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

SANI Membranes

SANI Membranes A/S
www.sanimembranes.com
Ryttermarken 8 | DK-3520 Farum | Denmark

Vibro-I User Manual

Contents

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1. Description

1.1. 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 limited 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. The Vibro-I is fully drainable resulting in minimal product loss and faster CIP cycles.

The combination of the Free Flow Plate™ and the Vibro® technology provides very gentle processing. A conventional Tangential Flow Filtration (TFF) circulation pump can damage cells or sensitive molecules 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 need for a high circulating flow rate also makes it possible to have virtually the same trans membrane pressure (TMP) throughout the entire unit. These uniform conditions allow for unique process control unlike any other industrial TFF membrane system.

The Vibro-I range is a modular design based on the 2.5 m^2 HP1 module. A Vibro-I Cartridge is a pre-assembled filtration device with one or more HP1 modules mounted between a top- and bottom plate, ready to be installed on a Vibro-I Drive. Vibro-I Cartridges are available from 2.5 m^2 to 20 m^2 membrane area. Additionally, 40 m^2 and 80 m^2 units are available using a larger Vibro-I Drive with 4 off 10 m^2 or 20 m^2 Cartridges, respectively.

For larger scale applications the Vibro-I 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.

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 a suitable feed, permeate and CIP systems. 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

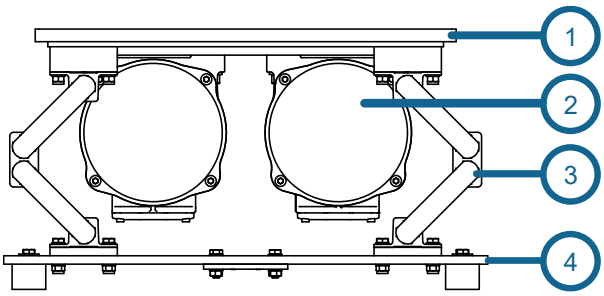
2.1. System description

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

Unit	Number of HP1 modules	Drive
Vibro-I 2.5 m²	1	Vibro-I 10 Drive + Adaptor
Vibro-I 5 m²	2	Vibro-I 10 Drive + Adaptor
Vibro-I 10 m²	4	Vibro-I 10 Drive
Vibro-I 20 m²	8	Vibro-I 20 Drive
Vibro-I 40 m²	16	Vibro-I 40 Drive
Vibro-I 80 m²	32	Vibro-I 80 Drive

2.1.1 Drive

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

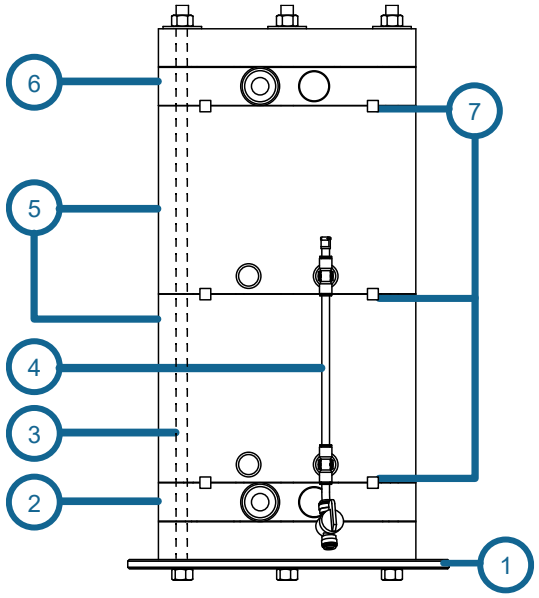


Part List:

1. Base plate
2. 2 x Vibro-I motors
3. 4 x Industrial springs
4. Vibro-I stand

The two Vibro-I motors (2) together with the four industrial springs (3) create the vibrations for the unit. The motors are delivered adjusted to the specific cartridge size of the Vibro-I units and is not compatible with other sizes. 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 stand (4) is designed for permanent installation on the floor or on a larger support structure. A foundation plan for each unit is available upon request. The Vibro-I Drive for 2.5, 5 & 10 m² units is supplied with machine feet that can be used until the units are permanently installed. As an option, these sizes can also be supplied on wheels. The Vibro-I 20, 40 & 80 m² can be supplied with an optional moveable base, suited for pallet lifters.

2.1.2 Cartridge



The Vibro-I cartridge consists of:

1. Cartridge bottom plate
2. Bottom cushion assembly
3. 4 x M16 rods with 8 x M16 nuts and spacers
   (The 20 m² uses 8 x M16 rods assembled in pairs using a threaded bushing with O-rings)
4. Permeate manifold
5. 1 to 8 HP1 membrane modules
6. Top cushion assembly
7. Internal square O-rings

The Vibro-I Cartridge consists of a number of stacked HP1 2.5 m² membrane modules (5) assembled with a cushion assembly (2 & 6) at the top and at the bottom of the HP1 stack. An internal square O-ring (7) seals between the assembly parts.

The Vibro-I Cartridge is assembled on a bottom plate (1) with four rods and the complete cartridge is tightened by four nuts (3). For the 20 m² the rods are extended using threaded bushing with O-rings and extension rods (3).

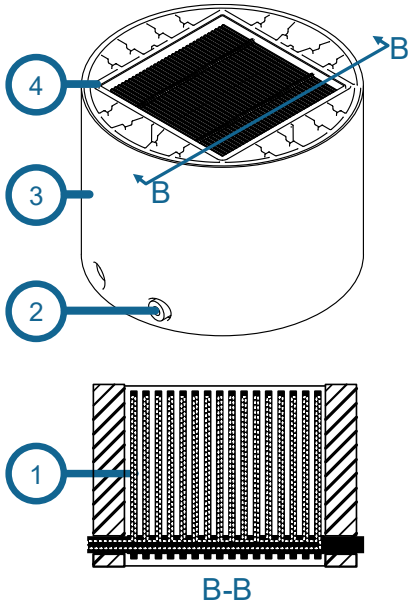
The Vibro-I Cartridge can be directly lifted onto the Vibro-I drive frame by placing lifting eyes on top of two of the rods. When positioned on the motor assembly, the cartridge is mounted on the base plate using four bolts.

