

# BioPAT® Low Flow

An Ultrasonic Clamp-On  
Sensor for High-Precision,  
Non-Invasive, Low Flow  
Rate Measurements in  
Bioprocessing



## Product Information

The BioPAT® Low Flow is an ultrasonic clamp-on sensor with an integrated converter for high-precision and robust non-invasive flow measurement. The sensor is specifically designed to measure with high precision across its entire specified flow range (0% - 100% Q<sub>max</sub>) including the low flow range.

## Features and Benefits

- No contamination due to non-invasive flow measurement
- No extra amplifier or transmitter needed for data read-out
- Improved bubble robustness
- Ideal for high-purity liquid

# Introduction

## Relevant Applications

- Early development
- Process development
- Clinical production
- Commercial manufacturing

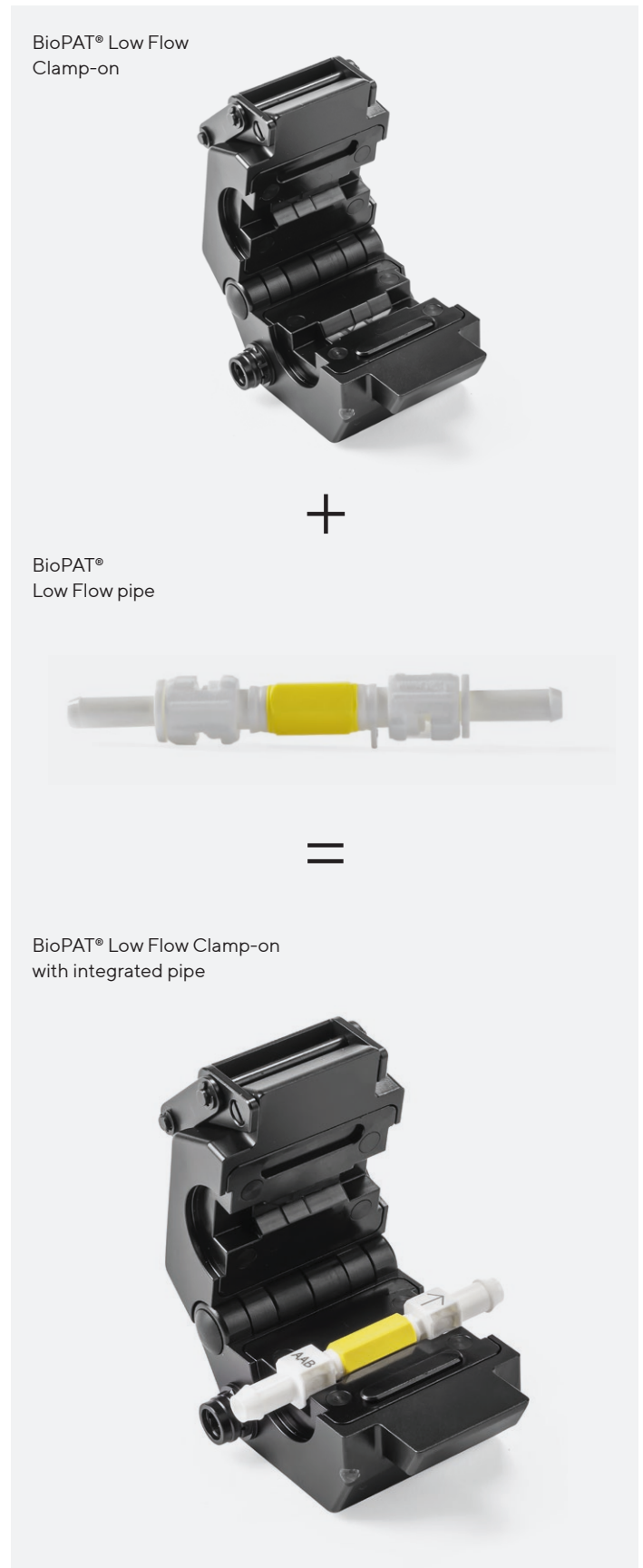
## Relevant Process Steps

- Final sterile filtration (determination of final product concentration)
- Chromatography (product concentration and breakthrough during load)

