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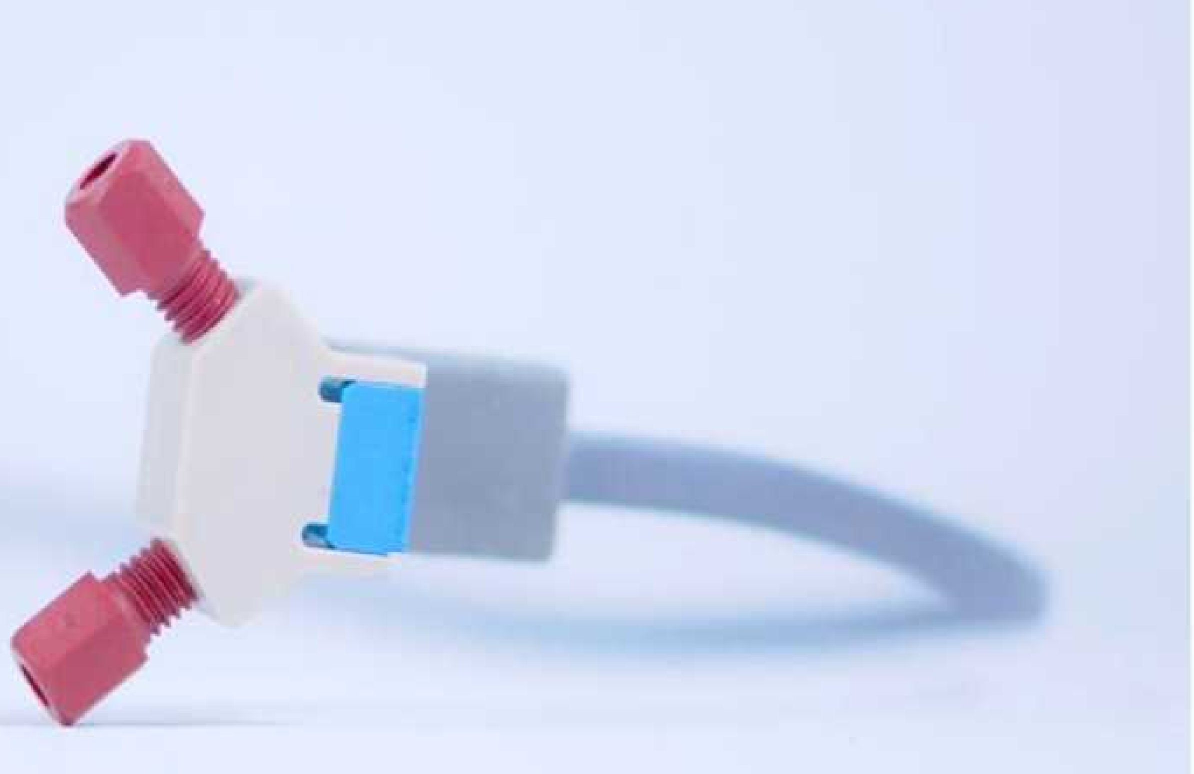
MPS MICROFLUIDIC PRESSURE SENSOR

DOCUMENT REF: UGMPS 211004

USER GUIDE



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Symbols used in this document

Important information. Disregarding this information could increase the risk of damage to the equipment, or the risk of personal injuries.

Helpful information. This information will facilitate the use of the instrument and/or contribute to its optimal performance.

Additional information available on the internet or from your Elveflow representative.

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Introduction

The Elveflow Microfluidic Pressure Sensor (MPS) is an in-line sensor designed to monitor pressures in different ranges for a wide variety of demanding microfluidic applications. Its unique design has been optimised to remove dead volume and to have a low internal volume which makes it a perfect choice for microfluidic applications.

The MPS pressure sensor comes in two packages: the small package fits 10-32 connectors to 1/16" OD tubing and the large package fits 3/32"ID tubing. The MPS small package sensor is designed especially for microfluidics with a 7 µL inner volume.

The MPS pressure sensors offer the possibility to read the output signal in two ways: with a sensor reader/OB1 pressure regulators and analogically. With the sensor reader, the data can be monitored by using the ESI software that allows you to perform real-time creation, monitoring and modifications on complex flow rate profiles such as sine, square, triangle, ramp, pulse or sawtooth. Last but not least, the ESI software allows you to record and export the data generated by all the Elveflow® instruments connected and involved in your experiment.

The MPS measures relative pressure, not absolute pressure.

Main Features & Benefits

- 5 ranges from 1 psi (70 mBar) to 100 psi (7 bar)
- Accuracy down to 0.2 % Full Scale
- Compatible with gas and liquids [1]
- No dead volume
- Ultra small internal volume of 7.5 µL in small package version
- Non-invasive measurements
- Up to 1 ms Settling time (when using the Sensor Reader & SDK)
- Fully compatible with other instruments from the Elveflow range (MSR Sensor reader and Flow Controllers (OB1, AF1))

Principle of the MPS Gauge Pressure Sensor

Our MPS pressure sensors work as gauge pressure sensors measuring positive and negative pressure relative to atmospheric pressure. This type of sensor is not an absolute pressure sensor.

What is a gauge pressure sensor?

A gauge pressure sensor measures the pressure at its port with respect to the local atmospheric pressure. For example, the pressure of 1 bar inside the vessel measured by a gauge pressure sensor is 1 bar more than the atmospheric pressure. Also, a 1 bar reading at high altitude (where air pressure is lower) would mean the pressure in the vessel has a lower absolute pressure than a 1 bar reading at sea-level.

