Vibro-I

User 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

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Vibro-I User Manual

Contents

1. Description

1.1. Introduction

Vibro® Membrane Filtration (VMF)
The patented Vibro® technology is an innovative filtration solution for a wide range of applications. It offers low shear impact on the processed media, which is ideal for sensitive products. Furthermore, it requires a minimum of energy and in most cases eliminates the need for cooling of the process.

Unlike conventional Tangential Flow Filtration (TFF), VMF operates independently of feed flow rates. This allows for unique process control, enabling uniform membrane conditions that conventional TFF cannot achieve.

Vibrations are used for controlling the fouling mechanisms by generating shear only at the membrane surface. This eliminates vigorous pumping and dramatically reduces energy consumption for the process. The result is a gentle and efficient technology platform that opens for new ways of optimized micro- and ultrafiltration processes.

Microfiltration with VMF
For microfiltration (MF) applications such as harvest / clarification steps, Vibro® technology makes it possible to control the process at low and uniform Transmembrane Pressures (TMP), enabling high product transmission and significantly higher yield.

As a cell retention device, the Vibro® filtration is ideal due to the low shear impact on the processed medium. Fragile cells are handled with a minimum of cell damage, limiting the release of intracellular components such as host cell protein (HCP) and host cell DNA.

For intracellular products the Vibro® technololgy is ideal for cell harvest delivering high cell concentrations without damaging the cells. Diafiltration can be applied for reducing the levels of extracellular impurities.

Ultrafiltration with VMF
For ultrafiltration (UF) applications, the Vibro® technology allows reaching high concentrations at gentle conditions, saving energy and delivering a consistent product quality with high yields.

The low shear impact is ideal for large biomolecules, preventing aggregate formation during concentration and diafiltration, and for nanolipoprotein particles (NLP), ensuring the particle size distribution unaffected during concentration and buffer exchange steps.

Taking your membrane process further
For continuous processing, the independence of flow rates makes it simple to design and control multi-stage installations.

Single-pass or in-line processing is another attractive processing option, which is an ideal match for the Vibro® technology. With fouling control independent of the flow rates the performance is unlike any other available technology in the market, delivering high conversion rates, and stable, continuous process conditions over extended periods of time.

For traditional batch operation, Vibro® technology is ideal for parallel scale-up, with process scale cartridges from 2.5 m² up to 20 m² and single Vibro® units up to 80 m².

For larger scale applications multiple Vibro-units can be connected in parallel and/or series according to the individual process layout. The elimination of large circulation pumps & pipework enables compact system layouts with very small footprints.

All media contacting parts are in durable polymeric materials or stainless steel.

1.2. Validity

This manual applies to all Vibro-I versions: Vibro-I 2.5 m^2; Vibro-I 5 m^2, Vibro-I 10 m^2; Vibro-I 20 m^2, Vibro-I 40 m^2 and Vibro-I 80 m^2.

This manual applies to the Vibro-I in combination with suitable systems for controlling the process flows and operating conditions, including cleaning in place (CIP) of the system. The design and the degree of automation of said systems can vary a lot depending on the application and other needs of the end-user. A dedicated feed, permeate and CIP system should be designed and constructed in collaboration with the end-user.

1.3. 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.

2. System

2.1. System description

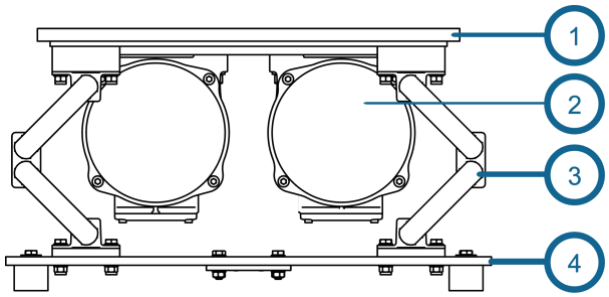
The Vibro-I unit is a membrane filtration system consisting of a mechanical part, the Vibro-I Drive, providing the vibrational movement, and a membrane filtration part, the Vibro-I Cartridge, where the filtration process takes place.

The Vibro-I Cartridge is a self-contained membrane device ready to be installed on the Vibro-I Drive. The configuration of each Cartridge (membrane selection, ports, installed permeate system, etc) varies, depending on the individual requirements. In all cases, the Cartridge is delivered ready to install on the Vibro-I Drive, and ready to be connected to a process control system.

Vibro-I Drive	**Vibro-I Cartridge** quantity x size	**Required accessories**
Vibro-I Drive 2.5, 5, 10	1 x 2.5 m²	Drive adapter for 2.5 & 5 m² Cartridges
	1 x 5 m²	Drive adapter for 2.5 & 5 m² Cartridges
	1 x10 m²	
Vibro-I Drive 20	1x 20 m²	
Vibro-I Drive 40	4 x 10 m²	Vibro-I 40 m² Manifold System
Vibro-I Drive 80	4 x 20 m²	Vibro-I 80 m² Manifold System

2.1.1 Vibro-I Drive

The Vibro-I Drive generates the vibrations for the Vibro-I unit. It consists of:



Part List:

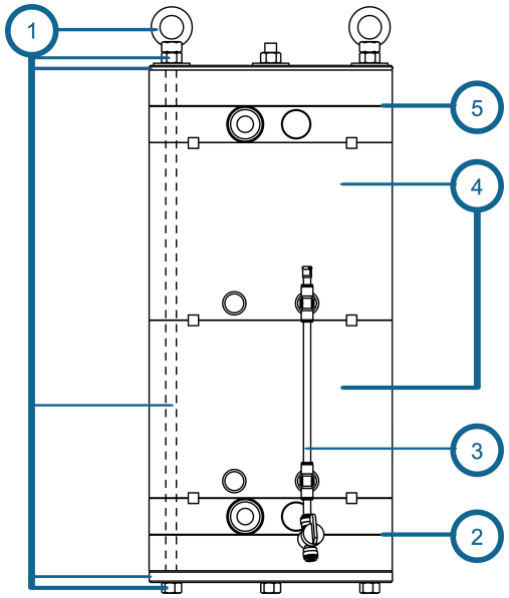
1. Base plate
2. 2 x Vibro-I motors
3. 4 x elastic elements
4. Vibro-I installation frame

The two Vibro-I motors (2) together with the four elastic elements (3) create the vibrations for the unit. The motors are adapted to the specific cartridge size of the Vibro-I unit. The Vibro-I Drive 2.5, 5, 10 is directly compatible with 10 m² Cartridges, and by using a drive adapter, also compatible with 2.5 and 5 m² Cartridges. The larger units are only compatible with one size each.

The base plate (1) is configured for mounting one or four Vibro-I Cartridges depending on the Vibro-I unit size. The Vibro-I Cartridge(s) are fixed to the base plate using four bolts for each cartridge.

The Vibro-I installation frame (4) provides the basis for correct installation. For The Vibro-I Drive 2.5, 5, 10 the installation frame is fitted with lockable wheels. For flexible production environments, the Vibro-I 20, 40 & 80 m^2 can be supplied with a moveable platform suited for pallet lifters. Otherwise, these units are designed for permanent installation on the floor or on a larger support structure. A foundation plan for correct floor installation is available for each unit upon request.

