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

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**Content**

# 1. Description

### 1.1. Introduction

This manual covers a standard Vibro-Flow 5 designed for controlling the process for a single Vibro-I cartridge installation. The system is optimized for 2.5 and 5 $m^2$ units.

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 media. 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), Vibro® Membrane Filtration (VMF) operates independently of feed flow rates. This allows for unique process control, enabling uniform membrane conditions that conventional TFF cannot achieve. As a result, Vibro® technology can operate at very low Transmembrane Pressures (TMP), enabling high product transmission and thus significantly higher yield.

The Vibro-Flow 5 is a process skid designed to deliver the full benefit of the Vibro® technology. The flux control option makes it ideal for optimizing microfiltration processes at low and uniform TMP conditions. It includes a PLC based control system with semi-automated functions and data acquisition.

The Vibro-I membrane cartridges are available with a variety of membranes ranging from tight ultrafiltration to open microfiltration. Cartridges are available in sizes of 2.5, 5, 10 or 20 $m^2$ per cartridge. Additionally, units are available for 40 and 80 $m^2$ membrane area and complete plants can be configured with multiple units, operated in parallel or series to deliver the required process and capacity.

Please find a separate manual for the Vibro-I units on our Webpage at: www.sanimembranes.com.

The Vibro-Flow 5 is a stainless-steel system for process development and small-scale production with food compliant media contact materials.

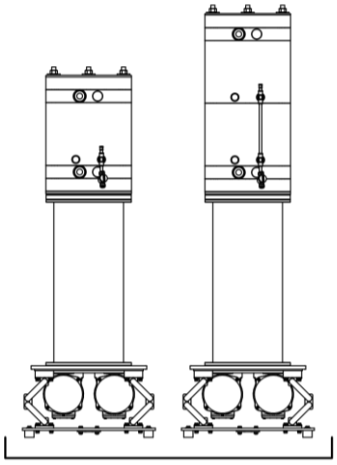
The Vibro-Flow 5 has the following features:

1. Control cabinet with electrical power supply, Variable Frequency Drive (VFD) for the feed pump motor, panel mounted peristaltic pump, power supply for the Vibro® drive, and all necessary electrical components for instrumentation and controlling of the unit
2. Touchscreen Human Machine Interface (HMI) on the front of the control cabinet with process mimic, display of all process values, access to setpoints, control loops, data logging of the process values, system state and alarms
3. Positive displacement pumps for control of the feed (rubber impeller type) and permeate (peristaltic type) with speed indication (%) on the HMI
4. Flow transmitters for the retentate and permeate flow rates with local display and values displayed on the HMI
5. Pressure transmitters for the feed, retentate and permeate lines with process values displayed on the HMI
6. Temperature sensor for the feed medium displayed on the HMI
7. Calculated TMP displayed on the HMI
8. Optional permeate control using the peristaltic permeate pump to control either the TMP or the permeate flow rate (the flux)
9. Feed pump controls either the system pressure (when using the permeate control option) or the TMP
10. Vent valve for safe drainage of the Vibro-I unit
11. Drain valve for drainage of the feed / retentate side of the system
12. Components, manual valves and stainless-steel pipework all mounted on a stainless-steel frame with control panel and all hardware
13. All internal and external media connections are with sanitary Tri-clamps (feed inlet, retentate outlet and permeate collection)

An emergency stop button is located on the front of the control cabinet.

### 1.2. Validity

This manual applies to the Vibro-Flow 5 in combination with:



**Vibro-I 2.5 / 5 m² unit**

### 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 risk of minor damage to property if not avoided.

### 1.4. Nomenclature

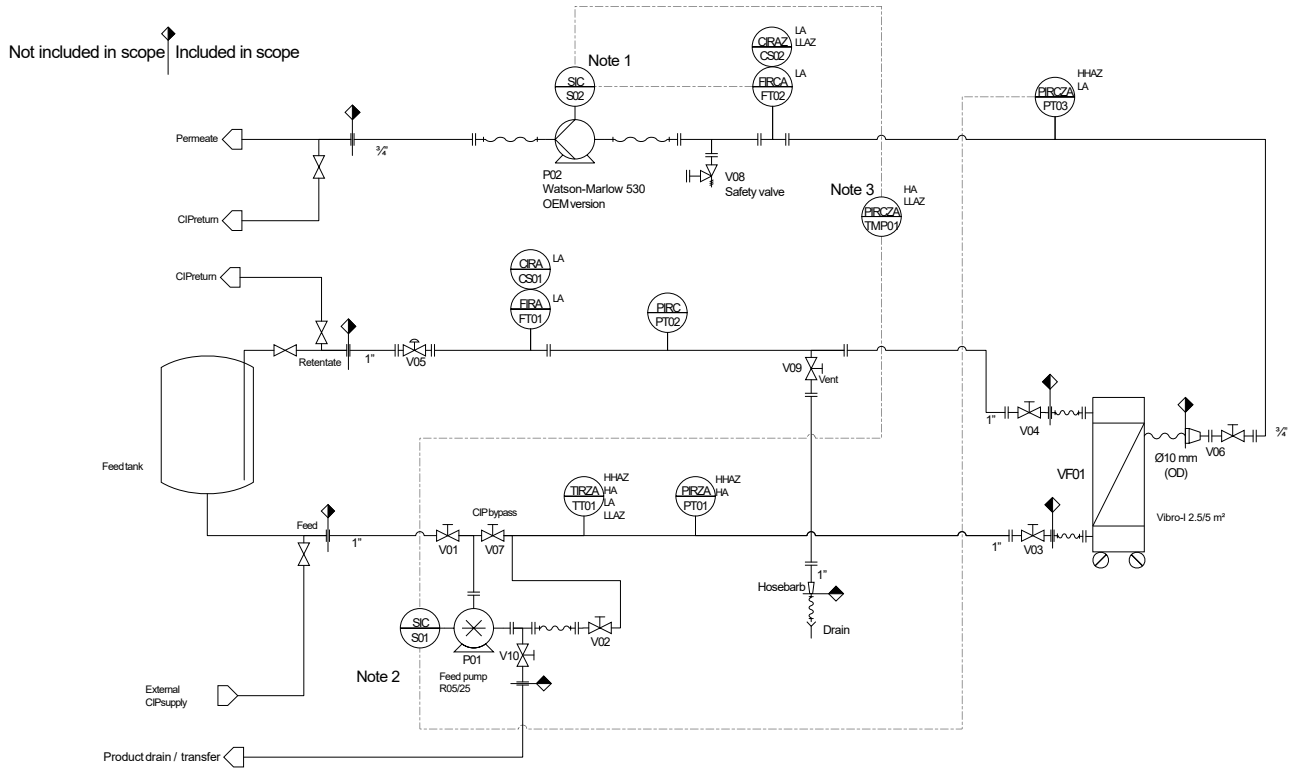
| Abbreviations | |
|---|---|
| TFF | Tangential Flow Filtration |
| VMF | Vibro® Membrane Filtration |
| TMP | Transmembrane Pressure [bar] |
| Flux | Permeate flow rate per membrane surface area [LMH] |
| VFD | Variable Frequency Drives |
| HMI | Human Machine Interface |
| MF | Microfiltration |
| UF | Ultrafiltration |
| CIP | Clean In Place |
| SP | Setpoint |
| QC | Quality Control |
| MAN | Manual mode |
| AUTO | Automatic mode |
| LMH | $L/m^2/h$ |

## 2. System description

The Vibro-Flow 5 can be manually operated from the HMI on the control panel or run in automated process control mode.

During manual mode the pumps can be turned on and off, the pump speed can be adjusted, and the Vibro® motors can be turned on and off.

In automatic mode the system can operate with or without permeate control:
- When not using the permeate control option, the feed pump controls the TMP (classical TFF approach).
  In this mode the permeate pump is bypassed.
- When using the permeate control option the feed pump controls the system pressure to prevent vacuum in the permeate line.
  In this mode the permeate pump can be in one of two modes:
  - Flux control, by regulating according to setpoint (SP)for the permeate flow rate
  - TMP control, by regulating according to setpoint for the TMP




Note 1: When P02 control is active: Two alternative control loops: 1) Permeate flow or 2) TMP
Note 2: When P02 control is active: P01 controls Permeate pressure
When P02 control is inactive: P01 controls TMP
Note 3: TMP = 0.5*(PT01+PT02)-PT03

*P&I Diagram*

## 3. Safety

Please be sure to read this entire user manual prior to use of the equipment.
Please read all safety instructions carefully.
This Vibro-Flow 5 user manual is part of the product. Keep it in a safe place for future reference.

Please find a separate manual for the Vibro-I on our webpage at:
**www.sanimembranes.com**

### 3.1. Intended use

The Vibro-Flow 5 is a feed system for MF and UF that can be operated in manual or automatic mode. The user should read and understand this manual before use.
The Vibro-Flow 5 is intended to be used with Vibro-I's from SANI Membranes.
The Vibro-Flow 5 is NOT suited for use in explosive (ATEX classified) environments. ⚠ WARNING
This instruction manual is part of the Vibro-Flow 5.
The Vibro-Flow 5 is intended exclusively for use in accordance with this instruction manual.