Thus, the important thing is to understand the difference in pressure or vacuum compared to atmospheric pressure, not the exact pressure or vacuum being generated.

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[1] Limited only to media compatible with polyetherimide, silicon, and fluorosilicone seals

How does a MPS gauge pressure sensor work?

It works based on the piezoresistive effect of bonded or formed strain gauges to detect strain due to applied pressure, resistance increasing as pressure deforms the material. Generally, pressure changes the resistance by mechanically deforming the sensor membrane, enabling the sensor to detect pressure variations as a proportional differential voltage through a piezoelectric effect.

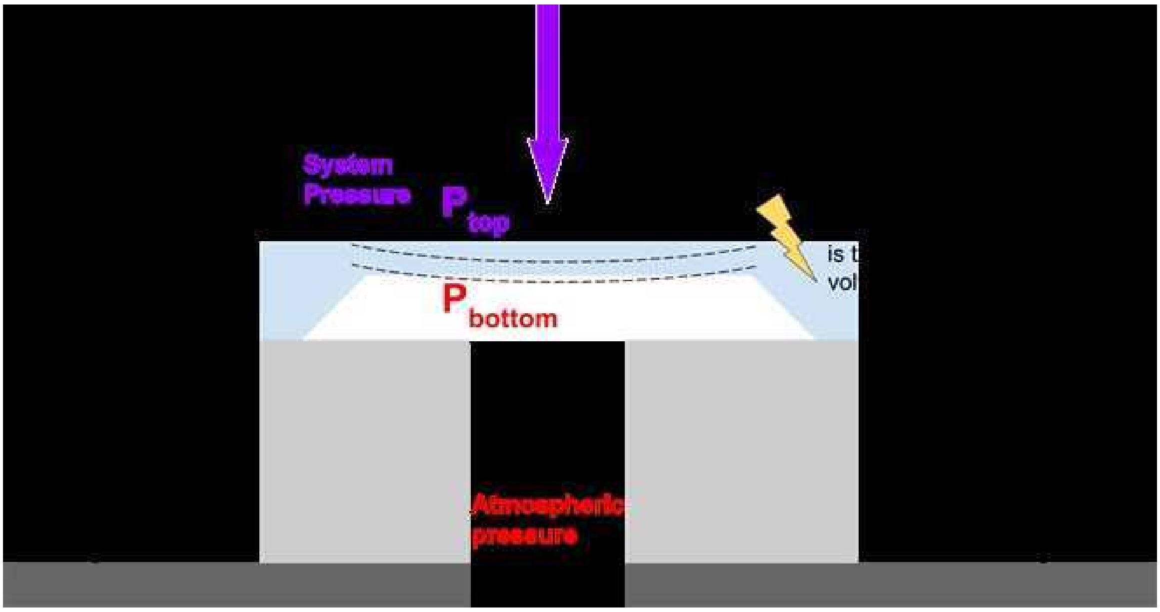


Fig 1. *Pressure variations are detected in the MPS sensor through the mechanical deformation of a semiconductor sensing membrane that is transduced into resistance changes by means of the piezoresistive effect.*

MPS Gauge pressure sensors can be calibrated.
See details about the pressure sensor calibration below.

MPS Gauge pressure sensors are not Absolute pressure sensors.
Gauge sensors pressure measurements are dependent on atmospheric pressure.

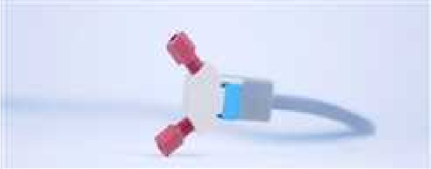
MPS Gauge pressure sensors can be simultaneously used in several positions in your setup to monitor pressure values at specific points of interest.

Important information. The pressure sensor has a thin membrane that is flexible and can deform to some extent. Excessive stresses that can be exerted in particular when handling the sensor can damage the thin sensor detection membrane (see figure 1 above) and make the sensor unusable. This kind of damage requires the replacement of the sensor, and is not covered by the Elveflow one year warranty.

Technical Specifications & Design

The Elveflow Microfluidic Pressure Sensor (MPS) is manufactured from specially selected materials (PEEK/polyetherimide, silicon, and fluorosilicone seals).

PRESSURE SENSOR		**MPS 0**	**MPS 1**	**MPS 2**	**MPS 3**	**MPS 4**
Sensor range		70 mbar 1 psi	340 mbar 5 psi	1 bar 15 psi	2 bar 30 psi	7 bar 100 psi
Pressure range min - max		-1 to 1 psi	-5 to 5 psi	-15 to 15 psi	-15 to 30 psi	-15 to 100 psi
Maximum overpressure		20 psi	20 psi	45 psi	60 psi	200 psi
Pressure accuracy liquids		up to ± 0.5 % of max range	up to ± 2 % of max range	up to ± 0.2 % of max range		
Linearity % span	Typical	0.25	0.4	0.25	0.1	0.4
	Max.	0.5	0.5	0.5	0.2	0.6
Repeatability & hysteresis % span		± 3.0	± 0.4	± 0.2		
Operating temperature		-40 °C to +85 °C				
Specified temperature range		0 °C to +50 °C				

PACKAGE MODEL	**LARGE**	**SMALL**
Sensor design		
Connection type	arrow for 3/32 ID tubing	10-32 thread with ferrule
Internal dead volume	70 µL	7.5 µL
Recommended tubing diameter (inch)	3/32" ID	1/16" OD
Wetted materials	polyetherimide, silicon and fluorosilicone seal	PEEK, silicon and fluorosilicone seal
Electrical connection	4 point measurement M8 connector compatible with Elveflow Sensor Reader and a Sensor Reader	

