SANI Membranes

Vibro-I 10 – 80 m² Series 2

Manual

Please be sure to read this entire user manual prior to use of the equipment.

Please read all safety instructions carefully.

This user manual is part of the product. Keep it in a safe place for future reference.

Replacement manuals can be downloaded from our Webpage at: www.sanimembranes.com

Version: 20221219

1. Contents

2. Description

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A. Introduction

The Vibro-I is an industrial filtration solution for applications where low energy consumption, high flux, sanitary function, low capital investment and gentle filtration are key words. The Vibro-I delivers continuous low fouling filtration where the filter is kept clean by vibration shear.

The membrane module vibrates while the patented Vibro® technology makes the media inside the module stationary. The relative vibration of media and membrane creates turbulence on the membrane surface and thereby keeps the fouling layer at a minimum. The turbulence is only created at vertical surfaces. Thus, the energy required to create the turbulence at the membrane surfaces is minimized.

Because the Vibro® technology creates turbulence at the membrane surfaces, the need for a large circulation pump known from other membrane technologies is eliminated. This also reduces and often eliminates the need for cooling of the retentate, which again adds to the energy savings.

The Vibro-I utilizes the Free Flow Plate™ technology which is an innovative membrane module design with free flow filtration on flat membrane surfaces. The Free Flow Plate™ can be configured with most commercially available microfiltration or ultrafiltration membranes.

The Free Flow Plate™ has a 1.7 mm free flow channel between the membranes that

allows for filtration with no need for pre-filtration even for high solids loading and high viscosity media. The Free Flow Plate™ element has an integrated and open permeate channel design. Thus, the retentate as well as the permeate can be drained completely and with a minimum of product loss.

The combination of the Free Flow Plate™ and the Vibro® technology provides very gentle processing. A conventional circulation pump can damage cells, molecules etc. during operation. By eliminating the circulation pump Vibro-I has become the most product gentle industrial scale microfiltration and ultrafiltration system on the market.

The elimination of the circulation pump also gives you virtually the same trans membrane pressures throughout the unit. These uniform conditions allows for unique process control unlike any other industrial membrane system.

The Vibro-I is fully drainable of both retentate and permeate resulting in minimal product loss and faster CIP cycles.

The Vibro-I range is a modular design based on the 2.5 m² Free Flow Plate™ module HP1. A Vibro-I unit consists of one or more assembled HP1 modules mounted on a Vibro-drive. Vibro-drives for single membrane assemblies are available from 2.5 m² to 20 m² membrane area. Additionally, 40 m² and 80 m² units are available using a larger Vibro-drive that holds 4 membrane assemblies.

For larger scale applications the Vibro-units can be connected in series and/or parallel according to the individual process layout.

The highly compact configuration and the elimination of circulation pumps, cooling aggregates, booster pumps and intricate piping layout gives the Vibro-I systems a small footprint. All media contacting parts are in durable polymeric materials or stainless steel.

The Vibro-I can conform to GMP/FDA/EC regulations for materials in contact with food and other sanitary standards on request.

B. Validity

This manual applies to Vibro-I units in the following versions:

- Vibro-I 10 – 80 m² Series 2

  Designed for vertical installation of 1 or 4 cartridges each containing 4 or 8 HP1 modules resulting in installed membrane areas of 10 m², 20 m², 40 m² and 80 m²

Please refer to separate manuals covering

- Vibro-I 7.5 – 20 m² Series 1

  Designed for vertical installation of 3, 4, 6 or 8 HP1 modules resulting in membrane areas of 7.5 m², 10 m², 15 m² and 20 m²
- Vibro-I 2.5 and 5 m² Series 1

  Designed for horizontal installation of a cartridge containing one or two HP1 modules resulting in membrane areas of 2.5 m² and 5 m²

The Vibro-I should be combined with suitable feed, permeate and CIP systems. The design and the degree of automation of such systems depend on the application and other requirements of the end-user.

C. Symbols

As warning of danger, all text statements in these instructions to be noted will be marked as follows:

⚠ WARNING

This symbol denotes a possible danger with medium risk that death or (severe) injury may result if it is not avoided.

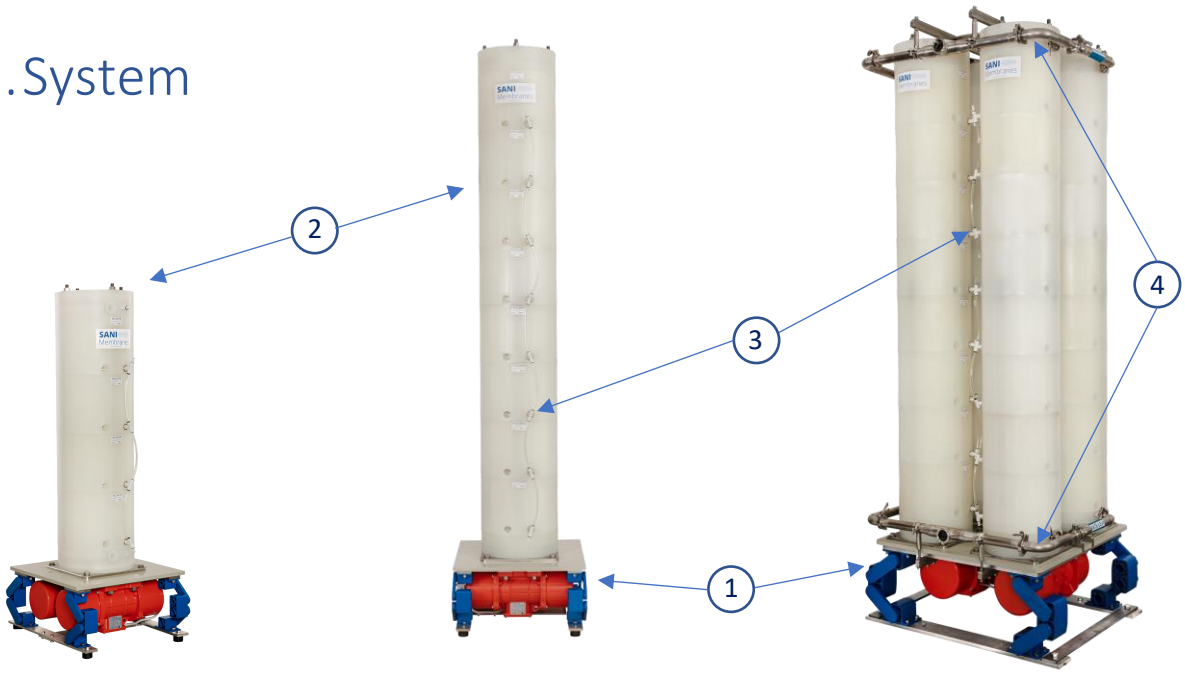
⚠ CAUTION

This symbol denotes a possible danger with a low risk that moderate or minor injury may result if it is not avoided.

ATTENTION

This symbol denotes a danger with low risk of damage to property if not avoided.

3. System



A. Parts list

1. Vibro-I drive frame
2. Vibro-I cartridge
3. Permeate manifold system
4. Liquid manifolds for the 40 or 80 m² units

B. System description

The Vibro-I system is a modular design based on the 2.5 m² HP1 membrane module. A cartridge assembly (2) consisting of 4 or 8 HP1 modules is mounted on the Vibro-I drive frame (1). Each cartridge includes a permeate manifold system (3).

- For the Vibro-I 10 or 20 m² units one cartridge with 4 or 8 HP1 modules, respectively, is mounted on the Vibro-I drive frame.
- For the Vibro-I 40 or 80 m² units 4 cartridges each with 4 or 8 HP1 modules, respectively, are mounted on the Vibro-I drive frame.

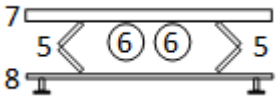
For the 40 and 80 m² units liquid manifolds (4) are available to provide a single connection point for each Vibro-I unit for the feed, retentate and permeate. The manifold design is application dependent.

Vibro-I drive frame

The Vibro-I drive frame generates the vibrations for the Vibro-I unit.

It constists of

5. Industrial springs, 4 off
6. Vibro-I motor, 2 off
7. Base plate
8. Vibro-I stand



Vibro-I drive frame

The two Vibro-I motors (6) together with the four industrial springs (5) create the vibrations for the unit. The motors are adjusted from the factory according to the installed membrane area, and will not work optimally for a different membrane area.