The Vibro-Flow 5 must only be used as intended the following are examples of improper use ⚠ WARNING:

- Unauthorized modifications and technical changes to the Vibro-Flow 5 are improper use
- Operation outside the permissible physical conditions given in this document (e.g. temperature, pressure, chemical vapors etc.) and given by the specification sheet for the membrane cartridge used in the connected Vibro-I unit(s)
- Installation of unauthorized items on the Vibro-Flow 5 or the Vibro-I units
- 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 the product contact materials of the system and the connected membrane cartridge
  For the standard Vibro-Flow 5 the typical product contact materials include stainless Steel, silicone, EPDM and / or PTFE. For the membrane cartridge used in the connected Vibro-I unit(s) this further includes polypropylene and the membrane material itself. Process hoses can be selected to match the specific media processed.

### 3.2. Personnel qualification

All personnel operating the Vibro-Flow 5 must have read this instruction manual thoroughly and be skilled in the art of pressurized filtration. All personnel operating the Vibro-Flow 5 should be used to conduct themselves in a laboratory or industrial process environment and have passed mandatory safety courses etc. Students operating the Vibro-Flow 5 must be instructed thoroughly by skilled teachers or other skilled personnel in proper use of the Vibro-Flow 5.

### 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, storage and conduct in emergency situations). ⚠ **WARNING**
Personal safety equipment should always be worn when applicable (e.g. safety goggles, safety gloves etc.). ⚠ **WARNING**
Do Not use media with biological materials in Safety Classes 2 and 3. ⚠ **WARNING**
Do Not use flammable or potentially explosive substances. ⚠ **WARNING**
Do Not use unstable media where concentration changes might start chemical reactions within the media. ⚠ **WARNING**
The operator should always make sure that the media to be filtered is compatible with the product contact materials of the system. **ATTENTION**

### 3.4. Pressurized components

The pressure and media flow needed to drive the filtration is generated by the feed pump of the Vibro-Flow 5. The Vibro-Flow 5 has a high-level feed pressure alarm with interlock that stops the plant operation including the feed pump if the operating range of the Vibro-I membrane filtration cartridge ("cartridge" in the following) is exceeded.
As the pressure rating of the cartridge depends on temperature, the high-level alarm for the feed pressure has different maximum limits, accordingly: 4 bar(g) at 5-35 °C, 3 bar(g) at 35-55 °C and 1 bar(g) at 55-80 °C.
The user must ensure that any system connected to the Vibro-Flow 5 interface is technically unable to deliver a higher pressure than the specified operating limits. This can be ensured by installing a certified safety relief valve when exceeding the max. allowed operating pressure. ⚠ **WARNING**

**Important: Temperature dependent maximum operating pressure:**
This Vibro-Flow 5 is designed for the operating pressure range of the cartridge which is temperature dependent. The Vibro-Flow 5 alarms and interlocks are default set accordingly:
Operating Pressure: 0-4 bar(g) at 5-35 °C, 0-3 bar(g) at 35-55 °C and 0-1 bar(g) at 55-80 °C.
If the Vibro-Flow 5 is used in connection with other membrane systems the user must ensure that the pressure alarms and interlocks are suitable for that system, or install safety relief valves according to such other systems ⚠ **WARNING**
ATTENTION: The permeate tubing has a lower pressure limit than the remaining system of around 3.8 bar. The system is equipped with a relief valve on the permeate line ensuring a max pressure of 2.5 bar.

**Important: Liquid discharge from the retentate line**
Make sure that the discharge pipe from the vent valve is permanently connected to a suitable drain for safe discharge of liquid from the pressurized retentate line. If the vent valve is opened during normal operation (or during CIP for cleaning of the valve) without the discharge pipe being connected to a drain point this will result in media being released from the discharge pipe opening. ⚠ **WARNING**

### 3.5. Leaking fluids

If the system is leaking, liquid spill can cause serious health danger depending on media. The operator should always seek the applicable safety information for the media to be filtered (e.g. handling and storage and conduct in emergency situations).
Personal safety equipment should always be worn when applicable (e.g. safety goggles, safety gloves etc.). ⚠ **WARNING**
If the fluid system is leaking, liquid spilling to the floor can cause a slipping hazard. ⚠ **CAUTION**
ATTENTION: Peristaltic pumping causes gradual wear of the permeate tubing. Regular inspection and timely replacement are required to prevent leakage.

### 3.6. Moving parts

The pumps have moving parts that require inspection and maintenance at regular intervals.
ATTENTION: Always make sure that the motor supply power is off before disassembling the pumps.
Body parts can be injured if the pumps are accidentally turned on during maintenance or inspection. ⚠ **WARNING**
Loose hair or clothing parts can be caught in moving parts and cause injuries. ⚠ **CAUTION**

### 3.7. Personal protective equipment

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

- Tight-fitting work clothing - Protects against being caught in 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 Vibro-I unit(s) ⚠ **WARNING**

### 3.8. Accessories and spare parts

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
- 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 user.

## 4. Assembly & installation

### 4.1. Installation

The Vibro-Flow 5 is provided on a frame with wheels suitable for moving to the final location. Alternatively, a forklift or a pallet jack may be used.

### 4.2. Assembly

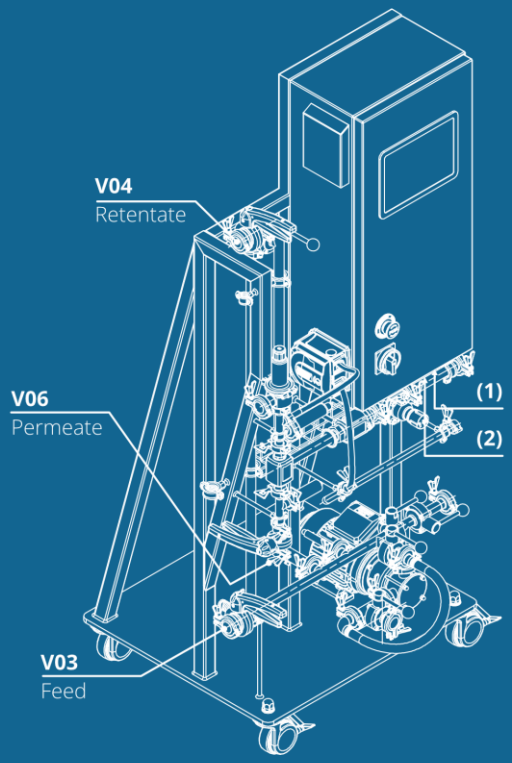
The Vibro-Flow 5 is supplied with most components already assembled.

The three valves V03, V04 and V06 are supplied with the system, and they should be installed as shown in the illustration to the right.

A power supply (1) cable for the system is pre-installed with a CEE plug. This is used for final testing of the system before dispatch.

The permanent installation to local power supply must be carried out in accordance with local codes, by an authorized electrician.

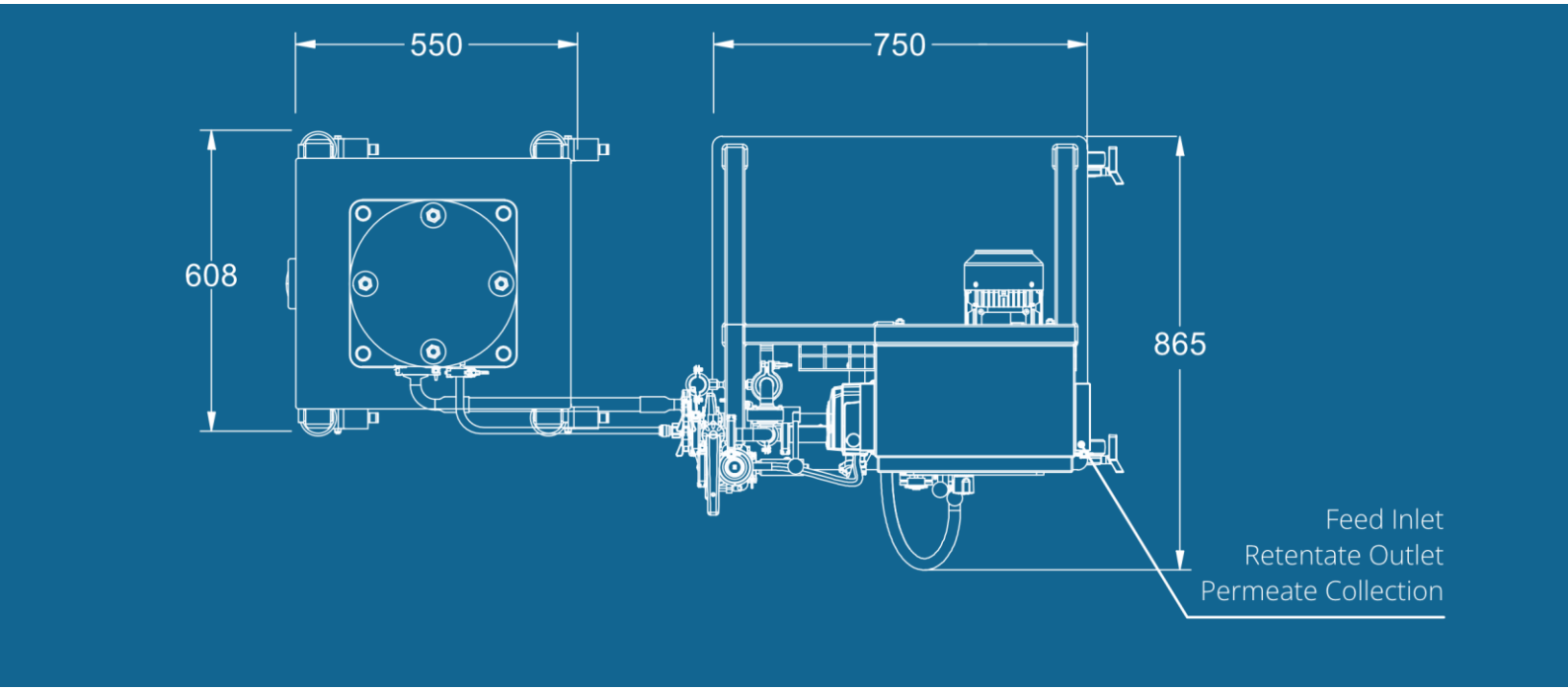
The control panel supplies the power to the connected Vibro-I unit. The cable connection between the control cabinet and the Vibro-I unit (2) shall be installed by an authorized electrician.



