

BFS CORIOLIS PREMIUM FLOW SENSOR

DOCUMENT REF: UGBFS 211004

USER GUIDE



Table of contents

Introduction	3
Main Features & Benefits	3
Principle	3
Technical Specifications & Design	4
Product package contents	7
Installation	8
Electrical connection using Digital RS232 interface	8
Microfluidic connection	10
Storing conditions	11
Operation	12
ESI Software and SDK	12
Mass flow measurement and control	12
Calibration - How to calibrate a BFS flow sensor?	12
Maintenance of BFS sensors, and Advanced Use	14
Sensors Cleaning general recommendations	14
Working with water	14
Working with oils	14
Working with silicone oils	14
Working with paints or glues	14
Storing conditions	15
Additional information	15
Linked products	16
Customer Support	16

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.

Introduction

The Bronkhorst Flow Sensor (BFS) is an in-line sensor based on the Coriolis principle designed to monitor flow rates in different ranges for a wide variety of demanding microfluidic applications.

The BFS sensor is monitored by a computer through a RS 232 Interface. This sensor is fully integrated within the Elveflow® ESI software that allows you to perform real-time creation, monitoring and modifications of complex flow rate profiles such as sine, square, triangle, ramp, pulse, or sawtooth. Last but not least, the ESI software allows recording and exporting the data generated by all the Elveflow® instruments connected and involved in your experiment.

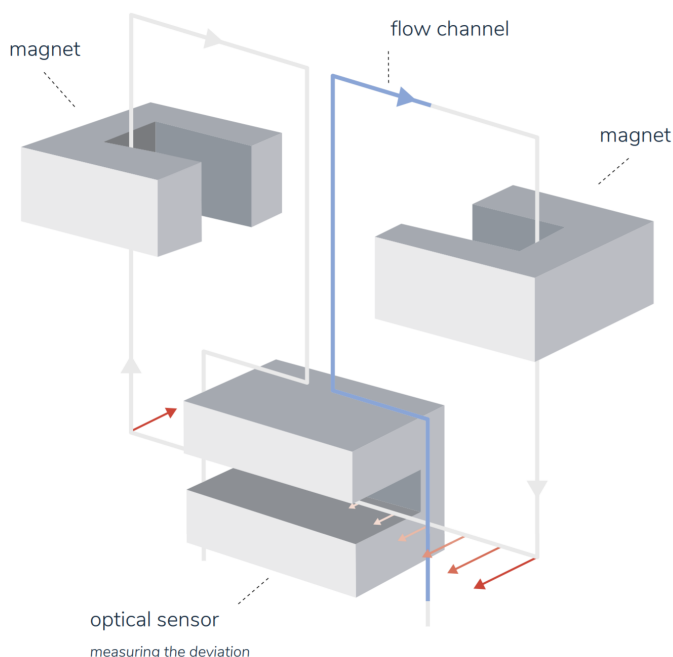
Main Features & Benefits

- 3 flow rate ranges from 1.6 $\mu\text{L}/\text{min}$ to 500 mL/min for water
- High accuracy - down to 0.2% accuracy
- Compatible with any liquids or gases without calibration
- Direct mass flow measurement, independent of fluid properties
- Additional density and temperature outputs
- Bi-directional flow rate measurement (positive & negative)
- Compatible with an OB1 flow controller for direct flow rate control
- Fast response
- Non-invasive measurements

Principle

BFS Coriolis flow sensors operate according to the Coriolis principle. The instrument can be used to simultaneously measure mass flow, temperature, and density. When a fluid flows through a vibrating tube, Coriolis forces are generated which bend or twist the tube. The extremely small tube displacements are detected by optimally positioned sensors and evaluated electronically.

Since the measured phase shift of the sensor signals is proportional to the mass flow, the BFS sensor measures the mass flow directly. The measurement principle is independent of the density, temperature, viscosity, pressure, heat-capacity, or conductivity. The tubes always vibrate at their natural frequency, which is a function not only of the tube geometry and the tube material properties but also the mass of the fluid in the vibrating tubes.



Additional information is available on our website. Go to [this page](#) to see a Webinar presented by Elveflow and Bronkhorst, and download the free PDF of this presentation.

Technical Specifications & Design

The BFS Flow Sensor is manufactured from specially selected materials (Stainless steel and Hastelloy - optional) and offers superior performance in terms of chemical resistance and biocompatibility.