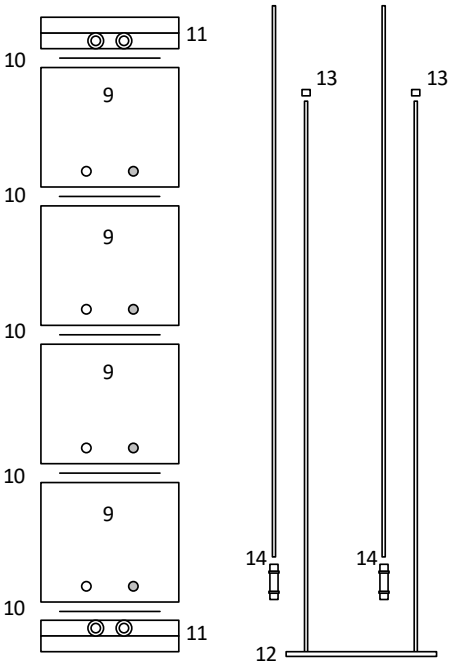
The base plate (7) is configured for mounting of one or four Vibro-I cartridges. The Vibro-I cartridge(s) are fixed to the base plate using four bolts for each cartridge.

The Vibro-I stand (8) is designed for permeanent installation in the shop floor or on a larger support structure. Foundation plan for each unit is available upon request. Drive frames for 10 and 20 m² units are supplied with machine feet that can be used until the units are permanently installed. As an option, the 10 m² unit can also be supplied on wheels.

Vibro-I cartridge

The Vibro-I cartridge consists of

9. 4 or 8 HP1 membrane modules
10. 5 or 9 internal square o-rings
11. Top and bottom cushion assembly
12. Cartridge bottom plate with 4 rods
13. 4 nuts
14. 4 extension rods for 20 m² incl. threaded bushing with o-rings



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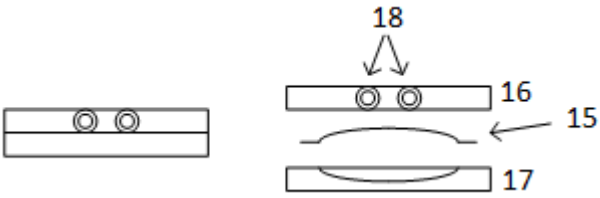
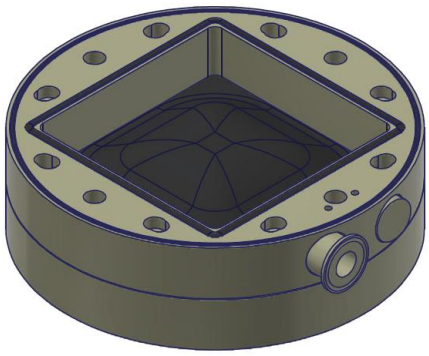
The Vibro-I cushion assembly (11) consists of

15. Vibro-I cushion
16. Media inlet/outlet part
17. Top/bottom part
18. Media inlet/outlet ports





Vibro-I Cushion Assembly
Bottom inlet assembly shown

The Vibro-I cushion (15) is secured between a media inlet/outlet part (16) and a top/bottom part (17). Each media inlet/outlet part (16) is configured with up to two media inlet/outlet ports (18). The ports are for the feed and retentate connections, and for possible vent and/or connection to instruments such as pressure transducer or temperature sensor.

The Vibro-I cartridge consists of a number of stacked HP1 2.5 m² membrane modules (9) assembled with a cushion assembly (11) at the top and at the bottom of the HP1 stack. An internal square o-ring (10) seals between the assembly parts.

HP1 module with
permeate ports

The Vibro-I cartridge is assembled on a bottom plate with four rods (12) and the complete cartridge is tightened by four nuts (13). For the 20 m² the rods are extended using threaded bushing with o-rings and extension rods (14).

The Vibro-I cartridge can be directly lifted onto the Vibro-I drive frame by placing lifting eyes on top of two of the rods. When positioned on the motor assembly, the cartridge is mounted on the base plate (7) using four bolts.

Liquid manifolds

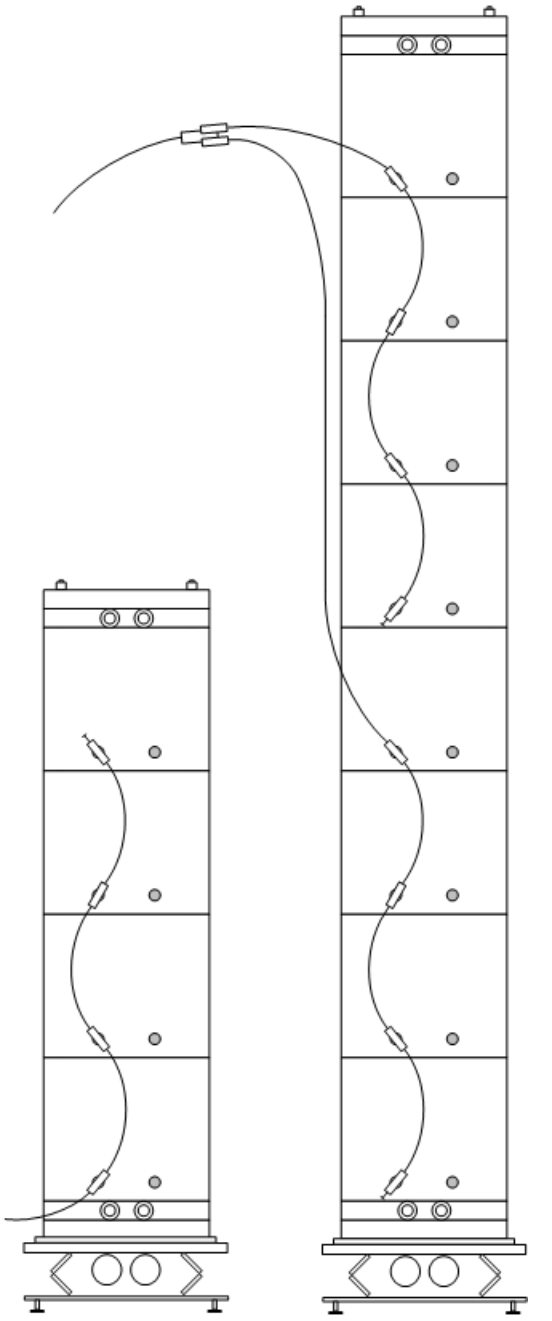
Each HP1 module has two permeate ports. In the standard configurations one is blinded, and the other is configured with a push-fit T-connection. As an alternative option the permeate port can be configured with a Mini-TC clamp connection.

The standard configuration includes a permeate manifold joining the push-fit T-connections of the HP1 modules with 10 mm tubing.

At one end of each manifold there is a blind plug and at the other end a drain line for leading the permeate ot the collection vessel.

For microfiltration applications the drain line is as standard at the top of the manifold, and the blind plug at the bottom. This configuration helps to ensure that the transmembrane pressure is uniform throughout the entire membrane area.

For ultrafiltration it is not as critical and the standard manifold is provided with the drain line at the bottom.



10 m² for ultrafiltration 20 m² for microfiltration

These are the default configurations but the manifold can be reconfigured according to preference.

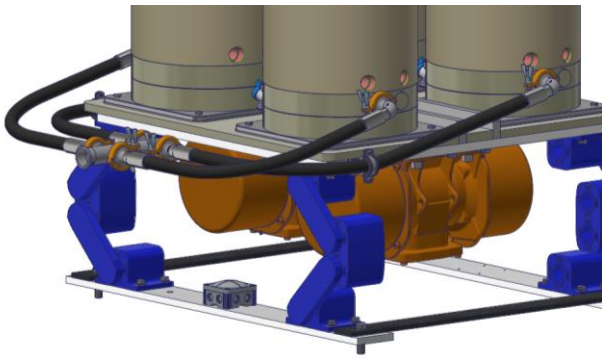
To facilitate draining of the permeate volume a vent valve can be added instead of the blind plug at the closed end. This is particularly useful for the microfiltration configuration.

For 10 m² cartridges a single permeate manifold is provided. When used for the 40 m² unit the drain lines from each 10 m² cartridge are joined in a stainless steel manifold with push-fit fittings.

On the 20 m² cartridges the permeate manifold is divided into an upper and a lower manifold. These are joined to a 12 mm drain line via a Y-piece, or joined in a stainless steel manifold with push-fit fittings when used for the 40 and 80 m² units.

The 40 and 80 m² units may also include liquid manifolds for the feed and retentate lines. These are to be connected by flexible hoses to the feed / retentate system.

Below are shown two examples of this but the solution may vary depending on the application and other specific requirements. It is also an option to connect flexible hoses directly to and from the 20 m² cartridges.