### 4.3. Arranging the Vibro-I unit

The Vibro-I unit shall be placed relative to the Vibro-Flow 5 according to the outline below. There should be space around the unit to allow for service and maintenance.

The control cabinet with HMI and the pipework connections for external tanks (for feed, retentate and permeate lines) are towards the bottom of the illustration. The connections between the Vibro-Flow 5 and the Vibro-I unit and the drain connection port are placed on the left side of the unit. The vent pipe discharge is at the back of the Vibro-Flow 5.




### 4.4. Electrical installation of the Vibro-Flow 5

All internal electrical connections for pumps and instrumentation on the Vibro-Flow 5 are included in the delivered scope. The Vibro-Flow 5 is supplied with a CEE plug which is installed and used during QC release testing. For final installation at customer site this cable may be replaced by an authorized installation professional to ensure compliance with local codes.

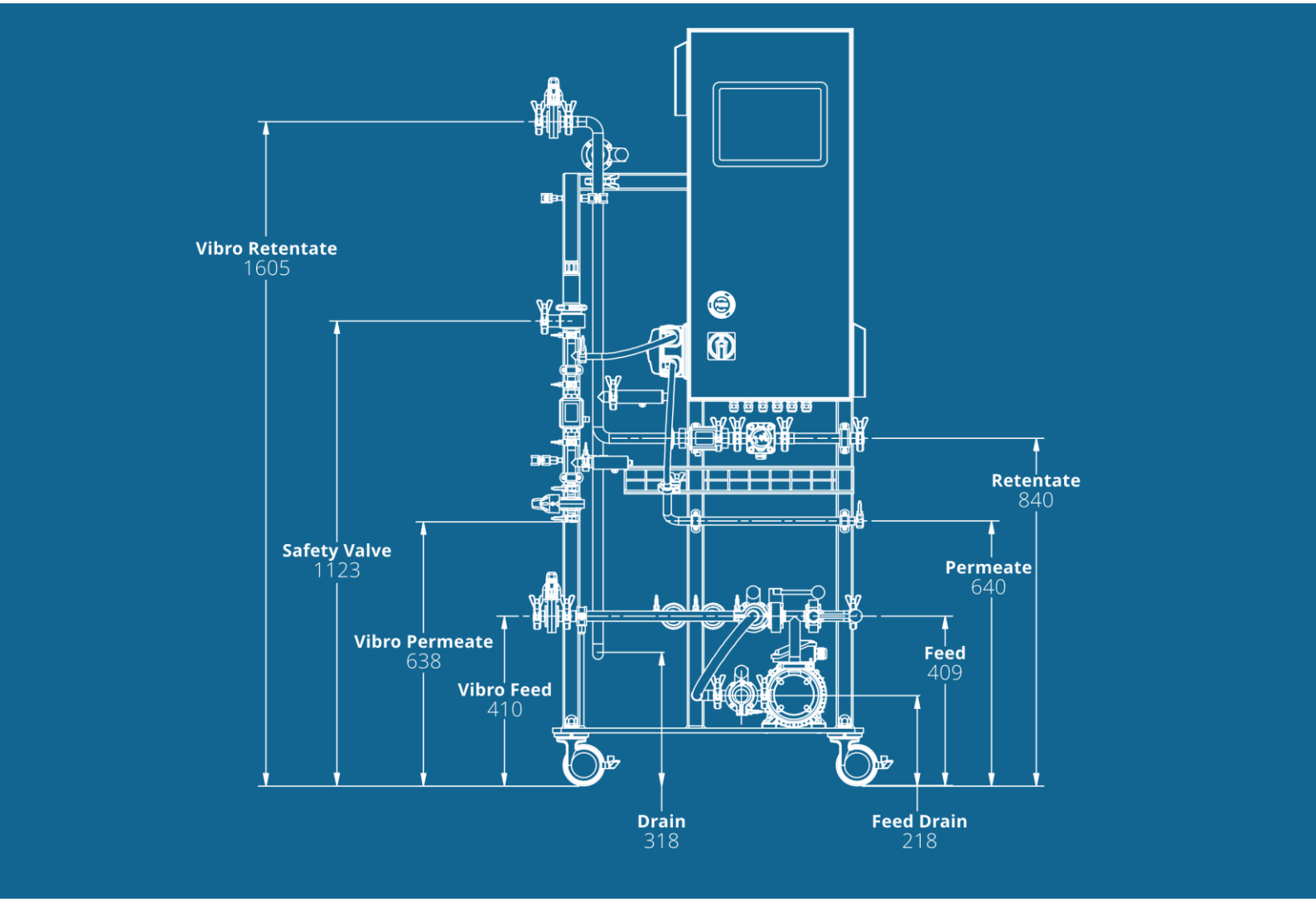
The control system includes a power supply for switching on / off the connected Vibro-I Drive. By default, the Vibro-Flow 5 is shipped with a short cable connection with a female CEE plug for power supply to the Vibro-I unit. The cable is installed and used for QC release testing of the Vibro-Flow 5 and can also be used for connecting a Vibro-I Drive with a corresponding male CEE plug. Installation of the male CEE in the Vibro-I Drive Junction Box must be done by an authorized installation professional to ensure compliance with local codes. Electrical diagrams are available for this procedure.

Alternatively, a direct cable connection may be established between the junction box of the Vibro-I Drive and the designated terminals in the control cabinet through a cable port at the bottom of the cabinet. Electrical diagrams are included inside the control cabinet. To comply with local codes this cabling and other electrical connections shall be carried out by an authorized installation professional.

### 4.5. Liquid connections

The liquid connection interfaces between the Vibro-Flow 5, Vibro-I and external tanks are located as shown in the illustration below.

The permeate line is equipped with a safety relief valve that is designed to activate if the pressure in the permeate line exceeds 2.5 bar. The safety valve shall be securely connected to a drain using a hose suitable for the intended operating conditions. The drain system must be designed and rated to safely accommodate the maximum possible discharge pressure from the safety valve without leakage, backpressure, damage, or risk of rupture to the drain or associated piping. **⚠ WARNING**



# 5. Operation

When the system is installed, it can be turned on using the main switch on the front of the control cabinet. The main menu will appear on the touch screen. The safety stop on the front of the control cabinet should be "out" / released in order to start the system.

### 5.1. General guidelines – process

1. The feed pump is a rubber impeller type and must not run dry. If running dry the flexible impeller will rapidly heat up and it will be damaged **ATTENTION**
2. The Vibro-I motors should be activated only when there is liquid flow and positive pressure on the retentate side of the system. If the transmembrane pressure (TMP) becomes negative this will generate a reverse flow in the membranes which can result in membrane damage if vibrations are on. When the system is started up in automatic mode this will be controlled by the control system.
3. The Vibro-Flow 5 is designed with a feed pump to circulate liquid in the feed / retentate loop and a permeate pump to optionally control the permeate flow rate.
4. When operating the system in automated mode, it can either be with Permeate control active, or with Permeate control inactive:

| **When Permeate control is active:** | **When Permeate control is inactive:** |
|---|---|
| The permeate pump P02 speed is regulated to control either the TMP or the permeate flow rate (flux). The feed pump P01 speed is regulated to control the system pressure via a setpoint (SP) value for the permeate pressure PT03. | In this mode the pump tubing shall be removed from the peristaltic pump to allow the permeate to discharge freely to the collection tank / container. The feed pump P01 speed is regulated to keep a SP value for the TMP. |

5. Unlike crossflow systems the flow velocity is not a critical factor for maintaining a continuous anti-fouling effect, but it is important to maintain homogeneous conditions on the feed/retentate side of the membrane. During processing of product, a typical range for the retentate flow rate would be 800 – 1200 L/h for a single cartridge Vibro-I system. For concentrated or highly viscous liquids, higher retentate flow rates may be required. The retentate flow rate is adjusted using the V05 valve on the retentate line.

| **When Permeate control is active:** | **When Permeate control is inactive:** |
|---|---|
| The feed pump is regulated in pressure control mode. The retentate flow can be increased or decreased by adjusting the retentate valve V05. Gradually opening the valve reduces the resistance in the line, causing the feed pump speed to increase in order to reach/keep the SP value for the permeate pressure. The effect is a higher retentate flow rate. And vice versa. | The feed pump is regulated in TMP control mode. The retentate flow can be increased or decreased by adjusting the retentate valve V05. Gradually closing V05 will increase the flow resistance in the recirculating liquid and result in a TMP increase. This causes the feed pump to slow down, thereby reducing the retentate flow rate. And vice versa. |

6. The operator can set a high feed pressure alarm to alert if the pressure is increasing more than intended. If the feed pressure exceeds the maximum operating conditions of the membrane, the system will stop. Note that the max. operating pressure for the Vibro-I cartridge is temperature dependent, see section 3.4.
7. After each run the membranes must be cleaned with appropriate CIP procedures, according to the application and the membrane. Please refer to the Vibro-I manual for more details.
8. Between batches the membranes may be stored in an appropriate storage solution. Please refer to the Vibro-I manual for more details.