Technical specifications

CORIOLIS FLOW SENSOR	BFS 1	BFS 1+	BFS 2	BFS 3
Flow range	0.1 g/h to 200 g/h		1 g/h to 2000 g/h	30 g/h to 30000 g/h
Minimum flow rate (water)	1.6 µL/min		16.6 µL/min	500 µL/min
Maximum flow rate (water)	3.3 mL/min		33.3 mL/min	500 mL/min
PERFORMANCE				
Mass flow accuracy liquids	down to ± 2 % of the measured value	down to ± 0.2 % of the measured value		
Mass flow accuracy gases	up to ± 0.5 % of the measured value			
Repeatability	± 0.05 % of rate ± 1/2 (ZS* x 100/flow) % based on digital output			
Zero stability (ZS) (1)	< ± 0.01 g/h		< ± 0.2 g/h	< ± 6 g/h
Density accuracy	< ± 5 kg/m3			
Temperature accuracy	± 0.5 °C			
Temperature effect (2)	Zero drift: ± 0.01 g/h/°C		Zero drift: ± 0.02 g/h/°C	Zero drift: ± 0.5 g/h/°C
Mounting (3)	Any position, attitude sensitivity negligible			
Device temperature	0...70 °C			
Response time (t 98 %)	0.2 s to fill the tubing then 35 ms			
MECHANICAL PARTS				
Wetted material	Stainless steel 316 L or comparable		Stainless steel 316 L or comparable	
			Optional: Hastelloy-C22	Optional: Hastelloy-C23
Pressure rating	200 bar		200 bar; higher on request	
Sensor inner diameter	250 µm		0.5 mm	1.3 mm
Microfluidic fitting type	1/4-28"		Swagelok	
Internal volume	13 µL		0.45 mL	0.82 mL
Calibration	N. A.	Individual calibration certificate is provided		

FLOW SENSOR SIZE (length x width x height): 65 x 32 x 144 mm **WEIGHT:** 3 kg

- (1) Guaranteed at constant temperature and for unchanging process and environment conditions.
- (2) Depends on flow rate, heat capacity fluid, T amb., T fluid, and cooling capacity.
- (3) To be rigidly bolted to a stiff and heavy mass or construction for guaranteed zero stability. External shocks or vibrations should be avoided.

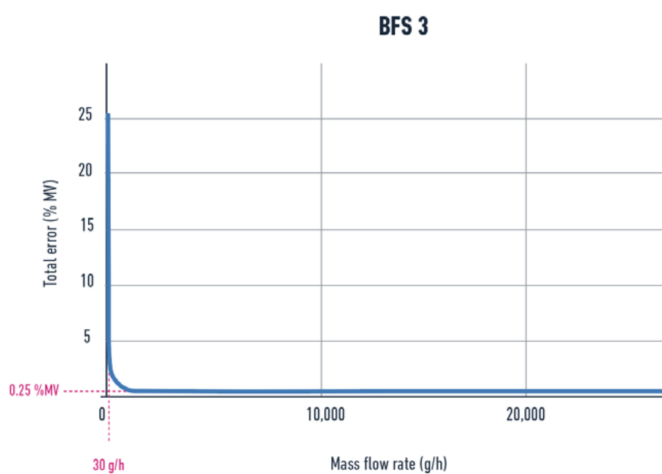
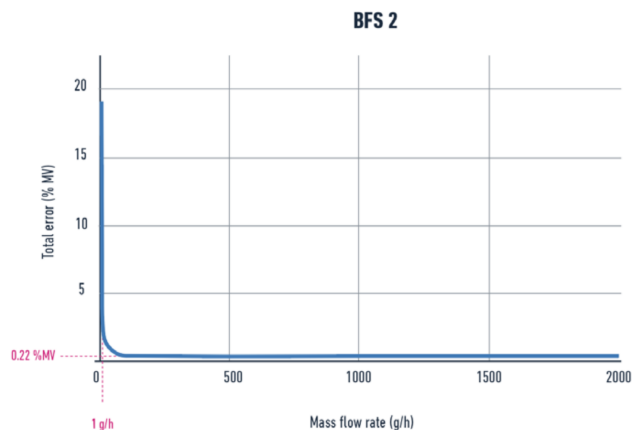
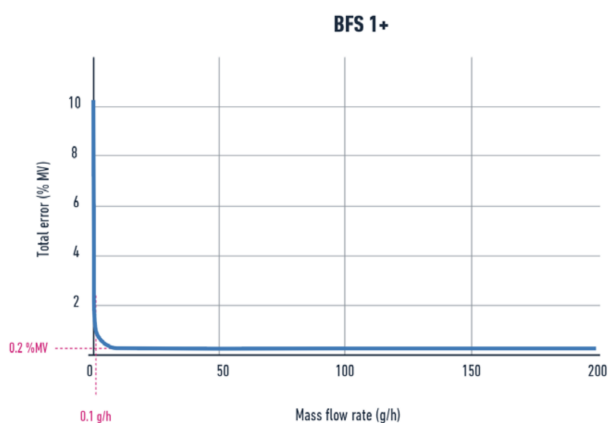