Feed manifold for 40 / 80 m² units

Retentate manifold for 40 / 80 m² units

4. Safety

Please be sure to read this entire user manual prior to use of the equipment.

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This user manual is part of the product. Keep it in a safe place for future reference.

A. Intended use

The Vibro-I is a filtration system for microfiltration and ultrafiltration that can be operated in numerous ways both 100% manual, 100% automated and every option in-between. The user should read and understand this manual before use. The Vibro-I is intended for use in an industrial or research facility.

The Vibro-I is intended to filter media and can only be used with HP1 membrane modules from SANI Membranes.

The Vibro-I can only be used together with a feed system with a built-in safety to protect the Vibro-I against over-pressure. If the feed system is able to deliver over-pressure, a CE approved safety valve set to the applicable maximum operating pressure of the Vibro-I system must be included before the Vibro-I inlet.

The applicable operating pressure range of the system is 0-4 bar(g) at 5-35 °C, 0-3 bar(g) at 5-55 °C and 0-1 bar(g) at up to 80°C.

The Vibro-I is a vibrating machine product that must be placed on a foundation that can absorb the reactions from the vibrations. Preferable vibration absorption is through suitable heavy flooring or foundations. Be aware that eigenfrequency or natural frequency response in buildings can lead to structural damage. ⚠ **WARNING**

The Vibro-I is NOT suited for use in explosive environments. ⚠ **WARNING**

This instruction manual is part of the Vibro-I. The Vibro-I is intended exclusively for use in accordance with this instruction manual.

The Vibro-I must only be used for intended use.

The following are examples of improper use ⚠ **WARNING**:

- Unauthorized modifications and technical changes to the Vibro-I are improper use.
- Operation outside the permissible physical conditions given in this document (e.g. temperature, pressure, chemical vapors etc.) and given in the specification sheet for the HP1 membrane module used.
- Installation of unauthorized items on the Vibro-I.
- Connection of unsuited devices to the Vibro-I (e.g. unsuited feed systems).
- Use of media with biological materials in Safety Classes 2 and 3.
- Use of flammable or potentially explosive substances.
- Filtration of unstable media.
- Use of media which are incompatible with PP, Stainless Steel, Silicone, EPDM or other materials in the Vibro-I, HP1 membrane module or feed system used.

B. Personnel qualification

All personnel operating the Vibro-I must have read this instruction manual thoroughly and be skilled in the art of pressurized filtration. All personnel operating the Vibro-I should be used to conduct themselves in a laboratory or industrial process environment and have passed mandatory safety courses etc. Students operating the Vibro-I must be instructed thoroughly by skilled teachers or other skilled personnel in proper use of the Vibro-I.

C. Media

The media used in the system can be dangerous to handle and cause personnel injuries or equipment damage when not handled correctly.

The operator should always seek the applicable safety information for the media to be filtered as well as media used for the cleaning and storage of membrane modules (e.g. handling and storage and conduct in emergency situations). ⚠ **WARNING**

Personal safety equipment should always be worn when applicable (e.g. safety goggles, safety gloves etc.). ⚠ **WARNING**

Do Not use media with biological materials in Safety Classes 2 and 3. ⚠ **WARNING**

Do Not use flammable or potentially explosive substances. ⚠ **WARNING**

Do not use unstable media where concentration changes might start chemical reactions within the media. ⚠ **WARNING**

The operator should always make sure that the media to be filtered is compatible with the materials in fluid connection in the Vibro-I (PP, Stainless Steel and silicone) and the feed system used. **ATTENTION**

D. Pressurized components

The pressure and media flow needed to drive the filtration in the Vibro-I is generated by an external feed system (not included). The external feed system and the pipes, hoses and fittings between the external feed system and the Membrane Assembly including the Membrane Assembly are a separate pressurized system.

The system must be operated at maximum 4 bar(g) at room temperature and the external feed system must have a CE approved safety valve set at **maximum 4 bar(g)**. Parts of the system can burst if they are subjected to pressures over 4 bar(g). ⚠ **WARNING**

Operating Pressure: 0-4 bar(g) at 5-35 °C, 0-3 bar(g) at 5-55 °C and 0-1 bar(g) at up to 80°C.

⚠ **WARNING**

E. Leaking fluids

If the fluid system is leaking, liquid spill can cause a serious health danger depending on media. The operator should always seek the applicable safety information for the media to be filtered (e.g. handling and storage and conduct in emergency situations).

Personal safety equipment should always be worn when applicable (e.g. safety goggles, safety gloves etc.). ⚠ **WARNING**

If the fluid system is leaking, liquid spill to the floor can cause a slipping hazard. ⚠ **CAUTION**

F. Moving parts

Body parts can be crushed when they come into contact with moving parts, e.g. the membrane assembly, the industrial springs. This can lead to injuries. ⚠ **WARNING**

Lose hair or lose clothing parts can be caught in moving parts and cause injuries. ⚠ **CAUTION**

The Vibro-I must be placed on a horizontal non-slippery surface as the vibrating movement can otherwise make the Vibro-I move doing operation and cause injuries. ⚠ **CAUTION**

G. Personal protective equipment

Mandatory personal protective equipment to protect against risks arising from the equipment or the material being processed:

- Tight-fitting work clothing - Protects against being caught by moving parts. ⚠ **CAUTION**
- Head covering - Protects hair from being pulled into moving parts. ⚠ **CAUTION**
- Safety glasses - Protects against substances leaking under high pressure, splashing liquids etc. ⚠ **WARNING**

- Safety shoes - Protects against injuries to the feet caused by mechanical effects. ⚠ **CAUTION**
- Safety helmet – Protects against injuries in case of loose items falling from the top of Vibro-I unit(s) ⚠ **WARNING**

H. Accessories and spare parts

The Vibro-I can only be used together with a feed system with a CE approved safety valve set according to the section D. “Pressurized Components” above. ⚠ **WARNING**

The use of unsuitable accessories, consumables and spare parts can be hazardous and have the following consequences:

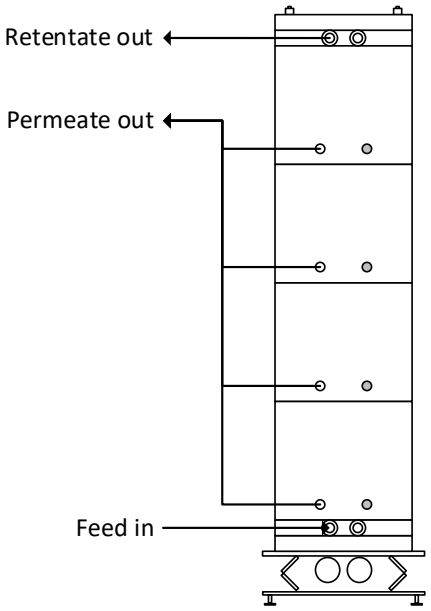
- Severe personnel injury ⚠ **WARNING**
- Damage to the device ⚠ **WARNING**
- Malfunctions of the device **ATTENTION**
- Device failure **ATTENTION**

Only use accessories, consumables and spare parts that are in technically perfect condition. The use of accessories, consumables and spare parts **not** approved by SANI Membranes is the sole responsibility of the operator.

5. Operation

A. Introduction

The standard way to run the assembled unit is to pump feed in through a media port in the bottom of the Vibro-I membrane assembly.



The permeate is collected via the permeate outlets using a permeate manifold and the retentate is leaving the unit at the desired rate through a media port in the top.

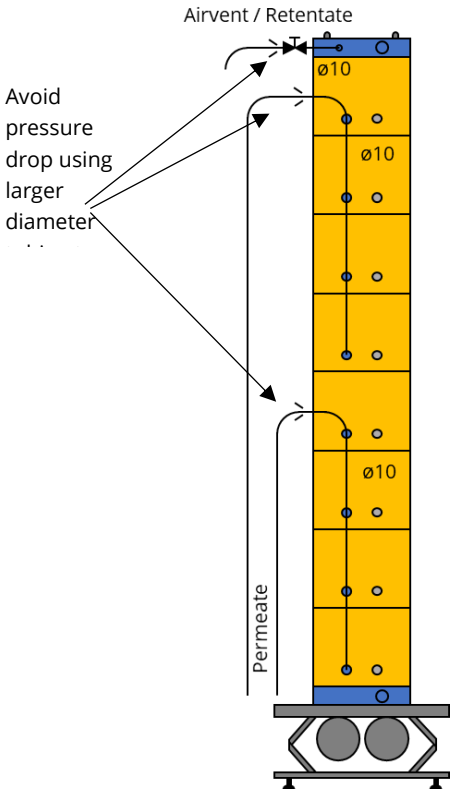
All connections between the vibrating equipment and static equipment such as feed pump, permeate tank and retentate tank must be done with flexible tubing or hoses.

