CERAFILTEC
CLEAN WATER. EVERYWHERE.

Manual for CERAFILTEC membrane module

(General information, Assembling & Installation, O & M)

CERAFILTEC Ceramic Membrane Modules

Revision: 01.2022 – Version 2.1.3

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Notes

Content

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List of pictures and tables

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1 Introduction

Congratulations on choosing CERAFILTEC's ceramic membrane module.

The CERAFILTEC system is a highly sophisticated product. We strongly recommend using only trained and experienced technicians for assembly, installation and troubleshooting. To locate the closest authorized service technician or to request an assembly training please contact your CERAFILTEC representative or visit our website at http://www.cerafiltec.com/team/.

If you decide to install the equipment yourself, please follow this assembling manual. For installation assistance, contact your CERAFILTEC representative. You will ensure a successful installation as well as reliable operation by carefully reading this manual and following the operational guidelines. Convince yourself about the easy assembling. Under the following links we show you demonstration videos of assembling and operation references:

http://www.cerafiltec.com/how-to-assemble/

http://www.cerafiltec.com/videos-processes-references/

This document contains general guidelines. Depending on the application and project specific installation requirements, e.g. how many modules per tower to be assembled, construction of accessories inside the filtration tank, like position holders, aeration and sprinkler sets, hose connections of tower, main filtered water header, and other need to be considered. Please follow these additional instructions, listed in the project design and execution documents. If you do not have the project design or execution documents, please contact your CERAFILTEC representative.

Please contact your CERAFILTEC representative or check on our website http://www.cerafiltec.com for any further manual updates to insure correct and safe assembly and installation.

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2 Technology and Product Introduction

2.1 Filtration classification, applications and removal targets

CERAFILTEC's filtration module is a chemical and temperature resistant Ultra-Filtration (UF) ceramic membrane filter for solid-liquid separation. It can be used in various sources of contaminated water. The technology is well used in the following applications:

- Drinking water from ground- and surface water sources
- Brackish water and seawater reverse osmosis pre-filtration
- Municipal and industrial wastewater treatment
- Mining wastewater treatment
- Oily wastewater treatment
- Produced water treatment
- Scrubber wastewater for marine scrubbers
- Recovery of backwash wastewater from sand filters
- Sludge thickening of activated sludge
- Hot water filtration
- Others challenging industrial waters

With an average filter pore size of 0.1 micron the UF membrane acts as a physical barrier to removal any suspended solids from the water, like:

- Sand particles, silt and colloidal silica
- Metal oxides, like iron and manganese oxides
- Pollen, Germs and bacteria
- Algae
- Oil and grease
- Colloidal fractions
- Chlorinated diphenyl
- TEP (Transparent Exopolymer Particles)
- EPS (Extra polymeric Substances)
- Others

Ultra-filtration technologies with a pore size of 0.1 µm are commonly understood as filtration solution to remove suspended solids such as clay and silt, pollen, algae, precipitated metal oxides as well as fractions of colloids. They are also a physical barrier for germs and bacteria and are classified as disinfection solution with typical log removal value (LRV) above 5.

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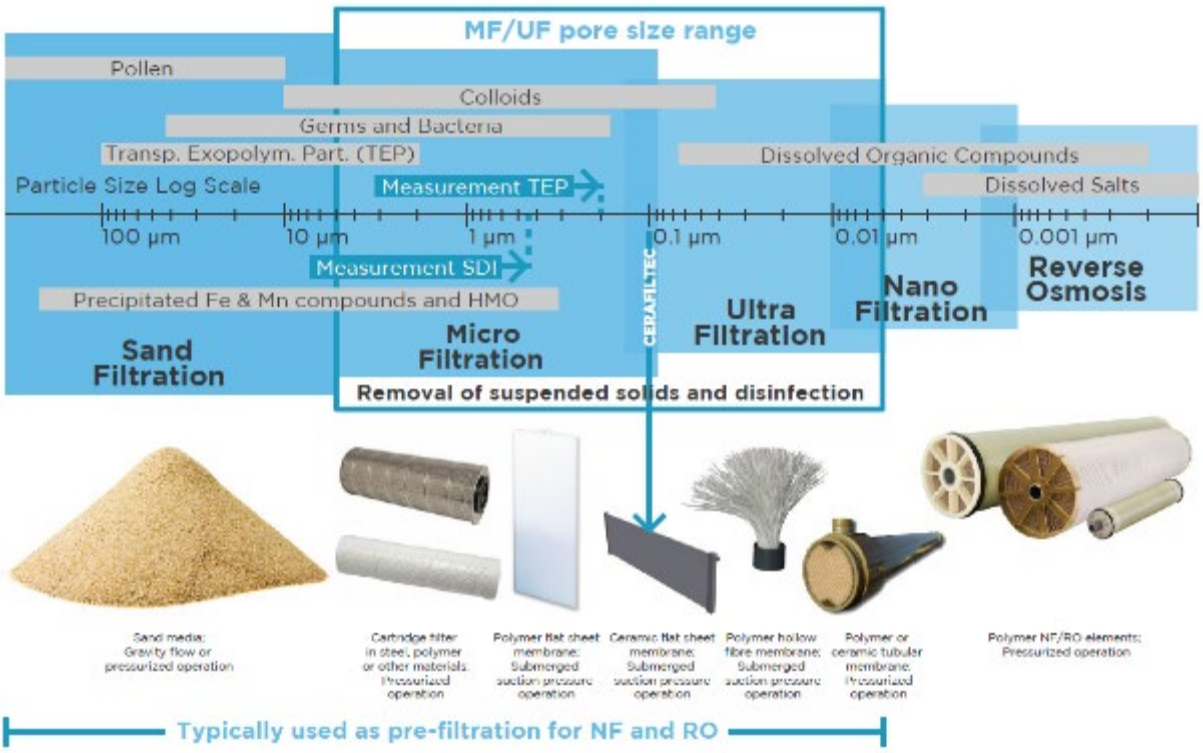

Figure 1: Classification of filtration technologies

CERAFILTEC's ceramic flat sheet membrane solution is more than just a common ultra-filtration. In conjunction with developed pre-treatment processes, e.g. active cake layer filtration for a selective removal of dissolved ions, CERAFILTEC provides a superior filtration solution. Therewith, only CERAFILTEC achieves unprecedented filtered water quality, and consequently being the best pre-filtration solution for all NF and RO applications. The technology is typically used as pre-filtration for desalting technologies, like Nano-Filtration and Reverse Osmosis. CERAFILTEC's filtration module is highly seawater resistant and corrosive free.

http://www.cerafiltec.com/classification/

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3 Ceramic Flat Sheet Materials

The CERAFILTEC module housing can be used with a wide variety of ceramic flat membranes. The module housing of CERAFILTEC is the standard and the different ceramic membranes can be used specifically according to the application. The ceramic plates marketed by CERAFILTEC have different properties depending on their choice. Please refer to the manufacturer's instructions for the membranes.

3.1 Ceramic Membrane properties

The high resistance of ceramic materials and the resulting cleaning possibilities generate a unique high-performance system. Depending on the medium and the operating conditions, mechanical, thermal, and chemical cleaning strategies it can be combined individually to achieve a stable and low maintenance long-term operation.

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4 CERAFILTEC´s Ceramic Membrane Module

One module is a single, modular and expandable filtration unit consisting of a glass fiber reinforced plastic housing and the flat sheet ceramic plates. The module housing was developed to tightly transport the liquid medium in internal channels, while at the same time withstanding high mechanical forces. Our 3rd generation module is flow optimized to achieve the maximum performance of the ceramic membranes. The four large internal filtered water channels allow for flux rates up to 1,500 LMH (equal to 9 m^3/hr) with one single module at minimal pressure losses. The entire housing, as well as all accessories are free of any metals and therefore usable in the harshest applications and at the same time achieving a very long lifespan. Additionally, no surrounding frames or hose connections between the modules are required.

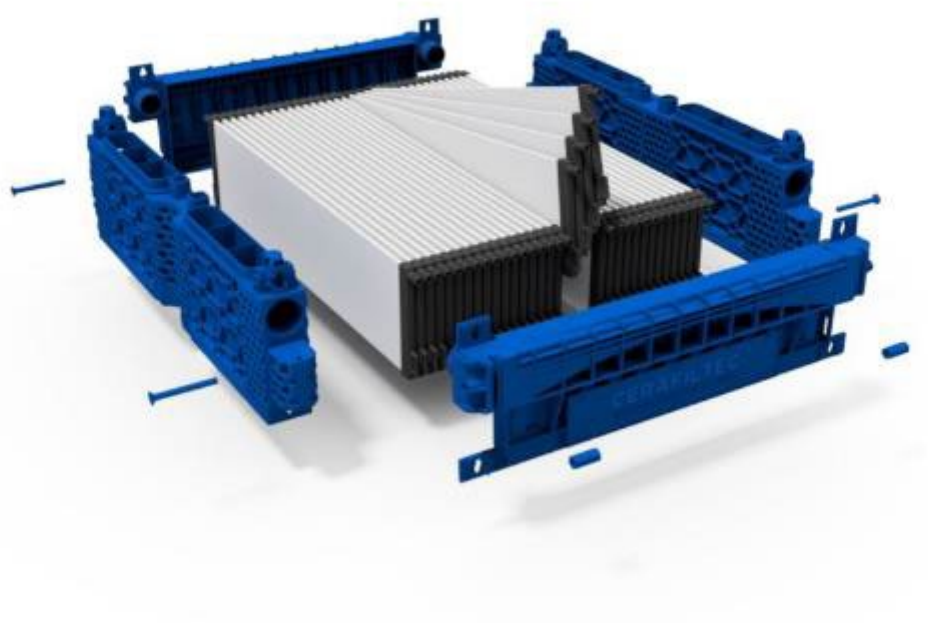

Figure 2: Exploded drawing of CERAFILTEC Module

Benefits:

- Less filter area needed due to high flux operation – high CAPEX savings
- Suitable for seawater and other challenging applications without any risks of corrosion problems
- Operation at hot temperature up to boiling water
- Fully modular due to no surrounding frame – option to change number of modules per tower at any time either to optimize project costs or to increase the plant capacity in future
- Most compact design – towers can be installed in close distance to each other as no hoses are needed

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4.1 Module 6.0 S

The Module 6.0 S is our standard for most applications.

- Filtration module with ceramic flat sheet membranes suitable for submerged applications
- Multi ceramic plate configuration with exchangeable single ceramic plates
- Internal filtered water piping
- Module housing fully made of glass fiber reinforced resin – free of any steel parts
- Suitable for harsh applications like groundwater, seawater, surface water, MBR, TSE and other challenging industrial waters
- High flux operation up to 1,500 LMH

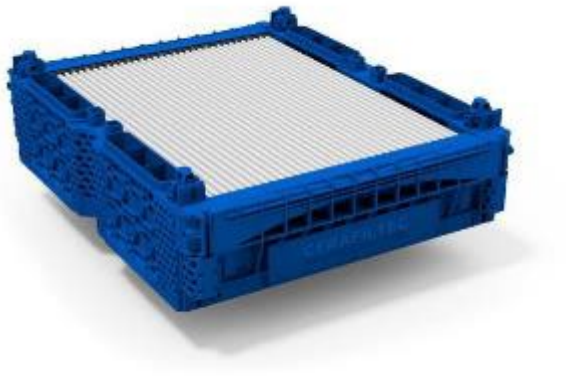
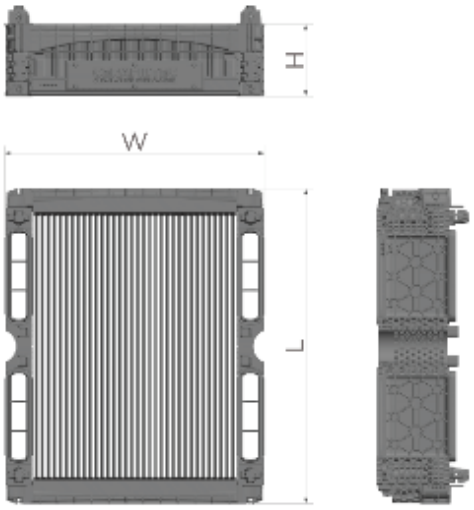


Figure 3: Product -Module 6.0 S

Specifications

Table 1: Specifications for Module 6.0 S

Dimension LxWxH	700x567x160 mm
Dry weight	37.7 kg
Module housing material	NORYL™ resin 30% glass fiber reinforced blend of PPE/PS
No. of single ceramic plates	34
Avg. distance between ceramic plates	6.7 mm
Filter active area	6.0 m²
Max flow	9.0 m³/hr
Max. negative (suction) pressure	-0.7 bar
Max. positive (backwash) pressure	1.2 bar
Operating temperature	5 - 65 °C
Field of application	Drinking water / sewage / industrial water



4.2 Module 6.0 H

The Module 6.0 H is our specialist for hot water applications above 60°C.

- The Module 6.0 S is our standard for most applications.
- Filtration module with ceramic flat sheet membranes suitable for submerged applications
- Multi ceramic plate configuration with exchangeable single ceramic plates
- Internal filtered water piping
- Module housing fully made of glass fiber reinforced resin – free of any steel parts
- Suitable for hot water applications like deep groundwater, produced water, boiler and heat exchanger systems
- High flux operation up to 1,500 LMH

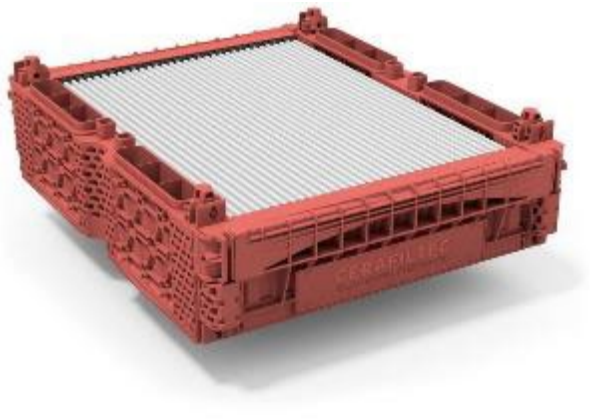
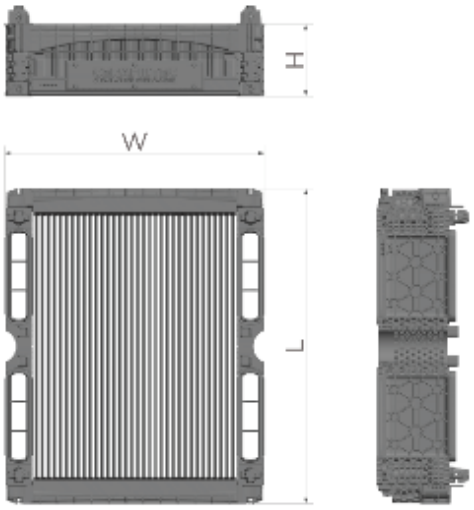


Figure 4: Product – Module 6.0 H

Specifications

Table 2: Specifications for Module 6.0 H

Dimension LxWxH	700x567x160 mm
Dry weight	37.7 kg
Module housing material	NORYL™ resin 30% glass fiber reinforced blend of PPE/PS
No. of single ceramic plates	34
Avg. distance between ceramic plates	6.7 mm
Filter active area	6.0 m²
Max flow	9.0 m³/hr
Max. negative (suction) pressure	-0.7 bar
Max. positive (backwash) pressure	1.2 bar
Operating temperature	60 - 99 °C
Field of application	Drinking water / sewage / industrial water



4.3 Module ST Series

The Modules ST Series is the allrounder for sludge thickening applications.

