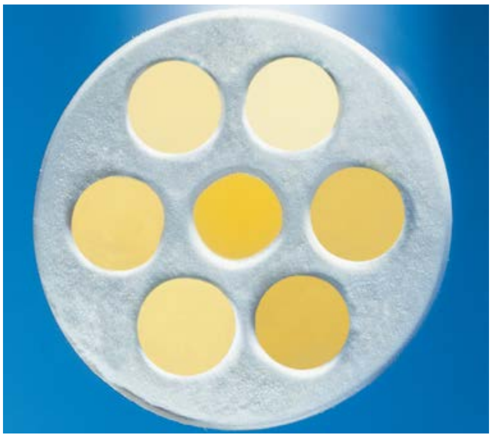


Figure 2-1: Multibore® membrane developed by inge GmbH

inge GmbH supplies its Multibore® membranes in a choice of 0.9 mm or 1.5 mm (0.035 or 0.059 inch) capillary diameters to cater to different types of applications. Even the smaller diameter of 0.9 mm (0.035 inch) is actually larger than that of the conventional capillary membranes typically used in similar applications. This larger diameter enables the fibers to cope with a higher solid content. It also leads to a significant reduction in the pressure drop along the individual fibers in comparison to smaller capillaries. This results in a more even and uniform distribution of the water along the capillaries. Another advantage of this design is that it improves the backwash process: The accumulated foulant is removed more efficiently, which generally means you need smaller quantities of backwash water and a smaller membrane area.

Fibers with a capillary diameter of 1.5 mm (0.059 inch) are a sensible choice for applications involving high levels of solids – for example backwash waters for conventional filters, the treatment of water discharged from a municipal waste water treatment plant or 2-stage UF systems. A capillary diameter of 1.5 mm (0.059 inch) is generally recommended for water with a concentration of suspended solids greater than 50 mg/L. The larger diameter significantly increases the solids content that can be handled by the capillaries and in principle, enables higher flow velocities and lower pressure drops in a crossflow operation, if employed.

The Multibore® membrane is "spun" in a single step from just one material (polyethersulphone = PES) in a patented production process. Spinning the membranes using just one material creates what is known as an "integral" membrane. Unlike composite membranes, which consist of multiple layers of various materials, integral membranes do not pose the risk of individual layers peeling away. This is a huge advantage in terms of membrane integrity.

The PES base polymer is modified in a way that boosts the hydrophilicity of the membrane. This increased hydrophilicity reduces the capacity of the membrane surface to adsorb organics, thereby improving operating performance with less membrane fouling. The manufacturing process produces a defined ultra-thin filtration surface (interface) on the inside of the seven capillaries with extremely low resistance to permeation and with inner pores measuring approximately 20 nanometers (see Figure 2-2). The membrane support structure is constructed asymmetrically with outer pores measuring approximately 1 µm in diameter. Despite the tiny size of the inner pores, the membrane/module (see section on "dizzer® Module Technology") is capable of achieving a permeability of approximately 700 LMH/bar (28.4 GFD/psi) in clean water thanks to its optimized porosity and pronounced asymmetry.

The individual capillaries are firmly connected to each other by a homogeneous support structure that has a permeability some 1,000 times higher than that of the actual filtration interface of the capillaries. The capillaries are spaced at defined distances from each other to ensure a uniform distribution of water within the Multibore® membrane and superior overall stability.

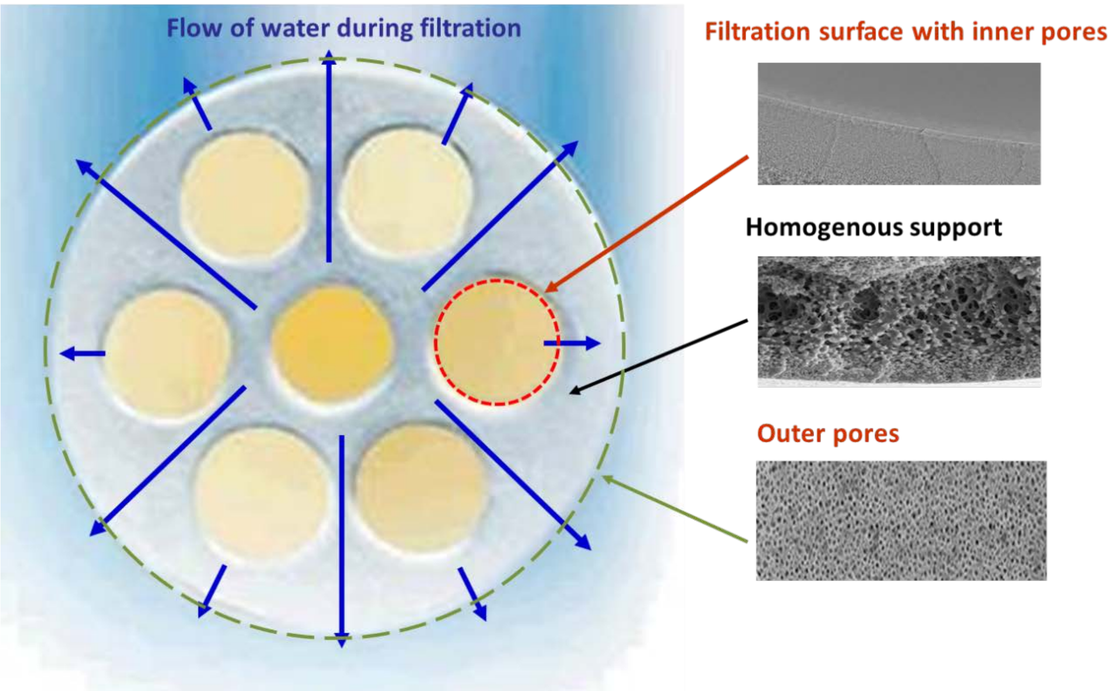


Figure 2-2: Cross-section of a Multibore® membrane

Multibore® ultrafiltration membranes operate "inside-out", which means that the feed water flows from the inside to the outside of the capillaries in filtration mode and flows in the reverse direction, i.e. from the outside to the inside of the capillaries, in backwash mode.

inge® Multibore® ultrafiltration membranes reliably remove particles, bacteria and viruses from a variety of water sources, even if fluctuations in the quality of the feed water exist. Maintaining the integrity of the membrane fibers is a key prerequisite for ensuring that contaminants are properly removed from the system. Although capillary defects are extremely unlikely due to the extraordinary stability of Multibore® membranes, the integrity of the membranes or capillaries can still be affected negatively by factors such as non-approved substances in the feed water and, in particular, by excessive mechanical stress caused by improper operation. To prevent this from occurring, it is important to observe the instructions and specifications outlined in the sections "Design and Construction" and "Guidelines on Operating inge® Modules/Racks".

2.2 dizzer® Module Technology

The UF membranes developed by inge GmbH are encased in a pressure vessel. The resulting array is known as the inge® dizzer® module, which includes unique design features tailored to the specific requirements of ultrafiltration in the water treatment industry. Particular attention has been paid to optimizing the hydrodynamic characteristics of the internal module design in order to improve backwash efficiency and membrane integrity. These improvements are explained in more detail below.

dizzer® modules are available in a selection of sizes ranging from small-scale systems for PoU (Point of Use) and PoE (Point of Entry) all the way up to large-scale systems for industrial facilities and municipal plants (see Figure 2-3). Each module is fully equipped with its own housing and end caps and can be operated as a single, independent unit. The modules are designed to be easy to assemble and remove.

Figure 2-3: Various sizes of dizzer® modules

For more information on the technical specifications of the inge®dizzer® modules listed in Table 2.1, please consult the relevant product data sheets.

dizzer® modules are designed to be installed vertically to ensure effective venting of the modules and the entire UF system. Vertical installation also makes it possible to run pressure hold tests to perform a simple and reliable check of membrane integrity. Thanks to the use of transparent pipes (either on the feed or filtrate side depending on the system; see section on "Integrity Testing"), operators can detect defective modules during an integrity test without having to remove the modules first.

Table 2.1: inge® dizzer® modules

Module type	Capillary diameter		Membrane surface	
	mm	Inch	m²	ft²
dizzer® XL 0.9 MB 70	0.9	0.035	70	753
dizzer® XL 0.9 MB 60	0.9	0.035	60	646
dizzer® XL 1.5 MB 50	1.5	0.059	50	538
dizzer® XL 1.5 MB 40	1.5	0.059	40	431
dizzer® XL 0.9 MB 38	0.9	0.035	38	409
dizzer® XL 1.5 MB 25	1.5	0.059	24	258
dizzer® 5000plus	0.9	0.035	50	538
dizzer® 3000plus	0.9	0.035	30	323
dizzer® P 4040-6.0	0.9	0.035	6	65
dizzer® P 4021-2.5	0.9	0.035	2.5	27
dizzer® P 4040-4.0	1.5	0.059	4	43
dizzer® P 4021-1.8	1.5	0.059	1.8	19
dizzer® P 2521-1.0	0.9	0.035	1	11
dizzer® P 2514-0.5	0.9	0.035	0.5	5

The flexible design of the dizzer® modules allows operators to choose between multiple different options. The modules can be operated in both dead-end and crossflow modes, though dead-end operation is generally the most economical choice for the majority of applications. Filtration and module cleaning can be performed both top-to-bottom and bottom-to-top (see Figure 2-4 and the section on "Membrane Operating ").

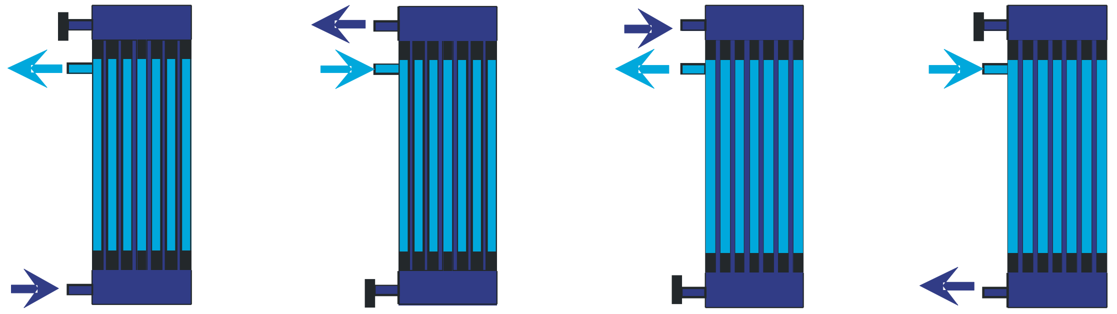


Figure 2-4: Direction of flow in a dizzer® module in filtration and backwash modes

2.3 Hydrodynamically Optimized dizzer® Module Design

By definition, only the irreversible component of the foulant/scalant (i.e. the cake of particulate matter and precipitation which builds up on the membrane surface) remains on the membrane and in the module following a backwash. This component can subsequently be removed by adding chemicals to the backwash. This process requires varying intensities of chemical cleaning depending on how long the foulant/scalant has been in place and how firmly it is attached. Studies have shown that increasing the frequency of intensive chemical cleaning reduces membrane life expectancy. Therefore, simple effective backwashes that penetrate all areas of the module can help to reduce chemical usage and clean-in-place frequency and thus to increase the membrane fibers' service life. In addition to reducing chemical loads, it is also important to minimize the mechanical stress experienced by the membrane during the backwash process.

To achieve these two goals, dizzer® modules feature an optimum hydrodynamic design and are equipped with a perforated inner tube to produce an annular gap between the inner and outer tubes (see Figure 2-5).

Figure 2-5: dizzer® module with perforated inner tube

This innovative design gives dizzer® modules a major advantage over systems that use a central core tube, by creating a uniform flow distribution throughout the entire module diameter and length during both filtration and backwash.

Thanks to the steady increase in the transfer surface of dizzer® modules in the radial direction of flow, the volume flow rate of both the filtrate and backwash water is proportional to the membrane surface through which it is forced at every point along the entire module cross-section. Figure 2-6 shows the basic flow principle. The original dimensions have been modified for the sake of clarity.

Cross-section – filtration mode

Cross-section – backwash mode

Figure 2-6: Radial distribution of flow in dizzer® XL and dizzer® 5000plus modules

Figure 2-7 illustrates this difference by showing the radial flux distribution across the module cross-section. In systems with a central core tube, the velocity of the backwash flow decreases as it moves from the center of the module (the zero point of the abscissa) to the edge of the module because the surface through which the water must pass becomes steadily larger. In filtration mode, the velocity increases in the direction of the central core tube, i.e. the volume flow rate increases as the transfer surface becomes smaller, which causes a significant drop in pressure. In dizzer® modules, however, where the water is distributed from the outside in, the system offers largely stable velocity and uniform water distribution across the entire module cross-section during both backwash and filtration. In other words, every capillary in the module "sees" the same quantity of water.

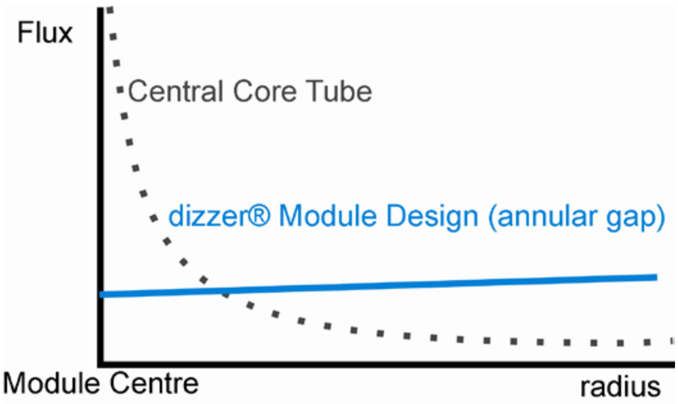


Figure 2-7: Comparison of radial flux distribution between annular gap and central tube

This uniform distribution is extremely important, particularly in backwash mode where the flow quantities and flux rates are approximately 3 times higher than in filtration mode.

As well as being highly uniform, the radial pressure drop is also very low despite the high packing density. This is because Multibore® fibers have a large external diameter which means that the flow resistance through the membrane bundle is negligible.

Pressure distribution is also very uniform in the axial flow direction. This is because the annular gap between the perforated inner tube and the outer tube distributes the water over the entire length of the module with a negligible drop in pressure.

One result of this innovative design is that dizzer® modules are able to guarantee effective backwash results throughout the module.

2.4 dizzer® Modules in Conventional Rack Systems

In addition to the structure and set-up of the membrane and modules, the other crucial element in an ultrafiltration system is the design of the rack. The dizzer® modules are mounted vertically in racks which typically comprise a frame, interconnecting piping, various measuring devices and the modules. This allows for a simple modular design which can be up-scaled or down-scaled as necessary.

Thanks to the vertical arrangement of the modules, access for maintenance and repair purposes are easy while making module venting also very simple. The system is designed to enable automatic integrity testing when required. Each individual module is easily accessible. Figure 2-8 and Figure 2-9 show a conventional two-row and four-row arrangement. The typical dimensions of different sizes of conventional racks are shown in Table 2.2, though the information provided is only suitable for obtaining a rough approximation. The actual dimensions may vary significantly from the specifications given in this table depending on the design of the rack.

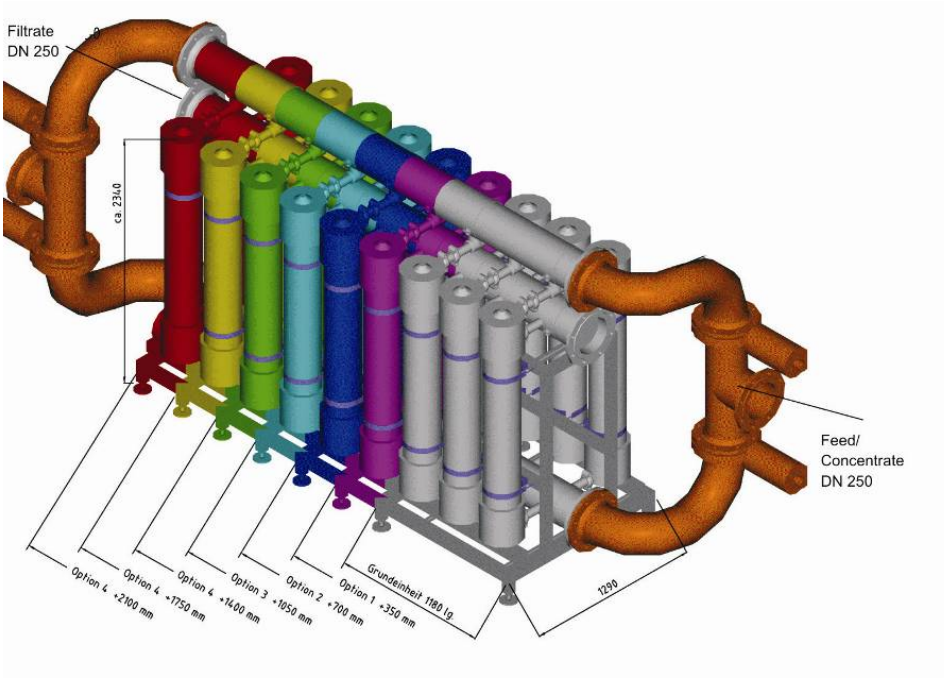


Figure 2-8: Typical rack design for 18 dizzer® modules with central header and a single row arrangement on each side

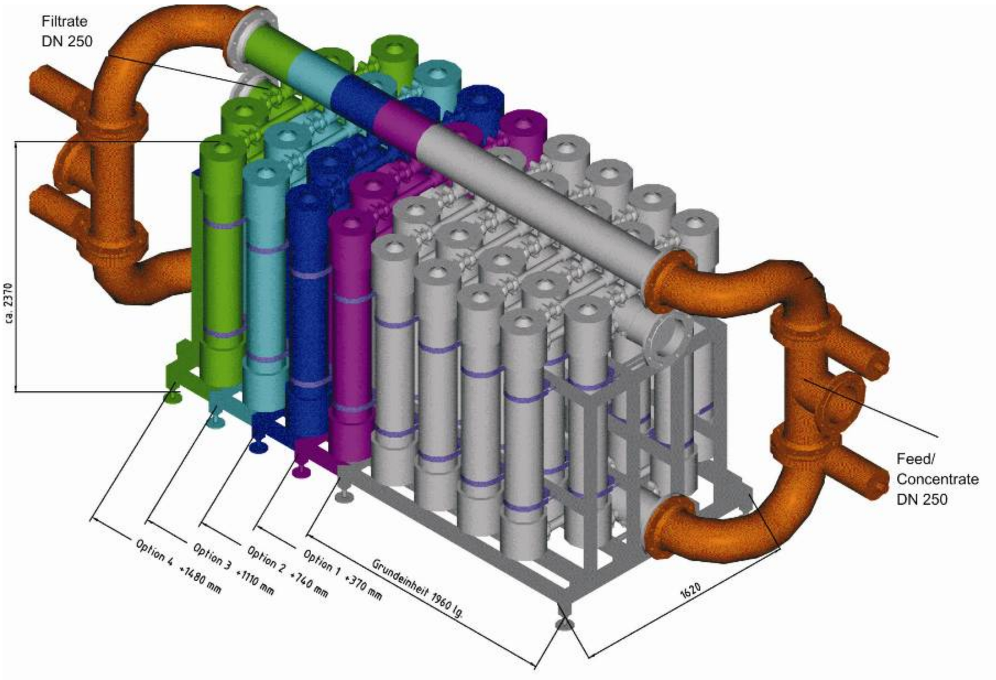


Figure 2-9: **Typical rack design for 34 dizzer® modules with central header and a double row arrangement on each side**

Table 2.2: **Typical dimensions of conventional rack systems with dizzer® modules**

No. of modules per rack	6	24	48	68
Module layout	2-row	2-row	4-row	4-row
Space between racks (mm)	900	900	900	900
Space between racks (inch)	35.4	35.4	35.4	35.4
Rack weight (kg):				
Dry	800	2,500	5,000	7,800
In operation	1,200	4,000	9,000	12,600
Rack dimensions (mm) :				
Length	1,180	3,150	5,500	7,800
Width	1,200	1,200	1,900	1,900
Height	2,150	2,400	2,550	2,550
Rack dimensions (inch) :				
Length	46.5	124	216.5	307
Width	47.2	47.2	74.8	74.8
Height	84.7	94.5	100.4	100.4

2.5 dizzer® Modules in the T-Rack® System

The company inge GmbH is the first UF supplier to develop a unique integrated module/rack design. inge GmbH's ultra-compact system is equipped with vertically mounted dizzer® XL modules in the same basic configuration as a conventional rack system.

But unlike conventional systems, the T-Rack® system has feed and drain headers already integrated in the end caps, a design feature that saves space by cutting down on piping and fittings (see Figure 2-10).

Figure 2-10: The T-Rack® integrated module/rack technology

The entire system is made of corrosion and UV-resistant PVC-U, thereby avoiding the comparatively expensive choice of stainless steel. PVC-U has proven to be a highly durable material that eliminates the risk of corrosion, especially when treating sea water and other aggressive types of water. Unlike conventional rack systems, the T-Rack® does not require a steel frame to join the modules and headers together. The T-Rack® design consists exclusively of a flexible support system connected to the upper and lower header pipes.

The T-Rack® 3.0 was developed for applications which require higher levels of pressure resistance, particularly at higher temperatures. Thanks to the direct welding of the T-pieces to the module body, connection of the individual modules to the headers using 6" flexible pipe couplings, and a design that eliminates all adhesive connections, the T-Rack® is able to offer a design pressure of 5 bar at 40°C with a service life of 10 years (see section on "Permitted Conditions of Operation, Rinsing, Cleaning and Disinfection" for more details).

The T-Rack® 3.0 can be assembled as a single system containing up to 68 (136) dizzer® UF modules (exact number varies depending on module type and T-Rack® system/configuration; see section on "Assembly and Maintenance" for more details) with a capacity of approx. 3,300 GPM (750m^3/h) (depending on water quality). The configuration of the system is highly flexible and can be closely tailored to the on-site requirements in each case. For example, it is possible to construct a T-Rack® with 34 modules comprising three sub-units – containing 2x12 and 1x10 modules – which are connected in-series or sequentially (two-row arrangement, see Figure 2-11). Alternatively, the T-Rack® units can be arranged in a configuration where they are adjacent to each other (four-row arrangement, see Figure 2-12). The four-row design offers a high degree of flexibility by enabling the operation of up to four independent ultrafiltration lines (assuming the piping configuration is suitable).

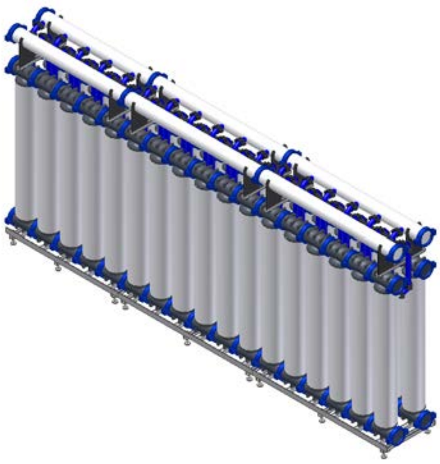


Figure 2-11: 34 dizzer® XL modules in a 2-row T-Rack® 3.0 configuration

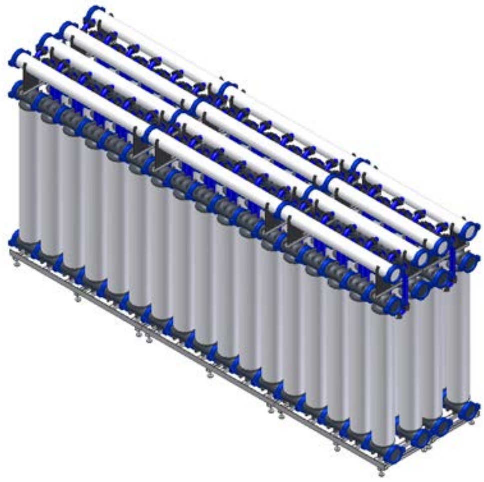


Figure 2-12: 68 dizzer® XL modules in a 4-row T-Rack® 3.0 configuration

Typical dimensions of various different T-Rack® 3.0 configurations are provided in Table 2.3 as examples:

Table 2.3: Typical dimensions of sample T-Rack® 3.0 configurations

No. of modules per rack	6	24	48	68
Module layout	2-row	2-row	4-row	4-row
Space between racks (mm)	900	900	900	900
Space between racks (inch)	35.4	35.4	35.4	35.4
Rack weight (kg):				
Dry	458	1,775	3,550	5,038
In operation	899	3,538	7,076	10,034
Rack dimensions (mm) :				
Length	991	3,966	3,966	5,618
Width	710	710	1,420	1,420
Height	2,700	2,700	2,700	2,700
Rack dimensions (inch) :				
Length	39	156,1	156,1	221,2
Width	28	28	55,9	55,9
Height	106,3	106,3	106,3	106,3

2.6 How does T-Rack® Technology compare to conventional rack systems?

The T-Rack® is a space-saving solution that offers clear advantages over conventional rack designs. Its compact design creates a footprint that is up to 60 % smaller. In fact, it is the most compact UF system available on the market (see Figure 2-13).