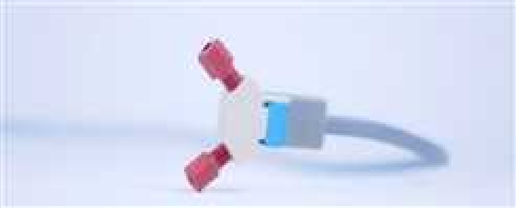
SENSOR SIZE (length x width x height): **LARGE:** 29 x 13 x 27 mm **SMALL:** 40 x 33 x 19 mm **AMPLIFICATION MODULE SIZE:** 52 x 24 x 24 mm

Design

The MPS pressure sensor comes in two packages:

- **The small package** uses 10-32 connectors for 1/16" OD tubing. The MPS small package sensor is designed especially for microfluidics with a 7 µL inner volume.
- **The large package** fits 3/32"ID tubing.

They are shown in the following picture:

1. 

2. 

Fig 2. *MPS sensors come in two different connection types: Small package (1) and Large package (2).*

Both sensor connection packages have differences but also similarities. The figure 2 below describes the elements of each package so you can easily differentiate between the two.

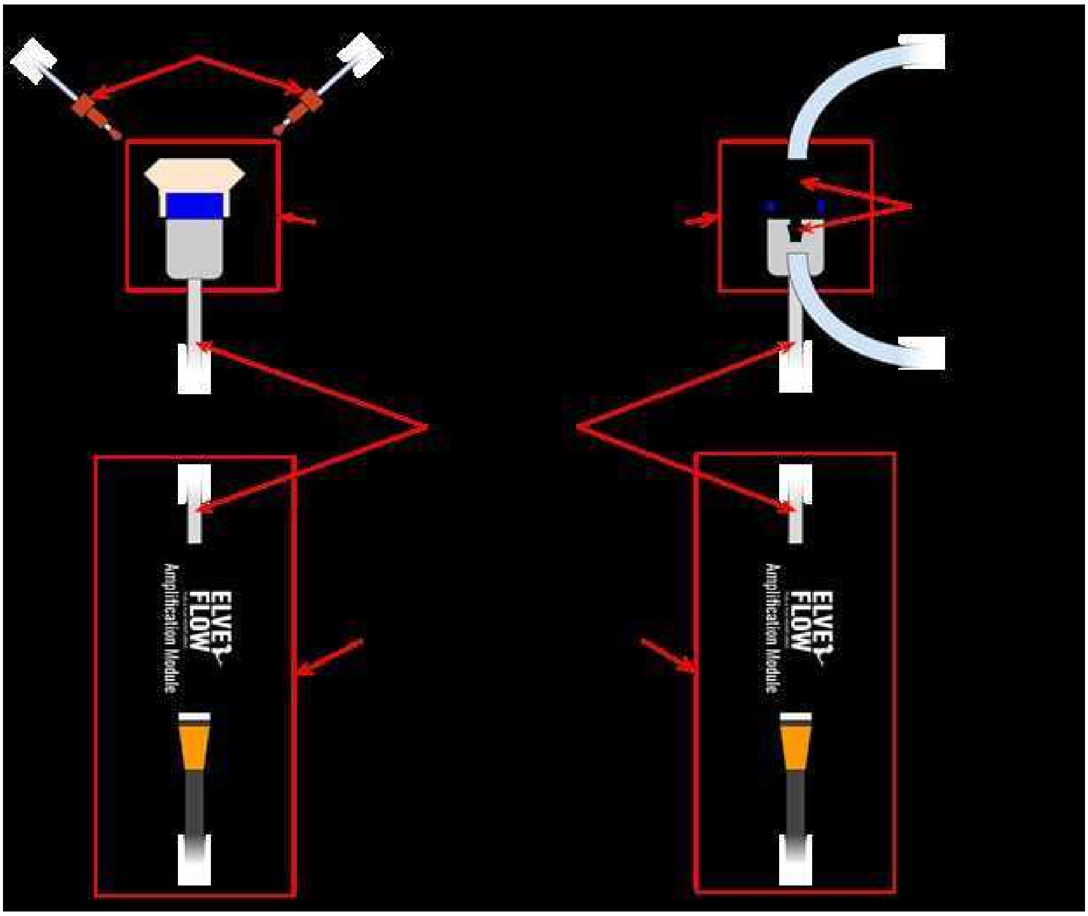


Fig 3. *MPS sensors Small package and Large package description.*

The MPS pressure sensor comes in two packages: the small package fits 10-32 connectors to 1/16" OD tubing and the large package fits 3/32"ID tubing. The MPS small package sensor is designed especially for microfluidics with a 7 µL inner volume.

The Elveflow Pressure Sensors have inlet/outlet ports which can be used in either direction.

Product package contents

Each MPS pressure sensor includes the following:

- 1 x MPS pressure sensor (small or large package)
- 1 x Data Cable
- 1 x Amplification Module
- 2 x 10-32 connectors for 1/16 OD tubing + ferrules (Optional) - Small package

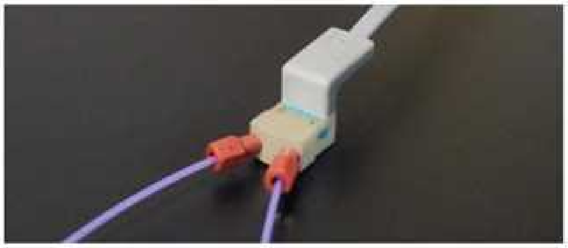
In addition to the above items. The user should have the necessary fluidic accessories (tubing, additional fittings) to connect the inlets/outlets to the rest of the setup.