- Filtration module with ceramic flat sheet membranes suitable for sludge thickening process and other applications with very high TSS concentrations
- Multi ceramic plate configuration with exchangeable single ceramic plates
- Extra large distance between single plates available in 3 standard configurations
- Internal filtered water piping
- Module hosing fully made of glass fiber reinforced resin – free of any steel parts exchanger systems

STANDARD CONFIGURATIONS

Figure 5: Product – Module ST Series

SPECIFICATIONS

Table 3: Specifications for Module ST Series

Module configuration	ST 20	ST 33	ST 46
Distance between ceramic plates	20 mm	33 mm	46 mm
Max. recommended cake layer thickness	7 mm	12 mm	18 mm
Max. sludge volume per module	21 L	27 L	36 L
No. of single ceramic plates	16	11	8
Filter active area	2.8 m²	2.0 m²	1.4 m²
Dry weight	21.0 kg	16.9 kg	14.5 kg
Max. flow [m³/hr]	4.2 m³/hr	3.0 m³/hr	2.1 m³/hr
Dimension LxWxH [mm]	700x576x160 mm		
Module material	NORYL™ resin 30% glass fiber reinforced blend of PPE/PS		

4.4 Accessories and tools

The accessories can be divided into essential accessories and optional accessories. The essential accessories must be supplied by CERAFILTEC, the optional accessories can also be manufactured according to CERAFILTEC´s specifications. It is recommended to use optional accessories and is depending on the process specification in the technical projection.

http://www.cerafiltec.com/accessories/

4.4.1 Header Set

- Essential to connect tower to standard header piping
- Contains 2 header collectors, 2 plastic tri-clamps, 2 plastic pipe adapters, 4 keys and all necessary gaskets
- To be installed on the top module of each tower
- Simply to be connected via key lock system
- Plastic pipe adapter available in different sizes, metric as well as ASTM standard
- Plastic pipe adapter to be glued to standard hose or pipe sizes

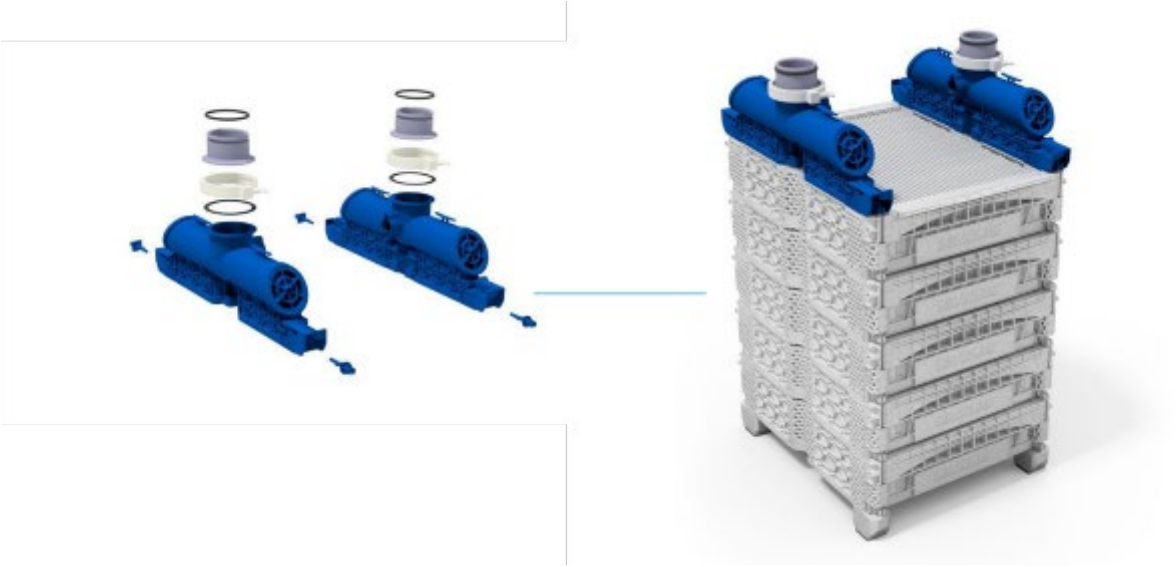


Figure 6: Essential Accessories – Header Set for Module Towers

4.4.2 Base Set

- Essential to install tower on the tank bottom
- Contains 4 corner feet, lifting rope and 4 keys
- To be installed below the bottom (base) module of each tower
- Simply to be connected via key lock system
- Rope to be threaded through each module and to be connected on lifting device for installation of the tower inside the tank
- Once tower is installed rope end to be fixed on header collector

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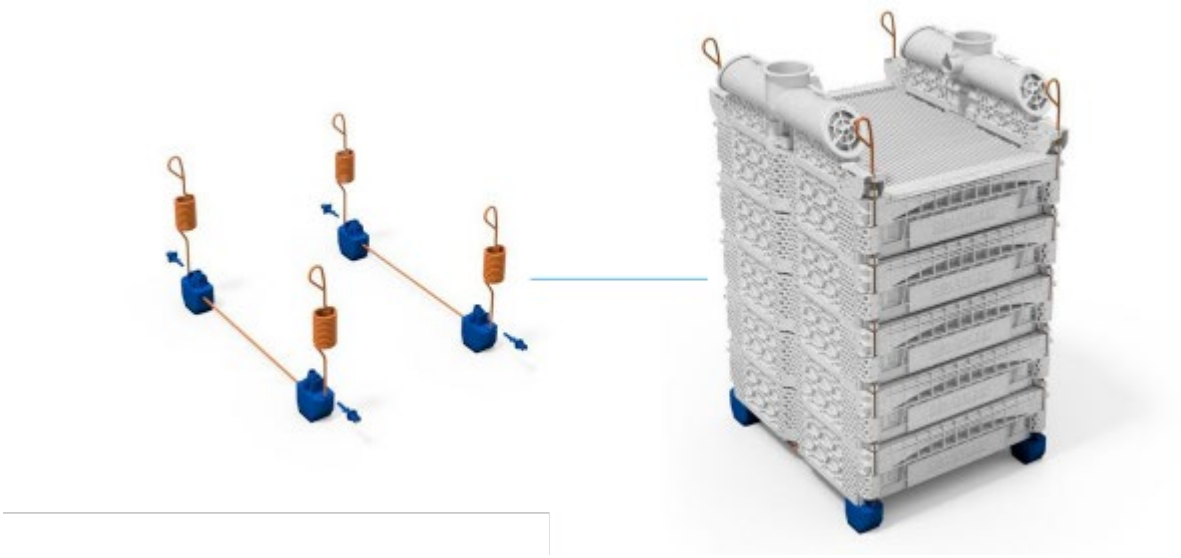

Figure 7: Essential Accessories – Base Set for Module Towers

4.4.3 Sprinkler Set

- Recommended for all applications with dead-end filtration and cake layer formation (filtration process without air-scouring)
- Ideal for projects in which CEB and CIP (chemical contamination of filtered water piping) need to be avoided
- Contains 2 perforated plastic pipes and 4 pipe clips
- Pipe clips to be connected to header collectors

Figure 8: Optional Accessories – Sprinkler Set for Module Towers

4.4.4 Air-Scouring Set

- Recommended for all applications in which a cake layer formation needs to be avoided (permanent air-scouring during filtration process), e.g. MBR or sludge thickening

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- Recommended for all applications with heavy cake layer formation to mix removed cake layer during backwash mode while filtration tank is drained
- Contains 4 or 5 perforated plastic pipes and clip holders (not PVC fittings)
- Clip holders to be installed below the tower on the tank bottom (not connected to the tower)

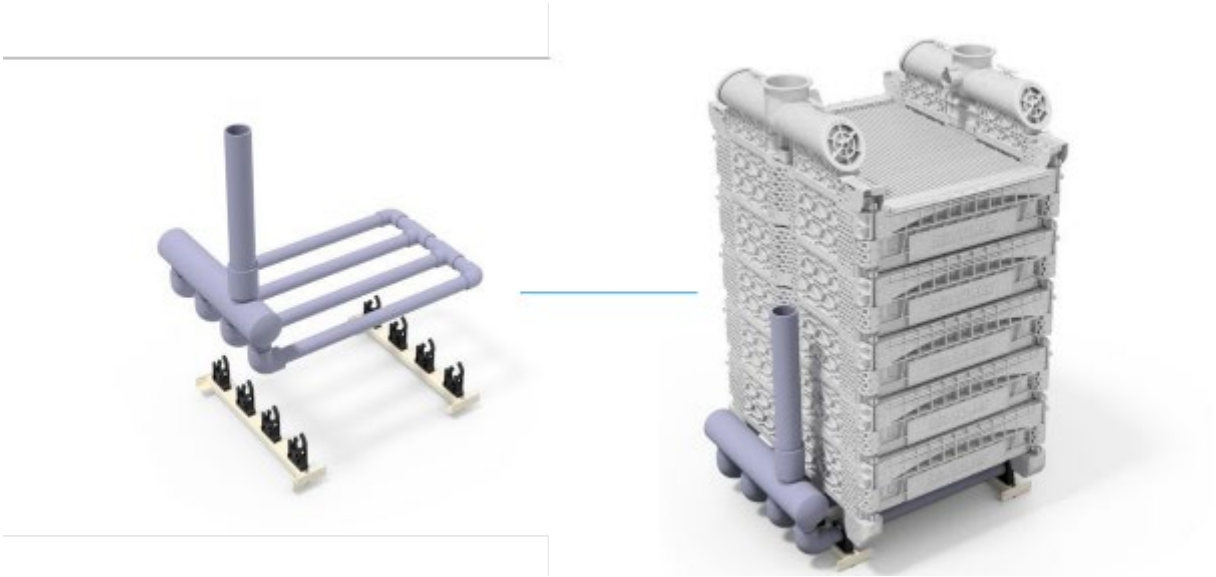

Figure 9: Optional Accessories - Air Scouring Set

4.4.5 Lifting Device

- To be used for installation of single tower
- Simply to be connected to lifting rope
- Can handle up to 16 modules per tower
- Available in steel 304 and 316

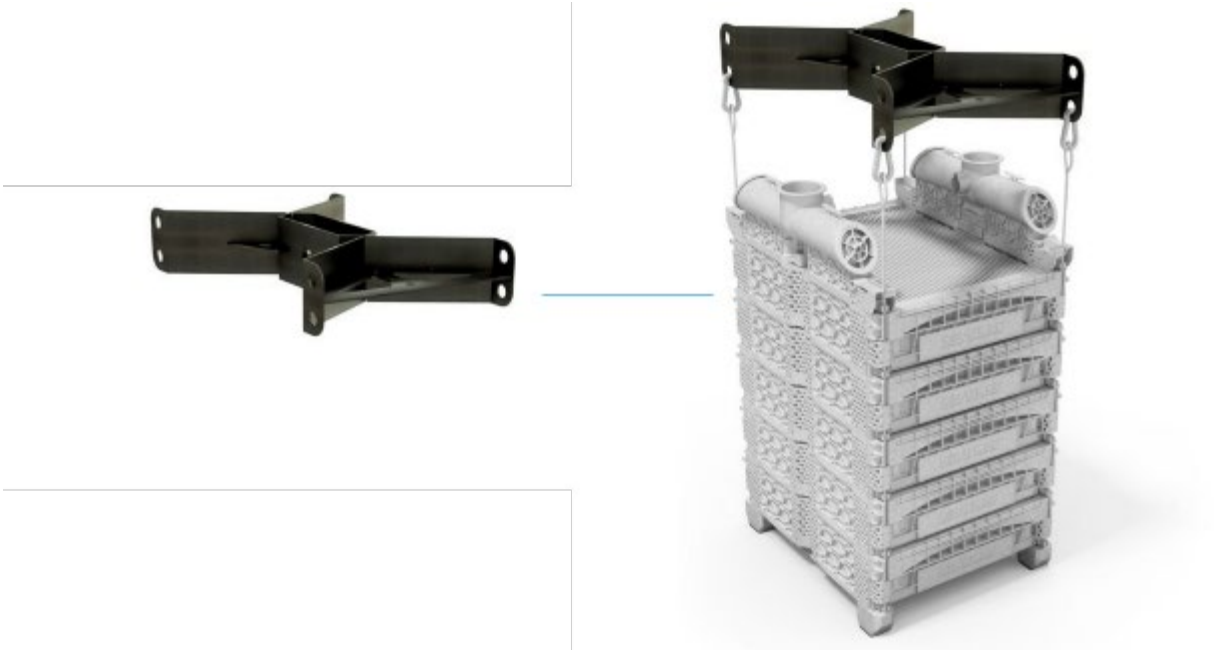

Figure 10: Optional Tool – Lifting Device for Module Towers

4.5 Features

4.5.1 Double line sprinkler

The integrated sprinkler system is used as water jet to enhance the removal of cake layers during on-air backwash.

At lower flow rates, the sprinkler can also be used for an efficient chemical cleaning by spraying concentrated chemicals over the ceramic flat sheet membrane surface (on-air cleaning). Due to the capillary force of the membrane pores, the chemicals are sucked into the membrane (CapClean mode).

Sprinkler Mode	CapClean Mode
Mechanical cleaning with spray flow up to 20 m^3/hr @ 2 bar	Chemical cleaning with spray flow up to 8 m^3/hr @ 1 bar

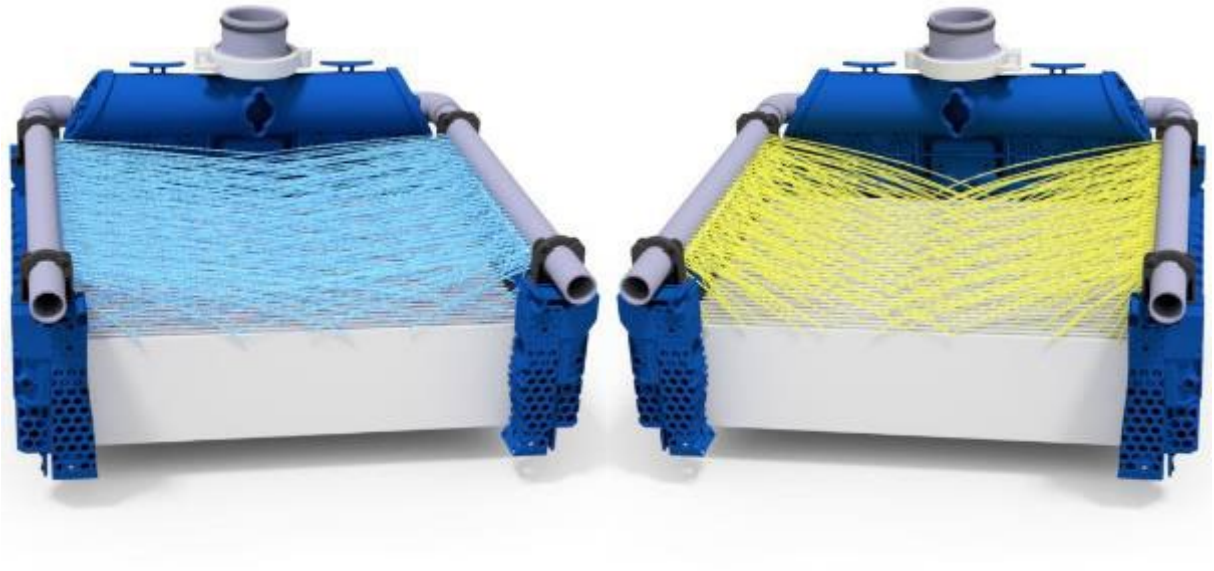

Figure 11: Sprinkler and CapClean mode for cleaning of membranes

Sprinkler Mode	CapClean Mode
▪ Safe operation in applications with very high suspended solids concentrations ▪ Prevention of sludge clogging or accumulation due to complete removal of cake layer and deposits inside the filtration tower during backwash	▪ Fastest cleaning option – full membrane recovery within less than 15 min ▪ Strong chemical cleaning but very low chemical consumption ▪ No contamination of filtered water piping secures chemical free product water at any time

http://www.cerafiltec.com/double-line-sprinkler/

4.5.2 Module with variable distance between ceramic plates

For applications with very high sludge or TSS concentrations a larger distance between the ceramic plates is essential to avoid clogging and to mitigate the risk of sludge dewatering, which could damage the ceramic flat sheet membranes. Four different plate distances are available starting from 6.7 mm

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up to 46.0 mm which allows a maximum cake layer formation of up to 18 mm. Single plate slots can be closed with a plug on the front sides of the module housing.

Benefits:

- Safe operation in applications with extremely high sludge and TSS concentrations up to 5 %
- Change of plate distance at any time even during operation
- Change at a later time is possible with minimum efforts – plates to be removed and plugs to be fixed
- No additional changes of module housing or accessories are required

http://www.cerafiltec.com/variable-plate-distance/

4.5.3 Active cake layer Filtration

The module is designed as submerged solution with an out-to-in filtration process. It allows a targeted formation of a cake layer on the ceramic flat sheet membrane, contrary to pressurized membrane filtration solutions in which a cake layer formation needs to be avoided.

Figure 12: Differences between submerged (out-to-in) and pressurized (in-to-out) Filtration

SUBMERGED OUT-TO-IN FILTRATION

- Filtration pressure on filtered water side
- No compression of formed cake layer
- High flux operation at very low pressure
- Insensitive to high suspended solids loads – cake layer formation of up several mm/cm depending on selected module / ceramic plate distance
- Long dead-end filtration period
- Low and short-duration backwash requirements
- Very high recovery rate
- Low power consumption
- Easy to clean

PRESSURIZED IN-TO-OUT FILTRATION

- Filtration pressure on feed side
- Compression of formed cake layer (collected suspended solids)
- Strong decline of membrane permeability – high pressure or low flux operation
- Limited to suspended solids loads – risks of membrane blocking and clogging (additional pre-treatment recommended or frequent backwash)
- High feed pressure can lead to passing of deformable contents, like TEP and decrease filtered water quality
- High power consumption
- High cleaning efforts

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Benefits:

- Cake layer can be used as additional filter bed for enhanced removal of very small particles and colloidal fractions
- Sorption processes inside the cake layer enable the selective removal of dissolved contents, like radium, uranium, arsenic or organics
- Formed cake layer can function as protective coating to minimize biofouling or scaling
- Improvement of filtered water quality can reduce design and process efforts of subsequent treatment steps

http://www.cerafiltec.com/active-cake-layer-filtration/

4.5.4 Hydrophilic ceramic membrane surface

The water contact angle is a measuring method which qualifies the hydrophilicity. The more hydrophilic the membrane surface the higher the operating flux performance. In comparison to polymeric membranes, ceramic membranes can achieve up to 15 times higher flux rates.