2.1.2 Vibro-I Cartridge



The Vibro-I cartridge consists of:

1. Cartridge assembly parts (base plate, top plate, rods, nuts and eye-bolts)
2. Cartridge Bottom with integrated Vibro cushion and media port(s) for connection to feed line
3. Permeate manifold
4. Module(s) with the selected membrane installed, and integrated permeate channel(s)
5. Cartridge Top with integrated Vibro cushion and media outlet port(s) for connection to retentate line and vent (optional)

The Vibro-I Cartridge consists of a number of 2.5 m² modules (4) with the selected membrane. Each module has integrated port(s) for permeate discharge and the cartridge is supplied with an optional permeate manifold (3) for connecting the permeate lines to the process control system. The Cartridge Bottom (2) and Top (5) provides for the liquid connections between the main feed and retentate lines of the process control system. The cartridge is fitted between a stainless steel base plate and top plate to ensure the correct and even assembly compression of the internal gaskets.

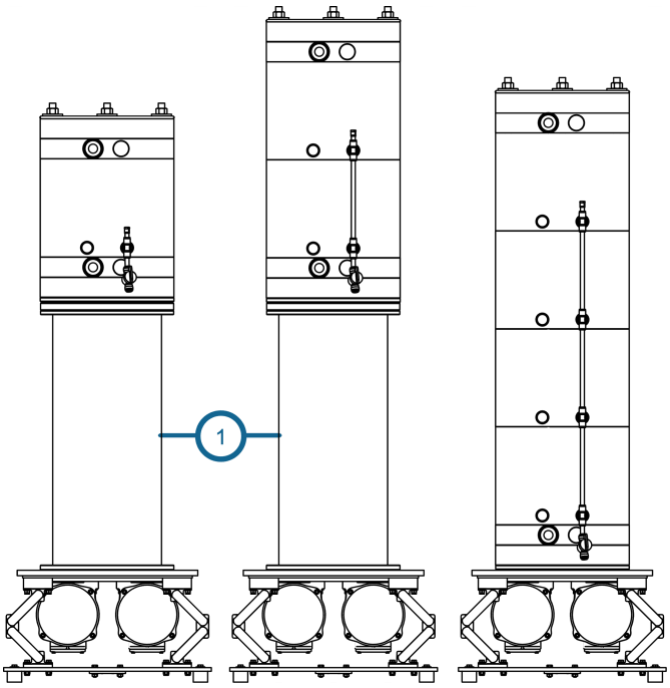
The Cartridge is supplied with two eye-bolts for lifting the cartridge during installation. The eye-bolts can be removed when the Cartridge has been installed.

2.1.3 Adaptor

The Vibro-I 2.5 m², 5 m² and 10 m² Cartridges are all compatible with the same Vibro-I Drive 2.5, 5, 10.

For the Vibro-I 2.5 & 5 m² Cartridges, an adaptor (1) is needed to ensure the correct height and total mass. This ensures the correct performance, and that the vibrational movement is stable and consistent.

Do not attempt to use the Vibro-I 2.5 & 5 m² Cartridges without the adaptor, as this could lead to an unstable system **WARNING**



2.1.4 Module

Each Vibro-I Cartridge consists of a number of 2.5 m² Modules containing the filter element itself. The Modules are an integrated part of a cartridge, and should only be replaced by a SANI Membranes authorized person.

2.1.5 Cartridge Bottom / Cartridge Top

The Cartridge Bottom and Top provide the media connections between the membrane and the process control system. The media inlet/outlet parts are configured with one or two inlet/outlet ports. The ports are for the feed and retentate connections but can also be used for connecting to a vent.

The integrated cushions of the Bottom and Top are essential for the correct functioning of the Vibro® technology. New cartridges are supplied with cushions pre-inflated for the correct Vibro-effect. During use, the cushions may deflate over time and should therefore be inspected on a regular basis. In case of a deflated cushion the entire Bottom or Top should be replaced to ensure the correct and optimal performance of the system. This operation should be carried out by a SANI Membranes authorized person.

2.1.6 Permeate manifold

Each module can be configured with one or two open permeate ports. In the standard configurations one is blinded, and the other is configured with a push in T-connection. As an alternative option the permeate port can be configured with a Mini-TC clamp connection. For high-flux applications, both permeate ports can be configured open.

The standard configuration includes a permeate manifold joining the push in T-connections of the 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 via the process control system to a permeate collection vessel.

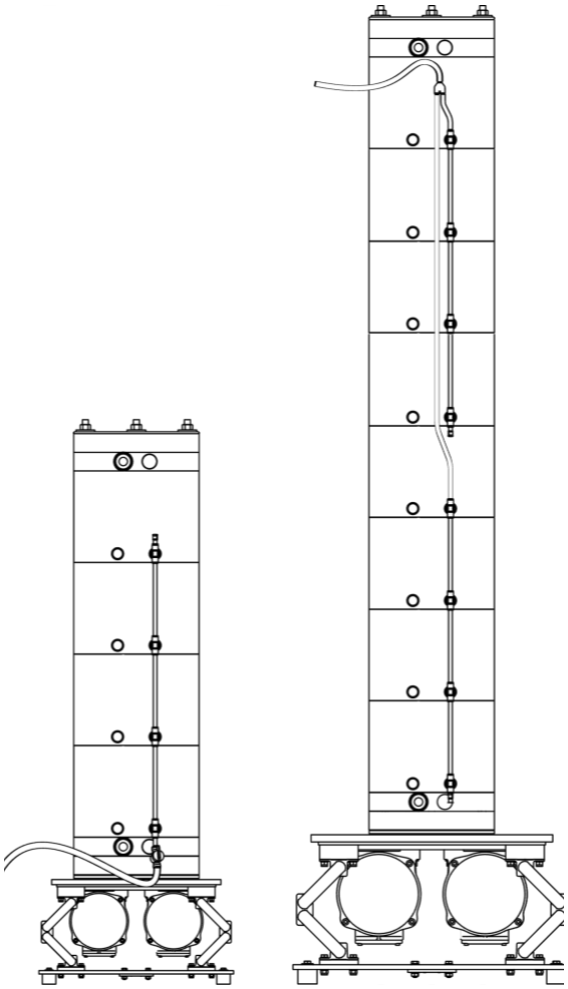
For microfiltration applications the permeate is collected from the top of the manifold, and the blind plug is placed at the bottom. This configuration helps to ensure that the transmembrane pressure is uniform throughout the entire membrane area. For ultrafiltration it is not as critical, and the standard permeate manifold for ultrafiltration is provided with the drain line at the bottom. These are the default configurations, but the manifold can be reassembled according to preference.

Once the system is filled with liquid it is not recommended to drain the permeate volume. In case this is anyway required, draining of the permeate volume can be facilitated by installing a vent valve instead of the blind plug at the closed end of the manifold.

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 4-port manifold with push in 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. When used for the 80 m² units the drain lines are joined in an 8-port manifold with push in fittings.

The 40 and 80 m² units also include liquid manifolds for the feed and retentate lines. These manifolds as well as the permeate manifold are to be flange mounted to Customer's firmly supported (static) feed and retentate lines at specific height and position relative to the Vibro-I units. Each manifold is then connected by flexible hoses to the 4 Cartridges. Installation details are available upon request.