Additional information is available on Bronkhorst website.

The Bronkhorst User Guides are available for:

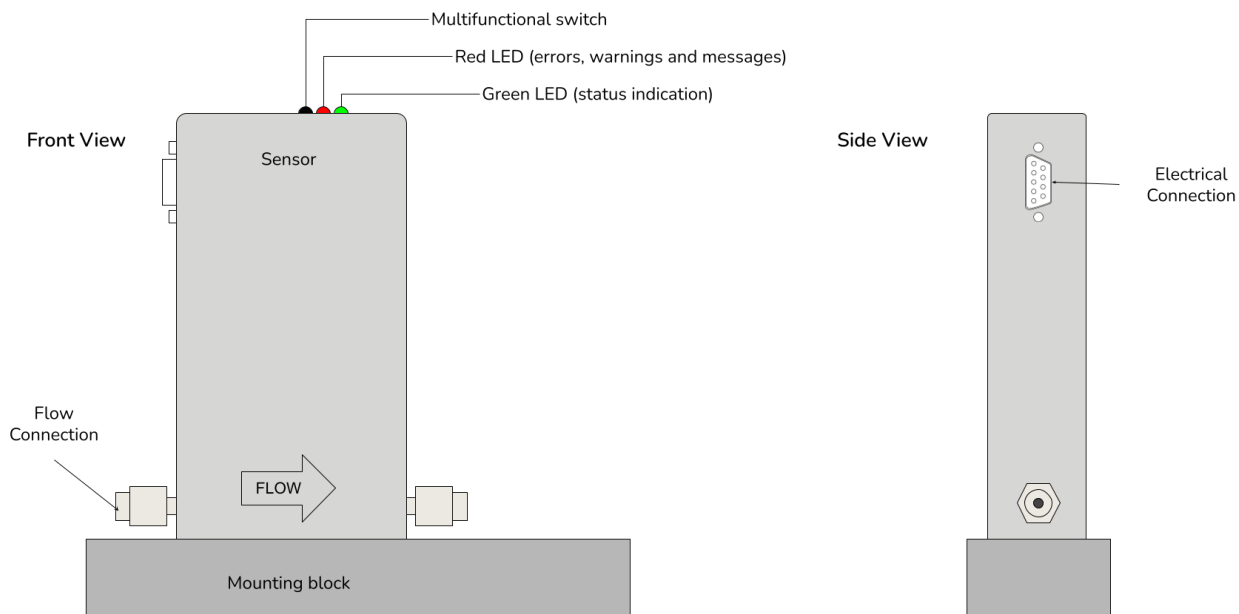
- the BFS1/BFS1+ (i.e. Bronkhorst ML120 flow sensor): [see here](#).
- the BFS2 and BFS3 + (i.e. respectively Bronkhorst M13 and M14 Flow Sensors): [see here](#).