Its minimal footprint and carefully-chosen materials enable significant reductions in the cost of the initial investment. Depending on the scale of the project, savings of up to 5% can be made on the cost of the actual UF system. In the majority of existing treatment plants, the space available for upgrading a depth filtration system into an ultrafiltration system is minimal, which means that it is often impossible to upgrade to a conventional style of UF rack system. By choosing the T-Rack® design, however, even small buildings with low roofs can be equipped with UF technology (e.g. containers and basements). For example, a capacity of 500m^3/h can be achieved in a space measuring just 8 m².

And depending on the T-Rack® configuration chosen, it is possible to achieve weight savings of up to 30% as well as having a smaller footprint.

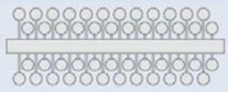
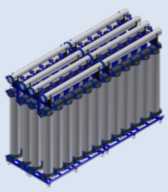
T-Rack® 3.0	Conventional rack
1,4 m width	1,9 m width
4,0 m length	5,5 m length
2,7 m height	2,5 m height
5,6 m^2 footprint	10,6 m^2 footprint
	
Reduced footprint	
	
More compact solution	

Figure 2-13: Comparing the T-Rack® 3.0 to a conventional rack

3 Membrane Operating Modes

3.1 Filtration and Backwash

In filtration mode, the source water is treated by being forced through the ultrafiltration membrane from the feed side to the filtrate side. The contaminants in the water, which are blocked by the filtration surface, accumulate on the inner surface of the membrane capillaries. The filtrate flows into the filtrate/backwash tank, which serves as a storage container for the backwash water and the water that is to be used for further processing or consumption. Alternatively, the filtrate can be piped directly to the ultimate consumers, in which case the tank is used solely as a storage container for backwash water. The amount of water that can be treated by a module depends on a number of factors, including the origin of the water being treated (e.g. ground water, surface water, sea water, or pretreated waste water), the composition of the source water (e.g. turbidity, concentration of solids, dissolved organics/inorganics, temperature), and the chosen cost strategy (capital cost, operating costs).

The diagrams below show the two operating modes "Filtration Top" and "Filtration Bottom" in dead-end mode. Figure 3-1 shows filtration being performed from top-to-bottom (FT) with the source-water being fed into the top of the module, while Figure 3-2 shows filtration being performed from bottom-to-top (FB) with the source-water being fed into the bottom of the module.

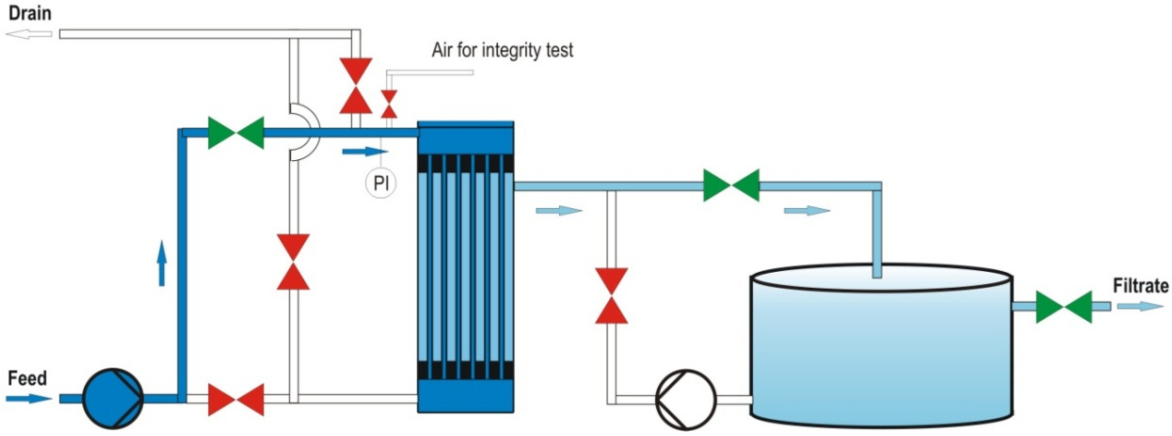


Figure 3-1: Filtration Top (FT) mode

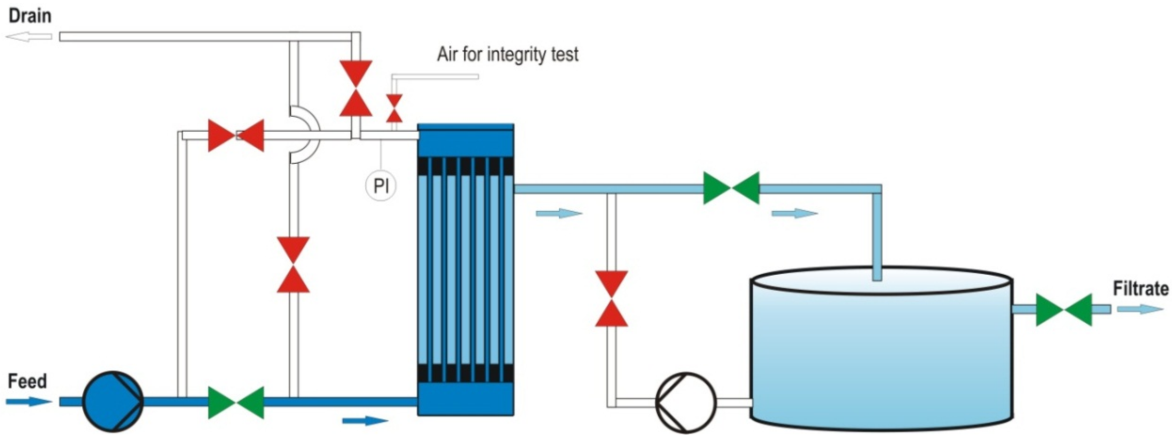


Figure 3-2: Filtration Bottom (FB) mode

Normal flux rates generally lie between 60 and 140 LMH (35 to 82 GFD). In special applications (e.g. swimming pool applications) it may be possible to set the flux rate higher under certain circumstances.

Important

- The flux rate must be kept constant, for example using an electronically controlled filtration pump with a frequency converter.

Depending on the quality of the source water and the flux rate, between 30 and 120 minutes of filtration time can typically be expected before a backwash is performed. In some applications (for example water treatment for swimming pools), the filtration time may be considerably longer (e.g. 360 minutes). During the filtration process, the contaminants accumulate on the UF membrane surface and form a coating layer, or cake. As a result, the pressure drop required for filtration – also known as the transmembrane pressure (TMP) – increases gradually. In order to remove the build-up of foulant from the membrane surface and reduce the TMP, backwashes are performed at regular intervals. The water required for the backwash is drawn from the backwash tank and forced through the module from the filtrate side using the backwash pump. It passes through the membrane from the outside in (i.e. opposite to the direction of flow used in filtration mode) and detaches the accumulated foulant coating from the membrane surface. The backwash water is then rinsed out of the fiber capillaries and channeled through the module inlet connection to the drain.

Important

- The backwash water must be free of abrasive or membrane-blocking particles, i.e. the level of water cleanliness must be at least as high as that of inge® UF filtrate. When drawing water from the backwash tank, it is also important to ensure that no corrosion or erosion products that may have formed in the tank or in the pipes are reversed flowed into the membrane module.

- To be sufficiently effective, the backwash must be conducted at a flux rate of at least 230 LMH (135 GFD).

Effective backwash duration varies between 30 and 60 seconds depending on the quality of the feed water, the type of operating cycle (see section on "Operating Cycles") and the size of the installation.

Important

- To ensure reliable cleaning even when the membranes are heavily fouled, it is important to maintain a constant flow rate using a flow control system. One way this can be achieved is by using a backwash pump driven by a frequency converter. The frequency converter should be used to control the process to ensure that the minimum flux rate of 230 LMH (135 GFD) is achieved within 5 - 10 seconds or less without pressure surges.

The following diagrams show the two backwash operating modes "Backwash Top" and "Backwash Bottom". Figure 3-3 shows a Backwash Top (BWT) in which the backwash water (filtrate) flows through the module from top-to-bottom, while Figure 3-4 shows a Backwash Bottom (BWB) in which the backwash water (filtrate) flows through the module from bottom-to-top.

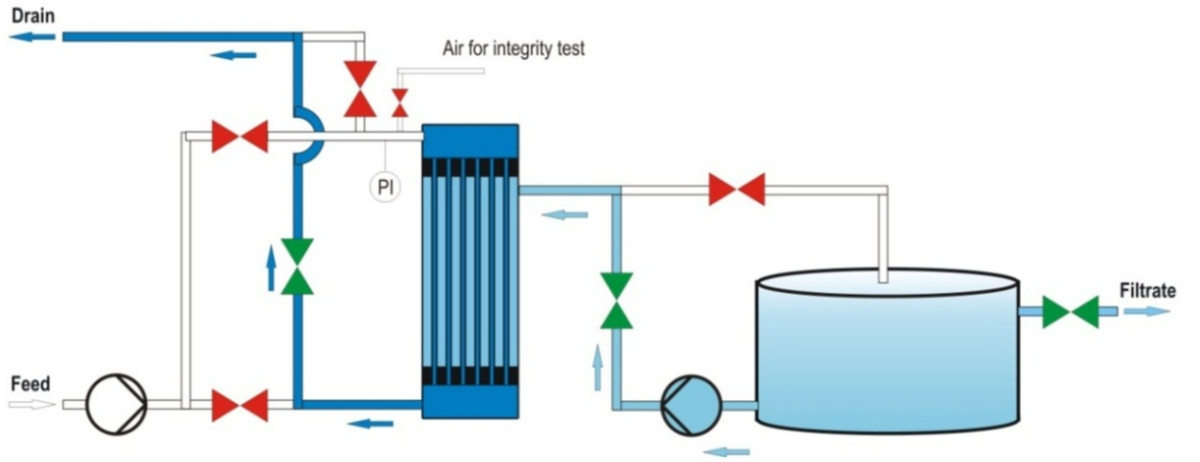


Figure 3-3: Backwash Top (BWT)

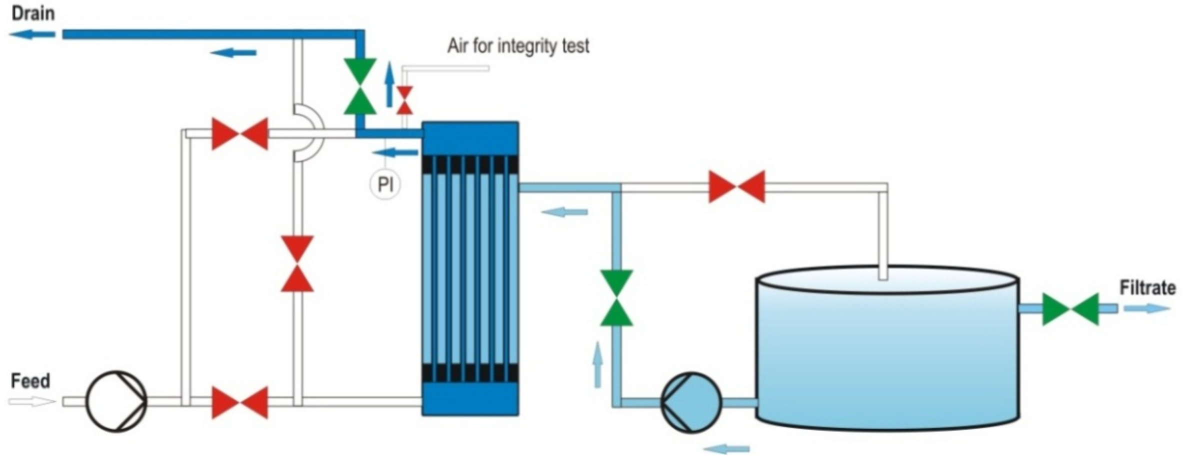


Figure 3-4: Backwash Bottom (BWB)

3.2 Forward Flush

When treating source-water with high concentrations of solids, it may be advantageous to perform a forward flush prior to the backwash. A forward flush can also be used to flush solids out of the system which have been loosened from the membrane by a backwash, thereby potentially reducing the quantity of filtrate required for the backwash. A forward flush also serves to ensure that no residues of the preceding backwash can return to the membrane in a subsequent filtration stage. This method can boost cleaning performance while simultaneously improving recovery rates.

Performing a forward flush is optional; if this option is activated, the forward flush will be performed before and/or after a backwash. The forward flush is carried out using the filtration pump at a volume flow rate equivalent to the filtration flux rate. For this reason, the volume flow rate for the forward flush is specified here in LMH (GFD). No additional pump is required for the forward flush.

As shown in Figure 3-5 and Figure 3-6, the drain is kept open and the filtrate valve is closed during a forward flush. This means that all the water flows lengthwise through the membrane capillaries. This method is particularly effective at removing particulate matter, especially at the end of the membrane capillaries. A forward flush generally occurs between 20 and 40 seconds. It can be performed either top-to-bottom (FFT) or bottom-to-top (FFB).

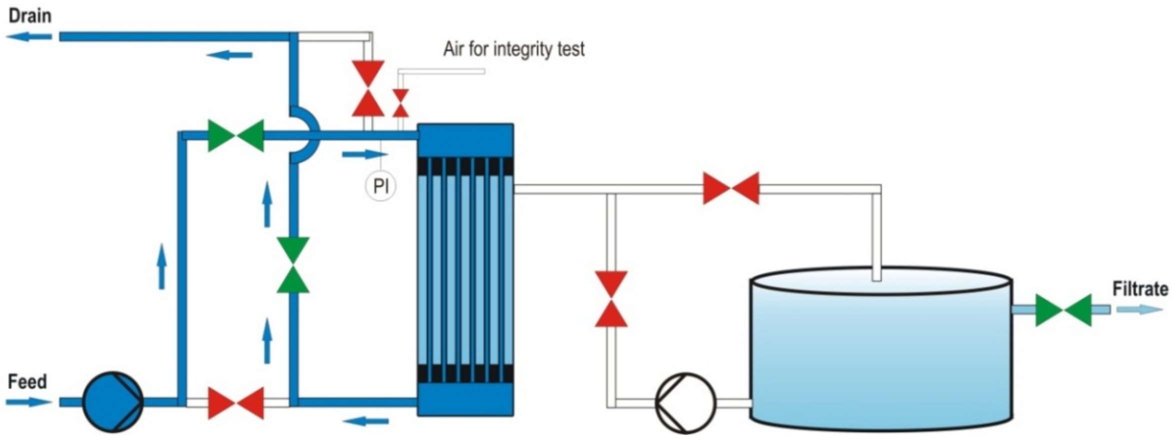


Figure 3-5: Forward Flush Top (FFT)

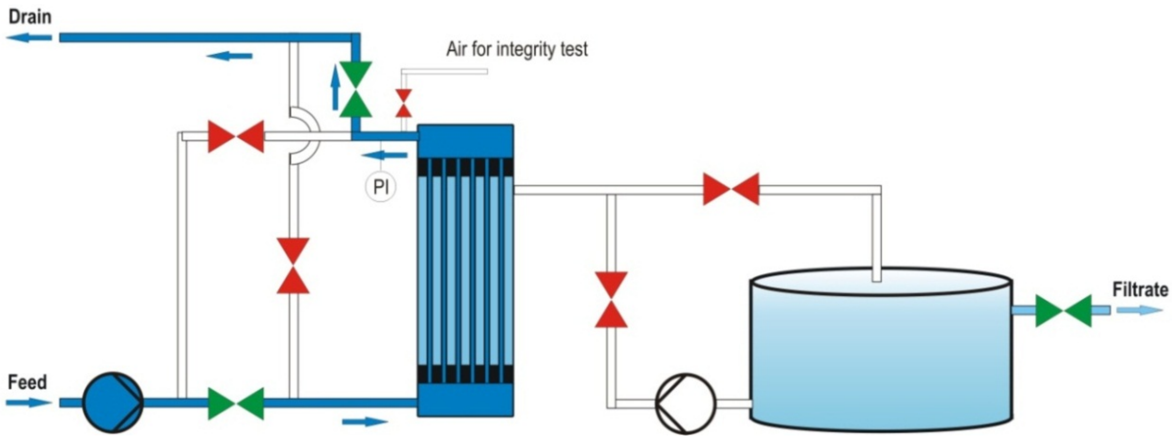


Figure 3-6: Forward Flush Bottom (FFB)

3.3 Operating Cycles

In this context, an ultrafiltration operating cycle refers to a sequence of operations comprising a filtration sequence followed by a cleaning sequence. The cleaning sequence includes at least one backwash, though it may include multiple backwashes and forward flushes. In general, inge® modules are very flexibly operated with different operating cycles. It is hereby important to observe the following rules.

Rules for Operating Cycles

- An operating cycle contains exactly one filtration sequence and one cleaning sequence.
- A cleaning sequence must include at least one backwash, though it may include multiple backwashes and forward flushes.
- An operating cycle is automatically controlled and monitored
- The first cleaning stage after a filtration sequence (i.e. a backwash or a forward flush) must always be performed in the same direction as the filtration process in the preceding filtration sequence.
- Two operating cycles are considered to be identical if all the operating modes in the filtration and cleaning sequences and all their respective durations are the same. If one of these two criteria differ, then the operating cycles are considered to be different.

- As a general rule, a completed operating cycle can either be followed by the same operating cycle or an operating cycle with different operating modes and/or different durations of the individual operating modes.
- The duration of each filtration sequence and the individual cleaning steps within a cleaning sequence may differ from one cleaning cycle to the next. However, the full duration of the cleaning cycles within one operating cycle shouldn't be longer than 60 sec.
- In combination with the selection of operating parameters such as filtration flux, filtration time and backwash flux, backwash time, the choice of operating cycle determines the filtrate recovery rate and ultimately, the overall efficiency of the process.
- The duration of each filtration sequence is set on the basis of the source-water quality and the selected filtration flux rate, though generally speaking it does not vary from one operating cycle to the next. In contrast, the duration of the individual cleaning stages within a cleaning sequence may differ from one operating cycle to the next
- Advice for the programming of the control which is related to choosing an operating cycle, can be obtained upon request at inge GmbH.

Figure 3-7 and Figure 3-8 show examples of operating cycles including a filtration sequence (Filtration Bottom or Filtration Top) and a cleaning sequence (Forward Flush Bottom or Forward Flush Top and also Backwash Bottom or Backwash Top) each in the same direction and with indication of the normal time range. It is generally sufficient to run the cleaning sequences without a forward flush, in other words, only to do a backwash. The duration of the forward flush should generally be set to 0 sec. In certain applications, however, forward flushes may proof necessary either before or after the backwash event. In general, duration of backwash as well as forward flush should be user settable to allow for process flexibility.

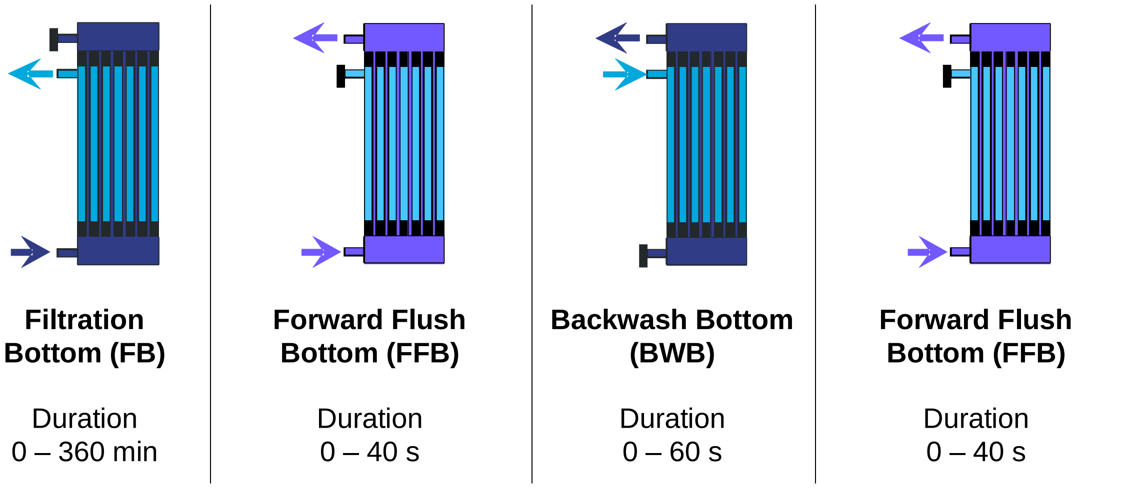


Figure 3-7: Exemplary operating cycle with Filtration Bottom, Forward Flush Bottom and Backwash Bottom

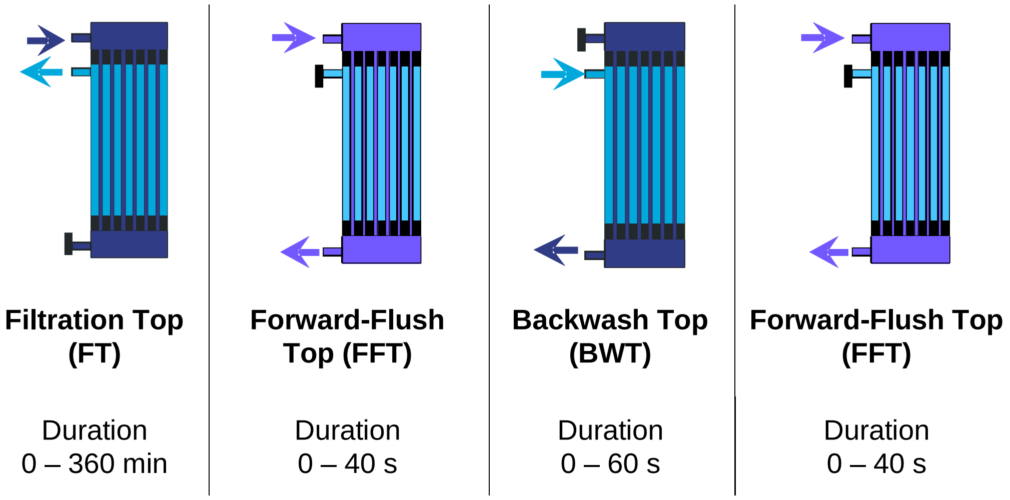


Figure 3-8: Operating cycle with Filtration Top, Forward Flush Top and Backwash Top

As a standard, inge® modules are operated in an alternating manner: Filtration bottom/backwash bottom is followed by filtration top/backwash top and so on in a continuous repetition (see Figure 3-9).

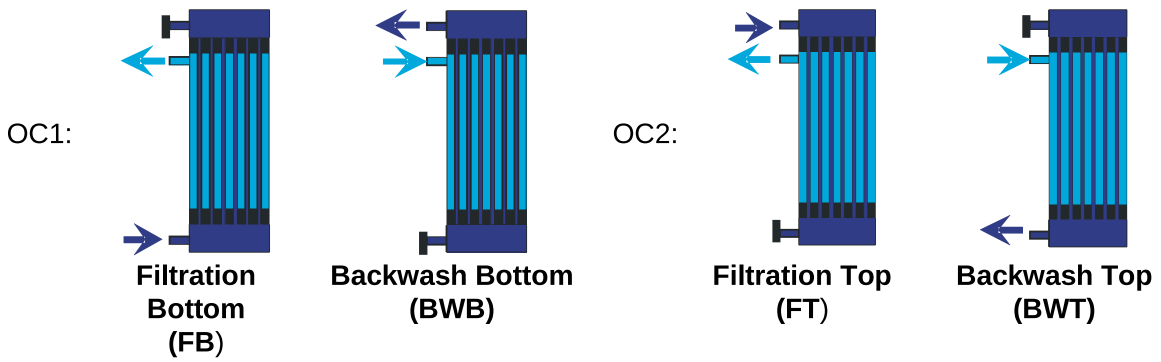


Figure 3-9: Two consecutive different operating cycles (OC) for a mutual operation

4 Feed Quality and Pretreatment

4.1 Maximum Feed Concentration and Goals of Pretreatment

Important

- In some situations the feed water may be judged to contain substances that could potentially damage the membrane or membrane fibers or that may cause fouling or scaling which would be too costly to remove even with chemical CIP (see section on "Guidelines on Operating inge® Modules/Racks"). In such cases it is essential to carry out pretreatment to remove these substances from the water prior to ultrafiltration.

- The presence of particularly large particles in the feed water may result in irreversible fouling of the capillaries or in damage to the membrane or membrane fibers. Large dirt particles must therefore be removed by an upstream screen filter (see section on “Design and Construction”).

The quality of the water fed into a membrane system has a major impact on the membrane's performance, recovery and availability. Substances in the water that permanently exceed a critical concentration or temporarily rise above a maximum concentration can cause flux rates, achievable permeability and recovery rates to fall below the stated design values. This also applies to the dosing of inorganic iron or aluminum-based coagulants (see also section 4.2) and powdered activated carbon. Concentrations that exceed permitted levels may also significantly increase the frequency of chemically enhanced backwashes (CEB) required to maintain stable permeability as well as the frequency of chemical clean-in-place (CIP) to remove stubborn fouling/scaling substances. This could lead to higher chemical consumption and negatively affect system availability.

No fixed values can be given for critical and maximum concentrations because these values will differ depending on the type and even the sub-type of the source-water used. Generally speaking, groundwater will generally be simpler to treat than surface water or seawater, which tends to have higher concentrations of dissolved organics (DOC) and which may contain algae and algae-like substances. Equally, surface water is generally easier to treat than water discharged from a municipal waste water treatment plant.