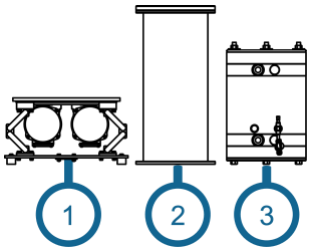


10 m² for ultrafiltration permeate flows down

20 m² for microfiltration permeate flows upwards

2.2. Part List

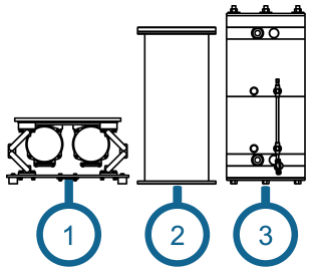
Vibro-I 2.5 m²



Part List:

1. Vibro-I 10 Drive
2. Vibro-I 2.5 & 5 Adaptor
3. Vibro-I 2.5 Cartridge

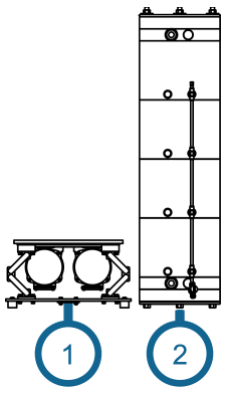
Vibro-I 5 m²



Part List:

1. Vibro-I 10 Drive
2. Vibro-I 2.5 & 5 Adaptor
3. Vibro-I 5 Cartridge

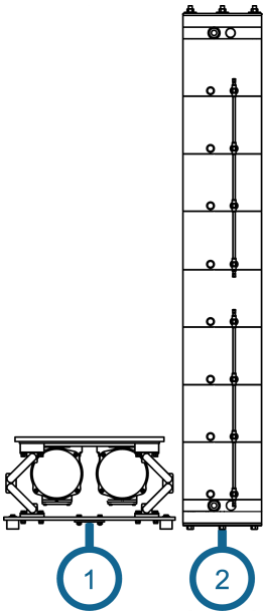
Vibro-I 10 m²



Part List:

1. Vibro-I 10 Drive
2. Vibro-I 10 Cartridge

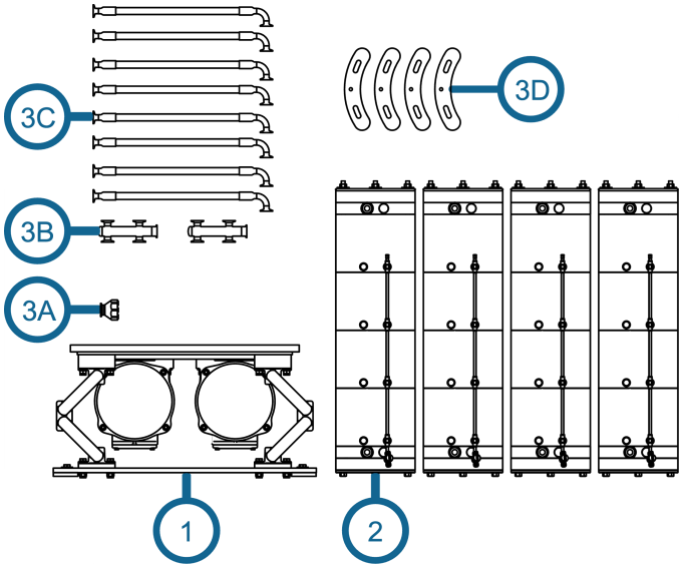
Vibro-I 20 m²



Part List:

1. Vibro-I 20 Drive
2. Vibro-I 20 Cartridge

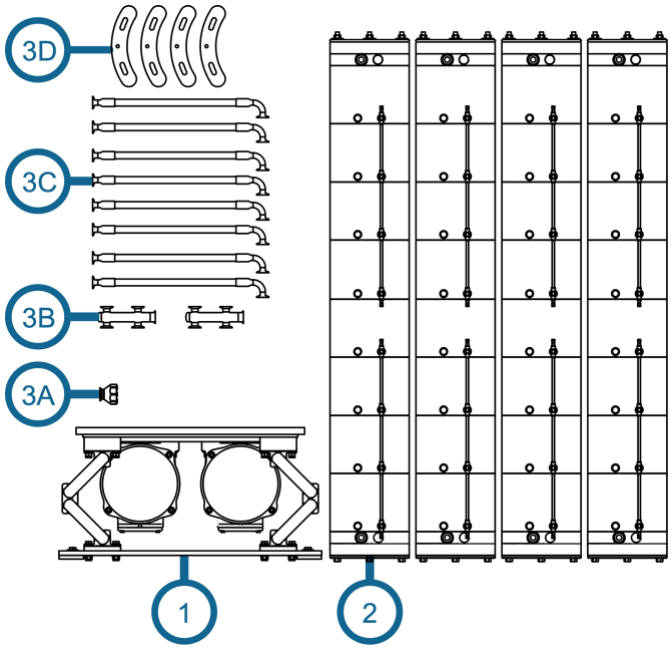
Vibro-I 40 m²



Part List:

1. Vibro-I 40 Drive
2. 4 x Vibro-I 10 Cartridges
3. Vibro-I 40 m² Manifold System:
   A: Permeate Manifold, 4 ports
   B: 2 x Feed inlet/retentate Manifold
   C: 8 x Hose
   D: 4 x Top locking brackets

Vibro-I 80 m²



Part List:

1. Vibro-I 80 Drive
2. 4 x Vibro-I 20 Cartridges
3. Vibro-I 80 m² Manifold System:
   A: Permeate Manifold, 8 ports
   B: 2 x Feed inlet/retentate Manifold
   C: 8 x Hose
   D: 4 x Top locking brackets

3. Safety

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.

3.1. 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 Vibro-I Cartridges from SANI Membranes.

The Vibro-I must 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 Vibro-I Cartridge 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 or feed system used.

3.2. 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.

3.3. 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 (e.g. handling and storage and conduct in emergency situations). ⚠ **WARNING**

Personal safety equipment should always be worn when applicable (e.g. safety googles, 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 and the feed system used. **ATTENTION**

3.4. 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 Vibro-I including the Vibro-I comprise 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**

3.5. Leaking fluids

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

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

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

3.6. Moving parts

Body parts can be crushed when they come into contact with moving parts, e.g. the membrane assembly. 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 should be fixed mechanically in the shop. When supplied as a movable configuration, the Vibro-I must be levelled, and placed on a horizontal surface as the vibrating movement can otherwise make the equipment move during operation which can lead to a hazardous situation. ⚠ **CAUTION**

3.7. 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**

3.8. Accessories and spare parts

The Vibro-I can only be used together with a feed system that provides a maximum pressure of 4 bar(g). If the system is capable of providing more than 4 bar(g) a CE approved safety valve set to maximum 4 bar(g) must be used.
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.

4. Assembly

4.1. Tools required for installation and maintenance

Tools	Size
Spanners	19 & 24 mm (and 22 mm if vent port is included)
Torque Wrench	35 – 120 Nm (14 x 18 mm insert)
Ratchet insert for torque wrench	14 x 18 mm insert
Sockets for torque wrench	24 mm
Spanner for torque wrench	24 mm (14 x 18 mm insert)

For Vibro-I 2.5 and 5 m², additionally:

Tools	Size
Socket for torque wrench	19 mm

For Vibro-I 40 and 80 m², additionally:

Tools	Size
SANI Membranes torque extender	14 x 18 mm insert

For movable configurations, additionally:

Tools	Size
Torque Wrench	200 Nm
Spanner for torque wrench	30 mm

4.2. Installation of the Vibro-I Drive

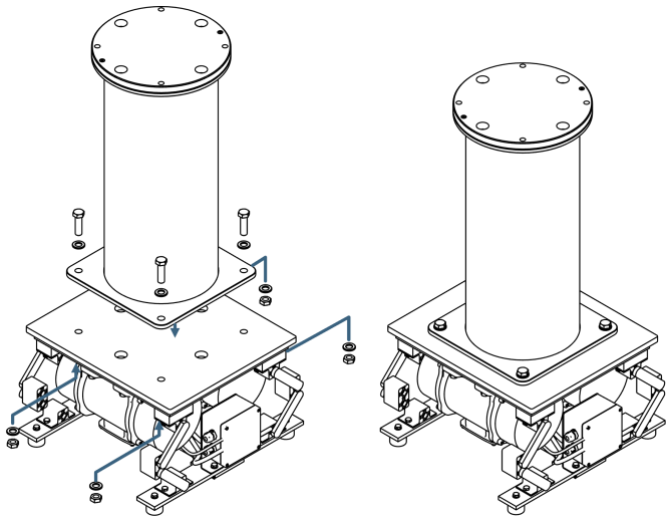
Start by unpacking and moving the Vibro-I drive to the intended location. For permanent installations, the drive should be bolted to the floor. A foundation plan for each unit is available upon request.