2.1.3 HP1 Element

Each Vibro-I Cartridge is built up of a number of 2.5 m^2 Free Flow Plate™ modules (HP1). Each module contains a filter element consisting of 33 Stacked Free Flow plates (1) each fitted with membrane on both sides adding up to 2.5 m^2 of total membrane area.

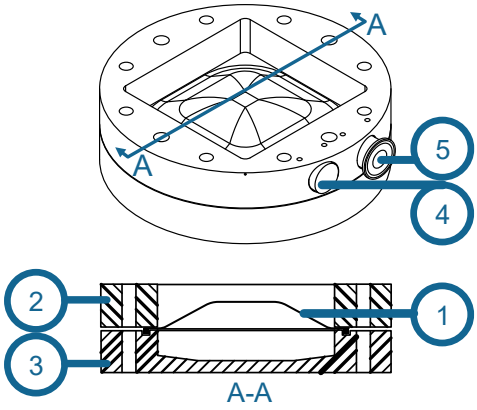
The filter element is held in place inside a pressure housing (3) with an outlet port for permeate collection on the side (2).

The top of the housing comes with a gasket (4), that provides the sealing with the top cushion assembly, or with another HP1 element on top.



2.1.4 Top / bottom element

The Vibro-I cushion (1) is secured between a media inlet/outlet part (2) and a top/bottom part (3). Each media inlet/outlet part is configured with up to two media inlet/outlet ports (4, 5). The ports are for the feed and retentate connections (5), and for possible vent and/or connection to instruments such as pressure transducer or temperature sensor (4).

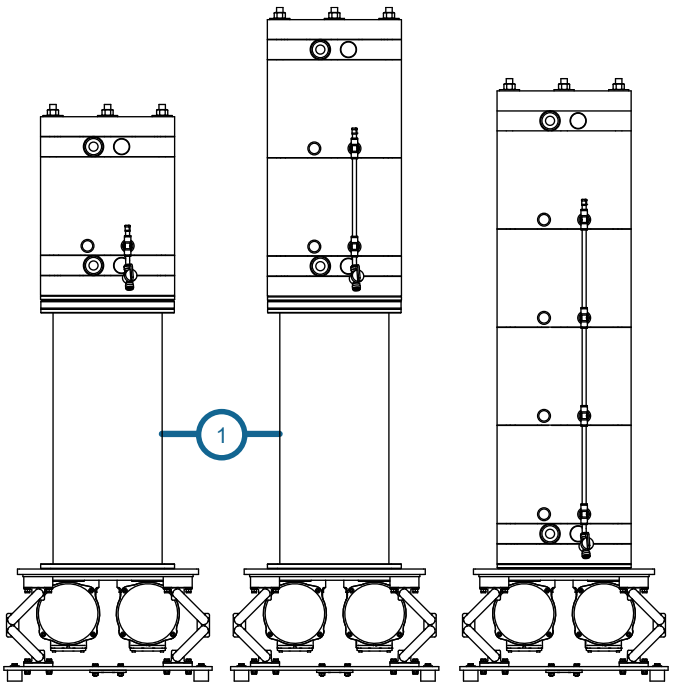


2.1.5 Adaptor

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

For the Vibro-I 2.5 & 5 m² Cartridges, an adaptor (1) is needed to ensure the correct height and total mass. This ensures that all systems have a similar performance, that the cartridges are always in a practical height and that the vibrational movement is stable and consistent.

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



2.1.6 Permeate manifold

Each HP1 module has two 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.

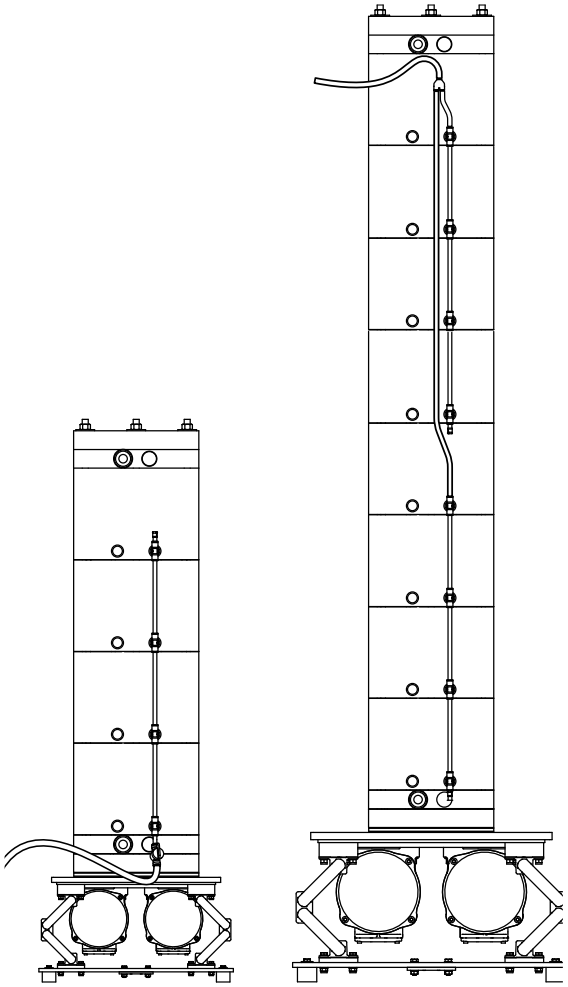
The standard configuration includes a permeate manifold joining the push in T-connections of the HP1 modules with 10 mm tubing. At one end of each manifold there is a blind plug and at the other end a drain line for leading the permeate to the collection vessel.

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 reconfigured according to preference.

To facilitate draining of the permeate volume a vent valve can be installed instead of the blind plug at the closed end. This is particularly useful for the microfiltration configuration. For 10 m^2 cartridges a single permeate manifold is provided. When used for the 40 m^2 unit the drain lines from each 10 m^2 cartridge are joined in a manifold with push in fittings.

On the 20 m^2 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 manifold with push in fittings when used for the 80 m^2 units.

The 40 and 80 m^2 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 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.