## Product Highlights

- High-precision measurements across its entire specified flow range
- Automatic selection of calibration tables, eliminating the need for user interaction
- Easy integration into system installations due to integrated measurement amplifier and Modbus RTU
- Low dependency on fluid temperature and pressure
- Very small footprint
- Air detection functionality
- Empty line detection

**Figure 1:** *BioPAT® Low Flow Components*



## Benefits of Using a Flow Pipe

Alongside the BioPAT® Flow ultrasonic sensors, the BioPAT® Low Flow ultrasonic sensors are the only flow meter clamp-ons available on the market that use a single-use flow pipe instead of measuring directly on the tube.

This innovation comes with several advantages:

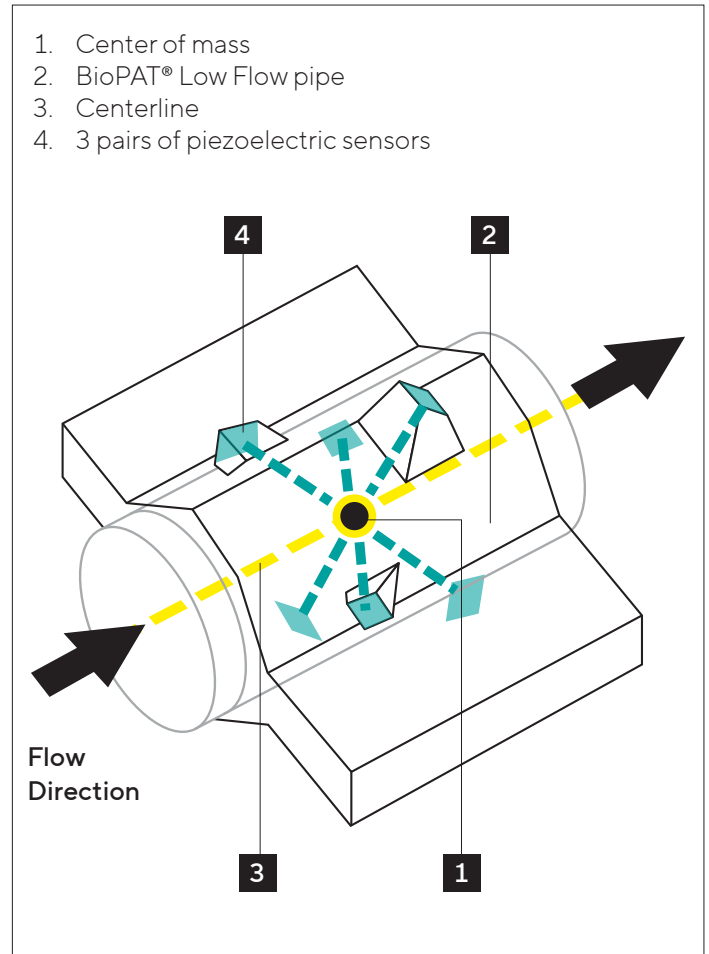
- Superior accuracy: Provides better precision than measurements on tubes due to optimized coupling, rigid material, and a straight flow path.
- Consistent reproducibility: Unlike tubes, the flow pipes do not have deviations in their cross-sectional area and wall thickness, an essential factor for the operability of the system.
- Excellent chemical resistance: Suitable for ADC applications due to its high chemical resistance.
- Pressure independence: Measurement remains stable despite pressure changes, as the rigid flow pipe material does not expand or collapse. Suitable for high-pressure applications up to 5 bar (g).
- Versatile applications: Flow pipes can connect to all types of tubes with a specific inner diameter, including reinforced tubing. Conventional clamp-on flowmeters require additional calibration for each tube material and thickness.
- Defined measurement position: The flow pipe is integrated at a specific location in the tube system, reducing the risk of operator errors and ensuring higher precision by preventing incorrect positioning.

## Measurement Principle

Inside the flow clamp-on, three pairs of piezoelectric sensors function both as a source and a detector for ultrasound waves. The sensor pairs are oriented diagonally in the corners of the clamp-on.