Installation & use

Microfluidic connections for the Small Pressure Sensor

1. Place the 1/16 OD tubing in a 10-32 flangeless nut fitting, then position the ferrule on the tip of the tubing. Note that this last step may be difficult, since the ferrule is designed so that a maximum sealing is achieved. Once inserted, the tubing must be at the same level as the flat face of the ferrule.

2. Screw the flangeless nut directly into the connector.



Microfluidic connections for the Large Pressure Sensor

The Large version of the Elveflow Pressure Sensors uses barb fittings that are inserted into microfluidic tubing.

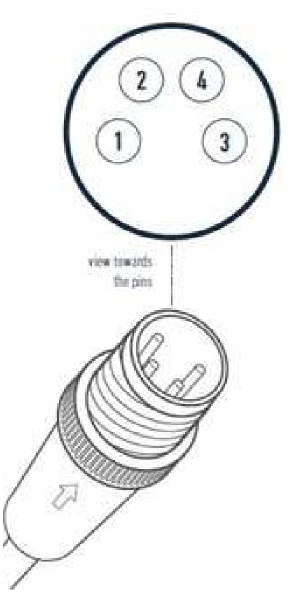
Electronic data cable connection

These sensors come with an amplification module that can be connected to the instrument (OB1, Sensor Reader, etc…).

Connect the male part of the cable to the female connector on your instrument.

Custom Sensor Connection

The MPS pressure sensor can also be readout analogically without requiring the sensor reader. The pin out diagram and the specifications are listed in detail below.



MPS Pressure Sensor Amplification module pinout

1. Vcc 11.5 - 15 V, 7 mA[1] (power supply)
2. Not in use
3. Ground
4. Signal - see below:

MODEL	ZERO PRESSURE VOLTAGE [V]	SENSITIVITY [mbar/V]
MPS0 (70 mbar)	5	136,7
MPS1 (340 mbar)	5	229.8
MPS2 (1 bar)	5	344.7
MPS3 (2 bar)	5	689.47
MPS4 (7 bar)	5	2298

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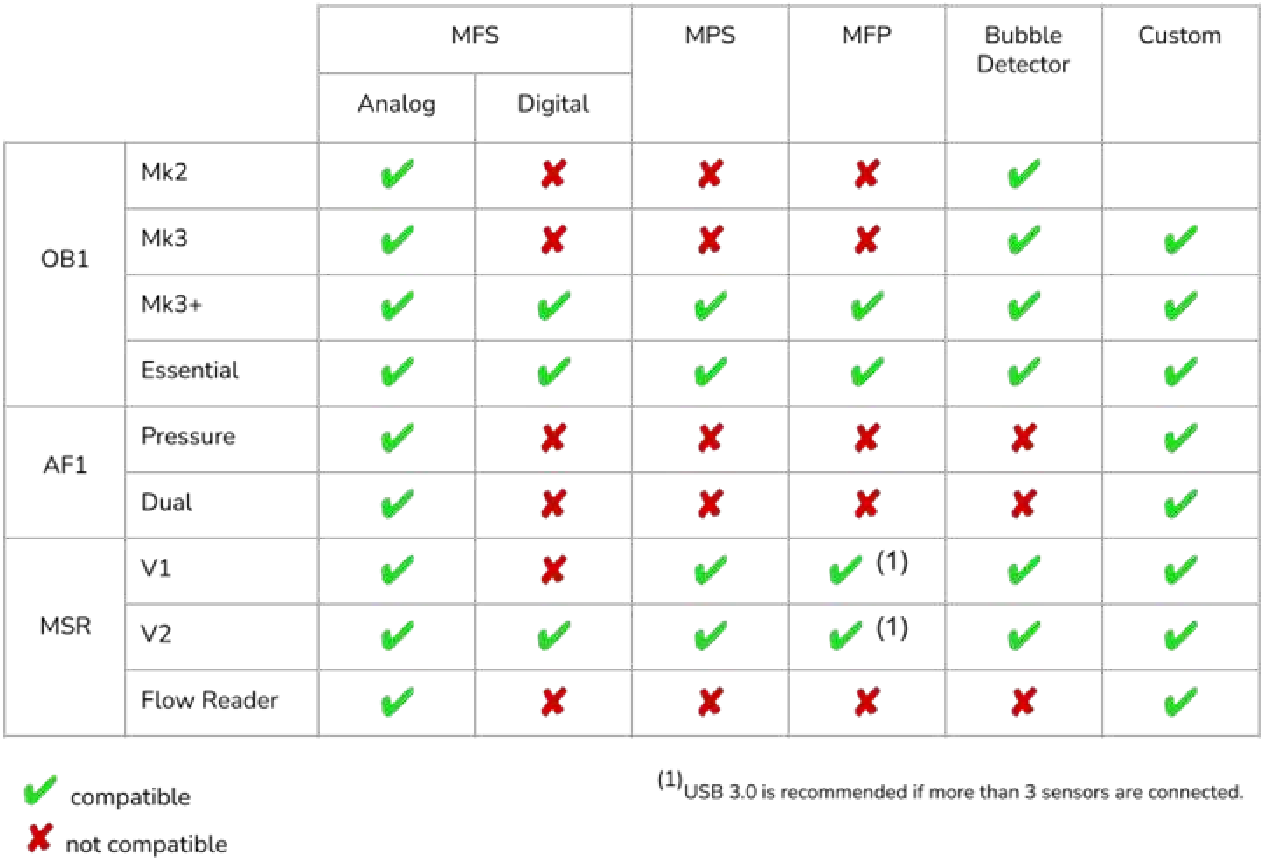
[1] Typical current consumption

Important warranty Notice

About custom sensor wiring: The sensor pin diagram above is for understanding purposes only. Sensor wiring modification is not covered under warranty. Any damage resulting from a miswiring or any other type of misuse is not covered by warranty.