Total error (% MV)

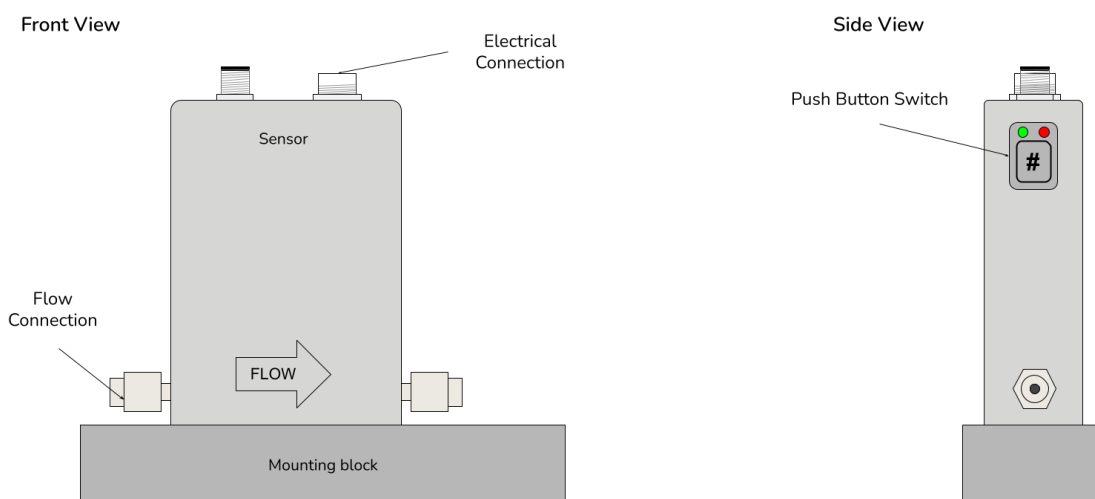


Design

Description of BFS1 and BFS 1+



Description of BFS2 and BFS3



The BFS sensors have “in” and “out” markings which indicate the flow direction. It can read positive flux (full range), and negative flux (up to 70% of the full range).

Product package contents

Each BFS flow sensor package includes the following:

BFS1 / BFS 1+

- Bronkhorst flow sensor
- Bronkhorst Documentation
- Bronkhorst mounting block
- RS 232 connection cable (sub D9) bronkhorst
- Bronkhorst RS232 / USB converter
- Bronkhorst power supply (SubD9)
- Bronkhorst calibration certificate (only for BFS1 +)
- Red plastic ferrules (cone shaped elements) for 1/16OD tubing

BFS2 / BFS3

- Bronkhorst flow sensor
- Bronkhorst Documentation
- Bronkhorst shock absorber base
- Bronkhorst RS 232 (DIN 8) cable
- Bronkhorst RS232 / USB converter
- Bronkhorst power supply (DIN 8)
- Swagelok Stainless Steel Reducer, 1/8 "to 1/16"
- Red plastic ferrules (cone shaped elements) for 1/16OD tubing.

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

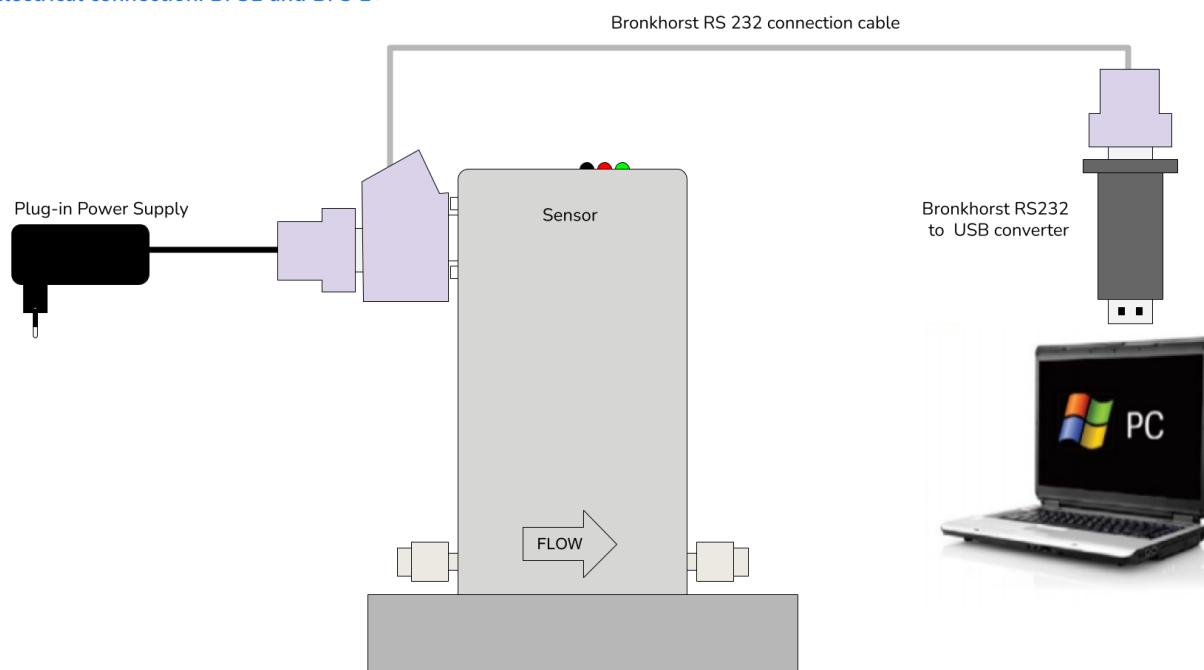
Electrical connection using Digital RS232 interface