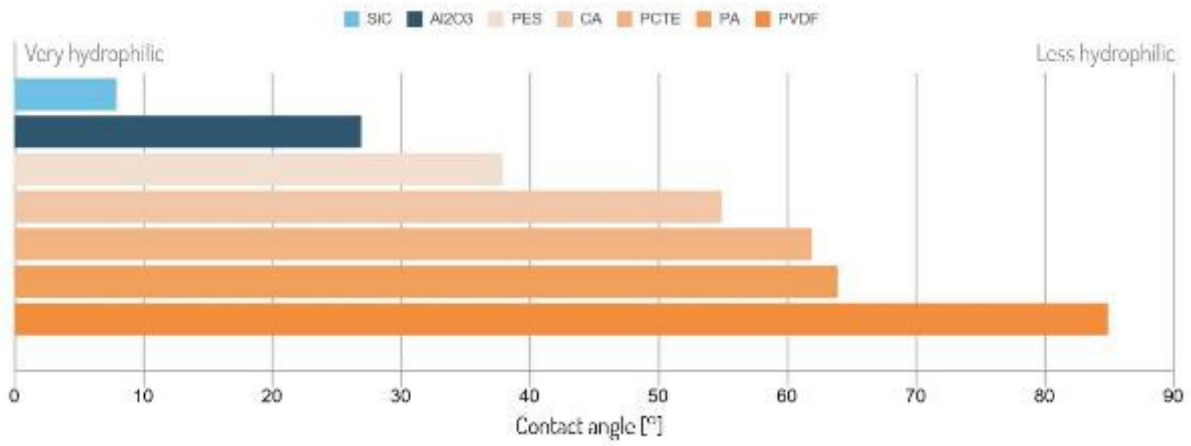

Figure 13: Contact angle of different membrane materials

Benefits:

- Ceramic membranes with very high hydrophilicities – superior for removal of hydrophobic water contents, like oil
- High flux operation of ceramic flat sheet membrane at very low pressure leads to low power consumption

http://www.cerafiltec.com/hydrophilic-membrane/

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4.5.5 Low Fouling potential on ceramic membrane surface

The higher the negative charge of the membrane the lower the susceptibility to fouling and clogging.

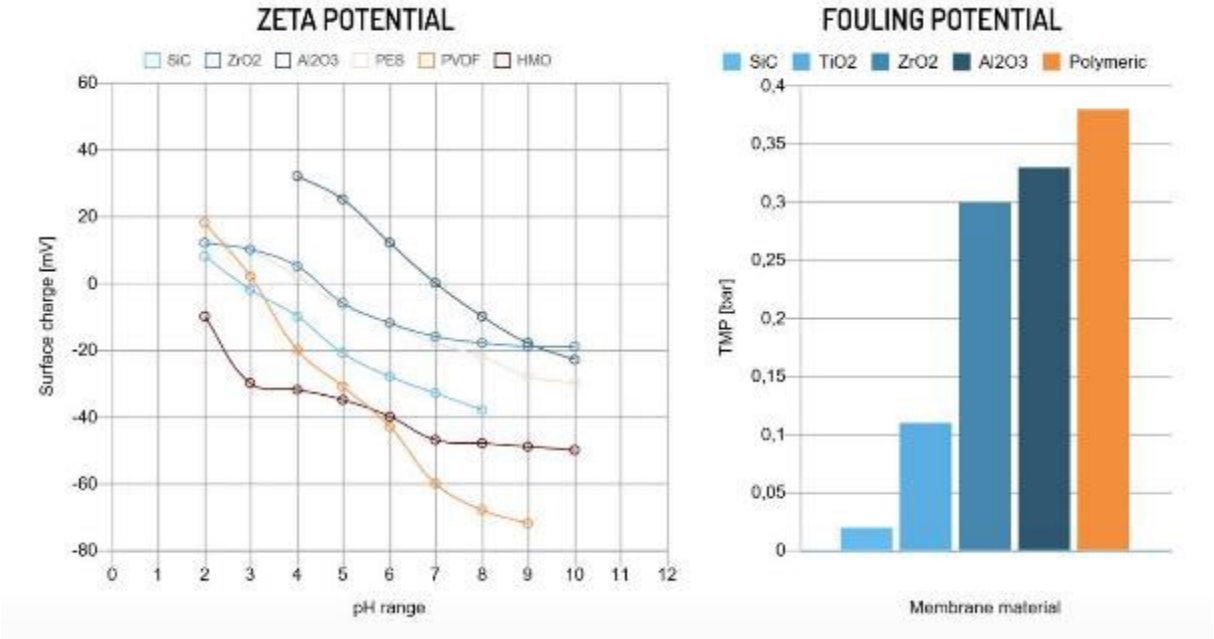

Figure 14: Zeta- and Fouling potential of different membrane material

Benefits:

- Ceramic flat sheet membrane material based on SiC with very high negative charge and isoelectric point at around pH 3 leads to stable high flux and low-pressure operation even at very low operating pH
- Lowest cleaning and maintenance requirements using SiC membranes
- Negatively charged ceramic flat sheet membranes are ideal for active cake layer filtration process using negatively charged HMO for the removal of heavy metals and radioactive isotopes
- SiC membrane achieves highest removal rates of negatively charged contents, like germs & bacteria, TEP and oil

http://www.cerafiltec.com/low-fouling-potential/

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4.6 CERAFILTEC´s Design Concept

A module is equipped with up to 34 exchangeable ceramic plates and a total membrane surface area up to 6 m². A single module or up to 15 modules can be stacked up to a tower. In addition to the modules a tower consists of a base set and a header set with a distribution channel for internal channels and are connection to common piping systems.

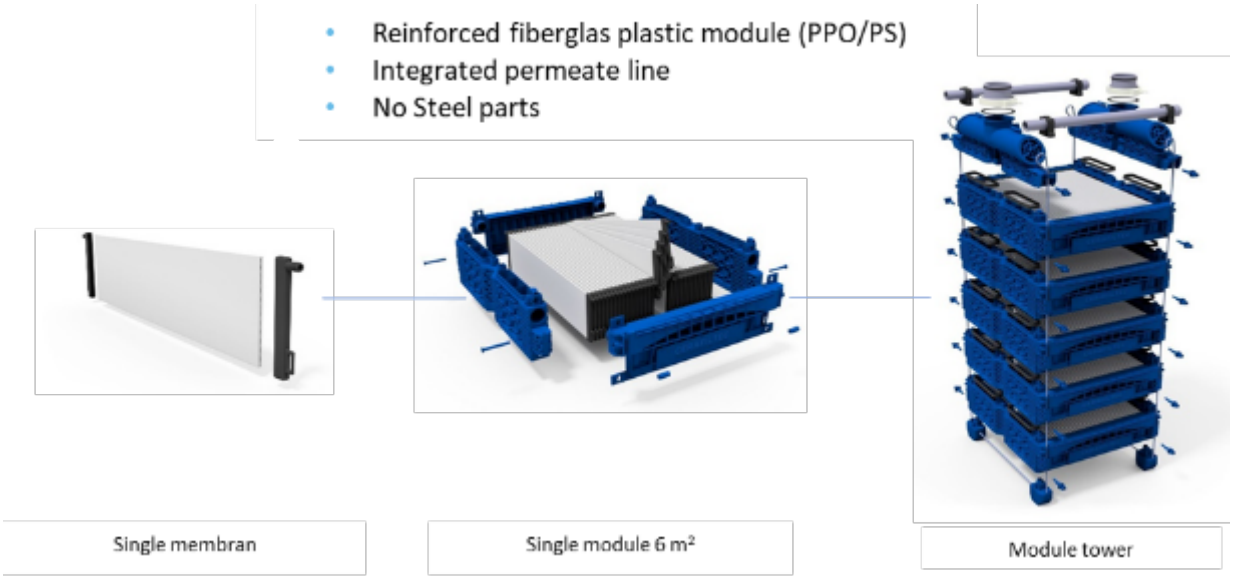

Figure 15: From single plate to a stack of modules (tower)

A module tower can be configured as a multi-tower. Several single towers can be simply connected through a common header pipe at the top. A fully modular configuration, no limitation in tower design as there is no surrounding steel frame.

Figure 16: Different tower configurations possible

The membrane surface area is the determining factor for the capacity of the installation, the more surface area the more flow through the plant. For more information see:

http://www.cerafiltec.com/design-concept/

4.7 How it works

The filtration principle works from OUT-TO-IN. Single ceramic plate with filter active layer on the outside of the membrane. Suspended solids are rejected on the membrane surface and forming a cake layer while clean water is passing through the membrane body and is collected at both end caps.

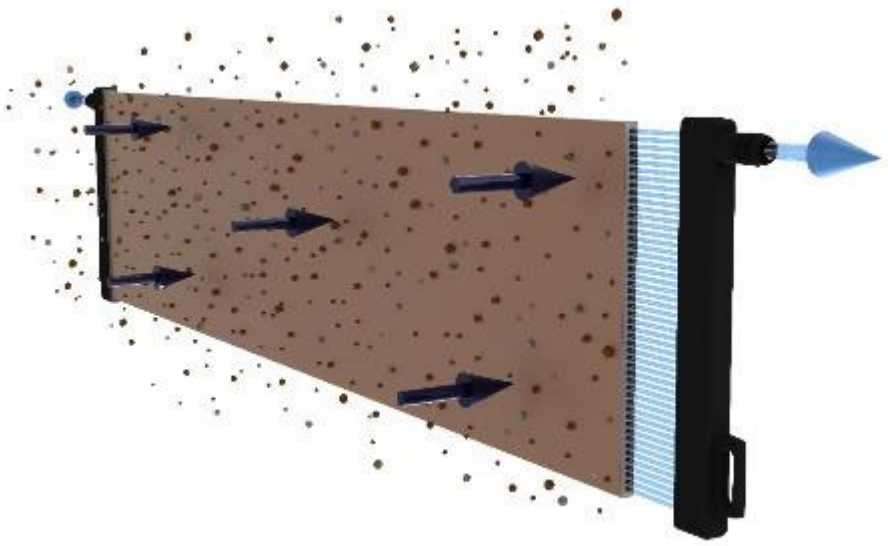

Figure 17: Membrane principle of filtration process – from out-to-in

Filtered water from each single plate is collected inside the module housing and transported to the header set through 4 filtered water channels integrated in both module housing sides.

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Figure 18: Module principle of filtration process

The filtration towers are fully submerged in a tank (filtration train) which contains the feed (raw) water. All towers are connected at the top with a common header pipe. The filtered water is transported through the header set of each tower to the top and from there through the common header pipe to the tank outside where a filtration pump is connected to transfer the clean water to the filtered water tank.

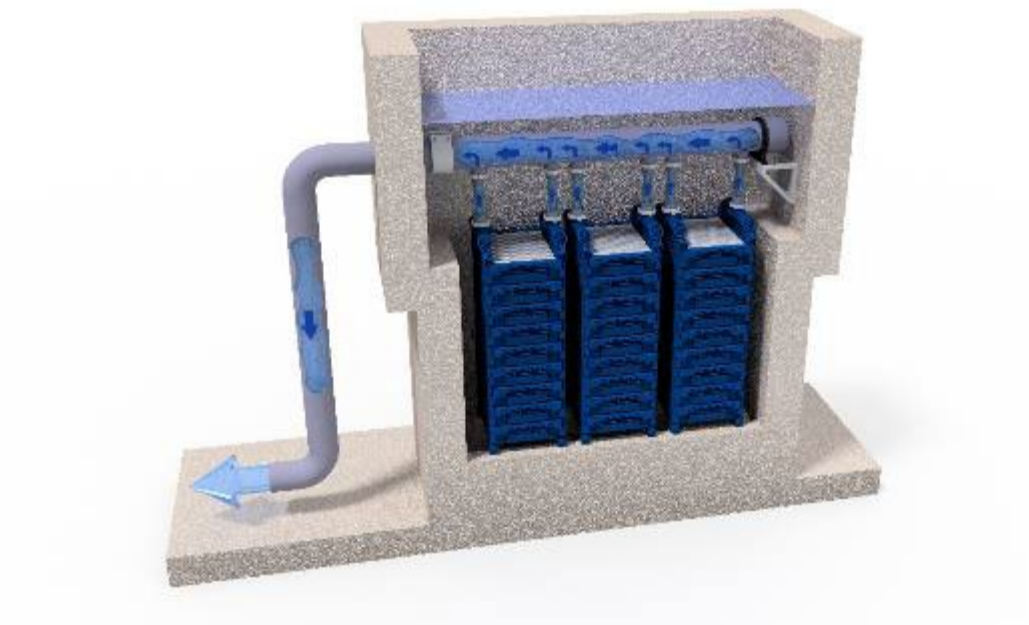

Figure 19: Filtration train principle of filtration process

Reversed flow direction to filtration. A very small amount of filtered water is used to backwash the membrane. Within seconds, the formed cake layer comes off in flakes. Air-scouring can enhance the cake layer removal.

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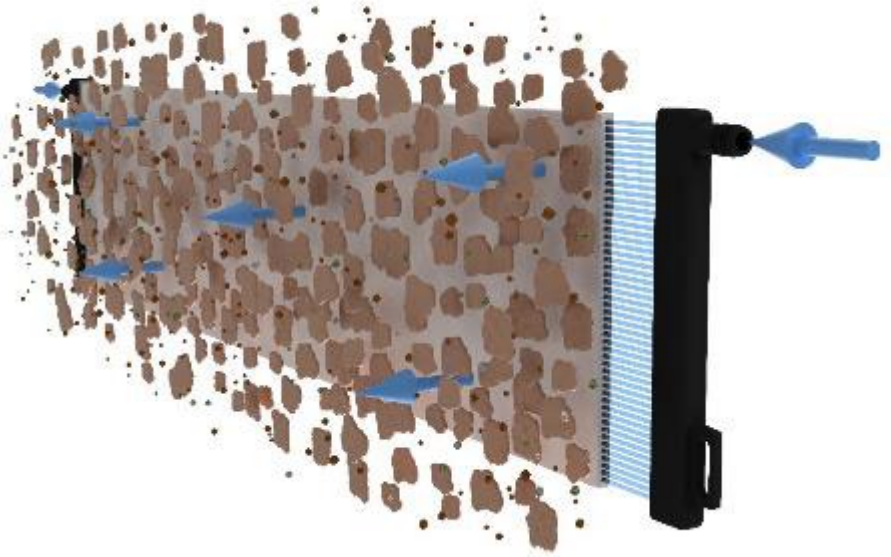

Figure 20: Membrane principle of backwash process – from in-to-out

Filtered water from all 4 filtered water channels is transported to both module fronts and enters from there into each single plate. Filtered water from all 4 filtered water channels is transported to both module fronts and enters from there into each single plate.

Figure 21: Module principle of backwash process

A small portion of the produced filtered water is taken from the filtered water tank and is transferred by a backwash pump through the common header pipe into each filtration tower.