In order to reduce the tranfer of vibrations the connecting hoses should not be straight but ideally include at least a 90° bend between the vibrating and the static connection point. See picture to the right showing suitable ways of connecting the flexible hoses.

Avoid any contact between vibrating hoses and other equipment parts as this can result in wear and damage of the hoses.

B. Permeate system

The manifold is designed to avoid negative transmembrane pressure (TMP) as this can cause damage to the membrane modules. A negative TMP can occur when reducing the feed pressure dramatically or stopping the feed system quickly.



In microfiltration applications it is often key to have a low, uniform TMP. To facilitate this the manifold for microfiltration systems leads the permeate up along the modules, as shown in the illustration to the right. To enable drainage of the permeate side a drain valve can be included at the bottom of the permeate manifold.

The permeate rate may be controlled by using a positive displacement type pump on the permeate line. This will restrict the permeate flow and will enable unique process control at low uniform TMP during microfiltration. Read more about this in Section E below ("Examples of membrane filtration process configurations").

For ultrafiltration applications the pressure conditions are less critical and the manifold can instead be designed to lead the permeate down along the modules. A vent valve can optionally be included at the top of the manifold to assist draining of the permeate side.

In general it is recommended to reduce the pressure drop in the permeate system by using a larger diameter tubing between the Vibro-I and the collection tank.

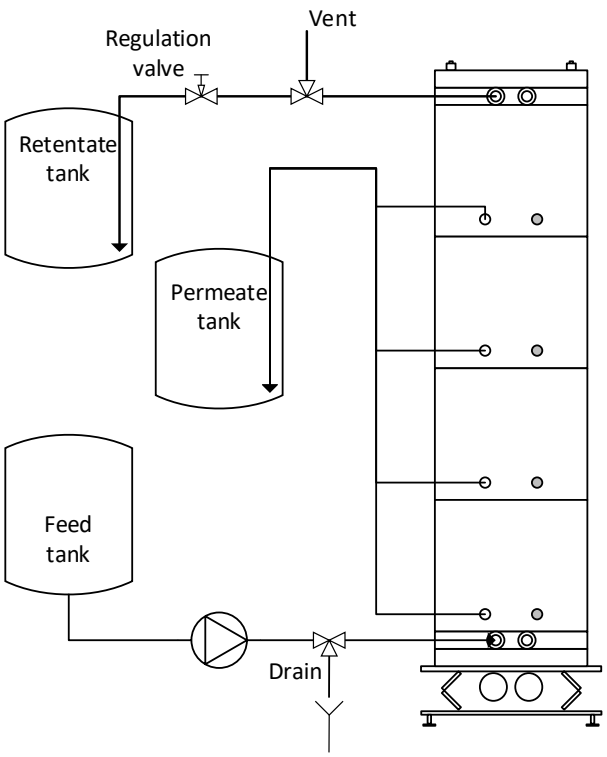
C. Feed and retentate system

All Vibro-I systems need a supply of liquid from a feed system. There are endless ways of designing a feed system all depending on the application and scale, and the degree of automation required.

When designing a feed system, the maximum allowed feed pressure of the HP1 membrane modules must be taken into consideration. The Vibro-I is designed to work at: 0-4 bar at 5-35 °C, 0-3 bar at 5-55 °C and 0-1 bar at up to 80 °C. If the feed system is technically capable of providing a higher feed pressure at the given temperatures, a corresponding safety valve on the feed supply line is mandatory. If an automated control system is used the alarms and interlocks settings must ensure the safe operations with respect to these limits.

During filling and draining the individual Vibro-I may be vented to avoid over/under pressure inside the membrane assembly. The Vibro-I motors must be turned off during filling or draining. Once filled with media the Vibro-I motors are turned on. It is important to start the Vibro-I motors as soon as the filling is done as the fouling starts immediately.

Starting the Vibro-I motors too late can result in initial fouling of the membranes, which will often be irreversible. **ATTENTION**



It is highly recommended to automate the starting and stopping of the Vibro-I motors. This can be done by using the pressure at the retentate outlet of each unit as a pressure switch and at eg. 0.05 bar(g) turning the Vibro-I motors on and off. The actual setpoint must consider the static pressure conditions in the specific installation pipework.

D. Preparation for first use

Conditioning of new membrane

Before using a new membrane with product it should be prepared for use. New membranes are provided with a protective layer of water-soluble glycerin and / or preservative solutions that should be removed before first use.

This is done by flushing the membrane for 30 minutes with clean hot water (50-55 °C). Do not recirculate the water but lead both the retentate and the permeate to drain. After this rinse it is recommended to perform a cleaning in place (CIP) cycle.

Determine the initial clean water flux

Once the membrane has been conditioned before the first use it is recommended to measure the clean water flux of the new membrane. This value can be used throughout the lifetime of the membrane as a benchmark for the efficiency of the CIP regime after each production.

The clean water flux should be measured at a set of standard conditions (pressure and temperature) that can be repeated after every future CIP cycle. The value can be corrected to a reference temperature (typically 25 °C) using a temperature conversion table.

E. General Guidelines – Process

Guidance for processing of product

- Avoid operating the unit at excessive flux leading to fast and high fouling of the membranes
- Recommended trans membrane pressure for microfiltration is 0.05 - 1 bar
- Recommended trans membrane pressure for ultrafiltration is 1 - 3 bar
- Maintain a positive trans membrane pressure (min 0.02 bar) when vibration mode is on and always keep the permeate drain open. If using a permeate pump make sure the pump is running whenever the system is operating

- Maintain a minimum retentate flow out of each cartridge to avoid dead-end type filtration. A suitable retentate flow is normally 800 – 1200 L/h per cartridge (so that means 3.2 – 4.8 m^3/h for a 40 or 80 m^2 plant). This is application dependent and if the media is highly concentrated or very viscous the flow rates may need to be higher.
- If a lower retentate flow is required or desired a mix flow within each unit can be established to ensure the above mentioned retentate flows. This is relevant if running the unit as a continuous single pass concentration step.
- When performing microfiltration of media with high solids load, the mix flow and vibration must be initiated as soon as the unit is filled to avoid severe fouling
- Operating Pressure: 0-4 bar(g) at 5-35 °C, 0-3 bar(g) at 5-55 °C and 0-1 bar(g) at up to 80 °C ⚠ **WARNING**

<u>Microfiltration (transmembrane pressure 0 – 1 bar)</u>

- Keeping a very low trans membrane pressure between 0.05 to 0.25 bar often gives the best long-time results. The optimum is membrane and product dependent.
- The initial flux can be very high and easily result in severely fouled areas in the Vibro-I unit. Reduce the flux by lowering the trans membrane pressure and let more retentate out to avoid severe fouling.
- Consider to use a positive displacement pump to control the permeate rate instead of controlling pressure. It can be very difficult to control at the very low pressures required for some microfiltration processes.

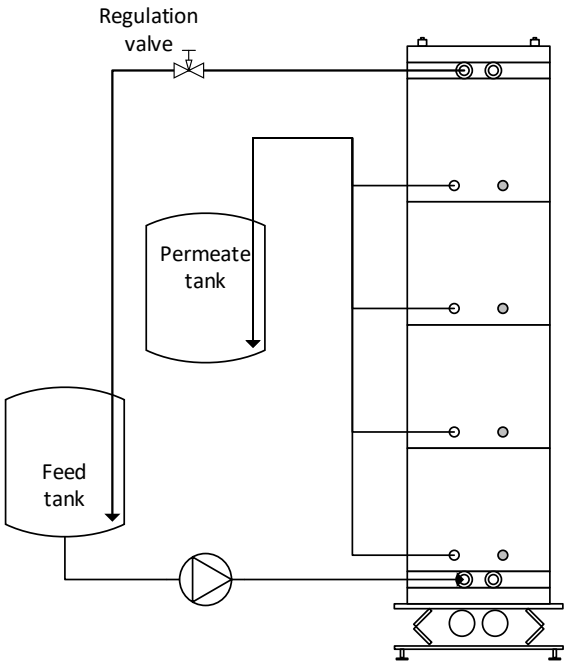
<u>Ultrafiltration (transmembrane pressure 1 – 4 bar)</u>