### 5.2. General guidelines – recommendation for microfiltration

Keeping a very low TMP can be key for certain processes, especially microfiltration clarification. The anti-fouling effect of the vibrations will help to stabilize the flux for the duration of a batch. If the TMP increases too rapidly it may promote fouling and flux depression prematurely, leading to a lower overall performance.

The dynamic pressure losses in the pipes of the feed / retentate system, caused by circulating the feed solution, result in a certain pressure level on the feed/retentate side of the membrane. If the permeate is discharged to ambient pressure, the resulting TMP may exceed the optimal conditions for the process. To prevent this, the Permeate control function of the Vibro-Flow 5 can restrict the permeate flow using a peristaltic pump and hereby increase the pressure on the permeate side of the membrane. This mode of controlling the process enables operation at very low TMP values.

With Permeate control active, the permeate pump can be used in two different control modes: Permeate flow (flux) control mode and TMP control mode. In both modes, the action of the permeate pump can result in having an unintended vacuum in the permeate line. To prevent this, the feed pump is set to regulate SP for the permeate pressure PT03, keeping it positive.

In Flux control mode the system will control the permeate flow rate. This is especially useful in the initial phases of microfiltration. Controlling the permeate flux in the initial phase often results in TMP staying extremely low which delays the initial fouling and flux depression and leads to a higher overall average flux. Especially in transmission sensitive applications this can be the key to achieving higher yields and product recovery.

Eventually, the TMP may increase when running in Flux control mode. A process alarm can be set to remind the operator that the TMP has reached a certain level. At this point the process may be switched to TMP control instead, to keep the process at a set TMP value. The shift between modes is done manually.

The optimal TMP is process dependent but is often quite low for the Vibro® technology compared to other microfiltration technologies, such as TFF. Especially for transmission sensitive processes (product recovery, clarification and polishing steps), it is recommended to evaluate the process based on flux control rather than TMP to fully benefit from the Vibro® technology.

### 5.3. General guidelines – recommendation for ultrafiltration

Traditionally, ultrafiltration is run at constant TMP which is significantly higher than the dynamic pressure drops of the system. For this purpose, the Permeate control should be inactive and the pump tubing should be removed from the peristaltic pump, and the TMP controlled by the feed pump P01. Although the optimal TMP is typically high compared to microfiltration it should be noted that it may be lower for Vibro® filtration, compared to ultrafiltration with traditional TFF technologies.

If preferred, the Permeate control approach can also be used for ultrafiltration. Especially for open ultrafiltration membranes like 100 - 500 kDa this will give a gentle start-up, preventing too fast fouling and will allow the membrane to perform in line with its nominal cutoff rather than be defined by secondary layer formation.

For tight ultrafiltration membranes the Vibro-Flow 5 can be started up with Permeate control inactive, controlling TMP using the feed pump alone. For this mode, the pump tubing must be removed from the peristaltic pump.

Note that the system must be stopped and the pump tubing inserted into or removed from the peristaltic pump in order to shift between Active or Inactive permeate control.

Always observe the maximum operating pressure of the Vibro-I cartridge or other membrane device connected to the system.

### 5.4. General guidelines – recommendation for cleaning

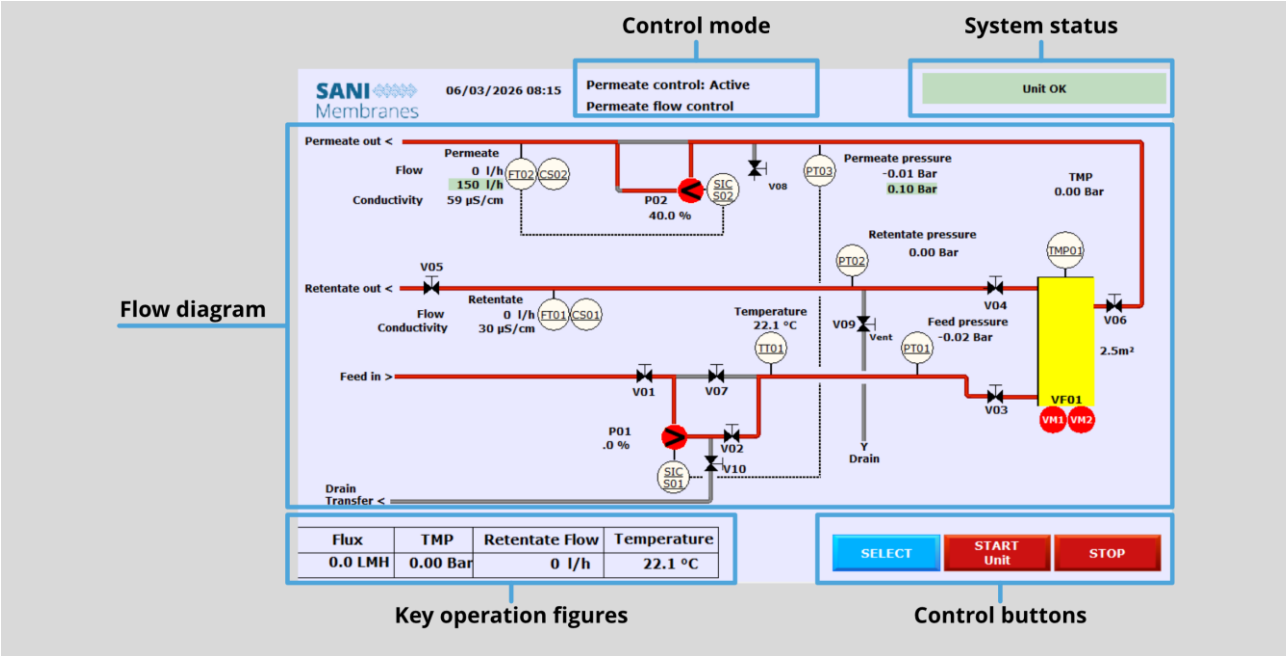
If an external CIP pump is connected it is possible to open the CIP bypass valve V07 to allow for higher flow rates than the feed pump can provide. In such case keep the feed pump running throughout the CIP cycle to efficiently clean the pump and connecting pipes.

During CIP the pump tubing should be removed from the peristaltic pump. The permeate flow rate during CIP will typically exceed the capacity of the peristaltic pump. It is recommended to operate the feed pump at 70-90% during CIP.

1. Always use a CIP protocol (cleaning solution, temperature and duration) suitable for the application in question and chemically compatible with the membrane used.
2. Connect the CIP supply to the feed inlet and connect the retentate outlet, the permeate outlet and the product transfer line to the CIP return.
3. For efficient cleaning, higher retentate and permeate flow rates are recommended compared to the values used during production.
4. The automated operation with Inactive permeate control can also be used for the CIP. The SP value for the TMP may need to be adjusted (reduced) several times to prevent P01 from running excessively fast when the permeability of the membrane increases during CIP.
   **Note:** When rinsing with water of low conductivity, the flow transmitters will stop functioning and the flow rates will no longer be reported. An alarm value can be set to notify the operator before this limit is reached.
5. Optionally, drain the system from CIP solution between the cleaning steps. This can help to reduce the amount of water required to flush the system after the cleaning steps.
   **Note:** To protect the membranes, always make sure to open the vent valve V09 before draining the system.
   See 5.8 System drainage.

**Please refer to the separate manual for the Vibro-I on our Webpage at: www.sanimembranes.com for more operation advice of the Vibro-I.**

### 5.5. Detailed system description
#### 5.5.1 Home screen




**Key operation figures**
At the bottom left the system key operation figures are displayed. From here the current Flux, Temperature, TMP, and Retentate Flow values are displayed

**System status**
At the upper right corner is a status of the system, showing Unit OK. In case of an instrument signal failure – or an instrument not connected correctly, this is shown in this corner. Alarms will be shown in this corner. An alarm can be cleared by touching this area.

**Control Mode**
The currently selected function mode is displayed at the top center of the screen; with permeate control activated, either Permeate TMP control mode or Permeate flux control mode can be chosen and displayed. With permeate control disabled, TMP control mode by P01 will be active.