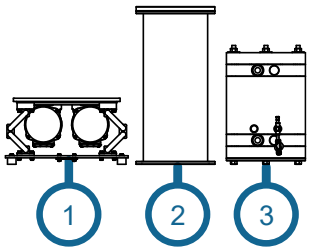


10 m^2 for ultrafiltration permeate flows down

20 m^2 for microfiltration permeate flows upwards

2.2. Part List

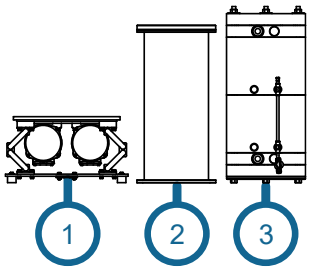
Vibro-I 2.5 m²



Part List:

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

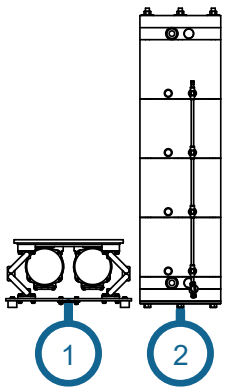
Vibro-I 5 m²



Part List:

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

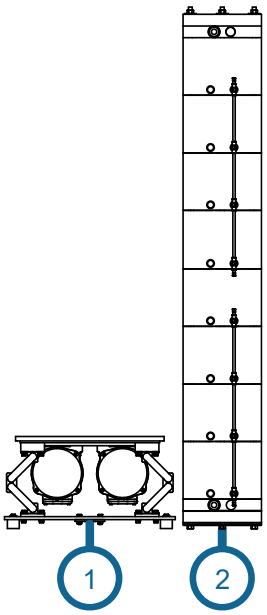
Vibro-I 10 m²



Part List:

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

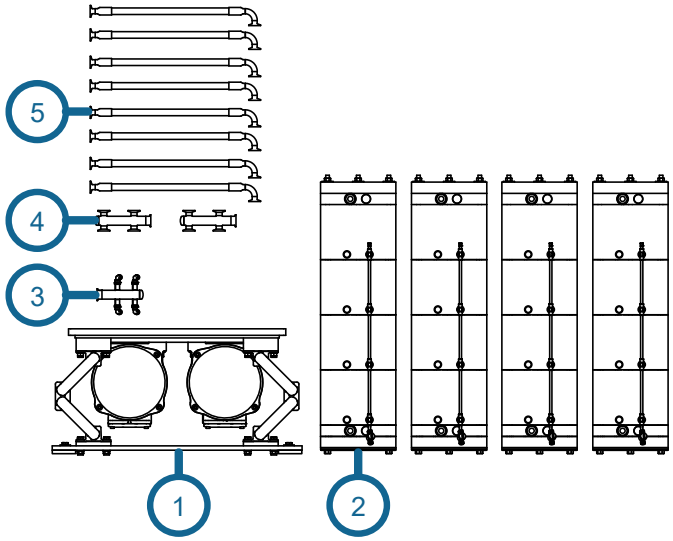
Vibro-I 20 m²



Part List:

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

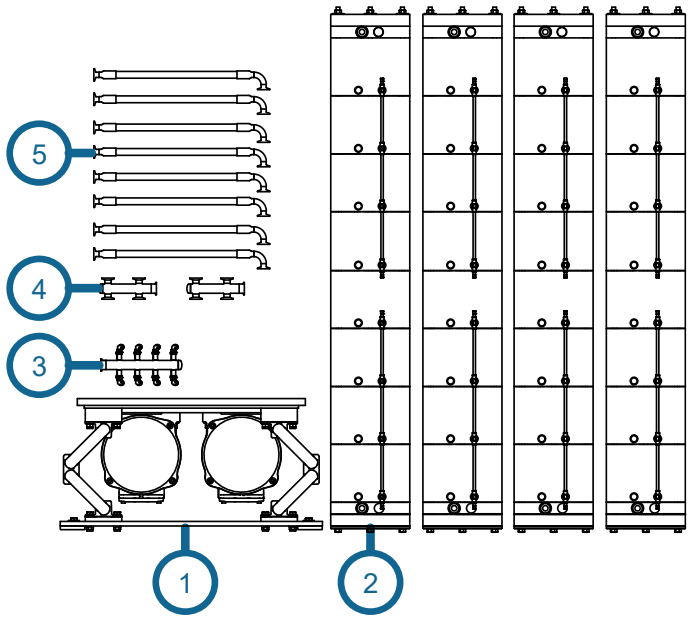
Vibro-I 40 m²



Part List:

1. Vibro-I 40 Drive
2. 4 x Vibro-I 10 Cartridges
3. Permeate Manifold
4. 2 x Feed inlet/retentate Manifold
5. 8 x Hose

Vibro-I 80 m²



Part List:

1. Vibro-I 80 Drive
2. 4 x Vibro-I 20 Cartridges
3. Permeate Manifold
4. 2 x Feed inlet/retentate Manifold
5. 8 x Hose

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, HP1 membrane module 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 must be placed on a horizontal non-slippery surface as the vibrating movement can otherwise make the Vibro-Lab move during operation and can cause injuries if it falls to the floor. ⚠ **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 assembly and maintenance

Tools	Size
Spanners	19 & 24 mm (and 22 mm if vent port is included)
Torque Wrench for sockets	35 – 100 Nm
Sockets for torque wrench	24 mm (and 19 mm for Vibro-I 2.5 and 5 m^2)
For Vibro-I 40 and 80 m^2, additionally:	
Torque Wrench for spanners	35 – 50 Nm
Spanner for torque wrench	24 mm

4.2. Installation of the Vibro-I Drive

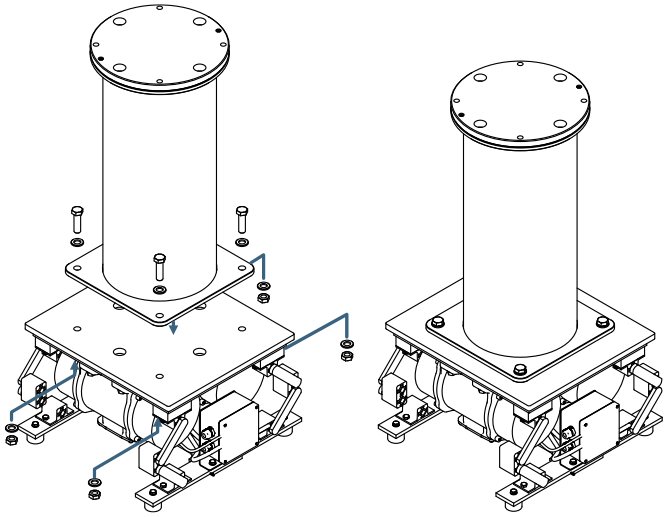
Start by unpacking and moving the Vibro-I drive to the intended location. For permanent installations, the drive should be bolted to the floor. A foundation plan for each unit is available upon request.