- Ultrafiltration is less sensitive to pressure variation. Optimum transmembrane pressure is often lower than often seen in traditional cross flow systems. Typically, the ideal transmembrane pressure is between 1 – 2 bar.
- Make sure that the system pressure does not exceed 4 bar(g) – with a 4 bar(g) safety valve or a 4 bar(g) software hard stop. ⚠ **WARNING** Operating Pressure: 0-4 bar(g) at 5-35 °C, 0-3 bar(g) at 5-55 °C and 0-1 bar(g) at up to 80 °C. ⚠ **WARNING**

F. Examples of membrane filtration process configurations

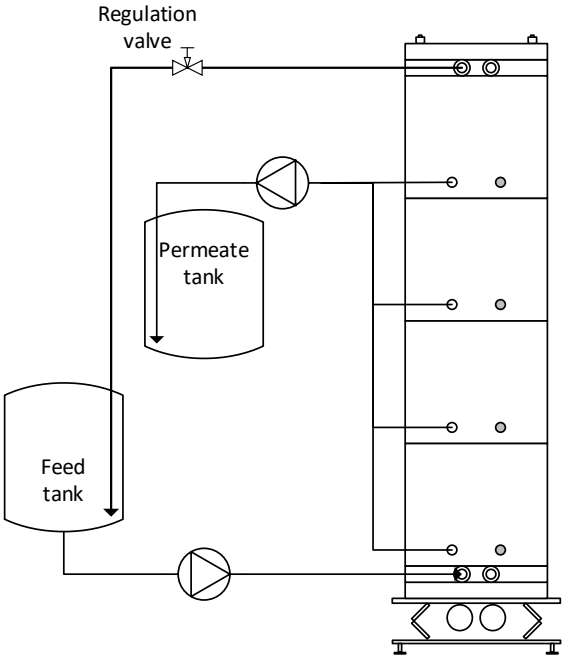
Membrane filtration batch mode with concentration in tank

- Simple configuration for viscosities up to ”cream level”
- The trans membrane pressure is regulated with the regulation valve
- The retentate flow is regulated with the speed of the feed pump in combination with the regulation valve
- The concentration factor in the retentate is calculated from the amount of permeate collected and the initial feed volume
- This setup can also be used for diafiltration applications



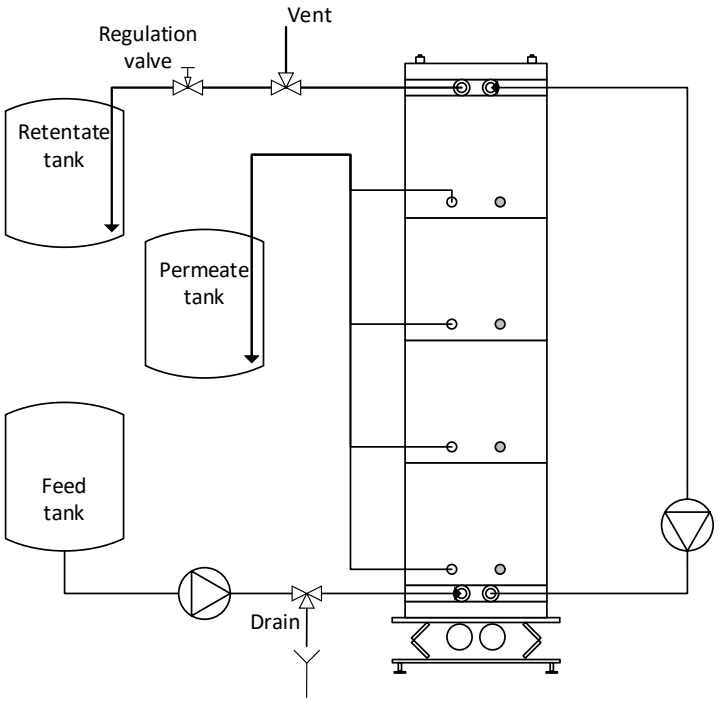
Microfiltration mode with permeate flow control pump

- Unique process control at extremely low and uniform transmembrane pressure
- The system pressure is regulated with the regulation valve
- A positive displacement pump restricts the permeate flux and keeps a low transmembrane pressure
- Reduces fouling and enables high protein transmission
- This approach can be advantageous with other configurations too



Continuous membrane filtration mode with mix pump – high solids or high viscosity

- Configuration for achieving high viscosity or high concentration
- The retentate is circulating using a mix flow pump in order to ensure sufficient mixing of the concentrated liquid
- The trans membrane pressure is generated by the feed pump and regulated using the regulation valve
- At steady-state the volumetric concentration factor can be controlled by regulating the retentate flow at a fixed ratio to the permeate flow.

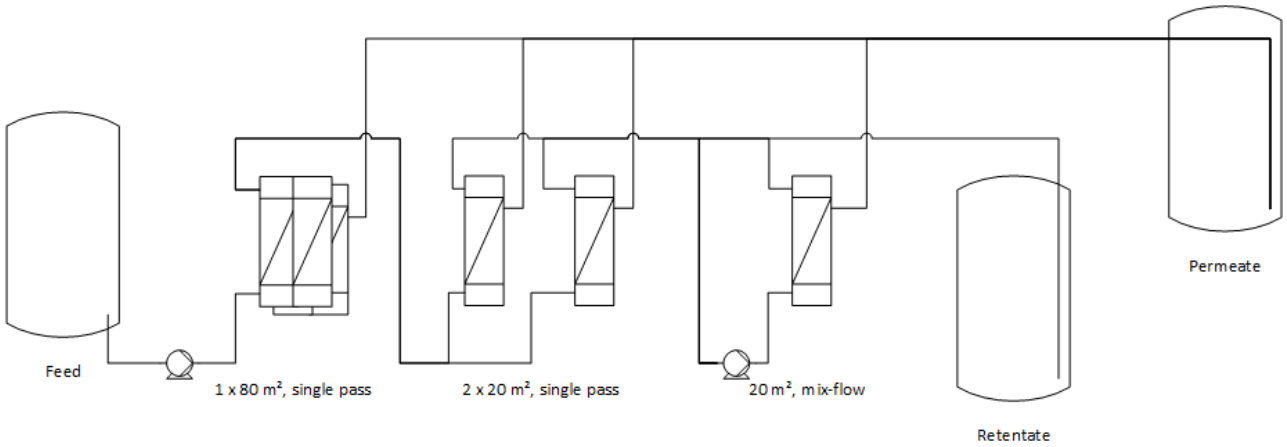


The above configurations are just a few simple examples of operation modes. The Vibro-I units can easily be configured for larger systems with units coupled in parallel and/or in series. The optimal process design will always be product and scale dependent.

A simple example of a more complex configuration is provided below. It includes a two-stage concentration plant where the first stage has two parallel Vibro-I units operating in a continuous “single pass” configuration followed by second stage of final concentration using a mix-flow loop to ensure the required mixing of the concentrated liquid.

For larger scale operation this can be optimized further by using a multi-stage approach. This will improve the average membrane performance. The first stages will be exposed to the more dilute liquid and will be able to provide higher flux performance. The final concentration stages will run at lower flux performance due to the higher solids load.

Multi-stage systems often incorporate 5-8 stages in order to optimize the performance of the membrane. Below is shown a simplified diagram of a three-stage system with mix-flow at the third stage.



The optimal process configuration is highly application dependent, and an application specific process configuration must be thought trough to each industrial application including CIP system, degree of automation, temperature control system etc.

G. CIP operation

The following procedure is a general guideline applicable for the cleaning of the Vibro-I. The individual process and product may require a different approach to achieve satisfactory cleaning results. Please consult a qualified chemicals supplier for application specific cleaning regimes.

For each cleaning step ensure that liquid flows through the permeate line. This is done by closing the retentate valve slightly to generate sufficient membrane pressure. As the membranes gets more clean the retentate pressure may be reduced again.

During CIP ensure around 50/50 flow through the permeate and the retentate outlet at as low trans membrane pressure as possible.

A typical CIP routine for processes with organic material could consist of:

1. Drain for product
2. Flush the system with 55 °C water
3. Caustic wash, 55 °C at pH 11-11.5 for 20-25 min
4. Flush with water for 5 min
5. Between each step the system can be drained.

Sometimes an acidic step may be required, this could consist of:

6. Acidic cleaning solution at pH 1.5 for 15-20 min
7. Flush with water for 5 min

Note that membranes have different pH tolerances and the CIP cleaning regime should be selected accordingly. For some applications enzymes, oxidizing agents or detergents may help the cleaning process.