4.2 Microflocculation

4.2.1 General Overview

In addition to the build-up of particulate substances, the flocculation process also causes dissolved organics (DOC) in the water to precipitate and accumulate on the arising metal hydroxide flocs and thus to be removed by the membranes. Experience has shown that these are more difficult to remove from the membrane than the particulate matter. In many applications based on ultrafiltration technology, the overall process is optimized by using coagulation and microflocculation as effective pre-treatment processes. In contrast to sedimentation and depth filtration, which require the formation of larger macroflocs, ultrafiltration only requires coagulation with subsequent formation of microflocs. This has the advantage of reducing the required quantity of coagulants and minimizing the quantity of sludge produced.

Depending on the concentration and characteristic structure of the dissolved organics in the feed water, specific quantities of inorganic coagulant (usually metal salts such as $FeCl_3$, polyaluminum chloride (PACl)) are added to the water prior to ultrafiltration and moderate amounts of energy are then applied to form microflocs. This method can be used to increase or stabilize membrane performance. The principal effects are a reduction in organic contaminants as a result of the binding of the dissolved organics in the iron or aluminum flocs and the formation of a porous coating layer of microflocs on the membrane surface which helps to promote a stable filtration process and high backwash effectiveness.

In addition, proper handling of the microflocculation process can improve filtrate quality, particularly in regard to the concentration of DOC (which in many cases can be reduced by up to 60%), the SDI (Silt Density Index = clogging index; a key quality parameter for a reverse osmosis system downstream from the UF system), and the phosphate concentration (especially important in waste water applications).

When performing microflocculation, it is important to note that the concentration of the residues of dosed metal salts in the filtrate should not exceed 1% of the added metal concentration and should under no circumstances exceed any relevant limits that may apply (e.g. for drinking water treatment).

4.2.2 Performing Microflocculation

The goal of microflocculation is to remove as much DOC as possible while simultaneously minimizing the amount of coagulant that remains in the UF filtrate. Achieving this goal requires precise adjustment of the coagulation and flocculation process. Based on the type of coagulant and the quality of the source water, an acid or caustic must be used to adjust the pH value in order to ensure an optimum pH for coagulation and microflocculation. The required contact time for the coagulant depends on the type of coagulant, the water chemistry and the water temperature.

In order to define the best possible coagulation and microflocculation parameters, we recommend conducting jar tests in a preliminary phase. The system can then be designed based on the results of these tests. It is important that the jar tests focus on analytical parameters such as residual concentrations of Al and Fe and DOC removal rather than optical parameters such as floc formation. Table 4.1 gives an overview of various coagulants and their key characteristics.

Table 4.1: Coagulation and microflocculation parameters

Coagulant	Dosage of Fe/Al[1] in [mg/L]	Specific dosing (Me^{3+}/DOC) in [mg/mg]	pH range	Optimum pH	Contact time[2] in [s]	DOC elimination rate[3] in [%]	Residual quantity (as percentage of dosage)[4]
$FeCl_3$	0.7-7.0	0.5-2.0	5.0-10.0	6.8-7.0	30-60	10-60	1%
PACl	0.5-5.0	0.25-0.5	6.5-7.5	6.8-7.0	30-60	10-60	1%

[1] The dosage can be decreased for swimming pool applications (e.g. 0.03 mg/L AL/Fe)

[2] Contact time may show significant variation depending on water temperature, pH value, water chemistry and treatment goals (t << 30s and t >> 60s) → potential for optimization

[3] Removal of organics depending on water chemistry and coagulation parameters (pH value, etc.)

[4] Significant residues of Me^{3+} (metal salts) indicate a problem with the coagulation parameters (mixing conditions, pH value, alkalinity, contact time, dosage) and should be strictly avoided.

Using the prefilter to mix the coagulant may lead to fouling or scaling of the prefilter (e.g. precipitation of Al hydroxides). Chemicals may then be required to remove this fouling if it can no longer be removed by backwashing alone. We therefore recommend installing the prefilter upstream from the coagulant dosing station or downstream from the contact zone. In the event that the existing piping does not guarantee sufficient contact time, a contact tank can be installed to increase the coagulant contact time. The following process diagrams show a range of different configurations for inline flocculation:

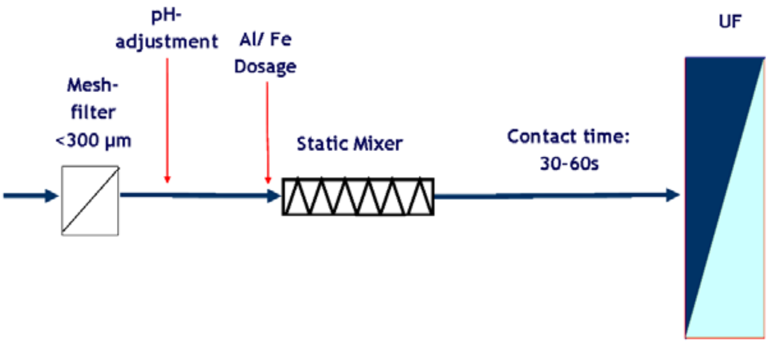


Figure 4-1: Example 1: Prefilter – microflocculation – static mixer – UF

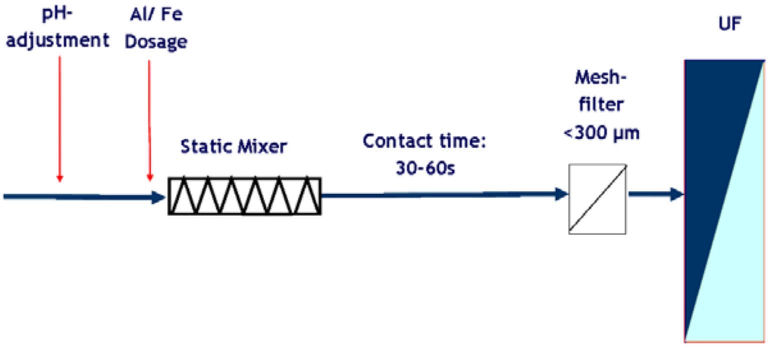


Figure 4-2: Example 2: Microflocculation – static mixer – prefilter – UF

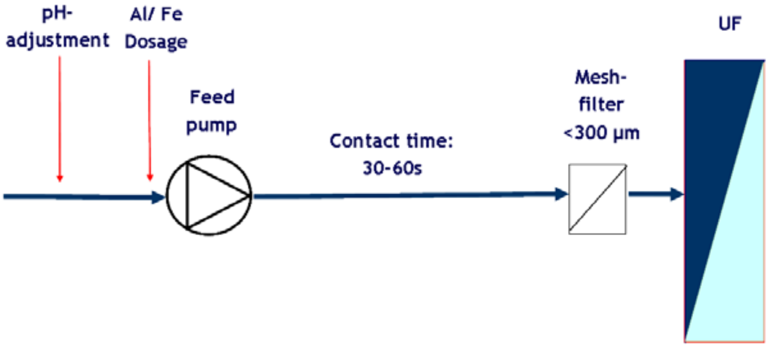


Figure 4-3: Example 3: Microflocculation – feed pump – prefilter – UF

Important

- It is important to ensure proper mixing and adequate contact time. To achieve the best microflocculation results, the contact time for the chemicals should be adjusted to reflect the source-water quality (e.g. temperature) and the requirements regarding filtrate quality (e.g. DOC, residual concentration of Al or Fe in the filtrate). Under no circumstances should flocculation take place in the membrane or on the filtrate side (this would lead to unacceptable precipitation processes in or on the membrane).

- When calculating contact time, please note that coagulation and flocculation processes are significantly slower at low temperatures (< approx. 5°C). To counter this, we recommend using polyaluminum chloride (PACl) which reacts significantly faster than other coagulants at low temperatures.

- When calculating the size and shape of the contact tank, it is important to choose a design that avoids short-circuiting in the tank.

- If the above-mentioned coagulants are added prior to UF then special instructions must be followed for CEB and clean-in-place (CIP) (see the following sections for more information: "Chemically Enhanced Backwash (CEB)", "Chemical Clean In Place (CIP)" and "Using Chemicals for CEB/CIP").
- No organic coagulants or coagulation aids (e.g. polyelectrolytes) may be used either alone or in combination with inorganic coagulants since this may lead to severe, chemically irreversible fouling on the membranes which even CIP may be unable to remove. In certain special circumstances it may be possible to use substances of this type, but only if this has been tested and approved by inge GmbH in advance.
- To avoid excessive dosing of coagulants, it is important to monitor and document the concentration of coagulants in the source water, feed and filtrate.

4.3 Using Chlorine

In some countries, continuous chlorination is often used as a form of pretreatment to combat bacterial growth in water treatment facilities. For a number of reasons, we specifically advise against using any feed pre-chlorination.

Important

- Chlorine is a powerful oxidant which can lead to the formation of volatile chlorinated hydrocarbons in water chlorination processes. This by-product occurs as a result of free chlorine reacting with organic material. The best-known by-products are trihalomethanes (THMs), a class of chemicals that includes chloroform, which has been shown to cause cancer in laboratory animals, and chloramines, which are believed to trigger allergies and which cause the chlorine smell associated with chlorinated swimming pools.
- THMs and other chlorinated hydrocarbons that are formed as by-products in the chlorination process are grouped under the parameter AOX, which stands for adsorbable organic halogen compounds (the "X" is used in chemistry as a general abbreviation for any halogen. It is essential to make every effort to avoid the formation of AOX.
- Experience has shown that the use of chlorination in combination with ultrafiltration is highly counterproductive. Chlorination of organic matter in the water creates numerous tiny organic fragments which can cause blockage of the membrane pores.
- In addition, the organic fragments produced by chlorination also tend to be bioavailable, a situation that is compounded by the significant increase in the rate of bacterial growth in the water. Together, these factors lead to an increase in the formation of biofilms on any downstream reverse osmosis membranes.
- In some cases, the application of sub-lethal doses of chlorine may increase the resistance of a microorganism, resulting in the need for ever-higher doses of chlorine to achieve the same effects.

For this reason, continuous chlorine dosing should not be used as a pretreatment stage and should be used as infrequently as possible in chemically enhanced backwash (CEB) and chemical clean-in-place (CIP) processes (see section on "Using Chemicals for CEB/CIP").

Important

- If the decision is taken to use chlorination despite its negative side-effects, it is important to ensure that the concentration of free chlorine on the membrane does not exceed the maximum concentration for continuous dosing specified in the "Guidelines on Operating inge® Modules/Racks".
- A better choice for pretreatment is a process known as shock chlorination, which involves adding a high dose of chlorine to the source-water for a short period of time at less frequent intervals. Shock chlorination is subject to certain maximum permitted concentrations and exposure times (see the "Guidelines on Operating inge® Modules/Racks").

An increasing number of applications are switching to chlorine dioxide as an alternative to chlorine. Unlike chlorine, the dosing of chlorine dioxide (ClO_2) does not have the potential to form trihalomethanes. Additionally, ClO_2 is an excellent disinfectant even at pH values > 8. One caveat is that oxidation with ClO_2 forms the anions chlorite and chlorite as disinfection by-products. This may lead to excessive chlorite levels. For example, with a concentration of dissolved organic carbon (DOC) of 2 mg/L and a ClO_2 dosage concentration greater than 0.4 mg/L, the level of chlorite in the water would exceed the level specified for drinking water in in certain countries (0.2 mg/l in Germany, 2 mg/L in US) after a contact time of just 30 minutes. In addition, the yield of by-products increases significantly as contact times are extended. The continuous dosing of chlorine dioxide is therefore to be avoided in pretreatment stages.

5 Chemically Enhanced Backwash (CEB)

5.1 General Overview

A chemically enhanced backwash (CEB) is used to boost the effectiveness of a backwash. It is performed after a defined number of operating cycles, either after a backwash or after a forward flush (see section on "Operating Cycles"). The standard cleaning process carried out before the CEB removes large particles from the membrane. This enhances the effectiveness of the cleaning solution in the subsequent CEB.

Important

- The guidelines stipulated in the section on "Using Chemicals for CEB/CIP" must be observed. For most applications, alkaline and caustic CEBs have generally proved to be the best choice. Before using any other chemicals, it is necessary to contact inge GmbH to obtain written approval and information on permissible concentrations.
- Before performing a CEB, a backwash must be performed first.
- A CEB may only be performed using water of inge® UF filtrate quality or higher or reverse osmosis permeate. The water used must be free of abrasive and membrane-blocking particles. When drawing water from the tank for a CEB, the same rule applies as for normal backwashes, i.e. ensure that no corrosion or erosion products that may have formed in the tank or in the pipes are washed into the membrane module.
- CEB frequency depends on feed water quality and other operating conditions such as flux and recovery rate. The CEB is usually carried out several times a week.
- It is important to ensure that the CEB chemicals are washed around the system for a long enough period to ensure that they are distributed evenly and homogeneously throughout the entire rack (see section entitled "How a CEB is Performed").
- The effectiveness of a CEB depends not only on the chemicals used, but also on the operating cycles and time intervals between CEBs. The sequence of the various CEBs should therefore be programmed as flexibly as possible (see "" for more details).
- Depending on the water quality and pre-treatment process, it may be necessary to run a CEB sequence consisting of multiple individual CEBs performed in succession with different cleaning chemicals. A CEB sequence may even include a complete operating cycle (= filtration sequence and cleaning sequence) between the individual CEBs, in which case the complete cycle is treated as a single CEB, particularly when it comes to programming the control system (see "Table 5.1" for more information).
- For the vast majority of applications, alkaline CEBs have proved to be the best choice for removing organic build-up and acid CEBs have been proven as the best solution for removing inorganic fouling. The use of chlorine in isolation is only required for disinfection purposes (see section on "Using Chemicals for CEB/CIP").
- Since there is always the possibility of precipitation in an alkaline CEB, this must always be followed by an acid CEB. Running an operating cycle between a caustic CEB and an acid CEB serves to refill the backwash tank and neutralize the water in the membrane fibers. A caustic/acid CEB is considered to be one single CEB.
- An alkaline CEB must always be performed in combination with acid as a caustic/acid CEB. Acid CEBs may be performed by itself or in combination with caustic as a caustic/acid CEB.

- If iron-based coagulants are used in the pretreatment stage, the residue can only be removed by an acid CEB. If aluminum-based coagulants are used, then either acid or alkaline CEBs may be performed.
- If using a coagulant in the pretreatment stage, it is essential to perform an acid CEB no later than 6 to 8 hours before any CEB that involves chlorine in order to avoid the catalytic formation of highly oxidative hydroxyl radicals due to the breakdown of chlorine and to prevent coagulant from being deposited on the membrane. Before adding the chlorine, it is important to ensure that the acid CEB solution has been completely rinsed out of the module. It is therefore necessary to perform at least one operating cycle (= filtration and cleaning sequence) between the acid CEB and a chlorine CEB.
- Unlike a standard backwash, a CEB must be performed in both directions in succession (first from bottom-to-top and then from top-to-bottom) to ensure that the cleaning solution is evenly distributed throughout the UF rack.
- The use of coagulants in the pretreatment stage (see section on "Feed Quality and Pretreatment") usually requires an increase in CEB frequency due to the fact that the coagulant cannot be fully removed by normal backwashes.
- Chlorine containing CEB solution rinsed out of the system should under no circumstances be mixed with acid CEB solutions (e.g. in a neutralization tank), since this could lead to the formation of toxic chlorine gas.

The CEB's mentioned in Table 5.1 or their combination with defined frequencies are used depending on the application and water quality and where the following points must be considered during the programming or organization of the CEB:

Important

- A caustic/acid CEB is treated as a single CEB. In Table 5.1, this is designated as CEB 1 and is divided into an alkaline CEB 1.1 and an acid CEB 1.2. If chlorine is added to the alkaline CEB 1.1, it is referred to as CEB 1.1 (B); if no chlorine is added, it is designated as CEB 1.1 (A).
- The acid CEB is designated as CEB 2 (Table 5.1). The acid CEB 2 is considered stand-alone, which means it is used independently from other CEB's to enable the effective removal of foulant build-up caused by inorganic water constituents or coagulants (e.g. $FeCl_3$, PACl).
- The chlorine CEB is designated as CEB 3 (Table 5.1). CEB 3 is considered stand-alone, which means it is used independently from other CEB's. It is only required in applications involving the treatment of water discharged from a municipal wastewater treatment plant.

Table 5.2: Organization of the CEB´s

CEB	CEB 1			CEB 2	CEB 3
Note	Sequence of two chemical cleaning stages (CEB 1.1 and CEB 1.2): alkaline followed by acid			Performed separately from other CEBs	Performed separately from other CEBs
Purpose	To clean off organic deposits and then to clean off inorganic deposits and/or remove precipitation			To remove inorganic deposits (including coagulant residue)	Disinfection
Subprogram	CEB 1.1(A)	CEB 1.1(B)	CEB 1.2	-	-
Characteristics	Purely alkaline	Alkaline + oxidative	Acid	Acid	Disinfecting
Chemicals	NaOH	NaOH and NaOCl	HCl or H_2SO_4	HCl or H_2SO_4	NaOCl or ClO_2

Further advice for the programming of the control can be requested at inge GmbH.

5.2 How a CEB is Performed

The CEB is essentially performed in a similar way to a backwash, i.e. filtrate flows from the filtrate side to the feed side. In addition, a cleaning chemical is added to the filtrate to boost the effectiveness of the process. Figure 5-1 shows the basic sequence of steps generally used to perform a CEB based on typical values for the respective parameter settings.

To introduce the chemicals into the system, a flux rate is established (referred to here as the intake flux) of approx. 120 LMH (71 GFD), which is lower than the backwash flux rate. Once the rack has been completely filled with cleaning solution (controlled by the chemical injection time setting), chemical dispersion ceases and the system enters standby mode. The time required to wash the chemicals into the system in a CEB depends on the position of the dosing points and on the respective flow velocities in the backwash piping and in the piping systems built into the rack. At an intake flux rate of 120 LMH (71 GFD), the chemical intake time (measured from the moment the CEB solution enters the T-Rack® until the entire rack is full) is approximately 90 seconds. This time period is referred to here as t_{int}.

Important

- To improve the distribution of the CEB solution within the rack, the injection of the solution must be divided into a "chemical injection bottom" and a "chemical injection top" (see Figure 5-1). The duration of the injection bottom and injection top must be at least 20% of the total duration of the chemical injection time in each case.

This marks the beginning of the soak period. Once the soaking time has elapsed, the chemical solution and the substances removed from the membrane must be washed out of the rack with filtrate. This is achieved by means of a Backwash Bottom (with a duration of approximately 30 seconds) followed by a Backwash Top (also with a duration of approximately 30 seconds). The flux rate for rinsing out the solution should be at least 230 LMH (135 GFD) just like a normal backwash.

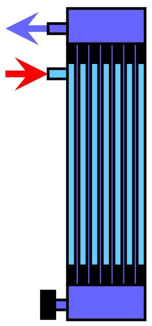
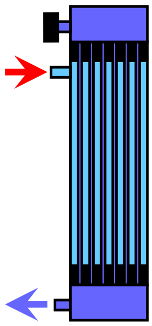
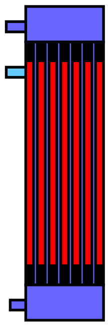
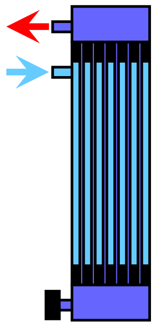
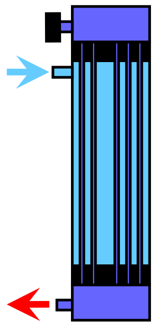
Chemical injection Backwash Bottom Intake flux min. 120 LMH (71 GFD)	Chemical injection Backwash Top Intake flux min. 120 LMH (71 GFD)	Soak period (residence time)	Chemical rinse out Backwash Bottom Rinsing flux min. 230 LMH (135 GFD)	Chemical rinse out Backwash Top Rinsing flux min. 230 LMH (135 GFD)
				
$t_{int,bottom}$ =70 s	$t_{int,top}$ =20 s	5-60 min	30 s	30 s

Figure 5-1: The chemically enhanced backwash (CEB) process with typical parameters for an intake flux rate of 120 LMH (71 GFD)

The total chemical intake time t_{total} is the sum of t_{int} and the time period t_{ex} which is defined as the time required for the CEB solution to make its way from the dosing point to the rack (see Figure 5-2). The precise figures for these two time periods are calculated as part of the system commissioning process (see section on "System Commissioning").

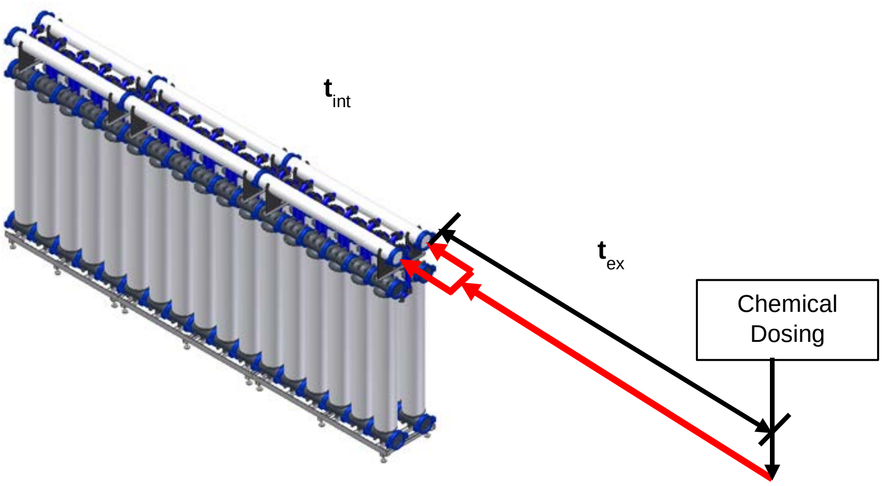


Figure 5-2: Total chemical intake time during CEB

6 Chemical Clean In Place (CIP)

6.1 General Overview

Clean-in-place (CIP) is an effective method of restoring membrane performance by tackling the kind of fouling and scaling that is difficult to remove using conventional backwashes or chemically enhanced backwashes (CEBs). This type of fouling may occur due to difficult operating conditions, for example in situations where there is significant fluctuation in the quality of the feed water, or as a result of improper use, such as a lack of effective pre-treatment, excessive flux rates or incorrect doses of chemicals. As a rule, CIP is not required in normal operation.

A CIP is performed by introducing a chemical solution into the modules and shutting down the membrane system for a longer period of time than is required for conventional cleaning methods. One of the major differences to a CEB is that a CIP is characterized by a forward flush with the circulation of different chemicals using a CIP tank (see section 6.2) on the feed side and an extended soak time (in some cases the feed tank can also be used as a CIP tank).

Important

- A CIP should be performed if the permeability of the system falls below 100 - 150 LMH/bar (4 – 6 GFD/psi) and if this drop cannot be reversed by performing a CEB. A CIP is rated as successful if the permeability of the system subsequent to the CIP is restored to a value of at least 70 - 80% of the reference value[1] recorded after the commissioning of the ultrafiltration system.

- Only those chemicals specified in the section "Using Chemicals for CEB/CIP" may be used for a CIP, and only in conformance with the concentrations and soak times specified in that section. No other chemical may be used unless prior written approval has been obtained from inge GmbH specifically agreeing to its use and stating the permissible concentration.

- The water used to prepare the CIP cleaning solution should be at least of drinking water quality. If reverse osmosis permeate is available, this should be used for the alkaline CIP. Please note that precipitation may occur in the CIP water, particularly if UF filtrate or water of drinking water quality is used for the alkaline CIP. An alkaline CIP must therefore always be followed by an acid CIP.

- For all of the chemicals listed in the section "Using Chemicals for CEB/CIP", the frequency of the CIPs should not exceed four applications a year. In the event that more frequent CIPs are required to deal with special source water situations, this parameter may only be changed in consultation with inge GmbH.

- The overall duration of the circulation and soak time of a CIP depends on the effectiveness of its cleaning results, though it should not exceed 12 hours.

---

[1] Experience has shown that permeability falls during the initial running-in phase of a membrane, which generally lasts around one week, dropping from its initial level to a lower yet stable level of permeability which depends on a number of factors including the quality of the source-water. It is this subsequent, stable level that is classified as the reference value. The initial permeability of inge® modules lies somewhere in the range of approximately 700 LMH/bar (28.4 GFD/psi), while the reference permeability lies between 300 and 600 LMH/bar (12.2 – 24.4 GFD/psi) depending on the source-water quality.