The use of our sensors with instruments that are not part of the Elveflow range is not guaranteed. If you use these sensors with different electronics (eg: Arduino) or with a wiring diagram different from the standard wiring, any damage that may occur to these sensors will not be covered by the warranty.

Sensors compatibility chart with Elveflow instruments



		MFS		MPS	MFP	Bubble Detector	Custom
		Analog	Digital				
OB1	Mk2	✓	✗	✗	✗	✓	
	Mk3	✓	✗	✗	✗	✓	✓
	Mk3+	✓	✓	✓	✓	✓	✓
	Essential	✓	✓	✓	✓	✓	✓
AF1	Pressure	✓	✗	✗	✗	✗	✓
	Dual	✓	✗	✗	✗	✗	✓
MSR	V1	✓	✗	✓	✓ (1)	✓	✓
	V2	✓	✓	✓	✓ (1)	✓	✓
	Flow Reader	✓	✗	✗	✗	✗	✓

✓ compatible
✗ not compatible

(1) USB 3.0 is recommended if more than 3 sensors are connected.

Application example: pressure monitoring

You can connect the MPS sensors wherever you want in the setup in order to monitor your microfluidic experiment. When used with e.g. the Sensor Reader, this allows you to control 4 sensors simultaneously via our ESI software.

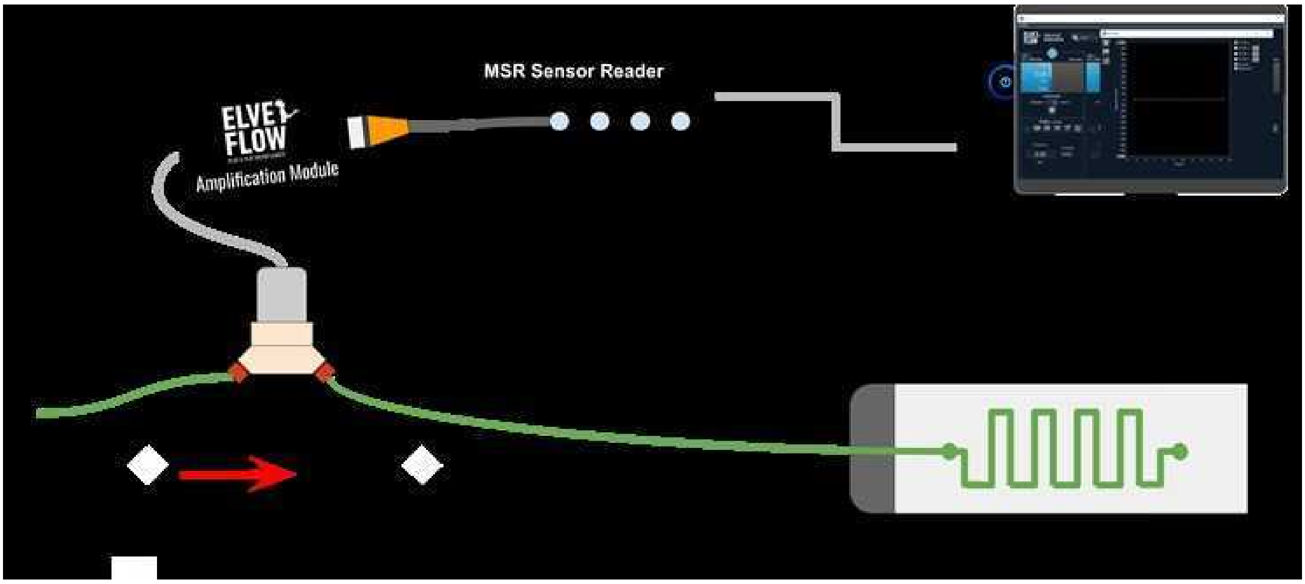


Fig 4. *A typical setup using a MPS sensor for monitoring pressure in any point of your microfluidic setup.*

To monitor pressure in a simple microfluidic setup, the basic steps would be:

1. Place the pressure sensor (MPS) anywhere you want on your fluidic path and electrically connect your sensors to the microfluidic sensor reader. Thanks to their small footprint, sensors can be placed anywhere within your fluidic system.
2. Connect the microfluidic sensor reader (MSR) to your computer via USB and monitor sensor data using the Elveflow Smart Interface (ESI).
3. Connect the chip for which you'd like to monitor pressure to your flow path. In this position, the sensor directly measures the pressure entering the microfluidic chip. you can add another pressure sensor at the chip outlet in order to get the difference in pressure and/or the microfluidic resistance.

Tips & tricks - Recommendations

Cleaning

Sensors Cleaning general recommendations

It is recommended to clean the sensors after each use according to procedure detailed in the dedicated user guides. If possible, dedicate a discrete sensor for each different liquid to be measured. If this is not possible, plan a proper change of the media and include a cleaning step in-between.