Elveflow recommends electrical connection is made using the manufacturer's (Bronkhorst) standard cables. These cables have the right connectors and if loose ends are used, these are marked to prevent wrong connection.



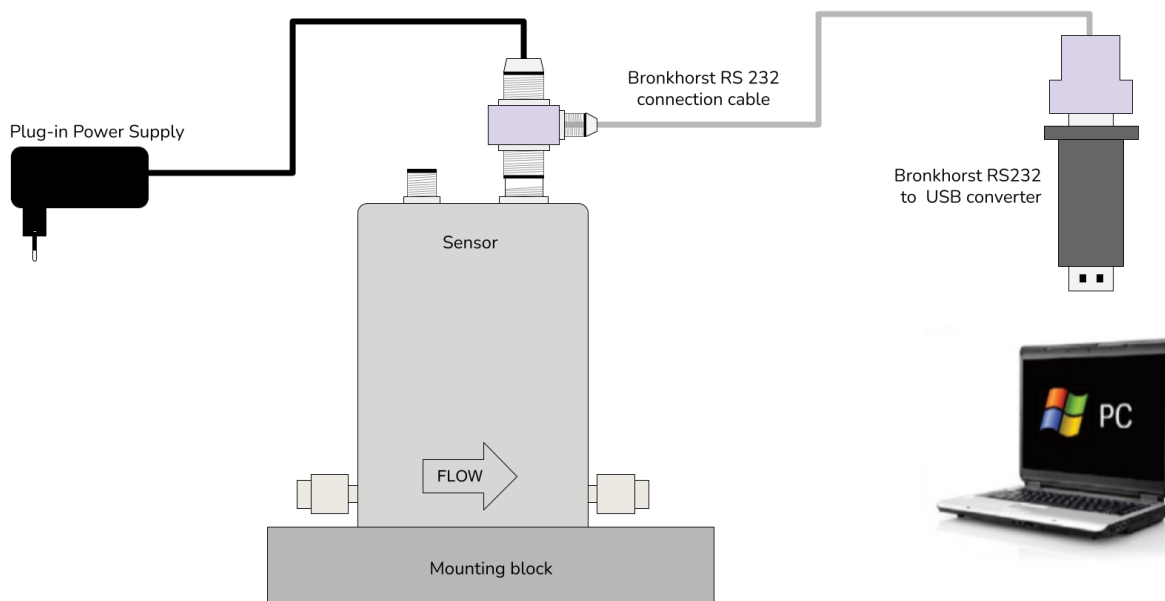
Important information. Never power the instrument simultaneously from two different power sources (e.g. Fieldbus and Plug-in Power Supply). Doing so will damage the printed circuit board irreparably.

Electrical connection: BFS1 and BFS 1+



The special T-part cable provided is required for connecting the 9-pin D-sub side connector of a BFS1 or BFS1+ instrument to a COM port of a Windows computer for RS232 communication. Please use the RS232 to USB2.0 converter provided to connect to a USB port. Then use the Plug-in Power Supply for powering the instrument.