H. Clean water flux

After cleaning the membrane, the clean water flux should be measured. By comparing the clean water flux after each cleaning cycle with the original membrane performance it is possible to determine if the cleaning regime is sufficient to ensure a good recovery of the membrane.

The clean water flux should be compared by using at the same reference parameters (same transmembrane pressure and a standard water temperature, typically 25 °C). If the water temperature deviates the measured water flux can be normalized to the standard temperature using a temperature correction table.

A recovery of 80% or more of the initial water flux should be expected from a good cleaning regime. However, it is equally important to monitor the trend of the clean water flux in order to evaluate if the cleaning regime is efficient and sufficient.

I. Storage of membranes

The membrane should never be allowed to dry out. Keep the system filled with water between batches. For longer periods it is recommended to add a suitable solution to keep the membranes wetted, and to prevent bacterial growth during storage. The storage solution should be selected in accordance with the chemical compatibility of the specific membrane material. Some examples of storage solutions are:

- 0.1 N NaOH
- 20% ethanol
- 20% isopropanol

Always seek the applicable safety information for the selected checmicals used as storage solution (e.g. handling and storage and conduct in emergency situations). For long term storage it is recommended to replace the storage solution at regular intervals, for instance every 3-6 months.

When preparing the membrane module for storage it is important to evacuate the permeate compartment from air. This is best done by recirculating the storage solution at a pressure suitable for the given membrane until air does not appear in the permeate outlet. Once the membrane module is evacuated from air all valves should be closed off.

6. Assembly and disassembly of the Vibro-I unit

A. Installation and assembly of new Vibro-I units

The Vibro-I unit consists of a motor assembly and one or four cartridge assemblies. The motor assembly should be installed in the facility floor or on a support frame. A machine specific foundation layout is available upon request.

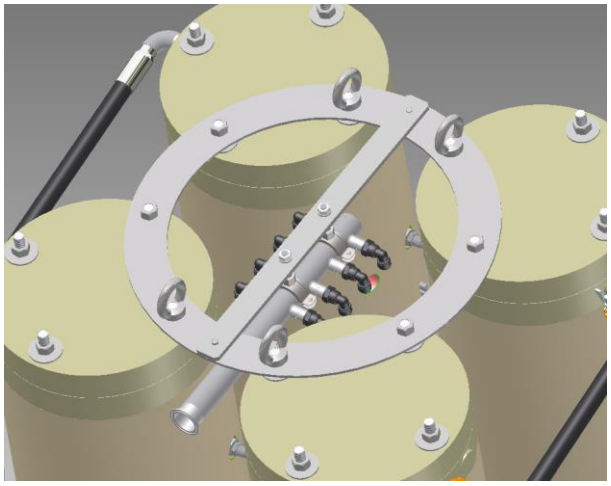
Once the Vibro-I motor assembly has been installed correctly, the cartridge(s) can be mounted on the base plate. For the 10 m² and 20 m² units the orientation of the cartridge is free. For the 40 m² and 80 m² units the orientation of the four cartridges must be in accordance with the specific manifold design.

Each cartridge is lifted onto the base plate by placing two lifting eyes on two of the diagonally opposite rods. Once in position the cartridge is mounted onto the base plate using four bolts.

The four cartridges for the 40 m² and 80 m² units are kept in position at the top with a stainless steel top ring. The top ring has 8 holes that fit over two of the rods from each cartridge like shown in the illustration below.

Also in the illustration:

- Position of lifting eyes is shown, only relevant in case the entire unit with cartridges is to be lifted.
- A permeate manifold used for microfiltration applications is supported under the shown support ring. For ultrafiltration applications the permeate manifold may be placed at the base plate of the unit.



B. Disassembly of the Vibro-I cartridge

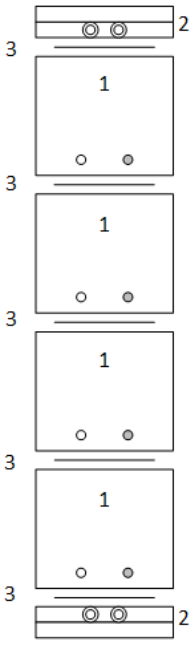
For inspection or maintenance purposes it will be required to disassemble the cartridges from time to time. This may be for routine inspection of gaskets or cushions or for replacement of one or more membrane element.

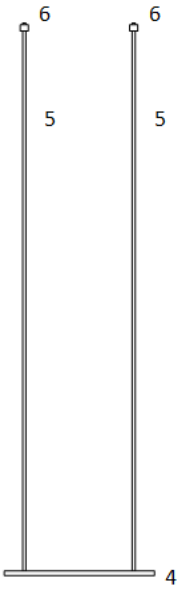
The Vibro-I cartridge should be disassembled while being mounted on the Vibro-I motor assembly. Alternatively, it can be moved to another area for this operation. In that case unbolt the cartridge from the Vibro-I motor assembly and move it by using lifting eyes in two

diagonally placed rods. 20 m² cartridges should always be bolted onto a stable support to minimize the risk of accidents during disassembly. Due to the lower height the 10 m² cartridges can – with caution – be disassembled without being bolted onto a support.

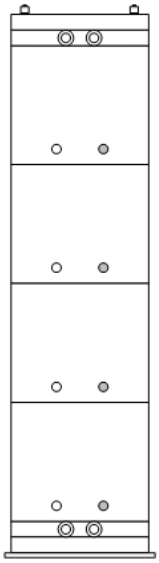
Overview of the cartridge components:

1. HP1 2.5 m² membrane module
2. Vibro-I cushion assembly
3. Inner gasket
4. Cartridge bottom plate
5. Rods
6. Nuts





Vibro-I cartridge parts



Vibro-I cartridge

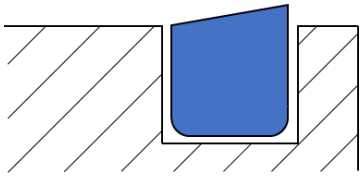
Instruction for disassembly:

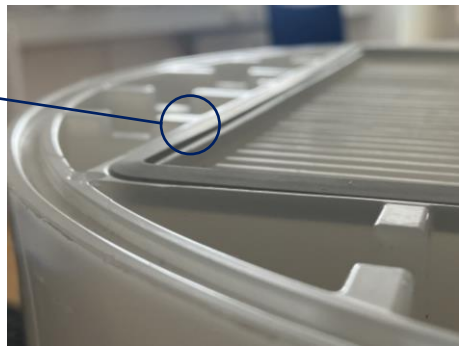
1. Disconnect the Vibro-I unit from all other equipment and power
2. Drain the cartridge to be disassembled
3. Take off the 4 nuts (6) and the washers at the top of each membrane assembly
4. Remove the top Vibro-I cushion assembly (2)
5. Remove the inner gasket (3) from the top HP1 module (1)
6. Remove the HP1 modules (1) one by one, and remove the inner gasket (3) from each module
7. For the 20 m² cartridge the rods (5) are joined by a bolt after the first 4 HP1 modules. Remove the upper rods and the joining bolt before removing the last 4 HP1 modules
8. Remove the inner gasket (3) from the bottom Vibro-I cushion assembly (2)
9. Make sure that all parts are intact and clean them for instance with 50% ethanol if necessary
10. Make sure the HP1 modules (1) do not dry out while the cartridge is disassembled. For longer duration the HP1 modules may be stored in a suitable storage solution (see “Storage of used HP1 membrane modules” in section D below.

C. Re-assembly of the Vibro-I cartridge

For this instruction for re-assembly of the cartridge, please refer to the overview of components in the previous section.