It is important to not let the sensor dry out, and clean your sensor after each use, so that there is no residue building in the sensor flow channel over time. Residue buildup will typically happen if the sensor is only drained after use but not properly cleaned. The residue inside the flow channel wall will become a constant deposit and will be more difficult to clean over time. These residues will likely cause measurement deviations. Particles and other matter can clog a sensor and quickly make it inoperable. Sensor clogging is a serious problem that often requires a replacement of the sensor (not covered by the Elveflow guarantee). Some solutions can be used to clean clogged sensors (see Hellmanex protocol below), but cleaning your sensor once it is clogged does not automatically imply unclogging success.

The following strategies are just general guidelines that any Elveflow Sensor user should adapt, taking into account the specificities of each experiment performed. Ensure that you have found a good cleaning procedure before performing the first tests, and always clean immediately after emptying the sensor. Routine cleaning after each use is the key to ensure a long life for your sensor.

Working with water

When working with water, it is not recommended to let the sensor dry out. Salts and minerals in the water will deposit inside the flow channel and are difficult to remove. Although salt solutions are particularly prone to these problems, even clean water can contain enough dissolved minerals to form a deposition layer. Therefore, we recommend flushing with DI water on a regular basis to prevent build-up. Should you still encounter problems, occasionally flush the sensor with slightly acidic cleaning agents.

Working with oils

When working with oil, it is not recommended to let the sensor dry out. Edible oils can become rancid, dry out or simply change their composition over time and leave sticky films on the wall of the flow channel. It is recommended to clean the flow channel right after emptying the flow meter. Flush with solvents such as IPA, methanol, ethanol, acetone, etc., or cleaning detergents on a regular basis, to remove oil films.

Working with silicone oils

When working with silicone oil it is not recommended to let the sensor dry out. Silicone oils can be cleaned out using acetone or special cleaners.

Working with paints or glues

When working with paints or glues, it is critical to not let the sensor dry out. Deposits of paints and glues are often hard or impossible to remove after they have dried. Flush the sensor with cleaning agents recommended by your paint or glue manufacturer. Make sure that the agents are compatible with the flow meter’s wetted materials.

Warnings and recommendations

Serious Warnings and Precautions

Any cleaning by mechanical means should be avoided. Never enter the sensor’s flow channel with rigid or sharp objects that could scratch the flow channel surface. Furthermore, no abrasives or liquids containing solids that can grind the flow channel surface should be used. Anything that affects the flow channel wall will cause deviations in the measurement performance, or permanently damage the flow meter.

Abrasive liquids are not to be used for cleaning! Strong acids and bases should also not be used to clean the flow meter.

Material compatibility

Remember to always check your fluids for compatibility with the Elveflow equipment’s wetted materials. Exposing Elveflow equipment to multiple chemicals and compounding application factors like temperature, pressure, concentration, etc… can result in significantly different performance. Specific material compound formulations can significantly alter generalized performance ratings. Elveflow makes no warranty, expressed or implied of actual performance in specific end user applications. It's the user's responsibility to evaluate specific chemical compatibility of parts prior to use. Contact customer@elveflow.com if you’d like to know the wetted material of the sensor you’re using.

Choose a washing step based on your experiment.

One of the fundamentals that will help you early on is that you have to choose the washing solution based on the solubility of the compounds used. This is critical if the goal is to remove material which may foul the sensor over time. Please always take some time to think about how to adapt a generic cleaning protocol to your specific situation.

Overpressure and handling precautions

These sensors feature a sensing technology that uses a thin piezoresistive sensing membrane to offer high sensitivity and accuracy. It should be noted that these sensing membranes are fragile, and that special care must be taken to avoid sudden pressure changes (do not expose to overpressure, see pressure ratings in section *“Technical Specifications & Design”* above, p4).

Handle with care. These sensors can be severely damaged by even brief overpressure pulses, so particular attention must be given when using syringe pumps. Also, hand manipulations (e. g. sensor fluidic connection, washing, etc…), may seem a relatively simple operation, but care must be taken to avoid twisting and bending, that could damage the sensor membrane.

Never mechanically clean the sensor’s fluidic channel.

Ensure your pressure sensor is used below the overpressure limit anytime.

Pressure Sensor Calibration

Calibration using ESI sensor calibration module

The sensor calibration module allows the user to calibrate the pressure value from a pressure sensor with pressure output by the OB1. It allows matching the OB1 pressure. To perform this calibration, a pressure sensor needs to be connected to an OB1 pressure output and a plug has to be set after the pressure sensor.