The Vibro-I units can be supplied with a larger moveable base for non-permanent installations. This is suited for use with a pallet lifters and makes it easier to move the units without lifting equipment.

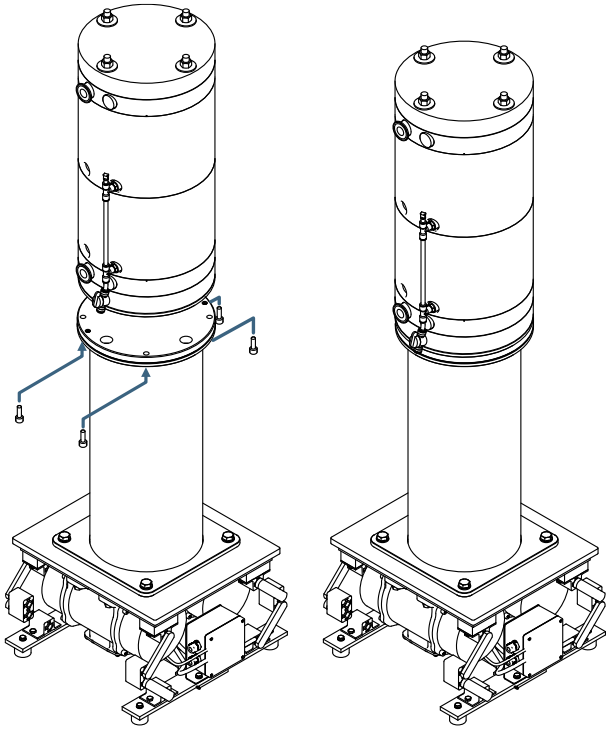
The Vibro-I Drive for 2.5, 5 & 10 m^2 units are supplied on wheels as standard, and can alternatively be supplied on machine feet.

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.

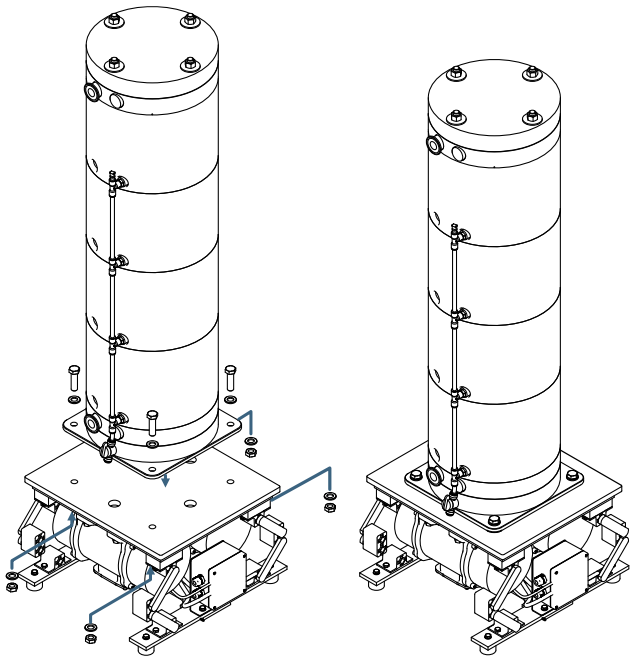


4. Place the cartridge onto the Vibro-I 2.5 & 5 Adaptor (align the nuts to the groves of the plate).
5. Secure the adapter with 4 x M12 x 40mm screws.
6. Tighten with Approx. 65 Nm.



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

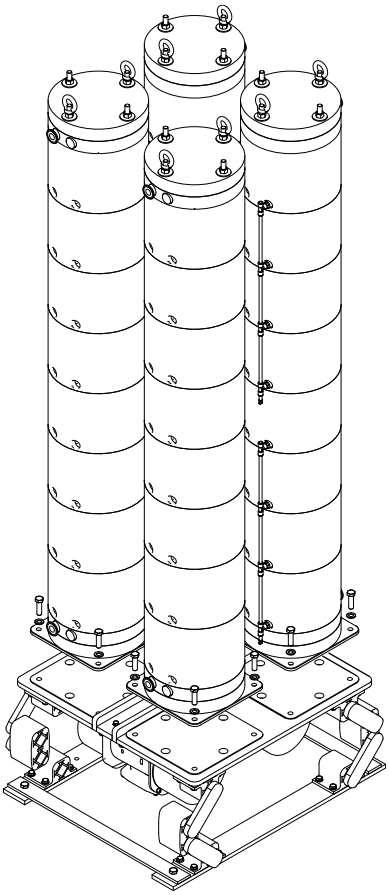


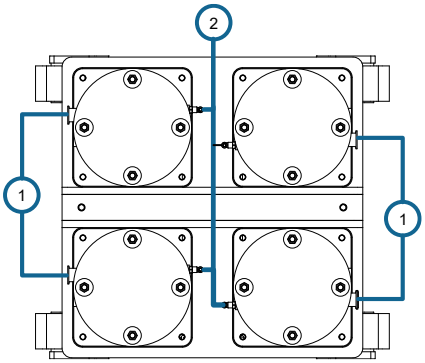
4.5. Installation of cartridge 40 & 80 m²

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 screws and add washers.
4. Tighten the bolt with 100-120 Nm.
5. Repeat steps 1 – 3 for the next three cartridges – ensuring to orient them correctly.