- A conventional backwash should be performed prior to a CIP to ensure that the membrane surface is as clean as possible and to rinse out any foreign particles that may be contained in the piping of the modules or racks.
- When performing a CIP, ensure that the modules and racks being cleaned are disconnected from the rest of the water main system.
- The CIP solution must be fed into the system from the feed side of the membranes/modules. This prevents any damaging substances which could cause fouling or scaling from entering through the filtrate side of the membranes during CIP recirculation.
- In some applications it may be possible to improve the effectiveness of the cleaning process and reduce the soak time by heating the CIP solution, though it is worth noting that this effect is far less pronounced in caustic/acid CIPs than in oxidative CIPs. If a system is available to heat the CIP solution, this system must observe the maximum permitted temperature of 40°C and the maximum permitted rate of temperature change of 1°C/min. A significant amount of energy is required to heat the solution and the process of ensuring compliance with the maximum 1°C/min temperature change rate can be relatively complicated. Heating of the CIP solution is therefore not recommended for applications using inge® modules.
- Ensure adequate ventilation of the area before and during the use of cleaning chemicals.
- When preparing the chemical solution in a CIP tank (mixing together the cleaning chemical and water), the chemicals must always be added to the tank of water, not the other way around. Adding water to concentrated chemicals could cause a violent reaction.
- It is important to ensure that the CIP chemicals are recirculated in the system for a long enough period to ensure that they are distributed evenly and homogeneously throughout the entire rack in the concentration required in each case. If the concentration falls below the required value, more of the chemical must be added.
- Note that the concentration of the CIP solution will be diluted by the water stored in the rack (known as the "hold-up volume") and that this hold-up volume may lead to precipitation in the case of an alkaline CIP. When performing a CIP using reverse osmosis permeate, it may therefore be a sensible idea to empty the rack before injecting the CIP solution.
- To increase the efficiency of a CIP, we recommend performing multiple successive cleaning steps using different chemicals.
- If using a coagulant in the pretreatment stage, or if there are concerns that metal may have accumulated on the membrane surface, it is essential to perform an acid CIP before any CIP or disinfection process that involves chlorine in order to avoid the catalytic formation of highly oxidative hydroxyl radicals due to the breakdown of chlorine and to prevent coagulant from being deposited on the membrane. Ensure that the acid CIP solution has been completely rinsed out of the system before performing the chlorine CIP or disinfection process.
- Chlorine-containing CIP solutions should under no circumstances be mixed with acid CIP solutions (e.g. in a neutralization tank), since this could lead to the formation of toxic chlorine gas.

6.2 Establishing CIP Circulation

The CIP tank must be designed large enough to ensure that the minimum level of water delivers sufficient initial pressure to the intake side of the CIP pump and that the previously empty pipes of the circulation system can be filled. The total volume of the CIP tank is therefore obtained by adding together the following partial volumes:

- Empty volume of the piping from the top feed to the module/rack (V1)
- Empty volume of the filtrate piping (V2)
- Empty volume of the piping from the bottom feed to the module/rack (V3)
- Volume required to protect the CIP pump from running dry (V4)

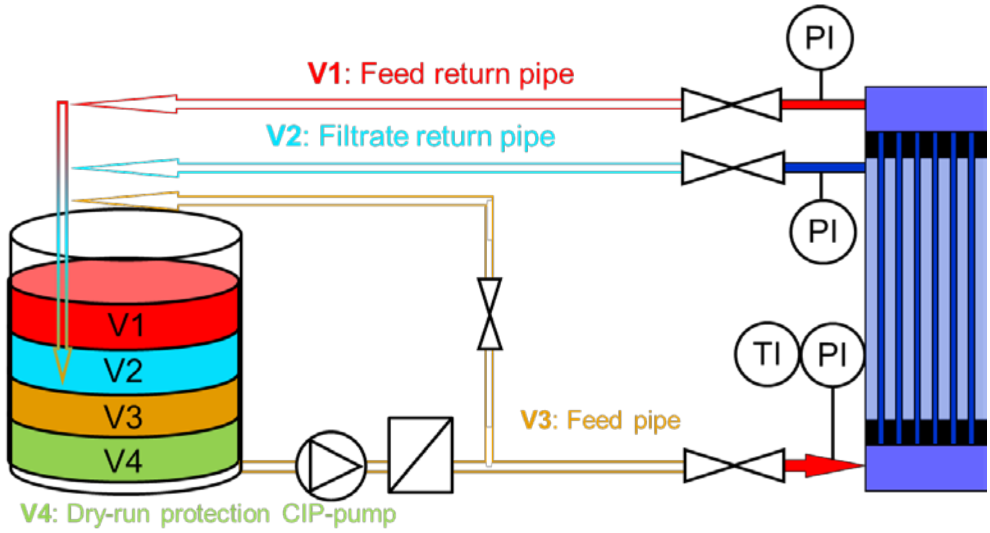


Figure 6-1: Partial volumes for determining the size of the CIP tank

To protect the membranes from damaging particles, it is important to install a screen filter with a minimum cut-off of 300 µm in the circulation system or at the point where the CIP solution is fed into the system. The recommended volume flow rate for cleaning all inge® UF modules is at least 20 LMH (12 GFD), the maximum hydraulic pressure loss 1 bar /14.5 psi). For a dizzer®XL 0.9 MB 60 module with an active membrane surface of $60m^2$ ($646 ft^2$), this corresponds, for example, to a minimum volume flow rate of 20 LMH x $60m^2$ = 1,200 L/h = $1.2m^3/h$ (12 GFD x $646ft^2$ = 323 GPH).
[Design recommendation for the CIP cleaning pump:
Number of modules x surface/module x 20 LMH (12 GFD) = volume flow rate]

6.3 How a CIP is Performed

6.3.1 Preparing the Chemical Solution for a CIP

1. The CIP tank is filled with UF filtrate, reverse osmosis (RO) permeate or drinking water. If available, RO permeate should be used for the alkaline CIP.
2. The cleaning chemicals are added to the water-filled CIP tank, not the other way around (see above).
3. The chemical solution is mixed using a mixer or a special recirculation system.
4. After mixing, check that the pH value and concentration of the solution correspond to the target values. Is important to ensure that the concentrations do not exceed the maximum concentrations specified in the section "Using Chemicals for CEB/CIP".

5. If a heating system is to be used to heat the chemical solution, the heating process may not commence until the chemical solution has begun circulating through the modules. Significant differences in temperature between the chemical solution and the water inside the modules could lead to stress cracks in the module and should therefore be avoided. Do not exceed the maximum permitted rate of temperature change or the maximum permitted operating temperature for the modules (see above or section on "Guidelines on Operating inge® Modules/Racks").

6.3.2 Preparing for a CIP Process

1. For a manual CIP, ensure that the valves are in the correct positions and that the connections are set properly for the cleaning cycle:
   - Cleaning solution inflow = feed bottom header connection
   - Cleaning solution outflow = feed top header connection
   - Filtrate outflow = filtrate drain
2. The cleaning solution may be pumped either in forward flush or in filtration mode. However, the CIP method described should under no circumstances be used in the backwash direction since this could cause large-scale contamination or bacterial growth on the filtrate side.

6.3.3 Circulation and Soak Time

1. In the first stage, recirculation should only take place via the feed side for at least 60 minutes in order to perform initial cleaning of just the fiber lumen. The filtrate valve is closed during this procedure.
2. Injection of the chemical solution into the fiber lumen on the feed side is triggered by starting the CIP cleaning pump (Figure 6-2). Set the minimum volume flow rate in accordance with the section "Establishing CIP Circulation". It is important to ensure a feed side venting.

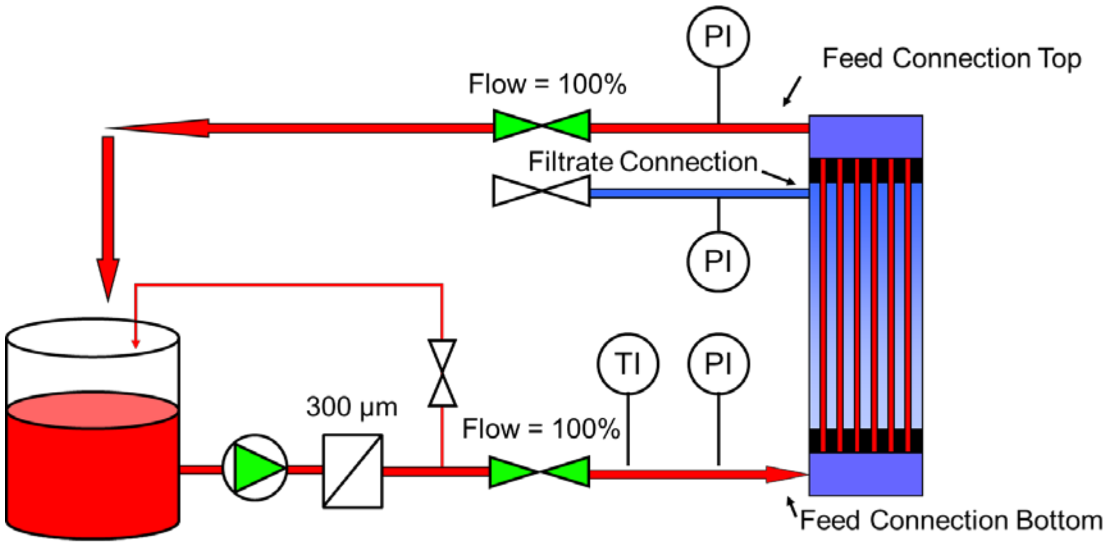


Figure 6-2: Circulation on the feed side

3. If the chemical solution is to be heated, it should be slowly heated to 30-35°C while it is circulating through the system. Do not exceed the maximum permitted rate of temperature change or the maximum permitted operating temperature for the modules (see above or section on "Guidelines on Operating inge® Modules/Racks").

4. The readings of the temperature, pH value and concentration of the cleaning solution are to be continuously monitored and documented to ensure that they remain within the required range and within the scope of the permissible operating conditions (see "Guidelines on Operating inge® Modules/Racks"). Long periods of recirculation could potentially heat the solution to a level above the maximum permitted temperature due to waste heat from the pump entering the equation. If the temperature exceeds the required level, this must be countered by adding fresh UF filtrate, RO permeate or drinking water. The pH value and chemical concentration should be adjusted to meet requirements.
5. Once at least 60 min have passed with the solution circulating exclusively through the feed side, the process moves on to a second stage in which the filtrate side is incorporated in the recirculation process. This involves opening the filtration valve and throttling the feed top valve (Figure 6-3) to allow a partial flow (50%) of the cleaning solution through the membranes into the filtrate return. It is important to ensure a filtrate side venting.

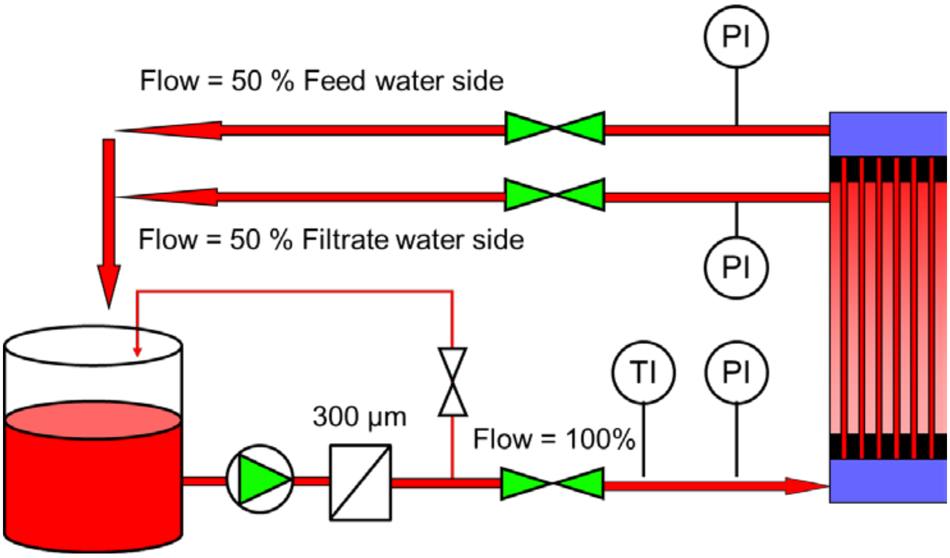


Figure 6-3: Circulation on feed and filtrate sides

6. During the entire circulation process, which should last for at least a further 60 min, it is important to ensure that the chemical solution circulates through both the feed and filtrate sides.
7. Once the chemical solution has been circulating through the system for approximately 2 hours, the process moves on to a third stage which alternates between soaking periods and circulation through the feed and filtrate sides. In this third stage, the cleaning pump is stopped, the heating element is switched off, and the feed side valves are closed.
8. As a rule, 60 min is sufficient for the soak time prior to the next circulation, though longer soak times may be necessary in the case of stubborn fouling or scaling. To maintain a high temperature during lengthy soak times, a brief circulation process lasting approximately 5 min should be conducted midway through the soak time.
9. The next steps involve alternating between circulation through the feed and filtrate sides and soak times. Note that the duration of a circulation period should not exceed 60 min and the overall duration of circulation and soak time should not exceed 12 hours.

6.3.4 Preparing to Rinse out the System

1. Once the recirculation process has been completed, the chemical solution is drained from the CIP tank. Where required, the solution should be neutralized before being discharged. Ensure that the discharged solution complies with all the local regulations regarding discharges into the sewage system. Before emptying the CIP tank, ensure that the feed side valves of the modules/racks are closed.
2. Once the CIP tank is empty, it can then be refilled with UF filtrate, RO permeate or drinking water ready for the next rinsing process. It is not necessary to use RO permeate to rinse out the system even if this is available.

6.3.5 Rinsing out the System

1. If the chemical solution has previously been heated, the first step before beginning the rinsing process is to equalize the respective temperatures of the rinsing water and the chemical solution contained within the module by heating and circulating the rinsing water in the CIP tank. Significant differences in temperature between the rinsing water and the chemical solution inside the modules could lead to stress cracks in the module and should therefore be avoided. Do not exceed the maximum permitted rate of temperature change or the maximum permitted operating temperature for the modules (see above or section on "Guidelines on Operating inge® Modules/Racks").

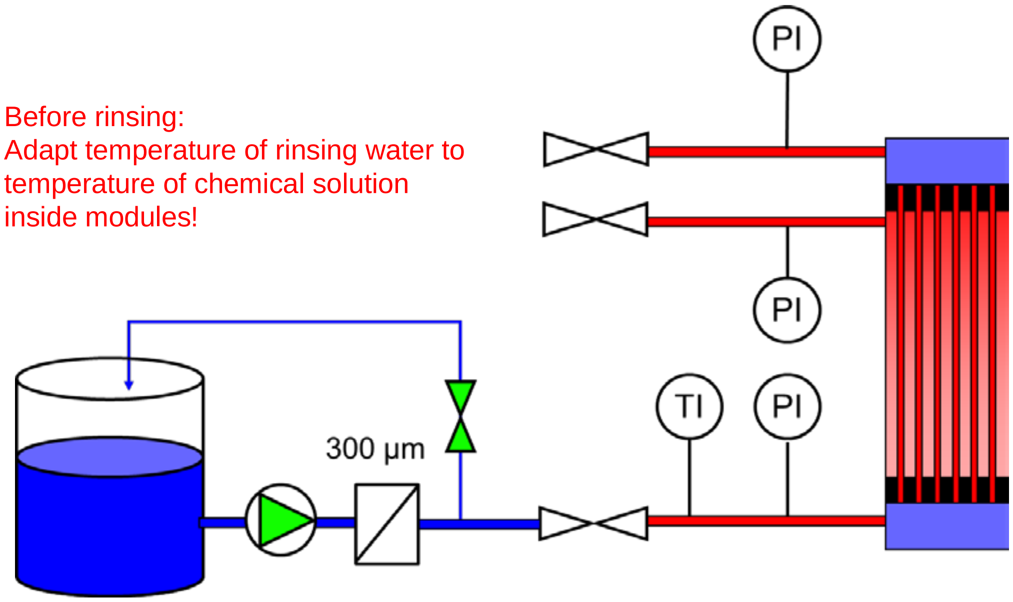


Figure 6-4: Preparing to Rinse out the System

2. Once the soak time has elapsed and the temperature of the rinse water has been adjusted as necessary, the first step is to empty the feed side and then the filtrate side without any further circulation of the solution.
3. To begin with, the feed side valves of the modules/racks are opened and the cleaning/feed pump is put into operation (Figure 6-5). Set the minimum volume flow rate in accordance with the section "Establishing CIP Circulation". The discharge is collected directly from the system. If required, the chemical solution must be neutralized prior to discharge. Ensure that the discharged solution complies with all the local regulations regarding discharges into the sewage system.

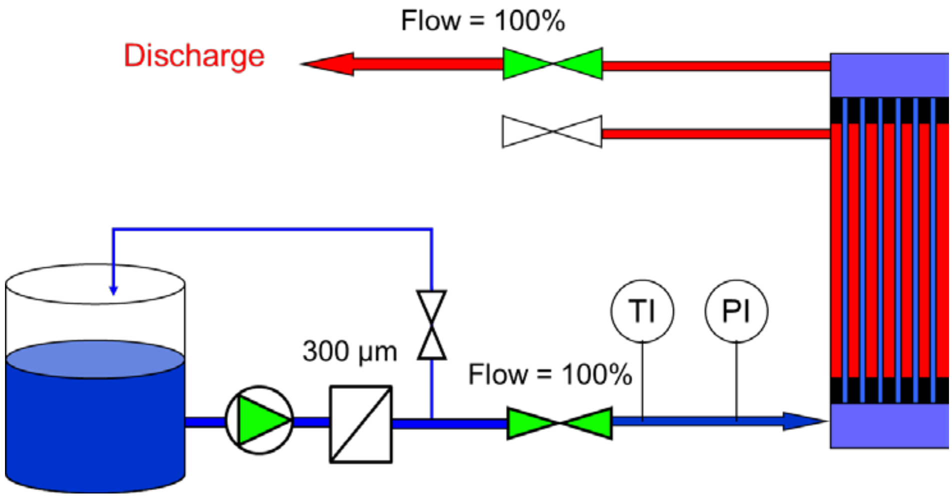


Figure 6-5: Rinsing out the chemicals on the feed side

4. Once the rinsing of the feed side has been completed, the filtrate side is rinsed out by opening the filtration valve and closing the top feed side valve (Figure 6-6).

   Alternatively, to conserve the RO permeate which may be used for CIP, the rinsing of the filtrate side may be conducted by activating the backwash pump and using UF filtrate. Just like in the CEB rinsing process, a backwash bottom rinse is followed by a Backwash Top rinse at a rinsing flux rate of 230 LMH (135 GFD) (see Figure 6-7).

   The discharge is collected directly from the system. If required, the chemical solution must be neutralized prior to discharge. Ensure that the discharged solution complies with all the local regulations regarding discharges into the sewage system. The rinsing process should be continued until a neutral pH value is recorded on the filtrate side.

5. During the rinsing process, the TMP should be monitored and documented in order to check the cleaning efficiency of the preceding cleaning process.

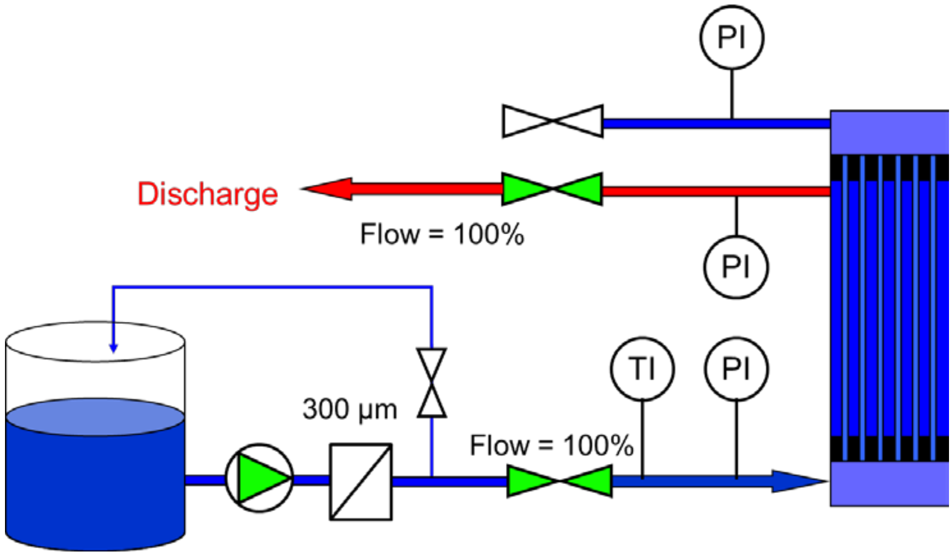


Figure 6-6: Rinsing out the chemicals on the filtrate side

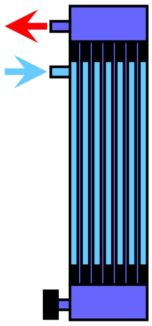
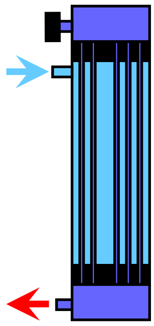
Chemical rinse out backwash bottom Rinsing flux min. 230 LMH (135 GFD)	Chemical rinse out backwash top Rinsing flux min. 230 LMH (135 GFD)
	

Figure 6-7: Rinsing out the chemical solution on the filtrate side by activating the backwash pump

6. Once the rinsing process has been completed, the permeability should be measured at a constant flux and then monitored and documented in filtration mode in order to check the efficiency of the CIP. This should be conducted after every CIP, even if two CIPs are performed in succession.

   Alternatively, the permeability can also be measured while the system is being rinsed out using the backwash pump, as described above.

7 Using Chemicals for CEB/CIP

7.1 Differences between CIP and CEB

The goal of a CEB and a CIP is essentially the same: To remove build-up on the membrane which decreases membrane performance and which cannot be removed using standard backwashes. The key differences between CEB and CIP are their levels of automation, frequency and intensity. As a rule, CIP is only required once or twice a year. A train of modules (train = independent backwashable unit of membrane modules) is shut down completely, and the CIP is generally performed semi-automatically or manually (see the section "Chemical Clean In Place (CIP)" for more details). In contrast, a CEB is usually carried out several times a week and is integrated in the automatic plant operating system (see "Chemically Enhanced Backwash (CEB)"). To intensify the cleaning effect, a CIP also involves the dosing of higher concentrations of cleaning chemicals, additional recirculation of the chemical solution and, in some cases, heating of the CIP solution and longer soak times. It is also possible to use other chemicals in a CIP that are not normally used in a CEB.

Important

- In addition to the instructions stipulated in this section, the performance of CEBs and CIPs is also subject to the permissible operating conditions stipulated in the section "Guidelines on Operating inge® Modules/Racks" and the guidelines and instructions contained in the sections "Chemically Enhanced Backwash (CEB)" and "Chemical Clean In Place (CIP)".

7.2 Permissible Chemicals and Operating Conditions

As a rule, the parameters of a CEB and, in particular, a CIP – for example the type of cleaning chemical – should be tailored to the type of membrane fouling/scaling and thus to the quality of the water being treated. Three different types of water have been defined for this purpose:

- Water type A: Ground water and surface water
- Water type B: Discharge water from a municipal waste water treatment plant
- Water type C: Sea water

Important

- The permissible chemicals and operating conditions for the different types of water are listed in Table 7.1 for the CEB and Table 7.2 for the CIP. The only chemicals that are permitted for use in CEB and CIP are the chemicals listed here, and only in the concentrations and soak times specified in the tables. Written approval must be obtained from inge GmbH before using any other chemicals (e.g. specially designed membrane cleaners).

- With the concentrations and soak times defined in Table 7.1 and Table 7.2, the chemicals listed here are generally a very effective choice for the CEB/CIP of inge® membranes, though in some cases they must be further adapted/optimized to cater to special source water situations. Should this be necessary, the modification of the parameters must be carried out in consultation with inge GmbH.

- As a general rule, chlorine dioxide (ClO_2) may be used as a replacement for sodium hypochlorite (NaOCl) for disinfection purposes. Attention must be paid to the formation of by-products (chlorite, chlorate) in this process. In each case described below, the permissible dosage concentrations for chlorine dioxide in mg ClO_2/L correspond to half the concentration indicated for sodium hypochlorite. In alkaline media (pH > 10) ClO_2 undergoes a significant disproportionation reaction into chlorite and chlorate; in acid media it undergoes disproportionation into chlorine and hydrochloric acid (pH < 6). It is therefore not advised to use ClO_2 in situations where pH < 6 or pH > 10.

- Hydrogen peroxide (H_2O_2) may be used up to a concentration of 500 mg/L. However, experience has shown that the cleaning and disinfection effect of H_2O_2 is seldom satisfactory. In the acid range (pH < 5), H_2O_2 may not be used in the presence of metal salts on the membrane. If there is any reason to believe that metal salts may be present on the membrane, an acid CEB or CIP must be performed before using H_2O_2. Ensure that all the chemical solution is rinsed out of the system once the acid CEB or CIP has been completed.

For the vast majority of applications, basic alkaline CEBs/CIPs with caustic soda have proved to be the best choice for removing organic build-up and acid CEBs/CIPs with hydrochloric acid or sulphuric acid have emerged as the best solution for removing inorganic fouling. The alkaline chlorine CEB/CIP should only be used to remove stubborn organic fouling which is usually only encountered in applications involving the water types B and C. Special guidelines must be followed when using chlorine for CEB/CIP if coagulants are being added at the pretreatment stage (see the following sections for more details: "Chemically Enhanced Backwash (CEB)" and "Chemical Clean In Place (CIP)").