Each sensor sends a wave to its opposite counterpart. The waves travel through the flowing liquid at a certain angle, such that they either travel downstream and are accelerated by the flow stream or they travel upstream and are decelerated by the flow stream. This leads to a transit time difference between the two signals that is proportional to the flow velocity, from which the flow rate can be calculated using the inner diameter of the flow pipe. To increase measurement accuracy, the three sensor pairs measure the transit time difference simultaneously.

**Figure 2:** Operating Principle of the BioPAT® Low Flow



## Data Read-Out

The BioPAT® Flow sensors can be read out using different options:

### Integration Into Sartorius Bioprocessing Systems

The sensors can be fully integrated into the hardware and software of Sartorius bioprocessing systems. For system configuration the sensor must be connected via Modbus RTU cable, which is available in different lengths.

### Configuration and Read-Out via PC

The sensors can be connected to a PC with corresponding service software for data logging and monitoring. A dedicated cable to connect the sensor to a PC is available on request (please see Ordering Information).

## Influence of Process Conditions

### Temperature

Variations in temperature have a significant influence on the ultrasonic flow measurement, as they change both the viscosity of the flowing liquid and the velocity of the ultrasonic waves. BioPAT® Low Flow sensors offer five standard calibration tables, stored in every clamp-on, that ensure the highest accuracy in the following working temperature ranges:

- Water 6 °C | -∞ - 10 °C
- Water 13 °C | 9 - 17 °C
- Water 20 °C | 16 - 24.5 °C
- Water 28 °C | 23.5 - 33 °C
- Water 37 °C | 32 - ∞ °C

In addition to the five water calibration tables, there are additional calibration tables available: one for a 200 g/L BSA solution (derived theoretically from water calibration table 3: BioPAT® Low Flow Pipe, Water @ 20 °C), which is valid in the range of +20 °C to +25 °C, and one for 80 g/L *Saccharomyces cerevisiae* (derived theoretically from water calibration table 4: BioPAT® Low Flow Pipe, Water @ 28 °C), valid in the range of +30 °C to +35 °C.

In addition to the five water calibration tables, there are additional calibration tables available (see “Composition of the Liquid Stream”)

### Pressure

Thanks to the design and material of the flow pipes, pressure influences the flow measurement in a negligible way. Changes in pressure do not affect the accuracy of the BioPAT® Low Flow single-use pipe.

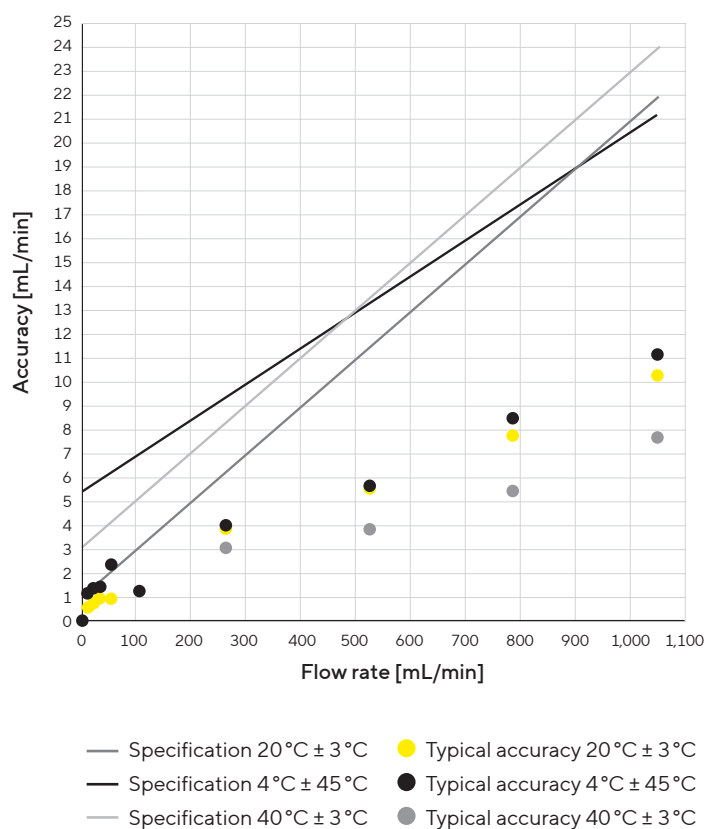
### Composition of the Liquid Stream

The standard calibration tables for BioPAT® Flow use water as calibration fluid. The measurement accuracy depends on the viscosity and density. Therefore, additional calibrations for BSA and *Saccharomyces cerevisiae* are available as part of the standard product, and further calibration tables are available on request. The stated accuracy has been confirmed for:

- Aqueous solutions (e.g., buffer solutions)
- Protein suspensions: BSA 200 g/L, (derived theoretically from water calibration Table 3 at 20 °C), valid in the range of +20 °C to +25 °C
- Cell suspensions: *Saccharomyces cerevisiae* 80 g/L (dry weight, derived theoretically from water calibration Table 4: BioPAT® Low Flow Pipe, Water @ 28 °C), which is valid in the range of +30 °C to +35 °C

For more challenging solutions, such as high-concentration buffers, preliminary studies are recommended to assess whether the standard calibration tables are suitable for the specific application. If not, customized calibration tables, which are available on request, are recommended. For more information, please contact our technical support.

**Figure 3:** BioPAT® Low Flow Sensors Show Consistent Performance and High Accuracy Over a Wide Temperature Range



## Sensor Integration Into Single-Use Assemblies

Proper installation of the BioPAT® Low Flow sensor ensures reliable and accurate ultrasonic measurement. When installing the sensor into a single-use assembly, it is important to position the sensor so that the pipe is always filled with liquid and does not run dry or catch air bubbles. This can be achieved by positioning the sensor at a low position. Integration suggestions are presented in Figure 4.

Furthermore, a straight inlet path length is recommended (see Technical Specifications). When planning the integration of BioPAT® Low Flow next to a pump, the preferred position for the sensor is on the suction side. This placement prevents loss of signal quality due to the temporary presence of air bubbles on the discharge side of the pump.

## Qualification and Quality Assurance

All BioPAT® Low Flow sensors comply with the quality and safety requirements of typical biopharmaceutical processes. Full batch traceability and quality control ensure that the single-use flow pipes follow the directives and guidelines of the relevant regulatory agencies.

A comprehensive testing procedure includes, among others:

- Extractable studies
- CE | UKCA compliance
- RoHS | REACH compliance
- EMC compliance

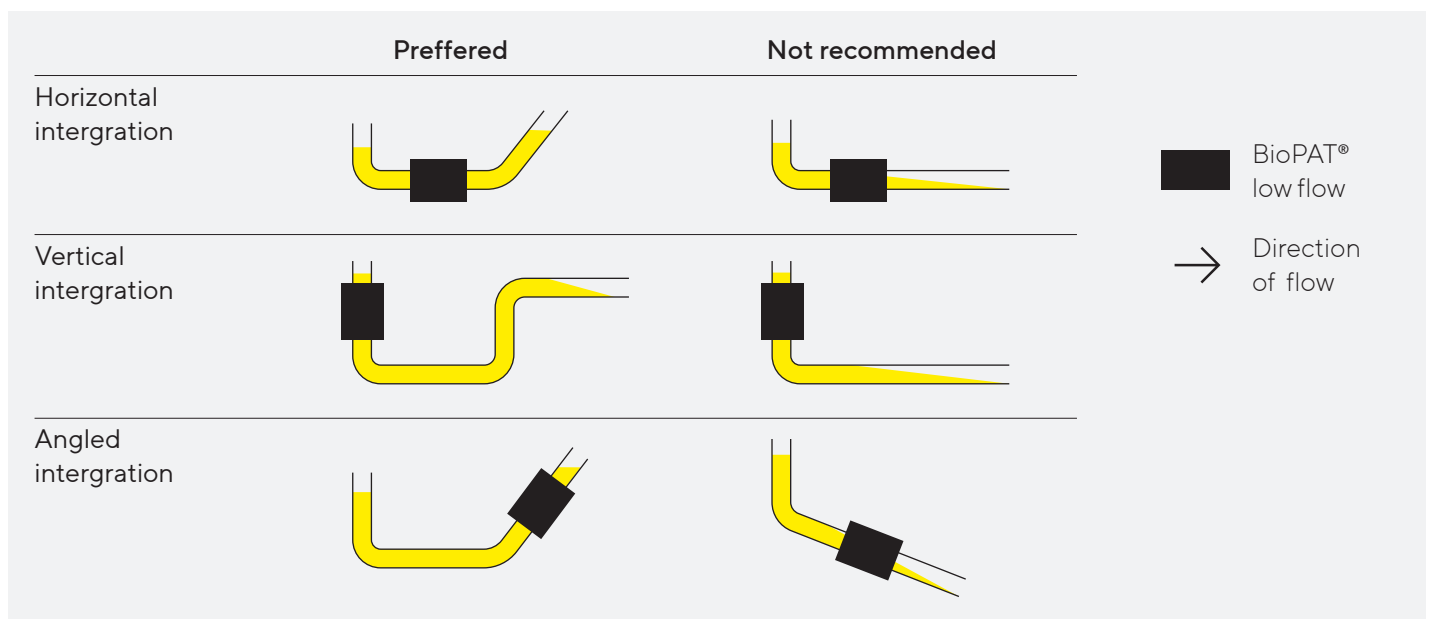
Non-cytotoxic (according to ISO-10993-5 and USP <788>, <85>).