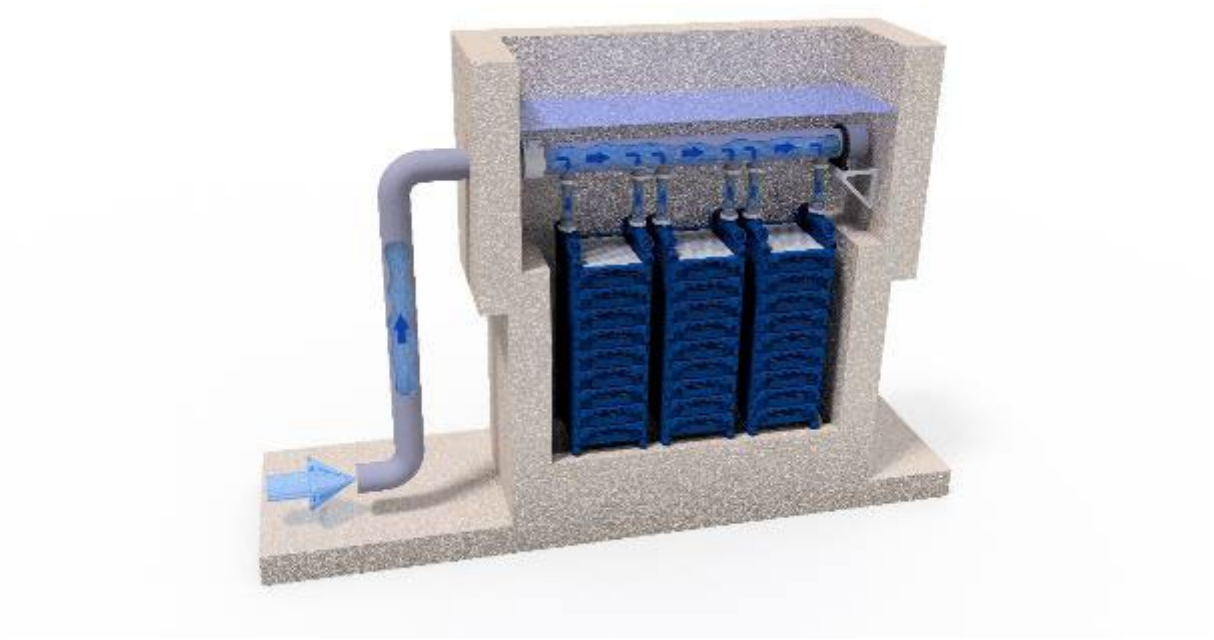

Figure 22: Filtration train principle of backwash process

http://www.cerafiltec.com/how-it-works/

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5 How to assemble a Module Tower

A filtration tower consists mainly from ceramic filtration modules. The ceramic is a very robust material and withstand for long time in harsh conditions inside of the filtration tank. But if a mechanical impulse comes on the ceramic it can break and must be repaired or changed. Also dust and oily aerosols will be not helpful if the equipment should later be installed in drinking water application.

If a new delivery comes to installation site, please open only the top of the wooden box to control if it is all ok with the modules and to check with the bill of delivery if all components are there. Afterward close the box and keep it closed until the assembling of the towers will start.

The ready assembled modules normally come stacked in a wooden box on a euro pallet. Even if the stacked modules are looking as a ready tower it is necessary to dis- and reassemble the tower to put the permeate gaskets between each module. To fix the tower during transport the key locks are installed and must be removed first.

5.1 Different Tower Types

The tower size can be between 1 and 15 modules which is a different in the height between 43.5 cm and 267.5 cm. Please check which size is chosen for your project. A filtration tower always begins with a base module, this is the lowest module of a tower.

Table 4: Basic information and part list for mounting filtration towers

Tower size in No. of Modules	Height in mm	Weight in kg	Rope length in mm
1	435	46	2 x 2520
2	595	82	2 x 2840
3	755	118	2 x 3160
4	915	154	2 x 3480
5	1075	190	2 x 3800
6	1235	226	2 x 4120
7	1395	262	2 x 4440
8	1555	298	2 x 4760
9	1715	334	2 x 5080
10	1875	370	2 x 5400
11	2035	406	2 x 5720
12	2195	442	2 x 6040
13	2355	478	2 x 6360
14	2515	514	2 x 6680
15	2675	550	2 x 7000

5.2 Part list for Tower assembling

If a tower must be assembled, please be sure that all the necessary parts are on site with the right quantity and in good condition. The quantity can be checked refer to the packing list. If admissible deviations appear during the inspection of the packing units, modules (packing units) shall be separately labeled and stored in bonded warehouse. The packing units shall not be installed under any circumstances until the quality assurance department of CERAFILTEC is consulted and has decided whether the modules or accessories, can be used, returned or need to be scrapped.

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5.3 Tools for Tower assembling

The filtration tower can be assembled only with a few tools and with at least two persons. The following things should be on site:

- Sliding agent for all profile gasket at the permeate connections. As a standard the gasket is made from EPDM. Because of this, the sliding agent must not contain mineral oils or other ingrediencies which degrades EPDM. Depending on the application the agent must meet the local regulations for the application (e. g. drink water approval).
- Clean brush for putting the slide agent.
- A flat stable floor of the size of at least 1x1 m (3x3 ft).
- One or two ring spanner size 17 or similar (e. g. which works very well is a spark plug spanner). This tool is used for the key lock. Do not use a screwdriver, the key lock can be damaged.

Figure 23: Sliding agent to be put with brush (e.g. Molykote compound 111)

5.4 Assembling of module Tower

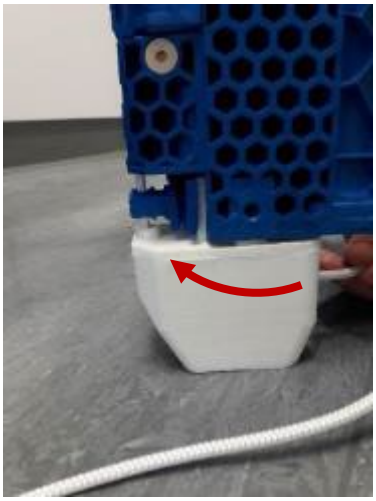
Did you like to play with LEGO™? Then you will love to work with our system!

Two persons must do the assembling of a filtration tower at least. Please follow the steps in the correct succession:

(1) Put one base module on the floor. Put it on the front frame and lift one side. Put 2 corner feet in and fix it with 2 key locks. Lift the module in the same way on the other side and assemble the other both feet inclusive key lock.

(2) For one tower two ropes are necessary. The ropes must have all the same and right length. Both ends must be cut with a special hot rope cutter not with a knife or a scissors. The diameter of the rope ends should not much wider than the rope itself otherwise it comes to problems during threading.

(3) Thread one rope left and right into the holes on the lower side of the corner feet until it comes out on the top of the first module. If it stops, try to drill the rope with the fingers under light pressure. Do the same with the second rope on the other side. Finally, all 4 ends of the two ropes are on the top of the first module.



(4) Put 4 asymmetric profile gaskets on the first module. Put the thicker side down. When all 4 gaskets are in the right position coat only the outer side of the gasket with slide agent. Use a clean brush for this work. ***If gaskets are installed incorrectly (upside down for instance), the module will pass pressure decay testing under pressure, but leaking under suction is possible. Please verify largest rib of gasket is on bottom.***

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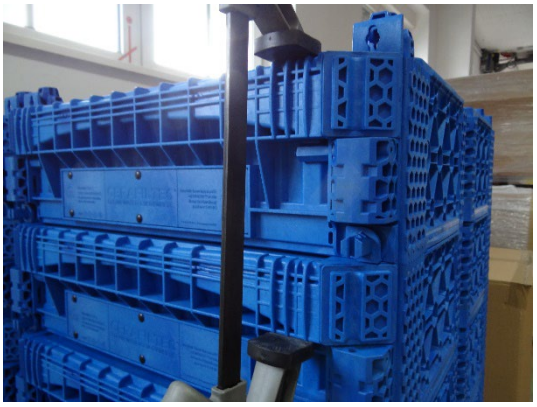
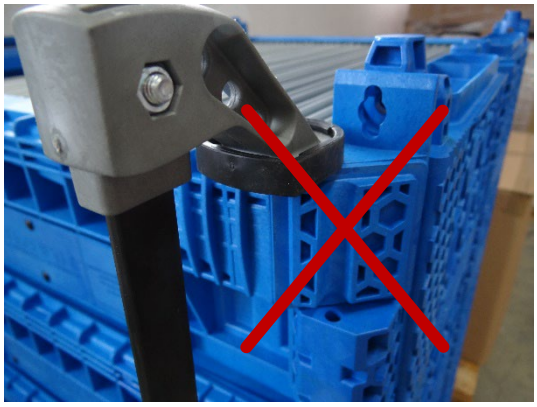
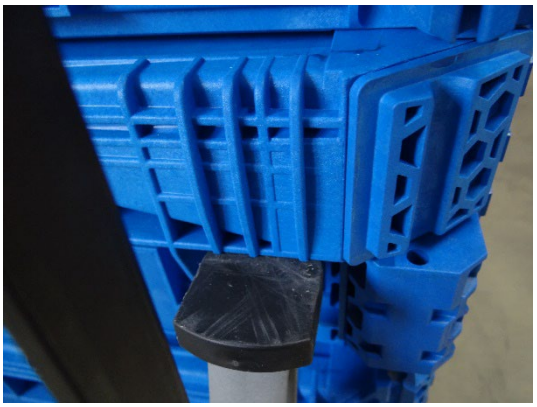
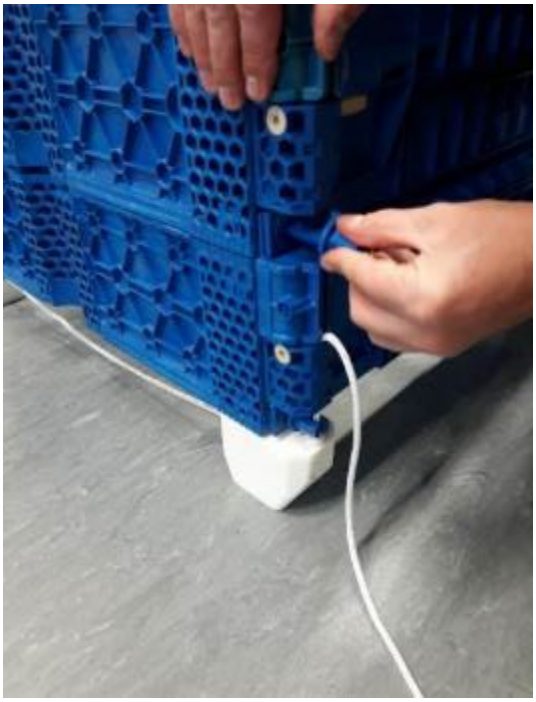
(5) Put the second module on the top press it and use the one-handed clamps from the CERAFILTEC toolbox. Don’t force the welded edges of the plastic frame!





(6) Press the one-handed clamps and put the key lock into the holes and close it with the ring spanner.





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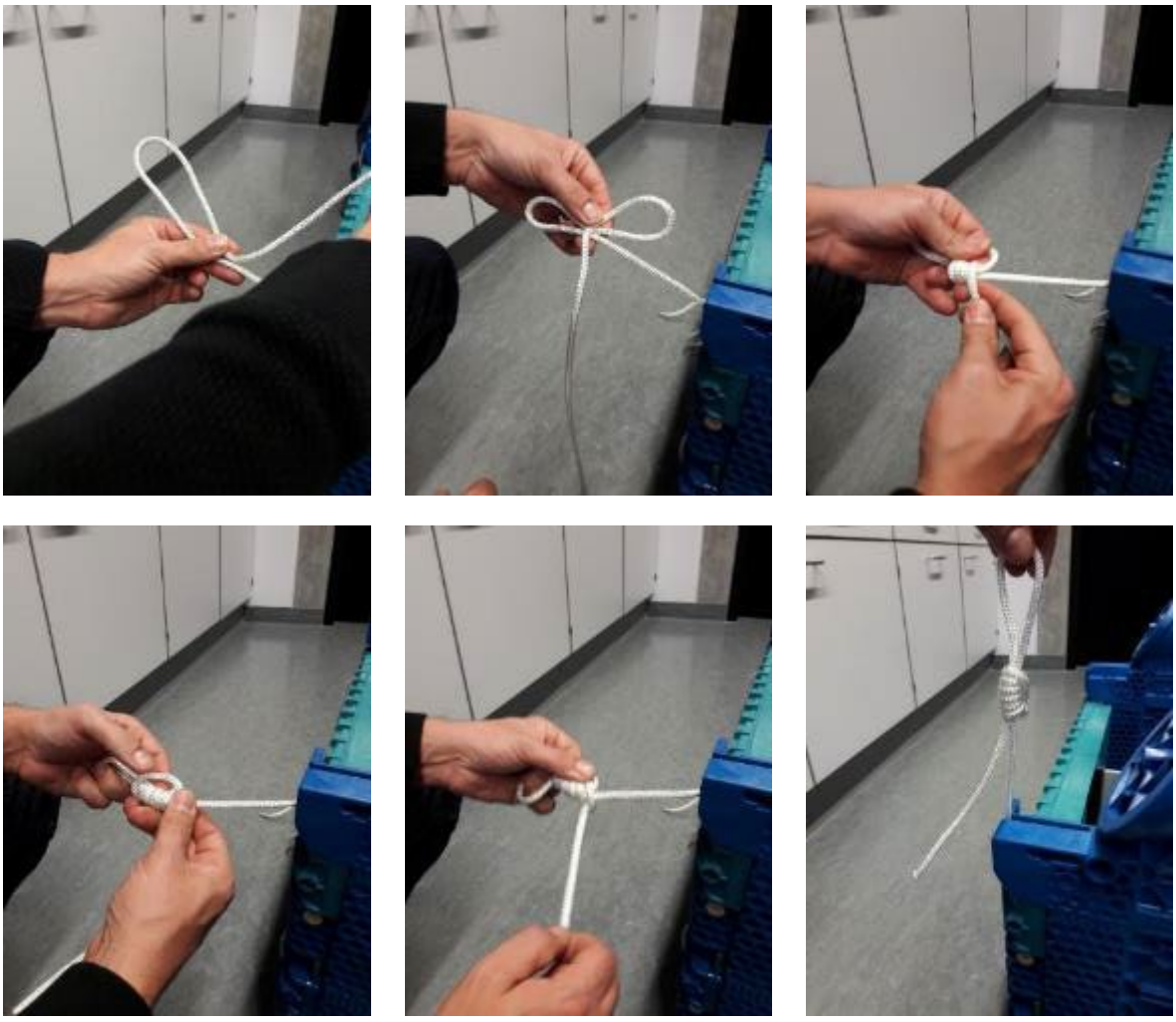
(7) Thread the rope on every corner inside of the top module.

(8) Repeat the instruction (4) to 0 until the right size of the tower is reached.

(9) The completion of a tower is the header collector. Installation is the same as for a module (step (4) to 0).

(10) Prepare the lifting knots at every end of the ropes (see special chapter and video).



(11) Install the pipe clips for sprinkler system. Put the sprinkler pipes and turn until the top holes are horizontal.

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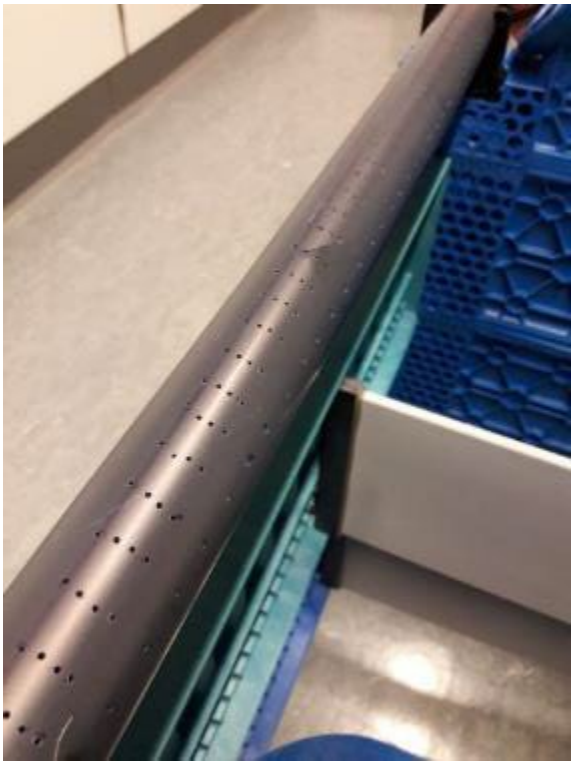

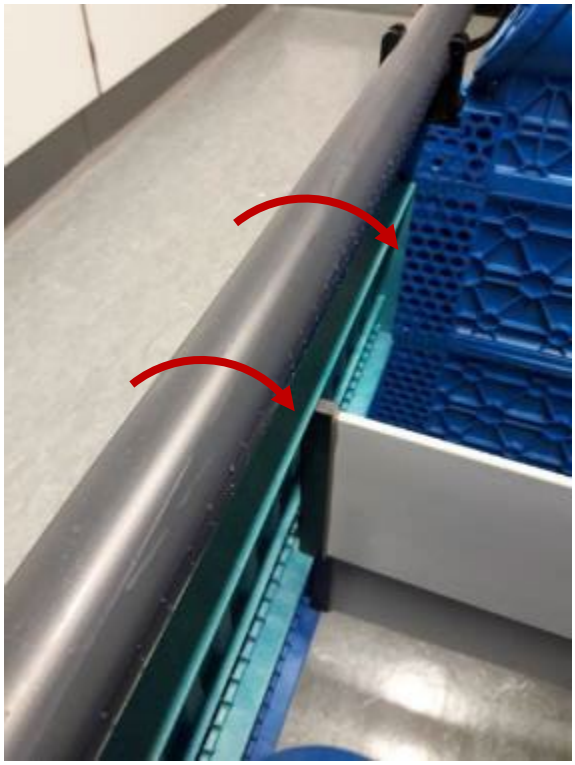

(12) Assemble the header adapter to the header collector

(13) Insert the thimble and the shackles for lifting the tower



For more details “How to assemble a tower” see the CERAFILTEC website.

http://www.cerafiltec.com/how-to-assemble/

5.5 Disassembling of Module Towers

Lift the tower and put it on a flat floor. Remove the header by opening the 4 keys and tire on the header parts. Put the header parts onto a clean floor.