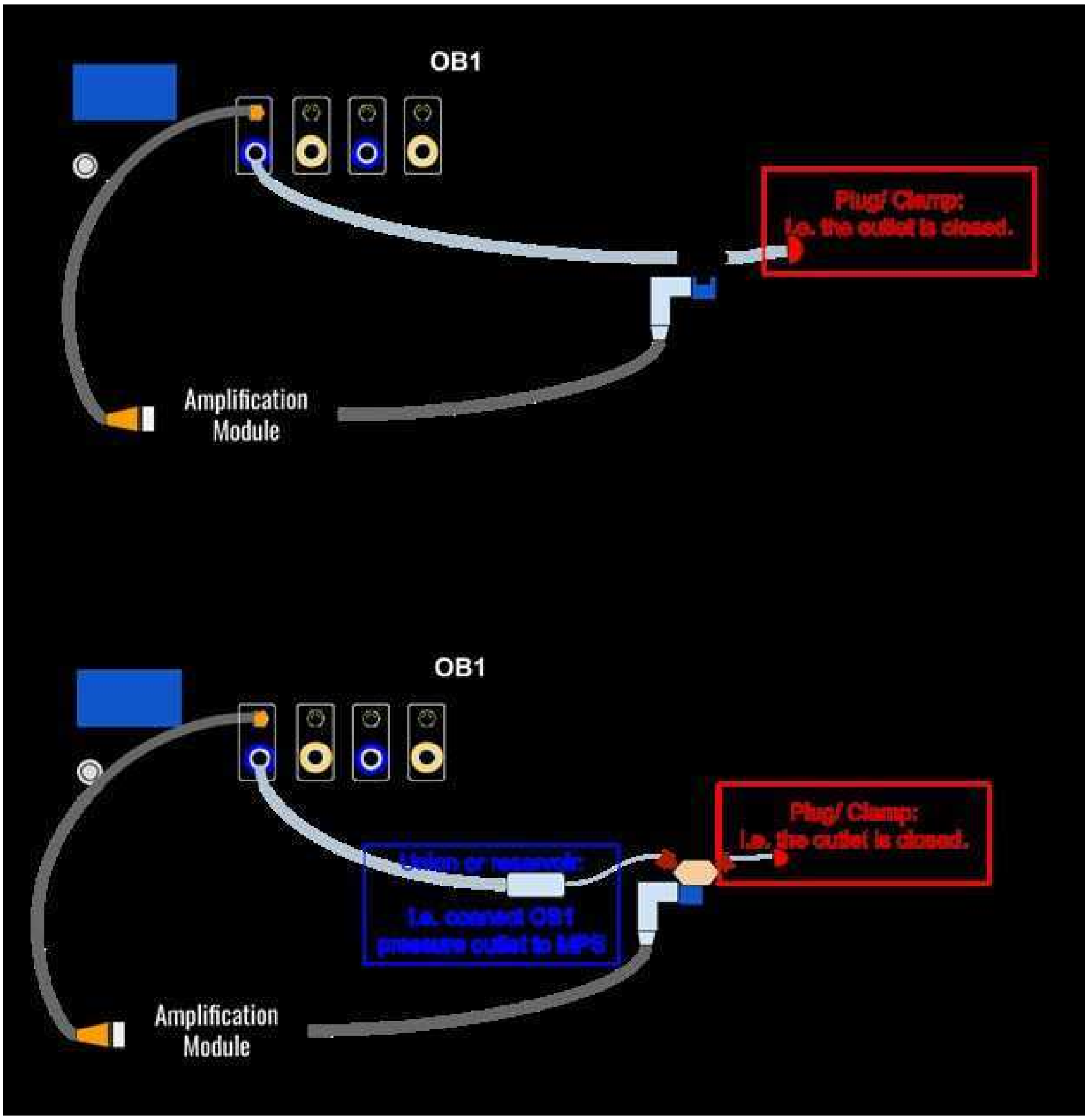


Fig 5. *Pressure Sensor Calibration recommended connection scheme for each MPS package type.*

Then, in the ESI main windows (see step 1 in fig 1 below) open the sensor calibration module, by clicking on “Add module”, then select “sensor calibration”.

Fig 6. *How to reach and open the Sensor Calibration module in ESI.*

Then, in this new window, select “Custom Range”, and enter your sensor Min and Max values, while making sure not to exceed your sensor range, to prevent sensor damage. To proceed, click on “Calibrate”.

You can stop the process and cancel the calibration at any time by clicking on “ABORT”. If you performed a calibration and want to go back to original values before calibration, go to the pressure sensor parameters in the scaling tab and put back Scale Factor to 1 and Offset to 0 (see how to reach these settings in the method described below).

Sensor Calibration Mo...

Custom Range

Min: 0

Max: 80

Fig 7. *Set sensor Min and Max values*

Calibration using an OB1.

When required, please follow these steps to calibrate your pressure sensor:

1. Connect your pressure sensor directly to your OB1 channel and close the air output after the sensor.
2. Go to your MPS sensor settings.
3. Under "Scaling" the "Scale factor" should be 1.00 and "Offset" should be 0.00.

***Fig 8a.** The MPS Scale Factor and Offset fields can be reached in the "Scaling" tab of the MPS settings.*

4. First modify offset at 0 mbar (for example) to set the sensor value to 0 mbar.

***Fig 8b.** Adjusting the MPS Scale Factor and Offset (1/2).*

Then increase the pressure and modify the scale factor to fit your pressure source value. An OB1 is used as the pressure source reference in this example, but any calibrated pressure source is ok, as long as the pressure value fits with the sensor range, to avoid sensor damage. Set a moderate pressure, for example 300 mbar depending on your pressure sensor range. **Be careful about your sensor range, which must not exceed the pressure limit of your sensor!**

5. Your sensor is now calibrated. If you increase or decrease the pressure you will obtain the right pressure value. You can repeat the modification in the range of interest by modifying offset and scale factor.

Fig 8c. *Adjusting the MPS Scale Factor and Offset (2/2).*

Calibration using a U-tube Manometer (water column hydrostatic pressure reference).

Sometimes you will use a pressure sensor in a very simple setup, e.g. with just a syringe pump and a chip. Therefore you may not have an OB1 or another trusted pressure source reference to calibrate your sensor.

If you're in this situation, you may still be able to use alternative pressure references, such as a water column, that could give you a hydrostatic pressure reference. Hydrostatic pressure is the pressure that is generated by the weight of liquid above a measurement point, when the liquid is at rest.