When the system is set to have Permeate control Inactive, the feed pump will instead control the TMP value, and this would be indicated by a single dotted line between the feed pump and the TMP. In this mode P02 will be idle, and the pump tubing must be removed from the peristaltic pump to allow free discharge of the permeate.

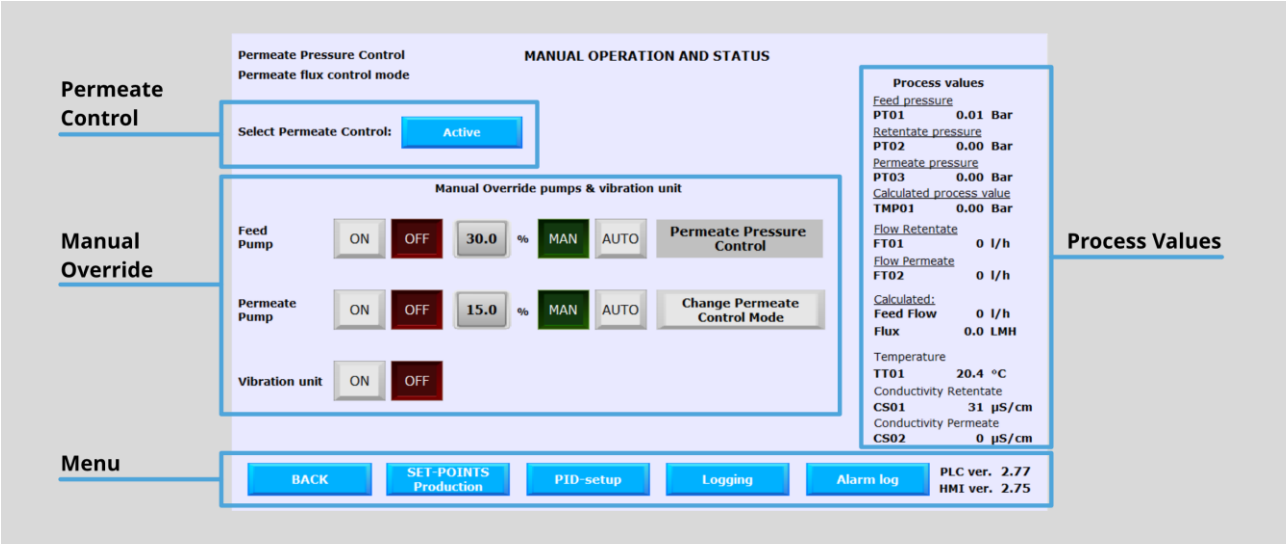
When pumps are manually initiated, the top center will display Manual Control, indicating no active control is currently monitoring the system.

**Flow diagram**
The diagram shows the Vibro-I unit to the right. The red lines in the flow diagram indicate that no process is currently active. The pumps and the Vibro-motors are also red, indicating they are not active. Process values are shown next to the instruments whereas active SP values are shown in green background under the respective instrument values. When a control loop is active the relevant SP figures will be displayed.

The black, dotted lines between the pumps and instruments indicate control loops when running in automated operation. In the above screen, the automated control has Permeate control Active selected, with the permeate pump controlling the flow (flux) and with a SP of 150 L/h for FT02. The feed pump is set to control the SP of PT03, which in this case is set to 0.1 bar. The permeate pump P02 can also be set to control TMP, and also in this case, P01 pump speed will be regulated to control to the SP for PT03.

### 5.5.2 Manual Operation and Status.

Control modes can be changed in the Manual Operation and Status screen. Press the SELECT button on the main screen to access Manual Operation and Status.




**Permeate control**

The overall control mode can be chosen to circumvent or include control of the permeate flow or TMP through P02. This selection can be made when the system is idle. Once the system is running in automatic mode this selection is locked.

By selecting Inactive as the Select Permeate Control setting, P02 is excluded from the control loop. Remove the pump tubing from the peristaltic pump to allow free discharge of the permeate.

By selecting Active, the control mode for the permeate becomes interactive and a choice between controlling the permeate flow (flux) or TMP, through permeate pressure, is selectable through the button Change Permeate Control Mode in the Manual Override section**.** In this mode the pump tubing must be inserted in the peristaltic pump.

**Process Values**

The actual process values of pressure, flows and temperature are shown to the right on the screen. The calculated value TMP01 is shown below the three individual pressure transmitters.

The conductivity of the liquid is reported by the two flow transmitters and is also shown below the process values.

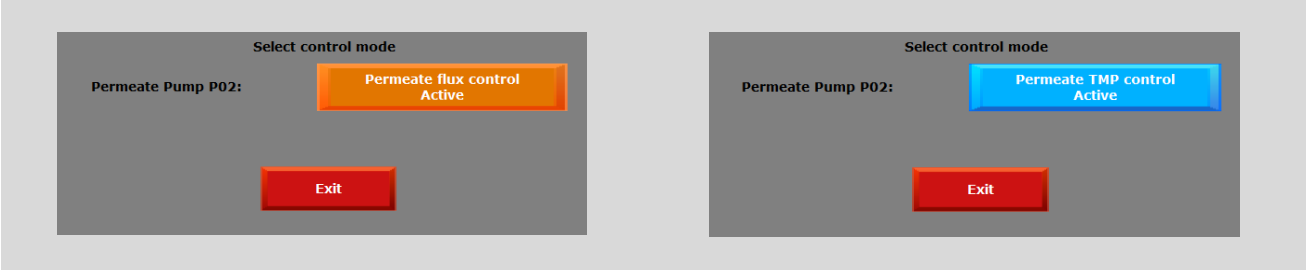
In case of a sensor fault (a missing signal) a red light will indicate this next to the affected sensor.

The Manual operations and status screen is also used for accessing screens for setpoints during production, PID-setup, Logging and Alarms using the related buttons at the bottom of the screen. These are explained in the following.

**Manual override**

The permeate control mode can be switched during automatic operation. When selecting the mode in automatic mode, the system will instantly switch the control loop for the permeate pump.

Pressing the **Change Permeate Control Mode** will make a popup appear to allow the switch, as depicted below.




Press Exit when the desired function mode is selected.

The Manual operation and Status screen can be used for manual operation of the system. The Vibro-I vibrating motors can be turned on or off during automatic mode by pushing the OFF override button.

When the system is in manual mode the speed output setting (%) of each pump can be adjusted and the pumps can be turned on and off. First, the MAN button must be pressed, hereby taking the pump into manual mode.

When the system is in Auto mode P01 and optionally P02 will be controlled by regulation loops. Also here, by pressing the MAN button for one of the pumps the regulation loop will be paused. The pump will continue at the current speed it had when taken out of Auto mode. The operator can now manually regulate the pump speed by typing a new value or turn the pump on and off. When pressing the AUTO button the regulation loop will take over the pump again.

**Menu**

Back | Returns to the home screen

SETPOINTS Production | Opens the Setpoints & Timers screen.

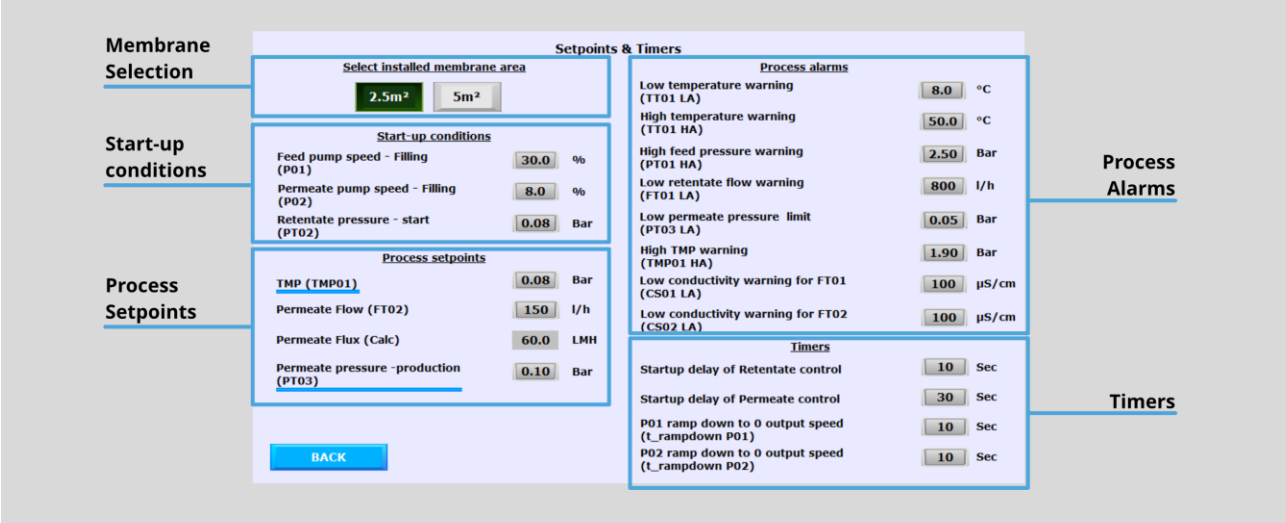
PID-setup | Opens the PID Setpoints screen.