Important

- Conducting an alkaline CEB/CIP may lead to precipitation, though generally only to a minor extent. This precipitation can be completely removed by the subsequent obligatory acid CEB/CIP.
- The use of chlorine by itself without the addition of caustic is only required for system disinfection (see section on "Disinfecting the System"), system shutdowns (see "System Shutdowns") and in waste water applications (water type C). Since the potential for bacterial growth is far higher in waste water applications than in applications involving other types of water, systems used to treat waste water should be disinfected twice a week in accordance with Table 7.1.

In addition, citric acid can be used to enhance the removal of inorganic foulant in the CIP (not in CEBs) and the surfactant sodium lauryl sulfate can be used to help remove organic foulant in an alkaline CIP.

The UF system does not retain salts. Consequently, the salt concentration in the UF filtrate remains unchanged in sea water applications. If UF filtrate is used for CEB/CIP in sea water applications, the high magnesium concentration (1,200 – 1,600 mg/L) means that magnesium hydroxide ($MgOH_2$) precipitation begins to occur as soon as the dosage of OH- ions in the form of caustic soda (NaOH) reaches approximately 2-5 mmol/L (exact dosages can be determined by titration). This quantity of dosed NaOH corresponds to an increase in the pH value to approximately 9.5 - 10. As the dosing of caustic continues, the quantity of $MgOH_2$ precipitation increases up until the point at which there is virtually no magnesium left in the water. The pH value does not increase any further during this process. As a result of the very high magnesium concentration, the level of precipitation increases substantially if dosing is continued.

Important

- When using ultrafiltered sea water for a CEB, we specifically advise against using NaOH dosages in excess of approximately 2 mmol/L or setting the pH value > 9.5 - 10.
- If the UF system is being used as a pretreatment stage for reverse osmosis (for example in a sea water desalination or waste water reuse facility), RO permeate must be used for every alkaline CIP (with or without chlorine) in order to avoid precipitation and maximize the effectiveness of the CIP. For the same reasons, RO permeate is recommended to be

used for an alkaline CEB (whether this is performed with or without chlorine). To reduce the use of RO permeates, UF filtrate can be used to rinse out the system after the CEB.

The key factors in using chemicals to remove irreversible fouling or scaling are, firstly, the required contact between the chemical cleaning solution and the membrane foulant and, secondly, the interaction between variables such as concentration, circulation, soak time and temperature. The vast majority of cases also feature a combination of different types of foulant or scalant, which means that multiple cleaning steps are required to remove it. The use of chemicals at low temperatures reduces the effectiveness of the cleaning process and requires longer soak times and/or higher concentrations.

7.3 Information on Dosages

The following dosages are required for typical surface water with a pH value of approx. 8 and an acid capacity of 2 mmol/L:

- To set a pH value of approx. 2.3, approx. 640 mL/m³ of 32 wt% hydrochloric acid or 760 mL/m³ of 37 wt% sulphuric acid
- To set a pH value of approx. 12.0, approx. 900 mL/m³ of 32 wt% caustic soda at 20°C.

Dosing of 2 mmol/L NaOH (for alkaline CEB in seawater applications at 35 °C) requires approx. 200 mL/m³ of 32 wt% caustic soda and 120 mL/m³ of a 14% hypochlorite solution to set the level of free chlorine to 20 ppm.

Setting the respective pH value for a CIP with reverse osmosis permeate requires the following:

- To set a pH value of approx. 2.0, approx. 1,200 mL/m³ of 32 wt% hydrochloric acid or 1,900 mL/m³ of 37 wt% sulphuric acid.
- To set a pH value of approx. 12.0, approx. 700 mL/m³ of 32 wt% caustic soda at 20°C and 580 mL/m³ of a 14% hypochlorite solution to additionally set the level of free chlorine to 100 ppm.

The following dosages are required for a typical pretreated municipal wastewater (discharge from treatment plant after sedimentation) with a pH value of approx. 7.0 and an acid capacity of 5 mmol/L:

- To set a pH value of approx. 2.3, approx. 950 mL/m³ of 32 wt% hydrochloric acid or 1,300 mL/m³ of 37 wt% sulphuric acid.
- To set a pH value of approx. 12.0, approx. 1,200 mL/m³ of 32 wt% caustic soda at 20°C.
- Approximately 120 mL/m³ of a 14% hypochlorite solution to set the level of free chlorine to 20 ppm for disinfection or in combination with simultaneous caustic dosing for alkaline chlorine CEB.

Table 7.1: Chemicals, Concentrations and Soak Times for CEBs

	Chemicals		Water type A: Groundwater and surface water	Water type B: Discharge water from a municipal wastewater treatment plant	Water type C: Seawater	Notes
Inorganic fouling Scaling	Hydrochloric acid (HCl)	pH value: typical: Soak time: typical:	1 < pH < 2.5 pH 2.3 10 - 60 minutes 15 minutes	1 < pH < 2.5 pH 2.3 10 - 60 minutes 15 minutes	1 < pH < 2.5 pH 2.3 10 - 60 minutes 15 minutes	
	Sulphuric acid (H_2SO_4)	pH value: typical: Soak time: typical:	1 < pH < 2.5 pH 2.3 10 - 60 minutes 15 minutes	1 < pH < 2.5 pH 2.3 10 - 60 minutes 15 minutes	1 < pH < 2.5 pH 2.3 10 - 60 minutes 15 minutes	
Organic fouling	Caustic soda (NaOH)	pH value: typical: Soak time: typical:	12 < pH < 13 pH 12 10 - 60 minutes 10 minutes	12 < pH < 13 pH 12 10 - 60 minutes 10 minutes	9.5 < pH < 10 pH 9.5 10 - 60 minutes 10 minutes	Seawater: using RO permeate for CEB pH 12.3 (12)
	Sodium hypochlorite (NaOCl) + caustic soda (NaOH)	Free chlorine: typical: pH value: typical: Soak time: typical:	-	max. 50 mg/L 20 mg/L 12 < pH < 13 pH 12 5 - 60 minutes 7 minutes	max. 50 mg/L 20 mg/L 9.5 < pH < 10 pH 9.5 5 - 60 minutes 7 minutes	Seawater: using RO permeate for CEB pH 12.3 (12)
Disinfection	Sodium hypochlorite (NaOCl)	Free chlorine: Soak time: Frequency:	-	> 1 mg/L < 10 mg/L 30 minutes 2x a week	-	The specified concentrations must be complied with in the discharged rinse water at the end of the soak time

Table 7.2: Chemicals and Concentrations for CIPs (overall duration of soak time and circulation max. 12 h)

	Chemicals		Water type A: Groundwater and surface water	Water type B: Discharge water from a municipal wastewater treatment plant	Water type C: Seawater	Notes
Inorganic fouling Scaling	Hydrochloric acid (HCl)	pH value: typical:	1 < pH < 2.5 pH 2	1 < pH < 2.5 pH 2	1 < pH < 2.5 pH 2	
	Sulphuric acid (H_2SO_4)	pH value: typical:	1 < pH < 2.5 pH 2	1 < pH < 2.5 pH 2	1 < pH < 2.5 pH 2	
	Citric acid + hydrochloric acid or sulphuric acid	Concentration: typical: pH value: typical:	max. 10 g/L 4 g/L 1 < pH < 2.5 pH 2	max. 10 g/L 4 g/L 1 < pH < 2.5 pH 2	max. 10 g/L 4 g/L 1 < pH < 2.5 pH 2	
Organic fouling	Caustic soda (NaOH)	pH value: typical:	12 < pH < 13 pH 12.5	12 < pH < 13 pH 12.5	12 < pH < 13 pH 12.5	Use RO permeate if available
	Sodium hypochlorite (NaOCl) + caustic soda (NaOH)	Free chlorine: typical: pH value: typical:	-	max. 200 mg/L 100 mg/L 12 < pH < 13 pH 12	max. 200 mg/L 100 mg/L 12 < pH < 13 pH 12	Use RO permeate if available
	Sodium lauryl sulfate + caustic soda (NaOH)	Concentration: typical: pH value: typical:	-	max. 10 g/L 4 g/L 12 < pH < 13 pH 12	max. 10 g/L 4 g/L 12 < pH < 13 pH 12	Use RO permeate if available
Disinfection	Sodium hypochlorite (NaOCl)	For information on performing disinfection, see the section "Disinfecting the System"				

8 Design and Construction

Thanks to inge GmbH's many years of experience in treating different types of source water, we are able to provide estimates and rough approximations for the design of UF systems based on comprehensive analysis of the source water in each case.

The following parameters are the minimum basis we need to perform an analysis:

- Particulate water constituents:
  - Turbidity / Total Suspended Solids (TSS)
- Organic water constituents:
  - DOC/TOC and SAK254,
  - for waste water: Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD)
- Inorganic water constituents:
  - Ca, Mg, alkalinity / HCO3, Fe, Mn, Al
- pH value
- Temperature

If the quality and temperature of the source water is subject to seasonal changes, details on the range of fluctuation are also required for the analysis (ideally in the form of a distribution, otherwise at least stating the minimum, maximum and median values). Other important information for surface waters (and for source waters affected by surface waters) includes the duration and impact of heavy rain and flooding events.

inge GmbH has developed the software program "iSD = inge® System Design" which can help elaborate a rough approximation of the required UF system for a specific application, including the metering pumps. This tool can be downloaded for free from the inge® website. Further support is available from your inge GmbH representative. Pilot testing has shown to be an excellent strategy in many cases. Performing pilot testing before designing the plant enables the operator to define and optimize the design and operating parameters in advance.

Avoiding errors in the design and construction of a UF system is fundamental to achieving smooth, trouble-free operation when the plant is completed. It also reduces the risk of damaging the membranes and modules or suffering irreversible loss of performance. Proper compliance with the following instructions is a key prerequisite for making successful claims under the warranty should this become necessary.

Important

- The design and construction of any UF system should be based on state-of-the-art technology.
- The system should be specifically designed to avoid any pneumatic and/or hydraulic pressure surges or siphoning effects. All UF systems should include the following components and observe the following requirements:
  - The system should include a means of controlling the feed and backwash volume flow rates (e.g. using frequency-controlled pumps or control valves with PID controllers). For the backwash pump controller, it is important to ensure that the set point value for the volume flow is reached within 5 - 10 seconds (time depends on pump capacity).

- The actuators of all (butterfly) valves should be equipped with air throttling valves to control the opening and closing procedure. Air/water hammer can occur if the valves open or close too abruptly.
- Air vent valves must be provided to vent the dead ends of the T-Rack® feed and filtrate headers to prevent pressure surges caused by air trapped in the dead end. Further air vent valves should be provided on higher sections of the piping.
- The rinse water piping must be equipped with vacuum breakers (air intake valves).
- The switching circuits of the pumps and valves must be designed to ensure that no pressure surges are produced in the system, i.e. the pumps and valves should be actuated in a controlled sequence at intervals of approximately one second so that pumps are never running against closed valves.
- Any change of operating mode that involves a switch between the feed and backwash pump, including the switching of the required valves (e.g. backwash to filtration) must include an idle interval of approx. 5 - 10 seconds between the completion of one operating mode and the activation of the subsequent operating mode.

☝ Every module in a membrane rack must be operated under the same operating conditions.

☝ The metering pumps must be designed and scaled to cater to the concentrations and pH values required for CEBs (see section on "Using Chemicals for CEB/CIP").

☝ Only air bleed valves may be used. The use of combination air intake/bleed valves or valves designed purely for air admittance is prohibited (with the exception of vacuum breakers in the rinse water piping) in order to prevent air from accidentally entering the system.

☝ The use of gap-type/edge filters is not permitted for the required prefilter stage, which should have a maximum mesh size of 300 µm. The prefilter should be automatically backwashable.

☝ When designing/constructing an ultrafiltration system, it is important to ensure that there are no dead spaces, particularly on the filtrate side, which could encourage microbial growth on the filtrate side. For the same reason, it is essential that there is no direct connection between the feed and filtrate sides which could create a bypass between the two sides of the filtration process.

☝ When designing/constructing an ultrafiltration system, it is also important to ensure that no corrosion or erosion products from the feed tank, backwash tank or piping can be rinsed back into the membrane modules. For this reason, the tanks used for source water, filtrate/backwash and Clean in Place (CIP) must be made of non-corroding materials which will not release any contaminants or damaging (e.g. abrasive) substances into the water. The same applies to the piping and all other components installed within the ultrafiltration system.

☝ It is important to protect the water in the filtrate/BW tank from direct sunlight and exposure to light in order to prevent excessive heating and avoid exposure to sunlight which could pose a risk of promoting bacterial and/or algae growth.

☝ Sealed filtrate/backwash tanks with air filters must be used.

☝ UF membranes cannot retain dissolved substances. This physical fact should be taken into account for all parameters (SDI, turbidity, etc.) when designing a UF system (including the effect on any downstream treatment processes) and when measuring UF filtrate quality.

- We recommend providing three chemical dosing points for CEBs for each membrane train (= independent backwashable unit of membrane modules). These dosing points should be as close to the train as possible. Experience has shown that it is sensible to place the acid dosing unit furthest upstream in the system. Any precipitation that builds up on the other dosing units further downstream can then be removed by means of acid dosing. It is important to ensure that the chemicals are properly mixed into the flow of water (mixing devices should be used if required). This system offers numerous advantages over the alternative of a central dosing unit:
  - Reduces the volume of water that must be replaced when dosing and rinsing, thereby reducing dosing time.
  - Avoids the mixing of different chemicals in the backwash piping which could otherwise occur if two CEBs were performed one immediately after the other for two different trains.
  - Reduces chemical consumption and provides higher recovery rates because less water is used
  - Introduces fewer variables for the control system.

- When using coagulants in the pretreatment on an iron basis, residuals can only be removed with an acid CEB. In this case, a device for the implementation of an acid CEB has to be provided.

- UF systems with dizzer® modules and UF systems with T-Rack®s should adhere to the basic flow diagrams shown in the following diagrams (see Figure 8-1 and Figure 8-2).

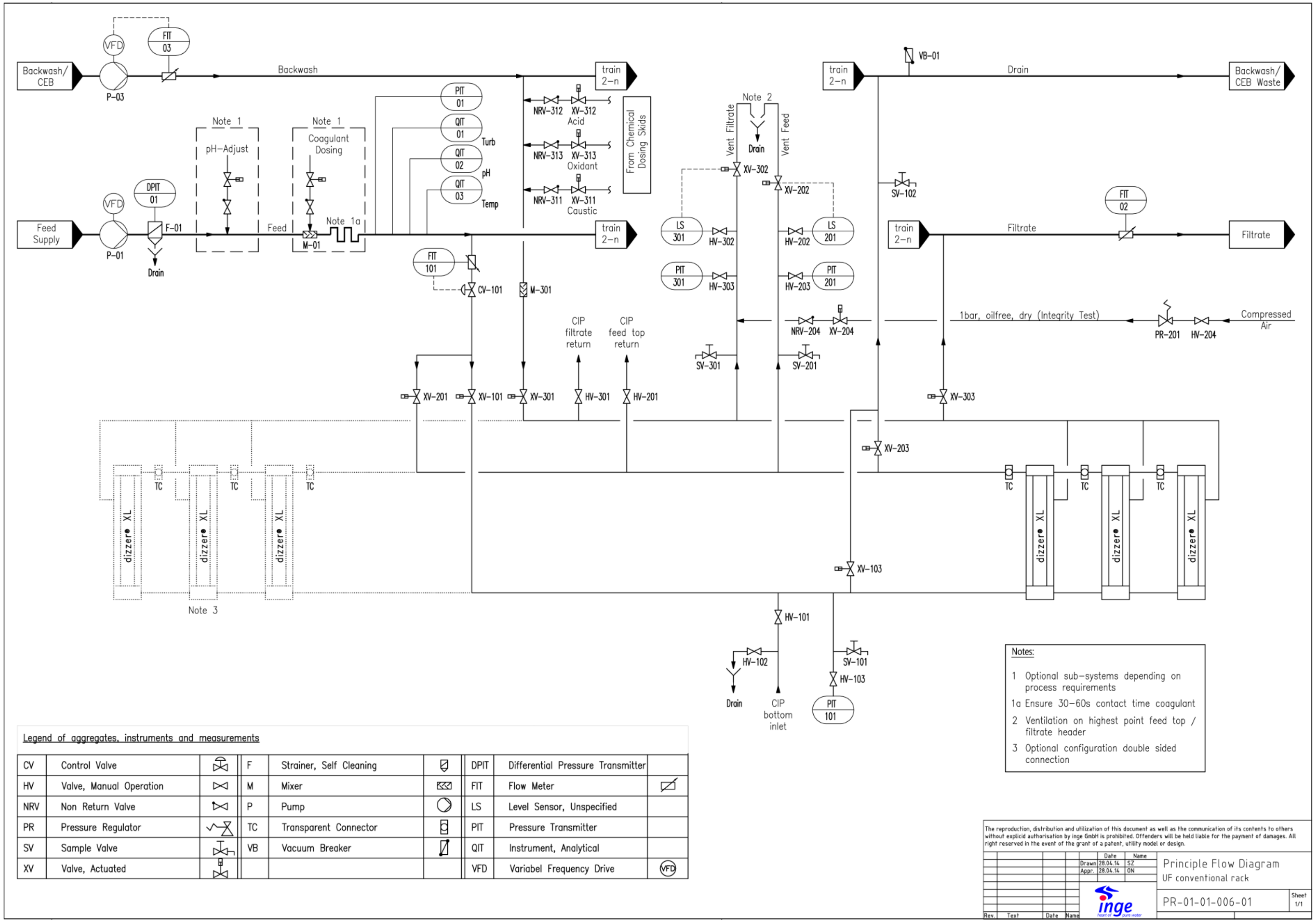


Figure 8-1: Flow diagram for a UF system with dizzer® modules

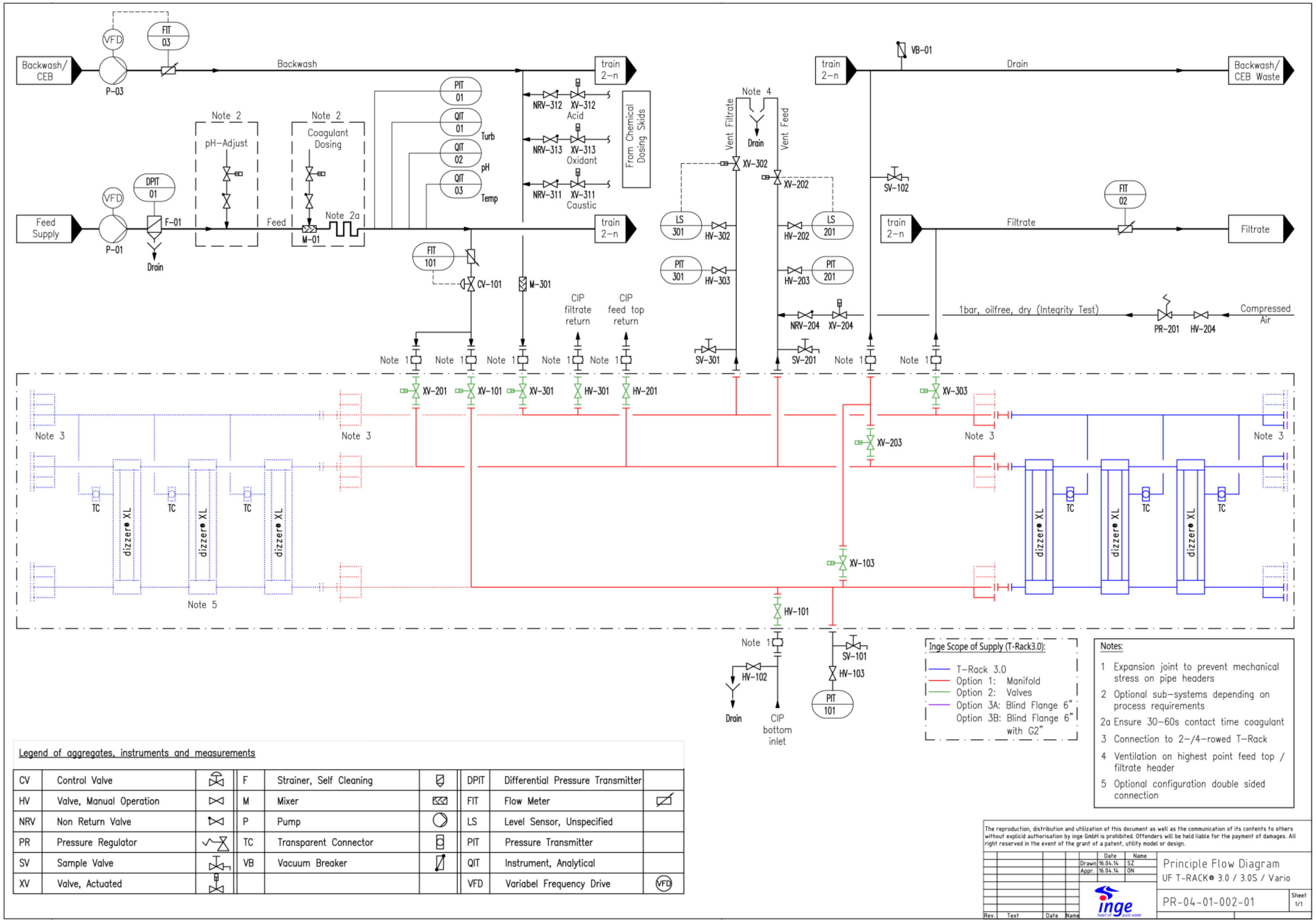


Figure 8-2: Flow diagram for UF system with T-Rack®

9 Shipping, Handling and Storage

9.1 Warranty Claims

Important

- Modules that are still contained within their original, sealed packaging may be stored for 12 months from the date they are shipped from the factory. Storing the modules for longer than 12 months shall render the warranty void unless otherwise agreed by inge GmbH in writing. In some circumstances modules may still be considered to be in storage even if they have been connected to a rack or assembled in a T-Rack® on condition that the modules have not been put into operation and are sealed off from their surroundings (for example using protective covers) and provided that inge GmbH has given written approval for this type of storage.
- Modules and components that are irreparably destroyed due to improper shipping, handling or storage shall not be covered by inge GmbH's warranty provisions. It is therefore important to ensure that the modules and components are shipped, handled and stored properly and carefully in accordance with this manual.

9.2 Packing and Stacking

inge GmbH modules and T-Rack® components are shipped from the factory in specially designed boxes on stable wooden pallets. The connection ports of each module are sealed with plastic covers. The modules are packed horizontally in multiple individual boxes stacked on top of each other or in groups of multiple modules secured vertically or horizontally on a wooden pallet. For reasons of stability, the stacking height of the individual boxes and wooden pallets is restricted to specified limits. This restriction on stacking height ensures that the modules are properly protected during transportation and storage. It must therefore be adhered to, even after accepting delivery of the modules from inge GmbH.

Important

- Any impact to the units or packaging, including boxes being dropped or knocked over, may cause mechanical damage/breakage of the module housing and connection ports.
- The following maximum stacking heights must be observed:

Module type/ components	Unit	Position	Stacking height (unit)	Stacking height (wooden pallet)
dizzer® P	individual box	horizontal	7	Do not stack
dizzer® 5000	individual box	horizontal	3	Do not stack
dizzer® XL	individual box	horizontal	3	Do not stack
dizzer® XL 0.9 MB 70	individual box	horizontal	3	Do not stack
dizzer® 5000	batch of 10	vertical	Do not stack	Do not stack
dizzer® XL	batch of 10	vertical	Do not stack	Do not stack
dizzer® XL 0.9 MB 70	batch of 12	horizontal	Do not stack	2
T-Rack® vario	-	-	-	3
T-Rack® 3.0	-	-	-	3

9.3 Preservation

All inge® UF modules are subjected to wet tests to check integrity before they leave the factory. To prevent the membranes from drying out and to avoid bacterial growth during transportation and storage, the membranes are saturated with a non-hazardous solution consisting of water (UF filtrate)/glycerin/propylene glycol [80:10:10:wt%] after completing the wet test. The connection ports of the dizzer® modules are sealed with plugs and securely wrapped in plastic prior to shipment. In some cases the modules themselves are shrink-wrapped in plastic (depends on module type).

Important

- After removing the preservation solution from the membranes and module, the module must be protected from freezing at all times during transportation, handling, operation and storage. Irreversible damage to the membrane and brittleness of the shell may result if the module or the membrane freezes.

- The preservation solution must be replaced once the modules have been in storage for 12 months. The solution should ideally be prepared using reverse osmosis permeate or demineralized water. Alternatively, any water solution consisting of water/glycerin and sodium bisulfite [74,25:25:0,75 wt%] may be used. The solution should be injected into the module from the feed side in order to avoid contaminating the filtrate side. Before being returned to storage, the modules must first be closed with the delivered connection plugs. The modules can then be stored for a further three months in this state, after which the preservation solution must be replaced once again.

9.4 Effects of Temperature Changes

The pressure housings used in inge® modules and the components of the T-Rack® system are made of corrosion and UV-resistant PVC-U. Variations in temperature may cause this thermoplastic to exhibit changes in its dimensions and elasticity. These changes are reversible within the normal expected temperature range. The membrane material also exhibits high temperature stability. Only at very high or very low temperatures does the risk emerge of causing irreversible damage to the material.