The Vibro-I units can be supplied on a moveable platform for non-permanent installations. This is suited for use with a pallet lifters and makes it easier to move the units without lifting equipment.
The Vibro-I Drive for 2.5, 5 & 10 m² units are supplied on wheels as standard, and can alternatively be supplied on machine feet.

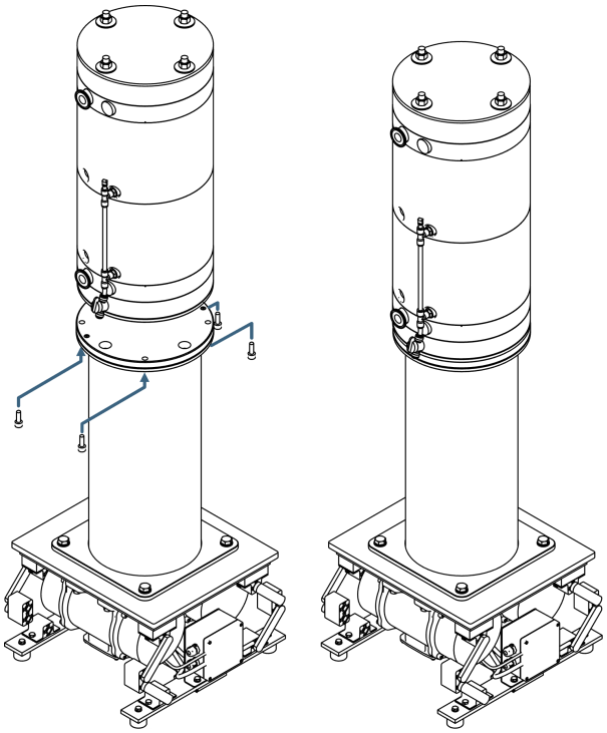
In all cases make sure to adjust the equipment so that the base plate is levelled.

4.3. Installation of cartridge 2.5 & 5 m²

1. Place the Vibro-I 2.5 & 5 Adaptor onto the Vibro-I Drive.
2. Secure the adapter with 4 x M16 x 50 mm bolts and M16 nuts (add washers on each side).
3. Tighten the bolts with 100-120 Nm.

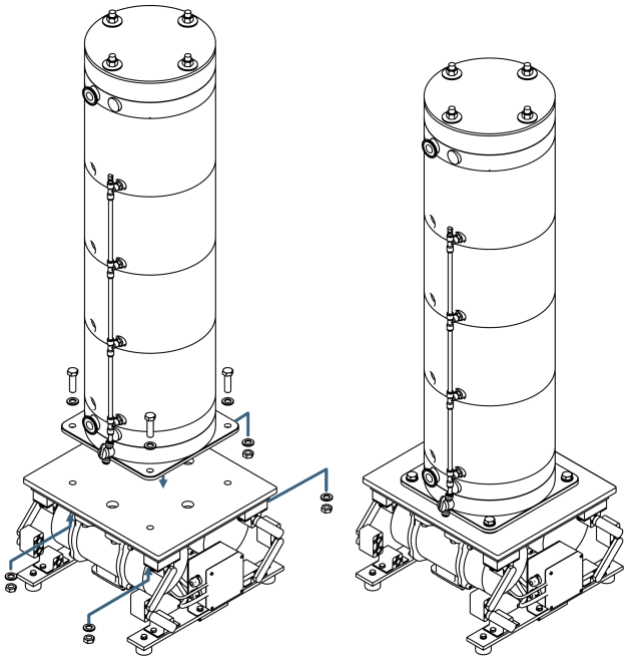


4. Place the cartridge onto the Vibro-I 2.5 & 5 Adaptor (align the nuts to the groves of the plate).
5. Secure the adapter with 4 x M12 x 40mm screws.
6. Tighten with Approx. 65 Nm.



4.4. Installation of cartridge 10 & 20 m^2

1. Place the Vibro-I Cartridge onto the Vibro-I Drive
2. Secure the Cartridge bottom plate with 4 x M16 x 50 mm bolts and M16 nuts (add washers on each side)
3. Tighten the bolt with 100-120 Nm

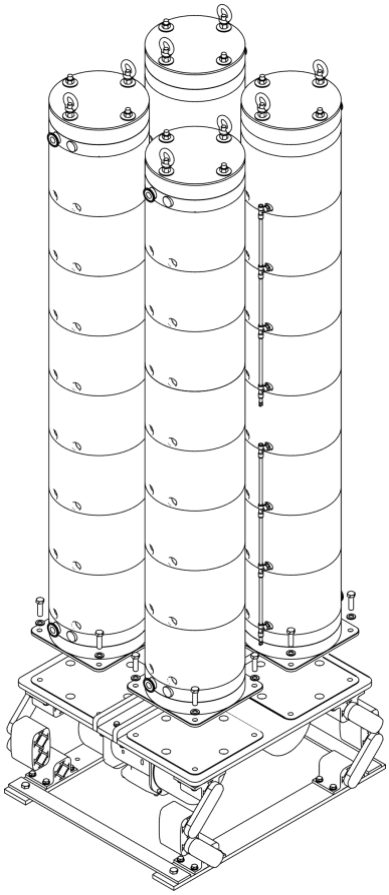


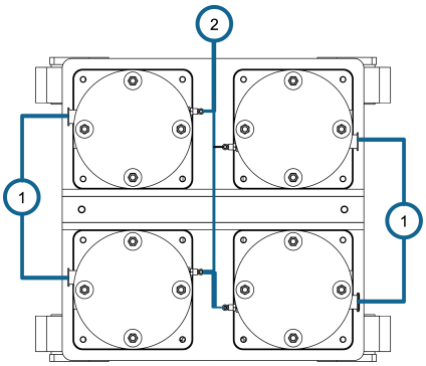
4.5. Installation of cartridge 40 & 80 m²

⚠ **WARNING**

1. Place one of the Vibro-I Cartridges onto the Vibro-I Drive by lifting it in the lifting eyes placed on the top rods.
2. Make sure that the feed-Inlets (1) are pointing outwards, and that the permeate outlets (2) are faced towards the center.
3. Secure each Cartridge with 4 x M16 x 55 mm bolts and add washers.
4. Tighten each bolt with 100-120 Nm.
5. Repeat steps 1 – 3 for the next three cartridges – ensuring to orient them correctly.
6. For the last bolt towards the center a special extender tool is required for the torque wrench for correct tightening.
   Important: Reduce the torque setting for the torque wrench as prescribed on the extender tool when using this: The extra arm using the extender changes the resulting torque on the bolt.