Logging | Opens the data logging screen

Alarm log | Opens the alarm log

### 5.5.3 Setpoints & Timers

Pushing the button SETPOINTS Production will open the Setpoints & Timers screen (see right).




**Membrane selection**
Select installed membrane area**.** Depending on the Vibro-I unit being fed by the system, a different membrane area can be chosen.

**Start-up conditions:**

- Feed pump speed – Filling (P01)
  This value sets the initial speed of the feed pump P01 when the automated operation is started.

  The feed pump does not have active cooling, so the speed can be set and regulated down to 15 % as the lowest setting. The max. speed can be set and regulated to 100%.

- Retentate pressure – start (PT02)
  This value is the PT02 value required before the system will turn on the Vibro-motors in automated operation.

- Permeate pump speed – Filling (P02)
  This value sets the initial speed of the permeate pump P02 when the automated operation is started.

  The permeate pump can be set and regulated down to 1 % as the minimum operating value. The maximum speed can be set and regulated up to 100%.

**Process setpoints:**

- TMP (TMP01)
  This value is used as the setpoint for the transmembrane pressure when the TMP control function is selected for P01 or P02 during automated operation.

- Permeate flow (FT02)
  This value is used as the setpoint for the permeate flow rate when the Flux control function is selected for P02 during automated operation.

- Flux (FT02)
  This value is a calculated value, depicting the flux rate for the chosen permeate flow setpoint and membrane area.

- Permeate pressure – production (PT03)
  This value is used as the setpoint for the permeate pressure for the P01 pressure control function, when the Permeate Control is Active during automated operation.

**Process alarms:**

- Low temperature warning (TT01 LA)
  This alarm will warn the operator that the temperature is reaching a certain low level.

  **Note:** *Operational safety of the system is ensured by a TT01 HHAZ ("high-high" level alarm with an interlock) that will shut down the system if the maximum allowed temperature is exceeded.*

- High feed pressure warning (PT01 HA)
  This alarm will warn the operator if the feed pressure is reaching a certain level.

  **Note:** *Operational safety of the system is ensured by a PT01 HHAZ ("high-high" level alarm with an interlock) that will shut down the system if the maximum allowed pressure is exceeded.*

- Low retentate flow warning (FT01 LA)
  This alarm will warn the operator that the retentate flow is reaching a certain low level.

- Low permeate pressure warning (PT03 LA)
  This alarm will warn the operator that the permeate pressure is reaching a certain low level. Always avoid running the system with a negative pressure in the permeate line.

- High TMP warning (TMP01 HA)
  This alarm warns the operator if the TMP is reaching a certain level. The alarm is for information and may for instance be used for alerting the operator to switch from flux control mode to TMP control mode to limit the TMP for the remainder of a batch.

  **Note:** *Protection of the membranes against negative TMP conditions is ensured by a TMP01 LLAZ ("low-low" level alarm with an interlock) that will shut down the system if a TMP below the minimum allowed level is detected.*

- Low conductivity warning for FT01 (CS01 LA)
  This alarm warns the operator that the conductivity of FT01 is getting low. At low conductivity the flow transmitter will stop reporting a value.

- Low conductivity warning for FT02 (CS02 LA)
  This alarm warns the operator that the conductivity of FT02 is getting low. At low conductivity the flow transmitter will stop reporting a value.

  **Note:** *Operational safety of the system is ensured by a CS02 LLAZ ("low-low" level alarm with an interlock). In case P02 regulates according to the FT02 value, the interlock will switch the automated control of P02 to MAN and continue running at the current speed).*

**Timers:**

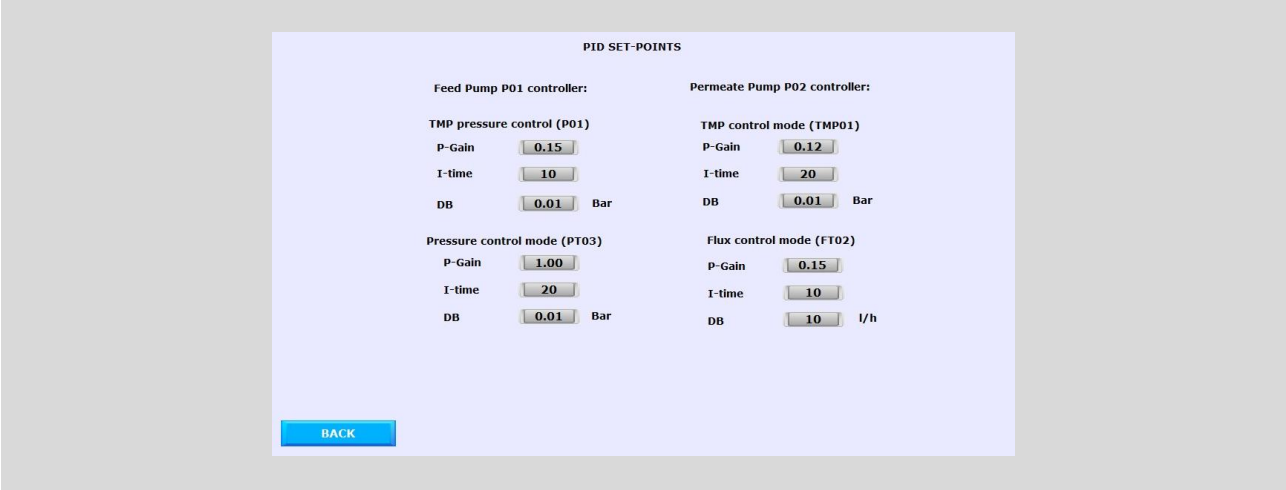
- Startup delay of the feed pump control function
  This timer is a delay in the start-up of the automated mode before the selected feed pump control function is activated.

- Startup delay of Permeate control function
  If permeate control is Active, this timer is a delay before the selected Permeate control function is activated.

- P01 ramp down to 0 output speed (t_rampdown P01)
  This is a ramp down timer to have a controlled speed reduction of the feed pump P01 before turning it off.

Pressing the button BACK will bring the operator back to the Manual operation and status screen.

#### 5.5.4 PID Setpoints




For each of the four PID controllers the values used for the P-Gain, I-time and Dead Band (DB) are shown and can be changed by the operator.

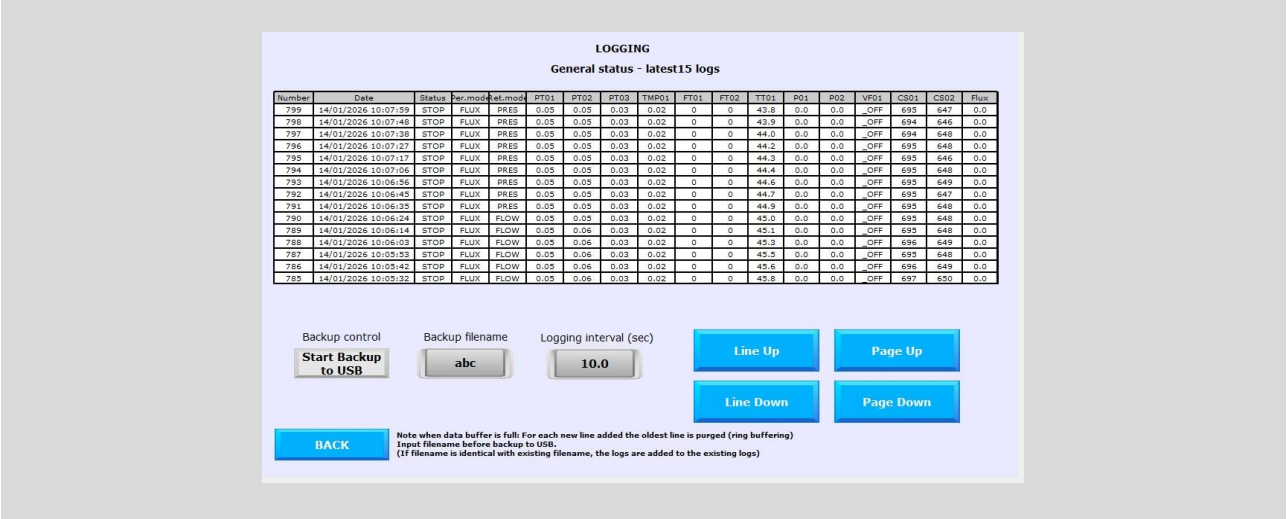
**P-Gain**
The P value determines how aggressively an instrument ramps up/down when not at the specified setpoint.
Increasing it makes the unit ramp up/down faster.

**I-Time**
The I value determines how many times per second the P value is multiplied.
A high I value reduces the time before a unit ramps up/down.
A low I value increases the time before a unit ramps up/down.

**DB**
The Deadband depicts an acceptable offset range from the setpoint. If the setpoint is 100 l/h and the deadband is 10 l/h, instruments won't ramp up/down while between 90-110 l/h.

Pushing the button BACK will bring the operator back to the Manual operation and status screen.