A calibration of the pressure sensor can then be performed using a simple U-shaped manometer. In the figure below, one end of the manometer is open to air while the other end is connected with tubing to the outlet of the sensor. The inlet of the sensor is connected to a syringe by a plastic tube.
The principle of the manometer is that the pressure to be measured is applied to one side of the tube producing a movement of liquid, as shown in figure below.
The hydrostatic pressure inside the sensor, varied by the syringe, is proportional to the difference in water height in the manometer. Assuming the inlet pressure is of constant value, the liquid will only stop moving when the pressure exerted by the column of liquid, *h* is sufficient to balance the pressure applied to the left side of the manometer, i.e. when the head pressure produced by column *h* is equal to the pressure to be measured.

Knowing the length of the column of the liquid, H, and density of the filling liquid, we can calculate the value of the applied pressure.

The applied Pressure is $\mathbf{P = \rho \times g \times h}$ where

p = pressure in liquid
ρ = density of liquid
g = acceleration of gravity (9.81 m/s2)
h = height of fluid column

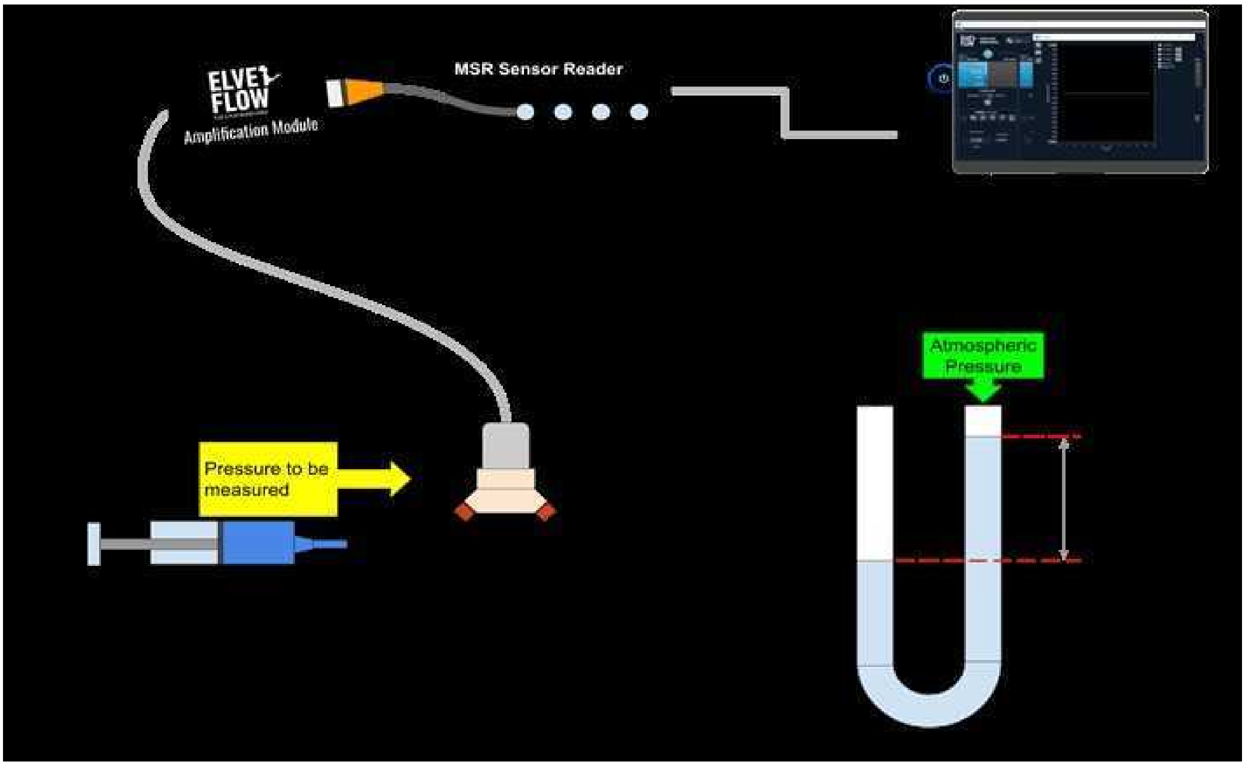


Fig 9. *Calibration using hydrostatic pressure (water column) reference.*

Then to calibrate your sensor in ESI using the calibrated hydrostatic pressure references calculated earlier is easy. It can be performed using the same method as above (see [Calibration using an OB1](#)). First modify the offset at 0 mbar in ESI, then modify the scale factor to fit your pressure source value, using data resulting from the U-tube hydrostatic pressure references calculated.

Linked products

[Live Cell Perfusion Pack](#)
A liquid handling platform for cell-based experimentations

[OB1 MK3+ Flow Controller](#)
The most responsive and stable flow controller on the market

[Microfluidic Reservoirs](#)
microfluidic adapters for Eppendorf © , Falcon © tubes or GL45 threaded glassware

Customer Support

You are welcome to browse through the Elveflow Support Portal accessible online anytime (https://support.elveflow.com/support/solutions). You can find lots of guidance on how to use our product line. It is most likely that the answers you're looking for are already here.

In case there are still some questions and you'd like further clarification, please don't hesitate to let us know by email at customer@elveflow.com.

With critical context information readily at hand, Elveflow Support employees will be better prepared to help you.

The elements usually required are:

- the serial number of the Elveflow device(s) used (Sensors, Instrument)
- the ESI software initialization file located in C:\Users\Public\Documents\Elvesys\ESI\data. It is called either "ConfigESI.ini" or "ESI.ini", depending on your ESI version.
- the screenshots of the error messages received, if applicable.
- Some pictures, or movies of your setup and your issue. WeTransfer is perfect for easily sending us large files.

We are always happy to help ❤️