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. Start by loosening the 16 top nuts of the cartridges. (Figure *1*)
2. Slide the top ring onto the 8 central rods and place eight bolts and washers on top. (Figure 2)
3. Gradually cross-tighten the nuts according to the numbering pattern (figure 1). Final tightening to 42 Nm (80 m^2) and 38 Nm (40 m^2).
4. Now tighten the nuts holding the top ring in place.
5. Install two hose clamps to the side of the Vibro Base (Figure 2, detail 5)
6. Attach the feed and retentate hose as shown in Figure 2 (1: 1150 mm, 2: 850 mm, 3: 1100 mm, 4: 775 mm), using a gasket and a tri-clamp.
7. Place the two long hoses at the bottom in the hose clamps (Figure 2, detail 5).
8. Connect the other end of the hoses to the manifold using a tri-clamp and gasket.
9. Each cartridge of the 40 m^2 has a single permeate line and for the 80 m^2 the permeate lines are split into a bottom and a top half.
10. Connect the top of each permeate line to the manifold using 10 mm tubing.

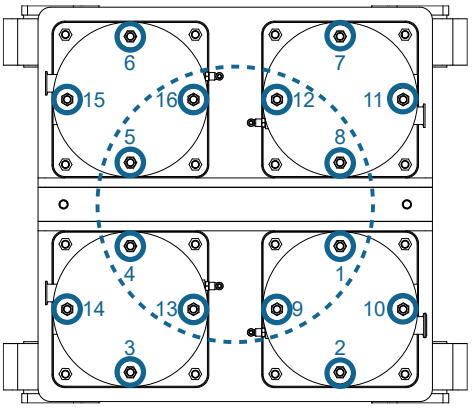


Figure 1

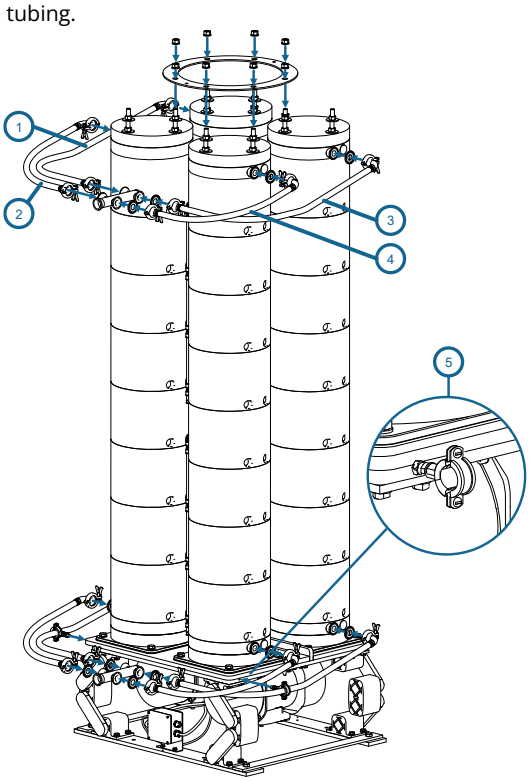


Figure 2

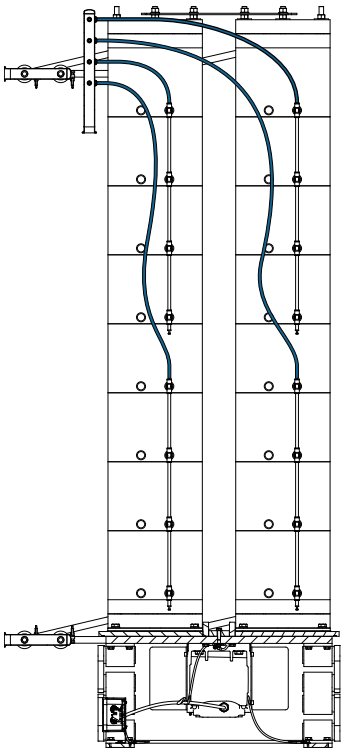
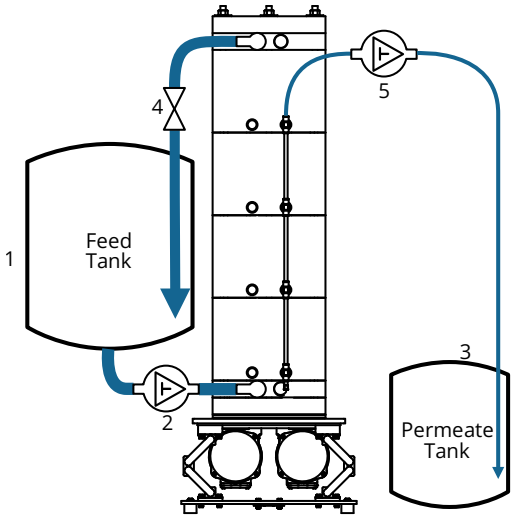


Figure 3

5. Operation

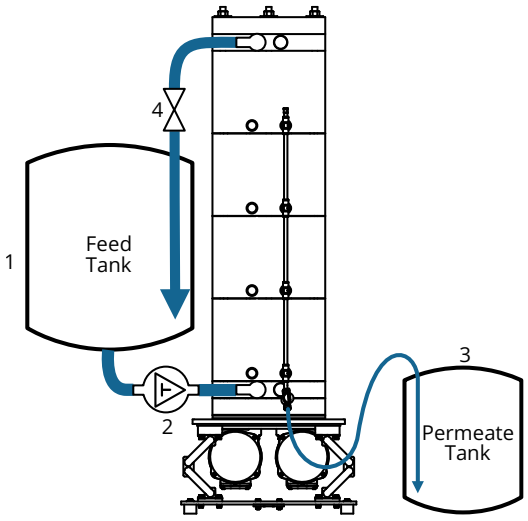
5.1. Introduction to microfiltration setup



Components:

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

5.2. Introduction to Ultrafiltration setup



Components:

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

5.3. 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 flush the membrane for 30 minutes with clean hot water (50-55 °C). For the first 5-10 minutes lead both the retentate and the permeate streams to drain without any recirculation. Establish a positive transmembrane pressure to force liquid through the membrane's porous layer. 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.

5.4. 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. As the measured TMP is directly influenced by the specific equipment the NWP will always be specific to 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.