Install one cartridge at the time, and make sure it is securely fastened before moving on to the next. ⚠ **WARNING**





4.6. Installation of manifold system 40 & 80 m²

1. Position the 4 locking brackets between the cartridges over the central rods to lock the position of the four cartridges, see Figure 1. Use a washer below and above each bracket (see Figure 2, detail 6).
2. Apply and tighten the nuts holding the top locking brackets in place. These should be tightened to 100 – 120 Nm
3. Install two hose supports to the side of the Vibro-I Drive Base plate (Figure 2, detail 5)
4. Attach the feed and retentate hoses as shown in Figure 2 (1: 1200 mm, 2: 800 mm, 3: 1100 mm, 4: 725 mm), using a gasket and a tri-clamp.
5. Place the two long feed hoses in the hose clamps (Figure 2, detail 5).
6. Connect the other end of the hoses to the manifold using a tri-clamp and gasket.
7. Each cartridge of the 40 m^2 has a single permeate line and each cartridge of the 80 m^2 has two permeate lines (they are split into a bottom and a top half).
8. Connect the top of each permeate line to the permeate manifold using 10 mm tubing.
9. To prevent the PU tubing from moving around during vibrations; Use cable ties to fix the free lengths of tubing from the lower permeate lines to the upper permeate line (Figure 3, red arrows), and collect the 4 (40 m²) or 8 tubings (80 m²) to form a bundle at the top.

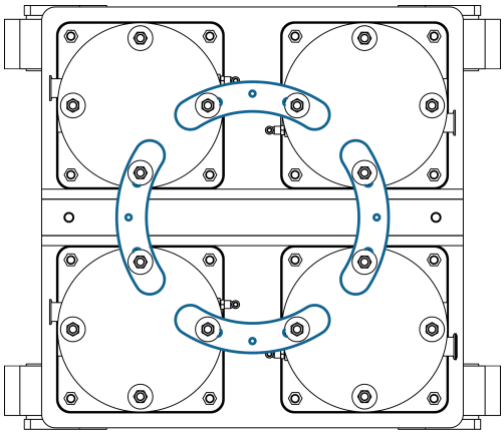


Figure 1

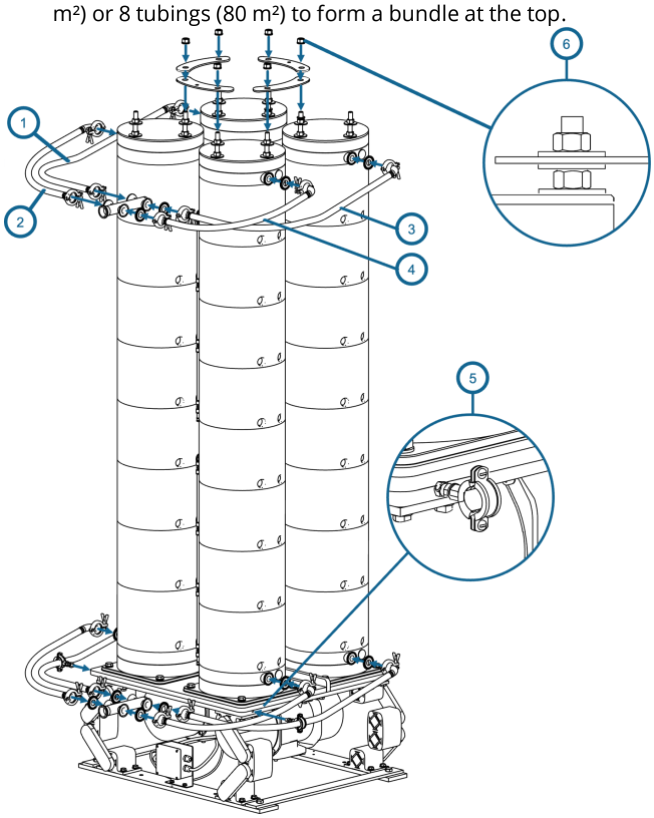


Figure 2

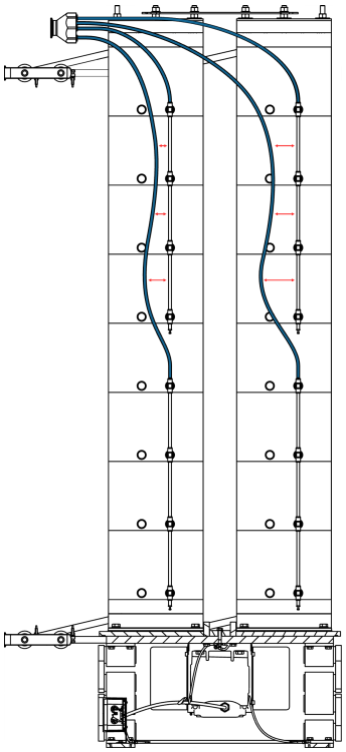


Figure 3

5. Operation

5.1. Important considerations for correct use

Membrane systems are in general sensitive to rapid changes in flow, pressure and temperature. For automated operation, measures should be taken that prevent abrupt changes of such conditions. These measures can include ramp-up time for pumps, moderate PID regulation parameters, well-planned valve schedules with delays, etc.

For the Vibro-technology it is furthermore important to establish a flow of liquid on the feed/retentate side before activating the vibrations, and similarly to turn off the vibrations once the feed flow is stopped. Automated systems should be designed with a dependency between a measured flow or pressure on the retentate side, and the activation of the vibration motors.

Avoid any situation that can cause a backflow from the permeate side to the feed/retentate side of the membrane:

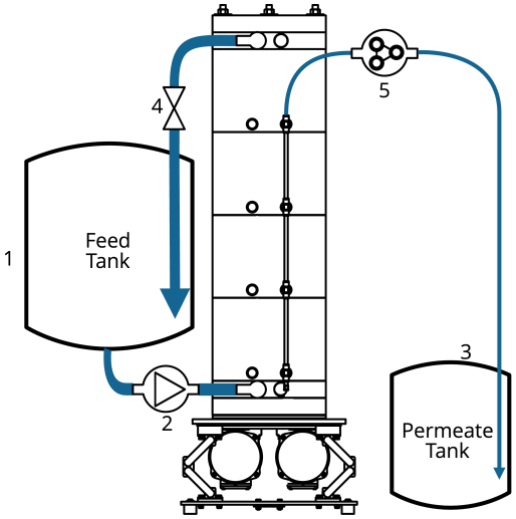
- At all times, avoid the creation of negative transmembrane pressure (TMP).
- Never drain the feed/retentate side without efficient venting of the retentate line.
  NOTE: Without efficient venting, suction during drainage can create negative TMP and damage the membranes.
- If the permeate collection vessel is at a higher level than the feed tank, include a non-return valve on the permeate line. This will prevent a back flow due to the level difference when the system is stopped.

Please consult SANI Membranes on any questions regarding the design and control strategy for automated membrane systems.

Prevent the introduction of foreign objects, sharp particles, etc. that may damage the membranes. It is recommended to pass the feed liquid through a 400 µm pre-filter or strainer, to prevent physical damage of the membrane surface.

The Vibro® technology can process feed streams with suspended particulate materials. Abrasive materials, however, may damage the membranes or other parts of the system over time. Lab studies can help to establish if this will be the case.