## Measurement Range and Accuracy

Size	1/8"	1/4"	3/8"
Flow range	0 – 1,050 mL/min	0 – 4,200 mL/min	0 – 10,000 mL/min
<b>System accuracy *1</b>			
at 20°C ± 3°C media temperature	± 1 mL/min ± 2.0% of current value	± 4 mL/min ± 1.8%	± 7.5 mL/min ± 1.5%*2
at 37°C ± 3°C media temperature	± 3 mL/min ± 2.0% of current value	± 3 mL/min ± 1.5%	± 13 mL/min ± 1.5%*2
4°C - 45°C media temperature	± 5.5 mL/min ± 1.5% of current value	± 23 mL/min ± 1.5%	± 15 mL/min ± 1.5%*2

\*1 Zeroing required for application temperature \*2 Only for ambient temperature +20 - +25°C

**Figure 4:** Preferred Installation of the BioPAT® Low Flow Clamp-On

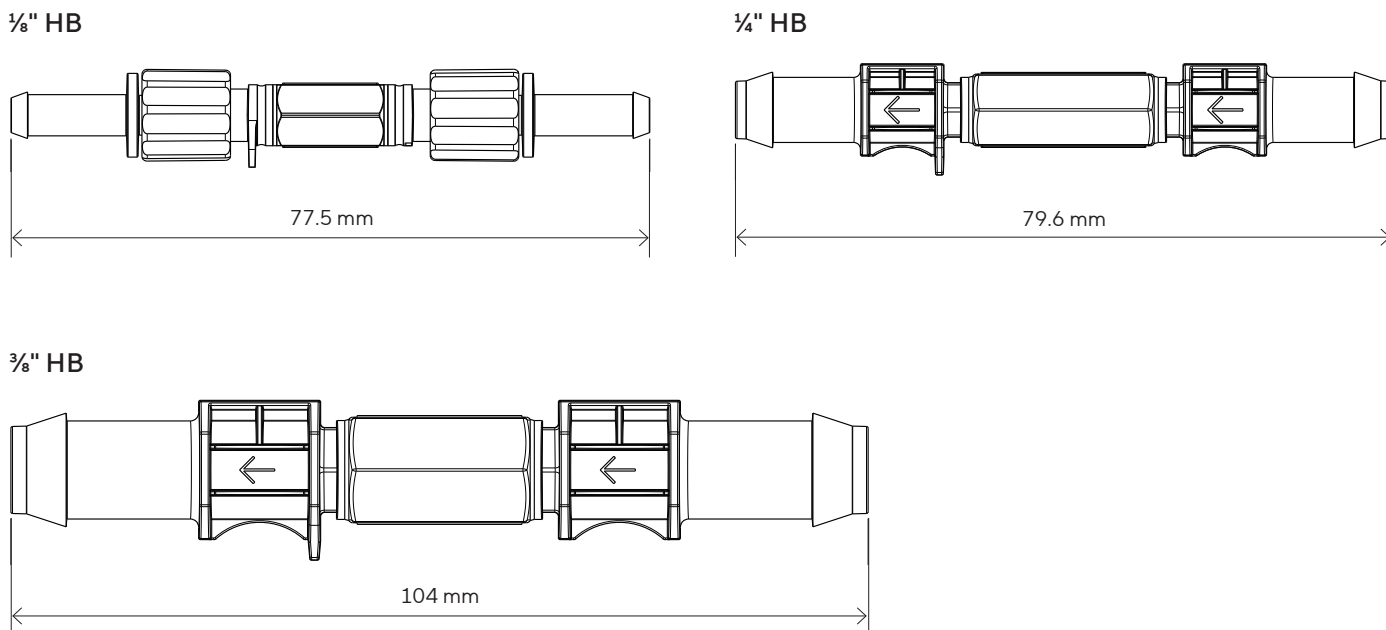


# Technical Specifications

## Single-Use Pipes

Material	In contact with product: Polybutylene terephthalate (PBT) Other: Thermoplastic elastomer (TPE; styrene block copolymer based)
Sizes (ID)	$\frac{1}{8}$ " , $\frac{1}{4}$ " , $\frac{3}{8}$ "
Connections	HB
Operating temperature range	4 - 45 °C
Operating pressure range	0 - 5 bar
Minimum inlet path length	$\frac{1}{8}$ " : 18 × ID (57, 15 mm), $\frac{1}{4}$ " : 18 × ID (114, 30 mm), $\frac{3}{8}$ " : 18 × ID (171, 45 mm)
Chemical resistance*	1 M NaOH at 40 °C for 2 hours 1 M HCl at 25 °C for 30 min EtOH 20% aqueous solutions at 25 °C for 24 hours IPA 30% aqueous solutions at 25 °C for 24 hours 20% aqueous solutions of the following compounds at 20 °C for 24 hours: N, N-dimethylacetamide (DMAc), dimethyl sulfoxide (DMSO), N, N-dimethylformamide (DMF), propylene glycol (PG), acetonitrile (ACN), and N-methyl-pyrrolidone (NMP). Solutions with pH 1 - 13 comparable to aqueous 75 mM PAA at 25 °C for 30 min