### 5.5.5 Data logging




| Number | Date | Status | Per.mode | Set.mode | PT01 | PT02 | PT03 | TMP01 | FT01 | FT02 | TT01 | P01 | P02 | VF01 | CS01 | CS02 | Flux |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 799 | 14/01/2026 10:07:59 | STOP | FLUX | PRES | 0.05 | 0.05 | 0.03 | 0.02 | 0 | 0 | 43.8 | 0.0 | 0.0 | _OFF | 695 | 647 | 0.0 |
| 798 | 14/01/2026 10:07:48 | STOP | FLUX | PRES | 0.05 | 0.05 | 0.03 | 0.02 | 0 | 0 | 43.9 | 0.0 | 0.0 | _OFF | 694 | 646 | 0.0 |
| 797 | 14/01/2026 10:07:38 | STOP | FLUX | PRES | 0.05 | 0.05 | 0.03 | 0.02 | 0 | 0 | 44.0 | 0.0 | 0.0 | _OFF | 694 | 648 | 0.0 |
| 796 | 14/01/2026 10:07:27 | STOP | FLUX | PRES | 0.05 | 0.05 | 0.03 | 0.02 | 0 | 0 | 44.2 | 0.0 | 0.0 | _OFF | 695 | 648 | 0.0 |
| 795 | 14/01/2026 10:07:17 | STOP | FLUX | PRES | 0.05 | 0.05 | 0.03 | 0.02 | 0 | 0 | 44.3 | 0.0 | 0.0 | _OFF | 695 | 646 | 0.0 |
| 794 | 14/01/2026 10:07:06 | STOP | FLUX | PRES | 0.05 | 0.05 | 0.03 | 0.02 | 0 | 0 | 44.4 | 0.0 | 0.0 | _OFF | 695 | 648 | 0.0 |
| 793 | 14/01/2026 10:06:56 | STOP | FLUX | PRES | 0.05 | 0.05 | 0.03 | 0.02 | 0 | 0 | 44.6 | 0.0 | 0.0 | _OFF | 695 | 649 | 0.0 |
| 792 | 14/01/2026 10:06:45 | STOP | FLUX | PRES | 0.05 | 0.05 | 0.03 | 0.02 | 0 | 0 | 44.7 | 0.0 | 0.0 | _OFF | 695 | 647 | 0.0 |
| 791 | 14/01/2026 10:06:35 | STOP | FLUX | PRES | 0.05 | 0.05 | 0.03 | 0.02 | 0 | 0 | 44.9 | 0.0 | 0.0 | _OFF | 695 | 648 | 0.0 |
| 790 | 14/01/2026 10:06:24 | STOP | FLUX | FLOW | 0.05 | 0.05 | 0.03 | 0.02 | 0 | 0 | 45.0 | 0.0 | 0.0 | _OFF | 695 | 648 | 0.0 |
| 789 | 14/01/2026 10:06:14 | STOP | FLUX | FLOW | 0.05 | 0.06 | 0.03 | 0.02 | 0 | 0 | 45.1 | 0.0 | 0.0 | _OFF | 695 | 648 | 0.0 |
| 788 | 14/01/2026 10:06:03 | STOP | FLUX | FLOW | 0.05 | 0.06 | 0.03 | 0.02 | 0 | 0 | 45.3 | 0.0 | 0.0 | _OFF | 696 | 649 | 0.0 |
| 787 | 14/01/2026 10:05:53 | STOP | FLUX | FLOW | 0.05 | 0.06 | 0.03 | 0.02 | 0 | 0 | 45.5 | 0.0 | 0.0 | _OFF | 695 | 648 | 0.0 |
| 786 | 14/01/2026 10:05:42 | STOP | FLUX | FLOW | 0.05 | 0.06 | 0.03 | 0.02 | 0 | 0 | 45.6 | 0.0 | 0.0 | _OFF | 696 | 649 | 0.0 |
| 785 | 14/01/2026 10:05:32 | STOP | FLUX | FLOW | 0.05 | 0.06 | 0.03 | 0.02 | 0 | 0 | 45.8 | 0.0 | 0.0 | _OFF | 697 | 650 | 0.0 |

Pushing the Logging button will open the LOGGING screen (seeabove).

Datalogging takes place whenever the power is on and will log the process status and process values.

The screen will show the latest 15 data points. The four blue buttons are used for navigating up and down to show additional stored data points.

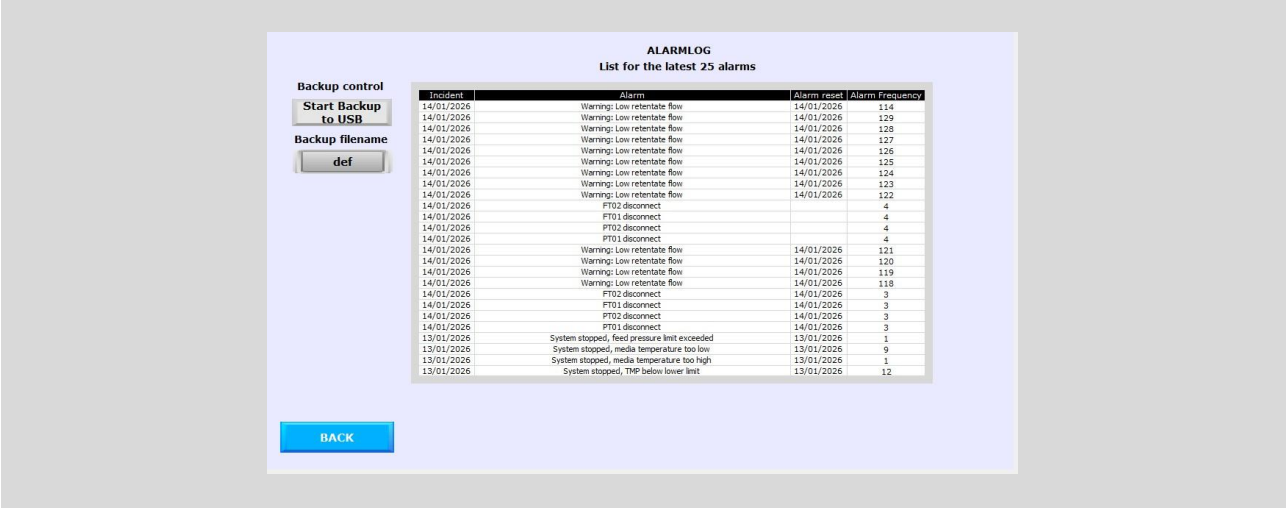
The Logging interval (sec) is the number of seconds between each logged data point. The system will store up to approx. 800 data points. For each additional logged data point the oldest data point will be overwritten.

At any time, the logged data can be backed up to a USB stick. The USB stick is inserted in the USB port on the back of the touch panel (inside the control cabinet). The USB stick must be formatted according to FAT32 file system. The Backup filename can be used for naming the backup file. Use max. 8 characters for the file name (no special characters are allowed).

When pressing Start Backup to USB the system will generate a file with the defined file name on the USB stick containing the currently logged data. If a file of the same name already exists, the system will append the new data to the existing file. If the interval is set to a low value, the backup should be done more often to save data from the entire process / batch.

Pushing the button BACK will bring the operator back to the Manual operation and status screen.

### 5.5.6 Alarm Log




| Incident | Alarm | Alarm reset | Alarm Frequency |
|---|---|---|---|
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 114 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 129 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 128 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 127 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 126 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 125 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 124 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 123 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 122 |
| 14/01/2026 | PT02 disconnect | | 4 |
| 14/01/2026 | PT01 disconnect | | 4 |
| 14/01/2026 | PT02 disconnect | | 4 |
| 14/01/2026 | PT01 disconnect | | 4 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 121 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 120 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 119 |
| 14/01/2026 | Warning: Low retentate flow | 14/01/2026 | 118 |
| 14/01/2026 | PT02 disconnect | 14/01/2026 | 3 |
| 14/01/2026 | PT01 disconnect | 14/01/2026 | 3 |
| 14/01/2026 | PT02 disconnect | 14/01/2026 | 3 |
| 14/01/2026 | PT01 disconnect | 14/01/2026 | 3 |
| 13/01/2026 | System stopped, feed pressure limit exceeded | 13/01/2026 | 1 |
| 13/01/2026 | System stopped, media temperature too low | 13/01/2026 | 9 |
| 13/01/2026 | System stopped, media temperature too high | 13/01/2026 | 1 |
| 13/01/2026 | System stopped, TMP below lower limit | 13/01/2026 | 12 |

Pushing the Alarm log button will open the ALARM LOG screen (see above).

One line is added for every alarm being activated. The last 25 alarms are listed.

Similarly, as for the Data logging a file backup can be done to the USB stick. The backup file is named by changing the text under Backup filename.

### 5.6. Preparing the system for operation

**General preparation**

The impeller pump P01 used on the system is lubricated and cooled by the pumped media and should never run dry.

For routine operation the plant should be left with liquid between the batches. However, for first use or if the system has been drained off for maintenance or similar, it should be ensured that the pump is primed with liquid (water) before startup.

The feed connection should ideally be made so that liquid flows to the pump by gravity ensuring that the pump has liquid before starting. If this is not the case (due to the way the pipework or hose connections are made) the inlet to the pump should be disconnected and water must be poured into the inlet side of the pump to provide lubrication before start-up.

Check that the connected Vibro-I unit is ready for use.