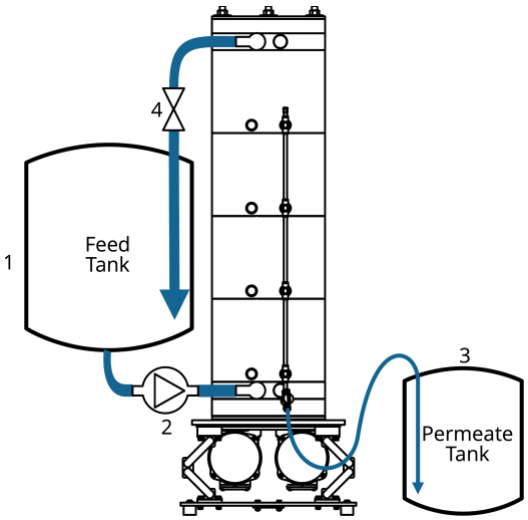
5.2. Introduction to microfiltration setup



Components:

1. Feed tank
2. Feed pump
3. Permeate tank
4. Retentate regulation valve
5. Optional flow-restricting permeate pump

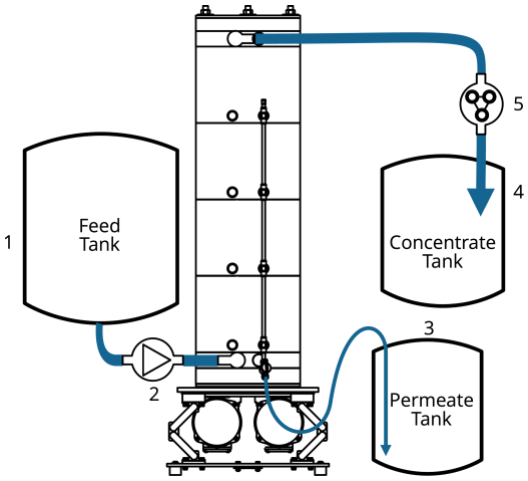
5.3. Introduction to Ultrafiltration setup



Components:

1. Feed tank
2. Feed pump
3. Permeate tank
4. Retentate regulation valve

5.4. Single-pass or in-line concentration



Components:

1. Feed tank
2. Feed pump
3. Permeate tank
4. Concentrate tank
5. Flow-restricting concentrate pump

5.5. Conditioning of new membranes

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

SANI Membranes recommend to connect the new Cartridge to the process control system, and flush the membrane for 30 minutes with clean hot water (50-55 °C). Establish a positive transmembrane pressure (TMP) to force liquid through the membrane's porous layer. Activate the vibrations only when having established a positive TMP and flow through the permeate line.

For the first 5-10 minutes lead both the retentate and the permeate streams to drain without any recirculation. Once a stable permeate flow has been established, the retentate can be recirculated, while the permeate is sent to drain for the full duration of the flush.

After this rinse it is recommended to perform a cleaning in place (CIP) cycle, followed by another clean water rinse.

5.6. Determine initial normalized water permeability (NWP)

Before introducing product on the membrane, it is recommended to measure the Normalized Water Permeability (NWP) of the new membrane. This value is essentially the flux at a reference temperature (normally at 25 °C) and a given transmembrane pressure (TMP). It is useful to monitor the NWP throughout the lifetime of the membrane as a benchmark for the efficiency of the CIP after each production.

NWP is calculated this way:

$$\text{NWP [L/m}^2\text{/h/bar @25 °C]} = \text{Flux [L/m}^2\text{/h]} / \text{TMP [bar]} * \text{TCF}$$

where TCF is a temperature correction factor.

It is important to note that the measured TMP is influenced by the specific installation, especially the piping and instrumentation between the Vibro-unit and the pressure sensors. Hence, the NWP will always be a specific reference for each installation. Most membrane manufacturers indicate typical NWP range for their membrane, however this information can be misleading, as these values are measured in a laboratory setup where the pressures are measured right at the membrane.

Always aim to measure the NWP value at the same conditions (recirculation flow rate, temperature and TMP). This will ensure that the dynamic pressure drops in the pipework and tubing is similar for each measurement. A temperature conversion table is available upon request.

5.7. General guidelines – process

Vibro® membrane filtration (VMF) is different from traditional Tangential Flow Filtration (TFF) and to unlock the full potential of VMF the optimal operating conditions should be established through experimental work.
Below are some general guidelines for the processing:

1. Avoid operating the unit at excessive flux leading to fast and irreversible fouling of the membranes.
2. Always maintain a positive TMP or a controlled permeate flow through the membranes when the vibration mode is on.
3. Maintain a minimum retentate flow out of each cartridge to avoid over-concentration of retained material, leading to dead-end type filtration. A suitable retentate flow for normal batch operation is normally 800 – 1200 L/h per cartridge.
4. 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 stage in a continuous multi-stage line.
5. For single-pass or in-line concentration processes, low retentate flow rates apply. In this case, thorough optimization is required to establish a stable retentate flow range.

Microfiltration

1. The optimal trans membrane pressure (TMP) for VMF microfiltration is often very low, and typically in the range 0.05 – 0.5 bar.
2. For microfiltration processes where transmission of product is essential, restricting the permeate flow is often preferred over controlling of the TMP.
3. To control the process at very low TMP values a flow restricting regulation of the permeate is required. Consider to use a positive displacement pump for this.
4. Without flow restriction on the permeate line, the initial flux can be very high even at low TMP values. This may result in early and irreversible fouling of the unit.

Ultrafiltration

1. Ultrafiltration is less sensitive to pressure variation.
2. Optimum TMP is often lower than what is seen for traditional TFF. Typically, the ideal TMP using Vibro technology is between 1 – 2 bar.
3. Make sure that the system pressure does not exceed 4 bar(g) at ambient temperature – using a 4 bar(g) safety valve or a 4 bar(g) software hard stop. ⚠ **WARNING**
4. Temperature dependent max. 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**

5.8. CIP operation

The following procedure is a general guideline for the cleaning of the Vibro-I. The individual process and product may require an optimization of the cleaning procedures to achieve satisfactory cleaning results. The selection of CIP chemicals, their concentration and the temperature used should be made in accordance with the chemical compatibility of the individual membrane.

For each cleaning step ensure that liquid also flows through the permeate line. This is done by adjusting the retentate valve to generate higher TMP. If the system is configured with a positive displacement pump for permeate flow control it may be necessary to establish a parallel by-pass of this pump to allow for sufficient permeate flow during CIP.

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

1. A 55 °C hot water flush to remove loosely attached material and warm up the system before CIP.
2. A 30 min 55 °C caustic wash at pH 11-12 with an appropriate CIP chemical (observe membrane compatibility).
3. A water flush to replace the caustic liquid.
4. A 15-20 min 55 °C acid wash at pH 2 with an appropriate CIP chemical (observe membrane compatibility).
5. A thorough water flush.

Please consult a qualified chemicals supplier for application specific cleaning regimes.

After cleaning the membrane, the normalized water permeability (NWP) should be measured (please ref. to 5.6). Although it is membrane and application dependent, a recovery of 80% or more of the initial water flux is typically seen from a suitable cleaning regime.

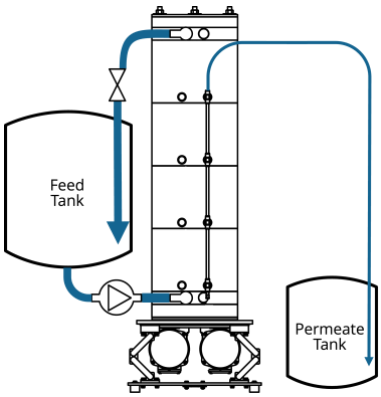
6. Examples of process configurations

The system can be configured and operated in a number of different configurations, depending on the type of product, membrane and process objective. The most commonly used are the batch configurations described in the previous sections.

In the following a few other configurations are listed along with a brief description of the main purpose of each one. A 10 m² unit is used for illustration but the configurations are applicable for any size of unit, and for multiple parallel units.

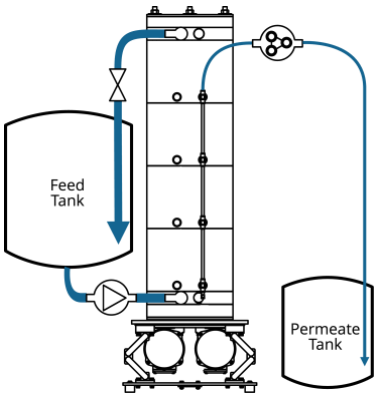
6.1. Membrane filtration batch mode with concentration tank

- 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.