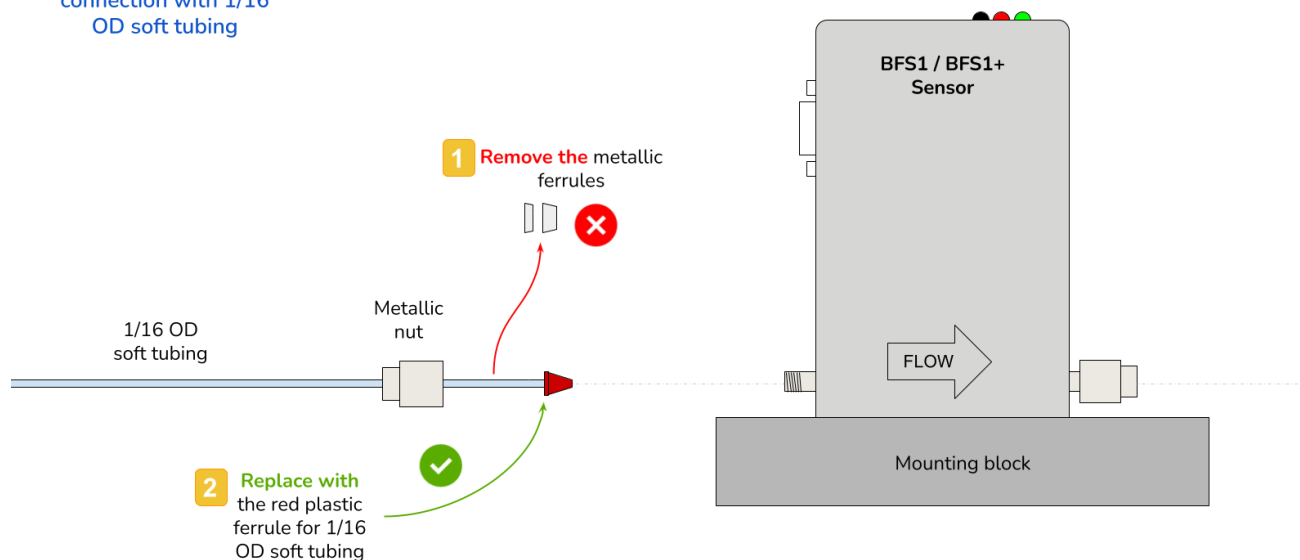
Electrical connection: BFS2 and BFS3



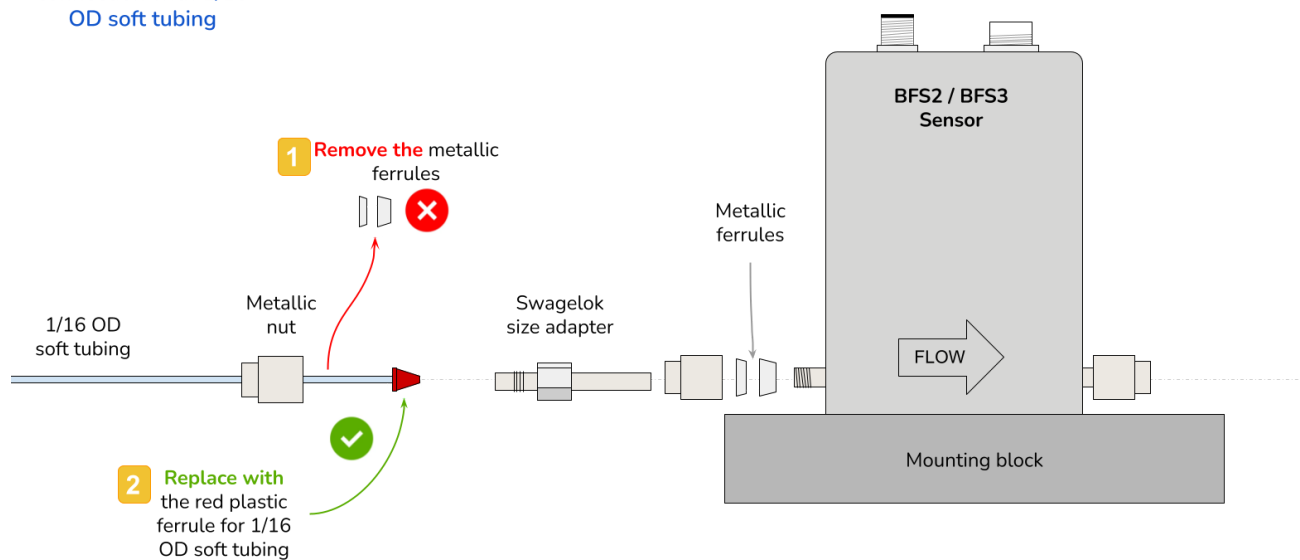
Using a special T-part RS232 cable, the 8-pin DIN connector of the BFS2 or BFS3 instrument can be connected to a USB port (via an RS232/USB converter) of a Windows computer. Power can be supplied by a Plug-in Power Supply.