Check that no tools or loose items are left on the base plate or on the top of the cartridge. When the vibro-motors start loose items may bounce or fall and can cause a dangerous situation. **⚠ WARNING**

**External connections**

All external connecting pipes or hoses should be mounted. This includes a feed supply line to the feed inlet side of P01, a retentate collection line returning the retentate to the feed tank and a permeate collection line for collecting the permeate from the system.

**Internal connections**

The system is provided with isolation valves to be used between the Vibro-I unit and the Vibro-Flow 5 (for the feed line (V03), retentate line (V04) and permeate line (V06)). These should be mounted on the system and be opened before starting the system. The valves controlling the flow path within the Vibro-Flow 5 shall be opened (V01 and V02) and the retentate regulation valve V05 must be partly open.

The bypass valve around the feed pump (V07) should be checked that it is in the desired position. Further, the pump tubing must be removed from the peristaltic pump to allow the free discharge of permeate. For normal process control regulated by P01 the V07 should be closed. For CIP or other liquids supplied at high flow by external pumping the V07 should be open.

When planning to operate the system with Permeate control Active the pump tubing must be installed in the peristaltic pump.

When planning to operate the system with Permeate control Inactive the pump tubing must be removed from the peristaltic pump to allow free discharge of the permeate.

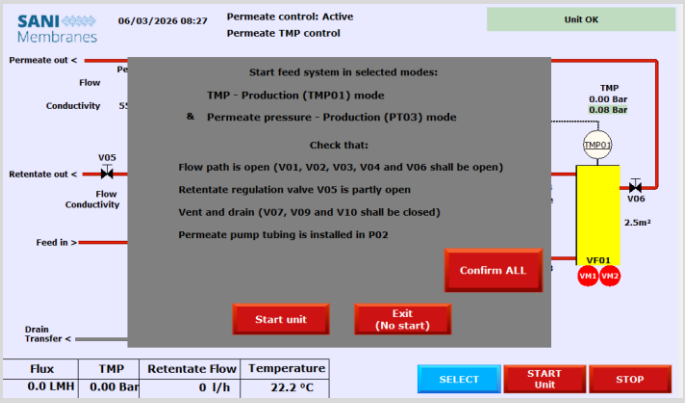
The vent and drain valves (V09 and V10) should be closed.

Finally, the operator should check that the process setpoints are correctly set for the planned operation and that the correct control mode is selected (permeate control active or inactive, and if relevant, TMP or flux control mode for the permeate pump controls).

### 5.7. Running the system

When pressing the START Unit button from the main screen a pop-up (see right) will remind the operator to check these points.

The Confirm ALL button must be pressed before the Start unit button can be used for initiating the automated operation.




**System start-up**
After Confirm ALL and pushing the Start unit button the feed pump P01 and the permeate pump P02 will be turned on and ramp up to their initial speed setpoints. The system will now fill with liquid and once the setpoint for Retentate pressure – start (PT02) is reached the vibration motors will be turned on. Once the vibration motors are running, the system will initiate the control functions.

After a delay defined by Startup delay of feed pump control the selected control loop for the feed pump P01 is activated. If permeate control is active, the selected control loop for the permeate pump will be activated after another delay defined by Startup delay of Permeate control function. The unit will now display Unit running and with indication of which of the control functions are selected and active.

**Change between operating modes**
If Permeate control is active the permeate control functions can be changed between TMP and Flux control.

This is done by pressing the SELECT button opening the Manual operation and status screen. From here the control mode can be changed by pressing the Change Permeate Control Mode button.

If pressed, a popup will ask the operator to confirm the shift. Before changing mode, the operator should check that the SP for the new control mode is correct. To ensure a gentle transition shift to a SP value close to the current process value.

In the SELECT screen the operator can disable or enable the automated regulation at any time by pressing the AUTO / MAN buttons next to the relevant pump.

**Stopping the process**
When the processing has finished the system can be stopped by pressing the STOP button from the main screen. The pumps will ramp down to stop completely and the power to the Vibro-I units will be turned off when the pumps are stopped.

### 5.8. System drainage and product transfer

**Membrane system drainage**

Draining of the retentate side of the membrane system must be carried out correctly to prevent damage of the membranes. The key is to avoid negative TMP conditions for the membrane.

Firstly, make sure that the permeate line is filled with liquid and isolated by closing V06. This prevents air from being pulled backwards into the permeate line in case of suction.

Secondly, open the vent valve V09 to allow air to replace the drained volume and hereby prevent suction of liquid through the membranes. **ATTENTION**

Draining of the cartridge retentate volume can now proceed. Make sure that a hose is connected to the drain flange for collection of the retentate, either in a second container, or by leading it back to the feed tank. Alternatively, lead the hose to drain in case the liquid is to be discharged.

Two options are available:

- Drain cartridge by gravity – typically for leading to drain / waste:
  Check that V01 and V07 are closed, and V02 is open.
  Check that vent valve V09 is open. **ATTENTION**
  Start draining of the cartridge by opening V10.

- Drain cartridge using the feed pump – typically for draining back to the feed tank, or to a product collection tank:
  Check that V01 and V02 are closed.
  Open V07 and V10.
  Check that vent valve V09 is open. **ATTENTION**
  Set P01 to MAN and set the speed setpoint to 15%.
  Activate P01 to actively drain the cartridge.
  Stop the pump as soon as the drainage is complete, and close V10 when the pump is stopped.
  NOTE: Leaving the pump running dry will quickly damage the rubber impeller.

It important to leave the vent valve V09 open while the cartridge is drained off liquid.
Remember to close the vent valve V09 before introducing liquid into the cartridge again.

**Product transfer**

The feed pump P01 can be used for transferring the liquid from the feed tank as well. Close V02, V04 and V07 before opening V01 to establish connection between the feed tank and P01. Make sure that a hose is connected to the drain flange for collection of the liquid from the feed tank to the correct receiving point.

**NOTE:** Emptying a tank without venting will potentially damage the tank by the vacuum created. Always make sure that the feed tank is an open tank, or that it is fully vented before initiating transfer by any pump.

Open V10, set P01 to MAN and set the speed setpoint to 15%.

Activate P01 to start the transfer from the feed tank. The speed setting can be increased to drain faster but observe that once the liquid is emptied and the pump runs dry the rubber impeller will rapidly wear and be damaged.

Once complete stop P01 and close V10. Check that all valves are in the correct position for the next operation.

### 5.9. CIP of the system

**General recommendations for CIP**

Use a combination of chemicals, temperature and duration that is suitable for removing the accumulated material, deposits, and process residues while ensuring chemical compatibility with the installed membrane.

An initial flush once-through with hot water at 50-55 °C will remove the majority of loose material and process residues. Consider to drain the system between flushing and actual CIP steps to remove residual material and avoid dilution of the CIP solution. This also helps to reduce the consumption of clean water. Refer to the Vibro-I manual for more information on CIP cleaning of the membrane units.

To reduce the amount of fouling material in the recycled CIP solution the initial returned volume should be sent to drain.

Note that the pressure rating of the Vibro-I cartridge is temperature dependent (see section 3.4 for details).

**Preparations for CIP**

The external CIP supply should be connected to the P01 inlet. The retentate and permeate outlets should be connected to the external CIP return line. If a product transfer line is mounted from V10 this can be connected to the external CIP return line or alternatively to a drain. The vent / drain should be connected by a hose to drain during CIP.

During CIP the V09 and the V10 valves should be opened for some time in order to clean the vent valve V09, the vent line, the drainage / product transfer valve V10 and any connected line.

**NOTE:** It is very important that the V09 and V10 are safely connected via hoses to a drain point before opening and discharging CIP solution through these lines.

The pump tubing must be removed from the peristaltic pump during CIP to allow the free discharge of permeate.

**CIP procedure**

It is possible to connect an external CIP pump to increase the flows through the lines during CIP. If this is used, the bypass-valve around the feed pump (V07) can be opened to allow for higher liquid circulation rates.

If CIP liquid is supplied by an external pump it is recommended to set P01 to a fixed speed setting, for instance 70-90%. If no external CIP supply pump is used, the system can be used in automated mode by selecting Permeate control inactive and set the feed pump to control a certain TMP01 SP. Regulate the retentate flow resistance using V05 and/or the TMP SP to make sure that P01 runs at 70-90% during CIP.

**CIP sequence**

Between chemical CIP steps make sure to flush and rinse the system with clean water. Draining the system between each medium / water may reduce the amount of liquid required. Lead the initial CIP liquids to drain for some minutes before returning to the feed tank for recirculation. This will ensure that the majority of dirt is removed from the recirculating CIP liquid. Flushing should be carried out without recirculation.

## 6. Maintenance

The pumps and instruments must be maintained according to their individual manuals delivered with the system.
Gaskets, rubber impellers and flexible hoses should be exchanged at regular intervals depending on use frequency and wear. The Vibro-I must be maintained according to the manual for the Vibro-I on our webpage at: www.sanimembranes.com

## 7. Conformity

The Vibro-Flow 5 is CE marked to demonstrate compliance with relevant regulations including the European Machinery, Electrical and Pressure Directives.
All media contacting parts are in durable elastomer materials, durable polymeric materials or stainless steel and comply to FDA CFR 21 and EC 1935/2004 for materials in food contact.