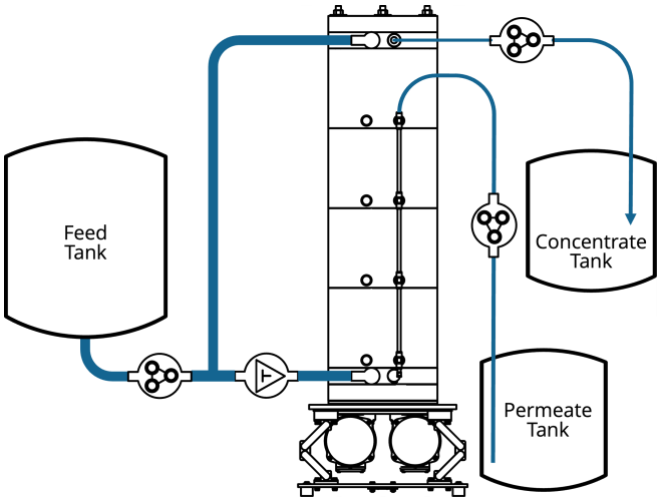
6.2. Microfiltration batch mode with permeate flow control pump

- 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 flow rate in order to keep a low transmembrane pressure.
- Reduces fouling and enables high protein transmission.
- This approach can be advantageous with other configurations too.



6.3. Continous 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 inside the membrane unit.
- 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.
- This setup is useful for simulating an individual stage in a multi-stage membrane installation



6.4. Single-pass or in-line concentration

- Configuration for truly continuous processing of liquids
- The medium is fed to the membrane from a feed tank, and being processed in single step operation.
- In the simplest case one unit separates the retentate and permeate in one step, by regulating the flows to the desired volumetric concentration factor (VCF).
- Where needed, the process can be split on more units, and combined with diafiltration between the stages.

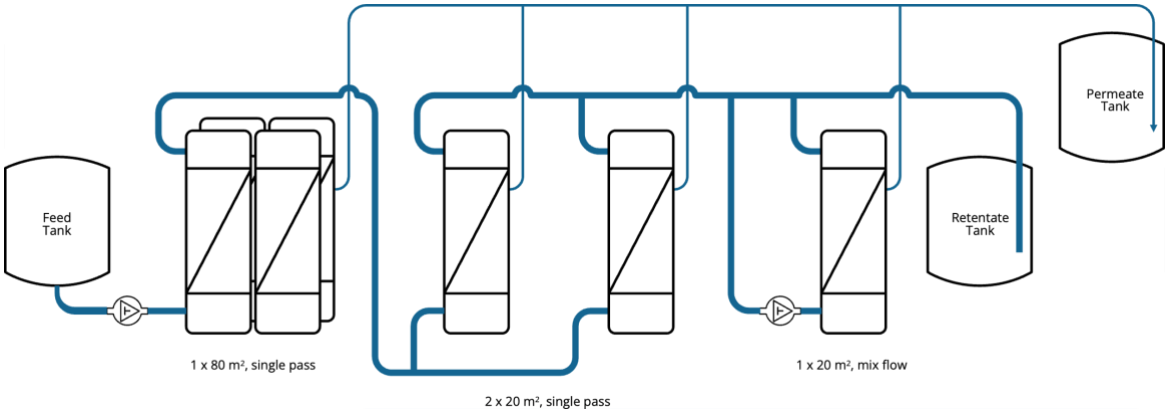
6.5. Example of three-stage system

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 developed to meet the requirements of each industrial application including CIP system, degree of automation, temperature control system etc.



7. Maintenance

7.1. General Maintenance

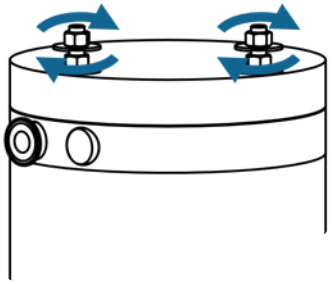
All intervention

Inspection & recommended service intervals	
Cartridge bottom and top (A drop in flux may be due to fault in cushion inflation.)	Inspect cushions every 3-6 mth. Change with new cartridge or during yearly service
Wheels (on smaller Vibro-I Units)	Expected lifetime 1000 hours of operation. Replacement during yearly service
Elastic elements	Monitor clearance and inspect the rubber at yearly service Expected lifetime approx. 20,000 hours or 3 yrs. Replacement during scheduled service
Vibration motors	Expected lifetime approx. 30,000 hours or 10 yrs Replacement during scheduled service
Mounting bolts	Supplied with new cartridge Expected lifetime approx. 3,000 hours Replacement with new cartridge or during yearly service

7.1.1. Tightening and re-tightening the Vibro-I top nuts

The 4 nuts on top of each module tower must be tightened with a torque wrench adjusted to:

2.5 m²	35 Nm
5 m²	35 Nm
10 m²	38 Nm
20 m²	42 Nm

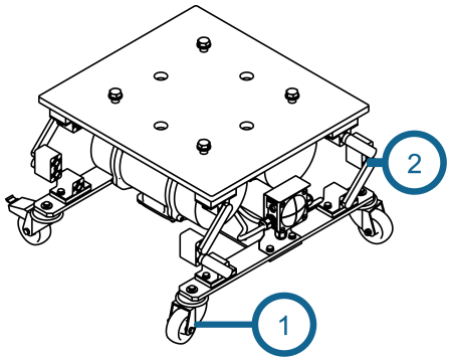


(The nuts must be re-tightened once after 8 hours in operation of the Vibro-I after each re-assembly).

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.

7.1.2. Maintenance and exchange of the wheels

If the Vibro-I model is on wheels (1), it is recommended that they are inspected regularly. These are wear parts and will need to be replaced eventually. The lifetime of the wheels will dependent on conditions such as the floor surface finish for instance.



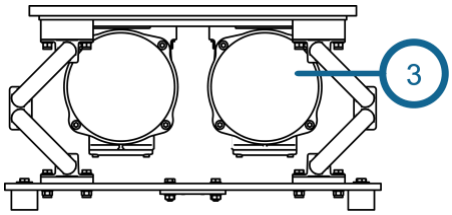
7.1.3. Maintenance and exchange of the elastic elements

The elastic elements (2) supporting the base plate are wear parts and should be replaced according to the above guidance.

Replacement of the elastic elements should be done by SANI Membranes during scheduled service.

7.1.4. Maintenance and exchange of the vibration motors

The vibration motors (3) are wear parts and will need to be replaced eventually. Both motors should be replaced at the same time to ensure the correct and well-balanced vibrating effect.



Replacement of the Vibration motors should be done by SANI Membranes during scheduled service.

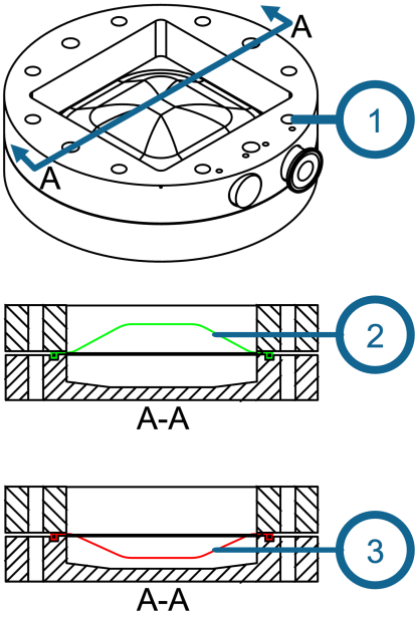
7.1.5. Tightening and re-tightening of mounting bolts

The four bolts mounting the cartridges to the drives must be re-tightened with 100 – 120 Nm on a regular basis, preferably, once a quarter. Remember to tighten bolts in a cross pattern.
The four bolts mounting the cartridges to the Vibro-I Drive will wear over time. Install the new bolts that are supplied with every new cartridge. Replace bolts preventatively at least during annual service in case of prolonged use of cartridges.