- For inge® modules in their original packaging, temperatures between a minimum of minus 20°C and a maximum of 40°C encountered during storage and transportation have no impact on the functionality and performance of the modules. It is, however, important to avoid storage and transportation outside this temperature range.

9.5 Further Shipping and Storage Instructions

Important

- The integrity of the packaging must always be preserved during transport, handling and storage. A closed (roofed) transport should be provided to protect against dampness (e.g. rain) and excessive heat, the same applies for storage.

- All T-Rack® components and modules must be stored in dry, moderately ventilated conditions, away from any sources of heat, ignition and direct sunlight. To avoid abrupt variations in temperature the modules must be stored for at least two days at a temperature above freezing before the original cardboard boxes can be opened.

10 Assembly and Maintenance

10.1 General Overview

Important

- Before assembly, check that no components are missing and inspect components for any signs of mechanical damage. Do not install damaged components! These must be returned to inge® – please contact your inge® representative without delay to resolve this issue.

- The shipping weights of unfilled dizzer® modules are shown in Table 10.1. This weight is higher once the modules have been put into operation and accumulated water. Applicable statutory requirements for the lifting, holding and carrying of heavy loads must be fully adhered to during assembly and dismantling. Lifting equipment may be required[1]. Please note that at least two installation engineers are required to assemble a T-Rack® (all versions).

Table 10.1: Shipping weights of inge® modules

Module type	Shipping weight in kg
dizzer® XL 0.9 MB 70 incl. T-pieces	58
dizzer® XL 0.9 MB 60	48
dizzer® XL 1.5 MB 50 incl. T-pieces	58
dizzer® XL 1.5 MB 40	42
dizzer® XL 0.9 MB 60 incl. end caps / T-pieces	55
dizzer® XL 0.9 MB 38 incl. end caps	40
dizzer® XL 1.5 MB 40 incl. end caps / T-pieces	55
dizzer® XL 1.5 MB 25 incl. end caps	40
dizzer® 5000plus incl. end caps	55
dizzer® 3000plus incl. end caps	40
dizzer® P 4040-6.0	4.5
dizzer® P 4021-2.5	2.3
dizzer® P 4040-4.0	4.5
dizzer® P 4021-1.8	2.3
dizzer® P 2521-1.0	0.7
dizzer® P 2514-0.5	0.4

- The working environment must be kept clean at all times during the assembly process. Take care that no residues from the assembly and installation process enter water-bearing parts of the system. Any residues that do make their way into water-bearing components must be removed.

[1] The European Agency for Safety and Health at Work has published Key Indicator Methods (KIMs) for activities involving lifting, holding and carrying which provide assistance in assessing working conditions for the lifting and carrying of loads. These can be downloaded from http://osha.europa.eu/de/topics/msds/slic/handlingloads/29.htm (last updated November 2012).

- Before installing the modules in the rack it is necessary to clean the entire system (all pipes and rack pipework). The utmost care must be taken to prevent any impurities from being rinsed into the modules, especially abrasive materials and/or oily materials from feed pipes.
- Document the module serial number(s) and corresponding rack position(s) of all the modules installed in a module rack.
- All the dizzer® module types described in the manual are to be installed and operated in a vertical position.
- When assembling the modules to form the membrane rack, it is important to ensure that the module and the module connectors are not subjected to any mechanical stress (i.e. the installation should be free of tension).
- Only use the supplied components to install dizzer® modules in T-Rack®s.
- Lubrication of all coupling seals is an essential part of proper assembly. Lubricating the seals prevents them from jamming and facilitates the installation process. Ensure tight, leak-proof seating of all seals during assembly.
- Do not use silicone or any lubricants or sealants that contain silicone. Only glycerin may be used as a lubricant for seals, o-rings, couplings etc. (with a purity of > 99.7 %). Only Teflon tape may be used for thread sealing.
- To ensure proper assembly of flexible couplings, tighten the connector nuts evenly and alternately until the mating surfaces come into contact.
- The inge® Ultra S 250 pipe couplings used to connect the module bodies to the end caps or T-pieces must be fastened with a tightening torque of 40 Nm to ensure proper assembly.
- The stainless steel components used in the system (e.g. inge® Ultra S 250 pipe couplings) are suitable for installations designed for applications involving the treatment of fluids which contain corrosive ingredients (e.g. sea water treatment). However, the stainless steel components could still corrode if they come into direct contact with corrosive substances for a lengthy period of time (e.g. due to leaks in pipes, couplings, etc.). To prevent the risk of corrosion in these situations, we recommend treating the stainless steel components with an anticorrosive agent. The anticorrosive agent (e.g. BRUNOX® LUB & COR) should be silicone and solvent-free, have good creep properties and be easy to apply with a brush or spray bottle. The parts to be treated must be clean and free from corrosion. Make sure to remove any existing corrosion by mechanical means before applying the anticorrosive agent. Please make sure to carefully follow the instructions provided by the manufacturer of the anticorrosive agent.

10.2 Assembling the Pressure Housings of dizzer® P Modules

Important

- When assembling the pressure housings of dizzer® P modules, it is important to ensure that the pressure housing and pressure housing connections are not subjected to any mechanical stress (i.e. the installation should be free of tension).

To ensure proper installation of the pressure housing, follow the instructions provided by the pressure housing supplier.

10.3 Installing dizzer® XL and dizzer® 5000plus Modules in Conventional Module Racks

Important

Proceed as follows to ensure proper installation of the module in a conventional membrane rack:

1. Check the alignment of the module connection ports before installing the modules:
   - The positions of the module connection ports are factory aligned to match the technical specifications (see Figure 10-1) and the inge® Ultra S 250 pipe couplings used to connect the module bodies to the end caps are fastened with a tightening torque of 40 Nm. However, the position of the connection ports may shift slightly during transportation. It is therefore important to check that the alignment is correct before installing the modules.
   - If the alignment does not correspond to the technical specifications, the end caps (top feed and bottom feed connections) can be rotated. To do this, open the inge® Ultra S 250 pipe coupling by loosening the 8mm Allen screw [Caution: Do NOT remove the screw completely!]. It should now be a simple process to properly align the end caps. Once the alignment process is complete, the pipe coupling must be tightened again. Tighten the pipe coupling using a torque wrench to ensure that the coupling holds the end cap and module firmly enough. Use a tightening torque of 40 Nm to achieve this. The ribs on the end caps can be used as orientation when aligning the pipe couplings. Ensure that the ribs are positioned between the coupling housing and the grip ring (see Figure 10-2). Do not rotate the coupling on the module housing once the grip ring teeth are engaged.

Figure 10-1: Alignment of the module connection ports

Figure 10-2: Alignment of the pipe couplings using the ribs on the end caps

2. To ensure the module is securely fastened to the rack, at least two pipe clamps must be used. These should be attached to the top third and the bottom third of the module, respectively. Ensure that the module is securely mounted to eliminate any vibrations. Fastening the module in place solely using the flexible couplings does not provide sufficient mounting stability. Modules placed on rack supports on their end caps must have their center of gravity and at least 40 percent of their end cap surface on the rack supports in order to prevent tipping.
3. To ensure tension-free installation and compensate for on-site assembly tolerances in the area of the filtrate and feed connections, two flexible 2" couplings and a connecting piece must be used for each module connection (see Figure 10-3). The distance required between the two couplings depends on the rack configuration and tolerances in each particular case. We recommend using a connecting piece with a minimum length of 80mm (3.2 inch) for the connection. Suitable spacers can be purchased from inge GmbH. Ensure the seals of the 2" couplings are properly seated and leak-proof.

Two flexible 2" couplings + connecting piece on each port

Figure 10-3: Module with flexible 2" couplings

4. By incorporating a transparent connecting piece on the filtrate side, it is also possible to perform integrity tests on dizzer® XL and dizzer®5000plus modules from the feed side where required (also see section "Integrity Testing").
5. Ensure that all these seals and screwed connections are properly seated. To ensure proper assembly of flexible couplings, tighten the connector nuts evenly and alternately until the mating surfaces come into contact. Ensure the seals of the couplings are properly seated and leak-proof.

10.4 T-Rack® vario Assembly

Important

- The smallest available T-Rack® vario unit consists of a total of 4 dizzer® modules in two rows, with 2 modules in each row. The largest available T-Rack® vario consists of 80 modules in a four-row arrangement. The largest sub-unit consists of 24 modules in a two-row arrangement. A four-row arrangement is created by placing 2 two-row configurations next to each other.

- When assembling the T-Rack® vario system, ensure that none of the rack components or connection pipes are subjected to any mechanical stress (i.e. the installation should be free of tension). For racks consisting of several sub-units, the whole system should always be assembled from bottom-to-top, rather than sub-unit by sub-unit.

Figure 10-4 shows the components of the T-Rack® vario. Refer to this illustration to check that no components are missing from the delivery.

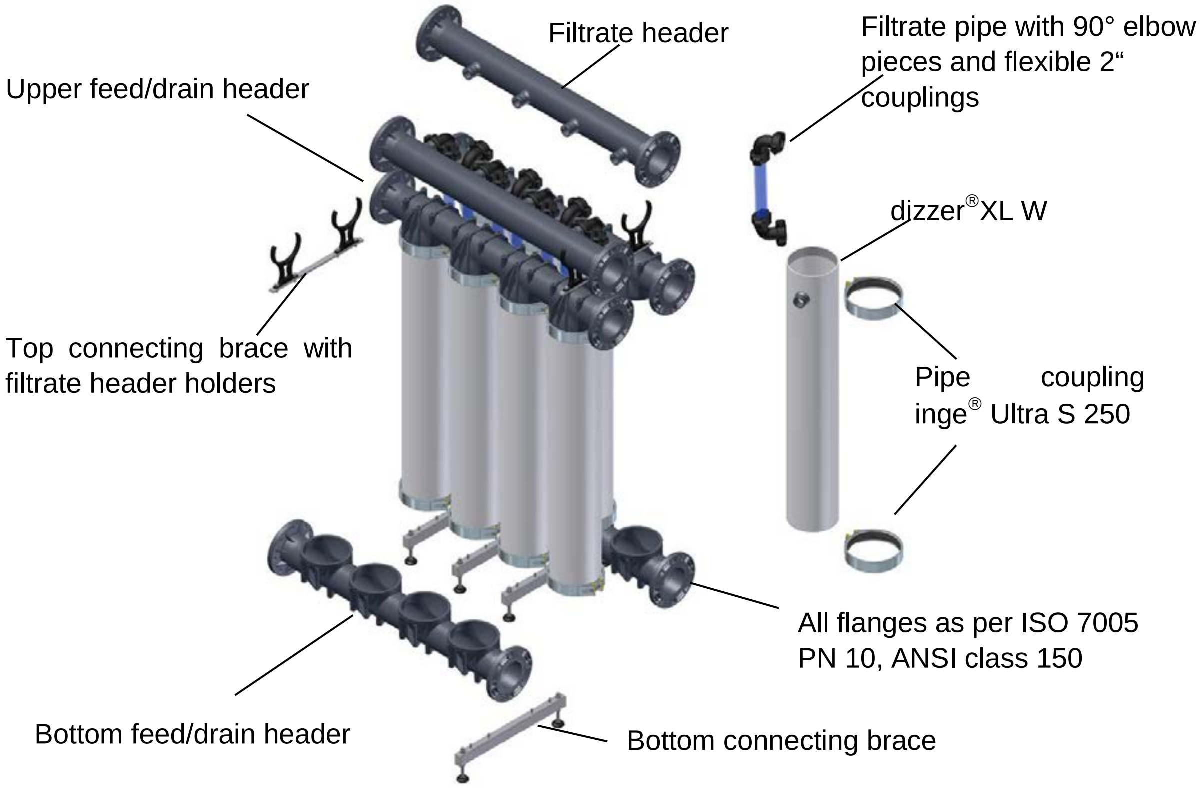


Figure 10-4: T-Rack® vario components

Proceed as follows to ensure proper assembly of an inge® T-Rack® vario sub-unit:

1. Connect the bottom feed/drain headers (Figure 10-5) (M10 x 80 bolts, M10 lock washers) to the bottom cross braces (60x40 mm) to form the base and fit the adjustable feet to the bolt heads as shown in Figure 10-6.

Figure 10-5: Bottom feed/drain header

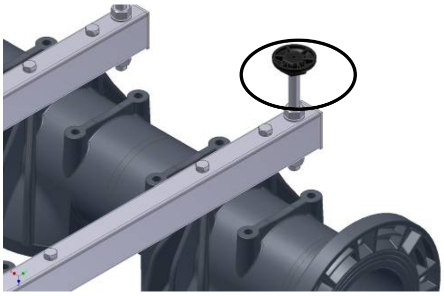


Figure 10-6: Attaching the adjustable feet

2. Rotate the base 180º, place it in the location in which you wish to install the system and use a spirit level to check that the base is perfectly level both front to back and side to side, adjusting the feet as necessary. Do not fix the feet to the floor! Make sure the weight is distributed evenly across all the feet.
3. Next, fit the inge® Ultra S 250 pipe couplings over the module discharge points on the bottom feed/drain headers. Ensure that the screws on the pipe couplings (8 mm Allen screws) are easily accessible for assembly and dismantling of the modules. To do this, align the screw heads of the pipe couplings with the mounting side in each case. For a two-row arrangement with two freely accessible mounting sides, the pipe couplings can be arranged offset from each other (see Figure 10-7). If only one side is easily accessible for installation, or if each of the two rows is combined into a four-row configuration after the modules are installed, then the screw heads on the pipe couplings should all point in the same direction on all the rows. This is the only way of ensuring that it will be possible to remove the screws at a later point in time (Figure 10-8).
4. Once the pipe couplings have been properly aligned, tighten the screws to a sufficient degree to ensure that they cannot slip over the raised ribs of the feed/drain headers (see Figure 10-9).

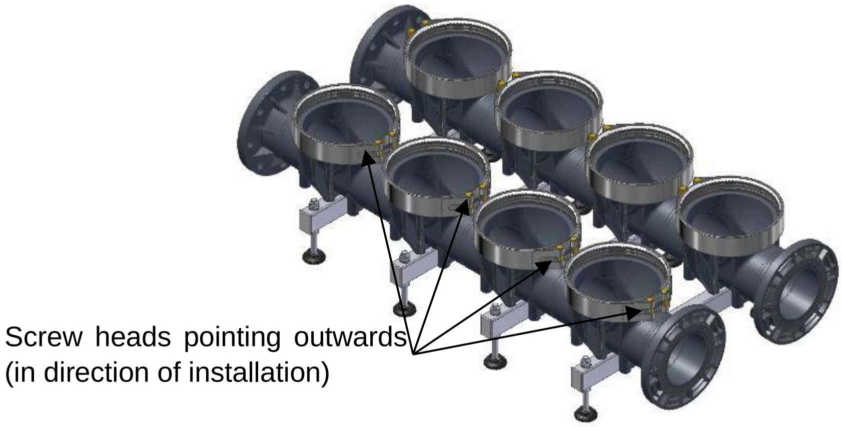


Figure 10-7: Alignment of screw connection of inge® Ultra S 250 pipe couplings in two-row configuration

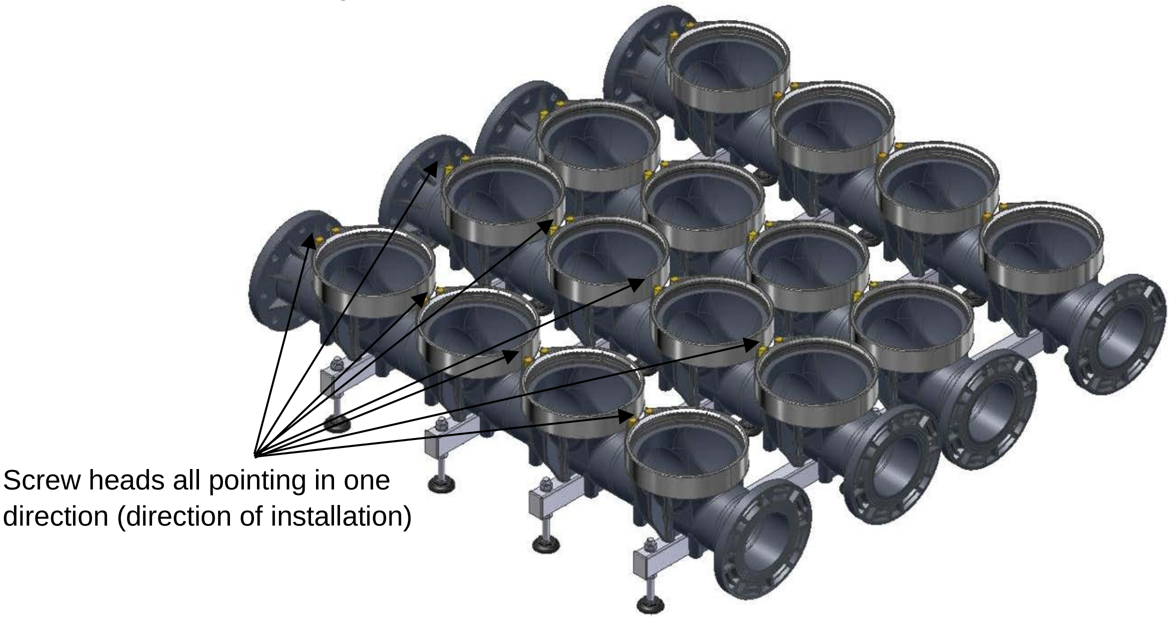


Figure 10-8: Alignment of screw connection of inge® Ultra S 250 pipe couplings in four-row configuration

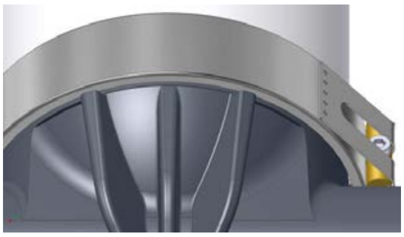


Figure 10-9: Raised ribs

5. The transparent 2" filtrate pipe and the two 90° elbow pieces are to be attached to the filtrate connection on the module using the three flexible 2” couplings (Figure 10-10). Ensure the seals of the couplings are properly seated and leak-proof. Next, place a dizzer® module body on the bottom module outlet point, as shown in Figure 10-11. To ensure the inge® Ultra S 250 pipe coupling is correctly positioned, the pipe coupling housing is designed to abut against the raised ribs of the feed/drain header. The pipe coupling must now be fastened to a degree that still allows the module to be rotated (tightening torque < 1 Nm). Continue installing all the additional modules one by one, switching sides each time you install a module.

Figure 10-10: Transparent filtrate pipe with flexible 2" couplings

Figure 10-11: Installing a module

6. Push the top inge® Ultra S 250 pipe couplings over the modules and fit the top feed/drain headers one by one (see Figure 10-12). The screw heads on the pipe couplings should all point in the same direction as that of the bottom pipe couplings (also see point 2).

Figure 10-12: Assembly of top pipe coupling

7. Push up the inge® Ultra S 250 pipe coupling until it abuts against the raised ribs of the feed/drain header (see Figure 10-13). Now fasten the pipe coupling to a degree that still allows the module to be rotated (tightening torque < 1 Nm). Next, fasten the top cross braces (M10 x 30 bolt, M10/30 washer) into their proper positions making sure they are not under stress (see Figure 10-14).

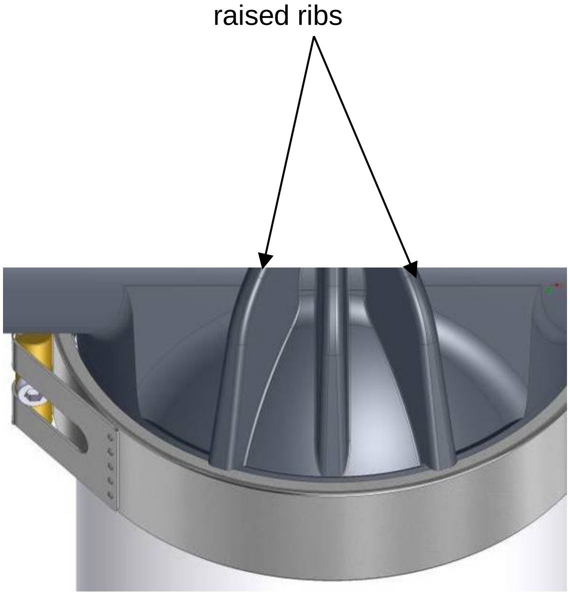


Figure 10-13: Raised ribs on feed/drain headers

Figure 10-14: Top cross braces

8. After installing the seals of the 2" flexible couplings on the filtrate connections to the filtrate header, place the filtrate header into the filtrate header holders from above (see Figure 10-15). Ensure the seals of the couplings are properly seated and leak-proof. The flanges of the filtrate headers should be flush with the other flanges. Align the dizzer® module bodies by rotating them as shown in Figure 10-16.

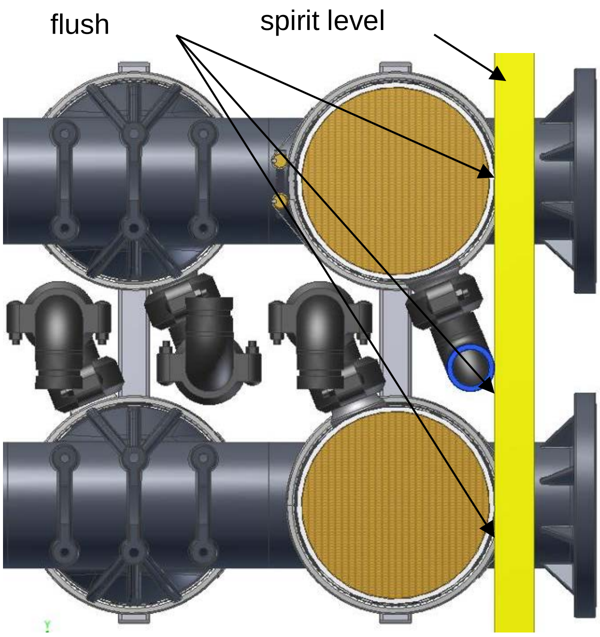


Figure 10-15: Installing the filtrate header

Figure 10-16: Aligning the modules

9. Connect the 90° elbow pieces to the filtrate headers using the flexible 2“ couplings (see Figure 10-17 and Figure 10-18). Ensure the seals of the couplings are properly seated and leak-proof. Finally, check that all the inge® Ultra S 250 pipe couplings are correctly positioned and use a torque wrench to tighten them to a torque of 40 Nm. Also check that the flexible 2" connection couplings have been correctly mounted.

Figure 10-17: 2" couplings on filtrate header, two-row

Figure 10-18: 2" couplings on filtrate header, four-row

10. The feed and drain headers and the filtrate header of each sub-unit end in a 160 mm non-rotatable flange (connecting dimensions as per ISO 7005 PN10, 6“ ANSI class 150). This is used to connect either to the next sub-unit, to the main collection pipe, to other components or to a blank flange. To join each connection, it is essential to use a torque wrench to properly fasten the bolts in multiple rounds. The required tightening torque depends on a number of factors, including the type of seal used, nominal size, and the material from which the connecting flange is made. When connecting up T-Rack® sub-units, do not exceed a tightening torque of 60 Nm for the flange connections.

10.5 T-Rack® 3.0 / T-Rack® 3.0 S Assembly

Important

- The smallest available T-Rack® 3.0 / T-Rack® 3.0 S unit consists of a total of 4 dizzer® XL modules in two rows, with 2 modules in each row. Other sub-units consist of 6, 8, 10 and 12 modules each in a two-row arrangement. A four-row arrangement is created by placing 2 two-row configurations next to each other.
- The safety caps in the T-pieces (feed header) at the top, bottom and in the filtrate connection are to be removed before assembling the modules.
- When assembling the T-Rack® 3.0 / T-Rack® 3.0 S system, ensure that none of the rack components or connection pipes are subjected to any mechanical stress (i.e. the installation should be free of tension). For T-Rack®s consisting of several sub-units, the whole system should always be assembled from bottom-to-top (not sub-unit by sub-unit).

Figure 10-19 shows the components of the T-Rack® 3.0 / T-Rack® 3.0 S. Refer to this illustration to check that no components are missing from the delivery.