Shelf-life	Prior to gamma irradiation: 3 years. After gamma irradiation: 3 years

ID = inner diameter \*1 tested in 1 year-aged irradiated pipes



## BioPAT® Low Flow Clamp-Ons

Material	PPSU   PTFE-similar coating   PP
Cable length [cm]	30, 100, 280 (see Ordering Information)
Head dimensions [mm]	51.3 × 54 × 82.2 (1/8", 1/4") 61.7 × 54.0 × 92.2 (3/8")
IP code	IP54
Calibration tables	Supplied with 5 standard calibration tables
Calibration frequency	Every 2 years (recommended)
Cleaning and disinfection	Clean and disinfect using alcohol-based surface cleaners
Interface	Modbus RTU, analogue output 4–20 mA

## Ordering Information

### Single-Use Pipes

Product Description	Order Number
BioPAT® Low Flow Pipe 1/8" HB	BPL1010
BioPAT® Low Flow Pipe 1/4" HB	BPL1020
BioPAT® Low Flow Pipe 3/8" HB	BPL1030

### Clamp-Ons

Product Description	Order Number
BioPAT® Low Flow Clamp-On 1/8"	BPL1110
BioPAT® Low Flow Clamp-On 1/4"	BPL1120
BioPAT® Low Flow Clamp-On 3/8"	BPL1130

### Accessories

Product Description	Order Number
BioPAT® low flow clamp-on cable, 30 cm	BPL1290
BioPAT® low flow clamp-on cable, 100 cm	BPL1291
BioPAT® low flow clamp-on cable, 280 cm	BPL1292
BioPAT® low flow PC connection cable	BPL1294

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