7.1.6. Inspection of the Vibro-I cushion

The Cartridge bottom and top (1) has an integrated cushion which is a wear part that should be inspected regularly. New cushions will be filled with air as shown in (2). Through regular operation the cushions may gradually deflate, as illustrated (3) and as a result impact negatively on the Vibro® effect.
To inspect the cushions:

- Drain the Vibro-I unit from liquid.
  Note: Always remember venting when draining the unit.
- Disconnect the feed and retentate hoses from the port connections
- Look through the port to visually check if the cushion is still inflated
- The top of a fully inflated cushion reaches to about the halfway of the port opening. If the cushion top is lower but still clearly visible, the Vibro-effect is still functioning.
- If the cushion is not visible it is likely deflated (3) and should be replaced with the next scheduled service.



7.1.7. 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-fouling effect is no longer efficient. Membrane fouling will take place more rapidly and result will be a drop in the flux.

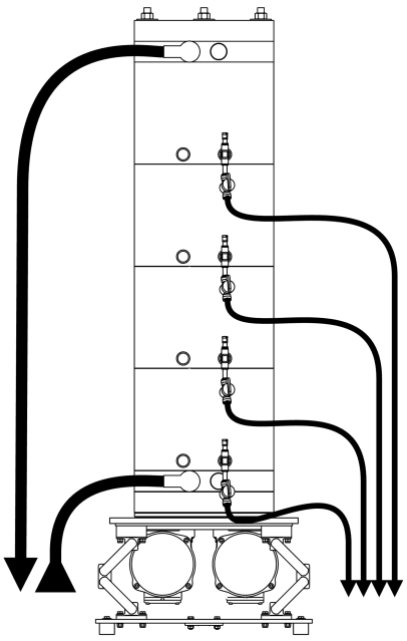
Please refer to previous section for how to inspect the Vibro® cushion.

7.1.8. Permeate quality

If permeate quality is not acceptable, one of the filter modules might have a defect membrane. Identify the defect module by evaluating the permeate from each individual module and isolate the faulty module. In some cases, 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:

- If more Vibro-I units operate in parallel evaluate the permeate from each unit in order to identify the unit in question
- Isolate the Vibro-I unit in question and drain it for permeate and retentate
- 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
- Run a test production on the unit to analyze permeate samples from each module. The test setup could be like shown in the below illustration
- Mark the module(s) with unacceptable permeate quality



Temporary solution:
When a faulty 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 module, and this can lead to further membrane defects in that module.

Permanent solution:
The affected module is replaced by a new module. This should be done by SANI Membranes to ensure that no other membranes are damaged in the process, and the overall integrity of the Cartridge is ensured.

Remember to go through the initial conditioning steps (5.5) when a new module has been installed.

7.2. Storage of membranes

If the Vibro-I is not used for a period of time, the membrane must be preserved in a suitable storage solution. This is mainly to prevent microbial activity, while keeping the organic membranes wetted. If membranes are allowed to dry out they will become damaged and will need to be replaced.

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

Examples of Storage solutions:
0.1 N NaOH
20% Ethanol
20% Isopropanol

Prepare a sufficient amount of storage solution in the feed tank or in a container connected to the unit. Feed the solution to the cartridge and recirculate the retentate to the feed tank / container. Keep the permeate line open and if connected to a flow restricting pump ensure that this is running. Recycle both streams for some time to ensure that the liquid is distributed to the entire cartridge. Isolate the supply lines to keep the storage solution inside the cartridge.

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

8. Technical Data

Vibro-I 2.5 m² on wheels Option: Machine feet or Movable platform (700 mm x 700 mm)	
Weight	160 kg (full)
Dimensions (L x W x H)	608 mm x 570 mm x 1545 mm (with wheels)
Membrane	1 x 2.5 m² Free Flow Plate Modules (HP1)
Internal Retentate Volume	5.5 L
Internal Permeate Volume	0.7 L
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
Vibration Motor	400 VAC, 50 Hz, 540 W

Vibro-I 5 m² on wheels Option: Machine feet or Movable platform (700 mm x 700 mm)	
Weight	180 kg (full)
Dimensions (L x W x H)	608 mm x 570 mm x 1790 mm (with wheels)
Membrane	2 x 2.5 m² Free Flow Plate Modules (HP1)
Internal Retentate Volume	9.5 L
Internal Permeate Volume	1.4 L
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
Vibration Motor	400 VAC, 50 Hz, 540 W

Vibro-I 10 m² on wheels Option: Machine feet or Movable platform (700 mm x 700 mm)	
Weight	174 kg (full)
Dimensions (L x W x H)	608 mm x 570 mm x 1596 mm (with wheels)
Membrane	4 x 2.5 m² Free Flow Plate Modules (HP1)
Internal Retentate Volume	17.5 L
Internal Permeate Volume	2.8 L
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
Vibration Motor	400 VAC, 50 Hz, 540 W

Vibro-I 20 m² Option: Movable platform (1000 mm x 1000 mm)	
Weight	264 kg (full)
Dimensions (L x W x H)	584 mm x 625 mm x 2520 mm
Membrane	8 x 2.5 m² Free Flow Plate Modules (HP1)
Internal Retentate Volume	33.5 L
Internal Permeate Volume	5.6 L
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
Vibration Motor	400 VAC, 50 Hz, 1240 W

Vibro-I 40 m² Option: Movable platform (1200 mm x 1200 mm)	
Weight	545 kg (full)
Dimensions (L x W x H)	1000 mm x 860 mm x 1650 mm
Membrane	16 x 2.5 m^2 Free Flow Plate Modules (HP1)
Internal Retentate Volume	70 L
Internal Permeate Volume	11.2 L
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
Vibration Motor	400 VAC, 50 Hz, 3,140 W

Vibro-I 80 m² Option: Movable platform (1200 mm x 1200 mm)	
Weight	837 kg (full)
Dimensions (L x W x H)	1000 mm x 860 mm x 2660 mm
Membrane	32 x 2.5 m^2 Free Flow Plate Modules (HP1)
Internal Retentate volume	134 L
Internal Permeate Volume	22.4 L
Operation 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
Vibration Motor	400 VAC, 50 Hz, 3,140 W

9. Conformity

SANI Membranes are committed to develop and supply products that meet relevant regulatory standards and requirements set by governing bodies. For further compliance or safety information, please contact SANI Membranes customer support.

The Vibro-I system is CE marked to demonstrate compliance with pertinent regulations, including the European Machine, Electrical and Pressure Directives. Hereunder we declare our sole responsibility that, the models mentioned in this manual are, when used as specified, in conformity with the technical requirements of the standards and the provisions of the essential requirements of the EU and other Directives detailed below:

- 2006/42/EC – Safety of machinery.
- 2014/35/EU – Low voltage equipment.
- 2014/68/EU – Pressure Equipment.

Electrical and electronic equipment (EEE) contains materials, components and substances that may be hazardous and present a risk to human health and the environment when waste electrical and electronic equipment (WEEE) is not handled correctly. Components marked with the crossed-out wheeled bin are EEE and we advise caution when discarding it and attention towards proper sorting.