For disassembling a tower, first must be opened all 4 knots of the ropes. Next step is to open all 4 keys of the top module with a ring spanner. Lift the top module with 2 people. Repeat this procedure for the next modules.

Take care by handling with the modules. Put them on a flat floor. Don’t put tools on the modules. If the modules should store for longer time, cover the module, or put them into a box.

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6 How to Install

We provide all details of the tank design and surrounding filtration equipment. Due to the modular design concept of the towers it is very easy to install our equipment. During the project execution, we provide all requirements and guidelines for a fast installation and start-up.

6.1 Preparation of filtration tank

Normally the filtration tank should be as tight as possible to reduce water loss during discharge and cleaning operations. If a cross-flow during filtration – produced by continuous aeration during the filtration process - is necessary, the area around each single tower should be at least the same as the cross-section from the top view of a module tower. This is required for the downstream.

Most important for every process is a good working sludge removal during a backwash with emptying the tank. For this, under every tower or tower row a ditch with a defined slope of at least 5° and a width of the total inner width of the membrane tower is necessary (in general 520 mm).

The train should be prepared for installation which means the civil works construction is completed; piping, valves and instrumentation are installed (scope of project partner).

6.2 Installation of Filtration Line

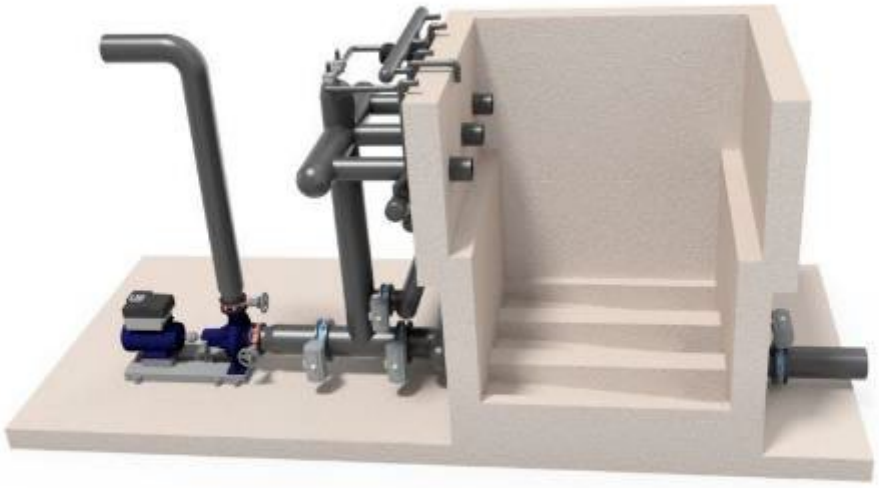

Figure 24: Filtration train is prepared for installation

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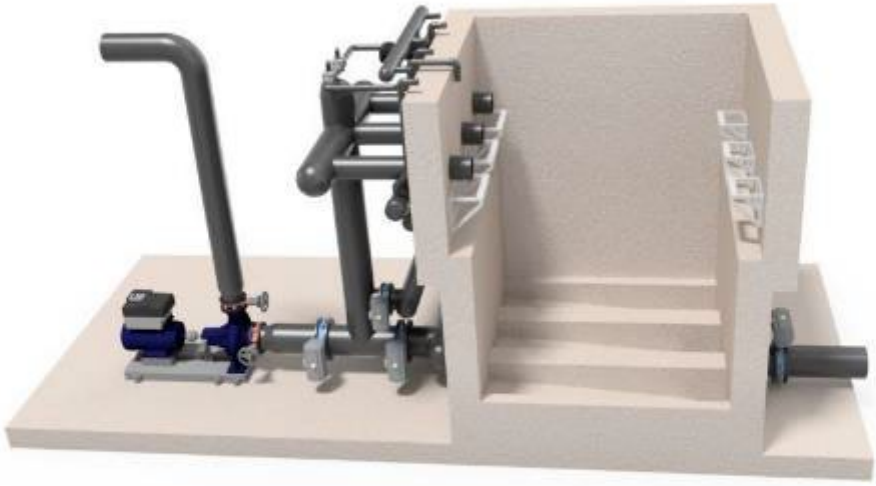
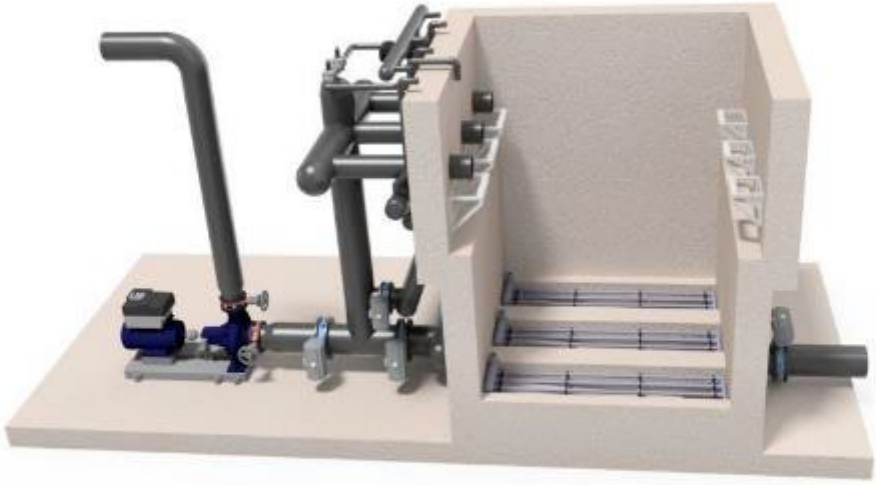
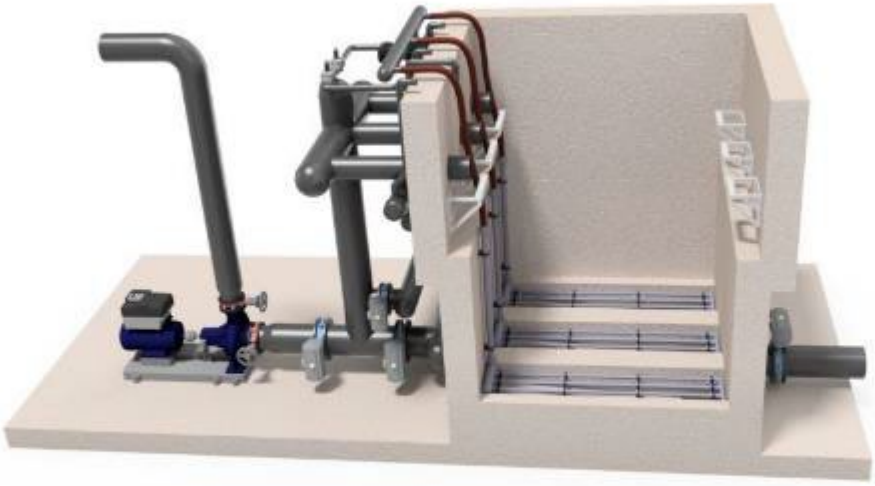
(1) Installation of filtered water header pipe holders on left and right side of concrete walls.



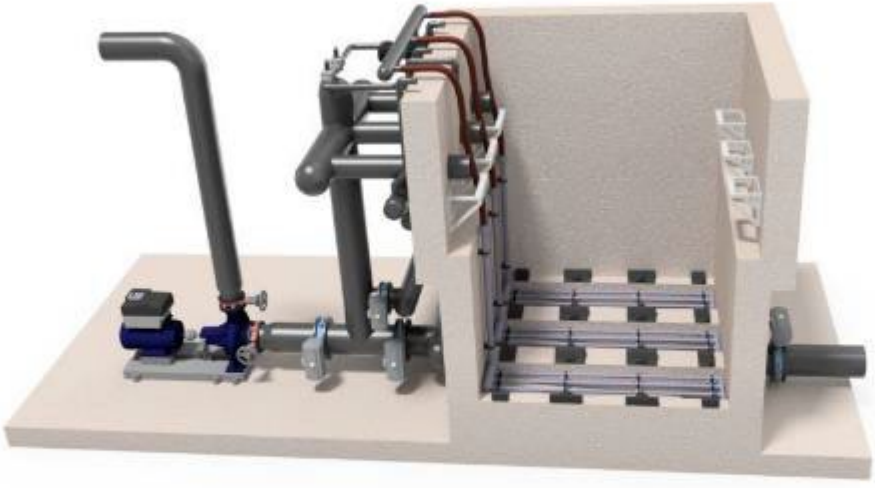
(2) Installation of air scouring sets to be fixed by screws on concrete bottom.



(3) Connection of installed air-scouring sets to common blower pipe.



(4) Installation of tower position holders on the bottom of the tank.



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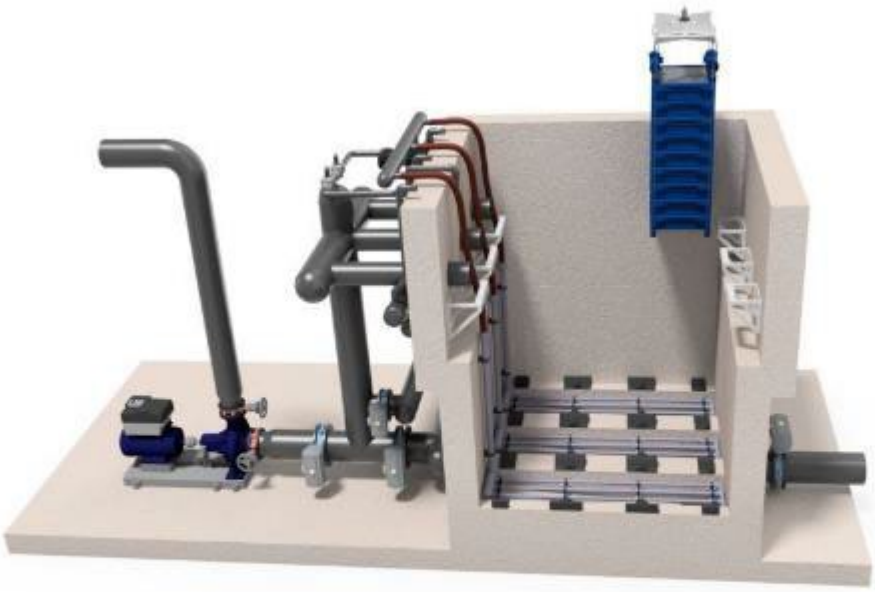
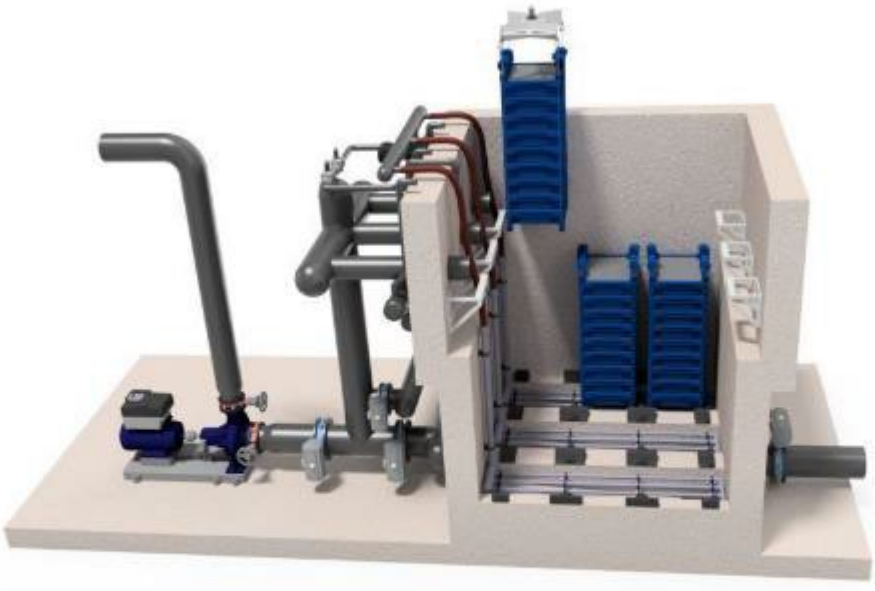
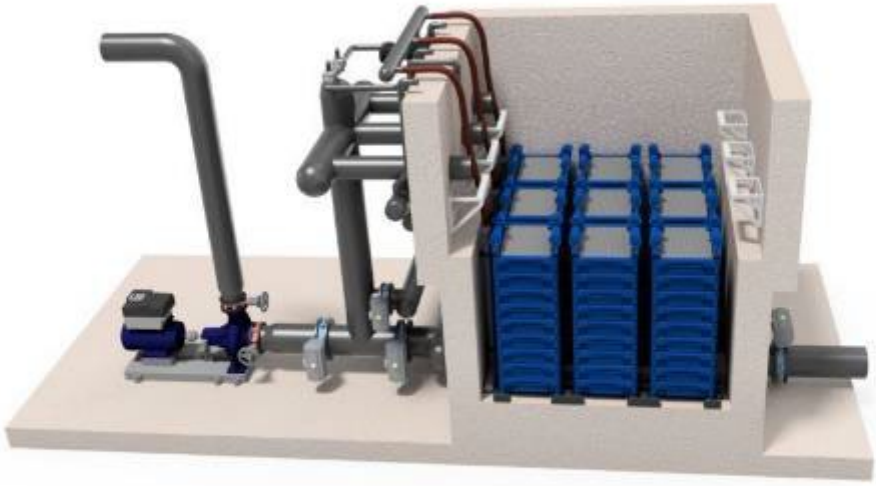
(5) Position of first module tower.



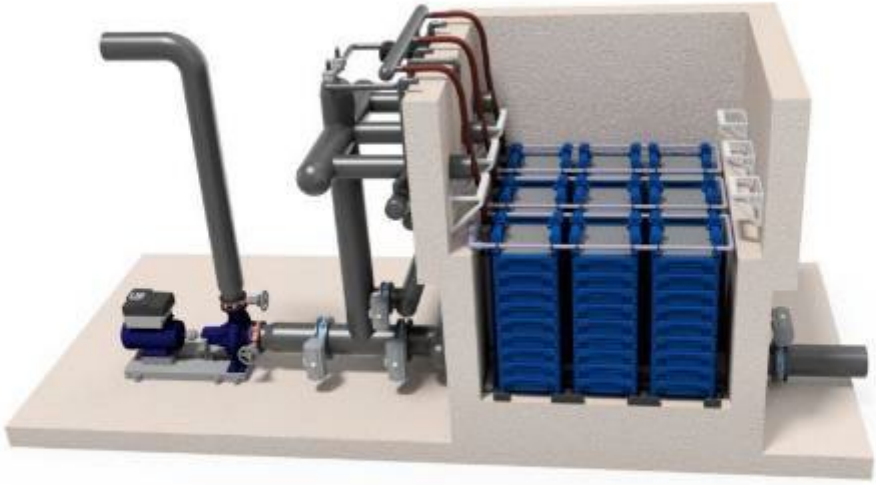
(6) Completion of first tower line.



(7) Repetition of tower positioning for all remaining tower lines.



(8) Installation of sprinkler sets on top of all tower lines.