Microfluidic connection

BFS1 and BFS 1+
connection with 1/16
OD soft tubing



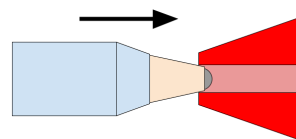
BFS2 and BFS3
connection with 1/16
OD soft tubing



Most microfluidic setups use soft tubing (tygon, PTFE) instead of stainless steel tubing that the BFS sensors were designed to use. In order to use soft microfluidic tubing, soft ferrules (the little cone shaped elements) should be used. Slide the tubing into the provided BFS metallic nut then remove the two-metallic ferrule assembly and replace it with the red plastic ferrule reaching the tip of the tubing.



Sliding the tubing into the ferrule may sometimes be difficult since the ferrule is designed to achieve maximum sealing. Some users report that using a ball-point pen to gently press the tip against the ferrule may make things easier.



Using PTFE Thread Seal tape may help to adjust fitting tightness and prevent leaks.

PTFE thread seal tape is an ideal material for microfluidic fittings. Pull the PTFE tape taut as you begin wrapping the tape around the fitting or pipe. Make sure the tape stays tense as you wrap it around the threads. Overlap the PTFE tape slightly as you continue to go around the threads. Break tape off the spool once the threads are covered. **Then use wrench tightening to assemble the parts.**



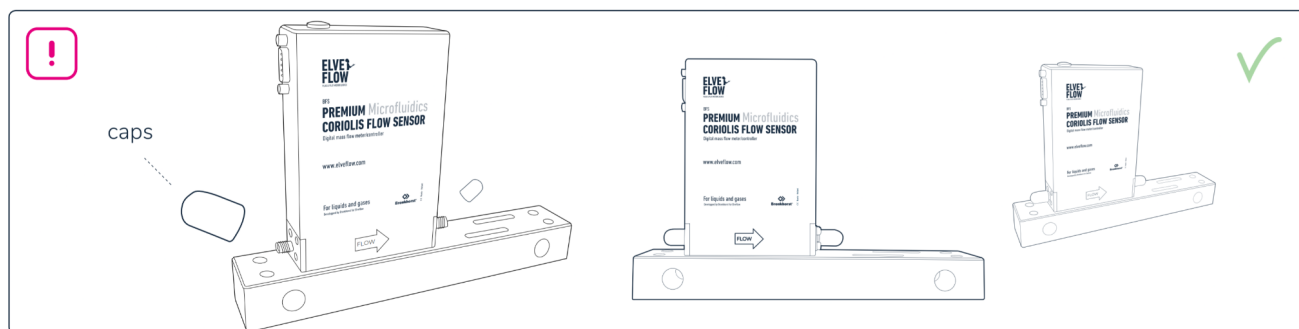
Vibration influences the measurement.

Avoid vibrations or mechanical shocks on the BFS sensor. Vibrations can influence meter performances. Therefore a vibration damper is provided with the BFS sensor. Nevertheless avoid connecting the pump directly to the meter or install an extra dampening device. A flexible connection (eg. Teflon tubing) or extra loop in the piping to neutralize vibrations is advised. Do not mount the sensor in areas subject to vibration.

Storing conditions

Always dry the flow sensor with clean, dry air before storing it.

Remove the microfluidic connectors and tubing and connect the caps to prevent dirt and dust from entering the capillary



Operation

ESI Software and SDK

You are now ready to use your instrument. It can be either controlled by the Elveflow® Smart Interface software or by software development Kit (C++, Python, MATLAB® and LabVIEW® libraries). The Elveflow® Smart Interface and the SDK main features and options are covered by specific guides. Please refer to those guides for a detailed description.



- BFS sensors have to be added as instruments in ESI
- If MUX Distribution/Distributor/Recirculation/Injection or BFS are used, additional drivers are required (<http://www.ftdichip.com/Drivers/D2XX.htm>). You can find these drivers in the same folder the ESI is installed. Default location would be C:\Program Files (x86)\Elvesys\driver (look for driver_MUX_distAndBFS.exe).