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

5.5. General guidelines – process

1. Avoid operating the unit at excessive flux leading to fast and irreversible fouling of the membranes.
2. Optimal trans membrane pressure (TMP) for microfiltration is typically in the range 0.05 – 1 bar.
3. Optimal TMP for ultrafiltration is typically in the range 1 – 3 bar.
4. Maintain a positive TMP when vibration mode is on. For configurations without a permeate pump keep the permeate drain open and make sure that the retentate pressure exceeds the permeate pressure. When using a configuration with a permeate pump make sure the pump is a flow restricting type and that it is running whenever the system is vibrating.
5. 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.
6. 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, or as a single pass concentration step.
7. 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.

Microfiltration (typically 0 – 1 bar)

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

Ultrafiltration (typically 1 – 3 bar)

1. Ultrafiltration is less sensitive to pressure variation. Optimum TMP is often lower than seen in traditional cross flow systems. Typically, the ideal TMP using Vibro technology is between 1 – 2 bar.
2. 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**
3. 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**

5.6. 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.

Water flushes, buffer flushes or CIP cleaning must be performed after each run with media in the Vibro-I.

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 (especially microfiltration) it may be necessary to establish a parallel by-pass of this pump to allow 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. By comparing this to the initial NWP it is possible to determine if the cleaning regime is sufficient to ensure a good recovery of the membrane. As the NWP is temperature and pressure dependent the measurement should be done at the same reference conditions (recirculation flow rate, temperature and TMP) for direct comparison.

Although it is membrane and application dependent, a recovery of 80% or more of the initial water flux should be expected from a suitable cleaning regime.

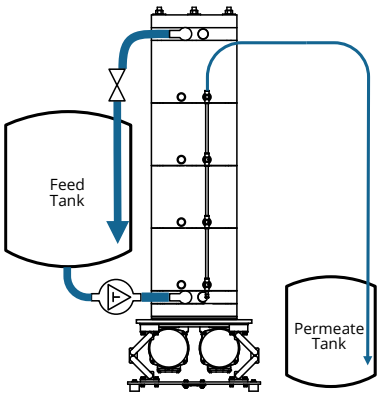
6. Examples of process configurations

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 m^2 unit is used for illustration but the configurations are applicable for any size of unit, and for multiple parallel units.

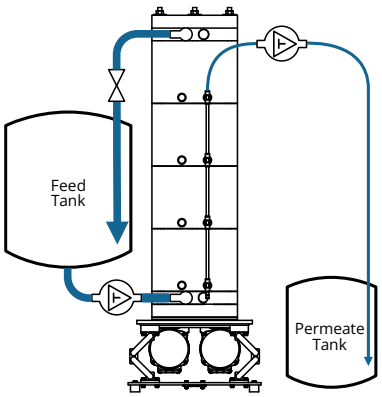
6.1. Membrane filtration batch mode with concentration tank

- 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.



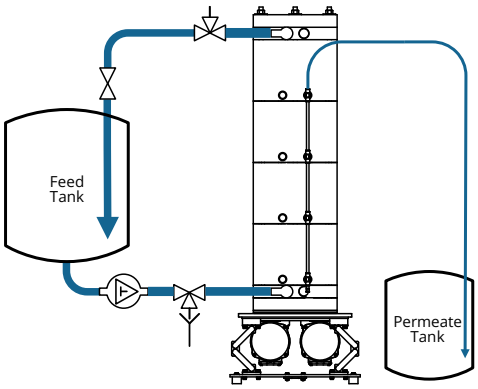
6.2. Microfiltration mode with permeate flow control pump

- 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



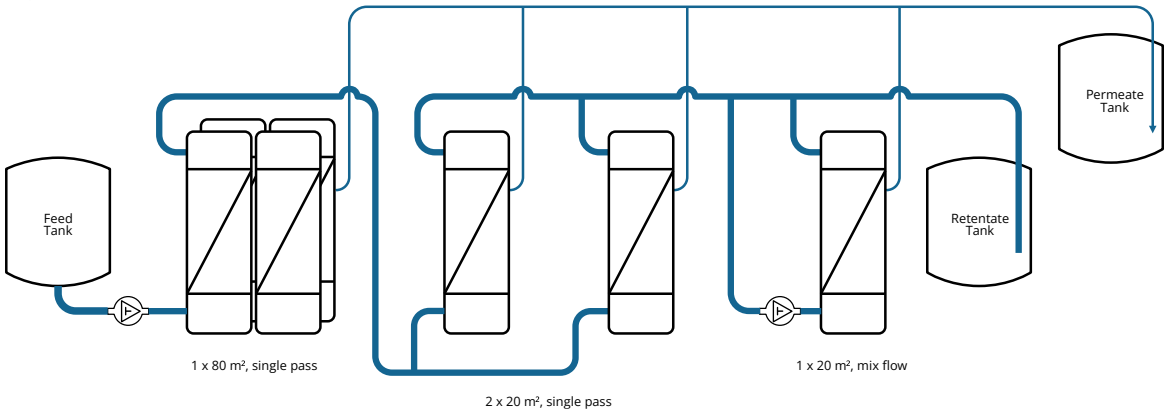
6.4. Example of three-stage system

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

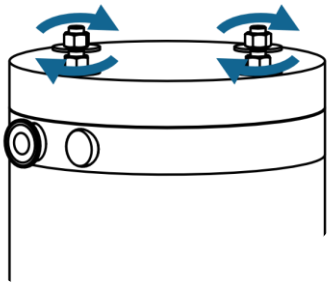
7.1. General Maintenance

Inspection / Replacement Intervals	
Cushion assemblies (A drop in flux may be due to fault in cushion.)	Inspect every 3-6 mth. Change yearly
Mounting rods in Cartridges	Replace with new cartridge or after approx. 6,000 hours
Wheels (on smaller Vibro-I Units)	Expected life time 1000 hours of operation. Replace in due time as unit may tip in case of wheel failure.
Industrial Springs	Replace after approx. 20,000 hours or after 3 yrs.
Vibration motors	Replace after approx. 30,000 hours or after 10 yrs.
Mounting bolts	Replace with cartridge, after approx. 3,000 hours or after 1 yrs.