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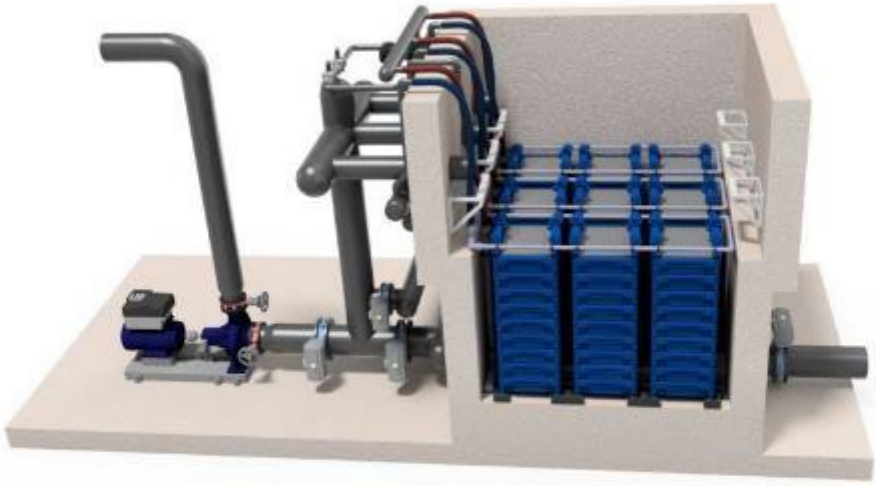
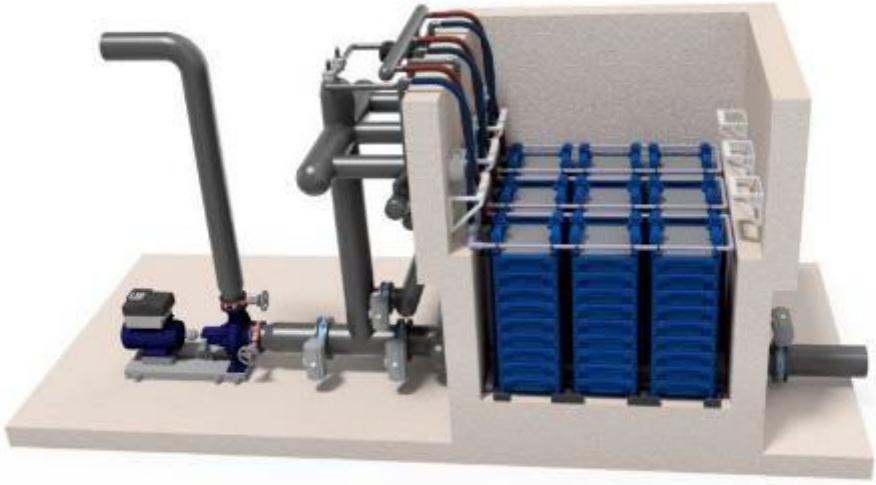
(9) Connection of installed sprinkler sets to common sprinkler pipe.



(10) Mounting of filtered water header pipe couplings.



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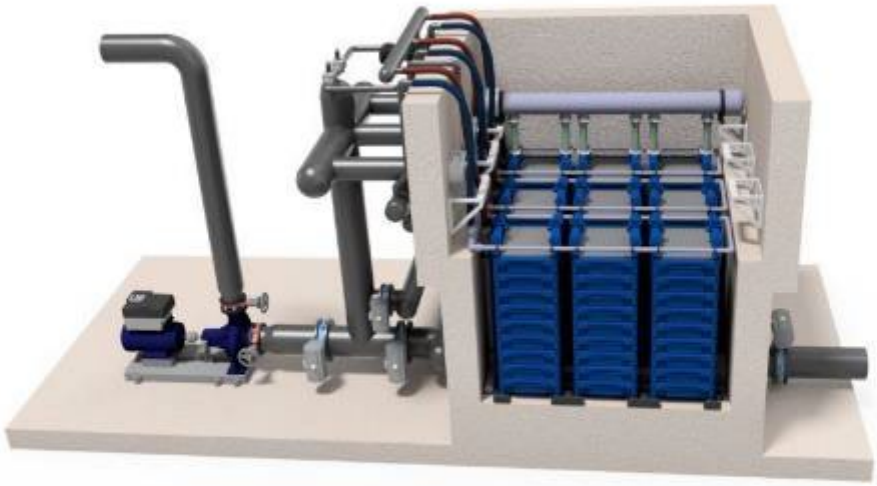
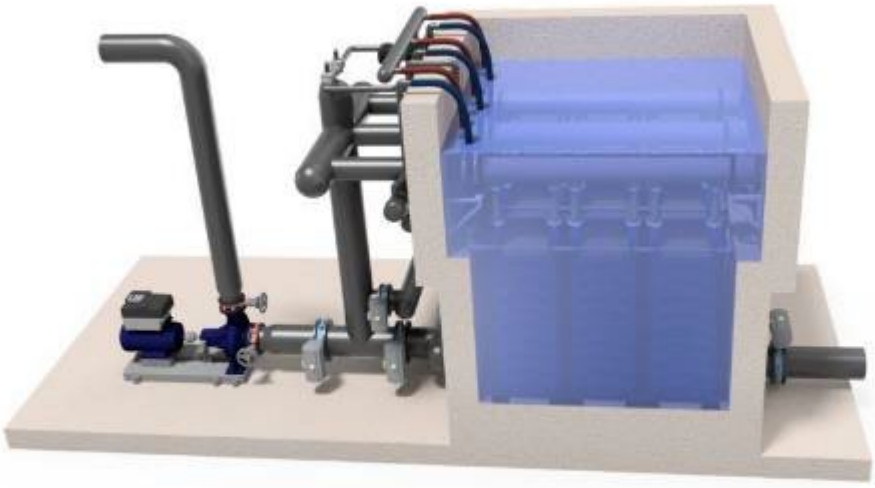
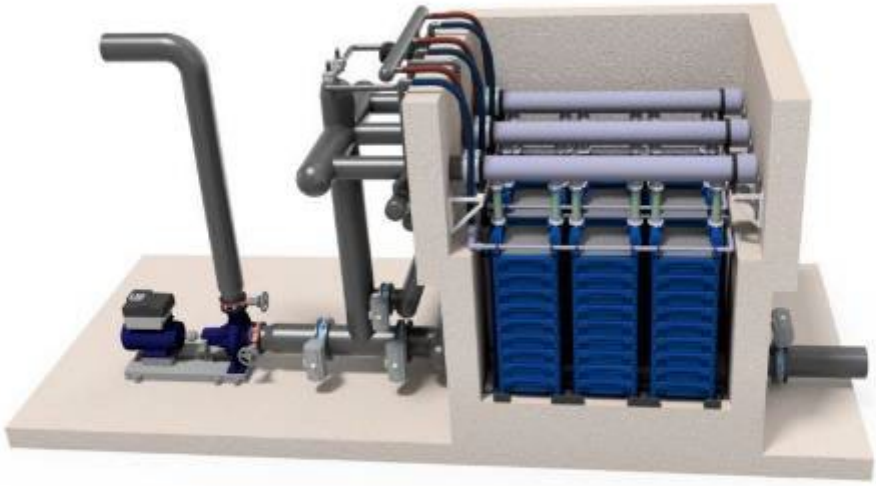
(11) Installation of first filtered water header pipe, connection to each tower, fixing on wall holders and coupling.



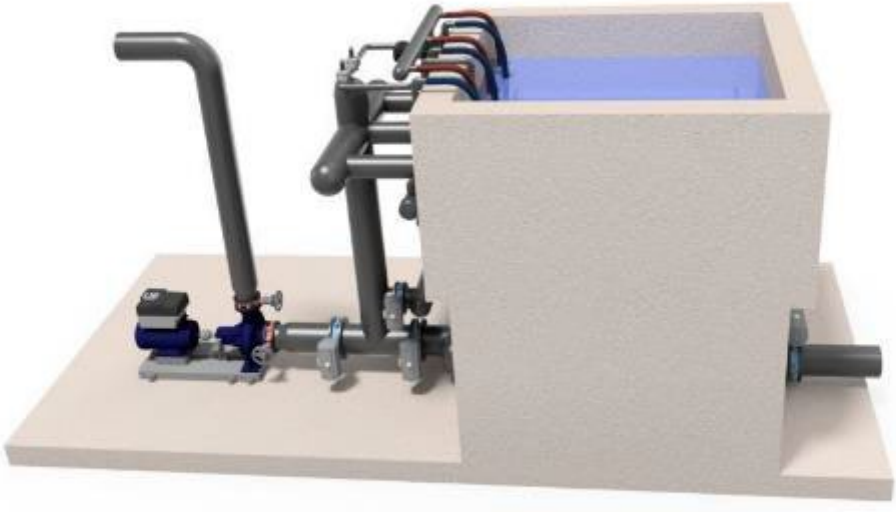
(12) Repetition of filtered water header pipe installation for all remaining tower lines.



(13) Test and process start-up



(14) Ready for operation. Train can be put into operation as per projection



http://www.cerafiltec.com/how-to-install/

7 Transportation and Lifting of a Module Tower

A filtration tower with already installed profile gaskets at the permeate channels should be not transported over long distances to protect the gasket for damaging. This also depends on the size of the tower, the packaging, and the expected shocks during the transport.

For the lifting of a tower it is necessary to follow the local set of regulation and safety instruction for lifting heavy goods by crane.

It is also recommended to use the original traverse from CERAFILTEC for lifting a filtration tower. Otherwise the danger of destroying the filter tower or the rupture of the rope can be the consequence.

7.1 Lifting of a Module Tower

For the lifting of a tower it is necessary to follow the local set of regulation and safety instruction for lifting heavy goods by crane.

The following things should be on site:

- Original CERAFILTEC lifting traverse inclusive shackle, grommet, and coil loop.
- A crane which can handle the given weight at the necessary cantilever.

Take care that all 4 ends of the rope are at the same height. If not, it is necessary to open one knot and put it on the right position to achieve the same height. Put a grommet inside of every knot.

The lifting tool should be hanged-up in the middle of the tool onto a crane hook by a suitable belt.

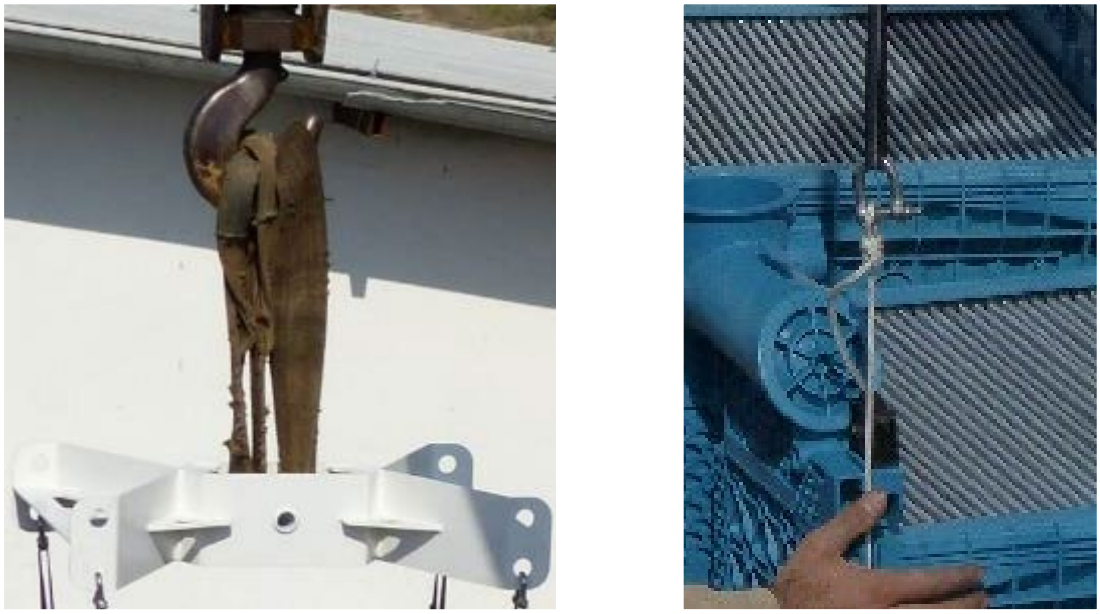


Figure 25: Fixing the tool onto a crane hook (left). Connect coil-loop with rope by shackle.

Connect 4 coil-loop with 4 shackles (best to use triangle shackles) with the lower holes of the lifting tool. The length of the coil-loop depends on the individual requirements of the location. The coil-loop should relate to the rope by shackle or with carabiner.

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During connecting the lifting tool with the filtration tower, take care on the right position. Because the module has a rectangular cross-section it is necessary to have the right position of the lifting tool. The coil-loops must be exact vertical. If this is not the case, the shackles must be opened, and the lifting tool must be turned by 90°.

Figure 26: Lifting a tower with the Lifting Tool. The coil-loops must be exact vertical

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8 Operation

8.1 Membrane Filtration Process

In this manual there are two fully independent running filtration trains.

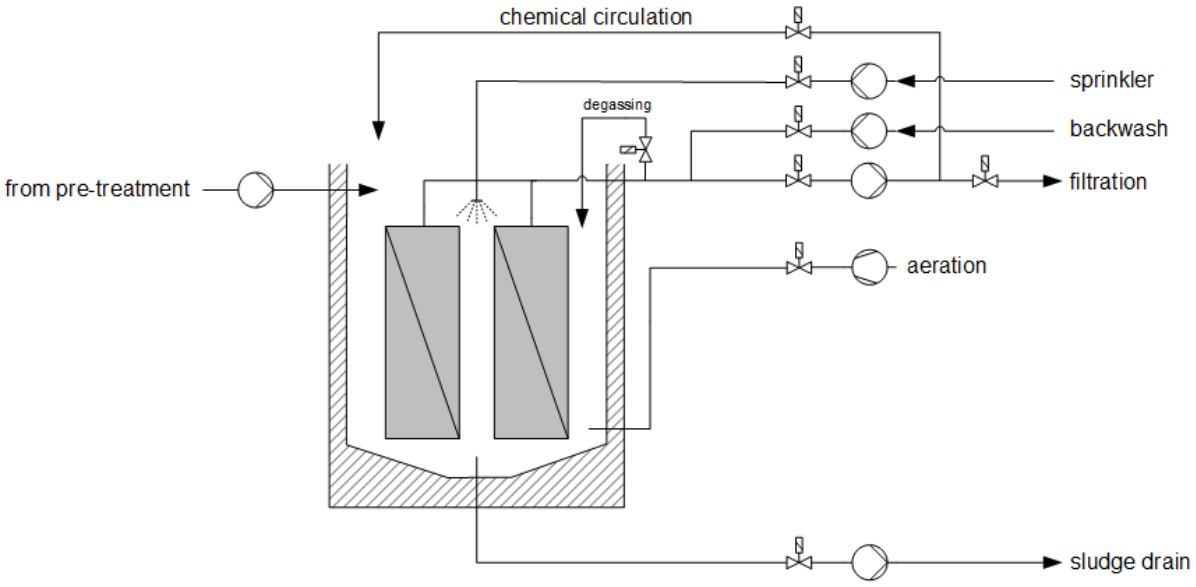

Figure 27: Process flow of one filtration train

The membrane filtration process includes several process steps that are described below:

- **Filtration:** The filtration step is a physical barrier that removes oxidized metals, suspended solids, and bacteria.
- **Backwash:** A periodical backwash is needed to remove the cake layer from the membrane surface.
- **Sprinkler:** Water is sprayed directly onto the top of the filtration tower to increase the backwash and cleaning efficiency.
- **Aeration:** Air is supplied from the bottom of the filtration towers. The upstreaming coarse bubbles improve the backwash and cleaning process.
- **Chemical circulation:** Removal of fouling or scaling from inside of the membrane body.
- **CapClean:** Removal of fouling or scaling from outside of the membrane body.

8.2 Periodical Backwash

Inside the filtration tank, the membranes separate the solids from the liquid, which accumulate on the membrane surface (cake layer, TEP, EPS, etc). This leads to an increase in filtration resistance and thus to a decrease in the filtration performance of the membrane. If filtration performance is to be kept constant, this can only be compensated by an increase in pressure or be contained by specific measures. For this purpose, periodic backflushing is performed.

The key objective of this backflushing is to remove the outside layer and flush out the pores by reversing the filtrate flow for a short period. Membrane backflushing is usually carried out by stopping the filtration pump and changing the flow direction of filtration pump or starting the backwash pumps.

The picture below shows a typical flow diagram of a filtration process with periodical backwash and without backwash.

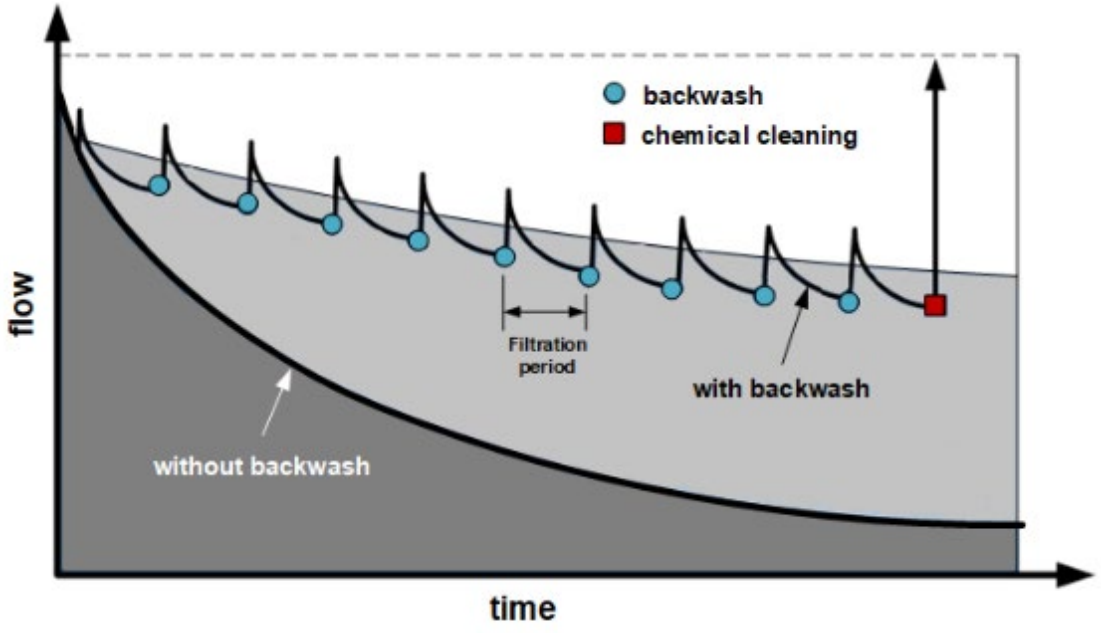

Figure 28: Flow diagram filtration process with periodical backwash

If the decreased flow and/or increased transmembrane pressure reach a certain defined value a chemical cleaning is required. The typical maximum transmembrane pressure for filtration is 0.5 – 0.7 bar, depending on the water source and process steps. The calculated maximum filtration pressure can be find in the specific technical projection document.