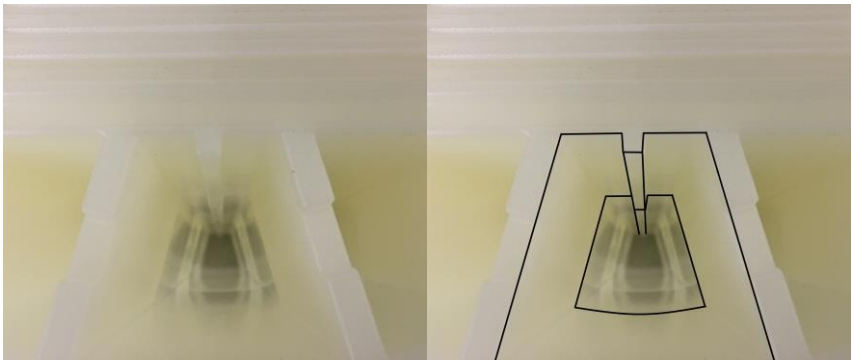
1. Make sure that all parts are intact and clean
2. Place the bottom Vibro-I cushion assembly (2) in the desired orientation by sliding it over the 4 rods (5).
3. Place the inner gaskets (3) carefully in the gasket grove of the bottom Vibro-I cushion assembly. Make sure that the "lip" of the inner gasket is facing up:



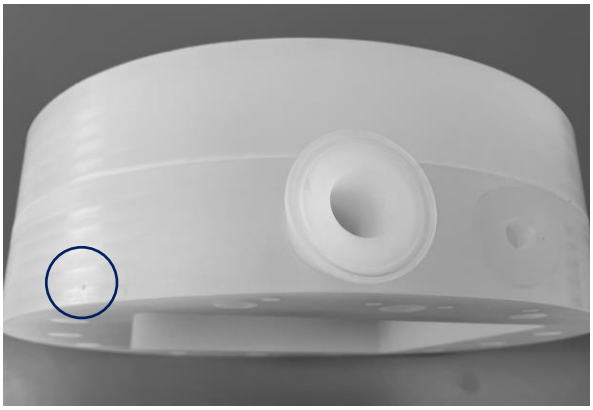


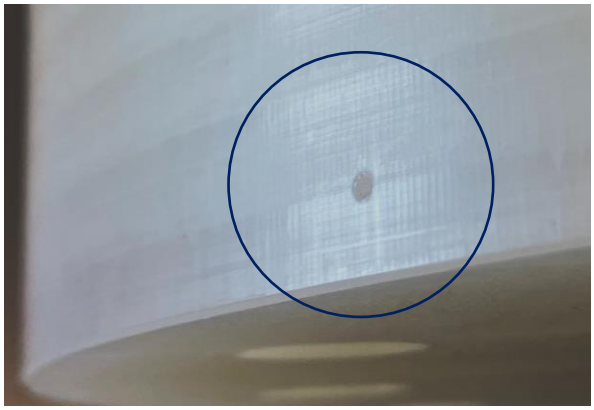
A cross-section of the inner gasket placed correctly with the 'lip' on the top right

4. Place the first HP1 module (1) in the desired orientation by sliding it over the rods (5) and ensure it is perfectly aligned with the Vibro-I cushion assembly.
5. Place the inner gasket (3) carefully in the gasket grove of the HP1 module – again with the lip facing up
6. Repeat for the remaining HP1 modules. Make sure they are perfectly aligned with the previous HP1 modules and that the inner gasket lip is facing up on each module. Check the alignment by looking into the cavities of the assembly:

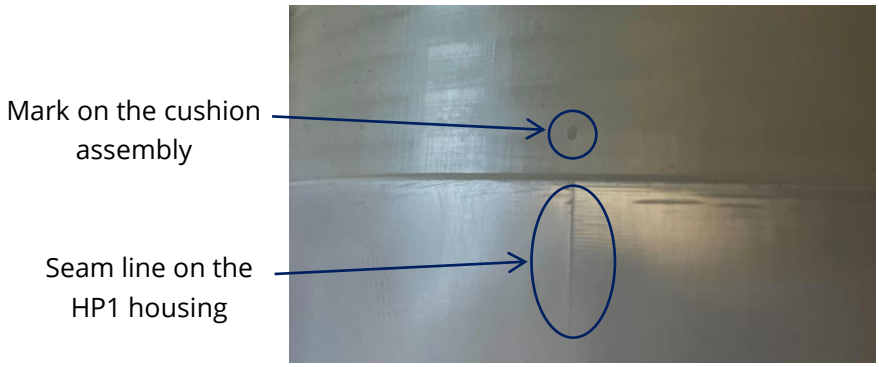


7. For the 20 m² cartridge the rods (5) are joined by a bolt after the first 4 HP1 modules. Mount the joining bolt and the upper rod before placing the last 4 HP1 modules
8. Place the top Vibro-I cushion assembly (2) on the upper HP1 module.
   For correct aligninment a mark has been applied to the plastic near the inlet port. This mark should be aligned with the visible seam line on the HP1 module.
   Please see below illustrations:





Correct alignment of the cushion assembly and the HP1 module:



9. Place a washer on each rod (5) and secure the nuts (6) by cross tightening them slowly with a torque wrench adjusted to 35 Nm for the 7.5 m², 38 Nm for the 10 m², 40 Nm for the 15 m² or 42 Nm for the 20 m².
   Note: The nuts must be re-tightened after 8 hours in operation of the Vibro-I.
10. The permeate outlets on the HP1 modules (1) are secured with lock-nuts and should not be disassembled or tightened without expert knowledge.

11. Fittings for the permeate connections are mounted on the permeate outlets. It is important to secure the permeate outlets from turning inside the module using an Allen wrench on the opposite side of the module.

12. Connect the Vibro-I to power, feed system etc.

D. Storage of used HP1 membrane modules

If the Vibro-I is disassembled the HP1 membrane modules should not be allowed to dry out. For longer term storage they should be stored in a suitable storage solution that also prevent bacterial growth.

The HP1 module can be placed in suitable containers such as a large plastic bucket with lid. Make sure that the entire module is submerged in the storage solution.

The storage solution should be selected in accordance with the chemical compatibility of the specific membrane material. Some examples of storage solutions are:

- 0.1 N NaOH
- 20% ethanol
- 20% isopropanol

For long term storage it is recommended to replace the storage solution at regular intervals, for instance every 3-6 months.

7. Service and maintenance

A. Tightening and re-tightening the Vibro-I top bolts

The 4 nuts (8) on top of each module tower must be tightened with a torque wrench adjusted to 35 Nm for the 7.5 m², 38 Nm for the 10m², 40 Nm for the 15 m² and 42 Nm for the 20 m² (The nuts must be re-tightened after 8 hours in operation of the Vibro-I after each re-assembly).

It is important to note that the nuts should only be tightened as described above. Further tightening or repeated tightening can result in reduced tension in the internal bolts in the top- and bottom assemblies which will cause these to come loose when the unit is vibrating.

B. Inspection of the Vibro-I cushion assemblies

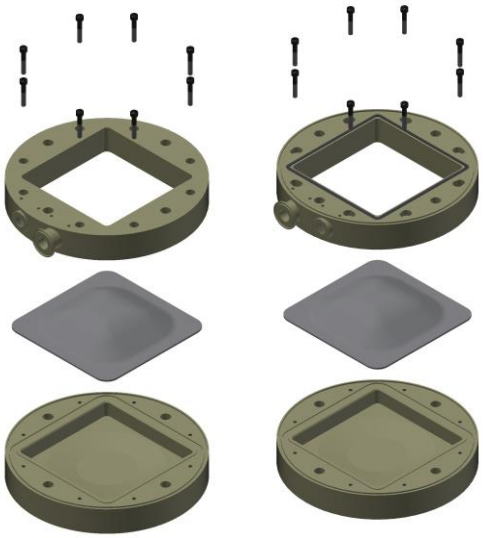
The cushion assembly is a wear part that should be inspected regularly. Through regular operation the cushions may gradually deflate and as a result lose the cushion effect.

Every 4 – 6 months of regular use the Vibro-I cushion assemblies should be inspected and maintained as described below.

1. Disassemble the Vibro-I membrane assembly (see separate instruction above)
2. Inspect that the cushions in the Vibro-I cushion assemblies are intact and still inflated.
3. If the cushion is inflated and intact check and/or re-tighten the 8 M8 Allen bolts in the Vibro-I cushion assembly with a torque wrench adjusted to 4 Nm
4. If deflated or defect, exchange or re-inflate the cushion (see separate instruction below)
5. Re-assemble the Vibro-I (see separate instruction above)

C. Exchanging or re-inflating the Vibro-I cushion

1. Disassemble the Vibro-I cushion assembly by un-screwing the 8 M8 Allen bolts
2. Clean the top/bottom part and the inlet part of the Vibro-I cushion assembly with 50% ethanol
3. Place the top/bottom part of the Vibro-I cushion assembly on a flat surface
4. Inspect the cushion and replace if there are defects or sign of wear
5. Place the new or reinflated cushion in the cushion pocket in the top/bottom part of the Vibro-I cushion assembly and align it with the sides of the pocket.