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

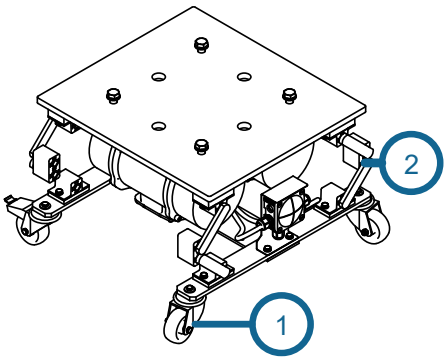


(The nuts must be re-tightened once after 8 hours in operation of the Vibro-I after each re-assembly).

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.



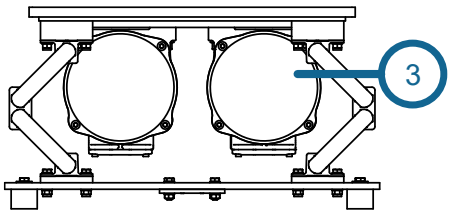
7.1.3. Maintenance and exchange of the industrial springs

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

Replacement of the industrial springs should be done by a SANI Membranes Technician.

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 a SANI Membranes Technician.

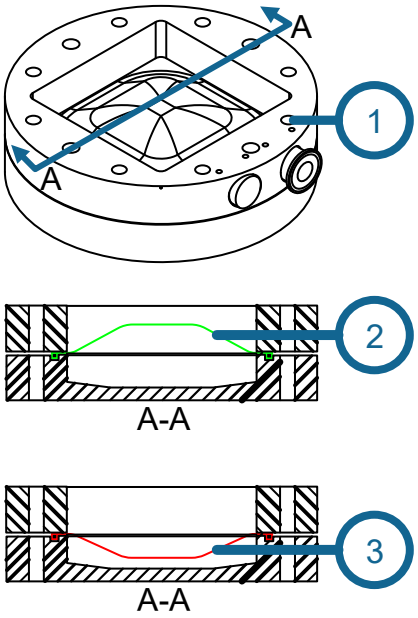
7.1.5. Tightening and re-tightening of mounting bolts

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.

7.1.6. 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 (3) and as a result lose the cushion effect.
To inspect the cushions:

- Drain the Vibro-I unit from liquid
- Disconnect the feed and retentate hoses from the port connections
- Look through the port to visually check if the cushion is 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).
- It is recommended to disassemble the Vibro-I to further inspect the issue, and potentially replace the cushion assembly (see section 7.2)
- If the cushion is deflated it is recommended to replace the entire cushion assembly. Reinflating the cushion should not be done without expert knowledge.
- Re-assemble the Vibro-I (see section 7.3).



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.

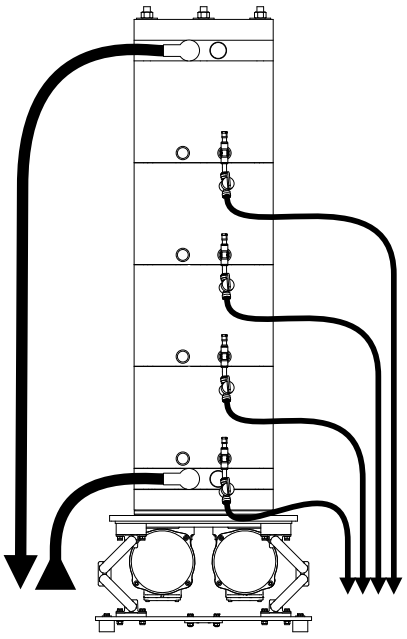
Please refer to previous section for trouble shooting of this problem.

7.1.8. 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:

- 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 HP1 module. The test setup could be like shown in the below illustration
- Mark the HP1 module(s) with unacceptable permeate quality



Temporary solution:
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.

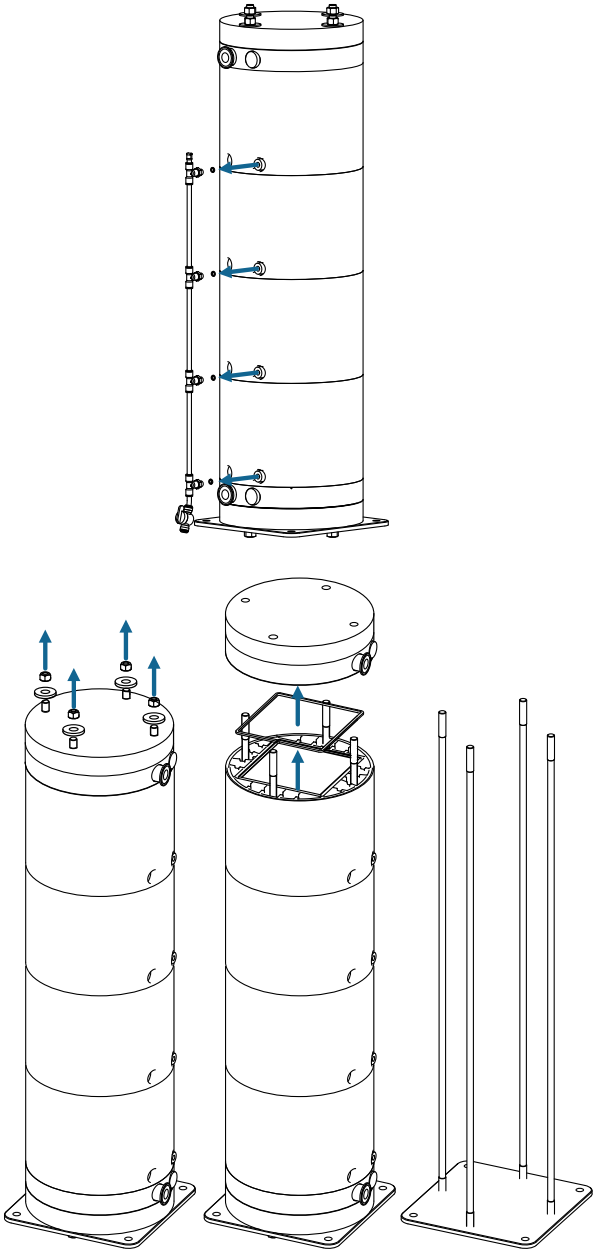
Permanent solution:
The affected HP1 membrane module is replaced with a new module. Stop the production clean the Vibro-I and drain it. Disassemble the unit and exchange the affected membrane, refer to the section “Assembly and disassembly of the Vibro-I” for detailed instructions. Reassemble the unit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

7.2. Disassembly of 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 (or from the adaptor in case of 2.5 or 5 m^2 cartridge) and move it by using lifting eyes in two diagonally placed rods. 20 m^2 cartridges should always be bolted onto a stable support to minimize the risk of accidents during disassembly. Due to the lower height the 10 m^2 cartridges can – with caution – be disassembled without being bolted onto a support.