The chemical cleaning frequency depends on the characteristic of the inflow water (concentration of inorganic, organic, and non-oxidized compounds). In general, an intense chemical cleaning mode is required after 1 – 3 months of operation but depends on local effects.

8.3 Chemical cleaning

Due to the asymmetric membrane structure all potential macro fouling or blocking effects will be generated only on the outside of the membrane. The results during all tests and running references had shown that only a cake layer on the outside is formed and the membrane body itself is not affected on fouling or blocking and no accumulations were detected.

Biological / colloidal fouling is the term used to describe the accumulation of colloidal dissolved substances on the membrane surface whereby a slimy film is formed. This is generated by a bacterial growth caused by the nutrients available in the feed. This type of fouling occurs in all places where moistened surfaces are prevalent and they are present in almost every technical system that does not operate on a sterile basis. This type of deposit on the surface can reduce pore diameter, which result in a decrease in membrane flux. Membrane blocking caused by fouling can be removed by cleaning with an oxidant. To make a rough estimate p(permeate) ~ p(backflush) can be apply.

Scaling is the term used to describe salts that have formed on the membrane and in the pore structure caused by inorganic precipitation. These generated by exceeding the solubility product on the membrane surface in the form of sulphates, carbonates and phosphates. Since inorganic salts cannot degrade biologically and solubility cannot be increased by raising the pH value for example, the only possible way to prevent this is to avoid wastewater with high salt concentrations. In any case, salt concentration should be measured to detect possible scaling. If scaling occurs, the deposits can generally be removed with acids. To make a rough estimate p(permeate) < p(backflush) can be apply.

In addition, due to the pre-oxidation before the filtration process all potential organic fouling effects are minimized.

Therewith, the main effect of the membranes will be an inorganic micro-scaling. Typically used cleaning chemicals are acids (pH reduction down to 2.5 for re-dissolving), e.g. citric acid or HCl or a mixture from both.

The inorganic micro-scaling is a typically long-term effect. The chemical cleaning frequency depends on the characteristic of the inflow water (concentration of inorganic and non-oxidized compounds). In general, a chemical cleaning mode is required after 1 – 3 months of operation but depends on local effects.

The following table introduces the possible chemical dosing volume of citric acid and sodium hypochlorite in the cleaning solution.

Table 5: Chemical dosing of Citric Acid and Sodium Hypochlorite (NaOCl)

Type of chemical cleaning	Chemical concentrate characteristic	Chemical dosing volume	Concentration of the cleaning solution	Corresp. pH-value
Citric Acid	30 wt.%	7 mL/L	2,100 ppm	3.5
NaOCl	12 wt.%	8 mL/L	1,000 ppm	9.2

If available concentrates of sodium hypochlorite or citric acid features different concentrations than specified above, dosing volumes must be recalculated by the user. The temperature of the cleaning solution shall be in the range of 10 - 45°C.

8.4 Leakage Check

Before starting the filtration process the filtration towers must be checked for any leakages. A leakage test is a procedure to detect damages of a filtration tower which can result from manufacturing errors or damages during transport or handling.

Leakages can be detected with a bubble-point test. For this, the filtered water header pipe is connected to an air pipe with a suitable adapter/connector. The complete tower including header pipe must be submerged in clear water (filtration tank or separate tank).

While filling the tank larger leakages can already be identified. In case of using the filtration tank, hand valves or all automatic valves related to the filtration line (filtration, degassing, circulation,…) have to be closed before the tank is smoothly filled with clear water (e.g. tap water). If there are any larger leakages, the air inside of the filtration tower will exhaust and coarse bubbles will occur in the water.

If no leakages are detected during filling, the filtered water pipe is afterwards charged with an over pressure. The applied pressure depends on the actual submersion depth respective hydrostatic head above the filtration tower. We recommend a submersion depth of about 3,0 m and thus a total over pressure of 550 mbar. Actual over pressure is calculated as follows:

250 mbar + (fill level in m x 100 mbar / m)

Before charging full over pressure to the filtration tower, pressure is increased step by step as described in the following:

- Charging 50-100 mbar in order to detect leakages on the filtered water header and connected piping. Holding time: 5 minutes.
- Increasing pressure up to 100-150 mbar in order to detect leakages on the upper filtration modules and piping. Holding time: 5 minutes.
- Increasing pressure up to 200-250 mbar in order to detect leakages on the median filtration modules and piping. Holding time: 5 minutes.
- Increasing pressure to 550 mbar (depending on actual submersion depth, see above) in order to detect leakages on the lower filtration modules and piping. Holding time: 10 minutes.

Intact filtration towers show an evenly distributed forming of fine bubbles only above the ceramic membranes.

If a filtration tower shows uneven distributed coarse bubbles, one or several membranes, sealings or frame parts are possibly damaged. In that case, a detailed leak verification and fault correction has to be operated.

We recommend checking for leakages periodically, e.g. after every chemical cleaning.

8.5 Start-up of Filtration

During the start-up of the system, the functionality of all components like pumps, blowers, valves and sensors is checked. Make sure that feed flow is available and the pre-treatment is working according to the process description (measurement of manganese). Check all hand valves for right position. The membranes have to be clean; with longer decommissioning period a chemical cleaning of the membranes is recommended before starting the filtration process.

Only filtration towers which are faultlessly assembled and installed may be started. A successful leakage test of the filtration towers is mandatory before start-up. All pipes and tanks should be rinsed and free from any deposits (e.g. production residues, sludge). If tank filling was combined with leakage test the degassing valve needs to be opened until all air is evacuated.

Once the preparation procedure is completed, sequence part can be put into operation:

- After filling of the filtration tank, the filtration should be started first with a reduced flow of 25 % and after trouble-free operation it can be increased in 25 % steps every hour. Recommended operation time: 3 hours
- Aeration system is started and functionality of blower and air pipes is checked. An even distribution of air bubbles must be ensured. Recommended operation time: 5 minutes
- Sprinkler system is started and functionality is checked. Recommended operation time: 5 minutes

- Backwash (including aeration and sprinkler) is started as specified in the description of operation after finishing 1 normal filtration step. Backwash pressure and flow as well as time for emptying and filling the filtration tank should be recorded.

During the start-up time, the following parameters should be checked periodically, at least every hour:

- Transmembrane pressure filtration/backwash
- Flux
- Permeability
- Permeate quality: SDI, Turbidity, Metals, organic matters

After three hours of operation the values of these parameters should be in accordance with the design parameters. During the first 3 days of operation, permeate quality and all operation parameter (pressure, flow) should be checked and recorded every two hours.

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9 Maintenance

In order to ensure a safe operation of the membrane filtration system and to prevent damages to the environment, people or system components, regular maintenance and service activities have to be conducted. The user has to carry out all maintenance work that essentially consists of status and function checks as well as checking of the most important operating parameters. Additionally, all status, function and operating parameter checks shall be documented in a log book. Deviations from target values and malfunctions shall be noted in a log book and eliminated immediately with the help of responsible maintenance personnel. Malfunctions that could adversely affect safety must be reported to the responsible expert personnel immediately. All described intervals and duties only relate to parts and components delivered by CERAFILTEC, but e.g. unusual noises of pumps, compressors and any other component should be recorded as well. The operating instructions described in this document must be observed for all arising tasks!

9.1 Visual check

- The membrane plate distance must be checked daily for clogging.
- The function of Degassing must be checked daily. Degassing must be filled after Backwash sequence.
- The perforated aeration piping should be cleaned with water once a week via the flush connection.
- The aeration shall create uniform bubbles which should be checked daily.

9.2 Water Quality check

The water quality of inflow and outflow of UF system must be checked regularly. The quality for inflow should be within the limits to reach the calculated quality and water flow.

9.3 Maintenance of Modules

Normally Modules from CERAFILTEC will come ready assembled to the customer. In this case it is only necessary to build-up the filtration towers. Nevertheless, in some cases it could be necessary to assemble or disassemble modules at customer side. Even the module and the ceramic plates are very robust it is good to read this part carefully and follow the instructions.

9.3.1 Tools for Module assembling

For easy assembling some tools and accessories are helpful. The following things should be on site:

- Sliding agent for all O-Ring connections. As a standard all O-Rings are made from EPDM. Because of this, the sliding agent must not contain mineral oils or other ingrediencies which degrades EPDM. Depending on the application the agent must meet the local regulations for the application (e. g. drink water approval).
- Clean brush for putting on the slide agent.
- A flat stable table of the size of at least 1x1 m (3x3 ft). It is helpful if on the table 3 sides wooden strips forms an open rectangle with the size of one module.
- Membrane mounting rake which can be ordered at CERAFILTEC.
- 3 collets with a free length of at least 800 mm.
- Allen key (hexagon socket screw key) size 17 mm.

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Figure 29: Sliding agent to be put with brush (e.g. Molykote compound 111 or vegetable glycerine)

For perfect easy installing CERAFILTEC have an assembling tool contains the rake and the collets. This tool can be ordered at CERAFILTEC.

9.3.2 Disassembling of Modules

The disassembling of a ceramic membrane module can be done by one person only, but a third hand will be helpful. Please follow the steps in the correct succession:

(1) Put the collets between the two front frames and increase slowly the forces on the collets.

(2) One side of the front frames opens.

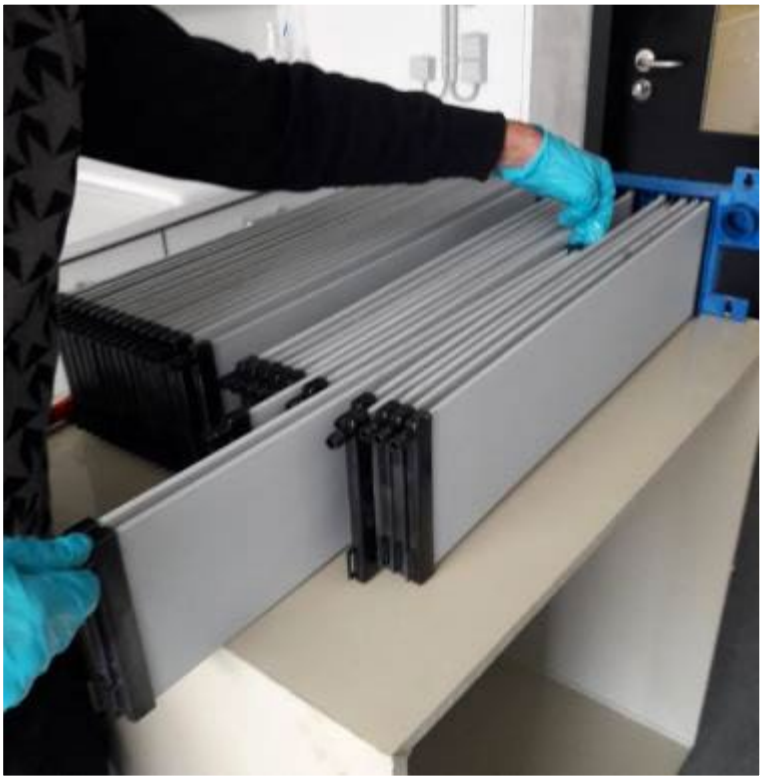
(3) Remove the membranes on the opened side.

(4) Remove the front frame.

(5) Remove both side frames by using a tool between indentation of front and side frame.

(6) Remove the single plates successively. For this, hold the membrane plate only on the plastic shoes.

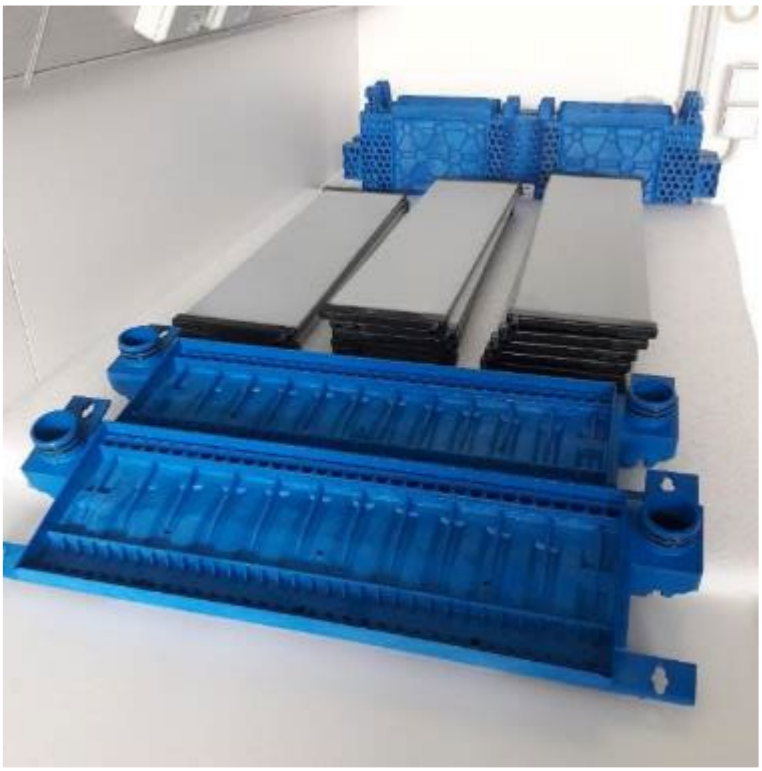
(7) Remove the loose membrane plates.



(8) Remove the non-loose plates with aid of plastic tool or with hose protected screwdriver.

(9) Remove the last membrane plates.

(10) Put the disassembled parts carefully on a proper storage area.



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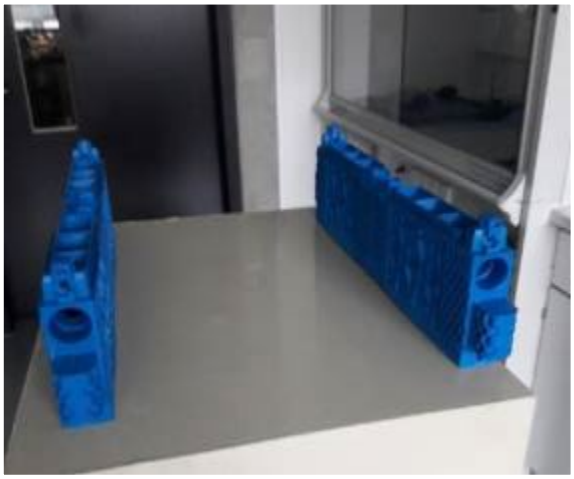
9.3.3 Assembling of Module

The assembling of a membrane module can be done by one person only, but a third hand will be helpful. Please follow the steps in the correct succession:

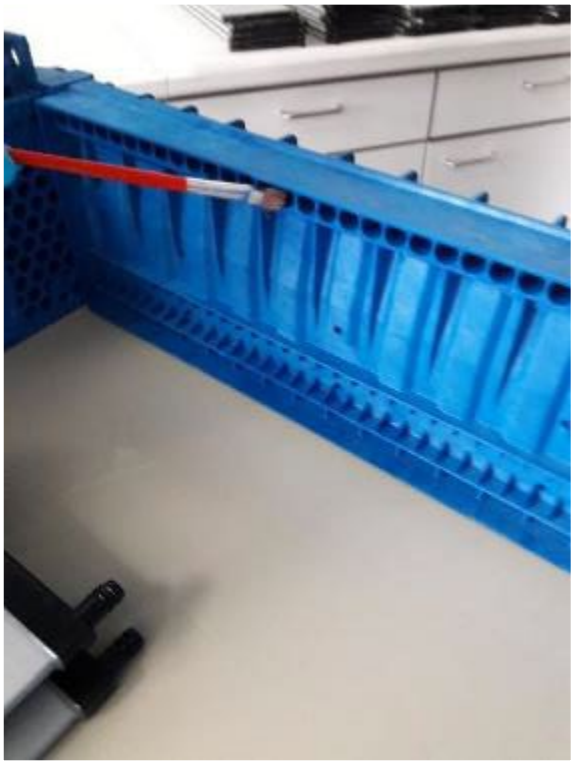
(1) Take one front frame and mount the 4 O-Rings (36,2mm x 2,6mm) on the left and right permeate channel.