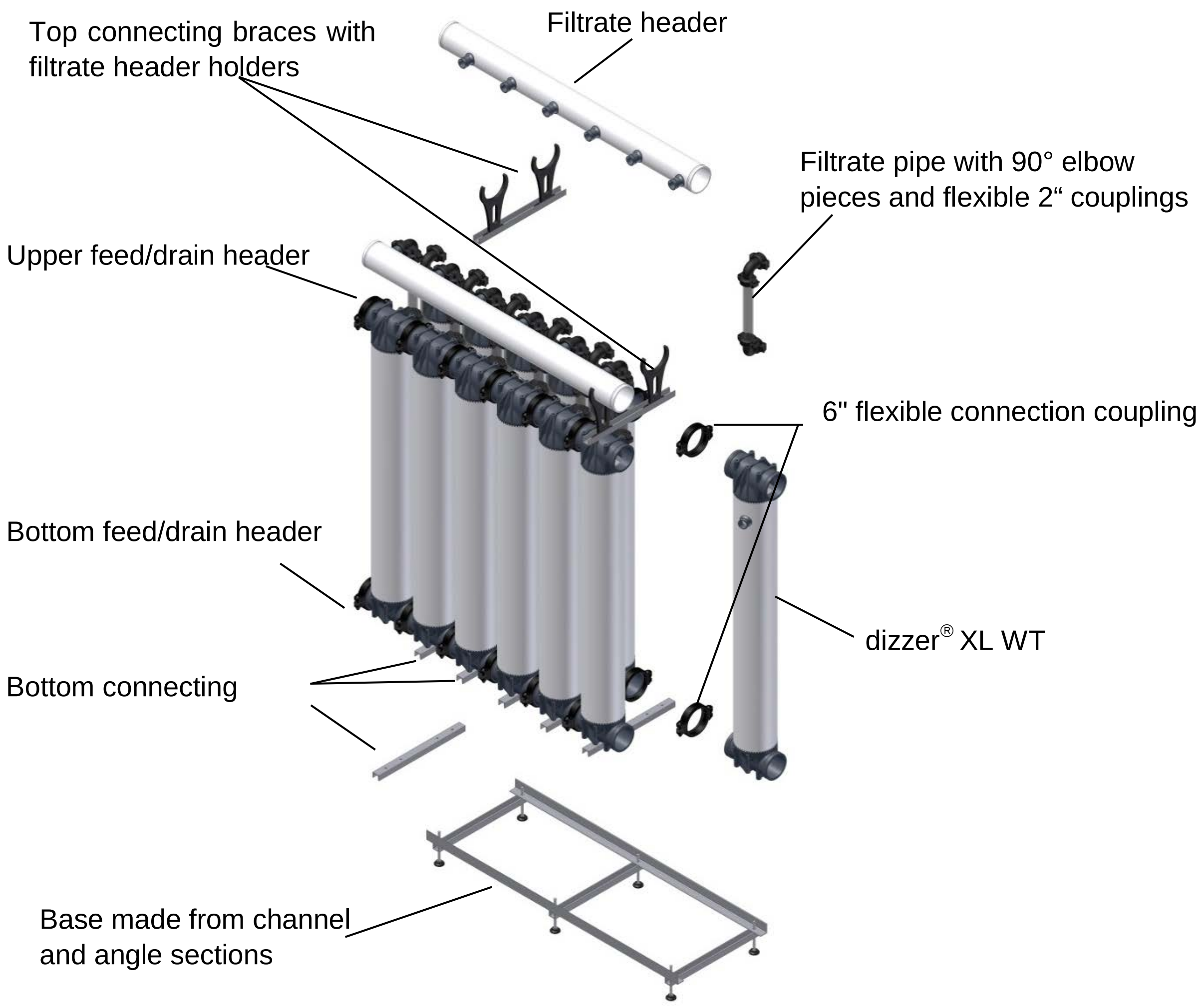


Figure 10-19: T-Rack® 3.0 / T-Rack® 3.0 S components

Proceed as follows to ensure proper assembly of an inge® T-Rack®3.0 sub-unit:

1. Construct the base by bolting the three channel sections to the two angle sections (bolts with nuts and lock washers M16 x 150) and fit the adjustable feet to the bolt heads as shown in Figure 10-20. Place the base in the location in which you wish to install the system and use a spirit level to check that the base is perfectly level both front to back and side to side, adjusting the feet as necessary. Make sure the weight is distributed evenly across all the feet. Thanks to the floating mounting of the bottom cross braces on the base (see point 2), it is also possible to fix the feet to the floor.
2. Position the bottom cross braces in the angle sections of the base (see Figure 10-21). Do not attach the cross braces to the sections!

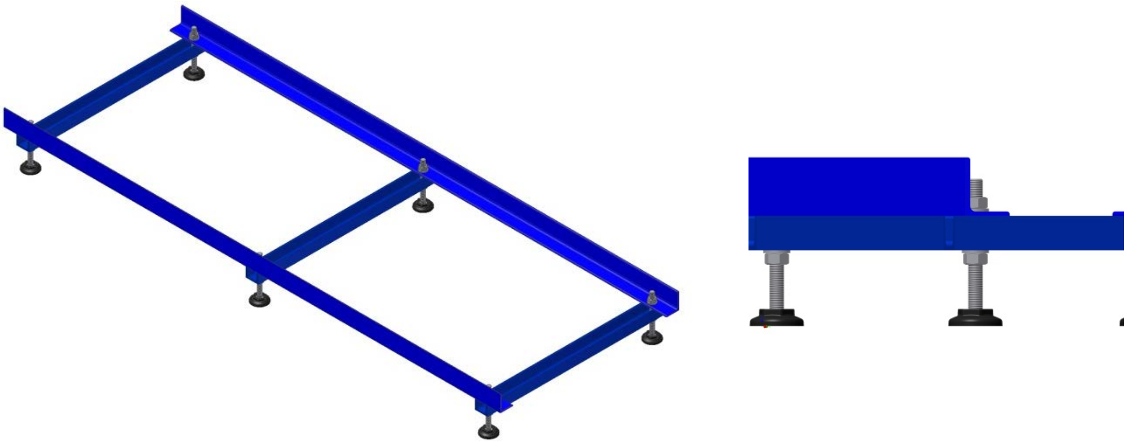


Figure 10-20: Constructing the base by connecting the three channel sections to the angle sections

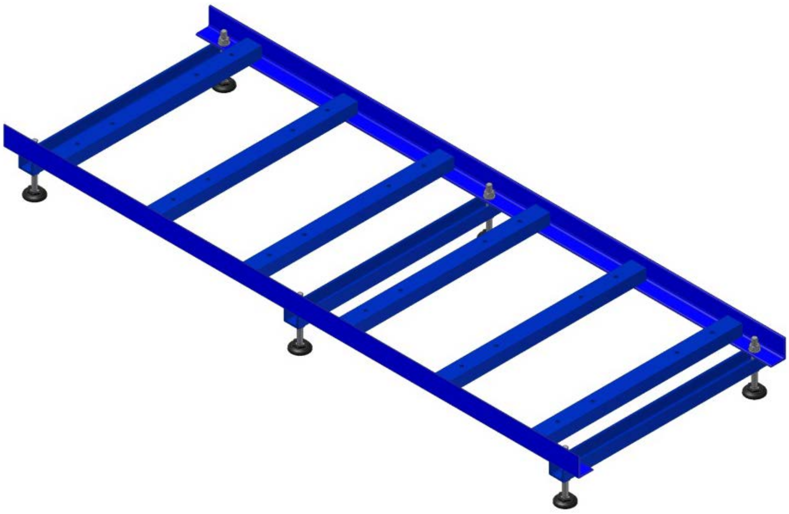


Figure 10-21: Inserting the bottom cross braces in the angle sections of the base

3. Attach a transparent 2" filtrate pipe and two 90° elbow pieces to the filtrate connection of each module using three flexible 2” couplings in each case (see Figure 10-22). Lay the modules horizontally to make this process easier. Ensure the seals of the couplings are properly seated and leak-proof.
4. Insert two threaded pins (M10 x 50) in the threaded inserts of the T-pieces provided for this purpose on the bottom of the modules.

Figure 10-22: Mounting the transparent 2" filtrate pipe and the two 90° elbow pieces on the filtrate connection of a module using the three flexible 2" couplings

5. Next, place the first dizzer® module on the first cross brace (as shown in Figure 10-23) ensuring that the threaded pin screwed into the module is lowered into the hole provided for this purpose in the cross brace. Fasten the module to the cross brace using the nut and M10 lock washer. To avoid the risk of the module tipping over, one of the installation engineers must hold the module while it is being fastened in place (note that the assembly process requires a minimum of two installation engineers). At this stage it is sufficient to simply hand-tighten the nuts. Make sure that the front edge of the base is flush with the front edges of the two T-pieces of the outermost modules.

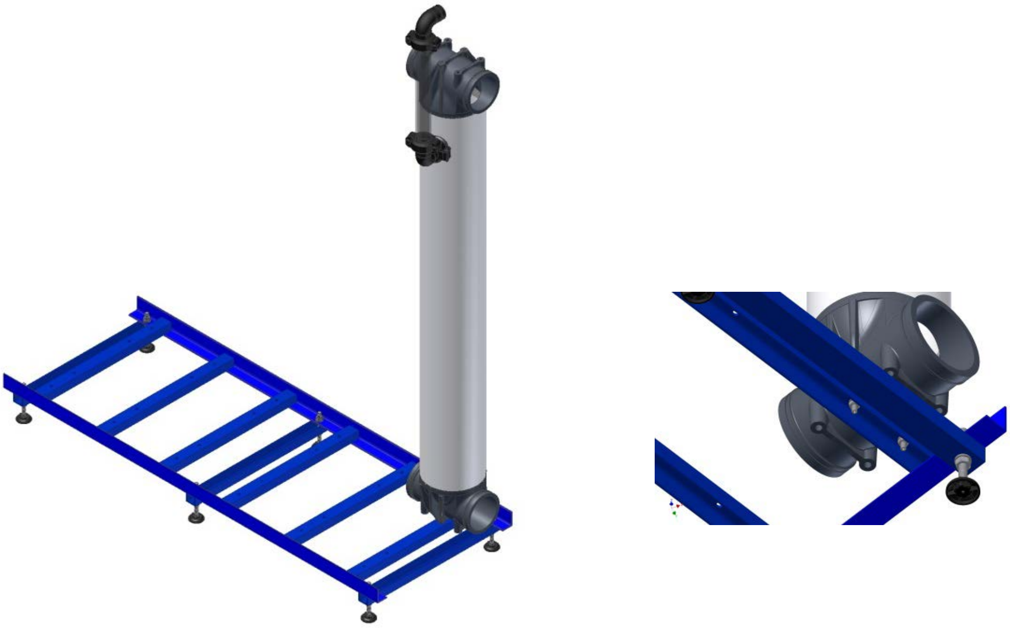


Figure 10-23: Mounting the modules on the bottom cross braces and connecting the bottom T-pieces of the modules with 6" flexible couplings

6. Use the same method for all the modules of the row being installed, placing each module on the next cross brace along in each case (as described in point 5), fastening it in place and connecting the top and bottom T-pieces to the neighboring modules (see Figure 10-24) using the 6" flexible couplings. Ensure the seals of the couplings are properly seated and leak-proof.

Figure 10-24: Connecting the top T-pieces of the modules using 6" flexible couplings

7. Insert two threaded pins (M10 x 50) in the points provided on the T-pieces of the two outermost modules of the row. Fasten the top cross braces and the filtrate header holders in place by inserting the threaded pins in the holes provided for this purpose in the cross braces and the filtrate header holders. Fasten the cross braces and filtrate header holders to the two modules ensuring they are not under stress, as shown in Figure 10-25. At this stage it is sufficient to simply hand-tighten the nuts.

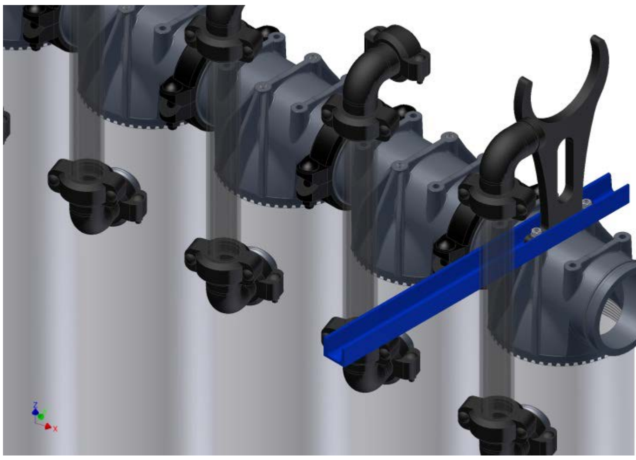


Figure 10-25: Fastening the top cross brace in place

8. Place a filtrate header into the filtrate header holders from above (see Figure 10-26). Make sure that the grooved pipe ends of the filtrate headers are flush with the grooved pipe ends of the feed/drain headers (T-pieces of the edge module of the sub-unit). The filtrate header must be placed in such a way that the filtrate connections of the modules and the filtrate connections on the filtrate header are properly aligned. (Note that the filtrate headers are not symmetrical; the spacing between the outer filtrate connection and the neighboring pipe end varies)

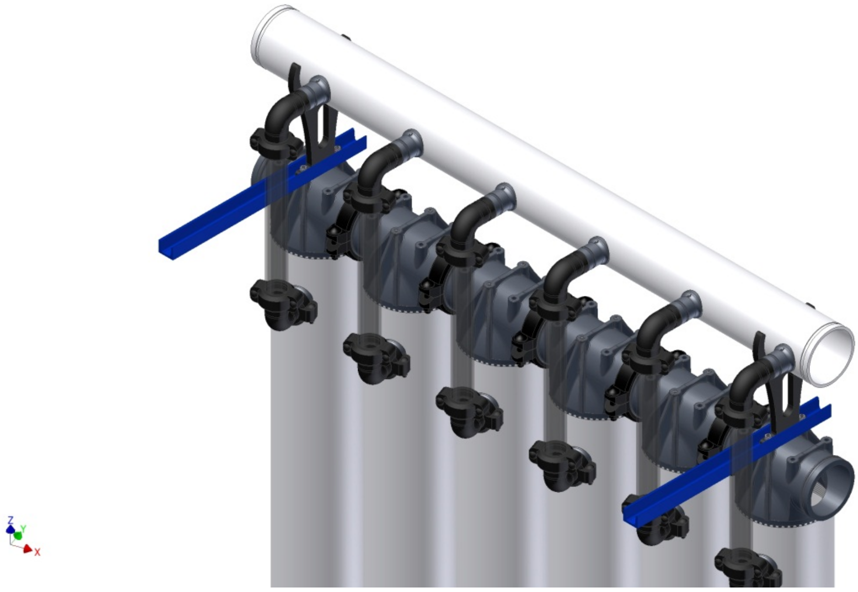


Figure 10-26: Placing the filtrate header in the filtrate header holders

9. Connect the 90° elbow pieces of the transparent 2" filtrate pipes of the modules to the filtrate header using the 2" flexible couplings (see Figure 10-27). Ensure the seals of the couplings are properly seated and leak-proof.

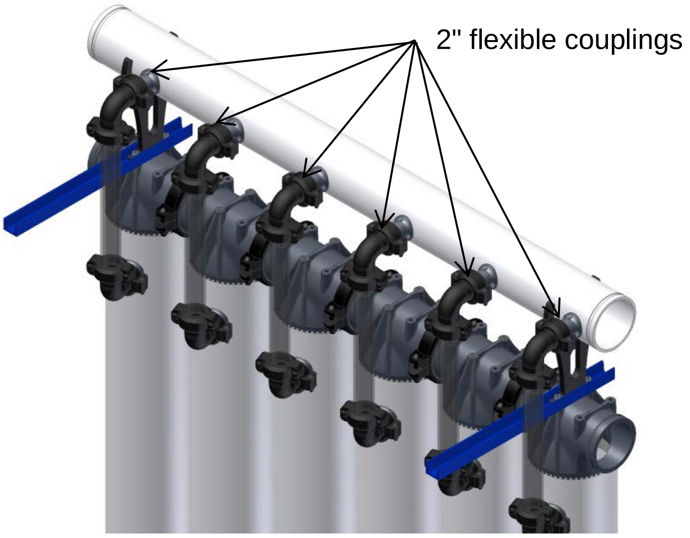


Figure 10-27: Attaching the transparent 2" filtrate connection of the modules to the filtrate header

10. Install the second row of modules on the base. To do this, repeat points 1 through 8. Next, screw all the M10 nuts onto the threaded pins and tighten them to a torque of max. 5 Nm, taking care not to overstress them when fastening them in place. All the feed and drain headers and all the filtrate headers of a sub-unit should be flush with each other. The headers end in a 6" grooved connection for flexible couplings. This is used to connect either to the next sub-unit, to the main collection pipe, to other components or to a blank flange. Figure 10-28 shows a four-row arrangement with two sub-units, each consisting of 12 modules.

Figure 10-28: Four-row arrangement

10.6 Notes on Maintenance

Regular general maintenance work on inge® modules/racks should include checking the tightness and proper working order of all joints and connections (flanges, valves, couplings, etc.) and repairing any damage that may have occurred.

Important

- Fluid leakage – especially where corrosive agents are involved – may cause corrosion to appear on the components concerned. Effective measures should be taken to avoid corrosion before it occurs.
- In the event of fluid escaping due to a leak, the affected area should be properly sealed, rinsed down with salt-free or low-salt water and rubbed dry.
- If the coating of a coated coupling has been damaged, the coating must be repaired or the coupling replaced.

11 System Commissioning

11.1 General Overview

Important

- System commissioning comprises functional testing and trial operation.
- All inge® UF modules/racks must be put into operation in accordance with the guidelines stipulated below.
- The steps involved in commissioning the system must be logged and archived.
- We recommend verifying the composition of the feed water before commencing the commissioning process.
- The operating personnel should be incorporated in the commissioning process.
- inge GmbH recommends performing integrity tests both during and immediately after the commissioning phase, as described in the section on "Integrity Testing". This is also an important means of determining the reference value required for testing. This reference value must be determined and documented during the commissioning process using new modules installed in the fully assembled rack.
- Before commencing water supply operations, the modules, T-Rack®, filtrate tank and filtrate piping (including all the installed valves and fittings) must be adequately rinsed and then disinfected (see section on "Disinfecting the System" for more details).
- During system commissioning it is also necessary to determine the chemical injection times for the CEB (see section on "How a CEB is Performed") by measuring the rise in concentration in the rinse water discharged from the rack during chemical dosing.
- Before commencing water supply operations, check that the water produced by the system meets the stipulated requirements.

11.2 Functional Testing

Important

- Before beginning trial operation, verify that the control software, connections and system instruments are properly assembled and installed and functioning correctly with the system in a dry state.
- Before activating the feed pump, check that all the air bleed valves are functioning properly and verify that no air pockets can form in the header pipes.
- Verify that the automatic program control system (programmable logic controller, PLC) is running error-free. Confirm that there is no risk of pressure surges or shocks (pneumatic and/or hydraulic) or incorrect valve actuation

11.3 Venting and Rinsing

Important

- ☝ After functional testing, but before trial operation, the entire system including the piping must be vented and cleaned to remove any contaminants, abrasive materials and oily substances from the system.
- ☝ Before filling the UF system/filtrate tank, it is important to thoroughly clean the filtrate tank to remove any contaminants.
- ☝ Ensure that the rinsing process removes all traces of the preservation solution from the system (see section on "Shipping, Handling and Storage"). The preservation solution is biologically available when sufficiently diluted with water. Consequently, it is possible that any residue of the preservation solution could cause microbial growth on the filtrate side in certain circumstances.

To vent the modules prior to system commissioning, proceed as follows (the various operating modes are described in the section on "Membrane Operating "):

1. Filling the feed side with source water
   - Confirm that no valves are closed on the filtrate side.
   - Fill the feed side of the system with source water slowly to avoid water hammer. For this purpose, run the system in filtration bottom (FB) mode at a flux rate of 40 LMH (23.5 GFD) for at least 20 minutes.
   - Where possible, the filtrate should be discharged before it reaches the filtrate tank to prevent the preservation solution from accumulating in the filtrate tank.
2. Venting the modules
   - Run system in forward flush bottom (FFB) mode at a volume flow rate corresponding to a flux rate of 80 LMH (47 GFD) for at least 10 minutes.
3. Filling the filtrate side
   - Confirm that no valves are closed on the filtrate side.
   - Run system in filtration bottom (FB) mode at a flux rate of 40 LMH (23.5 GFD) for at least 15 minutes.
   - Run system in filtration top (FT) mode at a flux rate of 40 LMH (23.5 GFD) for at least 15 minutes.
   - Where possible, the filtrate should be discharged before it reaches the filtrate tank to prevent the preservation solution from accumulating in the filtrate tank.
4. In the event that it was not possible to discharge the filtrate before it reached the filtrate tank, empty the filtrate tank completely (including removal of any residue), discharging its contents into the drain, and then clean the filtrate tank if necessary.

To rinse the system, proceed as follows:

1. Filling the filtrate tank
   - Confirm that no valves are closed on the filtrate side.
   - Run system in filtration bottom (FB) mode at a flux rate of 40 LMH (23.5 GFD) for at least 15 minutes to completely refill the filtrate tank.

2. Performing backwashes
   - Run system in backwash bottom (BWB) mode for at least 60 seconds (or use up the full volume contained in the filtrate tank).
   - Fill the filtrate tank (see point 1), but this time running the system in filtration top (FT) mode.
   - Run system in backwash top (BWT) mode for at least 60 seconds (or use up the full volume contained in the filtrate tank).
   - Fill the filtrate tank (see point 1).

12 Disinfecting the System

Important

- The chemical sodium hypochlorite (NaOCl) is used to disinfect the system. This chemical is normally supplied as a chlorine bleaching agent in a stock solution containing a concentration of free chlorine $c_{stock\ solution}$ of approx. 14 wt%.
- If necessary, the disinfection procedure should be performed multiple times.

Proceed as follows (see the section on "Membrane Operating " for more information on the respective operating modes):

1. Add the calculated volume V_{dosage} of an NaOCl stock solution to the filtrate tank, which should already be completely filled with filtrate, in order to obtain a concentration of 100 mg/L of free chlorine in the filtrate tank: (Calculations must be tailored to tank volume)

$$V_{dosage}\ in\ L = \frac{100\frac{mg}{L} \times tank\ volume\ in\ L}{c_{stock\ solution}\ in\ \% \ \times \rho_{NaOCl} \times\ 10^6}$$

   ρ_{NaOCl} = density of chlorine bleaching agent (12-14%) = 1.22 – 1.25 g/cm³

2. Run a backwash bottom (BWB) (see section on "Membrane Operating ") for at least 30 seconds in order to disinfect the filtrate piping. Alternatively, it is also possible to run a chemical enhanced backwash (CEB) bottom to top (see section on "Chemically Enhanced Backwash (CEB)") with a concentration of 100 mg/L free chlorine.
3. Run a backwash top (BWT) (see section on "Membrane Operating ") for at least 30 seconds. Alternatively, it is also possible to run a chemical enhanced backwash (CEB) from top to bottom (see section on "Chemically Enhanced Backwash (CEB)") with a concentration of 100 mg/L free chlorine.
4. Open and close all the filtrate sampling valves and all other valves in the filtrate piping/filtrate tank area multiple times.
5. Close all the feed valves.
6. Allow the NaOCl to soak for at least 30 minutes (max. 60 minutes).
7. Periodically check the concentration of free chlorine (at 5-10 min intervals). If the level of free chlorine falls below a value of 5 mg/L, repeat chlorination or add extra doses of fresh stock solution.
8. Run a backwash bottom (BWB) (see section on "Membrane Operating ") for at least 60 seconds.
9. Run system in filtration bottom (FB) mode (see section on "Membrane Operating ") at a flux rate of 80 LMH (47 GFD) for at least 10 minutes.
10. Run a backwash bottom (BWB) (see section on "Membrane Operating ") for at least 60 seconds.
11. Run system in filtration top (FT) mode (see section on "Membrane Operating ") at a flux rate of 80 LMH (47 GFD) for at least 10 minutes or until the filtrate tank is completely full.
12. Empty the filtrate tank completely (remove any residues right down to the deepest section of the tank).

13. Run system in filtration bottom (FB) mode (see section on "Membrane Operating ") at a flux rate of 80 LMH (47 GFD) for at least 10 minutes or until the filtrate tank is completely full.
14. Empty the filtrate tank completely (remove any residues right down to the deepest section of the tank).
15. Run the system in filtration top (FT) mode (see section on "Membrane Operating ") with the flux rate and filtration time that is envisioned for the subsequent process (i.e. normal operation).
16. Perform sampling and analysis to check the bacteriological filtrate quality. If the test results are not satisfactory, repeat the disinfection process. Contact inge GmbH If the number of required disinfection processes exceeds a total of six a year.

13 Integrity Testing

13.1 General Overview

Integrity testing can be an effective means of checking the intactness of the membrane fibers in ultrafiltration modules. Two types of test are available for inge® modules as standard: Fully automatic pressure hold tests and semi-automatic bubble tests with visual inspection.

Both tests are based on the phenomenon seen in wetted ultrafiltration membranes whereby water can pass through the pores, but air is prevented from passing through until a certain pressure has been exceeded (the minimum pressure at which air begins to flow is referred to as the "bubble point"). The bubble point pressure depends on the membrane's pore size and on the surface tension at the air-liquid interface. The bubble point pressure of the pores of inge® membranes is much higher than the applied test pressure (approx. 1 bar) that is required to detect non-intact fibers.

As a general rule, integrity testing can be performed on both the feed and filtrate sides. If air is used to displace all the water on one of the two sides of the membrane (feed or filtrate side), the pressure on this side will then continue to increase since the air cannot pass through the wetted pores (this side is referred to in this context as the "high-pressure side"). Once the test pressure has been reached, all the valves are closed on the pressure side. This means that the air can now only escape through defective fibers or faulty valves/pipes on the other side (referred to here as the "low-pressure side") or into the surrounding environment. A slight pressure drop may be observed due to the natural air diffusion process through the water-filled pores of the membranes. If the pressure differential from the high-pressure side to the low-pressure side is higher than the tolerance limit stipulated by inge®, this may indicate a defective fiber.