Instruction for disassembly:

- Disconnect the Vibro-I unit from all other equipment and power
- Drain the cartridge to be disassembled and remove the feed and retentate connections, as well as the permeate manifold.
- If required or preferred, unbolt and move the cartridge to a suitable position for performing the disassembly
- Take off the 4 nuts and the washers at the top of each cartridge.
- Remove the top Vibro-I cushion assembly
- Remove the inner gasket from the top HP1 module
- Remove the HP1 modules one by one, and remove the inner gasket from each module
- For the 20 m^2 cartridge the rods are joined by a bolt / bushing after the first 4 HP1 modules. Remove the upper rods and the joining bolt before removing the last 4 HP1 modules
- Remove the inner gasket from the bottom Vibro-I cushion assembly
- Make sure that all parts are intact and clean them for instance with 50% ethanol, if necessary
- Make sure the HP1 modules do not dry out while the cartridge is disassembled. For longer duration the HP1 modules may be stored in a suitable storage solution (see section 7.4 below).

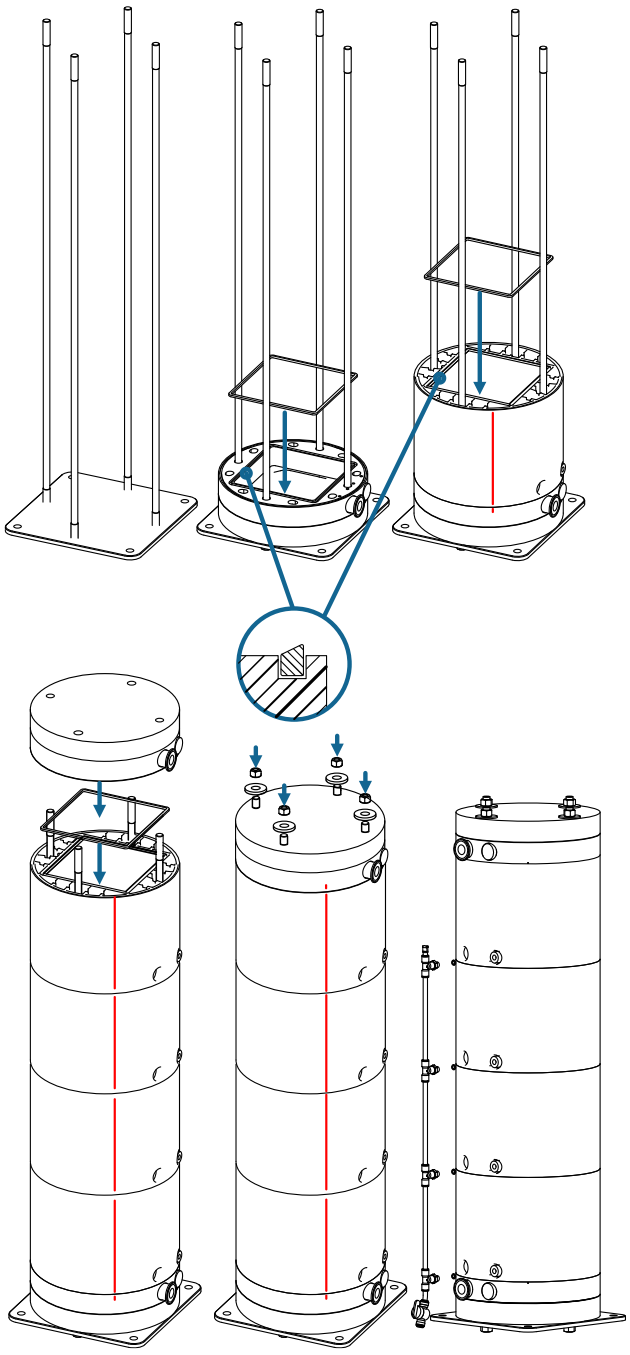


7.3. Assembly of Vibro-I Cartridge

For this instruction for re-assembly of the cartridge, please refer to the overview of components in the previous section. Make sure that all parts are intact and clean. It is recommended to use new inner square gaskets for reassembly of the cartridge. Even small impurities and wear marks can result in leaks.

- Place the bottom Vibro-I cushion assembly in the desired orientation by sliding it over the 4 rods.
- Place the inner gaskets carefully in the gasket grove of the bottom Vibro-I cushion assembly. Make sure that the "lip" of the inner gasket is facing up.
- Place the first HP1 module in the desired orientation by sliding it over the rods and ensure it is perfectly aligned with the Vibro-I cushion assembly. For correct alignment 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 (the red line in the illustration).
- Place the inner gasket carefully in the gasket grove of the HP1 module – again with the lip facing up
- Repeat for the remaining HP1 modules. Make sure they are perfectly aligned with the previous HP1 module and that the inner gasket lip is facing up on each module.
- For the 20 m^2 cartridge the rods are joined by a socket after the first 4 HP1 modules. Mount the joining socket and the upper rod before placing the last 4 HP1 modules
- Place the top Vibro-I cushion assembly on the upper HP1 module.
- For correct alignment 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.
- Place a washer on each rod and secure the nuts by cross tightening them slowly with a torque wrench in accordance the tightening torque specified in 7.1.1. Note: The nuts must be re-tightened after the first 8 hours of operation of the Vibro-I after a re-assembly.

NOTE:
The permeate outlets on the HP1 modules are secured with lock-nuts and assembled with spring loaded washers. These should not be disassembled or tightened without expert knowledge.



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

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

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, 480 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, 480 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, 480 W

Vibro-I 20 m² Option: Movable platform (800 mm x 800 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, 900 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, 3,200 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, 3,200 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.