(2) Put sliding agent on the O-Rings and stick the front frame into both side frames.

(3) Put the module frame on the table inside of the open rectangle with the open side in front of you.



(4) Put slide agent into all small permeate channels in the front frame with a clean brush. Before installing the membranes check if the 2 O-Rings (8,1mm x 1,6mm) on each plastic shoe are existing, if not install the O-Rings.



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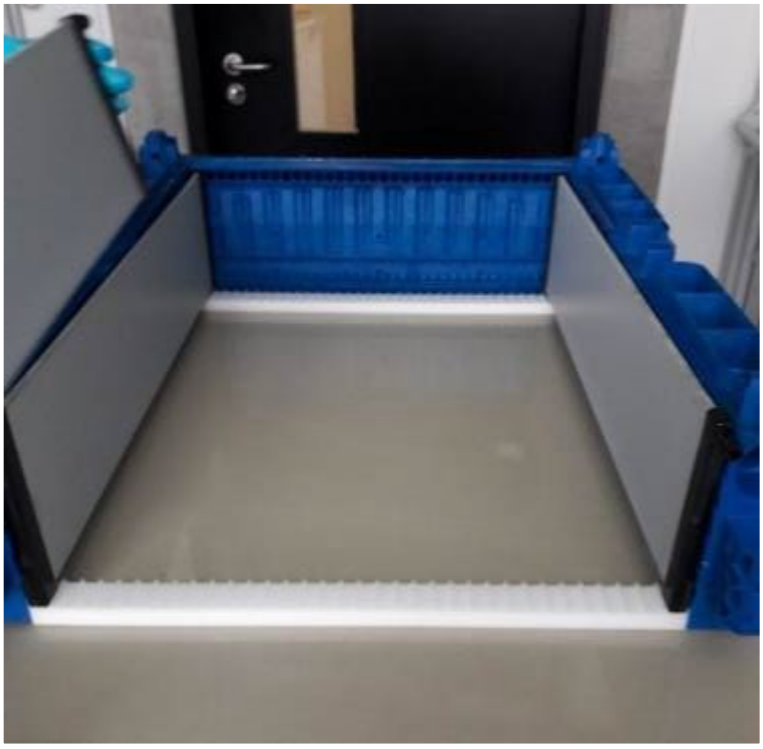
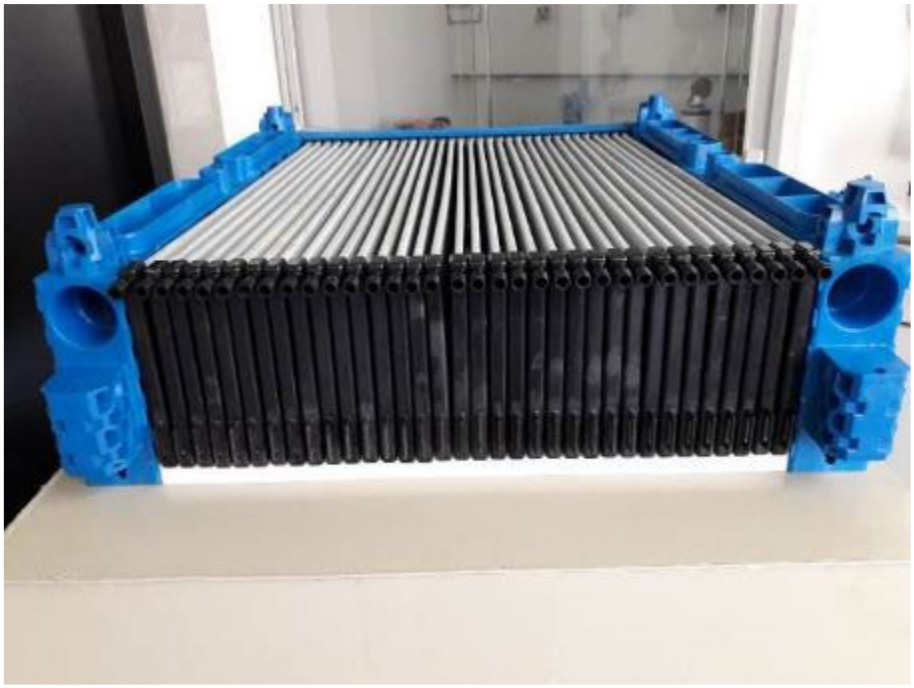
(5) Put the first membrane plat and slide it with its nipple into the right hole (left handed people start left). For this, hold the membrane plate only on the plastic shoes. Hold with the left hand the distant shoe in the middle of the shoe with the right hand same on the opposite side. Hold the plate exact vertical and slide it parallel to the side frame into the permeate channel. Control the right vertical position.

(6) Put the rake under the front shoe of the first membrane plate.



(7) Repeat point (5) for all remaining membrane plates until the module is fully loaded. If the space for the left hand is too small hold the membrane on the top of the shoe. Avoid touching the membrane surface.

(8) If all membranes are ready insert align the rake, so all shoes are standing on it. Take care that the front and side frames are forming a rectangular.



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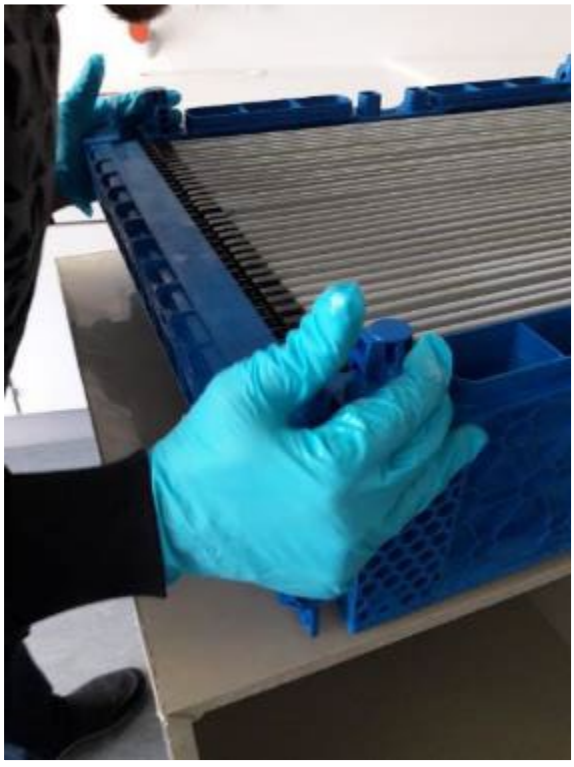
(9) Take the second front frame, mount the other 4 O-Rings and put slide agent on the O-Rings and on the small permeate holes for the membrane shoes.

(10) Put the front frame in front of you and hold it in the right position without pressure.



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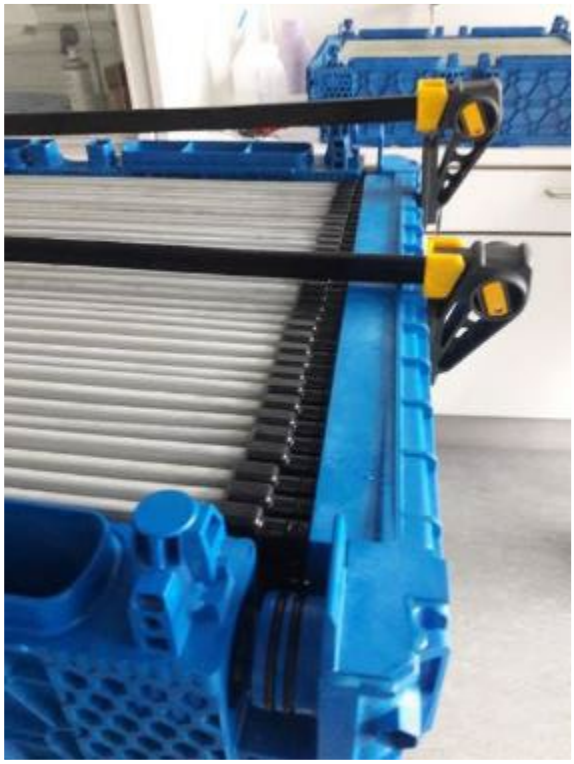
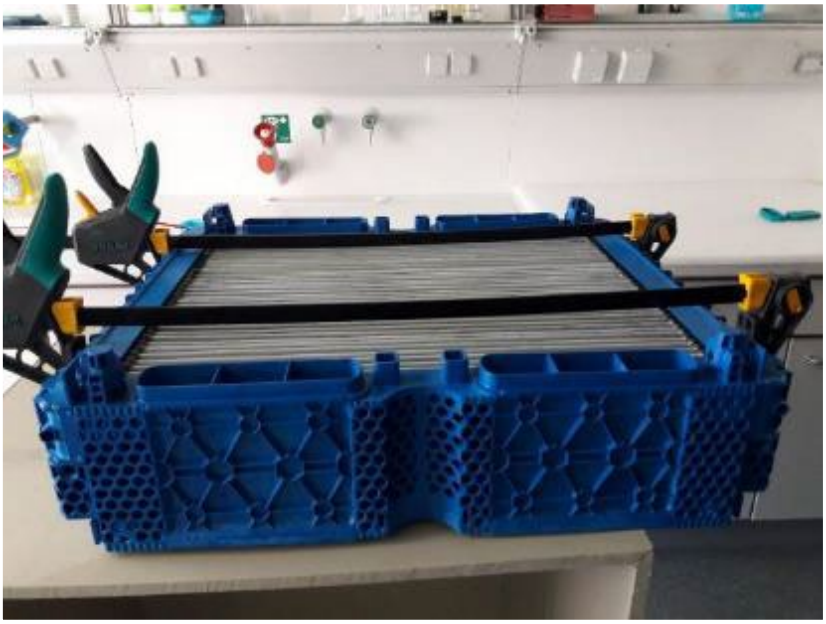
(11) The second person puts now the 2 collets on the left and middle position with low force. Please note: No pressure should be exerted on glued/ welded corners!

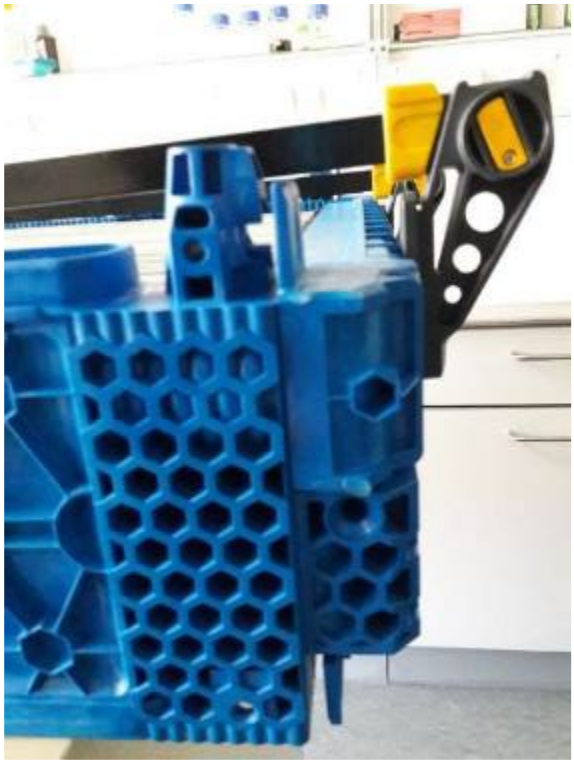
(12) Increase the force on the left and middle collets until the big permeate channels of the front frame starts to slide into the side frame.



(13) Install the third collet on the right or move the middle collet to the right of the front frame. Please note: No pressure should be exerted on the glued corners!



(14) Wobble on the top of the membrane shoes during increasing the force evenly on all collets until the front frame and the side frame are together without a gap.



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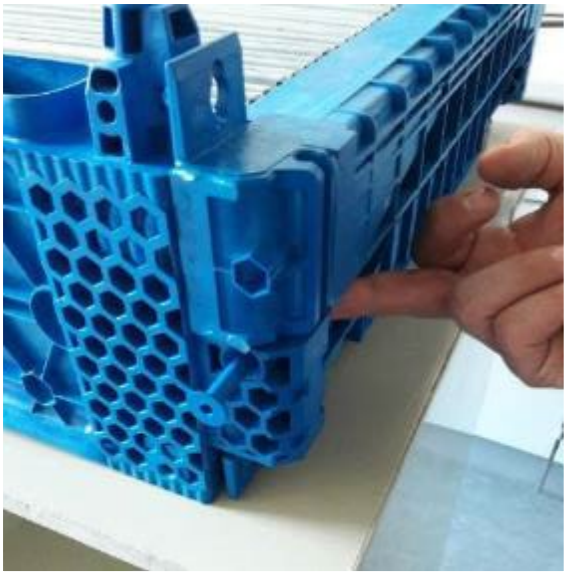
(15) Put on all 4 corners the plastic bolt and nut and fix them without strong force (hand strength of max. 10 Nm). A new set of bolts and nuts is mandatory. Do not use previously used bolts and nuts. No tool for the nut is necessary. Press the nut into the hexagon shape during turning the bolt with an Allen key (hexagon socket screw key) size 5mm. Stop turning when the first “clack” can be heard.



(16) Remove the module from the table with two persons. Hold the module on the front frame. The fingers must be beside the long nut.

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10 Safety instructions

The instructions in this chapter are to be followed to prevent damage to the person or the system.

10.1 Chemical Use and MSDS

Different chemicals are used for the cleaning of the filtration unit: Acid against deposit of inorganic salts and Sodium hypochlorite against fouling caused by a bacterial growth on the membrane surface.

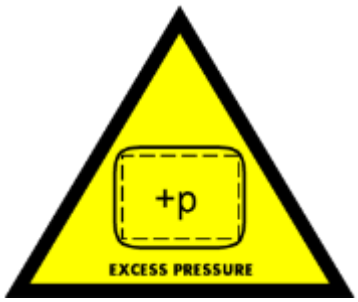
The re-filling of the chemical storage tanks needs to be done if the tanks are empty. Following procedure must be applied:

Wear adequate protection clothes for handling with chemicals (e.g. gloves & safety glasses) and follow the instruction in the MSDS.
It should be carefully attended to fill the chemicals in the correct storage tanks (compare with the safety labels on the storage tanks).

The confound can formed spontaneously gaseous chlorine. Not following the instructions might lead to severe injury or even death!!

10.2 Caution and Warnings

Hazard Symbol	Description	Safety Instructions
	WARNING OF TILTING DANGER! Always ensure the stability of the Filtration Unit against tilting. Depending on the height of the Filtration Unit an anti-tilting device may be necessary!	
	WATCH FOR FALLING OBJECTS! Watch always for falling objects. We recommend wearing safety helmet and safety shoes during assembly, replacement, maintenance or repair! Please follow the safety instructions in this document.	
	WATCH FOR SHARP EDGES! Watch always for sharp edges. We recommend wearing gloves during assembly, replacement, maintenance or repair! Please follow the safety instructions in this document.	

	WARNING OF HEAVY COMPONENTS! Some components may be heavy. Always ensure that adequate workforce is available. We recommend for the handling of the Filtration Modules at least 2 persons!	
	CORROSIVE MATERIAL In the event of cleaning (ACEC) avoid any contact with irritant and/or corrosive chemicals. We recommend wearing protective goggles and gloves during the whole cleaning process! Please follow the safety instructions in this document and the material safety data sheet (MSDS) of the chemicals!	
	RISK OF BREAKAGE! Some components are fragile (in particular the ceramic membranes). Always handle all components with care. We recommend wearing gloves in case of any damage! Please follow the safety instructions in this document.	
	EXCESS PRESSURE In the event of backwashing (periodically during the normal operation) and cleaning (CCC, iCC) the permeate channels and the Filtration Modules are charged with an excess pressure up to 2 bar. Keep clear of these components during the described processes. We recommend wearing protective goggles at any time!	
	BIOHAZARD In the event of using CERAFILTEC® for the treatment of e.g. waste water or other water with possible biological contaminations ensure that all local regulations are observed. We recommend wearing protective goggles and gloves at any time!	

	GENERAL WARNING Please note that not all local regulations, hazard warning notices and safety instructions are covered by this document using CERAFILTEC modules. Please acquaint yourself with the local regulations in order to avoid any health risk! We recommend wearing protective clothing at any time!	

11 Contact information

For more information visit our website www.cerafiltec.com, contact your sales representative http://www.cerafiltec.com/team/ or for technical questions contact the German engineering team.

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