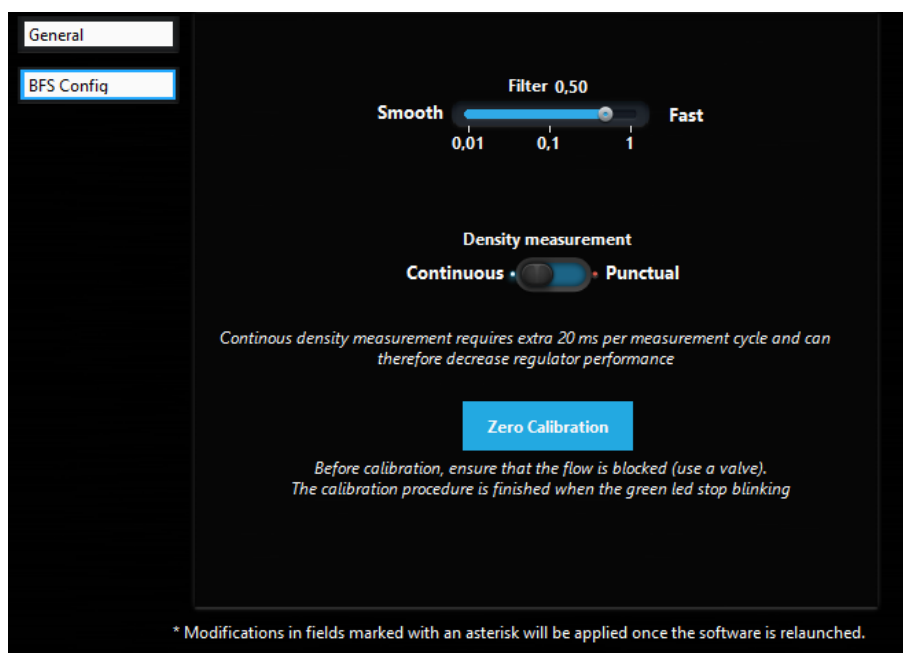
Mass flow measurement and control

When powering up, the instrument needs a couple of seconds to start up the electronics. As soon as the start-up sequence has finished (green LED glows continuously), the instrument is ready to measure mass flows, however, optimal accuracy is only reached after warming up (see Powering up and powering down below).

After powering up, the control valve closes (normally open) or stays closed (normally closed). The valve stays closed until the instrument receives a setpoint from the active setpoint source. The internal PID controller then immediately opens the control valve, until the measured flow rate matches the setpoint. It maintains the resulting flow rate until another setpoint is given.

Calibration - How to calibrate a BFS flow sensor?

The BFS sensor can be calibrated by filling it with liquid and then clamping the input and the output of the sensor to be in ZERO FLOW conditions, it is then necessary to indicate to the sensor that this state corresponds to zero. The procedure is described in the image below. In the config tab of the BFS, you will have to click on [Zero Calibration](#).



Maintenance of BFS sensors, and Advanced Use

Sensors Cleaning general recommendations

It is recommended to clean the flow 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 liquid flow 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 flow 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.



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.



Cleaning is not always successful.

If a series of cleaning attempts has been unsuccessful with the syringe, contact Elveflow to buy a new sensor, or replace the clogged component (if applicable). Sensor damage caused by bad cleaning and subsequent clogging is not covered under any warranty.

Never mechanically clean the sensor's fluidic channel.

Storing conditions

Store the sensor clean and dry.

Always drain the fluid, flush with a suitable cleaning agent and blow out with pressurized air.

Remove the microfluidic connectors and tubing and connect the yellow caps to prevent dirt and dust from entering the capillary.

Additional information



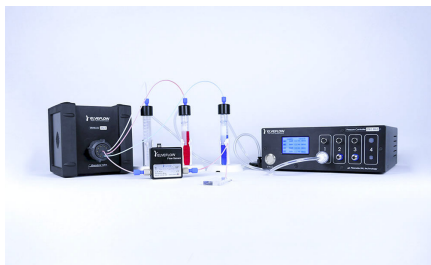
Additional information is available from the manufacturer Bronkhorst. See the official user guides available in the Elveflow USB documentation:

- User Guide BFS1 (Manual-mini-CORI-FLOW).pdf
- User Guide BFS2 BFS3 (Manual-mini-CORI-FLOW-ML120).pdf



Additional information is available on our website. Go to [this page](#) to see a Webinar presented by Elveflow, with Bronkhorst and download the free PDF of this presentation.

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.

We are always happy to help.