In the bubble test, air escaping on the low-pressure side due to defects in the system is visually confirmed by bubbles appearing in the transparent pipes on the feed or filtrate side (depends on the specific module/rack system; see Figure 13-3). In principle, the bubble test can therefore be performed in conjunction with every pressure hold test.

Important

- The dizzer® P module does not have a transparent filtrate pipe. This means that bubble testing cannot be performed on dizzer® P modules.
- In conventional rack systems with dizzer® XL modules the test is carried out on the filtrate side, i.e. the high-pressure side in this case is the filtrate side and the transparent pipe is located on the feed side of the module. In T-Rack systems with dizzer® XL modules the test is carried out on the feed side, i.e. the high-pressure side in this case is the feed side and the transparent pipe is located on the filtrate side of the module.
- Higher test pressures than those recommended by inge® are to be discussed with inge® and also approved by them.

The vertical installation of the membrane modules and the ergonomic configuration of the inge® system enable pressure hold testing to be carried out automatically, making it easy to detect any affected modules using the bubble test. Integrity testing is carried out on installed modules (i.e. it is not necessary to remove any of the modules from the system).

13.2 Testing Frequency

Both integrity tests (pressure hold and bubble test) should be performed during and at the end of the commissioning phase, after maintenance work, and in the event of any suspicion that the membrane system may be malfunctioning (e.g. increased bacteria counts on the filtrate side). Integrity testing can also be regularly carried out on an automated basis (for example once a day, once a week or once a month) and seamlessly integrated in standard filtration operations. There are no restrictions on the frequency of integrity testing for inge GmbH membrane modules. The frequency can therefore be flexibly tailored to match the operator's specific requirements and preferences.

13.3 How to Perform a Pressure Hold Test

A pressure hold test is carried out for each rack in turn, i.e. the modules of a single rack are tested in parallel.

1. Dewater the respective high-pressure side (feed or filtrate side) and build up the pressure:
   - Fill the entire high-pressure side with dry, oil-free compressed air at a pressure of 1 bar (14.5 psi). The low pressure side of the modules must be left open to atmospheric pressure. The applied air pressure forces the water through the membrane from the high-pressure side to the low-pressure side (dewatering phase; Figure 13-1 shows an example using the feed side as the high-pressure side). In principal air cannot pass integral membranes due to the surface tension of the water in the membrane pores (diffusion processes not considered). The duration of emptying a T-Rack depends on total rack size and volume of connected pipework and compressor capacity. In our experience, the dewatering phase takes approximately 10 minutes to complete.
2. Close the air pressure valve:
3. Once the high-pressure side has been completely emptied of water and a stable pressure of 1 bar (14.5 psi) has been reached (and maintained for at least 1 minute), close the air supply to the high-pressure side (Figure 13-2 shows an example using the feed side as the high-pressure side).

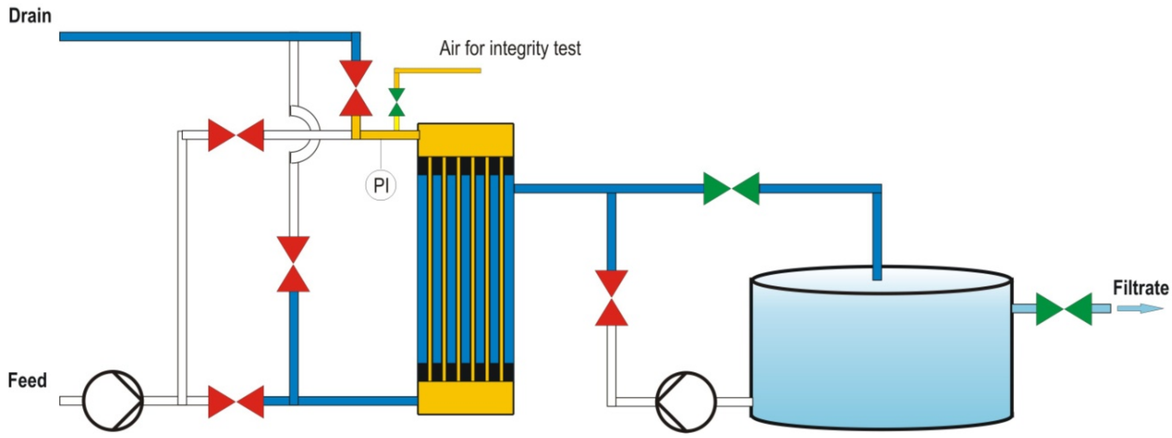


Figure 13-1: Dewatering phase for integrity test from feed side

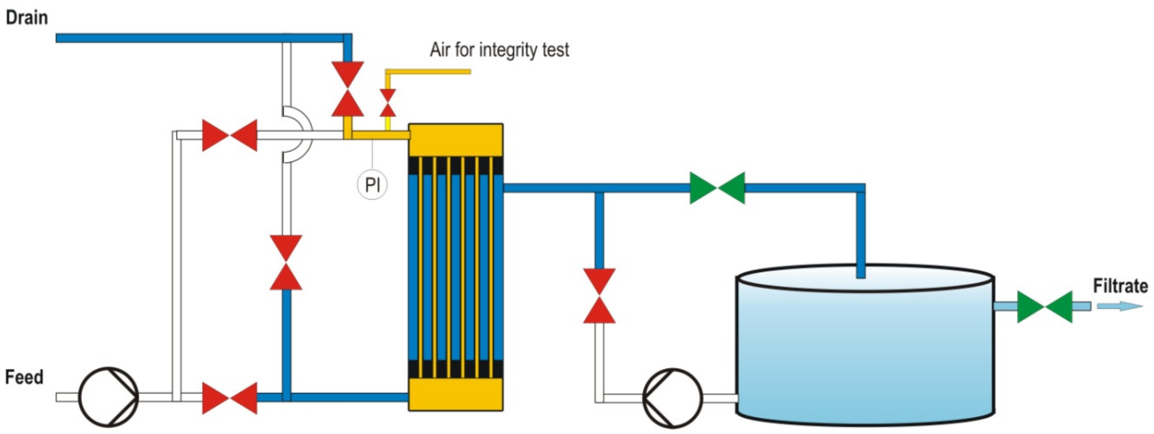


Figure 13-2: Pressure hold phase and pressure measurement for integrity test from feed side

4. Measure the pressure drop:

   - Measure the pressure drop on the high-pressure side for at least 3 minutes. Due to the air diffusion process through the water-filled pores of the membranes, a slight pressure drop may be observed. This should be taken as a base value and should not be regarded as a membrane leakage due to defective fibers. This diffusion effect may also result in a minor degree of bubble formation becoming visible in the transparent pipe. The base value is dictated by various factors, including the hold-up volume, the tightness of all valves and fittings and the diffusion component of the modules. In the event that the base value is exceeded, we recommend conducting a detailed examination to establish the cause.

Important:

- Determination of the base value must be performed using new modules (during system commissioning) in the fully assembled rack. This base value then serves as a reference value. At a test pressure of 1 bar (14.5 psi), this value should be lower than approximately 10 mbar/min for all rack sizes.

- It is important to ensure that the low-pressure side is open, unpressurized and completely filled with water when measuring this value.

5. Bubble test

   - Any leakage in an individual module can be detected on the low-pressure side using a built-in transparent pipe (see Figure 13-3; note that this is not available for dizzer® P modules). In the event of a leak, a continuous stream of air bubbles of a steady intensity will be visible during the integrity test.

   - If a significant, uniform stream of air bubbles is visible in the transparent pipe, and if the pressure drop is greater than the base value, it can be assumed that the system has a capillary defect, assuming that all other sources of error have been ruled out during the integrity test.

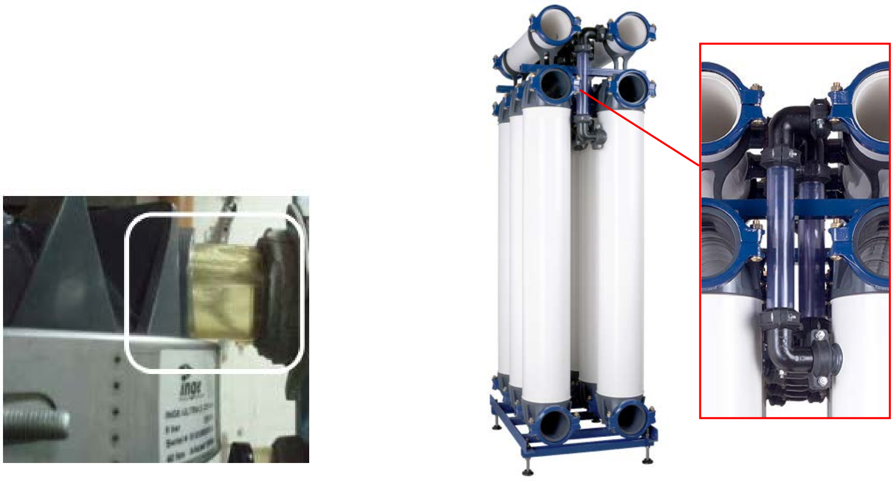


Figure 13-3: Monitoring and ensuring error-free operation of the assembled rack with the help of an integrated transparent pipe on the feed side in the dizzer® XL conventional system (left) and on the filtrate side in the T-Rack® 3.0 S (right)

6. Pressure relief:

   - After performing the pressure hold test, the pressure is released on the high-pressure side. For feed-side tests, this is achieved by opening a valve on the feed/rinse water side, while for filtrate-side tests the pressure is released by opening a valve on the filtrate side.

Important

☝ Make sure to carefully control the pressure release, among other reasons to prevent any risk to people who may be in the area.

7. Venting the system:

   - After completing the integrity test, the system must be vented. Confirm that no valves are closed on the filtrate side.
   - Run system in forward flush bottom (FFB) mode at a volume flow rate corresponding to a flux rate of 80 LMH (47 GFD) for 5 - 10 minutes.
   - Regular filtration operation can then resume, starting with a filtration bottom (FB). During the first approx. 5 – 10 minutes, filtration must be performed at a reduced flux rate of 40 LMH (23.5 GFD) to ensure the system is completely vented.

Figure 13-4 shows a clear overview of all the steps involved in a pressure hold test on the feed side.

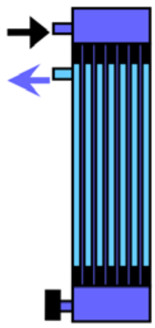
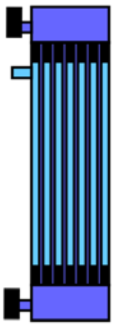
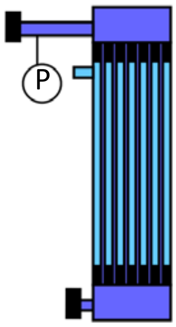
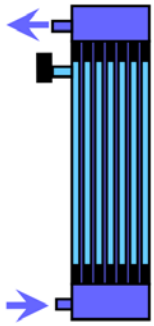
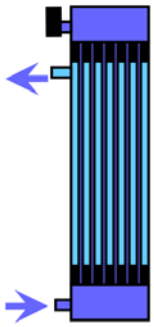
1	2	3	4	5	6	
Dewater feed side	Close pressure regulating valve on feed side	Measure pressure drop	Bubble test (optional)	Pressure relief 0 bar (feed side)	Vent with forward flush	Ventilation filtration at reduced flow rate
		 				

Figure 13-4: Procedure for a feed-side pressure hold test

14 Guidelines on Operating inge® Modules/Racks

14.1 Avoiding membrane-damaging particles and substances

inge® Multibore® membrane fibers are extraordinarily resistant to chemical, mechanical and thermal damage. Nevertheless, incorrect or improper operation of inge® membranes could still potentially cause damage to the membrane material, membrane resin or membrane fibers.

Important

- Any treatment of waters with concentrations of dissolved or non-dissolved substances in excess of 7 wt% is a special application which is not covered by the standard terms of the inge GmbH warranty policy. We therefore recommend performing pilot testing before building a membrane facility to treat waters of this kind.
- inge GmbH's warranty policy does not cover modules and membranes that are irreversibly destroyed by particles, substances or foreign objects that are produced within the module or washed into the module by feed water, backwash water, CEB/CIP water or compressed air (for example during integrity testing) due to a failure to comply with this Operator's Manual.
- In particular, the modules' conditions of use prohibit any of the following substances from being introduced into the membrane modules on either the filtrate or feed side:
  - Particles and foreign objects > 300 µm (see section on "Feed Quality and Pretreatment" for more details).
  - Abrasive, sharp-edged particles which could cause irreversible damage to the membrane surface.
  - Corrosion or erosion products produced in the water treatment plant and washed into the membrane module (e.g. sand or concrete residue from the backwash tank, see the sections "Filtration and Backwash" and "Design and Construction" for more details).
  - Foreign objects introduced during installation and maintenance such as metal or plastic shavings (see section on "Assembly and Maintenance").
  - Precipitated material washed into the module during operation (e.g. during a CEB or CIP) or precipitation that forms within the module which has not been properly removed from the module in accordance with the guidelines (see section on "Using Chemicals for CEB/CIP" for more details).
  - Polar, organic or chlorinated solvents.
  - Concentrated acids with a pH < 1 or caustics with a pH > 13.
  - Ozone or any other hydroxyl-radical-producing oxidizing agents from advanced oxidation processes (AOPs) such as UV + H_2O_2, UV + TiO_2 or Fenton-like reactions such as H_2O_2 + Fe(II), Cu(II), Ti(III), Cr(II) or Co(II).

14.2 Preventing Chemically Irreversible Fouling

Thanks to their high level of chemical resistance, Multibore® membranes can be cleaned using a range of chemicals in high concentrations (see section on "Using Chemicals for CEB/CIP" for more details). The standard inge® CIP is capable of removing practically all natural water constituents which cannot be removed by regular CEBs and which accumulate in or on the membrane over the course of time.

Nevertheless, failure to operate inge® membranes in accordance with the guidelines or the presence of non-membrane-compatible substances in the feed water, backwash water, CEB/CIP water or compressed air could potentially lead to cases of irreversible fouling/scaling which can no longer be removed at a reasonable cost even with the most intensive CIP. For example, this may involve precipitation resulting from oxidative CEB/CIP (Mn, Fe hydroxides and oxides) which has not been properly removed from the membrane in accordance with the guidelines, or organic/inorganic substances that do not naturally occur in the water being treated which are added to the system either directly upstream from the membrane or at some other point in the overall process. Substances of this kind can be found, for example, in blow-down waters from cooling tower water treatment processes, in industrial process waste waters and in surface waters containing a significant proportion of waste water. We therefore urgently recommend performing pilot testing before building a membrane facility to treat waters of this kind.

Important

- inge GmbH's warranty policy does not cover modules and membranes that are irreversibly contaminated – to an extent that cannot be successfully rectified even by intensive chemical cleaning – by particles, substances or foreign objects that are produced within the module or washed into the module by feed water, backwash water, CEB/CIP water or compressed air due to a failure to properly comply with this Operator's Manual.

- In particular, the modules' conditions of use prohibit any of the following substances from being introduced into the membrane modules on either the filtrate or feed side:
  - Organic polymers that are not naturally present in the water being treated. These polymers may not be added to the system either directly upstream from the membrane or at any other point in the overall process. These include, for example:
    - Organic coagulants and coagulation aids (see "Performing " in the section "Feed Quality and Pretreatment" for more details)
    - Organic corrosion inhibitors
    - Organic dispersants
    - Organic wetting agents
  - In exceptional cases, the substances listed above may be used or may be present in low concentrations in the water being treated if it has been proven that they do not cause any chemically reversible fouling. However, this requires prior approval by inge GmbH.

14.3 Permitted Conditions of Operation, Rinsing, Cleaning and Disinfection

Important

- All inge® modules/casings/racks must be operated and used in accordance with the following operating conditions. Proper compliance with the permitted operating conditions is a prerequisite for making a claim under the warranty.

Permissible Operating Pressures

- dizzer® P incl. filter case
  - Maximum operating pressure[1]: 10 bar
- dizzer® XL and dizzer® 5000plus:
  - Design pressure[2]: 5 bar up to 40°C
- T-Rack® and T-Rack® vario:
  - Design pressure: 5 bar up to 20°C; 3 bar up to 40°C
- T-Rack® 3.0:
  - Design pressure[3]: 8.2 bar up to 20°C; 6.6 bar up to 30°C; 5 bar up to 40°C

Permissible Transmembrane Pressure (TMP):

- Filtration: max. 1.5 bar
- Backwash: max. 3.0 bar
- Integrity test: max. 1.0 bar air pressure

The permissible transmembrane pressures are not calculated on the basis of membrane strength. Instead, they are designed to prevent compaction of the coating layer on the membrane and to ensure stable long-term operation. The burst pressure of the Multibore® membrane is in excess of 10 bar.

---

1 In accordance with NSF 42 (an international standard for Point of Use (PoU) and Point of Entry (PoE) systems), the maximum operating pressure should be equivalent to 25% of the burst pressure.

2 The design pressure corresponds to the maximum permitted operating pressure in continuous operation at the specified design temperature over a service life of 10 years. Higher operating pressures may be possible in certain individual cases. However, this must first be verified and approved by inge GmbH.

3 The design pressure of the T-Rack® 3.0 can be converted for further temperatures and service lives by referring to DIN ISO 9080 and/or ASTM D 2837. Once again, however, this must first be verified and approved by inge GmbH.

Permitted Chemicals:

- Chemicals may only be used in accordance with the guidelines given in the section "Using Chemicals for CEB/CIP".
- Permissible pH range during operation: pH 3 – 10
- Permissible pH range for cleaning: pH 1 – 13
- Maximum concentration of hydrogen peroxide (H_2O_2): 500 mg/L
- The use of chlorine is only permitted for the following applications in the maximum concentrations indicated below:
  - Maximum concentration of free chlorine for CIP: 200 mg/L at pH ≥ 9.5
  - Maximum concentration of free chlorine for CEB: 50 mg/L at pH ≥ 9.5
  - Maximum concentration of free chlorine at the membrane during continuous dosing: 0.2 mg/L
  - Maximum continuous concentration of free chlorine in swimming pool applications: 0.7 mg/L
  - Maximum concentration of free chlorine during shock chlorination at pretreatment stage: 10 mg/L for 30 minutes, max. once a day
  - Maximum concentration of free chlorine at the membrane in disinfection CEB in waste water applications: 10 mg/L for 30 minutes, max. 2x a week or daily in the event of shutdown > 24 h < 7d
  - Maximum concentration of free chlorine during system disinfection: 100 mg/L for 60 minutes, max. 6 times a year
- The use of chlorine dioxide (ClO_2) is only permitted for disinfection in the following maximum concentrations:
  - Maximum concentration of ClO_2 at the membrane during disinfection CEB in waste water applications: 5 mg/L for 30 minutes, max. 2x a week or daily in the event of shutdown > 24 h < 7d
  - Maximum concentration of ClO_2 for system disinfection: 50 mg/L for 60 minutes, max. 6 times a year

Permissible Temperature Ranges:

- Maximum temperature range: 1°C to 40°C
- Maximum rate of temperature change: < 1°C/min
  (see section on "Chemical Clean In Place (CIP)" for more details)

Important

☝ Please note that operating the membranes with a simultaneous combination of the maximum limits for temperature, pH, effective chemical concentration and/or pressure during production or cleaning will have an impact on the membranes' service life.

15 System Shutdowns

Important

- ☝ Membranes that have been used must be kept wet at all times.
- ☝ To avoid microbial growth during plant shutdowns or storage of decommissioned modules, wet membranes must be rinsed with a suitable disinfectant solution and properly preserved.

Please observe the following guidelines for different downtime conditions and durations:

- Rinsing prior to a downtime of up to 24 hours

  Before a downtime lasting less than 24 hours, a backwash of at least 60 seconds must be performed (see section on "Membrane Operating "). No further action is required.

- Rinsing and disinfection for downtimes > 24 hours

  Before a downtime lasting more than 24 hours but less than 7 days, a daily filtration sequence must be performed at a flux rate of at least 50 LMH (29 GFD) for at least 10 minutes. In addition, a complete CEB must be performed once a day for disinfection purposes (injection of chemicals, soak time and rinsing as described in the section "Chemically Enhanced Backwash (CEB)") using NaOCl and a soak time of 30 minutes. It is important to verify that the concentration of free chlorine in the discharged rinse water at the end of the soak time does not exceed 10 mg/L and does not fall below 1 mg/L.

- Preserving modules for downtimes > 7 days

  Membranes must be properly preserved in the event of a system shutdown lasting longer than 7 days. Before taking steps to preserve the membranes, it is absolutely essential to perform chemical cleaning to remove any organic or inorganic contaminants (fouling, scaling) from the membranes. After cleaning, inject a 0.75% sodium bisulphite solution into the membranes in top and bottom backwash mode (BWT, BWB; see section on "Membrane Operating "). The water used for this solution should be of UF filtrate quality or higher. The sodium bisulphite solution should be left in the module/rack and replaced every four weeks. Should additional frost protection be required then refer to section “Preservation” in the chapter “Shipping, Handling and Storage” for preparation of the aqueous preservation solution.

Important

- ☝ Whichever of the above situations applies, the modules should be kept hydraulically filled with liquid. The membranes must be kept free of any oxidizing agents during system shutdowns.
- ☝ If you wish to use any other disinfectants, please contact inge GmbH beforehand. It is essential to obtain prior written agreement and approval from inge GmbH regarding the chemicals and concentrations that are permitted for use.
- ☝ To put the system/modules back into operation, it is essential to follow the guidelines provided in the section on "System Commissioning".

16 Documentation of Operating Conditions

Important

- From the moment the modules are first put into operation, the operator is obliged to maintain complete and continuous documentation of the operating parameters and the amount of time the plant has been operated in each of the various operating modes.
- No warranties or warranty claims shall be valid without this documentation.
- The feed water quality must be measured after every chemical dosing procedure and after the prefiltration stage (for comparative analyses regarding feed quality). The results of the analyses must be documented.

The following UF system parameters must be recorded and documented:

1. pH value, temperature and turbidity in the feed immediately prior to ultrafiltration (UF);
2. Permeability (@ 20°C), volume flow rate, transmembrane pressure (TMP) and absolute pressure (feed/filtrate) per rack / per filtration line during filtration/backwash, CEB/CIP and integrity testing.

   The data must be captured and logged automatically at least every 2 seconds (at least every 3 minutes during operating cycles) to ensure that all the effects are registered of changes in pump operation and/or valve positions (changing modes and sequences). To ensure appropriate documentation can be provided and to help optimize the membrane plant, data should be captured and logged at the shortest possible intervals.
3. Chemicals
   - Use of chemicals for pretreatment, measured directly in the feed prior to ultrafiltration (UF):
     - Type and concentration of coagulants
     - Type and concentration of oxidants
   - Use of chemicals for CEB/CIP, measured within the rack (chemicals in contact with the membranes):
     - Type, contact time and concentration of oxidants or other membrane cleaning agents
     - Type, contact time and pH value of acids/bases

   The minimum interval for one complete set of measurements (lab measurements) is one per day (or one measurement per CEB/CIP).
4. In the event of a module defect, it is necessary to provide documentation on the position of the defective module within the rack (line, train/unit, side, position) together with details of the module serial number (for more information see the section on "Returning Modules").

17 Returning Modules

Important

- Modules shall only be accepted for return if this has been agreed in advance with inge GmbH and authorized in writing.
- Module returns that have been previously agreed and approved by inge GmbH are subject to the following mandatory requirements:
  - The modules must be cleaned before they are returned.
  - During storage and transportation, the modules must be properly preserved (see "System Shutdowns") and protected from drying out and freezing at all times (temperature must be maintained between 4°C and 35°C).
- Removal of the original inge® module serial number from the module automatically invalidates any warranty that may have applied.
- Failure to comply with any of the requirements stated above will result in inge GmbH refusing to accept the return of the modules; inge GmbH reserves the right to invoice the sender for any transportation or removal costs that may be incurred in this case.

18 Warranty Policy

Important

- ☝ Full and proper compliance with the Operator's Manual is a prerequisite for making a claim under the warranty. In the event of making a warranty claim, the operator agrees to automatically provide inge GmbH with a complete set of documentation as described in the section "Documentation of Operating Conditions".
- ☝ Please contact inge GmbH if you wish to deviate from any of the guidelines or specifications provided in this document and request written approval in advance. Otherwise you risk invalidating any warranty claims that you may make in the future.

19 How to Contact Us

Please contact inge GmbH if you require any further information:

inge GmbH
Flurstrasse 27
86926 Greifenberg
Germany

Tel.	+49 (0) 8192 / 997 – 700
Fax	+49 (0) 8192 / 997 – 999
E-Mail	info@inge.ag
Web	www.inge.ag

Note

The utmost care has been taken in developing the contents of this Operator's Manual. inge GmbH cannot accept any liability for loss or damage that may arise in connection with using our products. The quality of inge® UF modules and racks is warranted in accordance with our general terms of sale.

inge GmbH
Flurstraße 27
86926 Greifenberg, Germany
Phone +49 8192 997-700
Fax +49 8192 997-999
info@inge.ag

www.inge.ag