Top assembly (no grove for inner gasket)

Bottom assembly

6. Place the 8 M8 Allen bolts in the inlet part of the Vibro-I cushion assembly in the holes corresponding to the threads in the top/bottom part.
   (The middle hole along each side is not used)
7. Place the inlet part on top of the top/bottom part while aligning the 4 unused holes.
8. Cross-tighten the 8 M8 Allen bolts carefully and tighten them with a torque wrench adjusted to 4 Nm

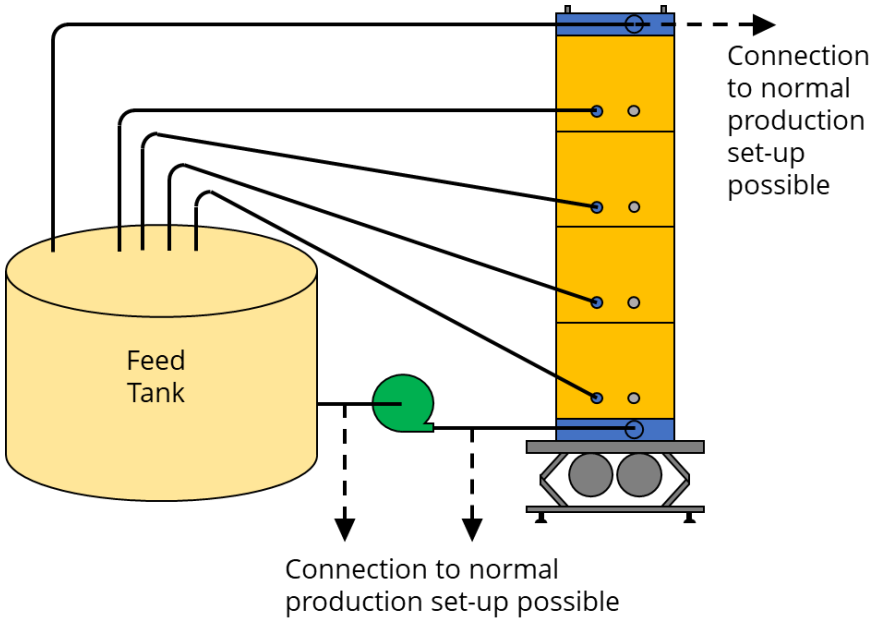
Note that the bottom cushion assembly has a grove for the inner gasket in the inlet/outlet part, whereas this is not the case for the top cushion assembly.

D. Permeate quality

If permeate quality is not acceptable, one of the filter modules might have a defect membrane. Identify the defect HP1 module by evaluating the permeate from each individual module and isolate or replace the faulty module. Often, the visual appearance of the permeate in the permeate tubing can reveal a damaged module.

If there is no visual differences it may be required to analyze samples from each permeate line to locate the problem:

1. If more Vibro-I units operate in parallel evaluate the permeate from each unit in order to identify the unit in question
2. Isolate the Vibro-I unit in question and drain it for permeate and retentate
3. If the permeate lines are collected in one or two manifolds then re-arrange this to have a single permeate tube from each permeate outlet
4. Run a test production on the unit to analyze permeate samples from each HP1 module. The test setup could be like shown in the below illustration
5. Mark the HP1 module(s) with unacceptable permeate quality



<u>Temporary solution:</u>

When a faulty HP1 module is identified the production can continue by isolating the permeate from the affected module. A pinch valve can be applied on the tubing to squeeze off the permeate tube from the faulty module. During CIP the affected module should have the permeate line open to properly clean the module. Remember to squeeze off again before next production.

Alternatively, the permeate from an affected modules can be directed back to the feed tank.

Note:

The squeeze-off solution can potentially lead to local back-pressure conditions in the isolated HP1 membrane module, and this can lead to further membrane defects in that module.

Permanent solution:

The affected HP1 membrane module is replaced with a new module. Stop the production clean the Vibro-I and drain it. Disassemble the unit and exchange the affected membrane, refer to the section “Assembly and disassembly of the Vibro-I” for detailed instructions. Reassemble the unit and the permeate system. Flush the unit with 55 °C clean water without recirculation for 30 minutes to remove the protective glycerin layer from the new module. CIP clean the Vibro-I unit and restart the production.

E. Flux performance

If the clean water flux performance of the plant drops the cleaning regime may be inadequate for the specific product and process. Consult a qualified chemicals supplier for application specific cleaning regimes.

If the clean water flux indicates a good membrane recovery and the production flux is dropping the likely cause is variations in the feed composition or processing conditions.

Also, a drop in the production flux performance will also happen in case one or both of the cushions are no longer inflated. The cushions are essential for the function of the Vibro® technology and if one or both cushions are deflated the anti-fouiling effect is no longer efficient. Membrane fouling will take place more rapidly and result wil be a drop in the flux.

Please refer to above Section B “Inspection of the Vibro-I cushion assemblies” for trouble shooting of this problem.

F. Maintenance and exchange of the wheels

If the Vibro-I model is on wheels, these are wear parts that will need to be replaced. Regular inspection of the wheels is recommended.

The frequency of such inspection depends on the use of the machine. The estimated lifetime of the wheels is around 1000 hours of operation but the actual lifetime will dependent on conditions such as the floor surface finish for instance.

G. Maintenance and exchange of the industrial springs

The industrial springs supporting the base plate are wear parts and should be replaced after estimated 20.000 hours of operation.

H. Maintenance and exchange of the vibration motors

The vibration motors should be replaced after estimated 30.000 hours of operation.

8. Technical Data

Vibro-I 10 m²

Option: on wheels

Weight	130 kg (full)
Dimensions (L x W x H)	625 mm x 504 mm x 1230 mm
Membrane	4 x 2.5 m² Free Flow Plate Modules (HP1)
Internal Retentate Volume	17,5 l, Fully Drainable
Internal Permeate Volume	2,8 l, Fully Drainable
Operating Pressure	0 - 4 bar at 5 - 35°C, 0 - 3 bar at 5 - 55°C and 0 - 1 bar at up to 80°C
Vibration Motor	400 VAC, 50 Hz, 480 W

Vibro-I 20 m²

Weight	180 kg (full)
Dimensions (L x W x H)	650 mm x 600 mm x 2420 mm
Membrane	8 x 2.5 m² Free Flow Plate Modules (HP1)
Internal Retentate Volume	33.5 l, Fully Drainable
Internal Permeate Volume	5.6 l, Fully Drainable
Operating Pressure	0 - 4 bar at 5 - 35°C, 0 - 3 bar at 5-55°C and 0-1 bar at up to 80°C
Vibration Motor	400VAC, 50Hz, 900 W

Vibro-I 40 m²

Weight	480 / 565 kg (drained / full)
Dimensions (L x W x H)	1000 mm x 860 mm x 1610 mm
Membrane	16 x 2.5 m² Free Flow Plate Modules (HP1)
Internal Retentate Volume	70 l, Fully Drainable
Internal Permeate Volume	11.2 l, Fully Drainable
Operating Pressure	0-4 bar at 5-35°C, 0-3 bar at 5-55°C and 0-1 bar at up to 80°C
Vibration Motor	400VAC, 50Hz, 3,200 W

Vibro-I 80 m2

Weight	660 / 815 kg (drained / full)
Dimensions (L x W x H)	1000 mm x 860 mm x 2660 mm
Membrane	32 x 2.5 m² Free Flow Plate Modules (HP1)
Internal Retentate volume	134 l, Fully Drainable
Internal Permeate Volume	22.4 l, Fully Drainable
Operation Pressure	0-4 bar at 5-35°C, 0-3 bar at 5-55°C and 0-1 bar at up to 80°C
Vibration Motor	400VAC, 50Hz, 3,200 W

Vibro-I Media In/Out

Retentate Standard	1 x DN25 Tri-Clamps (top & bottom) and 1 x 1/2" thread (top)
Retentate Options	Combinations of 1/4", 1/2" 3/4" threads and Tri-Clamps
Permeate Standard	1/4" to 10 mm Push-In Tee Fitting
Permeate Options	1/4" to miniclamp

More options are available upon request

Free Flow Plate™ Membrane Module (HP1) Standard Membranes

Membrane type	Cut-off	Available Membrane Material
Ultrafiltration	1 - 300 kDa	PES, PESH, RC, PVDF
Open ultrafiltration / microfiltration	500 – 800 kDa	PVDF
Microfiltration	0.2 µm, 0.45 µm, 1.0 µm	PES, PVDF, hydrophilic PTFE

The HP1 can be equipped with your membrane of choice. SANI Membranes have a line of standard MF and UF membranes from Synder, Microdyn-Nadir and others on stock. Most commercially available membranes can however also be used with the HP1. Please, do not hesitate to contact us with your membrane wishes.

9. Conformity

The Vibro-I system is CE marked to demonstrate compliance with relevant regulations including the European Machine, Electrical and Pressure Directives.

The Vibro-I can conform to GMP/FDA/EC regulations for materials in contact with food and other sanitary standards on request.