

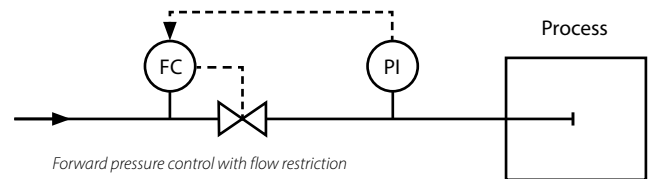
Advanced functionalities of FLEXI-FLOW™ instruments

Bronkhorst Mass Flow & Pressure Meters and Controllers of the FLEXI-FLOW series offer exceptional ease of use as well as additional capabilities that can reduce space and costs for additional parts, instrumentation or software. In this datasheet we provide a collection of these features, describing their advantages and benefits for users of our FLEXI-FLOW instruments.

› Flow/Pressure control

In general, monitoring upstream and/or downstream pressure while controlling the gas flow could warn the user via a NAMUR message for unexpected pressure drops or increases caused by leakage or clogging.

In some applications, the combined use of flow and pressure measurement can be advantageous, for instance at hydrogenation in catalytic processes. The supply of hydrogen must be accurately monitored, while increasing the pressure in the reactor. A FLEXI-FLOW instrument can be applied as forward pressure controller with flow restriction, maintaining the maximum feed of H₂ within the limits of the flow sensor. A traditional pressure control set-up with separate flow meter would not restrict the H₂ overshoot (> Full Scale) and thus provide an incorrect measurement of the total amount of H₂ that has entered the reactor. This principle of combined flow/pressure control can also be applied for e.g., performing leak tests or for testing the porosity of filters.



Alternatively, the flow/pressure control combination can prove to be beneficiary in systems where the flow should be restricted because the upstream or downstream pressure reaches its minimum respectively its maximum limit. This may, for instance, be applied to protect fragile reactors for overpressure or to prevent particle generation.

› Operational history / data logging

Logging process data could be helpful for engineers to comply with security policies or regulations, or for troubleshooting, trying to find an explanation for certain deviations. A separate data logging device may become superfluous when using FLEXI-FLOW, because the instruments can provide a comprehensive history (minimum, maximum, standard deviation and average values) of the past 24 hours, 30 days and lifetime for:

- ◆ measured flow
- ◆ measured upstream and downstream pressure
- ◆ setpoint (flow/pressure)
- ◆ temperature
- ◆ actuator output

› User stories

- ◆ "We directly improved product quality by using Bronkhorst instrument parameters. By measuring the device internal **temperature** and detecting temperature variations we were able to improve our processes."
- ◆ "In our process, we make use of the **response alarm** to monitor if an MFC reaches and maintains its setpoint within specified limits. This is helpful to know if an inlet pressure is too low, when a gas bottle is almost depleted, or to detect obstructions in the system."
- ◆ "The **power-up alarm** message, in combination with the function to return to the last setpoint after a power failure proved to be useful. We were happy that our bioreactor process directly continued after a detected power dip."
- ◆ "By following the relation between the values of **measure** and **valve out** over time, we can detect if something has changed in the setup. This can be the inlet pressure, but can also be clogging or wear of components somewhere in the setup. Maintenance can be considered if we observe such a change."
- ◆ "In our R&D environment, we use a variety of bottled gases. The inlet pressure measured by our FLEXI-FLOW instruments warns us when a gas bottle is almost empty, thus preventing an unexpected interruption of our experiment. An orange **NAMUR message** signals "insufficient pressure difference". This message could also be triggered by an (unintended) increase of the back pressure caused by an event in the downstream process."



› NAMUR NE107 diagnostics

At FLEXI-FLOW, the instrument's status is visualized by means of coloured LEDs on top of the electronics housing. This allows the user to see immediately that an instrument is displaying a warning. FLEXI-FLOW instruments provide the user with a wide range of digital parameters. These can be used for extended measurement or control functionalities, but also for continuous monitoring of the instruments and its process conditions. This valuable information can be used by maintenance systems to optimize the process and minimize the system's downtime.

The parameters mentioned in this document are a selection from an extensive parameter list, which can be found in the FLEXI-FLOW instructional manual (9.17.158). This parameter list is extended regularly with new insights and requests from customers. All instrument parameters are continuously available with any digital interface. Our implementation of digital interfaces is built up according to standard profiles for ultimate compatibility and convenience.

› Python / LabVIEW™

Bronkhorst provides drivers for LabVIEW™ and Python that implement the serial RTU commands used on the FLOW-BUS, Bronkhorst's protocol which is generally used on all our digital instruments. FLEXI-FLOW instruments, however, feature advanced functionalities. Thanks to the modular set-up, customers can easily modify our drivers according to their requirements.

› Bluetooth

In research institutes or at laboratories of universities and factories, fume cupboards with safety glass are applied to protect their staff from emissions from small scale processes or other experimental set-ups. Here, the degree of automation and the operation of the electrical components is often limited to the essentials. This is where the Bluetooth wireless transmission option of FLEXI-FLOW instruments comes in handy. The cupboards can remain closed when querying the process values and the test run or process does not need to be interrupted. Beyond safety, it is also a cost-effective solution since free apps are available for smartphones and tablets with intuitive operating software.

In industrial plants, system operators prefer to use one automation platform for all process components.

The use of additional operating software is usually not allowed, for safety reasons. Apart from the ability to monitor an instrument during production cycles, FLEXI-FLOW's Bluetooth option offers the benefits of easy data retrieval, analysis, function check or commissioning, even in cramped installation conditions.

› USB-C / Parameter monitoring

FLEXI-FLOW's USB-C connection offers the possibility of support/monitoring without having to take the instrument out of operation. Measurement, control and diagnostic parameters are of interest to monitor process conditions and set instrument messages that indicate a potential issue in the overall system. The parameters can also be used as possible indicators for maintenance.

In the tables below we listed the most used parameters with some typical suggestions for their application.

Diagnostics	Indicative parameters	Notes for use
Preventive maintenance	operation hours	input for maintenance schedule
	calibration date	input for recalibration schedule
	operational history	onboard data logging for capturing historical data
Electrical failure detection	power-up alarm message	informs the user that device has been rebooted due to loss of power
	hardware alarm message	detection of hardware issues; message for trouble-shooting
	NAMUR status indication	easy recognition of the status (self-monitoring)
	communication failure message	diagnostic info of (fieldbus) communication interface
Process failure detection	inlet pressure	low value may indicate that inlet pressure is insufficient for the process
	outlet pressure	high value may indicate possible blockage in downstream process line
	temperature	monitored value may indicate potential problems
	flow	measured signal may indicate overflow or underflow
	valve output	high value may indicate possible blockage in downstream process line
	response alarm	setpoint is not reached within the time limit
	min/max alarm	flow exceeds a minimum or maximum level

Green	Normal operation
Red	Failure
Yellow	Out of specifications
Blue	Maintenance required
Orange	Check function

